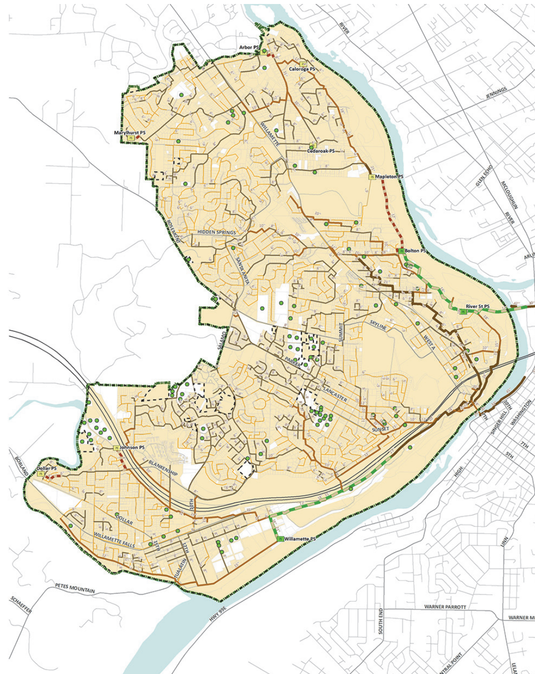
City of West Linn

Sanitary Sewer Master Plan Update



DRAFT

March 2019

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Brown AND Caldwell

City of West Linn
Sanitary Sewer Master Plan Update

SANITARY SEWER MASTER PLAN

DRAFT | March 2019

This document is released for the purpose of information exchange review and planning only under the authority of Matthew M. Huang, March 25, 2019, State of Oregon, P.E. No. 91512.

Contents

Attachments

Tables

Figures

EXECUTIVE SUMMARY

The City of West Linn (City) is located in Clackamas County, near Portland, Oregon. It is surrounded by the Clackamas River, Willamette River, and City of Lake Oswego. The City owns and operates most of the sewer collection system within the City limits. The City discharges wastewater to Clackamas County's Water Environment Services (WES)'s Regional Treatment Plant.

The City has prepared this Sanitary Sewer Master Plan (SSMP) to document the status of the City's sewer system and analyze the system to anticipate future needs. In order to provide effective, reliable, and safe sewer service, this SSMP will be used as a guide for operation, maintenance, and expansion of the sewer system for the next 20 years and beyond. This SSMP serves as the framework on which to evaluate future growth and system replacement and rehabilitation over the next 20 years, and estimate system capacity, ultimately leading to an updated Capital Improvement Plan (CIP) as part of the Sanitary Sewer Master Plan (SSMP). This SSMP covers the following main topics:

- Basis of Planning
- Existing System
- Model Development and Calibration
- Capacity Evaluation and Inflow/Infiltration Reduction
- Capital Improvement Program

This SSMP is a planning level document utilizing the best practices in the industry. The SSMP is a living document, and will allow for amendment as conditions change. This SSMP is inherently flexible to allow the City to respond to opportunities and changing conditions as they develop. In particular, Water Environment Services (WES) will complete their SSMP after the City's SSMP has been completed and the results of their SSMP may change the Capital Improvement Program recommended in this document. Beyond this, the City should be prepared to update the model to incorporate changes within the community and the collection system at approximately 10-year intervals.

Table 1 below summarizes the City's recommended Capital Improvement Program.

Table 1 CIP Overview Costs

	High Priority Cost ($)	Medium Priority Cost ($)	Low Priority Cost ($)	Total Cost ($)
Pipeline (P)	$ 2,363,000	$ 2,330,000	$ 1,320,000	$ 6,013,000
Gravity Main	$ 2,363,000	$ 1,113,000	$ 1,320,000	$ 4,796,000
Force Main	$ –	$ 1,217,000	$ –	$ 1,217,000
Pump Station (PS)	$ 1,049,000	$ 4,254,000	$ –	$ 5,303,000
Planning (PL)	$ 100,000	$ 200,000	$ 300,000	$ 600,000
General (G)	$ 5,947,000	$ 5,947,000	$ 11,895,000	$ 23,789,000
Total	**$ 9,459,000**	**$ 12,731,000**	**$ 13,515,000**	**$ 35,705,000**

Carollo Engineers, Inc. would like to acknowledge and thank the following individuals for their efforts and assistance in completing this SSMP. Their cooperation and courtesy in obtaining a variety of necessary information were valuable components in completing and producing this report:

- Erich Lais, City of West Linn, Assistant City Engineer
- Amy Pepper, City of West Linn, Senior Engineer
- Lara Kammereck, Carollo Engineers, Inc., Principal-in-Charge
- Matt Huang, Carollo Engineers, Inc., Project Manager
- Aurelie Nabonnand, Carollo Engineers, Inc., Project Engineer
- Angela Wieland, Brown and Caldwell, Project Manager
- Karen Hooge, Carollo Engineers, Inc., Document Processor
- Jackie Silber, Carollo Engineers, Inc., GIS Analyst

Section 1

BASIS OF PLANNING

The Study Area, shown as a dashed green line in Figure 1, is the currently agreed-upon service boundary. The Study Area contains area that coincide with the City limits and urban growth boundary (UGB).

Three planning periods are evaluated in this SSMP:

- Existing system.
- 5-year Planning Period.
- Build-out.

Evaluations are performed for both average dry weather flow (ADWF) and peak wet weather flows (PWWF).

ADWF is the average flow that occurs on a daily basis during the dry weather season, and is representative of routine wastewater discharges into the collection system from customers as well as baseline groundwater infiltration. PWWF is the highest observed hourly flow that occurs following the selected design storm event.

Estimated ADWFs for each basin were estimated using data from the Flow Monitoring Program for each of the flow monitoring basins. Flows were monitored at ten locations in the collection system. Future ADWF were estimated using an area based methodology using wastewater flow factors for the different land use categories. Peak wet weather flows in a sewer system can be more than ten times the base flow, causing utilities to construct high-capacity infrastructure to convey and treat these extraneous flows. Existing and projected PWWFs are predicted using the hydraulic model and design storm used for this SSMP. This analysis uses a 5-year, 24-hour design storm, accounting for climate change, with a maximum intensity of 0.5 inches/hour. To represent typical winter Pacific Northwest winter rainfall conditions, antecedent rainfall was added from historical data, as shown in Figure 2. Further detail on the development of the design storm can be found in Attachment A of this SSMP (Technical Memorandum (TM) 1 – Basis of Planning).

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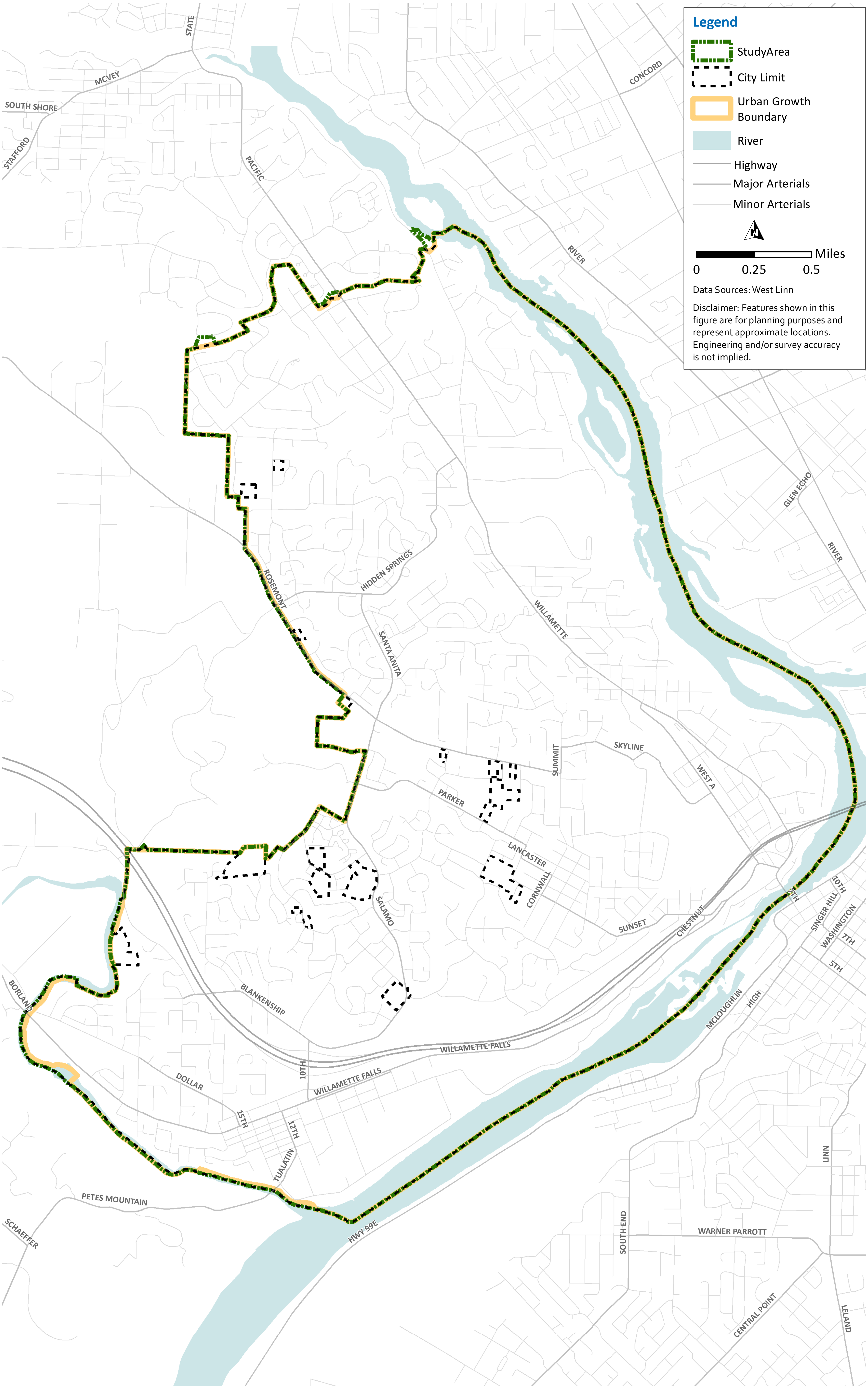

Figure 1 Study Area

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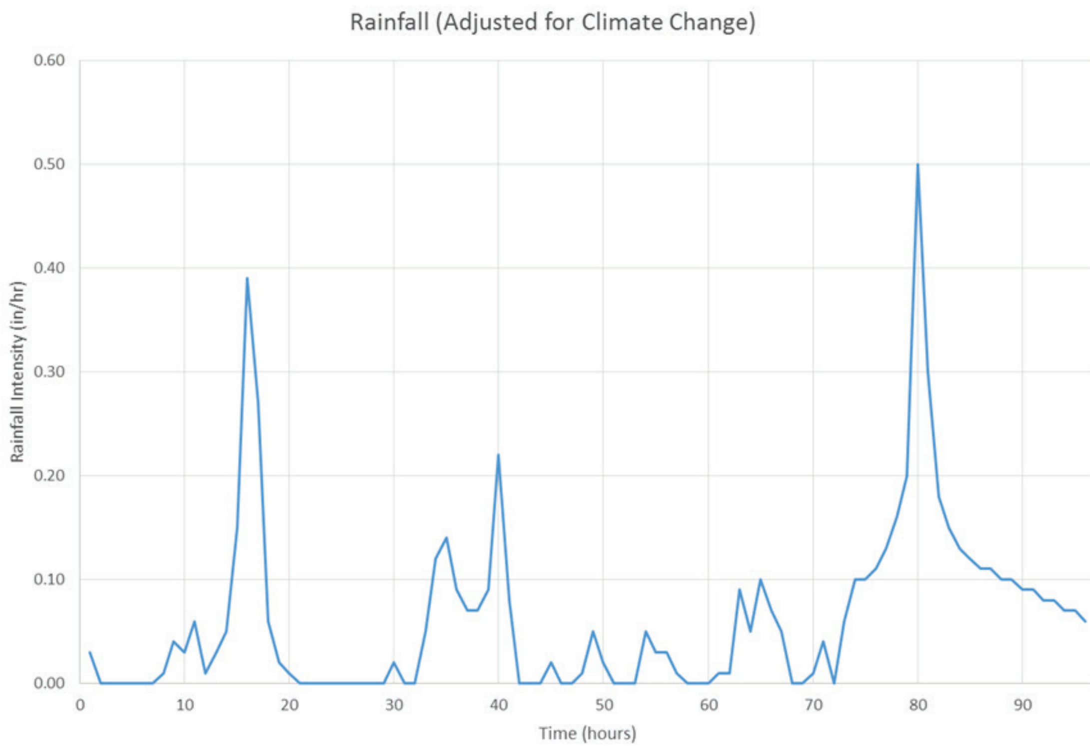

Figure 2 Design Storm Hyetograph

A summary of the predicted ADWF and PWWF flows for each planning period is shown in Table 2.

Table 2 Existing and Projected Wastewater Flows

Flow Condition	Existing Conditions	5-year Planning Period	Build-out Conditions
ADWF (mgd)	3.34	3.42	3.74
PWWF (mgd)	20.17	21.26	23.68
Peaking Factor (PF)	6.0	6.2	6.3

The City is responsible for managing and operating its sewer system in accordance with local, state, and federal regulations. To best manage the sewer system and comply with regulations, the City has adopted sewer system policies and criteria. These policies guide the development and financing of the infrastructure required to provide sewer service, and document the City's commitments to current sewer system customers as well as those considering service from the City.

Carollo performed a high-level review of the City's existing policies against similar policies developed for other wastewater agencies to identify potential missing policies or clarifications to better meet the City's current sewer management needs. While not comprehensive, this review provides recommended direction for future policy revisions. Recommended modifications and additions to these policies are shown in Tables 3, 4, 5, and 6.

Further information on the Basis of Planning can be found in Technical Memorandum (TM) 1 – Basis of Planning, which is in Attachment A of this SSMP.

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Table 3 Recommended Service & Extensions Policies

<table>
<tr><th>Subject</th><th>Policy</th><th>Source</th></tr>
<tr><td>Service Area</td><td>Clarify future service area extend.</td><td>Recommended Policy</td></tr>
<tr><td>Lateral Ownership</td><td>Future Recommendation (Example Text Provided):
Laterals shall be owned and maintained by the property owner up to and including the connection to the City-owned sewer main.</td><td>Recommended Policy</td></tr>
<tr><td>Sewer Extensions</td><td>Future Recommendation (Example Text Provided):
1) The extension of the sanitary sewer system may be initiated as follows:
a) Any person may request that the City extend the sanitary sewer system in order to serve property owned by that person.
b) The City may initiate the extension of the sanitary sewer system.
2) A request to extend the sanitary sewer system shall be in writing and shall consist of the following information:
a) A map of the property to be served by the extension of the system identifying the property by address and tax map and lot number;
b) A written report containing the reasons for the extension to the sanitary sewer system; and
c) Any other relevant information required by the City Engineer.
3) The City Engineer shall review each request for extension of the system and determine if it is in the City's interest to proceed with extension of the system. The review shall consider the following factors:
a) The potential health hazard if the system is not extended;
b) Whether the properties to be served by the extension are within the City limits at the time of the request, are likely to connect to the system and agree to be annexed within a reasonable period, or are slated to receive service from the City pursuant to a valid intergovernmental between the City and another governmental unit.
c) The number of properties that will benefit if the system is extended and whether those properties are currently developed; and
d) The potential water quality benefits if the system is extended.
e) Adequacy of the available funding source.
f) Availability of public right-of-way or easements.
If the City Engineer determines that it is in the City's interest to proceed with extension pursuant to subsection 3 of this section, the extension shall be scheduled for construction. Persons who apply to connect to the extended line shall pay the line charge established prior to and as a condition of connection.</td><td>Recommended Policy</td></tr>
<tr><td>Annexations</td><td>Future Recommendation (Example Text Provided):
Unincorporated property shall be required to annex prior to the receipt of City sanitary sewer service, or as set forth below:
Each of the following conditions must be met to provide unincorporated property with City sanitary sewer service prior to annexation:
1) The property shall be located within the Urban Growth Boundary;
2) Existing sanitary sewer line operated by the City to which connection can be made in accordance with subsection (4) below is within 300 feet of the property;
3) The City has found that the septic system serving the property is failing and the City has directed connection to a sanitary sewer system;
4) The extension of a sanitary sewer line to be connected to the City sanitary sewer line shall be subject to acceptance of an approved plan by the City Engineer.</td><td>Recommended Policy</td></tr>
<tr><td>Sewer Study For Oversizing</td><td>Future Recommendation (Example Text Provided):
A sanitary sewer study will be required when an 8-inch diameter gravity sewer is inadequate to serve the current or future development or when the City Engineer determines that a recently annexed area situated outside the limits of the currently adopted Plan warrants a study. The study shall incorporate the proposed design system including features as the pipe slope, cover, and size; the study shall include, but not be limited to, a detailed map of the sanitary sewer service, sewage flow calculations, and pipe hydraulic calculations.</td><td>Recommended Policy</td></tr>
<tr><td>Oversizing Pipes</td><td>Future Recommendation (Example Text Provided):
When land outside a new development will logically direct flow into a storm drain or sanitary sewer within the new development, the system shall be "public" and shall be extended to one or more of the upstream development boundaries. The pipes shall be sized to accommodate all off-site flows, based on a fully developed condition using the current Comprehensive Plan.</td><td>Recommended Policy</td></tr>
<tr><td>Sewer Drainage Basins</td><td>Future Recommendation (Example Text Provided):
Each facility system serves different geographic sub-areas of the City. While facilities such as parks and schools relate more to neighborhoods defined by population size and travel time/distance, systems such as sewers, water, and storm water drainage are more logically defined by topography, soils, and other natural constraints. Such disparities can interfere with coordination of planning for public facilities, affecting different client populations. To help overcome these barriers, the "Public Facilities Element" should be organized, where possible, in relation to a common set of geographic sub-areas.</td><td>Recommended Policy</td></tr>
<tr><td>Use of Public Sewers Required</td><td>Future Recommendation:
Modify policy in Municipal Code 4.005 to require connection to sanitary sewer system from 200 feet to 300 feet. This modification is recommended to match policies from other agencies in the Portland metropolitan area.</td><td>Recommended Policy</td></tr>
</table>

Table 4 Recommended System Reliability Policies

Subject	Policy	Source
Security	Future Recommendation (Example Text Provided): The City shall make reasonable attempts to protect the security of its sewer collection system. The City shall determine what information about the system should remain unavailable to the general public.	Recommended Policy
Reliability	Future Recommendation (Example Text Provided): The City shall manage the sewer collection system through developing design standards, overseeing construction, operating, and maintaining the system such that service to areas in the Urban Services Boundary is adequate and reliable. Whenever possible, the City shall anticipate system interruptions, such as power outages, and design and operate the system to minimize the impact of such interruptions on its customers and the environment.	Recommended Policy
Resiliency	Carollo can provide example text to reference Oregon Resilience Plan.	Recommended Policy
Maintenance	Future Recommendation (Example Text Provided): Unless specifically directed otherwise by the City, all facilities and equipment shall be maintained in accordance with manufacturers' specifications. The City adheres to maintenance and replacement schedules for all facilities and equipment.	Recommended Policy
Equipment Inventory	Future Recommendation (Example Text Provided): The City shall maintain a complete inventory of all City-owned equipment, supplies, parts, and service vehicles used for maintenance of sewer facilities. The inventory should include planned replacement dates as applicable.	Recommended Policy
Emergency Response Plan	Future Recommendation (Example Text Provided): On a regular basis, the City shall update their Emergency Operations Plan focusing on responding to emergencies and disasters.	Recommended Policy
Natural Hazards Mitigation Plan	Future Recommendation (Example Text Provided): On a regular basis the City shall update and maintain their Natural Hazards Mitigation Plan addressing risks associated with natural hazards.	Recommended Policy

Table 5 Recommended Environmental Policies

Subject	Policy	Source
Sustainability	Future Recommendation (Example Text Provided) The City will manage the sewer collection system, including monitoring and adapting plans, policies, and practices to collect and convey wastewater from its customers in a safe and sustainable manner in accordance with the City's Environmental element of the Comprehensive Plan.	Recommended Policy
Overflows	Future Recommendation (Example Text Provided) The City has implemented programs to prevent overflows of wastewater in the existing system, and requires all new construction to convey peak flows and storm events without overflowing the sewer during the design storm event.	Recommended Policy
Infrastructure Siting	Future Recommendation (Example Text Provided) New wastewater infrastructure will be sited outside of stream corridors, wetlands, and significant tree groves whenever feasible.	Recommended Policy

Table 6 Recommended Design Policies & Criteria

Subject	Policy	Source
Design Approach - Storm	Action Item: Update design storm requirement In accordance with all applicable federal, state, and local regulations, the City should design its sewer facilities to adequately and reliably convey peak hour flows associated with a 24-hour, 5-year recurring storm event without overflowing or discharging to any water bodies.	Action item
Surcharging	Action Item: Update surcharging requirement • New facilities shall be designed to prevent the hydraulic grade line from exceeding the crown of pipe during Peak Wet Weather Flow (PWWF). Allowable depth to full depth (d/D) ratios for new pipes can be based on a graduated criteria according to pipe size, as shown in the following: – <=12-inch; d/D = 0.5 – >=15-inch; d/D = 0.75 • The existing system shall be evaluated for two conditions of surcharging, as follows: – Under Peak Dry Weather Flow (PDWF), pipes can flow full with a depth to full depth (d/D) ratio of 0.90 – Under Peak Wet Weather Flow (PWWF), the Hydraulic Grade Line (HGL) may not rise above one feet above any pipe invert.	Action item
Manholes - Locations	Modify criteria such that cleanouts are never permitted at any location.	Recommended modifications to existing policy
Piping – Allowable Size	Future Recommendation: Modify policy from "A 6 in. diameter sewer will be allowed with the City Engineer's approval." To ". A 6 in. diameter sewer may be allowed with the City Engineer's approval."	Recommended modifications to existing policy
Pump Stations - Operability During Design Storm	Future Recommendation (Example Text Provided): Provisions shall be included in the design of any pump station to allow the station to remain fully operational and accessible during the design storm.	Recommended additions to existing policy
Pump Stations - Flow Meters	Future Recommendation (Example Text Provided): Permanent flow meters shall be provided in a separate vault for all new pump stations.	Recommended policy
Pump Stations - Reliability	Future Recommendation (Example Text Provided): In order to reduce the risk of overflows during power outages or when performing routine maintenance, the City shall install emergency back-up power generators, receptacles for portable generators and/or bypass pump connections at all of its pump stations. For pump stations without telemetry, it is recommended to install telemetry. The telemetry system shall have back-up battery power that allows the telemetry system to continue to operate for up to seven days.	Recommended additions to existing policy
Pump Station - Sizing	Future Recommendation: Wet well sizing can be achieved in stations with low influent flow rates, but would likely result in oversized wet wells for larger stations. We would recommended for the standard of 4 hours of storage above high water alarm to be respected whenever possible, but that a reduced duration be acceptable if approved by the City.	Recommended additions to existing policy
Pump Stations - Bypass Pumping Requirements	Future Recommendation (Example Text Provided): The City's pump stations shall be designed with bypass pump connections that will allow the City to pump directly from the wet well into the pump station's force main with a portable pump, thus bypassing the pumps in the dry well. This feature should allow the City to manage wet well levels during power outages and routine maintenance.	Recommended additions to existing policy
Pump Stations - DEQ Documentation	Future Recommendation (Example Text Provided): Design engineers shall provide to the City and DEQ all documentation required by OAR 340-052-0040 including the final O&M Manuals and certification that the construction was inspected by the design engineer and found to be in accordance with the plans and specifications.	Recommended policy
Design Approach - Design Flows	Future Recommendation (Example Text Provided) Sewer flows are composed of residential, institutional, commercial, and industrial sewage, along with infiltration and inflow. Sewers must be capable of conveying the peak hourly flows of these wastewater sources as estimated using the design storm.	Recommended policy
Testing	Future Recommendation: The existing policy requires an air test for gravity sanitary sewer testing. The City should also permit a water test.	Recommended modifications to existing policy

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Section 2

EXISTING SYSTEM

The City's collection system consists of approximately 115 miles of gravity mains, 1.5 miles of force mains, and 10 pump stations that collect and convey wastewater to the Tri-City Water Pollution Control Plant. Figure 3 presents the City's existing collection system, and shows the currently connected and contributing tax lots as provided by the City.

The City owns and maintains six small pump stations and one larger pump station, the Mapleton Pump Station. The remaining three pump stations (Bolton, River Street, and Willamette Pump Station) are operated and maintained by Clackamas County's Water Environment Services (WES). County customers contribute flow both upstream and downstream of the City collection system. This SSMP only discusses the City's system and does not cover WES' system.

The City's gravity mains are approximately 25 percent (%) clay pipe, 25% polyvinyl chloride (PVC) pipe, and 50% concrete pipe. A summary of the gravity pipelines are listed in Table 7 by diameter size. The City owns seven pump stations and their associated force mains; a summary of the pump stations are in Table 8 and the force mains in Table 9.

The City's collection system is divided into 25 wastewater basins that are denoted alphabetically. Figure 4 shows the wastewater basins, showing which areas contribute flows to which pipelines.

Further information on the Existing System can be found in TM 2 – Existing System, which is in Attachment B of this SSMP.

Table 7 Collection System Gravity Main Inventory

Diameter (inch)	Length (LF)	Percentage of System
Unknown	293,629	48.6%
4	164	0.03%
6	16,704	2.8%
8	212,131	35.1%
10	25,278	4.2%
12	15,798	2.6%
14	1,765	0.3%
15	15,107	2.5%
18	11,149	1.8%
21	7,898	1.3%
24	5,123	0.8%
Total (feet)	**604,747**	**100%**
Total (miles)	**114.5**	**100%**

Notes:
(1) System only includes gravity mains and excludes private sewers and WES pipes.

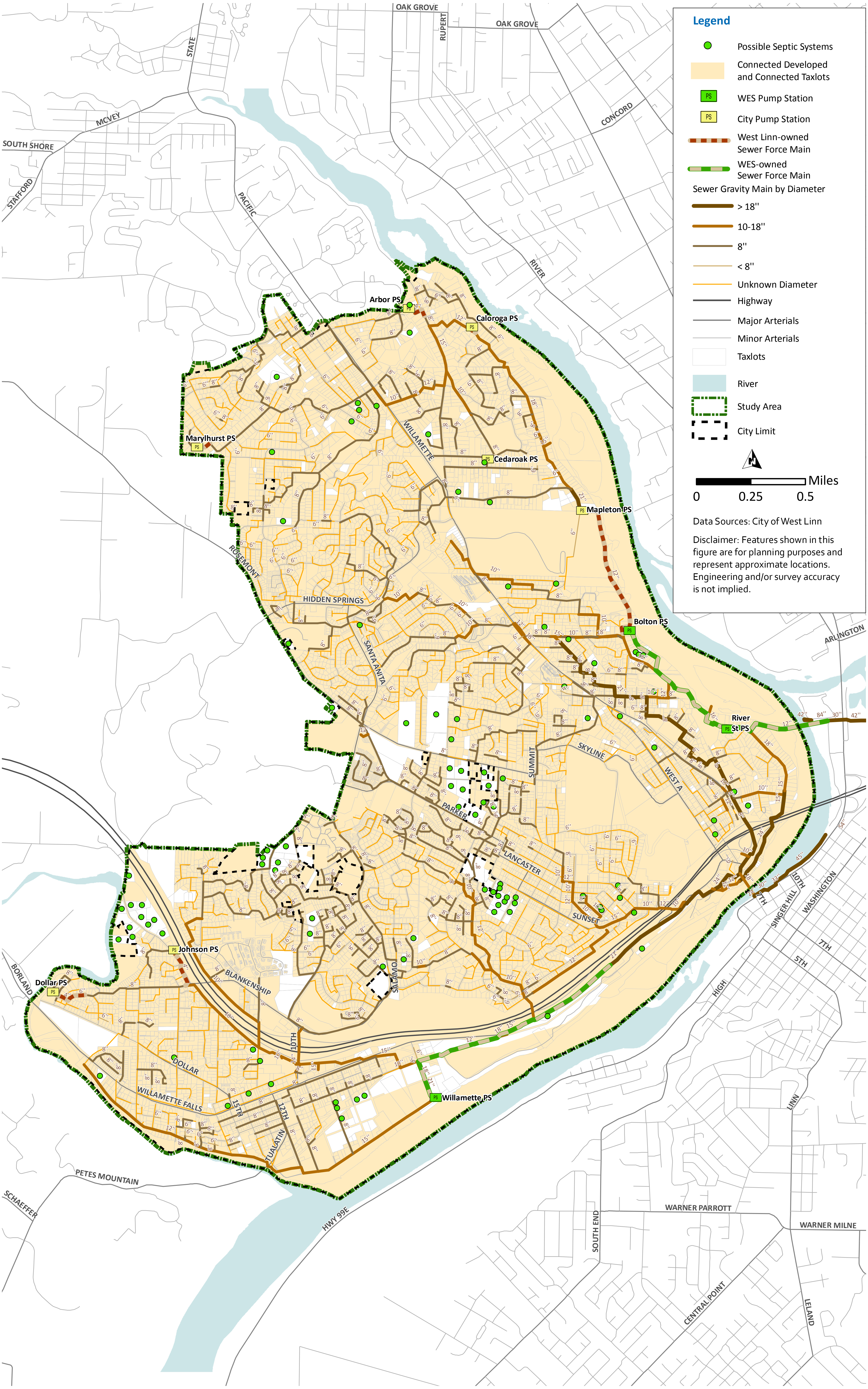
Table 8 Existing Pump Stations Inventory Summary (City Owned)

Pump Station	Sewer Basin	Address	Number of Pumps	Horsepower (hp)	Flow (gpm)	Head (ft)	Pump Station Capacity		Year Constructed / Rehabilitated
							Total(1) (gpm)	Firm(2) (gpm)	
Arbor PS	5A	3609 Arbor Dr	2	10	190	70	380	190	1990
Calaroga PS	4A	3831 S Calaroga Dr	2	7.5	80	44	160	80	1993
Cedaroak PS	7A	3964 Cedar Oak Dr	2	2	150	21.5	300	150	1990
Dollar (River Heights) PS	9D	2220 Brandon Pl	2	18	118	112	236	118	1992
Johnson PS	10A	23701 S Johnson Rd	2	6.5	175	64	350	175	1998
Mapleton PS	3C	19050 Nixon Ave	2		1,000	125	2,950	1,950	1998
			1		950	115			
Marylhurst PS	3A	900 Marylhurst Cir	2	3	160	28	320	160	1990

Notes:
Total capacity corresponds to the capacity of the station with all pumps running.
Firm capacity corresponds to the capacity of the station with largest pump out of service.

Table 9 Collection System Force Main Inventory

Pump Station	4-inch	8-inch	12-inch	16-inch	18-inch	Total (ft)	Percent System (%)
Arbor PS	628					**628**	**2.8%**
Bolton PS				6,380		**6,380**	**28.3%**
Calaroga PS	213					**213**	**0.9%**
Cedaroak PS	234					**234**	**1.0%**
Dollar PS	926					**926**	**4.1%**
Johnson PS	987					**987**	**4.4%**
Mapleton PS			3,746			**3,746**	**16.6%**
Marylhurst PS		394				**394**	**1.8%**
River Street PS			2,675			**2,675**	**11.9%**
Willamette PS					6,322	**6,322**	**28.1%**
Grand Total (ft)	**2,988**	**394**	**6,421**	**6,380**	**6,322**	**22,505**	**100%**


Legend
Possible Septic Systems
Connected Developed and Connected Taxlots
WES Pump Station
City Pump Station
West Linn-owned Sewer Force Main
WES-owned Sewer Force Main
Sewer Gravity Main by Diameter
> 18''
10-18''
8''
< 8''
Unknown Diameter
Highway
Major Arterials
Minor Arterials
Taxlots
River
Study Area
City Limit
Miles
0
0.25
0.5
Data Sources: City of West Linn
Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.
Arbor PS
Caloroga PS
Marylhurst PS
Cedaroak PS
Mapleton PS
Bolton PS
River St PS
Johnson PS
Dollar PS
Willamette PS
OAK GROVE
RUPERT
STATE
MCVEY
SOUTH SHORE
STAFFORD
PACIFIC
CONCORD
RIVER
WILLAMETTE
ROSEMONT
HIDDEN SPRINGS
SANTA ANITA
SUMMIT
SKYLINE
WEST A
PARKER
LANCASTER
SUNSET
BLANKENSHIP
SALAMO
10TH
DOLLAR
WILLAMETTE FALLS
15TH
12TH
TUALATIN
BORLAND
PETES MOUNTAIN
SCHAEFFER
HWY 99E
ARLINGTON
WASHINGTON
SINGER HILL
7TH
5TH
HIGH
LINN
SOUTH END
WARNER PARROTT
WARNER MILNE
CENTRAL POINT
LELAND

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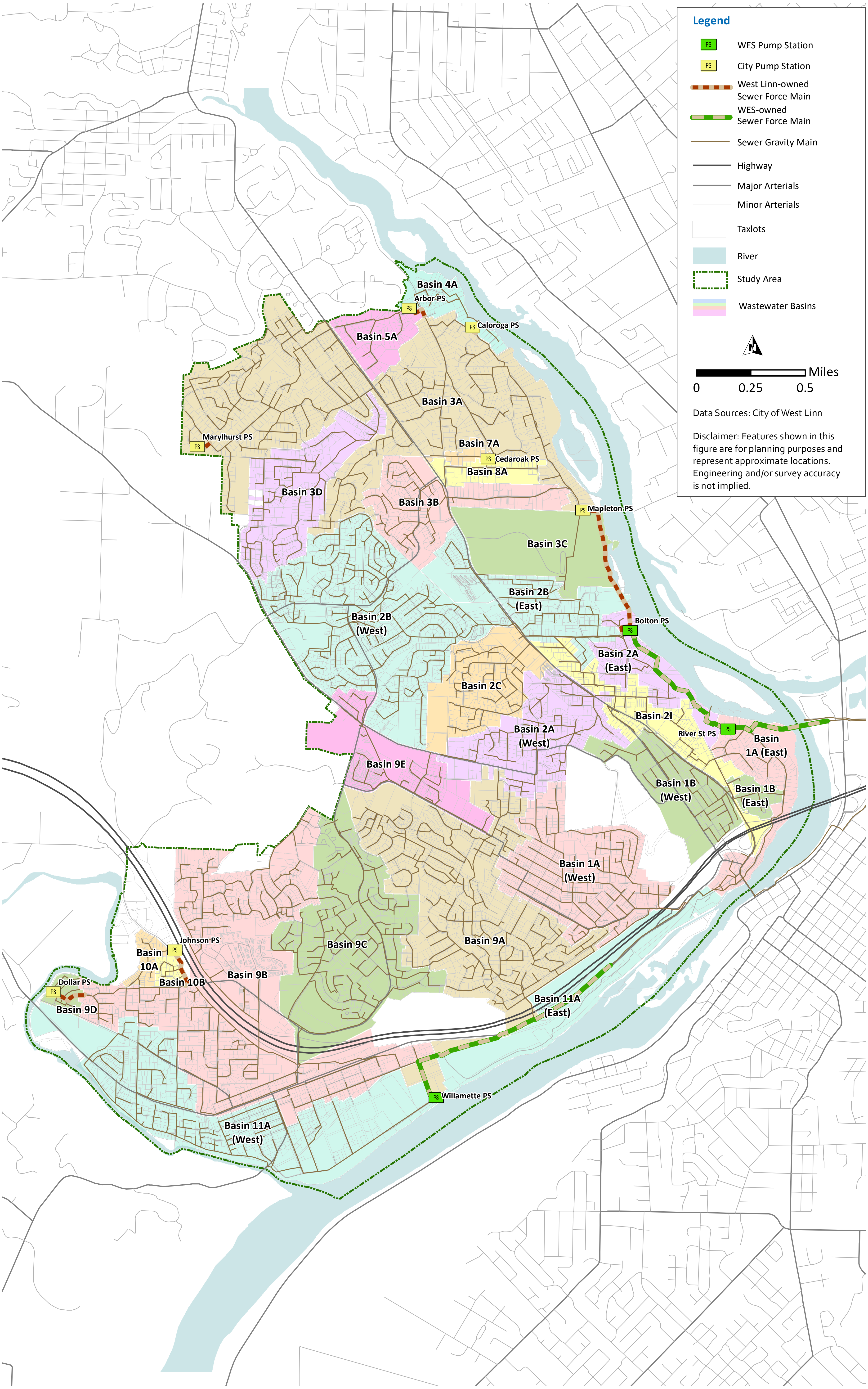

Figure 4 Wastewater Basins

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Section 3

HYDRAULIC MODEL DEVELOPMENT AND CALIBRATION

Wastewater collection system models are valuable tools used to assess the performance of collection systems during dry and wet weather conditions, and to plan for future improvements. These models provide a means to simulate the impact of different sized storms on the collection system, and determine where future system deficiencies are likely to occur. In addition, a well-calibrated model provides a method for testing alternative improvement scenarios.

A sewer collection system model is a simplified representation of the real sewer system. Sewer system models can assess the conveyance capacity for a collection system. In addition, sewer system models can perform "what if" scenarios to assess the impacts of future developments and land use changes. The City's collection system hydraulic model was constructed using a multi-step process utilizing data from a variety of sources. A hydraulic model was developed to evaluate the sanitary sewer system, with the model consisting of the City's main gravity pipelines, and all pump stations and force mains. The model was constructed in InfoSWMM, a hydraulic modeling software package, and the part of the collection system modeled is shown in Figure 5.

For this project, flow monitoring was conducted at 10 meter sites for a period of approximately nine weeks from January 2016 to March 2016. Dry weather flow (DWF) calibration ensures an accurate depiction of base wastewater flow generated within the study area. The wet weather flow (WWF) calibration consists of calibrating the hydraulic model to specific storm events to accurately simulate the peak and volume of infiltration/inflow (I/I) into the sewer system. The model was calibrated to field flow measurements. Further information on the hydraulic modeling can be found in TM 3, which is in Attachment C of this SSMP.

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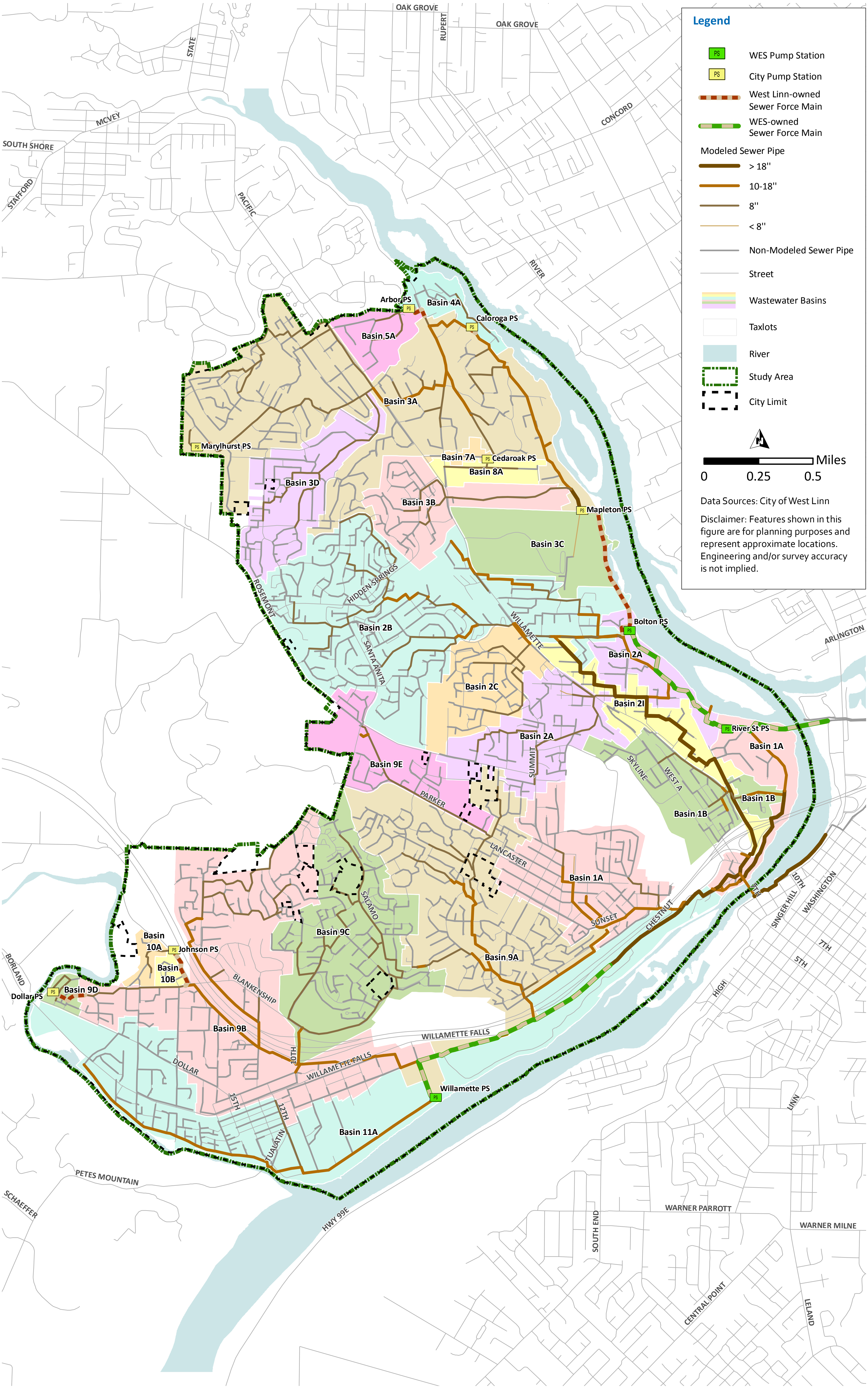

Figure 5 Modeled Sanitary Sewer Collection System

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Section 4

CAPACITY EVALUATION AND INFLOW/INFILTRATION REDUCTION

As the City continues to grow and age, some of the City's sewer infrastructure may reach capacity for adequately handling flows. Capacity evaluation of the wastewater collection system was performed in accordance with the following criteria, using the hydraulic model developed for this SSMP:

- During Peak Wet Weather Flow (PWWF), water levels were allowed to rise no more than 1 foot above the pipe crown. Sewers were allowed to surcharge under these maximum flow conditions during the design storm. Additionally, no surcharging was allowed for shallow manholes (the difference between the manhole rim and top of pipe was less than four feet).
- Pump capacity shall be sized to handle PWWF from a tributary area with the largest pump out of service.
- The existing force mains shall have a maximum pipe velocity of 8 feet per second (ft/sec) during pumping of PWWF.
- The 5-year, 24-hour desSection4.1ign storm is used for sizing the City's sewer infrastructure. Essentially, this design storm has a five percent chance (1/20) that 3.2 inches of rain will fall in any 24-hour period in a given year, and accounts for climate change assumptions.
- It was assumed that degradation (increase in peak I/I rate) would be 7 percent per decade.

4.1 Capacity Evaluation

A capacity analysis of the modeled collection system was performed with the City's calibrated hydraulic model using the system performance criteria outlined above. I/I degradation (increase in peak I/I rate) of 7 percent per decade was the assumption used for this analysis, allowing for a conservative scenario system outcome in 20 years.

The capacity analysis identified areas in the sewer system where flow restrictions may occur or where the pipe does not have capacity to convey design flows. Sewers that lack sufficient capacity to convey design flows could produce backwater effects in the collection system that increase the risk of Sanitary Sewer Overflows (SSOs). Potential system deficiencies were identified for PWWF for existing and build-out conditions and are highlighted in Figure 6.

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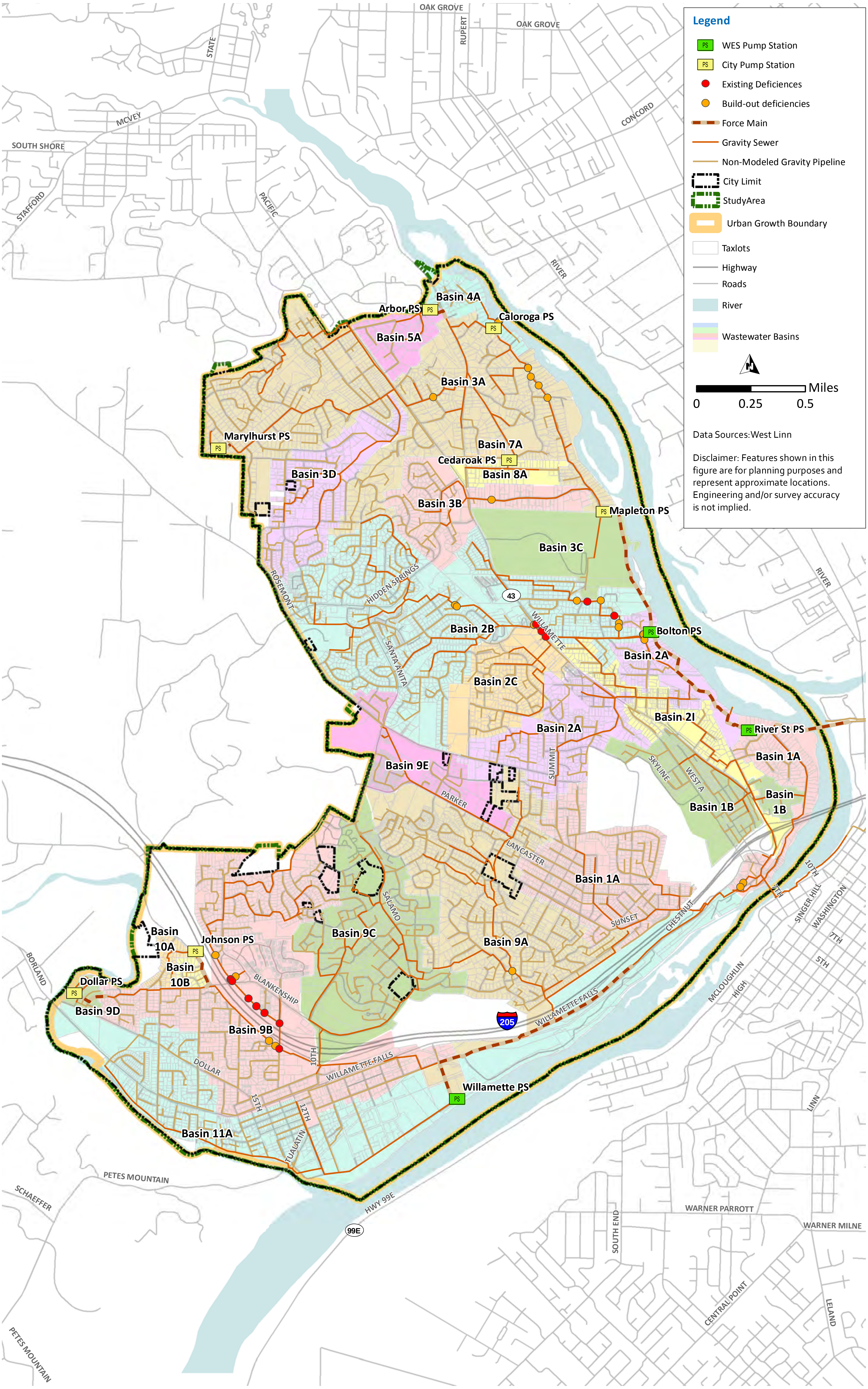

Figure 6 Potential System Deficiencies

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Table 10 summarizes the results of the City owned pump station capacity evaluation. The total capacity and firm capacity of each pump station is compared to the projected PWWFs for both existing and build-out conditions.

As seen in Table 9, all pump stations, except for the Mapleton and Calaroga pump stations, have adequate capacity for existing and build-out conditions. Calaroga is deficient by 0.07 mgd for total capacity and 0.13 mgd for firm capacity under existing conditions.

Mapleton has adequate total capacity for existing conditions, but is deficient by 1.1 mgd under firm capacity and does not meet the City's redundancy criteria. By build-out, Mapleton will be deficient by 0.62 mgd for total capacity and 2.06 mgd for firm capacity.

In conjunction with the pump station analysis, City-owned force mains were analyzed using the hydraulic model. All force mains are adequately sized, with the exception of Mapleton. At build-out, modeled velocity in the existing force main was 8.7 fps, greater than the City's 8 fps velocity criteria. This Mapleton force main deficiency should be addressed in conjunction with capacity improvements to the Mapleton pump station.

Table 10 Pump Station Evaluation

Pump Station Name	Total Capacity (mgd)	Firm Capacity (mgd)	Existing Maximum PWWF (mgd)	Build-out Maximum PWWF (mgd)	Existing Condition Deficiency (Total/Firm) (mgd)	Build-out Condition Deficiency (Total/Firm) (mgd)
Arbor	0.55	0.27	0.13	0.14	- / -	- / -
Calaroga	0.12	0.06	0.19	0.19	0.07 / 0.13	0.07 / 0.13
Cedar Oak	0.43	0.22	0.10	0.11	- / -	- / -
Johnson	0.50	0.25	0.11	0.12	- / -	- / -
Mapleton	4.25	2.81	3.91	4.87	- / 1.1	0.62 / 2.06
Marylhurst	0.46	0.23	0.02	0.02	- / -	- / -
River Heights	0.34	0.17	0.06	0.07	- / -	- / -

4.2 Inflow and Infiltration Reduction Program

Inflow and infiltration (I/I) into the sanitary sewer system increases as degradation of the system occurs, reducing total available capacity in pipelines, pump stations, and treatment facilities. The rainfall-dependent I/I is seen immediately (inflow) or within hours after a storm (infiltration).

An important factor in the reduction of I/I in the City's system is Water Environment Services (WES)' collection system. Flows and I/I from the City and neighboring partners may trigger capacity issues for WES's pump stations, pipelines, and treatment facility. The City's capacity analysis presented above did not show significant capacity deficiencies that would trigger the need for an extensive I/I program.

WES is currently developing its sanitary sewer master plan. As part as this effort, preliminary data and flow targets were provided by WES as guidance when investigating I/I status. The preliminary data from WES correspond to peak flow estimates in 2040, assuming a 65-percent I/I reduction in select sub-basins.

I/I reduction goals for the City to meet WES' preliminary data were developed using an iterative process with the City's calibrated hydraulic model. Several iterations were simulated using a range of wastewater basins and I/I percent reduction goals.

Based on modeling results, preliminary data available from WES at the time of the development of this SMMP and high expense ($99.3 M – see details in TM No.4) to implement an I/I program to meet WES' preliminary flow targets, it is not recommended that the City pursue an extensive I/I program at this time with a full Sanitary Sewer Evaluation Survey (SSES).

Further collaboration between the City and WES to refine and clarify future assumptions and I/I reduction goals is highly recommended. The City's capacity analysis presented in Section 4.1 did not show significant capacity deficiencies in the collection system that would trigger an extensive I/I program need. Further coordination should confirm flow reduction targets and assumptions. Further investigation of the cost of treatment and conveyance versus the cost of implementing I/I reduction strategies is needed.

In the meantime, it is recommended that the City focus its CCTV and repair and replacement program in the following basins:

- Basin 1A West
- Basin 2B East
- Basin 1B West
- Basin 1A East
- Basin 2A West
- Basin 2I

Given the relatively elevated I/I parameters identified in these basins, especially Basin 1A West, it is recommended that the City prioritize these wastewater basins for condition and repair and replacement (Project G-1 in the CIP). CCTV and repair and replacement in these basins will ultimately decrease flows from I/I.

Further information on the capacity reduction and I/I reduction evaluation can be found in TM 4, which is in Attachment D of this SSMP.

Section 5

CAPITAL IMPROVEMENT PROGRAM

The purpose of the CIP is to provide the City with a guideline for planning and budgeting for improvements to its sanitary sewer system. The CIP consists of cost estimates and timing for each project. Capital projects were categorized by the nature of infrastructure:

- Pipeline Projects (P)
- Pump Stations (PS)
- General (G)

CIP projects were prioritized based on the urgency to mitigate existing deficiencies and to service anticipated growth. The CIP projects were separated into three phases based on project priority:

- High Priority (2019-2023)
- Medium Priority (2024-2028)
- Low Priority (2029-2038)

5.1 Cost Estimating Assumptions

Association for the Advancement of Cost Engineering (AACE) Class 4 estimates were used for this SSMP. Class 4 cost estimates of this type are order of magnitude estimates; actual costs may vary from these estimates by minus 30 percent to plus 50 percent.

Baseline construction costs were calculated by multiplying estimated project quantities by the unit cost.

The Estimated Construction Cost consists of the Baseline Construction Cost and the following multipliers applied to Baseline Construction Cost:

- Construction Contingency (30 percent)
- Planning Contingency (20 percent)
- Traffic Control/Utility Relocation (5 – 10 percent)

The Capital Improvement Cost consists of the Estimated Construction Cost with the following multipliers applied on top of the Estimated Construction Cost:

- Engineering/Permitting/Project Administration (25 percent)
- Construction Administration (10 percent)

5.2 Capital Improvement Program

The CIP cost estimates were developed from cost curves, information obtained from previous studies, and experience from other projects. Estimated project quantities were developed in TM 4. These costs were determined based on the City's and Carollo Engineers, Inc.'s (Carollo's) understanding of current conditions at the project locations.

All cost estimates were made using September 2018 dollars. The Engineering News-Record (ENR) U.S. 20-City Construction Cost Index for September 2018 is 11,170. Cost estimates are subject to change as the project design matures. Cost of labor, materials, and equipment may vary in the future. Details on cost estimating and assumptions can be found in TM No. 5 – CIP (Attachment E).

Table 11 summarizes the City's recommended Capital Improvement Program. The CIP is graphically shown in Figures 7 and 8.

As per Section 4.2 discussion, an extensive I/I reduction program is not recommended at this time, therefore, no I/I reduction costs are included in this CIP. It is recommended that the City target higher I/I areas as part of its ongoing pipeline replacement program (included in General (G) project costs). Further collaboration between the City and WES to refine and clarify future assumptions and I/I reduction goals is highly recommended. The City's capacity analysis presented in Section 4.1 did not show significant capacity deficiencies in the collection system that would trigger an extensive I/I program need. Further coordination should confirm flow reduction targets and assumptions. Further investigation of the cost of treatment and conveyance versus the cost of implementing I/I reduction strategies is needed.

Further information on the capacity reduction and inflow/infiltration reduction program can be found in TM 4, which is in Attachment D of this SSMP.

Table 11 CIP Overview Costs

	High Priority Cost ($)	Medium Priority Cost ($)	Low Priority Cost ($)	Total Cost ($)
Pipeline (P)	$ 2,363,000	$ 2,330,000	$ 1,320,000	$ 6,013,000
Gravity Main	$ 2,363,000	$ 1,113,000	$ 1,320,000	$ 4,796,000
Force Main	$ –	$ 1,217,000	$ –	$ 1,217,000
Pump Station (PS)	$ 1,049,000	$ 4,254,000	$ –	$ 5,303,000
Planning (PL)	$ 100,000	$ 200,000	$ 300,000	$ 600,000
General (G)	$ 5,947,000	$ 5,947,000	$ 11,895,000	$ 23,789,000
Total	**$ 9,459,000**	**$ 12,731,000**	**$ 13,515,000**	**$ 35,705,000**

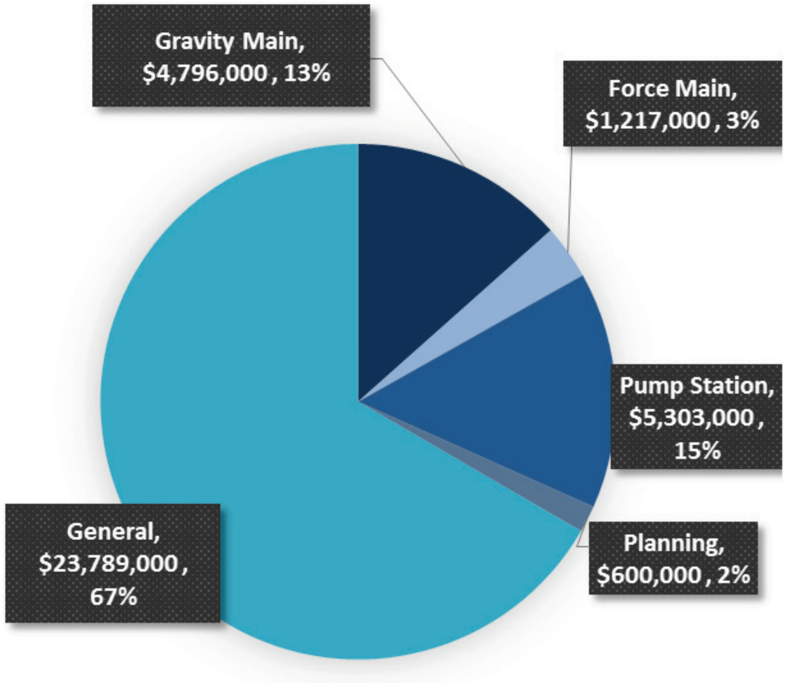

Figure 7 CIP Costs by Project Type

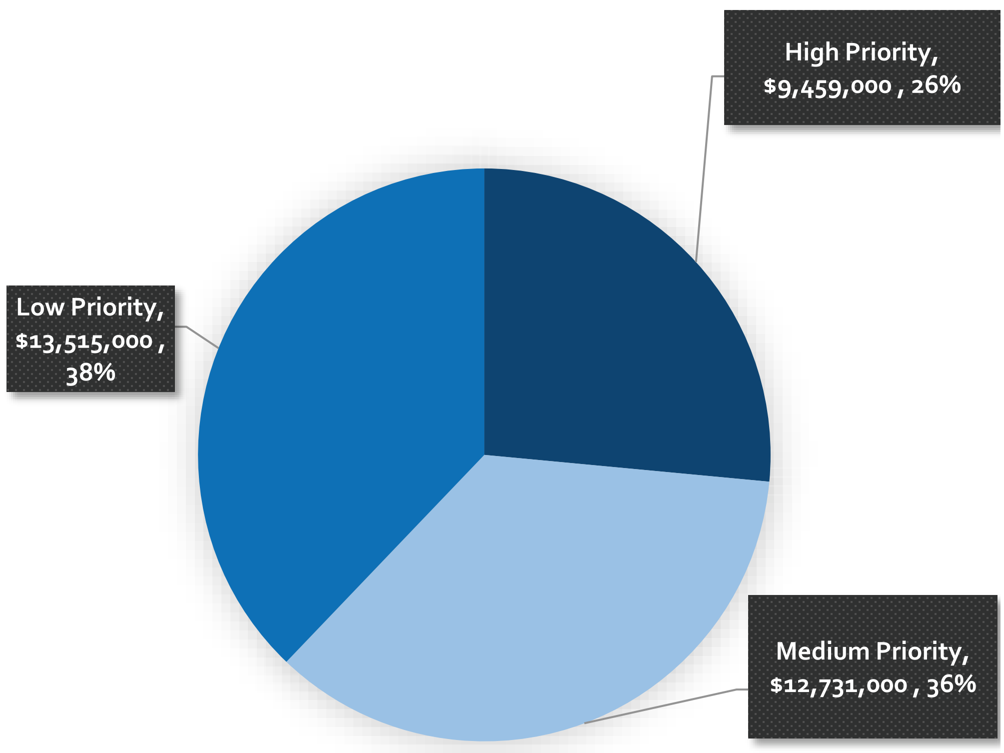

Figure 8 CIP Costs by Project Priority

5.3 Pipeline Projects

Pipeline projects are broken down into two categories: gravity main projects and force main projects. Details on both types of projects are provided below. The locations of all CIP projects are shown in Figure 9, with project prioritization shown in Figure 10.

5.3.1 Gravity Main Projects

5.3.1.1 I-205 Crossing (P-1)

The existing I-205 crossing acts as a bottleneck in the collections system due to inadequately sized pipes in the area. Hydraulic deficiencies were identified under existing conditions, and are amplified with additional flow in the basin under build-out conditions. Project P-1 is located in wastewater basin 9B and consists of upsizing 2,520 feet of existing 10-inch gravity main to 15 inch gravity main running parallel to 1-205 southwest of the Willamette Terrace Apartments and crossing I-205 at 13th Street. This includes 617 feet of highway crossing with 15-inch pipe and a 30-inch casing. This is a high priority project and is estimated to cost $2,363,000.

5.3.1.2 Wellington Drive (P-2)

Project P-2 is located in wastewater basin 9A and consists of upsizing 425 feet of existing 10-inch gravity main to 12-inch gravity main crossing Wellington Drive near the intersection of Wellington Drive and Wellington Court. This project resolves a deficiency identified under the build-out condition. This section of pipe is identified as deficient mainly due to a relatively flat slope section, which causes the hydraulic grade line (HGL) to rise above the one-foot above pipe crown criteria. No deficiencies are identified under existing condition, therefore, it is recommended that the City monitor this area as flows increase and system degrades in the future.

This is a low priority project to be addressed in the long-term and is estimated to cost $147,000.

5.3.1.3 Willamette Drive (P-3)

Project P-3 is located in wastewater basin 2B and consists of upsizing 614 feet of existing 12-inch gravity main to 15-inch gravity main along Willamette Drive between Magone Lane and Pimlico Drive. In addition, 69 feet of 15-inch gravity main is to be upsized to 18-inch gravity main along Dillow Drive from Willamette Drive to Tulane Street. This project resolves deficiencies identified under existing conditions due to relatively flat slopes for both sections of pipe. Both sections of pipe are surrounded by steeper sections upstream and downstream, a configuration that typically triggers the HGL to rise in the flat portions of the system.

This is a medium priority project and is estimated to cost $269,000. Note, this project is located in a basin (wastewater basin 2B), where an I/I reduction program might mitigate the need for this improvement.

5.3.1.4 Palomino Circle (P-4)

Project P-4 is located in wastewater basin 2B and consists of upsizing 508 feet of existing 8-inch gravity main running northwest of Palomino Circle and north of Pimlico Drive to the main southeast of Bronco Court to 12-inch gravity main. This section of pipe was identified as deficient under build-out conditions, with the deficiency caused mainly by a relatively flat slope section that causes the HGL to rise above the one-foot above pipe crown criteria.

This is a low priority project to be addressed in the long-term and is estimated to cost $175,000.

5.3.1.5 Larson Ave (P-5)

Project P-5 is located in wastewater basin 2B and consists of upsizing 1,162 feet of existing 8-inch gravity main to 12-inch gravity main along Larson Avenue from Tulane Street to Jolie Point Road and along Jolie Point Road to Munger Drive. This section of pipe was identified as deficient under existing conditions, with the deficiency caused mainly by a relatively flat slope section that causes the HGL to rise above the one-foot above pipe crown criteria. Additionally, modeling shows that the entire section is capacity deficient based on PWWF. I/I degradation and development are anticipated to amplify this problem.

This is a medium priority project and is estimated to cost $401,000. Note, this project is located in a basin (wastewater basin 2B), where an I/I reduction program might be recommended that could mitigate the need for this improvement.

5.3.1.6 Dillow Drive and Maple Terrace (P-6)

Project P-6 is located in wastewater basin 2B and consists of upsizing 351 feet of existing 10-inch gravity main to 15-inch gravity main between Dillow Drive and Maple Terrace. This project is triggered by deficiencies highlighted in the existing condition, and deficiencies are anticipated to be amplified once project P-5 is completed and with the addition of flows caused by growth and system aging. Additionally, this section of pipe is relatively flat, which causes the HGL to rise up quickly.

This is a medium priority project and is estimated to cost $132,000. Note, this project is located in a basin (wastewater basin 2B), where an I/I reduction program might be recommended that could mitigate the need for this improvement.

5.3.1.7 Nixon Ave (P-7)

Project P-7 is located in wastewater basin 3A and consists of upsizing 1,522 feet of existing 18-inch gravity main to 24-inch gravity main along Nixon Avenue from north of Island View Way to Calaroga Court. This project is triggered by deficiencies identified under build-out conditions. The City's effort to relining sewer lines in wastewater basin 3A decreased I/I rates in the northern part of the system significantly. The previous Master Plan, completed prior to these upgrades, showed high I/I and deficiencies in this area. It is recommended that the City monitor this area as the system degrades over time.

This low priority project is recommended for the long-term and is estimated to cost $876,000.

5.3.1.8 Fairview Way (P-8)

Project P-8 is located in wastewater basin 3A and consists of upsizing 160 feet of existing 10-inch gravity main to 12-inch gravity main along Fairview Way between Rose Way and Chippewa Court. This project addresses deficiencies identified under build-out conditions.

This is a low priority project and is estimated to cost $55,000.

5.3.1.9 Failing Street (P-9)

Project P-9 is located in wastewater basin 2A and consists of upsizing 160 feet of existing 12-inch gravity main to 18-inch gravity main from Failing Street to the Bolton Pump Station. This project addresses deficiencies identified under build-out conditions. It is recommended the City monitor this area as the system grows and degrades over time.

This low priority project is estimated to cost $67,000.

5.3.1.10 Mill Street (P-10)

Project P-10 consists of relocating the sewer line in the vicinity of Mill Street, as shown in Figure 9. As the properties between WFD and Mill Street redevelop, this section of sewer line needs to be upgraded and realigned to the street right-of-way. This project will be part of the waterfront line project. Modeling shows no capacity issues with the existing pipe diameter, therefore, the recommendation is to replace it with the same diameter. However, when this project is triggered, this project should be evaluated in more detail and confirm pipe size and alignment. This project is anticipated as a medium priority project and is estimated to cost $311,000.

5.3.2 Force Main Projects

5.3.2.1 Mapleton Force Main (P-11)

Project P-11 is located in wastewater basin 3A and consists of constructing 3,750 linear feet of 8-inch force main running parallel to the existing 12-inch force main from the Mapleton Pump Station to the Bolton Pump Station. Under build-out, velocities in the force main exceed the City’s criteria of 8 fps under PWWF conditions, and is considered to be deficient.

This is a medium priority project, to be completed in conjunction with the Mapleton PS improvements, and is estimated to cost $1,217,000.

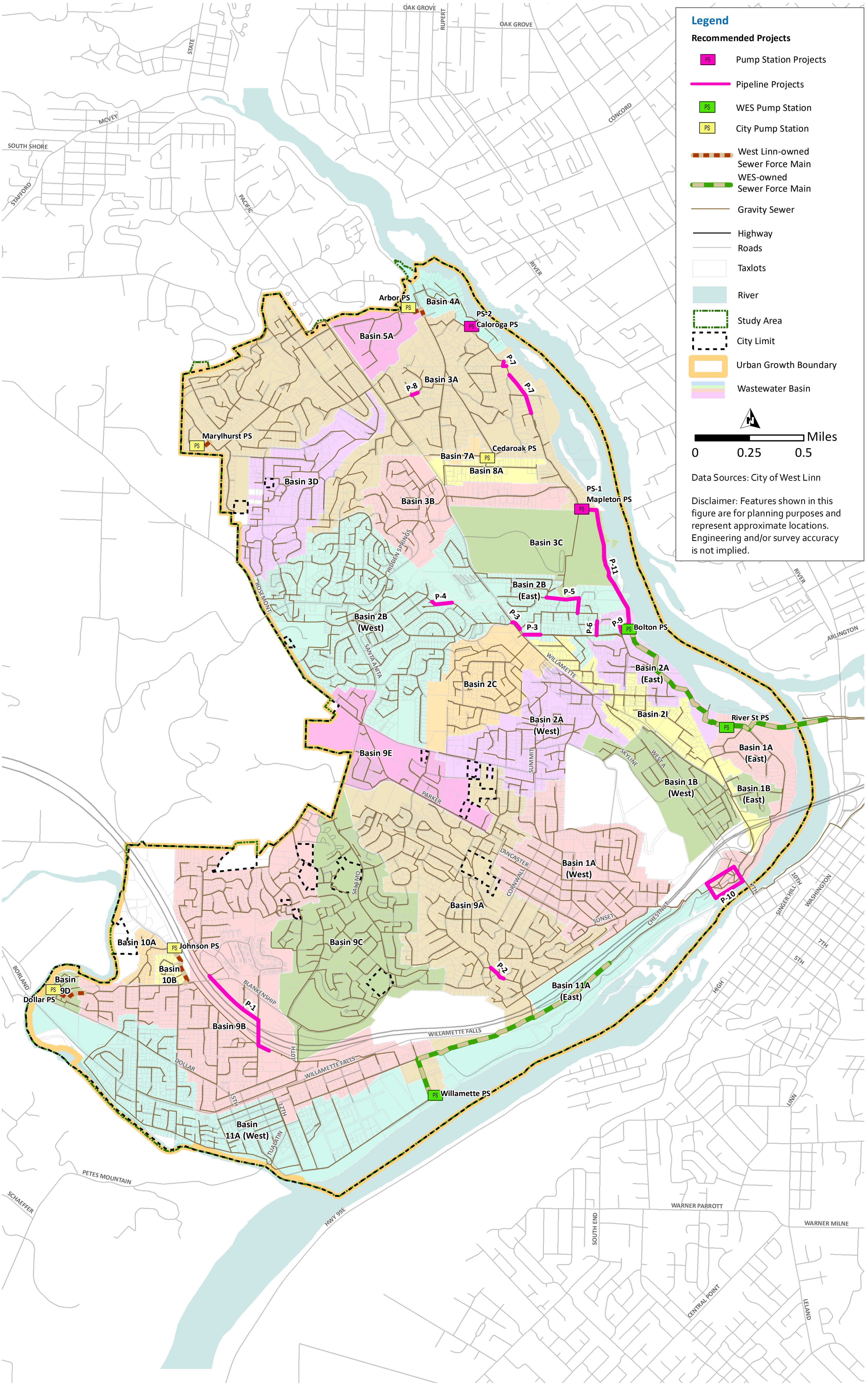

Figure 9 Recommended CIP Projects

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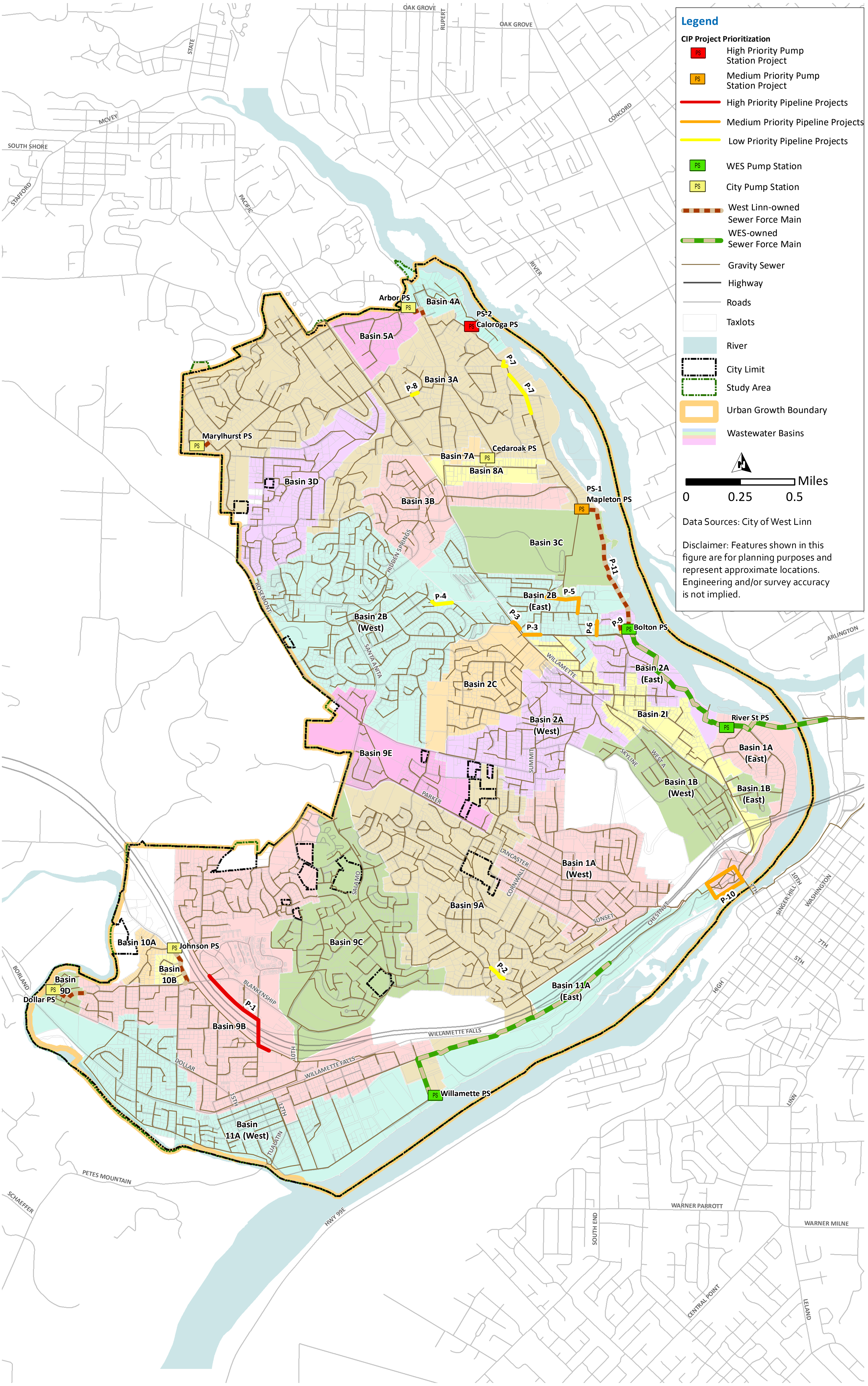

Figure 10 CIP Project Prioritization

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5.4 Pump Station Projects

5.4.1 Mapleton Pump Station (PS-1)

Project PS-1 consists of upgrading Mapleton Pump Station capacity from an existing 2.81 mgd (firm)/4.25 mgd (total) to 4.87 mgd firm capacity. This medium priority project is needed for the City to meet an existing firm capacity deficiency of 1.1 mgd and to provide sufficient capacity for build-out. Prior to completing this project, the City should evaluate the condition of this pump station and install a flow meter to better understand flow trends.

It is assumed this project will be completed in conjunction with the Mapleton force main project, and is estimated to cost $4,254,000.

5.4.2 Calaroga Pump Station (PS-2)

Project PS-2 consists of constructing a new pump station to increase Calaroga Pump Station capacity from an existing 0.06 mgd (firm)/0.12 mgd (total) to 0.19 mgd (firm)/0.40 mgd (total). A new pump station is recommended to address existing firm and total capacity deficiencies and existing issues with this pump station.

This project is estimated to cost $1,049,000.

5.5 Planning Projects

5.5.1 Asset Management Program (PL-1)

The City should develop an Asset Management Program (AMP) to assist in prioritizing repair and replacement of its aging wastewater infrastructure. Developing an asset management plan will help the City find the optimal timing for repair or replacement (R&R) of assets by weighing the costs of continued maintenance against the cost of R&R. Development of this SSMP will help prioritize projects to reduce operation and maintenance risks resulting in lower overall costs burdened by ratepayers.

It is recommended the City take the following initial steps to prepare for implementing an AMP:

- Continue to update data such as pipe material, year installed, and invert elevations, in the City's Geographic Information Systems (GIS) and Computerized Maintenance Management Software.
- Standardize condition assessments and closed-circuit television (CCTV) reports using the Pipeline Assessment and Certification Program (PACP). This may entail working with non-City contractors performing CCTV inspections. City staff could be trained on PACP scoring.
- Take the Strategic Asset Management Gap (SAM-GAP), a free, online utility self-assessment tool.

No project costs are included for these recommendations, as they are assumed to be performed by current City staff. In addition to these steps, the following strategy is recommended for the City to develop and implement an AMP:

1. Assess the City's Current Asset Management Practices.
2. Review Appropriate Asset Management Tools.
3. Identify and Prioritize Gaps in Current Asset Management Practices.
4. Prepare an Asset Management Plan.
5. Implement the Asset Management Plan.

It is anticipated full development and implementation of steps 1 through 5 will cost between $75,000 and $200,000. The more conservative estimate of $200,000 was used for planning in the CIP. Costs for implementing the projects prioritized by the AMP are assumed to come from other annual repair budgets. Development of the AMP was assumed to a medium priority project.

5.5.2 Sanitary Sewer Master Plan Update (PL-2)

This project assumes the City will update this Sanitary Sewer Master Plan one time in the long-term planning period. A long-term budget placeholder of $300,000 was included, with no contingencies or cost multipliers applied.

5.5.3 Pump Station Condition Evaluation (PL-3)

Although a capacity assessment was completed as part of this SSMP effort, it is recommended that the City perform a condition assessment on the City's pump stations. This project is recommended for the short-term, and a budget cost of $100,000 was assumed with no contingencies or cost multipliers applied.

5.6 General Projects

5.6.1 Repair and Replacement Program (G-1)

This project allocates an annual budget of $750,000 to be used for pipeline R&R projects to effectively replace aging or failing pipe, which equates to approximately one mile of pipe per year. Projects will be identified by City staff annually, including projects identified as part of the AMP. To more cost-effectively address pipeline R&R projects, the City should consider geographically concentrated projects that address multiple concerns and incorporate other utilities, such as water main projects or roadway resurfacing, and focus on areas with high inflow/infiltration.

5.6.2 CCTV Program (G-2)

It is recommended that the City implement an Annual program for CCTV inspection of the City's gravity mains. This program will help the City determine pipeline condition and identify potential sources of I/I. It is assumed that the City will inspect 10 percent of the system per year, approximately 60,000 linear feet of pipeline per year. An annual budget of $440,000 was allocated throughout the planning period for this effort, assuming a unit cost of $3.50/LF for CCTV.

Further information on the capital improvement program can be found in TM 5, which is in Attachment E of this SSMP.

Attachment A

TECHNICAL MEMORANDUM 1: BASIS OF PLANNING

City of West Linn

Sanitary Sewer Master Plan Update

TECHNICAL MEMORANDUM 1
BASIS OF PLANNING

DRAFT | March 2019

City of West Linn
Sanitary Sewer Master Plan Update

TECHNICAL MEMORANDUM 1

BASIS OF PLANNING

Matthew M. Huang,
March 13, 2019
State of Oregon,
P.E. No. 91512

Contents

Appendices

Tables

Figures

Abbreviations

AC	Acre
ADS	ADS Environmental Services, LLC
ADWF	Average Dry Weather Flow
BWF	Base wastewater flow
CDC	Community Development Code
Carollo	Carollo Engineers, Inc.
CCI	Construction Cost Index
CIP	Capital Improvement Program or cast iron pipe
City	City of West Linn
d/D	depth to full depth ratio
DEQ	Department of Environmental Quality (DEQ)
ENR	Engineering New Record (ENR)
F	Fahrenheit
ft	Feet
GIS	Geographic Information System
gpd/ac	gallons per day per acre
GWI	groundwater infiltration
HGL	Hydraulic Grade Line
mg/L	milligrams per liter
msl	Mean sea level
PS	Pump Station
PDWF	Peak Dry Weather Flow
PWWF	Peak Wet Weather Flow
RDII	rainfall dependent inflow and infiltration
SSMP	Sanitary Sewer Master Plan
SSO	sanitary sewer overflow
TM	Technical Memorandum
UGB	Urban Growth Boundary
WWF	Wet Weather Flow

Technical Memorandum 1

BASIS OF PLANNING

1.1 Introduction

This Technical Memorandum (TM) provides an overview of the planning elements required for evaluating the City of West Linn (City's) sanitary sewer system. It serves as the framework on which to evaluate future growth and estimate system capacity, ultimately leading to an updated Capital Improvement Plan (CIP) as part of the Sanitary Sewer Master Plan (SSMP). This basis of planning includes information regarding the sewer service area's history and physical characteristics, a review of the policies and criteria in place to guide the management and extension of the system, and current and future flow projections. The flow monitoring program performed by ADS Environmental Services, LLC (ADS) and the resulting flow calculations used to model the existing and future sewer system are also summarized herein.

1.2 Policies and Criteria

The City is responsible for managing and operating its sewer system in accordance with local, state, and federal regulations. To best manage the sewer system and comply with regulations, the City has adopted sewer system policies and criteria. These policies guide the development and financing of the infrastructure required to provide sewer service, and document the City's commitments to current sewer system customers as well as those considering service from the City.

Carollo performed a high-level review of the City's existing policies against similar policies developed for other wastewater agencies to identify potential missing policies or clarifications to better meet the City's current sewer management needs. While not comprehensive, this review provides recommended direction for future policy revisions. Existing policies are listed in Tables 1.1 through 1.6.

Recommended changes and additions to the policies were discussed with City staff and are included in Tables 1.7 through 1.10. The recommendations are listed as those that the City should take action to implement in the near future ("Action Item"), and those that may be helpful, but not essential ("Future Recommendation"). Where applicable, the recommendations include suggested language from other wastewater agencies; the suggested language should be further reviewed, refined, and approved by appropriate means to supplement or change existing policies. There are two action items that are also included on Table 1.10. These are recommended policies whose details the City needs to determine. The first action item is to update the City's design storm requirement. The second action item is to update the City's surcharging requirement.

The existing policy tables are organized into subject categories as listed below.

- Table 1.1 – Existing Service & Extension Policies
- Table 1.2 – Existing System Reliability Policies
- Table 1.3 – Existing Environmental Policies
- Table 1.4 – Existing Policies on Coordination with Other Agencies
- Table 1.5 – Existing Financial Policies
- Table 1.6 – Existing Design Policies & Criteria

Recommended policy tables are organized into subject categories as listed below. There are no recommended policies for coordination with other agencies and financial policies.

- Table 1.7 – Recommended Service & Extension Policies
- Table 1.8 – Recommended System Reliability Policies
- Table 1.9 – Recommended Environmental Policies
- Table 1.10 – Recommended Design Policies & Criteria

Existing policies listed in the tables were compiled from the following sources:

- 1999 Sanitary Sewer Master Plan
- 2016 Comprehensive Plan
- City of West Linn Municipal Code
- City of West Linn Public Works Standard Construction Specifications
- City of West Linn Municipal & Community Development Code (CDC)
- Oregon DEQ Standards for Design and Construction of Wastewater Pump Stations
- Oregon DEQ Division 52 Appendix 1B: Raw Sewage Lift Stations

Table 1.1 Existing Service & Extensions Policies

Subject	Policy	Source
Public Service	Require that essential public facilities and services (transportation, storm drainage, sewer, and water service) be in place before new development occurs and encourage the provision of other public facilities and services. Policy 4: The City, or entities designated in the future by the City, shall be the primary provider of sanitary sewer collection, treatment, and transport. Policy 6: Encourage cooperation and coordination between all public service agencies to maximize the orderly and efficient development and provision of all services.	2016 Comprehensive Plan Goal 11
General Land Use Plan	Maintain land use and zoning policies that continue to provide for a variety of living environments and densities within the city limits.	2016 Comprehensive Plan Goal 2
Service Responsibility in the Urban Growth Boundary	Prior to providing a public facility or service within the Urban Growth Boundary (UGB), require a detailed plan for provision for the coordinated development of all the other urban facilities and services appropriate to the area.	2016 Comprehensive Plan Goal 11
Service Responsibility	Recognize the City's responsibility for operating, planning, and regulating wastewater systems pursuant to the City's adopted Sanitary Sewer System Master Plan, which is a supporting document to the Comprehensive Plan, as well as agreements with the Clackamas County Water Environment Services Department.	2016 Comprehensive Plan Goal 6
Sewer Connections	Require the installation of new sanitary sewer collection facilities to be the responsibility of property owners who will receive direct benefit from those facilities. The City may participate in the development of those facilities to the extent that they benefit residents or businesses in addition to those directly involved.	2016 Comprehensive Plan Goal 11
Sewer Connections - Definitions	The following words and phrases when used in sections 4.000 to 4.090, shall having the meanings given to them in this section: 1) Public Sewer: The sanitary sewer system of the city. 2) Building Sewer: The sewer service line from a building to the point of connection with the sewer main or trunk lateral sewer.	Municipal Code 4.000
Use of Public Sewers Required	All premises on which there is located any building, structure, mobile home, motor home, vacation trailer, or any other facility containing sinks, water closets, bathtubs, showers, or any device for receiving sewage and/or waste water shall be connected to the city sanitary sewer system in all cases where such sewers are adjacent to, or within 200 feet of, such premises. Connection to the sanitary sewer shall not be required of any motor home, vacation trailer, or camper which is parked on the premises for storage only. All existing premises located adjacent to or within 200 feet of a city sanitary sewer at the time of enactment of the ordinance codified in sections 4.000 to 4.060 shall connect to said sanitary sewer within 90 days of receiving written notice from the city manager to connect to said sanitary sewer.	Municipal Code 4.005
Private Sewage Disposal	Where a public sanitary sewer is not available under the provisions of Sections 4.000 to 4.060, the building sewer shall be connected to a private sewage disposal system complying with the provisions of Sections 4.000 to 4.060.	Municipal Code 4.025
Sewer Connections – Authorization	No person, firm, or corporation shall install, construct, or lay any sanitary sewer pipe connecting to the city sanitary sewer system, or install, construct, or utilize any subsurface disposal system, without first making proper application, paying the required fee, and receiving a duly authorized permit from the city.	Municipal Code 4.005
Sewer Connections	Any person, firm or corporation desiring to obtain a permit to connect to the sanitary sewer system or to install a subsurface disposal system shall make written application therefor to the City. Such application shall be accompanied by a connection fee and in an amount conforming to the connection fee required by the Tri-City Service District at the time of the application for a sewer connection.	Municipal Code 4.005
Lateral Connections	No person other than the owner of the property on which the sewer is being installed or a licensed sewer contractor may install laterals in the City.	Municipal Code 4.110
Building Sewer Connections	1) No unauthorized person shall uncover, make any connections with or opening into, use, alter, or disturb any public sewer or appurtenance thereof without first obtaining a written permit from the City. 2) There shall be three classes of building sewer permits: For single-family residential service; for service to multifamily residential buildings; and for commercial establishments. In any case, the owner or his or her agent shall make application on a special form furnished by the City. 3) The permit application shall be supplemented by any plans, specifications, or other information considered pertinent by the city. A permit and inspection fee shall be as provided in Section 4.005(10). 4) All costs and expense incident to the installation and connection of the building sewer shall be borne by the applicant. The applicant shall indemnify the City from any loss or damage that may directly or indirectly be occasioned by the installation of the building sewer. 5) A separate and independent building sewer shall be provided for every building, except where otherwise approved by the City.	Municipal Code 4.030
Application for Building Sewer Permit	Application for a building sewer permit to connect to a sanitary sewer line shall be made contemporaneously with the application for a building permit for the building or structure which is to be connected to the sanitary sewer line, except when the building sewer permit is to allow connection to a sanitary sewer line from a building or structure already in existence and already serviced by a subsurface disposal system; and further provided, that such building or structure serviced by a subsurface disposal system is not in the process of being enlarged or altered so as to require the issuance of a building permit.	Municipal Code 4.040
Maintenance and Damage Responsibility for Private Sewer Lines	The customer shall be responsible for the maintenance of the private sewer line from the public sewer connection to the premises served. The City shall not be liable for any damage accruing from the failure of a private sewer or of fixtures or appurtenances attached thereto.	Municipal Code 4.045
Public Improvements	Whenever the council deems it expedient to construct, improve, or repair any sanitary sewer or any or any local improvement for which an assessment may be made on the property specially benefitted, for which it is anticipated that special assessments will be levied, it shall by motion direct the city engineer or engineer retained by the city to make an investigation of such project and to submit a written report, containing the information hereinafter specified. The city engineer or the engineer retained by the city shall file the report with the city manager within the time specified by the council. At the discretion of the council the time for filing the report may be extended. The report shall contain the following: 1) A map or plat showing the general nature, location, and extent of the proposed improvement and the land to be included in the proposed improvement district; 2) Estimated cost of the work to be done, including any legal, administrative and engineering costs attributable thereto; provided, however, that where the proposed project is to be carried out in cooperation with any other governmental agency, the engineer may adopt the estimates of such agency; 3) An analysis of the extent to which the proposed improvement benefits the entire city and a recommendation as to the method of determining the project costs that will be borne by the entire city; 4) The description and assessed value of each lot, parcel of land, or portion thereof, to be specially benefitted by the improvement, with the names of the record owners thereof and, when readily available, the names of the contract purchasers thereof; 5) A statement of outstanding assessments against property to be assessed. After approving the engineer's report as submitted or modified, the council shall, by resolution, declare its intention to make such improvement, provide the manner and method of carrying out the improvement and shall direct the city manager to give notice of such improvement. The estimated total cost of the portion of the project to be financed by assessments to benefitted properties shall be included.	Municipal Code 3.000/3.005/3.015

Table 1.1 Existing Service & Extensions Policies (Continued)

Subject	Policy	Source
Sewer Connections - Outside the Urban Growth Boundary	Allow the extension of water and sewer services outside the UGB only where a demonstrated health hazard exists, or for public facilities that serve West Linn.	2016 Comprehensive Plan Goal 11
Annexations	The purpose of Sections 2.915 to 2.940 is to establish a two-step process for annexation applications. The first step is a land use decision. The second step is a policy decision by the City Council to determine if the annexation should be approved. The Step 1 and Step 2 decisions can occur at the same meeting. An annexation to the City shall not be effective unless it is approved by the City Council at its discretion and by metro pursuant to its authority regarding annexations within its boundaries. A petition to annex to the City of West Linn may be initiated by a property owner(s) of the area to be annexed, or the City. When an annexation application has been properly initiated pursuant to ORS 222.111, 222.125, 222.170, or 222.840, Step 1 shall include review of the land use aspect of the petition pursuant to Community Development Code Chapter 81. If the application receives Council approval through the Step 1 process, the Council shall proceed to Step 2. A determination that the application meets the land use requirements does not obligate the City to approve the annexation application. Step 2 of the annexation process is a policy decision. If the annexation is approved in the Step 1 process, the Planning Director shall prepare a report which includes general information on the property or properties, including but not limited to location, size, access to infrastructure, recommended zone, protected resource areas and infrastructure, and cost to City of infrastructure that is not funded by SDCs. A decision on annexation shall also incorporate a decision on a zoning designation. The City zone shall be designated based upon the existing West Linn comprehensive plan/land use designation. Where the City Council has discretion to apply zoning, the Council shall consider the capacity of the City to provide sanitary sewer service to the site.	Municipal Code 2.920/2.930 and Community Development Code 81
Boundary Changes	Boundary changes include the formation, merger, consolidation, or dissolution of a city or district; annexation or withdrawal of territory to or from a city or district, or from a city-county to a city; or an extra-territorial extension of water or sewer service by a city or district.	Community Development Code 81.010
Use of Public Sewers – Unauthorized Connections	No person shall discharge or cause to be discharged, any stormwater, surface water, groundwater, roof runoff, subsurface drainage, or unpolluted industrial process waters to any sanitary sewer without prior written approval from the City to create a combined sewer.	Municipal Code 4.005
Use of Public Sewers – Storm Water	No storm water including drainage from roof drains, area or driveway drains, swimming pools, catch basins or storm sewers, springs, or any other source other than normal plumbing devices, shall be connected to or allowed to enter any sanitary sewer without prior approval by the City for that sewer to become a combined sewer.	Municipal Code 4.005
Subsurface Disposal Systems	Properly designed and approved subsurface disposal systems may be approved for installation where premises to be served are not adjacent to, or within 200 feet of, a city sanitary sewer Complete detailed plans and specifications shall be submitted with each application for a permit for a subsurface disposal system. These plans and specifications shall include, as a minimum, the following information: 1. Topographic map of the lot or parcel showing existing elevations, drainage channels and/or drainage patterns, together with a detailed, scaled, plot plan showing all existing or proposed and detailed layout of the proposed subsurface disposal system; 2. A valid permit, issued by the Oregon State Department of Environmental Quality, or the County Public Works Department. All permits issued for installation of subsurface disposal systems subsequent to the enactment of the ordinance codified in sections 4.000 to 4.060 shall be granted under the express condition and agreement, that, within 90 days following the installation of sanitary sewers adjacent to, or within 200 feet of, the premises, the use of such subsurface disposal system shall be discontinued and the premises connected to the sanitary sewer. Abandonment of the subsurface disposal systems shall be in accordance with the provisions of section 4.060 of this code. No person, firm, or corporation shall install, construct, or lay any sanitary sewer pipe connecting to the city sanitary sewer system, or install, construct, or utilize any subsurface disposal system, without first making proper application, paying the required fee, and receiving a duly authorized permit from the city. Any subsurface disposal system which is found to be malfunctioning as determined by the county soil scientist, D.E.Q., or the city manager, shall be repaired by the owner or occupant of the property within 30 days of delivery of written notice to make such repairs. All premises which are determined to have a malfunctioning subsurface disposal system, and are adjacent to, or within 200 feet of, a City sanitary sewer, shall be connected to said sanitary sewer within 90 days of receiving written notice from the City Manager to connect to said sanitary sewer, and the subsurface disposal system shall be abandoned in accordance with the provisions of Section 4.060. All premises on which there is located any building, structure, mobile home, motor home, vacation trailer, or any other facility containing sinks, water closets, bathtubs, showers, or any device for receiving sewage and/or waste water shall be connected to the city sanitary sewer system in all cases where such sewers are adjacent to, or within 200 feet of, such premises.	Municipal Code 4.005

Table 1.2 Existing System Reliability Policies

Subject	Policy	Source
Facility Standards	Operate sewer collection facilities to meet or exceed federal, state, and local standards. Maintain and operate the sanitary sewer system to meet all federal and state permitting requirements.	2016 Comprehensive Plan Goal 11
FOG	Grease, oil, and sand interceptors shall be provided when, in the opinion of the City, they are necessary for the proper handling of liquid wastes containing grease in excessive amounts, or any flammable wastes, sand, or other harmful ingredients; except that such interceptors shall not be required for private living quarters or dwelling units. All interceptors shall be of a type and capacity approved by the City and shall be located as to be readily and easily accessible for cleaning and inspection.	Municipal Code 4.050

Table 1.3 Existing Environmental Policies

Subject	Policy	Source
Waterways and Wetlands	Encourage and assist in the preservation of permanent natural areas for fish and wildlife habitat in suitable, scientific/ecological areas. Protect sensitive environmental features such as steep slopes, wetlands, and riparian lands, including their contributory watersheds.	2016 Comprehensive Plan Goal 5
Willamette River Greenway	Protect and enhance the valuable natural resource provided by the Willamette River, its islands, shores, and natural habitat.	2016 Comprehensive Plan Goal 15
Use of Public Sewers – Unauthorized Discharges	1) No person shall discharge or cause to be discharged, any of the following described waters or wastes to any public sewers: a) Any gasoline, benzene, naphtha, fuel oil, or other flammable or explosive liquid, solid, or gas; b) Any waters or wastes containing toxic or poisonous solids, liquids, or gases in sufficient quantity, either singly or by interaction with other wastes, to injure or interfere with any sewage treatment process, constitute a hazard to humans or animals, create a public nuisance, or create any hazard in the receiving waters of the sewage treatment plant, including but not limited to cyanides in excess of two mg/l or CN in the wastes as discharged to the public sewer; c) Any waters or wastes having a pH lower than 5.5 or having any other corrosive property capable of causing damage or hazard to structures, equipment, and personnel of the sewage works; d) Solid or viscous substances in quantities or of such size capable of causing obstruction to the flow in sewers, or other interference with the proper operation of the sewage works such as, but not limited to, ashes, cinders, sand, mud, straw, shavings, metal, glass, rags, feathers, tar, plastics, wood, unground garbage, whole blood, paunch manure, hair and fleshings, entrails, paper dishes, cups, milk containers, etc., either whole or ground by garbage grinders. 2) No person shall discharge or cause to be discharged, the following described substances, materials, waters, or wastes if it appears likely, in the opinion of the City, that such wastes can harm either the sewers, sewage treatment process, or equipment, have an adverse effect on the receiving stream, or can otherwise endanger life, limb, public property, or constitute a nuisance. In determining the acceptability of these wastes, the City will give consideration to such factors as to quantities of subject wastes in relation to flows and velocities in the sewers, materials of construction of the sewers, nature of the sewage treatment process, capacity of the sewage treatment plant, degree of treatability of wastes in the sewage treatment plant, and other pertinent factors. Substances prohibited are: a) Any liquid or vapor having a temperature higher than 150 degrees Fahrenheit (65 degrees Celsius); b) Any water or waste containing fats, gas, grease, or oils, whether emulsified or not, in excess of one hundred mg/l or containing substances which may solidify or become viscous at temperatures between 32 degrees and 150 degrees Fahrenheit (0 degrees and 65 degrees Celsius); c) Any garbage that has not been property shredded. The installation and operation of any garbage grinder equipped with a motor of three fourths horsepower (0.76 hp metric) or greater shall be subject to the review and approval of the City; d) Any waters or wastes containing strong acid iron pickling wastes, or concentrated plating solutions whether neutralized or not; e) Any waters or wastes containing iron, chromium, copper, zinc, and similar objectionable or toxic substances; or wastes exerting an excessive chlorine requirement, to such degree that any such material received in the composite sewage at the sewage treatment works exceeds the limits established by the City for such materials; f) Any waters or wastes containing phenols or other taste or odor producing substances, in such concentrations exceeding limits which may be established by the City as necessary, after treatment of the composite sewage, to meet the requirements of the State, Federal, or other public agencies of jurisdiction of such discharge to the receiving waters; g) Any radioactive wastes or isotopes of such half-life or concentration as may exceed limits established by the City in compliance with applicable State or Federal regulations; h) Any waters or wastes having a pH in excess of 9.5; i) Materials which exert or cause: i) Unusual concentrations of inert suspended solids (such as, but not limited to, fuller's earth, lime slurries, and lime residues) or of dissolved solids (such as, but not limited to, sodium chloride and sodium sulfate); ii) Excessive discoloration (such as, but not limited to, dye wastes and vegetable tanning solutions); iii) Unusual BOD, chemical oxygen demand, or chlorine requirements in such quantities as to constitute a significant load on the sewage treatment works; iv) Unusual volume of flow or concentration of wastes constituting "slugs" as defined herein; j) Waters or wastes containing substances which are not amenable to treatment or reduction by the sewage treatment processes employed, or are amenable to treatment only to such degree that the sewage treatment plant effluent cannot meet the requirements of other agencies having jurisdiction over discharge to the receiving waters.	Municipal Code 4.005

Table 1.4 Existing Policies on Coordination with Other Agencies

Subject	Policy	Source
Intergovernmental Coordination	Maintain effective coordination with other local governments, special districts, state and federal agencies, Metro, the West Linn-Wilsonville School District, and other governmental and quasi-public organizations.	2016 Comprehensive Plan - Goal 2
Urbanization	Promote cooperation between the City, County, and regional agencies to ensure that urban development is coordinated with public facilities and services within the Urban Growth Boundary.	2016 Comprehensive Plan - Goal 14

Table 1.5 Existing Financial Policies

Subject	Policy	Source
Rate Increases	Rate increases for the Environmental Services Utility are subject to the provisions of Section 44 of the City Charter. The storm sewer and sanitary sewer systems were separate systems at the time Section 44 was approved by the voters. Section 44 does not prevent the combination of utilities. For the purposes of consideration of rate increases, the Environmental Services Utility is one utility system. Any rate increase for the Environmental Services Utility is subject to the provisions of Section 44 as a single utility system.	Municipal Code 4.003
Funding	The fund for the City's sewerage system shall be known as the Environmental Services Fund. All revenue collected from charges imposed under Section 4.005 and 4.072 shall be placed in the Fund. Money in the Fund shall be used for planning, design, construction, regulation, maintenance and administration of the sewage system and providing sewage service, including repayment of indebtedness incurred after the effective date of this provision, and for all expenses of any kind incurred in the operation and management of the Environmental Services Utility and providing sewage service.	Municipal Code 4.003
Sewer Service Charges – Pass-through Rates	The sewer service charge schedule established for the Tri-City Service District by the Clackamas County Commission is established as the sewer service charge for the City with such changes being effective on the effective date of the adoption of the Clackamas County Commission orders regarding establishment and revision of such sewer service charges. The Tri-City sewer service charge is the charge passed through to the City for sewage treatment.	Municipal Code 4.005
Sewer Service Charges	Any sewer service charges within the City which are above and in addition to the pass-through rates charged by the Tri-City Service District, as established by the Clackamas County Commission, may be set by resolution of the City Council. The additional City charge may not increase by more than five percent in any calendar year without voter approval. Any request for an additional charge increase shall be referred to the Utility Advisory Board for consideration and recommendation to the City Council. The rates for sewer service charges and rates for storm drainage fees established by Section 4.072(2)(d) may be considered separately or in combination. The sum total increase that results from separate or combined consideration is the increase for the Environmental Service Utility system for the purpose of the five percent limitation of Section 44 of the City Charter. If considered separately the combined rate increase shall not exceed five percent in any calendar year without voter approval. If the Utility Advisory Board fails to refer a recommendation to the Council within 60 days of receipt of the request for consideration, the Council may consider the request without a Utility Advisory Board recommendation.	Municipal Code 4.005
Reduced Sewer Service Charges	Reduced sewer service charges shall be made available to low income citizens meeting the eligibility requirements pursuant to Section 4.155. This section shall in no way limit any similar reduction in sewer service charges by the Tri-City Service District for its portion of the rates.	Municipal Code 4.005
Sanitary Sewer Connection Fee	Any person, firm or corporation desiring to obtain a permit to connect to the sanitary sewer system or to install a subsurface disposal system shall make written application therefor to the City. Such application shall be accompanied by a connection fee and in an amount conforming to the connection fee required by the Tri-City Service District at the time of the application for a sewer connection. The Tri-City Service District is a service district under the jurisdiction of the Clackamas County Commission, which has the authority to establish sewer connection fee and sewer service charge within the City. The collection of the connection fee by the City is not to be construed as constituting the imposition of that fee by the City. Collection by the City occurs only for the purpose of providing convenient administration for the benefit of applicants. In the event of future revisions in the equivalent service unit connection fee and/or the sewer service charges by the Tri-City Service District, applications for sewer connections submitted after the effective date of such revised equivalent sewer connection unit fee and sewer service charges incurred after the effective date of such revised sewer service charge shall be charged the then prevailing connection fee and/or sewer service charge.	Municipal Code 4.005
System Development Charge – Definition	A reimbursement fee, an improvement fee or a combination thereof assessed or collected at the time of increased usage of a capital improvement, at the time of issuance of a development permit or building permit, at the time of connection to the capital improvement or as otherwise provided in this code. "Systems development charge" includes that portion of a sewer or water systems connection charge that is greater than the amount necessary to reimburse the City for its average cost of inspecting and installing connections with water and sewer facilities. "Systems development charge" does not include fees assessed or collected as part of a local improvement district or a charge in lieu of a local improvement district assessment, or the cost of complying with requirements or conditions imposed by a land use decision, expedited land division, or limited land decision.	Municipal Code 4.410
System Development Charge – Method for Establishment	1) Unless otherwise exempted by the provisions of Sections 4.400 to 4.485 or other local or state law, effective July 1, 1991, a system development charge is hereby imposed upon all development in the City and the Future Urban Area at the time of increased usage of a capital improvement, at the time of issuance of a development permit or building permit, or at the time of connection to a capital improvement. 2) System development charges shall be established and may be revised by resolution of the City Council. 3) On July 1st of each year the SDC reflected in this methodology shall be adjusted based upon the change in the Engineering New Record (ENR) Construction Cost Index (CCI) for the most recent 12-month period. No action is required of the City Council to effectuate such adjustment.	Municipal Code 4.415

Table 1.6 Existing Design Policies & Criteria

Subject	Policy	Source
Professional Engineer	Public works improvements are conditioned through the development review process, this Ordinance, other ordinances, and other City policies adopted by the City Council or the Public Works Director. No street, bridge, or utility construction shall commence prior to the City approval of the construction plans. Designs submitted shall be stamped by a Registered Professional Engineer licensed to practice in the state of Oregon.	Public Works Design Standards 1.0010
DEQ Requirements	Design shall comply with the sewer design guidelines of Oregon Department of Environmental Quality (DEQ), OAR Chapter 340, Division 52, and the requirements of Tri-City Service District.	Public Works Design Standards 3.0010
Preference of Gravity Systems	Sanitary sewer systems shall be designed to provide gravity service to all areas of development.	Public Works Design Standards 3.0010
Inspection	A televised inspection of the sanitary sewer pipe shall be performed. Any defects in material or workmanship shall be satisfactorily corrected prior to final acceptance of the work. All tests and inspections (including video-inspection) must be performed in the presence of the City Engineer or his/her representative to be valid. Upon completion of all sewer construction, repairs, cleaning, and required tests, the contractor shall notify the City Engineer when the television inspection will be performed. Before release of the maintenance or warranty bond, the City Engineer may require televised inspection of the piping at the Contractor's expense. The Contractor shall correct all deficiencies found by this inspection.	Public Works Standard Construction Specifications 301.03.09 / 301.03.11
Pump Stations - Operability During Design Storm	Design of the pump station shall include a station with firm capacity to pump the peak hourly flows associated with the 5-year, 24-hour storm intensity of its tributary area, without overflows from the station or its collection system.	Oregon DEQ Standards for Design and Construction of Wastewater Pump Stations
Pump Stations – Redundancy/Firm Capacity	A minimum of two pumps shall be supplied. Each pump shall be capable of pumping the peak wastewater flow. Where more than two pumps are used, the station shall be able to pump peak wastewater flow when the largest pump is out of service.	Public Works Design Standards 3.0131
Pump Stations - Reliability	For stations without on-site standby generators or a second source of power or a secondary electrical feed, install a manual transfer switch and an emergency plug-in power connection to the station for use with an approved portable generator. Power outages shall result in no raw sewage discharges or bypasses to waters of the state based upon a predictable maximum period of power outage which will occur from year-to-year. Where such reliability does not exist, facilities and/or procedures shall be provided to prevent the discharge or bypass. Means to prevent discharge or bypass include, but are not limited to electric generator (stationary/portable) or auxiliary fuel fired pump (stationary/portable).	Oregon DEQ Standards for Design and Construction of Wastewater Pump Stations/ Oregon DEQ Division 52 Appendix 1B: Raw Sewage Lift Stations
Pump Stations - Emergency Back-up Power	Where the flow is substantial or where environmental damage may occur due to power failure, the City Engineer may require permanent standby power.	Public Works Design Standards 3.0100
Pump Station - Sizing	Wet well shall be designed to provide 4 hrs. of storage above high water alarm. See Table 1.10 for recommended change.	Public Works Design Standards 3.0120
Pump Stations - Bypass Pumping Requirements	Unless otherwise approved by the Owner, all force mains shall have a connection with an isolation valve for temporary bypass pumping. A bypass pumping system, additional downstream gauge, and additional main isolation valve may also be required at the discretion of the Owner.	Oregon DEQ Standards for Design and Construction of Wastewater Pump Stations
Pump Stations - Operations & Maintenance Manuals	Compile product data and related information appropriate for City's maintenance and operation of products furnished under the contract. Prepare operating and maintenance manual. Instruct City's personnel in the maintenance of products and in the operation of equipment and systems.	Public Works Design Standards 3.0141
Force Main Maximum Velocity	Force main shall be designed for a nominal flow velocity in the range of 3 to 5 ft per second.	Public Works Design Standards 3.0138
Sewer Location/Main Line Alignment	All sewer mainlines shall be located within the public right-of-way or public easement as directed by the City Engineer. These lines are placed in the public streets and right-of-way for ease of maintenance and access, control of the facility, operation of the facility, and to provide required replacement and/or repair. Sanitary sewer lines shall be located in the street right-of-way, 5 ft. north and west of centerline whenever possible. All changes in direction of pipe shall be made at a manhole. Sewers shall be located in the street right-of-way. If streets have curved alignments, the center of the manhole shall not be less than 6 ft. from the curb face on the outside of the curve, nor the sewer centerline less than 6 ft. from the curb face on the inside of the curve. Curved alignments will not be permitted.	Public Works Design Standards 3.0010/3.0021

Table 1.6 Existing Design Policies & Criteria (Continued)

Subject	Policy	Source
Sewers Location in Easements	1) Sewers placed in easements along a property line shall have the easement centered on the property line and the sewer shall be offset 18 in. from the property lines. For sewers placed in easements located other than along a property line, the sewer shall be placed in the center of the easement. The conditions of the easement shall be such that the easement shall not be used for any purpose which would interfere with the unrestricted use for sewer main purposes. Under no circumstances shall a building or structure be placed over a sanitary sewer main or sewer easement. This shall include overhanging structures with footings located outside the easement. 2) Easements for sewers less than 12 in. in diameter shall have a minimum width of 15 ft. Sewers greater than 12 in. in diameter shall have a minimum easement width of 20 ft. In some instances larger width easements may be required, such as excessively deep pipes or location of a building near the easement. 3) Easement locations for public sewer mains serving a PUD, apartment complex, or commercial/industrial development shall be in parking lots, private drives, or similar open areas which will permit an unobstructed vehicle access for maintenance by City personnel. 4) All easements must be furnished to the City Engineer for review and approval prior to recording. Easements shall state that the City will not in any way be responsible for replacing landscaping including any shrubs or trees, fencing, or other structures that may exist or have been placed in the easement.	Public Works Design Standards 3.0024
Cover - Sanitary Sewers	Sanitary sewers in residential areas shall be placed in the street with the following minimum cover: 1) Building Service Lateral - 6 ft. 2) Trunk and Collector Sewer 3) In the roadway - 8 ft. 4) In easements - 8 ft. Where the topography is relatively flat and existing sewers are shallow 5 ft. or less; the minimum cover shall be 3 ft. Where required for additional strength or when minimum cover is not met, ductile iron pipe or concrete pipe with CDF backfill shall be required by the City Engineer.	Public Works Design Standards 3.0022
Manholes - Locations	Manholes shall be located at all changes in slope, alignment, pipe size, and at all pipe junctions with present or future sanitary sewers. Manhole spacing shall not be greater than 400 ft. Spacing may be increased for sewer mains in excess of 36 in. in diameter with City Engineer approval. Manholes outside of vehicle or pedestrian travel-ways shall have a tamper proof lid. Cleanouts will not be approved as substitutes for manholes on public sewer lines. Cleanouts are permitted at the upper end of a sewer that will be extended during a future construction phase. If future extension requires a change in sewer alignment or grade, a manhole will be required at the cleanout location.	Public Works Design Standards 3.0031/3.0032
Manholes – Materials	All manholes, except as otherwise specified, shall be constructed using precast, reinforced concrete base sections, riser sections, and other precast appurtenances conforming to ASTM C 478. Base riser sections shall be integral with the base slabs.	Public Works Standard Construction Specifications 302.03.02
Manholes - Diameter	Designs for manholes are shown in the West Linn Standard Drawings. They are suitable for most conditions.	Public Works Design Standards 3.0041
Manholes - Channel Slope	1) The crowns of incoming sewers shall be at least as high as the crown of the outgoing sewer. 2) If the incoming and outgoing sewers are of equal size and are passing straight through the manhole, no added elevation change is required. 3) If sewers intersect or the alignment changes at the manhole, the invert elevation difference shall be at least 0.10 ft. for 0°-45° of horizontal deflection angle, and 0.20 ft. for over 45° of horizontal deflection angle. 4) The slope of a sewer within a manhole shall be no less than the slope of the same sewer outside of the manhole. 5) Drop connections are required when the vertical distance between flow-lines exceeds 2 ft. The diameter of the drop connection must be specified on the construction drawings. The diameter of the drop connection shall not be more than one pipe size smaller than the diameter of the incoming sewer. Smooth flow-lines with vertical distances of less than 1 ft. must be provided wherever feasible. Outside drop assemblies only will be permitted, see the Standard Drawings. 6) All connections must enter the manhole through a channel in the base. This includes drop connections and connections to existing manholes.	Public Works Design Standards 3.0041
Manholes - Adjustments	Frame and cover shall be brought up to finish grade for asphaltic concrete. If only one lift of AC will be applied for a period of time exceeding 24 hours prior to second lift, the frame and cover shall be brought to the grade of the first lift, and standard cast iron riser rings shall be used to adjust grade at a later date for final lift. All storm manholes located outside of paved areas shall be raised 12 in. above final grade and tamper proof frames and lids shall be used.	Public Works Standard Construction Specifications 302.03.06
Manholes - Covers	All sanitary manholes shall be of watertight construction. If ground water or surface drainage can be expected, watertight covers shall be used. Watertight manhole frames and covers are to be used if floodwaters are expected to cover the manhole top or if the manhole must be located in the street gutter. Such conditions should be avoided wherever feasible. Tamperproof manhole frames (7 in. depth) and covers are required in all areas outside the paved public right-of-way or pedestrian travel ways. Rims shall be 1 ft. above the finished grade if not in a paved way.	Public Works Design Standards 3.0041
Manholes – Slab Top	Slab tops must be used in lieu of cones where there will be less than 4 ft. between the manhole shelf and the top of the manhole lid.	Public Works Design Standards 3.0041
Piping - Manning's "n" Value	The minimum pipe roughness coefficient for sanitary sewers shall be 0.013.	Public Works Design Standards 3.0012

Table 1.6 Existing Design Policies & Criteria (Continued)

Subject	Policy	Source
Piping - Allowable Material	All public sanitary sewers shall be constructed with PVC pipe or concrete pipe as specified Division Three – Sanitary Sewer Technical Requirements, of the West Linn Public Works Standard Construction Specifications. Where required for added strength, Class 50 Ductile Iron pipe will be used. Use pipes and fittings for service lines of one type of material throughout; no interchanging of pipe and fittings will be allowed. Use 4 in. diameter pipe for residential services when not otherwise specified.	Public Works Design Standards 3.0011 / Public Works Standard Construction Specifications 301.02.01
Piping – Allowable Size	All sanitary sewer main lines shall be a minimum diameter of 8 in. A 6 in. diameter sewer will be allowed with the City Engineer's approval.	Public Works Design Standards 3.0011
Design Approach – Slope and Velocity	Velocity - All sanitary sewers shall be designed on a grade which produces a mean velocity, when flowing half-full or full, of no less than 2-1/2 ft. per second. Where velocities greater than 15 fps are attained, special provisions shall be made to protect against displacement by erosion and shock. The minimum grades for the various sizes of pipe are shown in the table below. Inside Pipe Diameter (inches) – Grade (feet per 100 feet): 6 – 0.77 8 – 0.55 10 – 0.55 12 – 0.31 15 – 0.23 18 – 0.18 21 – 0.15 24 – 0.13 27 – 0.11 30 – 0.09 36 – 0.07	Public Works Design Standards 3.0012
Sanitary Sewer Laterals	Each individual building site shall be connected by a separate, private, building-sewer-service line connected to the public sewer. Each individual property shall have an individual lateral.	Public Works Design Standards 3.0050
Sewer and Water Line Separation Requirements	Water mains shall be installed a minimum clear distance of 10 ft. horizontally from sanitary sewers and shall be installed to go over the top of such sewers with a minimum of 18 in. of clearance at intersections of these pipes (in accordance with the requirements of OAR Chapter 333, Public Water Systems). Exceptions shall first be approved by the City Engineer. In all instances the distances shall be measured edge to edge. The minimum spacing between water mains and storm drains, gas lines, and other underground utilities, excepting sanitary sewers, shall be 3 ft. horizontally when the standard utility location cannot be maintained.	Public Works Design Standards 3.0023
Testing	1) All gravity sanitary sewers including service line sewers and appurtenances shall successfully pass an air test prior to acceptance and shall be free of leakage. Manholes shall be tested as specified in Section 302, Manholes and Concrete Structures. 2) All pressure sewer force mains shall be tested in accordance with applicable portions of Section 403, Construction, when not otherwise specified. 3) A televised inspection of the sanitary sewer pipe shall be performed. Any defects in material or workmanship shall be satisfactorily corrected prior to final acceptance of the work. 4) All tests and inspections (including video-inspection) must be performed in the presence of the City Engineer or his/her representative to be valid. 5) Tests shall be performed in the following order: deflection testing, air pressure testing, video inspection. If any one of the tests fail, all tests must be completed again after repair of the failed section in the testing order specified above. 6) Deflection testing, air pressure testing, and video inspection shall be done only after backfill has passed the required compaction tests based on AASHTO T-180 and the roadway base rock has been placed, compacted, and approved by the City Engineer. 7) The sanitary system must receive the approval of the City Engineer regarding deflection testing, air pressure testing, and video inspection before paving of overlying roadways will be permitted.	Public Works Standard Construction Specifications 301.03.09
Minimum Pipe Length	Minimum length of pipe shall be 3.5 ft	Public Works Standard Construction Specifications 301.02.01

Table 1.7 Recommended Service & Extensions Policies

Subject	Policy	Source
Service Area	Clarify future service area extend.	Recommended Policy
Lateral Ownership	Future Recommendation (Example Text Provided): Laterals shall be owned and maintained by the property owner up to and including the connection to the City-owned sewer main.	Recommended Policy
Sewer Extensions	Future Recommendation (Example Text Provided): 1) The extension of the sanitary sewer system may be initiated as follows: a) Any person may request that the City extend the sanitary sewer system in order to serve property owned by that person. b) The City may initiate the extension of the sanitary sewer system. 2) A request to extend the sanitary sewer system shall be in writing and shall consist of the following information: a) A map of the property to be served by the extension of the system identifying the property by address and tax map and lot number; b) A written report containing the reasons for the extension to the sanitary sewer system; and c) Any other relevant information required by the City Engineer. 3) The City Engineer shall review each request for extension of the system and determine if it is in the City's interest to proceed with extension of the system. The review shall consider the following factors: a) The potential health hazard if the system is not extended; b) Whether the properties to be served by the extension are within the City limits at the time of the request, are likely to connect to the system and agree to be annexed within a reasonable period, or are slated to receive service from the City pursuant to a valid intergovernmental between the City and another governmental unit. c) The number of properties that will benefit if the system is extended and whether those properties are currently developed; and d) The potential water quality benefits if the system is extended. e) Adequacy of the available funding source. f) Availability of public right-of-way or easements. If the City Engineer determines that it is in the City's interest to proceed with extension pursuant to subsection 3 of this section, the extension shall be scheduled for construction. Persons who apply to connect to the extended line shall pay the line charge established prior to and as a condition of connection.	Recommended Policy
Annexations	Future Recommendation (Example Text Provided): Unincorporated property shall be required to annex prior to the receipt of City sanitary sewer service, or as set forth below: Each of the following conditions must be met to provide unincorporated property with City sanitary sewer service prior to annexation: 1) The property shall be located within the Urban Growth Boundary; 2) Existing sanitary sewer line operated by the City to which connection can be made in accordance with subsection (4) below is within 300 feet of the property; 3) The City has found that the septic system serving the property is failing and the City has directed connection to a sanitary sewer system; 4) The extension of a sanitary sewer line to be connected to the City sanitary sewer line shall be subject to acceptance of an approved plan by the City Engineer.	Recommended Policy
Sewer Study For Oversizing	Future Recommendation (Example Text Provided): A sanitary sewer study will be required when an 8-inch diameter gravity sewer is inadequate to serve the current or future development or when the City Engineer determines that a recently annexed area situated outside the limits of the currently adopted Plan warrants a study. The study shall incorporate the proposed design system including features as the pipe slope, cover, and size; the study shall include, but not be limited to, a detailed map of the sanitary sewer service, sewage flow calculations, and pipe hydraulic calculations.	Recommended Policy
Oversizing Pipes	Future Recommendation (Example Text Provided): When land outside a new development will logically direct flow into a storm drain or sanitary sewer within the new development, the system shall be "public" and shall be extended to one or more of the upstream development boundaries. The pipes shall be sized to accommodate all off-site flows, based on a fully developed condition using the current Comprehensive Plan.	Recommended Policy
Sewer Drainage Basins	Future Recommendation (Example Text Provided): Each facility system serves different geographic sub-areas of the City. While facilities such as parks and schools relate more to neighborhoods defined by population size and travel time/distance, systems such as sewers, water, and storm water drainage are more logically defined by topography, soils, and other natural constraints. Such disparities can interfere with coordination of planning for public facilities, affecting different client populations. To help overcome these barriers, the "Public Facilities Element" should be organized, where possible, in relation to a common set of geographic sub-areas.	Recommended Policy
Use of Public Sewers Required	Future Recommendation: Modify policy in Municipal Code 4.005 to require connection to sanitary sewer system from 200 feet to 300 feet. This modification is recommended to match policies from other agencies in the Portland metropolitan area.	Recommended Policy

Table 1.8 Recommended System Reliability Policies

Subject	Policy	Source
Security	Future Recommendation (Example Text Provided): The City shall make reasonable attempts to protect the security of its sewer collection system. The City shall determine what information about the system should remain unavailable to the general public.	Recommended Policy
Reliability	Future Recommendation (Example Text Provided): The City shall manage the sewer collection system through developing design standards, overseeing construction, operating, and maintaining the system such that service to areas in the Urban Services Boundary is adequate and reliable. Whenever possible, the City shall anticipate system interruptions, such as power outages, and design and operate the system to minimize the impact of such interruptions on its customers and the environment.	Recommended Policy
Resiliency	Carollo can provide example text to reference Oregon Resilience Plan.	Recommended Policy
Maintenance	Future Recommendation (Example Text Provided): Unless specifically directed otherwise by the City, all facilities and equipment shall be maintained in accordance with manufacturers' specifications. The City adheres to maintenance and replacement schedules for all facilities and equipment.	Recommended Policy
Equipment Inventory	Future Recommendation (Example Text Provided): The City shall maintain a complete inventory of all City-owned equipment, supplies, parts, and service vehicles used for maintenance of sewer facilities. The inventory should include planned replacement dates as applicable.	Recommended Policy
Emergency Response Plan	Future Recommendation (Example Text Provided): On a regular basis, the City shall update their Emergency Operations Plan focusing on responding to emergencies and disasters.	Recommended Policy
Natural Hazards Mitigation Plan	Future Recommendation (Example Text Provided): On a regular basis the City shall update and maintain their Natural Hazards Mitigation Plan addressing risks associated with natural hazards.	Recommended Policy

Table 1.9 Recommended Environmental Policies

Subject	Policy	Source
Sustainability	Future Recommendation (Example Text Provided) The City will manage the sewer collection system, including monitoring and adapting plans, policies, and practices to collect and convey wastewater from its customers in a safe and sustainable manner in accordance with the City's Environmental element of the Comprehensive Plan.	Recommended Policy
Overflows	Future Recommendation (Example Text Provided) The City has implemented programs to prevent overflows of wastewater in the existing system, and requires all new construction to convey peak flows and storm events without overflowing the sewer during the design storm event.	Recommended Policy
Infrastructure Siting	Future Recommendation (Example Text Provided) New wastewater infrastructure will be sited outside of stream corridors, wetlands, and significant tree groves whenever feasible.	Recommended Policy

Table 1.10 Recommended Design Policies & Criteria

Subject	Policy	Source
Design Approach - Storm	Action Item: Update design storm requirement In accordance with all applicable federal, state, and local regulations, the City should design its sewer facilities to adequately and reliably convey peak hour flows associated with a 24-hour, 5-year recurring storm event without overflowing or discharging to any water bodies.	Action item
Surcharging	Action Item: Update surcharging requirement • New facilities shall be designed to prevent the hydraulic grade line from exceeding the crown of pipe during Peak Wet Weather Flow (PWWF). Allowable depth to full depth (d/D) ratios for new pipes can be based on a graduated criteria according to pipe size, as shown in the following: – <=12-inch; d/D = 0.5 – >=15-inch; d/D = 0.75 • The existing system shall be evaluated for two conditions of surcharging, as follows: – Under Peak Dry Weather Flow (PDWF), pipes can flow full with a depth to full depth (d/D) ratio of 0.90 – Under Peak Wet Weather Flow (PWWF), the Hydraulic Grade Line (HGL) may not rise above one feet above any pipe invert.	Action item
Manholes - Locations	Modify criteria such that cleanouts are never permitted at any location.	Recommended modifications to existing policy
Piping – Allowable Size	Future Recommendation: Modify policy from "A 6 in. diameter sewer will be allowed with the City Engineer's approval." To ". A 6 in. diameter sewer may be allowed with the City Engineer's approval."	Recommended modifications to existing policy
Pump Stations - Operability During Design Storm	Future Recommendation (Example Text Provided): Provisions shall be included in the design of any pump station to allow the station to remain fully operational and accessible during the design storm.	Recommended additions to existing policy
Pump Stations - Flow Meters	Future Recommendation (Example Text Provided): Permanent flow meters shall be provided in a separate vault for all new pump stations.	Recommended policy
Pump Stations - Reliability	Future Recommendation (Example Text Provided): In order to reduce the risk of overflows during power outages or when performing routine maintenance, the City shall install emergency back-up power generators, receptacles for portable generators and/or bypass pump connections at all of its pump stations. For pump stations without telemetry, it is recommended to install telemetry. The telemetry system shall have back-up battery power that allows the telemetry system to continue to operate for up to seven days.	Recommended additions to existing policy
Pump Station - Sizing	Future Recommendation: Wet well sizing can be achieved in stations with low influent flow rates, but would likely result in oversized wet wells for larger stations. We would recommended for the standard of 4 hours of storage above high water alarm to be respected whenever possible, but that a reduced duration be acceptable if approved by the City.	Recommended additions to existing policy
Pump Stations - Bypass Pumping Requirements	Future Recommendation (Example Text Provided): The City's pump stations shall be designed with bypass pump connections that will allow the City to pump directly from the wet well into the pump station's force main with a portable pump, thus bypassing the pumps in the dry well. This feature should allow the City to manage wet well levels during power outages and routine maintenance.	Recommended additions to existing policy
Pump Stations - DEQ Documentation	Future Recommendation (Example Text Provided): Design engineers shall provide to the City and DEQ all documentation required by OAR 340-052-0040 including the final O&M Manuals and certification that the construction was inspected by the design engineer and found to be in accordance with the plans and specifications.	Recommended policy
Design Approach - Design Flows	Future Recommendation (Example Text Provided) Sewer flows are composed of residential, institutional, commercial, and industrial sewage, along with infiltration and inflow. Sewers must be capable of conveying the peak hourly flows of these wastewater sources as estimated using the design storm.	Recommended policy
Testing	Future Recommendation: The existing policy requires an air test for gravity sanitary sewer testing. The City should also permit a water test.	Recommended modifications to existing policy

1.3 Study Area

The Study Area, shown as a dashed green line in Figure 1.1, is the currently agreed-upon service boundary. The Study Area contains everything within the City limits and urban growth boundary (UGB).

1.4 Planning Period

Three planning periods are evaluated in this SSMP:

- Existing system.
- 5-year Planning Period.
- Build-out.

The assumptions for each planning period are described in the sections below.

1.4.1 Existing System

The City sewer system currently spans approximately 8.2 square miles with approximately 25,600 residents of its population served by the City's collection system. The existing sewered area is presented in Figure 1.2, which includes currently developed and connected parcels contributing sanitary flows to the collection system.

In some parts of the City, wastewater is treated by private septic tanks. The estimated locations of septic tanks are shown as green dots on Figure 1.1. Approximately 100 taxlots equaling 110 acres (2.8%) of the total currently developed taxlots acreage within the City's Service Area have private septic systems.

1.4.2 5-year Planning Period

Projected sewer flows for the 5-year planning period were estimated based on linear interpolation between existing sewer flows and projected build-out flows.

1.4.3 Build-out

The Build-out scenario assumes that by 2040 all properties within the Study Area will be developed and connected to the sewer collection system. It is assumed that all existing private septic systems will be decommissioned and those properties connected to the City's collection system. The future land uses within the Study Area for the Build-out scenario are discussed later in this memo.

1.4.4 Study Area Physical Features

This section describes the unique physical features of the Study Area including water bodies, climate, and topography, which is illustrated in Figure 1.3.

1.4.4.1 Topography

Topography along the east and southwest boundaries of the Study Area is bounded by the Willamette River to the east and by the Tualatin River to the southwest. Elevations range from sea level along the banks of the rivers to over 700 feet MSL going north and west from the banks of the rivers to the center of the Study Area. The center of the Study Area is generally hilly with steep downhill slopes towards the two rivers.

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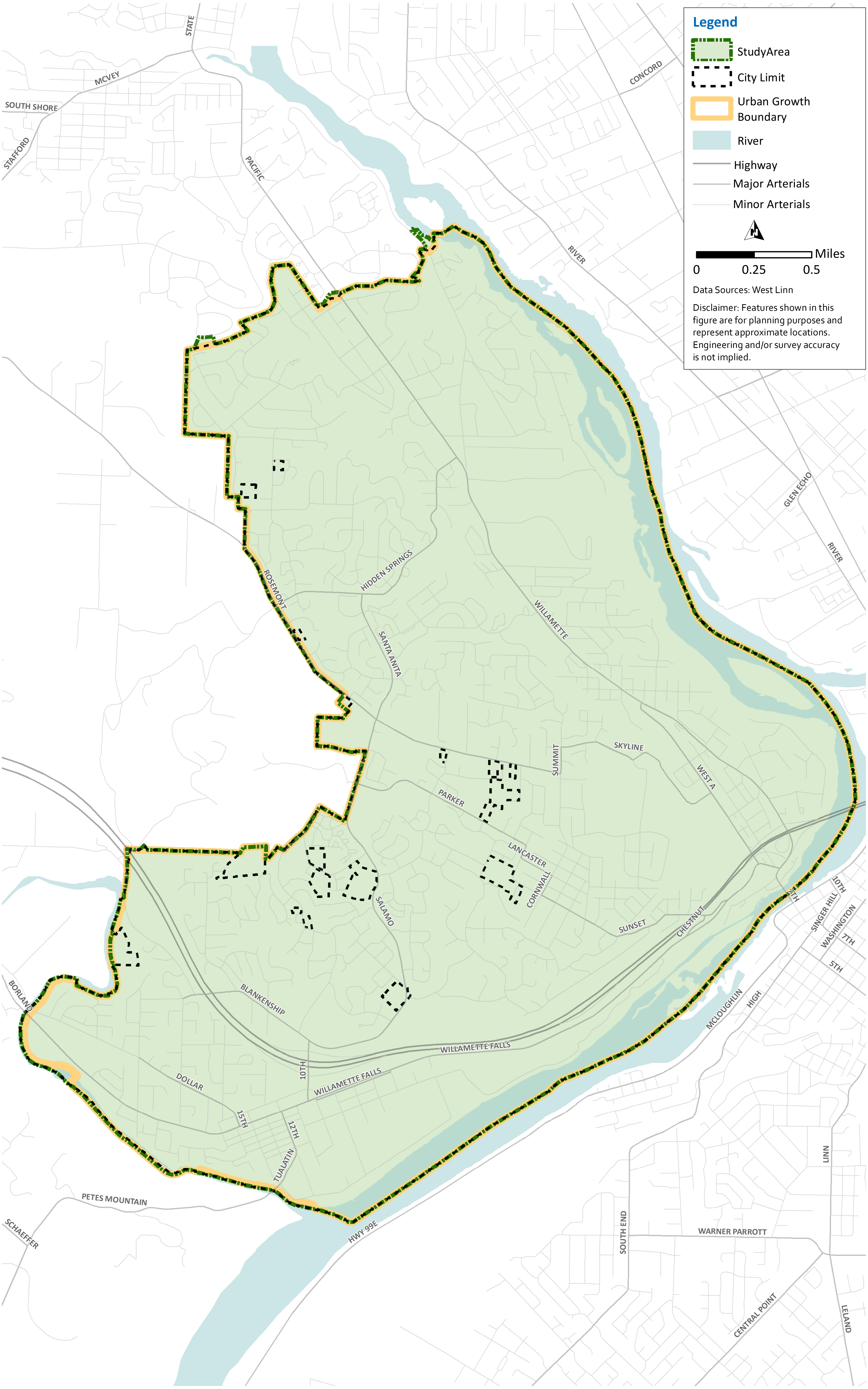

Figure 1.1 Study Area

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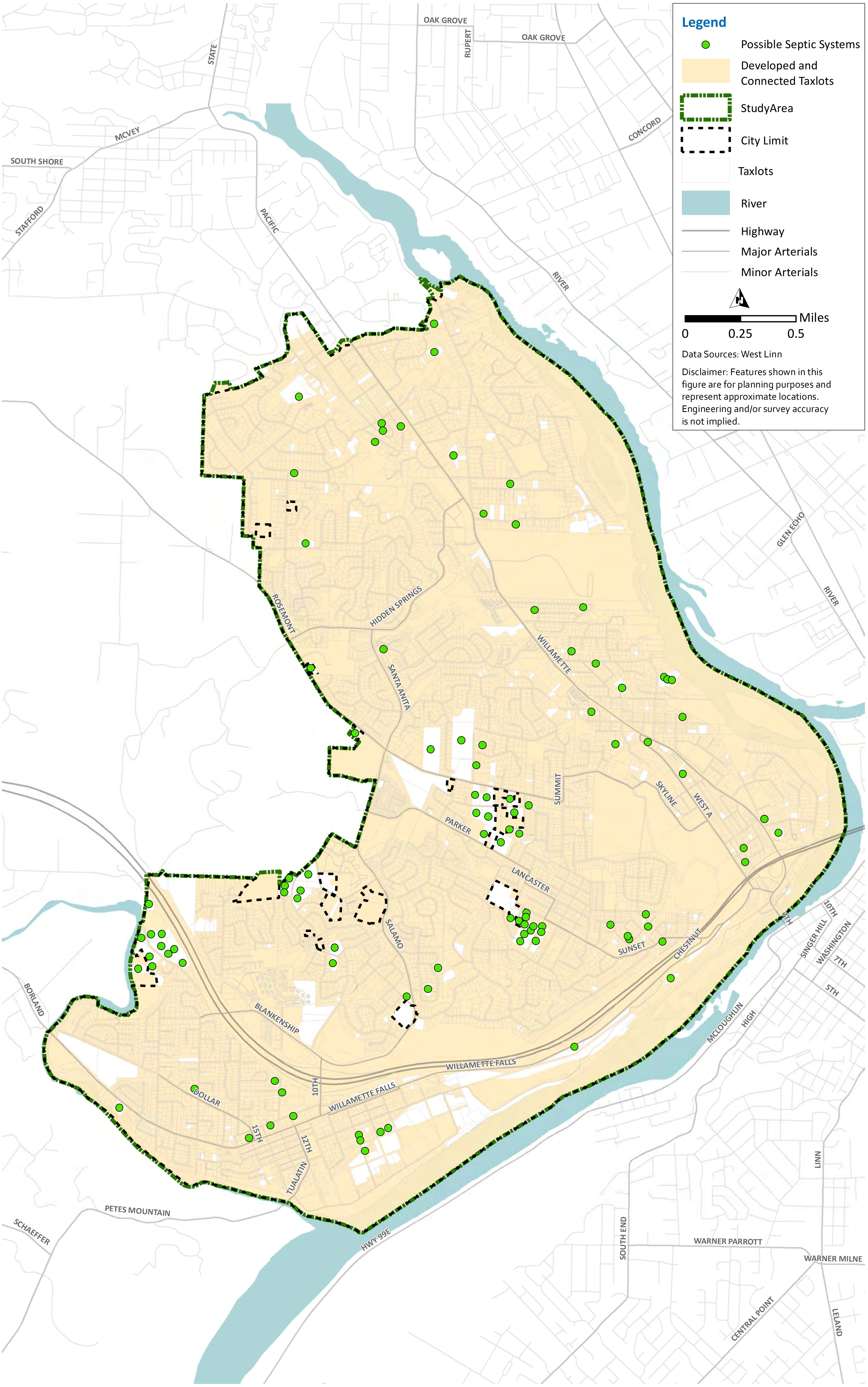

Figure 1.2 Currently Sewered Parcels

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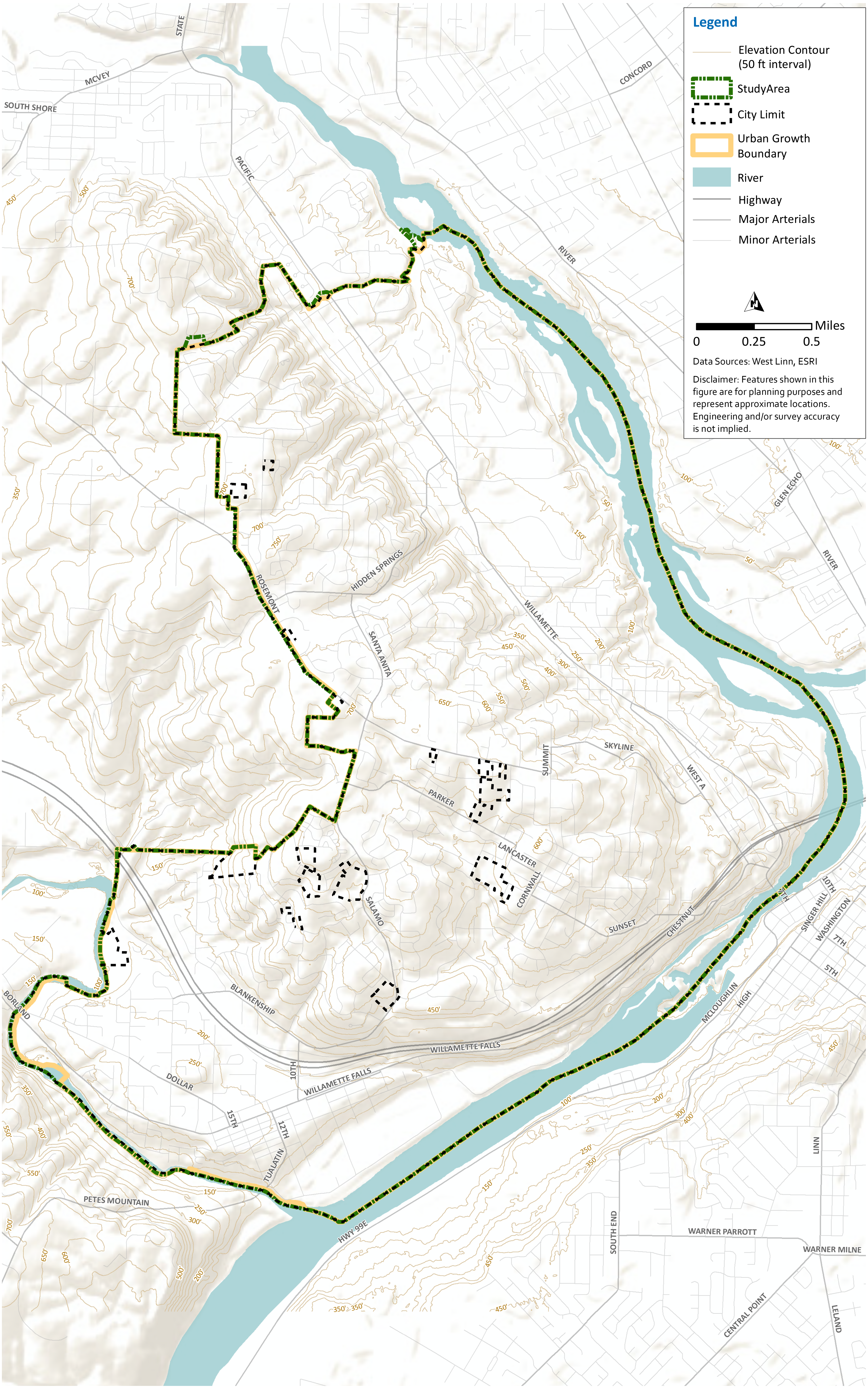

Figure 1.3 Topography and Physical Features

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1.4.4.2 Surface Waters

West Linn's surface waters consist of two rivers that serve as boundaries to the east and southwest of the Study Area. The Tualatin River serves as the boundary to the southwest and flows southeast into the Willamette River. The Willamette River serves as the eastern boundary to the Study Area and flows north towards Portland, eventually flowing into the Columbia River.

1.4.4.3 Climate

West Linn's climate is temperate with warmer, dryer summers and cooler, wetter winters. Table 1.11 summarizes monthly maximum and minimum temperatures and monthly precipitation for West Linn. December is the coldest month with an average high temperature of 48 degrees Fahrenheit and an average low temperature of 36 degrees Fahrenheit. The hottest month is August with an average high of 83 degrees Fahrenheit and an average low of 56 degrees Fahrenheit. December is the wettest month with an average of 7.2 inches of precipitation. The majority of rainfall occurs during the cooler fall and winter months, with 67 percent of rainfall occurring between November and March.

Table 1.11 West Linn Temperature and Rainfall Statistics

Month	Average Maximum Temperature (°F)	Average Minimum Temperature (°F)	Average Monthly Rainfall (inches)
January	48	36	6.6
February	53	37	5.5
March	58	40	4.7
April	63	43	3.5
May	70	48	2.7
June	76	52	1.8
July	83	56	0.8
August	83	56	1.0
September	78	52	1.9
October	66	46	3.5
November	53	40	6.8
December	47	36	7.2
Annual	**65**	**45**	**46**

Notes:
(1) Climate data from www.intellicast.com.

1.4.5 Land Use

Land use designations and regulations provide important information in evaluating sewer system capacity. Existing and future land use information is an integral component in projecting wastewater generation within the Study Area. The type of land use in an area will affect the volume of the wastewater generated. Adequately estimating the generation of wastewater from various land use types is important in sizing collection system facilities.

1.4.5.1 Existing Land Use

Maps of the City's existing land use were developed with Geographic Information System (GIS) data from the City's planning department. Existing land use is shown on Figure 1.4. Only land use for parcels that are currently developed and connected are shown on this figure.

Parcels were organized into 10 land use categories including:

- Commercial
- Industrial
- Low Density Residential
- Medium Density Residential
- Medium High Density Residential
- Mixed use
- No Zoning
- Open Space
- Park
- Vacant

The distribution in terms of acreage and percentage of existing land use is presented in Table 1.12.

Table 1.12 Existing Land Use Summary

Land Use Category	Acreage	Percent of Total
Commercial	112	2.8%
Industrial	124	3.2%
Low Density Residential	2,350	60.3%
Medium Density Residential	219	5.6%
Medium High Density Residential	142	3.7%
Mixed Use	9	0.2%
No Zoning	5	0.1%
Open Space	137	3.5%
Park	425	10.9%
Potential Septic Systems	110	2.8%
Vacant	264	6.8%
Total	**3,898**	**100%**

Approximately 60 percent of the Study Area is classified as Low Density Residential, and 9 percent of the Study Area as either Medium Density Residential or Medium High Density Residential. Approximately 6 percent is classified as either commercial or industrial.

1.4.5.2 Future Land Use

The 2016 Comprehensive Plan guides development within the City's planning boundary and establishes the long-range development policies. The 2016 Comprehensive Plan also provides land use projections. Appendix 1A includes the Land Use Element of the 2016 Comprehensive Plan.

Study Area future land use designations were developed with the guidance of the City's Planning Department and are based on the Land Use Plan Element of the 2016 Comprehensive Plan. Since the land use assumptions forecast the type of growth within the Study Area, this association to the SSMP should ensure that the sewer flow projections and facilities required to serve future growth are consistent with the City's guiding document on development. The areas located outside the City limits used the land use information from Clackamas County's GIS data.

The future land use designations represent the maximum build-out feasible for the Study Area. It is assumed that all parcels within the Study Area will be served by the City's collection system in the next twenty years.

Parcels were organized into nine future land use designations as shown in Table 1.13 and Figure 1.5. The future land use categories used in this SSMP are the same as the existing land use categories with the difference of the vacant category. All currently vacant parcels are assumed to be developed to their proposed use in the future.

Table 1.13 Future Land Use Summary

Land Use Category	Acreage	Percent of Total
Commercial	127	3.3%
Industrial	169	4.4%
Low Density Residential	2,626	67.4%
Medium Density Residential	237	6.2%
Medium High Density Residential	153	3.8%
Mixed Use	10	0.3%
No Zoning	10	0.3%
Open Space	137	3.6%
Park	425	10.8%
Total	**3,898**	**100%**

The majority of future development will be new developments located within the Study Area. As seen in Tables 1.12 and 1.13, areas served by the City's sewer system are expected to grow by an additional 374 acres (110 acres of properties currently on septic to connect, and 264 vacant acres to be developed) under build-out condition. Appendix 1A provides a description of the different land uses.

1.4.6 Population Information

Many factors influence growth. The state of the economy, interest rates, annexation of adjacent areas, and up-zoning all influence new development and population growth. The City's population within the city limits and employment over the next 20 years has been estimated by Oregon metro and is summarized in Table 1.14.

Table 1.14 Summary of Population Projections

Projection	2015 Estimate	2040 Forecast	Annual Growth
Population	25,605	27,861	0.3%
Employment	4,541	6,199	1.3%

Notes:
1. Source: Metro, 2040 Distributed Forecast, dated July 12, 2016.

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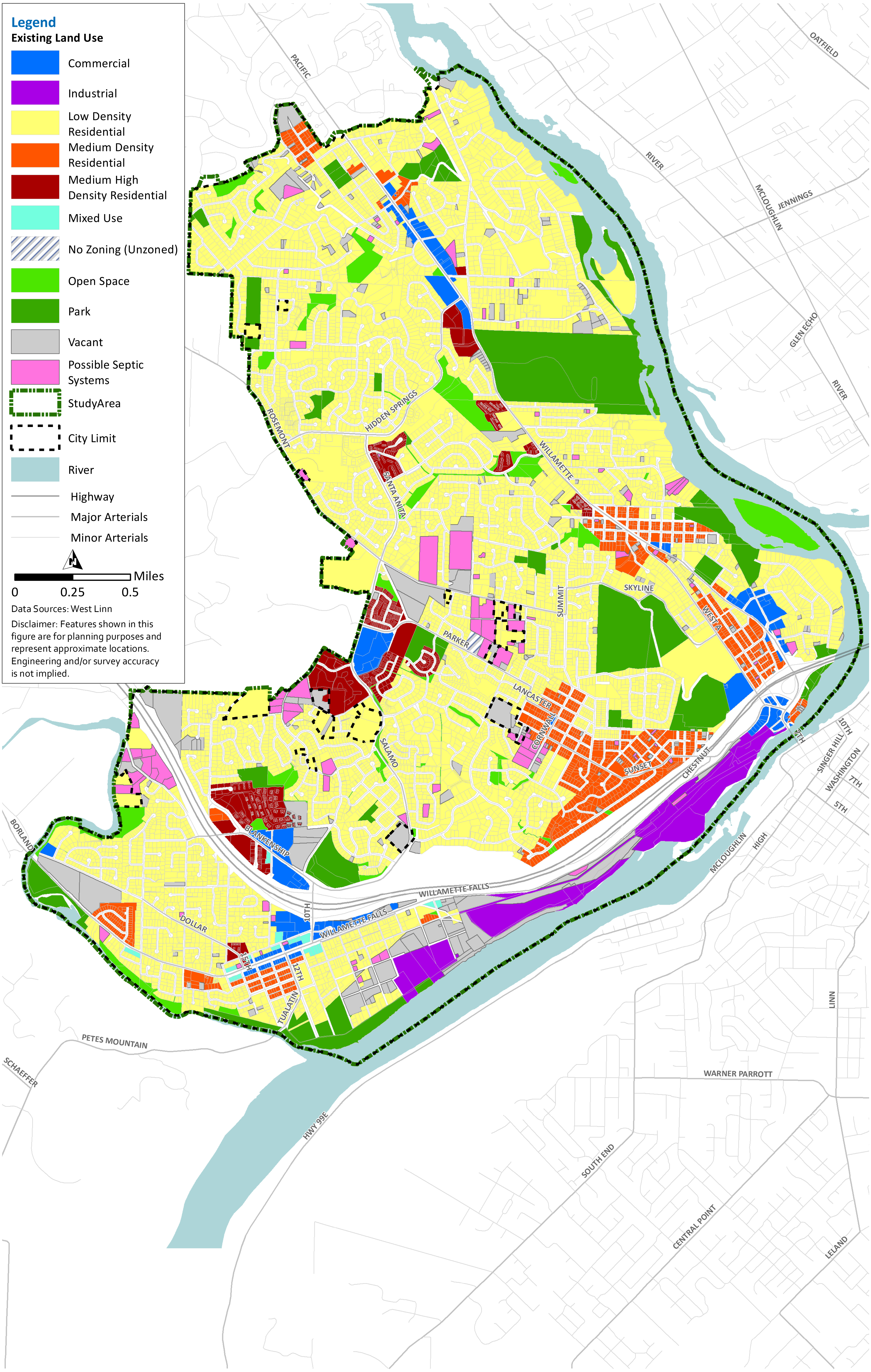

Figure 1.4 Existing Land Use

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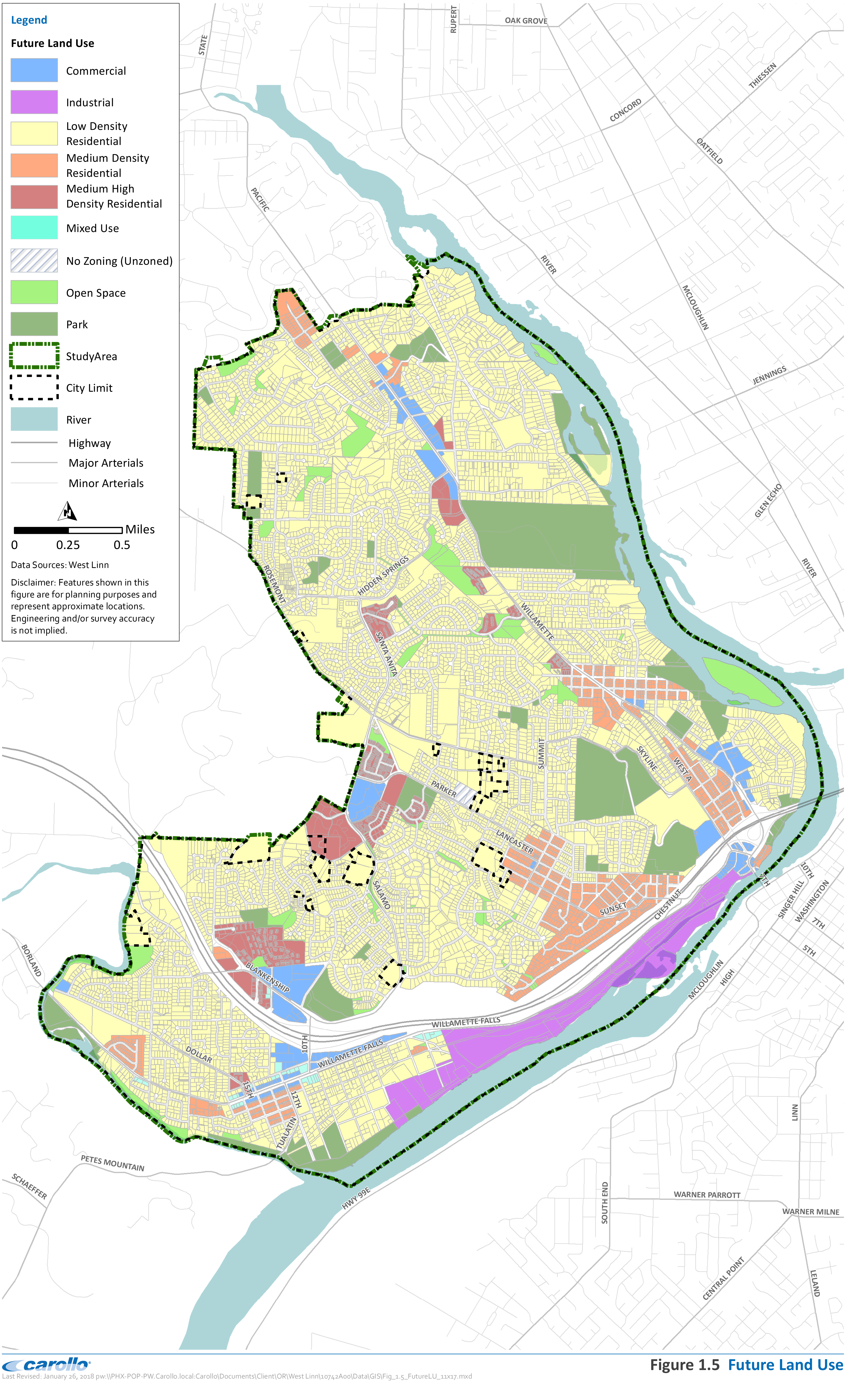

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Figure 1.5 Future Land Use

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1.4.7 Wastewater Basins

The City has identified twenty-five primary sewer basins in the Study Area. The wastewater basins have been defined with the Study Area boundary, and generally delineate large areas of the conveyance network that ultimately flow to one location. The primary sewer basins are shown in Figure 1.6. These basins are well known by City staff and will be used for calculation of sanitary flows based on land use types, area, and flow factors, and for summarizing deficiencies when evaluating the system later in this SSMP.

1.5 Flow Projections Overview

The remaining sections in this TM describe the data and methods used to estimate future sewer flows. This includes establishing the sewer flow definitions, reviewing the results of the 2016 flow monitoring program, confirming existing flows, establishing flow factors, and estimating future flows.

1.5.1 Sewer Collection System Flows Definitions

As a way to help the reader understand the wastewater flow components, this section describes and provides definitions of commonly used terminology in the wastewater collection system analysis and evaluations conducted as part of this SSMP. In general, wastewater consists of the following two components:

- Average Dry Weather Flow and,
- Wet Weather Flow.

1.5.1.1 Average Dry Weather Flow (ADWF)

Average Dry Weather Flow (ADWF) is the average flow that occurs on a daily basis during the dry weather season. ADWF is representative of routine wastewater discharges into the collection system from customers as well as baseline groundwater infiltration into pipes and manholes.

There are two primary components of ADWF:

- **BWF:** Base wastewater flow (BWF) is generated by routine water usage in the residential, commercial, business and industrial sectors of a collection system. The flow has a diurnal pattern that varies depending on the type of use. Commercial and industrial patterns, though they vary depending on the type of use, typically have more consistent, higher flows during business hours and lower flows at night. Furthermore, the diurnal flow pattern experienced during a weekend may vary from the diurnal flow experienced during a weekday.
- **Dry Weather GWI:** Dry weather groundwater infiltration (GWI) enters the sewer system when the relative depth of the groundwater table is higher than the depth of the pipeline and when the susceptibility of the sanitary sewer pipe or manhole allows infiltration through defects such as cracks, misaligned joints, and broken pipelines. GWI may occur throughout the year, although rates are typically higher in the late winter and early spring. Dry weather GWI (or base infiltration) cannot easily be separated from BWF by flow measurement techniques. Therefore, dry weather GWI is typically grouped with BWF, and the combination is referred to as average dry weather flow (ADWF).

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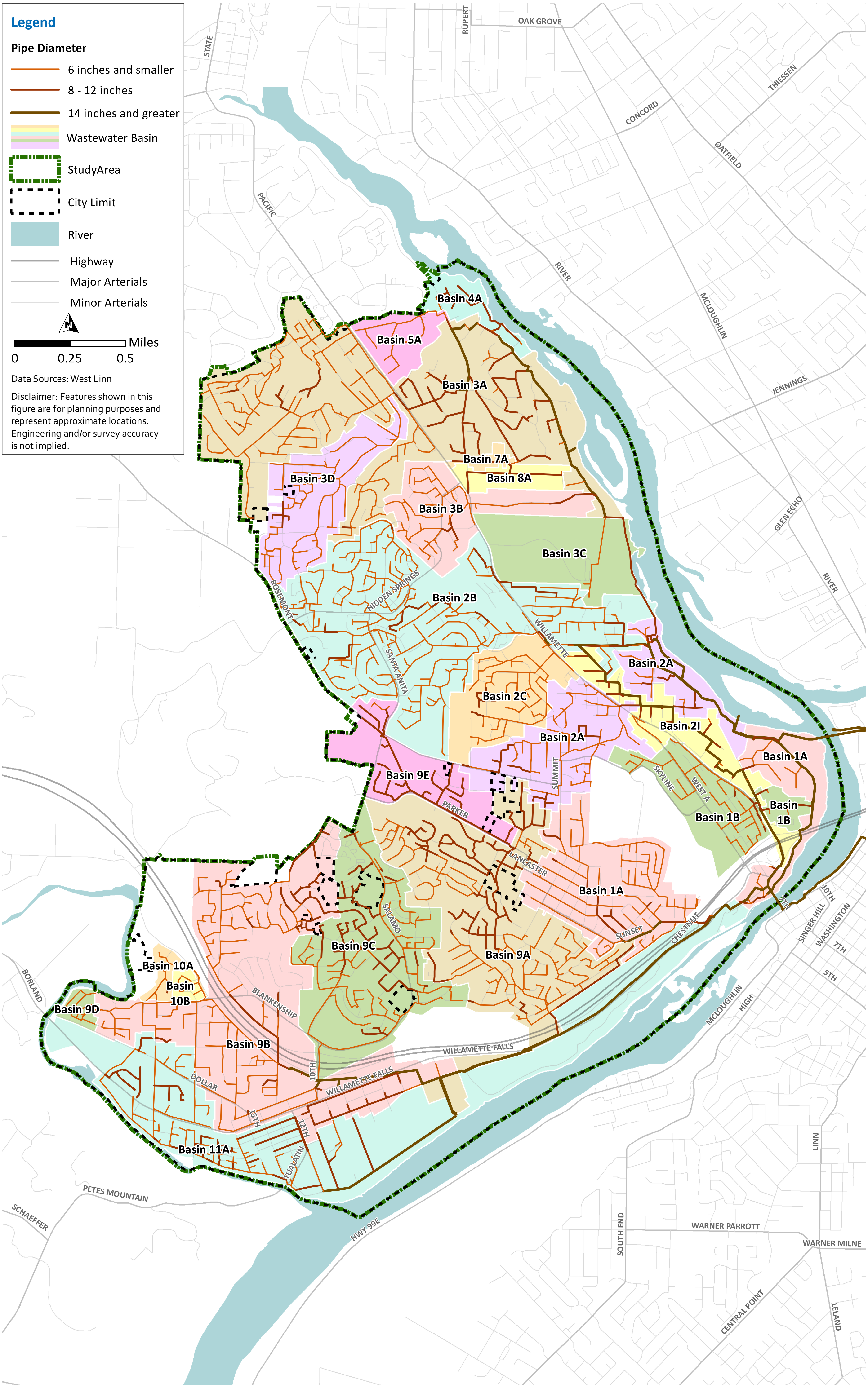

Figure 1.6 Wastewater Basins

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1.5.1.2 Wet Weather Flow (WWF)

Wet Weather Flow (WWF) is flow during or immediately after a storm and is greater than dry weather flows due to direct inflow into the system and increased groundwater infiltration. This type of inflow and infiltration is called rainfall dependent inflow and infiltration (RDII). Figure 1.7 illustrates the different flow components discussed in the following sections. WWF corresponds to the flows in a collection system during rainfall events. Wet Weather Flows comprised DWF and RDII.

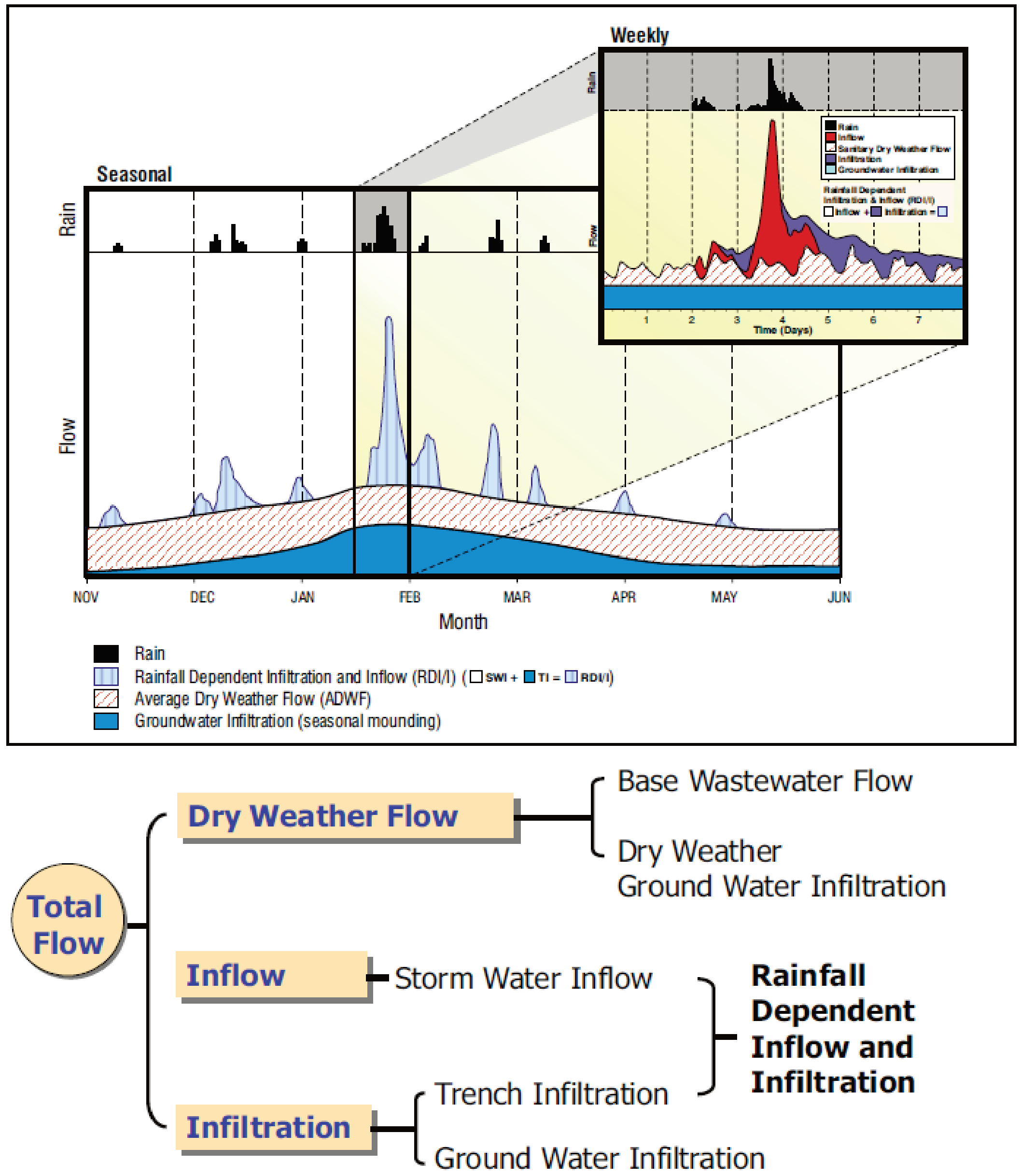
The RDII flow response in the sewer system to rainfall is seen immediately (inflow) or within hours after the storm (infiltration). All wastewater collection systems have some RDII, although the characteristics and severity vary by region and individual collection system.

Infiltration is stormwater that enters the sewer system by percolating through the soil and then through defects in pipelines, manholes, and joints. Inflow is stormwater that enters the sewer system via a direct connection to the system, such as roof drain and downspout connections, leaky manhole covers, and storm drain connections. Some of the most common sources of RDII are shown in Figure 1.8.

The adverse effect of RDII entering the sewer system is that it increases both the flow volume and peak flows such that the sewer system is operating at or above its capacity, as illustrated in Figure 1.9. If too much RDII enters the sewer system, sanitary sewer overflows (SSOs) could occur. The flow monitoring program results indicate that the City collection system does have significant RDII in certain parts of the system. The extent of the City's RDII will be described in TM 4 – Capacity Evaluation and I/I Reduction Program.

1.5.1.3 Peak Wet Weather Flow (PWWF)

Peak Wet Weather Flow (PWWF) is the highest observed hourly flow that occurs following the design storm event, and is typically used for designing sewers and pump stations (therefore referred to as the "design flow"). PWWF occurs because wet weather RDII causes flows in the collection system to increase. While there is a peak flow associated with each storm event, in this study the PWWF represents the peak flow resulting from a design storm. PWWFs are modeled by simulating a storm event in the hydraulic model, after RDII unit hydrographs have been assigned to the collection system and calibrated. The combination of the ADWFs and the RDII occurring from the storm event results in increased wet weather flows; during the design storm, these wet weather flows constitute the PWWF for the system.



Note: This figure is not based on flow data specific to the City or this Master Plan

Figure 1.7 Typical Wastewater Flow Components

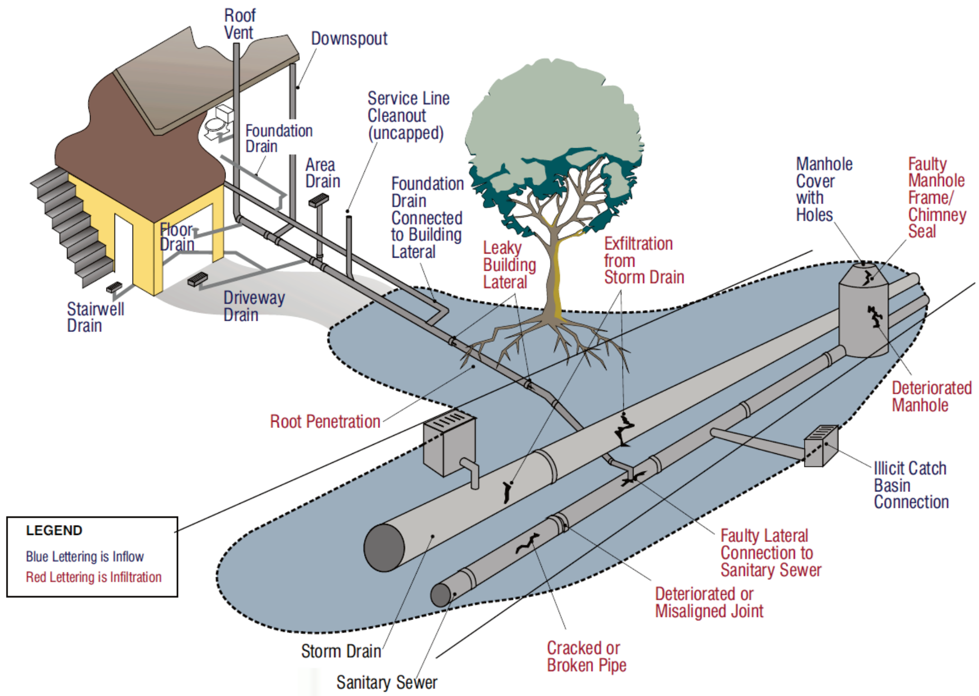


Figure 1.8 Typical Sources of Inflow and Infiltration

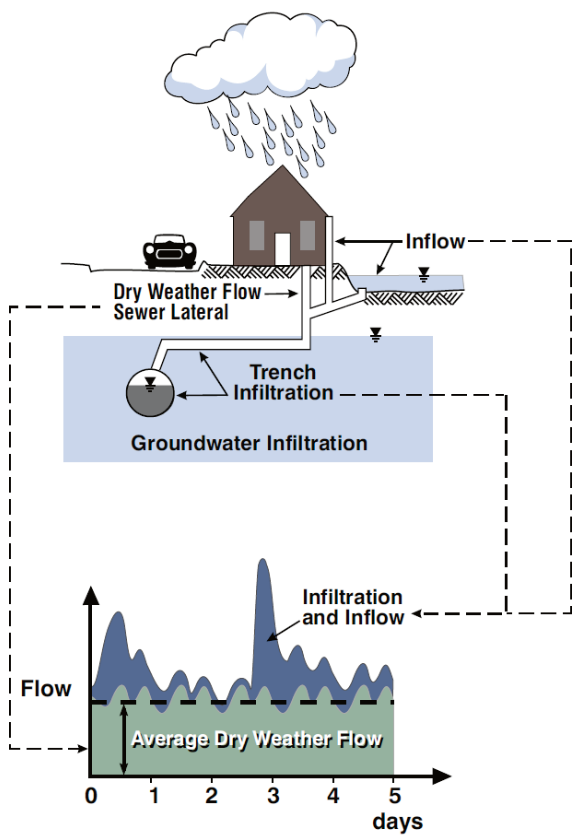


Figure 1.9 Typical Effects of Inflow and Infiltration

1.6 Flow Monitoring Program

Prior to this SSMP, the City contracted with ADS to conduct a temporary flow monitoring program within the City's sanitary sewer collection system. The purposes of the flow monitoring program were to correlate actual collection system flows to the hydraulic model predicted flows, evaluate the system's capacity, and estimate basin inflow and infiltration. The temporary flow monitoring data was collected for a period of approximately 90 days from January 7, 2016 to March 7, 2016. A copy of the report provided by ADS is included in Appendix 1B.

1.6.1 Flow Monitoring Program Description

1.6.1.1 Flow Monitoring Sites and Tributary Areas

Ten locations were monitored during the flow monitoring period. Ten (10) open-channel flowmeters were installed, maintained, and monitored by ADS.

The meter sites were selected to best isolate and model the critical areas and subareas within the sewer system. The 10 flow monitoring locations, as well as the areas tributary to each site, are shown on Figure 1.10. Table 1.15 lists the flow monitoring locations and the diameters for the sewers where the meters were installed. Figure 1.11 provides a schematic illustrating the flow monitoring locations to help understand how the basins connect.

Table 1.15 Flow Monitoring Locations

Flow Meter Site ID	Manhole ID	Pipe Size (in)	Wastewater Basin Monitored	Location	Wastewater Basin to Flow Meter Relationship(1)
9A-14	9A-14	10	9A	Willamette Falls DR. e/o bus barn	= 9A-14
11A-2	11A-2	15	11A	Volpp St before Willamette PS	= 11A-2
9A-2	9A-2	18	9B	4th St s/o 5th Ave	= 9A-2 – 9A-14 – 9C-3
1A-37-1-0	1A-37-1-0	10	1A	Sunset Ave at Chestnut St.	= 1A-37-1-0
3B-4	3B-4	8	3B	4426 Mapleton Dr.	= 3B-4
2B-1-0	2B-1-0	8	2B	2050 Dillow Dr.	= 2B-1-0
9C-3	9C-3	?	9C	10th St s/o Salamo n/o I205 sb ramp	= 9C-3
2A-19	2A-19	8	2A	2100 Caufield St	= 2A-19
3A-8	3A-8	18	3A	Nixon Ave n/o Mapleton	= 3A-8
2B-0-12	2B-0-12	12	2B	Tulane St and Dillow Dr	= 2B-0-12

Notes:
1. The wastewater basin to flow meter relationship shows how the flows for a particular wastewater basin was calculated.

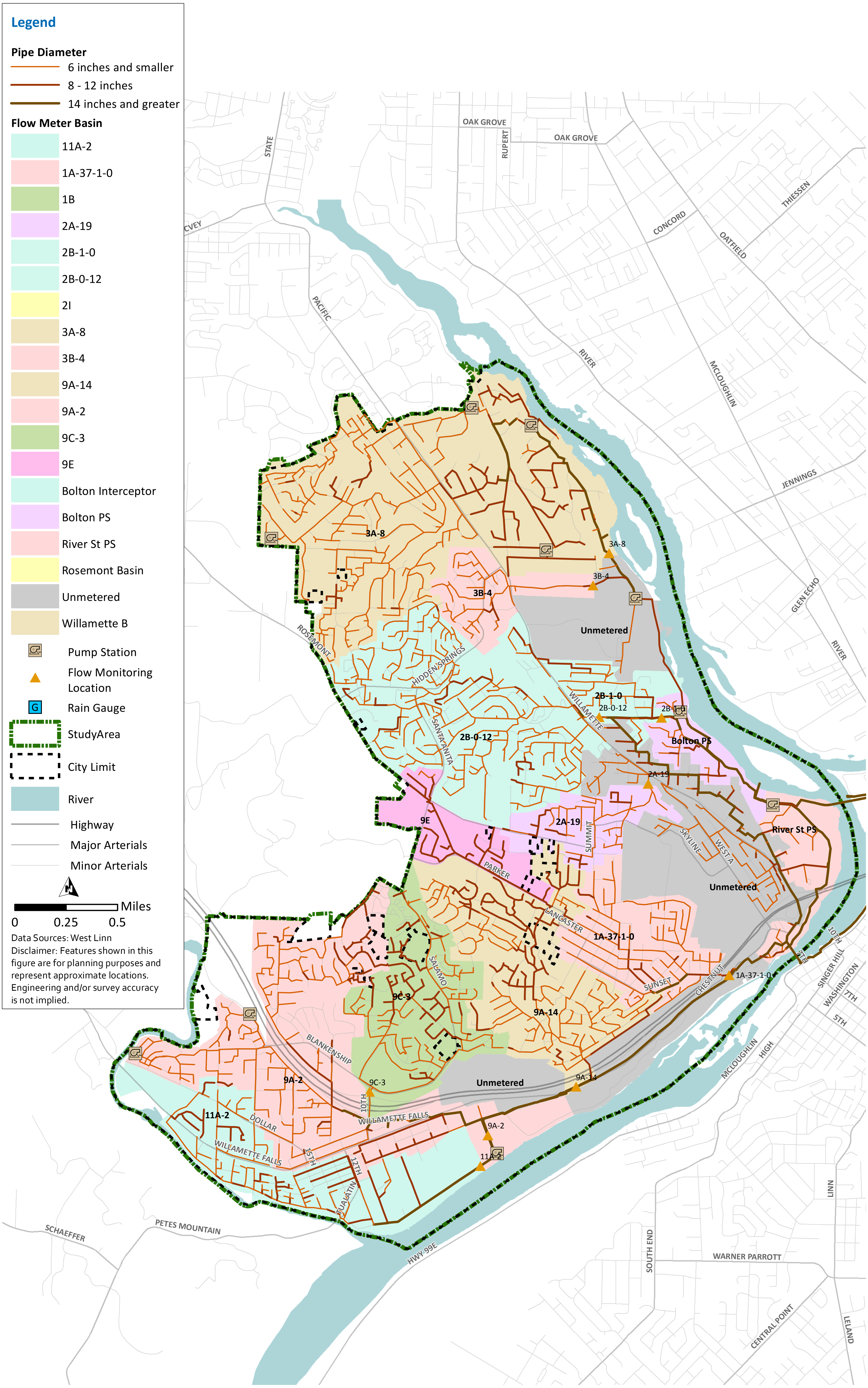


Figure 1.10 Flow Monitoring Sites Locations

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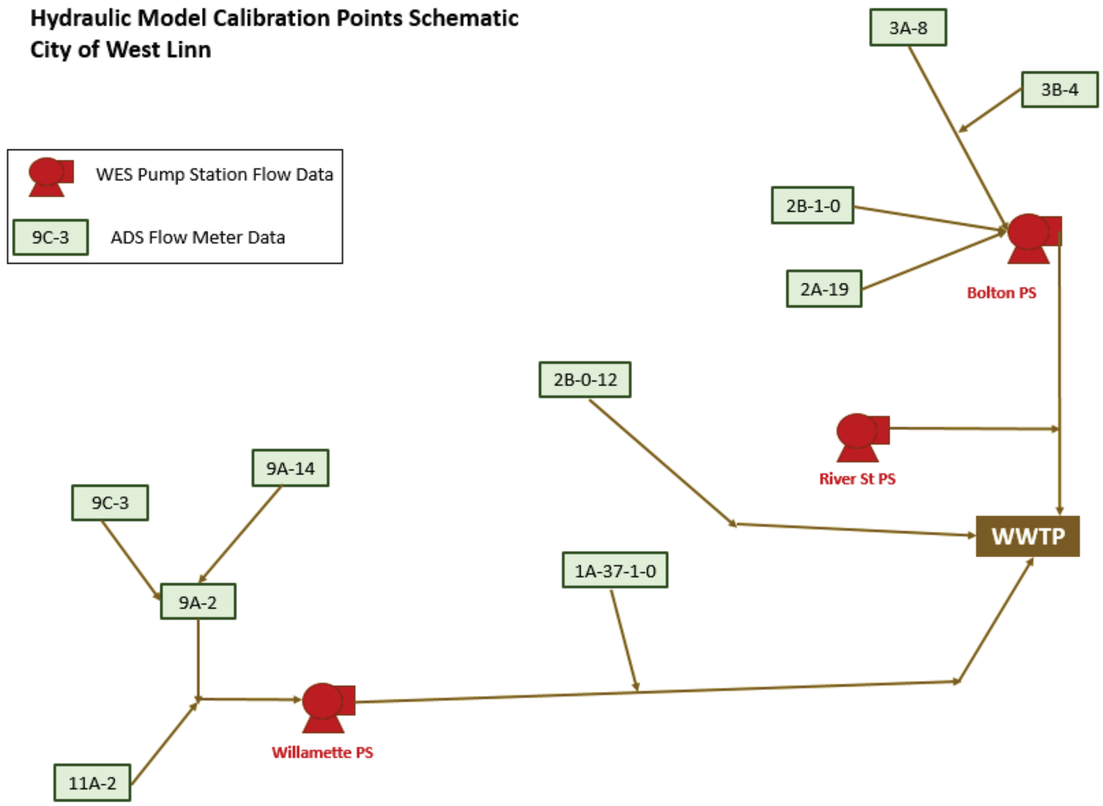

Figure 1.11 Flow Monitoring Schematic

1.6.1.2 Flow Meter Installation and Flow Calculation

ADS installed ten ADS FlowShark Triton monitors. This flow monitor is an area velocity flow monitor that uses both the Continuity and Manning's equation to measure flow.

ADS conducted an analysis of the data retrieved from each flow meter, and made adjustments as needed for calibration based on the field measurements. The flow at each meter was then calculated at 15-minute intervals based on the continuity equation:

$$Q = V \times A$$

where,

Q = Pipeline flow rate, cfs

V = Average velocity, ft/s

A = Cross sectional flow area, ft^2

1.6.1.3 Rain Gauges

One rain gauge was installed to capture rainfall that occurred throughout the flow monitoring program. The tipping bucket type rain gauge was installed from January 7, 2016 to March 18, 2016 at the City of Gladstone's shops as shown on Figure 1.10.

1.6.2 Flow Monitoring Results

This section summarizes the results of the flow monitoring program, including dry weather flow data, rainfall data, and wet weather flow data. Data collected from Meter 2B-1-0 is presented throughout this and other chapters as an example of the type of data and the results from the flow monitoring program. Refer to Appendix 1B for additional data summaries and other information associated with the remaining meter sites.

1.6.2.1 Dry Weather Flow Data

During the flow monitoring period, depth and velocity data were collected at each meter at 5-minute intervals. Carollo aggregated the 5-minute data to hourly data for use in the hydraulic model.

ADWF was developed using the driest days from the flow monitoring period defined based on the following set of minimum criteria:

- No rain occurring within the previous 2-day period,
- In addition, those dry days that exhibited unusual flow patterns were not used to generate net dry day flow values for a basin.

Characteristic dry weather 24-hour diurnal flow patterns for each site were developed based on the hourly data. The hourly flow data were used to calibrate the hydraulic model for the observed dry weather flows during the flow monitoring period.

Typically, a diurnal pattern with mostly residential uses has two peaks with the more pronounced peak following the wake-up hours of the day, and a less pronounced peak occurring in the evening. Commercial and industrial oriented-patterns, though they vary depending on the type of use, typically have more consistent higher flow patterns during business hours, and lower flows at night. Hourly patterns for weekday only could be developed. Not enough available weekend days were available to develop a weekend pattern.

In addition, Carollo estimated the average dry weather levels and velocities at each site from the data provided by ADS, which are used in the dry weather flow calibration.

Figure 1.12 illustrates a typical variation of weekday and weekend flow in the City, which is based on the data collection from Meter 2B-1-0. Similar graphics associated with the remaining sites are included in Appendix 1B. Table 1.16 summarizes the dry weather flows at each meter, and the different components of ADWF at each meter.

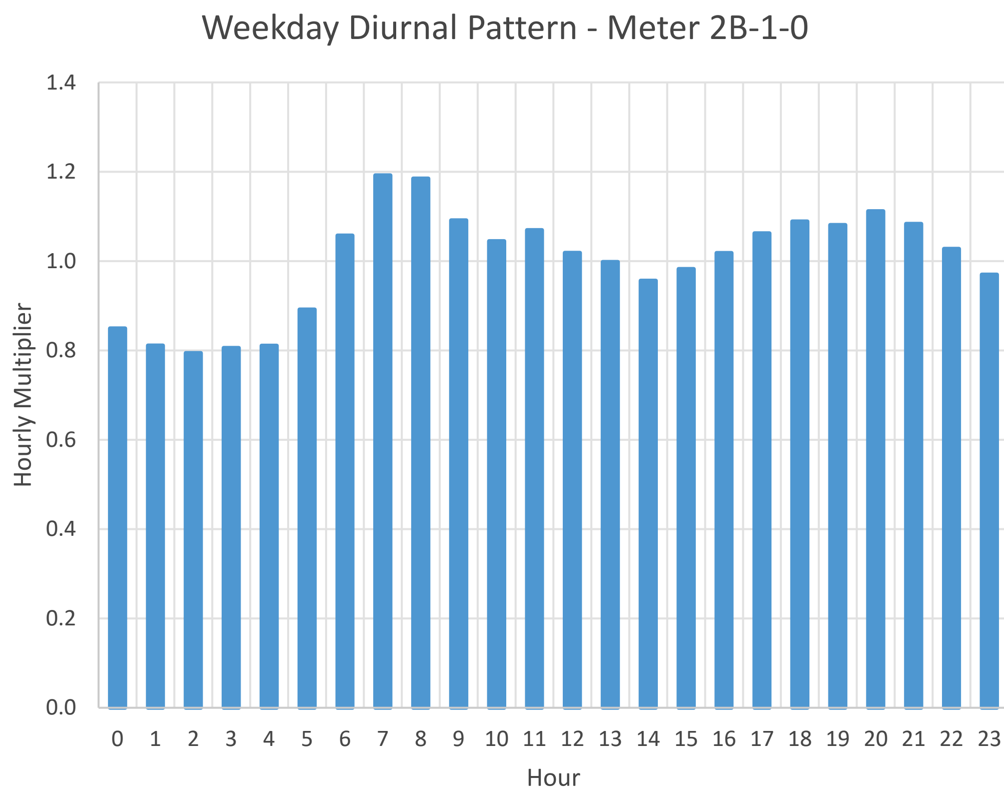

Figure 1.12 Typical Dry Weather Flow Variation (Meter 2B-1-0)

Table 1.16 Average Dry Weather Flow Estimates

Flow Meter Site ID	Gross ADWF (mgd)(1)	Net ADWF (mgd)(2)	Wastewater Basin to Flow Meter Relationship(2)
9A-14	0.316	0.316	= 9A-14
11A-2	0.172	0.172	= 11A-2
9A-2	0.964	0.446	= 9A-2 - 9A-14 - 9C-3
1A-37-1-0	0.392	0.392	= 1A-37-1-0
3B-4	0.098	0.098	= 3B-4
2B-1-0	0.219	0.219	= 2B-1-0
9C-3	0.201	0.201	= 9C-3
2A-19	0.101	0.101	= 2A-19
3A-8	0.408	0.408	= 3A-8
2B-0-12	0.397	0.397	= 2B-0-12

Notes:
1. Gross ADWF is the average dry weather flow through a particular flow meter.
2. Net ADWF is the average dry weather flow for a particular sewershed. The formula used to calculate the flow is shown in the Wastewater Basin to Flow Meter Relationship.

1.6.2.2 Rainfall Data

An important part of the RDII study is the collection and analysis of rainfall data. One tipping bucket type rain gauge was temporarily set up for the flow monitoring period. Four significant rainfall events occurred during the course of the flow monitoring period, as well as a few other relatively minor events. The rainfall data recorded over the course of the flow monitoring program is illustrated in Figure 1.13. Figure 1.14 illustrates the total accumulation of rainfall over the course of the flow monitoring period for the ADS tipping bucket type rain gauge. Table 1.17 summarizes the total rainfall recorded at the ADS rain gauge during the main rainfall event, as well as over the entire flow monitoring period.

Table 1.17 Rainfall Event Summary

Rainfall Event ID	Date (Duration)	Maximum Intensity (in/hr)	Total Volume (inches)
Storm Event 1	1/11/16 – 1/23/16 (13 days)	0.21	5.40
Storm Event 2	1/28/16 - 2/5/16 (9 days)	0.17	2.74
Storm Event 3	2/16/16 – 2/21/16 (6 days)	0.18	2.22
Storm Event 4	2/26/16 – 3/3/16 (7 days)	0.11	2.08

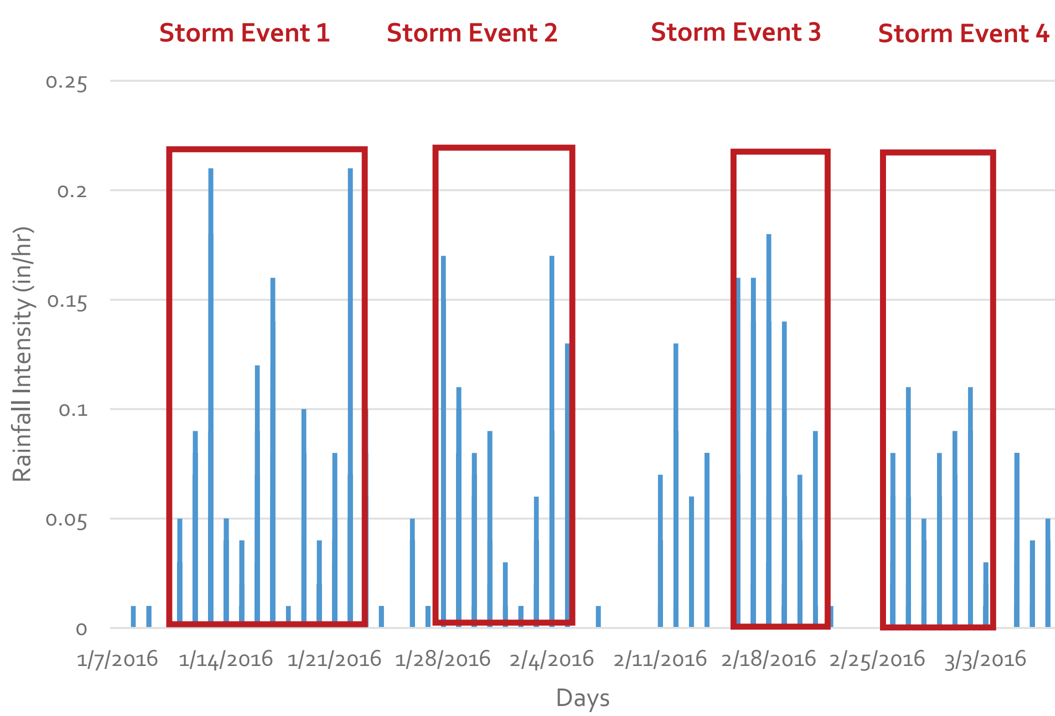

Figure 1.13 Rainfall Activity over Flow Monitoring Period

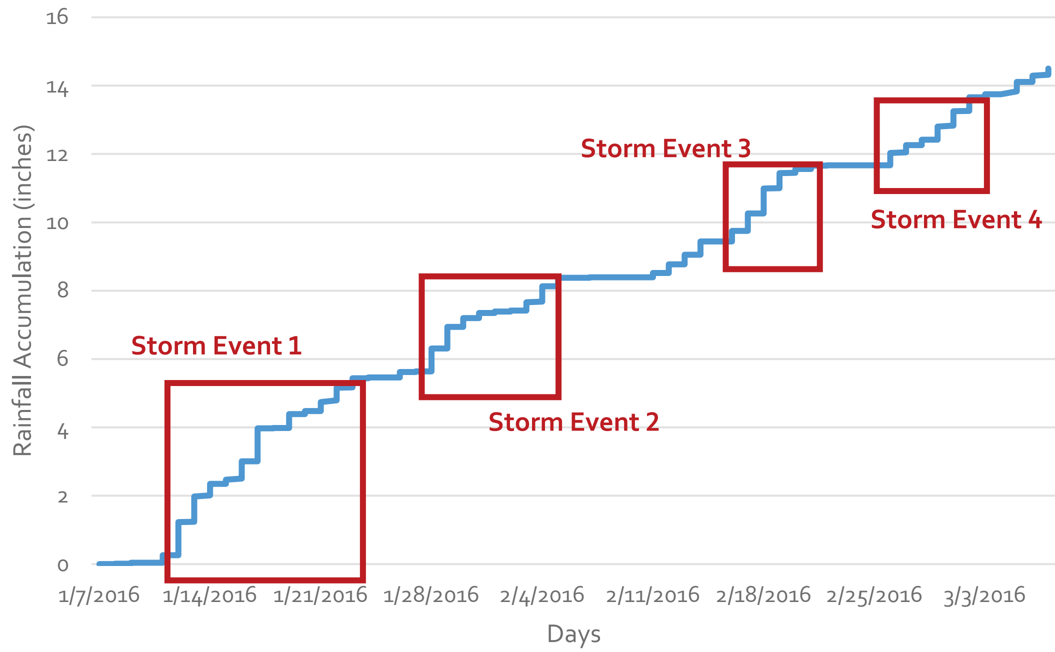

Figure 1.14 Rainfall Accumulation Plot

1.6.2.3 Wet Weather Flow Data

The flow monitoring data were also evaluated to determine how the collection system responds to wet weather events. As mentioned above, the flow monitoring program captured one main rainfall event. The rainfall event that occurred from January 11 to 23, 2016 was associated with the largest RDII response during the flow monitoring period, and is the most appropriate to be used for RDII analysis.

Figure 1.15 shows an example of the wet weather response at Meter 2B-1-0 during the January 11 to 23, 2016 rainfall event. This figure also illustrates the volume of RDII that entered the system from the collection system upstream of Meter 2B-1-0. The light blue area is the base sanitary flow while the dark blue line is the measured flow from the flow monitoring period. As can be seen in the figure, discernible amounts of RDII do enter the system during wet weather events. Similar graphs were generated for the remaining monitoring sites can be found in Appendix 1B.

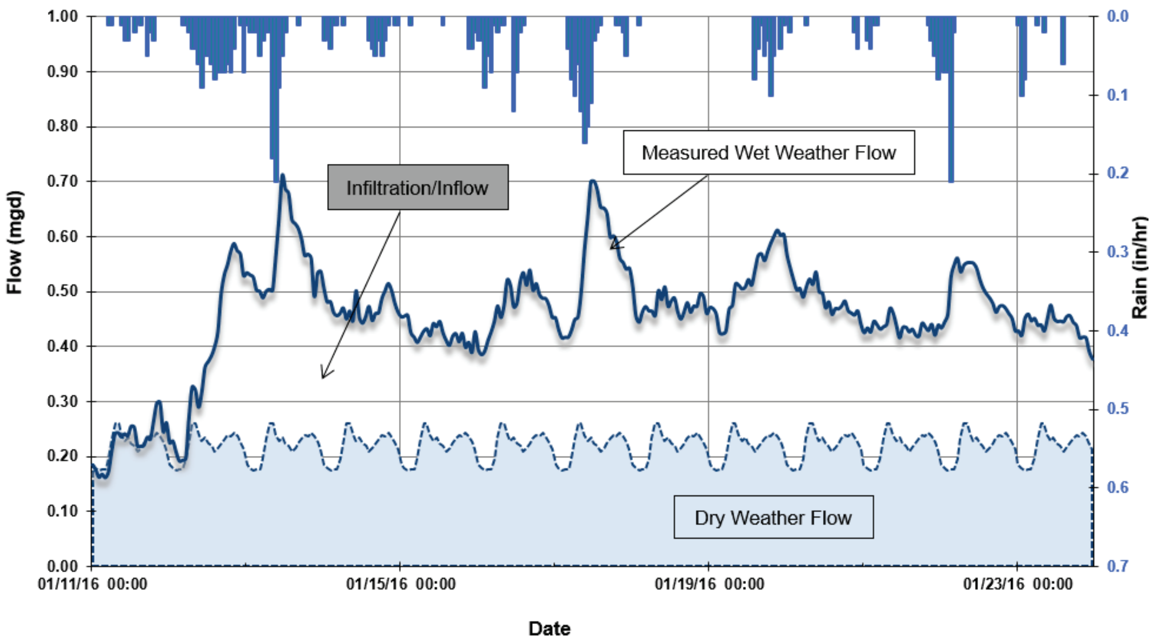

Figure 1.15 Example of Wet Weather Flow Response (Meter 2B-1-0)

1.7 Average Dry Weather Flow Projections

This section presents the ADWF projections methodology and results. Existing ADWF were estimated using data from the Flow Monitoring Program for each of the ten flow monitoring basins, as presented in Section 1.6.2.1, while future estimated ADWF were estimated using the wastewater flow factor method, as described below.

1.7.1 Planning Wastewater Flow Factors

In order to develop wastewater flow projections and allocate future flows to the collection system, relationships between land use and wastewater generation were developed. These relationships, called planning wastewater flow factors are established based on the average wastewater flow generated for each existing land use type. The land use flow factors were established to project the estimated ADWF through build out of the City's wastewater collection system and project future flows within the Study Area boundary.

1.7.1.1 Flow Factors Development Methodology

Planning wastewater flow factors are rates, usually expressed in gallons per day per acre (gpd/ac), applied to the number of acres for calculating average day flow generated from a particular land use. A flow factor was developed for each of the land use classifications discussed previously. The flow factor provides a means to transform a land use category from acreage into wastewater flow. The resulting flow is then input into the appropriate sewer area in the sewer system model. Wastewater flow factors for residential areas can range between 500 to 3,000 gpd/ac, and commercial and industrial areas might range from 500 to 2,500 gpd/ac, with typical values averaging approximately 1,000 gpd/ac for commercial areas. Land uses designated as vacant, parks and open space are assumed to generate negligible amounts of sewage flow, and as a result have a flow factor of zero.

The coefficients are developed using the following procedure:

- Average flows for each flow metering tributary area were derived from the flow-monitoring data (described in Section 1.6.2).
- Using GIS, the acres for each land use type contained in each flow-monitoring tributary area were calculated.
- Preliminary factors for each land use type were assumed based on typical values, which can be estimated from the approximate number of dwelling units per acre, the assumed per capita wastewater generation rates, and/or the typical number of people per dwelling unit for each land use type.
- The factors for each flow metering tributary area were adjusted up or down (balanced) within a reasonable amount (based on engineering judgment) until the calculated average flows from each tributary match what was measured during the flow monitoring period. If the flow factors produced average flows that were significantly different from the field measured flows, further investigation was conducted to verify that the tributary basins were delineated correctly and if the collection system configuration was correct. Flow Factors are developed using the field estimated ADWF.
- Once the factors for the 10 flow meter tributary areas were balanced, the weighted average of the factors for each land use type was calculated based on the acreage contribution from each metering tributary area. The weighted average factors are considered representative of wastewater generation by land use for the City as a whole, and are used to project future average wastewater flows.

1.7.1.2 Existing Flow Factors

For example, for Meter 2B-1-0, the ADWF during the flow-monitoring period was approximately 0.219 mgd. The tributary service area upstream of this flow monitor is developed with buildings falling into a variety of zoning categories, including Low Density Residential, and Medium High Density Residential. The preliminary flow factors were multiplied by the acreages for each land use designation and adjusted until the flows were as close to 0.219 mgd as possible. In this case, the calculated total equaled 0.220 mgd. This process was repeated for each flow meter, and weighted flow factors were calculated for each land use category.

Table 1.19 presents the weighted wastewater flow factors and land use areas that represent the City's existing ADWF. As with most cities, residential land use makes up the majority of developed land and wastewater flow. For the City, residential customers make up approximately 94 percent of the current base flow. The calibrated wastewater flow factors developed for this SSMP range from 940 gpd/acre to 3,500 gpd/acre, as shown in Table 1.18. The land use coefficients generate an ADWF to the metered areas of 2.74 mgd, a 0.38 percent different from the metered data observed during the Flow Monitoring Program. Flow Factor development for all other basins can be found in Appendix 1C.

Table 1.18 Flow Factor Development Summary

Land Use Category	Developed Area (acres)	Wastewater Flow Factor (gpd/ac)	Existing ADWF (mgd)
Commercial	79	1,000	0.08
Industrial	45	1,190	0.05
Low Density Residential	2,014	940	1.89
Medium Density Residential	162	2,040	0.33
Medium High Density Residential	129	2,710	0.35
Mixed Use	9	3,500	0.03
No Zoning - Freeway	1	0	0.00
No Zoning - River	0	0	0.00
No Zoning - Unzoned	0	0	0.00
Open Space	124	0	0.00
Park	139	0	0.00
Vacant	205	0	0.00
Potential Septic Systems	46	0	0.00
		Total Estimated ADWF =	**2.74**
		Measured ADWF =	**2.75**
		% Difference =	**0.38%**

1.7.1.3 Future Planning Flow Factors

The adjusted weighted average flow factors for each land use, as shown in Table 1.19, were used to project future flows.

Table 1.19 Future Planning Flow Factors

Land Use Category	Wastewater Flow Factor (gpd/ac)
Commercial	1,000
Industrial	1,190
Low Density Residential	940
Medium Density Residential	2,040
Medium High Density Residential	2,710
Mixed Use	3,500

1.7.2 Future Projected Average Dry Weather Flows

1.7.2.1 5-year ADWF Projections

Projected ADWFs for the 5-year planning period were estimated based on linear interpolation between existing and build-out projected ADWF, which is in close accordance with Oregon metro projection data.

1.7.2.2 Build-out Land Use Based ADWF Projections

The projected ADWFs were developed based on the future land use map (Figure 1.5). The flow factors shown in Table 1.20 were applied to the future build-out land use (acres) to project the wastewater flow generated from infill and new development. The resulting flows will be applied to the hydraulic model to represent the projected inflow.

Flows were developed for each parcel in the collection system. Flows are separated between existing flows and infill/growth flows. Existing flows developed in Section 1.6.3 remain the same for each wastewater basin. Infill/growth flows correspond to additional flows expected in the future. Parcels currently vacant and parcels with projected higher flow usage than existing are assigned planning flow factors to estimate additional future flows.

Each parcel's existing land use classification is compared with future land use classification from the Comprehensive Plan. The following analysis was then performed:

- Parcels that show the same land use classification are left as is; (existing flow developed remains as is and no additional flow is assigned).
- Parcels that show a higher future land use classification than the existing ones will be assigned additional ADWF. ADWFs for currently vacant parcels are developed using planning flow factors for each land use type. ADWFs for parcels that are currently developed, but assumed to be redeveloped with a higher wastewater production, are developed using the difference between existing and future flow factors. Only additional flow on top of the existing flow is assigned to these parcels.
- Unmetered areas were allocated the weighted average Flow Factors from the areas that the City monitored during the Flow Monitoring program (Refer to Table 1.18 and Table 1.19 for wastewater flow factors values used).
- All private septic systems are assumed to be decommissioned and the buildings connected to the collection system.

1.7.3 Average Dry Weather Flow Projections Summary

Table 1.20 and Table 1.21 summarize the projected ADWF for the different planning periods evaluated in this SSMP, respectively for flow monitoring basins and wastewater basins.

Table 1.20 ADWF Projections Summary by Flow Monitoring Basins

Flow Monitoring Basin ID	Existing ADWF (mgd)	5-year Planning ADWF (mgd)	Build-out ADWF (mgd)
11A-2	0.17	0.18	0.21
1A-37-1-0	0.40	0.40	0.41
2A-19	0.10	0.10	0.11
2B-0-12	0.41	0.41	0.44
2B-1-0	0.22	0.22	0.23
3A-8	0.42	0.43	0.47
3B-4	0.10	0.10	0.10
9A-14	0.32	0.32	0.34

Table 1.20 ADWF Projections Summary by Flow Monitoring Basins (Continued)

Flow Monitoring Basin ID	Existing ADWF (mgd)	5-year Planning ADWF (mgd)	Build-out ADWF (mgd)
9A-2	0.46	0.47	0.53
9C-3	0.20	0.20	0.22
Unmetered	0.57	0.59	0.69
Total (mgd)	3.34	3.42	3.74

Table 1.21 ADWF Projections Summary by Wastewater Basins

Wastewater Basin ID	Existing ADWF (mgd)	5-year Planning ADWF (mgd)	Build-out ADWF (mgd)
1A	0.463	0.465	0.473
1B	0.103	0.105	0.110
2A	0.171	0.174	0.189
2B	0.552	0.556	0.570
2C	0.077	0.081	0.097
2I	0.075	0.076	0.079
3A	0.342	0.351	0.387
3B	0.099	0.101	0.107
3C	0.003	0.003	0.003
3D	0.066	0.067	0.069
4A	0.021	0.021	0.024
5A	0.028	0.028	0.029
7A	0.005	0.005	0.005
8A	0.020	0.020	0.022
9A	0.318	0.327	0.362
9B	0.403	0.420	0.488
9C	0.195	0.200	0.217
9D	0.009	0.009	0.009
9E	0.077	0.082	0.103
10A	0.014	0.014	0.015
10B	0.007	0.007	0.007
11A	0.289	0.307	0.379
Total (mgd)	**3.34**	**3.42**	**3.74**

1.8 Wet Weather Flow Projections

Peak wet weather flows in a sewer system can be more than ten times the base flow, causing utilities to construct high-capacity infrastructure to convey and treat these extraneous flows. This section describes the methodology used for developing existing and future peak flow projections within the City's sanitary sewer system, which was subsequently used for performing the capacity analysis as described in TM 4 – Capacity Evaluation and I/I Reduction Program.

1.8.1 Design Storm

Design storms are rainfall events used to analyze the performance of a collection system under peak flows and volumes, and have a specific recurrence interval and rainfall duration. The storm is used for sizing projects. The National Oceanic and Atmospheric Administration (NOAA) publishes isopluvial (rainfall contour) maps[1] that approximate the total rainfall depth for a range of storm size recurrence intervals for standardized storm durations.

In Oregon, the 5-year, 24-hour design storm is typical for use with modeling wet weather flows in collection systems. The City selected the 5-year, 24-hour design storm for sizing the City's sewer infrastructure as it meets industry standards and Oregon Department of Environmental Quality standards. Total rainfall for the 5-year, 24-hour storm for the West Linn area is predicted to be 2.9 inches, per NOAA isopluvial maps. The NOAA isopluvials' accuracy is limited based on mapping and scale. Therefore the 2.9 inches of rainfall for a 5-year, 24-hour storm is an estimated number per mapping reading. Essentially, this design storm has a five percent chance (1/20) that 2.9 inches of rain will fall in any 24-hour period in a given year. The City is also considering climate change during the development of its design storm. Information from SWMM-CAT was used to account for climate change in this SSMP. SWMM-CAT provides a set of location-specific adjustments that were derived from global climate change models run as part of the World Climate Research Program (WCRP) Coupled Model Intercomparison Project Phase 3 (CMIP3) archive. For the City's location, a 5-year, 24-hour design storm is anticipated to increase by 8.5 percent in the near-term (2020-2049). The design storm for the City was therefore increased by 8.5 percent, which resulted in a total rainfall volume of 3.2 inches. This storm was accepted as the City's design storm for this SSMP, as it is in accordance with neighboring jurisdictions.

For the distribution of the design storm, it is possible to utilize a synthetic distribution or to establish a custom distribution based on historical data. The Natural Resources Conservation Service (NRCS), formally known as the Soil Conservation Service (SCS), method is used to distribute the rainfall volume and establish a peak intensity over a given storm duration. The NRCS method includes the use of developed normalized rainfall hyetograph distribution curves based on the storm's geographical location. The Type 1A distribution curve was used for the City's design storm. Figure 1.16 shows the distribution curve recommended based on geographical location.

Figure 1.17 shows the custom design storm used for the capacity analysis. Applying the synthetic distribution curve to the total rainfall volume resulted in an hourly peak rainfall intensity of 0.5 inches/hour. To represent typical winter Pacific Northwest privilege, antecedent rainfall was added from historical data.

[1] Miller, J., R. Frederick, and R, Tracey. Precipitation-Frequency Atlas of the Western United States, Volume IX-Washington. Washington DC, NOAA 1973.

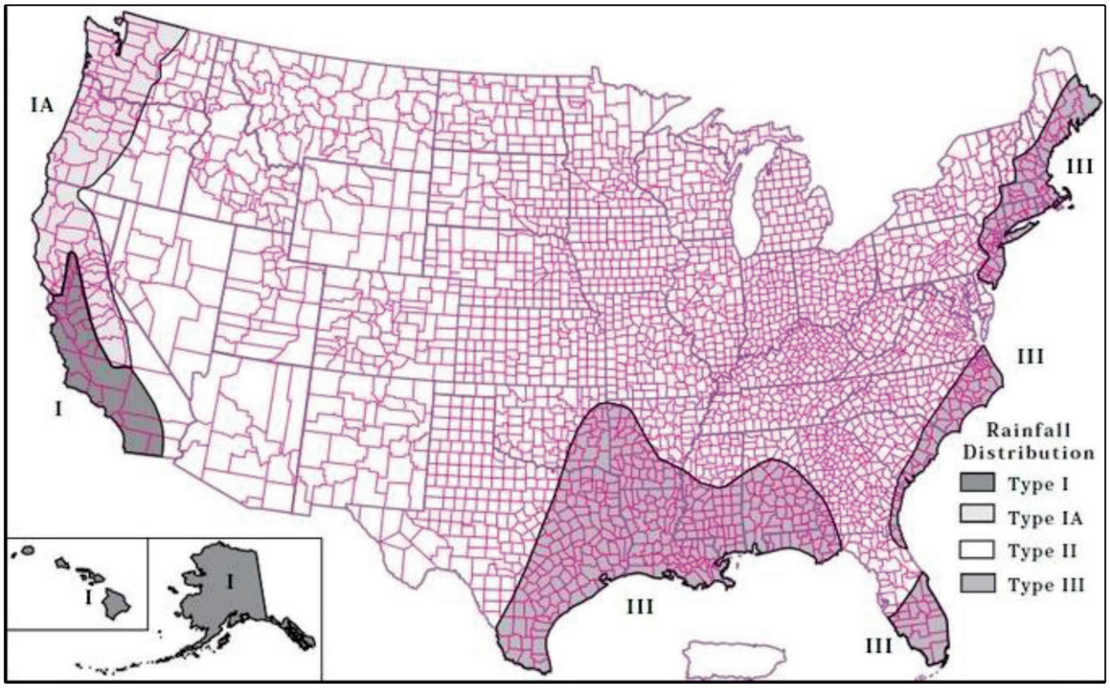

Figure 1.16 NRCS Distribution Rainfall Curve Locations

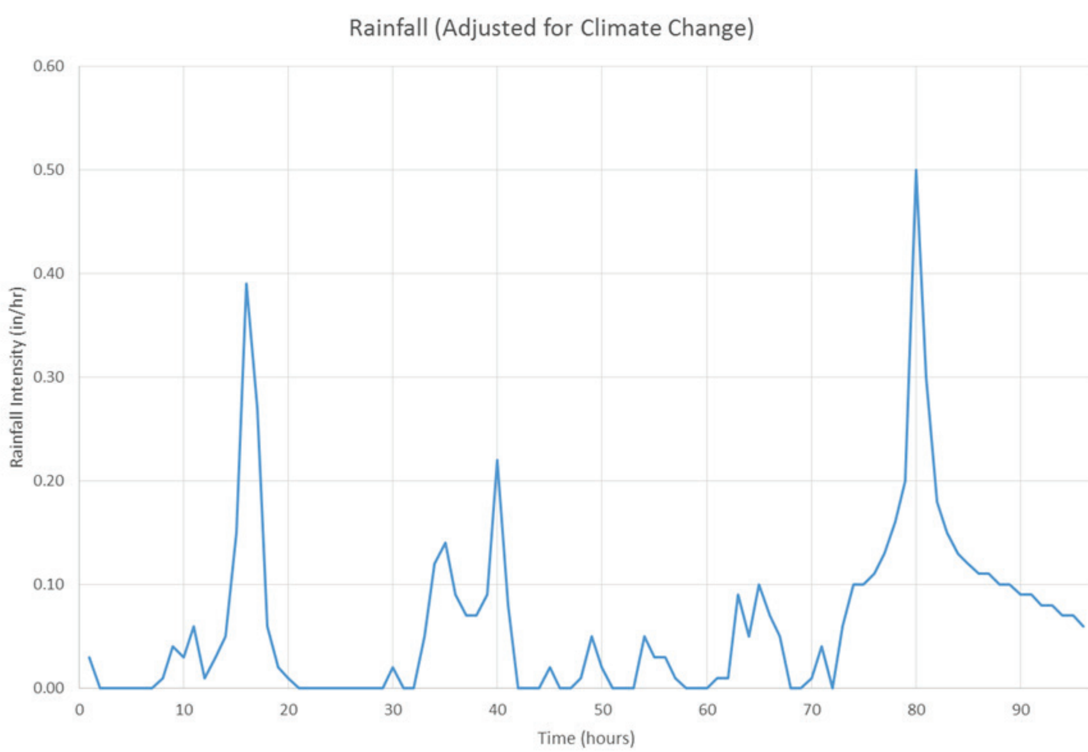

Figure 1.17 Design Storm Hyetograph

1.8.2 RDII Assumptions for Future Service Areas

To predict future peak flows, RDII in the future service area must be as defined. A direct inflow technique is used. Instead of simulating RDII using an RDII unit hydrograph, RDII is simulated by assuming a constant RDII flow factor per acre of new development. RDII flow factors can range from 1,000 to over 10,000 gpd/ac in the northwest. As detailed in TM 4 – Capacity Evaluation and I/I Reduction Program, existing peak I/I flow factors for the City range from 17,700 gpd/ac to 1,340 gpd/ac, with a City average of 5,190 gpd/ac. An RDII Flow Factor of 1,500 gpd/ac was selected for estimating RDII in areas of new development to reflect improved construction methods and integrity of new materials. Additionally, this value also meets the Department of Environmental Quality (DEQ) recommendation.

The City has an effective repair and replacement program, however, systems still degrade over time and the City decided to account for collection system degradation in the 20-year planning period of this SSMP. Degradation is the slow decline in the condition of the conveyance system that allows an increase in I/I. Increases in I/I can also be caused by illicit connections to the sewer system. It was assumed that degradation (increase in peak I/I rate) from 2000 would be 7 percent per decade, with a limit of 28 percent over four decades. King County (Washington) Wastewater Division published these guidelines in July 2014 based on their past experience and pilot projects.[2]

1.8.3 Existing and Projected Peak Wet Weather Flows

The PWWF represents the maximum hourly flow rate under the selected design storm and growth conditions. Components of the design flow include the ADWF predicted for the scenario and the peak RDII rate predicted by the model using the assumptions described above. To develop the design flows in the hydraulic model, the design storm is routed through the model and the resulting RDII from existing and future development creates the PWWF. Estimated PWWF for the various planning scenarios are summarized in Table 1.22. The maximum PWWF predicted for the Study Area at build-out is 23.68 mgd.

The peak flows presented in Table 1.22 assume that improvements to correct capacity deficiencies (as presented in TM 4 – Capacity Evaluation and I/I Reduction Program.) are implemented. The improvement projects alleviate capacity bottlenecks upstream in each basin, which allows higher peak flows to be conveyed through the system. The values in Table 1.22 represent the flows to the Regional Treatment Plant if the capacity bottlenecks are resolved. This ensures that the PWWF truly represents the highest flow, without dampening due to upstream capacity deficiencies. Peak flows without improvements would underestimate actual peak system inflow.

1.9 Flow Projection Summary

Table 1.22 presents the total projected ADWF and PWWF for the three planning periods. The table also includes the ratio between PWWF to ADWF, called the Peaking Factor, which ranges from 6.0 to 6.3. Note, peaking factor increase is mainly caused by the I/I degradation assumption of 7 percent per decade.

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[2] Updated Planning Assumptions for Wastewater Flow Forecasting, King County Wastewater Treatment Division, July 2014.

Table 1.22 Existing and Projected Wastewater Flows

Wastewater Basin ID	Existing Condition	5-year Planning Period	Build-out Condition
ADWF (mgd)	3.34	3.42	3.74
PWWF (mgd)	20.17	21.26	23.68
Peaking Factor (PF)	6.0	6.2	6.3

Appendix 1A

DESCRIPTION OF LAND USES

City of West Linn Comprehensive Plan

Adopted December 1983, Amended July 2000; October 2003; May 2005; April 2006; March 2008; May 2008; September 2008; December 2008; July 2013 December 2013; June 2014

<u>West Linn City Council</u>

Mayor John Kovash

Jody Carson

Thomas Frank

Mike Jones

Jenni Tan

<u>West Linn Planning Commission</u>

Chair Christine Steel

Russ Axelrod

Nancy King

Lori Griffith

Ryerson Schwark

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Shauna Shroyer, Administrative Assistant

Kathy Aha, GIS

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

INTRODUCTION

USING THE COMPREHENSIVE PLAN

This document is designed to respond to the desires, needs, and aspirations of the citizens of West Linn.

Comprehensive city planning addresses a wide range of topics and issues related to the growth and development of a community. This plan includes background and analytic sections that support recommendations for, among other things, sustainable economic activity, housing, recreation and open space, transportation, land use livability, and preventing degradation of quality of life in and for West Linn. The Plan is comprehensive in scope and its goals and policies are intended to be supportive of one another. West Linn's Comprehensive Plan provides guidelines and standards for decision makers, including City employees and officials, citizens, developers, community groups, and other local, state, regional, and federal agencies. This document pertains to the City of West Linn as the City limits exist in 2003 and the contiguous Urban Growth Boundary as it existed in October 2002.

The City of West Linn is dedicated to a policy of 100% cost recovery for growth attributable impacts in all categories of Systems Development Charges (SDCs) allowable by Oregon law. There is a charter requirement that all annexations require voter approval.

The Comprehensive Plan provides the basis for other plans, ordinances, and other implementing documents that set forth more detailed direction regarding specific activities and requirements. All City plans and implementing ordinances must be consistent with the Plan.

In 1997, West Linn citizens overwhelmingly approved a measure advising the City to exercise local control over growth-management and to seek changes in the Metro 2040 Functional Plan. In some situations, Comprehensive Plan policies and associated implementation programs may not be consistent with the Metro Functional Plan. In these situations, exemptions to Metro policies will be pursued through the Metro process for exemptions. The Land Conservation and

Development Commission initially acknowledged the Comprehensive Plan for compliance with the State Planning Goals in 1984. The Plan is periodically reviewed by the City in coordination with the Department of Land Conservation and Development and updated to ensure that it continues to comply with these goals. The Comprehensive Plan has been drafted to reflect the needs of the residents of West Linn and reviewed in terms of the vision of the Metro 2040 Growth Concept and its goals as set forth in the Functional Plan. It also has been reviewed to ensure consistency with other relevant plans from other jurisdictional agencies.

The Plan is organized around the Statewide Planning Goals and each chapter corresponds to a specific Statewide Goal. Some goals have been found to not be applicable to the City of West Linn and are not included in this plan. Specifically, the following goals are not included: Goal 3 (Agricultural Resources), since there are currently no commercial farming operations within City limits; Goal 4 (Forestry Resources), since there are currently no commercial forestry operations within city limits; Goals 16, 17, 18, and 19, since there are no estuarine resources; coastal shorelands, beaches and dunes or ocean resources within city limits.

GOALS, POLICIES, AND RECOMMENDED ACTION MEASURES

The West Linn Comprehensive Plan is organized around the Statewide Planning Goals and contains background information and findings that support City goals, policies, and recommended action measures.
The goals and policies contained within this plan have the force of law and the City is obligated to adhere to them in implementing the Plan. Additional information about City goals, policies, and recommended action measures follows.

Goal. A statement indicating a desired end or aspiration including the direction the City will follow to achieve that end. The City's goals must be consistent with the Statewide Planning Goals.

Policy. A statement indicating a definitive course of action to implement City goals. A policy may not be the only action the City can take to implement the goals. The City must follow relevant policies when developing other plans or ordinances that affect land use, such as public facility plans, zoning, and development standards.

Recommended Action Measure. A statement outlining a specific City activity, action, project or standard, which if executed, would implement goals and policies. Recommended action measures also refer to courses of action the City desires other jurisdictions to take regarding specific issues, and help define the relationship the City desires to have with other jurisdictions and agencies in implementing the Comprehensive Plan. These statements are suggestions to City decision-makers as ways to implement the goals and policies. Completion of projects, adoption of standards, or the creation of certain relationships or agreements with other jurisdictions and agencies will depend on a number of factors such as City priorities, finances, and staff availability.

GLOSSARY

For the purpose of the Comprehensive Plan, the following terms or words are defined as follows:

Accessory Dwelling Unit. Attached or detached dwelling that is secondary to the primary dwelling unit and intended to provide convenient and affordable housing opportunities.

Affordable Housing. Housing that is affordable to most residents of a community and does not cost more than 30% of a family's household income.

Aggregate Resources. Rock, sand, or gravel.

Ambient Noise. The total noise associated with a given environment, being a composite of sounds from many sources both near and distant. For the purpose of this ordinance, ambient noise levels shall be measured using the A-Scale and in accordance with the standards of the Sound Measurement Procedures Manual.

Base Zone. The underlying zoning upon which an overlay zone is placed.

Capital Improvements Program. A plan that describes when a community's major public facilities (e.g., roads, libraries, sewer systems, police stations) will be built, how much they will cost, and the source of funding. It usually covers a period of at least three years and up to ten.

Carrying Capacity. The level of use that can be accommodated and sustained without unacceptable damage to the environment, including air, land, and water quality, the transportation network, storm water management, and overall quality of life.

Cluster Development. A development design technique that concentrates buildings on part of the site to allow the remaining land to be used for recreation, common open space, and/or preservation of environmentally sensitive features.

Community Development Code. A document adopted by the City of West Linn which is designed to set forth the standards and procedures governing the development and use of land in West Linn and to implement the West Linn Comprehensive Plan.

Comprehensive Plan. An official document of a local government that includes goals and policies that direct how the community will develop. It may also include action measures or strategies for implementing the goals and policies. Oregon Administrative Rules further define a Comprehensive Plan as a "generalized, coordinated land use map and policy statement of the governing body of a local government that interrelates all functional and natural systems and activities relating to the use of lands, including, but not limited to, sewer and water systems, transportation systems, educational facilities, recreational facilities, and natural resources and air and water quality management programs" (ORS 197.015). In Oregon, a comprehensive plan is adopted by ordinance, has the force of law, and is the basis for zoning and subdivision ordinances and other regulations. A number of other City planning documents support and/or implement the plan.

Conditional Use. A use which may be permitted. By the approval authority following a public hearing, upon findings by the authority that the approval criteria have been met or will be met upon satisfaction of conditions of approval.

Density. The number of families, individuals, dwelling units, households, or housing structures per unit of land.

Design Review Guidelines. Standards related to the appearance and construction of buildings and related facilities (e.g., trees, street lights, or sidewalks). The guidelines typically are applied to specific types of development or specific zones and reviewed by City staff (also see Review Process).

Development. Any activity that results in a change in land use, or the construction or modification of a structure, or a man-made substantial alteration of land and vegetation. This term is further defined in the West Linn Community Development Code.

Drainageways. Open linear depressions, whether natural or man-made, for collection and drainage of surface water. They may be permanently or temporarily filled with water.

Ecological/Scientific Areas. Land and water that has retained much of its natural character, though not necessarily completely natural, and is significant for historical, scientific, palaeontological, or natural features.

ESEE Analysis. Analysis of economic, social, environmental, and energy impacts required under Statewide Planning Goal 5. The purpose of the ESEE analysis is to inventory natural resource sites and identify their relative resource value for the purpose of determining an appropriate level of protection through land use regulations.

FEMA (Federal Emergency Management Agency). The administrator of the National Flood Insurance Program.

Floodplain. Land subject to periodic flooding, including the100-year floodplain as mapped by FEMA flood insurance studies or other substantial evidence of flood events.

Floodway. The portion of a watercourse required for the passage or conveyance of a given storm event as identified and designated by the City. The floodway shall include the channel of the watercourse and the adjacent floodplain that must be reserved in an unobstructed condition in order to discharge the base flood.

4(d) Rule. A federal rule that establishes regulations to protect species listed as threatened under the Endangered Species Act (ESA). These requirements can be used by local governments to ensure that their activities and regulations are consistent with the ESA.

Garden Apartment. An apartment typically located within a relatively small group of one- to three-story structures that surround an internal courtyard or garden.

Goal 5 Rule. An Oregon Administrative Rule requiring local governments to develop and maintain inventories of natural resources, scenic and historic areas, and open spaces. The rule provides cities with the option of following general requirements for identifying "significant" resources or using state criteria to determine which resources are significant.

Habitat Friendly Development Practices. A broad range of development techniques and activities that reduce the detrimental impact on fish and wildlife habitat relative to traditional development practices. The objective of these practices is to ensure the natural pre-development functions of the site, both ecological and hydrological. These techniques may include a variety of site planning and stormwater management practices, as well as habitat sensitive designs.

Heritage Tree. A tree that is of special importance due to its historical significance, age or type. In West Linn, heritage trees are designated by the City Council following review of a nomination form submitted by a citizen and accepted by the property owner.

Historic District. An area containing a number of lots, blocks, and buildings that has special historical, architectural, or cultural significance as part of the heritage of the City. The Willamette area has been identified and designated as a Historic District.

Home Occupation. Any activity carried out for gain by a resident and conducted as a customary, incidental, and accessory use in the resident's home. Standards for home occupations are included in West Linn's Community Development Code.

Housing Type. The categorization of residential units as they are configured in the built environment. Examples include single-family detached, single-family attached (duplex, rowhouse, condominium), and apartments.

Impervious Surface. Solid surfaces, such as streets, parking lots, and roofs, that prevent rain from being absorbed into the soil, thereby increasing the amount of water runoff that typically reaches a receiving stream.

Infill. Use of vacant lots in predominantly developed areas, or the undeveloped portion of developed lots, to make more efficient use of land resources.

Infiltration. Seepage of groundwater into cracks of sewer or storm water collection pipes. This term is also used to describe the process of absorption of liquids into the ground.

Inflow. Entry of water into the sewer or storm water collection system through manholes, gutters connecting to the storm water system, and similar open facilities. This term typically is used in combination with infiltration to describe impacts on a sewer or storm water collection system from unintended outside sources.

Infrastructure. Facilities and structures used to provide public services to City residents and businesses. Examples include roads, sewer and water transmission lines, administrative buildings, and parks and recreation properties and structures.

Land Use Compatibility Statement. A statement that must be submitted by a business that is applying for a permit from the Oregon Department of Environmental Quality. The statement must be reviewed and signed by a local city planner approving or rejecting a new project. By signing, the City indicates that the proposed project is compatible with the Comprehensive Plan and other land use ordinances.

Level of Service (LOS). A term used to measure the effectiveness for the operation of a road or street intersection. It is similar to a report card rating based upon average vehicle delay. Levels of service A, B, and C indicate conditions where vehicles can move freely. Levels of service D and E are progressively worse. Level of service F represents conditions where traffic volumes exceed the capacity of the facility or a specific movement.

Main Street. "Main Street" refers to a design concept that includes commercial and residential uses, but does not imply that the City will meet Metro's density guidelines.

Main Street (Metro). A Metro concept for streets with a concentration of retail and service establishments possibly including some residential uses, typically accessible by transit, that serve neighborhoods. Metro specifies average densities for housing and employment at 39 persons per acre on the main street.

Manufactured Home. A structure, transportable in one or more sections, that is built on a permanent chassis and is designed for use with or without a permanent foundation when connected to required utilities. This term is further defined in the West Linn Community Development Code.

Mass Transit. A means of transportation designed to move large numbers of people along a fixed route.

Metro. Regional government responsible for providing various regional services and coordination of local planning efforts.

Metro Functional Plan. A set of regional requirements adopted by Metro for cities and counties to implement the Region 2040 Growth Concept. The plan addresses issues such as projected housing and job growth, parking management, water quality, and the regional road system.

Metro Title 3 Requirements. Regional requirements adopted by Metro to protect water quality and fish and wildlife habitat, primarily through standards for riparian areas and flood plains.

MSA (Metropolitan Statistical Area). A term used by the U.S. Bureau of the Census to define urban areas. According to the Census Bureau, an MSA consists of a "large population nucleus, together with adjacent communities having a high degree of social and economic integration with that core." Metropolitan Statistical Areas are defined by the United States Office of Management and Budget (OMB).

Minimum Lot Size. The smallest area permitted for a new lot in a particular zone. For example, in a single-family residential zone, a single house may be constructed on a lot no smaller than a certain size (e.g., 5,000 square feet). In a multi-family residential zone, the smallest allowable size of the lot may vary depending on the number of apartments or other units constructed.

Mixed Use Development. A combination of different types of uses. This most frequently refers to allowing homes and businesses to be located in the same area (e.g., apartments over shops or other businesses or apartments adjacent to grocery stores or other commercial establishments).

Native Vegetation. Any vegetation native to the Portland metropolitan area or listed on the Metro Native Plant list adopted by Metro Council resolution.

Natural Resource. A functioning natural system such as a wetland, riparian corridor, or fish and wildlife habitat and associated vegetation, including significant trees**.**

Natural Resource Area. The land containing the natural resource to be protected.

Neighborhood. In the context of this plan, a portion of the City for which City government has recognized a neighborhood association.

Neighborhood Design Standards. A West Linn Community Development Code provision for specific neighborhood standards for design and architectural issues within a neighborhood that are set forth in an adopted neighborhood plan.

Neighborhood Plan. A refinement of the Comprehensive Plan that applies to a specific city neighborhood or core neighborhood.

Noise-Sensitive Use. An activity or building that is particularly negatively impacted by noise, such as a home, school, library, or hospital.

Non-point Pollution Source. Pollution that is pervasive and does not come from a single source, such as carbon monoxide pollution from automobiles and water pollution from urban storm water runoff.

Open Space. Land that is undeveloped and that is planned to remain so indefinitely. The term encompasses parks, forests, and farmland. It also may refer only to land zoned as being available to the public, including playgrounds, watershed preserves, and parks.

Out-of-Direction Travel. Travel that is not toward the eventual destination of a trip, often caused by a lack of adequate connections between destinations.

Overlay Zone. A refinement of a basic zoning district, such as single-family residential or general commercial, that adds specific conditions and requirements for development within a particular area which needs special consideration.

Park. A city-owned or state-owned property used for recreation and open to all citizens. Parks are classified into five different categories by the West Linn Parks and Recreation Master Plan:

> **Regional Park.** A recreation area that serves people who live in and outside the City, owned by a county, regional, or state parks agency. It is usually a large site with unique facilities or characteristics, often offering a variety of potential active and passive uses (e.g., playing fields, hiking trails, picnic area, bird-watching, etc.). Mary S. Young State Park is an example.
>
> **Community Park.** A park designed for organized sports and recreational activities, as well as individual and family use. It may provide indoor facilities and typically serves an area within one to two miles of the park. Willamette Park is an example.
>
> **Neighborhood Park.** A combination playground and park intended primarily for non-organized recreation. It is generally relatively small. Typical facilities include children's playgrounds, picnic areas, trails, open, grassy areas for organized or passive activities, and outdoor basketball courts. Sunset Park is an example.
>
> **Mini-Park.** A small single-purpose play lot designed primarily for small children. Facilities in a mini-park usually are limited to an open, grassy area, a children's playground and a picnic area. Palomino Park and Mark Lane Tot Lot are examples.
>
> **Special Use Area.** Recreation site occupied by a specialized facility such as a boat ramp, waterfront park, community garden, or sports field complex.

Particulates. Small particles in the air that are a component of air pollution. They can be inhaled and, when lodged in the lungs, may damage lung tissue and lead to respiratory problems. Their chemical constituents may also be absorbed into the bloodstream and conveyed to, and cause damage in, other body organs and tissues.

Performance Standards. Requirements that govern impacts or characteristics of facilities rather than uses. Standards may be related to building size, noise, air, and water pollution, traffic generation or other attributes. The standards can limit the kinds of uses based on these impacts or characteristics.

Permitted (or outright) Use. A use of land that conforms with the underlying zoning designation and is allowed.

Planned Unit Development (PUD). A type of development based on a comprehensive design addressing the entire complex of land, structures, and uses as a single project.

Point Source of Pollution. A single, discrete facility or other source of air or water pollution such as a smokestack or sewage outfall pipe.

Pressure Reducing Station. A facility used to decrease the pressure in pipes that carry water to or from homes and businesses.

Public Facilities Plan. A plan for the sewer, water, and transportation facilities needed to serve a city. It is less specific than a capital improvements program and required by Oregon law for cities with a population of 2,500 or more. [ORS 197.712(2)(e); OAR 660-01500000(11)]

Redevelopment. Additional or new residential, commercial, or industrial development on land that is already developed, but has the capacity for additional or more intensive development through remodeling or demolition and reconstruction.

Review Process. Analysis of the appropriateness of a proposed development project against City plans and codes in order to determine whether the project should be approved or denied.

Riparian Area. Those areas associated with streams, lakes, and wetlands where vegetation communities are predominantly influenced by their association with water.

Row House. See Town House.

Service District. A local government agency that provides one or more specific services to people within the district (e.g., water, sewer, or fire protection). Service districts may encompass or overlap multiple municipalities. This term also is used to describe the area served by the agency. This term is sometimes used interchangeably with the term "special district," defined by Oregon Statute as "any unit of local government, other than a city, county, metropolitan service district formed under ORS chapter 268 or an association of local governments performing land use planning functions under ORS 195.025 authorized and regulated by statute."

Setback. The required separation between a structure and a road/right-of-way or property line (e.g., the distance from the sidewalk to the front of a house).

Significant Environmental Constraint. This term applies to areas with slopes greater than 25%, a location within the 100-year flood plain or within close proximity to a stream, or land designated as a significant natural or scientific/ecological area.

Significant Tree. Trees that are considered significant by the West Linn City Arborist, whether individually or in consultation with certified arborists or similar professionals, based on accepted arboricultural standards including consideration of their size, type, location, health, long-term survivability, and/or numbers.

Slope. Measurement of the deviation of a non-level land feature from the horizontal, measured as a percent calculated as maximum rise divided by minimum horizontal run. Example: a rise of one foot divided by a run of 10 feet equals slope of 10%. Slope shall be measured in intervals corresponding with slope analysis requirements in the Community Development Code. Slope shall be measured at a right angle from the mapped elevation interval lines.

Slump Topography. Land that is unstable as a result of a previous landslide or other geological event.

Solar Energy. Either:

a) electrical energy derived from or generated by the sun’s light energy in any of its manifestations including hydropower, wind power, and direct conversion by solar panels; or,

b) passive heat energy received and stored by direct absorption in thermal materials.

Storm Water Detention Facility. Pond, swale, or other facility used to store and eventually disperse storm water runoff from roads, parking lots, buildings, and other paved surfaces.

Stream. A body of running water moving over the earth's surface in a channel or bed, such as a creek, rivulet, or river. It flows at least part of the year, and may be perennial or intermittent. Streams are dynamic in nature, with a structure that is maintained by build-up and loss of sediment

Telecommute. Work at home using a computer and telecommunications to access one’s place of employment.

Telecommunity Center. A conveniently located place where people can access computers, the Internet, and other technology that make it efficient to get work done or obtain services electronically that otherwise might require a longer trip.

Town Center (Metro). Term adopted and used in the *Metro Functional Plan* to describe an area with a concentration of shopping opportunities and other commercial and public services for people in a local area (e.g., a small city or large neighborhood). Metro specifies average densities for housing and employment at 40 persons per acre.

Town House. An attached, single-family dwelling, usually with two or more stories and often with the living and dining areas on the first floor and bedrooms on the upper floors.

Transportation Demand Management. The process or set of techniques used to control or reduce the amount of traffic in a given area, or at a specific time of day. Tools often focus on employer-based programs such as flexible work hours, telecommuting (see definition above), and providing free transit passes or other incentives to use different modes of transportation or travel at different times of day.

Urban Growth Boundary (UGB). A boundary line encompassing an area that is adopted and planned for urban development and within which urban services (e.g., public sewer and water facilities) will be provided. Outside of the boundary, the provision of services and the level of development are restricted and development is restricted in intensity. West Linn's UGB is part of the regional boundary administered by Metro.

Urban Reserve. Former label used for lands outside of an urban growth boundary identified as having the highest priority for inclusion in the Urban Growth Boundary when additional urbanizable land was needed consistent with the requirements of Statewide Goal 14 (Urbanization). Metro discontinued using this term in 1999.

Variance. The allowance of a permit to modify the terms of the City's Community Development Code based upon specific findings delineated in that code.

Watershed. A geographical unit defined by the flow of rainwater or snowmelt. All land in a watershed drains to a common outlet, such as a stream, river, lake, or wetland.

Waterway. Any year-round or seasonal river, stream, or creek.

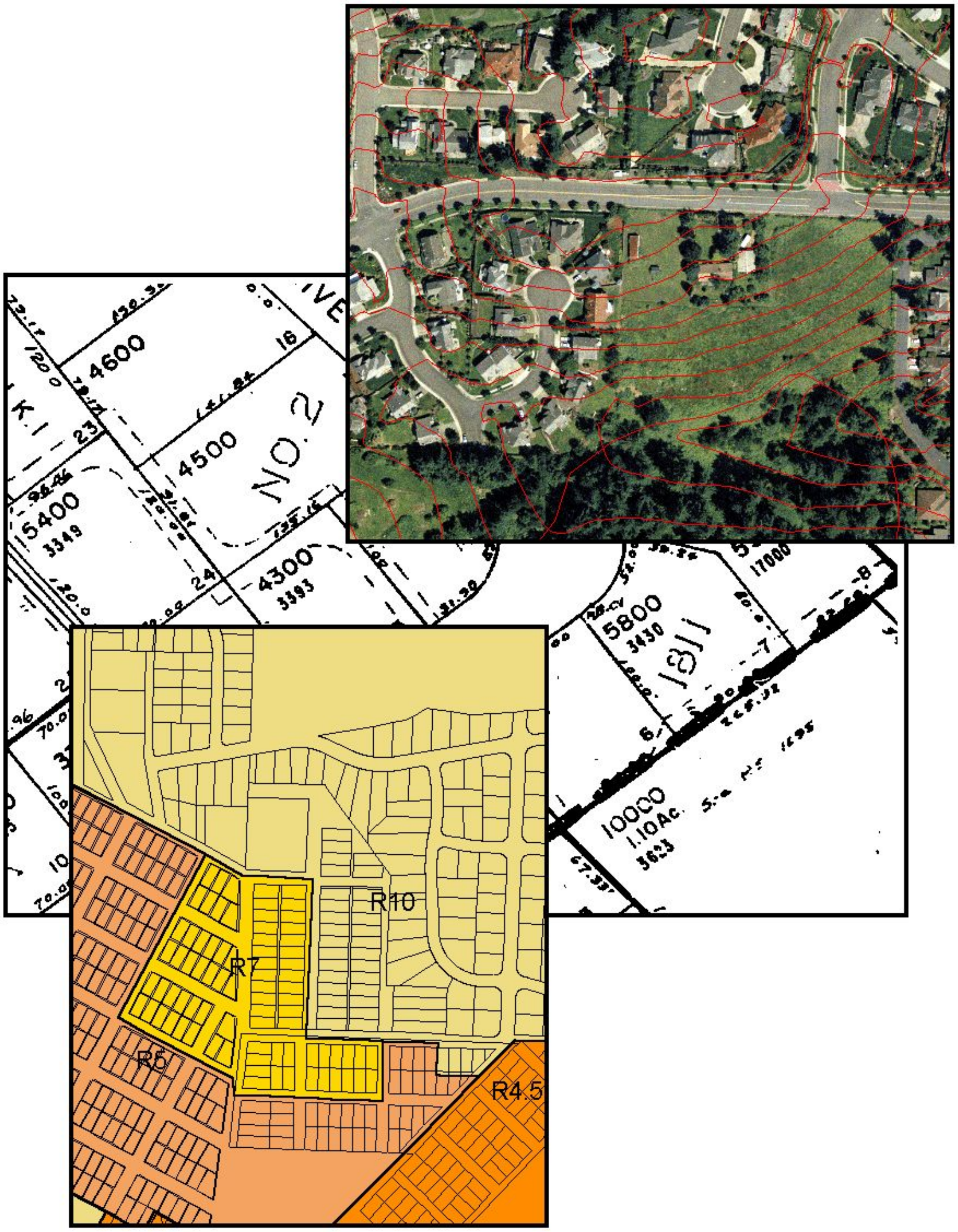
Wetland. An area inundated or saturated by surface or ground water at a frequency and duration sufficient to support and, under normal circumstances do support, vegetation primarily adapted for life in saturated soil. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands are those areas identified and delineated by a qualified wetland specialist as set forth in the 1987 Corps of Engineers Wetland Delineation Manual.

Willamette River Greenway. Land along the banks of the Willamette River intended to be protected and conserved for their natural, scenic, historical, agricultural, economic, and recreational qualities. Cities and counties are responsible for administering the Greenway within their boundaries by restricting development and providing access for recreation.

Zoning *(*also see Base Zone)*.* A category defining the use, placement, spacing, and size of land and buildings.

Zone District. The delineation or application of zoning to a specific geographic area.

GOAL 2: LAND USE PLANNING



GOAL 2: LAND USE PLANNING

The land use plan establishes the framework for the type, quantity, and location of various land use activities. It represents a blending of policies relating to residential, commercial, and industrial development, the City's transportation system, the provision of public facilities and services, energy conservation, and more.

SECTION 1: RESIDENTIAL DEVELOPMENT

BACKGROUND AND FINDINGS

Most houses in West Linn are single-family detached homes (approximately 77% in 1998, compared to 82% in 1990). Residential uses are located throughout the City, offering a variety of location, type, and density choices. As of 1990, over 65% of the City's dwellings have been built since 1970. As of January 2000, 670 potential new dwelling units were in various stages of review. Another 2,241 units are expected as vacant buildable land is developed and infill occurs. Buildable land does not include land constrained by steep slopes, in floodplains, or required for roads and other public facilities. An additional 135 units could be accommodated as accessory dwelling units (i.e., small dwellings, attached to an existing house). Another 200 units also could be accommodated through redevelopment, particularly in designated community interest areas. The City exceeds the allocation for residential capacity required by Metro's Functional Plan. West Linn has sufficient vacant, infill, and redevelopable land within current City boundaries at current density zoning to meet or exceed the Metro 2020 targets.

The West Linn Comprehensive Plan and implementing codes allow for a variety of densities and types of residences in each portion of the community. The Oregon land Conservation and Development Commission made acknowledgment of this fact originally in 1984. Since then, West Linn has undertaken additional measures, including increasing zoning densities for certain neighborhoods and properties, and adopting and implementing the Tanner Basin Master Plan, which have further allowed for a residential community with a wide variety of housing types and affordability levels. The plan and code remain in conformance with all relevant Statewide Planning Goals relating to availability of land for residential use.

In addition to a community-wide variety of zoning districts with diverse housing types, West Linn's existing codes allow for a considerable variety of housing types within each base zoning district. Accessory dwelling units are allowed in all zoning districts. In all zoning districts with a density of one unit per 7,000 square feet or greater density, at least two and in many cases several different housing types are permitted.

When the Comprehensive Plan was adopted in 1983 for initial compliance with Statewide Planning Goals, a number of guidelines were used to delineate low, medium, and medium-high density residential areas (see Comprehensive Plan Map, Figure 2-1). These guidelines included access to transportation facilities (roadways and public transit), physical constraints, availability of services and infrastructure, character of existing housing, and proximity to public and commercial facilities. The following policies, specific to West Linn, provide guidelines for determining appropriate land uses.

GOALS, POLICIES, AND RECOMMENDED ACTION MEASURES

GOALS

1. Maintain land use and zoning policies that continue to provide for a variety of living environments and densities within the city limits.
2. Allow mixed residential and commercial uses in existing commercial areas only in conjunction with an adopted neighborhood plan designed to ensure compatibility and maintain the residential character of existing neighborhoods.
3. Consideration of the concept of carrying capacity should also include the transportation network, storm water management, air quality, and overall quality of life.
4. Encourage energy efficient-housing (e.g., housing with solar energy, adequate insulation, weatherproofing, etc.).

POLICIES

1. Require all residential uses, except for single-family detached dwellings, to be subject to the design review process.

2. Allow clustering of residential development on land with significant environmental constraints only if:
    a. Such clustering can be demonstrated to protect environmental resources, not only on the affected parcel, but on surrounding parcels; and,
    b. Such clustering is found to be compatible with and complementary to existing neighborhoods in the vicinity of the parcel to be developed.
3. Develop incentives to encourage superior design, preserve environmentally sensitive open space, and include recreational amenities.
4. Require open space to be provided in planned unit developments to allow for shared active and passive recreational opportunities and meeting areas for future residents.
5. New construction and remodeling shall be designed to be compatible with the existing neighborhood through appropriate design and scale.
6. Prohibit gated accessways to residential development other than to an individual single-family home.
7. The following are criteria that shall be used when designating residential areas. This list is not exhaustive, but helps determine what types of residential densities are appropriate, given topographical constraints, available public facilities, etc.
    a. Low density residential lands will meet the following criteria:
        i) Areas with limited capacity for development in terms of the existing facilities such as sewer, water, and drainage; and/or,
        ii) Areas having development limitations due to the topography, soil characteristics, drainage, high water table, and flooding.
    b. Medium density residential lands will meet all of the following criteria:
        i) Areas that are not subject to development limitations such as topography, flooding, or poor drainage;
        ii) Areas where the existing services and facilities have the capacity for additional development;
        iii) Areas within one-half mile of public transportation.
    c. Medium-high density residential lands will meet all of the following criteria:
        i) Areas that do not rely solely on local streets for the provision of access;
        ii) Areas that are not subject to development limitations such as topography, flooding, or poor drainage;
        iii) Areas where the existing facilities have the capacity for additional development;

iv) Areas within one-quarter mile of public transit;

v) Areas within short distances of general commercial shopping center or office-business centers;

vi) Areas in close proximity to parks and schools.

8. Protect residentially zoned areas from the negative impacts of commercial, civic, and mixed-use development, and other potentially incompatible land uses.
9. Foster land use planning that emphasizes livability and carrying capacity.

RECOMMENDED ACTION MEASURES

1. Establish development regulations for accessory dwelling units.
2. Establish design standards that encourage attractive, pedestrian friendly, and compatible structures.
3. Develop and implement measures to connect service areas, neighborhoods, and subdivisions via all practical modes of travel.
4. Establish regulations that set minimum and maximum number of housing units to be allowed in each residential district. Regulations shall be established that encourage using land appropriately and wisely to both accommodate new residents and respect existing neighborhood design.
5. Coordinate land use decisions with the City's Transportation System Plan, which is a supporting document of the Comprehensive Plan.
6. Review current development code standards for subdivisions and create regulations that preserve environmentally sensitive open space, require recreational amenities, and promote design excellence.

SECTION 2: NEIGHBORHOOD COMMERCIAL DEVELOPMENT

Neighborhood commercial centers are intended to provide residents with opportunities to walk or bike to shops to purchase items or services needed on a frequent basis (i.e., weekly or more frequently). They also provide opportunities to reduce auto travel. They are to be very limited in size and include appropriate small businesses.

GOAL

Provide convenient shopping opportunities and services adjacent to, or within residential neighborhoods, reducing the need to travel by automobile and increasing opportunities to walk to shopping for frequently needed items.

POLICIES

1. Neighborhood commercial centers should be located to serve trade areas of up to 2,000 people and the center shall be no more than two acres in size.
2. Protect surrounding residential areas from possible adverse effects such as loss of privacy, noise, lights, and glare.
3. Require neighborhood commercial centers and uses therein to be aesthetically attractive and landscaped.
4. Emphasize pedestrian scale and accessibility and discourage auto-oriented development in neighborhood commercial centers.

SECTION 3: MIXED USE/COMMERCIAL DEVELOPMENT

BACKGROUND AND FINDINGS

West Linn is unique in that it does not have a major commercial district or downtown. Instead, it has four commercial districts (not including neighborhood commercial centers) that collectively fulfill the needs of residents for commercial retail and business activities. The major districts are Willamette, including the area north of I-205 at the 10th Street interchange, Bolton, the Robinwood area adjacent to Highway 43, and Tanner Basin.

The Historic Willamette District was one of the first commercial and residential areas in West Linn. The commercial area still retains some of the turn-of-the-century architecture along Willamette Falls Drive, and has on-street parking and residential units above retail establishments. Newer commercial and office buildings have been built to the north and east of the Historic District, including north of I-205.

Robinwood and Bolton commercial districts are centered around contemporary retail, service, and public uses. Some of the existing businesses have developed in small centers and others have developed along Highway 43, typically in strip commercial development fashion. As part of the *Imagine West Linn* visioning process in the early 1990s, a city center plan was created for the Bolton area. In part because this included lands fronting the Willamette River that are zoned industrial and currently support industrial uses, this plan was never implemented. The Tanner Basin commercial area continues to develop according to the 1991 Tanner Basin Master Plan.

Since the adoption of the 1983 Comprehensive Plan, West Linn has seen a significant growth in local business and commercial development. Major developments since then have included the Cascade Summit Shopping Center on Salamo Road, the West Linn Corporate Park Office Center on Blankenship Road, and the River Falls Shopping Center on Blankenship Road. These three projects resulted in the development of 32 acres with approximately 150,000 square feet of new retail commercial space and 130,000 square feet of new office space. In addition, the City has seen new commercial development along historic Willamette Falls Drive, and smaller commercial development projects along Highway 43 in the Robinwood and Bolton neighborhoods. These developments have reduced the need for City residents to leave the City in order to obtain goods and services and have provided greater employment opportunities within the City.

However, the amount of land dedicated for commercial and business development in West Linn is small (approximately 144 acres zoned for commercial and office uses). Only 35 of these acres remain undeveloped, and the remaining sites, while suitable for commercial use, have topographic and environmental constraints that will limit the size and scale of such uses. Any attempt to significantly expand this land base with the intent of providing greatly enhanced employment and shopping opportunities for West Linn residents has a high probability of altering, for the worse, the quiet, primarily residential character of West Linn which makes the City so attractive to its citizens.

Metro adopted the 2040 Growth Concept that includes a number of “design types” reflecting different growth patterns – regional centers, town centers, corridors, station communities, main streets, inner neighborhoods, and outer neighborhoods. Except for inner and outer neighborhoods, all are mixed use concepts that incorporate residential and commercial uses within compact, pedestrian-friendly environments. Particular design standards apply to these design types to encourage use of alternatives to the automobile and promote a stronger sense of community.

In the 2040 Growth Concept, the Bolton District is designated as a "town center." Town centers provide localized services to residents within a two- to three-mile radius. The Willamette District is designated a "main street," described as a district with traditional commercial identity and a strong sense of neighborhood community. Both of these designations fit the characteristics of these centers. The Robinwood area is designated a corridor, while Tanner Basin does not have a designation in the 2040 Growth Concept. Designations on the 2040 Growth Concept map and in the City's Comprehensive Plan will influence future funding decisions for transportation improvements and other financial support from grant-funding agencies.

The designations discussed above are tentative pending respective neighborhood plans. While West Linn recognizes the Metro land use designations, it is important that the ultimate evolution of these areas be further resolved through the neighborhood plan process. The decisions for these areas will be made primarily with the input of the residents and property owners within and adjacent to each of these commercial districts. Depending upon the outcome of these planning processes, the City may request an amendment to the Metro land use designations for West Linn.

GOALS, POLICIES, AND RECOMMENDED ACTION MEASURES

GOALS

1. Develop/redevelop commercial areas as mixed use/commercial districts that blend housing and commercial uses to: enhance the community's identity; encourage strong neighborhoods; increase housing choices; promote socioeconomic diversity; promote alternative modes of transportation; promote civic uses; and improve community interaction and involvement.
2. Consider the development of commercial and office facilities in West Linn that will increase employment opportunities, reduce dependence on services outside of the City, and promote energy-efficient travel and land use patterns, while recognizing that there will be limits imposed by West Linn's topography and limited available land.
3. Encourage retail commercial uses to be located in centers that facilitate one-stop shopping and discourage strip commercial development.
4. Protect surrounding residential areas from adverse effects of commercial development in terms of loss of privacy, noise, lights, and glare.

5. Require mixed use/commercial centers and uses to be aesthetically attractive and landscaped.
6. Provide for interconnections between mixed use/commercial centers via transit, pedestrian pathways, and other means.
7. Require standards for mixed-use areas that create livable areas that fit in with existing neighborhood character.
8. Provide enhanced opportunities for neighborhood involvement in neighborhood plan decisions to ensure they are livable, provide service improvements to area residents, and fit with the character of the neighborhood. Any significant changes of residential zones to commercial shall occur only after a neighborhood planning process is completed.

POLICIES

1. A portion of the Bolton District is currently designated in Metro's 2040 Design Map as a town center. The neighborhood plan for Bolton shall guide future changes to this area. If appropriate, the City will submit a request to Metro to remove the town center designation from Bolton, and substitute another more appropriate designation.
2. A portion of the Willamette District is currently designated in Metro's 2040 Design Map as a main street. The neighborhood plan for Willamette shall guide future changes to this area. If appropriate, the City will submit a request to Metro to amend land use designations for the Willamette District.
3. A portion of the Robinwood District is currently designated in Metro's 2040 Design Map as a corridor. The neighborhood plan for Robinwood shall guide future changes to this area. If appropriate, the City will submit a request to Metro to amend land use designations for the Robinwood District.
4. Design and locate existing or proposed commercial uses in a manner that:
   a. Protects remaining natural spaces, significant stands of trees, wildlife corridors, streams/riparian zones, and historic resources.
   b. Encourages the use of alternative transportation.
   c. Encourages creation of meaningful public gathering places that incorporate uses such as entertainment and recreation venues, restaurants, and unique shopping opportunities to increase activity in surrounding areas.
   d. Encourages small businesses, retail establishments, and other employment activities.

e. Requires that any redevelopment of existing land or buildings be completed in a manner which conforms to the adopted neighborhood plan.
f. Integrates aesthetically pleasing commercial development with residential uses.
g. Ensures ingress and egress points do not create traffic congestion.
h. Improves traffic patterns within the immediate area.
i. Provides easier access to transportation for the physically/mentally challenged.
j. Provides safe and convenient pedestrian and bicycle paths and crossings.

5. Commercial rezoning that promotes strip commercial activity shall be prohibited.
6. Commercial development shall be planned at a scale that relates to its location in the district and trade area to be served.
7. Until the City adopts new code provisions consistent with adopted neighborhood plans, the City shall apply appropriate development standards consistent with the existing Community Development Code.
8. Where appropriate and necessary, the City shall incorporate provisions for individualized neighborhood design standards consistent with adopted neighborhood plans as overlay zones within the Community Development Code.

RECOMMENDED ACTION MEASURES

1. Adopt and periodically update neighborhood plans.
2. If authorized by an adopted neighborhood plan, request that Metro amend the 2040 Growth Concept map to redesignate areas within West Linn in a manner consistent with the adopted neighborhood plan.
3. If authorized by an adopted neighborhood plan, amend the Community Development Code to modify existing zoning districts or create new zoning districts that best implement the provisions of the adopted neighborhood plan.
4. Continue to enforce the special standards that apply to the Willamette Historic District, and continually improve code language to meet the needs of the District.
5. Review, maintain, and enforce design and development standards for commercial centers.
6. Develop additional historic standards as appropriate to protect historic resources in all community interest areas.
7. Require businesses converting non-business structures to business use to redesign the structure in a professional and aesthetic way, compatible with surrounding buildings.

8. Encourage aesthetic designs of business structures to enhance the overall business and professional atmosphere of the immediate location and the community.

SECTION 4: INDUSTRIAL DEVELOPMENT

BACKGROUND AND FINDINGS

There are 173 acres of land in the City zoned for industrial development, with 167 acres zoned for general industrial use and six acres zoned as campus industrial. Much of the area zoned for industrial development is near the Willamette River and is constrained by severe slopes and areas susceptible to flooding.

Industrial uses can include clean, employee-intensive industries, offices, and retail commercial uses, as well as manufacturing, processing, and assembling businesses. Industrial areas typically constitute large areas of economic activity and centers for employment.

West Linn does not contain any additional lands suitable for large-scale industrial development. There are no remaining undeveloped areas in the City of at least 10 acres in size, relatively level terrain, adequate public services (particularly transportation), and suitable buffering from the residential development that characterizes most of the City. This factor, in conjunction with the slope and floodplain constraints on the existing industrially zoned areas along the Willamette River, means that West Linn will be unable to significantly increase its employment base through the construction of new industrial facilities.

GOALS, POLICIES, AND RECOMMENDED ACTION MEASURES

GOALS

1. Protect existing lands currently zoned for industrial development from encroachment by non-industrial or incompatible uses except for appropriately sized and sited supportive retail development.
2. Encourage compatible mixed commercial and industrial use of land near the river, including current industrial zoned land, which can gain value from views of the falls and river.

POLICIES

1. Maintain a general industrial zone to provide for manufacturing, processing, and assembling activities.
2. Maintain a campus industrial zone to provide for a combination of clean industries, offices, and supportive retail commercial uses.

SECTION 5: INTERGOVERNMENTAL COORDINATION

BACKGROUND AND FINDINGS

Because many regional and local agency plans affect what happens in West Linn, the City has maintained an intergovernmental coordination process, essential to the implementation of the Comprehensive Plan for the City. To be beneficial to all parties, intergovernmental coordination must be conducted on a sustained basis.

There are a large number of local, state, and federal agencies that have jurisdictional responsibilities in West Linn. The City's location in the Portland Metropolitan Area and urban Clackamas County, on the Willamette and Tualatin Rivers, adjacent to the intersection of a major interstate freeway (I-205) and state highway (Highway 43), and next to a Corps of Engineers navigational locks, requires West Linn to coordinate with a full range of agencies.Specific coordination activities include:

- Growth management, transportation, solid waste, and environmental planning with Metro, consistent with regionally adopted plans and policies, provided they are compatible with the long term interests of West Linn, particularly maintaining City livability.
- Operation of an urban planning area agreement with Clackamas County that governs land use and annexation issues.
- Jurisdictional and urban service boundaries with adjacent communities and service providers.
- Cooperation with the Oregon Parks Department in managing Mary S. Young State Park.
- Educational and training services with Clackamas Community College.
- Sewer facility and service planning with the Clackamas County Water Environment Services Tri-Cities Wastewater Treatment Plant.

- Coordinated recreational and school facilities planning with the West Linn-Wilsonville School District.
- Obtaining fire protection services from the Tualatin Valley Fire and Rescue District, and ambulance service from approved vendors.
- Management of highway facilities (I-205 and State Highway 43) with the Oregon Department of Transportation (ODOT).
- Coordination of transit service provided by Tri-Met.
- Water supply with the South Fork Water Board and the City of Lake Oswego.
- Coordination with Clackamas County and adjacent jurisdictions to provide law enforcement, emergency, and library services.
- Cooperation with the Oregon Department of Fish and Wildlife to protect habitat areas.
- Communication with providers including telephone, electric utilities, and electronic transmission companies. Participate in PGE's periodic re-licensing process and other planning activities associated with the company's landholdings within the City limits.
- Coordinate with federal agencies such as the Environmental Protection Agency, Army Corps of Engineers, and Federal Communications Commission.

GOALS, POLICIES, AND RECOMMENDED ACTION MEASURES

GOALS

1. Provide a coordinated approach to problems that transcend local government boundaries.
2. Encourage and support other agencies to help implement the City's Comprehensive Plan.
3. Facilitate the exchange of information and technical assistance among agencies with jurisdictional responsibilities in West Linn.

POLICIES

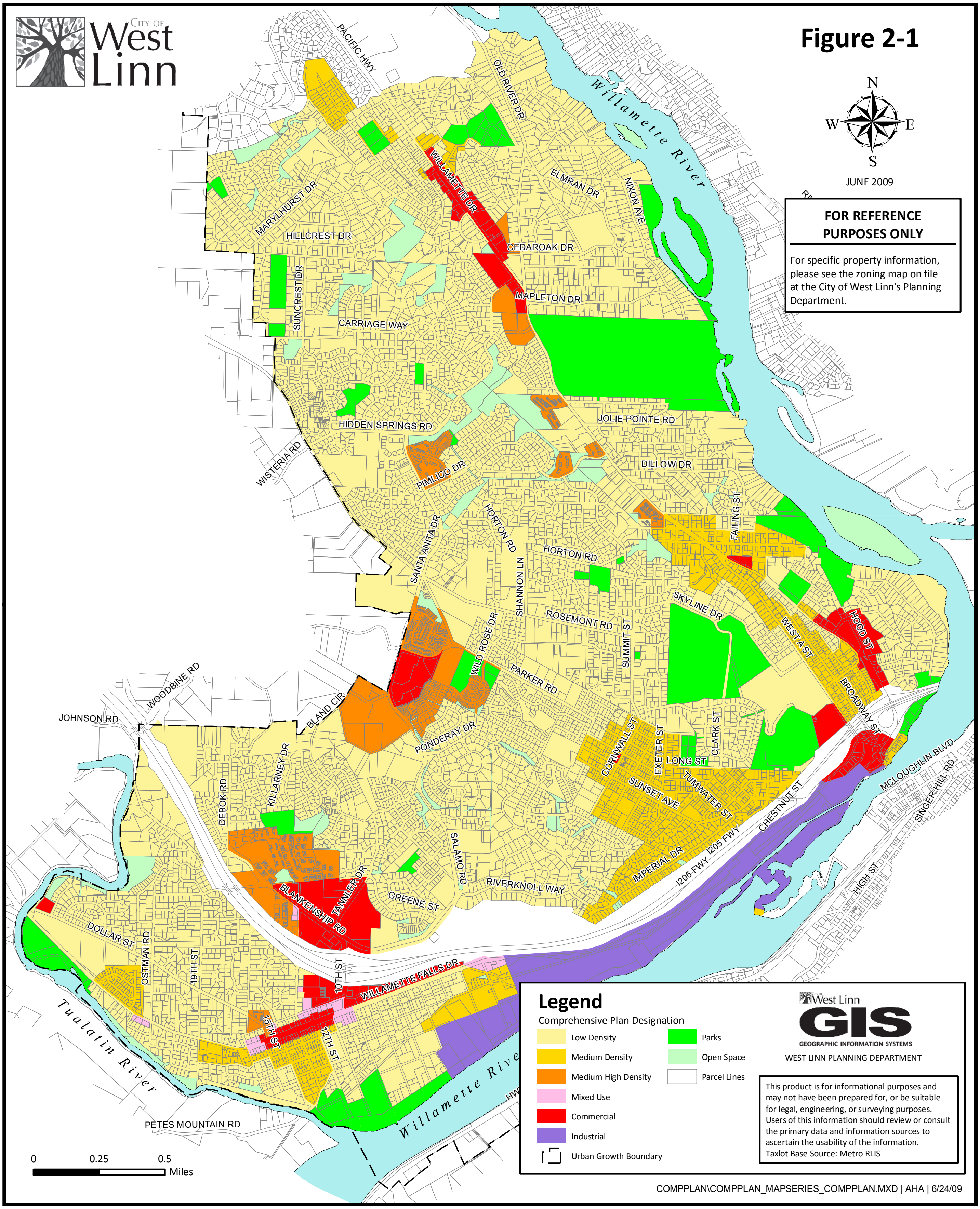
1. Maintain effective coordination with other local governments, special districts, state and federal agencies, Metro, the West Linn-Wilsonville School District, and other governmental and quasi-public organizations.

2. Coordinate the City's plans and programs with affected governmental units in the developing solutions to environmental quality problems, hazardous physical conditions, natural resource management programs, public facilities and services programs, transportation planning, annexation proceedings, and other municipal concerns with intergovernmental implications.
3. Solicit input from service providers on service availability and adequacy prior to an annexation agreement, subdivision approval, or the issuance of a building permit.
4. Coordinate with Metro planning activities on all areas in which Metro has jurisdiction and as specified in Goal 14 of this Plan.
5. Work with the West Linn-Wilsonville School District in a cooperative manner to achieve consistency between the School District Facility Plan and City plans and policies. Inform the District of any major changes in City population that would adversely affect school capacity.

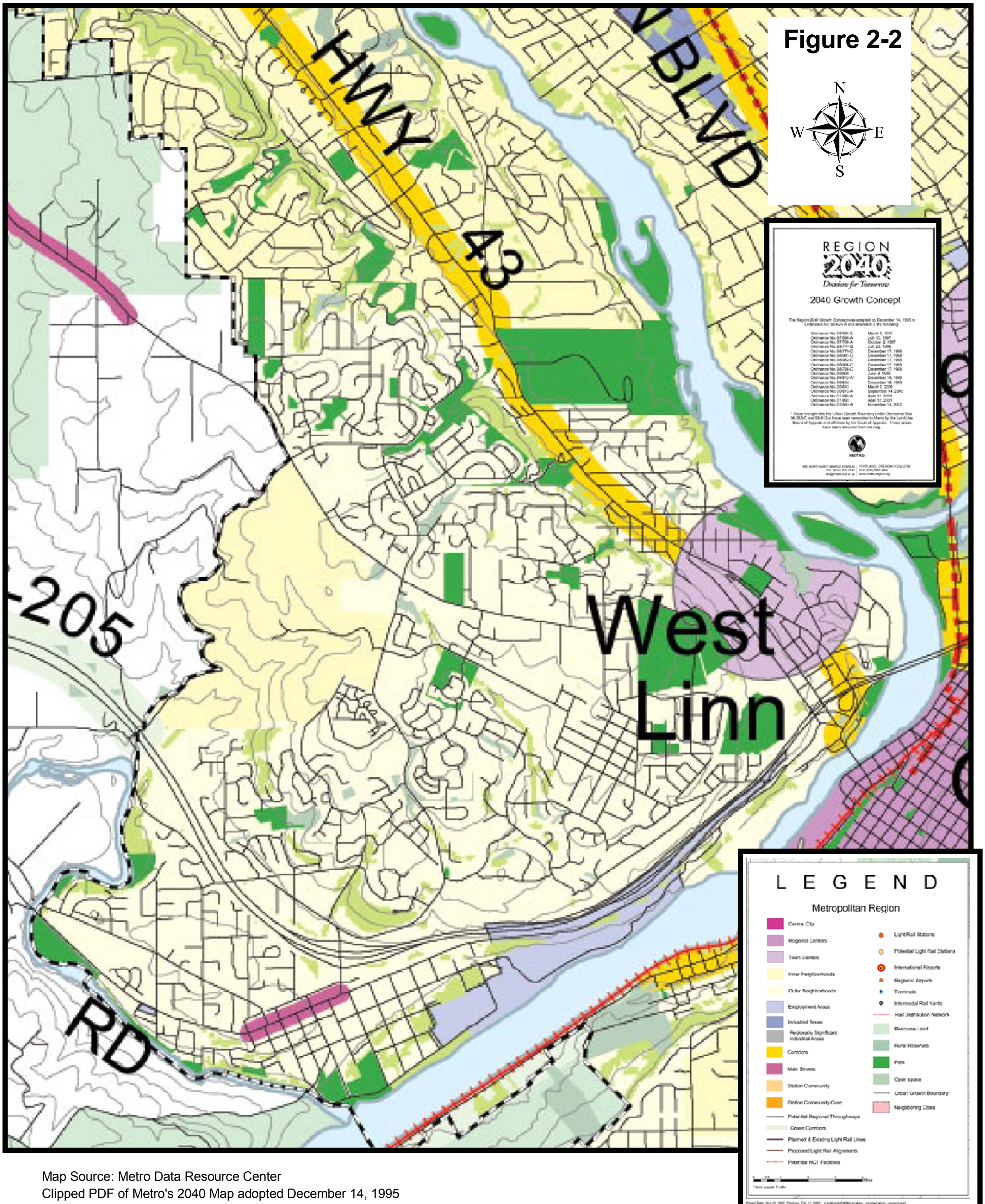
RECOMMENDED ACTION MEASURES

1. Amend the City's Urban Growth Management Agreement with Clackamas County and refine it to reflect changes in state and local legislation such as delayed annexation and voter annexation.
2. Establish a process to coordinate with surrounding cities, Clackamas County, and Metro regarding planning for future adjustments to the Urban Growth Boundary.
3. Adopt inter-agency agreements between City government, School District, Chamber of Commerce, neighborhood associations, and other community institutions.
4. Work with state and federal agencies to identify and obtain information about potential hazardous waste sites in West Linn.

Comprehensive Plan



Metro 2040 Growth Concept



Map Source: Metro Data Resource Center
Clipped PDF of Metro's 2040 Map adopted December 14, 1995
Detailed ammendment listing on Metro's 2040 Growth Concept Map
PDF from Metro DRC July 2003

GOAL 2: LAND USE

Metro 2040 Growth Concept -- Legend

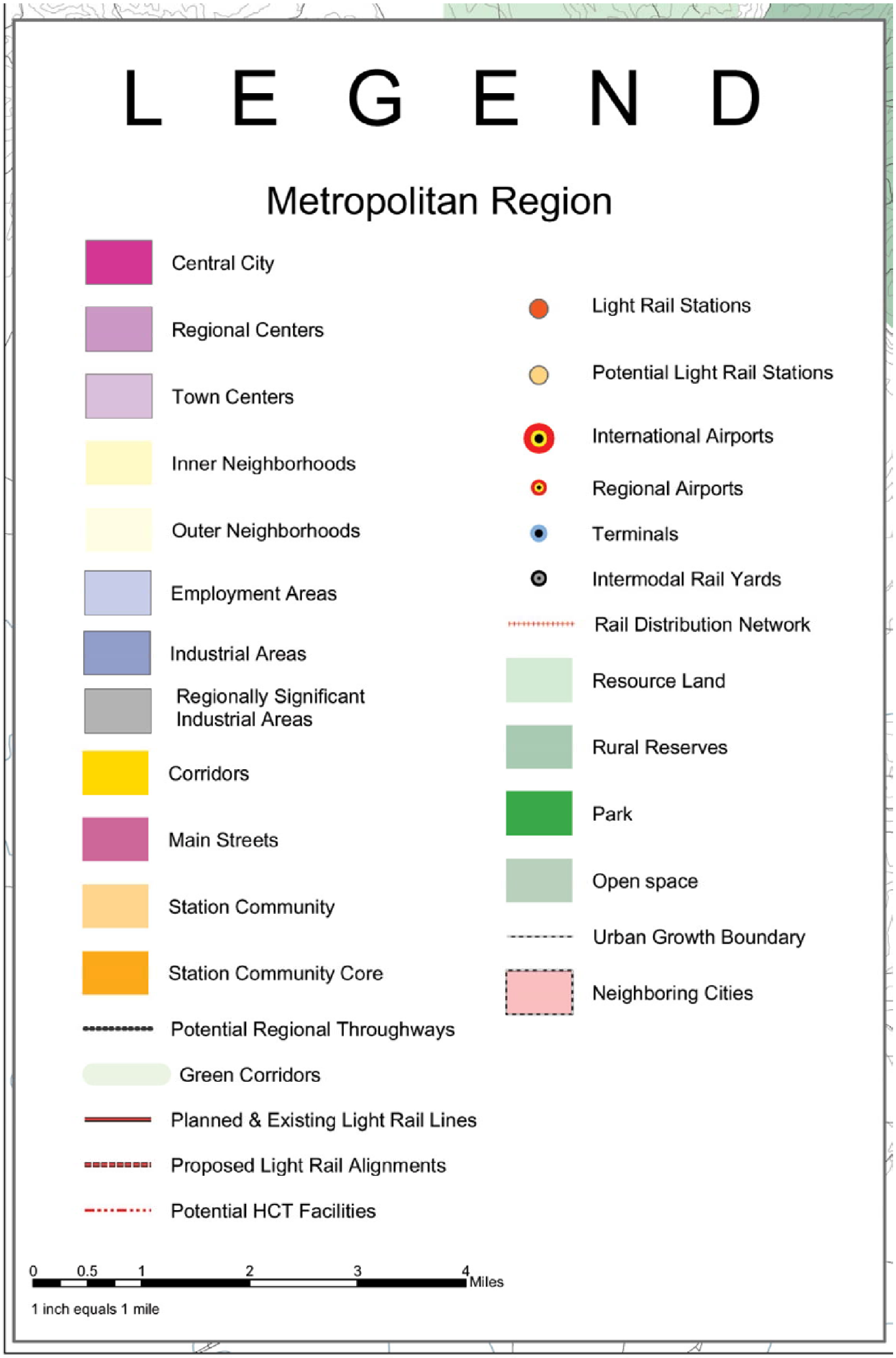
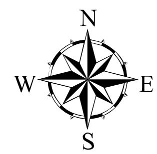


Figure 2-2



Project Date: Nov 20, 2002 Plot time: Feb 12, 2003 J:\hall\proj\02496\transition_map\transition_concept.mxd

Map Source: Metro Data Resource Center
Clipped PDF of Metro's 2040 Map adopted December 14, 1995
Detailed ammendment listing on Metro's 2040 Growth Concept Map
PDF from Metro DRC July 2003

Appendix 1B

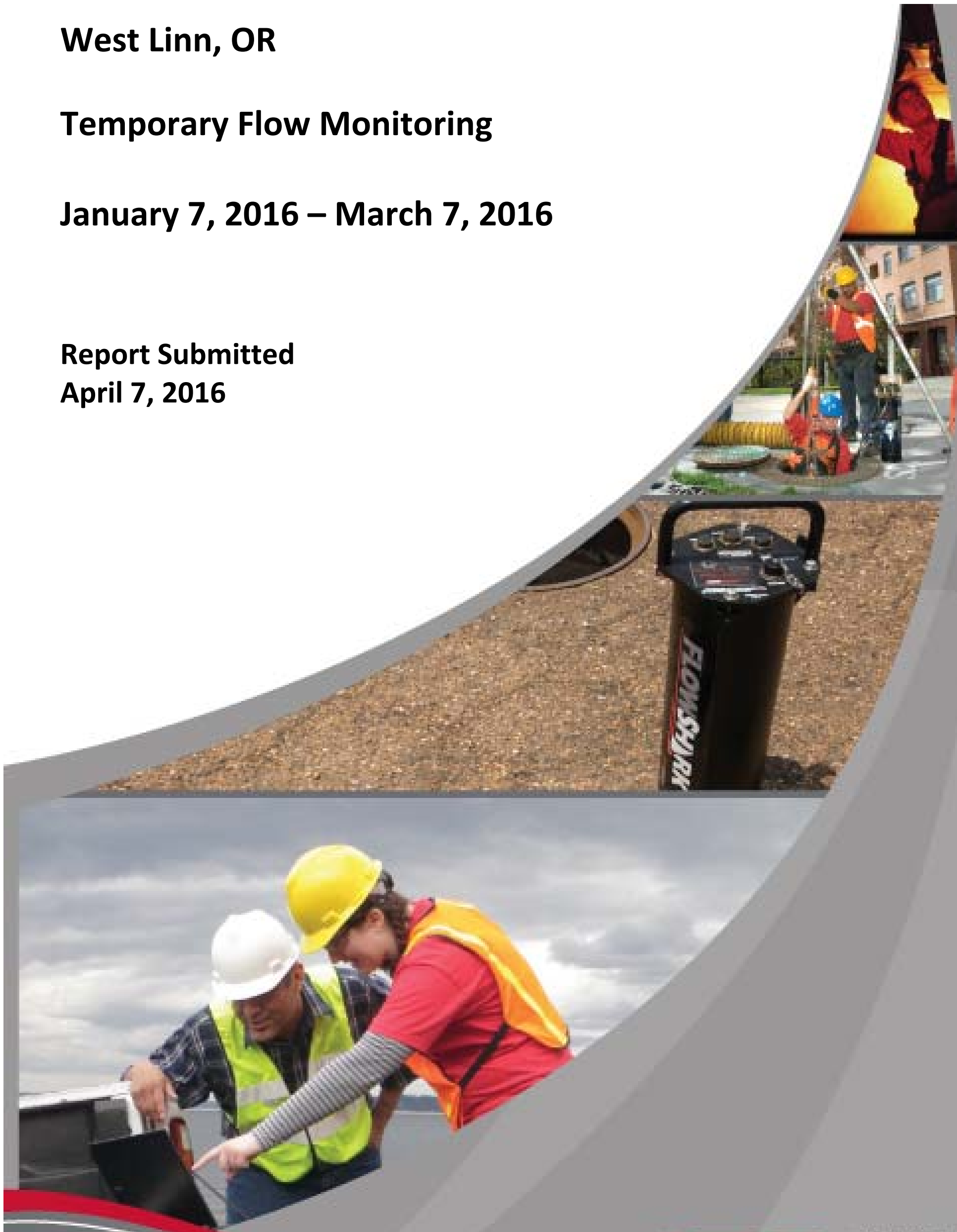
FLOW MONITORING REPORT

West Linn, OR

Temporary Flow Monitoring

January 7, 2016 – March 7, 2016

Report Submitted
April 7, 2016



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www.adsenv.com

April 7, 2016

Erich Lais

City of West Linn

22500 Salamo Road

West Linn, Oregon 97068

Re: West Linn Results and Analysis of 2016 Flow Monitoring Data

Dear Mr. Lais,

Thank you for the opportunity to complete this flow monitoring work effort for West Linn, OR. Please find attached the electronic report of results and conclusions based on the flow monitoring study conducted between January and March 2016.

Hydrographs and scattergraphs of the data are available in the report.

Erich, we certainly look forward to other opportunities to work on wastewater flow monitoring projects as they arise. If you have any questions regarding the content of this report, please do not hesitate to call me at (206) 255 6904.

Sincerely,

Mike Pina

Senior Project Manager

mpina@idexcorp.com

Introduction

Background

The City of West Linn, OR entered into agreement with ADS Environmental Services to conduct flow monitoring at (10) ten metering points and (1) rain gauge located in West Linn, OR. The study was contracted for a two month monitoring period. The objective of this study was to measure depth, velocity, and quantify flows for sewer lines.

Project Scope

The scope of this study involved using temporary flow monitors to quantify wastewater flow at the designated locations. Specifically, the study included the following key components.

- Investigate the proposed flow-monitoring sites for adequate hydraulic conditions.
- Flow monitor installations.
- Flow monitor confirmations and data collections.
- Flow data analysis.

Equipment installation was accomplished January 6, 2016. The monitoring period was completed on March 7, 2016.

Equipment and Methodology

Flow Quantification Methods

There are two main equations used to measure open channel flow: the Continuity Equation and the Manning Equation. The Continuity Equation, which is considered the most accurate, can be used if both depth of flow and velocity are available. In cases where velocity measurements are not available or not practical to obtain, the Manning Equation can be used to estimate velocity from the depth data based on certain physical characteristics of the pipe (i.e. the slope and roughness of the pipe being measured). However, the Manning equation assumes uniform, steady flow hydraulic conditions with non-varying roughness, which are typically invalid assumptions in most sanitary sewers. The Continuity Equation was used exclusively for this study.

ContinuityEquation

The Continuity Equation states that the flow quantity (Q) is equal to the wetted cross-sectional area (A) multiplied by the average velocity (V) of the flow.

$$Q = A * V$$

This equation is applicable in a variety of conditions including backwater, surcharge, and reverse flow. Most modern flow monitoring equipment, including the ADS Models, measure both depth and velocity and therefore use the Continuity Equation to calculate flow quantities.

Flow Monitoring Equipment

The ADS FlowShark Triton monitor was selected for this project . This flow monitor is an area velocity flow monitor that uses both the Continuity and Manning's equations to measure flow.

The ADS FlowShark Triton monitor consists of data acquisition sensors and a battery-powered microcomputer. The microcomputer includes a processor unit, data storage, and an on-board clock to control and synchronize the sensor recordings. The monitor was programmed to acquire and store depth of flow and velocity readings at 5-minute intervals.

The FlowShark Triton monitor features cross-checking using multiple technologies in each sensor for continuous running of comparisons and tolerances. The sensor option used for this project was the peak combo sensor.

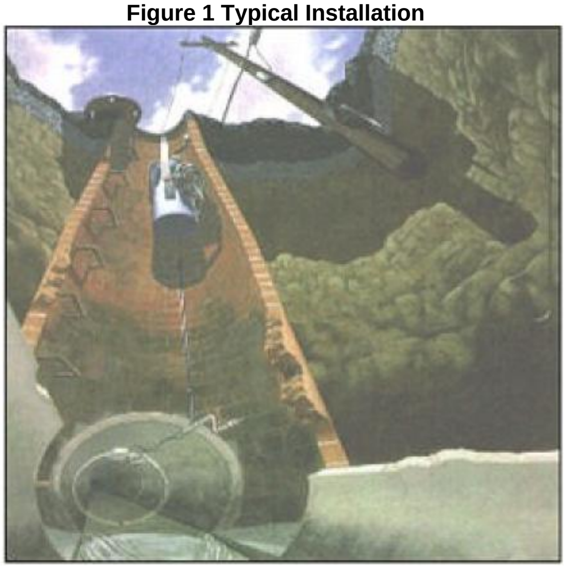
ThePeakComboSensor installed at the bottom of the pipe includes three types of data acquisition technologies. The *up looking ultrasonic depth* uses sound waves from two independent transceivers to measure the distance from the sensor upward toward the flow surface; applying the speed of sound in the water and the temperature measured by sensor to calculate depth. The *pressure depth* is calculated by using a piezo-resistive crystal to determine the difference between hydrostatic and atmospheric pressure. The pressure sensor is temperature compensated and vented to the atmosphere through a desiccant filled breather tube. To obtain *peak velocity*, the sensor sends an ultrasonic signal at an angle upward through the widest cross-section of the oncoming flow. The signal is reflected by suspended particles, air bubbles, or organic matter with a frequency shift proportional to the velocity of the reflecting objects. The reflected signal is received by the sensor and processed using digital spectrum analysis to determine the peak flow velocity.

Installation

Installation of flow monitoring equipment typically proceeds in four steps. First, the site is investigated for safety and to determine physical and hydraulic suitability for the flow monitoring equipment. Second, the equipment is physically installed at the selected location. Third, the monitor is tested to assure proper operation of the velocity and depth of flow sensors and verify that the monitor clock is operational and synchronized to the master computer clock. Fourth, the depth and velocity sensors are confirmed and line confirmations are performed. A typical flow monitor installation is shown in Figure 1.

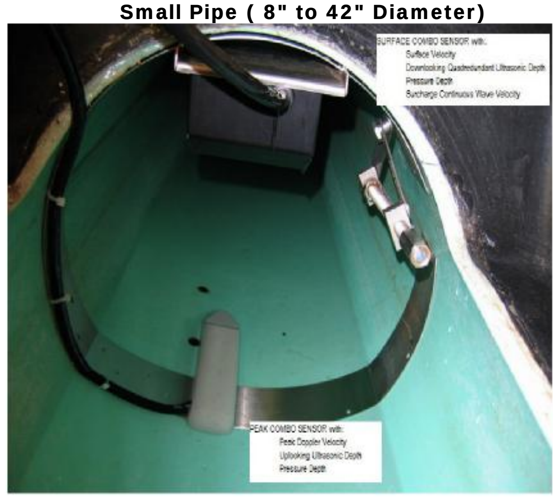
The installations depicted in Figure 1 are typical for circular or oval pipes up to approximately 104-inches in diameter or height. In installations into pipes 42-inches or less in diameter, combo sensors are mounted on an expandable stainless steel ring and installed one to two pipe diameters upstream of the pipe/manhole connection in the incoming sewer pipe. This reduces the effects of turbulence and backwater caused by the connection. In pipes larger than 42 inches in diameter, a special installation is made using two sections of the ring installed one to two feet upstream of the pipe/manhole connection; one bolted to the crown of the pipe for the surface combo sensor and the other bolted to the bottom of the pipe (bolts are usually placed just above the water line) to hold the peak combo sensor.

Figure 1 Typical Installation



Large Pipe (> 42" Diameter)

Small Pipe (8" to 42" Diameter)



Data Collection, Confirmation, and Quality Assurance

During the monitoring period data collects from the meters were done remotely via wireless connection. Quality assurance taken to assure the integrity of the data collected included:

- **Measure Power Supply:** The monitor is powered by a dry cell battery pack. Power levels are recorded and battery packs replaced, if necessary. A separate battery provides back-up power to memory, which allows the primary battery to be replaced without the loss of data.

- **Perform Pipe Line Confirmations and Confirm Depth and Velocity:** Once equipment and sensor installation is accomplished, a member of the field crew descends into the manhole to perform a field measurement of flow rate, depth and velocity to confirm they are in agreement with the monitor. Since the ADS V-3 velocity sensor measures peak velocity in the wetted cross-sectional area of flow, velocity profiles are also taken to develop a relationship between peak and average velocity in lines that meet the hydraulic criteria.

- **Measure Silt Level:** During site confirmation, a member of the field crew descends into the manhole and measures and records the depth of silt at the bottom of the pipe. This data is used to compute the true area of flow.

- **Confirm Monitor Synchronization:** The field crew and data analyst checks the flow monitor's clock for accuracy.

- **Upload and Review Data:** Data collected by the monitor is uploaded and reviewed for comparison with previous data. All readings are checked for consistency and screened for deviations in the flow patterns, which may indicate system anomalies or equipment failure.

Data Analysis and Presentation

Data Analysis

A flow monitor is typically programmed to collect data at either 15-minute or 5-minute intervals throughout the monitoring period. The monitor stores raw data consisting of (1) the updepth (distance from sensor to top of flow) for each active ultrasonic depth sensor, (2) the peak velocity and (3) the pressure depth. The data is imported into ADS's proprietary software and is examined by a data analyst to verify its integrity. The data analyst also reviews the daily field reports and site visit records to identify conditions that would affect the collected data.

Velocity profiles and the line confirmation data developed by the field personnel are reviewed by the data analyst to identify inconsistencies and verify data integrity. Velocity profiles are reviewed and an average to peak velocity ratio is calculated for the site. This ratio is used in converting the peak velocity measured by the sensor to the average velocity used in the Continuity equation. The data analyst selects which depth sensor entity will be used to calculate the final depth information. Silt levels present at each site visit are reviewed and representative silt levels established.

Occasionally the velocity sensor's performance may be compromised resulting in invalid readings sporadically during the monitoring period. This is generally caused by excessive debris (silt) blocking the sensor's crystals, shallow flows (~< 2") that may drop below the top of the sensor or very clear flows lacking the particles needed to measure rate. In order to use the Continuity equation to quantify flow during during such brief (in respect to overall study duration) periods of velocity sensor "fouling", a Sr. Analyst and/or Engineer will use the site's historical pipe curve (depth vs. velocity) data along with valid field confirmations to reconstitute and replace the false velocity recordings with expected velocity readings for a given historical depth along the curve.

Selections for the above parameters can be constant or can change during the monitoring period. While the data analysis process is described in a linear manner, it often requires an iterative approach to accurately complete.

1A-37-1-0

Located At: 1378 Sunset Ave (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016
Pipe Dimensions: 11.66 in x 11.88 in
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sewer pipe. The scattergraph indicates normal open channel flow. The data plots above the Froude =1 curve indicating supercritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the downward ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (in)	100%	100%
Velocity (f/s)	100%	99%
Quantity (MGD)	100%	99%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

Item	Depth (in)	Velocity (f/s)	Quantity (MGD)	% Full
Minimum	1.41	6.5	0.170	12%
Maximum	3.69	14.49	1.916	32%
Average	2.34	8.69	0.603	20%

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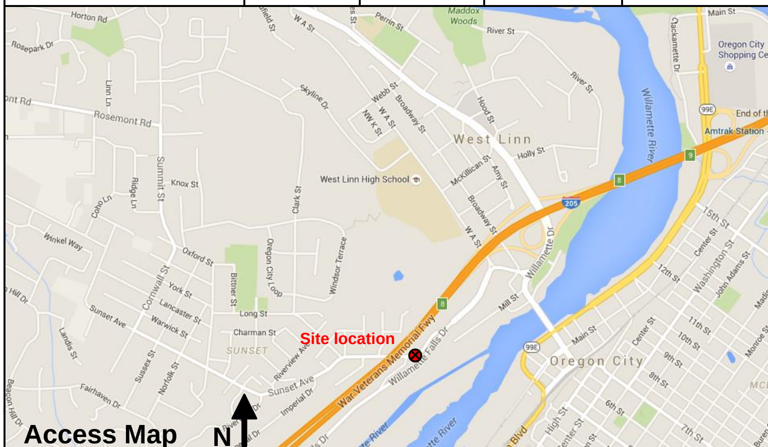
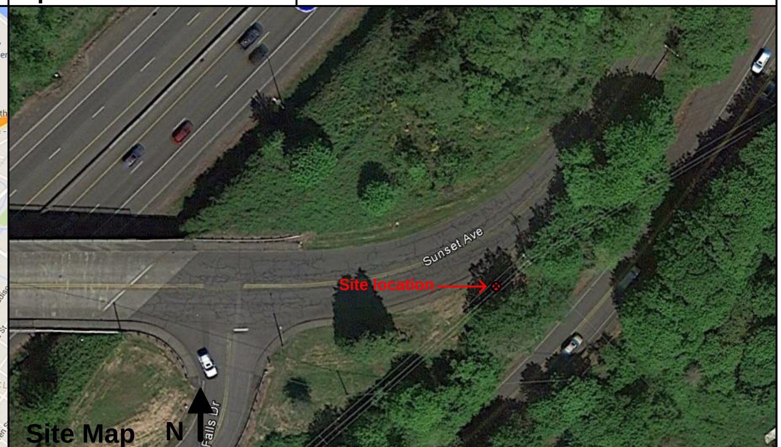
ADS Site Report

Quality Form

Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

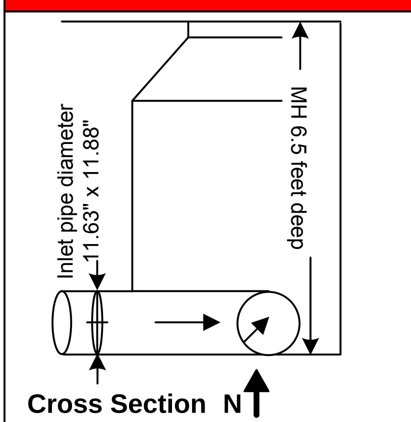
Site Name: 1A-37-1-0	**Monitor Series:** 8000-FST	**Monitor S/N:**	30334
Address/Location: 1378 Sunset Ave		**IP Address:**	166.219.50.34
		Manhole #	1A-37-1-0
		GPS Coordinates	45.357509° -122.616261°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	11.63"
		Pipe Width:	11.88"

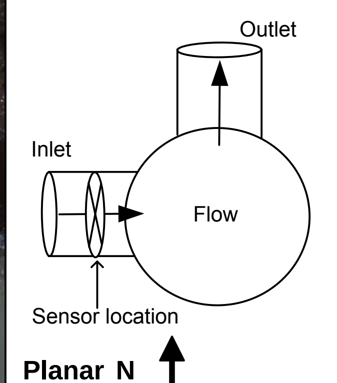




Investigation Information:		Manhole Information:	
Date/Time of Investigation:	12/16/2015 @ 12:33	**Manhole Depth:**	6.5'
Site Hydraulics:	Ripples, Fast Velocity	**Manhole Material / Condition**	Concrete / Good
Upstream Input: (L/S, P/S)	DNI	**Pipe Material / Condition:**	VCP / Good
Upstream Manhole:	DNI	**Mini System Character:**	Residential [X] Commercial [ ] Industrial [ ] Trunk [ ]
Downstream Manhole:	DNI	**Telephone Information:**	Does not apply
Depth of Flow:	2.25" +/- 0.25"	**Access Pole #:**	Does not apply
Range (Air DOF):	9.38" +/- 0.25"	**Distance From Manhole:**	Does not apply Feet
Peak Velocity:	10.06 fps	**Road Cut Length:**	Does not apply Feet
Silt:	None	**Trench Length:**	Does not apply Feet

Other Information:



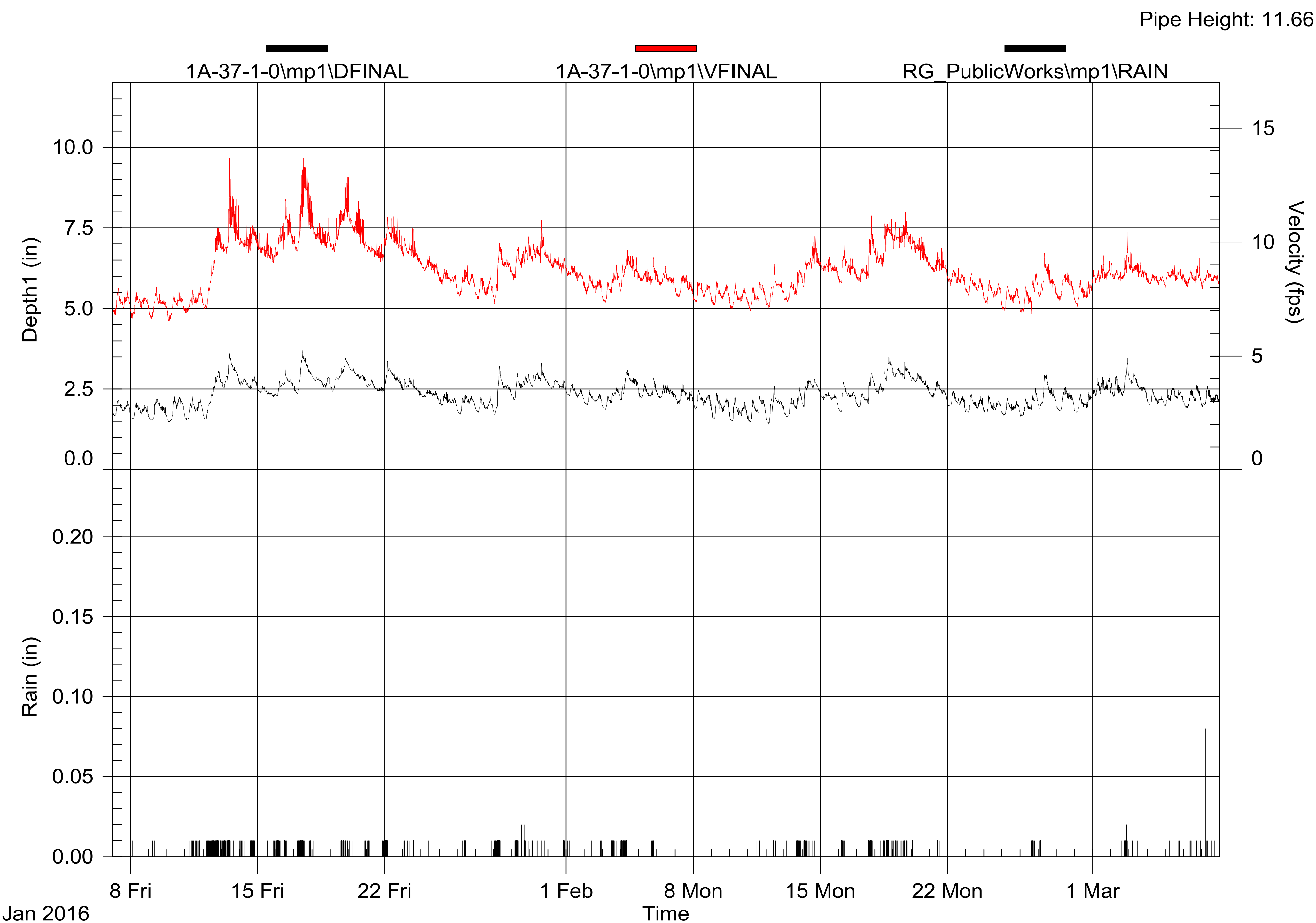


Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Standard	Trunk	[ ]	[X]	[ ]	
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity) CS5(Ultrasonic)	Lift / Pump Station	[ ]	[X]	[ ]	
Surcharge Height:	None Observed	WWTP	[ ]	[X]	[ ]	
Rain Guage Zone:	RG_Publicworks (Gladstone)	Other	[ ]	[X]	[ ]	

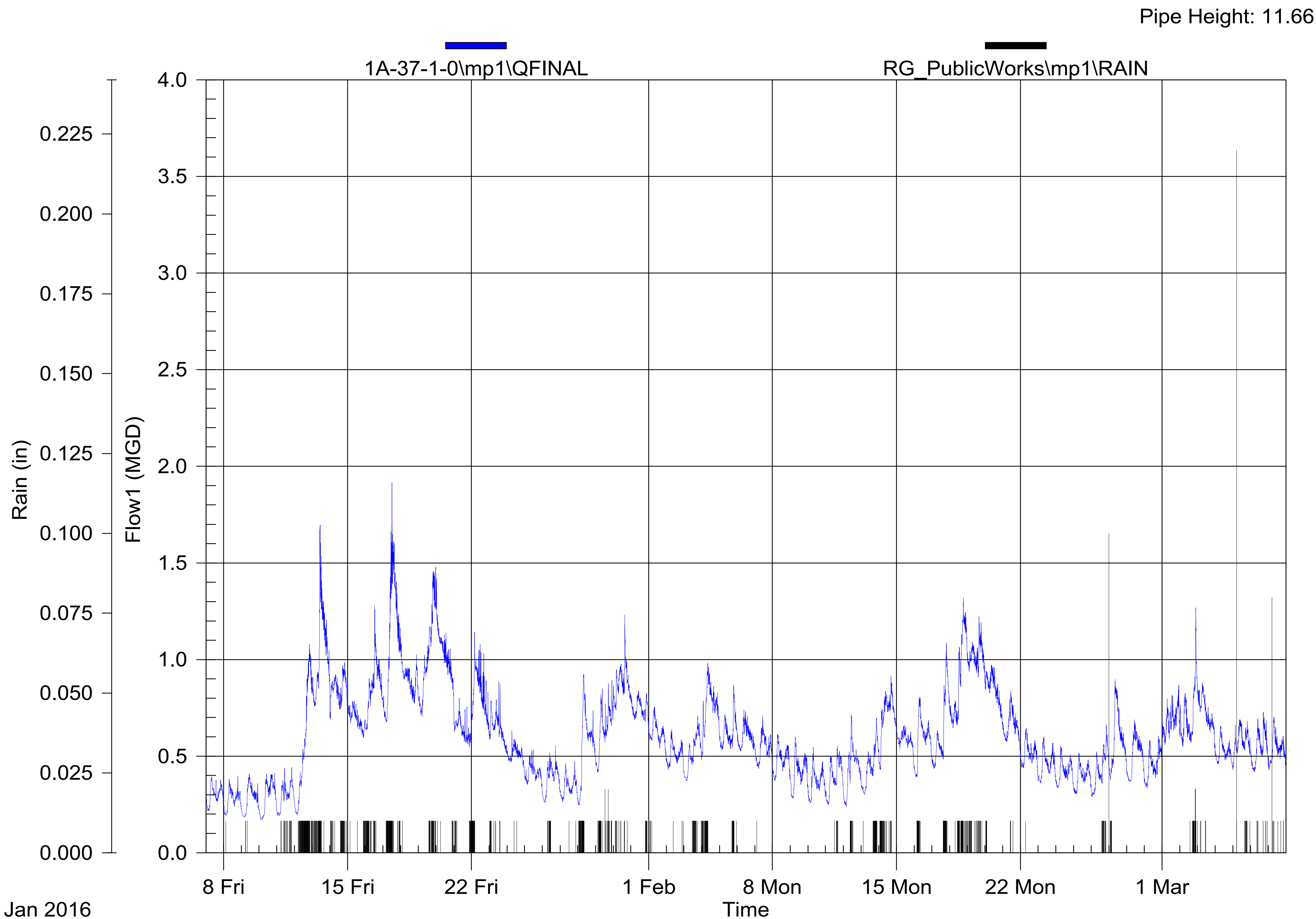
Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

ADS Environmental Services



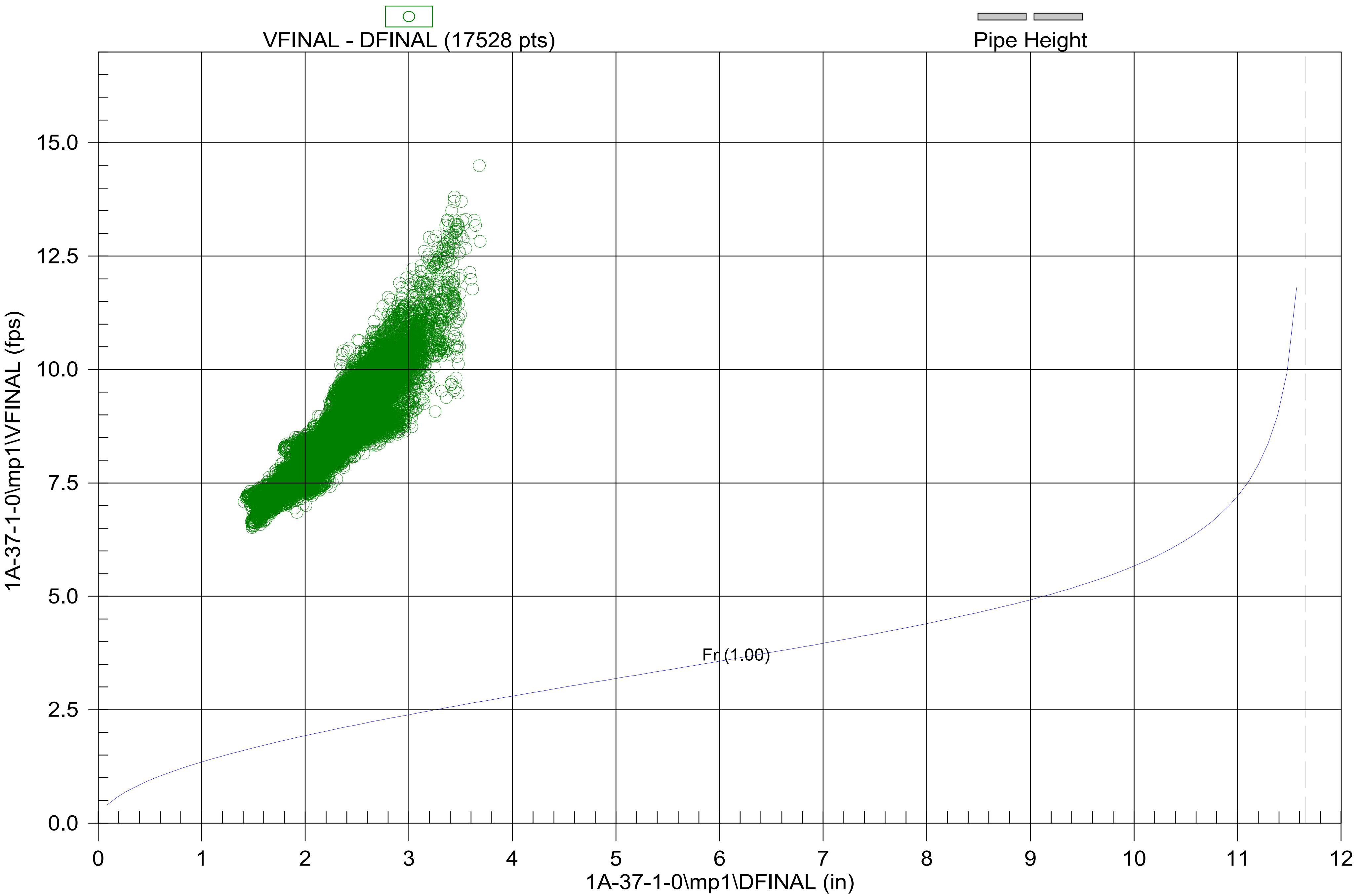
ADS Environmental Services



ADS Environmental Services

1/7/2016 12:00:00 AM - 3/7/2016 11:59:00 PM

Pipe Height: 11.66



ADS Environmental Services

	1A-37-1-0\mp1\DFINAL (inches)					1A-37-1-0\mp1\VFINAL (feet/sec)					1A-37-1-0\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
1/7/2016	3:50	1.6	7:55	2.2	1.9	4:30	6.8	8:10	8.0	7.3	2:50	0.215	8:00	0.396	0.298	0.298
1/8/2016	3:20	1.6	7:45	2.1	1.8	3:20	6.6	7:25	7.9	7.3	3:20	0.189	19:10	0.395	0.277	0.277
1/9/2016	3:45	1.5	11:30	2.2	1.8	4:00	6.6	10:30	8.0	7.2	3:45	0.184	10:30	0.409	0.276	0.276
1/10/2016	3:00	1.5	10:10	2.3	1.9	2:35	6.5	16:20	8.1	7.2	2:35	0.170	21:10	0.412	0.290	0.290
1/11/2016	3:35	1.5	10:30	2.3	1.9	1:05	6.9	20:10	8.1	7.4	3:35	0.190	20:15	0.443	0.299	0.299
1/12/2016	4:00	1.5	20:20	3.1	2.3	2:30	7.1	22:20	10.7	8.6	3:50	0.198	20:15	1.080	0.550	0.550
1/13/2016	3:55	2.5	10:20	3.6	3.0	7:10	9.5	10:40	13.7	10.5	3:00	0.756	10:40	1.696	1.046	1.046
1/14/2016	23:50	2.5	19:55	2.9	2.7	13:00	9.5	19:40	10.8	10.1	0:55	0.693	19:40	0.989	0.847	0.847
1/15/2016	21:40	2.2	7:30	2.6	2.4	18:00	9.1	11:25	10.5	9.6	21:40	0.597	9:10	0.785	0.693	0.693
1/16/2016	1:05	2.3	12:45	3.1	2.6	0:35	9.4	12:40	12.2	10.3	0:50	0.635	12:40	1.278	0.864	0.864
1/17/2016	4:30	2.3	11:55	3.7	3.0	5:20	9.5	12:10	14.5	11.2	5:15	0.677	12:10	1.916	1.122	1.122
1/18/2016	18:40	2.5	0:00	2.9	2.7	16:05	9.7	0:10	11.6	10.2	18:40	0.774	0:10	1.116	0.901	0.901
1/19/2016	5:00	2.4	20:10	3.5	2.9	5:50	9.6	23:25	12.9	10.7	5:00	0.705	23:25	1.479	1.025	1.025
1/20/2016	23:45	2.6	0:30	3.3	3.0	21:05	9.7	0:35	12.8	10.6	23:45	0.816	0:35	1.420	1.038	1.038
1/21/2016	20:50	2.4	7:30	2.9	2.6	18:40	9.1	23:35	10.2	9.6	20:50	0.544	23:30	0.825	0.640	0.640
1/22/2016	23:50	2.5	4:05	3.4	2.9	23:50	9.6	16:35	11.2	10.2	23:50	0.605	4:05	1.143	0.824	0.824
1/23/2016	23:55	2.3	9:25	2.9	2.6	23:35	9.0	12:55	10.6	9.6	23:55	0.511	12:55	0.888	0.642	0.642
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1/25/2016	23:55	1.9	11:35	2.4	2.1	23:55	8.0	11:35	8.8	8.4	23:55	0.313	11:35	0.534	0.413	0.413
1/26/2016	4:00	1.7	11:00	2.3	2.1	3:35	7.6	13:25	9.0	8.2	4:00	0.259	17:50	0.552	0.385	0.385
1/27/2016	3:35	1.8	19:40	2.3	2.0	3:40	7.5	19:40	8.5	7.9	3:35	0.263	19:40	0.472	0.341	0.341
1/28/2016	1:20	1.7	7:50	3.2	2.5	2:15	7.3	8:10	9.9	8.8	1:15	0.246	8:00	0.923	0.567	0.567
1/29/2016	3:40	2.1	17:30	3.0	2.6	2:45	8.3	22:20	10.2	9.2	2:45	0.417	22:15	0.894	0.638	0.638
1/30/2016	2:50	2.6	15:40	3.3	2.8	13:50	9.1	15:55	11.0	9.6	0:00	0.689	15:55	1.231	0.883	0.883
1/31/2016	23:55	2.4	10:30	2.8	2.6	18:05	8.6	3:15	9.5	9.0	23:55	0.642	10:20	0.836	0.748	0.748
ReportAvg					2.4					9.1					0.645	
ReportTotal																16.12

ADS Environmental Services

	1A-37-1-0\mp1\DFINAL (inches)					1A-37-1-0\mp1\VFINAL (feet/sec)					1A-37-1-0\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
2/1/2016	23:55	2.1	8:10	2.7	2.4	23:55	8.0	7:40	9.0	8.6	23:55	0.485	8:10	0.755	0.620	0.620
2/2/2016	2:40	2.0	7:30	2.5	2.2	23:20	7.6	6:55	8.5	8.1	23:55	0.428	7:30	0.639	0.507	0.507
2/3/2016	4:10	1.9	20:35	2.6	2.2	3:20	7.3	18:30	9.0	8.0	4:10	0.371	18:30	0.705	0.517	0.517
2/4/2016	0:05	2.1	8:55	3.1	2.7	0:10	7.8	9:25	9.6	8.8	0:05	0.480	8:15	0.983	0.762	0.762
2/5/2016	3:25	2.2	19:25	2.9	2.4	15:20	8.1	19:15	9.4	8.5	3:25	0.533	19:15	0.866	0.624	0.624
2/6/2016	4:50	2.2	9:05	2.7	2.4	22:50	7.8	11:25	9.0	8.3	4:50	0.525	9:05	0.740	0.602	0.602
2/7/2016	5:30	2.0	10:30	2.7	2.3	23:50	7.5	14:55	8.6	8.0	5:30	0.437	10:30	0.710	0.542	0.542
2/8/2016	3:40	1.9	7:10	2.5	2.1	3:10	7.3	7:55	8.3	7.8	3:40	0.370	6:45	0.613	0.480	0.480
2/9/2016	4:00	1.6	6:50	2.4	2.0	2:50	7.2	6:50	8.3	7.7	4:25	0.284	6:50	0.599	0.418	0.418
2/10/2016	3:00	1.5	7:30	2.3	1.8	3:35	7.0	7:30	8.2	7.6	3:40	0.260	7:30	0.546	0.366	0.366
2/11/2016	3:45	1.5	15:55	2.3	1.9	3:40	7.0	15:55	8.2	7.6	3:45	0.250	15:55	0.552	0.395	0.395
2/12/2016	4:15	1.4	10:45	2.6	2.0	4:15	7.1	11:25	9.0	7.9	4:15	0.237	11:05	0.714	0.435	0.435
2/13/2016	4:35	1.6	20:55	2.6	2.0	4:35	7.3	21:05	8.8	8.0	4:35	0.301	20:55	0.698	0.447	0.447
2/14/2016	2:20	1.9	16:35	2.8	2.5	1:45	8.0	16:50	10.2	9.1	2:20	0.430	16:50	0.917	0.709	0.709
2/15/2016	23:55	1.9	10:30	2.4	2.2	23:40	8.3	9:55	9.5	8.9	23:55	0.436	10:25	0.660	0.585	0.585
2/16/2016	3:50	1.8	6:35	2.7	2.3	1:45	8.2	8:10	10.0	8.8	3:55	0.391	7:10	0.806	0.593	0.593
2/17/2016	3:40	1.9	19:20	3.0	2.3	5:20	8.2	19:45	11.2	9.0	3:35	0.436	19:45	1.086	0.639	0.639
2/18/2016	4:55	2.4	18:40	3.5	2.8	9:45	8.9	21:50	11.0	9.9	4:55	0.646	18:50	1.318	0.903	0.903
2/19/2016	23:50	2.7	15:45	3.3	3.0	0:25	9.7	16:30	11.3	10.3	23:50	0.880	15:45	1.224	1.021	1.021
2/20/2016	23:55	2.4	8:40	3.0	2.7	22:40	8.9	13:20	10.3	9.6	23:55	0.666	9:10	0.972	0.848	0.848
2/21/2016	23:55	2.0	11:00	2.8	2.4	23:40	8.4	16:55	9.8	8.9	23:55	0.486	11:05	0.838	0.655	0.655
2/22/2016	23:50	1.9	7:55	2.4	2.1	23:55	7.9	14:30	8.9	8.4	23:55	0.396	7:55	0.648	0.513	0.513
2/23/2016	0:15	1.8	7:15	2.4	2.0	23:55	7.5	8:05	8.6	8.1	3:50	0.358	8:05	0.601	0.456	0.456
2/24/2016	2:45	1.7	6:25	2.3	2.0	4:45	7.3	7:35	8.3	7.7	2:40	0.336	6:25	0.553	0.418	0.418
2/25/2016	2:20	1.7	7:15	2.2	1.9	3:50	7.0	7:50	8.1	7.5	3:50	0.305	7:15	0.520	0.396	0.396
2/26/2016	1:25	1.6	20:35	2.5	2.0	14:40	6.9	21:40	8.6	7.6	1:00	0.290	20:35	0.666	0.431	0.431
2/27/2016	2:15	1.9	10:40	2.9	2.4	2:10	7.5	8:40	9.5	8.3	2:15	0.377	8:30	0.897	0.591	0.591
2/28/2016	4:45	1.8	10:20	2.6	2.2	4:25	7.4	14:20	8.7	8.0	4:45	0.366	10:20	0.689	0.505	0.505
2/29/2016	3:15	1.8	19:10	2.4	2.1	3:55	7.2	23:55	8.4	7.8	3:55	0.337	19:10	0.604	0.455	0.455
ReportAvg					2.2					8.4					0.567	
ReportTotal																16.43

ADS Environmental Services

	1A-37-1-0\mp1\DFINAL (inches)					1A-37-1-0\mp1\VFINAL (feet/sec)					1A-37-1-0\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
3/1/2016	4:10	2.3	22:40	3.0	2.6	3:55	8.2	14:45	9.4	8.6	4:00	0.560	22:40	0.868	0.687	0.687
3/2/2016	4:25	2.2	21:40	3.5	2.6	13:25	8.2	21:45	10.4	8.7	4:25	0.549	21:45	1.269	0.719	0.719
3/3/2016	23:40	2.2	6:35	3.0	2.6	22:30	8.2	2:15	9.6	8.8	23:45	0.542	6:35	0.881	0.726	0.726
3/4/2016	23:45	2.0	7:40	2.5	2.2	23:40	8.1	9:00	8.6	8.3	23:45	0.440	7:40	0.656	0.522	0.522
3/5/2016	0:30	2.0	9:20	2.6	2.3	0:15	8.0	12:00	9.0	8.5	0:15	0.432	9:50	0.691	0.578	0.578
3/6/2016	5:45	1.9	17:35	2.6	2.2	5:00	8.1	21:20	9.3	8.4	5:00	0.420	17:35	0.728	0.543	0.543
3/7/2016	0:40	2.0	7:35	2.6	2.2	1:05	7.9	7:45	8.8	8.4	1:05	0.429	7:35	0.704	0.537	0.537
ReportAvg					2.4					8.5					0.616	
ReportTotal																4.311

2A-19

Located At: 2125 Caulfield St (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016
Pipe Dimensions: 8 in x 8 in
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sewer pipe. The scattergraph indicates normal open channel flow with periods of backwater. The data plots above the Froude =1 curve indicating supercritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward and downward ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (in)	100%	100%
Velocity (f/s)	100%	99%
Quantity (MGD)	100%	99%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

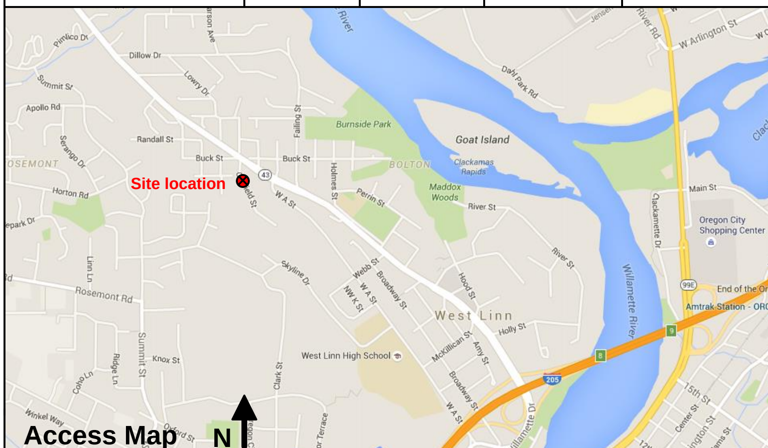
Item	Depth (in)	Velocity (f/s)	Quantity (MGD)	% Full
Minimum	0.62	2.75	0.036	7%
Maximum	4.19	8.68	0.563	52%
Average	1.41	6.49	0.177	18%

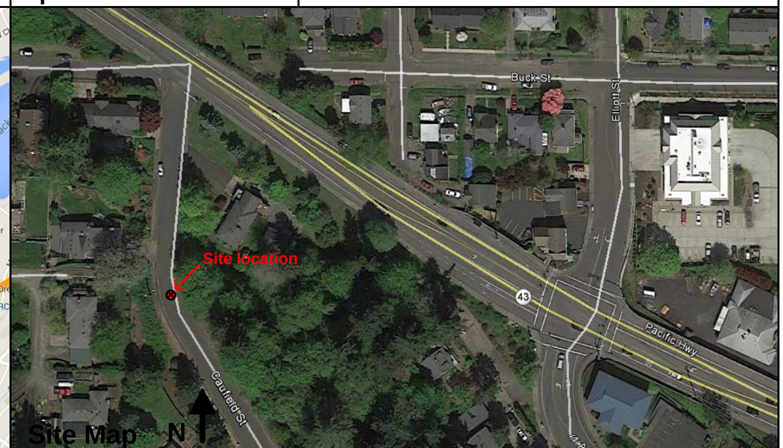
ADS Site Report — Quality Form

ADS ENVIRONMENTAL SERVICES®

Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

Site Name: 2A-19	**Monitor Series:** 8000-FST	**Monitor S/N:**	20378
Address/Location: 2125 Caulfield St		**IP Address:**	166.219.48.113
		Manhole #	2A-19
		GPS Coordinates	45.370845° -122.624833°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	8.00"
		Pipe Width:	8.00"

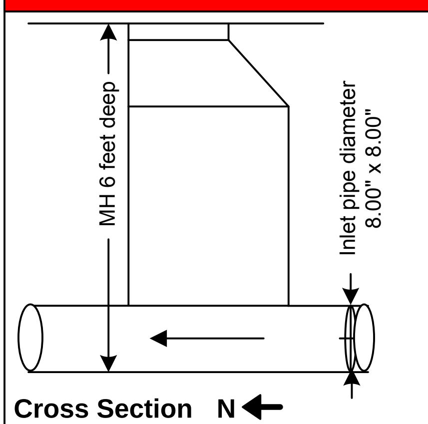


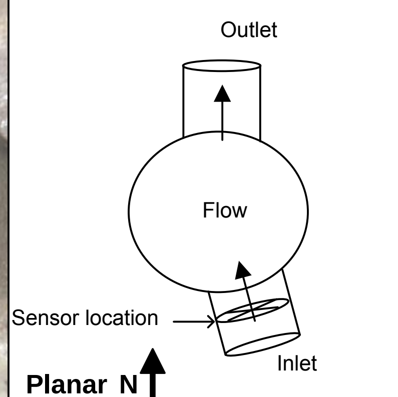


Investigation Information: / Manhole Information:

Date/Time of Investigation:	01/06/2016 @ 18:21	**Manhole Depth:**	6'
Site Hydraulics:	Ripples, Fast Velocity	**Manhole Material / Condition**	Concrete / Good
Upstream Input: (L/S, P/S)	DNI	**Pipe Material / Condition:**	Concrete / Good
Upstream Manhole:	DNI	**Mini System Character:**	Residential [X] Commercial [ ] Industrial [ ] Trunk [ ]
Downstream Manhole:	Pipe junction with turbulence	**Telephone Information:**	Does not apply
Depth of Flow:	1.25" +/- 0.25"	**Access Pole #:**	Does not apply
Range (Air DOF):	6.75" +/- 0.25"	**Distance From Manhole:**	Does not apply Feet
Peak Velocity:	6.63 fps	**Road Cut Length:**	Does not apply Feet
Silt:	None	**Trench Length:**	Does not apply Feet

Other Information:

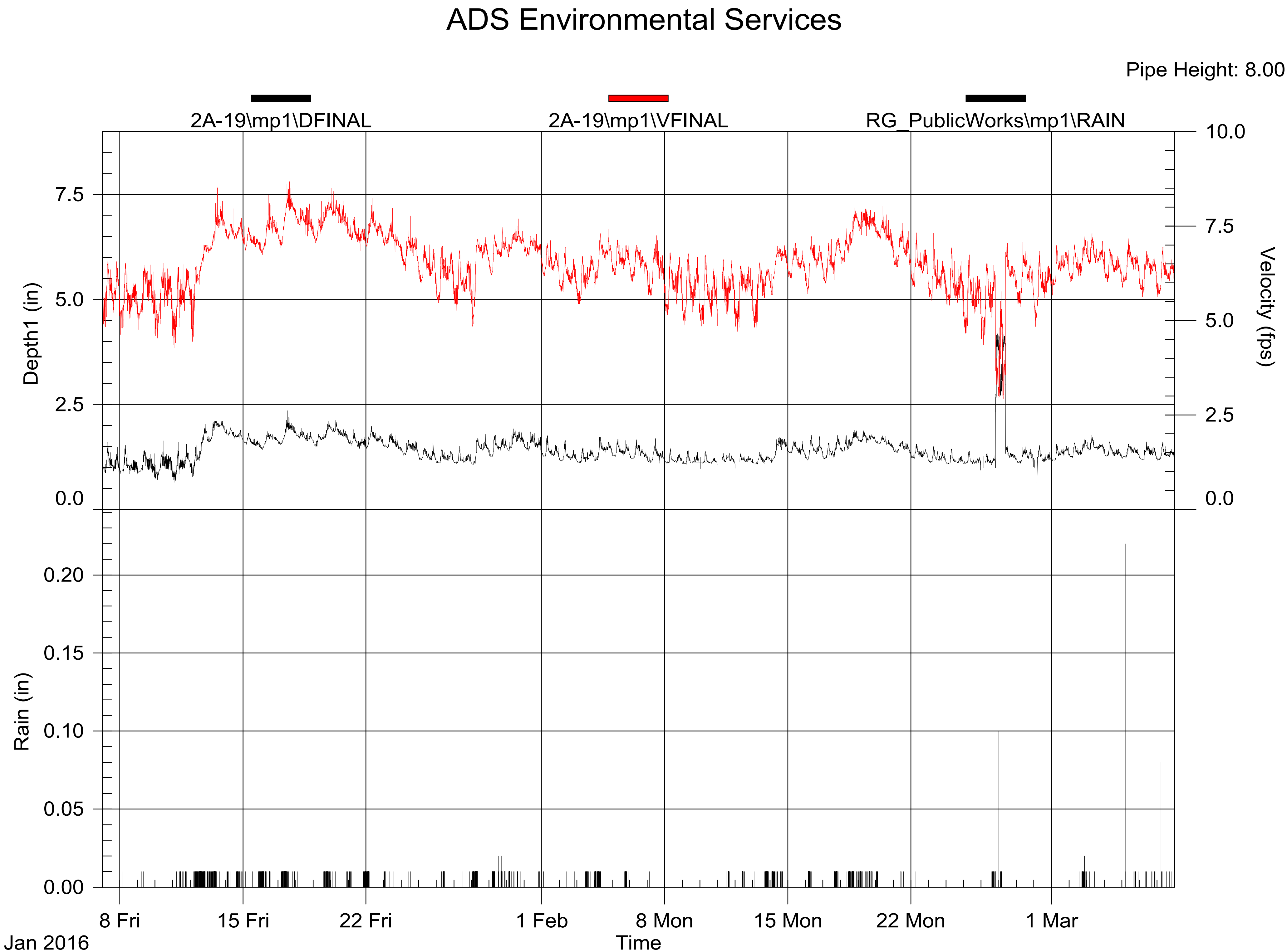




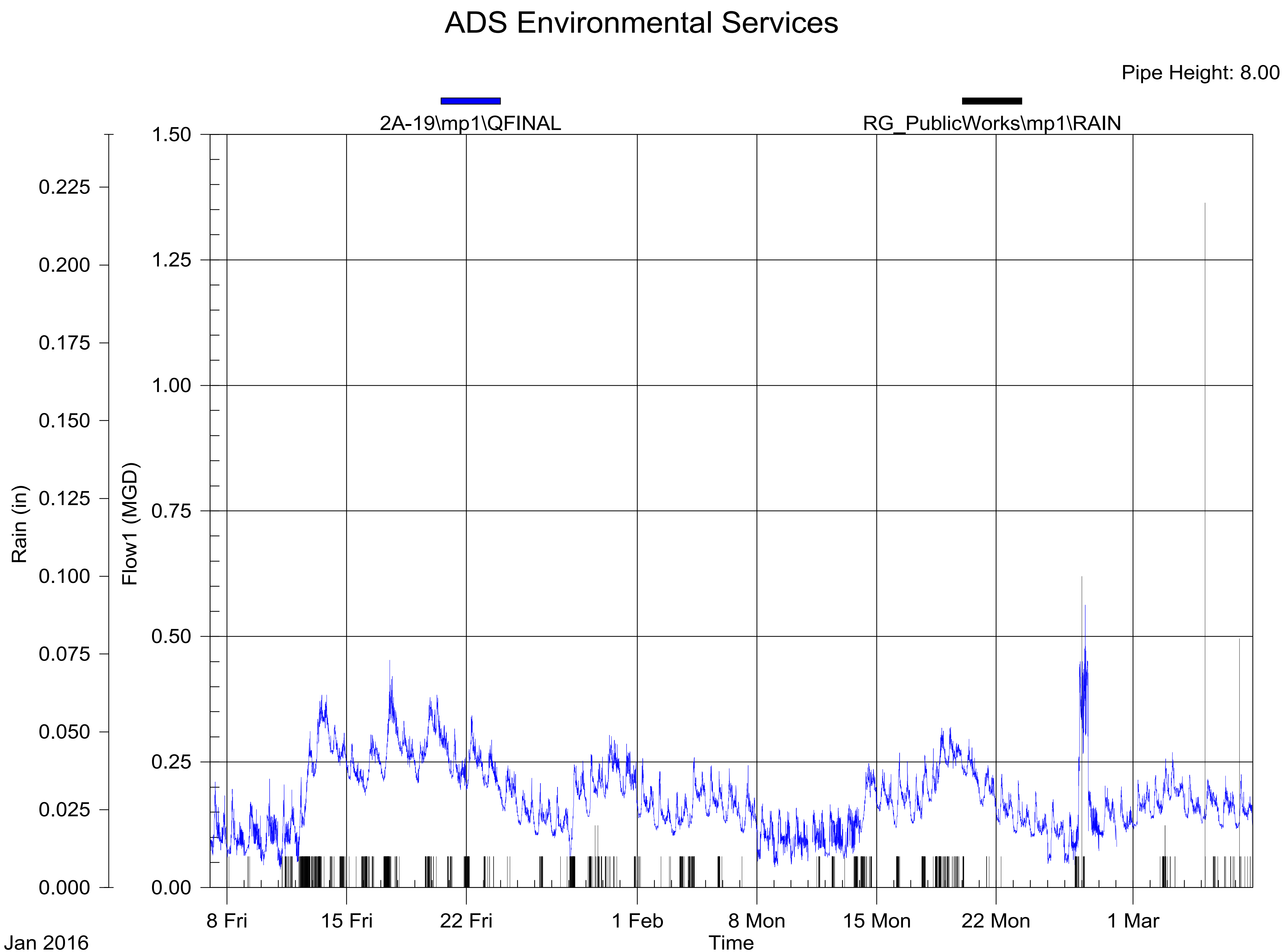
Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Standard	Trunk	[ ]	[X]	[ ]	
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity), CS5(Ultrasonic)	Lift / Pump Station	[ ]	[X]	[ ]	
Surcharge Height:	None Observed	WWTP	[ ]	[X]	[ ]	
Rain Guage Zone:	RG_Publicworks (Gladstone)	Other	[ ]	[X]	[ ]	

Additional Site Information / Comments:

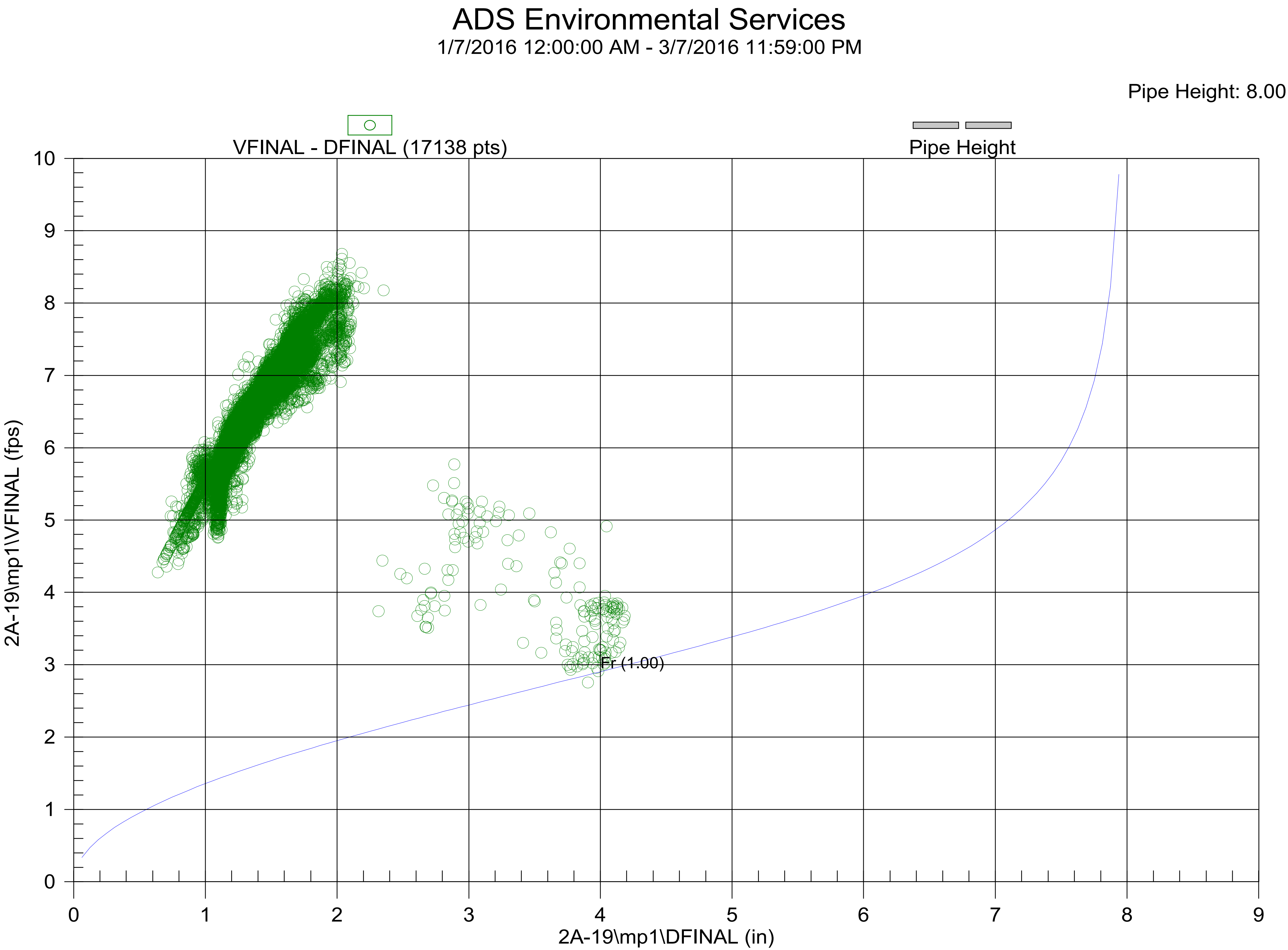
Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)



ADS Environmental Services
Pipe Height: 8.00
2A-19\mp1\DFINAL
2A-19\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Depth1 (in)
Velocity (fps)
Rain (in)
7.5
5.0
2.5
0.0
10.0
7.5
5.0
2.5
0.0
0.20
0.15
0.10
0.05
0.00
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time



ADS Environmental Services
Pipe Height: 8.00
2A-19\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow1 (MGD)
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
1.50
1.25
1.00
0.75
0.50
0.25
0.00
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time


ADS Environmental Services
1/7/2016 12:00:00 AM - 3/7/2016 11:59:00 PM
Pipe Height: 8.00
VFINAL - DFINAL (17138 pts)
Pipe Height
2A-19\mp1\VFINAL (fps)
2A-19\mp1\DFINAL (in)
Fr (1.00)
0
1
2
3
4
5
6
7
8
9
10

ADS Environmental Services

	2A-19\mp1\DFINAL (inches)					2A-19\mp1\VFINAL (feet/sec)					2A-19\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
1/7/2016	4:30	0.9	7:30	1.6	1.1	4:25	4.8	19:30	6.6	5.8	4:30	0.064	7:30	0.210	0.109	0.109
1/8/2016	23:50	0.8	7:30	1.5	1.0	0:40	4.6	8:05	6.5	5.6	0:40	0.060	7:40	0.196	0.098	0.098
1/9/2016	23:55	0.7	9:15	1.4	1.1	1:55	4.8	17:20	6.5	5.7	23:55	0.055	9:15	0.170	0.103	0.103
1/10/2016	3:25	0.7	12:00	1.6	1.1	3:25	4.5	12:00	6.5	5.6	3:25	0.044	12:00	0.216	0.102	0.102
1/11/2016	3:10	0.6	8:20	1.6	1.1	3:10	4.3	14:20	6.5	5.6	3:10	0.036	8:20	0.205	0.105	0.105
1/12/2016	3:40	0.8	20:40	2.0	1.4	2:30	4.4	18:50	7.0	6.2	2:30	0.051	20:40	0.311	0.165	0.165
1/13/2016	1:30	1.6	19:50	2.1	1.9	1:20	6.8	13:10	8.5	7.4	1:30	0.219	20:00	0.384	0.307	0.307
1/14/2016	23:40	1.6	7:35	2.0	1.8	23:55	7.1	10:20	8.0	7.3	23:40	0.239	7:30	0.324	0.276	0.276
1/15/2016	23:00	1.5	7:45	1.8	1.6	3:50	6.9	1:40	7.5	7.1	23:00	0.198	7:45	0.287	0.230	0.230
1/16/2016	2:25	1.4	9:55	1.9	1.7	2:30	6.7	11:20	8.3	7.3	2:30	0.183	9:55	0.304	0.248	0.248
1/17/2016	4:00	1.5	12:30	2.4	1.8	3:50	6.9	15:55	8.7	7.7	3:50	0.211	12:30	0.453	0.302	0.302
1/18/2016	16:20	1.6	8:20	1.9	1.7	16:20	7.2	19:00	8.1	7.6	16:20	0.239	8:30	0.331	0.275	0.275
1/19/2016	3:55	1.5	21:20	2.1	1.7	2:55	7.0	20:05	8.3	7.6	3:55	0.208	21:05	0.379	0.275	0.275
1/20/2016	23:35	1.6	6:40	2.1	1.8	22:55	7.3	0:20	8.5	7.8	22:55	0.247	6:40	0.384	0.307	0.307
1/21/2016	15:30	1.4	7:25	1.9	1.6	16:00	6.8	7:55	7.7	7.3	16:00	0.195	7:25	0.316	0.234	0.234
1/22/2016	0:20	1.4	7:35	2.0	1.7	1:20	6.9	8:30	8.2	7.4	0:25	0.193	7:55	0.343	0.256	0.256
1/23/2016	23:50	1.4	11:25	1.8	1.6	15:45	6.8	12:20	8.0	7.2	23:50	0.182	11:25	0.294	0.222	0.222
1/24/2016	23:15	1.3	10:15	1.7	1.4	6:15	6.3	13:05	7.8	6.8	23:15	0.149	10:15	0.243	0.187	0.187
1/25/2016	23:55	1.2	19:50	1.6	1.3	23:55	5.9	14:25	7.0	6.4	23:55	0.120	19:50	0.218	0.149	0.149
1/26/2016	1:15	1.1	8:00	1.5	1.2	3:10	5.5	8:00	7.0	6.2	1:20	0.104	8:00	0.208	0.137	0.137
1/27/2016	3:55	1.1	8:05	1.5	1.2	4:00	5.3	8:10	6.8	6.0	4:00	0.099	8:05	0.200	0.127	0.127
1/28/2016	2:40	1.1	19:35	1.8	1.4	1:50	4.8	19:35	7.2	6.5	1:35	0.054	19:35	0.252	0.172	0.172
1/29/2016	4:30	1.2	8:30	1.8	1.5	3:40	6.2	18:10	7.5	6.8	4:30	0.140	7:25	0.265	0.196	0.196
1/30/2016	3:15	1.4	9:00	1.9	1.6	2:45	6.7	16:05	7.7	7.1	3:05	0.177	9:00	0.304	0.235	0.235
1/31/2016	23:55	1.4	9:05	1.9	1.5	23:55	6.5	16:45	7.3	6.9	23:55	0.166	9:05	0.286	0.211	0.211
ReportAvg					1.5					6.8					0.201	
ReportTotal																5.026

ADS Environmental Services

	2A-19\mp1\DFINAL (inches)					2A-19\mp1\VFINAL (feet/sec)					2A-19\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
2/1/2016	23:50	1.2	7:30	1.8	1.4	23:55	6.1	11:50	7.1	6.5	23:50	0.133	7:30	0.258	0.169	0.169
2/2/2016	3:30	1.1	7:35	1.7	1.3	2:20	5.8	7:55	6.9	6.2	3:30	0.114	8:05	0.231	0.142	0.142
2/3/2016	2:40	1.1	8:10	1.5	1.2	3:35	5.4	19:20	6.7	6.1	2:40	0.102	8:10	0.190	0.137	0.137
2/4/2016	0:50	1.2	8:05	1.7	1.4	0:35	5.9	18:45	7.4	6.7	0:50	0.118	8:05	0.259	0.182	0.182
2/5/2016	4:10	1.2	8:10	1.7	1.4	3:05	6.2	7:35	7.1	6.6	4:10	0.140	8:10	0.243	0.174	0.174
2/6/2016	4:15	1.2	9:25	1.7	1.3	3:55	6.0	9:25	7.0	6.5	4:00	0.128	9:25	0.237	0.161	0.161
2/7/2016	16:20	1.1	11:40	1.7	1.3	4:30	5.7	12:45	7.3	6.3	4:25	0.108	11:40	0.243	0.145	0.145
2/8/2016	2:10	1.1	7:55	1.5	1.2	4:25	5.1	7:35	6.8	5.9	23:40	0.050	7:55	0.167	0.104	0.104
2/9/2016	5:15	1.1	7:35	1.4	1.2	3:30	4.9	8:05	6.8	5.8	1:00	0.041	6:55	0.157	0.095	0.095
2/10/2016	23:45	1.1	7:25	1.4	1.2	1:35	4.8	7:25	6.7	5.7	0:05	0.046	7:20	0.159	0.093	0.093
2/11/2016	23:55	1.1	7:50	1.3	1.2	23:55	5.1	8:00	6.6	5.9	23:35	0.063	8:00	0.154	0.108	0.081
2/12/2016	0:05	1.0	6:40	1.4	1.2	3:25	4.7	8:00	6.5	5.8	3:10	0.060	6:40	0.165	0.101	0.101
2/13/2016	5:50	1.1	12:40	1.4	1.2	5:40	4.8	9:35	6.5	5.8	1:55	0.057	9:25	0.166	0.110	0.110
2/14/2016	1:55	1.1	13:00	1.7	1.4	2:35	5.7	19:30	7.0	6.5	2:20	0.109	13:00	0.247	0.183	0.183
2/15/2016	23:50	1.3	8:30	1.7	1.4	5:15	6.1	10:50	7.1	6.5	23:55	0.143	8:30	0.235	0.178	0.178
2/16/2016	3:40	1.2	8:10	1.8	1.4	3:15	5.7	8:10	7.2	6.5	3:15	0.119	8:10	0.268	0.175	0.175
2/17/2016	1:45	1.2	19:40	1.8	1.4	3:05	6.0	21:30	7.2	6.6	3:05	0.127	19:40	0.264	0.175	0.175
2/18/2016	3:10	1.4	19:25	1.9	1.6	1:50	6.5	18:40	8.0	7.2	1:50	0.170	19:25	0.318	0.229	0.229
2/19/2016	11:20	1.6	8:10	1.9	1.7	11:15	7.2	10:00	8.0	7.6	11:20	0.237	8:10	0.319	0.267	0.267
2/20/2016	23:40	1.4	10:00	1.8	1.6	23:45	6.9	10:00	8.0	7.3	23:45	0.187	10:00	0.296	0.234	0.234
2/21/2016	23:55	1.3	12:35	1.6	1.5	5:35	6.4	12:20	7.6	6.8	23:55	0.149	12:35	0.243	0.193	0.193
2/22/2016	23:55	1.2	7:55	1.6	1.3	5:00	5.9	7:55	7.3	6.4	5:00	0.125	7:55	0.226	0.157	0.157
2/23/2016	3:15	1.1	7:00	1.5	1.2	3:55	5.5	7:00	7.3	6.1	3:15	0.107	7:00	0.213	0.134	0.134
2/24/2016	3:05	1.1	7:45	1.5	1.2	4:55	5.4	7:20	6.9	5.9	1:00	0.100	7:20	0.192	0.122	0.122
2/25/2016	23:05	0.9	8:00	1.4	1.2	2:45	4.7	8:05	6.7	5.6	0:45	0.046	8:00	0.176	0.105	0.105
2/26/2016	19:25	1.0	22:05	4.2	1.7	23:35	3.0	8:10	6.5	5.2	14:40	0.045	22:00	0.450	0.136	0.136
2/27/2016	23:55	1.2	7:05	4.2	2.2	8:40	2.8	11:55	7.1	5.5	23:55	0.073	4:55	0.563	0.232	0.232
2/28/2016	23:10	1.0	12:15	1.5	1.3	5:10	5.4	9:00	7.1	6.1	23:10	0.095	9:00	0.203	0.140	0.140
2/29/2016	4:20	0.6	7:40	1.5	1.2	2:05	4.8	7:20	6.8	5.9	1:15	0.081	7:40	0.201	0.134	0.106
ReportAvg					1.4					6.3					0.156	
ReportTotal																4.460

ADS Environmental Services

	2A-19\mp1\DFINAL (inches)					2A-19\mp1\VFINAL (feet/sec)					2A-19\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
3/1/2016	1:15	1.2	6:55	1.5	1.3	1:05	5.7	19:50	7.1	6.4	1:05	0.116	6:55	0.214	0.160	0.160
3/2/2016	4:20	1.2	21:45	1.7	1.4	1:30	6.0	21:45	7.3	6.5	1:30	0.136	21:45	0.256	0.174	0.174
3/3/2016	23:55	1.3	7:15	1.8	1.5	23:50	6.3	7:20	7.3	6.7	23:50	0.155	7:15	0.269	0.197	0.197
3/4/2016	23:55	1.2	7:30	1.6	1.4	23:50	6.0	7:45	7.0	6.4	23:50	0.133	7:45	0.224	0.163	0.163
3/5/2016	0:45	1.2	8:50	1.6	1.4	0:55	5.9	9:25	7.2	6.5	0:45	0.128	9:05	0.216	0.166	0.166
3/6/2016	4:00	1.2	9:55	1.6	1.3	4:20	5.6	9:55	6.8	6.3	4:20	0.117	9:55	0.223	0.154	0.154
3/7/2016	0:55	1.2	8:05	1.6	1.3	1:15	5.6	8:05	6.9	6.2	1:05	0.117	8:05	0.225	0.150	0.150
ReportAvg					1.4					6.4					0.166	
ReportTotal																1.165

2B-0-12

Located At: 2598 Dillow Dr (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016
Pipe Dimensions: 14.13 in x 14.25 in
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sewer pipe. The scattergraph indicates normal open channel flow. The data plots above the Froude =1 curve indicating supercritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	**Percentage Uptime Raw**	**Percentage Uptime Final**
Depth (in)	100%	100%
Velocity (f/s)	100%	100%
Quantity (MGD)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

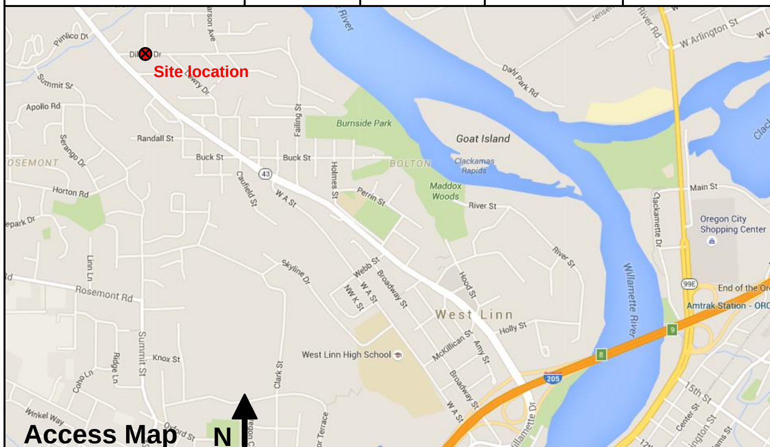
Item	Depth (in)	Velocity (f/s)	Quantity (MGD)	% Full
Minimum	1.32	5.41	0.185	9%
Maximum	3.67	10.39	1.399	26%
Average	2.20	8.40	0.608	16%

ADS Site Report — Quality Form

ADS ENVIRONMENTAL SERVICES

Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

Site Name: 2B-0-12	**Monitor Series:** 8000-FST	**Monitor S/N:**	20389
Address/Location: 2598 Dillow Dr.		**IP Address:**	166.219.50.36
		Manhole #	2B-0-12
		GPS Coordinates	45.375441° -122.629893°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	14.13"
		Pipe Width:	14.25"



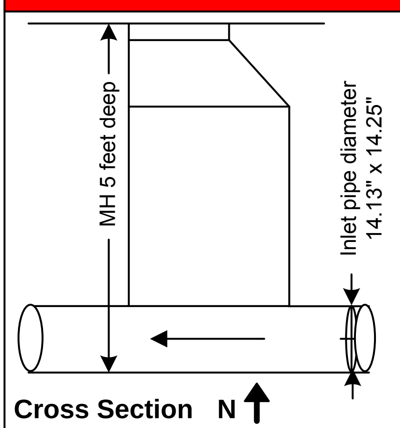
Investigation Information:

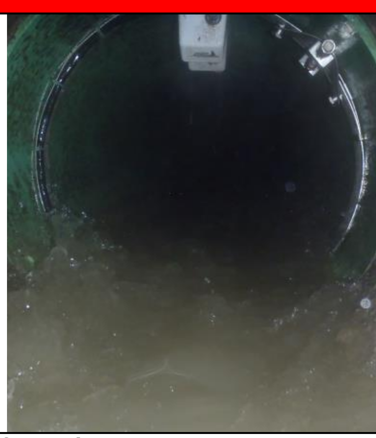
Date/Time of Investigation:	12/17/2015 @ 08:37
Site Hydraulics:	Ripples, Fast Velocity
Upstream Input: (L/S, P/S)	DNI
Upstream Manhole:	DNI
Downstream Manhole:	Ripples, Fast Velocity
Depth of Flow:	3.00" +/- 0.25"
Range (Air DOF):	11.13" +/- 0.25"
Peak Velocity:	10.44 fps
Silt:	None

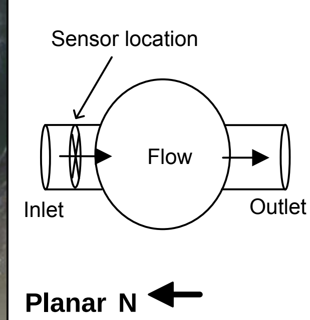
Manhole Information:

Manhole Depth:	5'
Manhole Material / Condition	Concrete / Good
Pipe Material / Condition:	PVC / Good
Mini System Character:	Residential [X] Commercial [ ] Industrial [ ] Trunk [ ]
Telephone Information:	Does not apply
Access Pole #:	Does not apply
Distance From Manhole:	Does not apply Feet
Road Cut Length:	Does not apply Feet
Trench Length:	Does not apply Feet

Other Information:





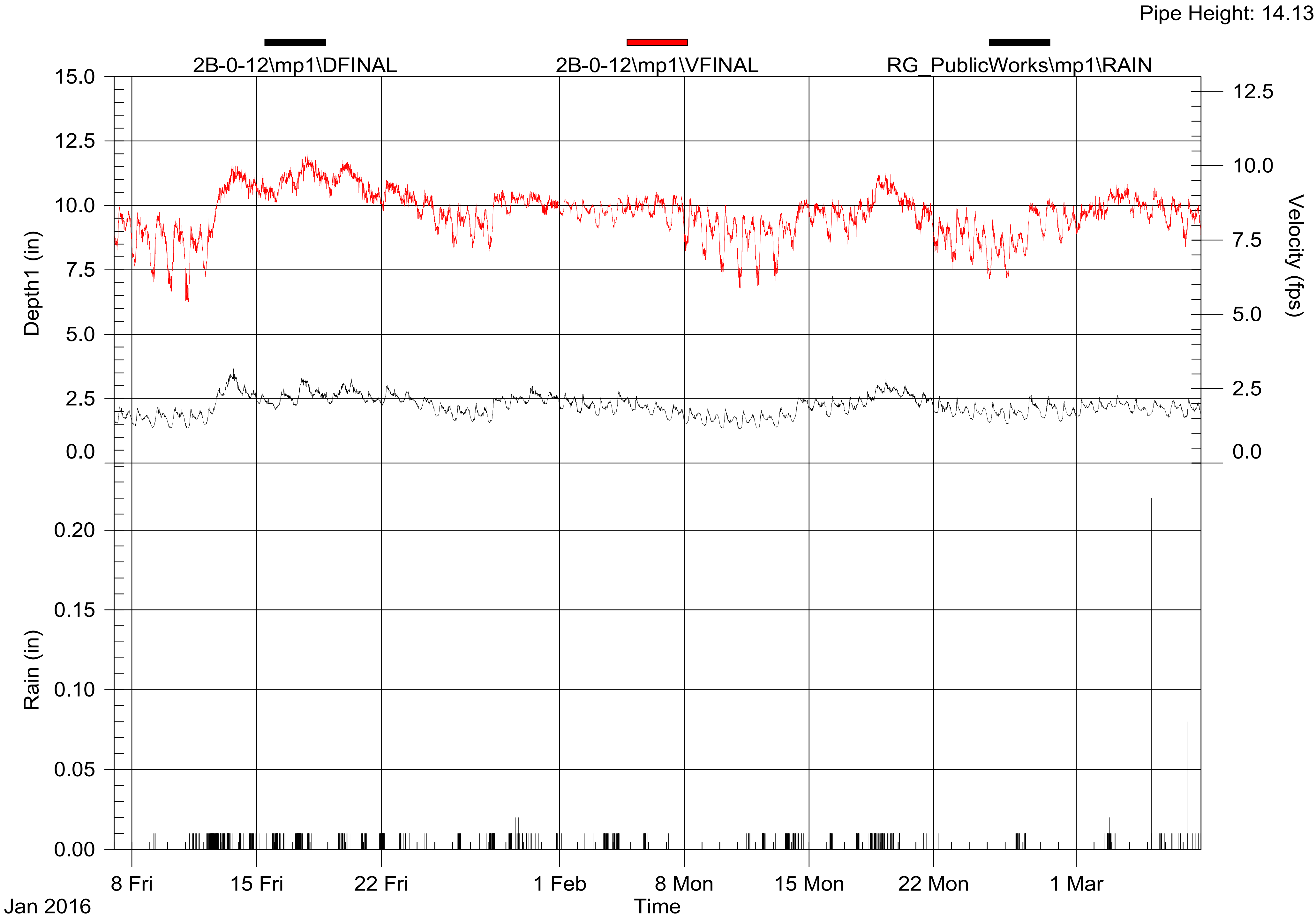


Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Standard	Trunk		X		
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity), CS5(Ultrasonic)	Lift / Pump Station		X		
Surcharge Height:	None Observed	WWTP		X		
Rain Guage Zone:	RG_Publicworks (Gladstone)	Other		X		

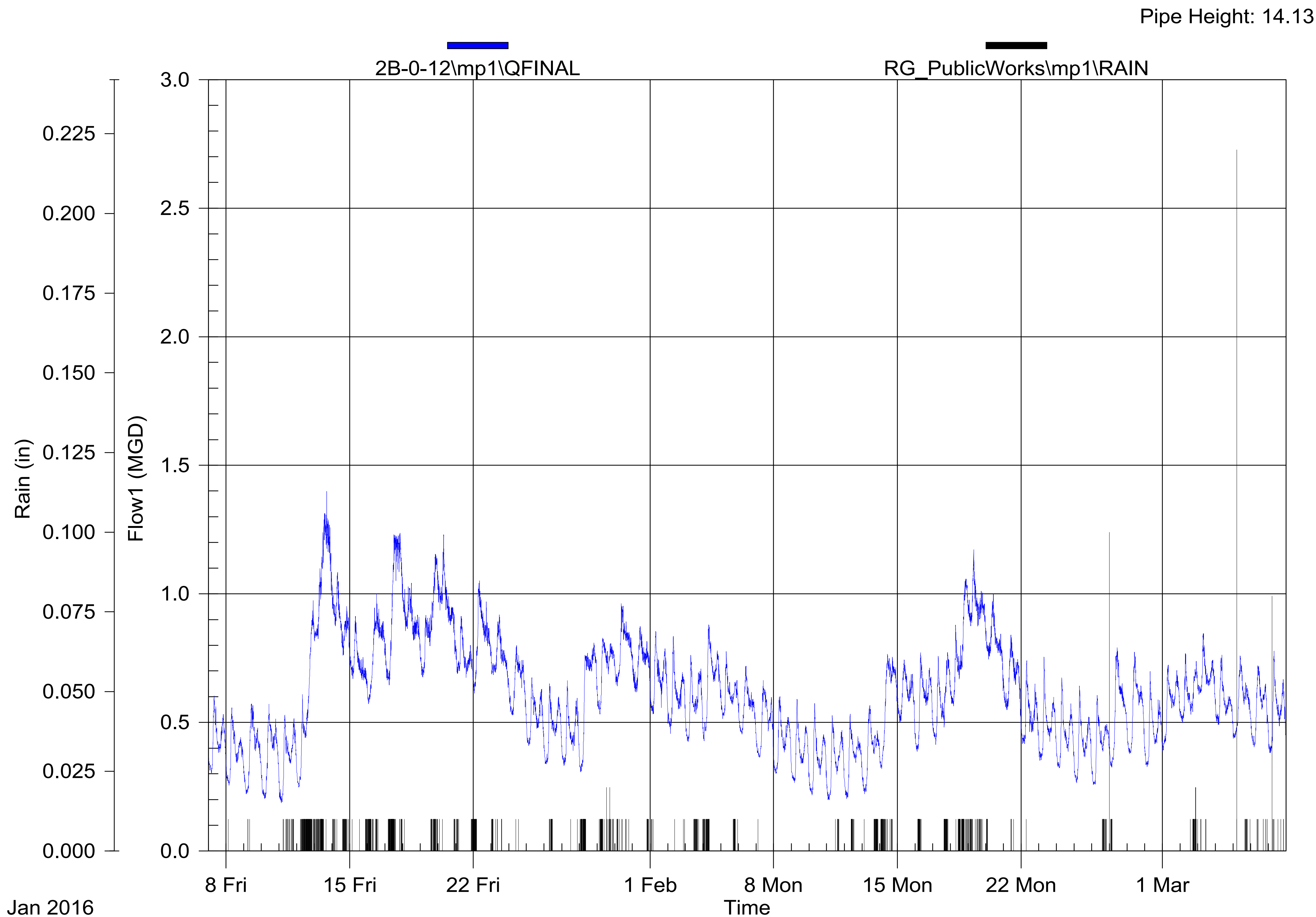
Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

ADS Environmental Services



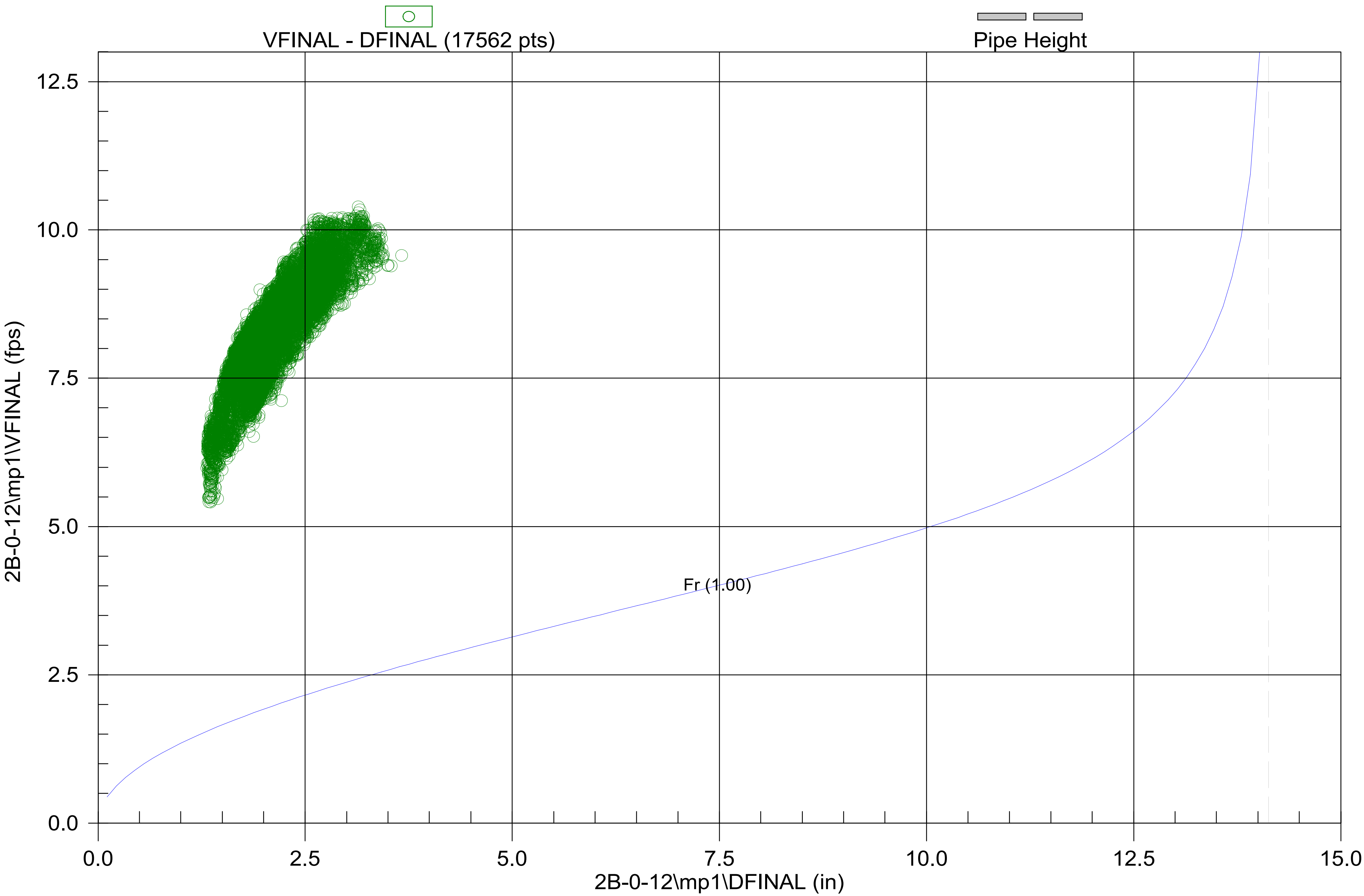
ADS Environmental Services



ADS Environmental Services

1/7/2016 12:00:00 AM - 3/7/2016 11:59:00 PM

Pipe Height: 14.13



ADS Environmental Services

	2B-0-12\mp1\DFINAL (inches)					2B-0-12\mp1\VFINAL (feet/sec)					2B-0-12\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
1/7/2016	4:10	1.5	7:50	2.2	1.8	4:05	7.2	7:45	8.6	8.0	4:10	0.303	7:50	0.603	0.429	0.429
1/8/2016	4:10	1.5	7:55	2.1	1.7	4:00	6.5	7:30	8.4	7.6	4:00	0.255	7:50	0.557	0.383	0.383
1/9/2016	4:25	1.4	10:30	2.2	1.8	5:30	6.1	13:15	8.4	7.4	3:20	0.222	10:30	0.572	0.386	0.386
1/10/2016	4:05	1.4	10:25	2.2	1.8	5:00	5.8	16:25	8.2	7.2	4:05	0.204	10:25	0.570	0.373	0.373
1/11/2016	3:15	1.3	7:50	2.1	1.7	4:20	5.4	20:20	8.0	7.1	3:20	0.185	7:50	0.529	0.362	0.362
1/12/2016	3:15	1.5	22:20	2.9	2.1	3:05	6.3	22:35	9.3	7.9	2:50	0.246	22:20	0.974	0.541	0.541
1/13/2016	1:05	2.6	16:45	3.7	3.1	0:00	8.8	14:55	10.0	9.4	0:05	0.816	16:45	1.399	1.078	1.078
1/14/2016	23:55	2.4	7:35	3.0	2.7	13:05	8.9	3:50	9.9	9.4	23:55	0.754	7:35	1.085	0.901	0.901
1/15/2016	22:25	2.2	8:00	2.7	2.4	16:15	8.8	7:25	9.7	9.2	23:30	0.634	7:55	0.912	0.729	0.729
1/16/2016	1:15	2.1	12:40	2.9	2.5	2:15	8.7	21:15	10.0	9.4	1:20	0.573	12:40	1.001	0.787	0.787
1/17/2016	6:15	2.2	12:45	3.3	2.8	5:40	9.0	20:20	10.4	9.7	5:40	0.645	20:35	1.237	0.981	0.981
1/18/2016	23:20	2.4	11:45	2.9	2.7	21:50	9.2	7:25	10.2	9.7	23:25	0.780	11:45	1.042	0.903	0.903
1/19/2016	4:10	2.3	21:35	3.1	2.7	2:45	8.9	20:15	10.2	9.6	3:25	0.676	20:35	1.156	0.890	0.890
1/20/2016	23:35	2.5	7:40	3.3	2.8	22:55	8.9	1:55	10.1	9.7	22:50	0.766	7:40	1.230	0.968	0.968
1/21/2016	23:55	2.3	7:05	2.8	2.5	4:45	8.7	6:35	9.5	9.0	23:55	0.656	7:35	0.914	0.750	0.750
1/22/2016	1:20	2.2	8:15	3.0	2.6	2:10	8.4	6:55	9.5	9.2	1:20	0.614	8:20	1.052	0.839	0.839
1/23/2016	23:05	2.3	9:45	2.8	2.5	13:15	8.6	11:15	9.4	8.9	23:05	0.635	11:15	0.919	0.756	0.756
1/24/2016	23:50	2.0	10:15	2.6	2.3	23:55	8.1	10:45	9.2	8.6	23:55	0.513	10:45	0.799	0.651	0.651
1/25/2016	3:40	1.8	7:25	2.4	2.0	23:50	7.4	19:35	8.7	8.2	23:50	0.399	7:25	0.675	0.523	0.523
1/26/2016	3:05	1.6	7:40	2.3	1.9	1:35	7.3	7:35	8.8	8.1	1:50	0.336	7:35	0.651	0.480	0.480
1/27/2016	2:55	1.6	7:50	2.3	1.9	2:45	7.2	7:45	8.7	8.0	2:55	0.332	7:50	0.662	0.457	0.457
1/28/2016	1:40	1.6	19:40	2.6	2.2	2:25	7.1	19:05	9.2	8.5	1:40	0.308	19:40	0.809	0.631	0.631
1/29/2016	3:55	2.0	7:30	2.7	2.4	4:20	8.3	8:25	9.1	8.8	3:55	0.532	7:35	0.830	0.717	0.717
1/30/2016	3:25	2.3	11:20	3.0	2.6	4:05	8.5	8:35	9.2	8.8	3:25	0.641	9:05	0.962	0.791	0.791
1/31/2016	5:25	2.3	10:50	2.8	2.5	6:40	8.3	10:10	9.1	8.7	4:55	0.617	10:25	0.873	0.738	0.738
ReportAvg					2.3					8.6					0.682	
ReportTotal																17.04

ADS Environmental Services

	2B-0-12\mp1\DFINAL (inches)					2B-0-12\mp1\VFINAL (feet/sec)					2B-0-12\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
2/1/2016	3:55	2.1	7:50	2.7	2.3	3:55	8.3	7:50	8.9	8.6	3:55	0.533	7:50	0.854	0.670	0.670
2/2/2016	3:55	1.9	7:45	2.7	2.2	3:55	8.0	7:45	8.9	8.5	3:55	0.456	7:45	0.835	0.606	0.606
2/3/2016	4:05	1.8	7:25	2.5	2.1	4:05	7.9	7:25	8.8	8.4	4:05	0.426	7:25	0.762	0.574	0.574
2/4/2016	1:20	1.8	7:50	2.8	2.4	1:20	7.9	19:15	9.0	8.5	1:20	0.428	7:50	0.880	0.669	0.669
2/5/2016	2:45	2.0	7:40	2.6	2.2	2:30	8.2	19:25	9.0	8.7	2:45	0.512	7:40	0.776	0.609	0.609
2/6/2016	4:40	1.8	9:55	2.4	2.1	23:55	8.2	10:25	9.1	8.6	5:00	0.454	10:00	0.719	0.559	0.559
2/7/2016	5:00	1.6	10:00	2.3	1.9	3:40	7.7	9:50	9.0	8.5	23:55	0.361	10:00	0.663	0.497	0.497
2/8/2016	3:20	1.5	7:50	2.2	1.8	1:55	7.1	7:30	8.9	8.2	3:05	0.301	8:25	0.601	0.432	0.432
2/9/2016	4:20	1.5	7:45	2.1	1.7	1:25	6.8	7:45	8.8	7.8	4:20	0.264	7:45	0.590	0.388	0.388
2/10/2016	4:15	1.3	7:45	2.1	1.6	4:10	6.2	7:40	8.7	7.6	4:15	0.215	7:45	0.574	0.356	0.356
2/11/2016	2:00	1.3	7:30	2.1	1.6	3:20	5.9	20:35	8.4	7.5	3:20	0.199	7:35	0.527	0.351	0.351
2/12/2016	3:05	1.3	7:55	2.1	1.7	3:10	6.0	7:45	8.3	7.5	3:10	0.203	7:55	0.536	0.363	0.363
2/13/2016	3:40	1.4	10:40	2.2	1.7	3:20	6.1	11:15	8.4	7.6	3:20	0.222	10:40	0.566	0.387	0.387
2/14/2016	1:45	1.6	10:30	2.6	2.2	2:55	7.1	21:05	8.9	8.3	2:55	0.318	10:35	0.768	0.593	0.593
2/15/2016	23:50	1.9	8:40	2.5	2.2	4:30	7.9	9:55	8.7	8.4	23:50	0.454	9:15	0.744	0.611	0.611
2/16/2016	3:00	1.8	7:50	2.6	2.2	4:35	7.4	7:15	8.9	8.3	3:00	0.387	7:50	0.771	0.583	0.583
2/17/2016	4:15	1.9	20:25	2.6	2.2	4:20	7.4	21:15	8.9	8.2	4:20	0.413	20:10	0.773	0.587	0.587
2/18/2016	1:45	2.2	20:30	3.0	2.6	4:05	8.1	21:45	9.7	8.8	4:15	0.563	20:30	1.058	0.776	0.776
2/19/2016	23:50	2.7	7:45	3.2	2.9	23:50	8.9	7:35	9.8	9.3	23:50	0.847	7:45	1.172	0.959	0.959
2/20/2016	23:45	2.3	10:25	3.0	2.7	23:45	8.0	8:40	9.1	8.8	23:45	0.623	10:25	1.000	0.816	0.816
2/21/2016	23:55	2.0	10:20	2.7	2.4	23:50	7.6	11:05	8.8	8.3	23:55	0.480	10:15	0.841	0.669	0.669
2/22/2016	3:10	1.9	7:40	2.6	2.1	5:00	7.1	7:10	8.3	7.7	5:00	0.414	7:40	0.740	0.524	0.524
2/23/2016	1:35	1.8	7:20	2.6	2.0	0:40	6.5	20:20	8.6	7.7	1:35	0.352	7:20	0.754	0.487	0.487
2/24/2016	4:25	1.7	7:25	2.4	2.0	4:00	6.7	7:30	8.5	7.4	3:55	0.323	7:30	0.676	0.448	0.448
2/25/2016	3:40	1.5	7:35	2.4	1.9	3:10	6.2	7:25	8.2	7.1	3:45	0.265	7:35	0.642	0.413	0.413
2/26/2016	4:30	1.5	7:35	2.3	1.9	2:50	6.1	7:05	8.0	7.2	2:00	0.257	7:35	0.605	0.417	0.417
2/27/2016	3:20	1.7	11:15	2.6	2.1	1:50	7.0	10:45	8.8	8.1	3:20	0.326	10:45	0.791	0.548	0.548
2/28/2016	4:50	1.7	10:05	2.6	2.1	3:25	7.5	11:50	8.9	8.3	3:25	0.378	10:05	0.774	0.550	0.550
2/29/2016	3:20	1.6	7:40	2.4	1.9	3:45	7.4	7:40	8.8	8.1	3:20	0.327	7:40	0.698	0.466	0.466
ReportAvg					2.1					8.1					0.549	
ReportTotal																15.91

ADS Environmental Services

	2B-0-12\mp1\DFINAL (inches)					2B-0-12\mp1\VFINAL (feet/sec)					2B-0-12\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
3/1/2016	0:30	1.7	7:55	2.5	2.1	0:35	7.7	19:40	8.8	8.3	0:35	0.388	7:55	0.724	0.572	0.572
3/2/2016	2:05	2.0	7:25	2.5	2.2	5:55	8.2	22:10	9.3	8.6	3:15	0.499	7:25	0.768	0.608	0.608
3/3/2016	23:45	2.1	7:35	2.7	2.3	8:50	8.7	20:35	9.4	9.0	23:55	0.574	7:55	0.846	0.681	0.681
3/4/2016	4:00	1.9	9:00	2.5	2.1	4:55	8.2	8:45	9.2	8.7	4:00	0.491	9:00	0.763	0.577	0.577
3/5/2016	0:25	1.8	9:45	2.5	2.1	2:45	8.0	9:40	9.3	8.6	0:25	0.438	9:50	0.759	0.579	0.579
3/6/2016	5:15	1.8	11:00	2.4	2.1	3:55	7.8	9:45	9.0	8.4	4:55	0.403	9:50	0.722	0.555	0.555
3/7/2016	1:50	1.8	7:40	2.5	2.1	3:05	7.3	7:40	9.0	8.2	1:50	0.382	7:40	0.777	0.538	0.538
ReportAvg					2.2					8.6					0.587	
ReportTotal																4.111

2B-1-0

Located At: 2042 Dillow Dr (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016
Pipe Dimensions: 10.13 in x 10 in
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sewer pipe. The scattergraph indicates normal open channel flow. The data plots above the Froude =1 curve indicating supercritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward and downward ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (in)	100%	100%
Velocity (f/s)	100%	100%
Quantity (MGD)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

Item	Depth (in)	Velocity (f/s)	Quantity (MGD)	% Full
Minimum	0.96	7.44	0.142	9%
Maximum	2.26	15.14	0.846	22%
Average	1.48	10.36	0.343	15%

ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

Site Name: 2B-1-0	**Monitor Series:** 8000-FST	**Monitor S/N:**	30011
Address/Location: 2042 Dillow Dr.		**IP Address:**	166.219.8.73
		Manhole #	2B-1-0
		GPS Coordinates	45.375627° -122.622766°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	10.13"
		Pipe Width:	10.13"

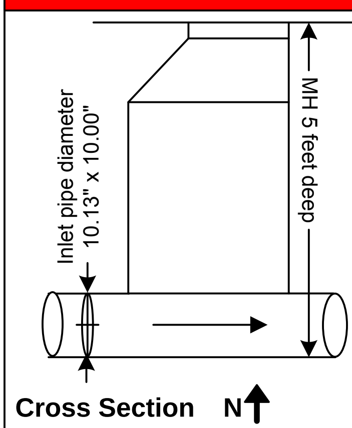
Investigation Information:

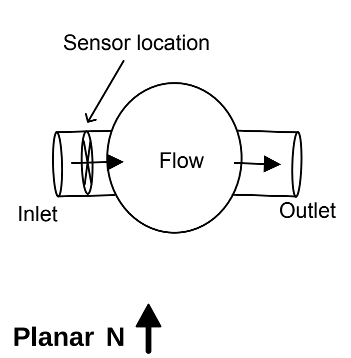
Date/Time of Investigation:	01/06/2016 @ 10:09
Site Hydraulics:	Ripples, Fast Velocity
Upstream Input: (L/S, P/S)	DNI
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow:	1.38" +/- 0.25"
Range (Air DOF):	8.75" +/- 0.25"
Peak Velocity:	10.83 fps
Silt:	None

Manhole Information:

Manhole Depth:	6.5'	
Manhole Material / Condition	Concrete / Good	
Pipe Material / Condition:	Concrete / Good	
Mini System Character:	Residential [X] Commercial [ ] Industrial [ ] Trunk [ ]	
Telephone Information:	Does not apply	
Access Pole #:	Does not apply	
Distance From Manhole:	Does not apply	Feet
Road Cut Length:	Does not apply	Feet
Trench Length:	Does not apply	Feet

Other Information:



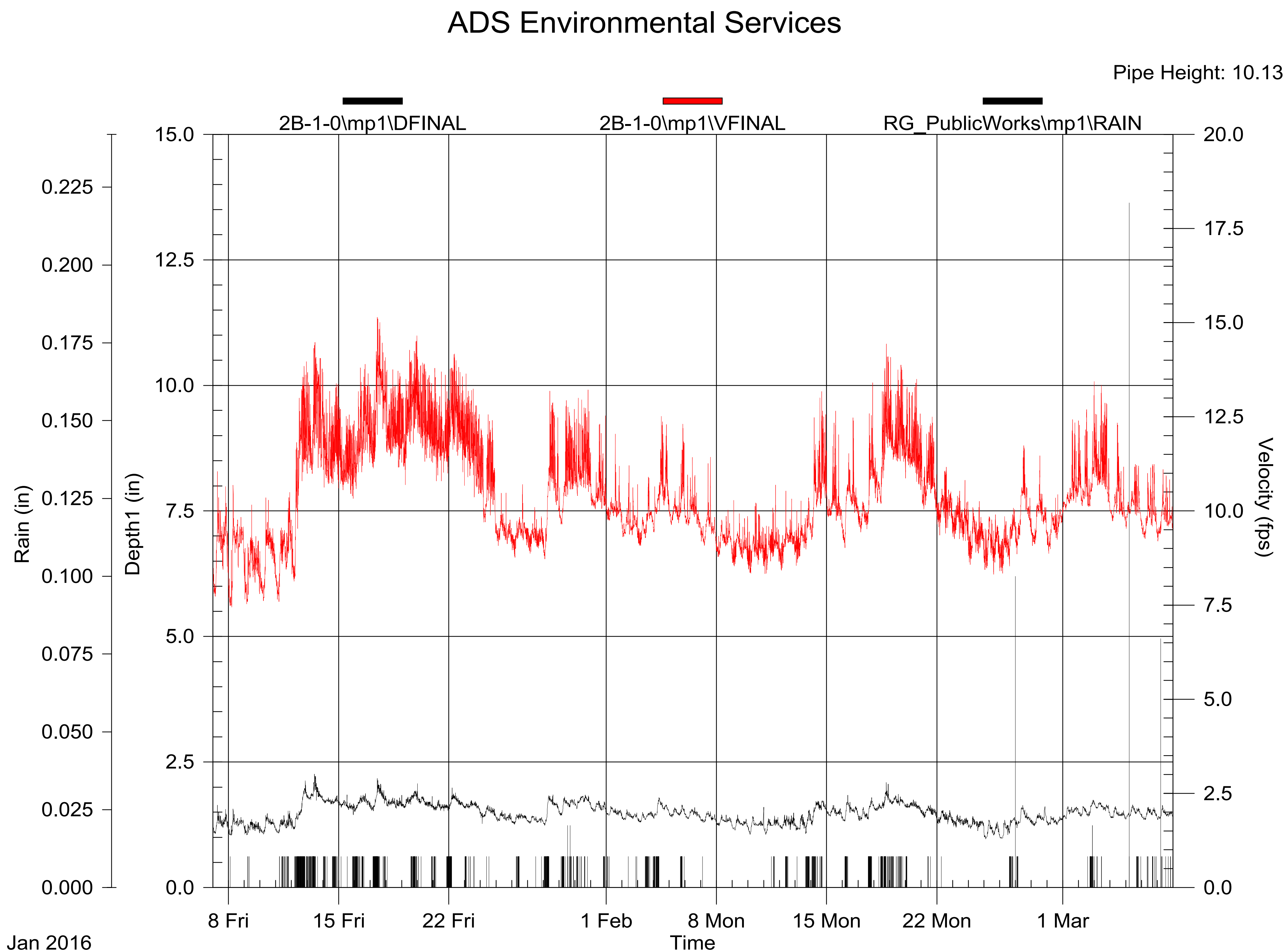


Installation Information	
Installation Type:	Standard
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity), CS5(Ultrasonic)
Surcharge Height:	None Observed
Rain Guage Zone:	RG_Publicworks (Gladstone)

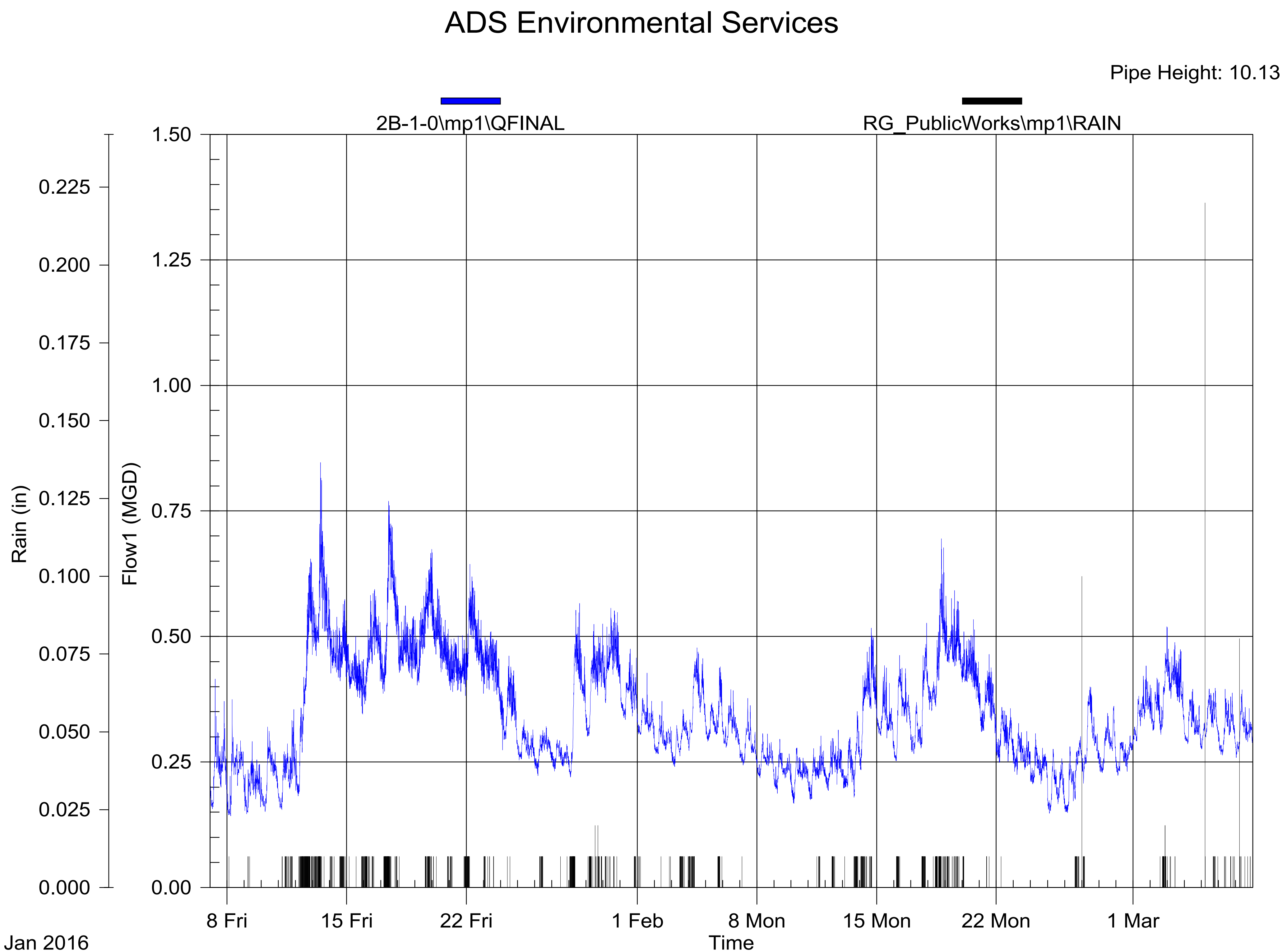
Backup	Yes	No	?	Distance
Trunk	[ ]	[X]	[ ]	
Lift / Pump Station	[ ]	[X]	[ ]	
WWTP	[ ]	[X]	[ ]	
Other	[ ]	[X]	[ ]	

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

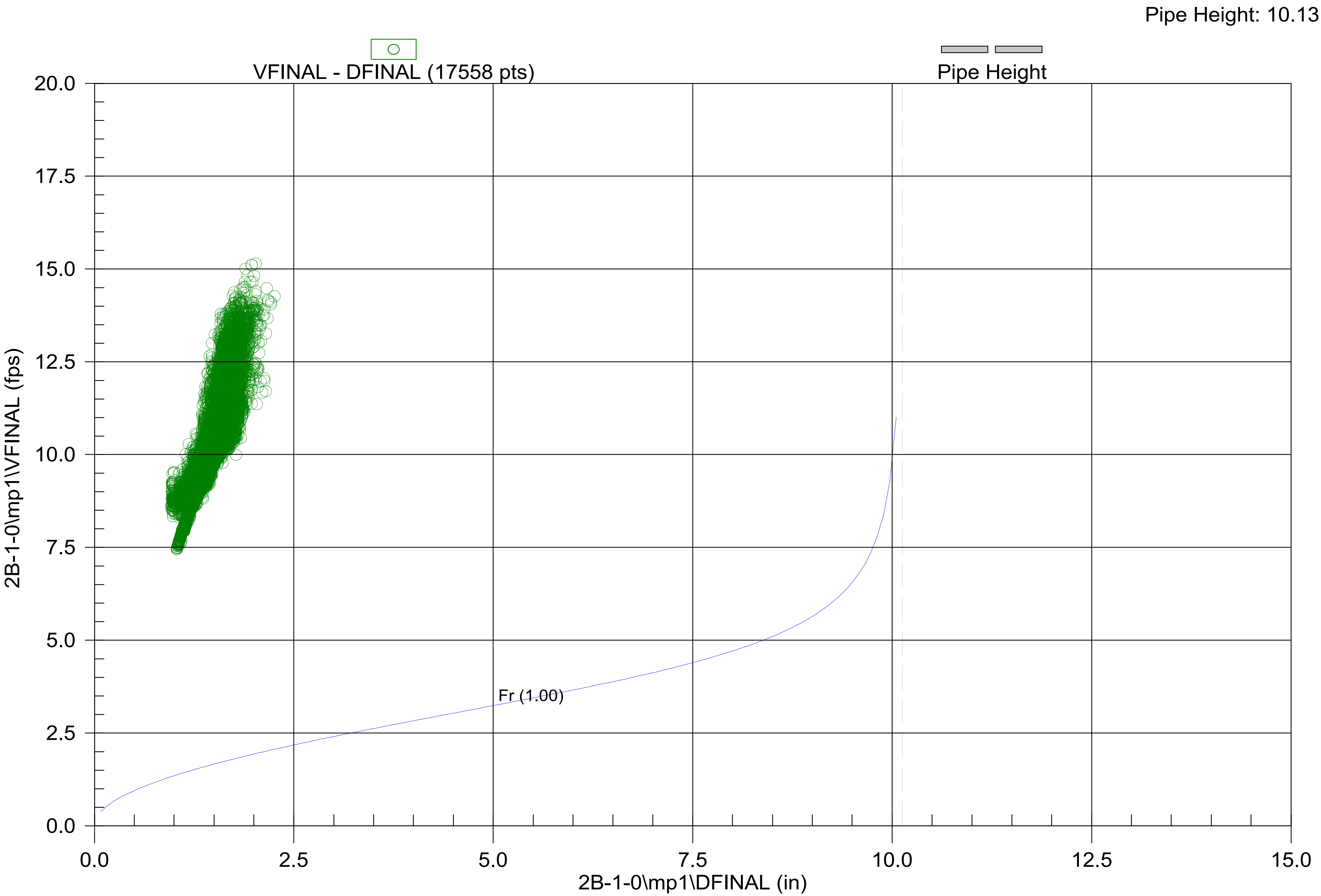


ADS Environmental Services
Pipe Height: 10.13
2B-1-0\mp1\DFINAL
2B-1-0\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Depth1 (in)
Velocity (fps)
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
0.225
0.0
2.5
5.0
7.5
10.0
12.5
15.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time



ADS Environmental Services
Pipe Height: 10.13
2B-1-0\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow1 (MGD)
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
1.50
1.25
1.00
0.75
0.50
0.25
0.00
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time

ADS Environmental Services
1/7/2016 12:00:00 AM - 3/7/2016 11:59:00 PM



ADS Environmental Services

	2B-1-0\mp1\DFINAL (inches)					2B-1-0\mp1\VFINAL (feet/sec)					2B-1-0\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
1/7/2016	3:40	1.1	7:30	1.6	1.3	3:40	7.7	7:30	11.0	9.0	3:40	0.157	7:30	0.415	0.234	0.234
1/8/2016	5:10	1.0	7:10	1.6	1.2	5:10	7.4	7:10	10.7	8.9	5:10	0.142	7:10	0.375	0.227	0.227
1/9/2016	3:50	1.0	11:25	1.4	1.2	3:50	7.5	11:25	10.2	8.5	3:50	0.147	11:25	0.291	0.199	0.199
1/10/2016	5:30	1.1	11:20	1.5	1.2	5:30	7.6	9:00	10.3	8.7	5:30	0.151	9:05	0.320	0.221	0.221
1/11/2016	4:40	1.1	19:10	1.5	1.2	5:15	7.6	21:40	10.5	8.9	5:15	0.155	21:40	0.355	0.226	0.226
1/12/2016	3:55	1.2	21:20	2.1	1.5	3:55	8.1	22:45	14.0	10.9	3:55	0.183	21:20	0.655	0.380	0.380
1/13/2016	23:40	1.7	11:20	2.3	1.9	7:45	11.0	11:55	14.5	12.4	5:35	0.461	11:20	0.846	0.566	0.566
1/14/2016	12:10	1.7	21:30	1.8	1.7	23:45	10.6	0:10	13.7	11.7	15:05	0.411	21:30	0.574	0.472	0.472
1/15/2016	22:20	1.4	12:45	1.8	1.6	22:05	10.3	1:20	12.7	11.4	22:20	0.345	12:45	0.500	0.424	0.424
1/16/2016	0:30	1.5	16:45	1.9	1.7	3:00	10.6	16:30	13.9	12.0	1:20	0.365	15:20	0.594	0.473	0.473
1/17/2016	5:20	1.5	10:50	2.2	1.8	5:05	11.1	11:05	15.1	12.9	3:15	0.386	11:05	0.769	0.550	0.550
1/18/2016	16:05	1.6	10:35	1.8	1.7	18:55	11.2	10:30	13.8	12.2	20:10	0.416	0:35	0.563	0.475	0.475
1/19/2016	4:45	1.6	21:40	1.9	1.7	5:45	10.7	23:35	14.7	12.6	3:10	0.403	23:35	0.673	0.521	0.521
1/20/2016	21:10	1.6	0:15	2.1	1.7	23:35	11.3	0:40	14.0	12.4	23:35	0.411	0:15	0.667	0.492	0.492
1/21/2016	16:30	1.5	9:00	1.7	1.6	5:00	10.8	2:45	13.8	11.9	22:40	0.382	18:45	0.502	0.435	0.435
1/22/2016	0:35	1.6	5:10	2.0	1.7	21:40	11.0	8:50	14.2	12.5	21:40	0.411	5:10	0.644	0.499	0.499
1/23/2016	23:30	1.5	10:20	1.7	1.6	14:55	10.4	2:10	13.6	11.7	23:55	0.349	10:40	0.510	0.437	0.437
1/24/2016	2:55	1.3	11:45	1.6	1.5	23:35	9.4	11:55	12.6	10.8	2:55	0.274	11:55	0.461	0.356	0.356
1/25/2016	2:20	1.3	9:05	1.5	1.4	3:35	9.1	15:10	10.5	9.5	23:35	0.250	9:05	0.335	0.281	0.281
1/26/2016	4:45	1.3	14:05	1.5	1.4	4:40	8.8	16:15	10.7	9.4	4:45	0.223	16:10	0.321	0.275	0.275
1/27/2016	3:40	1.3	7:40	1.4	1.3	3:55	8.9	10:55	10.1	9.3	3:55	0.232	7:40	0.294	0.263	0.263
1/28/2016	2:00	1.2	14:55	1.8	1.6	2:25	8.7	9:55	13.2	10.5	2:00	0.220	14:55	0.566	0.383	0.383
1/29/2016	2:10	1.4	8:40	1.8	1.6	3:05	9.6	11:30	12.9	10.8	2:10	0.301	23:25	0.525	0.408	0.408
1/30/2016	3:10	1.6	16:05	1.8	1.7	4:00	10.4	20:00	13.2	11.2	3:30	0.367	10:45	0.556	0.455	0.455
1/31/2016	23:55	1.5	12:20	1.7	1.6	7:15	10.0	22:35	12.5	10.5	23:55	0.329	14:05	0.475	0.381	0.381
ReportAvg					1.5					10.8					0.385	
ReportTotal																9.633

ADS Environmental Services

	2B-1-0\mp1\DFINAL (inches)					2B-1-0\mp1\VFINAL (feet/sec)					2B-1-0\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
2/1/2016	23:20	1.4	7:25	1.6	1.5	22:50	9.7	13:40	12.0	10.0	23:20	0.297	13:40	0.427	0.332	0.332
2/2/2016	5:05	1.3	7:30	1.6	1.4	23:55	9.3	10:40	11.2	9.6	5:05	0.265	10:40	0.371	0.294	0.294
2/3/2016	4:30	1.3	21:00	1.5	1.4	4:15	9.1	16:25	10.9	9.6	4:30	0.241	16:20	0.355	0.291	0.291
2/4/2016	0:50	1.4	8:30	1.8	1.6	0:15	9.4	11:55	12.5	10.5	0:50	0.273	11:55	0.478	0.376	0.376
2/5/2016	4:10	1.4	19:35	1.6	1.5	3:30	9.6	20:50	12.3	10.1	2:40	0.291	20:50	0.440	0.334	0.334
2/6/2016	23:55	1.4	14:45	1.6	1.5	23:55	9.5	11:20	11.4	10.0	23:55	0.272	11:20	0.394	0.315	0.315
2/7/2016	4:40	1.3	11:05	1.5	1.4	23:55	9.0	14:40	11.4	9.6	4:40	0.244	11:05	0.377	0.282	0.282
2/8/2016	23:55	1.2	8:15	1.5	1.3	2:30	8.8	17:50	10.0	9.2	23:55	0.217	8:15	0.307	0.254	0.254
2/9/2016	4:45	1.1	8:05	1.5	1.3	3:15	8.5	2:30	10.3	9.0	4:45	0.187	8:10	0.296	0.232	0.232
2/10/2016	3:50	1.1	7:25	1.4	1.2	4:30	8.3	11:55	10.2	9.0	3:50	0.167	8:15	0.279	0.224	0.224
2/11/2016	3:15	1.1	0:00	1.6	1.2	2:20	8.3	18:00	10.7	9.1	3:15	0.175	18:00	0.302	0.228	0.228
2/12/2016	16:25	1.1	21:45	1.5	1.3	3:15	8.4	9:40	10.5	9.2	4:25	0.193	18:25	0.314	0.243	0.243
2/13/2016	16:25	1.1	21:35	1.5	1.3	1:55	8.5	20:45	10.4	9.3	16:25	0.179	20:45	0.350	0.244	0.244
2/14/2016	1:50	1.2	16:55	1.7	1.6	1:10	9.2	16:40	13.2	10.7	2:20	0.234	16:40	0.517	0.379	0.379
2/15/2016	23:10	1.4	11:05	1.6	1.5	23:45	9.5	13:50	12.7	10.2	23:10	0.278	11:20	0.442	0.336	0.336
2/16/2016	4:10	1.3	8:15	1.8	1.5	3:45	9.0	16:15	12.5	10.2	3:45	0.252	8:15	0.462	0.348	0.348
2/17/2016	1:40	1.3	20:45	1.8	1.5	4:05	9.4	22:15	13.4	10.3	4:25	0.267	22:15	0.527	0.343	0.343
2/18/2016	2:30	1.5	19:00	2.1	1.7	10:55	10.2	19:10	14.4	11.5	5:10	0.352	19:00	0.695	0.446	0.446
2/19/2016	23:35	1.6	13:10	1.9	1.7	21:25	11.3	1:35	14.1	12.0	23:35	0.420	13:10	0.592	0.481	0.481
2/20/2016	23:20	1.5	12:20	1.7	1.6	23:45	10.6	17:10	13.5	11.7	23:50	0.364	15:55	0.534	0.433	0.433
2/21/2016	23:55	1.3	13:55	1.6	1.5	23:55	9.9	16:50	12.5	10.9	23:55	0.270	13:55	0.464	0.363	0.363
2/22/2016	16:35	1.3	8:10	1.5	1.4	4:30	9.4	14:20	11.2	10.1	4:30	0.249	7:55	0.359	0.302	0.302
2/23/2016	5:10	1.2	7:25	1.5	1.3	19:40	9.2	18:50	10.8	9.8	5:10	0.225	7:15	0.327	0.267	0.267
2/24/2016	14:45	1.1	7:10	1.4	1.3	2:55	8.6	16:55	10.3	9.3	14:45	0.206	7:10	0.307	0.241	0.241
2/25/2016	2:45	1.0	7:30	1.3	1.1	14:35	8.3	17:25	9.9	9.1	2:45	0.148	8:00	0.275	0.202	0.202
2/26/2016	2:10	1.0	22:30	1.4	1.2	4:15	8.3	20:40	10.1	9.2	4:15	0.149	22:30	0.301	0.221	0.221
2/27/2016	2:25	1.2	11:10	1.6	1.4	2:20	8.9	12:35	11.7	10.0	2:25	0.208	11:30	0.400	0.297	0.297
2/28/2016	4:50	1.2	21:05	1.6	1.4	1:45	9.1	13:05	11.5	9.8	4:50	0.229	21:00	0.361	0.282	0.282
2/29/2016	3:05	1.2	6:00	1.4	1.3	2:35	8.9	16:15	10.4	9.6	2:40	0.222	19:50	0.302	0.264	0.264
ReportAvg					1.4					10.0					0.305	
ReportTotal																8.853

ADS Environmental Services

	2B-1-0\mp1\DFINAL (inches)					2B-1-0\mp1\VFINAL (feet/sec)					2B-1-0\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
3/1/2016	0:00	1.4	8:10	1.6	1.5	0:15	10.0	14:55	12.4	10.5	0:00	0.285	18:25	0.442	0.348	0.348
3/2/2016	15:05	1.4	22:25	1.7	1.5	15:40	10.1	23:35	13.1	10.7	15:15	0.305	23:35	0.520	0.365	0.365
3/3/2016	23:55	1.5	8:30	1.7	1.6	23:55	10.1	0:00	13.4	11.2	23:55	0.323	0:00	0.518	0.410	0.410
3/4/2016	23:05	1.4	8:25	1.6	1.5	23:55	9.7	11:10	12.3	10.2	23:05	0.279	11:45	0.396	0.322	0.322
3/5/2016	0:15	1.4	10:35	1.6	1.5	0:55	9.5	14:55	11.2	10.1	0:35	0.275	19:35	0.397	0.334	0.334
3/6/2016	3:40	1.3	10:55	1.6	1.5	5:40	9.3	19:20	11.2	9.9	5:35	0.264	9:30	0.395	0.315	0.315
3/7/2016	0:55	1.3	8:05	1.6	1.5	0:55	9.2	8:55	11.1	9.8	0:55	0.259	9:00	0.394	0.312	0.312
ReportAvg					1.5					10.4					0.344	
ReportTotal																2.407

3A-8

Located At: 19150 Nixon Ave (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016
Pipe Dimensions: 16.88 in x 16.88 in
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sewer pipe. The scattergraph indicates normal open channel flow. The data plots below the Froude =1 curve indicating subcritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward and downward ultrasonic sensor.Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (in)	100%	100%
Velocity (f/s)	100%	100%
Quantity (MGD)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

Item	Depth (in)	Velocity (f/s)	Quantity (MGD)	% Full
Minimum	4.32	0.82	0.168	26%
Maximum	10.6	1.94	1.277	63%
Average	6.80	1.50	0.584	40%

ADS Site Report — Quality Form

ADS ENVIRONMENTAL SERVICES®

Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

Site Name: 3A-8	**Monitor Series:** 8000-FST	**Monitor S/N:**	20405
Address/Location: 19150 Nixon Ave		**IP Address:**	166.219.50.20
		Manhole #	3A-8
		GPS Coordinates	45.386992° -122.629380°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	16.88"
		Pipe Width:	16.88"

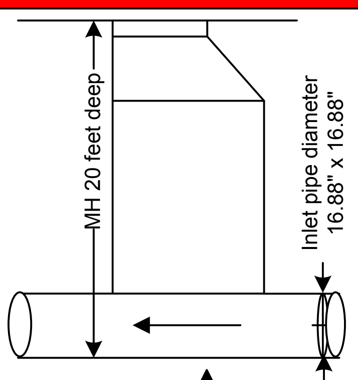
Investigation Information:

Date/Time of Investigation:	12/17/2015 @ 10:38
Site Hydraulics:	Smooth, Laminar
Upstream Input: (L/S, P/S)	P/S
Upstream Manhole:	DNI
Downstream Manhole:	Smooth, SlowVelocity
Depth of Flow:	10.88" +/- 0.25"
Range (Air DOF):	6.88" +/- 0.25"
Peak Velocity:	1.25 fps
Silt:	None

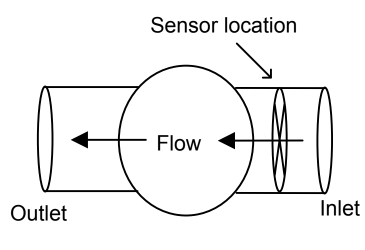
Manhole Information:

Manhole Depth:	20'	
Manhole Material / Condition	Concrete / Good	
Pipe Material / Condition:	PVC / Good	
Mini System Character:	Residential [ ] Commercial [ ] Industrial [ ] Trunk [X]	
Telephone Information:	Does not apply	
Access Pole #:	Does not apply	
Distance From Manhole:	Does not apply	Feet
Road Cut Length:	Does not apply	Feet
Trench Length:	Does not apply	Feet

Other Information:



Cross Section N



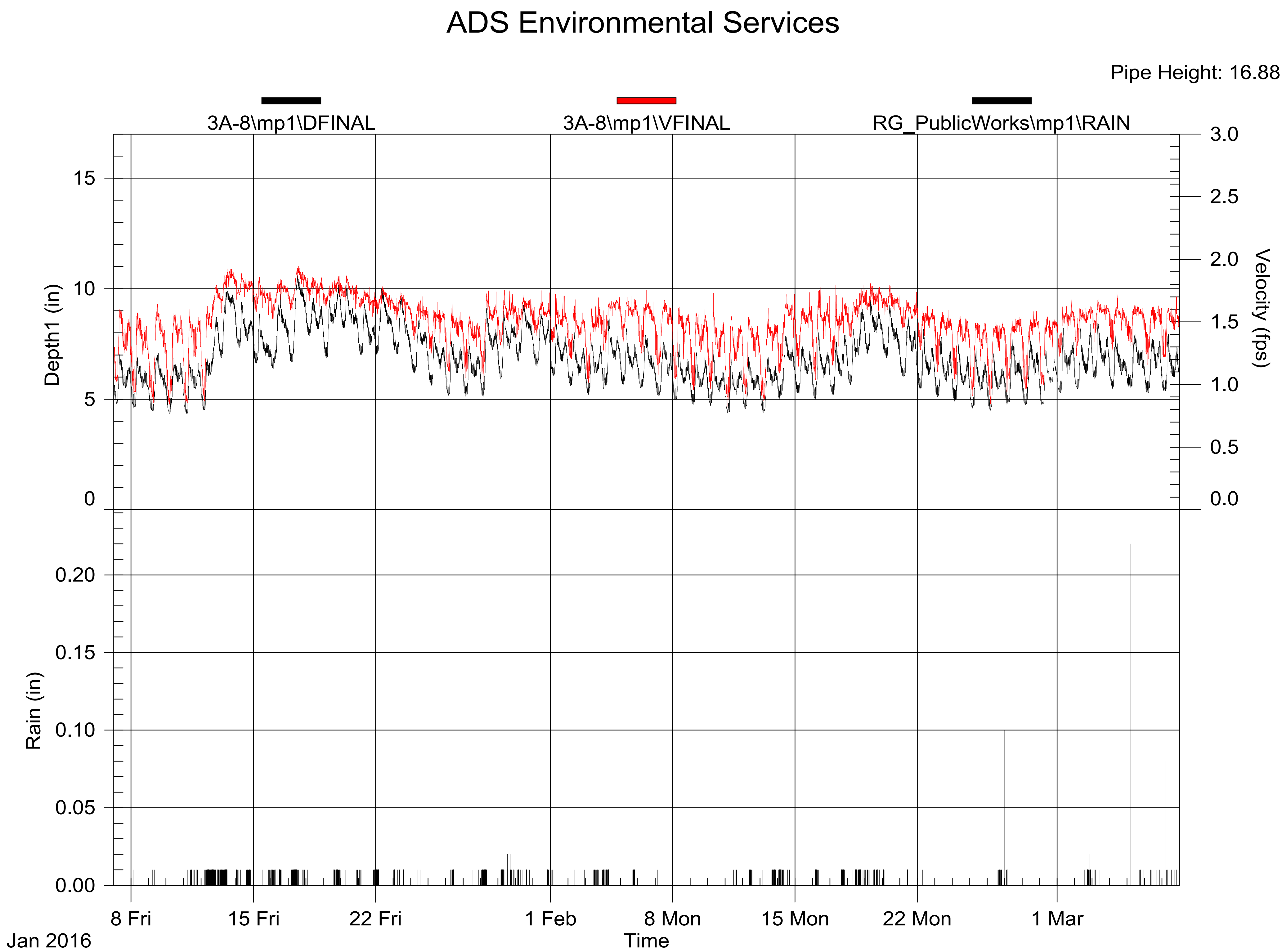
Planar N

Installation Information	
Installation Type:	Standard
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity)
Surcharge Height:	None Observd
Rain Guage Zone:	RG_Publicworks (Gladstone)

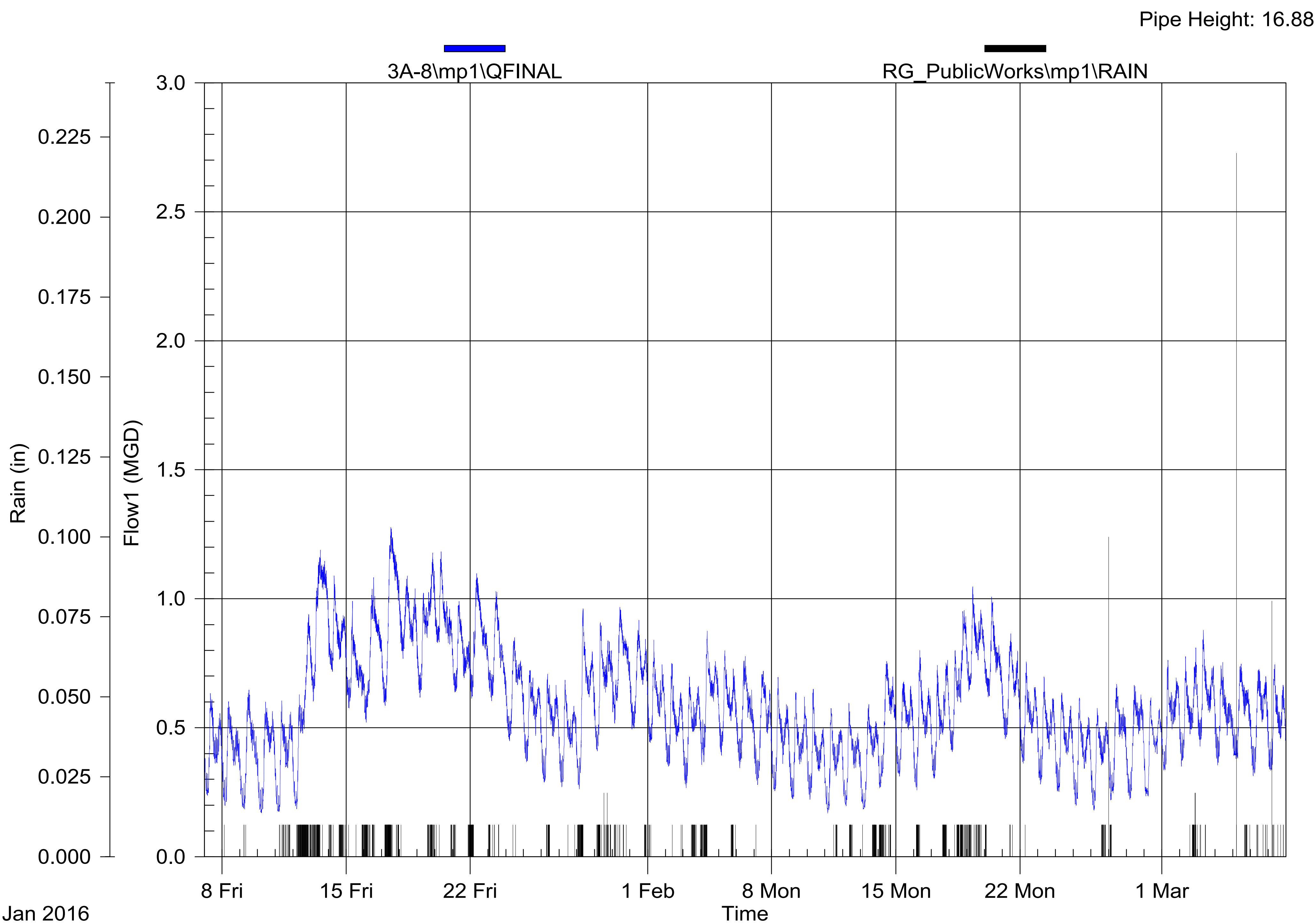
Backup	Yes	No	?	Distance
Trunk	[ ]	X	[ ]	
Lift / Pump Station	[ ]	X	[ ]	
WWTP	[ ]	X	[ ]	
Other	[ ]	X	[ ]	

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

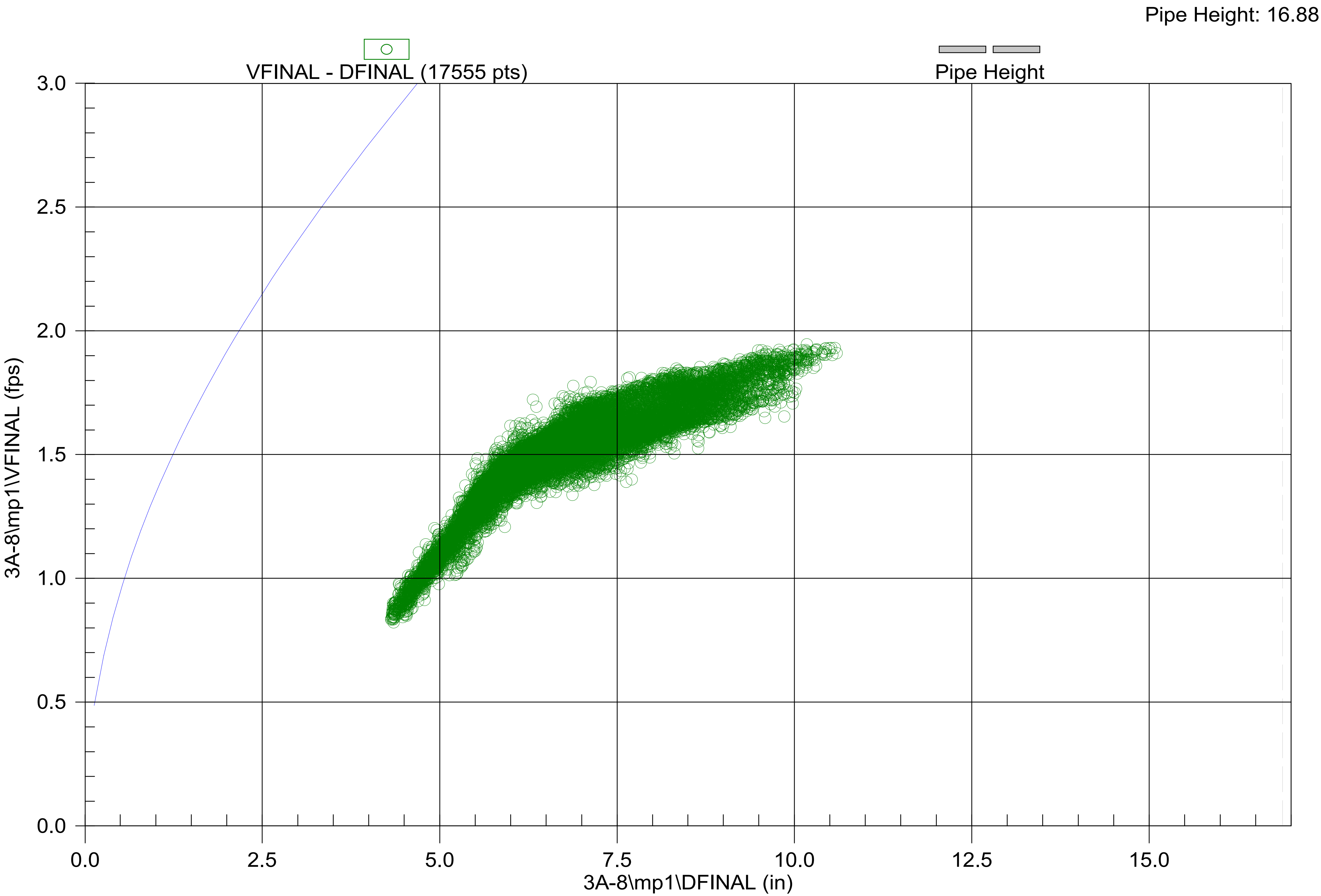

ADS Environmental Services
Pipe Height: 16.88
3A-8\mp1\DFINAL
3A-8\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Depth1 (in)
Velocity (fps)
Rain (in)
0
5
10
15
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0.00
0.05
0.10
0.15
0.20
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time

ADS Environmental Services



ADS Environmental Services

1/7/2016 12:00:00 AM - 3/7/2016 11:59:00 PM



ADS Environmental Services

	3A-8\mp1\DFINAL (inches)					3A-8\mp1\VFINAL (feet/sec)					3A-8\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
1/7/2016	4:10	4.8	8:20	7.0	5.8	3:25	1.0	8:20	1.6	1.3	4:10	0.238	8:20	0.634	0.420	0.420
1/8/2016	3:45	4.6	8:45	6.9	5.7	4:00	0.9	8:55	1.6	1.3	4:00	0.198	8:45	0.601	0.393	0.393
1/9/2016	5:05	4.4	13:20	7.1	5.7	6:30	0.9	12:20	1.6	1.3	6:30	0.184	12:20	0.647	0.395	0.395
1/10/2016	5:25	4.3	10:50	6.9	5.6	5:25	0.8	12:35	1.6	1.3	5:25	0.169	10:45	0.600	0.384	0.384
1/11/2016	4:35	4.3	8:50	6.8	5.6	5:40	0.9	8:50	1.6	1.3	4:35	0.174	8:50	0.605	0.383	0.383
1/12/2016	5:05	4.5	21:25	8.7	6.4	5:00	0.9	21:25	1.8	1.4	5:00	0.186	21:25	0.939	0.533	0.533
1/13/2016	3:45	6.9	13:05	10.0	8.8	3:40	1.6	13:05	1.9	1.8	3:40	0.602	13:05	1.191	0.956	0.956
1/14/2016	5:30	7.3	7:45	9.4	8.1	22:55	1.7	7:40	1.9	1.8	5:25	0.718	7:45	1.089	0.858	0.858
1/15/2016	3:15	6.6	8:25	8.9	7.4	20:55	1.6	8:25	1.9	1.7	3:15	0.575	8:25	0.991	0.718	0.718
1/16/2016	3:00	6.3	13:00	9.8	8.0	3:10	1.5	12:55	1.8	1.7	3:10	0.520	13:05	1.082	0.806	0.806
1/17/2016	4:35	6.6	12:30	10.6	8.8	2:50	1.6	13:45	1.9	1.8	4:40	0.585	12:35	1.277	0.964	0.964
1/18/2016	4:50	7.9	10:40	9.6	8.6	18:25	1.6	9:40	1.9	1.8	4:45	0.768	10:40	1.088	0.914	0.914
1/19/2016	4:05	6.9	20:55	10.2	8.6	4:00	1.6	23:05	1.9	1.7	4:05	0.617	21:00	1.177	0.900	0.900
1/20/2016	23:45	7.9	8:25	10.2	8.8	20:10	1.6	8:25	1.9	1.8	23:45	0.781	8:25	1.182	0.934	0.934
1/21/2016	3:10	7.0	8:15	9.3	8.0	19:50	1.5	15:55	1.8	1.7	2:55	0.638	8:55	0.990	0.780	0.780
1/22/2016	1:45	7.0	8:35	10.0	8.6	2:35	1.6	9:45	1.8	1.7	1:45	0.614	8:35	1.097	0.863	0.863
1/23/2016	5:50	7.1	11:55	9.6	8.1	16:55	1.5	10:40	1.8	1.6	4:45	0.604	10:40	1.029	0.780	0.780
1/24/2016	5:05	6.1	11:55	8.6	7.3	5:05	1.4	16:45	1.7	1.5	5:05	0.448	11:50	0.850	0.652	0.652
1/25/2016	5:30	5.6	9:15	7.8	6.7	4:15	1.2	12:35	1.7	1.5	4:20	0.365	9:15	0.722	0.555	0.555
1/26/2016	3:50	5.2	8:45	7.6	6.5	5:05	1.1	9:55	1.7	1.4	3:55	0.288	8:40	0.709	0.506	0.506
1/27/2016	4:00	5.1	8:05	7.6	6.3	4:00	1.1	8:10	1.6	1.4	4:00	0.270	8:10	0.685	0.470	0.470
1/28/2016	2:15	5.1	8:55	9.3	7.2	3:30	1.0	11:00	1.7	1.5	3:30	0.262	8:50	0.962	0.622	0.622
1/29/2016	4:00	5.9	7:55	9.0	7.5	3:55	1.3	9:05	1.8	1.5	3:55	0.410	7:55	0.908	0.675	0.675
1/30/2016	3:20	6.7	11:30	9.3	8.0	0:50	1.4	10:20	1.7	1.6	3:20	0.517	10:20	0.966	0.755	0.755
1/31/2016	5:45	6.4	11:30	8.9	7.7	2:50	1.3	12:15	1.7	1.6	2:50	0.495	12:15	0.917	0.692	0.692
ReportAvg					7.3					1.6					0.676	
ReportTotal																16.91

ADS Environmental Services

	3A-8\mp1\DFINAL (inches)					3A-8\mp1\VFINAL (feet/sec)					3A-8\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
2/1/2016	4:25	6.1	8:30	8.4	7.1	2:40	1.3	6:50	1.7	1.5	3:45	0.442	8:30	0.840	0.601	0.601
2/2/2016	4:35	5.6	8:40	8.0	6.5	5:15	1.2	11:00	1.7	1.4	4:20	0.350	8:45	0.751	0.519	0.519
2/3/2016	4:20	5.2	8:50	7.7	6.4	4:20	1.0	18:10	1.7	1.4	4:20	0.268	8:50	0.700	0.501	0.501
2/4/2016	1:10	5.4	8:45	8.8	7.0	4:10	1.3	22:55	1.7	1.6	1:10	0.357	8:45	0.875	0.623	0.623
2/5/2016	4:05	5.6	8:25	8.2	6.7	4:05	1.3	21:25	1.8	1.6	4:05	0.392	8:30	0.799	0.585	0.585
2/6/2016	3:55	5.5	10:50	7.9	6.5	4:40	1.2	12:15	1.8	1.5	4:40	0.342	12:15	0.776	0.551	0.551
2/7/2016	5:05	5.1	10:30	7.6	6.3	4:55	1.1	12:30	1.7	1.5	4:55	0.279	12:30	0.720	0.504	0.504
2/8/2016	4:25	4.9	8:50	7.5	6.0	4:10	1.0	8:40	1.6	1.4	4:20	0.255	8:45	0.696	0.449	0.449
2/9/2016	4:15	4.7	8:10	7.2	5.8	4:45	1.0	20:20	1.6	1.3	4:10	0.224	8:10	0.638	0.421	0.421
2/10/2016	3:50	4.7	8:25	7.2	5.7	4:00	1.0	8:00	1.7	1.3	3:50	0.220	8:00	0.650	0.393	0.393
2/11/2016	3:45	4.3	8:25	6.8	5.5	3:50	0.8	8:50	1.5	1.3	3:50	0.168	8:30	0.578	0.370	0.370
2/12/2016	3:55	4.6	8:30	6.9	5.6	4:50	0.9	8:35	1.5	1.3	4:50	0.197	8:30	0.596	0.380	0.380
2/13/2016	4:30	4.4	11:20	6.9	5.6	4:15	0.9	12:05	1.6	1.3	4:15	0.182	11:20	0.591	0.386	0.386
2/14/2016	3:20	5.0	11:40	7.9	6.5	2:05	1.1	23:25	1.7	1.5	2:05	0.267	11:40	0.757	0.528	0.528
2/15/2016	3:45	5.3	10:35	7.4	6.3	5:00	1.1	20:00	1.7	1.5	5:00	0.312	10:35	0.678	0.508	0.508
2/16/2016	4:30	5.0	8:20	8.0	6.4	4:35	1.0	10:40	1.8	1.5	4:35	0.258	8:30	0.800	0.516	0.516
2/17/2016	4:30	5.2	22:05	7.9	6.5	4:20	1.2	8:00	1.8	1.5	3:25	0.304	22:05	0.762	0.530	0.530
2/18/2016	4:20	5.7	20:30	9.1	7.3	5:10	1.4	22:35	1.8	1.6	4:20	0.407	20:30	0.956	0.672	0.672
2/19/2016	3:40	7.1	7:55	9.5	8.2	18:20	1.6	8:00	1.8	1.7	2:50	0.641	8:00	1.047	0.828	0.828
2/20/2016	5:05	6.8	9:55	9.3	7.8	3:35	1.6	9:50	1.8	1.7	5:00	0.619	9:50	1.007	0.761	0.761
2/21/2016	5:35	6.0	11:40	8.7	7.2	4:10	1.4	23:00	1.7	1.6	4:10	0.457	11:40	0.864	0.645	0.645
2/22/2016	3:30	5.5	8:40	8.2	6.5	4:35	1.3	13:55	1.6	1.5	4:35	0.362	8:40	0.756	0.539	0.539
2/23/2016	4:00	5.1	8:50	7.8	6.2	4:00	1.1	18:20	1.6	1.4	4:00	0.281	8:50	0.698	0.483	0.483
2/24/2016	2:45	4.9	8:50	7.5	6.0	5:00	1.0	10:40	1.5	1.4	5:00	0.253	8:55	0.636	0.438	0.438
2/25/2016	4:20	4.6	8:45	7.3	5.7	4:20	0.9	7:55	1.5	1.3	4:20	0.198	8:45	0.618	0.401	0.401
2/26/2016	4:15	4.5	8:50	7.1	5.6	4:10	0.8	21:25	1.5	1.3	4:10	0.180	8:50	0.576	0.391	0.391
2/27/2016	3:25	4.8	11:10	7.7	6.1	2:55	0.9	19:40	1.5	1.4	2:55	0.217	11:10	0.669	0.450	0.450
2/28/2016	4:40	4.7	10:45	7.7	6.1	4:50	1.0	19:45	1.6	1.4	4:50	0.222	10:45	0.664	0.458	0.458
2/29/2016	2:25	4.8	8:40	7.2	5.9	5:35	1.0	10:55	1.5	1.4	5:35	0.235	9:15	0.617	0.433	0.433
ReportAvg					6.4					1.4					0.513	
ReportTotal																14.86

ADS Environmental Services

	3A-8\mp1\DFINAL (inches)					3A-8\mp1\VFINAL (feet/sec)					3A-8\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
3/1/2016	4:45	5.3	8:30	8.2	6.6	3:05	1.2	19:35	1.7	1.5	3:05	0.335	8:30	0.762	0.541	0.541
3/2/2016	4:10	5.5	22:15	8.4	6.7	2:40	1.2	22:15	1.6	1.5	2:40	0.350	22:15	0.810	0.562	0.562
3/3/2016	3:05	5.9	8:25	8.7	7.0	3:50	1.3	8:30	1.7	1.6	3:50	0.428	8:25	0.878	0.624	0.624
3/4/2016	3:40	5.4	8:05	7.9	6.4	3:40	1.3	10:35	1.7	1.5	3:40	0.355	10:35	0.754	0.537	0.537
3/5/2016	5:25	5.5	11:20	8.0	6.6	4:25	1.3	10:40	1.6	1.5	5:25	0.379	11:20	0.747	0.558	0.558
3/6/2016	5:50	5.3	11:50	7.8	6.5	3:40	1.1	19:00	1.6	1.5	3:55	0.313	11:50	0.727	0.537	0.537
3/7/2016	2:00	5.3	9:05	7.9	6.4	3:40	1.2	20:00	1.7	1.5	3:40	0.334	9:05	0.746	0.517	0.517
ReportAvg					6.6					1.5					0.554	
ReportTotal																3.876

3B-4

Located At: 4426 Mapleton Dr (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016
Pipe Dimensions: 7.88 in x 8 in
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sewer pipe. The scattergraph indicates normal open channel flow with periods of backwater. The site surcharged several times during the monitoring period indication a capacity issue in the line. The data plots above the Froude =1 curve indicating supercritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward ultrasonic sensor and the pressure sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (in)	100%	100%
Velocity (f/s)	100%	100%
Quantity (MGD)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

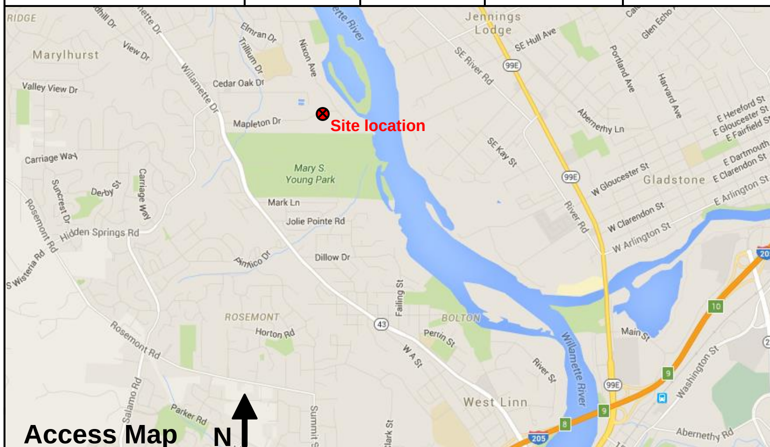
Item	Depth (in)	Velocity (f/s)	Quantity (MGD)	% Full
Minimum	0.87	0.54	0.036	11%
Maximum	15.2	4.84	0.902	192%
Average	1.74	3.88	0.132	22%

ADS Environmental Services — ADS Site Report — Quality Form

Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

Site Name:	3B-4	**Monitor Series:**	8000-FST
Address/Location:	4426 Mapleton Dr.		
Access:	Drive	**Type of System:**	Sanitary [X] Storm [ ] Combined [ ]

Monitor S/N:	20646
IP Address:	166.219.50.35
Manhole #	3B-4
GPS Coordinates	45.381743° -122.630919°
Pipe Height:	7.88"
Pipe Width:	8.00"



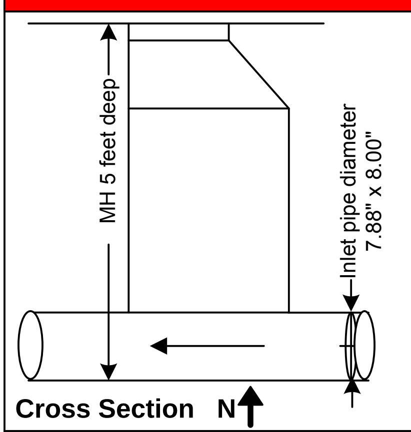
Investigation Information:

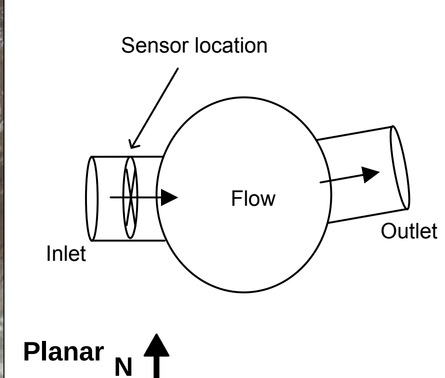
Date/Time of Investigation:	12/16/2015 @ 12:15
Site Hydraulics:	Ripples
Upstream Input: (L/S, P/S)	DNI
Upstream Manhole:	DNI
Downstream Manhole:	Shallow with fast flow
Depth of Flow:	1.63" +/- 0.25"
Range (Air DOF):	6.13" +/- 0.25"
Peak Velocity:	4.41 fps
Silt:	None

Manhole Information:

Manhole Depth:	5'	
Manhole Material / Condition	Concrete / Good	
Pipe Material / Condition:	Concrete / Good	
Mini System Character:	Residential [X] Commercial [ ] Industrial [ ] Trunk [ ]	
Telephone Information:	Does not apply	
Access Pole #:	Does not apply	
Distance From Manhole:	Does not apply	Feet
Road Cut Length:	Does not apply	Feet
Trench Length:	Does not apply	Feet

Other Information:



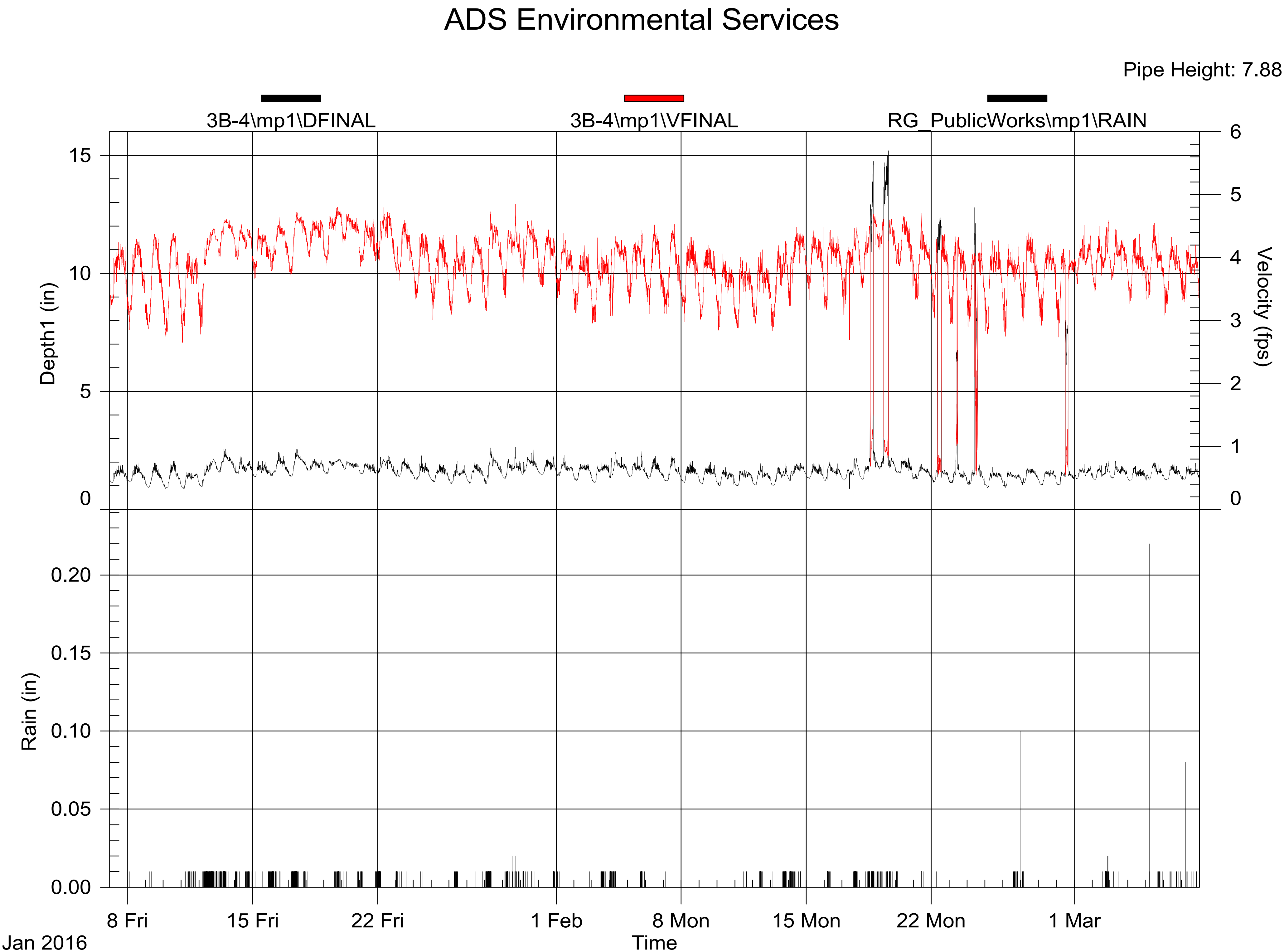


Installation Information	
Installation Type:	Standard
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity) CS5(Ultrasonic)
Surcharge Height:	1.25 ft
Rain Guage Zone:	RG_Publicworks (Gladstone)

Backup	Yes	No	?	Distance
Trunk			X	~935 ft
Lift / Pump Station		X	X	~1497 ft
WWTP		X		
Other				

Additional Site Information / Comments:

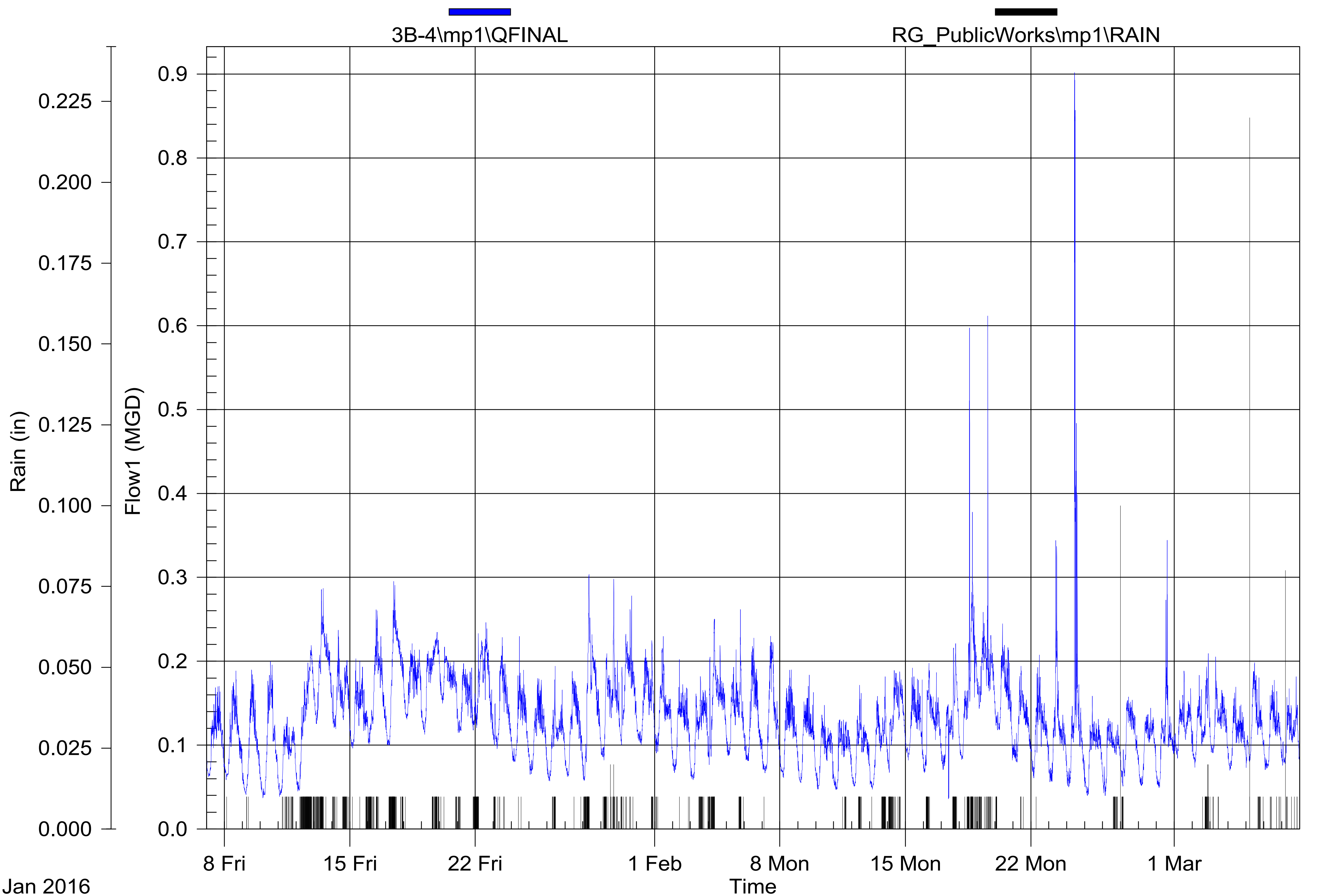
Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)



ADS Environmental Services
Pipe Height: 7.88
3B-4\mp1\DFINAL
3B-4\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Depth1 (in)
Velocity (fps)
Rain (in)
15
10
5
0
6
5
4
3
2
1
0
0.20
0.15
0.10
0.05
0.00
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time

ADS Environmental Services

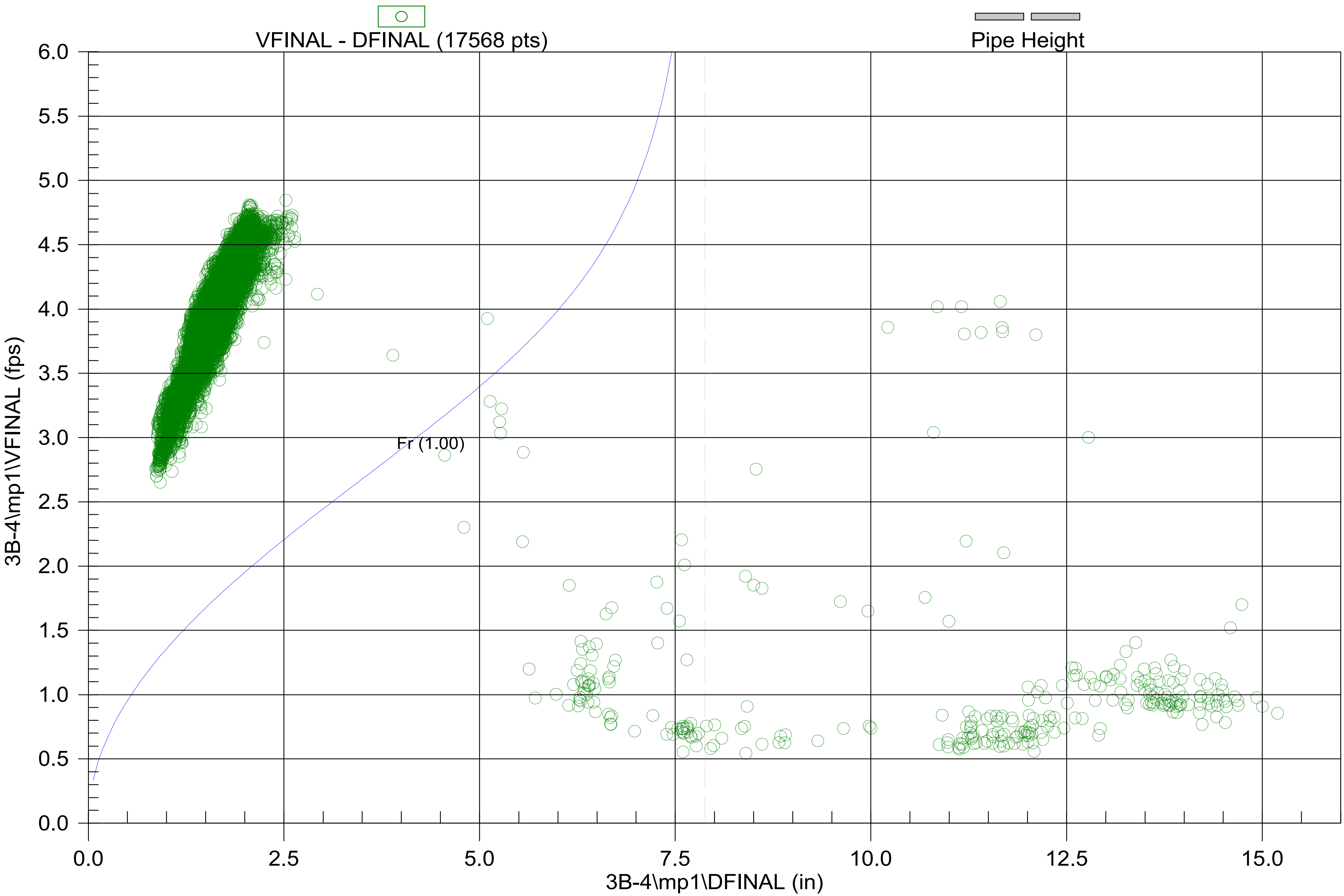
Pipe Height: 7.88



ADS Environmental Services

1/7/2016 12:00:00 AM - 3/7/2016 11:59:00 PM

Pipe Height: 7.88



ADS Environmental Services

	3B-4\mp1\DFINAL (inches)					3B-4\mp1\VFINAL (feet/sec)					3B-4\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
1/7/2016	2:40	1.1	17:10	1.9	1.4	0:40	3.2	11:45	4.2	3.8	2:40	0.062	17:10	0.170	0.106	0.106
1/8/2016	4:05	1.2	15:20	2.0	1.5	2:35	2.9	12:10	4.3	3.7	2:35	0.058	15:20	0.188	0.108	0.108
1/9/2016	4:40	0.9	12:15	2.0	1.4	4:45	2.9	12:20	4.4	3.6	4:40	0.041	12:15	0.190	0.097	0.097
1/10/2016	3:40	0.9	13:45	2.0	1.4	3:40	2.7	13:50	4.4	3.6	3:40	0.036	13:45	0.200	0.099	0.099
1/11/2016	3:20	0.9	12:05	1.6	1.3	1:50	2.6	11:55	4.1	3.6	1:50	0.039	12:05	0.134	0.088	0.088
1/12/2016	3:10	1.0	20:15	2.2	1.6	2:10	2.8	19:20	4.5	4.0	2:10	0.045	20:20	0.219	0.134	0.134
1/13/2016	3:20	1.6	12:25	2.6	2.0	4:35	4.0	13:20	4.6	4.4	3:20	0.126	12:25	0.287	0.193	0.193
1/14/2016	23:50	1.5	8:20	2.3	1.7	23:55	4.0	9:10	4.5	4.3	23:50	0.117	8:20	0.237	0.158	0.158
1/15/2016	3:15	1.4	13:20	2.0	1.6	2:25	3.7	8:05	4.5	4.1	3:50	0.096	8:05	0.203	0.138	0.138
1/16/2016	1:35	1.4	11:05	2.4	1.8	1:25	3.8	12:45	4.6	4.2	1:35	0.101	11:05	0.262	0.164	0.164
1/17/2016	4:55	1.4	10:45	2.6	1.9	3:35	3.7	10:45	4.7	4.3	4:30	0.100	10:45	0.295	0.186	0.186
1/18/2016	5:15	1.6	11:25	2.1	1.8	4:20	4.0	9:20	4.6	4.4	4:20	0.131	11:25	0.221	0.174	0.174
1/19/2016	4:30	1.5	20:40	2.2	1.9	4:10	3.9	18:40	4.8	4.5	4:10	0.113	20:45	0.235	0.184	0.184
1/20/2016	23:35	1.6	6:50	2.1	1.9	23:35	4.1	8:20	4.7	4.5	23:35	0.132	6:50	0.217	0.180	0.180
1/21/2016	2:25	1.5	8:20	2.0	1.7	1:15	3.9	19:15	4.6	4.3	1:15	0.115	8:20	0.197	0.151	0.151
1/22/2016	23:35	1.5	14:15	2.3	1.9	23:35	3.9	8:35	4.8	4.4	23:35	0.112	14:15	0.246	0.177	0.177
1/23/2016	1:35	1.4	11:55	2.2	1.7	5:00	3.6	11:55	4.6	4.1	5:15	0.096	11:55	0.228	0.145	0.145
1/24/2016	5:05	1.3	11:00	2.3	1.5	3:25	3.3	12:15	4.4	3.9	5:05	0.080	11:00	0.230	0.123	0.123
1/25/2016	3:20	1.2	13:20	1.9	1.5	1:20	3.0	16:15	4.4	3.8	1:20	0.065	11:45	0.180	0.116	0.116
1/26/2016	3:30	1.1	10:55	2.0	1.4	2:40	3.1	10:10	4.4	3.8	3:30	0.057	10:55	0.194	0.107	0.107
1/27/2016	3:35	1.1	9:45	2.0	1.5	2:55	3.3	11:15	4.4	3.9	3:35	0.063	9:50	0.188	0.118	0.118
1/28/2016	1:45	1.1	8:10	2.6	1.8	2:15	3.1	8:10	4.7	4.1	2:15	0.058	8:10	0.304	0.158	0.158
1/29/2016	4:20	1.3	17:10	2.6	1.7	4:30	3.3	17:20	4.8	4.1	4:15	0.082	17:20	0.298	0.153	0.153
1/30/2016	3:25	1.5	17:10	2.5	1.9	3:40	3.5	15:15	4.6	4.2	3:40	0.100	17:10	0.278	0.169	0.169
1/31/2016	5:55	1.5	20:30	2.2	1.8	6:00	3.5	13:55	4.4	4.0	6:00	0.101	20:30	0.225	0.149	0.149
ReportAvg					1.7					4.1					0.143	
ReportTotal																3.574

ADS Environmental Services

	3B-4\mp1\DFINAL (inches)					3B-4\mp1\VFINAL (feet/sec)					3B-4\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
2/1/2016	23:55	1.4	11:45	2.3	1.7	2:25	3.3	10:15	4.4	3.9	23:55	0.090	11:45	0.229	0.138	0.138
2/2/2016	3:05	1.2	9:25	2.2	1.6	2:50	3.1	13:50	4.2	3.7	2:50	0.067	9:25	0.202	0.120	0.120
2/3/2016	3:25	1.1	13:35	2.0	1.6	1:10	3.0	7:35	4.3	3.6	3:45	0.059	13:35	0.182	0.117	0.117
2/4/2016	1:10	1.3	8:20	2.4	1.8	1:10	3.1	8:05	4.3	4.0	1:10	0.076	7:55	0.250	0.157	0.157
2/5/2016	3:50	1.4	19:15	2.5	1.7	2:10	3.3	19:15	4.4	3.9	2:35	0.087	19:15	0.262	0.139	0.139
2/6/2016	4:20	1.3	13:10	2.2	1.6	5:50	3.1	12:05	4.5	3.9	5:10	0.081	13:10	0.228	0.133	0.133
2/7/2016	4:50	1.2	11:25	2.3	1.6	4:00	3.1	14:50	4.5	3.8	4:00	0.067	11:25	0.230	0.127	0.127
2/8/2016	4:30	1.1	15:00	2.0	1.5	4:50	3.0	13:00	4.3	3.8	4:50	0.061	15:00	0.190	0.115	0.115
2/9/2016	4:05	1.1	15:15	2.0	1.4	2:35	3.0	13:05	4.2	3.7	4:05	0.055	15:15	0.184	0.106	0.106
2/10/2016	3:10	1.0	11:35	1.8	1.4	2:10	2.8	8:05	4.1	3.5	3:10	0.047	11:35	0.147	0.092	0.092
2/11/2016	3:30	1.0	13:10	1.7	1.4	4:30	2.9	7:30	4.0	3.5	3:35	0.047	8:15	0.130	0.092	0.092
2/12/2016	3:45	1.0	10:40	1.9	1.4	3:35	3.0	11:10	4.4	3.6	3:45	0.051	10:40	0.171	0.095	0.095
2/13/2016	4:10	1.0	20:45	2.0	1.4	2:20	2.8	20:50	4.3	3.7	4:10	0.047	20:45	0.181	0.100	0.100
2/14/2016	2:35	1.2	8:55	2.0	1.6	1:45	3.2	11:00	4.5	4.1	2:35	0.067	8:55	0.189	0.138	0.138
2/15/2016	23:30	1.3	9:25	2.0	1.6	4:00	3.3	22:40	4.5	4.0	4:00	0.082	9:25	0.192	0.125	0.125
2/16/2016	2:15	1.2	7:40	2.0	1.6	3:05	3.2	8:20	4.4	4.0	1:25	0.067	7:40	0.198	0.128	0.128
2/17/2016	9:40	0.9	19:15	2.2	1.6	10:20	2.7	19:05	4.5	3.9	9:40	0.036	19:15	0.221	0.127	0.127
2/18/2016	3:45	1.3	17:55	14.7	3.5	14:25	0.7	18:20	4.7	3.6	3:25	0.083	13:55	0.597	0.176	0.176
2/19/2016	2:55	1.7	14:25	15.2	5.1	12:25	0.8	18:25	4.6	3.5	2:55	0.144	14:30	0.612	0.192	0.192
2/20/2016	23:20	1.3	10:00	2.3	1.7	23:20	3.5	10:45	4.7	4.2	23:20	0.082	10:00	0.245	0.155	0.155
2/21/2016	0:45	1.3	11:10	1.9	1.6	5:30	3.3	11:00	4.7	4.0	5:20	0.080	11:00	0.194	0.124	0.124
2/22/2016	2:45	1.1	11:25	12.5	3.7	9:50	0.6	17:50	4.4	3.1	4:10	0.061	11:25	0.207	0.117	0.117
2/23/2016	1:40	1.1	10:50	6.7	1.8	10:00	1.0	8:45	4.3	3.6	1:40	0.056	9:30	0.344	0.117	0.117
2/24/2016	2:55	1.0	10:20	12.8	2.7	12:30	0.5	19:00	4.2	3.3	2:55	0.050	10:30	0.902	0.149	0.149
2/25/2016	3:50	0.9	10:25	1.8	1.3	3:50	2.8	18:25	4.3	3.7	3:50	0.040	10:25	0.158	0.092	0.092
2/26/2016	3:35	0.9	8:20	1.6	1.3	3:35	2.7	8:25	4.2	3.7	3:35	0.040	8:25	0.133	0.093	0.093
2/27/2016	3:15	1.0	9:50	1.7	1.4	3:15	3.0	11:00	4.4	3.8	3:15	0.051	11:10	0.157	0.109	0.109
2/28/2016	4:40	1.0	16:35	1.7	1.4	4:05	2.9	16:40	4.2	3.7	4:05	0.052	16:35	0.144	0.099	0.099
2/29/2016	4:25	1.0	12:10	8.0	2.2	12:20	0.6	9:30	4.1	3.2	4:25	0.049	14:25	0.344	0.106	0.106
ReportAvg					1.9					3.7					0.123	
ReportTotal																3.577

ADS Environmental Services

	3B-4\mp1\DFINAL (inches)					3B-4\mp1\VFINAL (feet/sec)					3B-4\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
3/1/2016	4:25	1.3	13:20	1.9	1.5	4:30	3.6	13:20	4.5	4.0	4:25	0.084	13:20	0.188	0.124	0.124
3/2/2016	4:30	1.2	21:40	2.0	1.5	3:50	3.2	21:35	4.6	4.0	3:50	0.074	21:40	0.209	0.125	0.125
3/3/2016	3:30	1.3	7:45	2.1	1.6	1:50	3.6	7:45	4.4	4.0	3:30	0.090	7:45	0.205	0.127	0.127
3/4/2016	3:15	1.2	10:30	1.8	1.5	2:35	3.3	16:00	4.4	3.9	2:35	0.070	10:30	0.169	0.110	0.110
3/5/2016	0:35	1.2	9:55	2.0	1.6	0:35	3.3	11:45	4.6	3.9	0:35	0.073	11:45	0.198	0.125	0.125
3/6/2016	5:45	1.2	14:15	1.9	1.5	1:40	3.1	11:05	4.3	3.8	1:40	0.071	14:15	0.178	0.114	0.114
3/7/2016	1:20	1.2	19:15	2.0	1.5	4:40	3.3	19:15	4.2	3.8	1:15	0.076	19:15	0.182	0.114	0.114
ReportAvg					1.5					3.9					0.120	
ReportTotal																0.838

9A-2

Located At: 4th St and Volpe NE of Reservoir (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016
Pipe Dimensions: 17.63 in x 17.63 in
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sewer pipe. The scattergraph indicates normal open channel flow. The data plots above the Froude =1 curve indicating supercritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (in)	100%	100%
Velocity (f/s)	100%	100%
Quantity (MGD)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

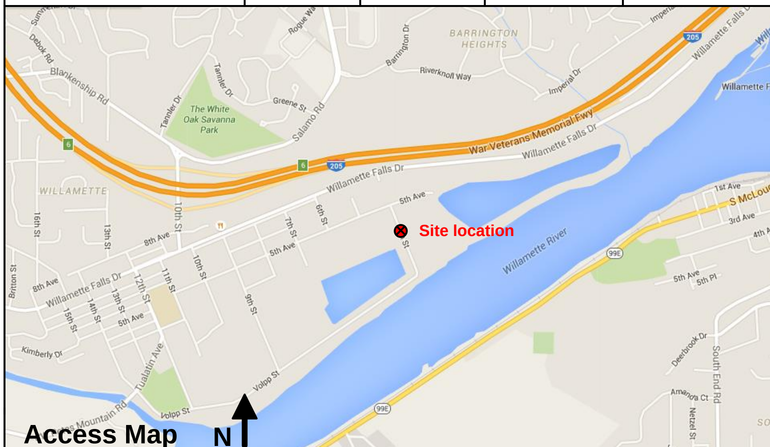
Item	Depth (in)	Velocity (f/s)	Quantity (MGD)	% Full
Minimum	2.43	4.25	0.404	12%
Maximum	6.44	7.17	2.557	37%
Average	4.31	5.88	1.253	24%

ADS Site Report — Quality Form

ADS ENVIRONMENTAL SERVICES

Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

Site Name: 9A-2	**Monitor Series:** 8000-FST	**Monitor S/N:**	20357
Address/Location:	4th St and Volppe NE of Resevoir	**IP Address:**	166.219.172.10
		Manhole #	9A-2
		GPS Coordinates	45.345884° -122.639997°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	17.63"
		Pipe Width:	17.63"



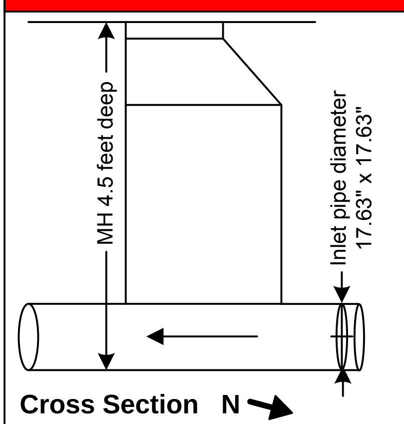
Investigation Information:

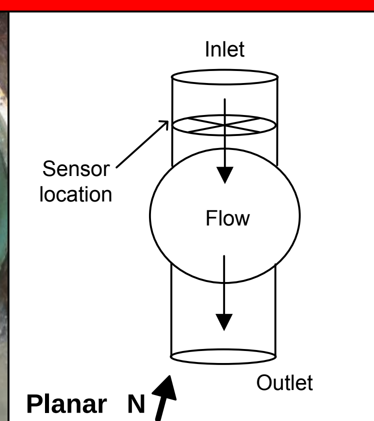
Date/Time of Investigation:	12/16/2015 @ 09:31
Site Hydraulics:	Ripples, Fast Velocity
Upstream Input: (L/S, P/S)	DNI
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow:	4.50" +/- 0.25"
Range (Air DOF):	13.13" +/- 0.25"
Peak Velocity:	6.80 fps
Silt:	None

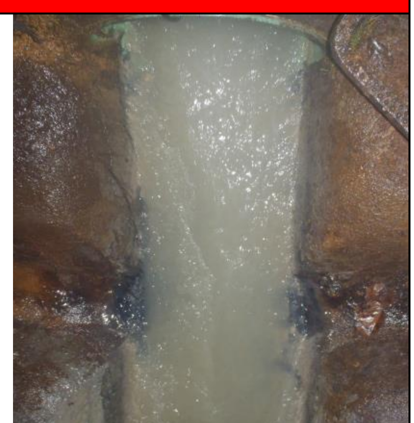
Manhole Information:

Manhole Depth:	4.5'
Manhole Material / Condition	Concrete / Good
Pipe Material / Condition:	PVC / Good
Mini System Character:	Residential [ ] Commercial [ ] Industrial [ ] Trunk [X]
Telephone Information:	Does not apply
Access Pole #:	Does not apply
Distance From Manhole:	Does not apply Feet
Road Cut Length:	Does not apply Feet
Trench Length:	Does not apply Feet

Other Information:





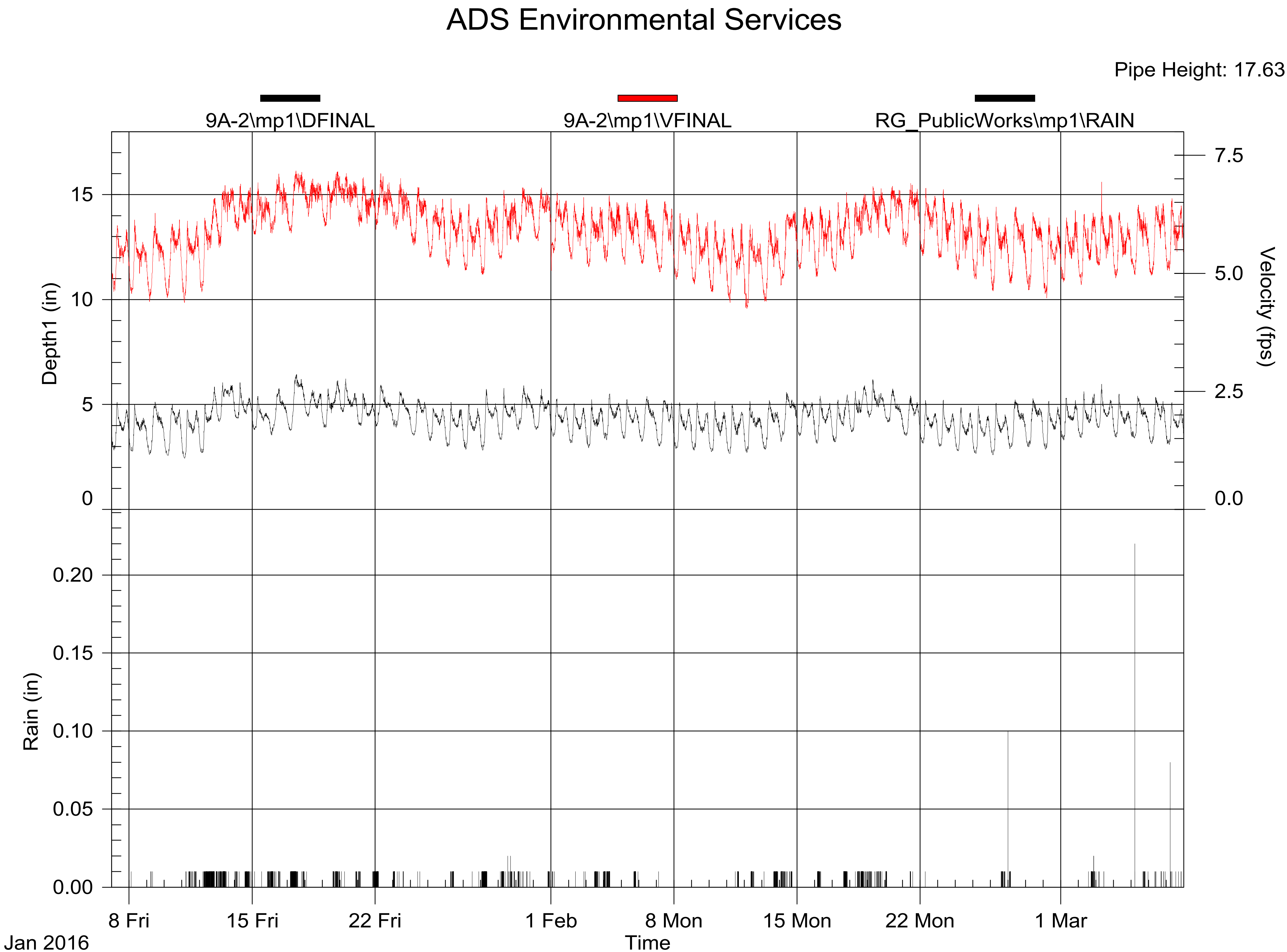


Installation Information	
Installation Type:	Standard
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity)
Surcharge Height:	None observed
Rain Guage Zone:	RG_Publicworks (Gladstone)

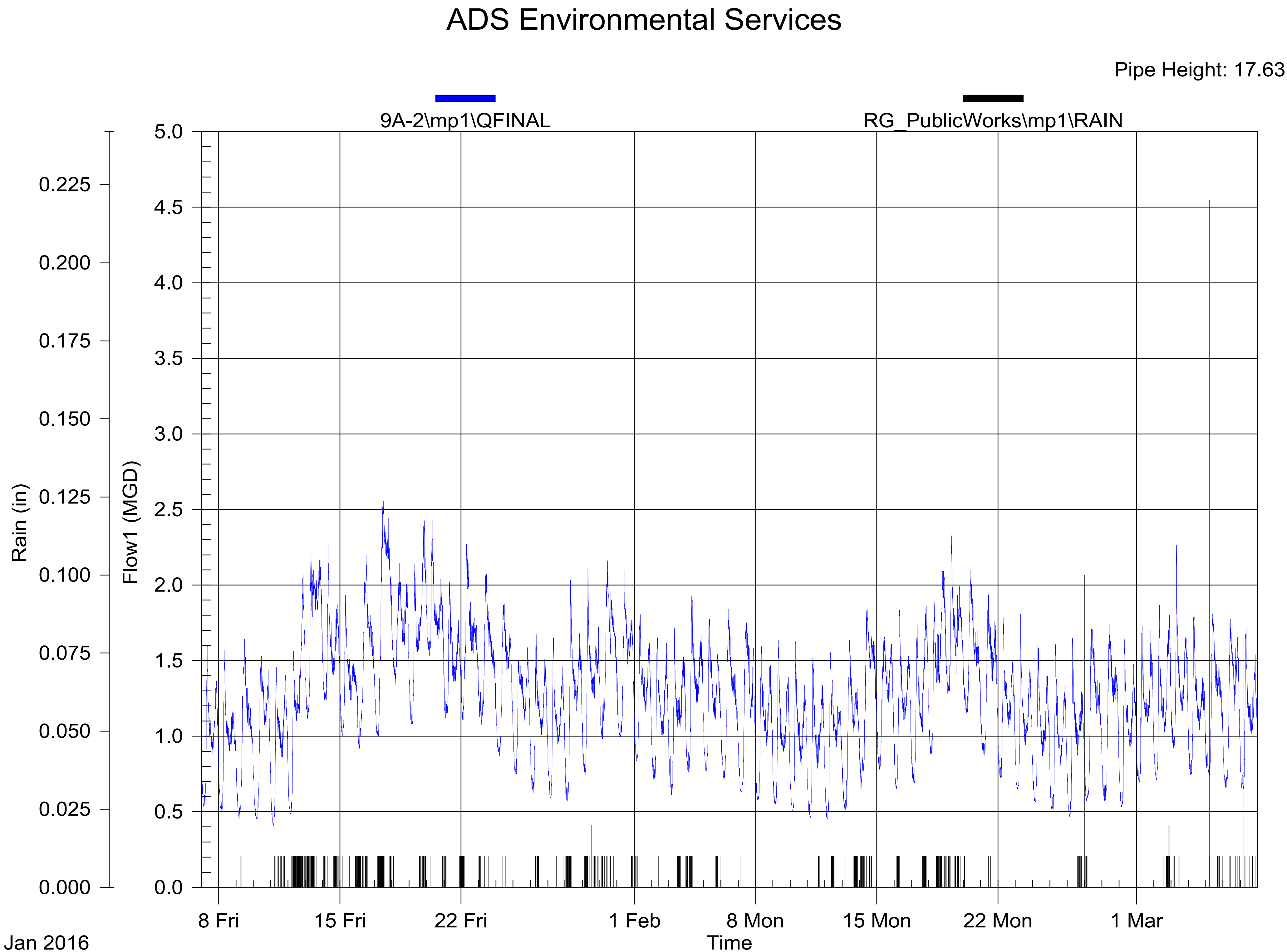
Backup	Yes	No	?	Distance
Trunk	[ ]	[X]	[ ]	
Lift / Pump Station	[ ]	[X]	[ ]	
WWTP	[ ]	[X]	[ ]	
Other	[ ]	[X]	[ ]	

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)



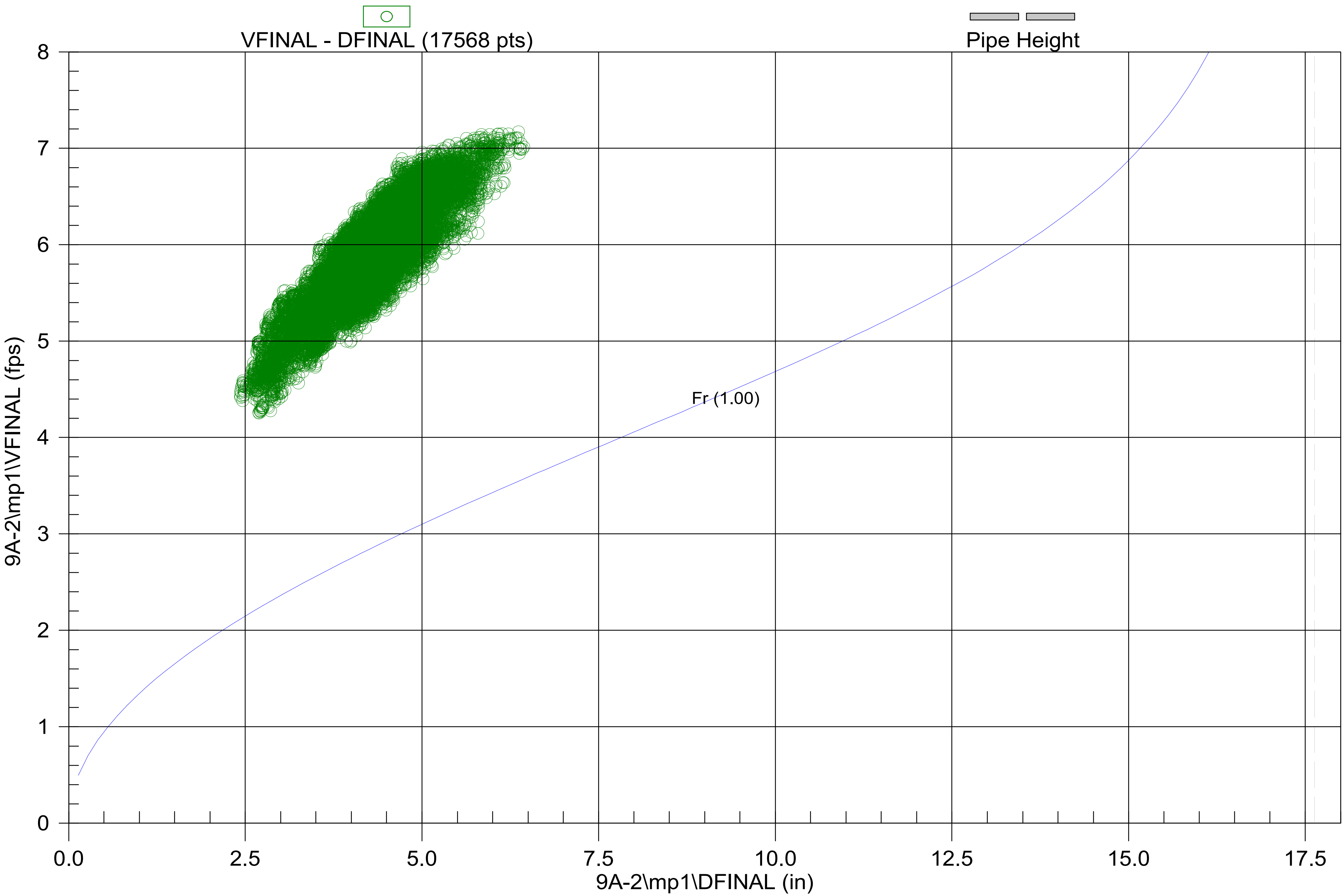
ADS Environmental Services
Pipe Height: 17.63
9A-2\mp1\DFINAL
9A-2\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Depth1 (in)
15
10
5
0
Velocity (fps)
7.5
5.0
2.5
0.0
Rain (in)
0.20
0.15
0.10
0.05
0.00
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time


ADS Environmental Services
Pipe Height: 17.63
9A-2\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow1 (MGD)
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
0.225
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time

ADS Environmental Services

1/7/2016 12:00:00 AM - 3/7/2016 11:59:00 PM

Pipe Height: 17.63



ADS Environmental Services

	9A-2\mp1\DFINAL (inches)					9A-2\mp1\VFINAL (feet/sec)					9A-2\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
1/7/2016	3:20	2.8	7:50	5.1	3.9	3:00	4.6	8:05	6.0	5.4	3:20	0.531	8:05	1.598	0.991	0.991
1/8/2016	4:30	2.8	7:40	5.0	3.8	3:35	4.6	7:40	6.1	5.3	3:30	0.504	7:40	1.568	0.940	0.940
1/9/2016	3:45	2.6	11:35	5.1	3.9	4:05	4.4	11:40	6.3	5.3	4:05	0.449	11:40	1.643	0.981	0.981
1/10/2016	5:15	2.6	11:15	5.0	3.9	4:05	4.5	20:35	6.1	5.4	5:10	0.449	11:15	1.533	0.988	0.988
1/11/2016	3:50	2.4	7:55	4.7	3.7	3:35	4.4	7:55	6.1	5.4	3:45	0.404	7:55	1.453	0.939	0.939
1/12/2016	3:20	2.7	20:45	5.8	4.2	3:15	4.6	21:10	6.6	5.7	3:20	0.484	20:45	2.066	1.195	1.195
1/13/2016	3:05	4.2	8:00	6.1	5.3	2:55	5.5	11:05	6.9	6.4	2:55	1.117	8:00	2.206	1.764	1.764
1/14/2016	4:00	4.3	7:30	6.0	4.9	4:35	5.9	8:05	6.9	6.4	2:45	1.239	7:30	2.274	1.573	1.573
1/15/2016	4:25	3.8	7:55	5.4	4.4	4:15	5.8	7:50	6.9	6.3	4:20	1.000	7:55	1.937	1.348	1.348
1/16/2016	3:15	3.5	12:40	5.8	4.7	3:15	5.8	12:20	7.1	6.5	3:15	0.917	12:20	2.201	1.519	1.519
1/17/2016	5:40	3.7	12:40	6.4	5.2	5:15	5.9	12:00	7.2	6.6	5:15	0.999	12:00	2.557	1.840	1.840
1/18/2016	4:40	4.4	10:45	5.7	5.0	4:40	6.2	10:50	7.0	6.7	4:40	1.336	10:45	2.142	1.713	1.713
1/19/2016	4:40	3.9	20:50	6.1	5.0	3:30	6.0	20:50	7.2	6.6	3:30	1.080	20:50	2.426	1.700	1.700
1/20/2016	23:55	4.5	7:55	6.2	5.1	14:15	6.4	8:40	7.1	6.8	23:55	1.410	7:55	2.431	1.801	1.801
1/21/2016	4:30	4.0	7:25	5.5	4.6	2:30	6.0	8:10	7.0	6.5	2:30	1.118	8:05	2.022	1.489	1.489
1/22/2016	1:35	3.9	7:45	5.9	4.9	1:05	5.9	7:35	7.1	6.5	1:30	1.108	7:40	2.269	1.638	1.638
1/23/2016	4:40	3.9	9:50	5.6	4.7	4:40	5.9	10:50	7.0	6.4	4:40	1.067	10:50	2.072	1.501	1.501
1/24/2016	5:05	3.5	10:45	5.3	4.4	5:00	5.6	10:15	6.8	6.2	5:00	0.868	11:50	1.873	1.356	1.356
1/25/2016	3:35	3.3	20:05	4.8	4.1	3:00	5.3	20:10	6.6	6.0	4:30	0.749	20:05	1.586	1.180	1.180
1/26/2016	3:45	3.0	7:50	5.1	4.0	3:50	5.1	7:45	6.6	5.8	3:50	0.625	7:45	1.734	1.103	1.103
1/27/2016	3:50	2.9	7:35	5.0	3.9	2:55	5.1	8:10	6.5	5.7	4:10	0.586	8:10	1.652	1.051	1.051
1/28/2016	2:40	2.8	7:40	5.7	4.3	3:30	5.0	7:50	6.6	5.9	2:50	0.564	7:45	2.033	1.247	1.247
1/29/2016	3:55	3.3	7:50	5.8	4.4	3:55	5.3	7:50	6.8	6.0	3:55	0.748	7:50	2.108	1.322	1.322
1/30/2016	3:40	3.8	11:00	5.9	4.8	3:50	5.7	9:05	6.8	6.3	3:50	0.981	11:00	2.161	1.554	1.554
1/31/2016	5:05	3.8	11:00	5.7	4.6	6:20	5.7	11:05	6.8	6.3	5:05	0.994	11:00	2.097	1.452	1.452
ReportAvg					4.5					6.1					1.367	
ReportTotal																34.19

ADS Environmental Services

	9A-2\mp1\DFINAL (inches)					9A-2\mp1\VFINAL (feet/sec)					9A-2\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
2/1/2016	3:25	3.5	8:15	5.3	4.3	0:15	5.1	8:25	6.7	6.1	3:30	0.835	8:15	1.807	1.261	1.261
2/2/2016	3:30	3.2	7:30	5.0	4.1	2:55	5.3	20:45	6.6	5.9	3:05	0.713	7:55	1.659	1.134	1.134
2/3/2016	3:40	2.9	7:40	5.2	4.0	3:30	5.1	7:55	6.4	5.8	3:30	0.613	7:40	1.713	1.121	1.121
2/4/2016	4:05	3.3	8:10	5.5	4.4	3:35	5.2	7:45	6.6	6.0	3:50	0.757	7:45	1.924	1.300	1.300
2/5/2016	4:10	3.3	7:50	5.3	4.3	5:05	5.2	8:15	6.5	5.9	4:20	0.772	8:15	1.773	1.222	1.222
2/6/2016	4:30	3.2	11:00	5.4	4.3	5:05	5.2	10:55	6.6	5.8	4:30	0.709	11:00	1.843	1.207	1.207
2/7/2016	5:20	3.0	11:10	5.2	4.2	4:25	5.0	11:35	6.5	5.8	4:50	0.627	11:10	1.763	1.170	1.170
2/8/2016	2:40	2.9	7:40	5.1	4.0	3:10	4.9	8:25	6.3	5.6	3:10	0.576	7:40	1.621	1.047	1.047
2/9/2016	3:35	2.8	7:25	5.1	3.9	3:45	4.8	7:30	6.3	5.5	3:25	0.542	7:30	1.636	0.992	0.992
2/10/2016	3:40	2.7	7:55	5.1	3.8	3:10	4.6	8:15	6.1	5.3	3:40	0.501	7:55	1.626	0.947	0.947
2/11/2016	3:55	2.7	7:45	5.0	3.8	4:30	4.4	20:10	6.1	5.2	4:30	0.457	7:40	1.517	0.940	0.940
2/12/2016	3:50	2.7	7:40	5.2	3.9	3:40	4.3	8:05	6.0	5.2	3:40	0.451	7:40	1.581	0.968	0.968
2/13/2016	4:10	2.9	10:20	5.2	4.0	5:45	4.4	10:35	6.1	5.3	5:05	0.512	10:15	1.637	1.030	1.030
2/14/2016	2:30	3.2	9:45	5.6	4.5	2:10	4.7	20:00	6.3	5.7	2:30	0.654	11:00	1.841	1.298	1.298
2/15/2016	3:55	3.5	9:10	5.1	4.4	3:35	5.1	10:45	6.4	5.8	3:55	0.780	10:30	1.658	1.259	1.259
2/16/2016	3:10	3.1	7:45	5.4	4.3	2:20	4.9	7:40	6.4	5.7	3:20	0.654	7:40	1.835	1.190	1.190
2/17/2016	4:30	3.2	20:40	5.5	4.3	4:45	5.0	19:30	6.7	5.8	4:30	0.688	20:40	1.862	1.233	1.233
2/18/2016	3:55	3.7	20:25	5.9	4.8	2:30	5.3	19:40	6.7	6.1	3:40	0.883	20:25	2.095	1.492	1.492
2/19/2016	2:55	4.4	7:45	6.2	5.1	15:15	5.7	7:35	6.8	6.4	2:55	1.243	8:10	2.326	1.676	1.676
2/20/2016	4:30	4.1	10:35	5.7	4.8	6:00	5.8	10:20	6.8	6.4	4:25	1.152	10:35	2.096	1.531	1.531
2/21/2016	5:20	3.5	10:55	5.4	4.4	5:00	5.5	11:15	6.9	6.2	4:55	0.861	11:00	1.937	1.355	1.355
2/22/2016	4:10	3.1	7:30	5.2	4.0	3:40	5.4	8:05	6.8	6.1	4:10	0.723	7:30	1.788	1.162	1.162
2/23/2016	3:20	3.0	7:40	5.2	3.9	1:40	5.3	7:45	6.8	6.0	3:20	0.649	7:40	1.806	1.076	1.076
2/24/2016	3:55	2.8	7:45	4.9	3.7	4:10	5.1	7:40	6.6	5.8	4:10	0.566	7:45	1.606	1.006	1.006
2/25/2016	4:35	2.7	7:40	4.9	3.7	4:30	4.9	7:45	6.5	5.6	4:35	0.508	7:40	1.605	0.957	0.957
2/26/2016	3:20	2.6	7:45	5.1	3.8	3:45	4.6	7:50	6.4	5.5	3:45	0.468	7:45	1.646	0.968	0.968
2/27/2016	2:40	2.9	10:00	5.2	4.1	3:30	4.8	10:40	6.4	5.6	3:30	0.567	10:05	1.711	1.125	1.125
2/28/2016	4:40	2.9	10:15	5.3	4.2	5:10	4.6	10:15	6.3	5.5	4:40	0.563	10:15	1.738	1.130	1.130
2/29/2016	4:00	2.9	7:50	5.2	4.0	5:05	4.5	7:50	6.2	5.4	4:00	0.530	7:50	1.649	1.023	1.023
ReportAvg					4.2					5.8					1.166	
ReportTotal																33.82

ADS Environmental Services

	9A-2\mp1\DFINAL (inches)					9A-2\mp1\VFINAL (feet/sec)					9A-2\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
3/1/2016	3:55	3.3	7:55	5.3	4.3	3:35	4.8	19:50	6.3	5.5	3:55	0.690	7:55	1.725	1.165	1.165
3/2/2016	3:40	3.4	7:50	5.6	4.4	4:10	4.8	20:25	6.3	5.6	4:10	0.711	7:50	1.868	1.224	1.224
3/3/2016	3:55	3.9	7:45	6.0	4.6	4:05	5.2	7:45	6.9	5.7	4:05	0.921	7:45	2.263	1.330	1.330
3/4/2016	3:40	3.4	7:35	5.5	4.3	3:05	4.9	8:10	6.3	5.6	3:25	0.742	7:50	1.826	1.162	1.162
3/5/2016	4:45	3.4	9:10	5.4	4.3	5:35	5.0	10:10	6.4	5.7	5:35	0.736	9:10	1.810	1.217	1.217
3/6/2016	4:25	3.1	9:45	5.3	4.3	4:45	5.0	20:05	6.5	5.8	4:40	0.656	10:15	1.774	1.206	1.206
3/7/2016	4:30	3.1	7:55	5.1	4.0	4:30	5.1	8:05	6.6	5.8	4:30	0.652	7:50	1.727	1.104	1.104
ReportAvg					4.3					5.7					1.201	
ReportTotal																8.408

9A-14

Located At: 3360 Willamette Falls Dr (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016
Pipe Dimensions: 16 in x 16 in
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sewer pipe. The scattergraph indicates normal open channel flow. The data plots below the Froude =1 curve indicating subcritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (in)	100%	100%
Velocity (f/s)	100%	100%
Quantity (MGD)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

Item	Depth (in)	Velocity (f/s)	Quantity (MGD)	% Full
Minimum	2.53	1.31	0.120	16%
Maximum	6.28	2.48	0.805	39%
Average	4.35	2.00	0.405	27%

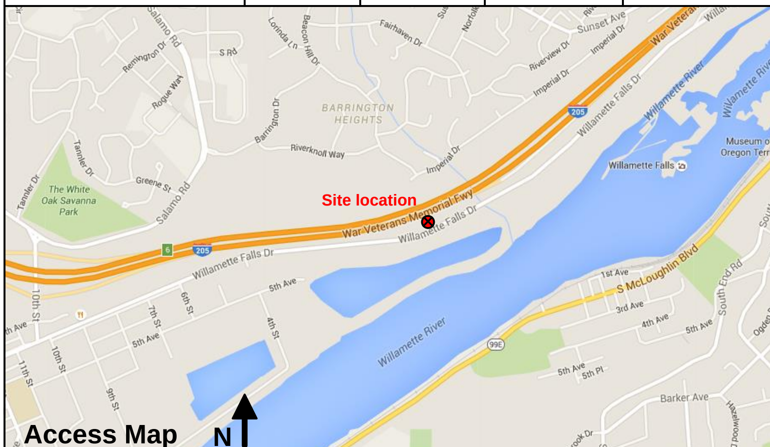
ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

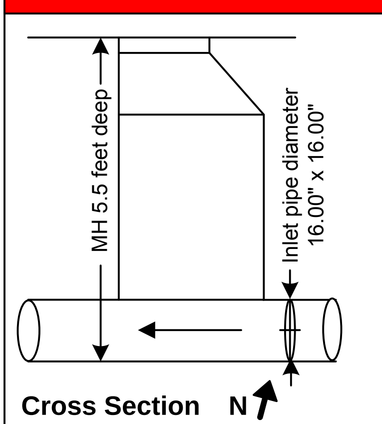
Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

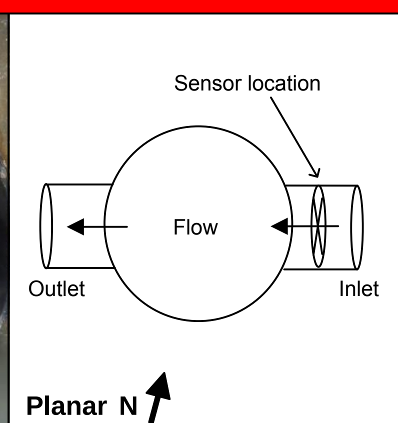
Site Name: 9A-14	**Monitor Series:** 8000-FST	**Monitor S/N:**	20646
Address/Location: 3360 Willamette Falls Dr.		**IP Address:**	166.219.50.35
		Manhole #	9A-14
		GPS Coordinates	45.34938° -122.63120°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	16.00"
		Pipe Width:	16.00"



Investigation Information:		**Manhole Information:**				
Date/Time of Investigation:	12/16/2015 @ 15:13	**Manhole Depth:**	5.5'			
Site Hydraulics:	Smooth with Small Waves	**Manhole Material / Condition**	Concrete / Good			
Upstream Input: (L/S, P/S)	DNI	**Pipe Material / Condition:**	CIPP / Good			
Upstream Manhole:	DNI	**Mini System Character:**	Residential [ ]	Commercial [ ]	Industrial [ ]	Trunk [X]
Downstream Manhole:	DNI	**Telephone Information:**	Does not apply			
Depth of Flow:	4.13" +/- 0.25"	**Access Pole #:**	Does not apply			
Range (Air DOF):	13.88" +/- 0.25"	**Distance From Manhole:**	Does not apply	Feet		
Peak Velocity:	2.32 fps	**Road Cut Length:**	Does not apply	Feet		
Silt:	None	**Trench Length:**	Does not apply	Feet		

Other Information:





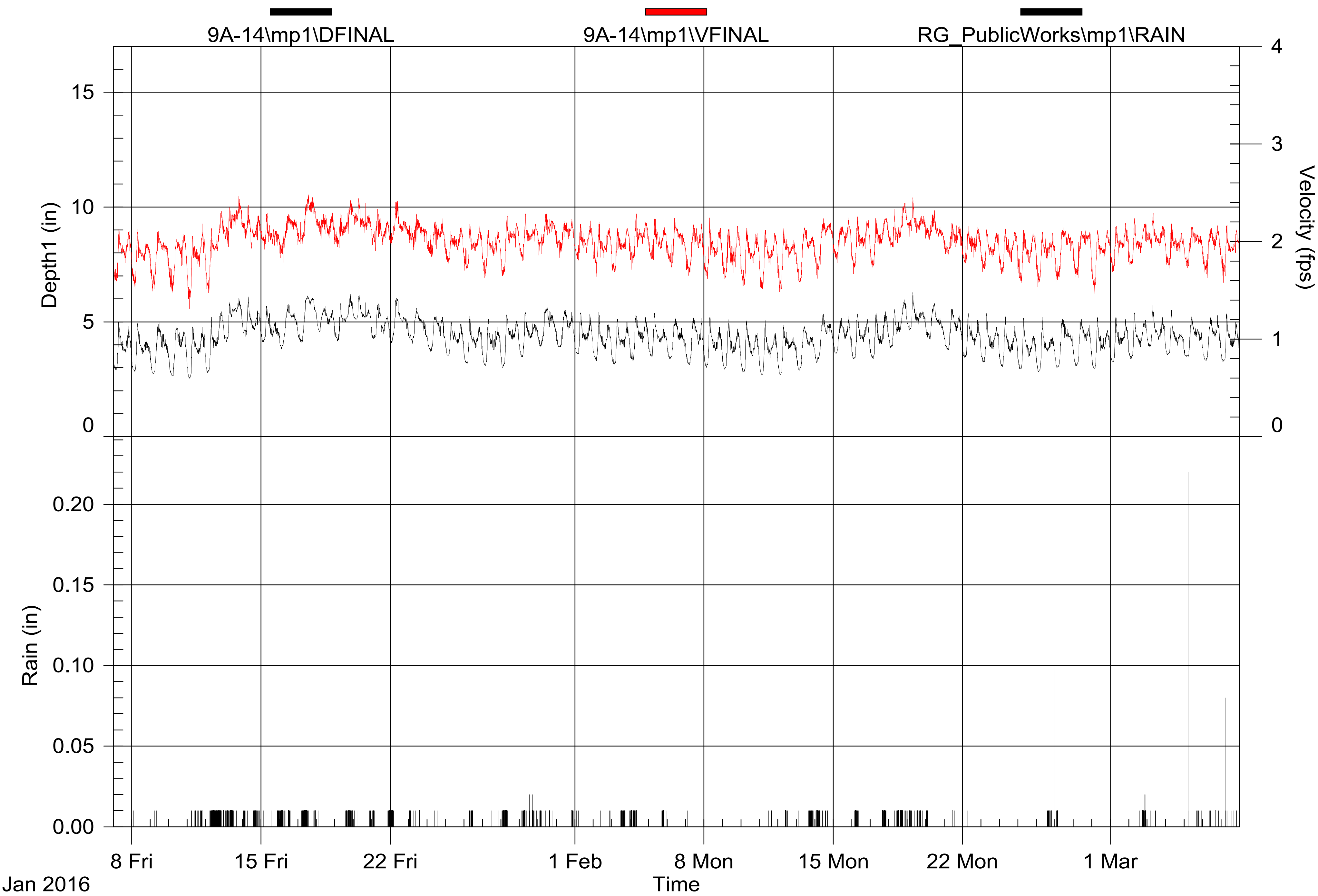
Installation Information	**Backup**	**Yes**	**No**	**?**	**Distance**
Installation Type: Standard	Trunk	[ ]	[X]	[ ]	
Sensors Devices: CS4(Ultrasonic, Pressure, Velocity)	Lift / Pump Station	[ ]	[X]	[ ]	
Surcharge Height: None Observed	WWTP	[ ]	[X]	[ ]	
Rain Guage Zone: RG_Publicworks (Gladstone)	Other	[ ]	[X]	[ ]	

Additional Site Information / Comments:

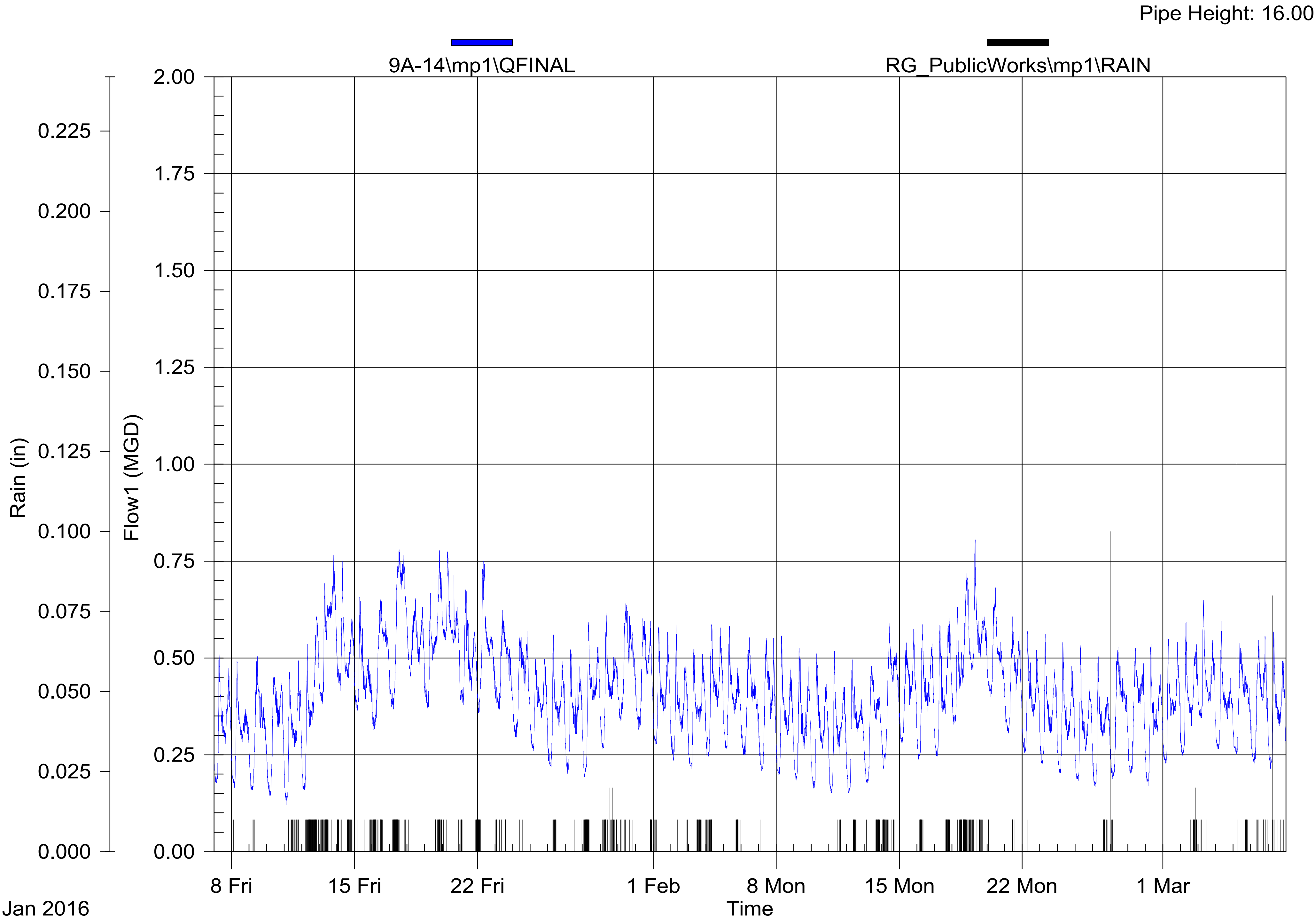
Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

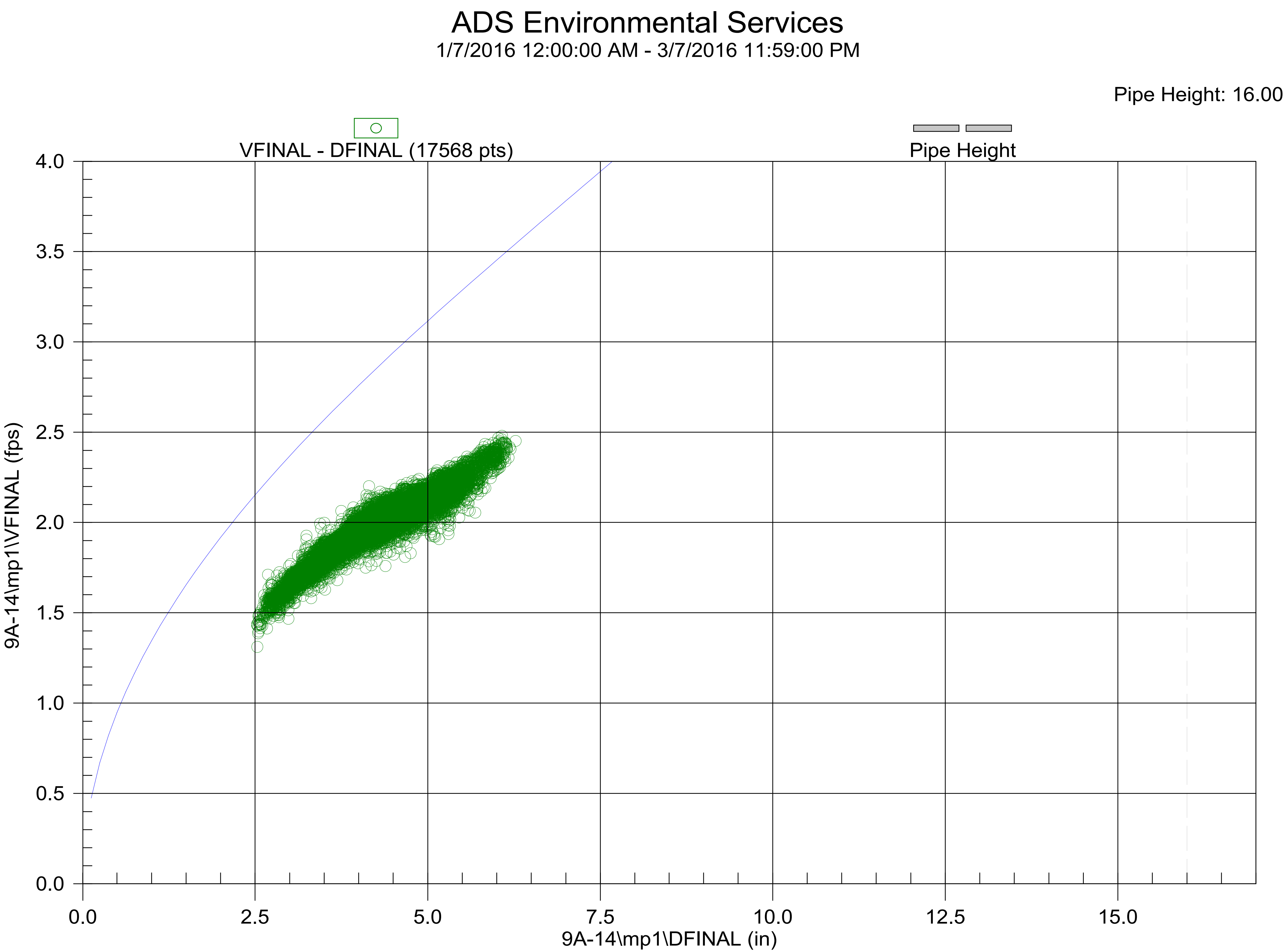
ADS Environmental Services

Pipe Height: 16.00



ADS Environmental Services





ADS Environmental Services
1/7/2016 12:00:00 AM - 3/7/2016 11:59:00 PM
Pipe Height: 16.00
VFINAL - DFINAL (17568 pts)
Pipe Height
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9A-14\mp1\VFINAL (fps)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
9A-14\mp1\DFINAL (in)

ADS Environmental Services

	9A-14\mp1\DFINAL (inches)					9A-14\mp1\VFINAL (feet/sec)					9A-14\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
1/7/2016	3:35	2.9	7:20	5.0	3.9	2:15	1.6	7:20	2.1	1.9	3:40	0.177	7:20	0.513	0.320	0.320
1/8/2016	4:05	2.8	7:40	4.9	3.8	4:00	1.5	8:10	2.1	1.8	4:00	0.165	7:40	0.492	0.303	0.303
1/9/2016	4:55	2.7	11:35	5.0	3.8	2:40	1.5	10:30	2.1	1.8	5:00	0.159	11:35	0.503	0.311	0.311
1/10/2016	5:00	2.6	11:00	4.8	3.8	5:35	1.5	20:00	2.1	1.8	5:00	0.144	11:00	0.451	0.312	0.312
1/11/2016	3:45	2.5	7:30	4.8	3.7	3:00	1.3	19:35	2.2	1.8	3:00	0.120	19:35	0.493	0.301	0.301
1/12/2016	3:00	2.8	20:35	5.4	4.1	3:45	1.5	20:45	2.3	1.9	3:35	0.159	20:35	0.621	0.373	0.373
1/13/2016	3:30	4.1	19:20	6.0	5.2	5:50	1.9	19:20	2.5	2.2	4:40	0.380	19:20	0.766	0.572	0.572
1/14/2016	4:30	4.3	7:20	6.1	5.0	11:25	1.9	7:25	2.4	2.1	4:30	0.415	7:20	0.750	0.514	0.514
1/15/2016	4:00	4.1	7:30	5.7	4.7	23:35	1.9	8:00	2.3	2.1	4:15	0.364	7:30	0.656	0.452	0.452
1/16/2016	2:45	3.8	11:25	5.8	4.9	5:55	1.8	11:50	2.3	2.1	2:45	0.313	11:25	0.651	0.495	0.495
1/17/2016	5:05	4.1	12:45	6.1	5.3	0:05	2.0	13:55	2.5	2.2	5:05	0.367	13:55	0.780	0.595	0.595
1/18/2016	23:55	4.5	11:30	5.7	5.1	23:50	2.0	20:50	2.3	2.2	23:55	0.423	11:30	0.654	0.541	0.541
1/19/2016	4:05	4.1	20:10	6.2	5.1	5:30	1.9	19:45	2.4	2.2	3:25	0.368	20:15	0.779	0.547	0.547
1/20/2016	23:55	4.5	7:45	6.2	5.4	15:05	2.1	7:10	2.4	2.2	23:55	0.441	7:15	0.775	0.590	0.590
1/21/2016	2:35	4.3	9:20	5.8	4.9	5:10	1.9	7:45	2.3	2.1	5:10	0.379	7:50	0.676	0.490	0.490
1/22/2016	2:25	4.1	8:45	6.0	5.0	1:10	2.0	9:40	2.4	2.2	1:40	0.359	8:50	0.751	0.529	0.529
1/23/2016	4:55	4.1	10:40	5.6	4.8	5:55	1.9	10:20	2.3	2.1	5:55	0.368	10:20	0.623	0.478	0.478
1/24/2016	5:00	3.7	11:45	5.2	4.5	6:05	1.8	19:35	2.2	2.0	5:05	0.295	19:35	0.569	0.433	0.433
1/25/2016	4:45	3.5	7:35	5.0	4.2	4:10	1.8	20:20	2.1	2.0	4:20	0.259	20:20	0.504	0.379	0.379
1/26/2016	3:55	3.2	7:40	5.2	4.1	1:10	1.7	7:45	2.2	2.0	4:40	0.219	7:40	0.560	0.360	0.360
1/27/2016	4:00	3.1	7:45	5.1	4.0	3:00	1.6	7:15	2.1	1.9	3:25	0.201	7:25	0.522	0.346	0.346
1/28/2016	2:15	3.0	7:30	5.3	4.3	2:30	1.6	7:55	2.3	2.0	2:30	0.193	7:55	0.592	0.392	0.392
1/29/2016	4:05	3.5	7:45	5.4	4.4	3:50	1.8	7:55	2.3	2.0	3:15	0.267	7:45	0.616	0.420	0.420
1/30/2016	2:55	3.9	10:40	5.6	4.8	1:35	1.9	11:10	2.3	2.1	3:00	0.336	10:40	0.640	0.488	0.488
1/31/2016	4:25	3.9	9:55	5.5	4.7	4:20	1.8	20:25	2.2	2.1	4:10	0.314	9:55	0.602	0.458	0.458
ReportAvg					4.5					2.0					0.440	
ReportTotal																11.00

ADS Environmental Services

	9A-14\mp1\DFINAL (inches)					9A-14\mp1\VFINAL (feet/sec)					9A-14\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
2/1/2016	3:45	3.6	8:05	5.4	4.4	4:35	1.8	20:05	2.2	2.0	3:45	0.276	7:35	0.580	0.400	0.400
2/2/2016	4:15	3.3	7:15	5.4	4.2	3:50	1.6	7:35	2.2	1.9	3:50	0.236	7:15	0.586	0.366	0.366
2/3/2016	3:30	3.1	8:00	5.1	4.1	3:50	1.7	7:40	2.1	1.9	3:45	0.214	7:30	0.522	0.360	0.360
2/4/2016	3:40	3.3	19:30	5.4	4.4	1:10	1.7	8:10	2.3	2.0	3:45	0.246	8:20	0.587	0.413	0.413
2/5/2016	4:15	3.5	8:00	5.4	4.3	6:30	1.8	7:40	2.2	2.0	4:10	0.267	8:00	0.582	0.390	0.390
2/6/2016	4:20	3.4	11:20	5.2	4.2	6:05	1.7	9:30	2.2	2.0	4:20	0.249	11:20	0.553	0.381	0.381
2/7/2016	5:15	3.1	10:55	5.2	4.1	4:10	1.7	20:25	2.2	1.9	4:10	0.209	20:25	0.552	0.369	0.369
2/8/2016	2:55	3.0	7:45	5.2	4.0	4:30	1.6	7:15	2.2	1.9	2:55	0.199	7:15	0.557	0.340	0.340
2/9/2016	3:05	2.9	7:15	5.1	3.9	2:55	1.6	19:35	2.2	1.9	3:05	0.184	7:15	0.525	0.324	0.324
2/10/2016	2:40	2.8	7:10	5.0	3.8	3:45	1.5	7:20	2.1	1.9	2:40	0.163	7:20	0.511	0.310	0.310
2/11/2016	3:10	2.7	7:30	5.1	3.7	3:25	1.5	7:55	2.1	1.9	3:25	0.152	7:30	0.517	0.304	0.304
2/12/2016	3:40	2.7	7:50	4.9	3.8	1:55	1.5	7:50	2.1	1.9	2:45	0.152	7:50	0.496	0.312	0.312
2/13/2016	4:25	2.9	11:00	4.8	3.9	3:30	1.6	10:50	2.1	1.9	4:25	0.177	11:00	0.486	0.331	0.331
2/14/2016	2:40	3.2	11:05	5.3	4.3	3:00	1.6	11:00	2.2	2.0	2:35	0.214	11:05	0.589	0.405	0.405
2/15/2016	3:30	3.6	20:20	5.2	4.4	4:55	1.8	19:15	2.2	2.0	5:00	0.279	19:15	0.575	0.413	0.413
2/16/2016	2:30	3.4	7:35	5.3	4.3	2:10	1.7	7:30	2.3	2.0	2:10	0.238	7:30	0.586	0.400	0.400
2/17/2016	4:05	3.4	19:55	5.4	4.4	3:45	1.7	21:40	2.2	2.0	3:50	0.245	19:55	0.604	0.414	0.414
2/18/2016	2:15	3.8	20:10	6.0	4.9	2:40	1.9	21:05	2.4	2.1	2:40	0.328	20:10	0.718	0.500	0.500
2/19/2016	3:00	4.6	7:35	6.3	5.2	3:30	2.1	7:35	2.5	2.2	3:55	0.468	7:35	0.805	0.560	0.560
2/20/2016	5:55	4.2	11:25	5.8	4.9	23:55	2.0	11:35	2.3	2.1	5:05	0.400	11:35	0.682	0.500	0.500
2/21/2016	4:55	3.8	10:55	5.5	4.6	23:50	1.9	10:05	2.2	2.0	5:40	0.303	10:55	0.606	0.438	0.438
2/22/2016	3:00	3.4	7:35	5.4	4.3	4:20	1.8	7:15	2.2	2.0	2:55	0.255	7:20	0.568	0.385	0.385
2/23/2016	3:00	3.2	7:05	5.4	4.1	2:05	1.7	7:10	2.1	1.9	3:40	0.228	7:10	0.562	0.355	0.355
2/24/2016	4:10	3.0	7:35	5.3	4.0	2:40	1.7	7:35	2.1	1.9	4:10	0.204	7:35	0.551	0.338	0.338
2/25/2016	4:05	3.0	7:30	5.2	3.8	4:15	1.6	7:20	2.1	1.9	4:15	0.182	7:15	0.533	0.314	0.314
2/26/2016	3:20	2.8	7:30	5.2	3.8	1:50	1.5	7:55	2.1	1.9	3:20	0.168	7:30	0.516	0.315	0.315
2/27/2016	2:50	3.0	9:50	5.1	4.1	3:05	1.6	10:45	2.1	1.9	3:05	0.188	10:45	0.529	0.359	0.359
2/28/2016	3:50	3.1	10:45	5.1	4.1	6:20	1.6	15:35	2.1	1.9	3:45	0.202	10:40	0.526	0.360	0.360
2/29/2016	4:10	2.9	7:55	5.2	4.0	3:45	1.5	8:05	2.1	1.9	3:45	0.170	7:55	0.537	0.335	0.335
ReportAvg					4.2					2.0					0.379	
ReportTotal																10.99

ADS Environmental Services

	9A-14\mp1\DFINAL (inches)					9A-14\mp1\VFINAL (feet/sec)					9A-14\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
3/1/2016	4:15	3.2	7:40	5.2	4.2	2:55	1.7	20:00	2.2	2.0	4:10	0.223	7:50	0.549	0.373	0.373
3/2/2016	3:30	3.4	7:40	5.4	4.3	1:35	1.8	7:35	2.2	2.0	3:30	0.246	7:40	0.593	0.394	0.394
3/3/2016	2:50	3.9	7:30	5.7	4.5	5:40	1.9	7:50	2.3	2.1	23:55	0.342	7:30	0.650	0.436	0.436
3/4/2016	3:05	3.6	7:15	5.5	4.2	4:25	1.7	7:50	2.2	2.0	4:25	0.264	7:45	0.595	0.377	0.377
3/5/2016	4:00	3.5	9:00	5.2	4.3	4:40	1.7	9:40	2.1	2.0	4:40	0.253	9:00	0.538	0.385	0.385
3/6/2016	4:25	3.3	19:30	5.3	4.3	6:10	1.6	19:50	2.2	1.9	5:40	0.225	19:30	0.557	0.382	0.382
3/7/2016	2:40	3.3	7:35	5.3	4.1	3:00	1.6	7:45	2.2	1.9	3:00	0.213	7:35	0.571	0.361	0.361
ReportAvg					4.3					2.0					0.387	
ReportTotal																2.708

9C-3

Located At: 10th St South of Salamo Rd (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016
Pipe Dimensions: 8 in x 8 in
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sewer pipe. The scattergraph indicates normal open channel flow. The data plots above the Froude =1 curve indicating supercritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward and downward ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (in)	98%	97%
Velocity (f/s)	98%	98%
Quantity (MGD)	98%	97%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

Item	Depth (in)	Velocity (f/s)	Quantity (MGD)	% Full
Minimum	1.17	4.13	0.093	15%
Maximum	2.43	9.23	0.515	30%
Average	1.71	7.13	0.259	21%

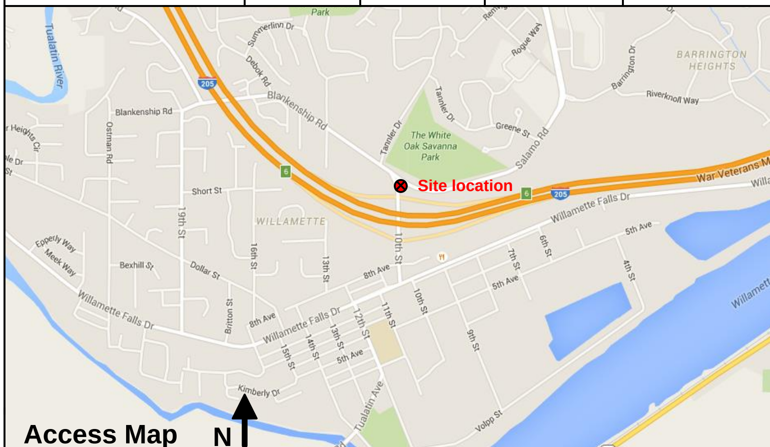
ENVIRONMENTAL SERVICES

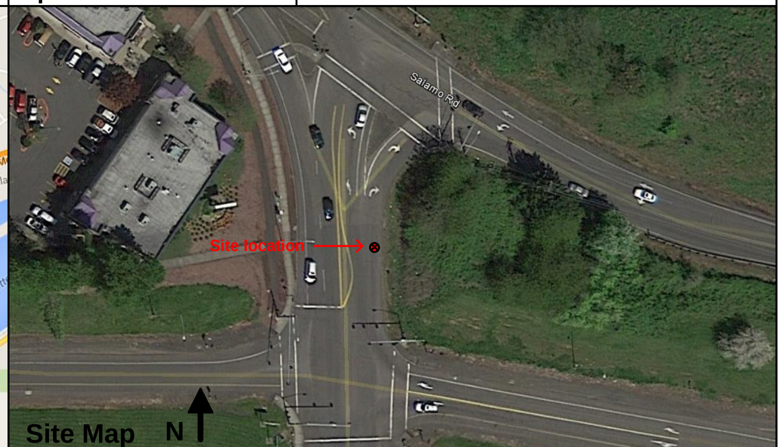
ADS Site Report

Quality Form

Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

Site Name: 9C-3	**Monitor Series:** 8000-FST	**Monitor S/N:**	21714
Address/Location: 10th St south of Salamo Rd		**IP Address:**	166.219.186.18
		Manhole #	9C-3
		GPS Coordinates	45.348594° -122.651790°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	8.00"
		Pipe Width:	8.00"





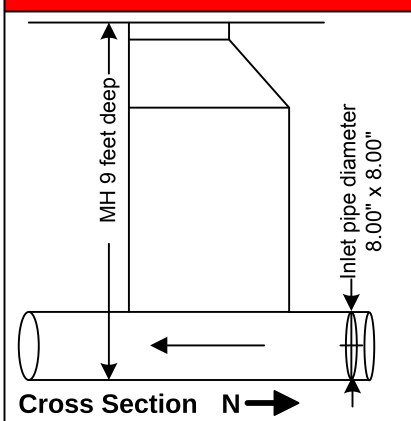
Investigation Information:

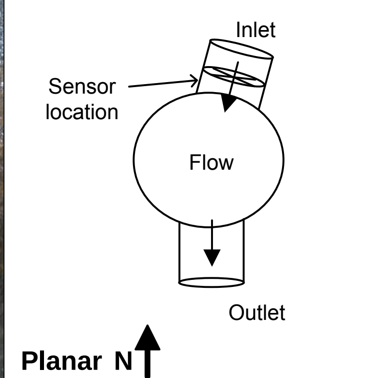
Date/Time of Investigation:	12/16/2015 @ 12:07
Site Hydraulics:	Ripples, Fast Velocity
Upstream Input: (L/S, P/S)	DNI
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow:	1.63" +/- 0.25"
Range (Air DOF):	6.38" +/- 0.25"
Peak Velocity:	7.63 fps
Silt:	None

Manhole Information:

Manhole Depth:	9'	
Manhole Material / Condition	Concrete / Good	
Pipe Material / Condition:	Concrete / Good	
Mini System Character:	Residential [X] Commercial [ ] Industrial [ ] Trunk [ ]	
Telephone Information:	Does not apply	
Access Pole #:	Does not apply	
Distance From Manhole:	Does not apply	Feet
Road Cut Length:	Does not apply	Feet
Trench Length:	Does not apply	Feet

Other Information:

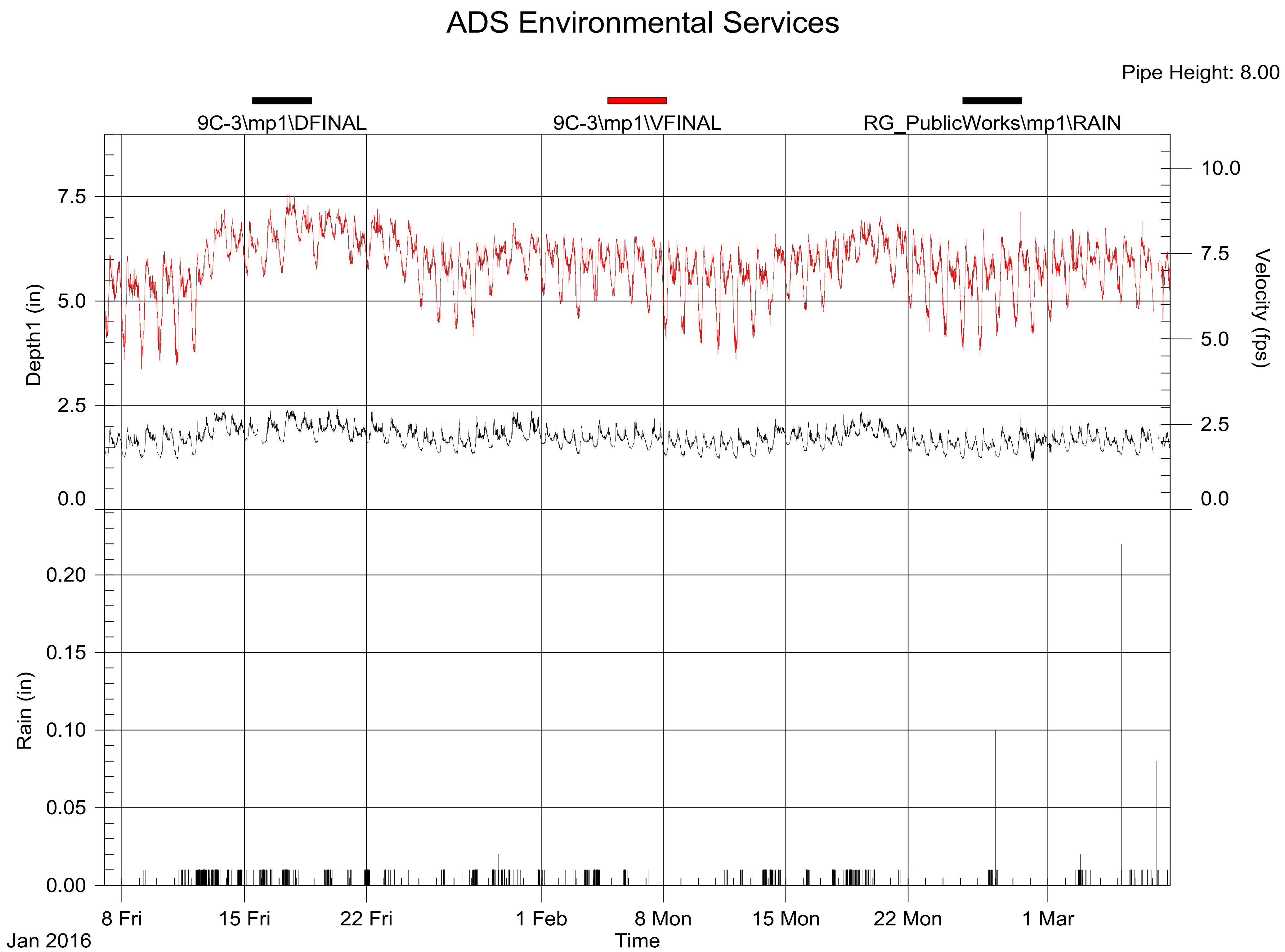




Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Standard	Trunk		X		
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity) CS5(Ultrasonic)	Lift / Pump Station		X		
Surcharge Height:	None Observed	WWTP		X		
Rain Guage Zone:	RG_Publicworks (Gladstone)	Other		X		

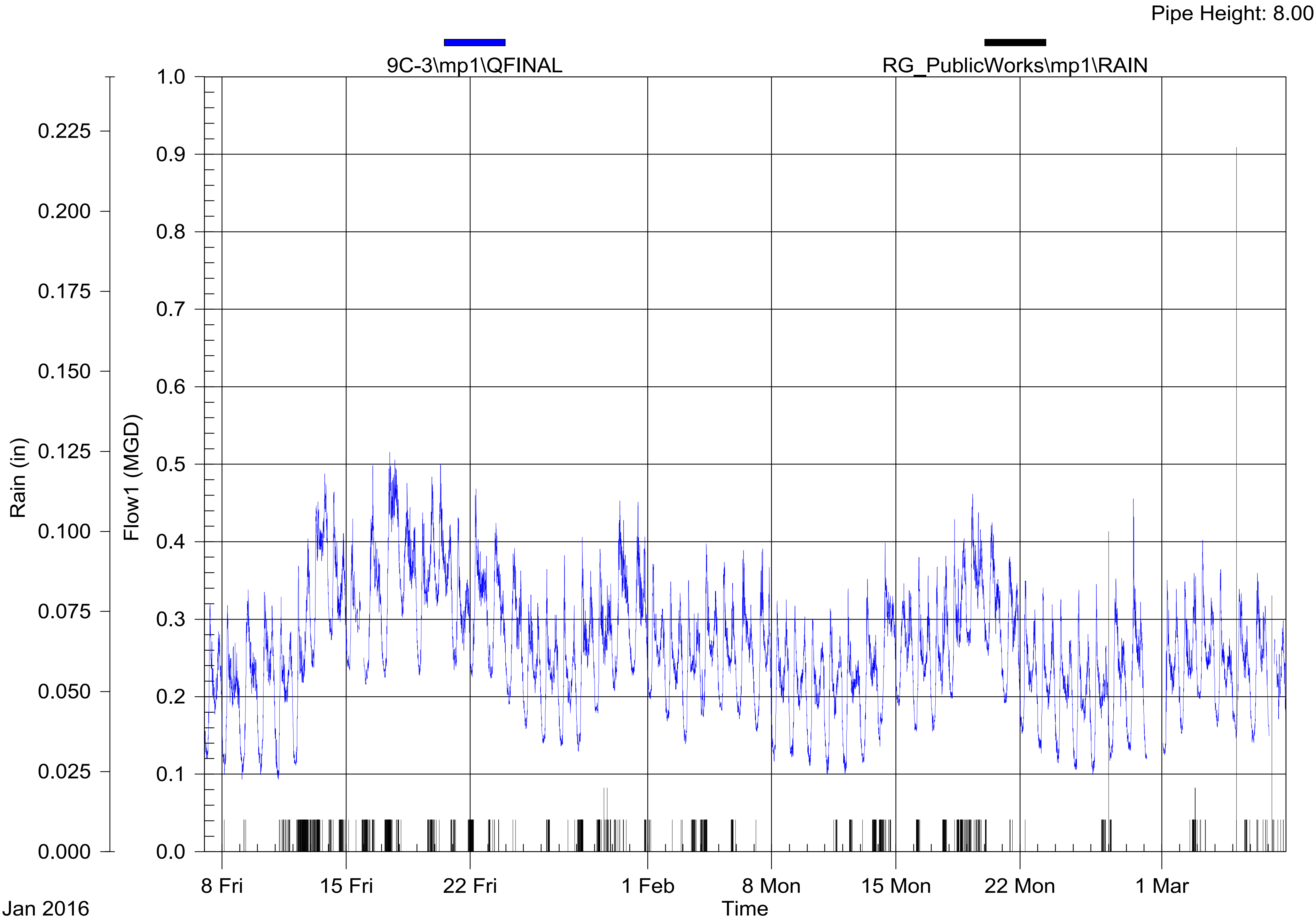
Additional Site Information / Comments:

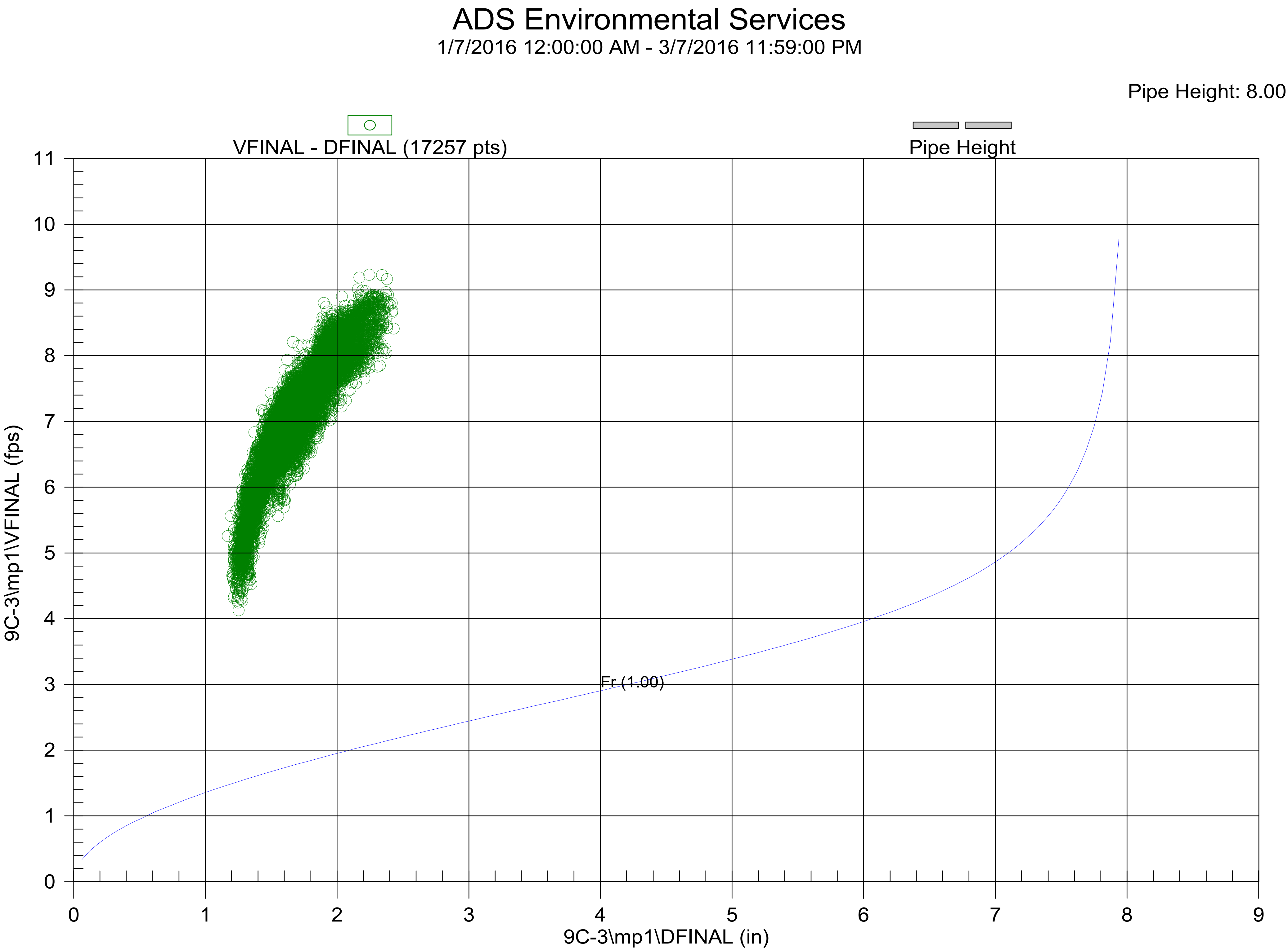
Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)



ADS Environmental Services
Pipe Height: 8.00
9C-3\mp1\DFINAL
9C-3\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Depth1 (in)
Velocity (fps)
Rain (in)
7.5
5.0
2.5
0.0
10.0
0.20
0.15
0.10
0.05
0.00
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time

ADS Environmental Services





ADS Environmental Services
1/7/2016 12:00:00 AM - 3/7/2016 11:59:00 PM
Pipe Height: 8.00
VFINAL - DFINAL (17257 pts)
Pipe Height
Fr (1.00)
9C-3\mp1\VFINAL (fps)
9C-3\mp1\DFINAL (in)
0
1
2
3
4
5
6
7
8
9
10
11

ADS Environmental Services

	9C-3\mp1\DFINAL (inches)					9C-3\mp1\VFINAL (feet/sec)					9C-3\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
1/7/2016	4:10	1.3	8:00	2.0	1.6	0:35	5.0	8:00	7.5	6.4	4:10	0.120	8:00	0.319	0.207	0.207
1/8/2016	3:15	1.2	7:05	2.0	1.6	3:10	4.4	7:55	7.4	6.2	3:10	0.100	7:05	0.318	0.199	0.199
1/9/2016	3:05	1.2	11:25	2.1	1.6	3:00	4.1	10:45	7.4	6.2	3:00	0.093	11:25	0.338	0.209	0.209
1/10/2016	4:50	1.2	9:20	2.0	1.6	4:10	4.3	10:25	7.6	6.3	4:10	0.100	9:20	0.335	0.214	0.214
1/11/2016	4:25	1.2	7:55	2.0	1.6	3:05	4.2	7:55	7.4	6.2	4:25	0.093	7:55	0.329	0.205	0.205
1/12/2016	2:00	1.3	20:20	2.2	1.7	4:20	4.6	20:05	7.9	6.6	3:40	0.111	20:20	0.404	0.244	0.244
1/13/2016	4:40	1.7	18:45	2.4	2.1	2:50	6.7	20:50	8.8	7.9	3:00	0.238	18:45	0.488	0.372	0.372
1/14/2016	23:55	1.7	7:10	2.3	2.0	4:10	7.3	11:25	8.6	7.8	23:55	0.263	7:40	0.464	0.339	0.339
1/15/2016	1:25	1.6	8:45	2.2	1.8	4:10	6.8	7:10	8.4	7.6	4:50	0.233	8:45	0.429	0.300	0.245
1/16/2016	2:10	1.6	11:55	2.4	1.9	2:25	6.8	11:55	8.8	7.8	2:55	0.216	11:55	0.498	0.325	0.325
1/17/2016	4:35	1.6	17:45	2.4	2.0	4:20	6.9	14:55	9.2	8.2	4:20	0.225	10:55	0.515	0.382	0.382
1/18/2016	23:55	1.8	10:30	2.3	2.0	23:40	7.4	14:20	8.9	8.3	23:55	0.275	10:30	0.475	0.369	0.369
1/19/2016	3:35	1.6	19:50	2.4	1.9	3:30	7.0	21:30	8.8	8.1	3:35	0.227	19:50	0.484	0.343	0.343
1/20/2016	23:55	1.7	7:35	2.4	2.0	23:40	7.6	9:45	8.8	8.3	23:55	0.277	7:35	0.500	0.372	0.372
1/21/2016	2:10	1.6	8:05	2.2	1.8	2:00	7.2	7:25	8.6	7.8	2:10	0.235	7:25	0.431	0.303	0.303
1/22/2016	1:10	1.6	7:50	2.4	1.9	2:25	7.0	15:10	8.8	8.0	2:25	0.226	7:50	0.468	0.327	0.327
1/23/2016	3:35	1.6	10:45	2.2	1.8	3:30	7.1	8:45	8.5	7.8	3:35	0.224	10:45	0.424	0.305	0.305
1/24/2016	4:05	1.5	11:40	2.1	1.7	4:10	6.6	9:55	8.5	7.5	4:10	0.190	11:40	0.392	0.276	0.276
1/25/2016	3:35	1.4	10:05	2.0	1.6	3:05	5.9	19:25	7.8	7.0	3:05	0.159	10:05	0.332	0.235	0.235
1/26/2016	4:25	1.4	7:35	2.1	1.6	3:05	5.5	7:35	8.0	6.8	3:05	0.139	7:35	0.364	0.224	0.224
1/27/2016	4:45	1.4	7:20	2.2	1.6	3:30	5.3	7:40	7.8	6.7	2:45	0.136	7:20	0.382	0.215	0.215
1/28/2016	2:10	1.3	7:30	2.2	1.7	2:20	5.1	7:40	7.8	7.0	2:20	0.129	7:30	0.406	0.254	0.254
1/29/2016	4:40	1.5	7:35	2.2	1.8	4:00	6.3	7:40	8.0	7.3	4:40	0.179	7:40	0.390	0.269	0.269
1/30/2016	3:35	1.5	10:30	2.4	1.9	3:30	6.9	10:00	8.4	7.6	3:15	0.208	10:30	0.453	0.314	0.314
1/31/2016	3:50	1.7	11:20	2.4	1.9	3:10	6.7	9:55	8.2	7.5	3:10	0.227	11:20	0.451	0.304	0.304
ReportAvg					1.8					7.3					0.284	
ReportTotal																7.052

ADS Environmental Services

	9C-3\mp1\DFINAL (inches)					9C-3\mp1\VFINAL (feet/sec)					9C-3\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
2/1/2016	4:05	1.6	7:05	2.1	1.7	3:05	6.3	7:15	8.1	7.3	3:00	0.197	7:05	0.371	0.262	0.262
2/2/2016	3:20	1.4	7:20	2.0	1.7	2:30	6.0	7:20	8.1	7.1	2:30	0.168	7:20	0.349	0.241	0.241
2/3/2016	3:10	1.3	7:30	2.0	1.6	3:10	5.6	7:30	8.0	7.0	3:10	0.139	7:30	0.350	0.233	0.233
2/4/2016	0:50	1.5	7:30	2.2	1.7	3:50	6.1	7:30	8.0	7.2	3:40	0.174	7:30	0.397	0.264	0.264
2/5/2016	4:25	1.5	8:00	2.1	1.7	3:50	6.2	8:00	8.0	7.2	4:30	0.182	8:00	0.373	0.255	0.255
2/6/2016	4:05	1.5	9:55	2.2	1.7	4:15	6.0	10:50	8.0	7.2	4:15	0.171	9:55	0.389	0.256	0.256
2/7/2016	2:45	1.4	11:35	2.2	1.7	4:10	5.7	10:00	8.0	7.0	4:10	0.155	11:35	0.391	0.245	0.245
2/8/2016	3:20	1.3	19:40	1.9	1.6	3:20	5.0	18:10	7.9	6.7	3:20	0.117	19:40	0.325	0.215	0.215
2/9/2016	3:05	1.3	20:40	1.9	1.6	4:50	5.1	7:00	7.7	6.7	3:05	0.122	7:35	0.317	0.209	0.209
2/10/2016	3:10	1.2	7:15	1.8	1.5	4:05	4.9	7:50	7.7	6.6	3:15	0.111	7:15	0.301	0.203	0.203
2/11/2016	3:30	1.2	7:10	1.9	1.5	2:40	4.5	7:15	7.8	6.6	3:30	0.101	7:15	0.314	0.204	0.204
2/12/2016	4:15	1.2	7:35	2.0	1.5	3:40	4.4	7:30	7.8	6.5	3:35	0.101	7:30	0.339	0.202	0.202
2/13/2016	3:05	1.3	9:45	2.0	1.6	3:20	5.0	9:50	7.8	6.6	3:05	0.115	9:50	0.352	0.216	0.216
2/14/2016	2:30	1.3	9:35	2.2	1.7	2:20	5.4	9:35	8.1	7.0	2:20	0.136	9:35	0.399	0.262	0.262
2/15/2016	23:55	1.5	11:00	2.0	1.7	4:45	6.1	9:45	7.8	7.1	4:30	0.188	11:00	0.346	0.261	0.261
2/16/2016	3:05	1.4	7:30	2.1	1.7	2:45	5.8	7:25	8.1	7.1	4:05	0.155	7:30	0.380	0.243	0.243
2/17/2016	3:05	1.4	19:30	2.1	1.7	3:30	5.8	20:20	8.2	7.1	1:40	0.155	19:30	0.382	0.250	0.250
2/18/2016	4:30	1.5	7:40	2.3	1.8	3:20	6.5	20:10	8.2	7.5	4:05	0.198	7:40	0.429	0.298	0.298
2/19/2016	4:50	1.7	7:55	2.3	2.0	0:35	7.2	7:45	8.5	7.9	2:55	0.265	7:55	0.461	0.347	0.347
2/20/2016	23:35	1.6	10:05	2.2	1.9	23:55	7.0	10:15	8.6	7.8	23:55	0.225	10:15	0.425	0.318	0.318
2/21/2016	5:30	1.5	9:40	2.0	1.7	3:45	6.5	10:15	8.4	7.5	4:20	0.192	10:15	0.380	0.274	0.274
2/22/2016	3:10	1.4	7:15	2.0	1.6	3:40	5.9	7:45	8.2	7.1	3:10	0.152	7:15	0.350	0.230	0.230
2/23/2016	3:05	1.3	7:30	1.9	1.6	4:50	5.2	7:30	8.1	6.9	4:50	0.127	7:30	0.340	0.215	0.215
2/24/2016	3:55	1.3	7:15	1.9	1.5	4:00	5.0	7:30	7.9	6.7	3:55	0.114	7:15	0.326	0.206	0.206
2/25/2016	3:50	1.2	7:40	2.0	1.5	4:50	4.7	7:40	7.9	6.5	4:50	0.106	7:40	0.338	0.195	0.195
2/26/2016	2:45	1.2	7:40	2.0	1.5	2:55	4.5	7:30	8.2	6.6	2:50	0.099	7:35	0.345	0.195	0.195
2/27/2016	3:40	1.3	10:00	2.0	1.6	2:00	5.1	8:40	8.0	6.9	2:00	0.118	10:00	0.352	0.221	0.221
2/28/2016	5:40	1.3	9:40	2.3	1.6	3:35	5.4	10:05	8.7	6.9	5:40	0.130	9:40	0.455	0.234	0.234
2/29/2016	3:10	1.2	7:50	2.0	1.6	3:20	5.1	7:35	8.0	6.8	3:35	0.120	0:00	0.170	0.135	0.021
ReportAvg					1.7					7.0					0.241	
ReportTotal																6.773

ADS Environmental Services

	9C-3\mp1\DFINAL (inches)					9C-3\mp1\VFINAL (feet/sec)					9C-3\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
3/1/2016	4:40	1.3	19:45	2.0	1.6	3:55	5.5	9:25	8.2	7.0	3:55	0.125	7:30	0.351	0.233	0.215
3/2/2016	2:40	1.4	21:45	2.0	1.7	2:25	5.9	9:55	8.2	7.2	2:40	0.152	20:00	0.359	0.247	0.247
3/3/2016	23:55	1.5	7:20	2.1	1.7	0:20	6.5	7:20	8.3	7.3	3:55	0.197	7:20	0.402	0.263	0.263
3/4/2016	2:50	1.4	8:00	2.0	1.6	3:05	6.2	7:15	8.2	7.2	3:25	0.161	7:45	0.364	0.232	0.232
3/5/2016	4:20	1.3	8:50	1.9	1.6	4:15	6.0	8:55	8.1	7.2	4:15	0.147	8:50	0.339	0.235	0.235
3/6/2016	4:45	1.3	10:25	2.0	1.6	4:35	5.9	9:35	8.5	7.1	4:45	0.140	9:35	0.360	0.240	0.240
3/7/2016	1:15	1.4	20:25	1.9	1.6	14:10	5.6	20:20	7.5	6.9	1:15	0.150	20:25	0.298	0.230	0.136
ReportAvg					1.6					7.1					0.241	
ReportTotal																1.573

11A-2

Located At: Volpe Rd South of Reservoir (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016
Pipe Dimensions: 15 in x 15.13 in
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sewer pipe. The scattergraph indicates normal open channel flow. The data plots below the Froude =1 curve indicating subcritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (in)	100%	100%
Velocity (f/s)	100%	100%
Quantity (MGD)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

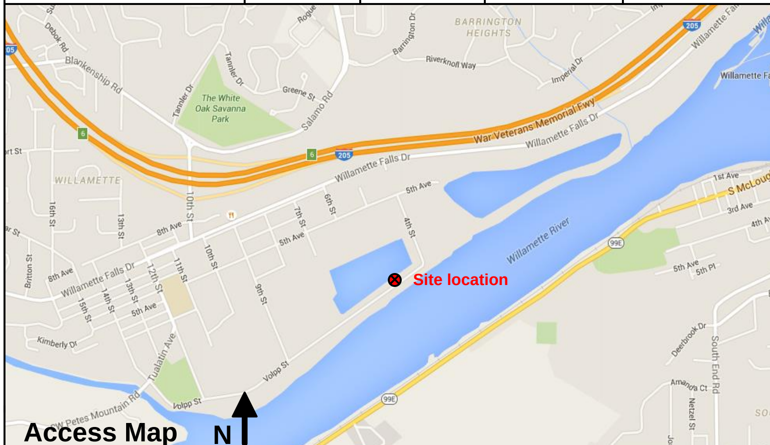
Item	Depth (in)	Velocity (f/s)	Quantity (MGD)	% Full
Minimum	3.2	0.7	0.095	21%
Maximum	5.1	1.4	0.336	34%
Average	4.1	1.1	0.196	27%

ADS Site Report — Quality Form

ADS ENVIRONMENTAL SERVICES®

Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

Site Name: 11A_2	**Monitor Series:** 8000-FST	**Monitor S/N:**	20591
Address/Location: Volpe Rd South of Resevoir		**IP Address:**	166.219.50.58
		Manhole #	11A-2
		GPS Coordinates	45.343602°-122.640526°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	15.00"
		Pipe Width:	15.13"



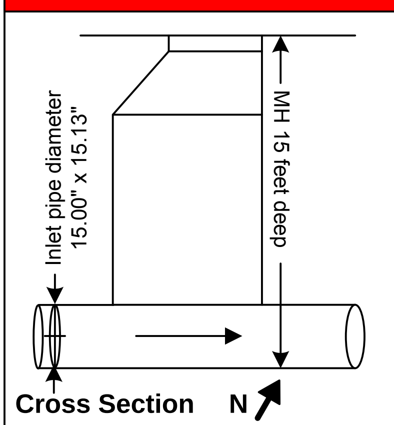
Investigation Information:

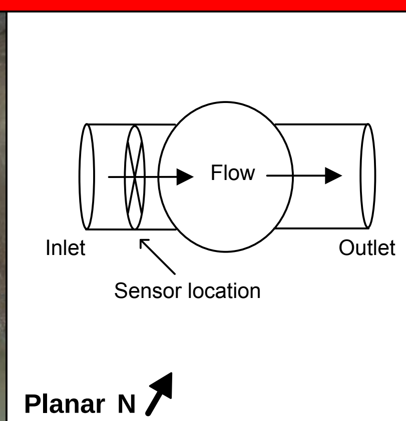
Date/Time of Investigation:	12/16/2015 @ 10:46
Site Hydraulics:	Smooth, Laminar
Upstream Input: (L/S, P/S)	DNI
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow:	4.88" +/- 0.25"
Range (Air DOF):	10.13" +/- 0.25"
Peak Velocity:	1.37 fps
Silt:	None

Manhole Information:

Manhole Depth:	15"	
Manhole Material / Condition	Concrete / Good	
Pipe Material / Condition:	Concrete / Good	
Mini System Character:	Residential [ ] Commercial [ ] Industrial [ ] Trunk [X]	
Telephone Information:	Does not apply	
Access Pole #:	Does not apply	
Distance From Manhole:	Does not apply	Feet
Road Cut Length:	Does not apply	Feet
Trench Length:	Does not apply	Feet

Other Information:



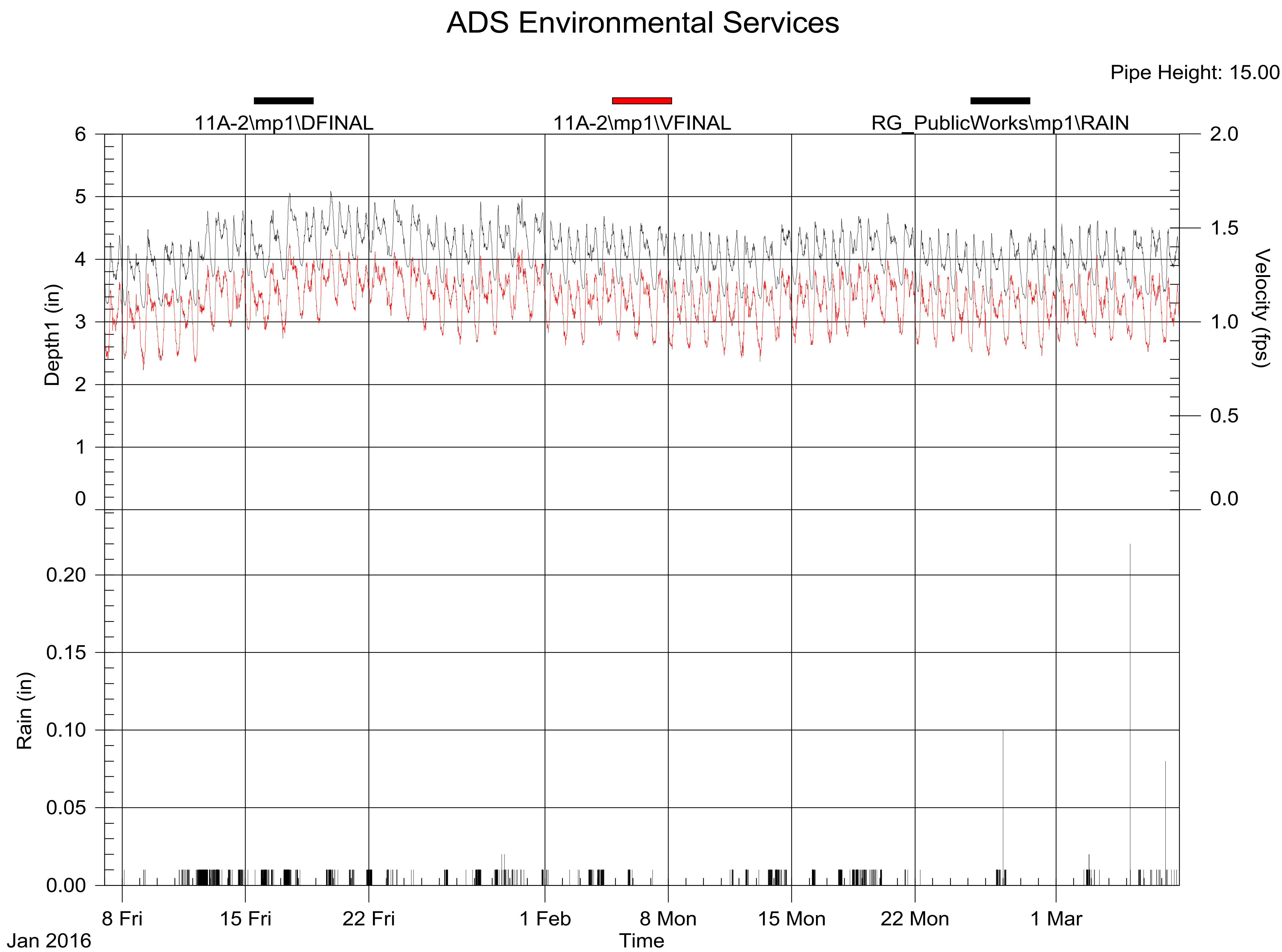


Installation Information	
Installation Type:	Standard
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity)
Surcharge Height:	None Observed
Rain Guage Zone:	RG_PublicWork (Gladstone)

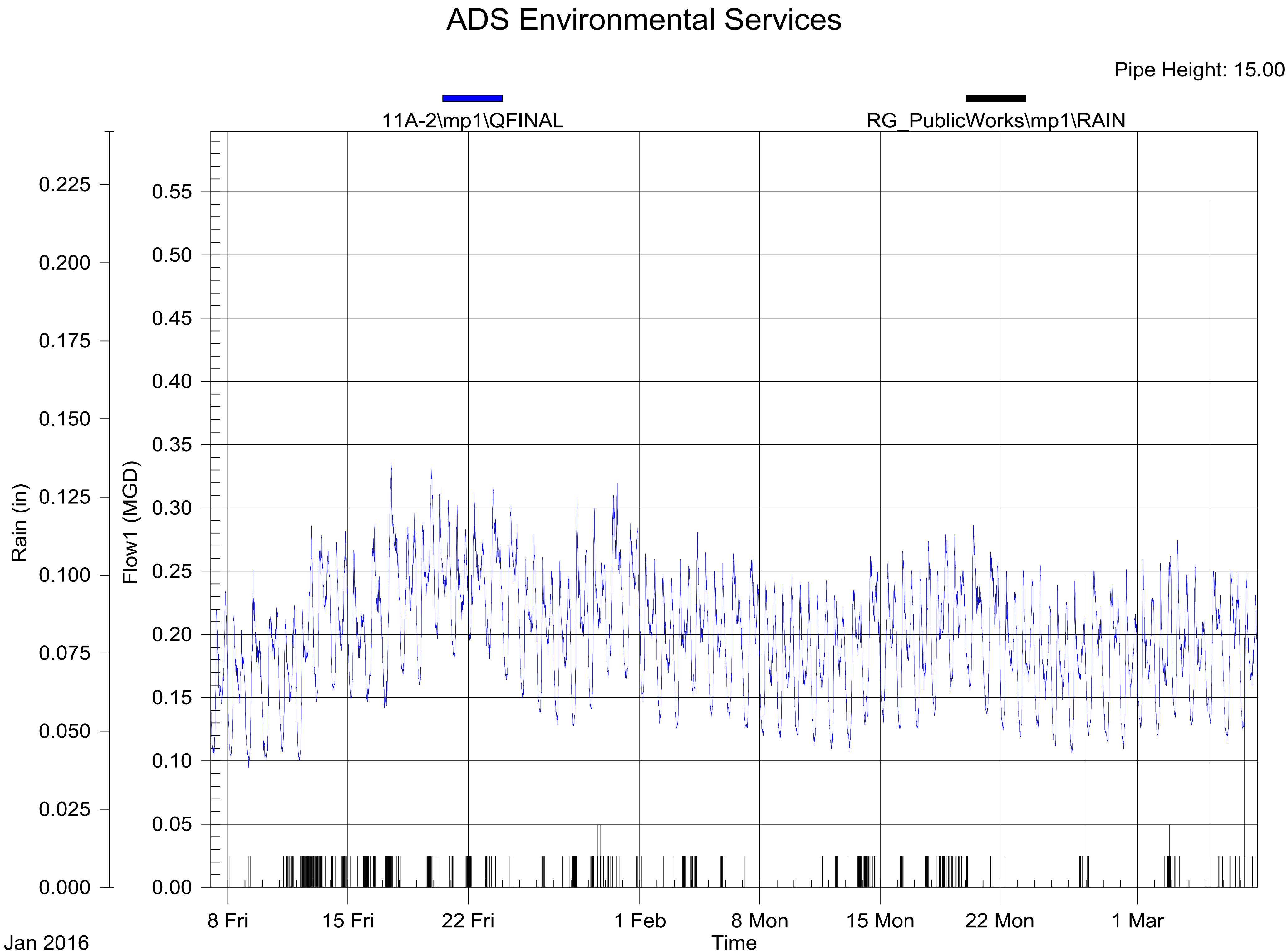
Backup	Yes	No	?	Distance
Trunk		X		
Lift / Pump Station		X		
WWTP		X		
Other		X		

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)



ADS Environmental Services
Pipe Height: 15.00
11A-2\mp1\DFINAL
11A-2\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Depth1 (in)
Velocity (fps)
Rain (in)
6
5
4
3
2
1
0
2.0
1.5
1.0
0.5
0.0
0.20
0.15
0.10
0.05
0.00
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time

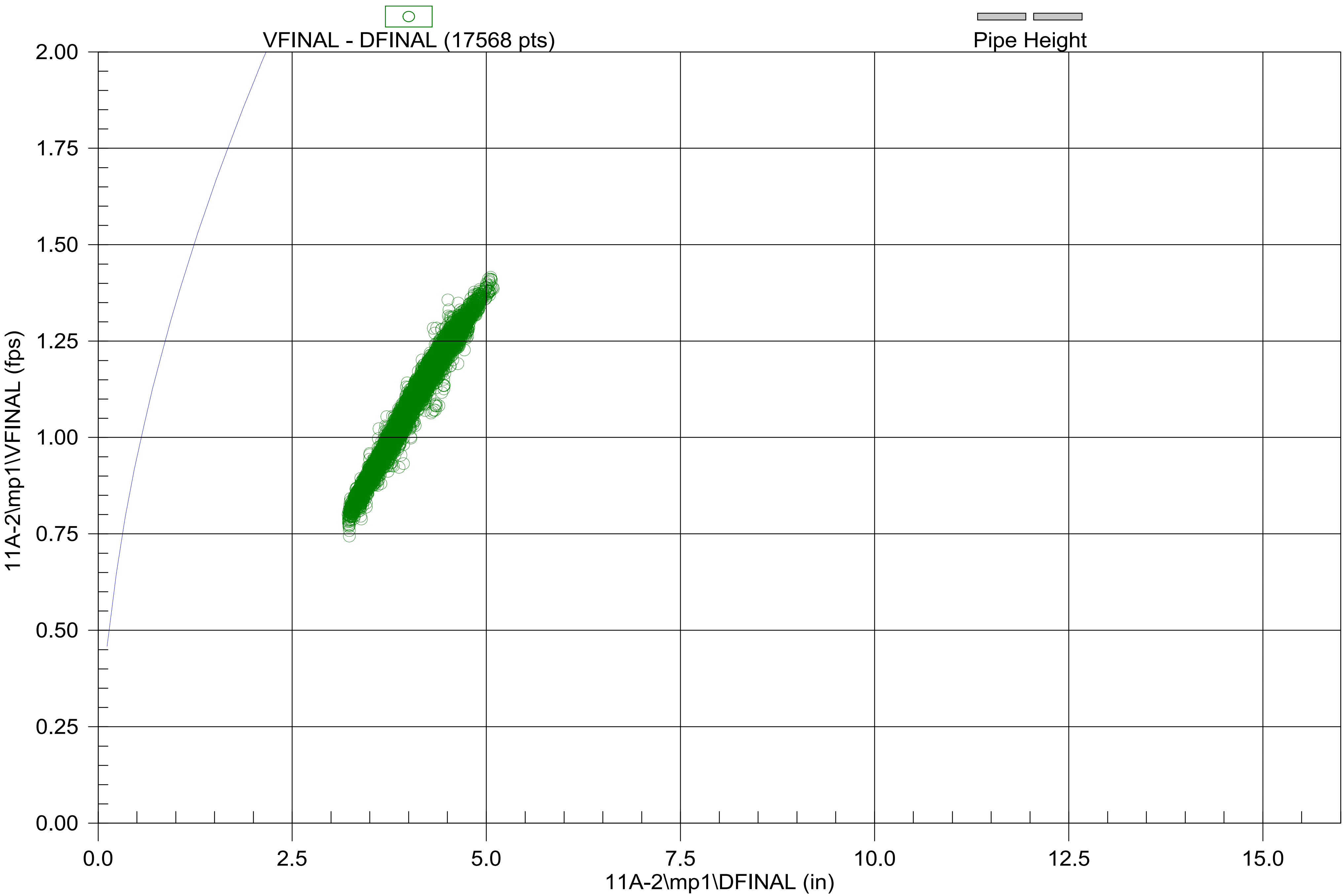


ADS Environmental Services
Pipe Height: 15.00
11A-2\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
Flow1 (MGD)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time

ADS Environmental Services

1/7/2016 12:00:00 AM - 3/7/2016 11:59:00 PM

Pipe Height: 15.00



ADS Environmental Services

	11A-2\mp1\DFINAL (inches)					11A-2\mp1\VFINAL (feet/sec)					11A-2\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
1/7/2016	5:00	3.3	20:35	4.4	3.8	4:45	0.8	20:30	1.2	1.0	4:45	0.104	20:35	0.234	0.163	0.163
1/8/2016	4:15	3.3	8:40	4.2	3.8	3:25	0.8	8:45	1.2	1.0	3:25	0.103	8:35	0.215	0.159	0.159
1/9/2016	6:25	3.2	11:25	4.5	3.8	5:10	0.7	11:20	1.3	1.0	5:10	0.095	11:20	0.251	0.164	0.164
1/10/2016	5:30	3.2	20:15	4.3	3.8	5:25	0.8	20:15	1.2	1.0	5:25	0.101	20:15	0.222	0.166	0.166
1/11/2016	4:25	3.3	21:20	4.3	3.8	3:45	0.8	21:25	1.2	1.0	3:45	0.107	21:20	0.223	0.163	0.163
1/12/2016	4:15	3.3	20:40	4.8	4.0	4:30	0.8	20:40	1.3	1.1	4:30	0.101	20:40	0.286	0.183	0.183
1/13/2016	4:05	3.7	11:10	4.8	4.3	4:10	0.9	11:00	1.3	1.2	4:10	0.147	11:00	0.278	0.222	0.222
1/14/2016	3:25	3.8	20:30	4.8	4.2	3:40	1.0	20:30	1.3	1.1	3:25	0.155	20:30	0.282	0.211	0.211
1/15/2016	4:45	3.7	8:05	4.6	4.1	4:10	1.0	8:35	1.3	1.1	4:40	0.149	8:05	0.267	0.198	0.198
1/16/2016	3:40	3.7	13:25	4.8	4.2	3:45	1.0	13:25	1.3	1.1	3:40	0.147	13:25	0.288	0.210	0.210
1/17/2016	3:40	3.7	12:30	5.1	4.4	2:50	0.9	12:15	1.4	1.2	2:50	0.142	12:15	0.336	0.236	0.236
1/18/2016	4:55	3.9	21:05	4.8	4.4	5:10	1.0	21:10	1.3	1.2	5:10	0.168	21:10	0.296	0.230	0.230
1/19/2016	4:40	3.8	20:30	5.1	4.4	4:00	1.0	20:25	1.4	1.2	4:00	0.160	20:30	0.332	0.242	0.242
1/20/2016	5:00	4.2	8:05	4.9	4.5	5:10	1.1	8:35	1.4	1.2	5:10	0.196	8:35	0.315	0.250	0.250
1/21/2016	5:40	4.0	8:40	4.8	4.4	5:35	1.1	8:40	1.4	1.2	5:40	0.181	8:40	0.302	0.232	0.232
1/22/2016	3:20	4.1	8:35	4.9	4.5	1:55	1.1	8:40	1.4	1.2	1:55	0.195	8:40	0.312	0.247	0.247
1/23/2016	5:15	4.0	11:05	5.0	4.5	6:00	1.0	10:50	1.4	1.2	6:00	0.181	10:50	0.315	0.244	0.244
1/24/2016	5:55	3.9	12:05	4.9	4.4	5:45	1.0	12:00	1.3	1.2	5:50	0.164	12:00	0.302	0.232	0.232
1/25/2016	4:55	3.8	20:10	4.7	4.2	3:35	1.0	20:10	1.3	1.1	3:35	0.150	20:10	0.279	0.210	0.210
1/26/2016	4:20	3.6	8:10	4.6	4.1	4:50	0.9	10:20	1.3	1.1	4:15	0.138	8:10	0.261	0.200	0.200
1/27/2016	4:05	3.6	8:15	4.6	4.0	4:20	0.9	8:15	1.3	1.1	4:20	0.128	8:15	0.259	0.191	0.191
1/28/2016	3:45	3.5	8:30	4.9	4.2	2:35	0.9	8:30	1.4	1.1	3:40	0.127	8:30	0.309	0.209	0.209
1/29/2016	4:10	3.7	8:25	4.9	4.2	2:40	0.9	8:25	1.3	1.1	4:15	0.141	8:25	0.300	0.214	0.214
1/30/2016	4:10	3.9	16:30	5.0	4.4	3:55	1.0	16:40	1.4	1.2	3:55	0.165	16:35	0.320	0.240	0.240
1/31/2016	6:00	3.8	21:20	4.7	4.3	3:35	1.0	11:10	1.3	1.2	3:35	0.165	11:10	0.287	0.228	0.228
ReportAvg					4.2					1.1					0.210	
ReportTotal																5.244

ADS Environmental Services

	11A-2\mp1\DFINAL (inches)					11A-2\mp1\VFINAL (feet/sec)					11A-2\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
2/1/2016	4:40	3.7	8:00	4.6	4.2	4:40	0.9	8:50	1.3	1.1	4:40	0.147	8:00	0.264	0.206	0.206
2/2/2016	4:50	3.6	8:40	4.5	4.1	3:55	0.9	20:25	1.2	1.1	3:55	0.130	8:40	0.248	0.189	0.189
2/3/2016	4:10	3.5	8:50	4.6	4.1	3:25	0.9	8:50	1.3	1.1	4:00	0.126	8:50	0.259	0.193	0.193
2/4/2016	2:15	3.7	8:30	4.7	4.2	2:15	1.0	8:40	1.3	1.1	2:15	0.153	8:30	0.281	0.207	0.207
2/5/2016	4:20	3.6	20:10	4.5	4.1	4:40	0.9	20:10	1.3	1.1	4:40	0.134	20:10	0.257	0.194	0.194
2/6/2016	5:30	3.6	10:40	4.6	4.1	5:20	0.9	10:45	1.3	1.1	5:20	0.133	10:45	0.264	0.196	0.196
2/7/2016	6:20	3.5	12:15	4.5	4.1	3:25	0.9	13:00	1.3	1.1	4:25	0.126	13:00	0.260	0.195	0.195
2/8/2016	4:05	3.5	8:30	4.4	4.0	5:15	0.9	20:55	1.2	1.1	5:15	0.120	8:25	0.242	0.179	0.179
2/9/2016	4:05	3.4	20:45	4.5	3.9	4:10	0.9	20:35	1.2	1.0	4:10	0.118	20:35	0.247	0.176	0.176
2/10/2016	4:40	3.5	8:35	4.4	3.9	4:05	0.9	20:40	1.2	1.0	4:10	0.120	8:05	0.241	0.175	0.175
2/11/2016	5:00	3.4	21:20	4.5	3.9	3:55	0.8	21:25	1.2	1.0	3:55	0.112	21:20	0.243	0.172	0.172
2/12/2016	4:00	3.4	8:35	4.4	3.9	4:00	0.8	11:10	1.2	1.0	4:00	0.109	8:35	0.231	0.175	0.175
2/13/2016	5:15	3.4	11:35	4.4	3.9	4:55	0.8	11:00	1.2	1.0	4:55	0.107	11:55	0.236	0.177	0.177
2/14/2016	3:05	3.5	10:45	4.6	4.1	2:40	0.9	11:45	1.3	1.1	3:05	0.129	10:45	0.261	0.198	0.198
2/15/2016	4:35	3.6	11:00	4.5	4.1	4:40	0.9	11:00	1.3	1.1	4:40	0.130	11:00	0.256	0.194	0.194
2/16/2016	4:25	3.5	8:00	4.6	4.1	3:15	0.9	8:00	1.3	1.1	4:15	0.125	8:00	0.266	0.194	0.194
2/17/2016	4:40	3.5	20:00	4.6	4.0	3:35	0.9	20:00	1.3	1.1	4:45	0.126	20:00	0.274	0.191	0.191
2/18/2016	4:05	3.6	19:15	4.7	4.2	4:05	0.9	19:35	1.3	1.1	4:05	0.136	19:15	0.279	0.208	0.208
2/19/2016	3:30	3.8	8:30	4.7	4.2	3:30	1.0	8:35	1.3	1.2	3:30	0.155	8:35	0.279	0.215	0.215
2/20/2016	6:00	3.8	10:55	4.7	4.2	6:00	1.0	10:40	1.3	1.2	6:00	0.156	11:00	0.286	0.213	0.213
2/21/2016	5:25	3.6	10:35	4.6	4.1	5:45	0.9	11:25	1.3	1.1	5:45	0.137	10:35	0.265	0.203	0.203
2/22/2016	4:30	3.5	8:40	4.5	4.0	4:10	0.9	8:40	1.2	1.1	4:10	0.124	8:40	0.250	0.183	0.183
2/23/2016	4:50	3.4	8:05	4.5	4.0	4:50	0.9	8:10	1.3	1.1	4:50	0.119	8:10	0.252	0.182	0.182
2/24/2016	5:05	3.5	8:10	4.5	3.9	3:20	0.9	8:20	1.3	1.1	4:50	0.126	8:20	0.255	0.175	0.175
2/25/2016	5:10	3.3	8:10	4.4	3.9	5:10	0.8	8:15	1.2	1.0	5:10	0.112	8:10	0.239	0.169	0.169
2/26/2016	4:30	3.3	8:35	4.4	3.8	4:20	0.8	8:30	1.2	1.0	4:20	0.106	8:30	0.242	0.169	0.169
2/27/2016	3:45	3.4	10:15	4.5	4.0	3:45	0.9	11:35	1.2	1.1	3:45	0.120	10:15	0.251	0.183	0.183
2/28/2016	6:20	3.4	13:20	4.4	3.9	6:05	0.9	10:40	1.2	1.1	6:20	0.115	13:20	0.239	0.180	0.180
2/29/2016	4:30	3.3	8:35	4.5	3.9	4:50	0.8	8:55	1.3	1.0	4:50	0.109	8:40	0.252	0.171	0.171
ReportAvg					4.0					1.1					0.188	
ReportTotal																5.463

ADS Environmental Services

	11A-2\mp1\DFINAL (inches)					11A-2\mp1\VFINAL (feet/sec)					11A-2\mp1\QFINAL (MGD - Total MG)					
Date	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Time	Min.	Time	Max.	Average	Total
3/1/2016	4:40	3.5	7:55	4.6	4.0	5:00	0.9	7:55	1.3	1.1	4:55	0.126	7:55	0.259	0.183	0.183
3/2/2016	5:00	3.4	22:30	4.6	4.0	4:50	0.9	22:55	1.3	1.1	4:50	0.120	22:35	0.262	0.184	0.184
3/3/2016	5:20	3.6	8:45	4.6	4.0	5:20	0.9	7:55	1.4	1.1	5:20	0.134	7:55	0.274	0.191	0.191
3/4/2016	4:00	3.5	8:25	4.5	4.0	2:10	0.9	8:30	1.3	1.1	3:35	0.128	8:30	0.256	0.180	0.180
3/5/2016	5:50	3.5	10:10	4.5	4.0	5:40	0.9	10:10	1.2	1.1	5:45	0.129	10:10	0.250	0.191	0.191
3/6/2016	5:25	3.4	10:20	4.5	4.0	5:20	0.8	20:50	1.3	1.1	5:20	0.115	10:40	0.251	0.187	0.187
3/7/2016	2:45	3.5	9:00	4.5	3.9	2:45	0.9	9:00	1.2	1.0	2:45	0.125	9:00	0.248	0.177	0.177
ReportAvg					4.0					1.1					0.185	
ReportTotal																1.293

RG-PublicWorks

Located At: 18595 Portland Ave (see attached site report for details)
Monitoring Period: January 7, 2016 – March 7, 2016

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Rain	100%	100%

Site Data Summary: A review of the hydrograph indicates that RG_OV functioned under normal conditions during the period Monday, January 7, 2016 through Thursday, March 7, 2016.

RG_PublicWorks	
Total Rainfall	13.19 "

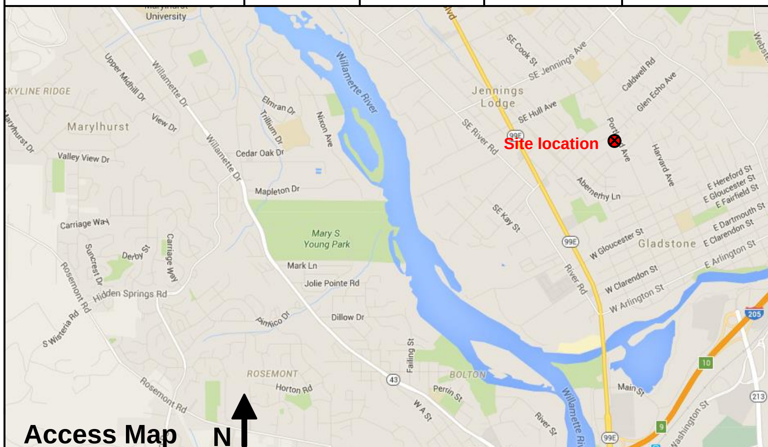
ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

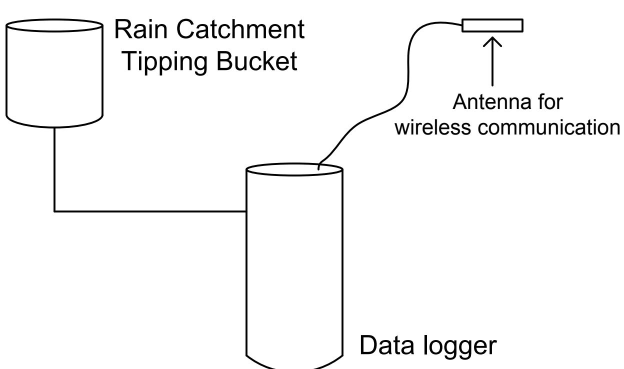
Project Name:	WestLinn.TFM.OR15-16	**City / State:**	West Linn, OR	**FM Initials:**	DS

Site Name: RG_Publicworks	**Monitor Series:** AG-5000	**Monitor S/N:**	26138
Address/Location: 18595 Portland Ave		**IP Address:**	166.219.50.7
		Location	Gladstone City Shops
		GPS Coordinates	45.387965° -122.600491°
Access: Drive	**Type of System:** Sanitary ☐ Storm ☐ Combined ☐	**Tipping Bucket Dia.**	8"
		Model	ADS



Investigation Information:		**Manhole Information:**	
Date/Time of Investigation:	11/19/2015 @ 17:28	**Manhole Depth:**	N/A
Site Hydraulics:	N/A	**Manhole Material / Condition**	N/A
Upstream Input: (L/S, P/S)	N/A	**Pipe Material / Condition:**	N/A
Upstream Manhole:	N/A	**Mini System Character:**	Residential ☐ Commercial ☐ Industrial ☐ Trunk ☐
Downstream Manhole:	N/A	**Telephone Information:**	Does not apply
Depth of Flow:	N/A	**Access Pole #:**	Does not apply
Range (Air DOF):	N/A	**Distance From Manhole:**	Does not apply Feet
Peak Velocity:	N/A	**Road Cut Length:**	Does not apply Feet
Silt:	N/A	**Trench Length:**	Does not apply Feet

Other Information:

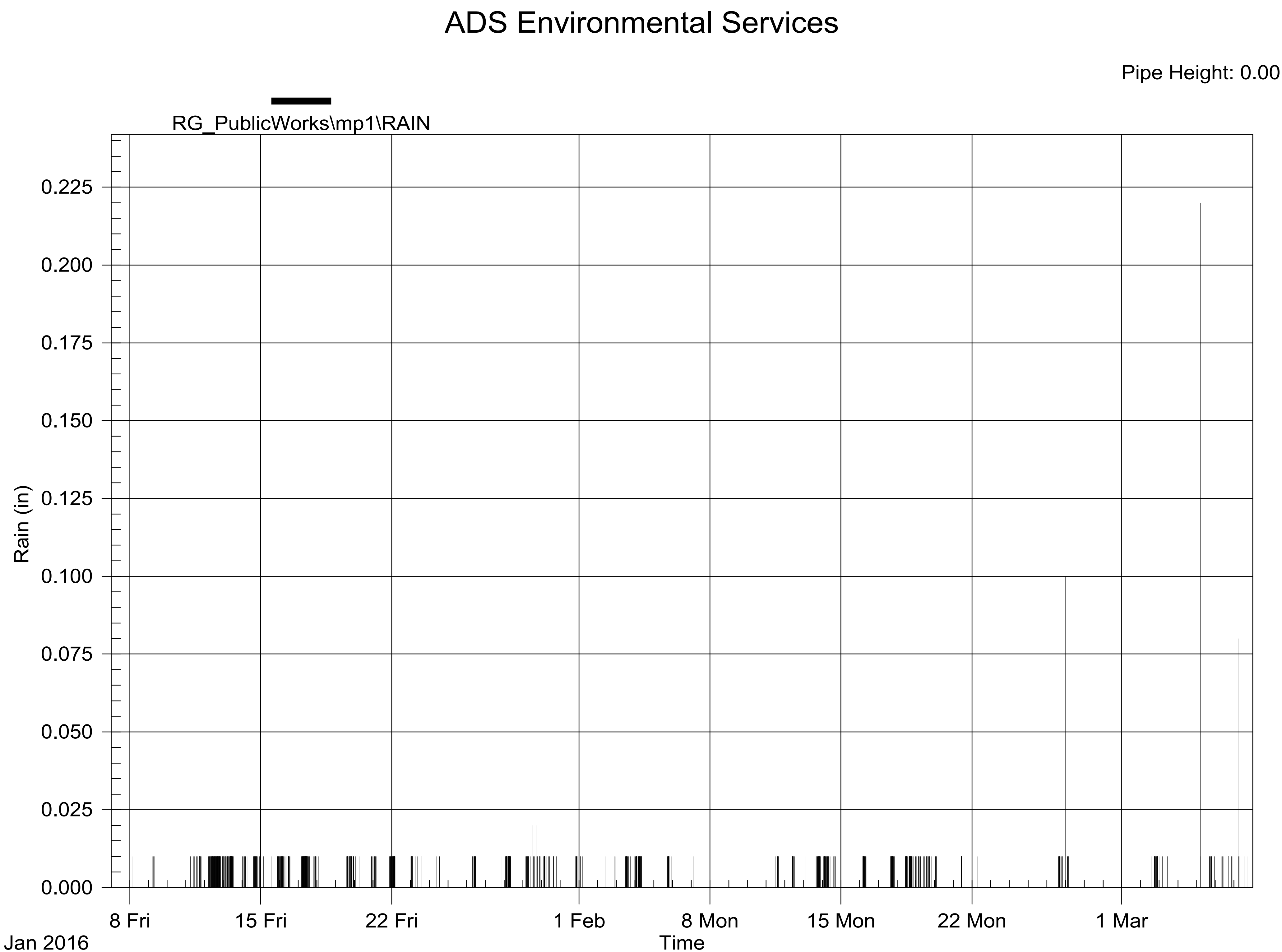


Schematic

Installation Information		**Backup**	**Yes**	**No**	**?**	**Distance**
Installation Type:	N/A	Trunk	☐	X	☐	
Sensors Devices:	N/A	Lift / Pump Station	☐	X	☐	
Surcharge Height:	N/A	WWTP	☐	X	☐	
Rain Guage Zone:	RG_Publicworks (Gladstone)	Other	☐	X	☐	

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)


ADS Environmental Services
Pipe Height: 0.00
RG_PublicWorks\mp1\RAIN
Rain (in)
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
8 Fri
15 Fri
22 Fri
1 Feb
8 Mon
15 Mon
22 Mon
1 Mar
Jan 2016
Time

ADS Environmental Services

	RG_PublicWorks\mp1\RAIN (inches)
Date	Total
1/7/2016	0.00
1/8/2016	0.01
1/9/2016	0.03
1/10/2016	0.00
1/11/2016	0.22
1/12/2016	0.97
1/13/2016	0.75
1/14/2016	0.37
1/15/2016	0.12
1/16/2016	0.54
1/17/2016	0.96
1/18/2016	0.01
1/19/2016	0.41
1/20/2016	0.09
1/21/2016	0.26
1/22/2016	0.42
1/23/2016	0.28
1/24/2016	0.02
1/25/2016	0.00
1/26/2016	0.16
1/27/2016	0.02
1/28/2016	0.67
1/29/2016	0.63
1/30/2016	0.26
1/31/2016	0.15
ReportAvg	
ReportTotal	7.35

ADS Environmental Services

Date	RG_PublicWorks\mp1\RAIN (inches) Total
2/1/2016	0.04
2/2/2016	0.03
2/3/2016	0.24
2/4/2016	0.47
2/5/2016	0.25
2/6/2016	0.00
2/7/2016	0.01
2/8/2016	0.00
2/9/2016	0.00
2/10/2016	0.00
2/11/2016	0.13
2/12/2016	0.25
2/13/2016	0.28
2/14/2016	0.39
2/15/2016	0.00
2/16/2016	0.31
2/17/2016	0.51
2/18/2016	0.73
2/19/2016	0.45
2/20/2016	0.12
2/21/2016	0.10
2/22/2016	0.01
2/23/2016	0.00
2/24/2016	0.00
2/25/2016	0.00
2/26/2016	0.19
2/27/2016	0.19
2/28/2016	0.00
2/29/2016	0.00
ReportAvg	
ReportTotal	4.70

ADS Environmental Services

	RG_PublicWorks\mp1\RAIN (inches)
Date	Total
3/1/2016	0.00
3/2/2016	0.46
3/3/2016	0.04
3/4/2016	0.00
3/5/2016	0.34
3/6/2016	0.14
3/7/2016	0.16
ReportAvg	
ReportTotal	1.14

Appendix 1C

FLOW FACTOR DEVELOPMENT

Appendix C - Detailed Flow Factor Development

Table 1 - Land Use Acreage

			Flow Monitoring Basins								
Land Use Category	Total	9A-14	11A-2	9A-2	1A-37-1-0	3B-4	2B-1-0	9C-3	2A-19	3A-8	2B-0-12
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Commercial	79	8	2	37	0	9		6		16	
Industrial	45	0	21	24							
Low Density Residential	2,014	222	133	275	74	74	88	151	78	590	330
Medium Density Residential	162	42	27	4	65				8	17	
Medium High Density Residential	129	18		55		12	6	19		1	18
Mixed Use	9		2	8							
No Zoning - Freeway	1			0				1			
No Zoning - River	0		0	0			0			0	
No Zoning - Unzoned	0										
Open Space	124	9	7	8		5	11	10	0	38	34
Park	139	9	43	6	7	0	0	22	4	38	9
Vacant	205	15	47	56	3	2	4	17	8	31	24
Potential Spetic Systems	46	12	3	2	1	1	1	4	1	9	11
Total (acres)	3,915	336	284	477	150	103	109	229	100	740	426

Table 2 - Planning Flow Factors

			Flow Monitoring Basins								
Land Use Category	Total	9A-14	11A-2	9A-2	1A-37-1-0	3B-4	2B-1-0	9C-3	2A-19	3A-8	2B-0-12
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Commercial	1,000	1,000	1,000	1,000	1,000	1,000		1,000		1,000	
Industrial	1,190		1,200	1,200							
Low Density Residential	940	870	810	740	2,600	780	2,240	970	1,100	635	1,040
Medium Density Residential	2,040	1,500	1,200	1,500	3,100				1,700	1,000	
Medium High Density Residential	2,710	2,700		2,600		2,600	4,000	2,600		1,600	2,900
Mixed Use	3,500		3,500	3,500							
No Zoning - Freeway	0										
No Zoning - River	0										
No Zoning - Unzoned	0										
Open Space	0										
Park	0										
Vacant	0										
Potential Spetic Systems	0										

Table 3 - ADWF

			Flow Monitoring Basins								
Land Use Category	Total	9A-14	11A-2	9A-2	1A-37-1-0	3B-4	2B-1-0	9C-3	2A-19	3A-8	2B-0-12
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Commercial	0.079	8,453	2,066	37,392	458	9,054	0	6,046	0	15,551	0
Industrial	0.054	0	24,963	29,067	0	0	0	0	0	0	0
Low Density Residential	1.901	192,929	107,859	203,523	192,574	57,771	196,458	146,638	85,627	374,392	343,074
Medium Density Residential	0.332	62,956	31,833	6,450	200,007	0	0	0	14,161	16,846	0
Medium High Density Residential	0.351	49,939	0	144,015	0	30,954	23,209	48,476	0	1,589	52,920
Mixed Use	0.032	0	5,514	26,735	0	0	0	0	0	0	0
No Zoning - Freeway	0.000	0	0	0	0	0	0	0	0	0	0
No Zoning - River	0.000	0	0	0	0	0	0	0	0	0	0
No Zoning - Unzoned	0.000	0	0	0	0	0	0	0	0	0	0
Open Space	0.000	0	0	0	0	0	0	0	0	0	0
Park	0.000	0	0	0	0	0	0	0	0	0	0
Vacant	0.000	0	0	0	0	0	0	0	0	0	0
Potential Spetic Systems	0.000	0	0	0	0	0	0	0	0	0	0
Total ADWF (mgd)	2.749	0.314	0.172	0.447	0.393	0.098	0.220	0.201	0.100	0.408	0.396
Measured ADWF (mgd)	2.751	0.316	0.172	0.446	0.392	0.098	0.219	0.201	0.101	0.408	0.397
Difference (%)	0.06%	0.70%	0.01%	-0.21%	-0.21%	0.27%	-0.25%	0.17%	0.86%	-0.20%	0.26%

Attachment B

TECHNICAL MEMORANDUM 2: EXISTING SYSTEM

City of West Linn

Sanitary Sewer Master Plan Update

TECHNICAL MEMORANDUM 2
EXISTING SYSTEM

DRAFT | March 2019

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City of West Linn
Sanitary Sewer Master Plan Update

TECHNICAL MEMORANDUM 2

EXISTING SYSTEM

Matthew M. Huang,
March 12, 2019,
State of Oregon,
P.E. No. 91512

Contents

Tables

Figures

Abbreviations

%	percent
Carollo	Carollo Engineers, Inc.
City	City of West Linn
ft	Feet
gpm	gallons per minute
hp	horsepower
LF	linear foot
PVC	polyvinyl chloride
TCSD	Tri-City Service District
TM	Technical Memorandum
WES	Water Environment Services

Technical Memorandum 2

EXISTING SYSTEM

2.1 Introduction

This Technical Memorandum (TM) describes the City of West Linn's (City) existing wastewater collection system and provides an inventory of the City's assets. The City operates and maintains approximately 115 miles of wastewater pipes and seven pump stations. Wastewater is conveyed to the Tri-City Water Pollution Control Plant for treatment.

Three additional pump stations that are part of the collection system belonging to the Tri-City Service District (TCSD), which is managed by Clackamas County's Water Environment Services (WES) department. Wastewater is conveyed to the Tri-City Water Pollution Control Plant for treatment.

A condition assessment of the pipelines or pump stations was not within the scope of this planning effort.

2.2 History

The community of West Linn was first occupied by settlers in the early 1840s and West Linn became an incorporated city in 1913. The oldest parts of the City's sewer system were built around 1900 including a primary wastewater treatment plant located on South Agnes Avenue in Oregon City, now called the Tri-City Water Pollution Control Plant.

2.3 Collection System Facilities

The City's collection system consists of approximately 115 miles of gravity mains, 1.5 miles of force mains, and 10 pump stations that collect and convey wastewater to the Tri-City Water Pollution Control Plant. The City owns and maintains six small pump stations and one larger pump station, the Mapleton Pump Station. The remaining three pump stations (Bolton, River Street, and Willamette Pump Station) are operated and maintained by WES. County customers contribute flow both upstream and downstream of the City collection system.

Figure 2.1 presents the City's existing collection system, and shows the currently connected and contributing tax lots as provided by the City.

2.3.1 Wastewater Basins

The City's collection system is divided into 25 wastewater basins that are denoted alphabetically, as shown in Figure 2.2. Wastewater basins delineate large areas of the conveyance system network that ultimately flow to one location, specifically the regional interceptor running throughout the City's collection system. The basin boundaries almost always follow topographic features such as ridge lines, streams, rivers, and capture each property contributing flow to the sewer collectors in that basin. The City and Carollo reviewed and updated the basin boundaries as part of this Plan such that all properties contributing flow to a basin are captured in the correct basin's boundary. To identify capacity requirements for specific facilities throughout the system, flows were developed for each wastewater basin.

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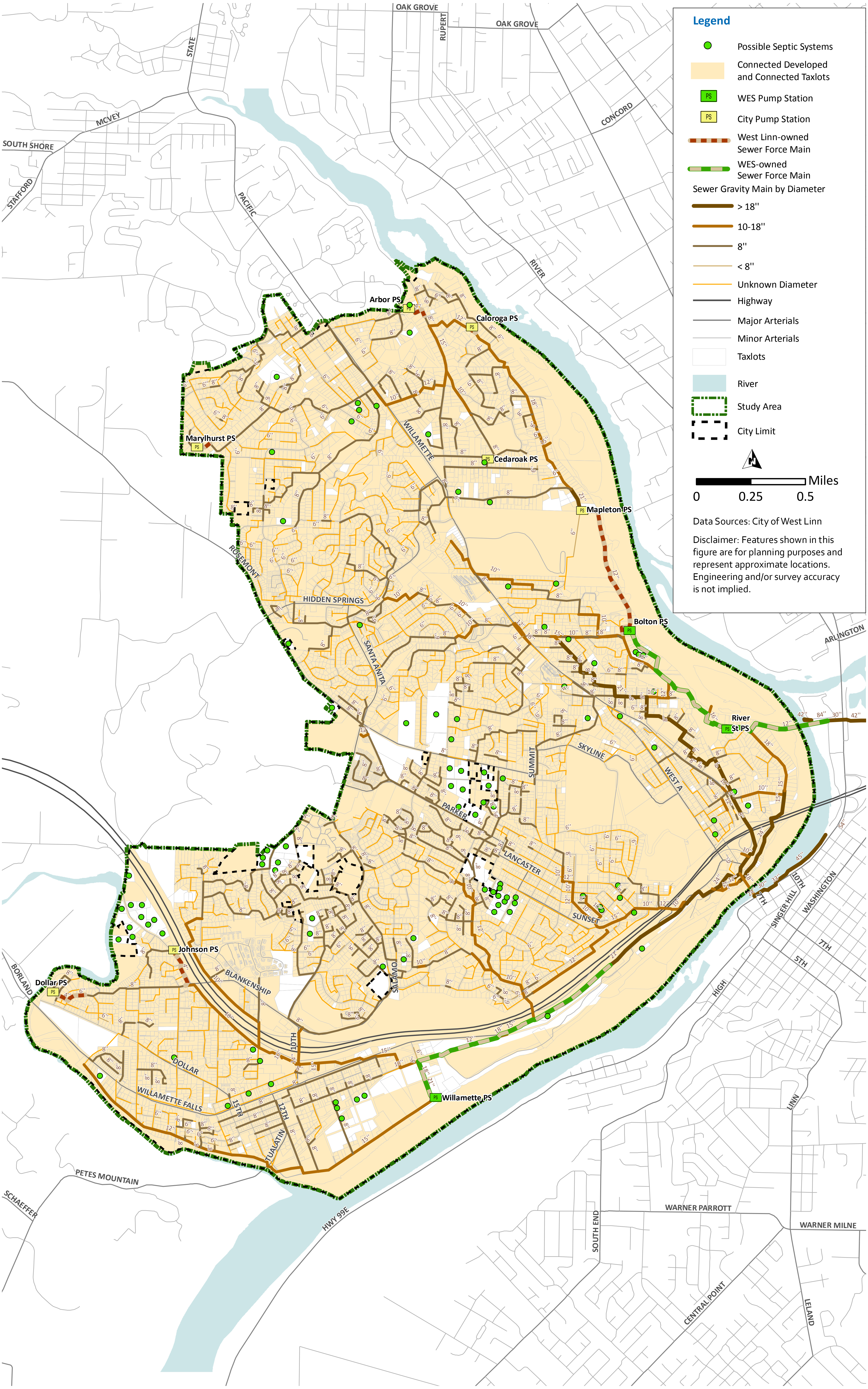

Figure 2.1 Existing System

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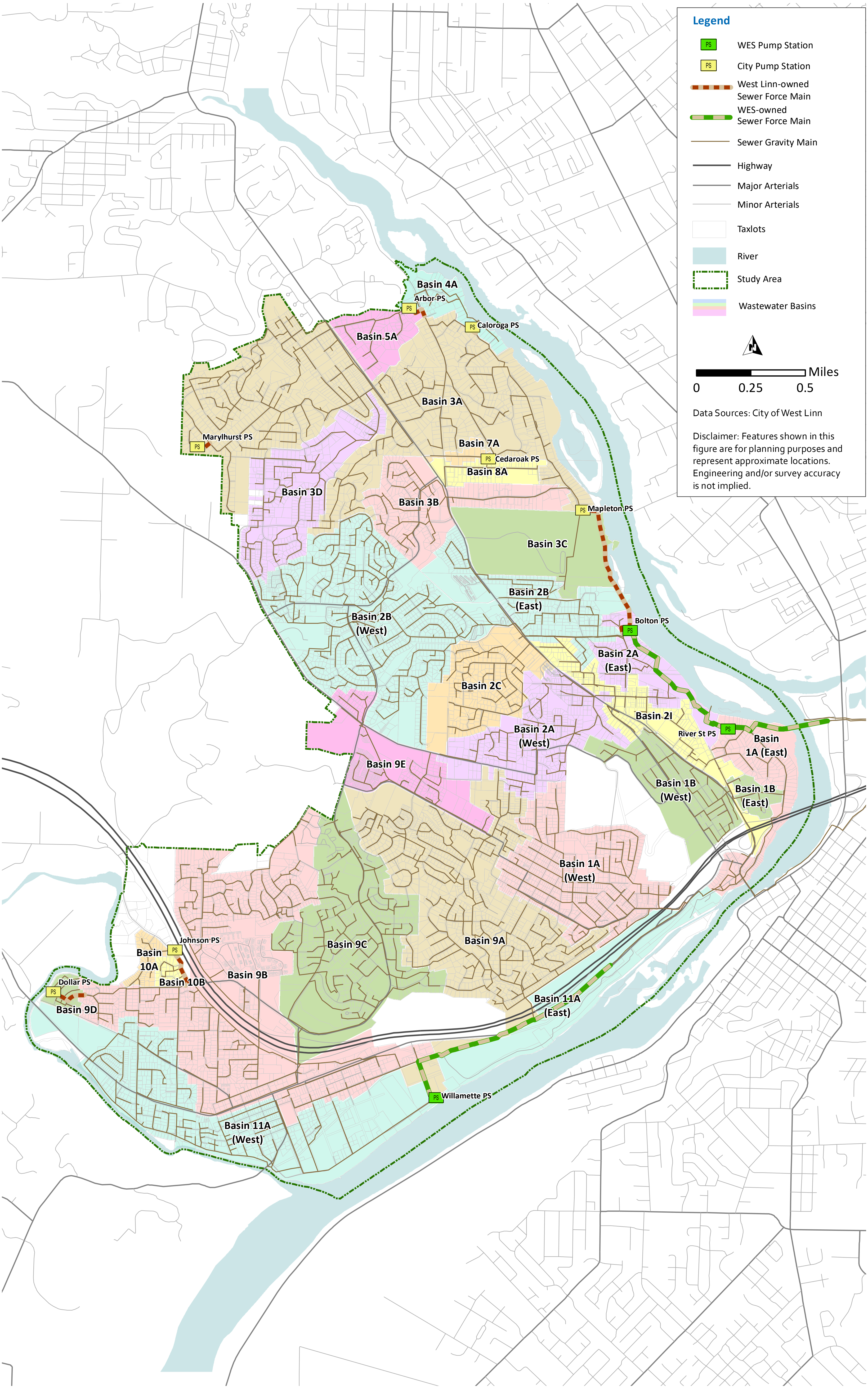

Figure 2.2 Wastewater Basins

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2.3.2 Gravity Collection System

The gravity pipelines within the City's collection system range in size from 4 to 24 inches in diameter. About 25 percent (%) of the system is constructed of clay pipe located in the Bolton and Sunset areas, 25% polyvinyl chloride (PVC), and 50% concrete pipe located mainly in the Robinwood, River Street, and Willamette areas. Table 2.1 provides an inventory of the gravity mains within the City's collection system. This table includes pipes owned by the City and excludes private pipes and pipes owned by WES.

Due to the terrain in many areas of the City, sewers were constructed on a steep grade, increasing the capacity of these pipelines and allowing them to service relatively large areas.

Table 2.1 Collection System Gravity Main Inventory

Diameter (inch)	Length (LF)	Percentage of System
Unknown	293,629	48.6%
4	164	0.03%
6	16,704	2.8%
8	212,131	35.1%
10	25,278	4.2%
12	15,798	2.6%
14	1,765	0.3%
15	15,107	2.5%
18	11,149	1.8%
21	7,898	1.3%
24	5,123	0.8%
Total (feet)	**604,747**	**100%**
Total (miles)	**114.5**	**100%**

Notes:
(1) System only includes gravity mains and excludes private sewers and WES pipes.

2.3.3 Pump Stations and Force Mains

The topography of the City's service area is such that most of the system is operated under gravity flow conditions, with the exception of some areas that require pumping to higher elevations. The City operates and maintains seven of the 10 pump stations in their collection system as illustrated in Figure 2.3. Six of these are smaller pump stations that serve isolated pockets of the City that cannot be served otherwise by gravity. The other pump station, Mapleton Pump Station, serves most of the Robinwood area and is a larger pump station. Figure 2.3 presents the pump station tributary areas and Table 2.2 summarizes the location and key features of each station as provided by the City. All pump stations, except Mapleton Pump Station, use a trailer-mounted generator, which must be towed to the site. Site visits by members of the engineering team were not performed during development of this Plan.

A description of each pump station showing rated pump capacity is presented on the following pages. Figure 2.4 shows an overall simplified schematic of the collection system, with wastewater basins and pump stations.

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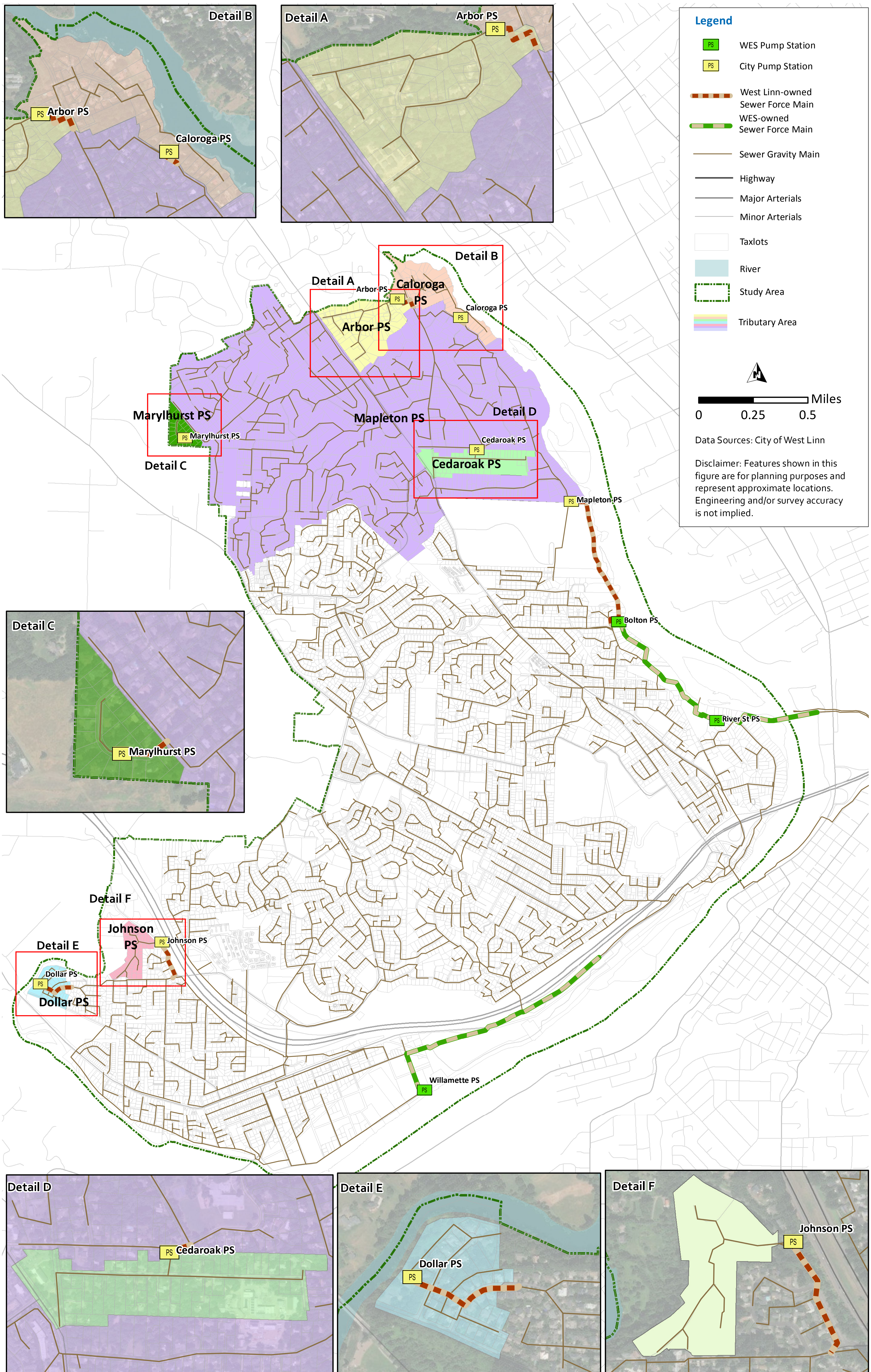

carollo

Last Revised: December 28, 2017 E:\KRC D DRIVE\WestLinn\MXD\Figure2.3_TributaryAreas.mxd

Figure 2.3 Pump Station Locations and Tributary Areas

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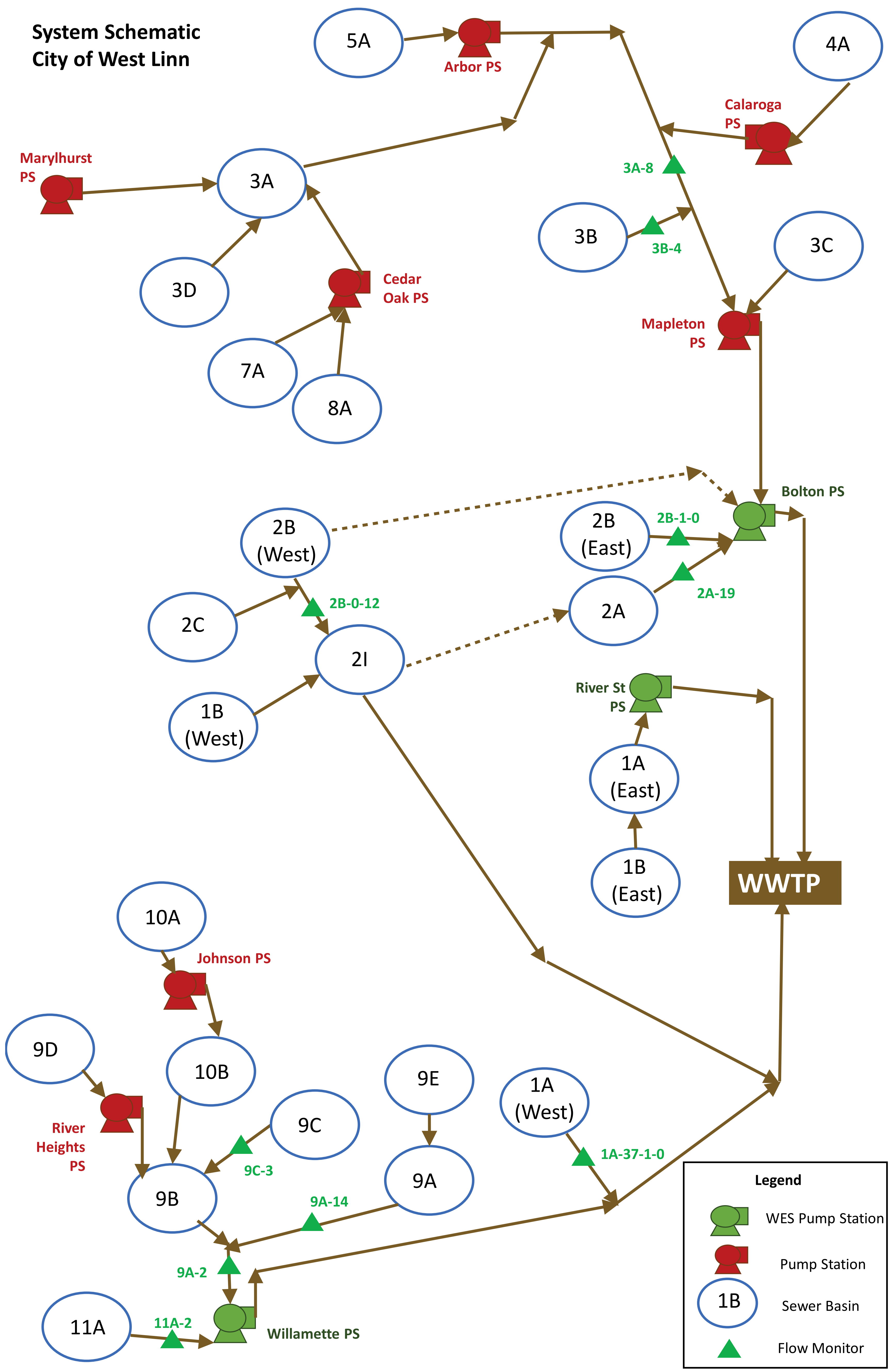

Figure 2.4 Existing System Schematic

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Table 2.2 Existing Pump Stations Inventory Summary (City Owned)

Pump Station	Sewer Basin	Address	Number of Pumps	Horsepower (hp)	Flow (gpm)	Head (ft)	Pump Station Capacity		Year Constructed / Rehabilitated
							Total(1) (gpm)	Firm(2) (gpm)	
Arbor PS	5A	3609 Arbor Dr	2	10	190	70	380	190	1990
Calaroga PS	4A	3831 S Calaroga Dr	2	7.5	80	44	160	80	1993
Cedaroak PS	7A	3964 Cedar Oak Dr	2	2	150	21.5	300	150	1990
Dollar (River Heights) PS	9D	2220 Brandon Pl	2	18	118	112	236	118	1992
Johnson PS	10A	23701 S Johnson Rd	2	6.5	175	64	350	175	1998
Mapleton PS	3C	19050 Nixon Ave	2		1,000	125	2,950	1,950	1998
			1		950	115			
Marylhurst PS	3A	900 Marylhurst Cir	2	3	160	28	320	160	1990

Notes:
(1) Total capacity corresponds to the capacity of the station with all pumps running.
(2) Firm capacity corresponds to the capacity of the station with largest pump out of service.

Table 2.3 Existing Pump Stations Inventory Summary (WES Owned)

Pump Station	Sewer Basin	Address	Number of Pumps	Horsepower (hp)	Flow (gpm)	Head (ft)	Pump Station Capacity		Year Constructed / Rehabilitated
							Total(1) (gpm)	Firm(2) (gpm)	
Bolton PS	2A	6698 Failing St	3	30	1,407	61.8	6,629	2,815	Unknown
				30	1,408	61.8			
				75	3,814	56.7			
River Street PS	1A	5750 River St	3	15	1,417	28	3,710	2,293	Unknown
				15	1,209	35			
				15	1,084	37			
Willamette PS	11A	1000 4th St	3	125	2,400	175	6,370	3,970	Unknown
				105	1,570	61.85			
				125	2,400	175			

Notes:
(1) Total capacity corresponds to the capacity of the station with all pumps running.
(2) Firm capacity corresponds to the capacity of the station with largest pump out of service.

A description of each pump station showing rated pump capacity is presented in the following sections.

2.3.3.1 Arbor Pump Station

The Arbor Pump Station is a City-owned pump station located at 3609 Arbor Dr and serves approximately 50 homes. The station was upgraded in 1990 with installations of new pumps, valves, guide rails in the wet well, access hatches and electrical panel change-outs. The total capacity is 380 gpm with a firm capacity of 190 gpm. The station operates two 10-hp submersible pumps, discharging its wastewater through a 4-inch force main. The wet well for the station is a six-foot-diameter, 17-foot-deep, cylinder vault.

2.3.3.2 Bolton Pump Station

The Bolton Pump Station is owned by WES and is located at 6698 Failing Street and is one of the three major wastewater pump stations bringing wastewater flows to the Regional Plant. The total capacity is 6,629 gpm with a firm capacity of 2,815 gpm. It operates three submersible pumps discharging wastewater into a 16-inch diameter force main across the Willamette River to the WES interceptor in Oregon City. The wet well for the station is a 14 by 11-foot, rectangular, 14-foot-deep vault.

2.3.3.3 Calaroga Pump Station

The Calaroga Pump Station is City-owned station located at 3831 S Calaroga Dr and serves approximately 43 homes. The station was upgraded in 1993. The total capacity is 160 gpm with a firm capacity of 80 gpm. The station is a wet well-mounted, drywell-wet well type station, with two vacuum-primed pumps. The station operates pumps discharging wastewater through a 4-inch force main. The wet well for the station is a 7-foot-diameter, 12-foot-deep cylinder vault.

2.3.3.4 Cedaroak Pump Station

The Cedaroak Pump Station is a City-owned station located at 3964 Cedar Oak Drive and serves approximately 28 homes. The station was upgraded in 1990 with installations of new pumps, valves, guide rails in the wet well, access hatches, and electrical panel change-outs. The total capacity is 300 gpm with a firm capacity of 150 gpm. The station operates two 2-hp submersible pumps, discharging wastewater through a 4-inch force main. The wet well for the station is a 6-foot-diameter, 15.4-foot-deep, cylinder vault.

2.3.3.5 Dollar (River Heights) Pump Station

The Dollar (River Heights) Pump Station is owned by the City and is located at 2220 Brandon Place and serves approximately 35 homes. The station was initially constructed in 1992. The total capacity is 236 gpm with a firm capacity of 118 gpm. The station operates two 18-hp submersible pumps, discharging, on average, 170 thousand gallons of wastewater per day through a 4-inch force main. The wet well for the station is an 8-foot-diameter, 13.25-foot deep, cylinder vault.

2.3.3.6 Johnson Pump Station

The Johnson Pump Station is City-owned and is located at 23701 S Johnson Road and serves approximately 53 homes. The station was initially constructed in 1998. The total capacity is 350 gpm with a firm capacity of 175 gpm. The station operates two 6.5-hp submersible pumps, discharging wastewater through a 4-inch force main. The wet well for the station is a 7-foot-diameter, 15-foot-deep, cylinder vault.

2.3.3.7 Mapleton Pump Station

The Mapleton Pump Station is a City-owned station located at 19050 Nixon Avenue and is the only major pump station for a service area that the City owns and operates. The total capacity is 2,950 gpm with a firm capacity of 1,950 gpm. It operates three submersible pumps that discharge its wastewater into a 12-inch-diameter force main to the Bolton Pump Station. The wet well for the station is a 12-foot-diameter, 30-foot-deep, cylinder vault.

The Mapleton Pump Station is the only station that contains a generator mounted inside the control building.

2.3.3.8 Marylhurst Pump Station

The Marylhurst Pump Station is located at 900 Marylhurst Circle, owned by the City, and serves approximately 15 homes. The station was upgraded in 1990 with installations of new pumps, valves, guide rails in the wet well, access hatches and electrical panel change-outs. The total capacity is 320 gpm with a firm capacity of 160 gpm. The station operates two 3-hp submersible pumps, discharging wastewater through an 8-inch force main. The wet well for the station is a 6-foot-diameter, 9-foot-deep, cylinder vault.

2.3.3.9 River Street Pump Station

The River Street Pump Station is owned and operated by WES and is located at 5750 River Street. The total capacity of this pump station is 3,710 gpm with a firm capacity of 2,293 gpm. It operates three 15-hp submersible pumps discharging wastewater into a 12-inch diameter force main across the Willamette River to the WES interceptor in Oregon City. The wet well for the station is a 28.6 by 9.3-foot, 18.3-foot-deep, rectangular vault.

2.3.3.10 Willamette Pump Station

The Willamette Pump Station is owned and operated by WES and is located at 1000 4th Street. The station operates three submersible pumps, discharging wastewater through an 18-inch diameter force main to a WES interceptor located in Oregon City. Its total capacity is approximately 6,370 gpm, with a firm capacity of 3,970 gpm. The wet well for the station is a 29.42 by 11–foot, 28.6-foot-deep, rectangular vault.

2.3.3.11 Force Mains

Wastewater from the pump stations is conveyed through the collection system via force mains. An inventory of all force mains operated by the City is summarized in Table 2.4.

Table 2.4 Collection System Force Main Inventory

Pump Station	4-inch	8-inch	12-inch	16-inch	18-inch	Total (ft)	Percent System (%)
Arbor PS	628					**628**	**2.8%**
Bolton PS				6,380		**6,380**	**28.3%**
Calaroga PS	213					**213**	**0.9%**
Cedaroak PS	234					**234**	**1.0%**
Dollar PS	926					**926**	**4.1%**
Johnson PS	987					**987**	**4.4%**
Mapleton PS			3,746			**3,746**	**16.6%**
Marylhurst PS		394				**394**	**1.8%**
River Street PS			2,675			**2,675**	**11.9%**
Willamette PS					6,322	**6,322**	**28.1%**
Grand Total (ft)	**2,988**	**394**	**6,421**	**6,380**	**6,322**	**22,505**	**100%**

Attachment C

TECHNICAL MEMORANDUM 3: HYDRAULIC MODEL DEVELOPMENT

City of West Linn

Sanitary Sewer Master Plan Update

TECHNICAL MEMORANDUM 3 HYDRAULIC MODEL DEVELOPMENT

DRAFT | March 2019

City of West Linn
Sanitary Sewer Master Plan Update

TECHNICAL MEMORANDUM 3

HYDRAULIC MODEL DEVELOPMENT

Matthew M. Huang,
March 12, 2019,
State of Oregon,
P.E. No. 91512

Contents

TECHNICAL MEMORANDUM NO.3 - HYDRAULIC MODEL DEVELOPMENT

Appendices

Tables

Figures

Abbreviations

%	percent
City	City of West Linn
DWF	Dry weather flow
EPA	Environmental Protection Agency
ft	feet
GIS	geographic information system
GUI	graphical user interface
I/I	infiltration/inflow
in	Inch
mgd	million gallons per day
RDII	Rainfall Derived Infiltration and Inflows
SSMP	Sanitary Sewer Master Plan
SWMM	Storm Water Management Model
TM	Technical Memorandum
WaPUG	Wastewater Planning Users Group
WWF	wet weather flow

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Technical Memorandum 3

HYDRAULIC MODEL DEVELOPMENT

3.1 Introduction

Wastewater collection system models are valuable tools used to assess the performance of collection systems during dry and wet weather conditions, and to plan for future improvements. These models provide a means to simulate the impact of different sized storms on the collection system, and determine where future system deficiencies are likely to occur. In addition, a well-calibrated model provides a method for testing alternative improvement scenarios. This Technical Memorandum (TM) summarizes the City of West Linn (City)'s collection system hydraulic model development and calibration for use in the City's wastewater conveyance planning.

3.2 Hydraulic Model Development

A sewer collection system model is a simplified representation of the real sewer system. Sewer system models can assess the conveyance capacity for a collection system. In addition, sewer system models can perform "what if" scenarios to assess the impacts of future developments and land use changes. The City's collection system hydraulic model was constructed using a multi-step process utilizing data from a variety of sources. This section summarizes the hydraulic model development process, including a summary of the modeling software selection, a description of the modeled collection system, the hydraulic model elements, and the model creation process.

3.2.1 Hydraulic Modeling Software Selection

In the past decade, significant improvements have been made to the hydraulic modeling software available on the market. Some examples of the improvements that have been made include modifications to the hydraulic routing engine as well as an enhanced graphical user interface (GUI), model output reports, and GIS compatibility.

Based on Carollo's experience and City's needs, it was agreed that InfoSWMM, by Innovyze, would be used to assemble the City's hydraulic model. InfoSWMM is a fully dynamic, geospatial wastewater and stormwater modeling and management software application, which is built to run within the ESRI ArcGIS software platform. The hydraulic modeling engine for the InfoSWMM software package uses the Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM), which is widely used throughout the world for planning, analysis, and design related to stormwater runoff, combined sewers, sanitary sewers, and other drainage systems. InfoSWMM routes flows through the model using the Dynamic Wave method, which solves the complete Saint Venant, one dimensional equations of fluid flow.

The latest version (v 14.6) of InfoSWMM was used to assemble the InfoSWMM hydraulic model.

3.2.2 Modeled Collection System and Skeletonization

Skeletonization is the process by which sewer systems are stripped of pipelines not considered essential for the intended analysis purpose. The purpose of skeletonizing a system is to develop a model that accurately simulates the hydraulics of a collection system, while at the same time reducing the complexity of a large model.

It is common practice in sewer system master planning to exclude small diameter sewers when developing a hydraulic computer model. As part of this SSMP, Carollo and the City identified the primary collectors within each of the City's wastewater basins. All sewers with diameters of 10-inch and greater were included in the process, however, some smaller diameter sewers are also included in the hydraulic model where needed for connectivity. The model created for the purposes of this SSMP only includes the pipelines identified as primary collectors within the collection system.

The modeled sewer system consists of approximately 43 miles of sanitary sewer pipelines (including both gravity and force mains) ranging in diameter from 4 inches to 24 inches, seven city-owned sanitary sewer pump stations were included for modeling purposes. The hydraulic model also included three of the WES pump stations to which the City's collection system discharges: Willamette, Bolton, and River St pump stations.

Figure 3.1 presents the City's modeled wastewater collection system. In this figure, pipes not included in the hydraulic model are shown in grey. Table 3.1 presents a summary of the modeled sewer system by diameter and length of pipe. Not included in these totals are the smaller sewer mains that were excluded during model skeletonization and therefore not modeled.

Table 3.1 Modeled System Pipelines

Diameter (inch)	Total Length (ft)	Percent System
<= 8-inch	123,031	53.8%
10-12-inch	47,217	20.6%
14-18-inch	41,233	18.0%
>18-inch	17,196	7.5%
Total System (ft)	228,678	100.0%
Total System (mile)	43.3	100.0%

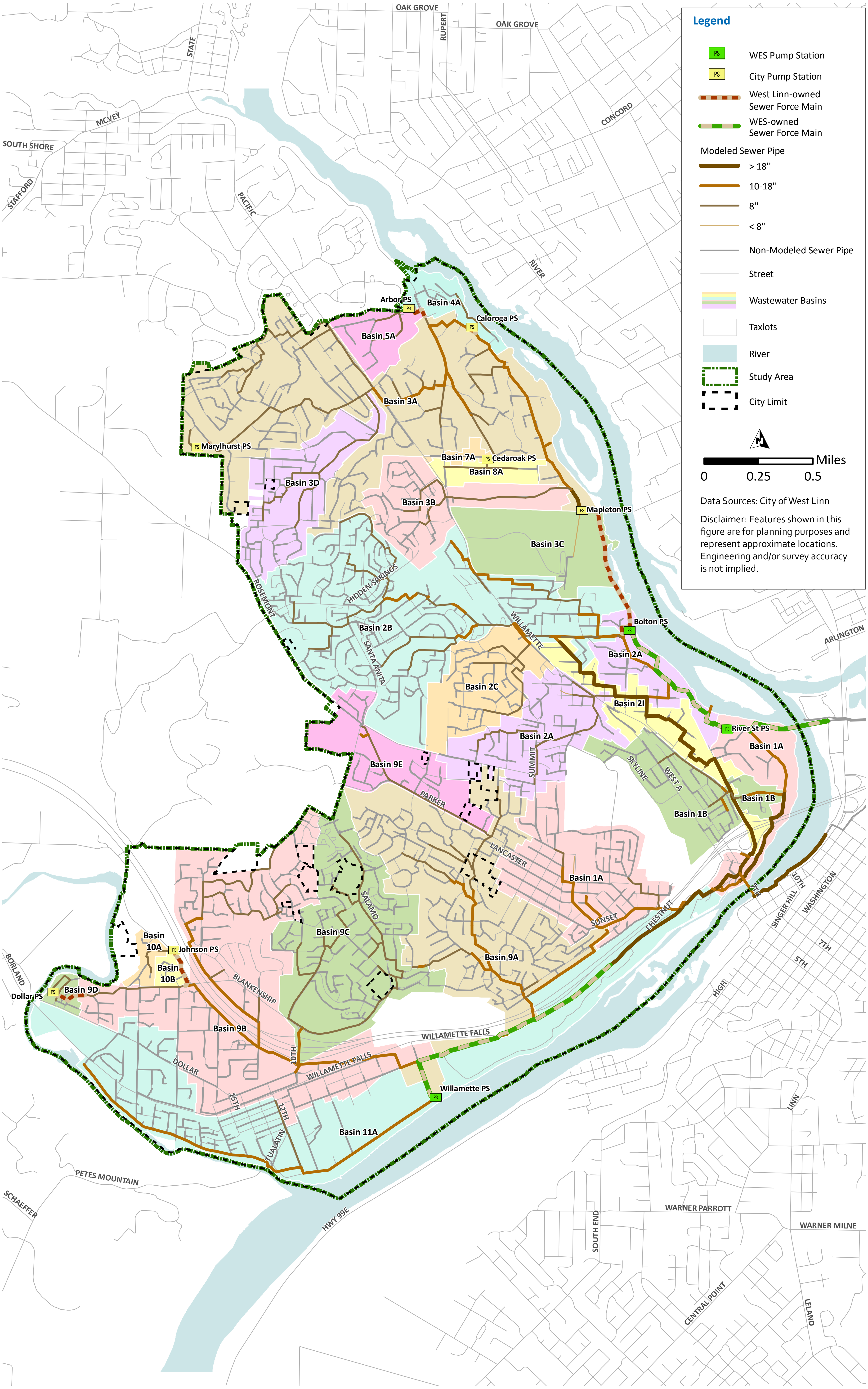

Figure 3.1 Modeled Sanitary Sewer Collection System

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3.2.3 Elements of the Hydraulic Model

The following provides a brief overview of the major elements of the hydraulic model and the required input parameters associated with each:

- **Junctions**: Sewer manholes, cleanouts, as well as other locations where pipe sizes change or where pipelines intersect are represented by junctions in the hydraulic model. Required inputs for junctions include rim elevation, invert elevation, and surcharge depth (used to represent pressurized systems). Junctions are also used to represent locations where flows are split or diverted between two or more downstream links.
- **Pipes**: Gravity sewers and force mains are represented as pipes in the hydraulic model. Input parameters for pipes include length, friction factor (e.g., Manning's n for gravity mains, Hazen Williams C for force mains), invert elevations, diameter, and whether or not the pipe is a force main.
- **Storage Nodes**: For sewer system modeling, storage nodes typically are used to represent pump station wet wells (although other storage basins, etc. can be modeled as storage nodes). Input parameters for storage nodes include invert elevation, wet well depth, and wet well cross section.
- **Pumps**: Pumps are included in the hydraulic model as links. Input parameters for pumps include pump curves and operational controls.
- **Outfalls**: Outfalls represent areas where flow leaves the system. For sewer system modeling, an outfall typically represents the connection to the influent pump station at a wastewater treatment plant. In the City's model, outfalls represent connections to the force mains leading to the treatment plant. It is assumed, for the purpose of this analysis, that the downstream system has sufficient capacity for West Linn flows.
- **Rain Gauges**: Rain gauges are input into the hydraulic model to simulate historical or theoretical hourly rainfall events.
- **Inflows**: The following are the three types of wastewater flow sources that can be injected into individual model junctions (and storage nodes):
  - External. External inflows can represent any number of flows into the collection system, such as metered flow data or groundwater inflow. External inflows are applied to a specific model junction by applying a baseline flow value and a pattern that varies the flow by hour, day, or month of the year.
  - Dry Weather. Dry weather inflows simulate base sanitary wastewater flows and represent the average flow. The dry weather flows can be multiplied by up to four patterns that vary the flow by month, day, hour, and day of the week (e.g., weekday or weekend). The dry weather diurnal patterns are adjusted during the dry weather calibration process.
  - RDII. Rainfall Derived Infiltration and Inflows (RDII) are applied in the model by assigning a unit hydrograph and a corresponding tributary area to a given junction. The unit hydrographs consist of several parameters that are used to adjust the volume of RDII that enters the system at a given location. These parameters are adjusted during the wet weather calibration process. Note, the terms RDII and I/I are used interchangeably in this report.

3.2.4 Model Construction

The City's hydraulic model combines information on the physical and operational characteristics of the wastewater collection system, and performs calculations to solve a series of mathematical equations to simulate flows in pipes.

The model construction process consisted of eight steps, as described below:

- **Step 1** - The City's geographic information system (GIS) shape files for the sewer collection system were obtained.
- **Step 2** - The GIS data were reviewed and formatted to allow easy import into the InfoSWMM modeling platform. The City's GIS data set was skeletonized, which means that only the main interceptors and paths of flow in each wastewater basins were included. Because of the City's system, the skeletonization process was not done based on diameter sizes, but rather flow paths to identify the primary collectors.
- **Step 3** - The City's GIS was missing information on pipeline inverts, manhole rims, and pipe diameters. Carollo determined manhole locations to obtain the minimum necessary data at to build the hydraulic model. The City provided information at the 62 locations identified based on as-built drawing and other institutional knowledge. A map showing the locations of missing data requested is shown in Figure 3.2. Data in between these locations was interpolated, as needed, using the inferring built-in tool in InfoSWMM and the slope was assumed to be constant between each survey manhole.
- **Step 4** - The collection system pipeline and facility data were imported into the modeling software and verified. Physical and operational data for the City's wastewater collection facilities was not available from the GIS data. This type of data, such as wet well dimensions, pump stations, and other special features, were input manually into the model based on available information.
- **Step 5** - Once all the relevant data was input into the hydraulic model, the model was reviewed to verify that the model data was input correctly and that the flow direction, size, and layout of the modeled pipelines were logical. Additionally, the modeled pump stations were also checked to verify that they operated correctly.
- **Step 6** - Dry weather wastewater flows were then allocated to the appropriate model junctions as described in Section 3.2.5.
- **Step 7** - The hydraulic model contains certain run parameters that need to be set by the user at the beginning of the project. These include run dates, time steps, reporting parameters, output units, and flow routing method. Once the run parameters were established, the model was debugged to ensure that it ran without errors or warnings.

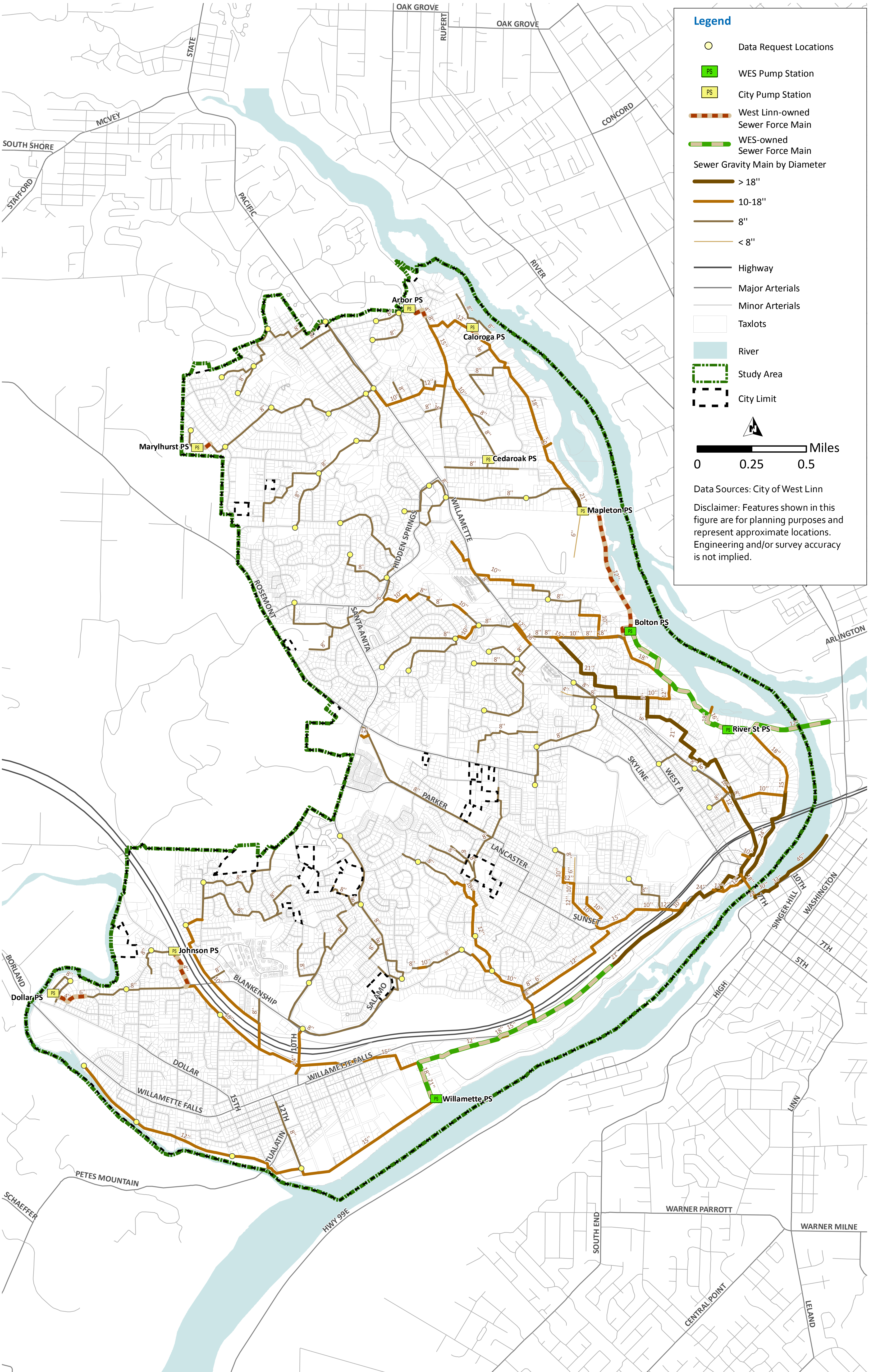

Figure 3.2 Missing Data Needs Locations

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3.2.5 Wastewater Load Allocation

Determining the quantity of dry weather wastewater flows generated by a municipality and how they are distributed throughout the collection system is an important component of the hydraulic modeling process. Various techniques can be used to assign wastewater flows to individual model junctions, depending on the type of data that is available. Adequate estimates of the volume of wastewater are important in maintaining and sizing sewer system facilities, both for present and future conditions. Baseline wastewater loads were allocated (assigned to specific nodes) in the hydraulic model based on land use data provided by the City and wastewater flow coefficients developed for each land use type (these are described in detail in TM No. 1). The flow coefficients and land use data provide a means to transform a specific land use category into an average dry weather flow, as described below:

- **Step 1** - The City's service area was broken up into 412 individual loading polygons. Each loading polygon represents the geographic area that contributes flows into a single model node (i.e., trunk system manhole). In an all pipe model, however, a loading polygon could be as small as a few parcels. In a skeletonized model, such as the City's hydraulic model, a loading polygon will usually encompass a particular subdivision or grouping of lots. Figure 3.3 shows the different individual loading polygons developed in this step.
- **Step 2** - The loads were calculated for each loading polygon using GIS by multiplying the appropriate flow factor (having units of gpad) by the land use acreage. A description of flow factor development is provided in TM No. 1.
- **Step 3** - The loads obtained in step 2 correspond to the average dry weather flow and were allocated to the appropriate node in the sewer system model.
- **Step 4** - The allocated loads were adjusted as necessary during the dry weather flow calibration process (see Section 3.3.2) to closely match the actual measured dry weather flows recorded during the flow monitoring period.

3.3 Hydraulic Model Calibration

Hydraulic model calibration is a crucial component of the hydraulic modeling effort. Calibrating the model to match data collected during the flow-monitoring program ensures the most accurate results possible. The calibration process consists of calibrating to both dry and wet weather conditions.

For this project, flow monitoring was conducted at 10 meter sites for a period of approximately nine weeks from January 2016 to March 2016. Dry weather flow (DWF) calibration ensures an accurate depiction of base wastewater flow generated within the study area. The wet weather flow (WWF) calibration consists of calibrating the hydraulic model to specific storm events to accurately simulate the peak and volume of infiltration/inflow (I/I) into the sewer system. The amount of I/I is essentially the difference between the WWF and DWF components.

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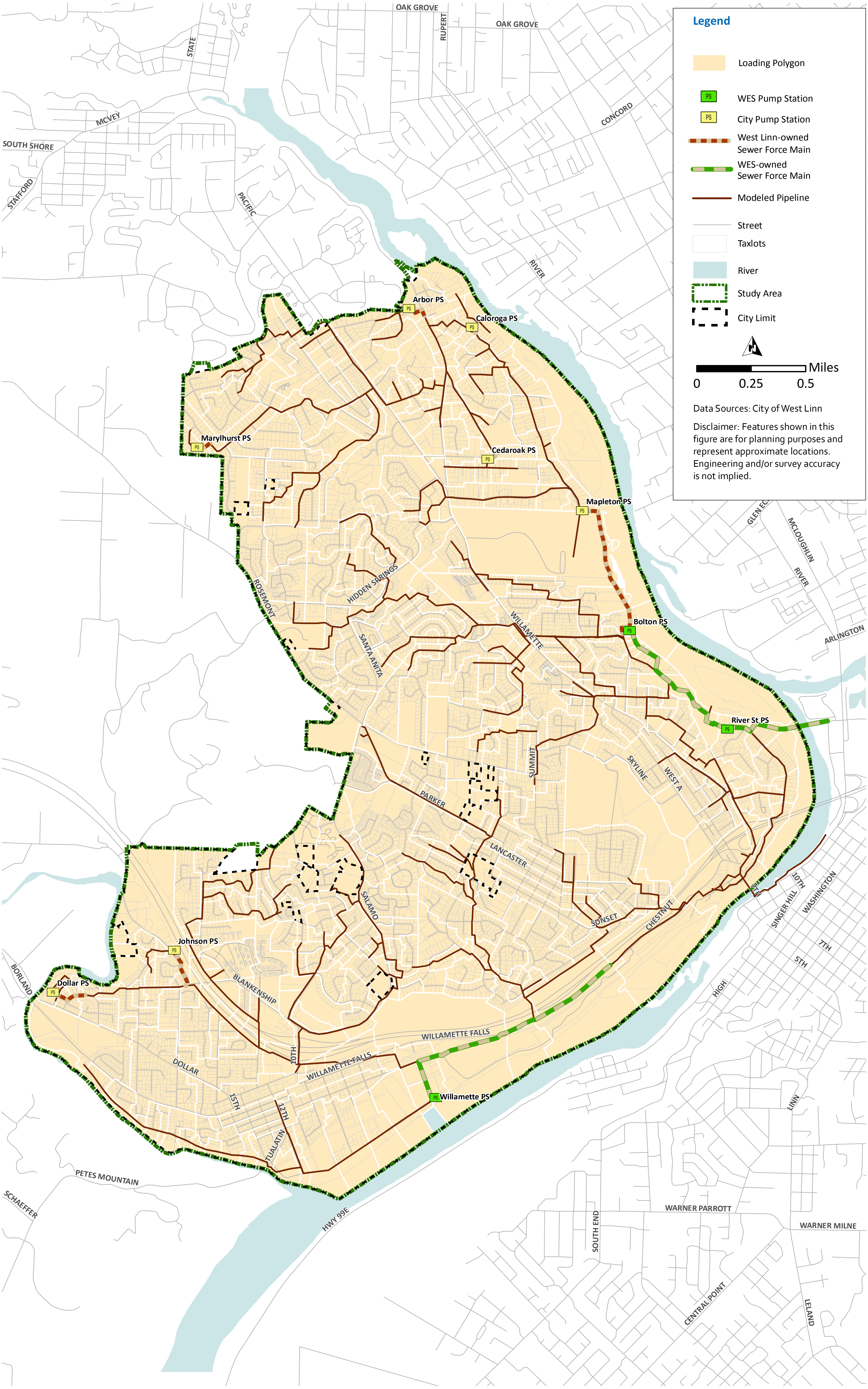

Figure 3.3 Sewer Loading Polygons

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3.3.1 Calibration Standards

The hydraulic model was calibrated in accordance with international modeling standards. The Wastewater Planning Users Group (WaPUG), a section of the Chartered Institution of Water and Environmental Management, has established generally agreed upon principles for model verification. The dry weather and wet weather calibration focused on meeting the recommendations on model verification contained in the "Code of Practice for the Hydraulic Modeling of Sewer Systems," published by the WaPUG (WaPUG 2002), as summarized below:

- **Dry Weather Calibration Standards**: Dry weather calibration should be carried out for two dry weather days and the modeled flows and depths should be compared to the field measured flows and depths. Both the modeled and field measured flow hydrographs should closely follow each other in both shape and magnitude.

  In addition to the shape, the flow hydrographs should also meet the following criteria as a general guide:
  - The timing of flow peaks and troughs should be within one hour.
  - The peak flow rate should be within the range of ±10 percent
  - The volume of flow (or the average rate of flow) should be within the range of ±10 percent. If applicable, care should be taken to exclude periods of missing or inaccurate data.

- **Wet Weather Calibration Standards**: For at least two storm events from the flow monitoring period, the model simulated flows and depths should be compared to the field measured flows and depths. The flow hydrographs for both events should closely follow each other in both shape and magnitude, until the flow has substantially returned to dry weather flow rates.

  In addition to the shape, the flow hydrographs should also meet the following criteria as a general guide:
  - The timing of the peaks and troughs should be similar with regard to the duration of the events.
  - The peak flow rates at significant peaks should be in the range of +25 percent to -15 percent and should be generally similar throughout.
  - The volume of flow (or the average flow rate) should be within the range of +20 percent to -10 percent.
  - The depth of surcharge should be in the range of +20-inches to -4-inches.
  - The unsurcharged depth should be within the range of ± 4-inches.

The WaPUG recommends that for wet weather calibration, the use of a single calibration period incorporating a number of rainfall events should be considered whenever possible. In other words, if the flow monitoring program captured several back to back storms, it may be preferable to use the back to back storms events as the calibration storms, as opposed to calibrating to two separate storms that have occurred weeks or months apart.

3.3.2 Dry Weather Flow Calibration

3.3.2.1 Dry Weather Flow Calibration Process

The DWF calibration process consists of several elements, as outlined below:

- **Divide the system into areas tributary to each flow meter**. The first step in the calibration process was to divide the sewer service area into flow meter tributary areas. Ten tributary areas were created, one for each flow meter from the temporary flow monitoring program. A map showing the locations of each flow monitoring site and their associated tributary area is provided in TM No.1 – Basis of Planning.
- **Define flow volumes within each area**. The next step was to define the dry weather flow volumes within each area, which was accomplished in the flow allocation step of model construction.
- **Create diurnal patterns to match the temporal distribution of flow**. A diurnal curve is a pattern of hourly multipliers that are applied to the base flow to simulate the variation in flow that occurs throughout the day. Typically, two diurnal curves are developed for each flow monitoring tributary area; one representing weekday flow and one representing weekend flow. However, not enough data was available to develop an accurate weekend pattern, therefore, only patterns representing weekday flow were developed. This, however, does not have any impact to the analysis, very minor difference is usually found between weekend/weekday other than timing of hourly peaks, which will not influence the evaluation.
  The diurnal patterns were initially developed based on the flow monitoring data and adjusted as part of the calibration process until the model simulated flows closely matched the field measured flows. Figure 3.4 shows the calibrated weekday diurnal pattern for the area tributary to Meter 2B-1-0. Similar diurnal curves were developed for each of the meters and its tributary area. These additional curves are available in Appendix 3A.
- **Adjust model variables to match field measured velocity and flow depths**. Once the model simulated flows acceptably matched the field measured flows, the model simulated velocity and flow depth were compared to the field measured velocity and flow depth. Adjustments were made to various model parameters until the modeled and measured velocity and depth closely matched one another. The primary variable parameters for this process are pipeline roughness (Manning's n) and sediment build up in the pipe, although other parameters can also be adjusted as calibration results are generated.

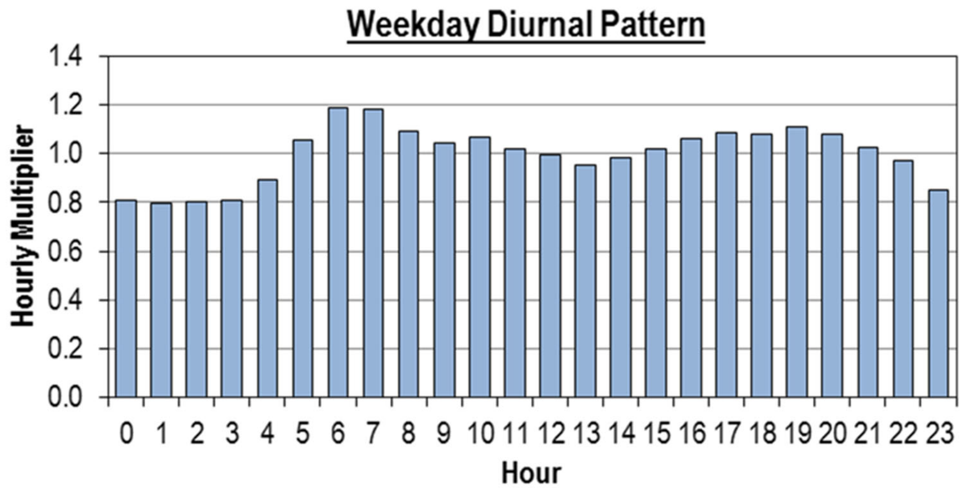

Figure 3.4 Example Diurnal Pattern (Meter 2B-1-0)

Manning's roughness coefficients, or n values, have industry accepted ranges based on a number of variables. Roughness coefficients increase over time depending on the construction methods, installation quality, system maintenance, and other environmental factors. There can be certain factors within the City's collection system that can result in roughness coefficients which differ from the typical range. For example, pipeline bellies, joint misalignment, cracks, and debris (e.g., root intrusion, etc.) lead to increased turbulence in a pipe, as well as the apparent Manning's n factor.

There are no standard for dry weather level values, however, adjusted levels were compared to standards during the wet weather flow calibration process.

3.3.2.2 Dry Weather Flow Calibration Results

Table 3.2 provides a summary of the dry weather flow calibration using the average and daily peak flow results for both weekday and weekend conditions. As shown on Table 3.2, the model simulated average flows volumes and flow peaks for weekday DWF were all within 10-percent. In general, the percent difference between the overall modeled and measured DWF ranged between 0.1 % and 5.9 % percent. Figure 3.5 shows an example comparison of modeled flows versus flows from the flow monitoring data for Meter 2B-1-0.

Appendix 3A provides a detailed dry weather flow calibration summary sheet for each of the ten meter sites. Each calibration sheet includes plots comparing the model-simulated and field-measured flow data for weekday condition. An example of the dry weather calibration for Meter 2B-1-0 is shown on Figure 3.5. As shown in Figure 3.5 and in Appendix 3A there is very good overall correlation of the field-measured data to the model output results.

Table 3.2 Dry Weather Flow Calibration Results

Meter Number	Pipe Diameter (in)	Weekday Dry Weather Flow								
		Measured Data(1)			Modeled Data(2)			Percent Error(3)		
		Avg.Flow (mgd)	Peak Flow (mgd)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Max Level Diff (in)
9A-14	10	0.316	0.494	3.8	0.318	0.465	3.2	**0.4%**	**-5.9%**	**1.08**
11A-2	15	0.172	0.235	3.9	0.172	0.229	3.5	**-0.3%**	**-2.5%**	**0.50**
9A-2	18	0.964	1.464	3.8	0.984	1.424	4.1	**2.1%**	**-2.7%**	**0.47**
1A-37-1-0	10	0.392	0.512	1.9	0.399	0.519	2.1	**1.6%**	**1.4%**	**0.24**
3B-4	8	0.097	0.124	1.4	0.098	0.125	1.6	**0.9%**	**0.8%**	**0.20**
2B-1-0	8	0.219	0.261	1.2	0.216	0.257	1.4	**-1.3%**	**-1.6%**	**0.19**
9C-3	?	0.201	0.302	1.5	0.201	0.301	1.7	**-0.5%**	**-0.2%**	**0.24**
2A-19	8	0.101	0.153	1.1	0.101	0.153	1.2	**0.3%**	**-0.1%**	**0.11**
3A-8	18	0.408	0.583	5.8	0.404	0.554	5.1	**-1.0%**	**-5.0%**	**0.99**
2B-0-12	12	0.397	0.569	1.8	0.407	0.582	2.0	**2.5%**	**2.3%**	**0.27**

Notes:
(1) Source: City of West Linn 2016 Temporary Flow Monitoring Program, ADS.
(2) Average flow, level, and velocity are computer from hydraulic modeling results. Maximum flow values are hourly peaks.
(3) Percent Difference = (Modeled - Measured)/Measured*100.

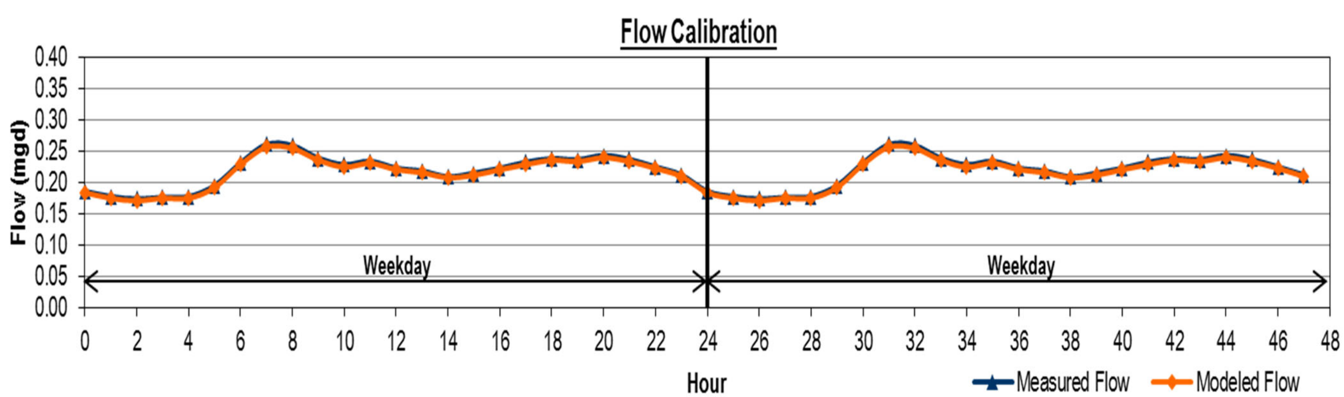

Figure 3.5 Example Dry Weather Flow Calibration (Meter 2B-1-0)

3.3.3 Wet Weather Flow Calibration

3.3.3.1 Wet Weather Flow Calibration Process

The WWF calibration enables the hydraulic model to accurately simulate Inflow and Infiltration (I/I) entering the collection system during a large storm. As outlined below, the WWF calibration process consists of several elements:

- **Identify calibration rainfall events**. The WWF calibration process consists of running model simulations of historic rainfall events based on data collected as part of the flow monitoring program. The goal of any wet weather flow monitoring program is to capture and characterize a system's response to a significant rainfall event, preferably during wet antecedent moisture conditions.

  The selection of a particular calibration storm or group of storms is based on a review of the flow and rainfall data. For WWF calibration, the model was run from January 8th, 2016 to March 6th, 2016, and calibrated to the three main rainfall events that occurred during the course of the flow monitoring period:

  - 1/12/2016 to 1/18/2016
  - 1/28/2016 to 2/3/2016
  - 2/15/2016 to 2/24/2016
- **Define RDII tributary areas**. For the WWF calibration, RDII flows are superimposed over the DWF. The model calculates RDII by assigning "RDII Inflows" to each node in the model. RDII inflows consist of both a unit hydrograph and the total area that is tributary to the model node. The RDII tributary areas were calculated in GIS using the loading polygons, excluding any large vacant, open space, or other areas in the system which are not expected to contribute to I/I into the collection system. The tributary area provides a means to transform hourly rainfall depth from the rainfall hyetographs into a rainfall volume. The rainfall volume is transformed into actual RDII flows using the unit hydrograph, as described in the next step.
- **Create I/I parameter database and modify to match field measured flows**. The main step in the WWF calibration process involves creating custom unit hydrographs for each flow monitoring tributary area using the "RTK Method," which is widely used in collection system master planning. Using the RTK Method, the RDII unit hydrograph is the summation of three separate triangular hydrographs (short-term, medium-term, and long-term), which are each defined by three parameters: R, T, and K. R represents the fraction of rainfall over the sewer shed that enters the collection system; T represents the time to peak of the hydrograph; and K represents the ratio of time to recession to the time to peak. Therefore, there are a total of nine separate variables associated with each unit hydrograph. Figure 3.6 shows an example of a unit hydrograph.

  The hydrographs utilize the R-values (percent of rainfall that enters the collection system) calculated for each basin to simulate I/I. The nine variables in each unit hydrograph were initially set based on engineering judgment. Through an iterative process, the variables are then adjusted until the model-simulated flows (both peak flows and average flows) match closely with the field-measured flows.

As with the dry weather calibration, the wet weather calibration process compared the meter data with the model output. Comparisons were made for average and peak flows as well as the temporal distribution of flow until flows returned to their baseline levels. According to the WaPUG, a hydraulic model is generally considered to be satisfactorily calibrated to WWF conditions if the modeled peak flows are within +25 percent to -15 percent of the field-measured data, and if the average modeled flows are within +20 percent to -10 percent of the field-measured data.

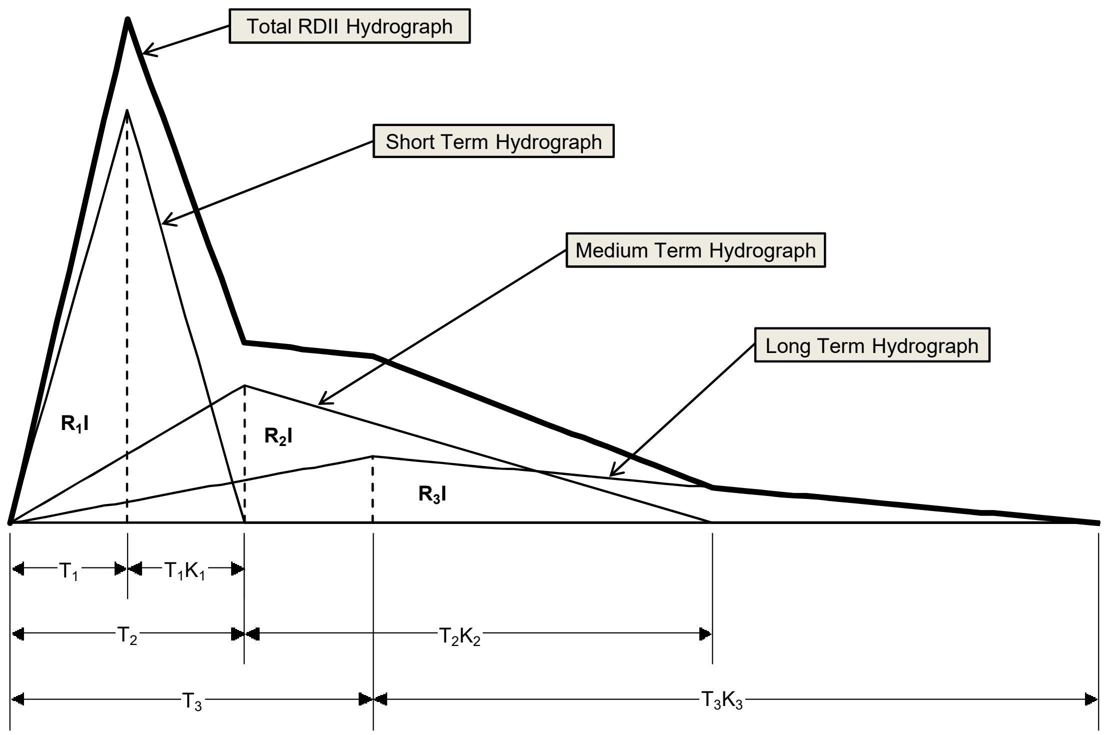

Figure 3.6 Example RDII Hydrograph

- **Refine model variables to match field-measured velocity and flow depths**. After the model was considered to be satisfactorily calibrated for wet weather flows, the model simulated velocities and flow depths were checked against the field measured velocities and flow depths during the calibration storms. Refinements were made to the various model parameters so that the modeled and measured velocity and depth closely matched one another. If any adjustments were made to Manning's n values or other parameters, the DWF calibration was rechecked as well to make sure that the flow depth and velocities still matched well under DWF conditions.

Water depths were also checked against WaPUG criteria. If the model is unable to match the field measured flow depth and velocity without leaving the acceptable range of Manning's roughness coefficients, further investigation is conducted to help determine the cause of the discrepancy. Some issues that could cause such a discrepancy can include errors in the slope or diameter of a pipeline, downstream blockages, pipeline sags, and, in some cases, influences from downstream pump station operations.

3.3.3.2 Wet Weather Flow Calibration Results

An example of the wet weather calibration for Meter 2-1-0 is shown on Figure 3.7. Table 3.3 provides a summary of the wet weather flow calibration using the average and peak flow results, and water levels results. As shown on Table 3.3, the model simulated average and peak flows at all meter sites were within the acceptable tolerances for at least two of the three calibration storms, and therefore the model was considered calibrated and ready to use for capacity analysis purposes.

Appendix 3B contains a detailed wet weather flow calibration summary sheet for each of the four meter sites. Each calibration sheet provides plots that compare the model simulated and field measured flow, velocity, and level data for the calibration storms.

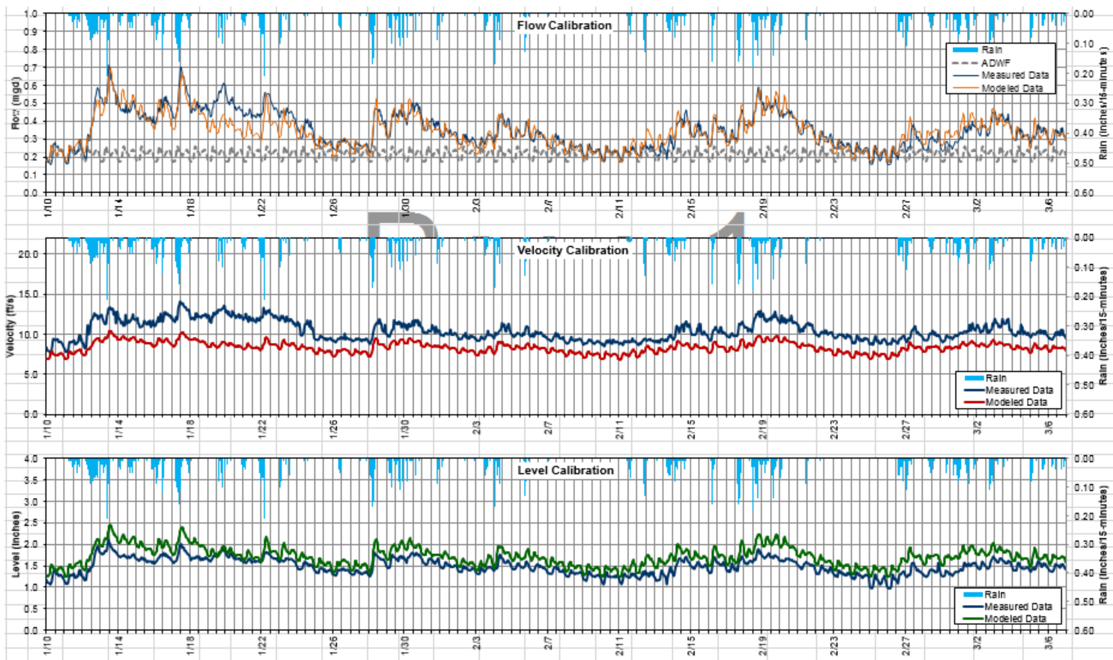

Figure 3.7 Example Wet Weather Flow Calibration

Table 3.3 Wet Weather Flow Calibration Results

Meter Number	Pipe Diameter (in)	Storm 1 (1/12/2016-1/18/2016)			Storm 2 (1/28/2016-2/3/2016)			Storm 3 (2/15/2016-2/24/2016)		
		Percent Error(3)		Max	Percent Error(3)		Max	Percent Error(3)		Max
		Avg. Flow (%)	Peak Flow (%)	Level Diff (inches)	Avg. Flow (%)	Peak Flow (%)	Level Diff (inches)	Avg. Flow (%)	Peak Flow (%)	Level Diff (inches)
9A-14	10	2.6%	1.7%	1.7	3.0%	8.3%	1.7	-2.0%	-7.8%	1.7
11A-2	15	3.9%	-11.2%	0.9	-6.3%	-7.9%	1.1	0.7%	6.7%	0.9
9A-2	18	16.0%	1.5%	2.2	10.4%	11.0%	2.2	10.5%	8.4%	2.2
1A-37-1-0	10	5.2%	-11.3%	0.9	3.7%	-0.5%	0.7	-1.5%	-6.5%	0.7
3B-4	8	16.0%	18.5%	0.8	-0.6%	-19.8%	0.7	-0.8%	-60.0%	11.9
2B-1-0	8	-2.4%	-2.0%	0.5	-3.0%	4.0%	0.4	-1.5%	-2.4%	0.6
9C-3	?	2.2%	-0.5%	2.2	1.4%	4.1%	0.9	3.1%	3.4%	0.8
2A-19	8	1.7%	-4.9%	3.5	5.6%	9.7%	0.5	4.3%	12.8%	4.6
3A-8	18	0.7%	-6.5%	2.4	2.3%	4.2%	2.3	8.8%	3.7%	1.7
2B-0-12	12	3.7%	8.8%	0.8	-4.2%	16.7%	0.8	-1.0%	7.6%	0.7

3.3.3.3 Wet Weather Calibration Discussion

Overall, the hydraulic model calibrated well, with the exception of the following two items:

Discussion Item 1 – System Response

System's response between 1/20/16 and 1/21/16 does not reflect rainfall recorded data. This discrepancy is observed in every of the 10 meters in the system. Carollo reviewed rainfall data from USGS in the vicinity of West Linn and confirmed that the rainfall recorded by ADS was accurate. These dates will be ignored during calibration and model will focus on the three major rainfall events discussed in Section 3.3.3.

Discussion Item 2 – Meter 3B-4

The hydraulic model shows issues with Meter 3B-4 and modeled data is outside calibration standards for two out of three storms. Meter data were reviewed and it does not appear results are caused by a monitor malfunction. Because all the depth sensors increased and the velocity decreased, this type of response is indicative of a backwater condition. Response also does not appear to be rain induced. There is an abrupt change in the depth and velocity, both at the beginning and at the end of each occurrence. Typically if it was rain induced, we would expect a more gradual rise and fall. It was also noted that the occurrences happen about the same time during the day and do not occur on the weekend. Because of these observances and the fact that (Lake Oswego-Tigard) LOT treatment plant (located right north of this meter) was under construction and start-up at the time of the program, it was determined that the response observed was triggered by temporary sewer pumping or diversion to this line. It was therefore concluded that calibration results for Meter 3B-4 can be accepted as is.

3.3.4 Hydraulic Model Calibration Summary

Calibration of the City's hydraulic model was a multi-step process that involved comparing model-simulated flow to the actual field-measured data for both dry and wet weather conditions. Results indicated that the model correlated well with the field-measured data.

Of the ten meter sites used for model calibration, 100 percent of the meters were within calibration standards for dry weather flow. For each meter site (with the exception of Meter 3B-4), at least two storms out of three were calibrated for each of the calibration parameters (peak flow, flow volume, average velocity, average level).

This provides a high level of confidence in the model's accuracy such that the model can be considered calibrated and ready to use for subsequent capacity analysis.

3.4 Hydraulic Model Maintenance

The sewer system hydraulic model will likely be maintained by a consulting firm through an on-call modeling contract. Many consulting firms in the wastewater industry maintain licenses for Innovyze InfoSWMM and can perform modeling tasks when needed. Generally, an on-call modeling contract consists of an hourly fee schedule. If no modeling services are required for the duration of the contract, the City incurs no cost. Ultimately, the costs of using and maintaining the sewer model depend on how the City plans to utilize the model in the future. The City may use the model to size developer extensions, consider new service areas, evaluate flooding, and size capital projects. To maintain and update the model and to make model runs to assess the impacts of system changes and growth proposals is estimated to require approximately 120 man-hours per year.

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Appendix 3A

DRY WEATHER FLOW CALIBRATION RESULTS

Table 1 Dry Weather Flow Calibration Results
Sanitary Sewer Master Plan
City of West Linn

		Weekday Dry Weather Flow								
		Measured Data[1]			Modeled Data[2]			Percent Error[3]		
Meter Number	Pipe Diameter (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Max Level Diff (in)
9A-14	10	0.316	0.494	3.8	0.318	0.465	3.2	0.4%	-5.9%	1.08
11A-2	15	0.172	0.235	3.9	0.172	0.229	3.5	-0.3%	-2.5%	0.50
9A-2	18	0.964	1.464	3.8	0.984	1.424	4.1	2.1%	-2.7%	0.47
1A-37-1-0	10	0.392	0.512	1.9	0.399	0.519	2.1	1.6%	1.4%	0.24
3B-4	8	0.097	0.124	1.4	0.098	0.125	1.6	0.9%	0.8%	0.20
2B-1-0	8	0.219	0.261	1.2	0.216	0.257	1.4	-1.3%	-1.6%	0.19
9C-3	?	0.201	0.302	1.5	0.201	0.301	1.7	-0.5%	-0.2%	0.24
2A-19	8	0.101	0.153	1.1	0.101	0.153	1.2	0.3%	-0.1%	0.11
3A-8	18	0.408	0.583	5.8	0.404	0.554	5.1	-1.0%	-5.0%	0.99
2B-0-12	12	0.397	0.569	1.8	0.407	0.582	2.0	2.5%	2.3%	0.27

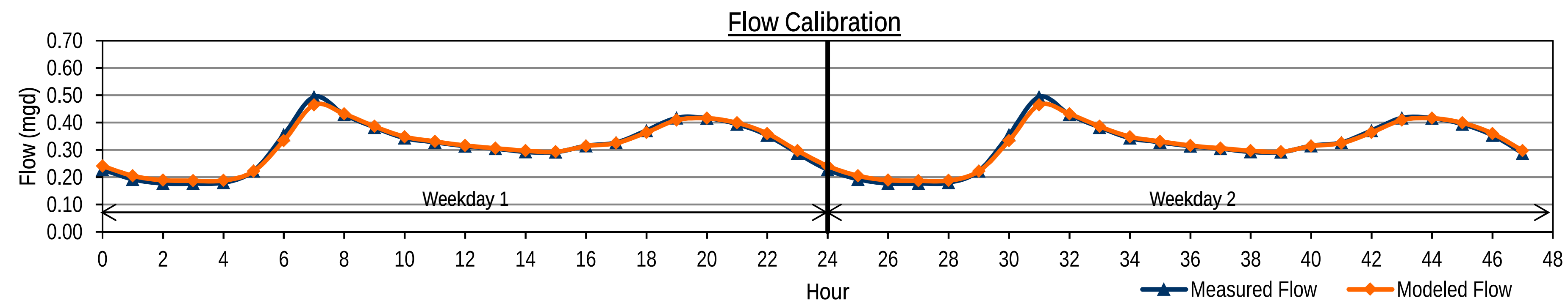
Notes:
1. Source: City of West Linn 2016 Temporary Flow Monitoring Program, ADS
2. Average flow, level, and velocity are computed from hydraulic modeling results. Maximum flow values are hourly peaks.
3. Percent Difference = (Modeled - Measured)/Measured*100.

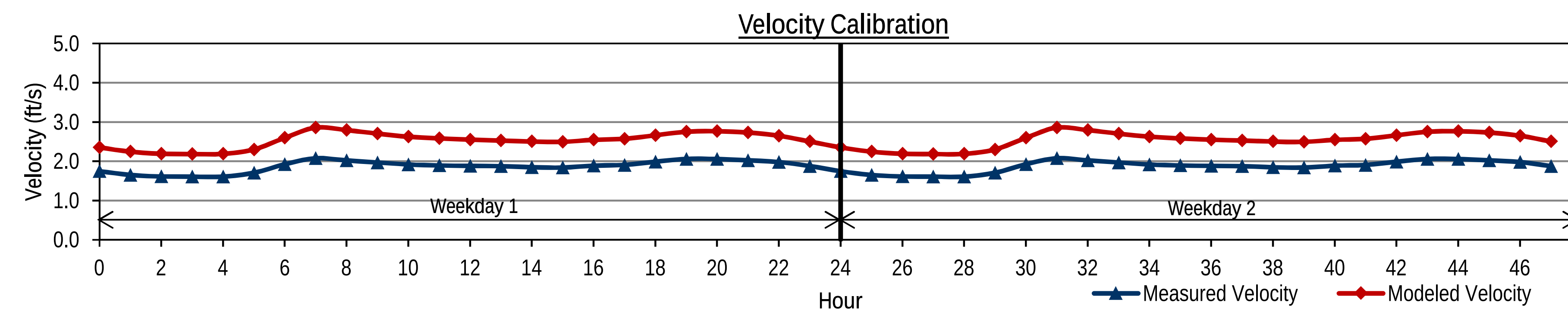
City of West Linn

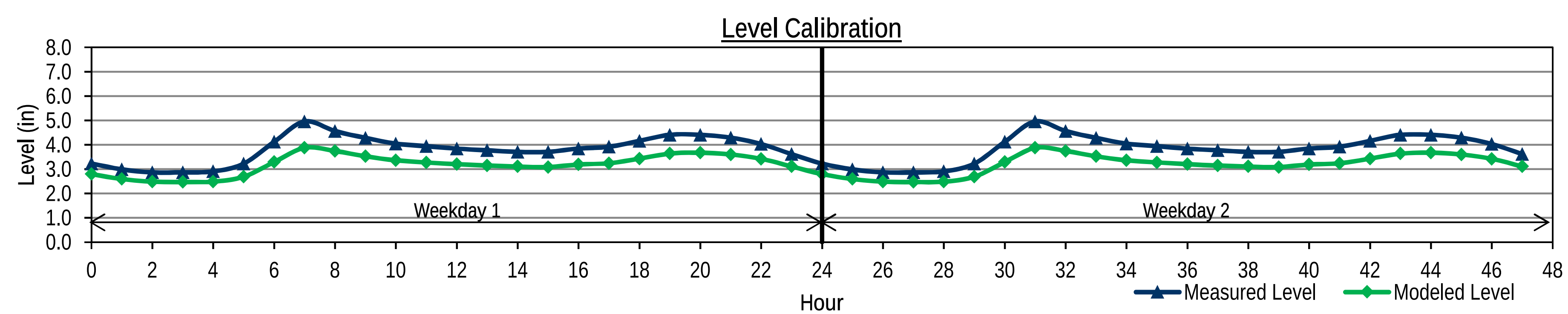
Sanitary Sewer Master Plan

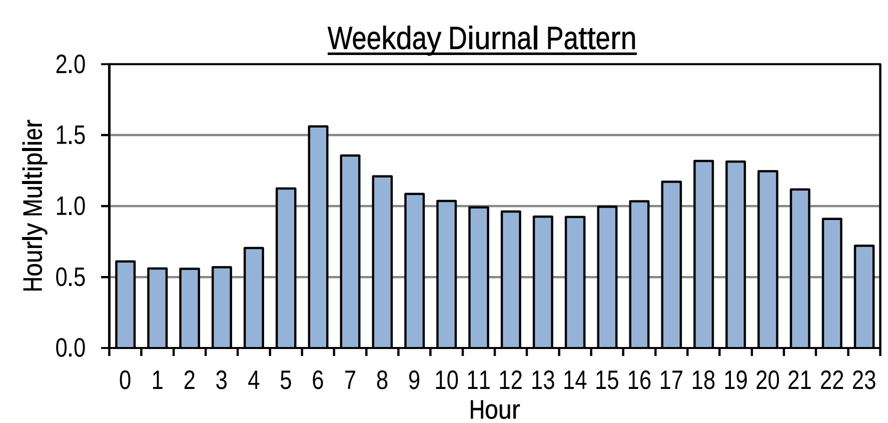
FLOW MONITORING SITE 9A-14 DRY WEATHER FLOW CALIBRATION

		Measured Data			Modeled Data				Diurnal
		Flow	Level	Velocity	Flow	Level	Velocity	Level Diff	Calibrated
	Hour	(mgd)	(in)	(ft/s)	(mgd)	(in)	(ft/s)	(in)	Diurnal
Weekday	0	0.228	3.2	1.75	0.241	2.8	2.35	0.43	0.61
	1	0.193	3.0	1.65	0.205	2.6	2.24	0.40	0.56
	2	0.177	2.9	1.61	0.189	2.5	2.19	0.38	0.56
	3	0.177	2.9	1.61	0.187	2.5	2.18	0.40	0.57
	4	0.180	2.9	1.61	0.188	2.5	2.19	0.42	0.70
	5	0.223	3.2	1.71	0.222	2.7	2.30	0.54	1.12
	6	0.356	4.1	1.93	0.334	3.3	2.60	0.83	1.56
	7	0.494	5.0	2.08	0.465	3.9	2.86	1.08	1.36
	8	0.430	4.6	2.02	0.432	3.7	2.79	0.82	1.21
	9	0.383	4.3	1.97	0.386	3.5	2.70	0.75	1.09
	10	0.344	4.0	1.92	0.348	3.4	2.63	0.68	1.04
	11	0.328	3.9	1.89	0.331	3.3	2.59	0.67	0.99
	12	0.314	3.8	1.88	0.316	3.2	2.55	0.64	0.96
	13	0.305	3.8	1.88	0.306	3.1	2.53	0.63	0.93
	14	0.293	3.7	1.85	0.297	3.1	2.50	0.60	0.92
	15	0.292	3.7	1.84	0.293	3.1	2.50	0.63	1.00
	16	0.315	3.8	1.89	0.314	3.2	2.55	0.65	1.03
	17	0.327	3.9	1.91	0.325	3.2	2.57	0.68	1.17
	18	0.371	4.2	1.99	0.364	3.4	2.66	0.73	1.32
	19	0.417	4.4	2.06	0.409	3.6	2.75	0.77	1.31
	20	0.416	4.4	2.06	0.416	3.7	2.76	0.74	1.25
	21	0.394	4.3	2.02	0.399	3.6	2.73	0.69	1.12
	22	0.353	4.0	1.98	0.360	3.4	2.65	0.61	0.91
	23	0.288	3.6	1.88	0.297	3.1	2.50	0.51	0.72
Weekend	24	0.228	3.2	1.75	0.241	2.8	2.35	0.43	0.61
	25	0.193	3.0	1.65	0.205	2.6	2.24	0.40	0.56
	26	0.177	2.9	1.61	0.189	2.5	2.19	0.38	0.56
	27	0.177	2.9	1.61	0.187	2.5	2.18	0.40	0.57
	28	0.180	2.9	1.61	0.188	2.5	2.19	0.42	0.70
	29	0.223	3.2	1.71	0.222	2.7	2.30	0.54	1.12
	30	0.356	4.1	1.93	0.334	3.3	2.60	0.83	1.56
	31	0.494	5.0	2.08	0.465	3.9	2.86	1.08	1.36
	32	0.430	4.6	2.02	0.432	3.7	2.79	0.82	1.21
	33	0.383	4.3	1.97	0.386	3.5	2.70	0.75	1.09
	34	0.344	4.0	1.92	0.348	3.4	2.63	0.68	1.04
	35	0.328	3.9	1.89	0.331	3.3	2.59	0.67	0.99
	36	0.314	3.8	1.88	0.316	3.2	2.55	0.64	0.96
	37	0.305	3.8	1.88	0.306	3.1	2.53	0.63	0.93
	38	0.293	3.7	1.85	0.297	3.1	2.50	0.60	0.92
	39	0.292	3.7	1.84	0.293	3.1	2.50	0.63	1.00
	40	0.315	3.8	1.89	0.314	3.2	2.55	0.65	1.03
	41	0.327	3.9	1.91	0.325	3.2	2.57	0.68	1.17
	42	0.371	4.2	1.99	0.364	3.4	2.66	0.73	1.32
	43	0.417	4.4	2.06	0.409	3.6	2.75	0.77	1.31
	44	0.416	4.4	2.06	0.416	3.7	2.76	0.74	1.25
	45	0.394	4.3	2.02	0.399	3.6	2.73	0.69	1.12
	46	0.353	4.0	1.98	0.360	3.4	2.65	0.61	0.91
	47	0.288	3.6	1.88	0.297	3.1	2.50	0.51	0.72
Average									
Weekday		0.316	3.8	1.87	0.318	3.2	2.54		1.00
Weekend		0.316	3.8	1.87	0.318	3.2	2.54		1.00
ADWF[(1)]		0.316	3.8	1.87	0.318	3.2	2.54		1.00
% Error									
Weekday					0.4%			1.08	
Weekend					0.4%			1.08	
Note:									







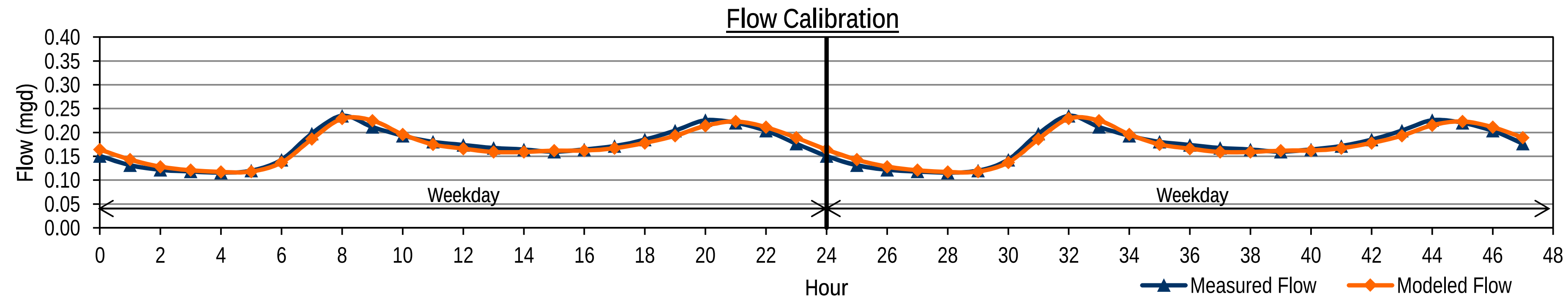


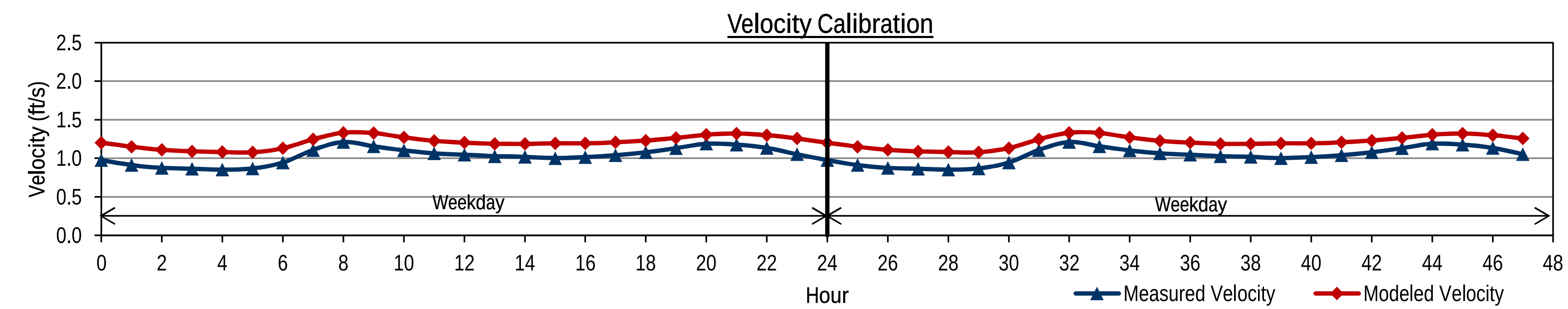
City of West Linn

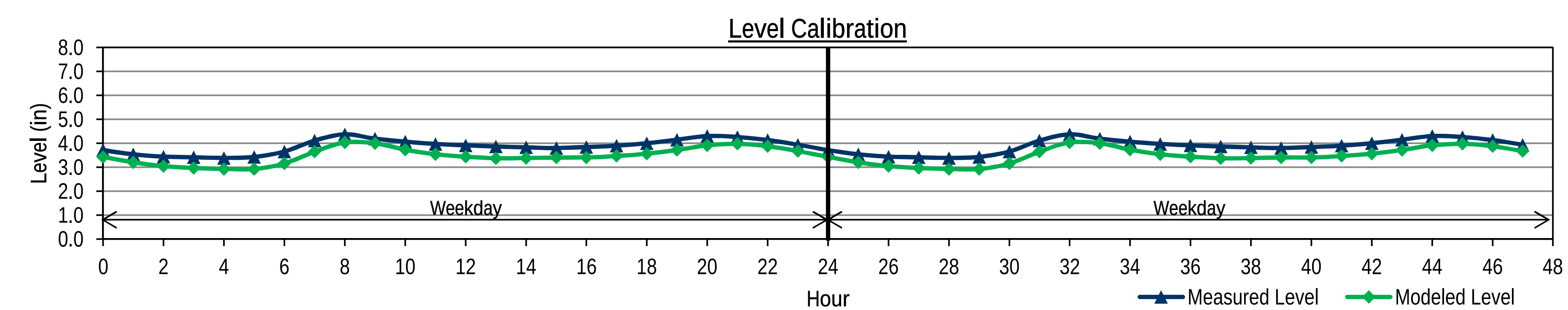
Sanitary Sewer Master Plan

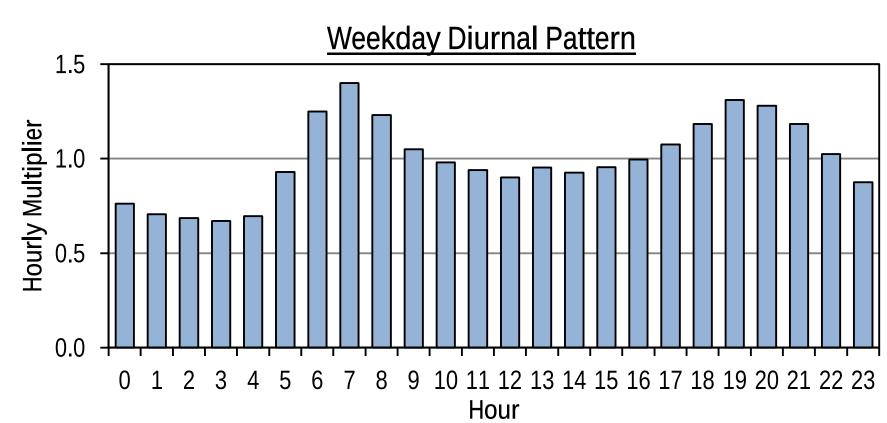
FLOW MONITORING SITE 11A-2 DRY WEATHER FLOW CALIBRATION

		Measured Data			Modeled Data				Diurnal
		Flow	Level	Velocity	Flow	Level	Velocity	Level Diff	Calibrated
	Hour	(mgd)	(in)	(ft/s)	(mgd)	(in)	(ft/s)	(in)	Diurnal
Weekday	0	0.151	3.7	0.98	0.164	3.4	1.20	0.28	0.76
	1	0.131	3.5	0.91	0.143	3.2	1.15	0.33	0.71
	2	0.122	3.4	0.88	0.128	3.0	1.11	0.39	0.69
	3	0.118	3.4	0.86	0.121	3.0	1.09	0.45	0.67
	4	0.116	3.4	0.85	0.117	2.9	1.08	0.46	0.70
	5	0.120	3.4	0.87	0.118	2.9	1.08	0.50	0.93
	6	0.143	3.7	0.94	0.137	3.2	1.13	0.50	1.25
	7	0.198	4.1	1.11	0.186	3.6	1.25	0.46	1.40
	8	0.235	4.4	1.21	0.229	4.0	1.33	0.34	1.23
	9	0.212	4.2	1.16	0.225	4.0	1.33	0.20	1.05
	10	0.193	4.1	1.10	0.196	3.7	1.27	0.33	0.98
	11	0.180	4.0	1.06	0.175	3.5	1.23	0.43	0.94
	12	0.174	3.9	1.05	0.166	3.4	1.20	0.47	0.90
	13	0.167	3.9	1.03	0.159	3.4	1.19	0.49	0.95
	14	0.164	3.8	1.02	0.159	3.4	1.19	0.45	0.93
	15	0.160	3.8	1.00	0.162	3.4	1.19	0.39	0.95
	16	0.164	3.8	1.02	0.162	3.4	1.19	0.43	1.00
	17	0.171	3.9	1.04	0.167	3.5	1.21	0.43	1.07
	18	0.185	4.0	1.08	0.178	3.6	1.23	0.44	1.18
	19	0.204	4.2	1.13	0.193	3.7	1.26	0.43	1.31
	20	0.226	4.3	1.19	0.214	3.9	1.31	0.39	1.28
	21	0.220	4.3	1.18	0.223	4.0	1.32	0.29	1.18
	22	0.204	4.1	1.14	0.211	3.9	1.30	0.26	1.02
	23	0.176	3.9	1.05	0.189	3.7	1.26	0.27	0.88
Weekend	24	0.151	3.7	0.98	0.164	3.4	1.20	0.28	0.76
	25	0.131	3.5	0.91	0.143	3.2	1.15	0.33	0.71
	26	0.122	3.4	0.88	0.128	3.0	1.11	0.39	0.69
	27	0.118	3.4	0.86	0.121	3.0	1.09	0.45	0.67
	28	0.116	3.4	0.85	0.117	2.9	1.08	0.46	0.70
	29	0.120	3.4	0.87	0.118	2.9	1.08	0.50	0.93
	30	0.143	3.7	0.94	0.137	3.2	1.13	0.50	1.25
	31	0.198	4.1	1.11	0.186	3.6	1.25	0.46	1.40
	32	0.235	4.4	1.21	0.229	4.0	1.33	0.34	1.23
	33	0.212	4.2	1.16	0.225	4.0	1.33	0.20	1.05
	34	0.193	4.1	1.10	0.196	3.7	1.27	0.33	0.98
	35	0.180	4.0	1.06	0.175	3.5	1.23	0.43	0.94
	36	0.174	3.9	1.05	0.166	3.4	1.20	0.47	0.90
	37	0.167	3.9	1.03	0.159	3.4	1.19	0.49	0.95
	38	0.164	3.8	1.02	0.159	3.4	1.19	0.45	0.93
	39	0.160	3.8	1.00	0.162	3.4	1.19	0.39	0.95
	40	0.164	3.8	1.02	0.162	3.4	1.19	0.43	1.00
	41	0.171	3.9	1.04	0.167	3.5	1.21	0.43	1.07
	42	0.185	4.0	1.08	0.178	3.6	1.23	0.44	1.18
	43	0.204	4.2	1.13	0.193	3.7	1.26	0.43	1.31
	44	0.226	4.3	1.19	0.215	3.9	1.31	0.39	1.28
	45	0.220	4.3	1.18	0.223	4.0	1.32	0.29	1.18
	46	0.204	4.1	1.14	0.211	3.9	1.30	0.26	1.02
	47	0.176	3.9	1.05	0.189	3.7	1.26	0.27	0.88
Average									
Weekday		0.172	3.9	1.04	0.172	3.5	1.21		1.00
Weekend		0.172	3.9	1.04	0.172	3.5	1.21		1.00
ADWF[1]		0.172	3.9	1.04	0.172	3.5	1.21		1.00
% Error									
Weekday					-0.3%			0.50	
Weekend					-0.3%			0.50	
Note:									









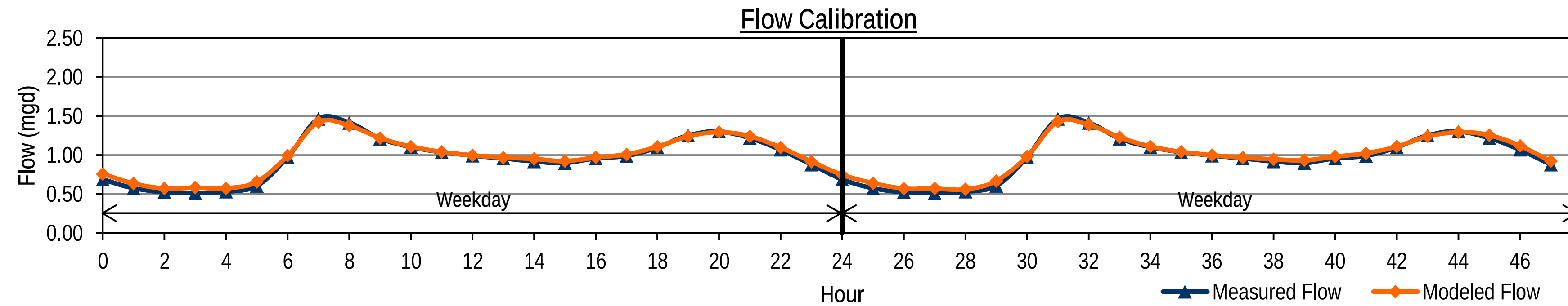
City of West Linn

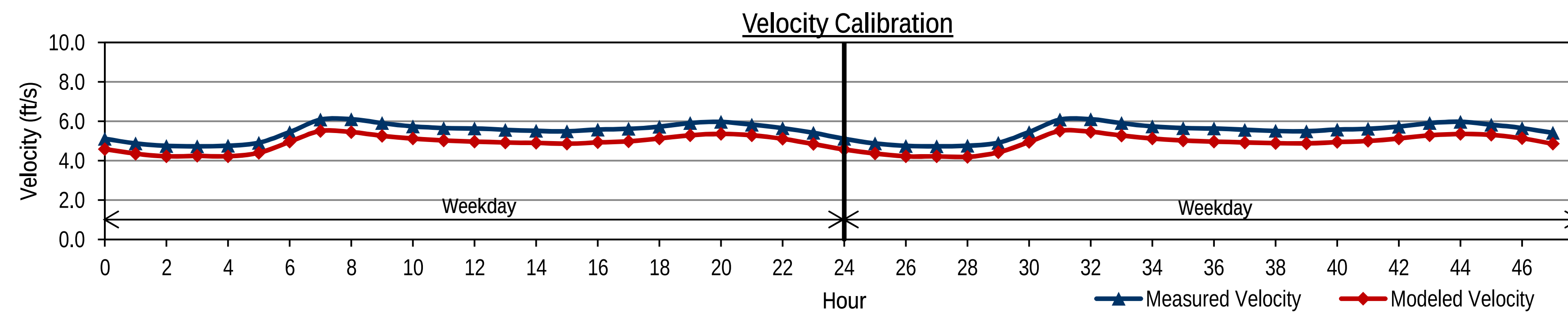
Sanitary Sewer Master Plan

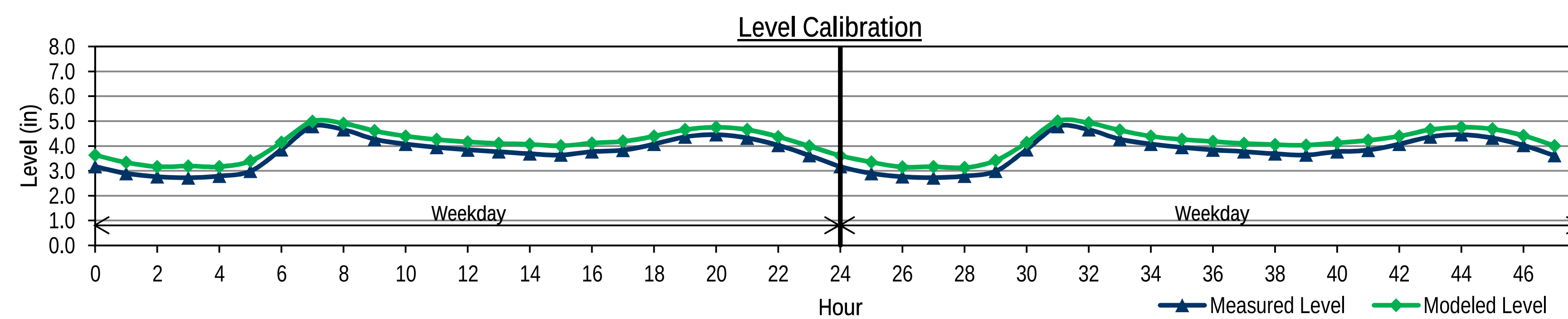
FLOW MONITORING SITE 9A-2 DRY WEATHER FLOW CALIBRATION

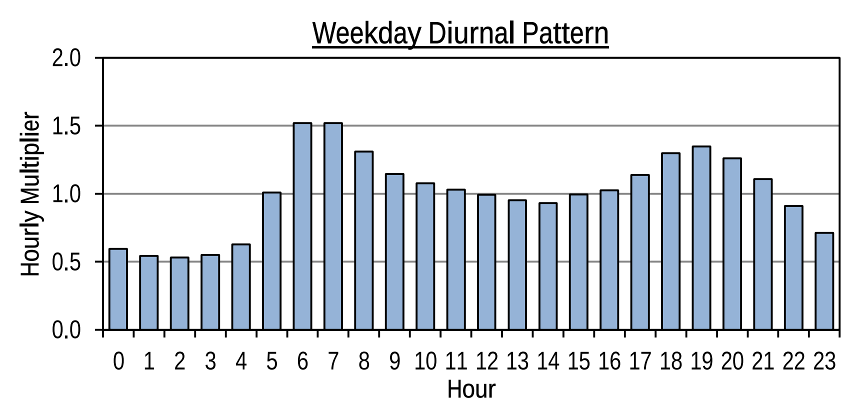
		Measured Data			Modeled Data				Diurnal
		Flow	Level	Velocity	Flow	Level	Velocity	Level Diff	Calibrated
	Hour	(mgd)	(in)	(ft/s)	(mgd)	(in)	(ft/s)	(in)	Diurnal
Weekday	0	0.686	3.2	5.11	0.757	3.6	4.59	-0.46	0.59
	1	0.573	2.9	4.88	0.635	3.3	4.36	-0.44	0.54
	2	0.523	2.8	4.75	0.570	3.2	4.22	-0.40	0.53
	3	0.511	2.7	4.73	0.581	3.2	4.24	-0.47	0.55
	4	0.529	2.8	4.76	0.572	3.2	4.22	-0.38	0.63
	5	0.605	3.0	4.91	0.657	3.4	4.40	-0.41	1.01
	6	0.972	3.9	5.45	0.990	4.2	4.96	-0.29	1.52
	7	1.464	4.8	6.08	1.424	5.0	5.51	-0.20	1.52
	8	1.413	4.7	6.10	1.378	4.9	5.45	-0.25	1.31
	9	1.211	4.3	5.91	1.216	4.6	5.26	-0.34	1.14
	10	1.103	4.1	5.74	1.107	4.4	5.12	-0.31	1.08
	11	1.037	3.9	5.65	1.039	4.3	5.03	-0.31	1.03
	12	0.992	3.8	5.63	0.996	4.2	4.97	-0.32	0.99
	13	0.957	3.8	5.56	0.965	4.1	4.92	-0.33	0.95
	14	0.917	3.7	5.51	0.949	4.1	4.90	-0.38	0.93
	15	0.897	3.6	5.49	0.921	4.0	4.86	-0.37	0.99
	16	0.958	3.8	5.58	0.969	4.1	4.93	-0.35	1.02
	17	0.988	3.8	5.62	1.007	4.2	4.98	-0.35	1.14
	18	1.098	4.1	5.73	1.106	4.4	5.12	-0.32	1.30
	19	1.251	4.4	5.91	1.239	4.7	5.29	-0.29	1.35
	20	1.300	4.5	5.97	1.292	4.8	5.36	-0.29	1.26
	21	1.215	4.3	5.83	1.240	4.7	5.29	-0.33	1.11
	22	1.067	4.0	5.65	1.095	4.4	5.11	-0.34	0.91
	23	0.878	3.6	5.41	0.915	4.0	4.85	-0.38	0.71
Weekend	24	0.686	3.2	5.11	0.746	3.6	4.57	-0.44	0.59
	25	0.573	2.9	4.88	0.639	3.3	4.37	-0.46	0.54
	26	0.523	2.8	4.75	0.569	3.2	4.22	-0.39	0.53
	27	0.511	2.7	4.73	0.570	3.2	4.22	-0.44	0.55
	28	0.529	2.8	4.76	0.559	3.1	4.20	-0.35	0.63
	29	0.605	3.0	4.91	0.666	3.4	4.42	-0.42	1.01
	30	0.972	3.9	5.45	0.982	4.1	4.95	-0.28	1.52
	31	1.464	4.8	6.08	1.429	5.0	5.51	-0.22	1.52
	32	1.413	4.7	6.10	1.389	4.9	5.47	-0.28	1.31
	33	1.211	4.3	5.91	1.227	4.6	5.28	-0.36	1.14
	34	1.103	4.1	5.74	1.108	4.4	5.13	-0.31	1.08
	35	1.037	3.9	5.65	1.039	4.3	5.03	-0.31	1.03
	36	0.992	3.8	5.63	0.997	4.2	4.97	-0.34	0.99
	37	0.957	3.8	5.56	0.964	4.1	4.92	-0.33	0.95
	38	0.917	3.7	5.51	0.945	4.1	4.89	-0.37	0.93
	39	0.897	3.6	5.49	0.931	4.0	4.87	-0.39	0.99
	40	0.958	3.8	5.58	0.979	4.1	4.94	-0.36	1.02
	41	0.988	3.8	5.62	1.021	4.2	5.00	-0.39	1.14
	42	1.098	4.1	5.73	1.108	4.4	5.13	-0.32	1.30
	43	1.251	4.4	5.91	1.237	4.7	5.29	-0.29	1.35
	44	1.300	4.5	5.97	1.293	4.8	5.36	-0.29	1.26
	45	1.215	4.3	5.83	1.254	4.7	5.31	-0.36	1.11
	46	1.067	4.0	5.65	1.116	4.4	5.14	-0.39	0.91
	47	0.878	3.6	5.41	0.920	4.0	4.86	-0.39	0.71
Average									
Weekday		0.964	3.8	5.50	0.984	4.1	4.91		1.00
Weekend		0.964	3.8	5.50	0.987	4.1	4.92		1.00
ADWF[1]		0.964	3.8	5.50	0.985	4.1	4.92		1.00
% Error									
Weekday					2.1%			0.47	
Weekend					2.4%			0.46	

Note:





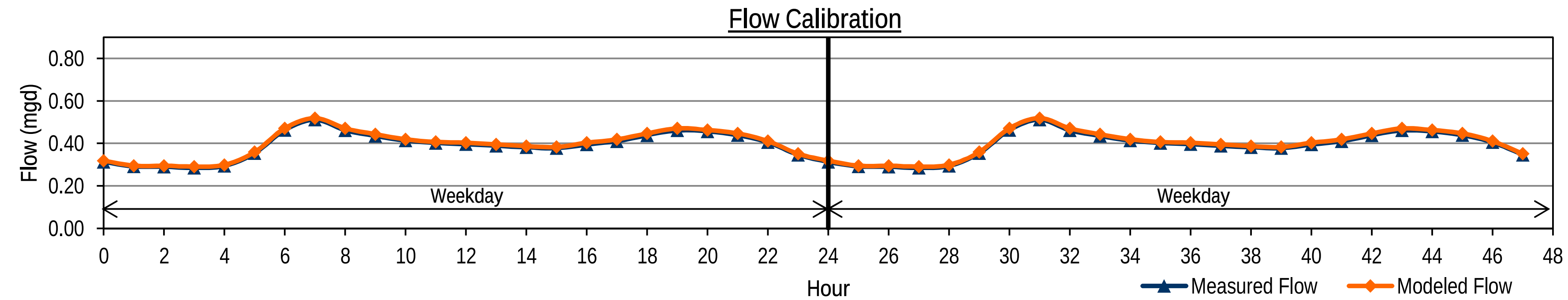


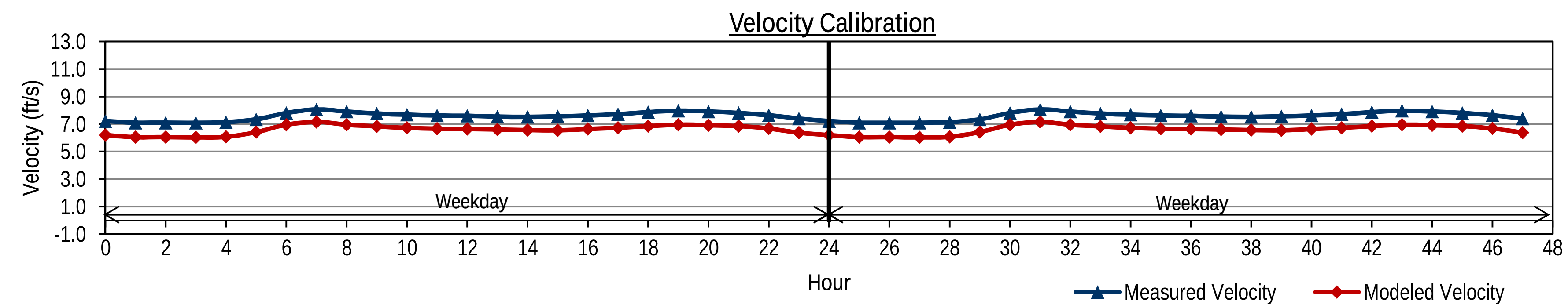


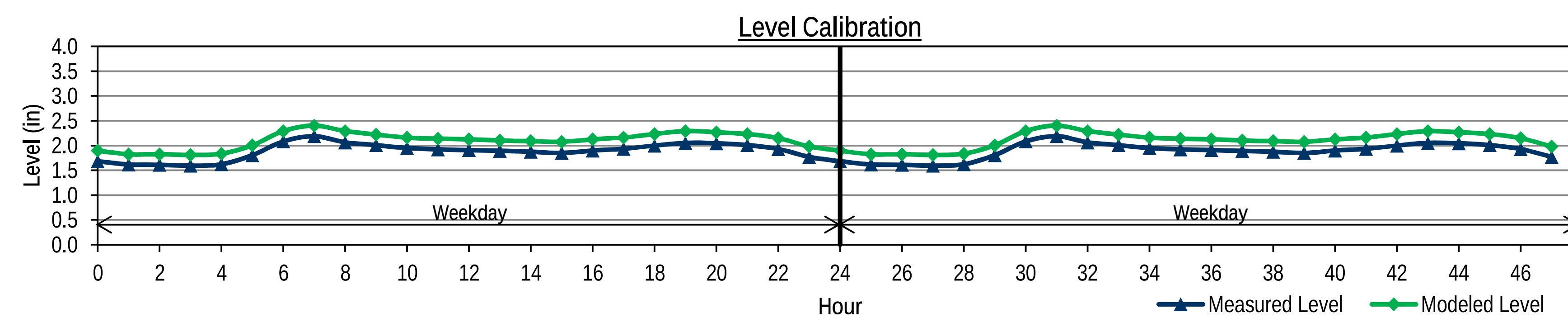
FLOW MONITORING SITE 1A-37-1-0 DRY WEATHER FLOW CALIBRATION

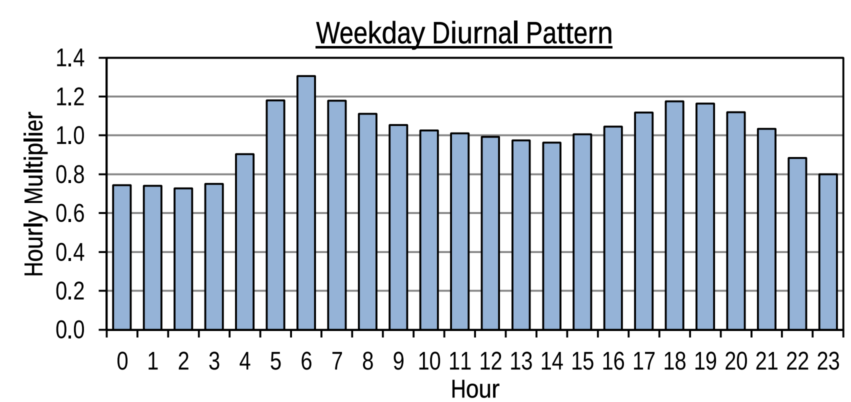
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Level Diff (in)	Diurnal Calibrated Diurnal
Weekday	0	0.314	1.7	7.21	0.319	1.9	6.20	-0.21	0.74
	1	0.292	1.6	7.10	0.295	1.8	6.05	-0.21	0.74
	2	0.290	1.6	7.09	0.295	1.8	6.05	-0.21	0.73
	3	0.285	1.6	7.10	0.291	1.8	6.03	-0.22	0.75
	4	0.294	1.6	7.14	0.299	1.8	6.08	-0.21	0.90
	5	0.354	1.8	7.34	0.359	2.0	6.41	-0.20	1.18
	6	0.463	2.1	7.81	0.471	2.3	6.95	-0.21	1.30
	7	0.512	2.2	8.06	0.519	2.4	7.16	-0.21	1.18
	8	0.462	2.1	7.91	0.471	2.3	6.95	-0.23	1.11
	9	0.435	2.0	7.76	0.443	2.2	6.83	-0.21	1.05
	10	0.413	1.9	7.68	0.419	2.2	6.72	-0.21	1.02
	11	0.402	1.9	7.62	0.407	2.1	6.66	-0.21	1.01
	12	0.396	1.9	7.60	0.403	2.1	6.64	-0.22	0.99
	13	0.389	1.9	7.55	0.395	2.1	6.60	-0.21	0.97
	14	0.382	1.9	7.51	0.387	2.1	6.56	-0.21	0.96
	15	0.378	1.8	7.57	0.383	2.1	6.54	-0.23	1.01
	16	0.395	1.9	7.62	0.403	2.1	6.64	-0.22	1.05
	17	0.410	1.9	7.72	0.419	2.2	6.72	-0.23	1.12
	18	0.438	2.0	7.87	0.447	2.2	6.85	-0.23	1.18
	19	0.461	2.1	7.97	0.471	2.3	6.95	-0.24	1.16
	20	0.456	2.0	7.92	0.463	2.3	6.92	-0.22	1.12
	21	0.439	2.0	7.81	0.447	2.2	6.85	-0.22	1.03
	22	0.406	1.9	7.64	0.411	2.1	6.68	-0.22	0.88
	23	0.347	1.8	7.41	0.351	2.0	6.37	-0.21	0.80
Weekend	24	0.314	1.7	7.21	0.319	1.9	6.20	-0.21	0.74
	25	0.292	1.6	7.10	0.295	1.8	6.05	-0.21	0.74
	26	0.290	1.6	7.09	0.295	1.8	6.05	-0.21	0.73
	27	0.285	1.6	7.10	0.291	1.8	6.03	-0.22	0.75
	28	0.294	1.6	7.14	0.299	1.8	6.08	-0.21	0.90
	29	0.354	1.8	7.34	0.359	2.0	6.41	-0.20	1.18
	30	0.463	2.1	7.81	0.471	2.3	6.95	-0.21	1.30
	31	0.512	2.2	8.06	0.519	2.4	7.16	-0.21	1.18
	32	0.462	2.1	7.91	0.471	2.3	6.95	-0.23	1.11
	33	0.435	2.0	7.76	0.443	2.2	6.83	-0.21	1.05
	34	0.413	1.9	7.68	0.419	2.2	6.72	-0.21	1.02
	35	0.402	1.9	7.62	0.407	2.1	6.66	-0.21	1.01
	36	0.396	1.9	7.60	0.403	2.1	6.64	-0.22	0.99
	37	0.389	1.9	7.55	0.395	2.1	6.60	-0.21	0.97
	38	0.382	1.9	7.51	0.387	2.1	6.56	-0.21	0.96
	39	0.378	1.8	7.57	0.383	2.1	6.54	-0.23	1.01
	40	0.395	1.9	7.62	0.403	2.1	6.64	-0.22	1.05
	41	0.410	1.9	7.72	0.419	2.2	6.72	-0.23	1.12
	42	0.438	2.0	7.87	0.447	2.2	6.85	-0.23	1.18
	43	0.461	2.1	7.97	0.471	2.3	6.95	-0.24	1.16
	44	0.456	2.0	7.92	0.463	2.3	6.92	-0.22	1.12
	45	0.439	2.0	7.81	0.447	2.2	6.85	-0.22	1.03
	46	0.406	1.9	7.64	0.411	2.1	6.68	-0.22	0.88
	47	0.347	1.8	7.41	0.351	2.0	6.37	-0.21	0.80
Average									
Weekday		0.392	1.9	7.58	0.399	2.1	6.60		1.00
Weekend		0.392	1.9	7.58	0.399	2.1	6.60		1.00
ADWF[1]		0.392	1.9	7.58	0.399	2.1	6.60		1.00
% Error									
Weekday					1.6%			0.24	
Weekend					1.6%			0.24	

Note:





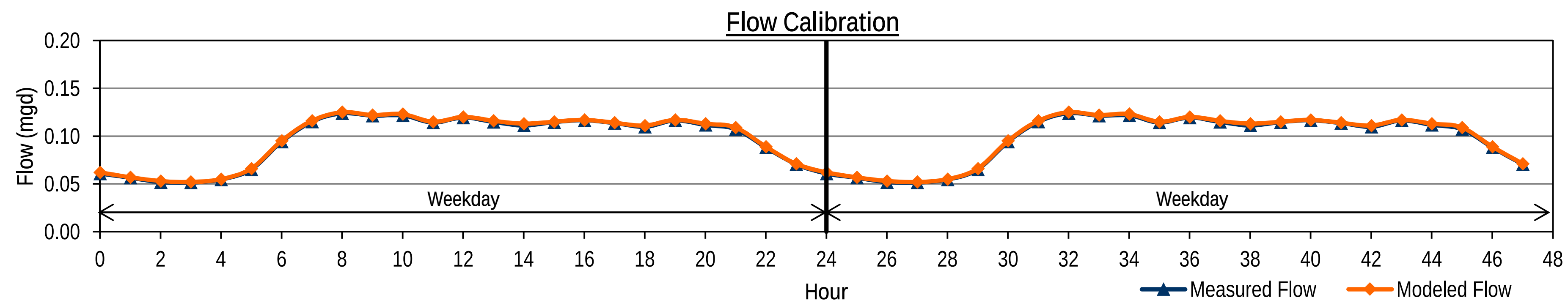


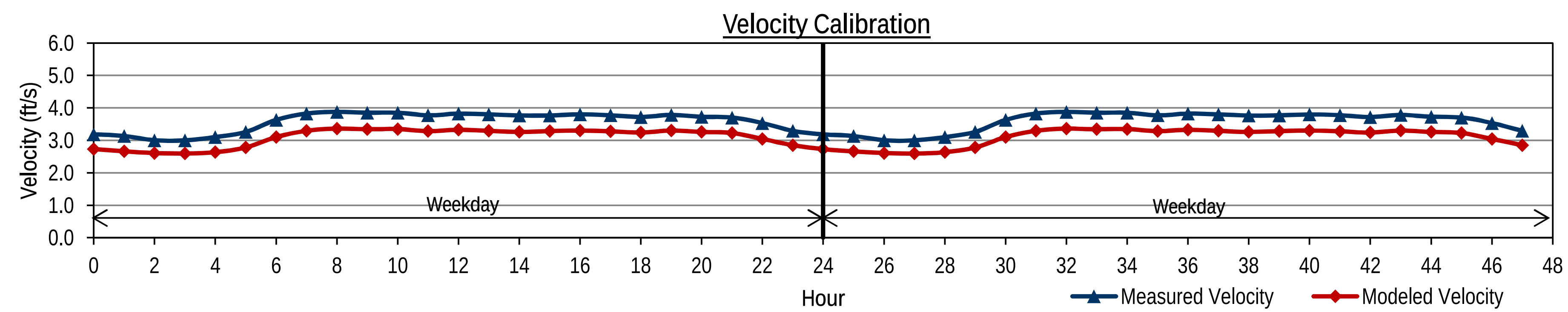


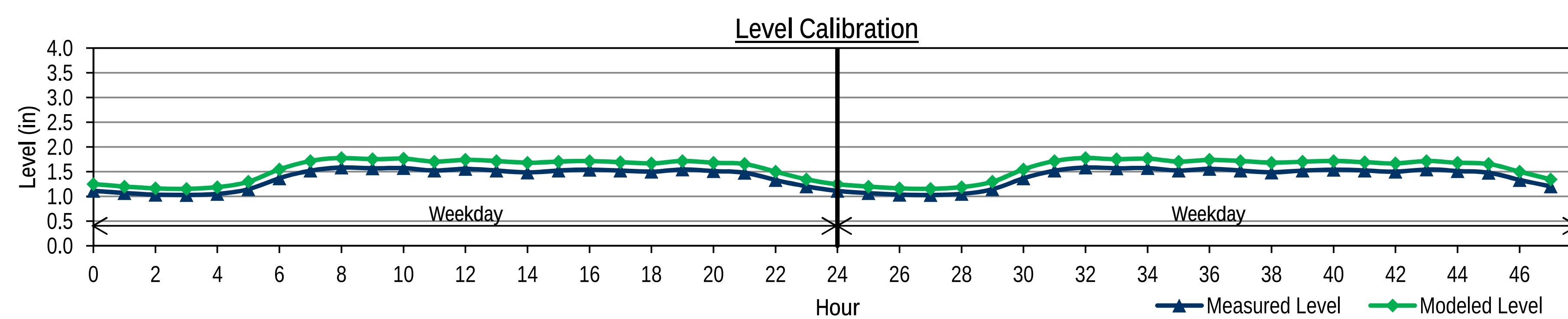
FLOW MONITORING SITE 3B-4 DRY WEATHER FLOW CALIBRATION

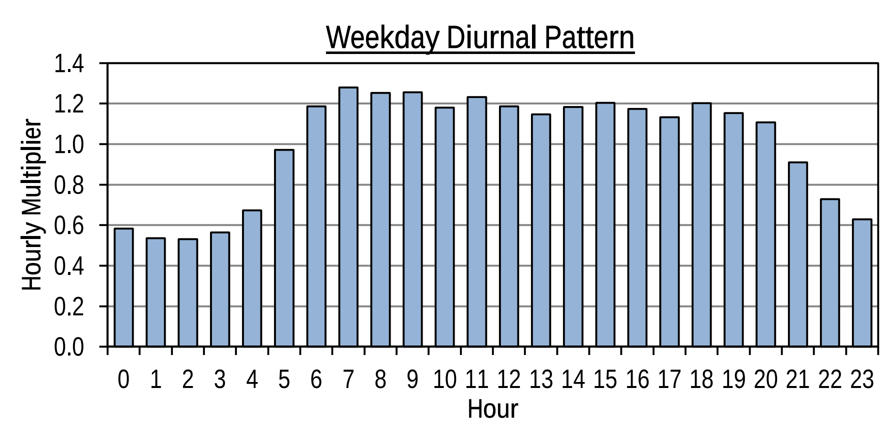
		Measured Data			Modeled Data				Diurnal
		Flow	Level	Velocity	Flow	Level	Velocity	Level Diff	Calibrated
	Hour	(mgd)	(in)	(ft/s)	(mgd)	(in)	(ft/s)	(in)	Diurnal
Weekday	0	0.061	1.1	3.18	0.062	1.2	2.73	-0.14	0.58
	1	0.057	1.1	3.14	0.057	1.2	2.66	-0.13	0.54
	2	0.052	1.0	3.00	0.053	1.2	2.61	-0.13	0.53
	3	0.052	1.0	3.00	0.052	1.2	2.59	-0.12	0.56
	4	0.055	1.1	3.10	0.055	1.2	2.64	-0.14	0.67
	5	0.065	1.1	3.26	0.066	1.3	2.78	-0.15	0.97
	6	0.094	1.4	3.63	0.095	1.5	3.10	-0.18	1.19
	7	0.115	1.5	3.83	0.116	1.7	3.29	-0.20	1.28
	8	0.124	1.6	3.88	0.125	1.8	3.36	-0.19	1.25
	9	0.121	1.6	3.85	0.122	1.8	3.34	-0.18	1.26
	10	0.122	1.6	3.85	0.123	1.8	3.35	-0.19	1.18
	11	0.114	1.5	3.77	0.115	1.7	3.29	-0.18	1.23
	12	0.120	1.6	3.82	0.120	1.7	3.33	-0.18	1.19
	13	0.115	1.5	3.80	0.116	1.7	3.29	-0.19	1.15
	14	0.111	1.5	3.77	0.113	1.7	3.26	-0.19	1.18
	15	0.115	1.5	3.77	0.115	1.7	3.29	-0.18	1.20
	16	0.117	1.5	3.80	0.117	1.7	3.30	-0.17	1.17
	17	0.114	1.5	3.77	0.114	1.7	3.28	-0.17	1.13
	18	0.110	1.5	3.72	0.111	1.7	3.24	-0.17	1.20
	19	0.117	1.5	3.78	0.117	1.7	3.30	-0.17	1.15
	20	0.112	1.5	3.73	0.113	1.7	3.26	-0.17	1.11
	21	0.107	1.5	3.70	0.109	1.7	3.23	-0.18	0.91
	22	0.088	1.3	3.53	0.089	1.5	3.04	-0.17	0.73
	23	0.071	1.2	3.29	0.071	1.3	2.85	-0.14	0.63
Weekend	24	0.061	1.1	3.18	0.062	1.2	2.73	-0.14	0.58
	25	0.057	1.1	3.14	0.057	1.2	2.66	-0.13	0.54
	26	0.052	1.0	3.00	0.053	1.2	2.61	-0.13	0.53
	27	0.052	1.0	3.00	0.052	1.2	2.59	-0.12	0.56
	28	0.055	1.1	3.10	0.055	1.2	2.64	-0.14	0.67
	29	0.065	1.1	3.26	0.066	1.3	2.78	-0.15	0.97
	30	0.094	1.4	3.63	0.095	1.5	3.10	-0.18	1.19
	31	0.115	1.5	3.83	0.116	1.7	3.29	-0.20	1.28
	32	0.124	1.6	3.88	0.125	1.8	3.36	-0.19	1.25
	33	0.121	1.6	3.85	0.122	1.8	3.34	-0.18	1.26
	34	0.122	1.6	3.85	0.123	1.8	3.35	-0.19	1.18
	35	0.114	1.5	3.77	0.115	1.7	3.29	-0.18	1.23
	36	0.120	1.6	3.82	0.120	1.7	3.33	-0.18	1.19
	37	0.115	1.5	3.80	0.116	1.7	3.29	-0.19	1.15
	38	0.111	1.5	3.77	0.113	1.7	3.26	-0.19	1.18
	39	0.115	1.5	3.77	0.115	1.7	3.29	-0.18	1.20
	40	0.117	1.5	3.80	0.117	1.7	3.30	-0.17	1.17
	41	0.114	1.5	3.77	0.114	1.7	3.28	-0.17	1.13
	42	0.110	1.5	3.72	0.111	1.7	3.24	-0.17	1.20
	43	0.117	1.5	3.78	0.117	1.7	3.30	-0.17	1.15
	44	0.112	1.5	3.73	0.113	1.7	3.26	-0.17	1.11
	45	0.107	1.5	3.70	0.109	1.7	3.23	-0.18	0.91
	46	0.088	1.3	3.53	0.089	1.5	3.04	-0.17	0.73
	47	0.071	1.2	3.29	0.071	1.3	2.85	-0.14	0.63
Average									
	Weekday	0.097	1.4	3.58	0.098	1.6	3.10		1.00
	Weekend	0.097	1.4	3.58	0.098	1.6	3.10		1.00
	ADWF[(1)]	0.097	1.4	3.58	0.098	1.6	3.10		1.00
% Error									
	Weekday				0.9%			0.20	
	Weekend				0.9%			0.20	

Note:







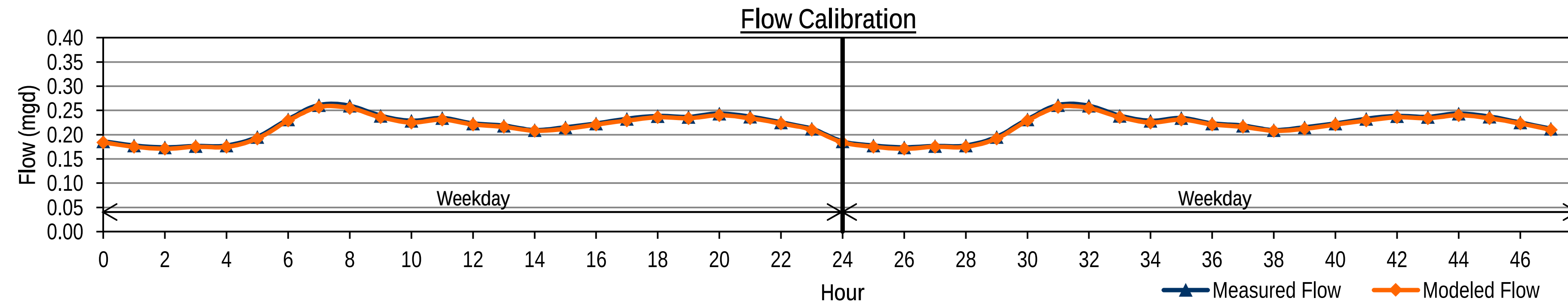


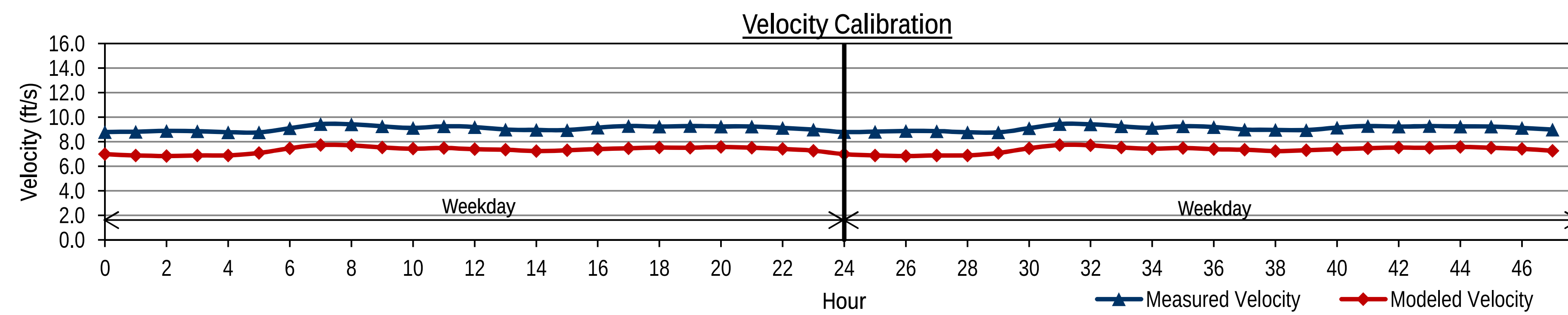
City of West Linn

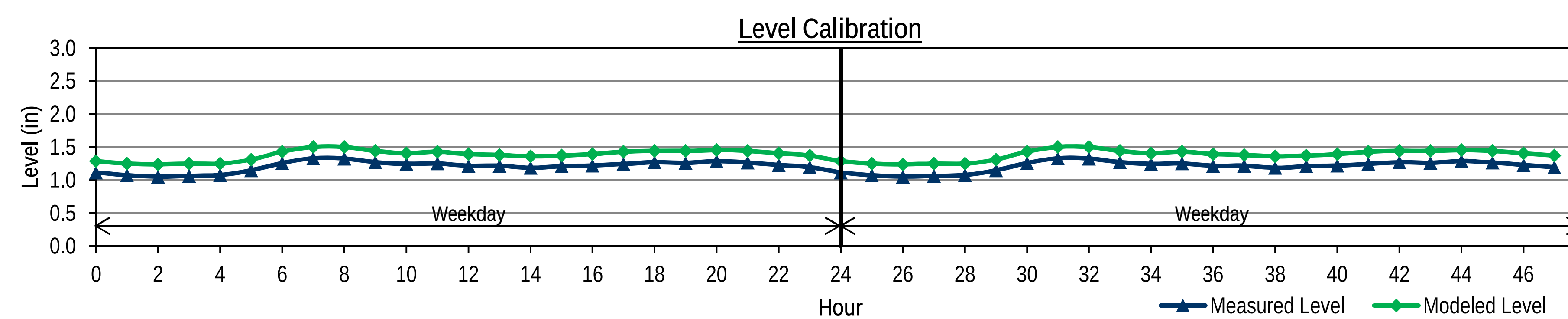
Sanitary Sewer Master Plan

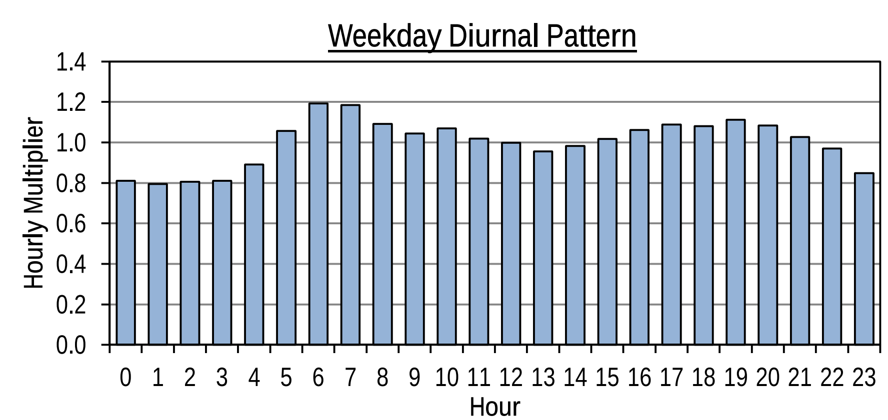
FLOW MONITORING SITE 2B-1-0 DRY WEATHER FLOW CALIBRATION

	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Level Diff (in)	Diurnal Calibrated Diurnal
Weekday	0	0.186	1.1	8.79	0.184	1.3	6.99	-0.17	0.81
	1	0.178	1.1	8.81	0.175	1.2	6.89	-0.18	0.79
	2	0.174	1.0	8.88	0.171	1.2	6.83	-0.19	0.81
	3	0.177	1.1	8.86	0.175	1.2	6.88	-0.19	0.81
	4	0.178	1.1	8.77	0.175	1.2	6.88	-0.17	0.89
	5	0.195	1.1	8.76	0.192	1.3	7.08	-0.16	1.06
	6	0.232	1.3	9.09	0.229	1.4	7.47	-0.17	1.19
	7	0.261	1.3	9.44	0.257	1.5	7.73	-0.17	1.18
	8	0.260	1.3	9.42	0.255	1.5	7.71	-0.17	1.09
	9	0.239	1.3	9.25	0.236	1.4	7.53	-0.17	1.04
	10	0.229	1.2	9.12	0.225	1.4	7.43	-0.16	1.07
	11	0.234	1.3	9.25	0.231	1.4	7.49	-0.18	1.02
	12	0.223	1.2	9.20	0.221	1.4	7.39	-0.18	1.00
	13	0.219	1.2	8.99	0.216	1.4	7.34	-0.16	0.96
	14	0.209	1.2	8.96	0.208	1.4	7.25	-0.17	0.98
	15	0.215	1.2	8.95	0.212	1.4	7.29	-0.16	1.02
	16	0.223	1.2	9.15	0.221	1.4	7.39	-0.17	1.06
	17	0.233	1.2	9.29	0.229	1.4	7.47	-0.19	1.09
	18	0.239	1.3	9.23	0.236	1.4	7.53	-0.17	1.08
	19	0.237	1.3	9.28	0.234	1.4	7.51	-0.18	1.11
	20	0.244	1.3	9.24	0.240	1.5	7.57	-0.17	1.08
	21	0.237	1.3	9.24	0.234	1.4	7.51	-0.18	1.03
	22	0.225	1.2	9.13	0.223	1.4	7.41	-0.18	0.97
	23	0.212	1.2	8.98	0.210	1.4	7.27	-0.18	0.85
Weekend	24	0.186	1.1	8.79	0.184	1.3	6.99	-0.17	0.81
	25	0.178	1.1	8.81	0.175	1.2	6.89	-0.18	0.79
	26	0.174	1.0	8.88	0.171	1.2	6.83	-0.19	0.81
	27	0.177	1.1	8.86	0.175	1.2	6.88	-0.19	0.81
	28	0.178	1.1	8.77	0.175	1.2	6.88	-0.17	0.89
	29	0.195	1.1	8.76	0.192	1.3	7.08	-0.16	1.06
	30	0.232	1.3	9.09	0.229	1.4	7.47	-0.17	1.19
	31	0.261	1.3	9.44	0.257	1.5	7.73	-0.17	1.18
	32	0.260	1.3	9.42	0.255	1.5	7.71	-0.17	1.09
	33	0.239	1.3	9.25	0.236	1.4	7.53	-0.17	1.04
	34	0.229	1.2	9.12	0.225	1.4	7.43	-0.16	1.07
	35	0.234	1.3	9.25	0.231	1.4	7.49	-0.18	1.02
	36	0.223	1.2	9.20	0.221	1.4	7.39	-0.18	1.00
	37	0.219	1.2	8.99	0.216	1.4	7.34	-0.16	0.96
	38	0.209	1.2	8.96	0.208	1.4	7.25	-0.17	0.98
	39	0.215	1.2	8.95	0.212	1.4	7.29	-0.16	1.02
	40	0.223	1.2	9.15	0.221	1.4	7.39	-0.17	1.06
	41	0.233	1.2	9.29	0.229	1.4	7.47	-0.19	1.09
	42	0.239	1.3	9.23	0.236	1.4	7.53	-0.17	1.08
	43	0.237	1.3	9.28	0.234	1.4	7.51	-0.18	1.11
	44	0.244	1.3	9.24	0.240	1.5	7.57	-0.17	1.08
	45	0.237	1.3	9.24	0.234	1.4	7.51	-0.18	1.03
	46	0.225	1.2	9.13	0.223	1.4	7.41	-0.18	0.97
	47	0.212	1.2	8.98	0.210	1.4	7.27	-0.18	0.85
Average									
Weekday		0.219	1.2	9.09	0.216	1.4	7.33		1.00
Weekend		0.219	1.2	9.09	0.216	1.4	7.33		1.00
ADWF(1)		0.219	1.2	9.09	0.216	1.4	7.33		1.00
% Error									
Weekday					-1.3%			0.19	
Weekend					-1.3%			0.19	
Note:									





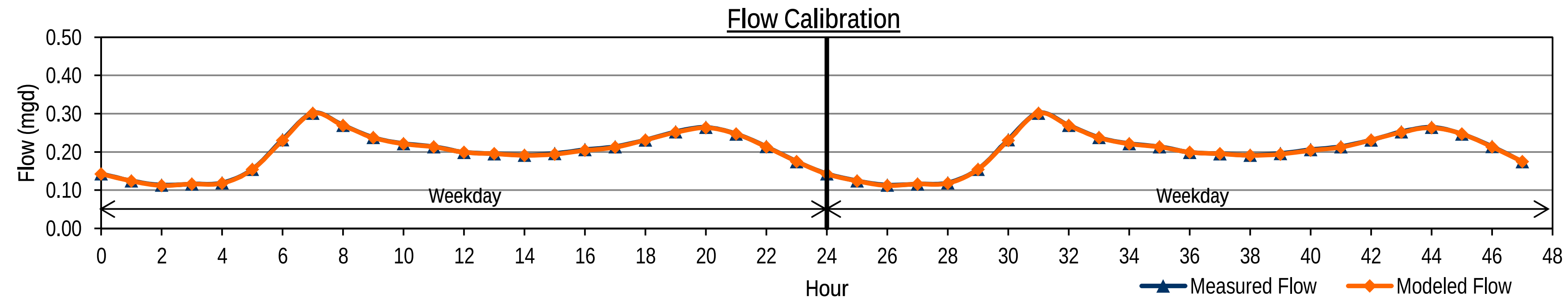


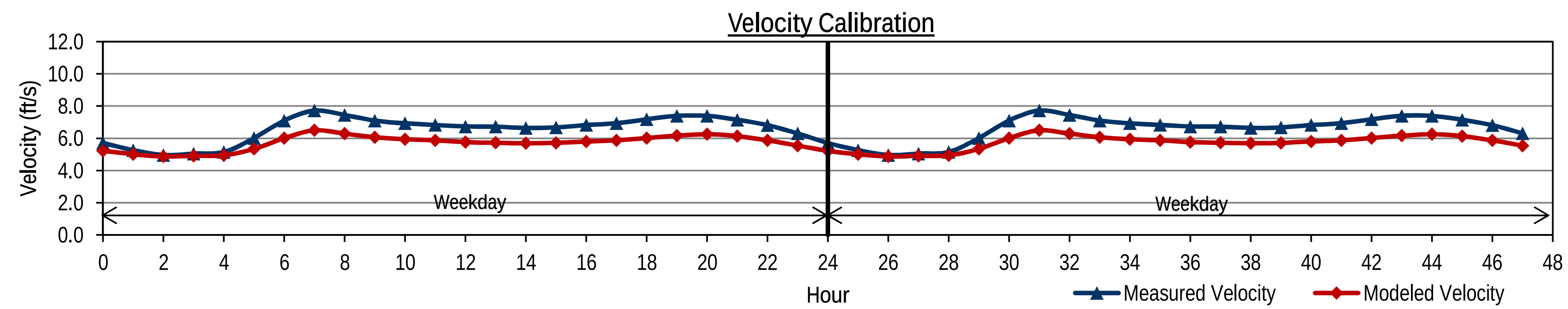


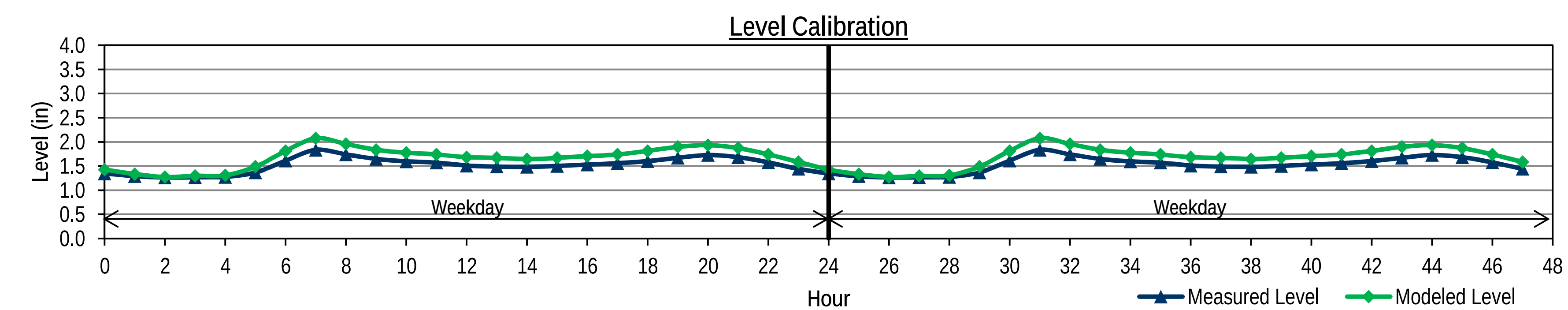
City of West Linn
Sanitary Sewer Master Plan
FLOW MONITORING SITE 9C-3 DRY WEATHER FLOW CALIBRATION

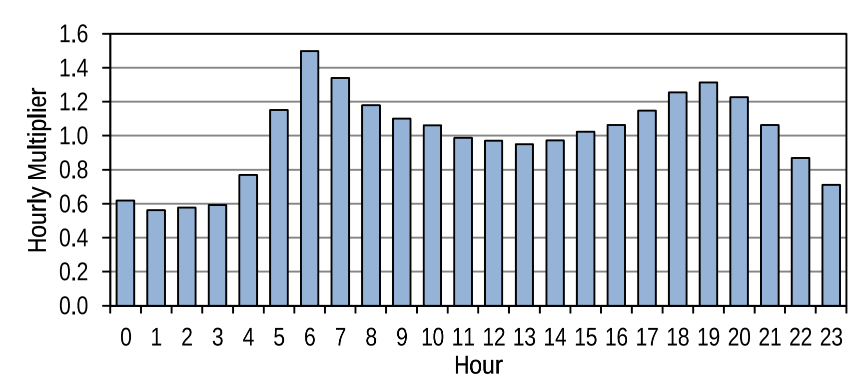
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Level Diff (in)	Diurnal Calibrated Diurnal
Weekday	0	0.143	1.3	5.71	0.142	1.4	5.22	-0.08	0.62
	1	0.124	1.3	5.26	0.124	1.3	5.01	-0.04	0.56
	2	0.113	1.3	4.96	0.112	1.3	4.87	-0.01	0.58
	3	0.116	1.3	5.05	0.116	1.3	4.91	-0.03	0.59
	4	0.119	1.3	5.15	0.118	1.3	4.94	-0.03	0.77
	5	0.155	1.4	6.01	0.154	1.5	5.34	-0.12	1.15
	6	0.232	1.6	7.10	0.230	1.8	6.01	-0.20	1.50
	7	0.302	1.8	7.72	0.301	2.1	6.49	-0.24	1.34
	8	0.270	1.7	7.45	0.269	2.0	6.29	-0.22	1.18
	9	0.238	1.6	7.10	0.237	1.8	6.06	-0.19	1.10
	10	0.222	1.6	6.93	0.221	1.8	5.94	-0.18	1.06
	11	0.214	1.6	6.83	0.213	1.7	5.87	-0.17	0.99
	12	0.199	1.5	6.73	0.199	1.7	5.76	-0.17	0.97
	13	0.196	1.5	6.72	0.195	1.7	5.72	-0.18	0.95
	14	0.191	1.5	6.64	0.191	1.6	5.69	-0.16	0.97
	15	0.196	1.5	6.67	0.194	1.7	5.72	-0.17	1.02
	16	0.206	1.5	6.83	0.204	1.7	5.80	-0.17	1.06
	17	0.214	1.6	6.93	0.212	1.7	5.87	-0.18	1.15
	18	0.231	1.6	7.18	0.231	1.8	6.01	-0.21	1.25
	19	0.253	1.7	7.39	0.251	1.9	6.16	-0.22	1.31
	20	0.265	1.7	7.39	0.263	1.9	6.25	-0.21	1.23
	21	0.247	1.7	7.15	0.247	1.9	6.13	-0.19	1.06
	22	0.214	1.6	6.81	0.213	1.7	5.87	-0.17	0.87
	23	0.175	1.4	6.30	0.175	1.6	5.54	-0.14	0.71
Weekend	24	0.143	1.3	5.71	0.142	1.4	5.22	-0.08	0.62
	25	0.124	1.3	5.26	0.124	1.3	5.01	-0.04	0.56
	26	0.113	1.3	4.96	0.112	1.3	4.87	-0.01	0.58
	27	0.116	1.3	5.05	0.116	1.3	4.91	-0.03	0.59
	28	0.119	1.3	5.15	0.118	1.3	4.94	-0.03	0.77
	29	0.155	1.4	6.01	0.154	1.5	5.34	-0.12	1.15
	30	0.232	1.6	7.10	0.230	1.8	6.01	-0.20	1.50
	31	0.302	1.8	7.72	0.301	2.1	6.49	-0.24	1.34
	32	0.270	1.7	7.45	0.269	2.0	6.29	-0.22	1.18
	33	0.238	1.6	7.10	0.237	1.8	6.06	-0.19	1.10
	34	0.222	1.6	6.93	0.221	1.8	5.94	-0.18	1.06
	35	0.214	1.6	6.83	0.213	1.7	5.87	-0.17	0.99
	36	0.199	1.5	6.73	0.199	1.7	5.76	-0.17	0.97
	37	0.196	1.5	6.72	0.195	1.7	5.72	-0.18	0.95
	38	0.191	1.5	6.64	0.191	1.6	5.69	-0.16	0.97
	39	0.196	1.5	6.67	0.194	1.7	5.72	-0.17	1.02
	40	0.206	1.5	6.83	0.204	1.7	5.80	-0.17	1.06
	41	0.214	1.6	6.93	0.212	1.7	5.87	-0.18	1.15
	42	0.231	1.6	7.18	0.231	1.8	6.01	-0.21	1.25
	43	0.253	1.7	7.39	0.251	1.9	6.16	-0.22	1.31
	44	0.265	1.7	7.39	0.263	1.9	6.25	-0.21	1.23
	45	0.247	1.7	7.15	0.247	1.9	6.13	-0.19	1.06
	46	0.214	1.6	6.81	0.213	1.7	5.87	-0.17	0.87
	47	0.175	1.4	6.30	0.175	1.6	5.54	-0.14	0.71
Average									
Weekday		0.201	1.5	6.58	0.201	1.7	5.73		1.00
Weekend		0.201	1.5	6.58	0.201	1.7	5.73		1.00
ADWF[(1)]		0.201	1.5	6.58	0.201	1.7	5.73		1.00
% Error									
Weekday					-0.5%			0.24	
Weekend					-0.5%			0.24	

Note:









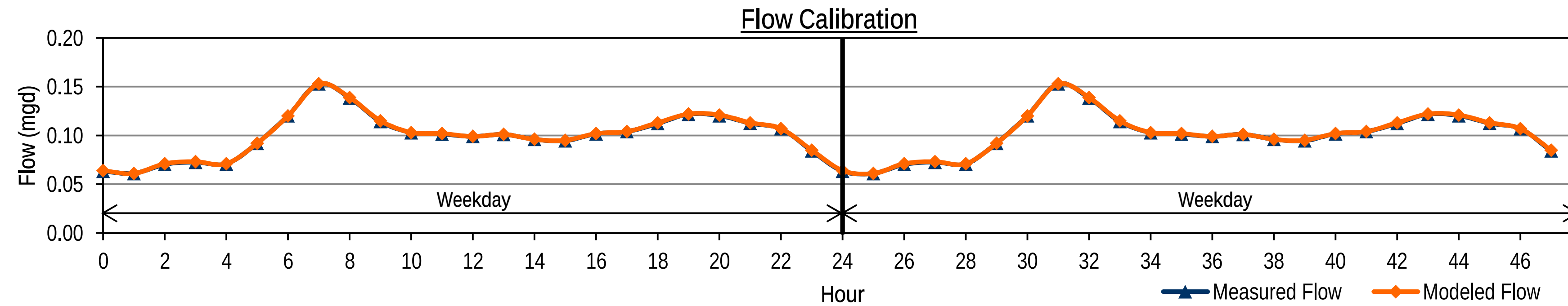
City of West Linn

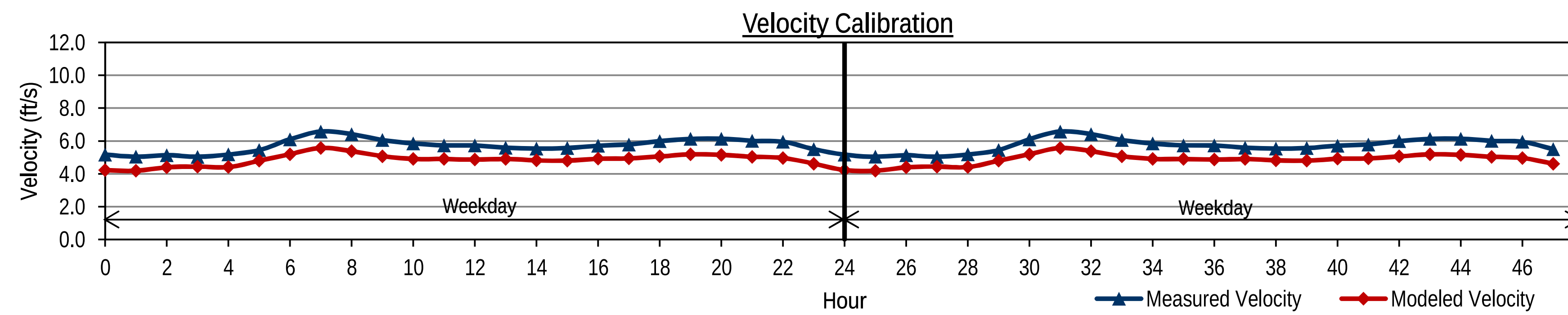
Sanitary Sewer Master Plan

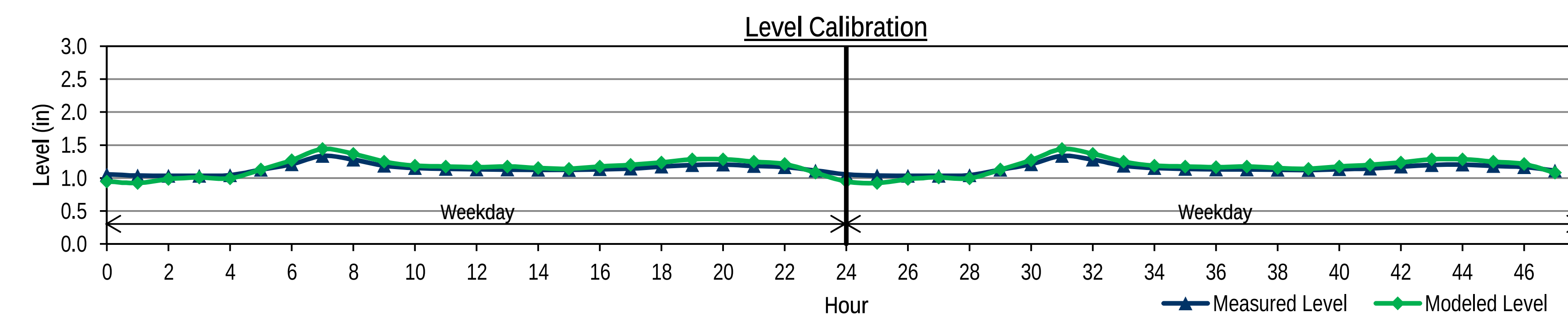
FLOW MONITORING SITE 2A-19 DRY WEATHER FLOW CALIBRATION

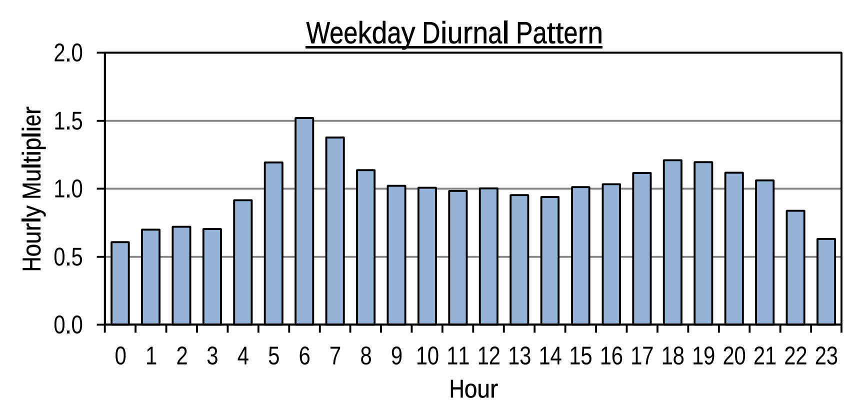
		Measured Data			Modeled Data				Diurnal
		Flow	Level	Velocity	Flow	Level	Velocity	Level Diff	Calibrated
	Hour	(mgd)	(in)	(ft/s)	(mgd)	(in)	(ft/s)	(in)	Diurnal
Weekday	0	0.063	1.1	5.17	0.064	0.9	4.23	0.11	0.61
	1	0.061	1.0	5.04	0.061	0.9	4.19	0.11	0.70
	2	0.070	1.0	5.13	0.071	1.0	4.39	0.05	0.72
	3	0.073	1.0	5.04	0.073	1.0	4.44	0.03	0.70
	4	0.071	1.0	5.18	0.071	1.0	4.41	0.05	0.92
	5	0.092	1.1	5.44	0.092	1.1	4.80	0.00	1.19
	6	0.120	1.2	6.11	0.120	1.3	5.20	-0.06	1.52
	7	0.153	1.3	6.58	0.153	1.4	5.58	-0.10	1.38
	8	0.139	1.3	6.42	0.139	1.4	5.38	-0.09	1.14
	9	0.114	1.2	6.05	0.115	1.2	5.07	-0.06	1.02
	10	0.103	1.2	5.85	0.103	1.2	4.91	-0.04	1.01
	11	0.102	1.1	5.73	0.102	1.2	4.90	-0.04	0.98
	12	0.099	1.1	5.72	0.099	1.2	4.86	-0.03	1.00
	13	0.101	1.1	5.59	0.101	1.2	4.90	-0.05	0.95
	14	0.096	1.1	5.54	0.096	1.2	4.83	-0.03	0.94
	15	0.095	1.1	5.57	0.095	1.1	4.81	-0.02	1.01
	16	0.102	1.1	5.71	0.102	1.2	4.92	-0.04	1.03
	17	0.104	1.1	5.79	0.104	1.2	4.94	-0.06	1.11
	18	0.112	1.2	5.99	0.113	1.2	5.06	-0.06	1.21
	19	0.122	1.2	6.13	0.122	1.3	5.18	-0.09	1.20
	20	0.120	1.2	6.14	0.121	1.3	5.15	-0.08	1.12
	21	0.112	1.2	6.01	0.113	1.2	5.04	-0.07	1.06
	22	0.107	1.2	5.95	0.107	1.2	4.96	-0.05	0.84
	23	0.084	1.1	5.50	0.085	1.1	4.62	0.03	0.63
Weekend	24	0.063	1.1	5.17	0.064	0.9	4.23	0.11	0.61
	25	0.061	1.0	5.04	0.061	0.9	4.19	0.11	0.70
	26	0.070	1.0	5.13	0.071	1.0	4.39	0.05	0.72
	27	0.073	1.0	5.04	0.073	1.0	4.44	0.03	0.70
	28	0.071	1.0	5.18	0.071	1.0	4.41	0.05	0.92
	29	0.092	1.1	5.44	0.092	1.1	4.80	0.00	1.19
	30	0.120	1.2	6.11	0.120	1.3	5.20	-0.06	1.52
	31	0.153	1.3	6.58	0.153	1.4	5.58	-0.10	1.38
	32	0.139	1.3	6.42	0.139	1.4	5.38	-0.09	1.14
	33	0.114	1.2	6.05	0.115	1.2	5.07	-0.06	1.02
	34	0.103	1.2	5.85	0.103	1.2	4.91	-0.04	1.01
	35	0.102	1.1	5.73	0.102	1.2	4.90	-0.04	0.98
	36	0.099	1.1	5.72	0.099	1.2	4.86	-0.03	1.00
	37	0.101	1.1	5.59	0.101	1.2	4.90	-0.05	0.95
	38	0.096	1.1	5.54	0.096	1.2	4.83	-0.03	0.94
	39	0.095	1.1	5.57	0.095	1.1	4.81	-0.02	1.01
	40	0.102	1.1	5.71	0.102	1.2	4.92	-0.04	1.03
	41	0.104	1.1	5.79	0.104	1.2	4.94	-0.06	1.11
	42	0.112	1.2	5.99	0.113	1.2	5.06	-0.06	1.21
	43	0.122	1.2	6.13	0.122	1.3	5.18	-0.09	1.20
	44	0.120	1.2	6.14	0.121	1.3	5.15	-0.08	1.12
	45	0.112	1.2	6.01	0.113	1.2	5.04	-0.07	1.06
	46	0.107	1.2	5.95	0.107	1.2	4.96	-0.05	0.84
	47	0.084	1.1	5.50	0.085	1.1	4.62	0.03	0.63
Average									
Weekday		0.101	1.1	5.72	0.101	1.2	4.86		1.00
Weekend		0.101	1.1	5.72	0.101	1.2	4.86		1.00
ADWF[1]		0.101	1.1	5.72	0.101	1.2	4.86		1.00
% Error									
Weekday					0.3%			0.11	
Weekend					0.3%			0.11	

Note:





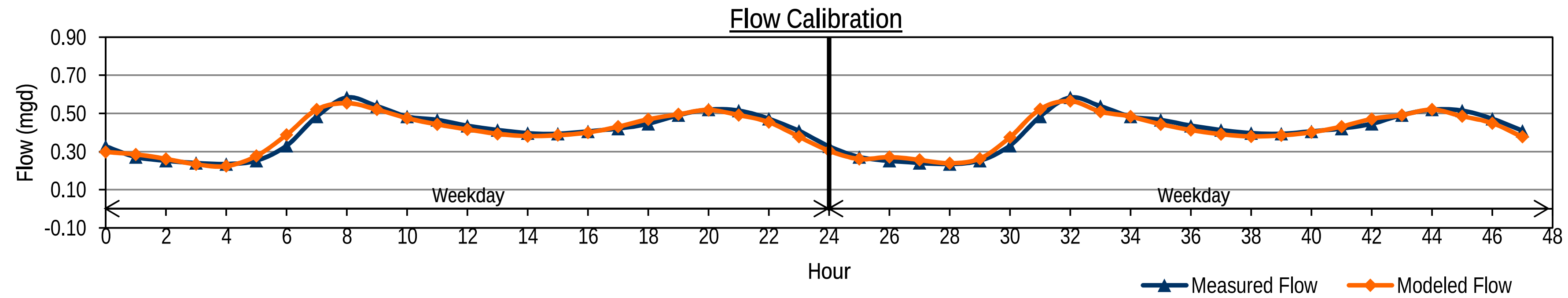


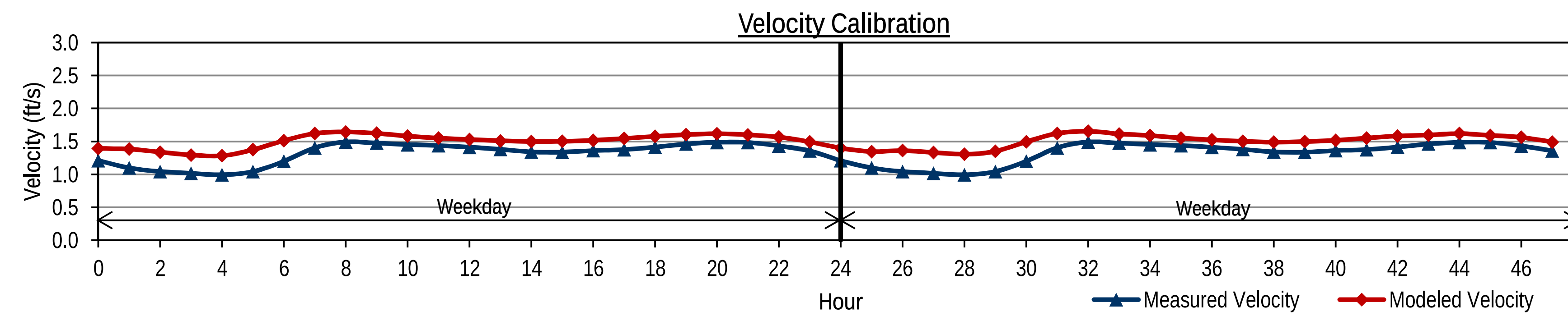


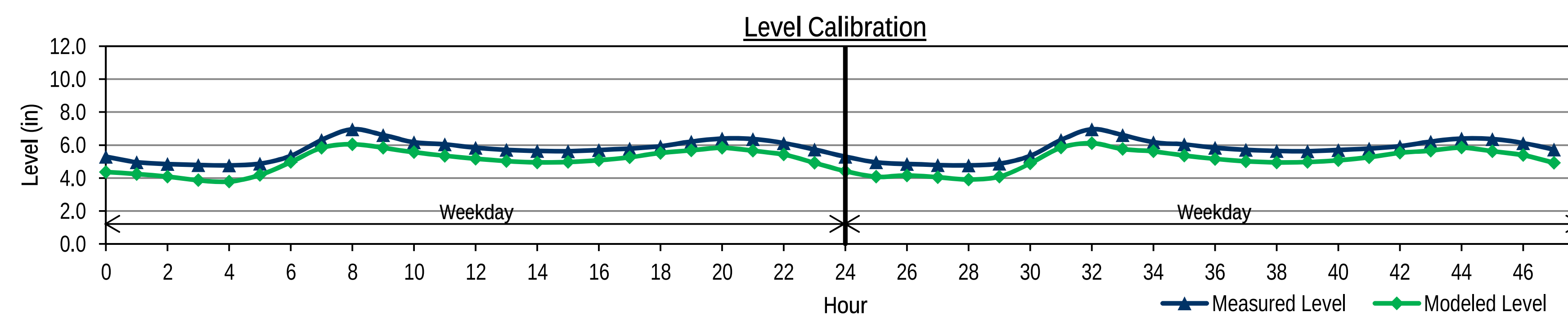
FLOW MONITORING SITE 3A-8 DRY WEATHER FLOW CALIBRATION

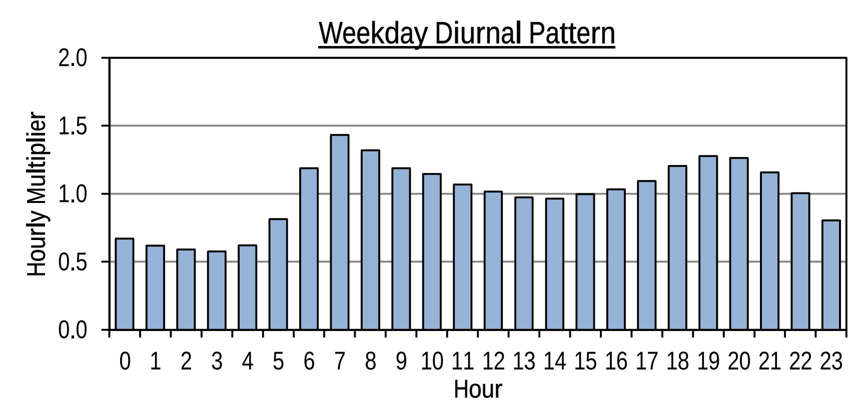
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Level Diff (in)	Diurnal Calibrated Diurnal
Weekday	0	0.327	5.3	1.21	0.298	4.4	1.39	0.93	0.67
	1	0.272	5.0	1.10	0.285	4.2	1.38	0.71	0.62
	2	0.252	4.9	1.04	0.261	4.1	1.34	0.78	0.59
	3	0.241	4.8	1.02	0.233	3.9	1.29	0.92	0.58
	4	0.235	4.8	0.99	0.224	3.8	1.28	0.99	0.62
	5	0.252	4.9	1.04	0.277	4.2	1.37	0.69	0.81
	6	0.331	5.3	1.20	0.388	5.0	1.51	0.38	1.19
	7	0.484	6.3	1.40	0.520	5.8	1.62	0.47	1.43
	8	0.583	7.0	1.49	0.554	6.0	1.64	0.91	1.32
	9	0.538	6.6	1.47	0.520	5.8	1.62	0.78	1.19
	10	0.484	6.2	1.45	0.475	5.6	1.58	0.60	1.14
	11	0.466	6.0	1.44	0.442	5.4	1.55	0.70	1.07
	12	0.435	5.8	1.41	0.416	5.2	1.53	0.67	1.01
	13	0.414	5.7	1.38	0.393	5.0	1.51	0.69	0.97
	14	0.396	5.7	1.34	0.381	4.9	1.50	0.71	0.96
	15	0.393	5.6	1.34	0.386	5.0	1.50	0.65	1.00
	16	0.406	5.7	1.36	0.400	5.1	1.52	0.62	1.03
	17	0.421	5.8	1.38	0.430	5.3	1.55	0.53	1.09
	18	0.446	5.9	1.41	0.469	5.5	1.58	0.41	1.20
	19	0.491	6.2	1.46	0.495	5.7	1.60	0.54	1.28
	20	0.520	6.4	1.49	0.518	5.8	1.62	0.56	1.26
	21	0.515	6.4	1.48	0.491	5.7	1.60	0.71	1.16
	22	0.472	6.1	1.43	0.454	5.4	1.57	0.70	1.00
	23	0.409	5.7	1.36	0.378	4.9	1.49	0.81	0.80
Weekend	24	0.327	5.3	1.21	0.304	4.4	1.40	0.88	0.67
	25	0.272	5.0	1.10	0.261	4.1	1.35	0.88	0.62
	26	0.252	4.9	1.04	0.271	4.2	1.36	0.71	0.59
	27	0.241	4.8	1.02	0.256	4.0	1.33	0.74	0.58
	28	0.235	4.8	0.99	0.239	3.9	1.31	0.86	0.62
	29	0.252	4.9	1.04	0.263	4.1	1.35	0.79	0.81
	30	0.331	5.3	1.20	0.375	4.9	1.49	0.46	1.19
	31	0.484	6.3	1.40	0.522	5.8	1.62	0.46	1.43
	32	0.583	7.0	1.49	0.565	6.1	1.65	0.85	1.32
	33	0.538	6.6	1.47	0.509	5.8	1.61	0.85	1.19
	34	0.484	6.2	1.45	0.484	5.6	1.59	0.56	1.14
	35	0.466	6.0	1.44	0.443	5.4	1.55	0.69	1.07
	36	0.435	5.8	1.41	0.413	5.2	1.52	0.68	1.01
	37	0.414	5.7	1.38	0.391	5.0	1.50	0.70	0.97
	38	0.396	5.7	1.34	0.379	4.9	1.49	0.71	0.96
	39	0.393	5.6	1.34	0.385	5.0	1.50	0.66	1.00
	40	0.406	5.7	1.36	0.401	5.1	1.52	0.62	1.03
	41	0.421	5.8	1.38	0.431	5.3	1.55	0.53	1.09
	42	0.446	5.9	1.41	0.471	5.5	1.58	0.39	1.20
	43	0.491	6.2	1.46	0.491	5.7	1.60	0.55	1.28
	44	0.520	6.4	1.49	0.520	5.8	1.62	0.55	1.26
	45	0.515	6.4	1.48	0.485	5.6	1.59	0.74	1.16
	46	0.472	6.1	1.43	0.449	5.4	1.56	0.73	1.00
	47	0.409	5.7	1.36	0.377	4.9	1.49	0.81	0.80
Average									
Weekday		0.408	5.8	1.32	0.404	5.1	1.51		1.00
Weekend		0.408	5.8	1.32	0.404	5.1	1.51		1.00
ADWF(1)		0.408	5.8	1.32	0.404	5.1	1.51		1.00
% Error									
Weekday					-1.0%			0.99	
Weekend					-1.0%			0.88	

Note:









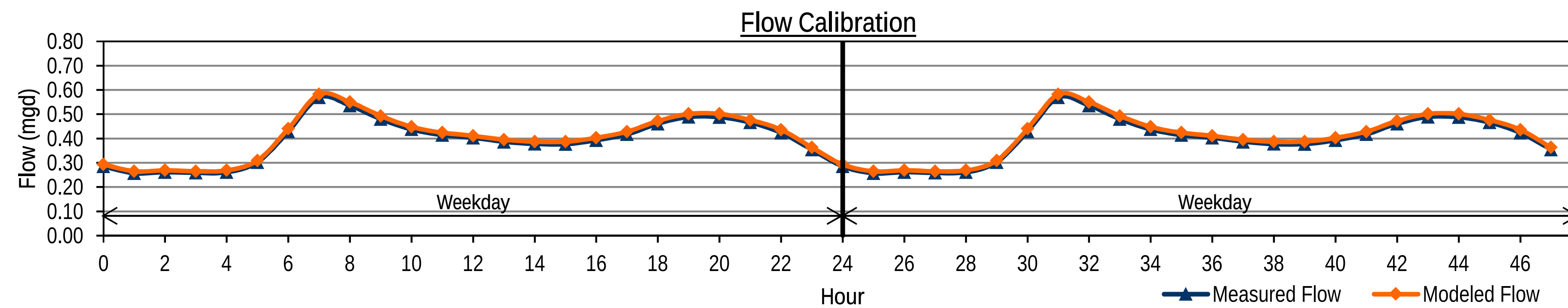
City of West Linn

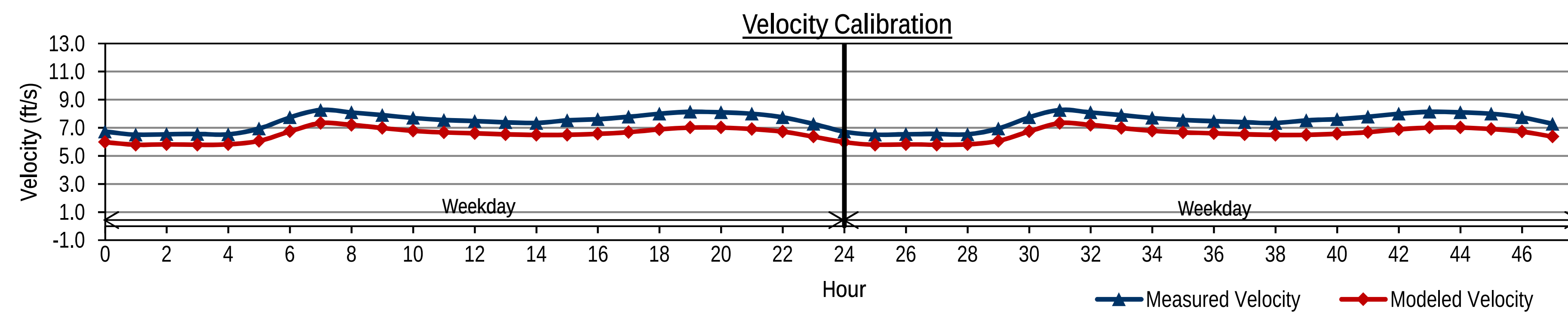
Sanitary Sewer Master Plan

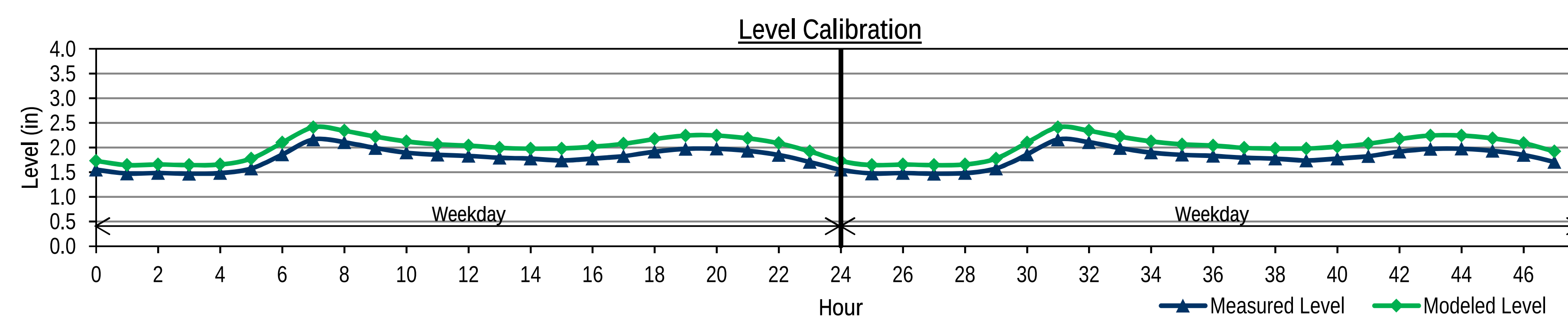
FLOW MONITORING SITE 2B-0-12 DRY WEATHER FLOW CALIBRATION

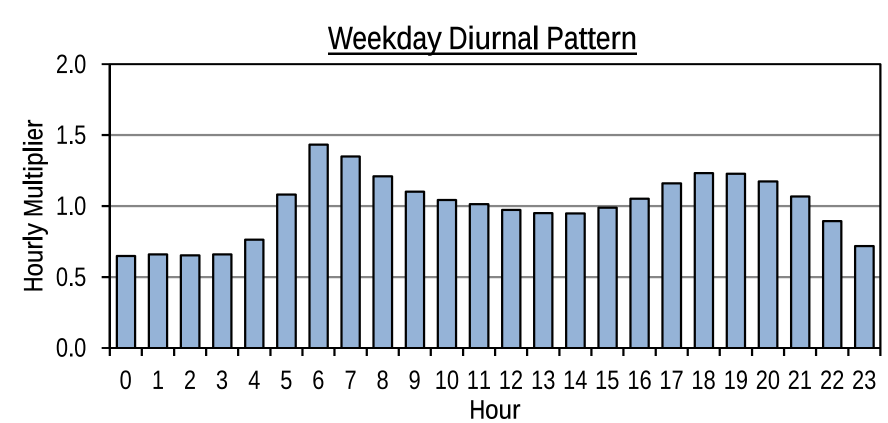
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Level Diff (in)	Diurnal Calibrated Diurnal
Weekday	0	0.285	1.5	6.72	0.293	1.7	5.97	-0.18	0.65
	1	0.257	1.5	6.51	0.265	1.6	5.79	-0.17	0.66
	2	0.261	1.5	6.54	0.269	1.7	5.82	-0.17	0.65
	3	0.259	1.5	6.56	0.265	1.6	5.79	-0.17	0.66
	4	0.261	1.5	6.54	0.269	1.7	5.82	-0.17	0.76
	5	0.303	1.6	6.94	0.309	1.8	6.07	-0.20	1.08
	6	0.429	1.9	7.74	0.440	2.1	6.74	-0.24	1.43
	7	0.569	2.2	8.27	0.582	2.4	7.33	-0.25	1.35
	8	0.536	2.1	8.09	0.550	2.3	7.21	-0.23	1.21
	9	0.480	2.0	7.90	0.493	2.2	6.98	-0.23	1.10
	10	0.438	1.9	7.70	0.448	2.1	6.78	-0.23	1.04
	11	0.414	1.9	7.55	0.424	2.1	6.67	-0.21	1.01
	12	0.403	1.8	7.47	0.411	2.0	6.61	-0.21	0.97
	13	0.387	1.8	7.39	0.395	2.0	6.53	-0.20	0.95
	14	0.378	1.8	7.34	0.387	2.0	6.49	-0.21	0.95
	15	0.376	1.7	7.53	0.387	2.0	6.49	-0.24	0.99
	16	0.393	1.8	7.61	0.403	2.0	6.57	-0.24	1.05
	17	0.418	1.8	7.78	0.428	2.1	6.69	-0.25	1.16
	18	0.461	1.9	8.00	0.472	2.2	6.89	-0.26	1.23
	19	0.489	2.0	8.14	0.501	2.2	7.01	-0.27	1.23
	20	0.487	2.0	8.10	0.501	2.2	7.01	-0.27	1.17
	21	0.466	1.9	8.00	0.476	2.2	6.91	-0.25	1.07
	22	0.424	1.8	7.74	0.436	2.1	6.72	-0.24	0.89
	23	0.355	1.7	7.28	0.363	1.9	6.37	-0.21	0.72
Weekend	24	0.285	1.5	6.72	0.293	1.7	5.97	-0.18	0.65
	25	0.257	1.5	6.51	0.265	1.6	5.79	-0.17	0.66
	26	0.261	1.5	6.54	0.269	1.7	5.82	-0.17	0.65
	27	0.259	1.5	6.56	0.265	1.6	5.79	-0.17	0.66
	28	0.261	1.5	6.54	0.269	1.7	5.82	-0.17	0.76
	29	0.303	1.6	6.94	0.309	1.8	6.07	-0.20	1.08
	30	0.429	1.9	7.74	0.440	2.1	6.74	-0.24	1.43
	31	0.569	2.2	8.27	0.582	2.4	7.33	-0.25	1.35
	32	0.536	2.1	8.09	0.550	2.3	7.21	-0.23	1.21
	33	0.480	2.0	7.90	0.493	2.2	6.98	-0.23	1.10
	34	0.438	1.9	7.70	0.448	2.1	6.78	-0.23	1.04
	35	0.414	1.9	7.55	0.424	2.1	6.67	-0.21	1.01
	36	0.403	1.8	7.47	0.411	2.0	6.61	-0.21	0.97
	37	0.387	1.8	7.39	0.395	2.0	6.53	-0.20	0.95
	38	0.378	1.8	7.34	0.387	2.0	6.49	-0.21	0.95
	39	0.376	1.7	7.53	0.387	2.0	6.49	-0.24	0.99
	40	0.393	1.8	7.61	0.403	2.0	6.57	-0.24	1.05
	41	0.418	1.8	7.78	0.428	2.1	6.69	-0.25	1.16
	42	0.461	1.9	8.00	0.472	2.2	6.89	-0.26	1.23
	43	0.489	2.0	8.14	0.501	2.2	7.01	-0.27	1.23
	44	0.487	2.0	8.10	0.501	2.2	7.01	-0.27	1.17
	45	0.466	1.9	8.00	0.476	2.2	6.91	-0.25	1.07
	46	0.424	1.8	7.74	0.436	2.1	6.72	-0.24	0.89
	47	0.355	1.7	7.28	0.363	1.9	6.37	-0.21	0.72
Average									
Weekday		0.397	1.8	7.48	0.407	2.0	6.55		1.00
Weekend		0.397	1.8	7.48	0.407	2.0	6.55		1.00
ADWF(1)		0.397	1.8	7.48	0.407	2.0	6.55		1.00
% Error									
Weekday					2.5%			0.27	
Weekend					2.5%			0.27	

Note:









Appendix 3B

WET WEATHER FLOW CALIBRATION RESULTS

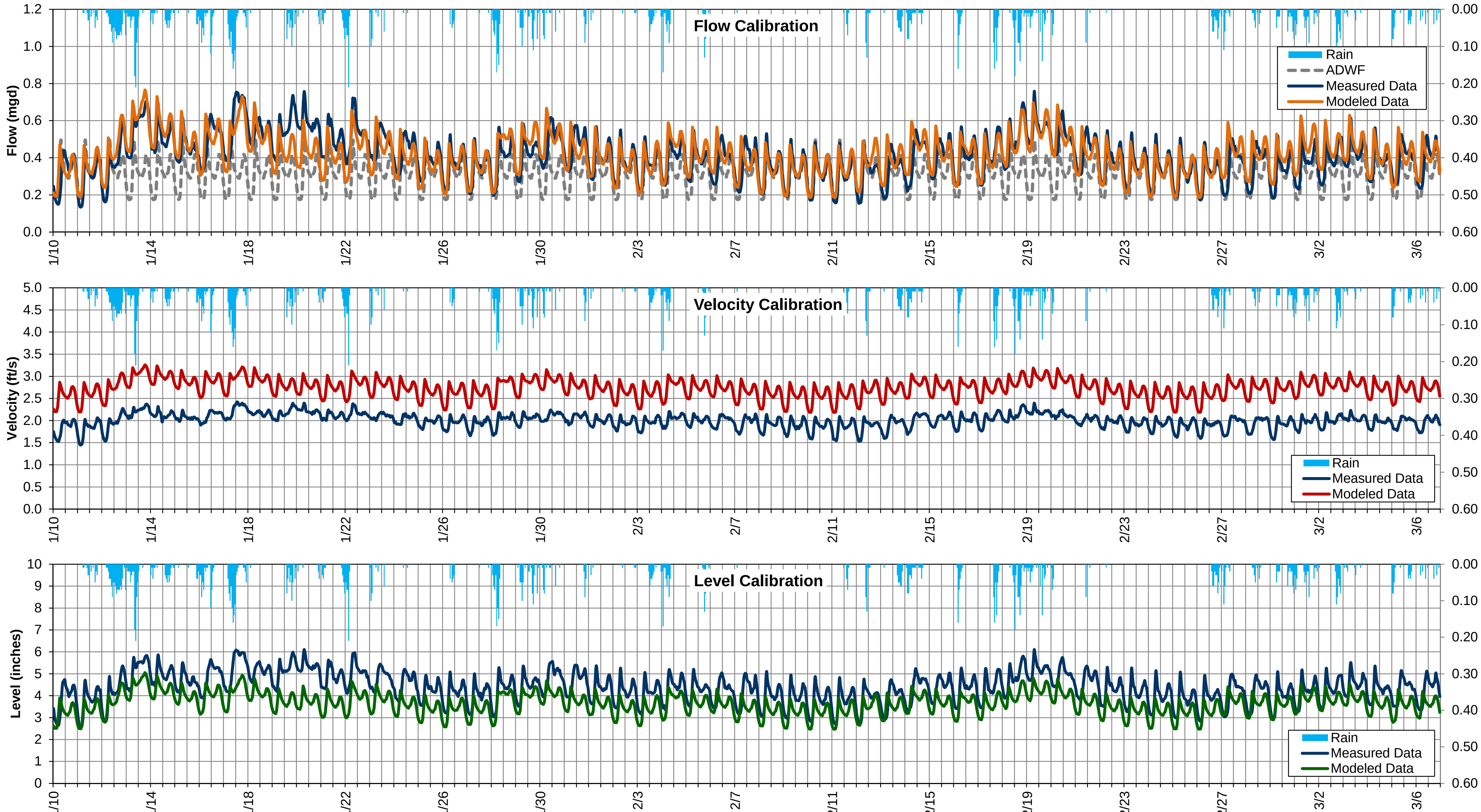
Table 1 Wet Weather Calibration
Sanitary Sewer Master Plan
City of West Linn

		Storm 1 (1/12/2016-1/18/2016)									Storm 2 (1/28/2016-2/3/2016)									Storm 3 (2/15/2016-2/24/2016)									
		Measured Data[(1)]			Modeled Data[(2)]			Percent Error[(3)]		Max	Measured Data[(1)]			Modeled Data[(2)]			Percent Error[(3)]		Max	Measured Data[(1)]			Modeled Data[(2)]			Percent Error[(3)]		Max
Meter Number	Pipe Diameter (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Level Diff (inches)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Level Diff (inches)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Level Diff (inches)
9A-14	10	0.507	0.752	4.9	0.520	0.765	4.1	2.6%	1.7%	1.7	0.412	0.616	4.4	0.424	0.667	3.7	3.0%	8.3%	1.7	0.430	0.757	4.5	0.421	0.698	3.7	-2.0%	-7.8%	1.7
11A-2	15	0.213	0.332	4.2	0.222	0.295	3.9	3.9%	-11.2%	0.9	0.211	0.312	4.2	0.198	0.287	3.7	-6.3%	-7.9%	1.1	0.196	0.275	4.1	0.197	0.293	3.7	0.7%	6.7%	0.9
9A-2	18	1.568	2.511	4.8	1.818	2.548	5.6	16.0%	1.5%	2.2	1.299	2.032	4.4	1.434	2.256	5.0	10.4%	11.0%	2.2	1.297	2.189	4.4	1.432	2.372	5.0	10.5%	8.4%	2.2
1A-37-1-0	10	0.864	1.569	2.7	0.909	1.392	3.2	5.2%	-11.3%	0.9	0.641	1.053	2.5	0.665	1.047	2.7	3.7%	-0.5%	0.7	0.662	1.240	2.4	0.652	1.160	2.7	-1.5%	-6.5%	0.7
3B-4	8	0.164	0.257	1.8	0.191	0.305	2.2	16.0%	18.5%	0.8	0.144	0.273	1.7	0.143	0.219	1.9	-0.6%	-19.8%	0.7	0.141	0.648	2.5	0.140	0.259	1.9	-0.8%	-60.0%	11.9
2B-1-0	8	0.479	0.712	1.7	0.467	0.698	2.0	-2.4%	-2.0%	0.5	0.364	0.504	1.6	0.353	0.524	1.7	-3.0%	4.0%	0.4	0.355	0.591	1.5	0.350	0.577	1.7	-1.5%	-2.4%	0.6
9C-3	?	0.326	0.486	1.9	0.334	0.484	2.2	2.2%	-0.5%	2.2	0.268	0.420	1.8	0.272	0.437	2.0	1.4%	4.1%	0.9	0.264	0.440	1.7	0.272	0.455	2.0	3.1%	3.4%	0.8
2A-19	8	0.258	0.380	1.7	0.263	0.361	1.9	1.7%	-4.9%	3.5	0.180	0.277	1.4	0.191	0.304	1.6	5.6%	9.7%	0.5	0.186	0.301	1.4	0.194	0.340	1.6	4.3%	12.8%	4.6
3A-8	18	0.824	1.239	8.0	0.830	1.159	7.5	0.7%	-6.5%	2.4	0.624	0.924	7.2	0.638	0.963	6.5	2.3%	4.2%	2.3	0.591	0.993	6.8	0.644	1.030	6.5	8.8%	3.7%	1.7
2B-0-12	12	0.849	1.263	2.6	0.880	1.374	2.9	3.7%	8.8%	0.8	0.676	0.920	2.4	0.648	1.074	2.5	-4.2%	16.7%	0.8	0.645	1.116	2.3	0.638	1.201	2.5	-1.0%	7.6%	0.7

Notes:
1. Source: City of West Linn 2016 Temporary Flow Monitoring Program, ADS
2. Average flows are computed from hydraulic modeling results. Maximum flow values are hourly peaks.
3. Percent Difference = (Modeled - Measured)/Measured*100.

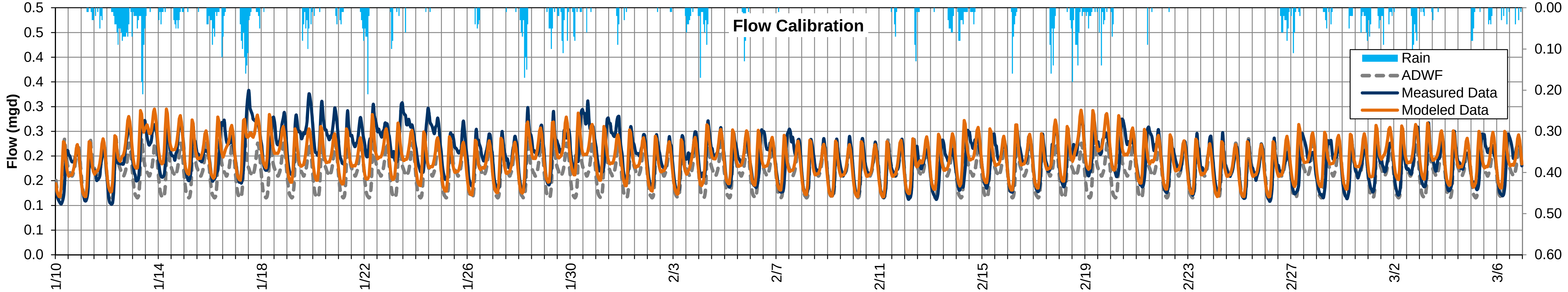
FLOW MONITORING 9A-14 WET WEATHER FLOW CALIBRATION
Sanitary Sewer Master Plan
City of West Linn

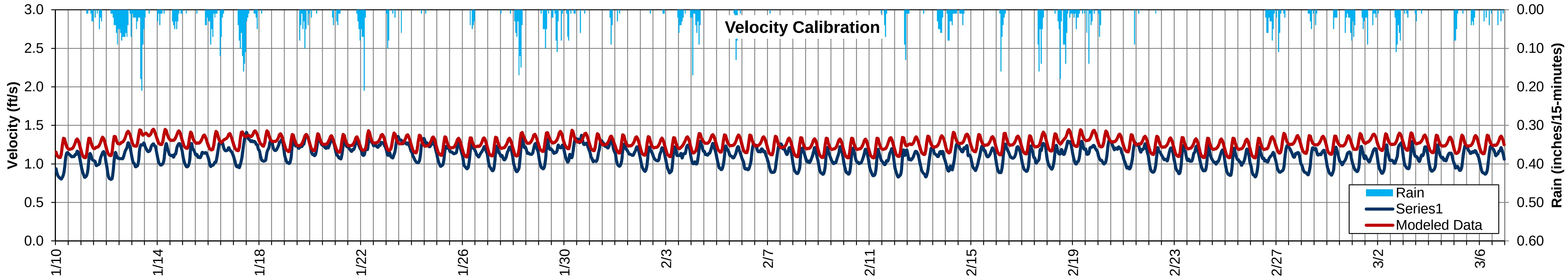
Location:
Pipeline diameter: 10"
City Manhole ID: 9A-14
Model Mahhole ID:
Silt Level at Site: "

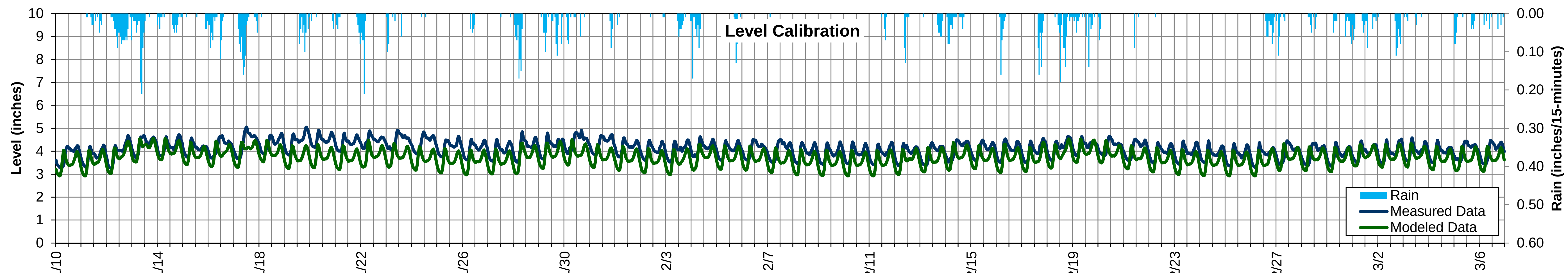


FLOW MONITORING 11A-2 WET WEATHER FLOW CALIBRATION
Sanitary Sewer Master Plan
City of West Linn

Location:
Pipeline diameter: 15"
City Manhole ID: 11A-2
Model Mahhole ID:
Silt Level at Site: "

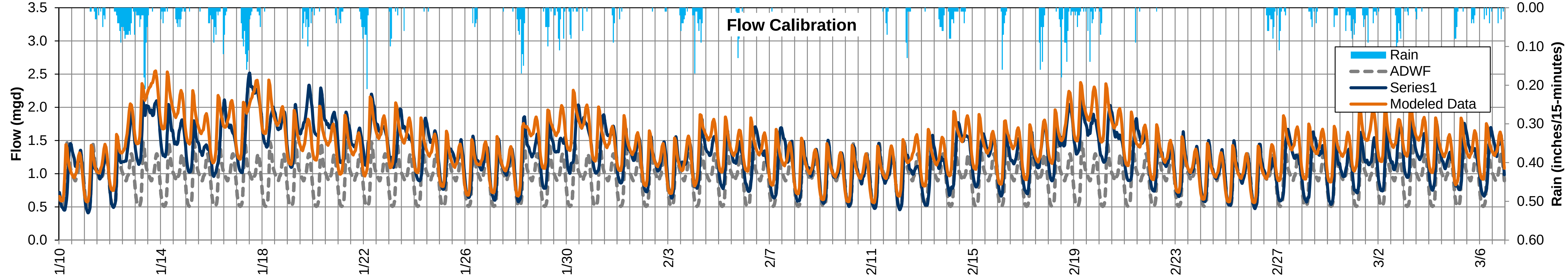


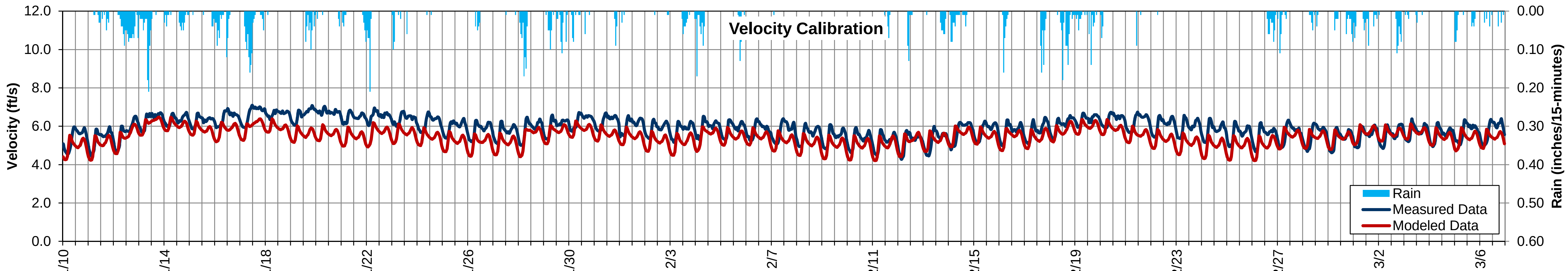


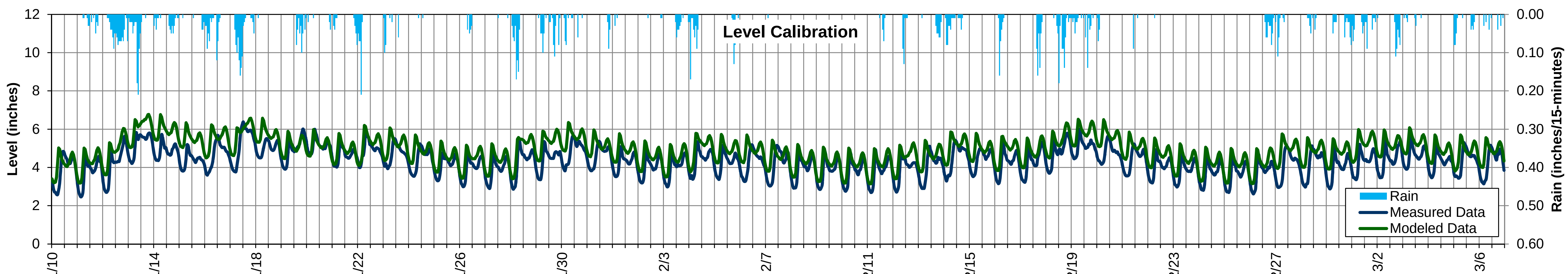


FLOW MONITORING 9A-2 WET WEATHER FLOW CALIBRATION
Sanitary Sewer Master Plan
City of West Linn

Location:
Pipeline diameter: 18"
City Manhole ID: 9A-2
Model Mahhole ID:
Silt Level at Site: "

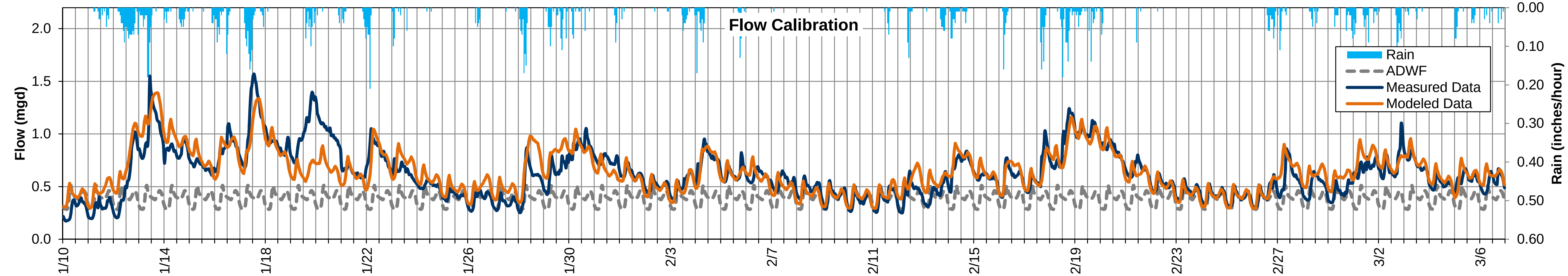


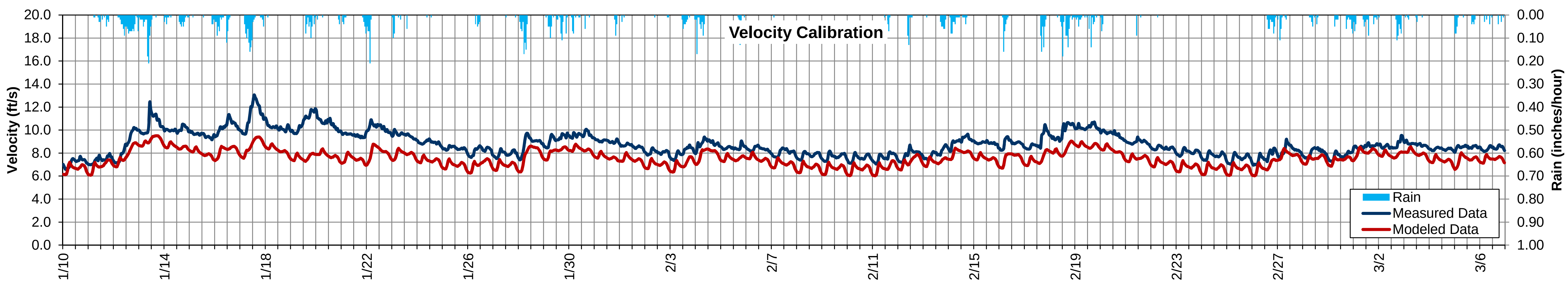


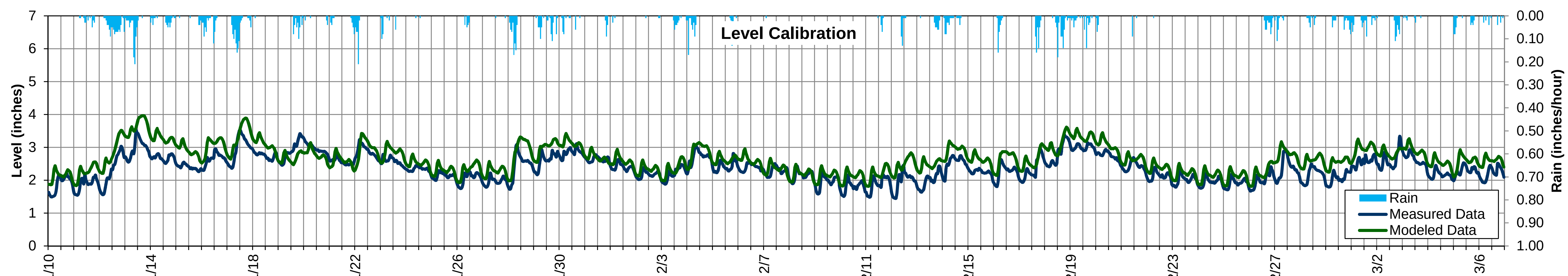


FLOW MONITORING 1A-37-1-0 WET WEATHER FLOW CALIBRATION
Sanitary Sewer Master Plan
City of West Linn

Location: 1378 Sunset Ave
Pipeline diameter: 10''
City Manhole ID: 1A-37-1-0
Model Mahhole ID:
Silt Level at Site: ''

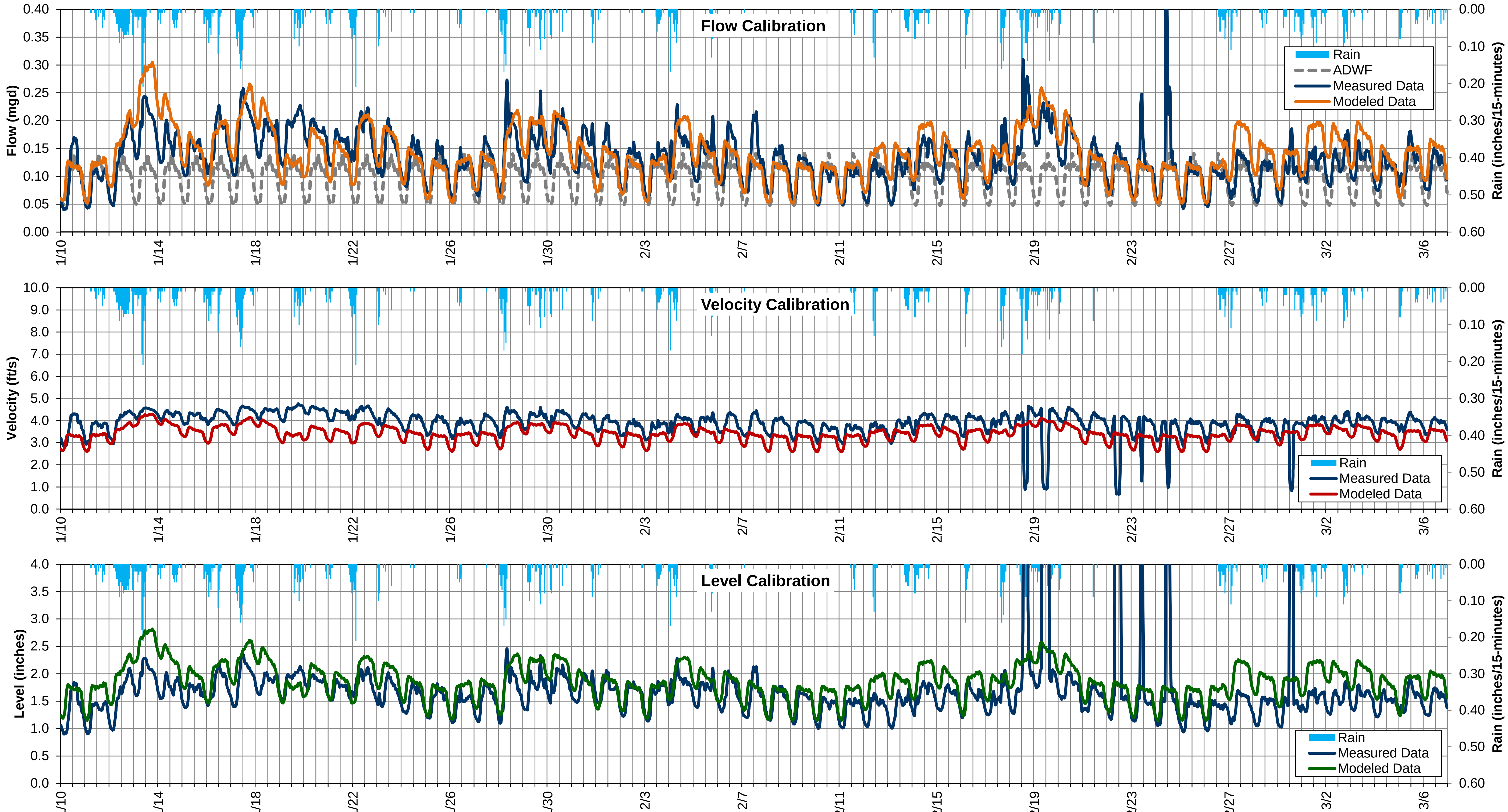






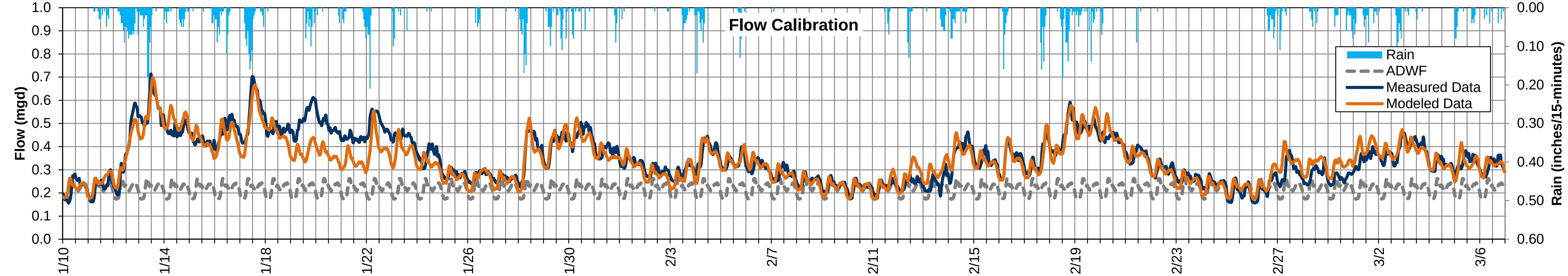
FLOW MONITORING 3B-4 WET WEATHER FLOW CALIBRATION
Sanitary Sewer Master Plan
City of West Linn

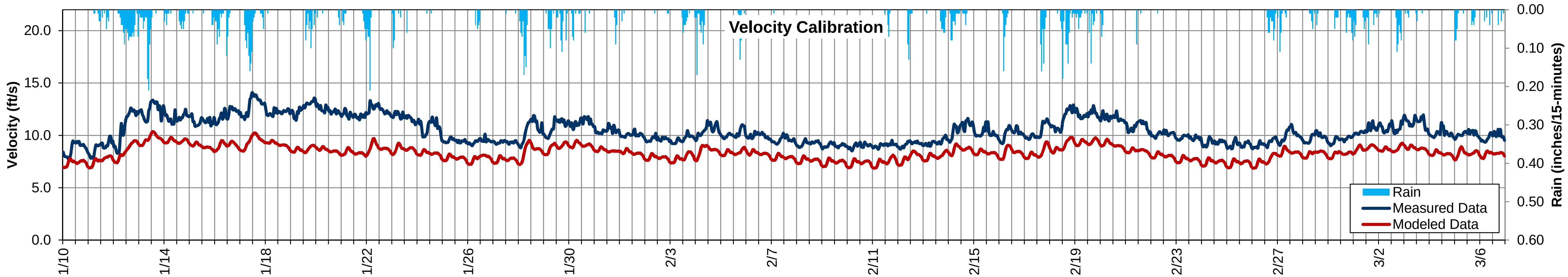
Location:
Pipeline diameter: 8"
City Manhole ID: 3B-4
Model Mahhole ID:
Silt Level at Site: "

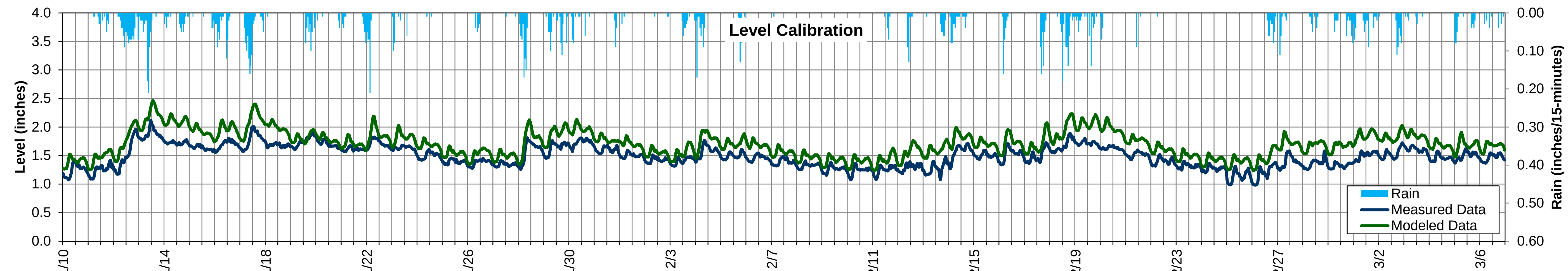


FLOW MONITORING 2B-1-0 WET WEATHER FLOW CALIBRATION
Sanitary Sewer Master Plan
City of West Linn

Location:
Pipeline diameter: 8"
City Manhole ID: 2B-1-0
Model Mahhole ID:
Silt Level at Site: "

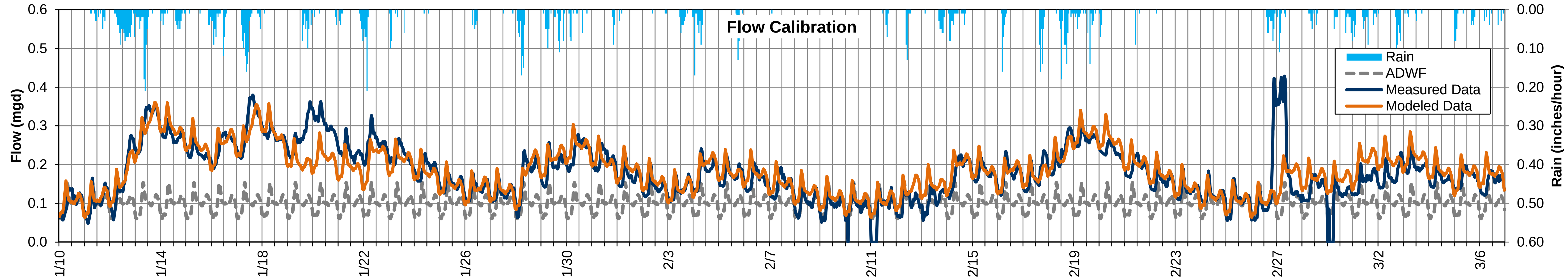


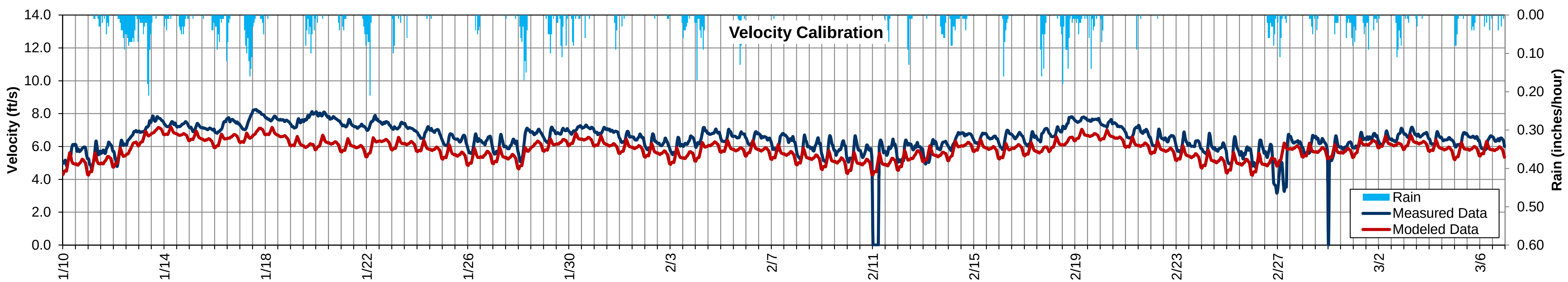


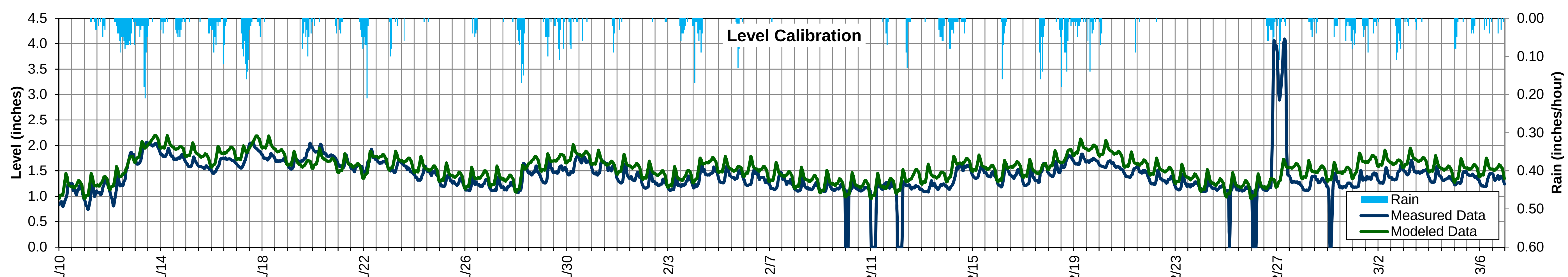


FLOW MONITORING 2A-19 WET WEATHER FLOW CALIBRATION
Sanitary Sewer Master Plan
City of West Linn

Location:
Pipeline diameter: 8"
City Manhole ID: 2A-19
Model Mahhole ID:
Silt Level at Site: "

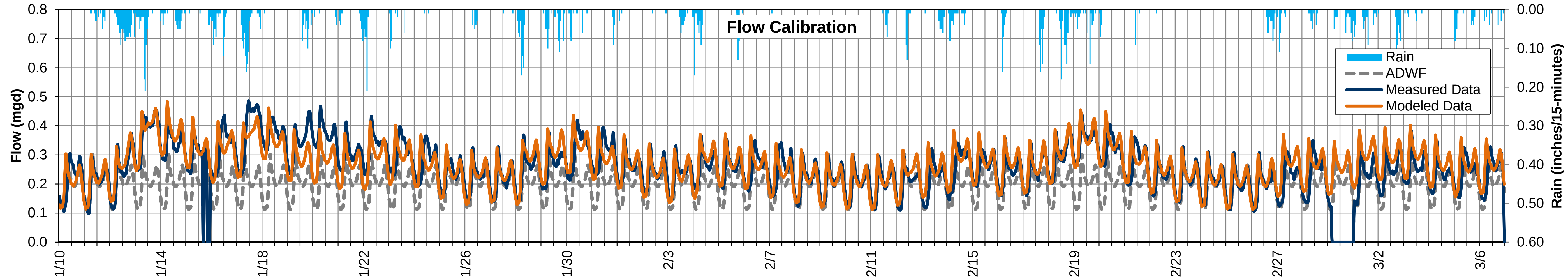


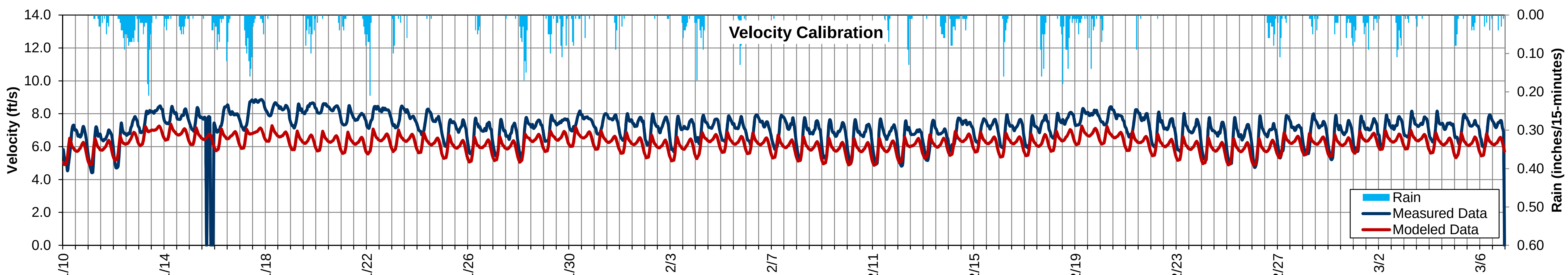


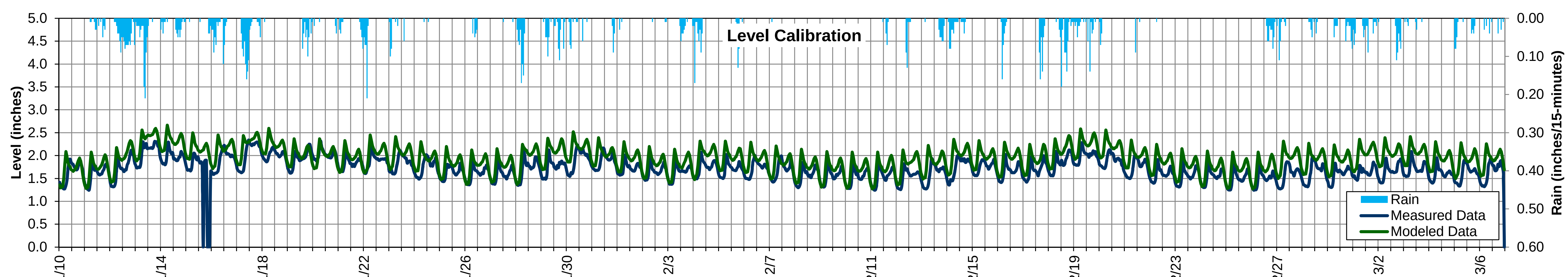


FLOW MONITORING 9C-3 WET WEATHER FLOW CALIBRATION
Sanitary Sewer Master Plan
City of West Linn

Location:
Pipeline diameter: ?"
City Manhole ID: 9C-3
Model Mahhole ID:
Silt Level at Site: "

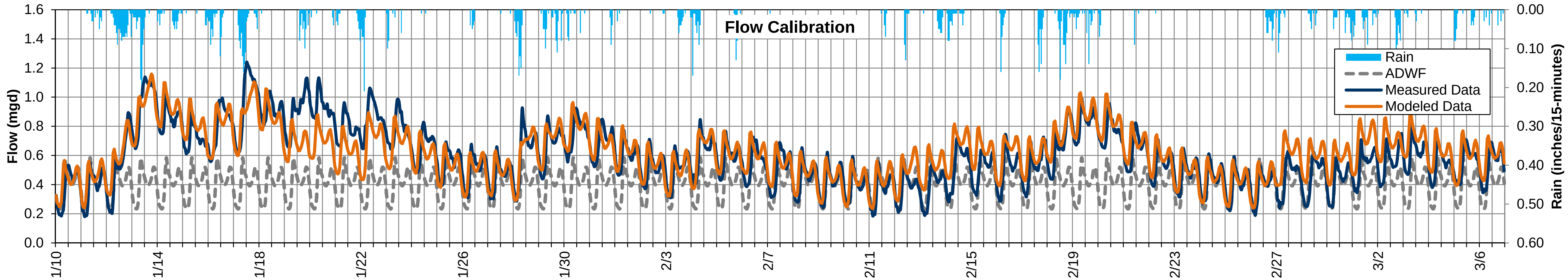


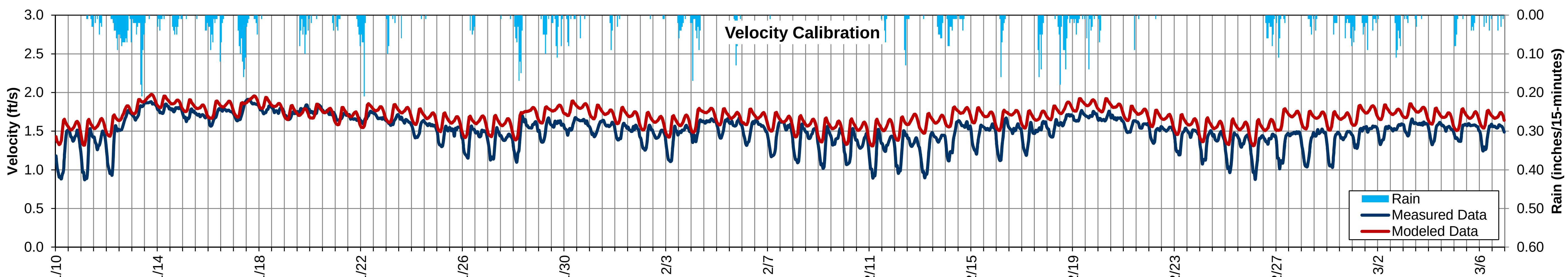


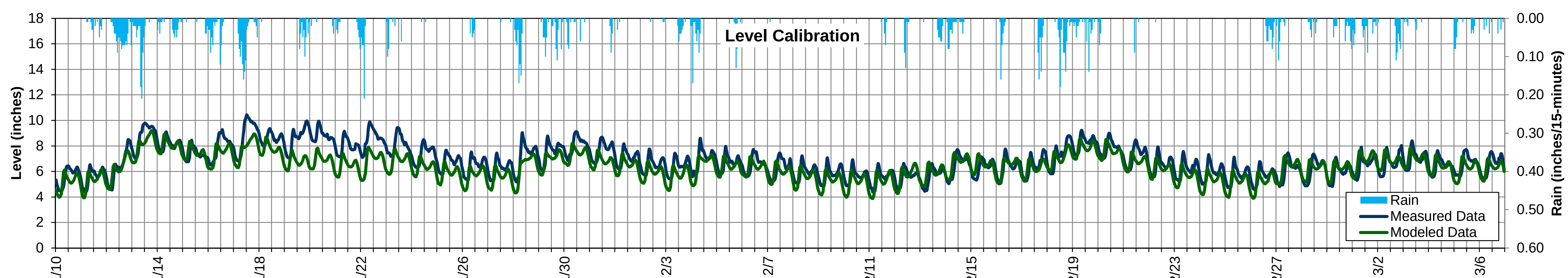


FLOW MONITORING 3A-8 WET WEATHER FLOW CALIBRATION
Sanitary Sewer Master Plan
City of West Linn

Location:
Pipeline diameter: 18"
City Manhole ID: 3A-8
Model Mahhole ID:
Silt Level at Site: "

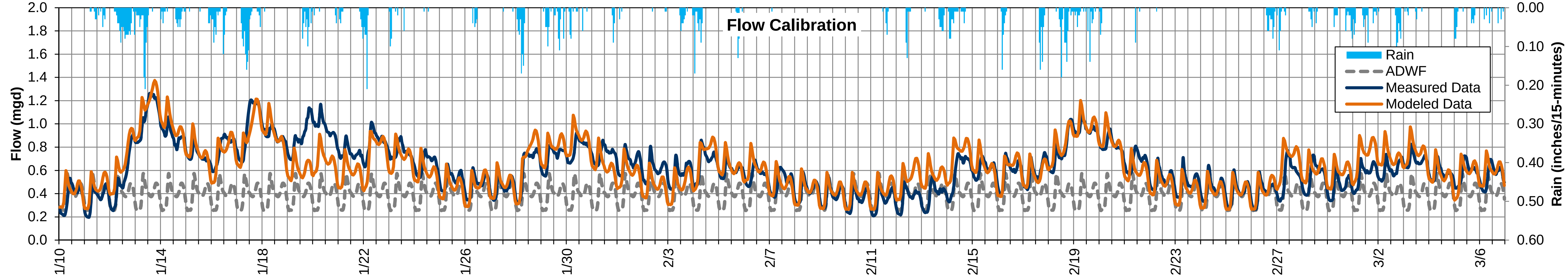


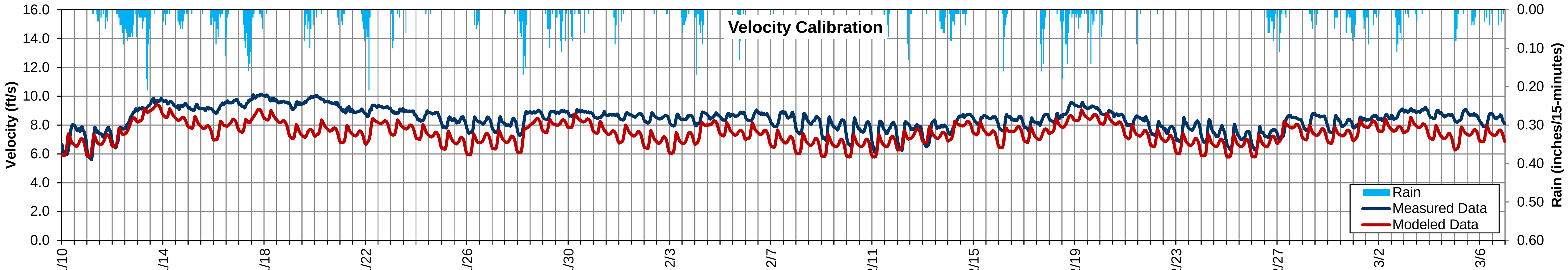


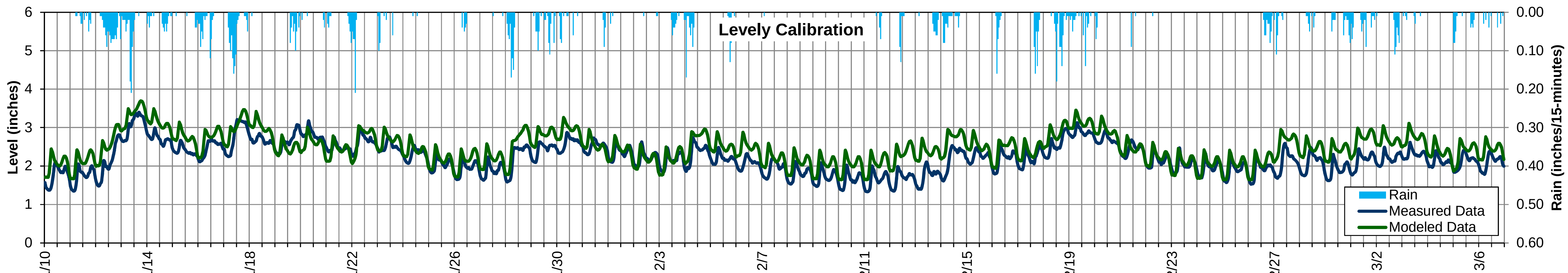


FLOW MONITORING 2B-0-12 WET WEATHER FLOW CALIBRATION
Sanitary Sewer Master Plan
City of West Linn

Location:
Pipeline diameter: 12"
City Manhole ID: 2B-0-12
Model Mahhole ID:
Silt Level at Site: "







Attachment D

TECHNICAL MEMORANDUM 4: CAPACITY ANALYSIS AND I/I REDUCTION PROGRAM

City of West Linn

Sanitary Sewer Master Plan Update

TECHNICAL MEMORANDUM 4 SYSTEM ANALYSIS AND I/I REDUCTION PROGRAM

DRAFT | March 2019

carollo®

City of West Linn
Sanitary Sewer Master Plan Update

TECHNICAL MEMORANDUM 4

SYSTEM ANALYSIS AND I/I REDUCTION

Matthew M. Huang,
March 25, 2019,
State of Oregon,
P.E. No. 91512

Contents

Appendices

Tables

Figures

Abbreviations

%	percent
Carollo	Carollo Engineers, Inc.
City	City of West Linn
ft	Feet
gpm	gallons per minute
hp	horsepower
LF	linear foot
PVC	polyvinyl chloride
TCSD	Tri-City Service District
TM	Technical Memorandum
WES	Water Environment Services

Technical Memorandum 4

SYSTEM ANALYSIS AND I/I REDUCTION

4.1 Introduction

As the City of West Linn (City) continues to grow and age, some of the City's sewer infrastructure may reach capacity for adequately handling flows. This Technical Memorandum (TM) presents an evaluation of the available capacity of the existing system to convey current and future sewer flows. Using the City's updated sewer model, modeled pipelines and pump station in the system are evaluated for meeting established performance criteria. This TM also presents recommended projects that correct capacity deficiencies and are required to serve future users.

Additionally, infiltration and inflow (I/I) are known problems for the City's sewer system. This TM also summarizes the current inflow and infiltration (I/I) estimate in each basin, reviews options for I/I reduction, and assesses the costs of I/I reduction. Note that I/I reduction might offset some of the recommended projects identified in Section 4.5 of this TM.

4.2 Planning and System Performance Criteria

4.2.1 Design and System Performance Criteria Goals

Defining system performance criteria is a critical step in the planning process because it sets the metrics by which existing collection system infrastructure will be evaluated to meet level of service goals set by the City. It is important to differentiate system performance criteria from design criteria for judging the performance of collection system infrastructure.

System performance criteria relate to metrics that are used to analyze the adequacy of existing facilities and to project future infrastructure needs for financial planning purposes. These metrics are described in detail in the sections below. These criteria are not intended to provide the same expected levels of safety and protection that design criteria provide. It is generally inappropriate to use standard design criteria as planning criteria, especially when significant wet weather flows impact an existing collection system (as is the case with an aged sewer system). For instance, new sewers are designed to convey flow under non-surcharged conditions, while surcharging may be permissible during the analysis of existing sewers, especially during peak wet weather flows.

4.2.2 Design Storm

Design storms are rainfall events used to analyze the performance of a collection system under peak flows and volumes, and have a specific recurrence interval and rainfall duration. The storm is used for sizing projects. The National Oceanic and Atmospheric Administration (NOAA) publishes isopluvial (rainfall contour) maps[1] that approximate the total rainfall depth for a range of storm size recurrence intervals for standardized storm durations.

In Oregon, the 5-year, 24-hour design storm is typical for use with modeling wet weather flows in collection systems. The City selected the 5-year, 24-hour design storm for sizing the City's sewer infrastructure as it meets industry standards and Oregon Department of Environmental Quality standards. Total rainfall for the 5-year, 24-hour storm for the West Linn area is predicted to be 2.9 inches, per NOAA isopluvial maps. The NOAA isopluvials' accuracy is limited based on mapping and scale. Therefore the 2.9 inches of rainfall for a 5-year, 24-hour storm is an estimated number per map reading. Essentially, this design storm has a five percent chance (1/20) that 2.9 inches of rain will fall in any 24-hour period in a given year. The City is also considering climate change during the development of its design storm. Information from SWMM-CAT was used to account for climate change in this SSMP. SWMM-CAT provides a set of location-specific adjustments that were derived from global climate change models run as part of the World Climate Research Program (WCRP) Coupled Model Intercomparison Project Phase 3 (CMIP3) archive. For the City's location, a 5-year, 24-hour design storm is anticipated to increase by 8.5 percent in the near-term (2020-2049). The design storm for the City was therefore increased by 8.5 percent, which resulted in a total rainfall volume of 3.2 inches. This storm was accepted as the City's design storm for this Plan, as it is in accordance with neighboring jurisdictions.

For the distribution of the design storm, it is possible to utilize a synthetic distribution or to establish a custom distribution based on historical data. The Natural Resources Conservation Service (NRCS), formally known as the Soil Conservation Service (SCS), method is used to distribute the rainfall volume and establish a peak intensity over a given storm duration. The NRCS method includes the use of developed normalized rainfall hyetograph distribution curves based on the storm's geographical location. The Type 1A distribution curve was used for the City's design storm. Figure 4.1 shows the distribution curve recommended based on geographical location.

Figure 4.2 shows the custom design storm used for the capacity analysis. Applying the synthetic distribution curve to the total rainfall volume resulted in an hourly peak rainfall intensity of 0.5 inches/hour. To represent typical winter Pacific Northwest privilege, antecedent rainfall was added from historical data.

[1] Miller, J., R. Frederick, and R, Tracey. Precipitation-Frequency Atlas of the Western United States, Volume IX-Washington. Washington DC, NOAA 1973.

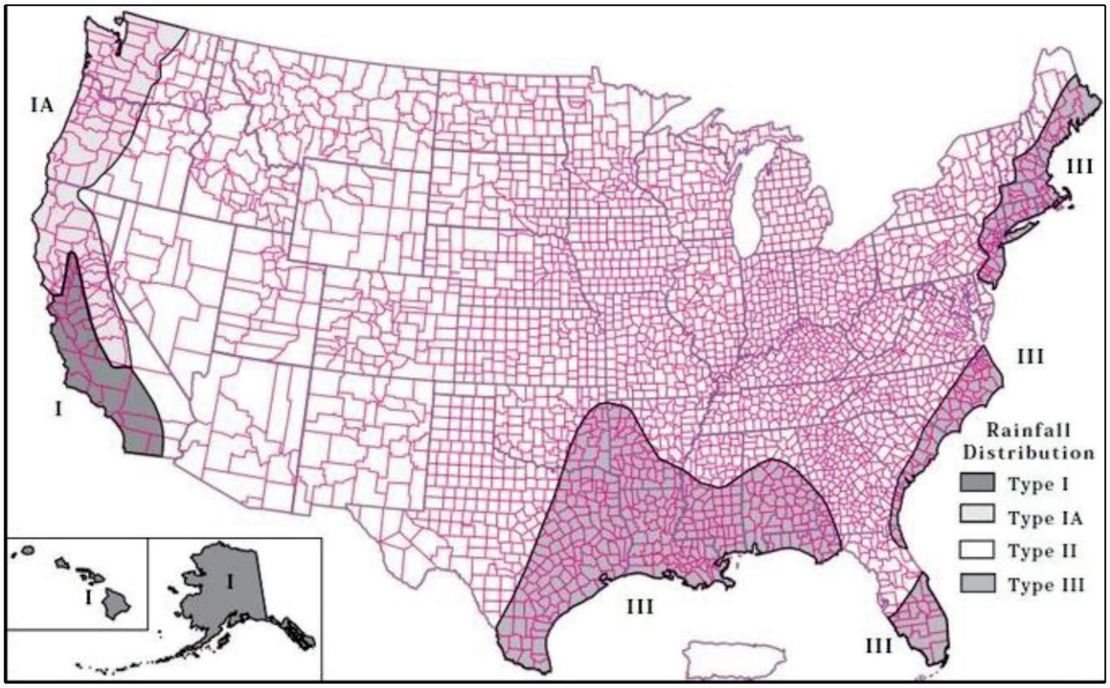


Figure 4.1 NRCS Distribution Rainfall Curve Locations

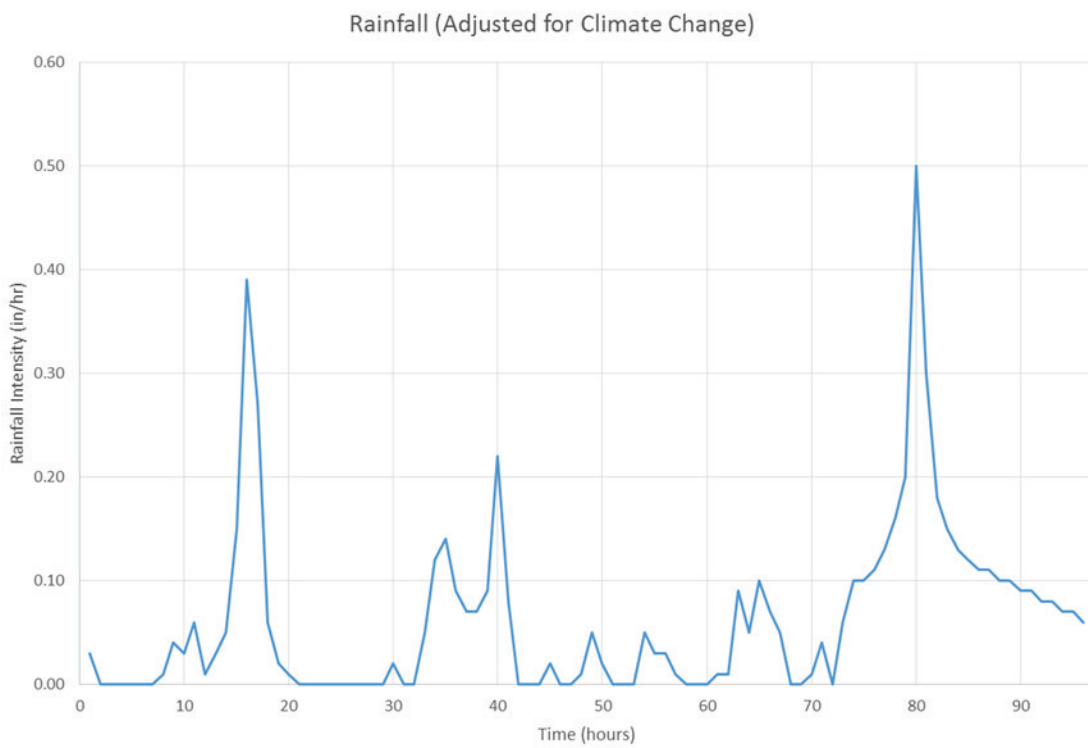


Figure 4.2 Design Storm Hyetograph

4.2.3 System Performance Criteria

Capacity evaluation of the wastewater collection system was performed in accordance with the criteria established in this TM in the sections below. Sewer pipe capacities are dependent on many factors, including roughness of the pipe, the maximum allowable depth of flow, minimum velocity, and slope of pipe. Assumptions of these factors are discussed below.

4.2.3.1 Manning Coefficient (n)

The Manning coefficient "n" is a friction coefficient and varies with respect to pipe material, size of pipe, depth of flow, smoothness of pipe and joints, and extent of root intrusion. For sewer pipes, the Manning coefficient typically ranges between 0.011 and 0.017, with 0.013 being a representative value used for sewer system master planning. New pipes were assumed to have a Manning’s coefficient of 0.013. Existing pipes were adjusted through model calibration. Pipes with a Manning's coefficient in excess of 0.017 were considered deficient.

4.2.3.2 Flow Depth Criteria (Maximum Allowable HGL)

The primary criterion used to identify capacity-deficient trunk sewers or to plan for future infrastructure is the maximum flow depth to pipe diameter ratio (d/D). The d/D value is defined as the depth (d) of flow in a pipe during peak flow conditions divided by the pipe’s diameter (D). When evaluating existing sewers, using a conservative d/D ratio may lead to unnecessary replacement of existing pipelines.

The maximum hourly peak flow that occurs from the design storm, also known as the peak wet weather flow (PWWF), was used for judging system performance. During PWWF, water levels were allowed to rise no more than 1 foot above the pipe crown. Sewers were allowed to surcharge under these maximum flow conditions during the design storm. If the flow depth was greater than the maximum allowed, then the sewer was deemed deficient. Additionally, no surcharging was allowed for shallow manholes (i.e. d/D = 1 is the maximum allowable criteria). Manholes were considered shallow when the difference between the manhole rim and top of pipe was less than four feet. Manholes identified as shallow are illustrated on Figure 4.3.

4.2.3.3 Pump Stations and Force Mains

According to City Sewer Standards, pump capacity shall be sized to handle PWWF from a tributary area with the largest pump out of service. Therefore, the City’s sewage pump stations should have sufficient firm capacity (capacity with the largest pump out of service) to pump the design flow without causing the flow depth criteria to be exceeded in the upstream collection system. Pump stations that could not meet these criteria were found deficient.

The existing force mains shall have a maximum pipe velocity of 8 feet per second (ft/sec) during pumping of PWWF. Any force main with velocity in excess of 8 ft/sec is considered above criteria and therefore deficient.

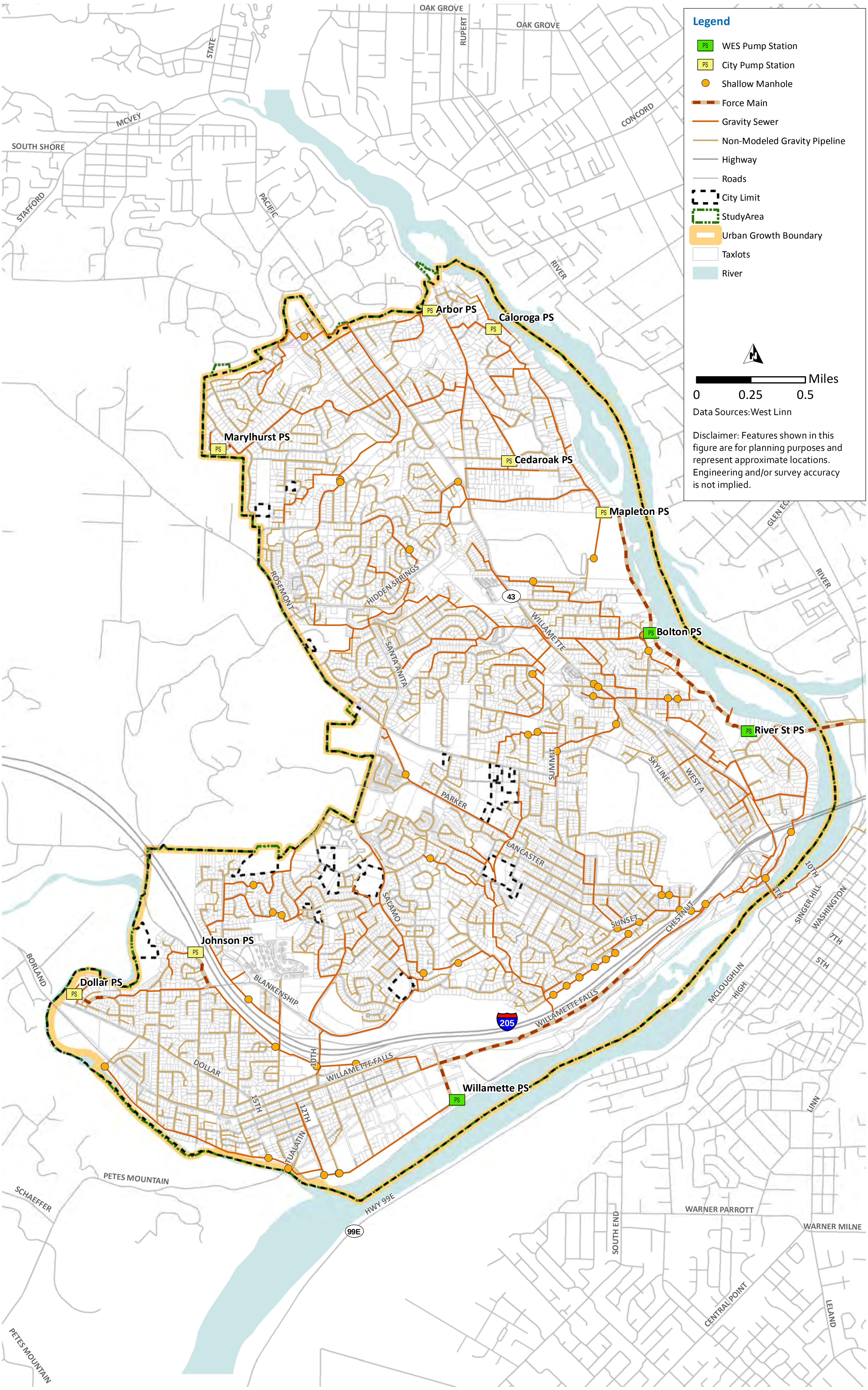


Figure 4.3 Shallow Manhole Locations

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4.2.4 Design Standards

This section summarizes the main design standards for construction of new infrastructure, mainly upsizing of existing pipes identified as deficient according to the System Performance Criteria presented in Section 4.3.

4.2.4.1 Design Criteria Standards

A review and update of the City's current design and construction standards and specifications for sanitary sewer infrastructure is not part of the current scope, but may be completed in the future.

4.2.4.2 Criteria Policy Recommendations

The policy recommendations of this section are critical for the development of a SSMP. These policies and criteria must be defined in order to evaluate the capacity limitations of the collection system:

- Surcharging for New Facilities:

Assign maximum allowable depth of flow for future development under peak wet weather flow. For example, HGL cannot rise above a given distance below manhole rim or HGL cannot rise above a given distance above pipe crown.

When designing new sewers, it is common practice to adopt variable flow depth criteria for different pipe sizes. Design d/D ratios typically range from 0.5 to 0.92, with the lower values used for smaller pipes, which may experience flow peaks greater than design flow or may experience blockages from debris, paper or rags. The Orange Book[2] provides guidance on pipeline design capacity.

The City defined the acceptable d/D values for design of new pipes as follows:

- All new sewers less or equal to 12-inch in diameter shall be designed to flow 50 percent full (d/D of 0.5) or less at peak wet weather flow rates.
- All new sewers larger than 12-inch in diameter shall be designed to flow 75 percent full (d/D of 0.75) or less at peak wet weather flow rates.

This design flow depths are relatively conservative and provide for some flexibility in capacity if projected flows change as a result of modifications in flow generation assumptions or land uses.

- Peak inflow and infiltration (I/I) value for development:

Specify method to estimate Peak Wet Weather Flow (PWWF), which corresponds to the maximum volume of flow anticipated to occur during a 1-hour period. To predict future peak flows, RDII in the future service area must be as defined. A direct inflow technique is used. Instead of simulating RDII using an RDII unit hydrograph, RDII is simulated by assuming a constant RDII flow factor per acre of new development. RDII flow factors can range from 1,000 to over 10,000 gpd/acre in the northwest. An RDII Flow Factor of 1,500 gpd/acre was selected for estimating RDII in areas of new development to reflect improved construction methods and integrity of new materials. Additionally, this value also meets the Department of Environmental Quality (DEQ) recommendation.

[2] https://fortress.wa.gov/ecy/publications/documents/9837.pdf

- I/I Due to System Aging:

The City has an effective repair and replacement program, however, systems still degrade over time and the City decided to account for collection system degradation in the 20-year planning period of this SSMP. Degradation is the slow decline in the condition of the conveyance system that allows an increase in I/I. Increases in I/I can also be caused by illicit connections to the sewer system. It was assumed that degradation (increase in peak I/I rate) from 2,000 gallon per acre per day (gpad) would be 7 percent per decade, with a limit of 28 percent over four decades. King County (Washington) Wastewater Division published these guidelines in July 2014 based on their past experience and pilot projects.[3]

4.2.5 Hydraulic Model Performance Criteria Summary

System performance criteria used to identify capacity limitations in the City's collection system has been established and is summarized below for both the gravity and pumped portions of the system. These triggers will be used to flag potential system deficiencies from the model results.

4.2.5.1 Gravity Pipe Criteria

The maximum allowable HGL level for existing system piping during PWWF is:

- 1 foot above pipe crown,
- No surcharging for shallow manholes (d/D < 1 for manhole depth < 4ft).

When these flow depth values are exceeded either for existing or build-out conditions, the pipe was flagged as potentially deficient. If a pipe Manning's n exceeds 0.017 from a model calibration, it will be noted as potentially deficient.

4.2.5.2 Pump Station Criteria

All City's sewage pump stations should have sufficient firm capacity (capacity with the largest pump out of service) to pump PWWF for current and build-out flows. The pump station force mains should have a maximum pipe velocity of 8 feet per second (ft/sec) or less during the design storm for current and build-out flows. If the pump station or force main does not meet criteria it will be identified as potentially deficient.

4.3 Collection Capacity Limitations

A capacity analysis of the modeled collection system was performed with the City's calibrated hydraulic model using the system performance criteria outlined in Section 4.2.3. The capacity analysis included identifying areas in the sewer system where the planning criteria for pipe segment HGL was exceeded, or where the capacity of the pump stations was exceeded. In addition, the force main velocities were checked with the peak pumped flows. The collection system as modeled was evaluated for the existing and future flow conditions for the design storm.

The capacity analysis identified areas in the sewer system where flow restrictions may occur or where the pipe does not have capacity to convey design flows. Sewers that lack sufficient capacity to convey design flows could produce backwater effects in the collection system that increase the risk of Sanitary Sewer Overflows (SSOs).

[3] Updated Planning Assumptions for Wastewater Flow Forecasting, King County Wastewater Treatment Division, July 2014.

Note that every pipe with an HGL that is at or over 1 foot above pipe crown in a manhole is not necessarily capacity deficient. Surcharging of a pipe can occur due to backwater effects of a downstream pipe. If the downstream pipe is capacity deficient, it can cause backup - and even reversal - of flow in the upstream pipe, resulting in surcharge of the upstream pipe that otherwise is not capacity limited. If the downstream pipe capacity is increased, then the upstream pipe may no longer require capacity improvements. An illustration of backwater effects is shown in Figure 4.4. The hydraulic model was analyzed to identify the pipeline segments that could be the cause of the surcharged conditions.

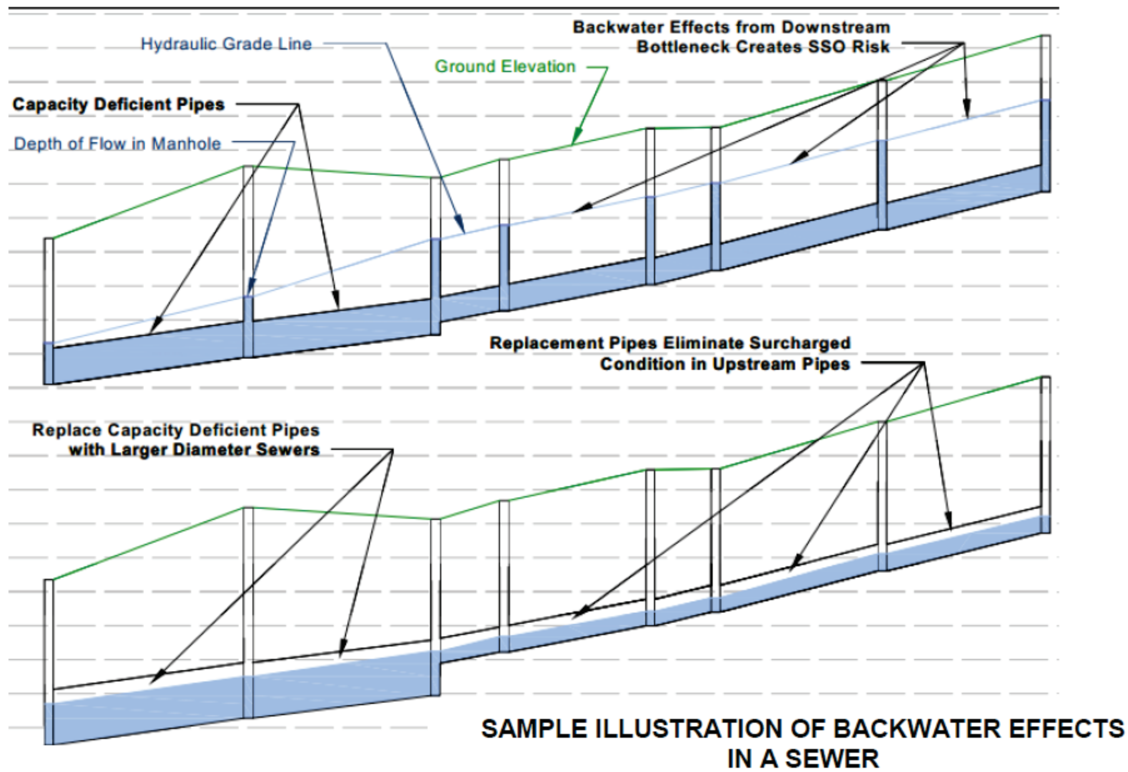

Figure 4.4 Backwater Effect

4.3.1 Potential System Deficiencies

Potential system deficiencies were identified for WWF for existing and build-out conditions. Wet weather flow potential deficiencies are highlighted for existing and build-out conditions in Figure 4.5. Existing deficiencies are shown with red dots, while build-out deficiencies are identified with orange dots on Figure 4.5.

In general, existing deficiencies were mainly identified in Basins 2B East and 9B. Of note, there were multiple deficiencies upstream of the I-205 crossing at 10th Street. The City has very limited pipes in the collection system that exceeded the performance criteria.

Under build-out condition, deficiencies were identified in Basins 3A, 2B East, and 9A. The City is expecting limited additional flow due to growth. TM 1 – Basis of Planning summarizes Average Dry Weather Flow (ADWF) projections, and ADWF is anticipated to increase from 3.34 mgd currently to 3.42 in the next five years, and 3.74 mgd under build-out conditions. The majority of the potential system deficiencies identified under build-out conditions are caused by increase in I/I due to system aging and degradation.

As described in Section 4.2.3, the City has a specific performance criteria for shallow manholes. Shallow manholes are defined as any manhole with a depth less than four (4) feet. For shallow manholes no surcharging shall occur, or they are deemed deficient. The locations of shallow manholes throughout the system are shown in Figure 4.3. There were no identified deficiencies associated with shallow manholes in the City's collection system under either existing or build-out conditions.

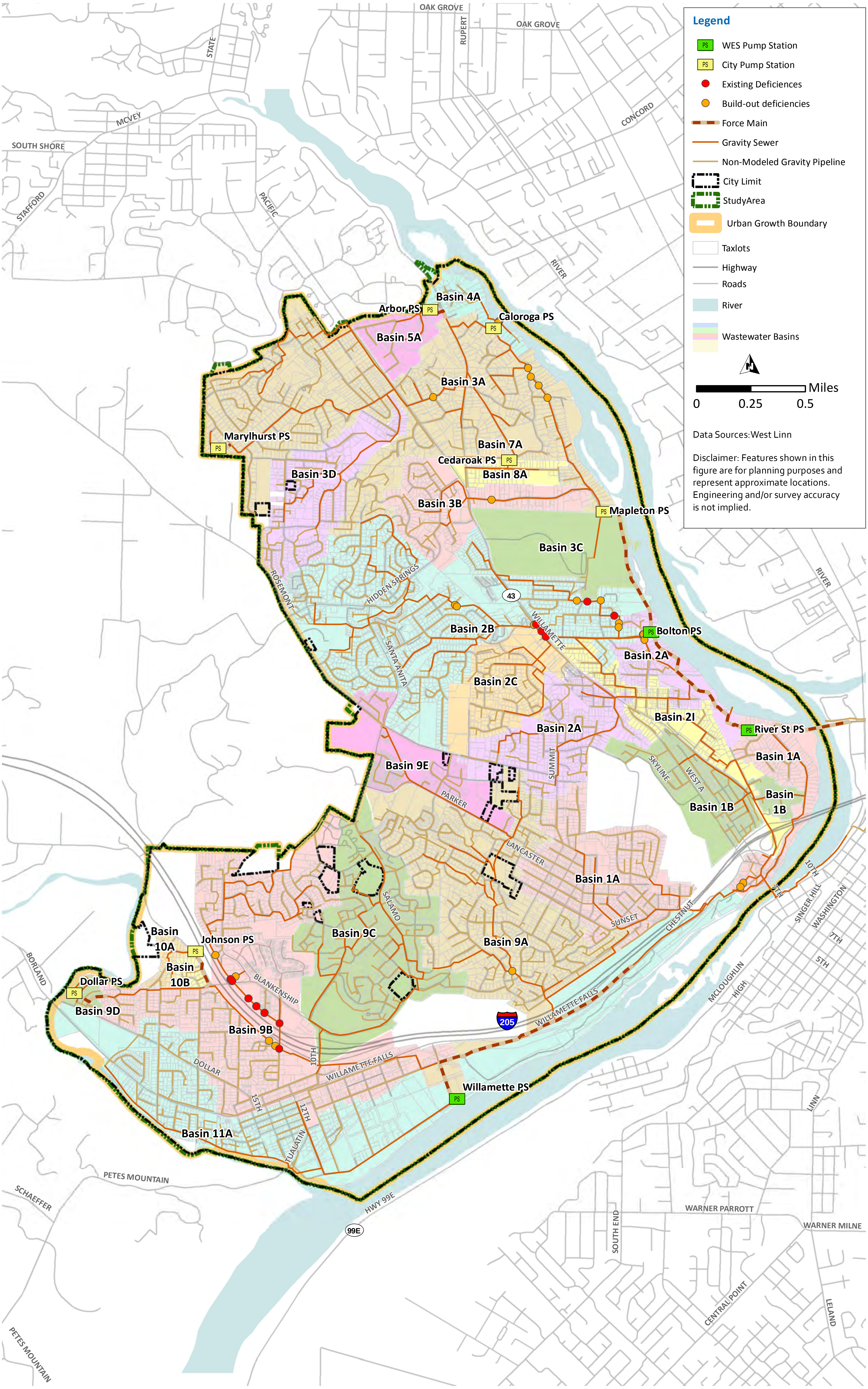

Figure 4.5 Potential System Deficiencies

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4.3.2 Pump Station Capacity Deficiencies

Ensuring that pump stations have adequate capacity to convey peak flows is important to prevent unwanted sewage overflows at pump stations. In accordance with the established performance criteria, the City's existing modeled pump stations were evaluated to determine if each one has available capacity to convey existing and future PWWFs. Pump stations with an influent PWWF above the existing firm capacity were flagged as deficient. The firm capacity of a pump station is defined as the capacity with the largest pump out of service.

If a pump station has inadequate capacity to pump the PWWFs, the water level in the wet well may rise to the overflow point, discharging sewage to stormwater collection systems that eventually discharge to water bodies. The following section presents the pump station capacity evaluation, which compares the estimated current and future peak flows to the pump station firm capacities. Recommendations to address identified deficiencies are presented in Section 4.4.

The City's hydraulic model includes seven City-owned pump stations. Table 4.1 summarizes the results of the pump station evaluation. The total capacity and firm capacity of each pump station is compared to the projected PWWFs for the existing and build-out conditions.

As seen in Table 4.1, all pump stations, except for the Mapleton and Calaroga pump stations, have adequate capacity for existing and build-out conditions. Calaroga is deficient by 0.07 mgd for total capacity and 0.13 mgd for firm capacity under existing conditions.

Mapleton has adequate total capacity for existing conditions, but is deficient by 1.1 mgd under firm capacity and does not meet the City's redundancy criteria (Public Works Design Standards Section 3.0131). By build-out, Mapleton will be deficient by 0.62 mgd for total capacity and 2.06 mgd for firm capacity.

In conjunction with the pump station analysis, City-owned force mains were analyzed using the hydraulic model. All force mains are adequately sized, with the exception of Mapleton. At build-out, modeled velocity in the existing force main was 8.7 fps, greater than the City's 8 fps velocity criteria. This Mapleton force main deficiency should be addressed in conjunction with capacity improvements to the Mapleton pump station.

Table 4.1 Pump Station Evaluation

Pump Station Name	Total Capacity (mgd)	Firm Capacity (mgd)	Existing Maximum PWWF (mgd)	Build-out Maximum PWWF (mgd)	Existing Condition Deficiency (Total/Firm) (mgd)	Build-out Condition Deficiency (Total/Firm) (mgd)
Arbor	0.55	0.27	0.13	0.14	- / -	- / -
Calaroga	0.12	0.06	0.19	0.19	0.07 / 0.13	0.07 / 0.13
Cedar Oak	0.43	0.22	0.10	0.11	- / -	- / -
Johnson	0.50	0.25	0.11	0.12	- / -	- / -
Mapleton	4.25	2.81	3.91	4.87	- / 1.1	0.62 / 2.06
Marylhurst	0.46	0.23	0.02	0.02	- / -	- / -
River Heights	0.34	0.17	0.06	0.07	- / -	- / -

4.4 Recommended System Improvements

This section presents the proposed capacity projects to mitigate the deficiencies identified in Section 4.3. The recommended pipeline improvements projects are shown in Figure 4.6 and described in further detail in the sections below.

4.4.1 Sizing Methodology

The City's design standards to size new gravity pipes define design criteria, which will be used to size all new pipes recommended in this Section:

- All new sewers less or equal to 12-inch in diameter shall be designed to flow 50 percent full (d/D of 0.5) at peak wet weather flow rates.
- All new sewers larger than 12-inch in diameter shall be designed to flow 75 percent full (d/D of 0.75) at peak wet weather flow rates.

According to City Design Standards, pump capacity shall be sized to handle PWWF from a tributary area with the largest pump out of service. The City's sewage pump stations should have sufficient firm capacity (capacity with the largest pump out of service) to pump the design flow without causing surcharging and backwater in the upstream collection system Additionally, when a force main is found deficient through modeling, the recommended force main size will be estimated based on a maximum velocity of 3 to 5 fps under PWWF condition (Public Works Design Standards Section 3.0138).

4.4.2 Recommended Pipeline Projects

4.4.2.1 P-1 – I-205 Crossing

Project P-1 is located in wastewater basin 9B and consists of upsizing 2,520 feet of existing 10-inch diameter gravity main to 15-inch diameter gravity main running parallel to I-205 southwest of the Willamette Terrace Apartments and crossing I-205 at 13th Street. This includes 617 feet of highway crossing with 15-inch diameter pipe and a 30-inch diameter casing. Upgrade of the highway crossing might consist of constructing a parallel pipe to the existing crossing. The deficiencies triggering this improvement occur under existing condition, and are amplified with the additional flow in the basin under build-out condition. This project is triggered by an inadequately sized pipes, and the I-205 crossing acts as a bottleneck in the collections system.

4.4.2.2 P-2 – Wellington Drive

Project P-2 is located in wastewater basin 9A and consists of upsizing 425 feet of existing 10-inch diameter gravity main to 12-inch diameter gravity main by Wellington Drive near the intersection of Wellington Drive and Wellington Court. This project is triggered by deficiencies identified under the build-out condition. No deficiencies are identified under existing condition, therefore, it is recommended that the City monitor this area as flows increase and system degrades in the future. The section of pipe identified as deficient per the City's criteria is mainly caused by a relatively flat slope section, which causes the hydraulic grade line (HGL) to rise above the one-foot above pipe crown criteria.

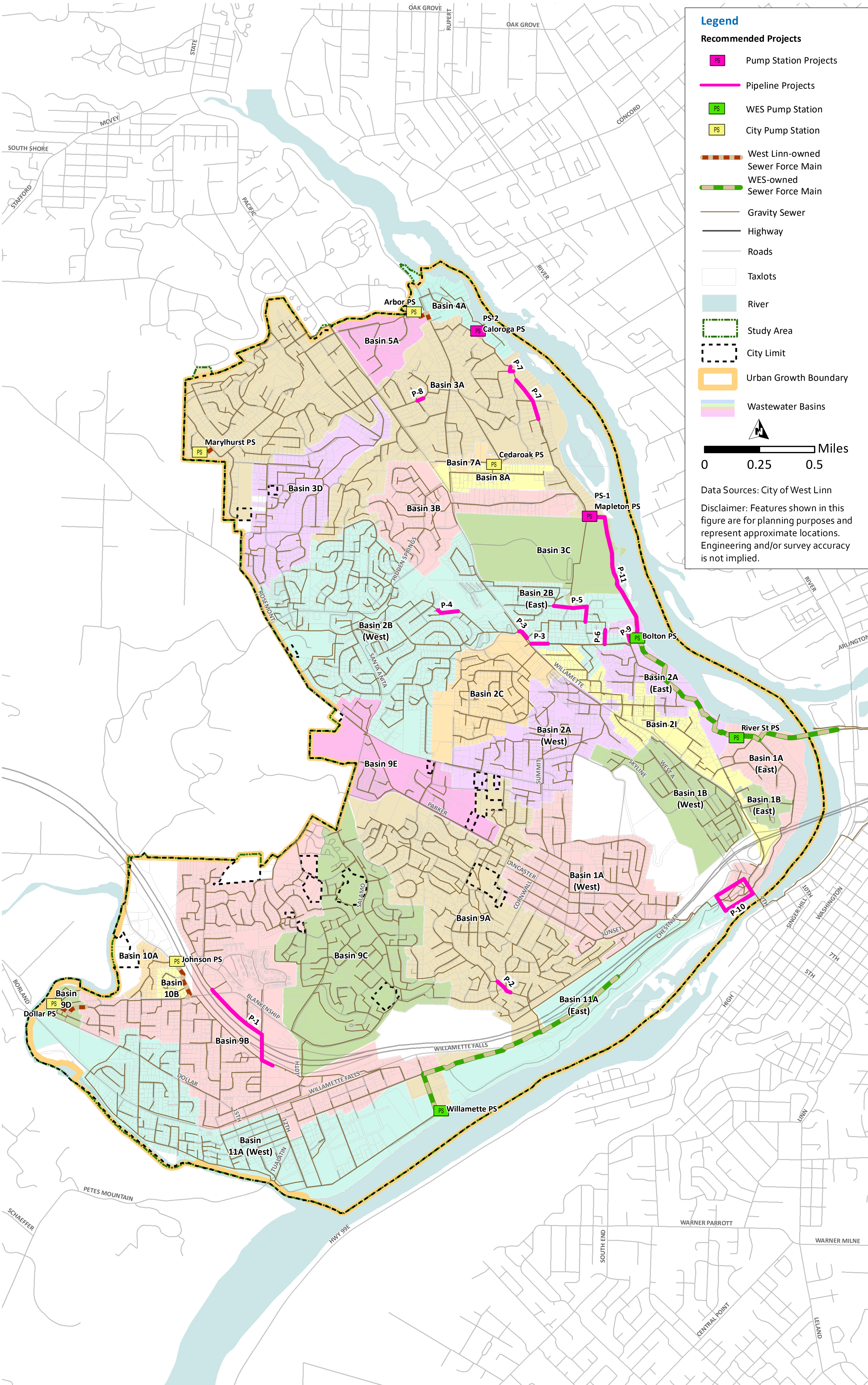

Figure 4.6 Recommended System Improvements

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4.4.2.3 P-3 – Willamette Drive

Project P-3 is located in wastewater basin 2B and consists of upsizing 614 feet of existing 12-inch diameter gravity main to 15-inch diameter gravity main along Willamette Drive between Magone Lane and Pimlico Drive. This project also includes upsizing 69 feet of 15-inch diameter gravity main to 18-inch diameter gravity main along Dillow Drive from Willamette Drive to Tulane Street. This project is triggered by deficiencies highlighted in the existing condition. Both these sections of pipe are relatively flat slope pipes surrounded by steeper sections upstream and downstream. This type of configuration typically triggers the HGL to rise in the flat portions of the system. Note, this project is also located in a basin (wastewater basin 2B) where an I/I reduction program might be recommended (see Section 4.5 in this TM).

4.4.2.4 P-4 – Palomino Circle

Project P-4 is located in wastewater basin 2B and consists of upsizing 508 feet of existing 8-inch diameter gravity main running northwest of Palomino Circle and north of Pimlico Drive to the main southeast of Bronco Court to 12-inch diameter gravity main. This project is triggered by deficiencies identified under the build-out condition. No deficiencies are identified under existing condition, therefore, it is recommended that the City monitor this area as flows increase and system degrades in the future. The section of pipe identified as deficient per the City's criteria is mainly caused by a relatively flat slope section, which causes the hydraulic grade line (HGL) to rise above the one-foot above pipe crown criteria.

4.4.2.5 P-5 – Larson Ave

Project P-5 is located in wastewater basin 2B and consists of upsizing 1,162 feet of existing 8-inch diameter gravity main to 12-inch diameter gravity main along Larson Avenue from Tulane Street to Jolie Point Road and along Jolie Point Road to Munger Drive. This project is triggered by deficiencies highlighted in the existing condition. The section of pipe identified as deficient per the City's criteria is mainly caused by a relatively flat slope section, which causes the hydraulic grade line (HGL) to rise above the one-foot above pipe crown criteria. Additionally, modeling shows that the entire section is capacity deficient based on PWWF. I/I degradation and development are anticipated to amplify this problem. Note, this project is also located in a basin (wastewater basin 2B) where an I/I reduction program might be recommended (see Section 4.5 in this TM).

4.4.2.6 P-6 – Dillow Drive and Maple Terrace

Project P-6 is located in wastewater basin 2B and consists of 351 feet of existing 10-inch diameter gravity main to 15-inch diameter gravity main between Dillow Drive and Maple Terrace. Project P-6 is located downstream of project P-5. This project is triggered by deficiencies highlighted in the existing condition, and deficiencies are anticipated to be amplified once project P-5 is completed and with the addition of flows caused by growth and system aging. Additionally, this section of pipe is relatively flat, which causes the HGL to rise up quickly.

4.4.2.7 P-7 – Nixon Ave

Project P-7 is located in wastewater basin 3A and consists of upsizing 1,522 feet of existing 18-inch diameter gravity main to 24-inch diameter gravity main along Nixon Avenue from north of Island View Way to Calaroga Court. This project is triggered by deficiencies identified under the build-out condition. No deficiencies are identified under existing condition therefore it is recommended that the City monitor this area as flows increase and the system degrades in the future. The City spent a lot of effort relining its sewer lines in wastewater basin 3A, which, in return, decreased I/I rates in the northern portion of the system significantly. The previous Master Plan, before any upgrades occurred, showed high I/I and deficiencies in the area.

4.4.2.8 P-8 – Fairview Way

Project P-8 is located in wastewater basin 3A and consists of upsizing 160 feet of existing 10-inch diameter gravity main to 12-inch diameter gravity main along Fairview Way between Rose Way and Chippewa Court. This project is triggered by deficiencies identified under the build-out condition therefore it is recommended that the City monitor this area as flows increase and the system degrades in the future. No deficiencies are identified under existing condition. The City spent a lot of effort relining its sewer lines in wastewater basin 3A, which, in return, decreased I/I rates in the northern portion of the system significantly. The previous Master Plan, before any upgrades occurred, showed high I/I and deficiencies in the area.

4.4.2.9 P-9 – Failing Street

Project P-9 is located in wastewater basin 2A and consists of upsizing 160 feet of existing 12-inch diameter gravity main to 18-inch diameter gravity main from Failing Street to the Bolton Pump Station. This is the incoming line to the Bolton Pump Station. This project is triggered by deficiencies identified under the build-out condition. No deficiencies are identified under existing condition, therefore, it is recommended that the City monitor this area as the system grows and degrades over time. It is recommended that this project be combined with project P-11 and project PS-1, described below.

4.4.2.10 P-10 – Mill Street

Project P-10 consists of relocating the sewer line in the vicinity of Mill Street, as shown in Figure 4.6. As the properties between WFD and Mill Street redevelop, this section of sewer line needs to be upgraded and realigned to the street right-of-way. This project will be part of the waterfront project. Modeling shows no capacity issues with the existing pipe diameter, therefore, the recommendation is to replace it with the same diameter. However, when this project is triggered, this project should be evaluated in more detail and confirm pipe size and alignment.

4.4.3 Recommended Pump Station Projects

4.4.3.1 PS-1 - Mapleton Pump Station

Project PS-1 consists of upgrading Mapleton Pump Station capacity to a firm capacity 4.87 mgd. Because no condition assessment was performed as part of this SSMP, it is recommended that the City understand the condition of this pump station beforehand to optimize this project. It is recommended that this project be combined with project P-9 and project P-11.

4.4.3.2 P-11 – Mapleton Force Main

Project P-11 is located in wastewater basin 3A and consists of constructing 3,750 linear feet of 8inch diameter force main running parallel to the existing 12-inch diameter force main from the Mapleton Pump Station to the Bolton Pump Station. Under build-out condition, the maximum velocity in the force main exceeds 8 fps under PWWF condition. Maximum reaches 8.7 fps under this condition, and the fore main is therefore considered deficient, per the City’s criteria. It is recommended that the City monitor flows in this area, and combine this project with P-9, and PS-1, if the project proceeds forward.

4.4.3.3 PS-2 - Calaroga Pump Station

Project PS-2 consists of upgrading Calaroga Pump Station capacity to a firm capacity of 0.19 mgd. The City is also experiencing issues with this pump station and it is recommended that this project remain on the CIP list. A new pump station is recommended to replace the existing pump station, and will be costed accordingly in TM 5 - CIP.

4.5 Inflow and Infiltration Program

4.5.1 Current Inflow and Infiltration

Inflow and infiltration (I/I) into the sanitary sewer system increases as degradation of the system occurs, reducing total available capacity in pipelines, pump stations, and treatment facilities. This section summarizes the I/I estimates for each of the City’s wastewater basins, reviews options for I/I reduction, identifies I/I reduction targets, and provides the costs of I/I reduction.

4.5.1.1 I/I Evaluation Parameters

Estimated peak flows were used to develop three important parameters for understanding I/I, as follows:

- **Peaking Factor**: Peaking factors are the ratio between peak flow and base sanitary flow and are commonly used for wastewater infrastructure design. These factors are derived by dividing the peak flow by the base sanitary flow for each basin. Due to the prolonged rainy season, wastewater agencies in the northwest typically experience peaking factors from 2 to 10, and in some cases more than 10. Systems with Peaking Factor of 3 or less are often considered as performing well. High Peaking Factors are typically signs of direct inflow in the collection system.
- **Peak I/I Rate**: The Peak I/I Rate is the peak flow rate of all non-sanitary flows. Peak I/I Rates are calculated by subtracting the base sanitary flow from the peak flow for each basin. Peak I/I Rates are largely dependent on the contributing area of land and are expressed in terms of gallons per acre per day (gpad). The Peak I/I Rate is calculated by dividing the Peak I/I flow by the total contributing area of land in acres in each basin. Peak I/I Rates can range from 1,000 to over 10,000 gpad in areas in the northwest. High Peak I/I Rates are usually signs of inflow. An I/I Flow Factor of 1,500 gpad is commonly used for estimating I/I in areas of new development to reflect improved construction methods and integrity of new materials.
- **R-Values:** R-Values correspond to the total volume of I/I in gallons divided by the total gallons of rainfall that fell within the acreage of the basin area. This is a ratio and is expressed as a percentage. R-Value is described as "the percentage of rainfall that enters the collection system." Systems with R-Values less than 5%[4] are often considered as performing well. High R-Values are usually signs for significant infiltration.

These parameters were developed for the City’s sewer basins (numbered 1A through 11A), using flow monitoring data collected for the City's 10 flow monitoring basins.

[4] Keefe, P.N. "Test Basins for I&I Reduction and SSO Elimination", 1998. WEF Wet Weather Specialty Conference, Cleveland.

4.5.1.2 I/I Evaluation Results

Table 4.2 presents the Peaking Factor, Peak I/I Rate, and R-Value for each basin for the City's design storm. These parameters are also shown for each basin in Figures 4.7, 4.8, and 4.9, respectively. I/I parameters are characterized as significant (red), moderate (yellow), or good (green). There are portions of the system with indicators of significant I/I, but overall the majority of the system is performing relatively well.

I/I parameters vary greatly among the basins; Peaking Factors range from 2.3 to 7.8, Peak I/I Rates range from 1,343 to 17,709 gpad, and R-Values range from 4.1% to 27.9%. Basins with high I/I parameters are generally located in the southeastern portion of the City. This area correlates well with areas of the system without storm sewer infrastructure. This combined with the high R-values are indicators of high infiltration. Basins with the highest I/I parameters are: Basin 1A West, Basin 2A West, Basin 2B East and Basin 1A East. These basins generally have moderate to high I/I parameters in all categories, indicative of both inflow and infiltration.

Figures 4.10 through 4.12 show the ranking of each of the City's basins for the Peaking Factor, Peak I/I Rate, and R-Value, respectively. Similar to Figures 4.7 through 4.9, I/I values are characterized as significant (red), moderate (yellow), or good (green).

Table 4.2 I/I Parameters by Wastewater Basin

Wastewater Basin ID	Basin Contributing Area (acres)(1)	Peaking Factor	Peak I/I Rate (gpad)	R-Value (%)
1A East	66.9	7.8	6,661	12%
1A West	142.0	7.3	17,709	28%
1B East	15.6	5.5	3,977	7%
1B West	64.5	6.5	7,623	14%
2A East	37.4	4.9	3,812	15%
2A West	109.1	7.2	7,577	15%
2B East	95.6	6.0	11,720	21%
2B West	299.4	5.9	5,351	10%
2C	74.0	6.5	5,724	9%
2I	64.8	6.9	6,848	13%
3B	96.9	7.1	6,240	10%
3C	3.3	6.7	5,372	10%
3A/7A	500.5	7.3	4,393	4%
3D	106.5	5.6	2,862	6%
4A	34.1	7.7	4,105	9%
5A	42.7	4.5	2,277	4%
8A	31.7	4.9	2,430	5%
9A	305.6	5.0	4,183	7%
9E	66.5	3.5	2,833	4%
10A/10B	27.4	4.9	3,031	6%
9B	369.6	5.0	4,379	8%
9D	12.1	6.2	4,013	8%
9C	174.9	4.3	3,704	7%
11A East	65.9	2.3	1,493	4%
11A West	218.4	2.4	1,343	8%

Notes:
(1) Basin contributing area is the estimated area that contributes flow to each basin. Note that upstream flows and acreage have been removed to isolate individual basins.

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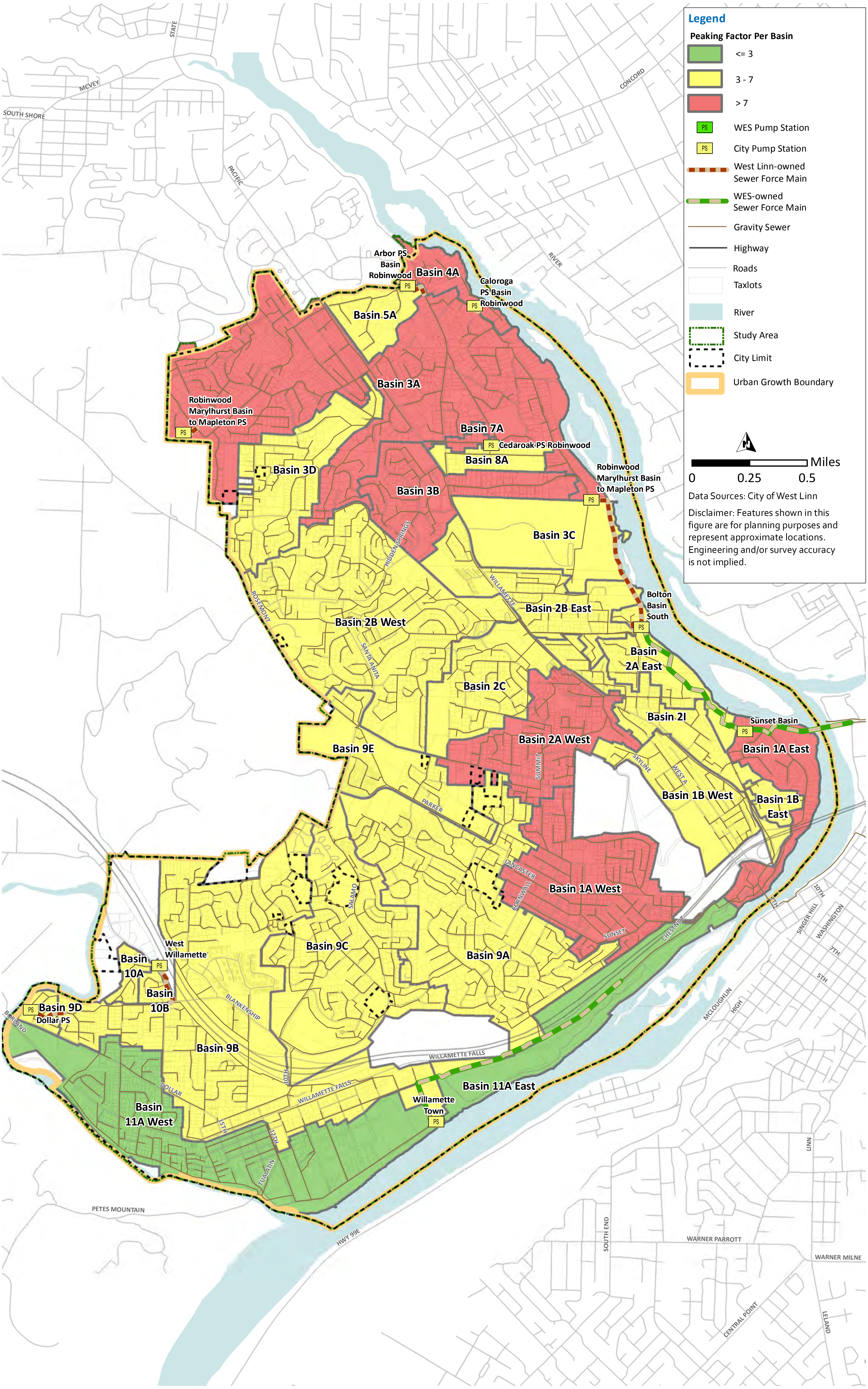

Figure 4.7 Peaking Factor Per Basin

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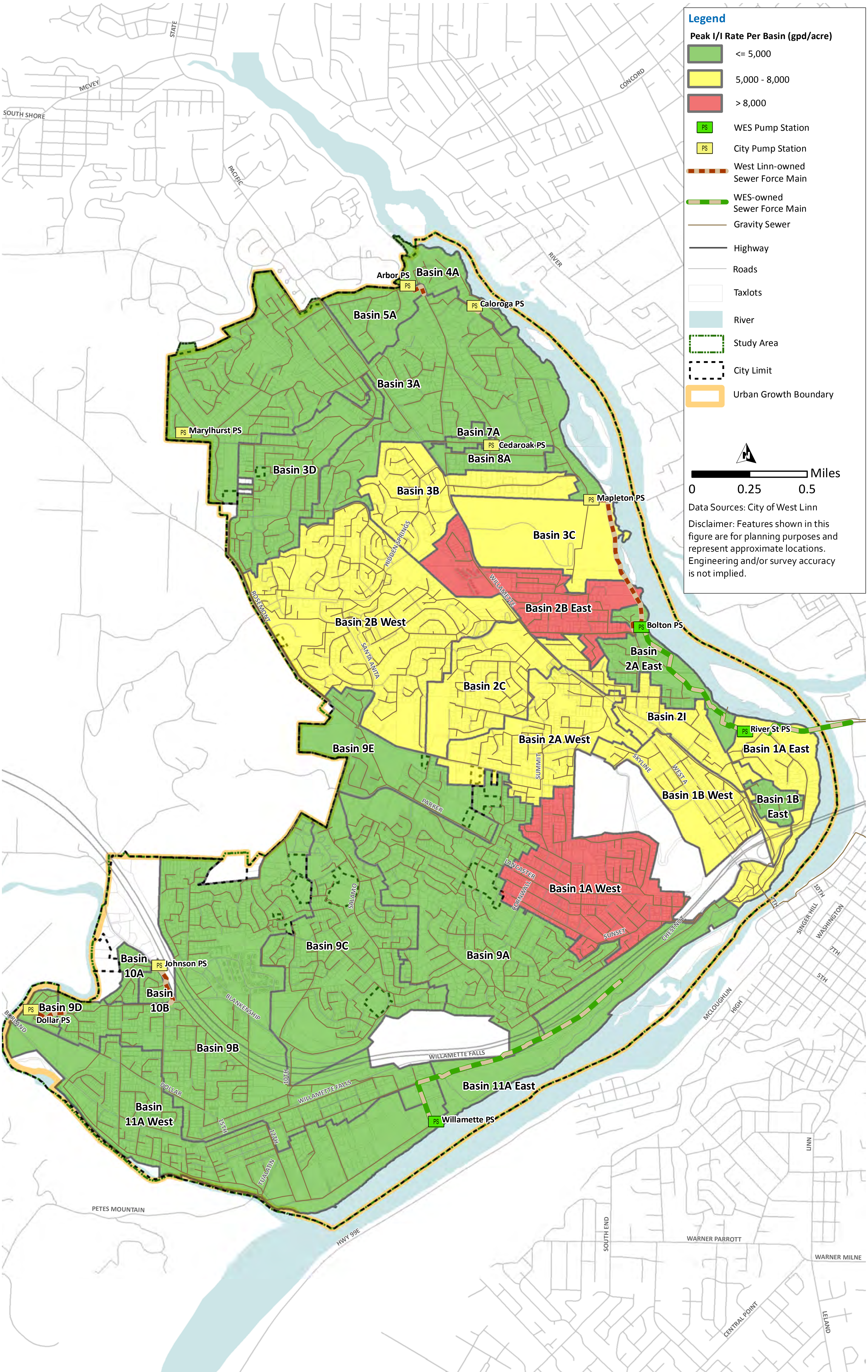

Figure 4.8 Peak I/I Rate Per Basin

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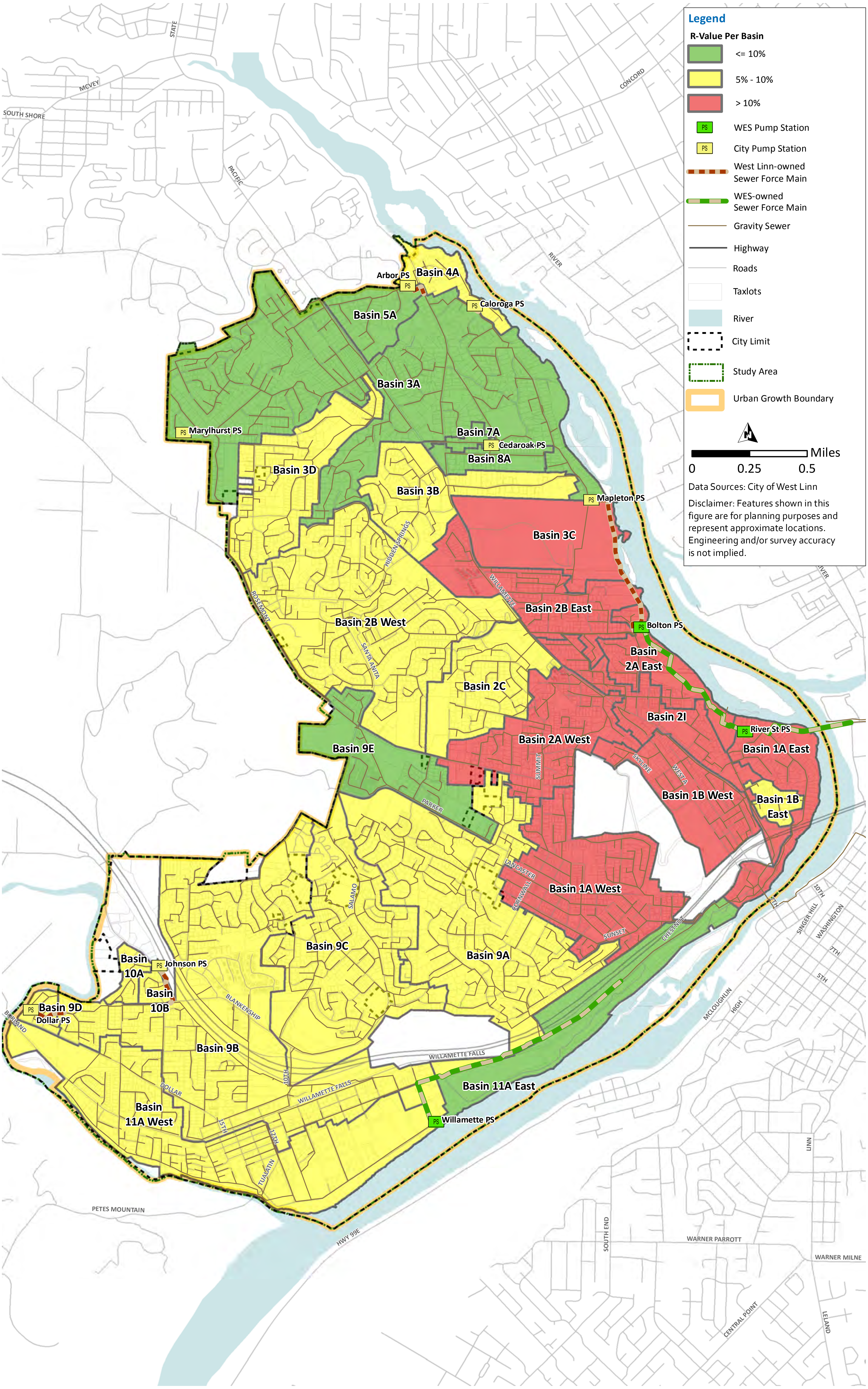

Figure 4.9 R-Value Per Basin

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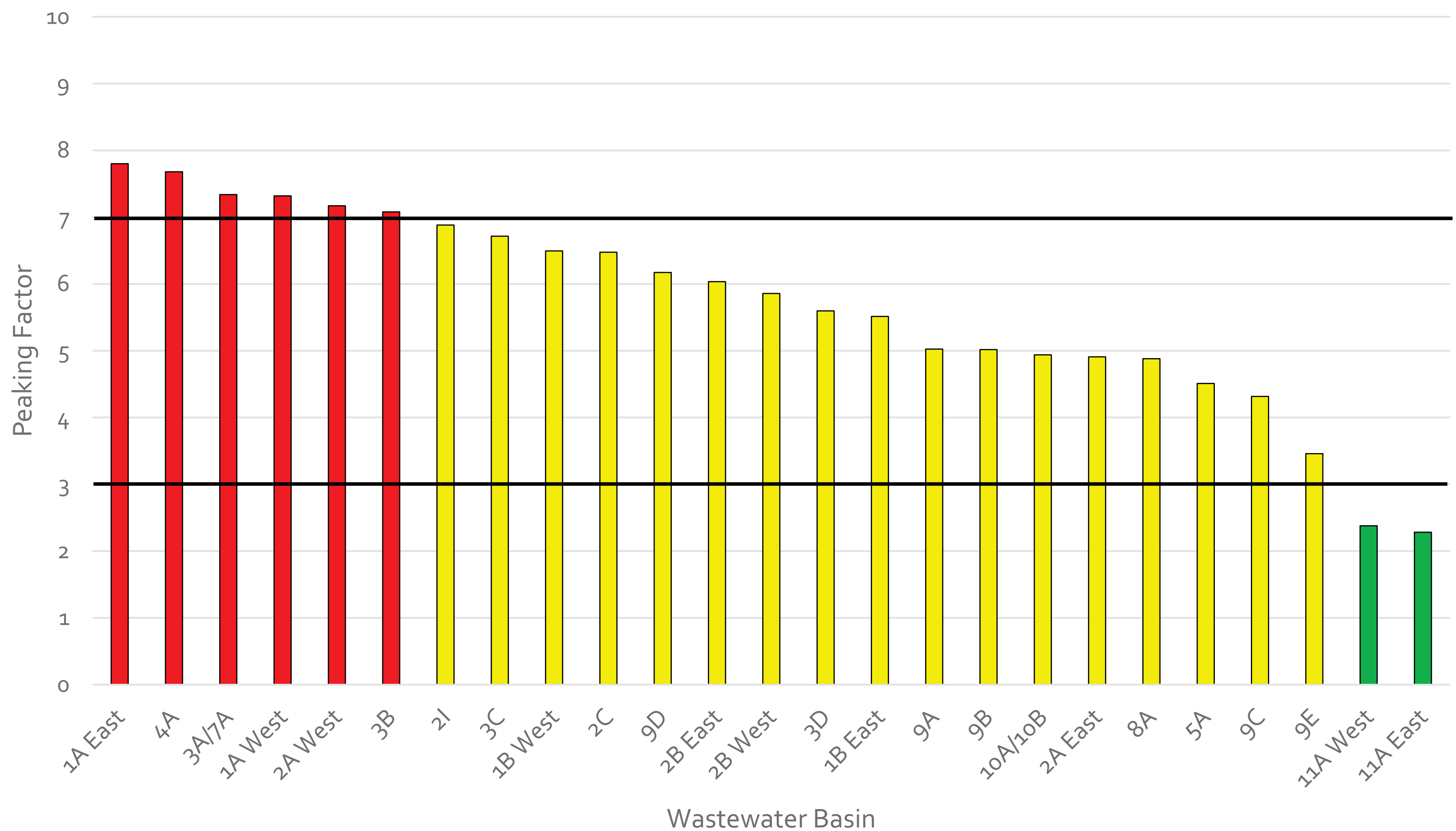

Figure 4.10 Peaking Factors Basin Ranking

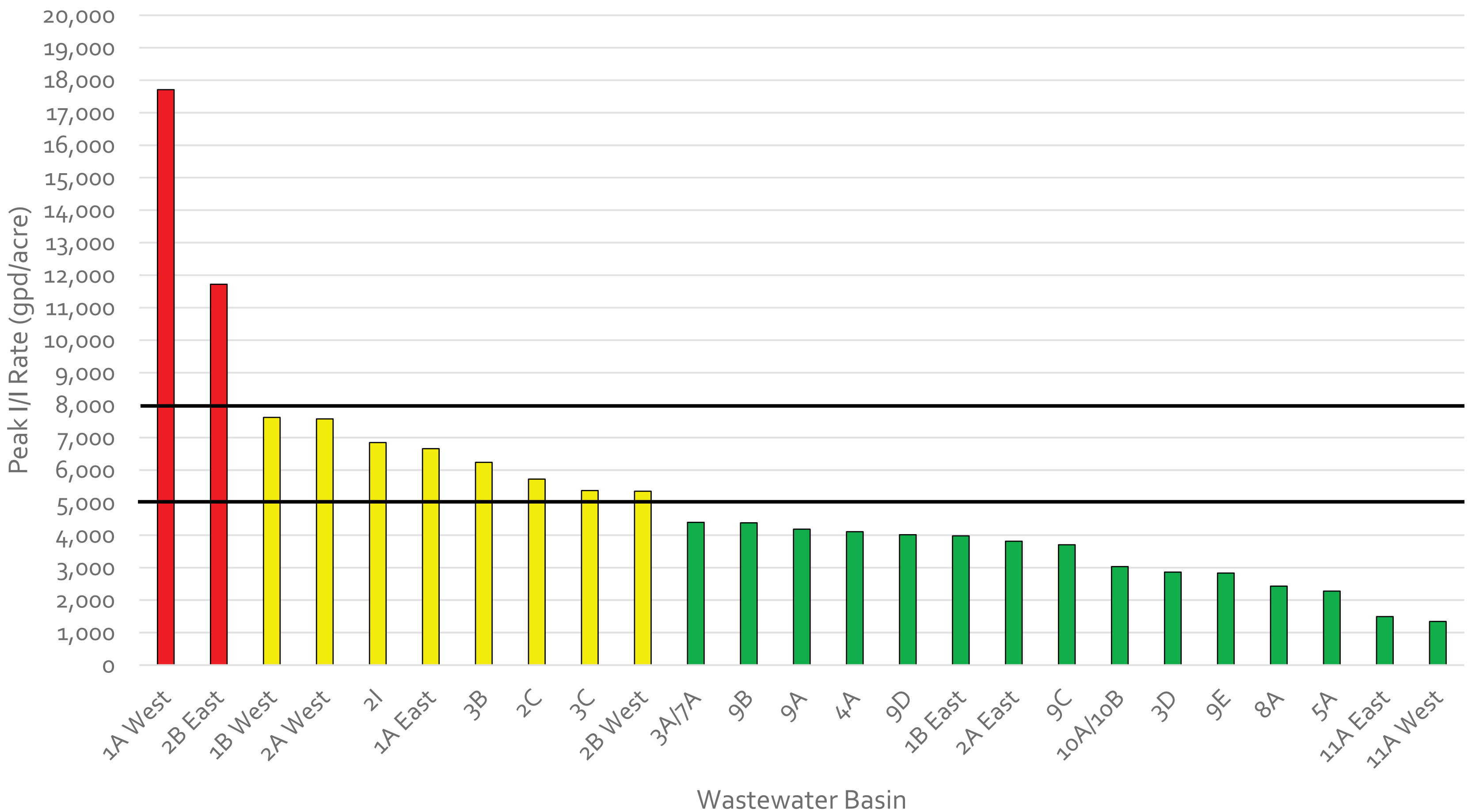

Figure 4.11 Peak I/I Rates Basin Rankings

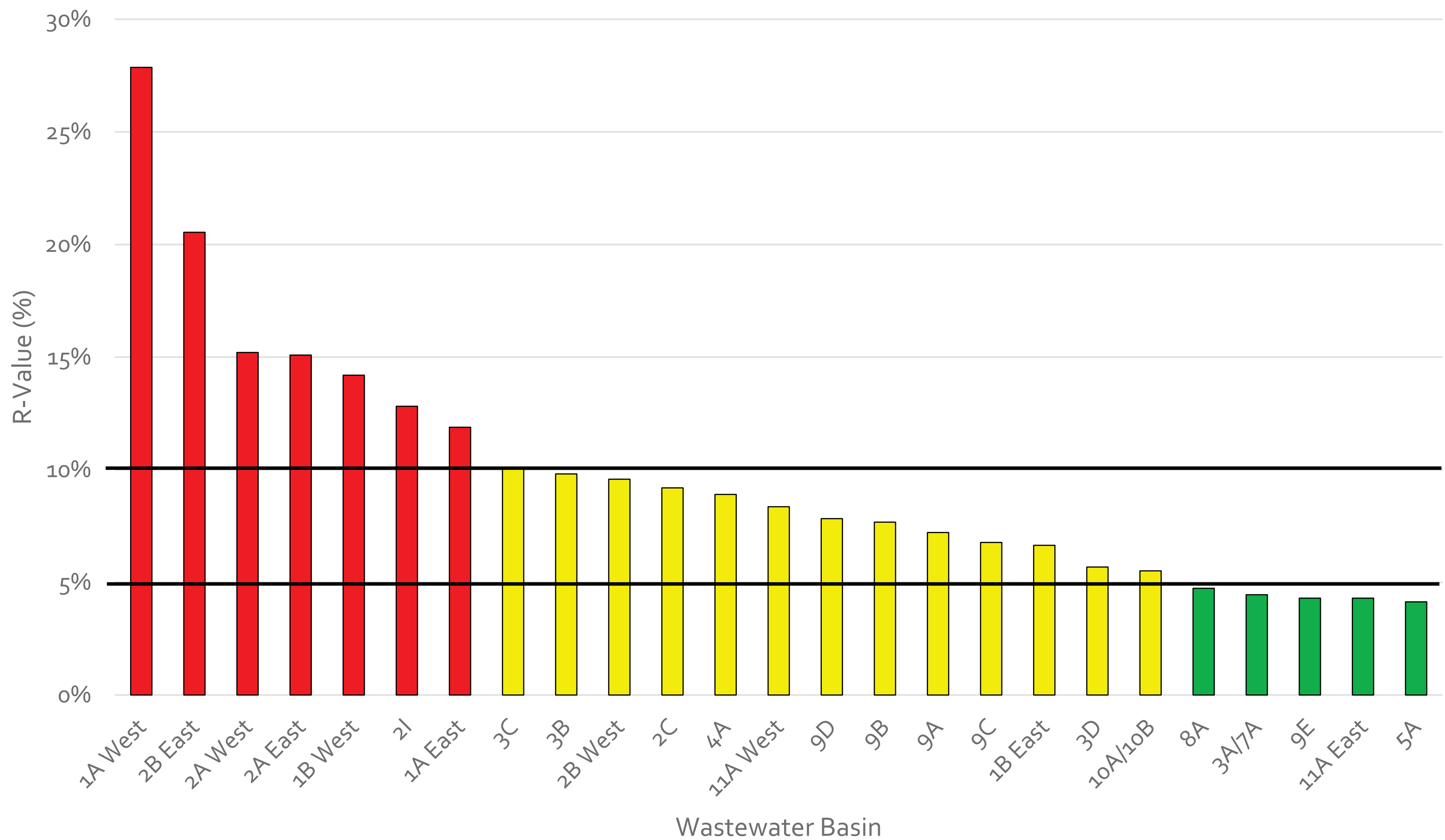

Figure 4.12 R-Values Basin Rankings

4.5.2 Inflow and Infiltration Reduction Methods

Reduction of I/I in sewers can be a difficult and costly task to undertake. Identifying specific sources, working with private property owners, developing metrics for tracking the effectiveness of reduction techniques, and balancing the cost against capacity projects are all major challenges.

Many small and large-scale programs for reducing I/I have been conducted over the last few decades as pressure to reduce overflows has increased. One of the best sources of I/I reduction data in the Northwest is a series of studies performed by King County, Washington, which began a Regional I/I Control Program in 1999. The program began with pilot-tests of I/I reduction techniques in nine sample basins. The results of their ongoing study provide useful information to sewer agencies in the Northwest. Some local agencies, such as the City of Portland Bureau of Environmental Services, are relying on the results of the King County program to address I/I in their sewer systems. The following sections describe I/I reduction methods, and some of the latest results from the King County I/I study.

4.5.2.1 Sanitary Sewer Evaluation Surveys

The first step in reducing I/I is to perform a study of the targeted sewer basins through what is commonly called a Sanitary Sewer Evaluation Survey (SSES). SSES' include isolating the locations and identifying the sources of I/I so that appropriate I/I reduction methods are selected.

King County created and employed SSES' as encompassing surveys and data review for employing techniques to identify causes of I/I in specific locations.

After completing nine pilot projects focusing on I/I reduction, King County publicized the following results regarding SSES[5]:

- Sources and volumes of I/I can be identified through comprehensive wet-weather flow monitoring.
- SSES' (specifically CCTV inspections) are most effective when done in the wet-weather season.
- A high percentage of I/I tends to originate in laterals.

Isolate Location

The first step in an SSES is to isolate areas of high I/I. This effort begins at the basin level, and through flow monitoring, and narrowed down to "mini-basins." Investing in initial flow monitoring at the mini-basin level can greatly decrease rehabilitation costs. This is because additional flow monitoring can identify areas with low I/I, thereby eliminating them from the rehabilitation program.

A recent side-by-side project comparison by ADS Environmental Services, LLC[6] shows that increasing initial flow monitoring to isolate mini-basins to the 10,000 linear foot size provides the optimum return on investment for flow monitoring expenses compared to the cost of rehabilitation.

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[5] *Regional Infiltration and Inflow Control Program Pilot Project Report*, King County, Washington, October 2004, p. 1-8

[6] "Recipe for Successful Measurement of RDII" Webinar by Patrick L. Stevens, ADS Environmental Services, LLC, February 15, 2011

Source Identification

The next step in an SSES is to identify the sources as closely as possible. Inflow and infiltration have many causes such as connected foundation drains, downspouts, leaking pipes, and leaking manholes. Inspection methods to identify I/I sources commonly include the following:

- Smoke testing.
- Flow Isolation (monitoring nightly flows in adjacent manholes to identify sources).
- Mainline closed-circuit television (CCTV) inspection.
- Lateral CCTV inspection.
- Visual inspection of manholes.

4.5.2.2 Reduction Techniques

Once an SSES is completed for a basin, the appropriate reduction techniques can be selected. Common techniques for reducing I/I include the following:

- **Direct Disconnects**: This includes disconnecting roof downspouts, yard drains, foundation drains, stormwater catch basins, and/or any connection to the sewer system causing inflow. Disconnection of these items may require additional provisions for stormwater drainage.
- **Replacement or Repair (R&R) of Pipes**: This includes replacing or repairing public sewer pipes, typically due to poor condition, root intrusion, and disconnected joints. Options for replacing pipes include open-cut trench construction or using trenchless technologies, such as pipe bursting or cured in-place pipe (CIPP). These options need to be assessed for local conditions, such as pipe condition, adjacent utilities, and soil type.
- **Replacement or Repair (R&R) of Manholes**: Several options exist for sealing manholes and preventing infiltration through faulty joints and cracks. Alternatives include grouting, coating, installing a liner, and/or applying an external sealant.
- **Replacement or Repair (R&R) of Laterals**: This includes replacing or repairing laterals (from house to public sewer) due to poor condition and the presence of infiltration. Faulty laterals are known to be large contributors of I/I. Identifying and repairing multiple faulty laterals on private property can be more difficult than repairing a public sewer pipe. Because of their location on private properties, replacing or repairing laterals involves the cooperation of property owners. Methods for repairing or replacing laterals are similar to those described for public pipes. Trenchless technologies, which are less obtrusive than open-cut trenches are effective for replacing laterals while minimizing impacts to landscaping and driveways.

4.5.2.3 General Effectiveness of Techniques Evaluated

The effectiveness of employing I/I reduction techniques will vary for each sewer system; it will also largely depend on correctly identifying the major sources of I/I in a particular location. After completing nine pilot projects focusing on I/I reduction, King County publicized the following results regarding I/I reduction techniques:

- I/I can be reduced through sewer rehabilitation.
- Very little I/I reduction will likely result from manhole rehabilitation alone. (*For this reason, replacing or improving manholes is not recommended as a cost-effective method for I/I reduction and is not included in the recommendations that follow*.)

- Success of I/I control projects depends on a high level of cooperation with local agencies and private property owners.
- Rehabilitating sewer mains at the same time that laterals are rehabilitated may be done for a relatively small increase in cost.

King County used the results of the Regional I/I Control Program Pilot Project to develop a Benefit/Cost Analysis Report, in which the effectiveness of specific I/I reduction techniques (or combinations thereof) were summarized. Table 4.3 presents the resulting percent I/I reduction for each of these techniques given the percent of the basin rehabilitated. As seen in the table, focusing on private property laterals with some direct disconnects (Technique 4) resulted in more I/I reduction than rehabilitating public sewers (Technique 3).

Table 4.3 Percent I/I Reduction for Specific Techniques (1)

Technique	% Basin Rehabilitated	% I/I Reduction
1. Direct disconnects	4%	10%
2. Replace everything and direct disconnects	95% Sewer Mains 95% Manholes 95% Laterals 4% Direct Disconnects	80%
3. Replace public sewers and direct disconnects	50% Sewer Mains 50% Manholes 50% Laterals (street portion only) 4% Direct Disconnects	40%
4. Replace private property and some laterals and direct disconnects	50% Laterals 45% Laterals (private property portion only) 4% Direct Disconnects	60%

Notes:
(1) Source: King County Regional I/I Control Program Benefit/Cost Analysis Report, Earth Tech Team, November 2005, p. 3-30.

Evaluating the effectiveness of I/I techniques requires flow monitoring data that can show the reduction in peak flows before and after a method is implemented. The quantity of I/I reduced can be compared to the cost of the I/I reduction technique to evaluate its cost-effectiveness. It is best to collect flow-monitoring data for several months in the wet weather period, and for at least one month in the dry weather period, before and after an I/I reduction technique has been implemented. Pre-implementation flow monitoring is commonly done as part of the SSES flow isolation. After implementing an I/I reduction technique, it is recommended that flow monitoring be completed in the wet weather period to quantify reductions and support future I/I reduction efforts.

4.5.2.4 Other Considerations for West Linn

High existing inflow and infiltration quantities indicate an aging system (including private laterals) in disrepair. An I/I reduction program is a critical investment in restoring the condition and increasing the asset value of the City's sewer infrastructure. I/I reduction can also delay or eliminate capacity improvement projects in sewer collectors, interceptors, and at the City's pump stations. However, I/I reduction can be costly compared to capacity improvement projects and presents challenges with implementation given the overlap onto private property.

4.5.3 West Linn I/I Reduction Evaluation

The following sections describe the recommended I/I reduction and basin prioritization.

An important factor in the reduction of I/I in the City's system is Water Environment Services (WES)' collection system. Flows and I/I from the City's and neighboring partners may trigger capacity issues for WES's pump stations, pipelines, and treatment facility. The City's capacity analysis presented in Section 4.3 did not show significant capacity deficiencies in the City that would trigger an extensive I/I program at first glance, with considering the City' system only. However, the City is discharging its wastewater flows to a regional partner; WES.

4.5.3.1 WES Preliminary Flow Targets and Data

WES is currently developing its sanitary sewer master plan. As part as this effort, preliminary data and flow targets were provided by WES as guidance when investigating I/I status. The preliminary data from WES correspond to peak flow estimates in 2040, assuming a 65-percent I/I reduction in select sub-basins.

4.5.3.2 Hydraulic Modeling Results

I/I reduction goals for the City to meet WES' preliminary data were developed using an iterative process with the City's calibrated hydraulic model. Several iterations were simulated using a range of wastewater basins and I/I percent reduction goals.

After these numerous modeling iterations, Figure 4.13 shows the basins where I/I reduction goals reduce system peak flows from the City's system to levels close to WES' preliminary flow targets. I/I in basins 1A East, 1B West, 2A East, 2B West, 2B East, 2I, and 2C would need to be reduced by 65%, and basin 2A West would need to be reduced by 80%, as shown in Table 4.4.

Table 4.4 I/I Reduction Goals for Identified Basins

Basin	I/I Reduction Goal Percentage (%)
1A East	65
1B West	65
2A East	65
2A West	80
2B East	65
2B West	65
2C	65
2I	65

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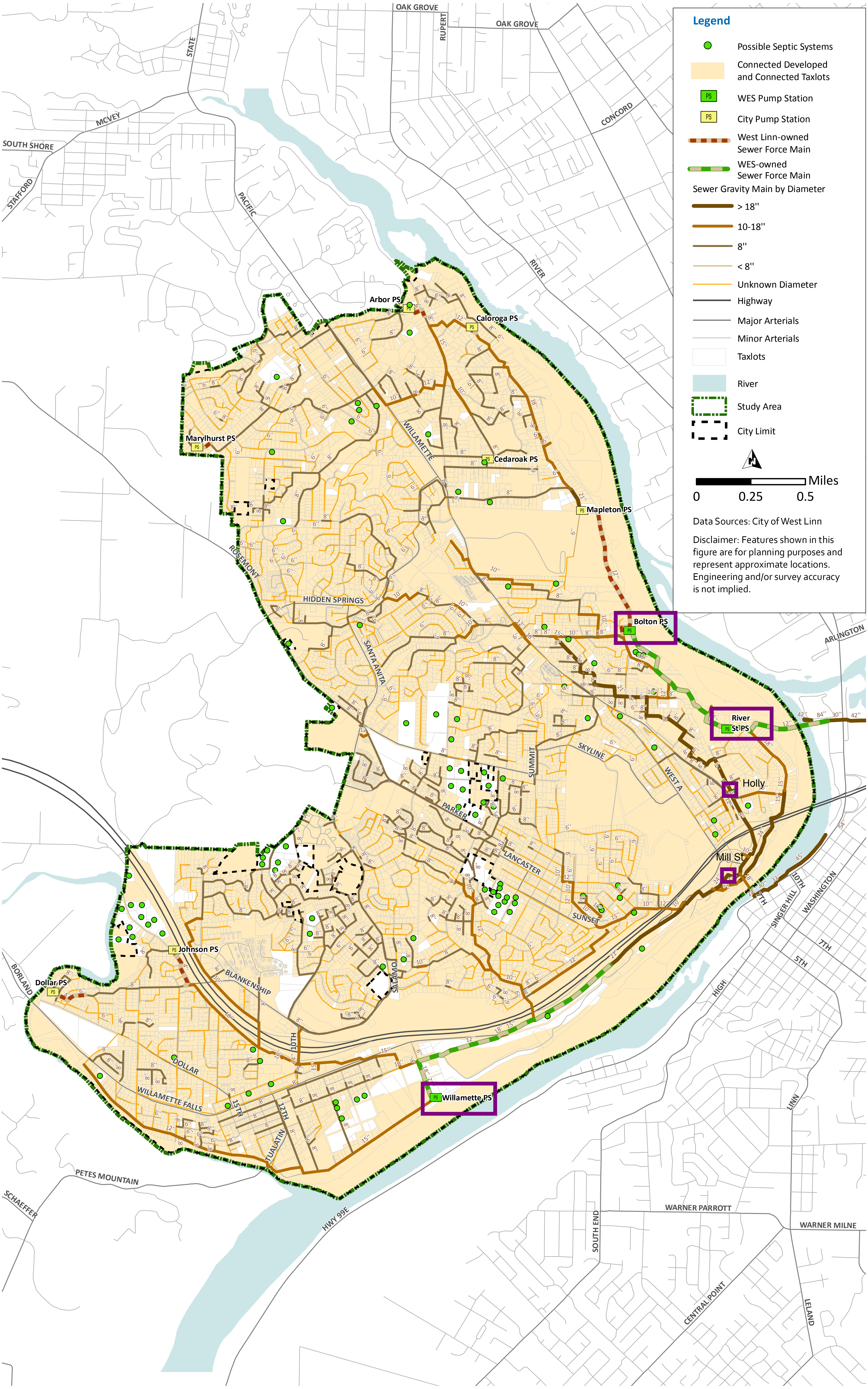

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Figure 4.13 WES Control Points Locations

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4.5.3.3 I/I Reduction Recommendations

Further collaboration between the City and WES to refine and clarify future assumptions and I/I reduction goals is highly recommended. The City's capacity analysis presented in Section 4.1 did not show significant capacity deficiencies in the collection system that would trigger an extensive I/I program need. Further coordination should confirm flow reduction targets and assumptions. Further investigation of the cost of treatment and conveyance versus the cost of implementing I/I reduction strategies is needed.

Based on modeling results, preliminary data available from WES at the time of the development of this SMMP and high expense ($99.3 M – see details in TM No.4) to implement an I/I program to meet WES' preliminary flow targets, it is not recommended that the City pursue an extensive I/I program at this time with a full Sanitary Sewer Evaluation Survey (SSES). It is, however, highly recommended that the City and WES coordinate further to refine and clarify preliminary target assumptions.

In the meantime, it is recommended that the City focus its CCTV and repair and replacement annual programs in the following basins. These basins showed the most I/I in the City's system. Annual CCTV should help the City focus its repair and replacement effort in these basins, and in return, will help decrease I/I in these areas:

- Basin 1A West
- Basin 2B East
- Basin 1B West
- Basin 1A East
- Basin 2A West
- Basin 2I

Given the relatively elevated I/I parameters identified in these basins, especially Basin 1A West, it is recommended that the City prioritize these wastewater basins for condition and repair and replacement (Project G-1 in the CIP). CCTV and repair and replacement in these basins will iultimately decrease flows from I/I.

4.5.4 Program Cost Estimates

Cost estimates were developed for meeting the target I/I reduction goals for each basin. The estimates include costs for the sanitary sewer evaluation surveys (to isolate the causes of I/I and select the appropriate I/I reduction technique(s)), implementing I/I reduction techniques, and program administration. Costs are at a planning level (+50/-30 percent of accuracy) and would require further refinement during project implementation. Appendix 4A presents the detailed assumptions and detailed cost estimates for each basin.

The I/I reduction project costs include assumptions for either public sewer main replacement, lateral replacement, direct disconnects, or a combination thereof to match the techniques studied by King County. Because it is unknown what technique will be employed at each basin until the SSES is completed for each basin, an average cost for all applicable methods was used. Thus, the cost for each basin is the average cost of applying each technique for that basin.

4.5.4.1 Assumptions

The following assumptions were used to develop the cost estimates for each basin's I/I reduction program:

- The number of laterals per basin is assumed to be equal to the number of taxlots connected to the sewer in that basin.
- The average length of a lateral is assumed to be 90 feet. It is assumed that the laterals are privately owned. The City considers the entire connection from the house to sewer main as the lateral.
- The percentage of pipes, laterals, and direct disconnects to be impacted by Techniques 1 through 4 are applied to the total length of pipes and laterals in each basin multiplied by the percent of basin to be targeted (estimated from I/I reduction targets).
- The total number of feet of pipe to be included in CCTV inspections, smoke testing, and flow isolation is dependent on the selected I/I reduction technique. It is assumed that 50 percent of the total length of all mains and laterals impacted by the selected technique from Table 4.3 will be included in physical inspections. This assumption reflects the concept that additional flow monitoring during the SSES will reduce the required amount of physical inspections by 50 percent.
- The number of direct connections is assumed to be two per 1,000 LF of wastewater piping.
- Cured-in-place plastic (CIPP) is assumed to be used for repair and replacement of pipes.
- Temporary flow monitoring assumes two months of flow monitoring, with an installation cost of $1,000, monthly rental cost of $500, and monthly data analysis cost of $800 per meter.

4.5.4.2 Unit Costs

Table 4.5 summarizes the estimated unit costs for the SSES, permanent flow monitoring, and I/I reduction projects. The unit costs were multiplied by the quantities of each element assumed for each basin, as shown in Appendix 4A. The resulting costs are referred to as the Baseline Construction Costs. Baseline Construction Costs were increased by several cost factors to determine an Estimated Construction costs:

- 30 percent construction contingency;
- 5 percent traffic control and utility relocation costs;
- 20 percent planning contingency.

Estimated construction costs were increased by additional cost factors to estimate a total program cost:

- 25 percent engineering, permitting, and project administration. Program administration includes costs associated with City staff time to oversee the SSES, refine the recommended programs for each basin, evaluate the effectiveness of I/I reduction techniques, and public education/outreach.
- 10 percent construction administration.

Additional details and assumptions can be found in TM 5 – CIP. Cost factor markups were not applied to the Direct Costs for the SSES.

As noted, some of these costs are from the results of the King County Regional I/I Control Program. These costs have been increased using the ratio of the Engineering News Report (ENR) 20-Cities Construction Cost Index (CCI) for November 2005 (7,628) to September 2018 (11,170). This index is used to estimate and update cost at the time of the study.

Table 4.5 I/I Reduction Program Cost Assumptions

Item	Element		Unit Cost(4)
Sanitary Sewer Evaluation Survey	CCTV Inspections Smoke Tests/Flow Isolation		$3.50/LF $1.20/LF
	Temporary Flow Monitoring(1)	Installation Monthly Rental Fee Monthly Maintenance and Data Analysis	$1,000 Ea $500 Ea/Mo $800 Ea/Mo
I/I Reduction Projects	Direct Disconnects(2) Replace Wastewater Mains(3) Replace Laterals(2)		$4,400 Ea $150/LF $10,800 Ea

Notes:
(1) Costs from ADS Environmental Services.
(1) Costs updated from King County Regional I/I Control Program Benefit/Cost Analysis Report, Earth Tech Team, November 2005, p. 3-33.
(2) Costs from recent projects. Average of pipe sizes; includes mobilization, traffic control, erosion control, pollution control, service reinstatement.
(3) Ea = Each, LF = Linear Foot, Yr = Year, Mo = Month.

4.5.4.3 Program Costs

Table 4.6 presents the costs estimated for achieving the desired I/I reduction in the City's focus basins defined in Section 4.5.3.3. Based on the percentage reduction required, one of the four applicable techniques shown in Table 4.3 was selected. The percentage of the basin for the technique to be applied was determined based on the effectiveness of the technique and the required reduction percentage. For example, Technique 2 results in an I/I reduction of 80 percent. Total quantities for rehab were calculated based on the percentage of the basin a technique was applied to and the percentages of rehab for each technique, as shown previously in Table 4.3. For basins where more than technique could be used to achieve the desired percent reduction goals, the costs of the techniques were averaged.

As seen in the table below, the recommended I/I Reduction Program requires a significant investment to meet the established flow reduction targets. To achieve the target reductions identified to be within WES flow targets, an I/I reduction program is anticipated to cost $99.3 M.

Table 4.6 I/I Reduction Program Costs Summary

Basin	Target Percent Reduction Goal	Total Program Cost
1A East	65%	$5,300,000
1B West	65%	$8,300,000
2A East	65%	$4,200,000
2A West	80%	$16,200,000
2B East	65%	$13,200,000
2B West	65%	$34,700,000
2C	65%	$$9,600,000
2I	65%	$7,500,000
Total		$99,300,000

It is assumed that ownership and maintenance of the sewer laterals (from house to City sewer main) are placed on the property owners, costs for improving laterals were isolated from the overall program costs to estimate what share of the program costs the City would pay. Private system costs were estimated to be $47.5 (48 percent), and public system costs are estimated to be $51.9 M (52 percent) of the overall program cost. This breakdown assumes all program administration costs are still paid for by the City.

4.6 Summary

This TM summarized both collection system capacity evaluation and I/I reduction program. The analysis showed that the City' system has limited deficiencies identified, and therefore recommended projects. Additionally, the analysis revealed that the City has relatively low inflow and infiltration in much of the system, with the majority of I/I in the center and eastern portion of the City.

Further collaboration between the City and WES to refine and clarify future assumptions and I/I reduction goals is highly recommended. The City's capacity analysis presented in Section 4.1 did not show significant capacity deficiencies in the collection system that would trigger an extensive I/I program need. Further coordination should confirm flow reduction targets and assumptions. Further investigation of the cost of treatment and conveyance versus the cost of implementing I/I reduction strategies is needed.

In the meantime, it is recommended that the City focus its CCTV and repair and replacement annual programs in the following basins. These basins showed the most I/I in the City's system. Annual CCTV should help the City focus its repair and replacement effort in these basins, and in return, will help decrease I/I in these areas:

- Basin 1A West.
- Basin 2B East.
- Basin 1B West.
- Basin 1A East.
- Basin 2A West.
- Basin 2I.

Given the relatively elevated I/I parameters identified in these basins, especially Basin 1A West, it is recommended that the City prioritize these wastewater basins for condition and repair and replacement (Project G-1 in the CIP). CCTV and repair and replacement in these basins will ultimately decrease flows from I/I.

Appendix 4A

DETAILED COST ESTIMATE

City of West Linn I/I Reduction Program
Detailed Cost Estimate

	Technique	SSES				Permanent Flow Monitoring[2]	I/I Reduction Projects													Total Program Cost	Total Program Cost
		CCTV Inspections	Smoke Testing/ Flow Isolation	Temporary Meter[1]	Total SSES		Sewer Main Rehab	Laterals	Laterals/ Side Sewers	Side Sewers	Direct Disconnects	Baseline Construction Cost	Construction Contingency	Traffic Control/Utility Relocation	Planning Contingency	Estimated Construction Cost	Engineering/Permitting/Project Administration	Construction Administration	I/I Improvements Project Cost		
Unit Costs		$3.50	$1.20	$3,600.00		$1,500	$150	$5,700	$10,000	$5,100	$4,400										
Basin		LF	LF	EA		EA	LF	EA	EA	EA	EA		30%	5%	20%		25%	10%			
1A East	2	$33,916	$11,628	$3,600	**$50,000**	**$0**	$1,246,612	$0	$1,230,000	$0	$4,400	**$2,481,012**	$744,300	$124,100	$496,200	**$3,896,000**	$974,000	$389,600	**$5,260,000**	**$5,300,000**	**$5,300,000**
	3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Average					**$50,000**	**$0**						**$2,481,012**	$744,304	$124,100	$496,200	**$3,896,000**	$974,000	$389,600	**$5,260,000**	**$5,300,000**	**$5,300,000**
1B West	2	$53,578	$18,369	$3,600	**$76,000**	**$0**	$1,784,368	$0	$2,080,000	$0	$8,800	**$3,873,168**	$1,162,000	$193,700	$774,600	**$6,079,000**	$1,519,800	$607,900	**$8,207,000**	**$8,300,000**	**$8,300,000**
	3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Average					**$76,000**	**$0**						**$3,873,168**	$1,161,951	$193,700	$774,600	**$6,079,000**	$1,519,800	$607,900	**$8,207,000**	**$8,300,000**	**$8,300,000**
2A East	2	$26,589	$9,116	$3,600	**$40,000**	**$0**	$1,010,024	$0	$940,000	$0	$4,400	**$1,954,424**	$586,300	$97,700	$390,900	**$3,069,000**	$767,300	$306,900	**$4,143,000**	**$4,200,000**	**$4,200,000**
	3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Average					**$40,000**	**$0**						**$1,954,424**	$586,327	$97,700	$390,900	**$3,069,000**	$767,300	$306,900	**$4,143,000**	**$4,200,000**	**$4,200,000**
2A West	2	$105,526	$36,180	$7,200	**$149,000**	**$0**	$3,253,605	$0	$4,290,000	$0	$8,800	**$7,552,405**	$2,265,700	$377,600	$1,510,500	**$11,855,000**	$2,963,800	$1,185,500	**$16,004,000**	**$16,200,000**	**$16,200,000**
	3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Average					**$149,000**	**$0**						**$7,552,405**	$2,265,721	$377,600	$1,510,500	**$11,855,000**	$2,963,800	$1,185,500	**$16,004,000**	**$16,200,000**	**$16,200,000**
2B East	2	$90,634	$31,075	$7,200	**$129,000**	**$0**	$2,436,134	$0	$3,950,000	$0	$8,800	**$6,394,934**	$1,918,500	$319,700	$1,279,000	**$10,041,000**	$2,510,300	$1,004,100	**$13,555,000**	**$13,700,000**	**$13,700,000**
	3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Average					**$129,000**	**$0**						**$6,394,934**	$1,918,480	$319,700	$1,279,000	**$10,041,000**	$2,510,300	$1,004,100	**$13,555,000**	**$13,700,000**	**$13,700,000**
2B West	2	$223,576	$76,655	$14,400	**$315,000**	**$0**	$7,675,144	$0	$8,510,000	$0	$22,000	**$16,207,144**	$4,862,100	$810,400	$3,241,400	**$25,436,000**	$6,359,000	$2,543,600	**$34,339,000**	**$34,700,000**	**$34,700,000**
	3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Average					**$315,000**	**$0**						**$16,207,144**	$4,862,143	$810,400	$3,241,400	**$25,436,000**	$6,359,000	$2,543,600	**$34,339,000**	**$34,700,000**	**$34,700,000**
2C	2	$61,934	$21,234	$3,600	**$87,000**	**$0**	$2,082,091	$0	$2,390,000	$0	$8,800	**$4,480,891**	$1,344,300	$224,000	$896,200	**$7,032,000**	$1,758,000	$703,200	**$9,493,000**	**$9,600,000**	**$9,600,000**
	3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Average					**$29,000**	**$0**						**$4,480,891**	$1,344,267	$224,000	$896,200	**$6,974,000**	$1,743,500	$697,400	**$9,415,000**	**$9,400,000**	**$9,400,000**
2I	2	$48,226	$16,534	$3,600	**$69,000**	**$0**	$1,690,121	$0	$1,810,000	$0	$4,400	**$3,504,521**	$1,051,400	$175,200	$700,900	**$5,501,000**	$1,375,300	$550,100	**$7,426,000**	**$7,500,000**	**$7,500,000**
	3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Average					**$69,000**	**$0**						**$3,504,521**	$1,051,356	$175,200	$700,900	**$5,501,000**	$1,375,300	$550,100	**$7,426,000**	**$7,500,000**	**$7,500,000**

Total	$99,500,000	$99,500,000

Notes:

1. Used to identify location of flow. Assumes two months per meter.
2. Assumes 20 years of maintenance and data collection

Attachment E

TECHNICAL MEMORANDUM 5: CAPITAL IMPROVEMENT PLAN

City of West Linn
Sanitary Sewer Master Plan Update

TECHNICAL MEMORANDUM 5
CAPITAL IMPROVEMENT PLAN

DRAFT | March 2019

carollo

City of West Linn
Sanitary Sewer Master Plan Update

TECHNICAL MEMORANDUM 5
CAPITAL IMPROVEMENT PLAN

DRAFT | March 2019

This document is released for the purpose of information exchange review and planning only under the authority of
Matthew M. Huang,
March 18, 2018,
State of Oregon, P.E. No. 91512.

Contents

Tables

Figures

Abbreviations

AACE	Association for the Advancement of Cost Engineering
CIP	capital improvement plan
Carollo	Carollo Engineers, Inc.
City	City of West Linn
ENR	Engineering News-Record
G	General
P	Pipeline Projects
PS	Pump Stations
ROW	Right of Way
TM	Technical Memorandum

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Technical Memorandum 5

CAPITAL IMPROVEMENT PLAN

5.1 Introduction

This Technical Memorandum (TM) describes the City of West Linn's (City's) capital improvement plan (CIP) for the sanitary sewer system that is based on the analyses presented in previous TMs. The purpose of the CIP is to provide the City with a guideline for planning and budgeting for improvements to its sanitary sewer system. The CIP consists of cost estimates and timing for each project.

5.1.1 Capital Project Categories

Capital projects were categorized by the nature of infrastructure:

- Pipeline Projects (P)
- Pump Stations (PS)
- General (G)

The above abbreviations were used as the initial letter(s) to identify projects and aid in delineating the project category. Pipeline projects include specific gravity main projects in the collection system. Pump Station projects include specific pump station and force main projects. General projects mainly include non-specific system-wide projects or recommended plans and studies. General projects may include pipeline replacement or repair, but without any specific location (i.e. percent of basin, linear feet per year).

5.1.2 Project Prioritization

CIP projects were prioritized based on the urgency to mitigate existing deficiencies and to service anticipated growth. The CIP projects were separated into three phases based on project priority:

- High Priority (2019-2023)
- Medium Priority (2024-2028)
- Low Priority (2029-2038)

5.2 Cost Estimating Assumptions

The CIP cost estimates were developed from cost curves, information obtained from previous studies, and experience from other projects. Estimated project quantities were developed in TM 4. All CIP cost estimates presented in this TM are Association for the Advancement of Cost Engineering (AACE) Class 4 estimates. Class 4 cost estimates of this type are order of magnitude estimates; actual costs may vary from these estimates by minus 30 percent to plus 50 percent. These costs were determined based on the City's and Carollo Engineers, Inc.'s (Carollo's) perception of current conditions at the project locations.

All cost estimates were made using September 2018 dollars. The Engineering News-Record (ENR) U.S. 20-City Construction Cost Index for September 2018 is 11,170. Cost estimates are subject to change as the project design matures. Cost of labor, materials, and equipment may vary in the future.

5.2.1 Baseline Construction Cost

Construction cost of project under normal conditions and schedules. Baseline construction costs were calculated by multiplying estimated project quantities by the unit cost.

5.2.2 Estimated Construction Cost

The Estimated Construction Cost consists of the Baseline Construction Cost and the following multipliers applied to Baseline Construction Cost:

- Construction Contingency (30 percent) – Costs that may occur due to unknowns in site-specific construction conditions, unforeseen items, and variations in final quantities.
- Planning Contingency (20 percent) – Costs associated with any unknown conditions in the design process that have not been identified during high-level planning.
- Traffic Control/Utility Relocation (5 – 10 percent) – Project location dependent costs for project traffic control/utility relocation.

5.2.3 Capital Improvement Cost

The Capital Improvement Cost consists of the Estimated Construction Cost with the following multipliers applied on top of the Estimated Construction Cost:

- Engineering/Permitting/Project Administration (25 percent) – Costs associated with project engineering and project administration. Engineering services include preliminary investigations and reports, Right of Way (ROW) acquisition, foundation exploration, preparation of drawings and specifications for bidding and construction, surveying and staking, and start-up services. Permitting and project administration include costs for project permits, legal fees, and other City staff administrative costs during construction.
- Construction Administration (10 percent) – Costs associated with construction phase professional services such as construction management and inspection during construction.

The following shows a sample calculation to determine the capital improvement cost for a project with a baseline construction cost of $1,000,000. The costs of all contingencies and multipliers is 116 percent of the baseline construction cost:

Baseline Construction Cost	**$1,000,000**
Construction Contingency (30%)	$300,000
Planning Contingency (20%)	$200,000
Traffic Control/Utility Relocation (10%)	$100,000
Estimated Construction Cost	**$1,600,000**
Engineering/Permitting/Project Administration (25%)	$400,000
Construction Administration (10%)	$160,000
Capital Improvement Cost	**$2,160,000**

5.2.4 Pipeline Unit Costs

Baseline construction unit costs for pipelines are presented in Tables 5.1 through 5.3. Gravity main pipeline unit costs are presented in Table 5.1, force main pipeline unit costs are presented in Table 5.2, and highway crossing pipeline unit costs are presented in Table 5.3. All pipeline unit costs assume open-trench construction and include pavement cutting, excavation, hauling, shoring, pipe materials and installation, backfill material and installation, and pavement replacement. These unit costs represent typical field conditions with construction in stable soil at a depth ranging from 10 to 15 feet for gravity mains and construction in stable soil at a depth ranging from 3 to 5 feet for force mains. Acquisition, easements, and right-of-way (ROW) may be required for some of the recommended projects. For the purpose of these cost estimates, pipeline corridors were assumed to be in public ROW, and do not require land acquisition.

Pipe sizes up to 21-inches with casings up to 42-inches in diameter were included for evaluating the crossing of I-205. Unit costs for pipeline casings are shown in Table 5.3, the sizes represent both pipeline diameter and associated casing size.

Table 5.1 Gravity Main Unit Costs

Pipe Size (inches)	Unit Construction Cost ($/LF)
8	$140
10	$160
12	$165
18	$200
24	$275
30	$325

Table 5.2 Force Main Unit Costs

Pipe Size (inches)	Unit Construction Cost ($/LF)
4	$145
6	$150
8	$155
10	$160
12	$165
24	$335

Table 5.3 Highway Crossing Unit Costs

Pipe Size/Casing Size (inches)	Unit Construction Cost ($/LF)
12/24	$990
15/30	$1,235
21/42	$1,730

5.2.5 Pump Station Costs

Costs for pump station projects were determined using a pump station cost curve shown in Figure 5.1. The costs shown in this curve were taken from recent pump station rehabilitation projects. Actual construction costs are highly variable and dependent on actual project conditions. However, the trend line correlates well for the range of total pump station flows being considered in the CIP. The pump station cost curve provides the total construction cost, including construction contingency. Cost factors for construction contingency and the traffic control/utility relocation were not applied to costs estimated from the pump station cost curve.

Other cost factors for planning contingency, engineering/permitting/project administration, and construction administration were applied to the total construction cost determined from the curve.

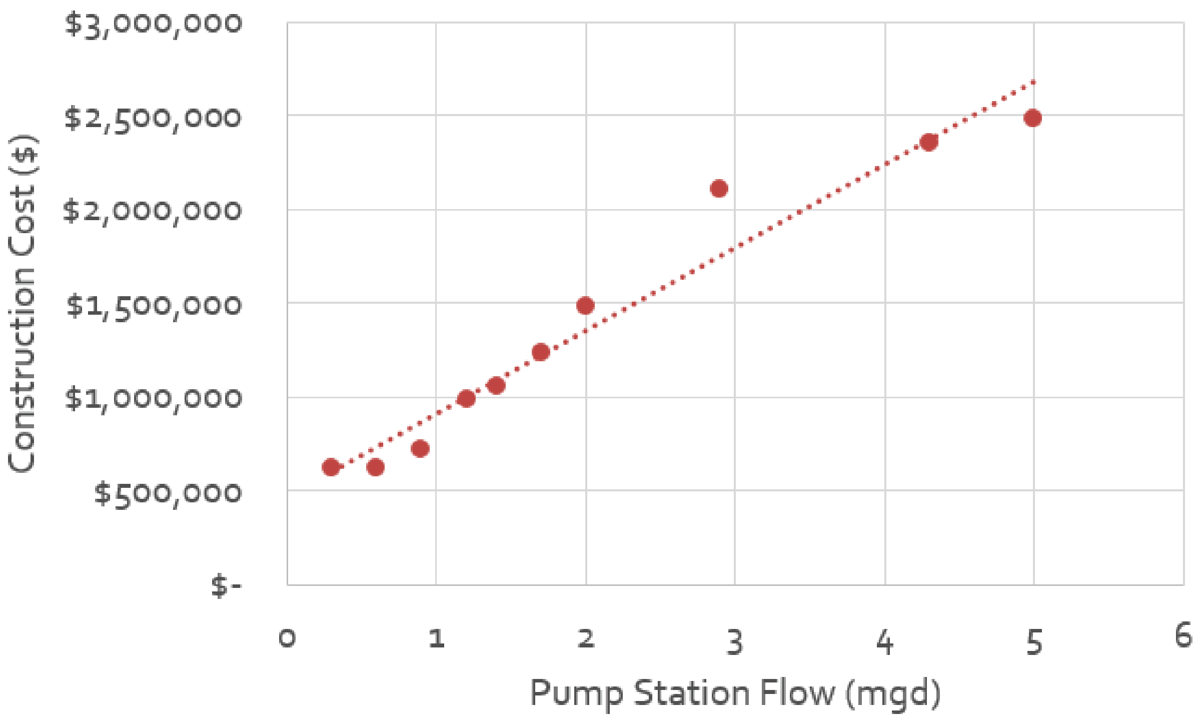

Figure 5.1 Pump Station Cost Curve

5.3 Capital Improvement Plan

5.3.1 Capital Improvement Plan Overview

This section present a summary of the proposed sanitary sewer system CIP. As detailed in Section 5.1, the proposed projects are divided into three main project types: pipelines, pump stations, and general.

Table 5.4 and Table 5.5 summarize total CIP costs by project type and priority. Table 5.4 summarizes CIP costs assuming the City only completes the capacity improvements identified in TM 4, and does not move forward with the comprehensive I/I program detailed in TM 4.

Table 5.5 summarizes total CIP costs assuming the comprehensive I/I reduction program is pursued and the reduction in I/I alleviates the need for capacity improvements projects in Basin 2B East (medium priority projects).

Table 5.4 Option A (No I/I Program) CIP Overview Costs

	High Priority Cost ($)	Medium Priority Cost ($)	Low Priority Cost ($)	Total Cost ($)
Pipeline (P)	$ 2,363,000	$ 2,330,000	$ 1,320,000	$ 6,013,000
Gravity Main	$ 2,363,000	$ 1,113,000	$ 1,320,000	$ 4,796,000
Force Main	$ –	$ 1,217,000	$ –	$ 1,217,000
Pump Station (PS)	$ 1,049,000	$ 4,254,000	$ –	$ 5,303,000
Planning (PL)	$ 100,000	$ 200,000	$ 300,000	$ 600,000
General (G)	$ 5,947,000	$ 5,947,000	$ 11,895,000	$ 23,789,000
Total	$ **9,459,000**	$ **12,731,000**	$ **13,515,000**	$ **35,705,000**

Table 5.5 Option B (with I/I Program) CIP Overview Costs

	High Priority Cost ($)	Medium Priority Cost ($)	Low Priority Cost ($)	Total Cost ($)
Pipeline (P)	$ 2,363,000	$ 1,528,000	$ 1,320,000	$ 5,211,000
Gravity Main	$ 2,363,000	$ $311,000	$ 1,320,000	$ 3,994,000
Force Main	$ –	$ 1,217,000	$ –	$ 1,217,000
Pump Station (PS)	$ 1,049,000	$ 4,254,000	$ –	$ 5,303,000
Planning (PL)	$ 100,000	$ 200,000	$ 300,000	$ 600,000
General (G)	$ 6,047,000	$ 54,947,000	$ 60,895,000	$ 121,889,000
Total	$ **9,459,000**	$ **60,929,000**	$ **62,515,000**	$ **132,903,000**

The total Option A (no I/I program) CIP cost is estimated to be $35.7M, or $1,785,000 per year. Figure 5.2 provides a graphical breakdown of project costs by project type for the Option A CIP and Figure 5.3 provides a graphical breakdown of project costs by project timing.

The total Option B CIP (with comprehensive I/I program) is estimated to be $132.9 M, or $6,645,000 per year. Figure 5.4 and Figure 5.5 provide graphical breakdowns of Option B CIP costs by project type and priority, respectively. Due to the high expense of an I/I program, and the fact that an extensive I/I program will not significantly reduce projects recommended in the CIP, it is not recommended that the City pursue an I/I program at this time to meet City needs. An I/I program may be necessary to meet WES flow targets, however, in the meanwhile, it is recommended that the City target high I/I areas as part of its ongoing pipeline replacement program.

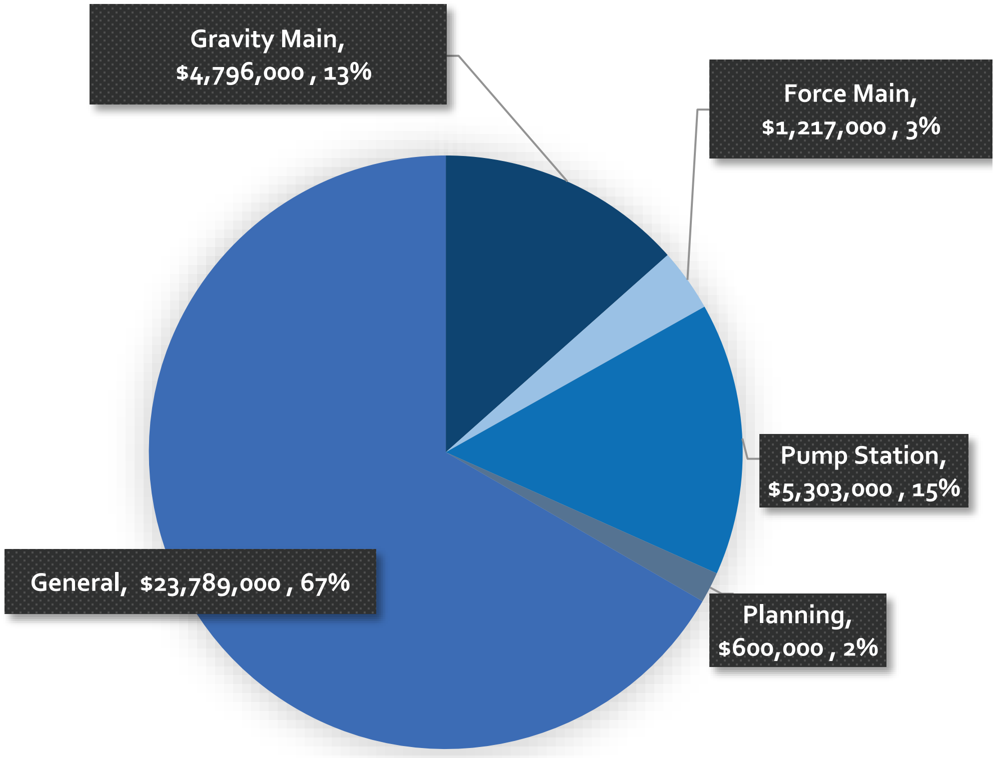

Figure 5.2 Option A (No I/I Program) CIP Costs by Project Type

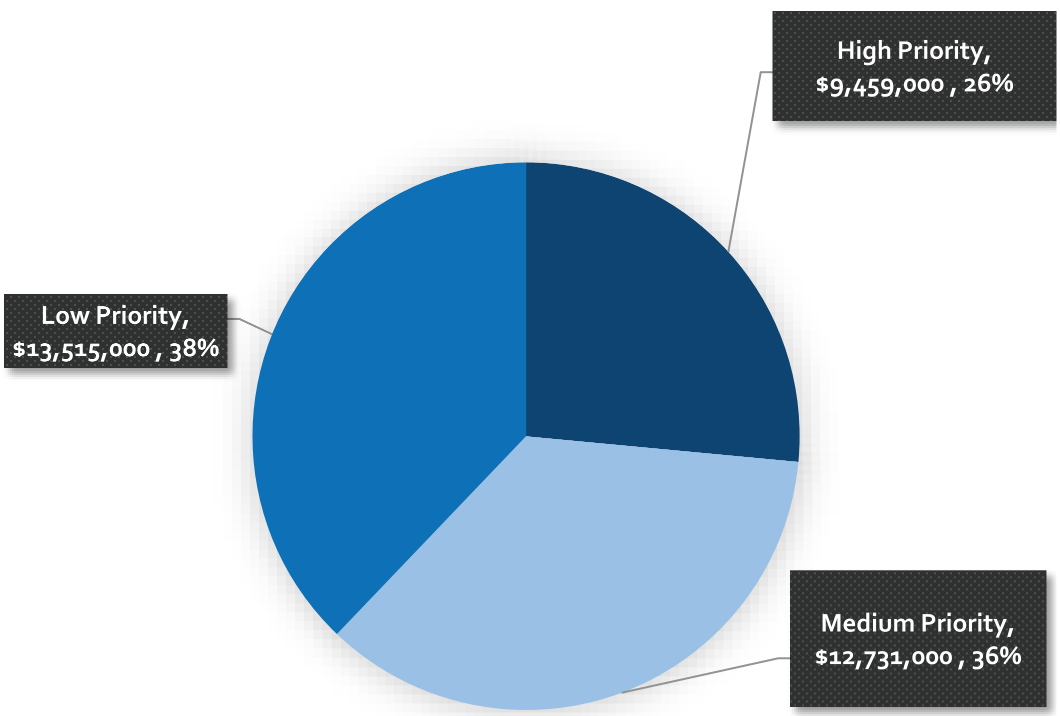

Figure 5.3 Option A (No I/I Program) CIP Costs by Project Priority

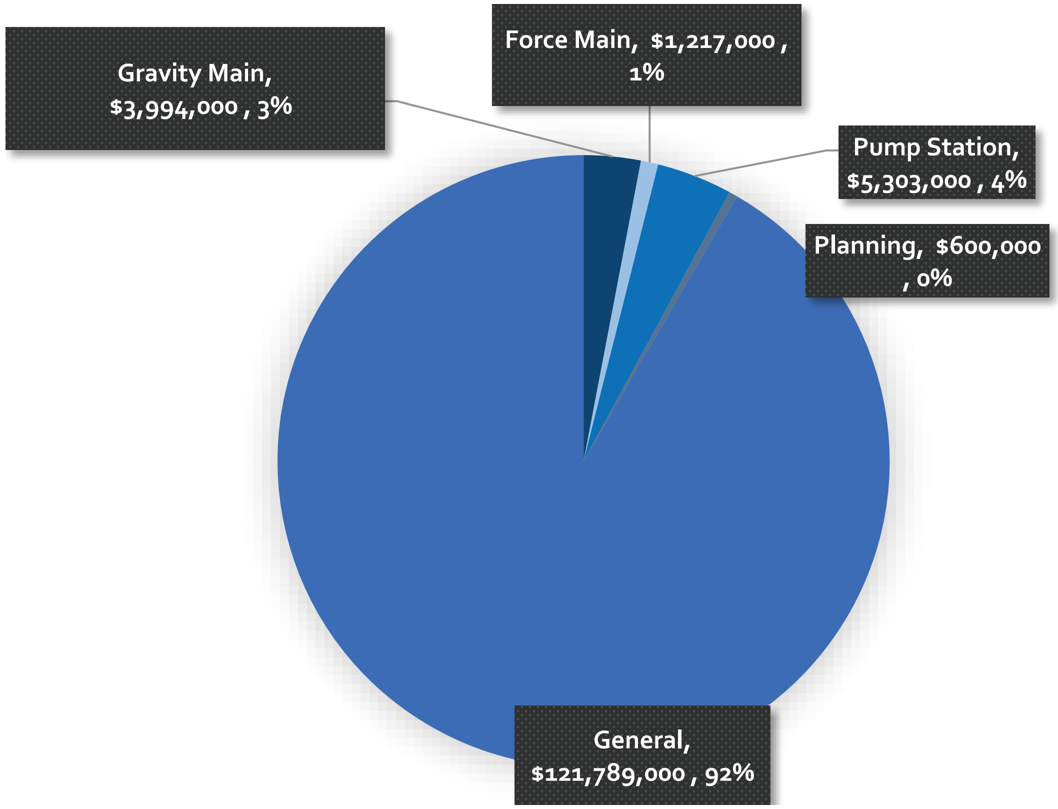

Figure 5.4 Option B (with I/I Program) CIP Costs by Project Type

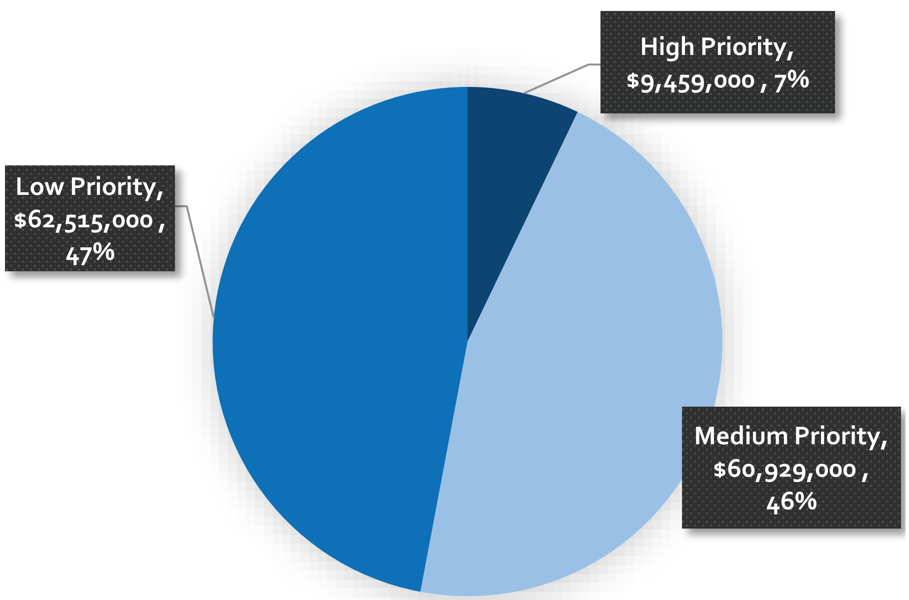

Figure 5.5 Option B (with I/I Program) CIP Costs by Project Priority

5.3.2 Pipeline Projects

Pipeline projects are broken down into two categories: gravity main projects and force main projects. Details on both types of projects are provided below. The locations of all CIP projects are shown in Figure 5.6, with project prioritization shown in Figure 5.7.

5.3.2.1 Gravity Main Projects

I-205 Crossing (P-1)

The existing I-205 crossing acts as a bottleneck in the collections system due to inadequately sized pipes in the area. Hydraulic deficiencies were identified under existing conditions, and are amplified with additional flow in the basin under build-out conditions. Project P-1 is located in wastewater basin 9B and consists of upsizing 2,520 feet of existing 10-inch gravity main to 15-inch gravity main running parallel to 1-205 southwest of the Willamette Terrace Apartments and crossing I-205 at 13th Street. This includes 617 feet of highway crossing with 15-inch pipe and a 30-inch casing. This is a high priority project and is estimated to cost $2,363,000.

Wellington Drive (P-2)

Project P-2 is located in wastewater basin 9A and consists of upsizing 425 feet of existing 10-inch gravity main to 12-inch gravity main crossing Wellington Drive near the intersection of Wellington Drive and Wellington Court. This project resolves a deficiency identified under the build-out condition. This section of pipe is identified as deficient mainly due to a relatively flat slope section, which causes the hydraulic grade line (HGL) to rise above the one-foot above pipe crown criteria. No deficiencies are identified under existing condition, therefore, it is recommended that the City monitor this area as flows increase and system degrades in the future.

This is a low priority project to be addressed in the long-term and is estimated to cost $147,000.

Willamette Drive (P-3)

Project P-3 is located in wastewater basin 2B and consists of upsizing 614 feet of existing 12-inch gravity main to 15-inch gravity main along Willamette Drive between Magone Lane and Pimlico Drive. In addition, 69 feet of 15-inch gravity main is to be upsized to 18-inch gravity main along Dillow Drive from Willamette Drive to Tulane Street. This project resolves deficiencies identified under existing conditions due to relatively flat slopes for both sections of pipe. Both sections of pipe are surrounded by steeper sections upstream and downstream, a configuration that typically triggers the HGL to rise in the flat portions of the system.

This is a medium priority project and is estimated to cost $269,000. Note, this project is located in a basin (wastewater basin 2B), where an I/I reduction program might be recommended that could mitigate the need for this improvement.

Palomino Circle (P-4)

Project P-4 is located in wastewater basin 2B and consists of upsizing 508 feet of existing 8-inch gravity main running northwest of Palomino Circle and north of Pimlico Drive to the main southeast of Bronco Court to 12-inch gravity main. This section of pipe was identified as deficient under build-out conditions, with the deficiency caused mainly by a relatively flat slope section that causes the HGL to rise above the one-foot above pipe crown criteria.

This is a low priority project to be addressed in the long-term and is estimated to cost $175,000.

Larson Ave (P-5)

Project P-5 is located in wastewater basin 2B and consists of upsizing 1,162 feet of existing 8-inch gravity main to 12-inch gravity main along Larson Avenue from Tulane Street to Jolie Point Road and along Jolie Point Road to Munger Drive. This section of pipe was identified as deficient under existing conditions, with the deficiency caused mainly by a relatively flat slope section that causes the HGL to rise above the one-foot above pipe crown criteria. Additionally, modeling shows that the entire section is capacity deficient based on PWWF. I/I degradation and development are anticipated to amplify this problem.

This is a medium priority project and is estimated to cost $401,000. Note, this project is located in a basin (wastewater basin 2B), where an I/I reduction program might be recommended that could mitigate the need for this improvement.

Dillow Drive and Maple Terrace (P-6)

Project P-6 is located in wastewater basin 2B and consists of upsizing 351 feet of existing 10-inch gravity main to 15-inch gravity main between Dillow Drive and Maple Terrace. This project is triggered by deficiencies highlighted in the existing condition, and deficiencies are anticipated to be amplified once project P-5 is completed and with the addition of flows caused by growth and system aging. Additionally, this section of pipe is relatively flat, which causes the HGL to rise up quickly.

This is a medium priority project and is estimated to cost $132,000. Note, this project is located in a basin (wastewater basin 2B), where an I/I reduction program might be recommended that could mitigate the need for this improvement.

Nixon Ave (P-7)

Project P-7 is located in wastewater basin 3A and consists of upsizing 1,522 feet of existing 18-inch gravity main to 24-inch gravity main along Nixon Avenue from north of Island View Way to Calaroga Court. This project is triggered by deficiencies identified under build-out. The City's effort to relining sewer lines in wastewater basin 3A decreased I/I rates in the northern part of the system significantly. The previous Master Plan, completed prior to these upgrades, showed high I/I and deficiencies in this area. It is recommended that the City monitor this area as the system degrades over time.

This low priority project is recommended for the long-term and is estimated to cost $876,000.

Fairview Way (P-8)

Project P-8 is located in wastewater basin 3A and consists of upsizing 160 feet of existing 10-inch gravity main to 12-inch gravity main along Fairview Way between Rose Way and Chippewa Court. This project addresses deficiencies identified under build-out conditions.

This is a low priority project and is estimated to cost $55,000.

Failing Street (P-9)

Project P-9 is located in wastewater basin 2A and consists of upsizing 160 feet of existing 12-inch gravity main to 18-inch gravity main from Failing Street to the Bolton Pump Station. This project addresses deficiencies identified under build-out conditions. It is recommended the City monitor this area as the system grows and degrades over time.

This low priority project is estimated to cost $67,000.

Mill Street (P-10)

Project P-10 consists of relocating the sewer line in the vicinity of Mill Street, as shown in Figure 4.6. As the properties between WFD and Mill Street redevelop, this section of sewer line needs to be upgraded and realigned to the street right-of-way. This project will be part of the waterfront line project. Modeling shows no capacity issues with the existing pipe diameter, therefore, the recommendation is to replace it with the same diameter. However, when this project is triggered, this project should be evaluated in more detail and confirm pipe size and alignment. This project is anticipated as a medium priority project and is estimated to cost $311,000.

5.3.2.2 Force Main Projects

Mapleton Force Main (P-11)

Project P-11 is located in wastewater basin 3A and consists of constructing 3,750 linear feet of 8-inch force main running parallel to the existing 12-inch force main from the Mapleton Pump Station to the Bolton Pump Station. Under build-out, velocities in the force main exceed the City's criteria of 8 fps under PWWF conditions, and is considered to be deficient.

This is a medium priority project, to be completed in conjunction with the Mapleton PS improvements, and is estimated to cost $1,217,000.

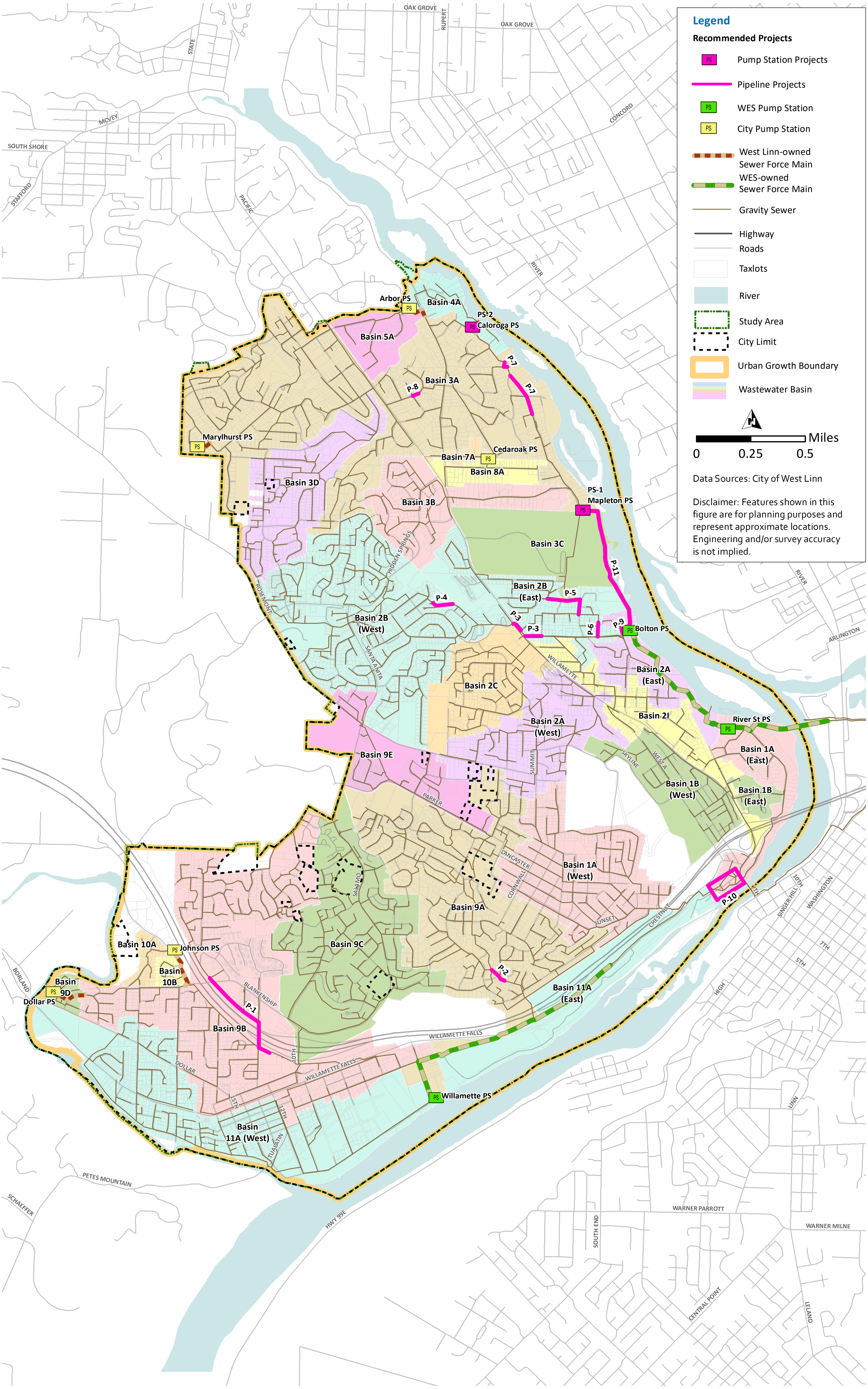

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Figure 5.6 Recommended CIP Projects

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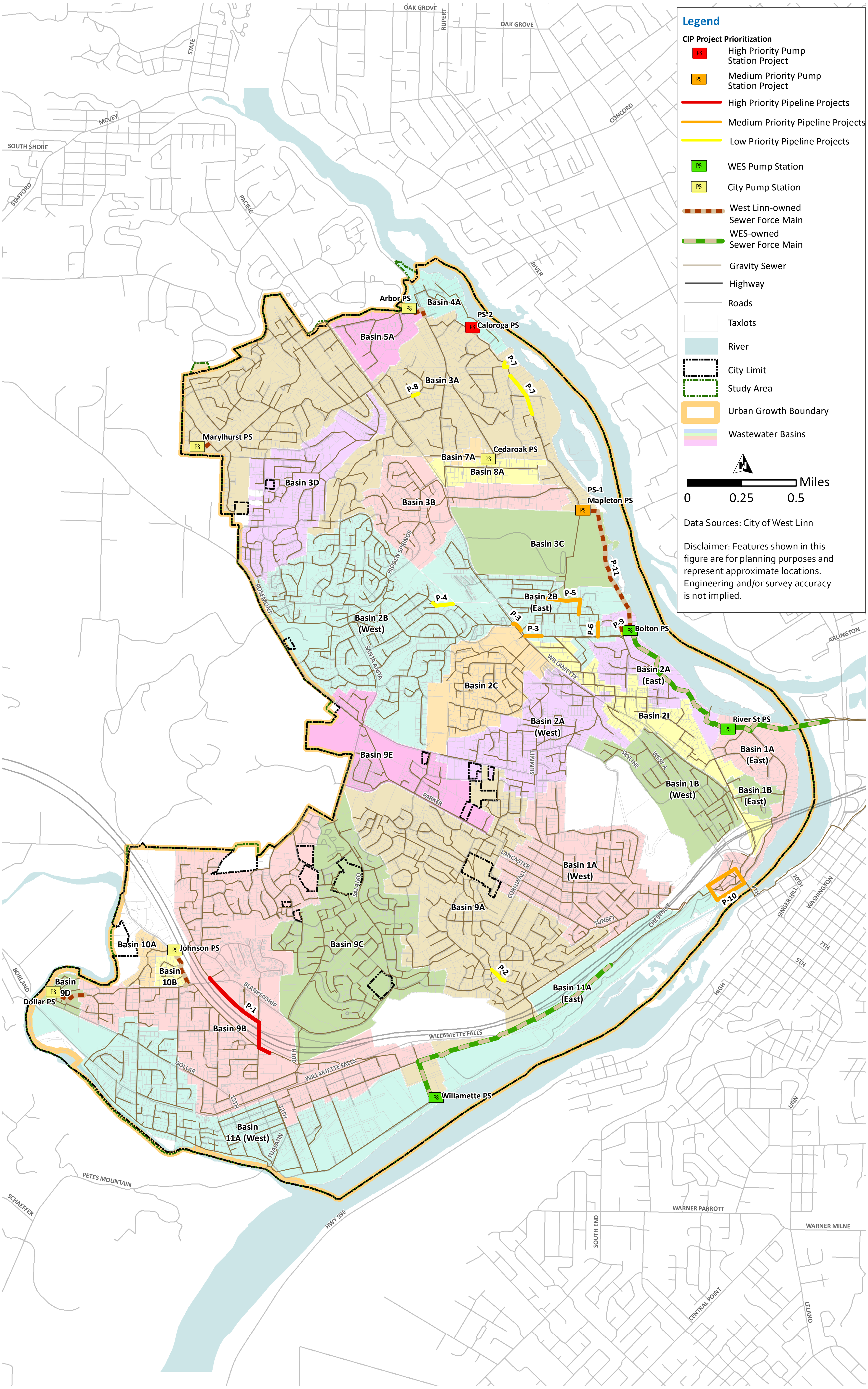

Figure 5.7 CIP Project Prioritization

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5.3.3 Pump Station Projects

5.3.3.1 Mapleton Pump Station (PS-1)

Project PS-1 consists of upgrading Mapleton Pump Station capacity from an existing 2.81 mgd (firm)/4.25 mgd (total) to 4.87 mgd firm capacity. This medium priority project is needed for the City to meet an existing firm capacity deficiency of 1.1 mgd and to provide sufficient capacity for build-out. Prior to completing this project, the City should evaluate the condition of this pump station and install a flow meter to better understand flow trends.

It is assumed this project will be completed in conjunction with the Mapleton force main project, and is estimated to cost $4,254,000.

5.3.3.2 Calaroga Pump Station (PS-2)

Project PS-2 consists of constructing a new pump station to increase Calaroga Pump Station capacity from an existing 0.06 mgd (firm)/0.12 mgd (total) to 0.19 mgd (firm)/0.40 mgd (total). A new pump station is recommended to address existing firm and total capacity deficiencies and existing issues with this pump station.

This project is estimated to cost $1,049,000.

5.3.4 Planning Projects

5.3.4.1 Asset Management Program (PL-1)

The City intends to develop an Asset Management Program (AMP) to assist in prioritizing repair and replacement of its aging wastewater infrastructure. Developing an asset management plan will help the City find the optimal timing for repair or replacement (R&R) of assets by weighing the costs of continued maintenance against the cost of R&R. Development of this plan will help prioritize projects to reduce operation and maintenance risks resulting in lower overall costs burdened by ratepayers.

It is recommended the City take the following initial steps to prepare for implementing an AMP:

- Continue to update data such as pipe material, year installed, and invert elevations, in the City's Geographic Information Systems (GIS) and Computerized Maintenance Management Software.
- Standardize condition assessments and closed-circuit television (CCTV) reports using the Pipeline Assessment and Certification Program (PACP). This may entail working with non-City contractors performing CCTV inspections. City staff could be trained on PACP scoring.
- Take the Strategic Asset Management Gap (SAM-GAP), a free, online utility self-assessment tool.

No project costs are included for these recommendations, as they are assumed to be performed by current City staff. In addition to these steps, the following strategy is recommended for the City to develop and implement an AMP:

1. Assess the City's Current Asset Management Practices.
2. Review Appropriate Asset Management Tools.
3. Identify and Prioritize Gaps in Current Asset Management Practices.
4. Prepare an Asset Management Plan.
5. Implement the Asset Management Plan.

It is anticipated full development and implementation of steps 1 through 5 will cost between $75,000 and $200,000. The more conservative estimate of $200,000 was used for planning in the CIP. Costs for implementing the projects prioritized by the AMP are assumed to come from other annual repair budgets. Development of the AMP was assumed to a medium priority project.

5.3.4.2 Sanitary Sewer Master Plan Update (PL-2)

This project assumes the City will update this Sanitary Sewer Master Plan one time in the long-term planning period. A long-term budget placeholder of $300,000 was included, with no contingencies or cost multipliers applied.

5.3.4.3 Pump Station Condition Evaluation (PL-3)

Costs for performing a condition assessment on the City's pump stations. This project is recommended for the short-term, and a budget cost of $100,000 was assumed with no contingencies or cost multipliers applied.

5.3.5 General Projects

5.3.5.1 Repair and Replacement Program (G-1)

This project allocates an annual budget of $750,000 to be used for pipeline R&R projects to effectively replace aging or failing pipe, which equates to approximately one mile of pipe per year. Projects will be identified by City staff annually, including projects identified as part of the AMP. To more cost-effectively address pipeline R&R projects, the City should consider geographically concentrated projects that address multiple concerns and incorporate other utilities, such as water main projects or roadway resurfacing.

5.3.5.2 CCTV Program (G-2)

Annual program for CCTV inspection of the City's gravity mains. This program will help the City determine pipeline condition and identify potential sources of I/I. It is assumed that the City will inspect 10 percent of the system per year, approximately 60,000 linear feet of pipeline per year. An annual budget of $440,000 was allocated throughout the planning period for this effort, assuming a unit cost of $3.50/LF for CCTV.

5.3.5.3 I/I Reduction Program (G-3)

Annual program for sanitary sewer evaluation surveys and I/I reduction projects to achieve I/I reduction targets established by WES. Total costs for this program were developed in TM 4 – System Analysis and I/I Reduction. This project covers an I/I program for both the Priority A and Priority B basins previously identified, and additional surrounding basins necessary to get results close to WES' flow targets. It assumed that the total estimated program cost of $99.M will be split evenly between medium and low priority, to be completed in the mid-term and long-term planning horizons. However, the fact that an I/I program will not significantly reduce projects recommended in the CIP, it is not recommended that the City pursue an I/I program at this time to meet City needs. An I/I program may be necessary to meet WES flow targets, however, in the meanwhile, it is recommended that the City target high I/I areas as part of its ongoing pipeline replacement program.

5.3.6 Capital Improvement Plan Details

Table 5.6 shows the City's detailed recommended CIP. This table identifies the projects, provides a brief description of the projects, facility size (e.g pipe diameter and length), project prioritization, project timing, and the reasoning for the project. The total CIP cost assuming the City moves forward with only capacity improvements and not the dedicated I/I program, are estimated to be $35,705,000 (Option A). Total CIP costs are estimated to be $132,903,000 if the I/I Reduction Program is fully implemented, and pipeline projects P-3, P-5, and P-6 are not needed to address capacity limitations.

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Table 5.6 Detailed CIP

Project ID	Improvement Type	Description	Basin ID	Firm Capacity (mgd)	Existing Diameter (inch)	Proposed Diameter (inch)	Length (ft)	Unit Cost	Total Capital Improvement Cost	Priority	Project Timing: High Priority (2019-2023)	Project Timing: Medium Priority (2024-2028)	Project Timing: Low Priority (2029-2038)	Reasoning
Pipeline														
P-1	Gravity	Parallel to I-205 southwest of Willamette Terrace Apartments. Highway crossing of I-205 at 13th Street.	9B				**2,520**	**Total**	**$2,363,000**	**High**	**$2,363,000**			This project is triggered by inadequately sized pipes, and the I-205 crossing acts as a bottleneck in the collections system. Deficiencies identified under existing conditions, and are amplified with the additional flow in the basin under build-out condition.
	Gravity				10	15	1,903	$180	$717,000					
	Casing				10	15/30	617	$1,235	$1,646,000					
P-2	Gravity	Crossing Wellington Drive near the intersection of Wellington Drive and Wellington Court.	9A				**425**	**Total**	**$147,000**	**Low**			**$147,000**	This section of pipe is identified as deficient per the City's criteria mainly due to relatively flat slope section, which causes the hydraulic grade line (HGL) to rise above the one-foot above pipe crown criteria under the build-out condition. No deficiencies are identified under existing condition, therefore, it is recommended that the City monitor this area as flows increase and system degrades in the future.
	Gravity				10	12	425	$160	$147,000					
P-3	Gravity	Along Willamette Drive between Magone Lane and Pimlico Drive. Along Dillow Drive between Tulane Street and Willamette Drive.	2B East				**683**	**Total**	**$269,000**	**Medium**		**$269,000**		This project is triggered by deficiencies highlighted in the existing condition. Both these sections of pipe are relatively flat slope pipes surrounded by steeper sections upstream and downstream. This type of configuration typically triggers the HGL to rise in the flat portions of the system. Note, this project is also located in a basin (wastewater basin 2B) where an I/I reduction program might be recommended.
	Gravity				12	15	614	$180	$239,000					
	Gravity				15	18	69	$200	$30,000					
P-4	Gravity	Running northwest of Palomino Circle and north of Pimlico Drive to main southeast of Bronco Court.	2B West				**508**	**Total**	**$175,000**	**Low**			**$175,000**	This project is triggered by deficiencies identified under the build-out condition. No deficiencies are identified under existing condition, therefore, it is recommended that the City monitor this area as flows increase and system degrades in the future. The section of pipe identified as deficient per the City's criteria is mainly caused by a relatively flat slope section, which causes the hydraulic grade line (HGL) to rise above the one-foot above pipe crown criteria.
	Gravity				8	12	508	$160	$175,000					
P-5	Gravity	Along Larson Ave to from Tualne Street to Jolie Pointe Road and along Jolie Pointe Road between Larson Ave and Munger Drive.	2B East				**1,162**	**Total**	**$401,000**	**Medium**		**$401,000**		This project is triggered by deficiencies highlighted in the existing condition. The section of pipe identified as deficient per the City's criteria is mainly caused by a relatively flat slope section, which causes the hydraulic grade line (HGL) to rise above the one-foot above pipe crown criteria. Additionally, modeling shows that the entire section is capacity-deficient based on PWWF. I/I degradation and development are anticipated to amplify this problem. Note, this project is also located in a basin (wastewater basin 2B) where an I/I reduction program might be recommended.
	Gravity				8	12	1,162	$160	$401,000					
P-6	Gravity	Between Dillow Drive and Maple Terrace.	2B East				**351**	**Total**	**$132,000**	**Medium**		**$132,000**		This project is triggered by deficiencies highlighted in the existing condition, and deficiencies are anticipated to be amplified once project P-5 is completed and with the addition of flows caused by growth and system aging. Additionally, this section of pipe is relatively flat, which causes the HGL to rise up quickly.
	Gravity				10	15	351	$180	$132,000					

Table 5.7 Detailed CIP (Continued)

Project ID	Improvement Type	Description	Basin ID	Firm Capacity (mgd)	Existing Diameter (inch)	Proposed Diameter (inch)	Length (ft)	Unit Cost	Total Capital Improvement Cost	Priority	Project Timing			Reasoning
											High Priority (2019-2023)	Medium Priority (2024-2028)	Low Priority (2029-2038)	
P-7	Gravity	Along Nixon Ave from north of Island View Way to Calaroga Court.	3A				**1,522**	**Total**	**$876,000**	**Low**			**$876,000**	This project is triggered by deficiencies identified under the build-out condition. No deficiencies are identified under existing condition. The City spent a lot of effort relining its sewer lines in wastewater basin 3A, which, in return, decreased I/I rates in the northern portion of the system significantly. The previous Master Plan, before any upgrades occurred, showed high I/I and deficiencies in the area. As the system degrades again over time, it is recommended that the City monitor this area.
	Gravity				18	24	1,522	$275	$876,000					
P-8	Gravity	Along Fairview Way between Rose Way and Chippewa Court.	3A				**160**	**Total**	**$55,000**	**Low**			**$55,000**	This project is triggered by deficiencies identified under the build-out condition. No deficiencies are identified under existing condition. The City spent a lot of effort relining its sewer lines in wastewater basin 3A, which, in return, decreased I/I rates in the northern portion of the system significantly. The previous Master Plan, before any upgrades occurred, showed high I/I and deficiencies in the area. As the system degrades again over time, it is recommended that the City monitor this area.
	Gravity				10	12	160	$160	$55,000					
P-9	Gravity	From Failing Street to Bolton PS.	2A East				**160**	**Total**	**$67,000**	**Low**			**$67,000**	This project is triggered by deficiencies identified under the build-out condition. No deficiencies are identified under existing condition, therefore, it is recommended that the City monitor this area as the system grows and degrades over time. It is recommended that this project be combined with project P-10 and project PS-1.
	Gravity				12	18	160	$200	$67,000					
P-10	Gravity	Mill Street	1A		12	12	**900**	**$160**	**311,000**	**Medium**		**311,000**		As the properties between WFD and Mill Street redevelop, this section of sewer line needs to be upgraded and realigned to the street right-of-way. This project will be part of the waterfront line project. Modeling shows no capacity issues with the existing pipe diameter, therefore, the recommendation is to replace it with the same diameter. However, when this project is triggered, this project should be evaluated in more detail and confirm pipe size and alignment.
	Gravity				12	12	900	$160	311,000	Medium		311,000		
P-11	Force Main	Mapleton Force Main. Parallel 3,750 feet of existing 12-inch force main with an 8-inch force main.					**3,750**	**Total**	**$1,217,000**	**Medium**		**$1,217,000**		Under build-out condition, the maximum velocity in the force main exceeds 8 fps under PWWF condition. Maximum reaches 8.7 fps under this condition, and the force main is therefore considered deficient, per the City's criteria. It is recommended that the City monitor flows in this area, and combine this project with P-9, and PS-1.
	Force Main					8	3,750	$155	$1,217,000					
Pump Stations														
PS-1	Pump Station	Upgrade Mapleton Pump Station to a firm capacity of 4.87 mgd.	3A					**Total**	**$4,254,000**	**Medium**		**$4,254,000**		Address redundant capacity deficiencies under existing conditions and redundant/total capacity deficiencies at build-out. Because no condition assessment was performed as part of this Plan, it is recommended that the City understand the condition of this pump station beforehand to optimize this project. It is also recommended that the City install a flow meter at the pump station to monitor flow trends in the future incoming to the station.
	Pump Station			4.87					$4,254,000					
PS-2	Pump Station	Upgrade Calaroga Pump Station to a firm capacity of 0.19 mgd.	4A					**Total**	**$1,049,000**	**High**	**$1,049,000**			Build a new pump station to address existing firm and total capacity deficiencies and existing issues at the pump station.
	Pump Station			0.19					$1,049,000					

Table 5.8 Detailed CIP (Continued)

Project ID	Improvement Type	Description	Basin ID	Firm Capacity (mgd)	Existing Diameter (inch)	Proposed Diameter (inch)	Length (ft)	Unit Cost	Total Capital Improvement Cost	Priority	Project Timing			Reasoning
											High Priority (2019-2023)	Medium Priority (2024-2028)	Low Priority (2029-2038)	
Planning														
PL-1	General	Asset Management Program							**$200,000**	**Medium**		**$200,000**		
PL-2	General	Sanitary Sewer Master Plan Update							**$300,000**	**Low**			**$300,000**	
PL-3	General	Pump Station Condition Evaluation							**$100,000**	**High**	**$100,000**			
General														
G-1	General	Repair and Replacement Program							**$15,000,000**		**$3,750,000**	**$3,750,000**	**$7,500,000**	
G-2	General	CCTV Program					**60,000**	**$3.50**	**$8,789,000**		**$2,197,000**	**$2,197,000**	**$4,395,000**	
G-3	General	I/I Reduction Program							**$35,500,000**			**$17,750,000**	**$17,750,000**	Comprehensive program to remove I/I and meet flow reduction targets identified by WES.
Option A	**Total**								**$35,705,000**		**$9,459,000**	**$12,731,000**	**$13,515,000**	
Option B	**Total**								**$132,903,000**		**$9,459,000**	**$60,929,000**	**$62,515,000**	

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