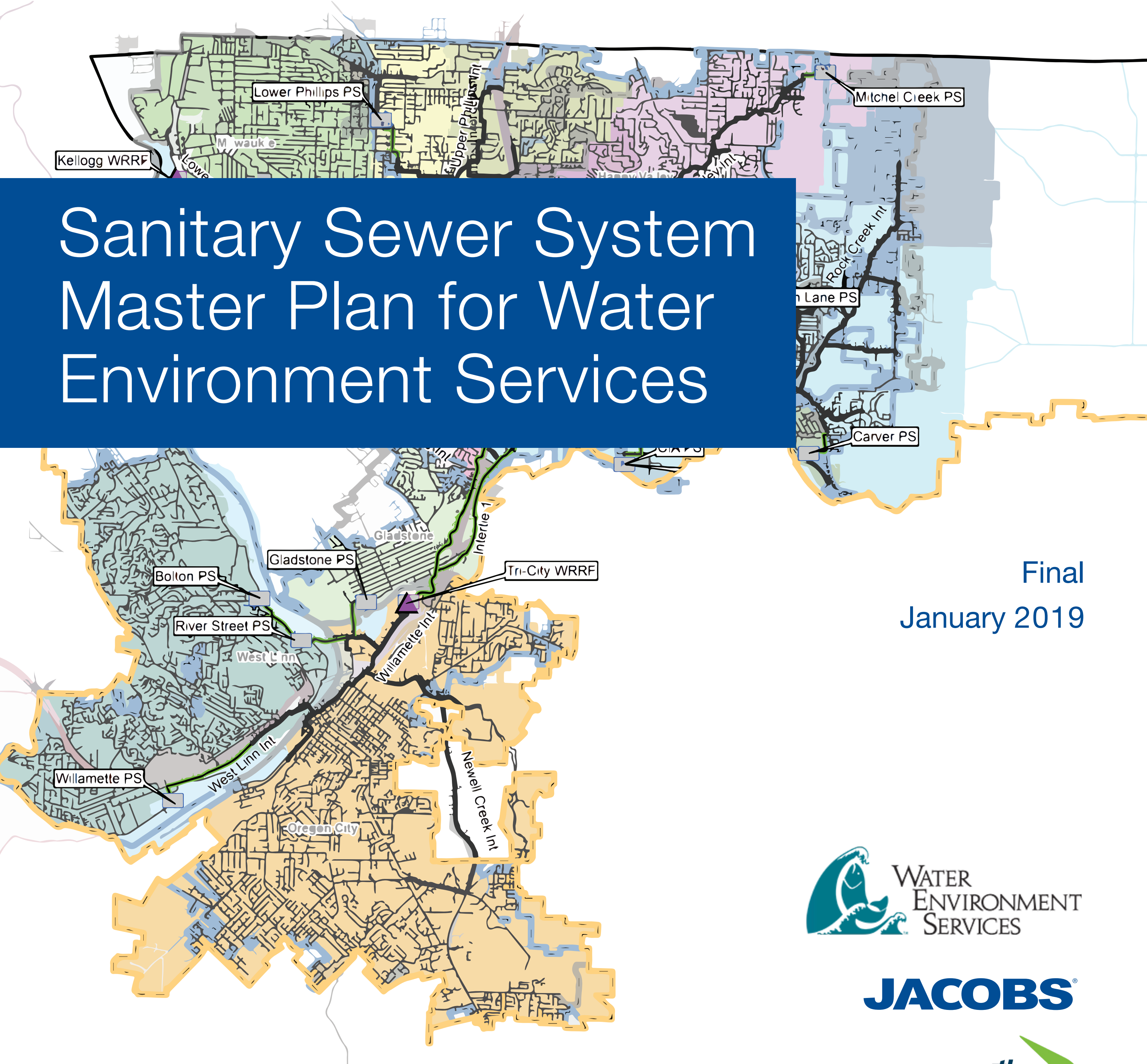

Sanitary Sewer System Master Plan for Water Environment Services

Final

January 2019

Water Environment Services

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Executive Summary

Water Environment Services (WES) is approaching a critical threshold for peak wet weather wastewater treatment capacity within its 46-square-mile service area. To address this capacity challenge, WES plans to expand the existing wastewater conveyance and treatment infrastructure while maintaining a critical focus on protection of public health and the environment.

Purpose

The purpose of this *Sanitary Sewer System Master Plan* (Master Plan) is to identify immediate needs in the sanitary sewer system and develop a corresponding set of capital improvement opportunities that WES can implement through the year 2040. The Master Plan was developed to provide a least-cost combination of conveyance and treatment improvements that provide maximum value across the system, including local infrastructure rehabilitation (tributary collection and local laterals), trunk line gravity conveyance upsizing, regional and intertie pump station upsizing, and wastewater treatment expansion. The Master Plan builds on an existing asset management framework to create a prioritized list of sustainable, long-term service alternatives, and provides guidance to member cities on future flow rates and rainfall-derived infiltration and inflow reduction targets and locations.

The purpose of this Master Plan is to identify immediate needs in the sanitary sewer system and develop a corresponding set of capital improvement opportunities that WES can implement through the year 2040.

This executive summary presents contextual background information on the WES sanitary sewer system, followed by an overview of each Master Plan major section and a list of the recommendations derived from the analyses performed.

Background

WES owns and operates the trunk wastewater collection system, pump stations, and treatment systems within major portions of Clackamas County, Oregon. Historically, the largest service areas were operated within two treatment basins: (1) the Kellogg Water Resource Recovery Facility (WRRF) Basin and (2) the Tri-City WRRF Basin. The Kellogg WRRF receives wastewater from the member cities of Milwaukie, Happy Valley, and unincorporated areas within Clackamas County, while the Tri-City WRRF receives wastewater from the member cities of Oregon City, West Linn, and Gladstone. In 2000 and 2013, two intertie pump stations were constructed to divert wastewater from the Kellogg Basin to the Tri-City Basin, allowing WES to focus major treatment expansion investment at a single treatment facility. This Master Plan identifies the capital projects required to operate the trunk conveyance and regional pumping systems within the combined Kellogg and Tri-City WRRF basins by the year 2040.

In 1997, Metro adopted the *2040 Regional Framework Plan*. The framework plan identifies regional policies for implementing the 2040 Growth Concept and delineates, among other topics, the regional urban growth boundary. Metro amended the framework plan in 2005 and 2010, and again in 2014 as part of the adoption of the Climate Smart Strategy. The study area for the analyses documented in this Master Plan follows the urban growth boundary established by Metro and includes the meter basins within the WES service area.

Figure ES-1 provides an overview of the Master Plan study area.

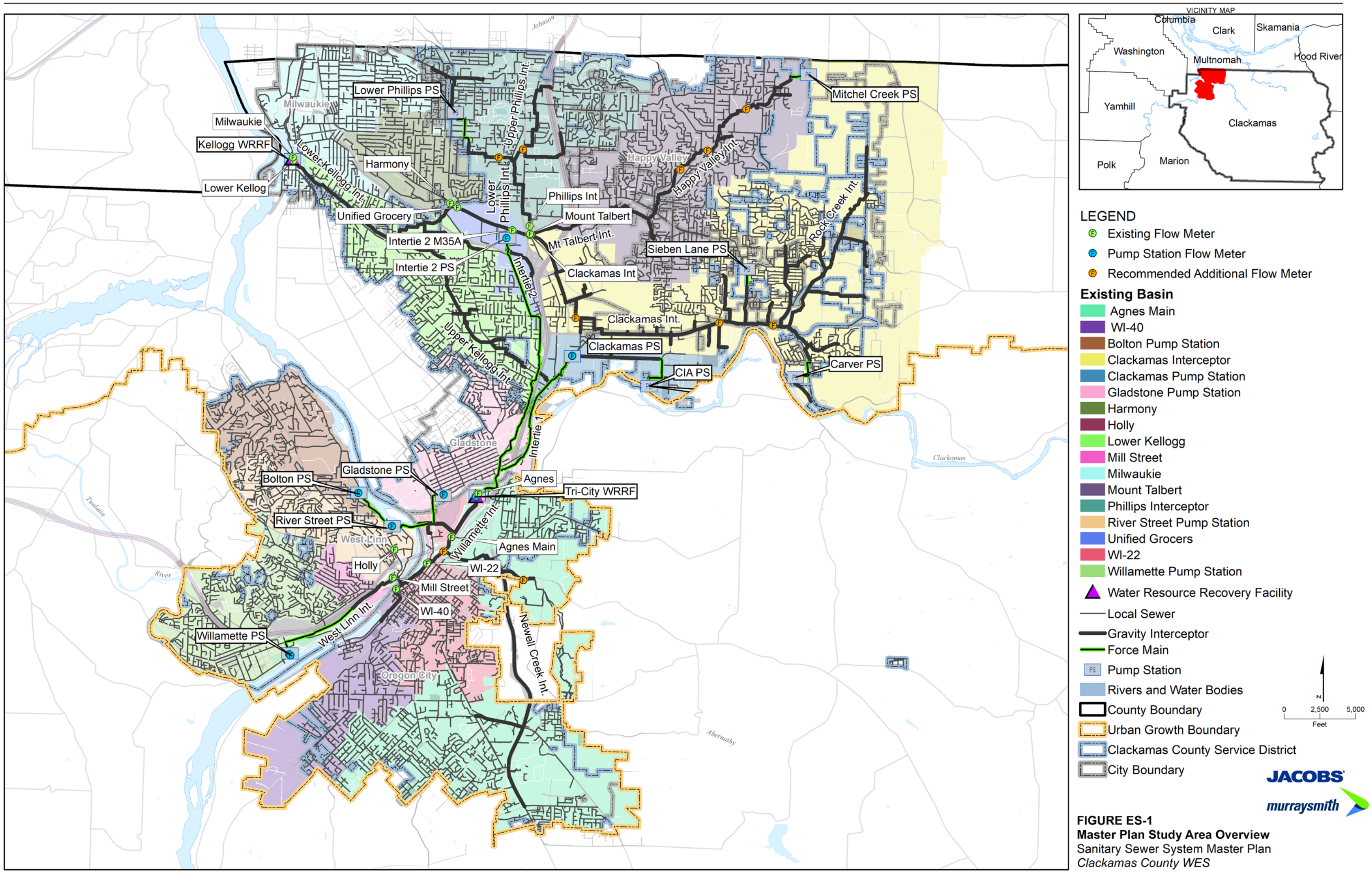

Figure ES-1. Master Plan Study Area Overview

Basis of Analysis

The primary objective of the Basis of Analysis was to develop an inventory of project data available from WES and request the data required for Master Plan development and completion. Data pertained to the condition assessment, geographic information systems, flowmeter, precipitation, and supervisory control and data acquisition, operation and maintenance, and other data consisting of future growth and existing assumptions summarized by transportation analysis zone, existing population, employee, and wet industrial data, a buildable lands inventory, and proposed capital sewer projects included in the 5-year capital improvement plan. The collected data were considered sufficient to complete the analyses described in this Master Plan.

Existing System Flow Development and Capacity Evaluation

Within the study area, WES owns and operates a large wastewater collection system with extensive infrastructure that consists of 13 trunk sewers (30 miles, 10-inch to 72-inch), 11 regional or intertie pump stations (including force mains), and two WRRF influent pump stations. Additionally, WES owns and maintains the smaller-diameter service piping in large portions of Happy Valley and unincorporated Clackamas County (about 300 miles of piping). Smaller-diameter tributary and service piping in Milwaukie, Oregon City, West Linn, and Gladstone are owned and operated by the respective cities.

WES owns and maintains flow monitoring equipment, permanent SCADA monitoring at pump stations, and precipitation gages, and relies on precipitation data from the City of Portland HYDRA rainfall network. The meter, gage, and SCADA data are used to evaluate existing system flow impacts and develop a calibrated hydrologic and hydraulic model.

To evaluate system capacity and associated capital improvements, the project team developed an InfoSWMM (Innovyze) hydraulic model that uses the industry-standard U.S. Environmental Protection Agency EPASWMM5 engine to evaluate system hydrologic response and system hydraulics. The model was developed to represent existing gravity piping greater than or equal to 10 inches in diameter, regional and intertie pump stations, and WRRF influent pump stations.

The historical storm event on November 22, 2011, was selected as the design storm to identify system deficiencies. The event exceeds 4.3 inches of precipitation over 60 hours. Because of the long storm duration and susceptibility of the system to RDI/I, the historic event produces an impact equal to or greater than the 5-year, 24-hour wintertime storm event.

The historical storm event on January 19, 2012, was selected as the design storm to size system improvements. The event exceeds 5.4-inches of precipitation over 60 hours. The design storm maximum 24-hour precipitation equals a one in 10-year precipitation frequency. The event was selected because of the trend showing increased frequency of large storms over the last decade.

The existing system has capacity to convey both dry weather flow (DWF) and groundwater infiltration (GWI) associated with winter season antecedent moisture conditions. During the design storm event, the resulting flow exceeds the treatment capacity and the existing gravity and pumping capacity at some locations. The capacity deficiencies result in predicted overflows at multiple locations. Peak flow rates are caused by high RDI/I, which in turn indicates the potential need for rehabilitation and reduction.

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Future System Flow Projections and Capacity Evaluation

The existing collection system capacity was evaluated for deficiencies with future flows in 5-year increments up to 2040 and for the buildout timeframe. The capacity evaluation used the November 22, 2011, design storm assuming system degradation (5-year design storm). The system was evaluated for flow depth, freeboard, velocity, and firm capacity deficiencies based on design criteria from WES.

Future DWF, GWI, and RDI/I peak flow estimates including degraded RDI/I cause system hydraulic deficiencies. The most substantial deficiencies occur during the design storm event and result from high RDI/I.

Future DWF, GWI, and RDI/I peak flow estimates including degraded RDI/I cause system hydraulic deficiencies. The most substantial deficiencies occur during the design storm event and result from high RDI/I.

Rainfall-derived Infiltration and Inflow Reduction Cost-Effectiveness Evaluation

Once the existing and future flow projections and capacity evaluations were completed, a system-wide cost effectiveness evaluation was performed to identify optimum levels of RDI/I reduction. The goal of the RDI/I reduction evaluation was to identify the least cost capital, operations, and maintenance investment across the system, including local infrastructure rehabilitation (tributary collection and local laterals), trunk line gravity conveyance upsizing, regional and intertie pump station upsizing, and wastewater treatment expansion.

The cost-effectiveness evaluation was performed by applying rehabilitation to subbasins sequentially from highest to lowest RDI/I impact, for three rehabilitation alternatives (20-, 30-, and 65-percent reduction), and for each timeframe. Costs encompass present value life-cycle estimates over 60 years including capital, operations, and maintenance.

The 65-percent reduction level was recommended by 2040 as the most cost-effective RDI/I reduction target. The recommendation assumes investment by cities and local jurisdictions to implement repair and replacement (R&R) programs and extend the useful life of aging pipelines, which also has the beneficial impact of reducing RDI/I. The R&R program must be supplemented by a RDI/I rehabilitation program to achieve the cost-effective solution.

Flow estimates for the future conditions at each WRRF for 2040 and buildout with targeted 65-percent RDI/I reduction are presented in Table ES-1 including a summary of Intertie 2 Pump Station diversion upgrades assuming a maximum capacity at the Kellogg WRRF of 25 million gallons per day (mgd). These flow rates are carried forward as the design flow rates for the alternatives evaluation.

The 65-percent reduction level was recommended by 2040 as the most cost-effective RDI/I reduction target. The recommendation assumes investment by cities and local jurisdictions to implement R&R programs. The R&R program must be supplemented by a RDI/I rehabilitation program to achieve the cost-effective solution.

Post-rehabilitation monitoring and hydraulic modeling are recommended to determine the impact and effectiveness of RDI/I reduction projects. This information may be used for ongoing refinement of both local RDI/I rehabilitation programs and downstream capacity improvements. To track the effectiveness of the RDI/I reduction target and update project priorities, WES should also continue the large-scale basin flow monitoring program at key locations. These flowmeter locations will serve as flow triggers for both capacity improvements and tracking of the 65-percent reduction level.

Table ES-1. Future Flow Estimates with Targeted 65-Percent RDI/I Reduction

Time	Flow Rate (mgd)	Kellogg WRRF	Intertie 2 PS	Tri-City IPS	Tri-City WRRF[a]
Existing	Average DWF	5.5	3.2	5.2	8.8
	Peak DWF	6.6	5.1	6.4	12.0
	Peak DWF + GWI	9.9	5.9	11.0	17.8
	Peak DWF + GWI + WWF[b]	25.0	14.5	62.3	78.3
	Peak Degraded DWF + GWI + WWF[c]	25.0	14.5	62.3	78.3
2040	Average DWF	7.2	5.5	6.6	12.6
	Peak DWF	9.2	6.6	9.2	16.2
	Peak DWF + GWI	14.2	7.4	14.1	22.3
	Peak DWF + GWI + WWF[b]	25.0	22.0	66.0	90.8
	Peak DWF + GWI + degraded WWF[c]	25.0	70.3	99.5	175.7
	Peak DWF + GWI + degraded & reduced WWF[d]	25.0	31.8	70.6	104.4
Buildout	Average DWF	11.0	7.1	9.7	17.7
	Peak DWF	13.9	7.9	13.8	22.6
	Peak DWF + GWI	21.2	8.9	20.1	30.5
	Peak DWF + GWI + WWF[b]	25.0	29.1	74.4	108.0
	Peak DWF + GWI + degraded WWF[c]	25.0	230.7	187.8	433.7
	Peak DWF + GWI + degraded and reduced WWF[d]	25.0	82.8	75.5	162.8

[a] Includes diversion flow rates from the Clackamas Pump Station and Intertie 2 Pump Station.

[b] Peak WWF during 11/2011 design storm, nondegraded flow rate.

[c] Peak WWF during 11/2011 design storm, degraded flow rate, no RDI/I reduction. Degraded flow rates by buildout are theoretical assuming no investment in replacement and repair of the system.

[d] Peak WWF during 11/2011 design storm, degraded flow rate, targeted 65-percent RDI/I reduction.

Collection System Condition Assessment

The project team performed a collection system condition assessment on a selection of the WES pump stations, gravity interceptors, and force main assets.

Pump Stations. The purpose of the pump station assessment was to assess the current condition of seven pump stations and their components. The component scores were combined for a comprehensive pump station assessment score. WES selected the pump stations that received the condition assessment. The pump stations not included in this assessment were either relatively new pump stations or had previously had a condition assessment evaluation by WES. The objective of the assessment was to help determine which pump station components will require attention to reduce the overall risk of an asset failure. Measures to reduce risk were incorporated into recommendations for capital improvement projects or as operational changes.

The project team performed a collection system condition assessment on a selection of the WES pump stations, gravity interceptors, and force main assets. Condition-based recommendations were incorporated into the identification and prioritization of overall capital improvement projects.

The data collected in the field condition assessment were summarized by asset. The pump station assets are in very good condition with 78 percent of the assets in asset condition rating 1. The high percentage of assets in good and very good condition indicates that the maintenance program has maintained the assets well.

Gravity Interceptors. The purpose of the gravity interceptor work was to assess the condition of a selection of large-diameter sewer interceptors following a tiered investigation approach. The objectives of the assessment were to characterize the likelihood of failure (LOF) and identify recommended improvements and preventive maintenance alternatives.

The defect observations coded within the CCTV database were organized into three categories: structural, O&M, and corrosion. Performance issues were identified through hydraulic modeling and a review of external and internal factors. Performance defects and external/internal factors are not represented in the CCTV data, but are quantified in the overall LOF ratings.

By observation, the key findings are as follows:

- Performance deficiencies are the most significant contributor to LOF in the system.
- Relatively few inspected pipe segment assets (approximately 3 percent) have a “poor” physical condition rating of 4 or higher.
- O&M issues do not appear to be deleterious.
- None of the inspected gravity interceptors have an overall rating more severe than “Fair” (rating 3).

By observation, the key finding is that Willamette Interceptor has the highest total footage of pipes with a “Fair” rating of 3, followed by Clackamas Interceptor.

Force Mains. The purpose of the force main work was to provide a condition assessment of four preselected force mains, characterize the LOF, and identify recommended improvements and preventative maintenance alternatives. A tiered approach was used to inspect the force mains and their associated appurtenances. The tiered approach is based on an assessment of the known common modes of failure, and on the available data at the time. This approach balances risk with inspection costs and cannot completely guarantee that any and all potential failures are accounted for. Continued forecasting and maintenance plans and budgets should still include provisions for responding to intangible events and for implementing needed repairs.

The LOF ratings were compiled separately for the individual force main pipe reaches and appurtenances, and then all asset components were rolled-up into a LOF rating for each force main. The LOF ratings are a combination of the total category ratings and the associated weighting of each category in the overall LOF. By observation, the key finding here is that Willamette Force Main is the only force main with asset component LOF ratings greater than 2, resulting in the highest overall LOF rating of the force mains inspected.

Condition-based recommendations were incorporated into the identification and prioritization of overall capital improvement projects.

Risk-based Asset Evaluation

The risk evaluation of assets was based on consequence of failure and likelihood of failure. The asset hierarchy from previous master plans was expanded and revised based on condition assessment and hydraulic modeling results to provide overall risk scores for all assets. To conduct the risk assessment, the project team reviewed the framework and risk-measurement factors with WES, expanded the hierarchy with additional assets, reviewed initial scoring with WES staff, using

The risk evaluation of assets was based on consequence of failure and likelihood of failure. The asset hierarchy from previous master plans was expanded and revised based on condition assessment and hydraulic modeling results to provide overall risk scores for all assets.

preliminary results to select assets for condition assessments, revising condition and capacity scoring, and calculated final risk scores for all assets.

The risk scores calculated were not used explicitly in the prioritization of projects because the capacity and condition deficiencies became a significant driver in project identification and prioritization. The risk scores can be considered in decisions regarding priority as more detailed capital improvement implementation plans are developed. Table ES-2 provides the overall risk scores for the existing assets that the projects and alternatives address.

Table ES-2. Risk Scores for Assets Addressed by Project Alternatives

Asset	Risk Score
Willamette Interceptor	68.5
West Linn Interceptor	66.3
Newell Creek Interceptor	42.8
Happy Valley Interceptor	41.6
Clackamas Interceptor	40.3
Mount Talbert Interceptor	36.6
Mount Scott Interceptor	31.7
Lower Phillips Interceptor	31.1
Country Village Interceptor	27.9
Intertie 2 Diversion Force Main	25.3
Oregon City Interceptor	21.4
Willamette Pump Station	21.2
Upper Phillips Interceptor	17.2
Willamette Force Main	16.5
Clackamas Force Main	16.5
Sieben Lane Pump Station	16.4
Lower Phillips Pump Station	12.0
Intertie 2 Pump Station	10.2
Intertie 1 Force Main	10.0
Clackamas Pump Station	8.7

WES may consider revising the existing likelihood of failure criteria weighting to better reflect actual drivers. Refining the risk score with higher weights on performance and physical condition is suggested for consideration to enhance the risk scoring process.

Alternatives Development and Evaluation

The alternatives development and evaluation process contributed to the selection of Master Plan improvement opportunities (also referred to as projects). Projects were developed based on the results of the capacity analysis, condition assessment, and cost-effective I/I reduction analyses. For some deficiency locations, more than one alternative was initially developed and evaluated using a set of screening criteria and presented to WES, where some alternatives were eliminated. The remaining alternatives were refined to incorporate feedback from WES and include sizing and cost estimates. The advantages and disadvantages of the alternatives were compared to support the selection of a preferred alternative(s).

Alternatives and associated design flow rates were developed for the 2040 timeframe with targeted 65% RDI/I reduction. Sizing of gravity infrastructure was identified for buildout capacity requirements as the gravity pipelines can have a life cycle of 80 to 100 years. The alternatives evaluation resulted in projects to mitigate risks associated with capacity and condition deficiencies and growth.

Alternatives and associated design flow rates were developed for the 2040 timeframe with targeted RDI/I reduction. Sizing of gravity infrastructure was identified for buildout capacity requirements as the gravity pipelines can have a life cycle of 80 to 100 years.

Project Recommendations and Prioritization

Following discussion of the alternatives developed and evaluated, WES decided to carry forward multiple alternatives for the systems served by the Clackamas Interceptor and Intertie 1 and 2 pump stations, and for the West Linn/Willamette interceptors. The complexity of the systems and the possible combinations available to fix them warranted the advancement of more than one alternative. In other locations, a single solution is recommended. Where multiple alternatives are carried forward, those alternatives will represent the starting point for subsequent predesign activities and selection of the preferred alternative.

WES decided to carry forward multiple alternatives for the systems served by the Clackamas Interceptor and Intertie 1 and 2 pump stations, and for the West Linn/Willamette interceptors. In other locations, a single solution is recommended.

Capital Improvement Projects

All of the recommendations assume the implementation of I/I reduction in the selected basins listed in Table ES-3 (Basin Details Identified for I/I Reduction by 2040).

Table ES-4 summarizes recommended projects and their respective priorities. Figure ES-2 shows the recommended projects. Projects were prioritized for implementation on the basis of: (1) the timing of the project need (based on deficiency timing) and (2) the requirements dictated by the interaction of an improvement relative to others in the system.

Table ES-3. Basin Details Identified for I/I Reduction by 2040

Priority	Subbasin	Basin	Jurisdiction	RDI/I Rate at Timeframe of Reduction Target	Estimated CIPP Rehab Length (miles)	Estimated Lateral Services	Category 1, Percentage (R&R Program)[a]	Category 2, Percentage (RDI/I Rehab Program)[b]
1	OC_M08	WI-40	Oregon City	54,600	9.7	300	100%	0%
2	OC_M10	WI-40	Oregon City	47,600	4.2	210	100%	0%
3	WL_2	Mill_Street	West Linn	31,500	8.0	1,410	87%	13%
4	Hwy_43	Holly	West Linn	28,000	20.2	1,570	79%	21%

Table ES-3. Basin Details Identified for I/I Reduction by 2040

Priority	Subbasin	Basin	Jurisdiction	RDI/I Rate at Timeframe of Reduction Target	Estimated CIPP Rehab Length (miles)	Estimated Lateral Services	Category 1, Percentage (R&R Program)[a]	Category 2, Percentage (RDI/I Rehab Program)[b]
5	US_1_10100 &DS_2_20400	Gladstone_PS	Gladstone	28,000	0.3	10	79%	21%
6	Buck_Street _2A-19	Holly	West Linn	27,600	3.6	290	78%	22%
7	1_10100	Gladstone_PS	Gladstone	25,400	7.3	1,320	73%	27%
8	Holly	Holly	West Linn	24,500	3.4	540	71%	29%
9	OC_M12	WI-40	Oregon City	24,500	30.9	1,920	71%	29%
10	2_20400	Gladstone_PS	Gladstone	23,700	9.5	1,020	69%	31%
11	River_Street	River_Str_PS	West Linn	23,200	2.1	490	68%	32%
12	WL_1_2B-1-0	Bolton_PS	West Linn	21,500	3.2	260	64%	36%
13	Willamette_9C-3	Willamette_PS	West Linn	20,600	10.2	670	62%	38%
14	Mill_Street	Willamette_PS	West Linn	19,700	19.7	990	60%	40%
15	OC_M05	Agnes_ Main	Oregon City	19,300	42.7	2,180	59%	41%
16	Mount_ Talbert	Mount_ Talbert	Clackamas Co	18,900	93.7	6,800	58%	42%
17	Bolton_3A-8	Bolton_PS	West Linn	18,000	21.1	1,450	56%	44%
18	Milwaukie	Milwaukie	Milwaukie	17,100	41.9	5,850	54%	46%
19	Clackamas_PS	Clackamas_PS	Clackamas Co	15,000	12.9	2,130	53%	47%

[a] Category 1, R&R Program: Percentage of piping/laterals within the subbasin excluded from the cost-effectiveness analysis and attributed to local pipe repair and replacement.

[b] Category 2, RDI/I Program: Percentage of piping/laterals within the subbasin included in the cost-effectiveness analysis and attributed to RDI/I reduction.

Table ES-4. Summary of Recommended Capital Improvement Projects

Area	Project Components	Capital Cost ($M)	Required Timeframe for Project to be in Service
West Linn/ Willamette	**Alternative 2 – West Linn/Willamette Storage Project** Retrofit existing lagoon for storage of 4 million gallons of untreated wastewater (eliminates 11 mgd peak flow) (Storage can be reduced for Build Out flows) – Includes sludge removal and rehabilitation of existing open lagoon Upsize Upper Willamette Interceptor to 18-36” Upsize Middle Willamette Interceptor to 36-54”	$37.3	Current

Table ES-4. Summary of Recommended Capital Improvement Projects

Area	Project Components	Capital Cost ($M)	Required Timeframe for Project to be in Service
	Alternative 3 – West Linn/Willamette Blue Heron Alignment Project Construct new Willamette PS at 10 mgd at 80 feet TDH Use existing 28" HDPE and 24" CCP Blue Heron piping Rehabilitate existing 24" FRP river crossing Install new 20" gravity pipe from Blue Heron piping to Willamette Interceptor Upsize Upper Willamette Interceptor to 18-42" Upsize Middle Willamette Interceptor to 54-60"	$21.5	
	Alternative 4 – West Linn/Willamette New Force Main Alignment Project Construct new Willamette PS at 10 mgd at 185 feet TDH Install new 24" parallel Willamette FM (using I-205 crossing alignment) Upsize Upper Willamette Interceptor to 18-36" Upsize Middle Willamette Interceptor to 42-54"	$23.3	
Mount Talbert/ Happy Valley	**Mount Talbert Interceptor Project** I/I source investigation	--	Current
Sieben Lane	**Sieben Lane Pump Station Project** Wet well and pump rehabilitation	$0.4	Current
WES Service Area	**I/I Reduction Program** Develop 65% I/I reduction program for 19 basins	--	Current
Clackamas/ Intertie 1/ Intertie 2	**Alternative 3 – Clackamas Diversion to Jennifer/Intertie 1 Project** Upsize Upper Clackamas Interceptor to 30-54" Increase Intertie 2 PS to 19 mgd at 150 feet TDH Complete and use 30" Intertie 2 FM segments Install new 48" gravity main from Clackamas Interceptor to Jennifer Main Upsize Jennifer Main to 42-48" Construct new Clackamas (Intertie 1) PS at 15 mgd at 120 feet TDH (Replaces existing PS) New 24" Intertie 1 FM Implement three Creeks hydraulic modifications	$52.6	Current (Intertie 2 PS and FM); 2020 (Clackamas Interceptor, Clackamas PS, Intertie 1 FM, Jennifer Main)
	Alternative 4 – Clackamas Diversion to Jennifer/Intertie 2 Project Upsize Upper Clackamas Interceptor to 30-54" Increase Intertie 2 PS to 19 mgd at 185 feet TDH Complete Intertie 2 30" FM segments Install new 48" gravity main from Clackamas Interceptor to Jennifer Main Upsize Jennifer Main to 42-48" Construct new second Clackamas (Intertie 1) PS at 12 mgd at 145 feet TDH Install new 30" FM from Clackamas PS to the 20" Intertie 2 FM (using Manfield Ct) and connect to lower segment of 20" existing Intertie 2 FM Implement three Creeks hydraulic modifications	$50.8	
Lower Clackamas	**Lower Clackamas Interceptor Rehabilitation Project** Rehabilitate existing Lower Clackamas Interceptor	$5.9	2025
Upper and Lower Phillips	**Lower Phillips Project** New Linwood PS at 2 mgd at 105 feet TDH New 12" Linwood FM Decommission existing Lower Phillips PS Reconfigure Lower Phillips FM to flow to new Linwood PS (no gravity improvements required) Upsize Lower Phillips Interceptor to 18-24"	$7.7	2025

Table ES-4. Summary of Recommended Capital Improvement Projects

Area	Project Components	Capital Cost ($M)	Required Timeframe for Project to be in Service
Rock Creek	**Rock Creek Interceptor Extension Project** 12"-18" extension to existing interceptor	$6.2	2025
Lower Willamette	**Lower Willamette Interceptor Rehabilitation Project** Line existing lower Willamette Interceptor	$11.8	2030
Oregon City	**Oregon City Interceptor Rehabilitation Project** Line existing upper Oregon City Interceptor	$1.5	2030
Newell Creek and Country Village	**Newell Creek Interceptor and Country Village Interceptor Project** Upsize upper Newell Creek Interceptor to 21" Use existing middle Newell Creek Int. Upsize lower Newell Creek Interceptor. to 24-27" Upsize Country Village Interceptor to 12-21"	$4.4	2040
Tri-City WRRF	**Treatment Plant Improvements with Storage** If West Linn/Willamette Alternative 2 (Storage) is implemented, increase treatment capacity to 93 mgd	$90	2020-2040[a]
	Treatment Plant Improvements Without Storage If any other alternatives are implemented, increase treatment capacity to 104 mgd	$112	

[a] The 93 mgd or 104 mgd capacity is not required until 2040; however, it is WES's intention to perform the full capacity increase in the 2020 to 2030 timeframe. The existing peak flow of 78.3 mgd exceeds current treatment capacity of 68 mgd.

Minor Condition-based Improvement Projects

Table ES-5 summarizes recommended minor projects associated with condition-based findings.

Table ES-5. Summary of Recommended Minor Condition-Based Improvement Projects

Area	Project Components	Capital Cost	Timeframe
Bolton and River Street Force Mains	**Bolton and River Street Force Main Rehabilitation Project** Coating, rehabilitation, and/or replacement of pipe spools and appurtenances exposed in vaults	$20,000	Existing
Gladstone Force Main	**Gladstone Force Main Painting Project** Inspection of the bridge superstructure and assessment of needed painting touchups	$100,000	Existing
Willamette Force Main	**Willamette Force Main Rehabilitation Project** Demolition of existing unused air-vacuum relief valve and vault	$7,000	Existing
Lower Kellogg	**Lower Kellogg Interceptor Project** Monitoring with isolated spot repairs to remove active infiltration	$200,000	2025

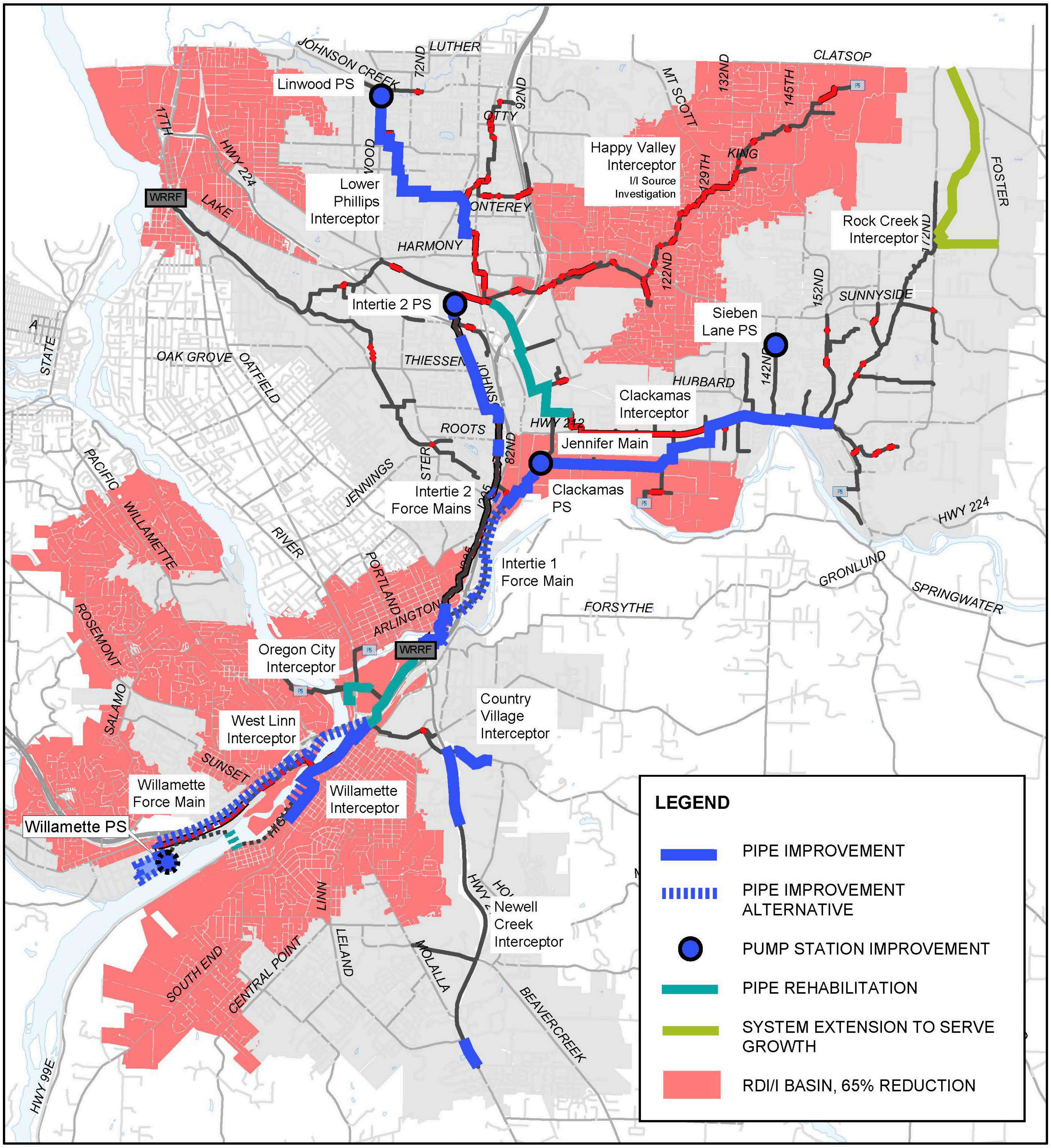

Figure ES-2. Recommended 2040 Capital Improvement Projects Map

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Early Action Projects to Delay Capital Costs

Limited locations represent flow restrictions that are not common to an entire reach or area. Therefore, key locations in the system and associated conveyance system components have been identified for early implementation so that other elements of the recommended capital improvements can be deferred. The following projects are recommended for early implementation to provide flexibility for CIP implementation.

Key locations in the system and the associated conveyance system components have been identified for potential phased implementation to delay other elements of the recommended capital improvements.

1) Early RDI/I source identification and RDI/I rehabilitation within the Mount Talbert and Happy Valley Interceptor Basin.

2) Early RDI/I source identification and RDI/I rehabilitation within the Milwaukie Basin.

3) Early projects on the Clackamas Interceptor, Jennifer Main, Clackamas Pump Station, and Intertie 2 Pump Station are recommended to create flexibility for full implementation over a 5 to 7-year time frame. The following sequencing is recommended:

   a) Implement near-term improvements to the upper portion of the Clackamas Interceptor, a diversion from the Clackamas Interceptor to the Jennifer Main, and the Jennifer Main are required to accommodate growth in the Clackamas Basin.

   b) Implement pump capacity increases at the Intertie 2 Pump Station and complete approximately 3,000 feet of parallel 30-inch force main at the southern end of the force main alignment.

   c) Implement new pumps, electrical, mechanical, and wet well capacity at the Clackamas Pump Station.

   d) Utilize recommended flowmetering at CL51, CL63, CL11, the permanent Clackamas Interceptor meter, and the permanent meter at the Clackamas Pump Station to evaluate optimal diversion flow split.

4) Early RDI/I source identification and RDI/I rehabilitation within the Willamette Pump Station Basin.

5) Early projects on the Willamette Interceptor and Willamette Pump Station are recommended to create flexibility for full implementation over a 5-year timeframe. The following sequencing is recommended:

   a) Implement near-term improvements to the upper portion of the Willamette Interceptor (between WI-54 and WI-22).

   b) If Alternative 3 is selected for the West Linn/Willamette deficiencies, perform inspection, preparation, and rehabilitation of existing Blue Heron river crossing and pipeline for use as new force main to the Willamette Pump Station. Extend gravity sewer between the Blue Heron pipeline and the Willamette Interceptor.

   c) Also associated with West Linn/Willamette deficiencies, implement new pumps, electrical, mechanical, and wet well capacity at the Willamette Pump Station including split wet well option for use of new Blue Heron Force Main and the existing Willamette Pump Station force main.

   For items (b) and (c), use permanent Willamette Pump Station, Mill Street, Holly, WI-40, and WI-22 meters to track capacity and to evaluate optimal diversion flow split. Coordinate project timing with RDI/I reduction in the Willamette Pump Station Basin.

Noncapital Master Plan Recommendations

Monitoring of RDI/I Trends, Degradation, and Success of RDI/I Reduction. The cost-effective solution identified in this Master Plan depends on the combined benefits of RDI/I reduction and improvements in the collection system to increase capacity. Because the rate and amount of both I/I increase over time and the effectiveness of RDI/I removal is estimated, it is critical to monitor flows in the system relative to these estimates. Monitoring locations similar to those used in the Master Plan will allow for the most direct comparisons of future actual flows and those estimated in this plan. Improvement timing can then be assessed for acceleration or delay based on the analysis of these data. Permanent monitoring that allows for the capture of multiple wet weather events is recommended in order to best compare the wet weather peak flows in the Master Plan to future system flows as the system ages, and RDI/I reduction and capacity improvements are implemented. Flow monitoring data can also identify key locations as indicators or flow triggers for both capacity improvements and tracking of the 65-percent reduction level.

General Preventive Maintenance. It is recommended that the interceptors be placed on a regular maintenance cycle that includes the following activities:

- Pipe and manhole assets should be inspected on a frequency based on their overall risk rating. The methods of inspection should mirror those used in the tiered approach followed during this study.
- For the interceptors that were not inspected as part of this study, inspection should proceed on a schedule prioritized by their current risk rating until more detailed condition assessment data can be collected to supplant the institutional knowledge ratings (similar to the process followed in this study).

For the force mains, it is also recommended to perform a regular maintenance cycle which includes the following activities:

- Air relief valves should be flushed at least every year. In addition, they should be disassembled, cleaned, and rebuilt every 2 to 3 years.
- Control valves should be exercised every 1 to 2 years.

Noncapital Master Plan recommendations are organized into the following categories:

- Monitoring of RDI/I Trends, Degradation, and Success of RDI/I Reduction
- General Preventive Maintenance
- Tier 3 Inspections for Gravity Pipelines and Force Mains
- Pump Station Asset Obsolescence

Pipe and vault assets should be inspected on a frequency based on their overall risk rating. The methods of inspection should mirror those used in the tiered approach followed during this study.

Tier 3 Inspections for Gravity Pipelines and Force Mains. Large-diameter rehabilitation projects can be more effectively designed and constructed if Tier 3, high resolution, multisensor information data are available. Multisensor inspection may include laser profiling, sonar, and/or pipe-penetrating radar. For the rehabilitation projects identified in this report, it is recommended that Tier 3 inspection be performed prior to detailed design or construction.

Based on the findings of the prior tiers, additional Tier 3 methods including acoustic surveying, in-line inspection tools, and dewatered CCTV were evaluated for some of the force mains. As of the time of this writing, no additional Tier 3 investigation were conducted as part of the Sanitary Sewer System Master Plan, but recommendations are made to conduct additional future Tier 3 investigation for select force mains.

Pump Station Asset Obsolescence. Pump station assets were placed into three categories relative to their obsolescence. The categories are Current—Supported, Not Current – Supported (asset is out of date, but parts/repairs are available), and Obsolete – Not supported (asset is out of date and parts/repairs are not available). Seven electrical components in the WES pump stations were found to be Not current--Supported, and four others were found to be Obsolete--Not supported. Replacement of not current or obsolete assets should be considered when developing planned capital improvements.