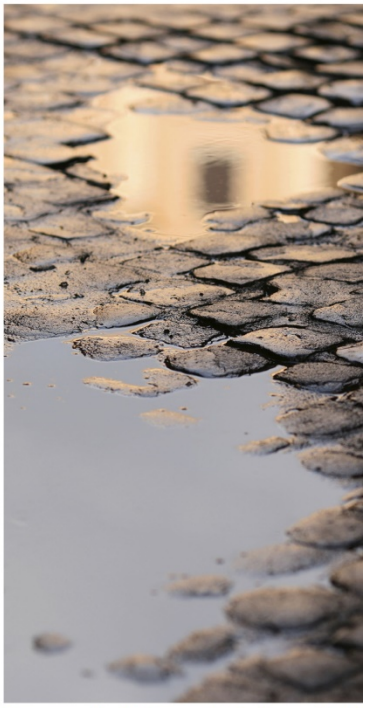
CITY OF
West Linn

Storm Drainage Master Plan

DRAFT FINAL // SEPTEMBER 2019



Brown AND Caldwell

West Linn Storm Drainage Master Plan

Prepared for
City of West Linn, Oregon
September 2019

This is a draft and is not intended to be a final representation
of the work done or recommendations made by Brown and Caldwell.
It should not be relied upon; consult the final report.

This page left intentionally blank.

Table of Contents

Executive Summary vii
Master Plan Technical Analyses vii
General Recommendations viii
Capital Improvement Program viii
Project and Program Summary viii
Policy Recommendations ix
1. Introduction 1
1.1 Storm Drainage Master Plan Objectives 1
1.2 Background and Related Studies 2
1.3 SMP Development Process 2
1.4 Document Organization 3
2. Study Area Characteristics 5
2.1 Location 5
2.2 Topography and Soils 6
2.3 Land Use and Population 6
2.4 Climate and Rainfall 7
2.5 Storm Drainage Infrastructure 8
2.6 Regulatory Framework 9
2.6.1 National Pollutant Discharge Elimination System (NPDES) Permit Program 9
2.6.2 Total Maximum Daily Load (TMDL) and 303(d) Listings 10
2.7 Storm Drainage System Maintenance and Program Management 11
3. Code Evaluation and Basis of Design 17
3.1 Code Recommendations 17
3.1.1 Technical Standards and Stormwater Policy Changes 18
3.1.2 Clarity and Implementation Changes 18
3.2 Basis of Design 19
4. Project Planning Process 21
4.1 Project Needs Assessment 21
4.2 Water Quality Assessment 22
4.3 Highway 43 Drainage Evaluation 23
4.4 Results 24
4.4.1 Project Prioritization 24
4.4.2 Modeling Needs 25
5. Storm Drainage System Capacity Evaluation 27
5.1 Modeling Approach 27

5.2 Hydrologic Model Development and Results 28
5.3 Hydraulic Model Development and Results 28
5.3.1 Model Development 28
5.3.2 Results and Capital Project Development 29
6. Capital Improvement Program 33
6.1 Summary of Recommended Actions 33
6.2 Cost Assumptions 34
6.3 Sizing and Design Assumptions 39
6.4 Capital Projects 39
6.4.1 Capacity Projects 39
6.4.2 Infrastructure Projects 40
6.4.3 Retrofit Projects 42
6.4.4 Planning Projects 43
6.5 Program Descriptions 44
6.5.1 CCTV Program (G-1) 44
6.5.2 Repair and Replacement (R/R) Program (G-2) 44
6.5.3 Inlet Installation and Replacement Program (G-3) 44
6.5.4 Public Pond Maintenance Program (G-4) 45
6.5.5 Green Street Pilot Program (G-5) 45
6.6 Policy Recommendations 46
6.5.1 Technical and Editorial Stormwater Code Updates 46
6.5.2 Beaver Management Requirements 46
6.7 Project and Program Cost Summary 47
7. References and Limitations 53
Appendix A: TM1: Stormwater Basis of Design and Code Review A-1
Appendix B: TM2: Stormwater Basis of Planning B-1
Appendix C: Final Stormwater Project Opportunity Areas C-1
Appendix D: TM3: Hydrology and Hydraulic Modeling Methods and Results D-1
Appendix E: Detailed Cost Estimates E-1
Appendix F: Capital Project Descriptions and Figures F-1

List of Figures

Figure ES-1. Capital Improvement Program overview xi
Figure 2-1. Location overview 5
Figure 2-2. Storm drainage system overview 13
Figure 2-3. Soils and topography 14
Figure 2-4. Existing land use 15
Figure 2-5. Stormwater treatment facilities and drainage areas 16
Figure 5-1. Hydraulic system overview (Targeted hydraulic model locations) 31
Figure 5-2. Hydraulic system overview (Highway 43 crossing) 32
Figure 6-1. CIP overview map 49
Figure 6-2. Blankenship Road improvements 50
Figure 6-3. Fairview Way pipe relocation 51

List of Tables

Table ES-1. Capital Project and Program Summary x
Table 1-1. Existing Stormwater Planning Documentation and Reports 2
Table 2-1. Soil Conditions 6
Table 2-2. City of West Linn Area Overview 7
Table 2-3. Land Use Coverage and Impervious Percentages 7
Table 2-4. System Asset Inventory–Pipes, Culverts, and Open Channels 8
Table 2-5. Storm Infrastructure 9
Table 2-6. TMDL and 303(d) Summary for West Linn 10
Table 2-7. City Maintenance Activities (per 2012 SWMP) 11
Table 2-8. Existing Program Funding (2018-19) 12
Table 3-1. Recommended Code and Standard Clarifications 19
Table 3-2. Project Evaluation and Design Criteria 19
Table 3-3. Design Storm Depths 20
Table 5-1. Capacity Evaluation Results 30
Table 6-1. Storm Drainage Capital Project and Program Summary [c] 35
Table 6-2. Summary of Capital Project and Program Cost and Schedule 48

List of Abbreviations

ac	acre
BC	Brown and Caldwell
BMP	best management practice
C	Capacity projects (capital planning)
CCTV	closed-circuit television
CDC	Community Development Code
CIP	capital improvement project
City	City of West Linn
CWA	Clean Water Act
DEQ	Oregon Department of Environmental Quality
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
G	general/asset management (capital planning)
GIS	geographic information system
H/H	hydrologic and hydraulic
Highway 43	Oregon Highway 43
HSG	hydrologic soil groups
I&I	inflow and infiltration
I	Addition projects (capital planning)
IGAs	intergovernmental agreements
LF	linear foot/feet
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
ODOT	Oregon Department of Transportation
P	Planning projects (capital planning)
PCB	polychlorinated biphenyl
Plan	Storm Drainage Master Plan
R	Erosion projects (capital planning)
R/R	repair and replacement
SMP	Storm Drainage Master Plan
SOPs	standard operating procedures
SWMP	Stormwater Management Plan
TMDL	total maximum daily load
UGB	Urban Growth Boundary
WLMC	West Linn Municipal Code

Executive Summary

In 2017, the City of West Linn (City) initiated development of a multi-objective storm drainage master plan to guide stormwater and drainage-related capital project, program, and policy needs over a 10-year planning period. Efforts were initiated due to the outdated nature of the City's previous Surface Water Management Plan (dated 2006), an increased focus on water quality in conjunction with the changing regulations and observed system deficiencies warranting additional study.

This 2019 Storm Drainage Master Plan (Plan or SMP) is a supporting document to the City's Comprehensive Plan and provides an overview of drainage system improvements to address future growth, water quality, maintenance/system condition issues, and capacity issues. The City's overall storm drainage system is composed of piped and open channel (e.g., ditches, creeks) conveyances, in addition to collection, treatment, and detention facilities for stormwater management. The master planning process included the following steps:

- Evaluate City code related to stormwater management, to define planning and design criteria and identify implementation gaps.
- Identify, investigate and study known problem areas.
- Create hydrologic and hydraulic (H/H) models to evaluate storm drainage system capacity for key problem areas.
- Identify implementation priorities and associated costs.
- Develop an integrated storm drainage capital improvement program to address capacity, water quality, and maintenance needs.
- Develop a Plan that is useful and easy to read, reference, and update.

Master Plan Technical Analyses

Development of this SMP included the following technical analyses to evaluate stormwater system deficiencies and define project, program, and policy needs.

Code Evaluation. This effort included review of code and standards applicable to this SMP, as contained in the City's Municipal Code (WLMC), Public Works Standards (PWDS), Construction Specifications, and Community Development Code (CDC). Elements of the code review included conveyance, water quality, erosion and sediment control, maintenance, and code enforcement.

Project Needs Assessment. This effort included the distribution of surveys to the City and public, a GIS data review, site visits, a maintenance assessment, and meetings/workshops with City staff. Information collected resulted in development of a robust inventory of problem areas specific to stormwater infrastructure and stormwater facilities. Problem areas were reviewed to identify locations in need of further analysis or study.

Water Quality Assessment. Water quality opportunity areas were initially identified using a desktop GIS analysis to assess high pollutant generating land use areas (i.e., industrial or commercial), existing stormwater facility placement, and publicly-owned areas with potential to incorporate water quality. Site visits were conducted, and water quality opportunity areas compared with problem areas to see if an integrated approach to stormwater management (i.e., installation of water quality facilities to mitigate stormwater runoff) could address a reported issue.

Targeted Stormwater Drainage System Capacity Evaluation. Hydrologic and hydraulic (H/H) modeling to simulate rainfall and runoff characteristics was conducted for targeted areas of the City. The models simulate stormwater flow through pipe networks, drainage ditches, and culverts to identify capacity limitations under current and future development conditions.

General Recommendations

Project, program and policy recommendations in this SMP are proposed to improve and enhance drainage infrastructure and water resources throughout the City, as summarized by the following recommended actions.

- Implement identified system capacity improvements (i.e., reconfiguration, rerouting, upsizing) to manage more frequent, nuisance system flooding.
- Increase water quality treatment throughout the City by expanding treatment area coverage and enhancing the level of treatment provided in existing facilities.
- Incorporate LID or green infrastructure to expand water quality treatment in locations where utility improvements or transportation-related/pedestrian improvements are anticipated.
- Incorporate system configuration and condition data (i.e., stormwater facility inspection records, closed-circuit television [CCTV], survey) into a larger asset management program to allow for proactive maintenance, repair, and replacement of stormwater infrastructure.
- Conduct regular updates to the WLMC and PWDS to ensure clear guidance is provided to the development community and is consistent with regulatory requirements.
- Establish city policies to address beaver management as pertaining to local flooding issues.
- Clearly document capital project and program costs and schedule to inform future funding and rate analyses.

Capital Improvement Program

Project, programmatic, and policy recommendations in this SMP represent an integrated strategy to address storm drainage needs in the City. Recommendations include 26 capital projects and 5 city-wide programmatic efforts. Policy recommendations are based on the code evaluation and support project and programmatic needs.

Project and Program Summary

Capital projects address current and future stormwater infrastructure needs as a one-time project cost. Capital projects are categorized as capacity projects (C), infrastructure improvement and addition projects (I), water quality and erosion control projects (R), and planning projects (P).

Program recommendations address city-wide system repair and replacement (R/R) needs, routine system maintenance, and ongoing and opportunistic water quality retrofits. Program recommendations are categorized as general/asset management (G) and reflect an annual cost need.

Project and city-wide program objectives include:

- Increase system capacity (flood control)
- Improve system configuration
- Add infrastructure
- Increase water quality treatment (retrofit)
- Prevent erosion
- Address maintenance need

Table ES-1 summarizes the estimate cost and priority of identified capital projects and city-wide programs. Costs are provided for high and medium priority needs, which are anticipated for implementation over the 10-year SMP implementation timeframe. Lower priority project needs are listed for reference, but no cost provided.

Figure ES-1 shows the location of the proposed capital projects and programs, highlighting those considered a priority need.

Policy Recommendations

Policy recommendations are provided to 1) support future updates to technical design standards for stormwater systems, and 2) outline beaver management strategies to address beaver activity as related to localized stormwater system flooding.

Updated technical design standards would help support water quality improvement efforts by specifying approved stormwater facility types and design criteria to address specific pollutants of concern for the City. Establishing and documenting beaver management strategies would help mitigate beaver activity in susceptible stream channels as it contributes to the deficiencies in the City's stormwater collection and conveyance system.

Policy recommendations should be addressed with future updates to the WLMC, CDC, PWDS, or addressed through internal directives.

Table ES-1. Capital Project and Program Summary

Project Number	Project Name	Prioritization and Implementation Schedule		
		2019-2028 One-time Cost (High/Medium Priority)	2019-2028 Annual Cost (Medium Priority)	Future (Low Priority)
Capacity Projects				
C-1	Phase I Highway 43 Culvert Replacements	$1,045,000		
C-2	5th Avenue Culvert Replacement	$847,000		
C-3	Sunset Creek at Willamette Falls Drive Culvert Replacement	$282,000		
C-4	Maddox Creek at River Street Culvert Replacement	$385,000		
C-5	Phase II Highway 43 Culvert Replacements			X
C-6	Kantara Way Capacity Deficiency			X
Infrastructure Projects				
I-1	Blankenship Road Improvements	$856,000		
I-2	Mark Lane Improvements	$1,092,000		
I-3	Buck Street Improvements	$966,000		
I-4	Fairview Way Pipe Relocation	$1,620,000		
I-5	Nixon Avenue Pipe Relocation	$174,000		
I-6	Sunset Avenue Improvements	$1,593,000		
Retrofit Projects				
R-1	Public Pond #22 Retrofit (Katherine Court)	$89,000		
R-2	Mary S Young Park Parking Lot Retrofit	$2,075,000		
R-3	West Linn Public Works Department Planters	$174,000		
R-4	Mary S. Young Park Erosion Measures			X
R-5	Mary S. Young Park Trillium Creek Restoration			X
R-6	Mary S. Young Park Fish Restoration			X
R-7	Arbor Creek Culvert Hydromodification Improvements			X
R-8	Willamette Park Parking Lot Retrofit			X
R-9	Public Pond #18 Retrofit			X
Planning Projects				
P-1	Tannler Drive/Bernert Creek Basin Feasibility Study	$20,000		
P-2	Fish Passage Evaluation	$20,000		
P-3	Storm Drainage Master Plan Update	$300,000		
P-4	Asset Management Program Development	$150,000		
P-5	Stormwater System Survey	$300,000		
City-wide Programs				
G-1	CCTV Program		$344,000	
G-2	Repair and Replacement (R/R) Program		$750,000	
G-3	Inlet Installation and Replacement Program		$25,000	
G-4	Public Pond Maintenance Program		$100,000	
G-5	Green Street Pilot Program		$50,000	
	TOTAL (One-time Project Cost)	**$11,988,000**		
	TOTAL (Annual Program Cost)		**$1,269,000**	

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 6-1: Storm Drainage Capital Improvement Program Overview

Project #	City-Wide Projects and Programs
P-2	Fish Passage Evaluation
P-3	Storm Drainage Master Plan Update
P-4	Asset Management Program
P-5	Storm Drainage System Survey
G-1	CCTV Program
G-2	Repair and Replacement Program
G-3	Inlet Installation/Replacement Program
G-4	Public Pond Maintenance Program
G-5	Green Street Pilot Program

Project Category

- Capacity
- Infrastructure
- Retrofit
- Planning
- Low Priority/Not Costed

- Stormwater Pipe
- Open Channel
- Streams
- Watershed Boundaries
- ODOT ROW
- City Limits
- UGB

CIPs C-1 (Phase I Highway 43 Culvert Replacement) and C-5 (Phase II Highway 43 Culvert Replacement) are not shown.

N

0 1,000 2,000 4,000 6,000 Feet

1:24,000 scale

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

8/29/2019

Section 1

Introduction

The City of West Linn (City) developed this Storm Drainage Master Plan (SMP or Plan) to guide stormwater and drainage-related capital project, program, and policy decisions over a 10-year planning period.

The City's overall storm drainage system includes piped and open channel (e.g., ditches, creeks) conveyances, in addition to collection, treatment and detention facilities for stormwater management. There are 21 tributary creeks and streams (surface water bodies) that convey a majority of stormwater runoff from developed portions of the City to the Willamette River and Tualatin River. Thus, this SMP collectively considers both piped and open channel conveyances as part of the overall storm drainage system. This SMP addresses water quantity and quality for constructed drainage systems under the City's management.

The City manages approximately 123 miles of piped and open channel storm drainage infrastructure. The City is primarily developed, with limited potential for growth (based on the current urban growth boundary [UGB]) and moderate potential for infill or redevelopment. As such, the City needs a proactive plan to address existing capacity deficiencies, failing infrastructure, and regulatory drivers related to water quality improvement.

This Plan documents the process and methods used to evaluate the City's storm drainage infrastructure. Results of the evaluation provide the City with projects, programs, and policies for implementation.

1.1 Storm Drainage Master Plan Objectives

The City's overarching goal for this SMP is to guide storm drainage infrastructure improvements over a 10-year implementation period. Improvements must address water quality, maintenance/system condition issues, and capacity issues into the future. Specific objectives of the City's SMP include the following:

- Establish a foundation for evaluating stormwater needs in West Linn.
- Solicit information from staff and stakeholders to inform the targeted and integrated identification of project needs and improvements.
- Identify known areas of storm drainage problems and flooding and provide project solutions related to collection, conveyance, treatment and detention.
    - Develop targeted hydrologic and hydraulic (H/H) models to evaluate system capacity based on current system information as obtained from the City's GIS and survey.
    - Assess the frequency of nuisance flooding based on developed H/H models.
- Enhance and expand water quality treatment throughout the City by improving existing treatment system functionality and implementing opportunistic retrofits to expand treatment area coverage within the City.
- Identify programmatic opportunities to address maintenance activities, system condition deficiencies, and water quality on a city-wide scale.

This Plan is intended to support regulatory directives under the City's Phase I National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer (MS4) Permit (Permit). The City is required to meet stormwater-related permit obligations as documented in their Stormwater Management Plan (SWMP) and referenced in intergovernmental agreements (IGAs), standard operating procedures (SOPs) and technical documents.

1.2 Background and Related Studies

The City's last storm drainage master plan was completed in 2006 (2006 Plan). Since 2006, identified capital projects have not consistently been implemented. Per objectives at the time, projects were primarily identified based on modeled system capacity deficiencies, specifically culverts. Projects were not prioritized in conjunction with observed deficiencies or City maintenance objectives. Project needs identified in the 2006 Plan require validation and update.

Various planning-level reports and studies prepared since the 2006 Plan were obtained during the development of this SMP to help inform areas of observed stormwater problems and potential project needs. Reports and studies reviewed and considered for this SMP are listed in Table 1-1.

Table 1-1. Existing Stormwater Planning Documentation and Reports

Report	Date	Summary and application to the SMP
West Linn Surface Water Management Plan	2006	Provides background information and historic basis for the need to update the SMP.
West Linn Stormwater Management Plan	2012	Summarizes programmatic and maintenance activities related to the implementation of the City's Phase I NPDES MS4 permit.
Stormwater Retrofit Plan for the City of West Linn	2015	Provides documentation of the City's retrofit strategy, which includes proposed stormwater pond retrofits and culvert retrofits.
Hydromodification Assessment	2015	Provides a summary of instream channel conditions and hydromodification indicators. Field notes and photo logs documenting system conditions are included. Project and policy needs are identified.
West Linn Transportation System Plan	2016	Identifies transportation improvement project needs including pedestrian improvements that may be coordinated with stormwater infrastructure or green street development activities.

1.3 SMP Development Process

The City developed this SMP using a collaborative approach with engineering and maintenance staff and the public to initially assess known storm drainage problem areas and identify areas where infrastructure addition, replacement, or retrofit is needed to address an issue. Individual assessment efforts to evaluate capacity limitations, water quality opportunities, and develop project concepts were conducted following this initial planning process. Capital project and program needs were prioritized prior to development of project and program costs. This overall process allowed the City to focus resources and develop information for areas and projects most likely to be prioritized in a capital improvement program.

Figure 1-1 outlines the approach used to develop this Plan. Detail related to specific assessment efforts can be found in the following technical memorandums, included in this Plan as appendices.

- Technical Memorandum #1 (TM1) - Stormwater Basis of Design and Code Review
- Technical Memorandum #2 (TM2) - Stormwater Basis of Planning
- Technical Memorandum # 3 (TM3) - Hydrology and Hydraulic Modeling Methods and Results

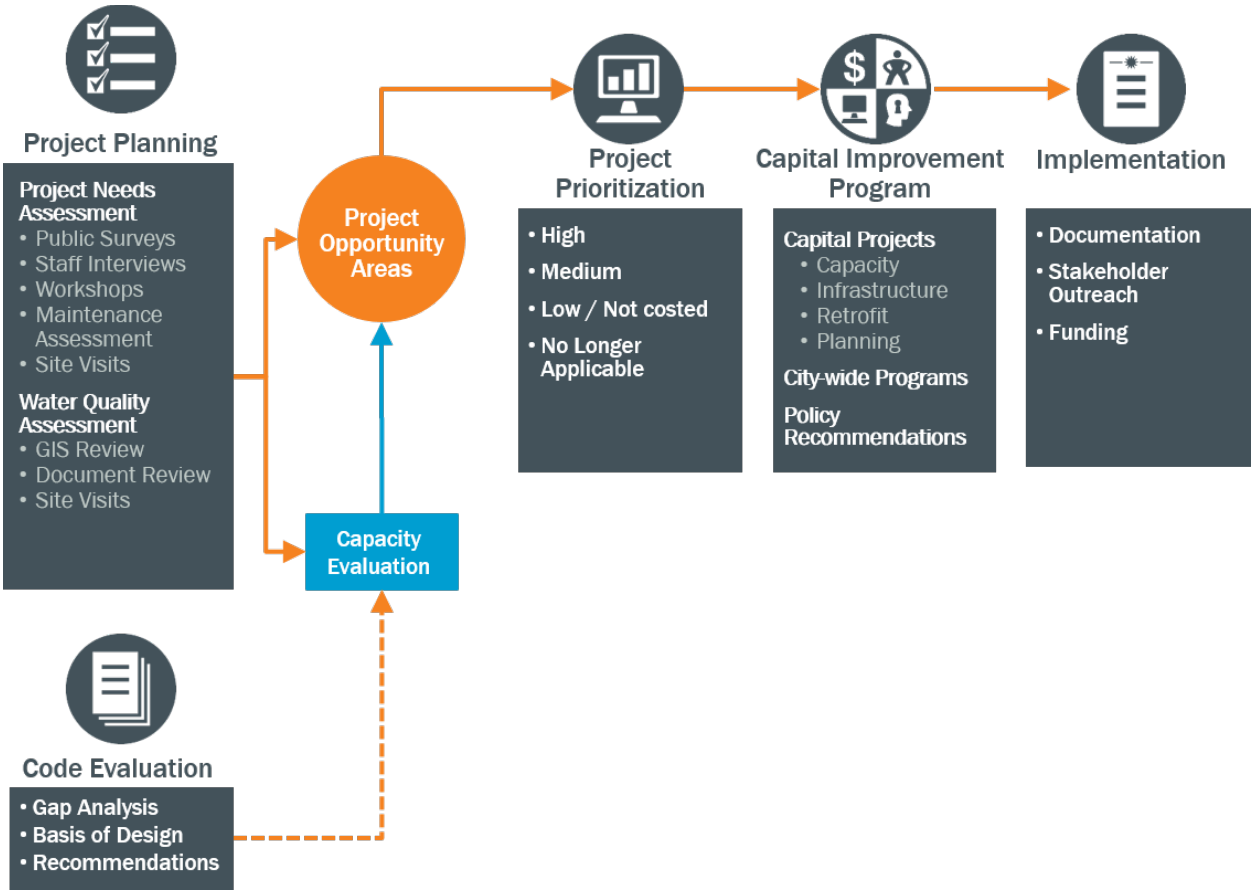


Figure 1-1. Storm Drainage Master Plan approach

1.4 Document Organization

Following this introductory Section 1, this SMP is organized as follows:

- Section 2 includes a description of the study area characteristics.
- Section 3 summarizes the stormwater code evaluation and determination of design criteria to serve as the basis of design.
- Section 4 summarizes the planning process including the project needs assessment (identification of stormwater problem areas) and the water quality assessment. Project Opportunity Areas stemming from the planning process are identified.
- Section 5 describes H/H modeling methods and results of the stormwater drainage system capacity evaluation, including qualification of capacity-related capital project needs.
- Section 6 summarizes the overall storm drainage capital improvement program recommendations including the final capital projects, city-wide programs, policies, and respective cost estimates.

This page left intentionally blank.

Section 2

Study Area Characteristics

This section provides an overview of study area characteristics, including location, topography, soils, land use, drainage system configuration, regulatory objectives, and current City stormwater program activities.

Referenced figures reflecting study area characteristics are located at the end of this section.

2.1 Location

The City of West Linn (City) is located 12 miles southwest of Portland, Oregon in Clackamas County. The City is approximately eight square miles in area, bounded on the north by the City of Lake Oswego, on the west by Unincorporated Clackamas County, and on the east by the Willamette River (Figure 2-1). Major transportation corridors of Interstate 205 (I-205) and Oregon Highway 43 (Highway 43) run through the City.

Figure 2-1. Location overview

There are several perennial streams within the City of West Linn that discharge to the Willamette and Tualatin Rivers (Figure 2–2) dividing the City into 24 major drainage basins that range in size from 40 to approximately 600 acres. Approximately 87 percent of the city area drains to Willamette River and the remainder is routed to the Tualatin River (West Linn TMDL Implementation Plan 2019).

2.2 Topography and Soils

West Linn's natural topography is characterized by steep hillsides to the west and relatively flat topography and floodplain area to the east and along the Tualatin and Willamette Rivers (Figure 2-3). Approximately 50 percent of the City has slopes exceeding 10 percent, including specific areas with slopes upwards of 25 percent. Topography can influence the conveyance capacity of channelized and piped infrastructure. Drastic slope changes can exacerbate ponding and backwater flow conditions. Significant grade changes are observed west of the Highway 43 corridor.

Soils are an important watershed characteristic for evaluating potential runoff rates and volumes. Soils are generalized into four categories, or hydrologic soil groups (HSG), which approximate soil runoff potential. These groups are A, B, C, and D, where A soils are characterized by high rates of infiltration and low runoff potential, and D soils are characterized by low rates of infiltration and high potential for runoff.

As shown in Figure 2-3, soils in the City are predominately silt loams with moderate to poor infiltration (HSG Type C, C/D, and D). Table 2-1 summarizes the NRCS hydrologic soil groups by percent coverage.

Table 2-1. Soil Conditions

Hydrologic Soil Group	Percent Coverage (%)
A	2.2
B	7.4
B/D	0.2
C	59.4
C/D	10.2
D	13.1
Water	7.5
Total	**100.0**

2.3 Land Use and Population

West Linn has experienced moderate growth over the last 20 years. In 2000, the City's population was 22,429. In 2019, the City of West Linn's population[1] is estimated to be 26,703, reflecting an average annual increase of less than 1 percent.

The City is primarily composed of low-density residential land use, with areas of commercial and industrial land use along the Willamette River, I-205 and Highway 43 corridors. Vacant lands with potential for redevelopment are located sporadically throughout the City. Expansion of the outer city boundary is not anticipated within the 10 year planning horizon of the SMP, but there are pockets of unincorporated area (mostly single tax lots) within the City where annexation is eventually anticipated. A breakdown of area within the city limits, UGB and contributing drainage basins is summarized in Table 2-2.

[1] http://worldpopulationreview.com/us-cities/west-linn-or-population/

Table 2-2. City of West Linn Area Overview	
Designated Area	Area (ac)
West Linn City Limits	5,186
Urban Growth Boundary	5,245
Contributing Drainage Area (for hydrology)	5,273

Land use coverage was developed in GIS to evaluate stormwater drainage conditions in the City. Land use coverage was based on City-provided GIS coverage of zoning and parks/open space areas. Vacant lands coverage from METRO was refined by City staff to reflect development that has occurred since the GIS coverage was developed. Impervious coverage by land use was provided by City staff based on values assumed in the 2006 Plan, compared with values used by neighboring jurisdictions, and verified based on spot comparisons to aerial imagery. Impervious percentage by land use is shown in Table 2-3.

Table 2-3. Land Use Coverage and Impervious Percentages		
Land Use Category	Impervious Percentage	Percentage of City Area
Commercial	85	2.9
Industrial	85	2.7
Vacant	3	5.3
Open Space/Park	0	11.7
Mixed Use	85	0.3
Residential (High/Multi-family)	50	3.4
Residential (Medium Density)	35	6.1
Residential (Low Density)	30	56.9
Transportation (ODOT Corridor)	35	4.4
No zoning (waterbodies)	0	6.2
TOTAL	--	**100.0**

Figure 2-4 reflects land use coverage for purposes of hydrologic calculations.

2.4 Climate and Rainfall

The northern Willamette Valley climate is characterized by cool wet winters and warm dry summers. Most rainfall occurs between October and April. On average, November is the wettest month with an average of 9.3 inches of rainfall. July and August are the warmest and driest months with average high temperatures above 80 degrees Fahrenheit and less than 1 inch of rain per month. The average annual precipitation for the Portland metropolitan area ranges from 37 to 43 inches, with an average of 1.8 inches of snowfall annually. West Linn specifically averages 44 inches of rainfall a year and 1 inch of snowfall annually.

In December 2015, the Portland metro area experienced a large rainfall event that delivered more than 5 inches of rain over a 3-day period and 2.81 inches in one 24-hour period. This event was estimated to represent between a 50- and 100-year recurrence event because of the intensity and nature of the rainfall. Research suggests that these “severe” events are expected to occur more frequently as the earth undergoes climate change.

2.5 Storm Drainage Infrastructure

The City manages more than 113 miles (approximately 595,260 linear feet [LF]) of stormwater drainage pipe and culverts and approximately 10 miles (52,422 LF) of open channels/ drainage ditches. Table 2-4 summarizes pipe, culvert and open channel system assets by mapped (in GIS) size throughout the City.

Table 2-4. System Asset Inventory–Pipes, Culverts, and Open Channels

Diameter	Length (LF)
N/A	8,570
0-6	29,130
8-12	431,490
14-18	77,950
20-24	28,030
27-30	6,470
36	10,990
40-42	890
48	920
54	310
60	230
66	100
72	220
>72	460
Total (Pipe and Culvert)	595,260
Total (Open Channel)	52,422
Total (Mapped Stream/Creek)	159,491

In addition to the storm drainage system assets identified above, approximately 30 miles of stream channels flow within the city limits, conveying stormwater to the Willamette and Tualatin Rivers. Approximately 15 percent of the stream channels in the City are piped, and thus included as part of the City's asset inventory in Table 2-4.

Table 2-5 summarizes major storm structures in the City, such as manholes, catch basins, clean outs, swales and ponds. Except for swales and ponds, other water quality facilities (i.e., raingardens, planters, porous pavement) are not mapped individually, and thus not included in the storm infrastructure inventory. However, the City does maintain a GIS coverage of public and private water quality facility drainage areas, for compliance with their National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer (MS4) permit. The water quality facility drainage area coverage was developed to reflect development-specific areas that are collectively treated by green streets or other low impact development techniques including raingardens and planters.

Figure 2-5 shows mapped individual public and private water quality facilities and contributing water quality facility drainage areas in the City. Approximately 17% of the City area currently has some form of onsite or regional stormwater treatment.

Table 2-5. Storm Infrastructure	
Facility	Number
Catch basin	2,977
Clean out	86
Ditch inlet/Inlet structure	665
Manholes/Pollution control manholes	1,543/142
Public ponds	47
Public wetlands	6
Swales (public and private)	203

Note: Excludes identified county, ODOT and private infrastructure, unless specified.

2.6 Regulatory Framework

The Oregon Department of Environmental Quality (DEQ) is responsible for implementing provisions of the federal Clean Water Act (CWA) pertaining to stormwater discharges and surface water quality. DEQ issues water quality permits related to surface water discharges, establishes water quality criteria for waterbodies based on designated use, and conducts studies and evaluations to determine whether a waterbody adheres to water quality standards.

Water quality regulations and improvement of instream (receiving water) quality are drivers for this SMP. As a result, a specific objective is identification of additional opportunities for water quality improvement and treatment facilities.

2.6.1 National Pollutant Discharge Elimination System (NPDES) Permit Program

The NPDES Municipal Separate Storm Sewer (MS4) permit program regulates discharges of stormwater to receiving waters from urban areas and requires permitted municipalities to develop and implement stormwater control measures to address stormwater quality.

The City of West Linn is one of 13 co-permittees on the Clackamas County Phase 1 NPDES MS4 Permit for discharges from their stormwater system. Other co-permittees include the neighboring cities of Oregon City, Milwaukie, Lake Oswego, and Gladstone, as well as Clackamas County. The City's NPDES MS4 permit was last issued in 2012 and is currently in administrative extension. Stormwater program requirements, as documented in the City's effective (2012) SWMP address:

- Illicit Discharge Detection and Elimination
- Industrial and Commercial Facilities
- Construction Site Runoff Control
- Education and Outreach
- Public Involvement and Participation
- Post-Construction Stormwater Management
- Pollution Prevention for Municipal Operations
- Stormwater Management Facilities Operation and Maintenance Activities

The 2012 NPDES MS4 permit required the City to prepare and implement a stormwater retrofit strategy and a hydromodification assessment. These technical assessments identified the need for development of water quality-related capital projects and are referenced in Table 1-1.

Future permit compliance has been considered in the identification of capital projects and programs documented in this SMP. Outcomes from the technical assessments were also referenced as part of the planning process. As such, implementation of this SMP is anticipated to help address future permit requirements that stem from previous analyses.

2.6.2 Total Maximum Daily Load (TMDL) and 303(d) Listings

Section 303(d) of the CWA requires states to develop a list of water bodies that do not meet water quality standards. This list is used to identify and prioritize water bodies for development of TMDLs. A TMDL identifies the assimilation capacity of a water body for specific pollutants and establishes pollutant load allocations for sources of discharge to the water body. DEQ is responsible for both the periodic assessment and establishment of the 303(d) list in Oregon and development of TMDLs.

The Willamette and Tualatin Rivers are the major receiving waters for West Linn. These rivers and corresponding tributaries are on the 303(d) list for various parameters of concern and hold TMDLs for specific sources of pollutant loading. Table 2-6 summarizes the current TMDL and 303(d) parameters relevant to the City. The current 303(d) list reflects the addition of pesticides and metals not reflected in previous 303(d) listings. A TMDL for mercury is underway and expected to be finalized in 2019.

Table 2-6. TMDL and 303(d) Summary for West Linn

Watershed/ Major Basin	Sub-basin(s)	TMDL Year	Applicable TMDL Parameters	TMDL surrogate Parameters	Applicable 303(d) Parameters [a]
Willamette River	Lower Willamette	2006	Mercury Bacteria (*E. coli*) Temperature	Effective shade (surrogate for temperature)	• Aldrin • Biological criteria • Chlordane • Chlorophyll a • Copper • Cyanide • DDT/DDE • Dieldrin • Iron • Lead • Polychlorinated biphenyls (PCBs) • Polynuclear Aromatic Hydrocarbons (PAHs)
	Middle Willamette	2006	Mercury Bacteria (*E. coli*) Temperature	Effective shade (surrogate for temperature)	• Aldrin • Biological criteria • Chlorophyll a • DDT/DDE • Dieldrin • Iron • PCBs
Tualatin River	Tualatin	2001 and 2012 (update)	Bacteria (*E. coli*) Chlorophyll a pH Dissolved Oxygen (DO) Temperature	• Total phosphorus (surrogate for chlorophyll a and pH) • Total suspended solids (equivalent parameter for SVS, a surrogate for DO) • Effective shade (surrogate for temperature)	• Ammonia • Biological criteria • Copper • Iron • Lead • Zinc

a. The 2012 303(d) list for Oregon was approved by EPA in December 2018. It is the effective list for Oregon.

As a Phase I NPDES MS4 jurisdiction, the City is required to establish TMDL benchmarks, which are quantifiable pollutant load reduction estimates established to evaluate progress towards meeting TMDL requirements applicable to the City. Through this SMP effort, and because the City is primarily built out, identification of water quality opportunities focused on the retrofit of existing stormwater facilities and less on the installation of new, regional stormwater treatment facilities. Additional information is provided in Section 4.2.

2.7 Storm Drainage System Maintenance and Program Management

The maintenance of the City's storm drainage system assets is important to ensure that the full life expectancy is achieved and the system is functioning as constructed. As part of the project planning process, current stormwater maintenance activities and frequencies were considered in conjunction with stormwater problem areas to determine if programmatic improvements (i.e., increased frequency, expanded program coverage, new program development) may be more effective than a capital project to meet City needs (see Section 4.4).

Under the City's Phase I NPDES MS4 permit and 2012 SWMP, certain stormwater system maintenance activities are required to address water quality improvements. Maintenance activities typically occur on a scheduled basis but also in response to citizen and staff inquiries and requests. Current stormwater maintenance activities and frequencies are outlined in Table 2-7.

Table 2-7. City Maintenance Activities (per 2012 SWMP)

Activity	Frequency required	Annual target [a]	Annual effort [a]
TV inspection	As needed	Varies	100-200 ft
Pipeline cleaning	As needed	Varies	Varies
Ditch inspection/cleaning	As needed	Varies	Varies
CB inspection and cleaning (public)	Annual	All	2,853 inspected; 713 cleaned
MH cleaning (Pollution Control)	Annual	All	145 PCMH inspected; 145 cleaned
Street sweeping	3-6x/year	Varies	Varies
Public water quality pond inspections [b]	Annual	49	49
Public pond maintenance	As needed	--	262 hours
Private WQ facility inspections [c]	As needed	--	27 facility inspections

a. *Based on the City's 2017-2018 annual report.*

b. *Inspection of public stormwater treatment and detention facilities is required per the SWMP. City efforts focus on pond inspection and maintenance activities.*

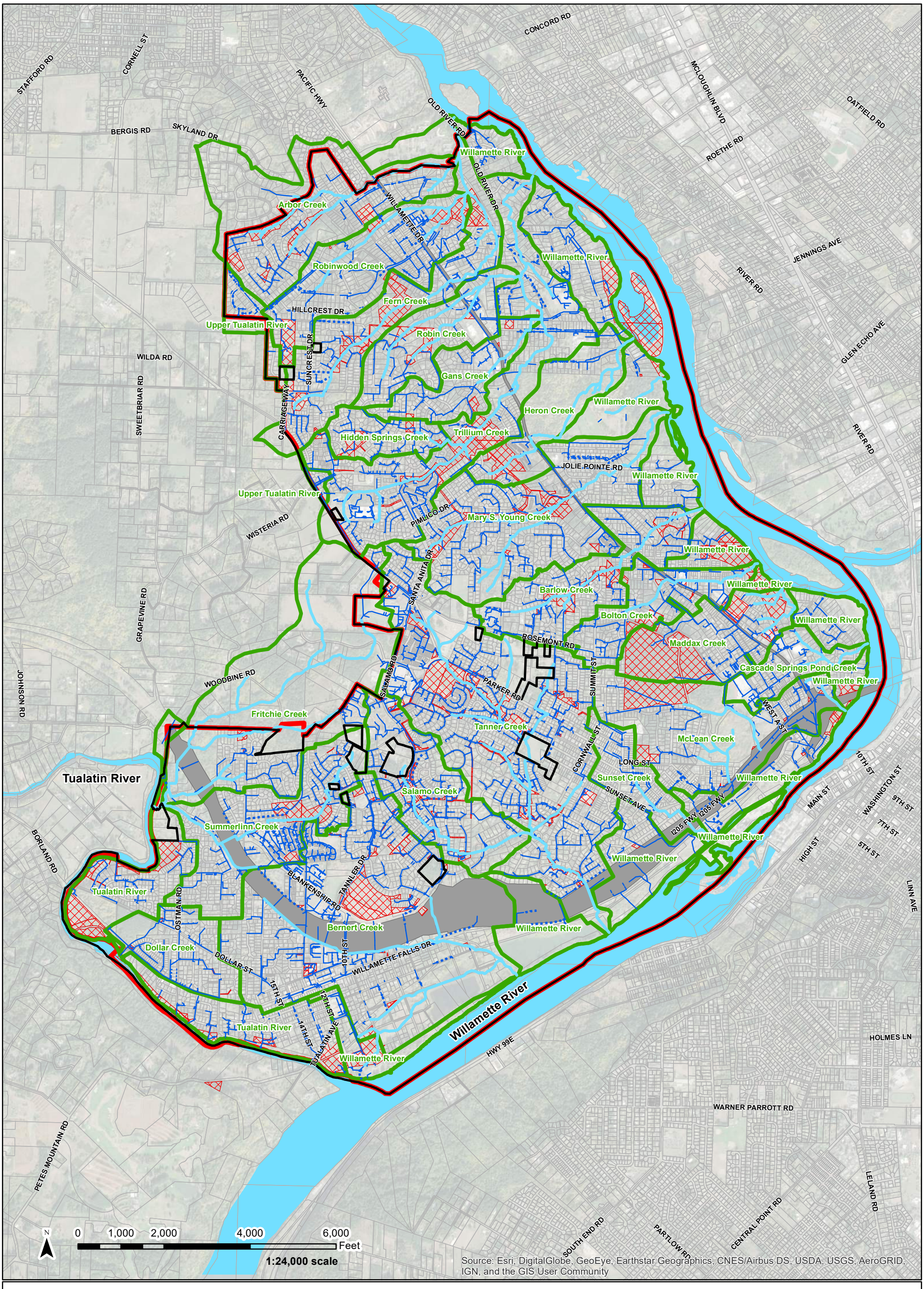
c. *Annual report indicates the number of new private maintenance agreements received. Approximately 30% of registered facilities report on maintenance compliance annually.*

Specific to water quality facility inspections and maintenance, the City has guidance documents and program instructions to assist City staff and the public in performing maintenance activities.

Funded maintenance programs conducted by the City's Environmental Services Division are defined in Table 2-8 per the City's 2018-2019 budget. Existing (current) funding allocations must be considered with respect to proposed expanded programmatic efforts and activities (see Section 6.4).

Table 2-8. Existing Program Funding (2018-19)

Relevant Activity	Annual Budget
Repair of Stormlines	$100,000
Repair of MH/CBs	$10,000
CCTV Inspection	Generally performed with in-house staff/equipment



CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 2-2: Storm Drainage System Overview

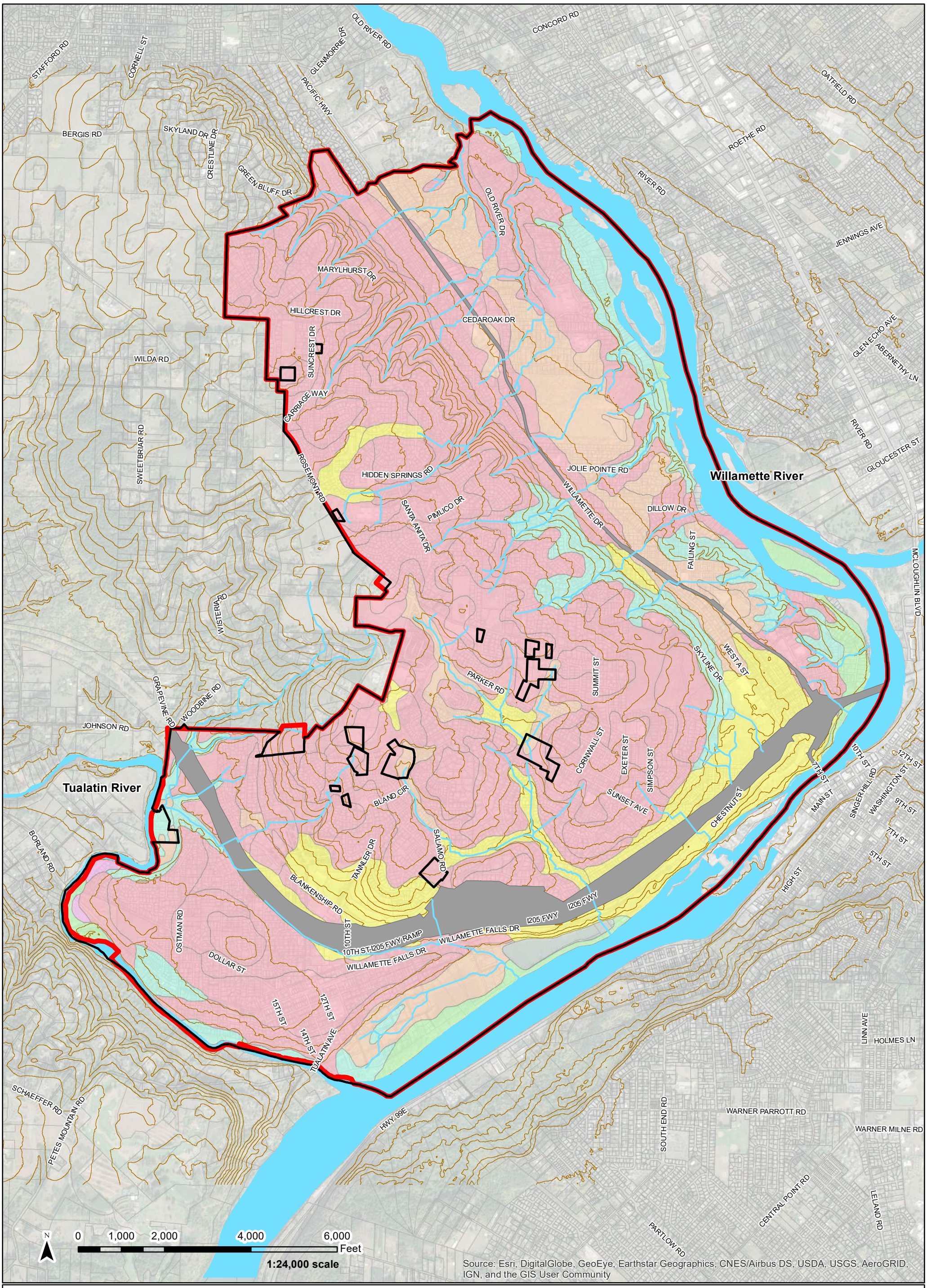
Public Property
Stormwater Pipe
Open Channel
Streams
Watershed Boundaries
ODOT ROW
City Limits
UGB

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

8/29/2019



CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 2-3: Soils and Topography

Hydrologic Soil Group
- A
- B
- B/D
- C
- C/D
- D

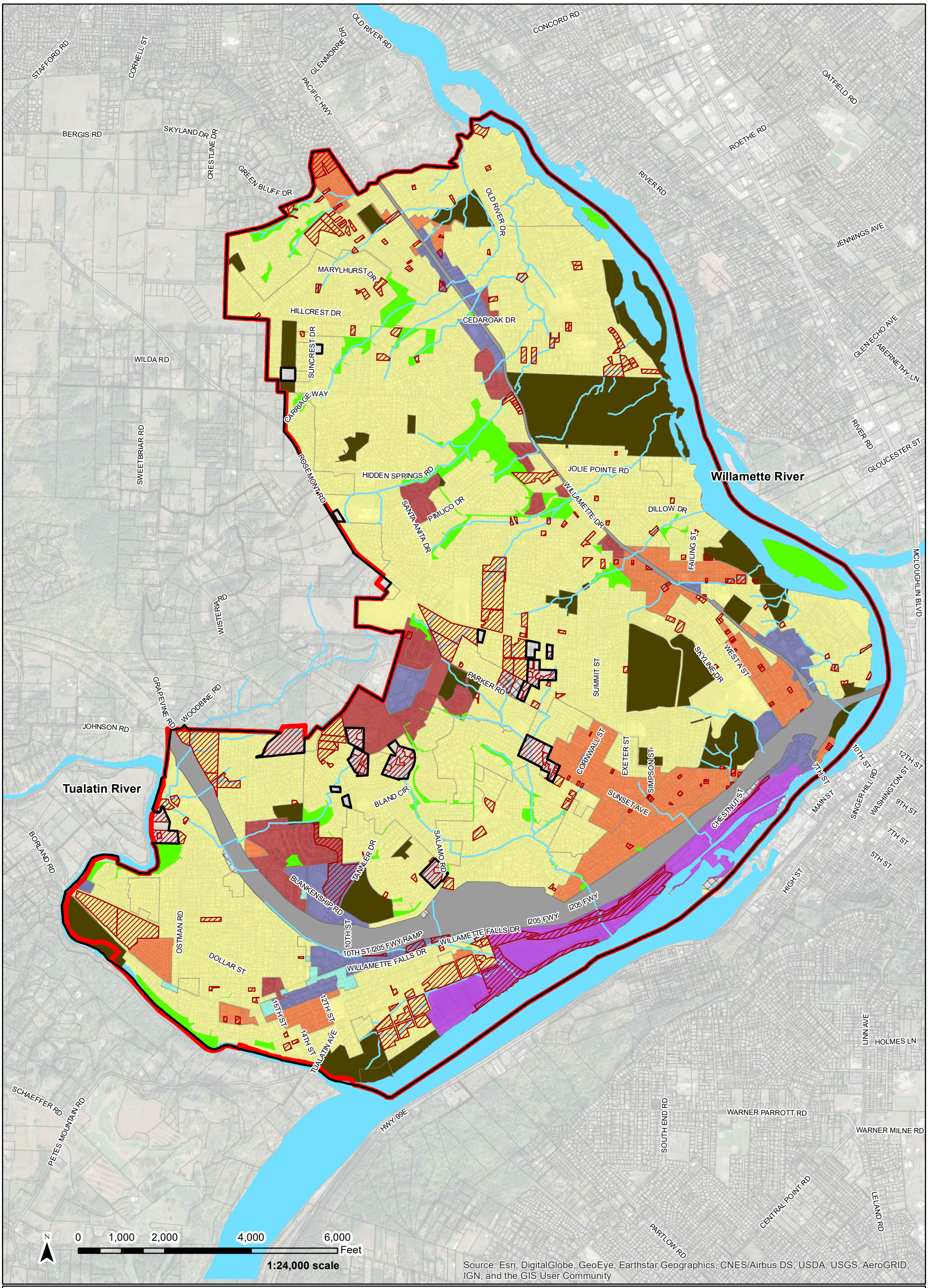
- Contours (50 ft)
- Streams
- ODOT ROW
- City Limits
- UGB

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

8/29/2019



CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 2-4: Existing Land Use

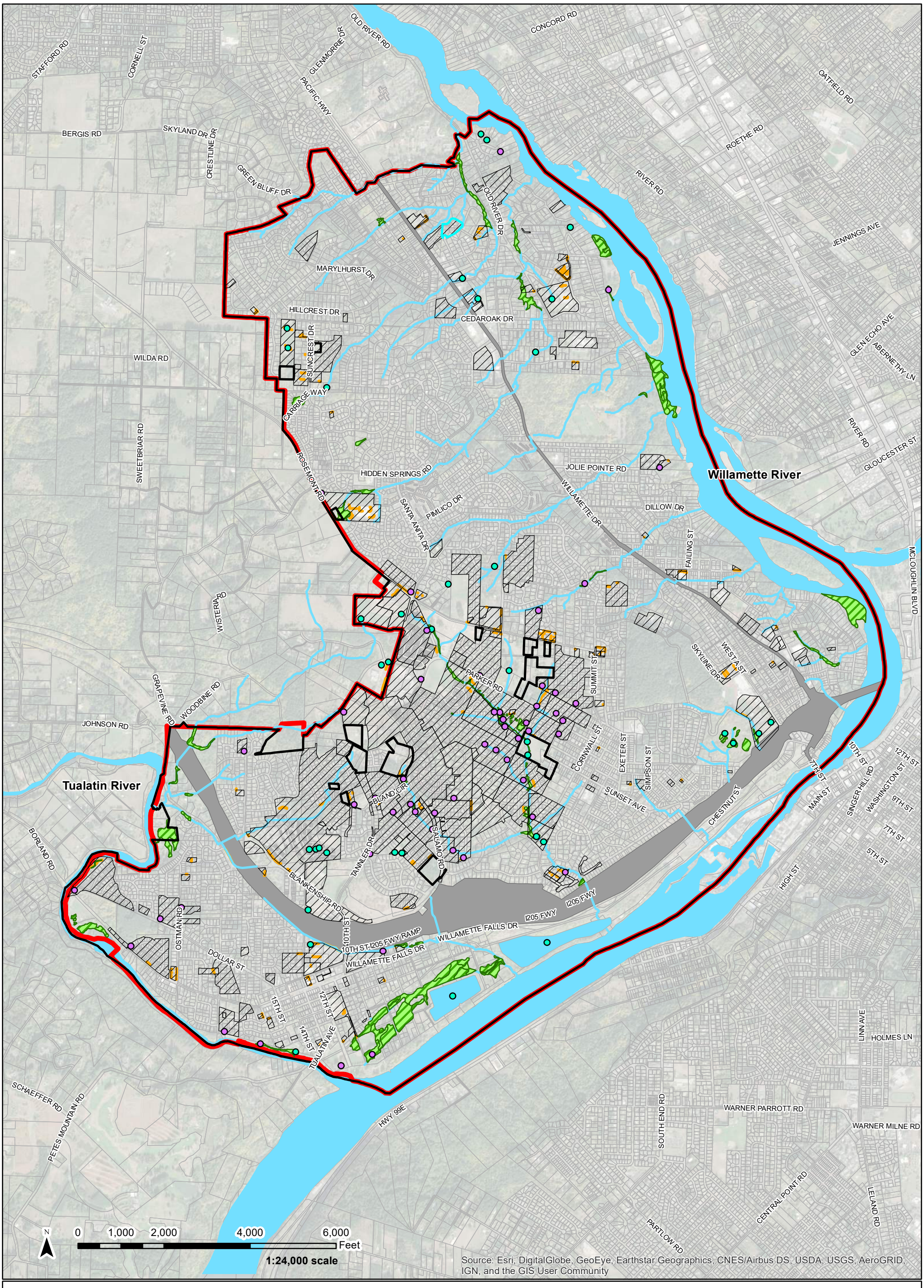
- Commercial
- Industrial
- Residential (Low Density)
- Residential (Medium Density)
- Residential (High Density/Multi-family)
- Mixed Use
- No Zoning (Unzoned)
- Vacant
- Parks
- Open Spaces
- Streams
- ODOT ROW
- City Limits (2017)
- UGB

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

8/29/2019



CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 2-5: Storm Drainage Treatment Facilities and Drainage Areas

- Private Ponds
- Public Ponds
- Swale
- Wetlands
- Water Quality Facility Drainage Areas[1]
- Streams
- ODOT ROW
- City Limits
- UGB

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

1. Other water quality facilities (i.e. rain gardens, planters, porous pavement) not individually mapped are reflected in this coverage.

9/9/2019

Section 3

Code Evaluation and Basis of Design

This section summarizes review of the City's current (as of October 2018) code and standards applicable to this SMP. Elements of the code review included conveyance, water quality, erosion and sediment control, maintenance, and code enforcement. Code review was limited to the following sections of City code and standards:

- West Linn Municipal Code (WLMC), Chapter 4 Utilities, Chapter 5 Nuisances, and Chapter 8.105 Building Permittee Responsible for Erosion Prevention and Sediment Control
- West Linn Public Works Design Standards (PWDS), Section 2, Storm Drain Requirements
- West Linn Public Works Standard Construction Specifications, Division 6, Storm Drain Technical Requirements
- West Linn Community Development Code (CDC), Chapter 55 Design Review, Chapter 56 Parks and Natural Area Design Review, and Chapter 92 Required Improvements

The initial code review was conducted in November 2017 and identified inconsistencies, implementation gaps, and technical recommendations. As a result, in October 2018, the City addressed select recommendations from the initial code review in an update of their PWDS. Outstanding (following the October 2018 update) recommendations and basis of design used to evaluate system deficiencies and develop capital projects for this SMP are detailed below.

The comprehensive code review, reflecting original recommendations and updates made to the PWDS in October 2018, is documented in Technical Memorandum #1 (TM1), included in this SMP as Appendix A.

3.1 Code Recommendations

The following outstanding code recommendations reflect: 1) potential modifications to the City's policies and technical design standards, and 2) adjustments to code to improve clarity, resolve discrepancies, and ease implementation of existing policy and standards.

Example language to address recommendations specific for PWDS 2.0040 and 2.0050 can be found in Appendix A, Attachment C.

3.1.1 Technical Standards and Stormwater Policy Changes

Recommendations listed are specific to the CDC and PWDS and intended to improve consistency with the NPDES MS4 permit requirements and guide developers implementing stormwater management in the City. Note that recommended changes may require a more in-depth review of current City practices and pending updates to the Portland Stormwater Management Manual (SWMM), to establish City policy prior to code development.

- **CDC**: Consider updating current floodplain management code sections to reflect floodplain standards consistent with the *Program Level Biological Assessment* for the National Floodplain Insurance Program for the State of Oregon (February 2013). In addition, floodplain management regulations should be moved from the CDC to the WLMC.
- **PWDS, Water Quality:** Modify PWDS 2.0013 to state specific design storms. Based on the site-specific analysis conducted for Clackamas County jurisdictions, the water quality design storm should be the 1 inch 24-hour design storm, resulting in capture of 80 percent of the annual runoff volume.
- **PWDS, Facility Selection:** Expand PWDS 2.0013 or 2.0040 and 2.0050 to list a City-specific facility selection hierarchy that prioritizes green infrastructure facilities and clarify which impervious area reduction techniques (e.g., green roofs, pervious pavers/pavements, tree planting, rainwater harvesting) are allowable in the City.

3.1.2 Clarity and Implementation Changes

Recommendations listed below are intended to improve clarity and ease implementation related to the referenced use of the Portland SWMM. Proposed revisions should not impact City policy or technical standards.

The PWDS currently references the entire Portland SWMM. Portland makes frequent updates to the SWMM and associated details and forms, which should be considered by the City. Recommended adjustments related to implementation of the Portland SWMM are listed below.

- **PWDS, Facility Selection:** Revise PWDS 2.0013 or 2.0040 and 2.0050 to include a City-specific list of allowable BMPs and BMP selection hierarchy. This would give the City more control over the types of facilities that are installed in West Linn. The PWDS could still refer to the Portland SWMM for a list of allowable proprietary treatment technologies.
- **PWDS, SWMM References**: Throughout the PWDS, revise general Portland SWMM references to instead refer to the "BMP sizing methodologies, design criteria, and typical drawings in the Portland Stormwater Management Manual" so that designers have clear guidance for the specific portions of the Portland manual that apply to West Linn.
- **PWDS, Technical Guidelines**: Consider adding detail to PWDS 2.0040 and 2.0050 to refer to specific technical guidelines in the Portland SWMM. These could include the Portland SWMM appendices related to infiltration testing, proprietary treatment technologies, source control standards, maintenance standards, and soil and plant lists.

Table 3-1 summarizes additional recommendations solely to improve clarity and minimize use of redundant or repetitive references in the City's current standards.

Table 3-1. Recommended Code and Standard Clarifications		
Section	Recommended Revision	Notes
WLMC4.063 General Discharge Prohibitions	Consider adding a list of permissible or conditionally allowable discharges, consistent with NPDES MS4 permit section A.4.a.xii.	
WLMC 4.065 City Responsibilities	Expand the list of drainage facilities to include "stormwater treatment and control facilities located on public property."	Current language indicates that the City is responsible only for flood control facilities.
WLMC 8.105 Erosion Prevention/Sediment Control	Add a reference to PWDS 2.0060 for erosion control permit types and applicable thresholds.	Erosion control permits are required only for projects that disturb over 1,000 sf. WLMC 8.105 indicates that all building permit projects require an erosion control permit.
PWDS 2.0011 Site Drainage Requirements	Delete items D and E	Items D and E relate to minimum requirements for detention and water quality facilities and are covered under the appropriate section (PWDS 2.0013).
PWDS 2.0045 Detention Facilities	Reformat for clarity: numbered items 3 and 5 should be C and D; numbered item 4 should be combined with item A.	Item A and item 4 have duplicate content.

3.2 Basis of Design

Table 3-2 lists applicable design criteria used to identify areas of the storm drainage system with capacity limitations and develop projects to address capacity deficiencies. Design criteria reflect the most recent update to the PWDS in October 2018. Expanded tables of drainage design criteria are included in Appendix A and Appendix C (TM3, *Hydrology and Hydraulic Modeling Methods and Results*).

Table 3-2. Project Evaluation and Design Criteria		
Criteria	Source	Standard
Water Quality Facility Design	PWDS 2.0013	All water quality facilities shall meet the design requirements of the current edition of the City of Portland SWMM.
Conveyance Piping Design	PWDS 2.0013	• Design to convey the 10-year storm event. • Minimum slope of 0.0055 (0.55%). • Minimum velocity of 2 feet per second, when flowing full. • Pipe roughness design coefficient shall not be less than 0.013.
Culvert Design	PWDS 2.0014	Design to convey the 25-year storm event such that the headwater does not exceed 1.5 times the culvert diameter.
Open Channel Design	PWDS 2.0013	Control discharge so that the average velocity during the 10-year event is below the erosive velocity of the channel.
Pipe Size	PWDS 2.0012 PWDS 2.0033	12" minimum diameter for mains in the public right-of-way.
Pipe Material	PWDS 2.0012	• Concrete, PVC, HDPE smooth interior/corrugated exterior are allowable. • Ribbed PVC is preferred for storm drains up to 24" in diameter. • Reinforced concrete is preferred for storm drains over 24" in diameter. • Ductile iron is allowed in areas where additional strength is required.
Pipe Cover	PWDS 2.0023	Minimum cover shall be 30" above the top of the bell of the pipe in paved areas and 36" in all other locations. When minimum cover cannot be provided, implement additional strength measures.
Structure Spacing	PWDS 2.0031-2.0033	Maximum of 500 feet between manholes.

Design storms are precipitation patterns typically used to evaluate the capacity of storm drainage systems and design capital improvements for the desired level of service. Design storms evaluated in this SMP include the 2-, 10-, and 25-year recurrence interval 24-hour events. Design storms are not specified in the City's PWDS (see Section 3.1.1). As such, the rainfall depths were taken from Clean Water Services (CWS') *Design & Construction Standards*, Standard Detail Drawing No. 1280 (Table 3-3).

Table 3-3. Design Storm Depths

Design storm event	Rainfall depth, inches
2-year, 24-hour	2.50
10-year, 24-hour	3.45
25-year, 24-hour	3.90

Section 4

Project Planning Process

This section summarizes the project planning process and identification of Stormwater Project Opportunity Areas, which inform the capital project, program and policy development efforts. A project needs assessment and a water quality assessment were conducted as part of this collaborative process with city staff (engineering and maintenance) and the public. Proposed roadway improvements along Oregon Highway 43 (Highway 43) also informed the process.

This process allowed the City to focus resources and develop information for areas and projects most likely to be prioritized in a capital improvement program. This process qualified project needs in consideration of the SMP objectives, specifically: resolving known areas of stormwater drainage problems and flooding; enhancing and expanding water quality treatment; and identifying programs and policies to address stormwater needs on a city-wide scale.

The project planning process is described in additional detail in Technical Memorandum #2 (TM2), included in this SMP as Appendix B. The final Stormwater Project Opportunity list and figure depicting project opportunity locations recommended for the storm drainage capital improvement program is provided in Appendix C.

4.1 Project Needs Assessment

The project needs assessment included the identification of "stormwater problem areas" as areas of the City with reported and observed deficiencies. It also included the evaluation of whether a public infrastructure improvement, addition, replacement, or retrofit would address the deficiency. As the City is not anticipating significant growth or change in contributing stormwater runoff, city-wide hydraulic modeling, as conducted for the 2006 Plan, was not conducted to identify project needs.

The City typically receives few complaints regarding the storm drainage system function or capacity. The City also anticipates limited growth (annexations) and new development over the SMP planning period (i.e., 10 years). As such, a qualitative effort to evaluate the identified stormwater problem areas was used to validate the need for system improvements (projects or programs).

Data sources used for the project needs assessment included the following:

- System GIS data[2]
- Public and City staff surveys

[2] Approximately 77% of the piped storm drainage system inverts were not reflected in GIS. This data gap was considered in the context of conducting city-wide hydraulic modeling.

- Planning documentation and reports
  - Stormwater Retrofit Plan (2015)
  - Hydromodification Assessment (2015)
- Previous Project List (per the City's 2006 Plan)
- Site Visits
- Project Workshops with City staff (November 30, 2017 and February 15, 2018)

A total of 65 stormwater problem areas were originally identified, compiled and categorized in accordance with the following primary deficiency:

- Capacity
- System Configuration
- Infrastructure Needs
- Erosion
- Water Quality (related to existing system performance)
- Maintenance
- System Condition

Identified system deficiencies include failing infrastructure as well as capacity limitations.

(Photo: Culvert crossing at 5th Ave.)

Stormwater problem areas were documented in a matrix format and sorted based on whether a capital project or city-wide program would best address the deficiency. See Appendix B for detail.

4.2 Water Quality Assessment

A water quality assessment was conducted to identify additional project opportunities for consideration in the City's SMP. This assessment addresses commitments outlined in the City's Stormwater Retrofit Plan (2015), 2012 NPDES MS4 permit, and 2012 SWMP.

City charter (West Linn Charter, Chapter 11, Section 46) limits the use of park property for any "nonauthorized" use without voter approval as related to the construction of utilities. A regional stormwater treatment facility would be considered a utility subject to provisions of this charter. As described previously, the City is also primarily built out with limited available property for acquisition and/or use for construction of a regional stormwater treatment facility. As such, the water quality assessment focused on the "retrofit" of existing stormwater infrastructure, to minimize land use and administrative challenges related to the addition of new stormwater infrastructure in public property. The water quality assessment focused on the following objectives:

1. Expand treatment area coverage of existing stormwater treatment facilities or practices;
2. Improve the function of existing stormwater treatment facilities; and
3. Incorporate low impact development (LID) or green infrastructure applications where possible, as they promote infiltration and runoff volume reduction in addition to treatment.

A desktop GIS evaluation was conducted to comprehensively look at locations that would benefit from water quality improvements and facilities that could be retrofit to improve water quality. Areas of the City with anticipated relatively higher pollutant load generation based on land use and pollutants of concern (see Table 2-6) were targeted. Existing, mapped stormwater ponds were inventoried and evaluated to assess retrofit potential. Pond ownership condition (public, private), installation date, configuration (online vs offline), and potential for future development to occur upstream were considered as part of the pond inventory. Stormwater problem areas (Section 4.1) where collection system improvements are identified as

needed were targeted for incorporation of LID or green infrastructure applications. Opportunistic areas (i.e., vacant, public, or undeveloped areas) where regional treatment facilities may be located were reviewed, but minimal opportunities identified.

A total of 21 water quality opportunities were initially identified. Ten opportunities (locations) overlapped with results of the project needs assessment, and thus water quality was integrated into the project development process for those locations. Five opportunities were identified as potential new projects. Six opportunities were removed from consideration due to site constraints, limited potential for retrofit or land acquisition, or where water quality is already being addressed. See Appendix B for detail.

Green infrastructure incorporated into existing streetscapes can aid in stormwater collection as well as treatment.

(Photo: Stormwater "bubbler" applications on Buck St.)

4.3 Highway 43 Drainage Evaluation

The City is currently partnering with ODOT under the Highway 43 Multimodal Transportation Project (Highway 43 Project) to construct a new bike lane and sidewalk along Highway 43. The project effort is divided into two phases, with Phase I extending from Arbor Drive to Hidden Springs Road. Phase II extends from Hidden Springs Road to I-205. The City entered into a Cooperative Maintenance Agreement with ODOT in February 2018 to initiate design and construction of Phase I. Construction of Phase I is anticipated to begin in 2020. Roadway improvements are anticipated to change the roadway grade and expand impervious surface area subject to water quality treatment requirements.

Given anticipated improvements to the roadway alignment and profile, five stormwater problem areas identified during the project needs assessment (Section 4.1) are likely to change or be addressed through the improvements to roadway drainage as part of this project. These areas are documented as a Stormwater Project Opportunity Area (Appendix C), but not directly addressed with a proposed project in this SMP.

There are currently 24 mapped crossings (culverts) under Highway 43 that convey upstream piped or open channel drainage systems. With timing of the Highway 43 project, the City opted to evaluate the conveyance capacity of the culvert crossings so that capital projects can be identified to address the upsizing and/or realignment of crossings and implementation can occur in conjunction with the scheduled roadway improvements. This hydraulic evaluation is summarized in Section 5.

New and replaced impervious area resulting from the Highway 43 Project are subject to the City design standards for stormwater treatment. Federal funding and anticipated Nationwide permitting requirements for this transportation project also make stormwater management subject to SLOPES V requirements. Opportunities for water quality treatment associated with Highway 43 improvements were evaluated as part of the water quality assessment (Section 4.2)[3], but due to the unknown gradation and design of the roadway, water quality treatment needs are not directly addressed with proposed projects in this SMP.

[3] The City received voter approval for the use of park property to support stormwater management associated with Highway 43 improvements, and therefore park property may be used to site stormwater facility installations for this purpose.

4.4 Results

Appendix C (Table C-1 and Figure C-1) summarizes the Stormwater Project Opportunity Areas identified through the project needs, water quality, and Highway 43 project assessment efforts. This information was originally compiled and documented as part of the project planning process (Appendix B). However, additional refinements during the project needs prioritization (Section 4.4.1) and capacity evaluation (Section 5) resulted in updates to the Appendix B documentation.

Table C-1 summarizes 22 capital project needs resulting from the assessments. Three of these capital project needs are proposed to be addressed as part of a planning study. Fourteen additional locations are proposed for consolidation, to be addressed as part of city-wide program development addressing city-scale maintenance needs and opportunistic water quality improvements. Additional detail on capital project and program development is provided in Section 6.

There were 28 originally-identified project needs that, upon additional review and discussion with the City, were not considered viable project or program opportunities. These locations are documented in Appendix C for reference.

4.4.1 Project Prioritization

Stormwater Project Opportunity Areas were reviewed by city staff to prioritize those areas requiring development of detailed project concepts and costs in accordance with a defined project implementation schedule. Project opportunities considered high or medium priority are anticipated to be initiated over the 10-year implementation period, and thus warranted a project concept and cost estimate. Program opportunities were collectively considered medium priority, thus warranting funding but not at the expense of high priority project needs.

Table 4-1 summarizes the prioritization criteria used to rank opportunities. Prioritization criteria applicable to specific Stormwater Project Opportunity Areas is reflected in Table C-1. Full results of the prioritization effort are described in Section 6.

Table 4-1. Prioritization Criteria

Criteria	Scoring Definition		
	High (H)	Medium (M)	Lower (L)
Flooding Issue	• Addresses an area of known or significant capacity deficiency or erosion potential. • Identified as currently flooding per hydraulic modeling efforts.	• Addresses localized flooding issue.	• No reported flooding concerns or safety issues associated with project location.
Water Quality Improvement	• Project addresses pollutants of concern and may be classified as a retrofit per the City's 2015 Retrofit Plan.		• Project moderately improves or doesn't improve water quality.
Location	• Located on public property or within the public ROW		• Located on private property in its entirety.
Maintenance	• Project addresses failing infrastructure or a lack of infrastructure. • Project provides increased longevity for facility function.	• Project will reduce existing maintenance needs or complaints.	• Project does not address existing maintenance deficiency.
Concurrence with Transportation Projects	• Project is associated with a transportation project anticipated for construction in the next 5-years.	• Project is associated with a transportation project anticipated for construction in the next 5 to 10 years.	• Associated transportation project is not expected in the next 10 years or a pending transportation project will address deficiency without additional resources.
Special Interest	• Project has City Council, city staff, or public interest/motivation.	• Project has some public interest/motivation.	• Project has no public driver or interest.

4.4.2 Modeling Needs

After identifying Stormwater Project Opportunity Areas and priorities, modeling needs were evaluated. The project needs assessment included the identification of six targeted areas of the city that would benefit from hydrologic and hydraulic modeling to confirm observed deficiencies and inform conceptual sizing of improvements:

1. 5th Avenue Culvert (Location ID 13)
2. Blankenship Road (Location ID 47)
3. Fairview Way (Location ID 56)
4. Sunset Creek Culvert at Willamette Falls Drive (Location ID 59)
5. Fern Creek at Kantara Way (Location ID 60)
6. Maddox Creek at River Street (Location ID 63)

In addition to the six locations listed above, the need to evaluate capacity of the 24 culvert crossings underneath Highway 43 was also identified.

Refer to Appendix C for description and map of modeling needs by Location ID. Detail related to the hydrologic and hydraulic (H/H) modeling methodology, model results and associated project development is included in Section 5.

This page left intentionally blank.

Section 5

Storm Drainage System Capacity Evaluation

Stormwater conveyance is the primary function of the City's storm drainage infrastructure. This section summarizes the H/H system modeling approach and results for targeted areas of the City, to verify observed capacity limitations and develop project solutions.

Existing and future system capacity was evaluated for six targeted areas of the City, as well as the 24 culvert crossings under Highway 43. Capital project recommendations were developed for each modeled area following verification of capacity limitations and assessment of project alternatives. Six capital project recommendations result from this H/H modeling effort (see Section 6.4).

The system capacity evaluation and H/H model results are described in additional detail in Technical Memorandum #3 (TM3), included in this SMP as Appendix D.

5.1 Modeling Approach

H/H modeling was conducted for areas of the City with known capacity limitations or where flooding is frequently observed. This targeted modeling approach focused resources on specific areas of the city where additional information is needed to quantify system flooding and develop project solutions.

For this SMP, the following modeling approach was used to evaluate conveyance capacity:

1. Compile a list of known and suspected problem areas and evaluate which areas will require modeling to inform corrective measures (see Section 4.1);
2. Assess modeling needs in terms of whether a detailed or more limited hydraulic model is required (refer to Section 5.3.1);
3. Review available data (via GIS, as-builts, etc.) to identify data gaps and data required for model development;
4. Document observed data gaps in a format to support the City-obtained collection of field survey information and updates to the City's GIS;
5. Refine delineated subbasins (per the City's 2006 Plan) and develop a city-wide hydrologic model to estimate stormwater runoff generated for existing and future development conditions;
6. Develop the hydraulic models;
7. Validate modeled flooding using anecdotal information (photographs, City records);
8. Verify capacity constraints and identify potential sources or causes of flooding with City staff; and
9. Use the validated hydraulic models to simulate alternative conveyance system designs and develop potential solutions to capacity problems.

5.2 Hydrologic Model Development and Results

A city-wide hydrologic model was developed using XP-Storm Water Management Model (XPSWMM) version 2016.1. Within the model, the RUNOFF method was used to estimate hydrology. The input parameters for the RUNOFF Method included subbasin area, slope, width, infiltration conditions, and impervious percentage. The hydrology routine in XPSWMM converts rainfall into stormwater runoff based on design storm parameters (e.g., volume and intensity of rainfall), the input parameters listed above, and the infiltration conditions of the soils based on soil type.

Hydrologic model methods are described in additional detail and results are tabulated in Appendix D. Overall, when compared to existing conditions, the hydrologic model results showed minimal increases in future flows for most subbasins, due to limited potential for new development activities (i.e., mapped vacant lands). The largest increases in flow were identified in subbasins with larger amounts of vacant land, such as in the Bernert Creek and Tanner Creek watersheds.

5.3 Hydraulic Model Development and Results

To evaluate flood hazards and stormwater infrastructure capacity, the XPSWMM computer model was used to simulate select pipe and open-channel systems and calculate peak flows, water surface elevations, and velocities within the modeled infrastructure for select design storms. Hydraulic model input parameters included conduit (pipe or open channel) name, upstream (US) and downstream (DS) node information (name, invert elevation, rim elevation), conduit length, conduit slope, conduit shape, and pipe diameter.

5.3.1 Model Development

For purposes of this SMP, hydraulic model development was categorized as either detailed hydraulic modeling or limited hydraulic modeling.

Detailed hydraulic modeling incorporated the use of multiple nodes and links to evaluate performance of a collection system network. Two areas of the City were selected for detailed hydraulic modeling due to reported flooding frequency and the need to understand the potential cause(s) and extents of flooding:

1. Blankenship Road (Location ID 47)
2. Fairview Way (Location ID 56)

Limited hydraulic modeling included the assessment of capacity of a single link (i.e., culvert), accounting for the contributing upstream drainage but not incorporating hydraulic modeling of the upstream collection system. Five areas of the City were selected for limited hydraulic modeling:

1. 5th Avenue Culvert (Location ID 13)
2. Sunset Creek Culvert at Willamette Falls Drive (Location ID 59)
3. Fern Creek at Kantara Way (Location ID 60)
4. Maddox Creek at River Street (Location ID 63)
5. Highway 43 Culvert Crossings (24 total)

Flat topography and an insufficient stormwater collection system along Blankenship Road frequently results in ponded water and road closures during storms.

(Photo: Blankenship Road at I-205)

Figure 5-1 provides an overview of the hydraulic modeling locations (with the exception of the Highway 43 culverts) and contributing drainage area. Figure 5-2 provides the same overview specific for the Highway 43 culverts.

5.3.2 Results and Capital Project Development

The hydraulic model results show very little increase in future flows for areas that are fully developed. The hydraulic model results confirmed stormwater problem areas/capacity limited areas as identified by City staff or in the 2006 Plan and provided additional information about potential sources of the flooding problems.

For the detailed hydraulic model areas, flooding was identified when water exited the closed conveyance system, or for open channels, when the maximum water surface elevation at any modeled node was equal to or greater than the ground elevation of the node. For the limited hydraulic model locations, flooding was identified for culverts based on whether the headwater was above 1.5 times the culvert diameter (see Table 3-2). A secondary design criterion for culverts (headwater was less than 1 foot below the roadway subgrade) was also evaluated, but not used to determine system deficiencies due to the unknown accuracy of the roadway elevations.

Detailed hydraulic modeling results are provided in Appendix D, including tables reflecting maximum water surface elevations and maximum peak flows for each modeled conduit.

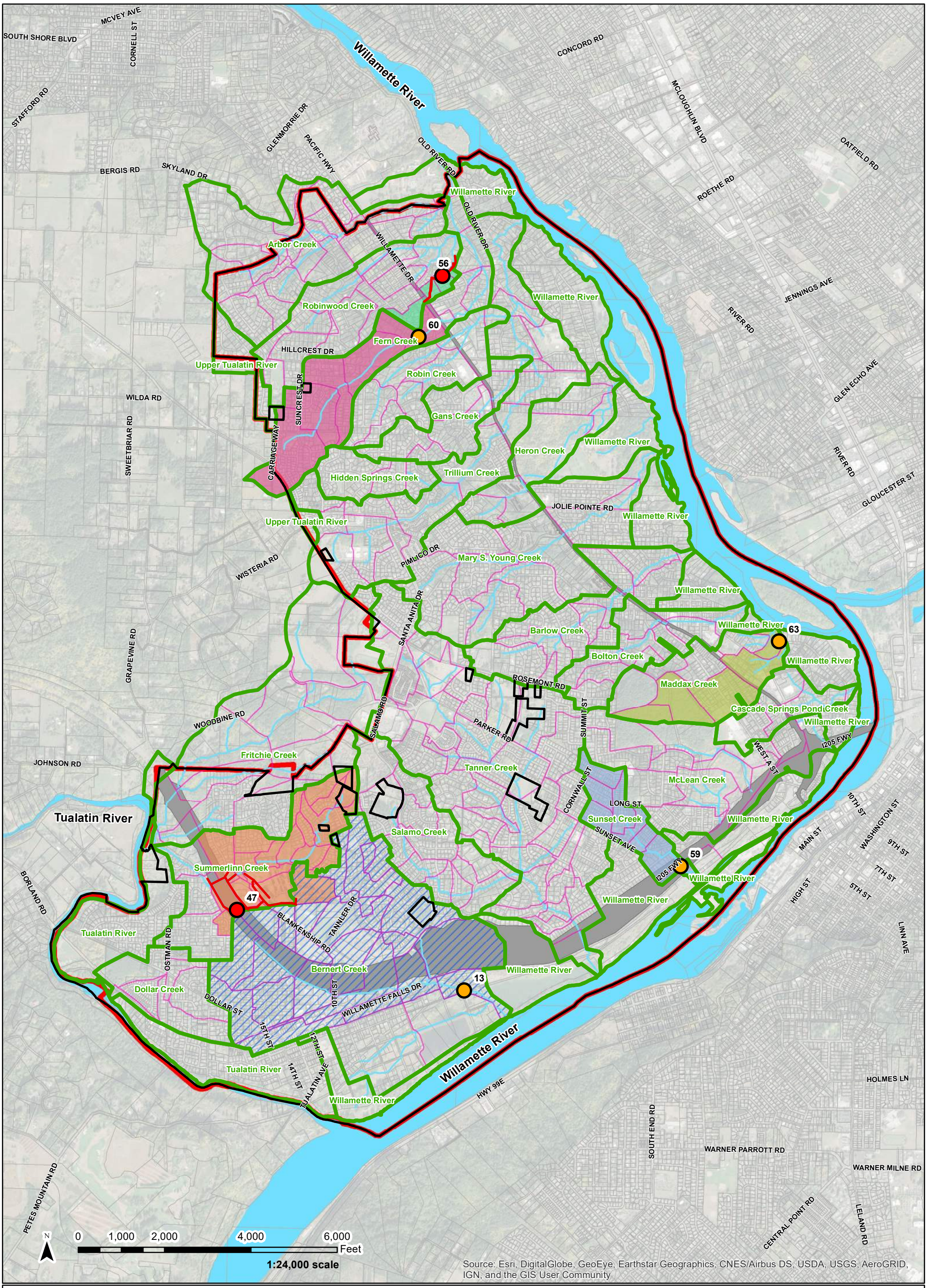
Table 5-1 below summarizes the model estimated frequency of flooding for each modeled system and resulting capital project development approach.

Table 5-1. Capacity Evaluation Results			
Model Area	Modeling Approach	Frequency of Flooding	Capital Project Development (Y/N)
5th Avenue Culvert (Location ID 13)	Limited	2-year, existing condition	Y – High Priority Project Need
Blankenship Road (Location ID 47)	Detailed	2-year and 10-year, existing condition for select pipes	Y - High Priority Project Need
Fairview Way (Location ID 56)	Detailed	10-year, existing condition for select pipes	Y – High Priority Project Need
Sunset Creek Culvert at Willamette Falls Drive (Location ID 59)	Limited	2-year, existing condition	Y – High Priority Project Need
Fern Creek at Kantara Way (Location ID 60	Limited	2-year, existing condition	Y – Low Priority Project Need [a]
Maddox Creek at River Street (Location ID 63)	Limited	2-year, existing condition	Y – High Priority Project Need
Phase I Highway 43 Culverts [b] (Crossings A – M)	Limited	• 2-year, existing condition (Crossings A, B, C, H, L, M) • 10-year, existing condition (Crossing D) • 25-year, existing condition (Crossing J)	Y – High Priority Project Need
Phase II (Future) Highway 43 Culverts [b] (Crossings N - X)	Limited	• 2-year, existing condition (Crossing P) • 10-year, existing condition (Crossings O, S, W) • 25-year, existing condition (Crossing R)	Y – Low Priority Project Need [c]

a. *This location is considered low priority following review with the City. The culvert location is in a ravine with no reported flooding or potential for property damage. It is still considered a capital project need but has not been costed under this SMP.*

b. *Refer to Figure 5-2 for crossing locations and naming.*

c. *These crossings are considered low priority following review with the City. Timing of the future, Phase II construction is unknown. These crossings are still considered a capital project need but have not been costed under this SMP.*



CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 5-1: Storm Drainage System Overview (Targeted Hydraulic Model Locations)

Contributing Drainage Area (by Location ID)
- 13
- 47
- 56
- 59
- 60
- 63
- Modeled Conveyance System (detailed model)

- Detailed Hydraulic Model
- Limited Hydraulic Model
- Streams
- Watershed Boundaries
- Subbasins
- ODOT ROW
- City Limits
- UGB

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

8/29/2019

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 5-2: Storm Drainage System Overview
(Highway 43 Crossing)

Contributing Drainage Area
- Highway 43 (Phase I)
- Highway 43 (Future)
- Highway 43 Crossings
- Streams
- Watershed Boundaries
- Subbasins
- ODOT ROW
- City Limits
- UGB

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

8/29/2019

N

0 1,000 2,000 4,000 6,000 Feet

1:24,000 scale

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Section 6

Capital Improvement Program

This section summarizes the capital project, program, and policy recommendations identified through the master planning process, collectively comprising the City's Storm Drainage Capital Improvement Program.

A total of 26 capital projects, including 5 planning-related studies, were identified to address current and future storm drainage infrastructure needs related to capacity/flooding, water quality, and system condition and repair. Capital project recommendations are considered a one-time cost and are categorized (numbered) as follows:

- Capacity Projects (C)
- Infrastructure Improvements/Addition Projects (I)
- Water Quality Retrofit/Erosion Prevention and Control Projects (R)
- Planning Projects (P)

Five programmatic recommendations addressing city-wide system repair and replacement (R/R) needs, routine system maintenance, and ongoing water quality retrofits were also identified. Program recommendations are intended to support ongoing asset management efforts and are considered annual costs. These city-wide programs are categorized as:

- General/Asset Management Programs (G)

Table 6-1 provides a comprehensive summary of the storm drainage capital improvement program, including project and program costs and schedule. Costs are provided for high and medium priority project needs. The SMP schedule is based on a 10-year implementation timeframe and is associated with identified project priorities. Program recommendations are considered medium priority and associated costs are annual. Policy recommendations are detailed in Section 6.5 but not reflected in Table 6-1, due to no cost being associated with the policies.

Figure 6-1, at the end of this section, provides an overview of project locations throughout the City by priority and category.

6.1 Summary of Recommended Actions

Project, program and policy recommendations in this SMP are proposed to improve and enhance drainage infrastructure and water resources throughout the City, as summarized by the following recommended actions.

- Implement identified system capacity improvements (i.e., reconfiguration, rerouting, upsizing) to manage more frequent, nuisance system flooding.
- Increase water quality treatment throughout the City by expanding treatment area coverage and enhancing the level of treatment provided in existing facilities.

- Incorporate LID or green infrastructure to expand water quality treatment in locations where utility improvements or transportation-related/pedestrian improvements are anticipated.
- Incorporate system configuration and condition data (i.e., stormwater facility inspection records, CCTV, survey) into a larger asset management program to allow for proactive maintenance, repair, and replacement of stormwater infrastructure.
- Conduct regular updates to the WLMC and PWDS to ensure clear guidance is provided to the development community and is consistent with regulatory requirements.
- Establish city policies to address beaver management as pertaining to local flooding issues.
- Clearly document capital project and program costs and schedule to inform future funding and rate analyses.

6.2 Cost Assumptions

Project costs are based on the total capital investment necessary to complete a project (i.e., engineering through construction). Program costs are more subjective in nature, qualified based on the City's current maintenance activities and annual expenditures.

Unit costs for project (construction) elements are based on recent bid tabs and stormwater master planning efforts, adjusted for 2018 based on a historical cost index. Cost estimates presented in this SMP are Association for the Advancement of Cost Engineering (AACE) Class 5 Conceptual Level or Project Viability Estimates. Actual costs may vary from these estimates between -50 percent to +100 percent, although changes to design may result in cost differences outside of this anticipated range.

Project cost estimates use unit cost information for construction elements and apply a 30 percent construction contingency, a 20 percent planning contingency, and multipliers to account for traffic control/utility relocation (5–10 percent) and erosion control (2 percent). Additional multipliers to account for engineering and permitting (15–35 percent) and construction administration (10 percent) are applied to the total construction cost with contingencies. The range in engineering and permitting costs is based on the anticipated permitting level of effort, such as whether in-water work is anticipated. For planning purposes, costs were rounded to the nearest $1,000.

Appendix E includes unit costs developed for this SMP and presents the planning-level cost estimates for high and medium priority capital projects. Cost assumptions related to program recommendations are described in Section 6.5.

Land acquisition and easements are not included in the cost estimates, as most projects are located on City property or within the City right-of-way.

Table 6-1. Storm Drainage Capital Project and Program Summary [c]

Project No. [a]	Stormwater Project Opportunity Area Location ID	Project Name	Project Objectives	Location	Basin/ Waterbody	Contributing Drainage Area, Acres	Project Summary	Estimated Cost [b]	SDC Eligible Cost [b]	Project Timing			
										Annual (2019-2028)	High Priority (2019-2023)	Medium Priority (2024-2028)	Low Priority/ Not costed (2029-2038)
Capacity Projects													
C-1	N/A	Phase I Highway 43 Culvert Replacements	• Increase system capacity	Various crossings along Highway 43	Varies	930	• City is partnering with ODOT on widening and pedestrian improvements along Highway 43. • Phase I extends from Arbor Drive to Hidden Springs Road. • Eight capacity deficient culvert crossings to be upsized in conjunction with the current roadway improvements (see Appendix F for detail).	$1,045,000	$28,000		X		
C-2	13	5th Avenue Culvert Replacement	• Increase system capacity • Improve system configuration • Prevent Erosion	5th Avenue just east of 4th Street	Bernert Creek	461	• Install approximately 160 LF of 4' x 9' reinforced concrete box culvert and relocate existing utilities as needed. • Align new box culvert with existing stream alignment.	$847,000	$106,000		X		
C-3	59	Sunset Creek at Willamette Falls Drive Culvert Replacement	• Increase system capacity	Sunset Creek crossing under Willamette Falls Drive southeast of Sunset Avenue and Imperial Drive intersection	Sunset Creek	69	• Replace approximately 95 LF of existing 18" diameter pipe with two parallel 30" diameter HDPE pipe.	$282,000	$2,000		X		
C-4	63	Maddox Creek at River Street Culvert Replacement	• Increase system capacity	Western end of River Street, west of the Burns Street intersection.	Maddox Creek	84	• Replace approximately 165 LF if existing 18" diameter culverts with two parallel 36" diameter HDPE pipe.	$385,000	$7,000		X		
C-5	N/A	Phase II Highway 43 Culvert Replacements	• Increase system capacity	Various crossings along Highway 43	Varies	789	• City is partnering with ODOT on widening and pedestrian improvements along Highway 43. • Phase II extends from Hidden Springs Road to the Interstate 205 overpass. • Five capacity deficient culvert crossings identified per hydraulic modeling (see Appendix D). • Phase II design to be initiated after 2020	---	---				X
C-6	60	Kantara Way Capacity Deficiency	• Increase system capacity	Kantara Way	Fern Creek	141	• Hydraulic evaluation indicates existing culvert is capacity deficient. Culvert grade results in scour and erosion. • Project location is in a canyon with no reported complaints or potential for property damage. • Potential project solution may require reconfiguration as an open channel and modification to existing water line near this location.	---	---				X
Infrastructure Projects													
I-1	47	Blankenship Road Improvements	• Increase system capacity • Improve system configuration	Blankenship Road between Debok Road and Johnson Road intersections.	Summerlinn Creek	159	• Install approximately 275 LF of 24" diameter HDPE storm sewer. • Remove and replace approximately 430 LF of 30" diameter HDPE storm sewer. • Install new field ditch inlet in the ditch north of Blankenship Rd.	$856,000	$97,000		X		
I-2	4	Mark Lane Improvements	• Add infrastructure • Increase water quality treatment (retrofit)	Mark Lane (east of Lowell Ave)	Mary S. Young Creek	6	• Install approximately 1,050 LF of new 12" main line pipe along Mark Ln. • Install flow-through stormwater planters along Mark Ln ROW to convey overflow to the main line via lateral piping.	$1,092,000	$5,000		X		

Table 6-1. Storm Drainage Capital Project and Program Summary [c]

Project No. [a]	Stormwater Project Opportunity Area Location ID	Project Name	Project Objectives	Location	Basin/ Waterbody	Contributing Drainage Area, Acres	Project Summary	Estimated Cost [b]	SDC Eligible Cost [b]	Project Timing			
										Annual (2019-2028)	High Priority (2019-2023)	Medium Priority (2024-2028)	Low Priority/ Not costed (2029-2038)
I-3	5	Buck Street Improvements	• Add infrastructure • Increase water quality treatment (retrofit) • Prevent Erosion	Buck Street (east of Greer Street)	Bolton Creek	5	• Install approximately 750 LF of new 12" main line pipe along Buck St. • Install flow-through stormwater planters along Buck St ROW to convey overflow to the main line via lateral piping. • Install new curb and gutter system for unimproved section of Buck St. • Replace existing outfall at the end of Buck St and provide outlet protection.	$966,000	$89,000		X		
I-4	56	Fairview Way Pipe Relocation	• Increase system capacity • Improve system configuration	Fairview Way between Highway 43 and Robinwood Creek.	Robinwood Creek Fern Creek	29	• Install new storm pipe alignment along Fairview Way from manhole RW-CB-0144 to manhole RW-CB-0126.1 and ultimately discharges to Robinwood Creek. • Install approximately 1,175 LF of 18" HDPE; approximately 255 LF of 30" RCP; and approximately 275 LF of 36" HDPE. • Install 11 manholes associated with the proposed conveyance system in Fairview Way.	$1,620,000	$40,000			X	
I-5	1	Nixon Avenue Pipe Relocation	• Improve system configuration	Nixon Ave (between 18730 and 18740 Nixon Ave)	Willamette River	10	• Relocate existing pipe currently under resident's garage. • Install new 12" piping to convey drainage north along Nixon Ave ROW and east between 18730 and 18740 Nixon Ave parcels to a new outlet structure.	$174,000	$2,000			X	
I-6	10	Sunset Avenue Improvements	• Add infrastructure • Prevent Erosion	Sunset Ave (between Cornwall St and Walnut St)	Tanner Creek Sunset Creek McLean Creek Willamette River	35	• Project to be constructed in conjunction with transportation system improvement project, which will install curb/gutter, bike lane, and sidewalk along Sunset Ave. • Install new 12" piping along Sunset Ave ROW from Cornwall St to Walnut St to replace to existing piping and open channel sections. • Install manholes and catch basins at intersections along the upper portion of Sunset Ave, where main line is in the middle of the road.	$1,593,000	$32,000			X	
Retrofit Projects													
R-1	70	Public Pond #22 Retrofit	• Increase water quality treatment (retrofit)	25545 Katherine Court	Willamette River	8	• Rehabilitate the existing water quality pond by clearing trees and invasive vegetation, removing accumulated sediment, replacing with amended soils, regrading, and planting of water quality appropriate vegetation. • Pond outflow structure to be inspected and replaced if needed.	$89,000	$1,000		X		
R-2	67	Mary S. Young Park Parking Lot Retrofit	• Increase water quality treatment (retrofit)	Mary S. Young Park Parking Lot	Mary S. Young Creek	2	• Replace existing impervious parking lot with 67,000 ft^2 of pervious pavers. • Connect pervious pavers drain layer to existing catch basin in northeast corner of parking lot.	$2,075,000	NA			X	
R-3	68	West Linn Public Works Department Planters	• Increase water quality treatment (retrofit)	West Linn Public Works Department (4100 Norfolk St)	Tanner Creek	1	• Install one stormwater planter on West Linn Public Works Department property to treat drainage from northern portion of site and one planter along Norfolk St ROW to treat drainage from the southern portion of site. • Remove existing bubbler within Norfolk St ROW and connect to new 12" piping to stormwater planter in Norfolk St ROW. • Connect stormwater planter overflow to existing catch basin along Norfolk St via 12" piping.	$174,000	NA			X	
R-4	40	Mary S. Young Park Erosion Measures	• Prevent Erosion	Mary S. Young Park	Heron Creek	TBD	• Install in-stream bank erosion measures to minimize erosion issues along park trail and bridge. • Bridge repair related to washout is currently funded; remaining work is restoration and a potential mitigation project. • Potential grant funding opportunity.	---	---				X

Table 6-1. Storm Drainage Capital Project and Program Summary [c]

Project No. [a]	Stormwater Project Opportunity Area Location ID	Project Name	Project Objectives	Location	Basin/ Waterbody	Contributing Drainage Area, Acres	Project Summary	Estimated Cost [b]	SDC Eligible Cost [b]	Project Timing			
										Annual (2019-2028)	High Priority (2019-2023)	Medium Priority (2024-2028)	Low Priority/ Not costed (2029-2038)
R-5	43	Mary S. Young Park Trillium Creek Restoration	• Prevent Erosion • Increase water quality treatment (retrofit)	Trillium Creek in Mary S. Young Park	Trillium Creek	TBD	• Restore channel connectivity with floodplain and improve bed material and channel meander for habitat improvement. • Conduct other creek stabilization measures. • Potential grant funding opportunity (see previous work completed).	---	---				X
R-6	45	Mary S. Young Park Fish Restoration Measures	• Increase water quality treatment (retrofit)	Mary S. Young Creek	Mary S. Young Creek	TBD	• Remove culvert at Mary S. Young Creek to improve water quality and provide fish restoration measures in accordance with the Mary S. Young Creek Restoration Concept Plan. • Potential grant funding opportunity.	---	---				X
R-7	49	Arbor Creek Culvert Hydromodification Improvements	• Prevent Erosion	Downstream of Arbor Creek culvert at Hillside Drive, near Skye Parkway	Arbor Creek	246	• Realign existing culvert crossing Arbor Creek to minimize drop. • Add bank protection and energy dissipation structure to alleviate existing scour hole and bank erosion.	---	---				X
R-8	66	Willamette Park Parking Lot Retrofit	• Increase water quality treatment (retrofit)	Willamette Park Parking Lot	Willamette River	2	• Replace existing impervious parking lot with pervious pavers.	---	---				X
R-9	69	Public Pond #18 Retrofit	• Increase water quality treatment (retrofit)	Public Pond #18 (BC ID)	Bernert Creek	TBD	• Rehabilitate the existing water quality pond by clearing trees and invasive vegetation, removing accumulated sediment, replacing with amended soils, regrading, and planting of water quality appropriate vegetation. • Pond outflow structure to be inspected and replaced if needed.	---	---				X
Planning Projects													
P-1	16	Tannler Drive/Bernert Creek Basin Feasibility Study	• Add infrastructure	Tannler Drive	Bernert Creek	N/A	• Closed stormwater system adjacent to Tannler Drive could be an opportunity to daylight the pipe for aesthetics and water quality. • Conduct feasibility study to identify project concept and estimated cost.	$20,000	N/A		X		
P-2	54, 57	Fish Passage Evaluation	• Add Infrastructure	East of Willamette Drive (Highway 43)	Varies	N/A	• The 2006 MP reported that there are variable needs to replace culverts throughout the City for fish passage. • Conduct evaluation and coordinate with ODFW to confirm culvert replacement needs.	$20,000	N/A			X	
P-3	N/A	Surface Water Master Plan Update	• Increase system capacity • Add infrastructure • Increase water quality treatment (retrofit)	City-wide	Varies	N/A	• Update the City's Surface Water Master Plan in the next 10+ year timeframe.	$300,000	N/A			X	
P-4	N/A	Asset Management Program	N/A	City-wide	Varies	N/A	• Develop an asset management program to assess current practices, review software and tools, identify gaps in current practices, and prepare/ implement an asset management program. • Cost assumes coordinated effort with sanitary asset management program (50% cost share)	$150,000	N/A			X	
P-5	N/A	Stormwater System Survey	N/A	City-wide	Varies	N/A	• Conduct city-wide survey of storm system assets including establishment of consistent datum, horizontal and vertical survey of structures including inverts and rim elevations, and GIS processing to incorporate results into asset database. • Data to be used to populate asset management program. • Does not assume survey of open channel systems or cross sections.	$300,000	N/A		X		

Table 6-1. Storm Drainage Capital Project and Program Summary [c]

Project No. [a]	Stormwater Project Opportunity Area Location ID	Project Name	Project Objectives	Location	Basin/ Waterbody	Contributing Drainage Area, Acres	Project Summary	Estimated Cost [b]	SDC Eligible Cost [b]	Project Timing			
										Annual (2019-2028)	High Priority (2019-2023)	Medium Priority (2024-2028)	Low Priority/ Not costed (2029-2038)
Programs													
G-1	N/A	CCTV Program	N/A	City-wide	Varies	N/A	• Complete city-wide inspection over a 10-year planning period (assumes 60,000 LF of pipe inspected annually) • Evaluate results to inform asset management program and repair/ replacement needs. • Annual cost includes contingency (30%) and engineering multiplier (15%)	$344,000	N/A	X			
G-2	N/A	Repair and Replacement Program	• Add infrastructure • Address maintenance need	City-wide	Varies	N/A	• Assume replacement of one mile of deficient pipe annually (due to age and failure risk). • Consider opportunities to realign pipe within the ROW. • Cost excludes contingency and multipliers.	$750,000	N/A	X			
G-3	20, 28, 32, 37, 42, 48	Inlet Installation/ Replacement Program	• Add Infrastructure • Address maintenance need	City-wide	Varies	N/A	• Install curb inlets to alleviate localized drainage issues in high-traffic or heavily vegetated roadways. • Cost assumes 10 inlets/ year. • Cost excludes contingency and multipliers.	$25,000	N/A	X			
G-4	52	Public Pond Maintenance Program	• Increase water quality treatment (retrofit) • Address maintenance need	City-wide	Varies	N/A	• Conduct extensive maintenance of ponds and/or retrofit detention ponds for water quality improvement. • Target facility locations in residential neighborhoods and those facilities installed pre-2004. • Cost assumes one facility per year.	$100,000	N/A	X			
G-5	11, 15, 18, 19, 23, 25, 35	Green Street Pilot Program	• Increase water quality treatment (retrofit)	City-wide	Varies	N/A	• Install green street retrofits in residential neighborhoods in conjunction with other utility or transportation-related improvements. • Identify sites based on local drainage concerns.	$50,000	N/A	X			

Notes: *N/A: Not Applicable*

TBD: To be Determined in conjunction with refined CIP development.

a. CIP numbering reflects the following project type designations: C = Capacity; I = Infrastructure Improvement/ Addition; R = Retrofit/ Erosion Prevention and Control; P = Planning; and G = General/ Annual Maintenance

b. Estimated costs and SDC eligible costs are based on detailed cost summaries provided in Appendix E. Costs and associated drainage areas were not developed and calculated for low priority (unfunded) CIPs.

c. Policy recommendations are not included due to no associated project number and/or cost.

6.3 Sizing and Design Assumptions

Capital project sizing generally followed the City's PWDS and design criteria summarized in Table 3-2.

- **Capacity Projects**. Projects to construct or replace stormwater infrastructure referred to the City's PWDS (dated October 2018). Conveyance-related projects were sized for the 10-year, 24-hour design event. Culvert sizing was based on maintaining a headwater elevation less than 1.5 times the diameter of the culvert. System surcharging was considered permissible.
- **Water Quality Projects**. Water quality projects were generally sized in accordance with the 2016 Portland SWMM. LID and green infrastructure (Projects I-2 and I-3) were sized based on a 6 percent sizing factor applied to contributing impervious area. However, it should be noted that retrofit project applications were typically unable to meet applicable design criteria due to area constraints. During final project design an attempt should be made to size facilities to maximize water quality treatment within the available area.
- **New Infrastructure**. Several capital projects require new infrastructure in locations where no storm system exists. New infrastructure alignments are in the public ROW only. However, it should be noted that final design may require additional structures, alternate alignments, or deeper/shallower infrastructure than assumed for the conceptual project design to address utility conflicts and other constraints not identified as part of this SMP. Survey will be required to verify elevations and locations. Conceptual layouts for select capital projects are illustrated in Appendix F.

6.4 Capital Projects

Capital projects are identified as one of four categories: capacity, infrastructure, retrofit, or planning.

Through an integrated project development approach (see Section 4), capital project needs and opportunities were consolidated by location and defined as Stormwater Project Opportunity Areas. As such, identified capital projects address multiple objectives in a single project. Project objectives included:

- Increase system capacity (flood control)
- Improve system configuration
- Add infrastructure
- Increase water quality treatment (retrofit)
- Prevent erosion
- Address maintenance need

High and medium priority capital projects that compose this capital improvement program are summarized below by category. Additional detail related to project layout and configuration used to inform cost estimating is provided in Appendix F.

6.4.1 Capacity Projects

Phase 1 Highway 43 Culvert Replacement (C-1). In 2018, the City and ODOT initiated design efforts to widen and construct pedestrian improvements along Highway 43 through West Linn. There are 24 mapped culvert crossings under Highway 43, of which 13 are identified as deficient under existing development conditions based on hydraulic modeling conducted for this SMP. Culvert upsizing and/or reconfiguration is recommended to occur in conjunction with the roadway improvements.

Project C-1 includes upsizing eight crossings located in Phase 1 (Arbor Drive to Hidden Springs Road) of the Highway 43 project alignment. Other utility improvement and replacement efforts are currently underway (water system replacement). This was identified as a high priority project need.

5th Avenue Culvert Replacement (C-2). This project need was identified in the City's 2006 Plan and confirmed based on recent site visits, City staff input, and hydraulic modeling. Project C-2 includes upsizing the existing 30-inch-diameter culvert under 5th Avenue with a 4 ft x 9 ft box culvert and realigning the culvert along the existing stream alignment to minimize bank erosion and degradation of existing infrastructure in its proximity. This was identified as a high priority project need.

Sunset Creek at Willamette Falls Drive Culvert Replacement (C-3). This project need was identified in the City's 2006 Plan and confirmed based on recent site visits, City staff input, and hydraulic modeling. Project C-3 includes upsizing the existing 18-inch-diameter culvert with two parallel, 30-inch-diameter pipes while maintaining the existing drainage patterns and point of discharge. Parallel pipes are proposed due to limited depth of cover in the project proximity. This was identified as a high priority project need.

Maddox Creek at River Street Culvert Replacement (C-4). This project need was identified during the project needs assessment and confirmed based on recent site visits, City staff input, and hydraulic modeling. Project C-4 includes upsizing the existing 18-inch-diameter culvert with two parallel, 36-inch-diameter pipes while maintaining the existing drainage patterns and point of discharge. The current system configuration is inconsistent with the City's GIS and will require field survey to confirm configuration and connectivity. This was identified as a high priority project need.

6.4.2 Infrastructure Projects

Blankenship Road Improvements (I-1). This project need was identified during the project needs assessment and confirmed based on recent site visits, City staff input, and hydraulic modeling. Previous efforts to address roadway flooding at this location have not been successful.

Project I-1 includes installation and/or upsizing of approximately 800' of stormwater conveyance pipe along Blankenship Road east of Interstate 205 (I-205). Reconfiguration of the system is required to divert flow from the drainage ditch along the I-205 right-of-way (ROW). Due to the flat grade of the open channel collection system and overland flow contribution, additional site survey is recommended to verify drainage patterns and contributing areas. Project sizing assumes that ODOT infrastructure is conveying drainage from the north/northeast of the project location. This was identified as a high priority project need.

Figure 6-2, located at the end of this section, shows the proposed project alignment.

Mark Lane Improvements (I-2). This project need was identified during the project needs assessment, water quality assessment, and confirmed based on recent site visits and City staff input. A lack of drainage infrastructure at this location results in localized flooding. This area was identified to have high inflow and infiltration (I&I), potentially related to the limited stormwater infrastructure.

Project I-2 includes installation of 1,050 feet of 12-inch-diameter storm pipe down Mark Lane and approximately 5,000 square feet (ft^2) of stormwater planters within the public ROW. Planter locations are considered conceptual and will need to be confirmed in conjunction with the final pipe alignment. This was identified as a high priority project need.

Buck Street Improvements (I-3). This project need was identified during the project needs assessment, water quality assessment, and confirmed based on recent site visits and City staff input. A lack of drainage infrastructure and presence of stormwater bubblers results in localized flooding in this area.

Project I-3 includes installation of 750 feet of 12-inch-diameter storm pipe down Buck Street and approximately 3,750 ft^2 of stormwater planters within the public ROW. Planter locations are considered conceptual and locations will need to be confirmed in conjunction with the final pipe alignment. Due to reported erosion concerns, this project also includes replacement of the stormwater outfall and inclusion of outfall protection. This was identified as a high priority project need.

Fairview Way Pipe Relocation (I-4). This project need was identified during the project needs assessment and confirmed based on recent site visits, City staff input, and hydraulic modeling. Much of the existing system is configured on private property and the system condition is questionable.

Project I-4 includes rerouting the existing collection system east of Highway 43 to the public ROW within Fairview Way and installation of approximately 1,780 feet of stormwater conveyance pipe ranging in diameter from 18 to 36 inches. The project includes abandoning the existing outfall to Robinwood Creek and relocating/rerouting localized drainage further downstream on Robinwood Creek. This was identified as a high priority project need.

Figure 6-3, located at the end of this section, shows the proposed project alignment.

Nixon Avenue Pipe Relocation (I-5). This project need was identified during the project needs assessment and confirmed based on recent site visits and City staff input. The existing system is configured on private property and the system condition is questionable. Project I-5 includes installation of 325 feet of 12-inch-diameter storm pipe within a public stormwater easement between 18730 and 18740 Nixon Avenue. This was identified as a medium priority project need.

Sunset Avenue Improvements (I-6). This project need was identified during the project needs assessment and confirmed based on recent site visits and City staff input. A lack of drainage infrastructure results in localized flooding and erosion of the adjacent roadside ditch. This area was also identified to have high I&I, potentially related to limited stormwater infrastructure in the area.

Project I-6 includes installation of 3,620 feet of 12-inch-diameter storm pipe down Sunset Avenue from Cornwall Street to Walnut Street. Water quality retrofits using green infrastructure were not considered along the project alignment due to grade constraints. This was identified as a medium priority project need.

6.4.3 Retrofit Projects

Public Pond #22 Retrofit (R-1). This project need was identified during the water quality assessment and confirmed based on recent site visits and City staff input. Project R-1 includes extended maintenance and retrofit of an existing detention pond to improve water quality function. Maintenance activities required include tree removal and sediment removal. To enhance treatment function, amended soils and vegetation will need to be installed and the outlet structure reconfigured to promote increased retention time. Expansion of the pond footprint may be considered to treat additional flows from upstream development. This was identified as a medium priority project need.

Mary S. Young Park Parking Lot Retrofit (R-2). This project need was identified during the water quality assessment and confirmed based on recent site visits and City staff input. Project R-2 includes the installation of approximately 1.5 acres of permeable pavers at the public parking lot at Mary S. Young Park. Existing pavement is in poor condition. Recent permeable paver applications have been successfully implemented at other public parking areas in the City (i.e., Willamette Park). This was identified as a medium priority project need.

Pavement restoration and asphalt resurfacing needs present opportunities to incorporate alternative surface water management strategies

(Photo: Mary S. Young Park Parking Lot Retrofit location)

West Linn Public Works Department Planters (R-3). This project need was identified during the water quality assessment and confirmed based on recent site visits and City staff input. This project need was also identified as part of the City's 2015 Stormwater Retrofit Plan. Project R-3 includes the installation of approximate 1,175 ft^2 of stormwater planters to improve water quality treatment of the City's Public Works Yard along Norfolk Street. Planter locations are considered conceptual and locations will need to be confirmed in conjunction with final pipe alignment. This was identified as a medium priority project need.

6.4.4 Planning Projects

Tannler Drive/Bernert Creek Basin Feasibility Study (P-1). This project need was identified during the project needs assessment. City staff and the public identified an opportunity to daylight a portion of the piped storm system, adjacent to Tannler Drive. Daylighting the pipe may improve aesthetics and water quality in the area. The reported pipe depth may result in geotechnical challenges and limit the ability to daylight the system without encroaching on adjacent natural resources (trees). Project P-1 is budgeted as a $20,000 planning study to evaluate the feasibility of the proposed project. This was identified as a high priority project need, based on feedback from the public.

Fish Passage Evaluation (P-2). This project need was identified during the project needs assessment. The 2006 Plan identified multiple culverts requiring replacement for fish passage. Project P-2 is budgeted as a $20,000 planning study to evaluate existing culverts east of Highway 43, coordinate with the Oregon Department of Fish and Wildlife to confirm species presence, and confirm which culverts require replacement for fish passage. This was identified as a medium priority project need.

Storm Drainage Master Plan Update (P-3). Project P-3 assumes the City will update this Storm Drainage Master Plan within the next 10-15-year planning period. An estimated budget of $300,000 is included for the update. This was identified as a medium priority project need.

Asset Management Program (P-4). Project P-4 reflects development of an asset management program to aid in the prioritization of repair and replacement (R/R) activities due to condition deficiencies. Implementation of an asset management program will help reduce reactionary operations and maintenance activities and result in development of proactive scheduled R/R activities based on system condition, age, and performance.

An asset management program requires assessment of current practices and procedures, review of software applications and tools, integration/refinement of GIS data, and development of procedures and documentation. Program development efforts will be coordinated with the sanitary utility. An estimated budget of $150,000 was included in this plan, assuming coordination with the sanitary system (see 2019 Sanitary Sewer Master Plan (SSMP), Project PL-1). Projects stemming from the asset management program will be addressed as part of the City's annual R/R budget (see Project G-2). This was identified as a medium priority project need.

Stormwater System Survey (P-5). Current stormwater system GIS information for the City is incomplete. Approximately 70 percent of mapped stormwater infrastructure is missing elevation or size related information. In addition, stormwater treatment facilities have not been routinely mapped in GIS. Project P-5 reflects development of a city-wide stormwater system survey to inform development of the asset management program (see Project P-4). An estimated budget of $300,000 is included, based on the need to survey approximately 4,500 structures (excluding open channel conveyances). This was identified as a high priority project need.

6.5 Program Descriptions

City-wide program development efforts also stemmed from the integrated project development approach. During the project planning process (Section 4), select maintenance-related project needs were consolidated into larger program opportunities instead of developed as multiple, stand-alone individual projects. Table 6-1 reflects specific opportunity areas by Location ID that are applicable to the identified programs.

Development of city-wide programs can be advantageous for a City as they can be used to establish dedicated funding sources in support of priority, multi-year and multi-objective efforts. Programs (with a dedicated annual funding source) can also provide additional flexibility with respect to project implementation schedules and allow projects to be conducted on an opportunistic basis.

Five programs were identified to address routine system maintenance needs and the opportunistic installation of water quality improvements. All programs are considered medium priority and require annual funding. The City's annual stormwater system maintenance budget should be referenced and considered when establishing programs so that existing funds are allocated accordingly. Program recommendations and cost assumptions are summarized below for each recommended program.

6.5.1 CCTV Program (G-1)

This program includes expanding the existing CCTV efforts to inspect the City's stormwater mainlines. This program will help the City determine pipeline condition as part of the larger asset management program (see Project P-4) and help determine R/R needs. It is assumed that the City will inspect approximately 10 percent of the system per year (or approximately 60,000 LF). An annual cost of $344,000 is estimated, which includes construction contingency (30 percent), traffic control, and an engineering multiplier of 15 percent to cover review of the results.

6.5.2 Repair and Replacement (R/R) Program (G-2)

This program includes allocating an annual cost of $750,000 to the R/R of aging and failing pipe, structures, and relocation of the public storm system into the public ROW. This estimate is consistent with the 2019 SSMP R/R Program effort, which assumes replacement of one mile of deficient pipe per year. Because the City's stormwater system is primarily composed of plastic pipe, the actual life span is unknown. Locations should be prioritized based on CCTV efforts and consider the schedule of other utility system improvements or projects to minimize construction impacts.

6.5.3 Inlet Installation and Replacement Program (G-3)

This program stemmed from the project needs assessment. It involves the relocation of existing inlets to address localized flooding and ponding. It may require replacement of grated inlets with curb inlets in high traffic roads where debris accumulates and clogs the inlets. Six locations were identified during the project needs assessment effort (refer to Table C-1 for descriptions of each location). Locations include:

- Failing Street (Location ID 20)
- Sinclair Street (Location ID 28)
- Summit Street between Apollo Avenue and Causey Street (Location ID 32)
- Elmran Drive near Old River Road (Location ID 37)
- Lower Midhill Road (Location ID 42)
- Debok Road (Location ID 48)

An annual cost of $25,000 was estimated.

6.5.4 Public Pond Maintenance Program (G-4)

This program stemmed from the project needs assessment and water quality assessment. It involves the routine and restorative maintenance of public stormwater ponds, based on inspection results. It may include the rehabilitation or retrofit of existing stormwater detention ponds (constructed prior to 2004) to promote increased water quality treatment function and/or coverage. Ponds located in or near residential neighborhoods may be prioritized, as they provide both aesthetic and water quality benefits.

As part of the water quality assessment, a pond inventory was conducted to identify: 1) ponds installed prior to 2004 (and likely installed without treatment function); and 2) ponds located near vacant lands (and could be retrofit to provide water quality treatment for new development). The pond inventory resulted in the identification of two ponds meeting both criteria, which were included as Stormwater Project Opportunity Areas. However, additional ponds may benefit from inclusion in an ongoing maintenance program. Potential locations include:

- Remington Drive and Rogue Way (Public Pond #68)
- Cascade Summit Apartments Pond at Weatherhill Road (Public Pond #49)
- Public Ponds at Sabo Lane and Beacon Hill Lane (Public Pond #54, 48, 52)

An annual cost of $100,000 was estimated and based on major maintenance of one public pond per year.

6.5.5 Green Street Pilot Program (G-5)

This program stemmed from the project needs assessment and water quality assessment. It involves the opportunistic incorporation of green street and LID features in conjunction with scheduled transportation improvements (i.e., unimproved streets requiring installation of curb and sidewalk) or other utility improvement projects. Sites may be prioritized based on the presence of local drainage issues. Installations will address NPDES MS4 requirements related to stormwater retrofits. Seven locations were identified during the project needs assessment effort (refer to Table C-1 for descriptions of each location). Locations include:

- Exeter Street and Lancaster Street (Location ID 11)
- Willamette Neighborhood between 14th and 16th Avenues (Location ID 15)
- Suncrest Avenue, Valleyview Drive, and Hillcrest Street (Location ID 18)
- LaFave Street, Jolie Point Road, Munger Drive, and Lowell Avenue (Location ID 19)
- Kenthorpe Way (Location ID 23)
- Cornwell Road and York Street (Location ID 25)
- Dillow Drive at Larson (Location ID 35)

An annual cost of $50,000 was estimated.

6.6 Policy Recommendations

The following policy recommendations were considered for potential incorporation into future updates to the West Linn Municipal Code (WLMC), West Linn Community Development Code (CDC), West Linn Public Works Design Standards (PWDS), or addressed through internal directives.

6.5.1 Technical and Editorial Stormwater Code Updates

As described in Section 3.1, results of the code review identified recommended modifications to the WLMC, CDC, and PWDS to: 1) update the City's policies and technical design standards related to stormwater management; and 2) adjust code to improve clarity, resolve discrepancies, and ease implementation of existing policy and standards. Such refinements would help support water quality improvement efforts by specifying facility types and design criteria to address specific pollutants of concern for the City.

Code recommendations are detailed in Section 3.1.1 and 3.1.2 and in Appendix A.

6.5.2 Beaver Management Requirements

The project needs assessment identified significant beaver activity contributing to localized flooding along investigated stream reaches (see Table C-1, Location ID 12). Beavers provide many benefits to stream ecology and habitat, but in urban areas, beaver activity can also result in localized flooding and backwater effects in stream channels.

Beaver activity can result in system clogging and backwater conditions in stormwater infrastructure

(Photo: Clogged stormwater conveyance pipe due to beaver activity at Johnson Road)

Beavers are classified as "Protected Furbearers" in Oregon, and thus excluded from take (Oregon Administrative Rule 498.012) (Portland 2010). Oregon Department of Fish and Wildlife (ODFW) encourages public and private landowners to first use beaver exclusion and habitat modification techniques to minimize beaver activity in locations that are susceptible to impacts from beaver activity. Live trapping of beavers is legal, but relocation is illegal without a permit from ODFW.

The City may choose to implement/codify beaver management techniques to selectively encourage/discourage beaver activity based on the characteristics of the stormwater drainage systems, topography and vegetation. The City of Portland and King County both implement actions and management strategies outlined in guidance documents to deter beaver activity on public property. Such management strategies the City may consider include:

- Selective planting: Encourage/discourage beaver activity through planting of preferred plant species. To minimize or deter beaver activity, avoid use of alder, birch, cottonwood, willow, and other preferred deciduous plants in riparian restoration projects. Use non-desirable plant species including Sitka spruce, elderberry, cascara, and osoberry, as they are not preferred food plants for beavers.

- Fencing/tree barriers: Install fencing to isolate one or groups of trees from beaver foraging. Fencing should extend between 2 feet and 4 feet in height. Install fencing around inlets of culverts or spillways to prevent inlets from being blocked by beavers.
- Tree painting: Paint the bottom (2 feet to 4 feet) of trunk with latex paint/sand mixture.
- Flood/Flow Control: Install a flexible pond leveler (a pipe through the beaver dam) to control water levels. Beaver dam removal can also be conducted to lower water levels, but this activity is time intensive and generally only a temporary solution.
- Relocation: Relocate beavers to intentionally create ponds/wetlands in desired locations. ODFW permitting is required.

6.7 Project and Program Cost Summary

A summary of capital project and program costs comprising this surface water capital improvement program is provided in Table 6-2 below. Low priority project needs scheduled outside of the 10-year implementation timeframe are not reflected.

Table 6-2. Summary of Capital Project and Program Cost and Schedule

Project Number	Project Name	Schedule		
		2019-2023 (High Priority)	2024-2028 (Medium Priority)	Annual Cost (Medium Priority)
Capacity Projects		**$2,559,000**		
C-1	Phase I Highway 43 Culvert Replacements	$1,045,000		
C-2	5th Avenue Culvert Replacement	$847,000		
C-3	Sunset Creek at Willamette Falls Drive Culvert Replacement	$282,000		
C-4	Maddox Creek at River Street Culvert Replacement	$385,000		
Infrastructure Projects		**$2,914,000**	**$3,387,000**	
I-1	Blankenship Road Improvements	$856,000		
I-2	Mark Lane Improvements	$1,092,000		
I-3	Buck Street Improvements	$966,000		
I-4	Fairview Way Pipe Relocation		$1,620,000	
I-5	Nixon Avenue Pipe Relocation		$174,000	
I-6	Sunset Avenue Improvements		$1,593,000	
Retrofit Projects		**$89,000**	**$2,249,000**	
R-1	Public Pond #22 Retrofit (Katherine Court)	$89,000		
R-2	Mary S Young Park Parking Lot Retrofit		$2,075,000	
R-3	West Linn Public Works Department Planters		$174,000	
Planning Projects		**$320,000**	**$470,000**	
P-1	Tannler Drive/Bernert Creek Feasibility Study	$20,000		
P-2	Fish Passage Evaluation		$20,000	
P-3	Surface Water Master Plan Update		$300,000	
P-4	Asset Management Program Development		$150,000	
P-5	Stormwater System Survey	$300,000		
Programs				**$1,269,000**
G-1	CCTV Program			$344,000
G-2	Repair and Replacement (R/R) Program			$750,000
G-3	Inlet Installation and Replacement Program			$25,000
G-4	Public Pond Maintenance Program			$100,000
G-5	Green Street Pilot Program			$50,000
	TOTAL	**$5,882,000**	**$6,106,000**	**$1,269,000**

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 6-1: Storm Drainage Capital Improvement Program Overview

Project #	City-Wide Projects and Programs
P-2	Fish Passage Evaluation
P-3	Storm Drainage Master Plan Update
P-4	Asset Management Program
P-5	Storm Drainage System Survey
G-1	CCTV Program
G-2	Repair and Replacement Program
G-3	Inlet Installation/Replacement Program
G-4	Public Pond Maintenance Program
G-5	Green Street Pilot Program

Project Category

- Capacity
- Infrastructure
- Retrofit
- Planning
- Low Priority/Not Costed

- Stormwater Pipe
- Open Channel
- Streams
- Watershed Boundaries
- ODOT ROW
- City Limits
- UGB

CIPs C-1 (Phase I Highway 43 Culvert Replacement) and C-5 (Phase II Highway 43 Culvert Replacement) are not shown.

N

0 1,000 2,000 4,000 6,000 Feet

1:24,000 scale

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

8/29/2019

CIP development assumes no stormwater contribution from this area. All drainage from the north/northeast is conveyed to the ODOT culvert. City to coordinate with ODOT to determine updates to culvert inlet to ensure all drainage is captured.

MARGERY ST
VILLAGE PARK PL
SL6
SL5-2
SL4
FALL OAKS CT
SL5-1
ODOT Culvert
SUMMERLINN DR
I205 FWY
SL3E1
SL3-2
DEBOK RD
SL3-1
JOHNSON RD
Node365
SL-MH-1608
SL-MH-0181
SL3-3
SL3-5
18"
24"
BLANKENSHIP RD
30"
24"
24"
24"
Node360
SL-DI-1606
30"
Node366
SL2
30"
30"
SL-MH-1604
SL-MH-1602
Node363
SL-CB-1612
SL3S1
BE5W2
SL3-4
ANN CT
BE5W3

0 50 100 200 300 Feet

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

1:1,200 scale

N

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 6-2: Blankenship Road Improvements (Project I-1)

- Streams
- ODOT ROW
- Subbasins
- Catch Basin
- Inlet
- Manhole
- Outfall
- Existing Stormwater Pipe
- New Manhole/Inlet
- New Pipe
- Remove Pipe

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

9/4/2019

1:1,200 scale

N

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 6-3: Fairview Way Pipe Relocation (Project I-4)

- Streams
- ODOT ROW
- Subbasins
- Catch Basin
- Inlet
- Manhole
- Outfall
- Existing Stormwater Pipe
- New Manhole
- New Pipe
- Abandon/Remove Pipe

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: Aug 2019 Produced by Brown and Caldwell

8/29/2019

Section 7

References and Limitations

Brown and Caldwell. 2015. Hydromodification Assessment prepared for the City of West Linn. June.

Brown and Caldwell. 2019. Draft Willamette and Tualatin Basin TMDL Implementation Plan. March.

Clean Water Services. Stormwater and Grading Design Standards. March 2017.

King County 2018a. Beaver Management Devices. January 2018. Online only. https://www.kingcounty.gov/services/environment/animals-and-plants/beavers/Resources.aspx Accessed Nov 2018.

King County 2018b. Beaver Management Solutions Matrix. February 2018. https://kingcounty.gov/~/media/environment/animalsAndPlants/beavers/Beaver_management_matrix__KingCountyWA_2-2018.ashx?la=en Accessed Nov 2018.

King County 2018c. Beaver Management Technical Paper #1: Beaver Management Tools Literature Review and Guidance. December 2017, revised April 2018. https://your.kingcounty.gov/dnrp/library/2018/kcr2944/kcr2944.pdf Accessed Nov 2018.

Misc Contracts and Agreements No. 32379. Cooperative Maintenance Agreement.

Misc Contracts and agreements No. 32348. Local Agency Agreement. July 2017

ODFW 2017. Requirements for Relocation of Beaver in Oregon. December 2017. https://www.dfw.state.or.us/wildlife/living_with/docs/Oregon_Beaver_Relocation_Requirements_Forms.pdf Accessed Nov 2018.

ODFW 2010. ODFW Guidelines for Relocation of Beaver in Western Oregon. May 2010. http://library.state.or.us/repository/2010/201006071625481/index.pdf Accessed Nov 2018.

ODFW 2009. Living with Wildlife: American Beaver. Fact sheet. December 2009. https://www.dfw.state.or.us/wildlife/living_with/docs/beaver.pdf Accessed Nov 2018.

ODOT. Region 1 District 2B. Oswego Highway No. 3. Culvert Inventory

City of Portland 2010. Guidance: Living with American Beaver (Caster canadensis). Version 1. City of Portland Terrestrial Ecology Enhancement Strategy. Environmental Services. October 2010. https://www.portlandoregon.gov/bes/article/354182 Accessed Nov 2018.

Soil Conservation Service (SCS). 1986. Urban Hydrology for Small Watersheds, Technical Release 55. June.

West Linn. 2017-2018 NPDES MS4 Annual Compliance Report. October 2018.

West Linn Municipal Code (WLMC), Chapter 4 Utilities, Chapter 5 Nuisances, and Chapter 8.105 Building Permittee Responsible for Erosion Prevention and Sediment Control

West Linn Public Works Standard Construction Specifications, Division 6, Storm Drain Technical Requirements

West Linn Community Development Code (CDC), Chapter 55 Design Review, Chapter 56 Parks and Natural Area Design Review, and Chapter 92 Required Improvements

West Linn Public Works Design Standards (PWDS), Section 2, Storm Drain Requirements. September 2018.

West Linn. Private Water Quality Facility Management Program. Undated.

West Linn. Retrofit Plan. July 2015.

West Linn. Transportation System Plan. March 2016.

West Linn. Water Quality Facility Inspector's Guidance Manual. July 2013.

Limitations

This document was prepared solely for City of West Linn in accordance with professional standards at the time the services were performed and in accordance with the contract between City of West Linn and Brown and Caldwell dated May 9, 2017. This document is governed by the specific scope of work authorized by City of West Linn; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by City of West Linn and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

Appendix A: TM1: Stormwater Basis of Design and Code Review

Brown AND Caldwell

6500 SW Macadam Avenue, Suite 200
Portland, OR 97239

T: 503-244-7005

Technical Memorandum

FINAL

Prepared for: City of West Linn

Project Title: Storm Drainage Master Plan

Project No.: 150752

Technical Memorandum

Subject: Stormwater Basis of Design and Code Review

Date: November 17, 2017 (Original)

May 21, 2019 (Updated)

To: Amy Pepper, P.E., City of West Linn

From: Alissa Maxwell, P.E. and Jessica Christofferson

Copy to: Lance Calvert, P.E., City of West Linn

Prepared by: _____
Alissa Maxwell, P.E.

Reviewed by: _____
Angela Wieland, P.E.

This page intentionally left blank.

Table of Contents

Section 1: Introduction 1
1.1 Objectives 1
1.2 Regulatory Framework 1
1.2.1 NPDES MS4 Permit 1
1.2.2 TMDL and 303(d) Listings 2
1.3 Resources Reviewed 2
1.3.1 Version Discrepancy 3
Section 2: Basis of Design 3
2.1 Public/City Responsibility 3
2.2 Design Standards 4
2.3 Basis of Design Recommendations 5
Section 3: Stormwater Code Review 6
3.1 Post Construction Runoff Control 6
3.1.1 Stormwater Management Policy 7
3.1.2 Barriers to LID 8
3.1.3 Stormwater Management Manual 8
3.1.4 Implementation 8
3.1.5 Site Limitations 8
3.1.6 Inspection and Enforcement 8
3.2 Illicit Discharge Detection and Elimination 9
3.3 Industrial/Commercial Inspections 9
3.4 Erosion Control 9
3.5 Operations and Maintenance 9
3.6 Enforcement 10
Section 4: Proposed Policy and Standard Modifications 10
4.1 Technical Standards and Stormwater Policy Changes 10
4.2 Clarity and Implementation Changes 11
References 12
Attachment A: Example Code and Standards A-1
Attachment B: Code and Standards Review Matrix B-1
Attachment C: Preliminary Language C-1

List of Tables

Table 1. Drainage Criteria and Design Standards 4
Table 2. Recommended Code and Standard Clarifications 12

Section 1: Introduction

The City of West Linn (City) is developing a Storm Drainage Master Plan (SMP) to improve understanding of stormwater system characteristics and infrastructure in the city. The SMP will also support the prioritization of capital projects to address conveyance, capacity, and water quality for both existing and future development.

To support the development of the SMP, Brown and Caldwell (BC) conducted a review of the City's current codes and standards to verify design guidelines for the stormwater system. The code review identified inconsistencies and implementation gaps in current standards as they relate to the provisions of the City's Phase I National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer (MS4) permit and other regulatory documents. The subject areas covered in this evaluation include stormwater system analysis and design, conveyance capacity, stormwater infrastructure design standards, erosion and sediment control, land use and design review, maintenance, and code enforcement.

1.1 Objectives

This code review includes two primary elements – to identify the basis of design for capital project development and to provide a comprehensive review of stormwater design standards. Both elements are related to the development of the SMP.

Section 2 of this technical memorandum (TM) presents the basis of design for developing the SMP. This includes a summary of the City's obligations and responsibilities in managing stormwater and drainage infrastructure. The basis of design also establishes the level of service (design storms) and assumptions to be used in evaluating the existing systems for capacity deficiencies and in designing conceptual capital projects for the SMP.

Sections 3 of this TM compares the City's existing stormwater code and design standards to the elements of the City's NPDES MS4 permit. The results of this comparison are a series of recommended modifications to the code and/or design standards. Some of the modifications are suggested in response to provisions of the NPDES permit. Other changes are recommended to support the City's implementation of the stormwater program. Modification of the City's stormwater standards may alter staff priorities and required levels of effort, which could impact the staffing analysis and maintenance priorities in the SMP.

1.2 Regulatory Framework

The regulatory framework for this evaluation focuses on the City's NPDES MS4 permit as issued by the Oregon Department of Environmental Quality for management of stormwater runoff, as well as the provisions of the total maximum daily load (TMDL) program and current State 303(d) listings for receiving waters.

1.2.1 NPDES MS4 Permit

The City is a co-permittee on the Phase 1 Clackamas County NPDES MS4 permit, along with 12 other jurisdictions in Clackamas County, for the management of stormwater runoff. The City's effective NPDES MS4 permit was issued in 2012 and expired in March 2017. The permit has been administratively extended until DEQ can reissue the permit.

Implementation of City's NPDES MS4 permit is outlined in the City's Stormwater Management Plan (West Linn, 2012). This plan describes the stormwater activities or best management practices (BMPs) designed to address the following permit elements:

- Illicit Discharge Detection and Elimination
- Industrial and Commercial Facilities
- Construction Site Runoff Control
- Education and Outreach
- Public Involvement and Participation
- Post-Construction Stormwater Management
- Pollution Prevention for Municipal Operations
- Stormwater Management Facilities Operation and Maintenance Activities

Coordination efforts between co-permittees include regular collaboration meetings and participation in the Comprehensive Clackamas County Stormwater Monitoring Plan (CCCSMP).

In addition to the permit elements listed above, the 2012 NPDES MS4 permit required the City to prepare a stormwater retrofit strategy, prepare a hydromodification assessment (to address instream channel erosion and modifications), conduct environmental monitoring activities, and develop TMDL pollutant load reduction benchmarks. These assessments were documented and submitted to DEQ and each included program and/or project recommendations that influence the City's overall stormwater management strategy and SMP priorities.

1.2.2 TMDL and 303(d) Listings

A majority of the city (approximately 85 percent) discharges to the Willamette River and its tributaries including Arbor Creek, Robinwood Creek, Trillium Creek, Tanner Creek, and Salamo Creek. Approximately 15 percent of the city's drainage area, located in the southwest portion of the City, discharges directly to the Tualatin River and its tributaries, which flows to the Willamette River at the city's southern boundary.

Water quality impairment and exceedance of water quality standards in the Willamette and Tualatin Rivers have prompted these rivers and corresponding tributaries to be placed on the State 303(d) list for various parameters of concern. TMDLs have been developed to address specific sources of pollutant loading. Parameters of concern include temperature, bacteria (*E. coli*), chlorophyll *a* and pH, dissolved oxygen, and heavy metals. The City is identified as a designated management agency (DMA) in the Tualatin Subbasin and Willamette Basin TMDLs. Stormwater system improvements to address water quality and TMDL and 303(d) parameters will be a major focus of the SMP and proposed capital project needs.

1.3 Resources Reviewed

The assessment and recommendations presented in this TM are based on a review of the City's codes and standards as of November 2017[1], including:

- West Linn Municipal Code (WLMC), Chapter 4 Utilities, Chapter 5 Nuisances, and Chapter 8.105 Building Permittee Responsible for Erosion Prevention and Sediment Control
- West Linn Public Works Design Standards (PWDS), Section 2, Storm Drain Requirements
- West Linn Public Works Standard Construction Specifications, Division 6, Storm Drain Technical Requirements

[1] Effective October 15, 2018, the City updated the PWDS and Public Works Standard Construction Specifications. See Section 4 of this technical memorandum for details on the updated content of the PWDS.

- West Linn Community Development Code (CDC), Chapter 55 Design Review, Chapter 56 Parks and Natural Area Design Review, and Chapter 92 Required Improvements

Other documents were referenced to support the analysis and recommendations, including the City's 2015 Hydromodification Study (BC, 2015) that included an initial review of the City's development standards related to stream protection and development restrictions related to natural resource areas.

To better evaluate the basis of design (Section 2.2), the public works standards of other local entities were reviewed. These included the Oregon Department of Transportation (ODOT), Clean Water Services, and the cities of Beaverton, Gresham, Lake Oswego, Milwaukie, Portland, Oregon City, Tualatin, and Wilsonville.

1.3.1 Version Discrepancy

The code review effort revealed several discrepancies between the hard copy (printed) version of the PWDS and the version posted on the City's website as of November 2017. The hard copy version is the primary resource used by City staff when reviewing projects and conducting design reviews. The online version is most readily available to the public including developers and engineers.

It is not clear which version is the most current. Both versions have the same footer: "City of West Linn Public Works Design Standards 2010." The printed hard copies of the PWDS are contained in 3-ring binders with a printed record of amendments. The printed records indicate that the most recent amendment to Section 2 was made on 05/04/16 to modify the erosion control standards in PWDS 2.006. The online version of the PWDS does not include a record of amendments.

It is suspected that the online version of Section 2 has undergone more recent updates. Changes noted in the online version are consistent with recommendations in the City's 2015 hydromodification study. The resulting discrepancies are as follows:

- The printed version of PWDS 2.0046 states that infiltration facilities, such as storm sumps and drywells, are not allowed within the city. The online version states that "infiltration facilities, such as storm sumps and drywells, are permitted as allowed by the City Engineer and DEQ". This change looks to be an intentional modification to address requirements of the City's NPDES MS4 Phase I permit.
- The printed version of PWDS 2.0051 includes an exemption for construction of water quality treatment facilities for one and two family (duplex) dwellings (PWDS 2.0051.A.4). This exemption is not listed in the online version.

The PWDS update in October 2018 effectively addressed these discrepancies. It is recommended that a matrix of amendments to the PWDS should be posted with the online documents, so that users can verify that they have the latest version of the standards.

Section 2: Basis of Design

This section outlines the City's obligations and responsibilities in managing stormwater and drainage infrastructure. It also establishes the level of service (design storms) and assumptions to be used in evaluating the existing systems for capacity deficiencies and designing conceptual capital projects for the SMP.

2.1 Public/City Responsibility

The City's stormwater related policies and obligations are outlined in WLMC 4.062 through 4.090. These sections authorize the City to operate a stormwater program, charge fees for the program, and conduct enforcement actions. The City's responsibilities are outlined in WLMC 4.065, and private responsibilities are outlined in WLMC 4.070.

The WLMC limits the City's responsibility for drainage elements located on public property. Under WLMC 4.065, the City is responsible for managing facilities including open drainageways, piped systems, roadside drainage ditches, and flood control facilities. However, the overarching requirement is that the facilities be located on City-owned property, City right-of-way, or within a City easement.

Under WLMC 4.070, the following storm drainage facilities are to be managed by private owners:

- Storm drainage facilities not located on City-owned property, right-of-way, or easements
- Private parking lot drainage systems
- Roof, footing, and area drains
- Storm drainage facilities not constructed with public funding or intended for public use
- Open drainageways
- Access drive culverts, including those located in the public right-of-way

The identification of capital project recommendations in the SMP should state the party responsible for the proposed project. Many identified drainage problems may be the responsibility of private owners and it is up to the City to determine whether to include them as part of the capital project list.

2.2 Design Standards

Design standards related to the sizing and design of stormwater infrastructure are described in the PWDS. While the standards are typically applied to new infrastructure, they can also be used as the basis of design for the SMP. The standards are used to evaluate existing infrastructure, identify capacity limitations, and size proposed capital projects.

BC reviewed both the printed version and online version of the City's PWDS to identify current standards related to water quality, flow control, and conveyance system design. In most cases, the PWDS provides clear guidance to evaluate the stormwater system and design future improvements. Where current standards do not provide clear guidance, alternative design standards were identified, based on the City's regulatory obligations or commonly accepted practices in the Portland Metro area.

The applicable design standards as of November 2017 are outlined in Table 1.

Table 1. Drainage Criteria and Design Standards

Criteria	Source	Standard
Water Quality Facility Design	PWDS 2.0013	• All water quality facilities shall meet the design requirements of the City of Portland Stormwater Management Manual (SWMM).
	NPDES Phase I Permit, A.4.f.i	• Capture and treat 80% of the annual average runoff volume, identified in Clackamas County as the 1" over 24-hour design storm.
Water Quantity Facility Design	PWDS 2.0013	• Design to provide storage up to the 25-year storm event with safe overflow conveyance for the 100-year storm event. • Use a unit hydrograph method to evaluate existing and proposed conditions and restrict post-development discharge rates to pre-development discharge rates for the 2-, 5-, 10-, 25-, and 100-year events. • Minimum orifice size of 1.0".
Conveyance Piping Design	PWDS 2.0013	• Design to convey the 100-year storm event. • Minimum slope of 0.0055 (0.55%). • Minimum velocity of 2 feet per second, when flowing full. • Pipe roughness design coefficient shall not be less than 0.013.

Table 1. Drainage Criteria and Design Standards		
Criteria	**Source**	**Standard**
Culvert Design	PWDS 2.0014	• Design to convey the 25-year storm event such that the headwater does not exceed 1.5 times the culvert diameter or remains at least 1 foot below the roadway subgrade, whichever is lower. • 100-year storm event shall not overtop the roadway. • Allow for fish passage as required by the Oregon Division of State Lands, Army Corps of Engineers, and Oregon Division of Fish and Wildlife and/or the National Marine Fisheries Service. • Bottomless culverts shall be used whenever feasible.
Open Channel Design	PWDS 2.0013	• No design storm identified. • Control discharge so that the average velocity during the 10-year event is below the erosive velocity of the channel.
Pipe Size	PWDS 2.0012 PWDS 2.0033	• 12" minimum diameter for mains in the public right-of-way. • 10" minimum diameter for laterals to catch basins and other inlets. • Minimum 4" in diameter for service laterals.
Pipe Material	PWDS 2.0012	• Concrete, PVC, HDPE smooth interior/corrugated exterior are allowable. • Ribbed PVC is preferred for storm drains up to 24" in diameter. • Reinforced concrete is preferred for storm drains over 24" in diameter. • Ductile iron is allowed in areas where additional strength is required.
Pipe Cover	PWDS 2.0023	• Minimum cover shall be 30" above the top of the bell of the pipe in paved areas and 36" in all other locations. When minimum cover cannot be provided, implement additional strength measures.
Structure Spacing	PWDS 2.0031-2.0033	• Maximum of 500 feet between manholes. • Maximum of 400 feet between gutter inlets.

In addition to the design standards outlined in Table 1, the City's PWDS (2.0010) identifies that storm drain systems should be designed for ultimate development of all upstream tributary areas.

The November 2017 design standards may result in an overdesign of the conveyance system. PWDS 2.0013 requires all conveyance system piping be designed to convey the 100-year storm event. This is a much larger storm event than is required by ODOT or other local jurisdictions. It is also larger than the 25-year design storm required for culverts (PWDS 2.0014). Using the 100-year storm event may result in larger pipes and more costly capital projects. The City may consider adjusting the conveyance design standard for the SMP and/or the PWDS to align with regional standards. Examples of regional conveyance standards are included in Attachment A.

2.3 Basis of Design Recommendations

Based on a review of design standards and municipal code as of November 2017, the following recommendations apply to the development of the SMP.

Responsibility. The SMP should evaluate reported problem areas to determine which are the City's responsibility to address and which are the responsibly of private property owners. This evaluation should initially be based on problem location and consider the source and impacts of the problem.

As outlined in Section 2.1, the City may choose to take responsibility for problems when public elements of the drainage system are contributing to problems on private property. An example would be a roadway culvert that is undersized and causing upstream flooding and downstream erosion of the banks of an open channel. In the same way, the City may also wish to take responsibility to correct problems on private property that have the potential to impact public infrastructure. An example would be erosion along an open channel that is located on private property, but has the potential to undermine a public roadway

embankment. In such cases, the City may consider investing public funds to construct a project on private property to maintain the safety and function of the public infrastructure.

Land Use Scenarios. The SMP should evaluate both existing condition flows and the flows produced under a future land use scenario reflecting ultimate development conditions. In the ultimate development condition, the assumption is that all currently undeveloped areas, whether in or out of city limits, will be developed to the maximum allowance under current zoning. Capital project design should also be based on providing stormwater infrastructure to support the ultimate development condition. For portions of the stormwater conveyance system not hydraulically evaluated in the SMP, the City may consider it a condition of future development to evaluate the downstream impacts of the proposed development.

Conveyance System Analysis. For portions of the stormwater conveyance system to be hydraulically evaluated in the SMP, the evaluation should include multiple storm events to identify locations and frequency of capacity constraints. System components that show flooding in smaller storms (i.e., the 2-year or 10-year, 24-hour storm events) should be higher priority for capital projects than those that only flood during a 100-year storm event.

Capital Project Definition. When outlining capital project concepts, the 25-year storm should be used as the basis of design to establish project cost estimates. However, the final design analysis may consider whether designing for the 10-year or 25-year storm would provide a better cost-benefit ratio by project.

Section 3: Stormwater Code Review

This section presents the comparison of the City's existing stormwater code, including the City's stormwater design standards as of November 2017, to the elements of the NPDES MS4 permit. The results of the analysis are a series of recommendations for municipal code changes. Some code modifications are suggested in response to provisions of the NPDES permit. Other changes are recommended to support the City's implementation of the stormwater program.

This analysis covers the following NPDES MS4 permit elements:

- Post Construction Runoff Control (NPDES MS4, Section A.4.f)
- Illicit Discharge Detection and Elimination (A.4.a)
- Industrial and Commercial Facilities (A.4.b)
- Construction Site Runoff Control (A.4.c)
- Stormwater Management Facilities Operations and Maintenance (A.4.h)

The details related to this analysis, including a line-by-line analysis of each permit element, are presented in Attachment B. Recommendations for specific code and standards changes are presented in Section 4.

3.1 Post Construction Runoff Control

The City's requirements for post construction runoff control are outlined in Section 2 of the City's PWDS. The NPDES MS4 permit includes extensive guidance for post construction runoff control. Topics include stormwater management policy (A.4.f.i), barriers to low impact development (LID) (A.4.f.ii), stormwater management manual (A.4.f.iii), implementation (A.4.f.iv), site limitations (A.4.f.v), and inspection and enforcement (A.4.f.vi).

3.1.1 Stormwater Management Policy

The City's stormwater management policy in Section 2 of the PWDS covers each of the provisions of the NPDES MS4 permit including stormwater management thresholds, flow reduction, green infrastructure/Low Impact Development (LID), and water quality. Each of these provisions is discussed below.

- **Thresholds.** PWDS 2.0041 defines an impervious threshold when commercial and residential projects are required to provide treatment and/or detention. All commercial and residential development creating 500 square feet (sf) or more impervious surface must provide treatment for the new impervious area. All commercial and residential development and redevelopment creating 5,000 sf or more impervious area must provide treatment and detention. The code provisions apply to all impervious surfaces added with commercial and residential development, regardless of whether that area is replacing existing impervious surfaces. As written, the standard does not specifically apply to public roadway projects.

  As described in Section 1.3.1, the printed version of PWDS 2.0051 includes an exemption for construction of water quality treatment facilities for one and two family (duplex) dwellings. This exemption is not listed in the online version.

  The City may consider reducing the detention threshold to 1,000 sf of impervious surface, consistent with the post-construction minimum threshold listed in the NPDES MS4 permit. The impact of lowering the threshold could be partially offset by identifying areas of the City that are exempt from flow control, regardless of project size. Other local jurisdictions allow flow control exemptions for projects with direct discharges to the Willamette River and Tualatin River. Examples of these exemptions are provided in Attachment A.

  In conjunction with a change to the detention threshold, the City may need to do an impervious area analysis or land use application review to identify how many projects or what percent of impervious area would become exempt from flow control standards, should revision to the detention threshold be included.

- **Flow Reduction**. The City's detention standard (PWDS 2.0013) requires a reduction in the rate of discharge from the facility. Post-development runoff rates for the 2-, 5-, 10-, and 25-year events must match pre-development rates for the same set of storm events. The PWDS does not define a specific curve number or date of development to be the basis of calculating pre-development runoff rates.

  As currently written, the PWDS does not directly address permit language to target volume or duration of flows. However, the City's Hydromodification Assessment (2015) states that "…given the limited number of hydromodification indicators observed in West Linn stream channels, there is little justification for adopting a more stringent flow duration standard on a citywide basis."

- **Green Infrastructure/LID.** The language in CDC 92.010 states a preference for natural systems and infiltration when designing pubic systems to manage stormwater runoff[2]. This language should result in stormwater management facilities that follow LID principals. However, the PWDS does not have a facility selection hierarchy that would clearly prioritize LID facilities over traditional stormwater management approaches.

  The City may also need to clarify what approaches are allowable for impervious area reduction credit. Other local communities allow techniques such as use of green roofs, pervious pavers/pavements, tree

[2] The current preferences for natural systems and infiltration facilities are only stated in CDC 92.010, related to the design of public facilities. The City has indicated their intent to apply those preferences to all development reviews and parks projects. City staff have drafted an ordinance that would modify CDC 55.130 and 56.130 to include language that matches CDC 92.010, stating that "Developers are encouraged to adapt stormwater management approaches that make use of natural systems and infiltration to manage stormwater runoff…where appropriate."

planting, and/or rainwater harvesting to reduce the contributing impervious area and associated onsite stormwater management requirements.

- **Water Quality.** Rather than list a specific water quality treatment standard, PWDS 2.0013 requires designs to comply with the requirements of the City of Portland SWMM. Due to differences in rainfall patterns across the region, following Portland standards may not directly result in water quality facilities sized to meet 80 percent of the average annual runoff volume (NPDES MS4 permit requirement) in West Linn. The PWDS should reference a specific water quality design storm. Based on the site-specific analysis conducted for Clackamas County jurisdictions, the water quality design storm should be the 1 inch over 24-hour design storm, resulting in capture of 80 percent of the annual runoff volume. The PWDS should also include a correction factor to apply to facilities sized using the City of Portland's online tools, so that the facilities are sized to manage the design storm in West Linn.

3.1.2 Barriers to LID

As described in Section 3.1.1, the CDC states a preference for facilities that follow LID principals to mimic natural systems and infiltration.

In addition, the online version of the PWDS includes updates that remove barriers to LID. PWDS 2.0046 has been modified to allow the use of infiltration facilities for stormwater management. Previous versions and the printed version of PWDS 2.0046, do not allow the use of infiltration facilities. This discrepancy should be resolved, so that the printed version of the PWDS includes the updates shown in the online version.

3.1.3 Stormwater Management Manual

Most of the NPDES MS4 permit language related to the stormwater management manual is focused on having a document that outlines the stormwater management policies discussed in Section 3.1.1.

The PWDS includes numerous references to the Portland SWMM for stormwater management design standards. The stormwater design and review processes could be improved by clarifying which sections of the Portland SWMM should be applied at each stage of design. The City should adopt a City-specific list of allowable BMPs and an associated facility selection hierarchy. The PWDS could then refer to the Portland SWMM for BMP sizing, design criteria, and typical drawings. It may also be helpful to reference specific appendices of the Portland SWMM, such as the technical guidelines for infiltration testing, proprietary treatment technologies, soil and plant lists, and/or maintenance standards.

3.1.4 Implementation

The CDC lists the submittal, review, and approval requirements, including those related to post-construction controls for stormwater detention and treatment. No modifications are recommended.

3.1.5 Site Limitations

PWDS 2.0051 states that onsite water quality facilities are required unless the site is constrained by topography, limited in area, or served by a regional facility. When onsite facilities are not feasible, the City may require construction of an offsite facility or an upgrade to an existing public facility. No modifications are recommended.

3.1.6 Inspection and Enforcement

PWDS 2.0070 states that the City is authorized to make inspections and take actions required to enforce the provisions in the design standards. WLMC 5.400 through 5.565 includes enforcement procedures for non-compliant sites. The City has the authority to correct problems and pass the cost to the owner or applicant. No modifications are recommended.

3.2 Illicit Discharge Detection and Elimination

WLMC 4.063 prohibits the discharge of pollutants to the stormwater system, consistent with the NPDES MS4 permit requirements. The list of prohibited discharges is based on characteristics (visible sheen, high or low pH, toxics, floatables, etc.) rather than specifically prohibited substances. However, the list also includes a prohibition of "any discharge which causes a nuisance or hazard…" which gives the City a wide authority to address non-stormwater discharges.

The City may consider refining the definition of prohibited discharges to include some specifically prohibited substances or adding a list of permissible or conditionally allowable non-stormwater discharges, consistent with the list provided in the NPDES MS4 permit (Section A.4.a.xii).

WLMC 5.425 identifies water pollution as a nuisance affecting public health, giving the City authority for abatement and enforcement.

3.3 Industrial/Commercial Inspections

The WLMC provides the City with the legal authority to inspect industrial and commercial properties for possible water pollution sources. The general nuisance provisions in WLMC 5.425 define water pollution as a nuisance and WLMC 7.035 gives City general authority to inspect licensed businesses for compliance with local, state, and federal laws.

No modifications are recommended.

3.4 Erosion Control

The City's erosion control requirements provide clear guidance and are in alignment with the NPDES MS4 permit requirements. PWDS 2.0060 requires erosion and sediment controls for all development and erosion control permits for sites with 1,000 sf or more disturbance area. The PWDS describes tiered requirements for erosion control applications, so that small sites can prepare an abbreviated erosion and sediment control plan. As an agent for DEQ's 1200-CN program, the City is authorized to review and permit projects with up to 5 acres of disturbance area. Sites with more than 5 acres of disturbance area must obtain an erosion control permit directly from DEQ.

PWDS 2.0069 refers to the erosion control design standards in the Clackamas County Erosion Prevention and Sediment Control Planning and Design Manual.

PWDS 2.0070 and WLMC 5.477 defines erosion as a nuisance subject to enforcement and abatement.

No modifications are recommended.

3.5 Operations and Maintenance

The City has clear standards related to the maintenance of private stormwater management facilities. WLMC 4.070 requires private facility owners to enter into a maintenance agreement that is recorded with Clackamas County. Facilities must be repaired and maintained and must be kept clear of debris and excessive vegetation. Private streets and private parking lots must be swept annually.

Under WLMC 4.070, violation of the maintenance requirements can be declared a danger to public health and safety and a nuisance subject to abatement as described in WLMC 5.400 through 5.430.

No modifications are recommended.

3.6 Enforcement

The City has clear enforcement and abatement procedures, outlined in WLMC 5.400 through 5.527. The code gives the City the authority to enter property to inspect stormwater facilities, remove nuisances, and assess property owners for the cost of abating nuisances that have not been corrected.

No modifications are recommended.

Section 4: Proposed Policy and Standard Modifications

This section summarizes potential modifications to the City's policies and technical design standards, recommended based on the review presented in Sections 2 and 3. The recommendations also include several adjustments to code to improve clarity, resolve discrepancies, and ease implementation of existing policy and standards. Refer to Attachment C for proposed PWDS 2.0040 and 2.0050 language changes.

Sections 4.1 and 4.2 of this TM were initially prepared in 2017 as part of the draft technical memorandum. Effective October 15, 2018, the City updated the PWDS. At that time, some of the recommendations from the 2017 draft technical memorandum were addressed, as described below.

4.1 Technical Standards and Stormwater Policy Changes

The following modifications are recommended to improve consistency with the NPDES MS4 permit and provide more detailed guidance related to stormwater management and design. These changes would require modifications to the WLMC, CDC, and PWDS, as outlined below.

- **WLMC**: No technical or policy changes recommended. See Table 2 for clarification changes.
- **CDC**: The City should consider updating current floodplain management code sections to reflect floodplain standards consistent with the *Program Level Biological Assessment* for the National Floodplain Insurance Program for the State of Oregon (February 2013). In addition, floodplain management regulations should be moved from the CDC to the WLMC.
- **PWDS**, Thresholds: Reduce the detention threshold in PWDS 2.0041 to 1,000 sf of impervious surface (NPDES MS4 permit requirement) and identify areas of the city that are exempt from flow control. See Attachment A for example language from other local jurisdictions. See example PWDS language in Attachment C.
  a. *This recommendation was addressed in the October 2018 PWDS Update.*
- **PWDS, Water Quality**: Modify PWDS 2.0013 to state a specific water quality design storm. Based on the site-specific analysis conducted for Clackamas County jurisdictions, the water quality design storm should be the 1 inch over 24-hour design storm, resulting in capture of 80 percent of the annual runoff volume. Include a correction factor to apply to facilities sized using one of Portland's online tools, so that the facility sizes are consistent with West Linn rainfall patterns.
  a. *This recommendation was partially addressed in the October 2018 PWDS Update. A correction factor for Portland's online tool was incorporated, but the water quality design storm is not listed.*
- **PWDS, Facility Selection**: Expand PWDS 2.0013 or 2.0040 and 2.0050 to list a City-specific facility selection hierarchy that prioritizes green infrastructure facilities and clarify which impervious area reduction techniques (e.g., green roofs, pervious pavers/pavements, tree planting, rainwater harvesting) are allowable in West Linn. See example PWDS language in Attachment C.

- **PWDS, Conveyance Standards**: The City should consider modifying the current conveyance standards in PWDS 2.0013 and 2.0014 to set a lower design storm for the conveyance system design standard. Examples of regional conveyance standards are included in Attachment A. Two general approaches that may be considered include the following:
  1. Selecting the design storm based on contributing drainage area (i.e., use the 10-year storm for systems under 40 acres and the 25-year storm for larger contributing areas), or
  2. Selecting a 10-year or 25-year design storm and a minimum pipe size. If a smaller design storm is required, projects should still be required to identify a safe overflow route for the 100-year storm event to verify that emergency flows would not endanger life or property.
     a. *This recommendation was addressed in the October 2018 PWDS Update.*

4.2 Clarity and Implementation Changes

The primary recommendation to improve clarity and ease implementation is to provide more detail regarding which portions of the Portland SWMM are applicable to projects in West Linn. The PWDS currently references the entire Portland SWMM. However, the City of Portland makes frequent updates to its manual and associated typical details and forms, which should be considered when using a secondary resource. In 2016, the City of Portland adopted a stand-alone Source Control Manual, which was previous Chapter 4 of the 2014 Portland SWMM.

The City should consider making the following adjustments:

- Revise PWDS 2.0013 or 2.0040 and 2.0050 to include a City-specific list of allowable BMPs and BMP selection hierarchy. This would give the City more control over the types of facilities that are installed in West Linn. The PWDS could still refer to the Portland SWMM for a list of allowable proprietary treatment technologies.
- Throughout the PWDS, revise general Portland SWMM references to instead refer to the "BMP sizing methodologies, design criteria, and typical drawings in the Portland Stormwater Management Manual" so that designers have clear guidance for designing stormwater management facilities in the City.
- Consider adding detail to PWDS 2.0040 and 2.0050 to refer to specific technical guidelines in the Portland SWMM. These could include the Portland SWMM appendices related to infiltration testing, proprietary treatment technologies, source control standards, maintenance standards, and soil and plant lists.
- Update language in PWDS 2.0041 and 2.0051, so that stormwater management thresholds apply to both public and private projects.
  a. *This recommendation was addressed in the July 2018 PWDS Update. PWDS 2.0041 indicates thresholds apply to all development.*

Attachment C includes preliminary language that would incorporate these recommendations into PWDS 2.0040 and 2.0050, clarify the references to the Portland SWMM, and improve the guidance provided to designers of both public and private projects.

In addition to the recommendations presented in Section 4.1, Table 2 lists additional modifications that would improve clarity and resolve discrepancies in the City's current standards. These revisions do not impact City policy or technical standards.

Table 2. Recommended Code and Standard Clarifications		
Section	**Recommended Revision**	**Notes**
WLMC4.063 General Discharge Prohibitions	Consider adding a list of permissible or conditionally allowable discharges, consistent with NPDES MS4 permit section A.4.a.xii.	
WLMC 4.065 City Responsibilities	Expand the list drainage facilities to include "stormwater treatment and control facilities located on public property."	Current language indicates that the City is responsible only for flood control facilities.
WLMC 8.105 Building Permitee Responsible for Erosion Prevention/Sediment Control	Add a reference to PWDS 2.0060 for erosion control permit types and applicable thresholds.	Erosion control permits are required only for projects that disturb over 1,000 sf. WLMC 8.105 indicates that all building permit projects require an erosion control permit.
PWDS 2.0010 General Discharge Requirements, Item 7	Delete the reference to the "Oregon Administrative Rule for the Tualatin River" and instead point to the City's own standards for water quality treatment facilities.	Incorporated in the October 2018 PWDS Update.
PWDS 2.0011 Site Drainage Requirements	Delete items D and E	Items D and E relate to minimum requirements for detention and water quality facilities and are covered under the appropriate section (PWDS 2.0013).
PWDS 2.0045 Detention Facilities	Reformat for clarity: numbered items 3 and 5 should be C and D; numbered item 4 should be combined with item A.	Item A and item 4 have duplicate content.
PWDS 2.0046	Revise the printed version to match the online version, allowing the use of infiltration facilities.	The (online) October 2018 PWDS Update allows the use of infiltration facilities for stormwater management.
PWDS 2.0051 Construction of a Water Quality Facility	Revise the printed version to match the online version, by deleting item D from printed version.	Incorporated in the October 2018 PWDS Update.
PWDS 2.0052 Plan Requirements PWDS 2.0053 Facility Design PWDS 2.0054 Pond Access Road	Revise these provisions to be a standalone section, applicable to all stormwater management facilities.	Incorporated in the October 2018 PWDS Update.

References

Brown and Caldwell. 2015. *Hydromodification Assessment prepared for the City of West Linn*. June.

Program Level Biological Assessment for the National Floodplain Insurance Program for the State of Oregon. February 2013.

West Linn Municipal Code (WLMC), Chapter 4 Utilities, Chapter 5 Nuisances, and Chapter 8.105 Building Permittee Responsible for Erosion Prevention and Sediment Control

West Linn Public Works Design Standards (PWDS), Section 2, Storm Drain Requirements as of November 2017 and updated as of July 1, 2018.

West Linn Public Works Standard Construction Specifications, Division 6, Storm Drain Technical Requirements

West Linn Community Development Code (CDC), Chapter 55 Design Review, Chapter 56 Parks and Natural Area Design Review, and Chapter 92 Required Improvements

West Linn. 2012. *Stormwater Management Plan.*

Attachment A: Example Code and Standards

Regional Examples for Conveyance and Flow Control Exemptions

This page intentionally left blank.

Example Language – Conveyance

Source: Clean Water Services

Design for the 25-year peak flow with one foot of freeboard between the hydraulic grade line and the top of the structure or finished ground elevation. Collection systems for streets shall be designed to limit water to 4 inches deep against the curb and no more than 2-feet encroachment into travel lanes during the 25-year event. Open channel systems shall have one foot of freeboard in the 25-year event.

Source: ODOT

Table 3-1 Design Recurrence Interval (Years)

Drainage Facility	Freeways	Highways Other Than Freeways	
		ADT[1] less than 750	ADT[1] greater than or equal to 750
Bridge Openings[2,4]	50	25	50
Bridge Scour	See Chapter 10	See Chapter 10	See Chapter 10
Bank Protection	50	25	50
Culverts[2,4]	50	25	50
Ditches, Inlets and Gutters	10	10	10
Depressed Roadways	50	25	50
Energy Dissipators[3]	50	25	50
Storage Facilities	See Chapter 12	See Chapter 12	See Chapter 12
Water Quality Facilities	See Chapter 14	See Chapter 14	See Chapter 14
Storm Drains	10	10	10
Storm Drain Outfalls from Sags	50	25	50
Temporary Drainage Facilities[5]	See Section 3.10	See Section 3.10	See Section 3.10
Channel Changes[2,4]	50	25	50

Source: City of Portland

Table 6.1 Drainage Facilities with their Design Storm Return Periods

Facility Type	Design Storm Return Period, years
Street Gutter and Inlet	10 [1]
Piped Flow - Separated Storm Sewer (Conduit)	10 [2]
Surface Flow - Open Channel including Roadside Swale, Channel or Ditch	25 [3]
Culvert	25 [4]
Sump System	10 [5]
Outfall	Variable
Flow Control Storage Volume	Variable [6]
Special Circumstances	Variable [7]
Bridges	ODOT Standards [8]
River with FEMA Floodplain	100

Source: City of Lake Oswego

Table 5.1. Storm Recurrence Intervals for Conveyance Facilities: Open Channels, Culverts, and Bridges.

Location	Contributing Area	Design Storm Recurrence Interval[c]
Improvements on waterways with mapped FEMA 100-year floodplain	Any	100-year Runoff Recurrence
Open channels[a]	<40 acres	10-year
	40- 640 acres	25-year
	>640 acres	50-year
Piped conveyance[b]	<40 acres	10-year
	40- 640 acres	25-year
Major Arterials	<40 acres	25-year
	≥ 40 acres	50-year
Collectors and Other Public Streets	<40 acres	10-year
	≥ 40 acres	50-year
Private Drives	<40 acres	10-year
	≥ 40 acres	25-year

[a] Includes roadside ditches, drainage swales, streams. Flow must be contained within channel and adjacent undeveloped floodplain; no additional flood control structures are assumed. Bankfull dimensions of stream channels to be maintained through crossing. See Section 5.5.4 for more details.

[b] Piped sections longer than typical normal culverted crossing of a single roadway.

[c] Assume full build-out under current zoning to determine flow peaks. Recurrence interval may be adjusted downward at discretion of City Engineer if there is no significant change in flood damage risk.

Source: City of Oregon City

Table 5-1. Conveyance System Design Storms

Contributing drainage area	Design storm for conveyance system sizing		
	Storm sewer, culverts, and outfall pipes[a]	Creek or stream channels	Bridges
Less than 40 acres	10-year, 24-hour storm	10-year, 24-hour storm	100-year, 24-hour storm
40 to 640 acres	25-year, 24-hour storm	25-year, 24-hour storm	
640 acres or greater	50-year, 24-hour storm	50-year, 24-hour storm	

[a] *When a backwater condition exists, the storm drain system shall be designed to convey and contain at least the peak runoff for the 25-year design storm as described in* ***Section 5.4.3.***

Source: City of Gresham

DRAINAGE SYSTEM DESIGN CAPACITY		
Drainage System Element		**Design Storm Recurrence Interval (Years)**
Minor:	Streets, curbs, gutters, inlets, catch basin and connector drains	10
Major:	Laterals (collectors) <250 tributary acres	10
	Trunk >250 tributary acres	50*
	Arterial Streets and the Drainage System in or under Arterial Streets	50*
Watercourses:	Without designated floodplain	50
	With designated floodplain	100
Bridges:		100
Detention Facilities:	Storage volume (onsite)	25
	Storage volume	100
	Discharge rate	Function of downstream capacity
Retention Facilities:	Drywell infiltration capacity	25**

*Surcharged conditions for pipe systems and culverts and bank-full conditions for open ditches and channels are acceptable only for demonstrating the adequacy of the conveyance system to convey the peak runoff for the 25 or 50-year design storms (as required) provided that:

a. runoff is contained within defined conveyance system elements; AND
b. the hydraulic grade line does not exceed the elevation of the roadway subgrade; AND
c. no portions of a building will be flooded.

Example Language – Flow Control Exemptions

Source: Portland SWMM, Subsection of 1.3.2 Flow and Volume Control

Flow Control Requirements When Discharging to a Stream

Most tributary streams in Portland show evidence of excessive stream bank and channel erosion. Any development that discharges stormwater offsite that eventually flows to a tributary stream must be designed to a more restrictive requirement to reduce the potential for further aggravation of in-stream erosion problems. This applies to all tributaries and storm sewers that drain to streams or overland storm drainage systems within the Portland area except the Columbia Slough, which is regulated by Multnomah County Drainage District.

Flow control in these areas should aim to avoid discharging flows that will cause channel erosion. Channel-eroding flow varies from stream to stream. Unless more specific data are available, the City assumes that channel-eroding flow is one-half of the 2-year, 24-hour pre-developed (Lewis & Clark era) peak flow, and the requirements of this manual are based on that assumption. Specifically, the more restrictive flow control requirement is to limit the 2-year, 24-hour post-development peak flow rate to the predevelopment erosion-initiating rate (one-half of the 2-year, 24-hour flow rate). The facilities must also control the post-development flows from the 5-, 10-, and 25-year, 24-hour peak flows to the predevelopment 5-, 10-, and 25-year, 24-hour levels.

Flow Control Exemptions

New development and redevelopment projects may be exempt from flow control requirements if they discharge stormwater runoff directly into the Willamette River, Columbia River, or Columbia Slough through a private storm sewer, separated public storm sewer, or Multnomah Country Drainage District system with available capacity.

This exemption is for flow control only; the pollution reduction requirements presented in **Section 1.3.3** still apply.

Development must still properly dispose of stormwater using approved methods in accordance with **Section 1.3.1**.

When flow control is not required, facilities may be downsized to meet pollution reduction requirements only. (This exemption does not apply to facilities sized with the Simplified Approach.) When facilities are downsized to meet pollution reduction requirements only, flows above the pollution reduction design flow must be routed around the facility with an approved diversion structure, unless otherwise approved by BES.

Source: Oregon City Stormwater and Grading Design Standards

An exemption to the flow control requirements (see **Section 4.2**) of these standards will be granted when **both** of the following apply:

- The development site discharges to the Willamette River, Clackamas River, or Abernethy Creek;
- That development lies within the 100-year floodplain or is up to 10 feet above the design flood elevation as defined by OCMC 17.42.

Source: Wilsonville

Properties or development draining directly to and within 300 feet of the Willamette River or the Coffee Lake wetlands are exempt from the flow control standards. These projects are still subject to the water quality, conveyance and erosion prevention and sediment control provisions of these standards.

Source: Flow Control Exemption Memo prepared for Oak Lodge Water Services District (formerly Oak Lodge Sanitary District)

An exemption to the onsite detention requirement of Section 6.3.040 will be granted when all of the following conditions apply:

- The entire development site discharges directly to the Willamette River; and
- The project site is drained by a conveyance system that is comprised entirely of man-made conveyance elements (e.g., pipes, culverts, outfall protection, etc.) and extends to the ordinary high-water line of the Willamette River; and
- [OPTIONAL] The flow path distance from the project site to the 100-year floodplain of the Willamette River is less than one half mile; and
- The conveyance system between the project site and the exempt receiving water shall have sufficient hydraulic capacity to convey discharge from future buildout conditions (under current zoning) of the site, and the existing development condition from the remaining drainage area contributing to the conveyance system, based on the conveyance standards outlined in Section 6.3.010; and
- Any erodible elements of the man-made conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

This page intentionally left blank.

Attachment B: Code and Standards Review Matrix

This page intentionally left blank.

Post Construction Site Runoff Control (Permit Requirement A.4.f)

Requirement from the permit	Current Status with Respect to Addressing the Requirement	Code Reference	Identified Gaps	Further Clarification or Discussion
A.4.f.i Program Requirements				
Implement and enforce a post-construction stormwater pollutant and runoff control program for new development and redevelopment projects that create or replace 1,000 sf (or greater) impervious surface.	• The Public Works Design Standards (PWDS) defines an impervious threshold when commercial and residential projects are required to provide treatment and/or detention. All development creating 500 sf or more impervious surface must provide treatment for the new impervious area. All development and redevelopment creating 5,000 sf or more impervious area must provide treatment and detention. • The provisions apply to all impervious surfaces added with the development, regardless of whether that surface is replacing existing impervious areas. • The printed version of PWDS 2.0051 includes an exemption for construction of water quality treatment facilities for one and two family (duplex) dwellings. This exemption is not listed in the online version.	PWDS 2.0041 PWDS 2.0051	• The thresholds are inconsistent with the NPDES permit requirement, if water quality treatment facilities that don't mitigate the volume, duration, and rate (i.e., not infiltration facilities) are used for development between 1,000 and 5,000 sf. • Printed and online versions of the standards have inconsistent exemptions. • Standards specifically apply to commercial and residential projects.	• May need to reduce the detention threshold to 1,000 square feet of impervious surface. • Consider expanding definition beyond commercial and residential site development. • Consider adding a flow control exemption for projects with direct discharge to the Willamette River and Tualatin River. • Resolve discrepancy between printed and online versions of the standards. • Clarify that standards apply to all development types, including both public and private projects.
Incorporate site-specific management practices that target natural surface or predevelopment hydrologic functions as much as possible. The site-specific management practices should optimize onsite retention based on the site conditions.	• PWDS 2.0041 states that "Methods contained in the City of Portland Stormwater Management Manual, as modified by the City of West Linn, may be used in mitigation as approved by the City Engineer." • Detention ponds are prioritized over underground storage. • The printed version of PWDS 2.0046 does not allow the use of infiltration facilities. The online version allows infiltration facilities. • Onsite water quality facilities are required unless the site is constrained by topography, limited in area, or served by a regional facility. When onsite facilities are not feasible, the City may require construction of an offsite facility or an upgrade to an existing public facility. • Facility design should follow the methods in the City of Portland Stormwater Management Manual (Portland SWMM). • The CDC states "Developers are encouraged to adapt storm water management approaches that make use of natural systems and infiltration to manage storm runoff, including the use of vegetated swales, rain gardens, and other like systems, where appropriate."	PWDS 2.0041 PWDS 2.0045 PWDS 2.0046 PWDS 2.0051 PWDS 2.0053 CDC 92.010 (Draft CDC 55.130 and 56.130)	• Use of management practices that promote natural hydrologic function are not directly referenced in Code. • Reference to the Portland SWMM may meet this requirement. • Conflicts between printed and online versions of the standards with regard to infiltration facilities.	• Consider clarifying which portions of the Portland SWMM are applicable to West Linn… • Allowable facilities • Facility selection/hierarchy • Facility sizing • Design criteria and standard drawings • Resolve discrepancy between printed and online versions of the standards.
Reduce site specific post-development stormwater runoff volume, duration, and rates of discharges to the municipal separate storm sewer system (MS4) to minimize hydrological and water quality impacts from impervious surfaces.	The City's detention standard requires reduced rates of discharge. Post-development runoff rates for the 2-, 5-, 10, and 25-year events must match pre-development rates for the same set of storm events. Hydrologic analysis methods should use the unit hydrograph method.	PWDS 2.0013	The City's Code does not target reduction of runoff volumes and durations to minimize hydrologic and water quality impacts. However, the City's Hydromodification Assessment (2015) states that "…given the limited number of hydromodification indicators observed in West Linn Stream Channels, there is little justification for adopting a more stringent flow duration standard on a citywide basis."	PWDS does not include a definition of pre-developed condition. Many other communities identify a specific curve number or a specific time period to define the pre-developed condition for matching peak flows.
Prioritize and implement low-impact development, green infrastructure or equivalent design and construction approaches.	• PWDS 2.0041 states "Methods contained in the City of Portland Stormwater Management Manual, as modified by the City of West Linn, may be used in mitigation as approved by the City Engineer." Developers may mitigate impervious area to reduce the effective impervious area below the thresholds or to reduce the facility size required for detention and/or treatment. • The CDC states "Developers are encouraged to adapt storm water management approaches that make use of natural systems and infiltration to manage storm runoff, including the use of vegetated swales, rain gardens, and other like systems, where appropriate."	PWDS 2.0041 CDC 92.010	The CDC language states a preference for natural systems and infiltration to manage stormwater runoff. It is not clear whether this fully addresses establishing LID/GI as a priority.	• May need to clarify how the City is prioritizing LID/GI. • May need to clarify what practices or approaches are allowable for impervious area reduction.
Capture and treat 80% of the annual average runoff volume, based on a documented local or regional rainfall frequency and intensity.	All water quality facilities shall meet the design requirements of the Portland SWMM, as amended by the City of West Linn.	PWDS 2.0013	Clarification needed. The Portland SWMM includes multiple methods for sizing water quality facilities. Use of the PAC Tool meets the water quality design storm requirements of 80% of the average annual runoff. The Portland SWMM volume calculation method is based on a design storm of 0.83"/24 hours with a 2x factor of safety. This design storm is often incorrectly applied as just the 0.83"/ 24-hour storm, neglecting the factor of safety.	The PWDS should reference a water quality design storm. Based on the site-specific analysis conducted for Clackamas County jurisdictions, the water quality design storm should be the 1" over 24-hour design storm, resulting in capture of 80% of the annual runoff volume.
A.4.f.ii Barriers to LID				
Identify, and where practicable, minimize or eliminate ordinance, code and development standard barriers that inhibit design and implementation techniques intended to minimize impervious surfaces and reduce stormwater runoff (e.g., Low Impact Development, Green Infrastructure).	• Developers may mitigate impervious area to reduce the effective impervious area below the thresholds or to reduce the facility size required for detention and/or treatment. • The online version of PWDS 2.0046 has been updated to allow the use of infiltration facilities in stormwater management. • The CDC states "Developers are encouraged to adapt storm water management approaches that make use of natural systems and infiltration to manage storm runoff, including the use of vegetated swales, rain gardens, and other like systems, where appropriate."	PWDS 2.0041 PWDS 2.0046 CDC 92.010 (Draft CDC 55.130 and 56.130)	The printed version of PWDS 2.0046 does not allow the use of infiltration facilities.	Resolve discrepancy between printed and online versions of the standards, so that the printed version includes language in PWDS 2.0046 to allow the use of infiltration facilities.

Requirement from the permit	Current Status with Respect to Addressing the Requirement	Code Reference	Identified Gaps	Further Clarification or Discussion
A.4.f.iii Stormwater Management Manual must include:				
A minimum threshold for triggering the requirement for post-construction stormwater management control and the rationale for that threshold.	• PWDS defines an impervious threshold when projects are required to provide treatment and/or detention. All commercial and residential development creating 500 sf or more impervious surface must provide treatment for the new impervious area. All development and redevelopment creating 5,000 sf or more impervious area must provide treatment and detention. • The printed version of PWDS 2.0051 includes an exemption for construction of water quality treatment facilities for one and two family (duplex) dwellings. This exemption is not listed in the online version.	PWDS 2.0040 PWDS 2.0051	• The thresholds are not consistent with the NPDES permit requirement. • Printed and online versions of the standards have inconsistent exemptions.	• May need to reduce the detention threshold to 1,000 sf of impervious surface. • Consider adding a flow control exemption for projects with direct discharge to the Willamette River and Tualatin River.
A design storm or acceptable continuous simulation method to capture and treat 80% of the annual average runoff volume.	All water quality facilities shall meet the design requirements of the Portland SWMM, as amended by the City of West Linn.	PWDS 2.0013	Clarification needed.	The PWDS should reference a water quality design storm. Based on the site-specific analysis conducted for Clackamas County jurisdictions, the water quality design storm should be the 1" over 24-hour design storm, resulting in capture of 80% of the annual runoff volume.
Applicable LID, GI or similar stormwater runoff reduction approaches.	• PWDS 2.0041 states "Methods contained in the City of Portland Stormwater Management Manual, as modified by the City of West Linn, may be used in mitigation as approved by the City Engineer." Developers may mitigate impervious area to reduce the effective impervious area below the thresholds or to reduce the facility size required for detention and/or treatment. • The CDC states "Developers are encouraged to adapt storm water management approaches that make use of natural systems and infiltration to manage storm runoff, including the use of vegetated swales, rain gardens, and other like systems, where appropriate."	PWDS 2.0041 CDC 92.010 (Draft CDC 55.130 and 56.130)	Reference to the Portland SWMM may meet this requirement if the City allows the full list of facilities in the Portland SWMM.	• Consider clarifying which portions of the Portland SWMM are applicable to West Linn. • Consider clarifying appropriate mitigation measures to reduce the effective impervious area below thresholds.
Conditions where the implementation of LID, GI, or equivalent approaches may be impracticable.	PWDS lists conditions where onsite water quality facilities may not be practical, but does not specifically reference LID or GI. The Portland SWMM has a facility selection hierarchy that prioritizes onsite infiltration.	PWDS 2.0051	Reference to the Portland SWMM may meet this requirement if the City follows the Portland SWMM hierarchy for facility selection.	Consider clarifying which portions of the Portland SWMM are applicable to West Linn.
BMPs with a description of the following: site-specific design requirements, design requirements that do not inhibit maintenance, and conditions where the BMP applies.	All water quality facilities shall meet the design requirements of the Portland SWMM, as amended by the City of West Linn.	PWDS 2.0013 PWDS 2.0041	None.	Does the City agree with the BMP descriptions and design requirements in the Portland SWMM?
Pollutant removal efficiency performance goals that maximize the reduction in discharge of pollutants.	All water quality facilities shall meet the design requirements of the Portland SWMM, as amended by the City of West Linn.	PWDS 2.0013	None.	None.
A.4.f.iv Implementation of Post-Construction Controls				
The co-permittee must review, approve and verify proper implementation of post-construction site plans for new development and re-development projects applicable to this section.	The CDC lists the submittal, review, and approval requirements, including those related to post-construction controls for stormwater detention and treatment.	CDC 24.080 CDC 24.100 CDC 55.110 CDC 55.130 CDC 56.130 CDC 60.060 and 070 CDC 85.170	None.	None.
A.4.f.v Site Limitations				
If a project site is characterized by factors limiting on-site stormwater management methods, the program must require equivalent pollutant reduction measures, such as off-site stormwater quality management. Off-site stormwater quality management may include off-site mitigation such as using low impact development principles in the construction of a structural stormwater facility within the sub-watershed, a stormwater quality structural facility mitigation bank or a payment-in-lieu program.	Onsite water quality facilities are required unless the site is constrained by topography, limited in area, or served by a regional facility. When onsite facilities are not feasible, the City may require construction of an offsite facility or an upgrade to an existing public facility.	PWDS 2.0051	None.	None.
A.4.f.vi Inspection and Enforcement				
Inspection and enforcement response procedures to address project compliance issues with the enforceable post-construction stormwater management performance standards.	PWDS states that the City is authorized to make inspections and take actions required to enforce the provisions in the design standards. The WLMC includes enforcement procedures for non-compliant sites. City has authority to correct problems and pass the cost to the owner or applicant.	PWDS 2.0070 WLMC 5.400 through 5.565 for enforcement	None.	None.

Illicit Discharge Detection and Elimination (Permit Requirement A.4.a)

Requirement from the permit	Current Status with Respect to Addressing the Requirement	Code Reference	Identified Gaps	Further Clarification or Discussion
A.4.a Program Requirements				
Prohibit through ordinance… illicit discharges to the co-permittee's MS4.	The WLMC includes a specific list of prohibited discharges to the storm drainage system and/or surface water bodies. The list of prohibited discharges is based on characteristics (visible sheen, high or low pH, toxics, floatables, etc.) rather than specifically prohibited substances. However, the list also includes "any discharge which causes a nuisance or hazard…"	WLMC 4.063	The list of characteristics may not be sufficient to enforce the illicit discharge policy.	• May need to expand this definition to include some specifically prohibited substances. • May want to include a list of permissible or conditionally allowable discharges. (listed in A.4.a.xii).
Legal authority to conduct illicit discharge inspections on private property.	WLMC defines water pollution and liquid waste from private premises to surface drainages as nuisances affecting public health. WLMC 5.425 could be used to enforce the prohibited discharges listed in WLMC 4.063. Under WLMC 5.510, the City has legal authority to enter property to investigate and correct problems, passing the cost along to the owner or responsible party.	WLMC 5.400 through 5.565 for enforcement	None.	None.

Industrial and Commercial Facilities (Permit Requirement A.4.b)

Requirement from the permit	Current Status with Respect to Addressing the Requirement	Code Reference	Identified Gaps	Further Clarification or Discussion
A.4.b Program Requirements				
Legal authority to conduct pollutant load inspections on private industrial and commercial properties.	• General nuisance provisions declare that pollution of body of water (including streams and drainage ditches) is subject to enforcement. • WLMC 7.035 gives City general authority to inspect licensed businesses for compliance with local, state, and federal laws.	WLMC 5.425 WLMC 7.035	None	None.

Construction Site Runoff Control (Permit Requirement A.4.c)

Requirement from the permit	Current Status with Respect to Addressing the Requirement	Code Reference	Identified Gaps	Further Clarification or Discussion
A.4.c Program Requirements				
Require erosion prevention and sediment controls to be design, implemented, and maintained…. Must apply to construction activities that result in land disturbance of 1.000 square feet or greater.	PWDS requires erosion and sediment controls for all development and erosion control permits for sites with 1,000 sf of disturbance and larger.	PWDS 2.0060-2.0070	None.	None.
Require construction site operators to develop erosion prevention and sediment control site plans and to maintain effective erosion prevention and sediment control BMPs.	PWDS requires preparation ESC plans, with tiered requirements, based on the size of the site. Individual, single family residential lots under ½ acre can prepare an abbreviated erosion control plan. All other sites under 1 acre must follow the Clackamas County Erosion Prevention and Sediment Control Planning and Design Manual. Sites between 1 and 4.99 acres must follow the Clackamas County 1200-CN ESC Plan Checklist. Sites greater than 5 acres must apply to DEQ for a 1200-C permit.	PWDS 2.0060-2.0070	None.	None. The City is an agent for the 1200-CN permit.
Require construction site operators to prevent or control non-stormwater waste that may cause adverse impacts to water quality.	PWDS 2.0068 and 2.0069 include approval criteria, based on preventing discharge of sediment, mud, dirt, rock and other debris to downstream areas.	PWDS 2.0029 and 2.0069	None.	None.
Site plan review procedures: At a minimum, construction site erosion prevention and sediment control plans for sites disturbing one acre or greater must be consistent with 1200-C permit.	Sites between 1 and 4.99 acres must follow the Clackamas County 1200-CN ESC Plan Checklist. Sites greater than 5 acres must apply to DEQ for a 1200-C permit.	PWDS 2.0066 and 2.0067	None.	None.
Legal authority for on-site inspections of construction sites.	The City has authority to make inspections and take action as required to enforce the provisions of the erosion control code.	PWDS 2.0070	None.	None.
Enforcement response procedures to ensure construction activities are in compliance.	PWDS includes authority for the City to require increased ESC measures. The WLMC includes enforcement procedures for non-compliant sites. City has authority to correct problems and pass the cost to the owner or applicant.	PWDS 2.0070 WLMC 5.477 WLMC 8.105	None.	WLMC 8.105 should include reference to PW Design Standards.

Stormwater Management Facilities Operations and Maintenance Activities (Permit Requirement A.4.h)

Requirement from the permit	Current Status with Respect to Addressing the Requirement	Code Reference	Identified Gaps	Further Clarification or Discussion
A.4.h Program Requirements				
Legal authority to inspect and require effective operation and maintenance of stormwater management facilities.	• City requires private facility owners to enter into a maintenance agreement that is recorded with Clackamas County. Facilities must be maintained to protect from damage and must be kept clear of debris and excessive vegetation. Private streets and private parking lots must be swept annually. • Under WLMC 4.070, violations of the maintenance requirements can be declared a as a danger to public health and safety and a nuisance to be abated as provided in WLMC 5.400 through 5.430. • City has legal authority to enter property to investigate and correct problems, passing the cost along to the owner or responsible party.	WLMC 4.070 for private facility maintenance responsibility WLMC 5.400 through 5.527 for enforcement	None.	None

This page intentionally left blank.

Attachment C: Preliminary Language

PWDS 2.0040 and PWDS 2.0050

This page intentionally left blank.

Attachment C

Preliminary Language
West Linn PWDS 2.0040 and 2.0050 (Revised)

The following language is a preliminary draft of PWDS 2.0040 and 2.0050, reflecting modifications outlined in Sections 3 and 4 of the memorandum. The goals of this revised language are:

- Consolidate design requirements and clarify that design requirements apply to both detention and water quality treatment facilities.
- Better define how the requirements of the Portland Stormwater Management Manual (SWMM) apply to projects in West Linn.

This language would replace PWDS 2.0040 and 2.0050 in its entirety. Additional modifications to other sections of the PWDS would also be necessary to fully implement the modifications proposed in this preliminary language. For example, throughout the PWDS, general references to the Portland SWMM should be modified to refer to the "facility sizing methodologies, design criteria, and typical drawings in the Portland Stormwater Management Manual."

Text shown in blue is proposed text to supplement the online version of the PWDS as of November 2017. Additional content needs are shown using *italics*. Retained text is shown in black, and the current PWDS section number is noted for all retained text.

Text shown in green reflects changes made in the October 2018 online version of the PWDS.

2.0040 Stormwater Management Facility Requirements

2.0041 Development Requiring Detention and/or Water Quality Improvements (from 2.0041)

A. Single-family residential site redevelopment is required to provide water quality improvements for all newly created impervious area, whether or not replacing existing impervious area, prior to off-site discharge. On-site disposal is preferred for single-family residential site redevelopment.

B. All development creating 500 sq. ft. or more of newly created impervious area, including replacement of existing impervious area, will be required to provide water quality improvement for the newly created impervious area. For development or redevelopment creating more than 1,000 sq. ft. of new impervious area, water quality improvements as well as detention will be required.

C. New development and redevelopment projects may be exempt from detention requirements if they discharge stormwater runoff directly into the Willamette River or Tualatin River through a conveyance system that is comprised entirely of man-made conveyance elements (e.g., pipes, culverts, outfall protection, etc.) with available capacity. This exemption is for detention only. Water quality improvement requirements still apply.

D. Developers may mitigate impervious area to reduce the new effective impervious area (EIA) below the thresholds listed above or to reduce facility size required for detention and/or water quality improvements. Methods contained in the City of Portland Stormwater Manual, as modified by West Linn, may be used in mitigation as approved by the City Engineer. Stormwater facilities must be aesthetically blended into surrounding landscape to greatest possible extent. Methods allowed for impervious area reduction are:

1. [insert City approved list of impervious area reduction methods – Methods included in the Portland SWMM are Ecoroof, pervious pavement, tree credits, , and]

2.

3.

E. When required, retaining wall will be allowed inside stormwater tract but shall be less than four feet. Retaining wall taller than four feet shall be constructed in tier with 1:1 slope and shall be approved by the City Engineer. Handrails per ODOT Standard Drawings RD770 and RD771 are required for facilities with retaining walls four feet and taller.

2.0042 Floodplain Information (from 2.0042)

A. Floodplain information, delineating the 100-year floodplain limits, shall be shown where it occurs within the development. Floodplain limits shall be based on maps prepared by the U.S. Army Corps of Engineers and the Federal Emergency Management Agency (FEMA). Where better information is available, it shall be used by the Design Engineer.

B. *[Move floodplain regulations from the CDC to this section]*

C. *[Floodplain regulations to be updated to address issues raised in the February 2013 Program Level Biological Assessment for the National Floodplain Insurance Program for the State of Oregon.]*

2.0043 Allowable Facilities

A. Stormwater management facilities contained in the City of Portland Stormwater Manual may be used in mitigation as approved by the City Engineer. Allowable facilities include the following:

1. *[insert City approved list of facilities with hierarchy (if applicable). Facilities included in the Portland SWMM are Rain Garden, Swales, Curb Extension, Planters, Basins, Filter Strips, Grassy Swales, Ponds, Sand Filters, Soakage Trenches, Drywells, Sumps, Manufactured Treatment Technologies, Structural Detention Facilities]*

2.

3.

4.

B. Facility Restrictions: (from 2.0045) Underground storage by tank or vault will be approved by the City Engineer only when a vegetated facility is impracticable. No underground detention facilities will be authorized for residential application. *[option to describe additional site use restrictions or insert a table that shows different facilities allowed for different site uses. For example: facilities that are allowed on private property, but not public or facilities that are allowed for commercial and industrial site uses, but not residential.]*

C. Facility Selection: (from WLMC 92.010) Designers are encouraged to adapt stormwater management approaches that make use of natural systems and infiltration to manage stormwater runoff, including the use of vegetated swales, rain gardens, and other like systems where appropriate.

D. Manufactured Treatment Technologies: Manufactured treatment technologies are permitted for private co, provided they are approved by and meet the design requirements of the City of Portland Stormwater Management Manual.

(from 2.0053) Storm filter or facilities utilizing similar technologies or process with replacement filter cartridges will generally not be approved for use in public or private stormwater treatment systems within the City, but may be approved by the City Engineer only if an above ground facility absolutely will not be functional as determined by the City Engineer. (Resolution 05-10 4/11/05)

E. Infiltration Facilities: (from 2.0046) Infiltration facilities such as storm sumps and drywells are permitted as allowed by the City Engineer and the Department of Environmental Quality. When infiltration facilities are proposed, infiltration testing and soil requirements shall follow the City of Portland Stormwater Management Manual.

2.0044 Site Constraints for Stormwater Management Facilities (from 2.0051)

A. A stormwater management facility shall be constructed unless, in the judgment of the City Engineer, any of the following conditions exists:

1. The site topography or soils makes it impractical, or ineffective to construct an on-site facility.
2. The site is small compared to the development plan, and the loss of area for the on-site facility would preclude the effective development.
3. There is a more efficient and effective regional site within the subbasin that was designed to incorporate the development.

B. If construction of an on-site facility is not required, then the City Engineer may require that development to construct an off-site stormwater management facility that will manage an equal or greater volume of stormwater elsewhere within the City. It is the developments responsibility to acquire the land necessary offsite to construct the proposed facility and to provide proof to the City Engineer that land has been acquired prior to the Land Use Application being deemed complete by the City. If the City is not furnished with adequate proof of ownership, then the application will not be deemed complete.

C. In lieu of constructing a new facility, the City Engineer may permit a development to upgrade an existing public facility at his discretion.

2.0050 Stormwater Management Facility Design

2.0051 Stormwater Management Manual

A. Stormwater facility sizing methodologies, design criteria, and typical drawings in the Portland Stormwater Management Manual will be used in designing stormwater management facilities for treatment and detention.

B. For water quality facilities sized using the Presumptive Approach Calculator (PAC), the facility surface area shall be increased by 25 percent to account for differences in rainfall patterns. No correction factor is required for onsite detention facilities sized using the PAC with flow control criteria.

2.0052 Plan Requirements

A. (from 2.0052) When construction of stormwater management facilities is required:

1. The application shall include a set of construction plans prepared by the Design Engineer that certifies the proposed water quality facilities have been designed in accordance with the criteria required in Subsection 2.0013, Minimum Design Criteria.
2. For facilities to be dedicated to the City, a financial assurance, meeting the requirements of the City shall be provided for the construction of the water quality facility and for maintenance for 2 years after acceptance of the facility.
3. An operation and maintenance plan shall be prepared showing how the water quality facility is to be maintained.
4. A landscape plan shall be prepared for the proposed facility.
5. A list of recommendations by a Geotechnical Engineer may be required at the discretion of the City Engineer.

B. (from 2.0045) All detention facilities shall be subject to testing prior to final acceptance per Standard Construction Specifications, Subsection 604.01, Construction Requirements, unless the City Engineer determines, in writing, testing is not required. All surface storage detention facilities shall be subject to testing prior to final acceptance per Standard Construction Specifications, Subsection 604.02, Pond Testing Requirements, unless the City Engineer determines, in writing, testing is not required. All underground detention facilities shall be subject to testing prior to final acceptance per Standard Construction Specifications, Subsection 604.03, Underground Detention Pond Requirements. (Resolution 05-10 updated 4/11/05)

2.0053 Facility Design

A. (from 2.0041) Stormwater facilities must be aesthetically blended into surrounding landscaping to greatest possible extent. Soil specifications and plant lists shall follow the requirements of the City of Portland Stormwater Management Manual.

B. (from 2.0041) When required, retaining wall will be allowed inside stormwater tract but shall be four feet tall or less. Retaining walls taller than four feet shall be constructed by tier with 1:1 slope (i.e. four foot wall, four foot horizontal setback before other walls) and shall be approved by the City Engineer.

C. (from 2.0045) Slopes to detention pond shall not to exceed 3:1 and be vegetated with native materials. Retaining walls of all types for a pond construction shall be approved by the City Engineer only when native sloped enclosure is impracticable.

D. (from 2.0045) Concrete pipe is the strongly preferred material for detention tank applications. Before corrugate aluminum alloy pipe may be used for detention tank applications, applicant must demonstrate that concrete pipe is either impractical or unavailable. Additionally, any corrugated aluminum alloy pipe requested must be accompanied by certification of it having a 75-year design life, and must be specifically approved by the City Engineer.

E. *[insert additional facility design guidelines]*

2.0054 Facility Access Road (from 2.0054)

Stormwater Management facilities shall be accessible for maintenance and shall have an access road that provides for maintenance and inspection of all inflow and outflow structures. The following criteria are the minimum City requirements:

1. 12 in. of 1-1/2”-0 compacted crushed gravel and subgrade shall be compacted to 95% of maximum dry density, as determined by AASHTO T-180.
2. At a minimum, a driveway approach shall be built per ODOT Standard Drawing RD740, RD745 or RD750.
3. Maximum grade is 15% with a 3% cross slope unless approved otherwise by the City Engineer.
4. Minimum width is 15 ft.
5. Access shall extend to within 10 ft. of all control structures, including both inflow and outflow structures unless otherwise approved by the City Engineer.
6. Access gates to pond, when required, shall be 15 ft. wide, lockable and per ODOT Standard Drawings RD820 and RD815.

2.0055 Emergency Overflow (from 2.0044)

A. The Design Engineer shall assess the impacts of system failure for on-site detention. Overflow may occur due to rainfall intensity which exceeds the design storm, debris blockage of storm drain system, or some other reason.

B. The storm drain system shall be designed such that overflows do not cause inundation of neighboring properties. Potential overflow routes shall be adequately protected from erosion.

C. If surface detention (e.g., pond) is used, an overflow system shall be included to provide controlled discharge of the 100-year, 24-hour design storm event for developed conditions, without overtopping any part of the pond embankment or exceeding the capacity of the emergency spillway. The overflow design shall assume failure of the normal outlet control structure. An emergency spillway shall be able to safely pass all flows over the pond embankment without overtopping the embankment. Sufficient armoring will be required to the toe on each face of the embankment to prevent failure of the embankment from erosion.

This page intentionally left blank.

Appendix B: TM2: Stormwater Basis of Planning

Brown AND Caldwell

6500 SW Macadam Avenue, Suite 200
Portland, OR 97239

T: 503-244-7005

Technical Memorandum

FINAL

Prepared for: City of West Linn

Project Title: Storm Drainage Master Plan

Project No.: 150752

Technical Memorandum #2

Subject: Stormwater Basis of Planning

Date: September 8, 2018

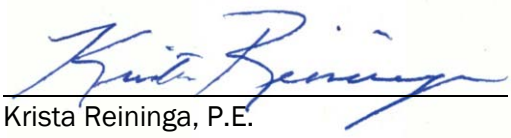
September 9, 2019 (Updated)

To: Amy Pepper, P.E., City of West Linn

From: Angela Wieland, P.E.
Jessica Christofferson

Copy to: Lance Calvert, P.E., City of West Linn

Prepared by: 
Angela Wieland, P.E.

Reviewed by: 
Krista Reininga, P.E.

This page intentionally left blank.

Table of Contents

Section 1: Introduction 1
1.1 Objectives and Background 1
1.2 Data Compilation and Review 1
1.2.1 GIS Data Compilation and Preliminary Mapping 2
1.2.2 Existing Planning Documentation and Reports 2
Section 2: Regulatory Background 3
2.1.1 NPDES MS4 Permit 3
2.1.2 TMDL and 303(d) Applicability 3
Section 3: Identification of Stormwater Problem Areas 5
3.1 Data Sources 5
3.1.1 Public and City Staff Surveys 5
3.1.2 Hydromodification Assessment 6
3.1.3 2006 Plan CIP List Review 6
3.1.4 Documentation of Findings 7
3.2 Site Visits (November 2017 and March 2018) 7
3.3 Stormwater Modeling Needs Workshop 7
Section 4: Water Quality Assessment 9
4.1 Water Quality Assessment Strategies 9
4.2 Methodology 10
4.2.1 Desktop Assessment 10
4.2.2 Site Visit 11
4.3 Results 11
Section 5: Stormwater Project Opportunity Areas 11
5.1 Programmatic Opportunities 12
5.2 Modeling Status 12
5.3 Next Steps 13
Attachment A: Matrices A-1
Attachment B: Preliminary Maps B-1

List of Figures

(Figures immediately follow page listed)

Figure 1. Stormwater Problem Areas 8
Figure 2. Water Quality Opportunity Areas 10
Figure 3. Stormwater Project Opportunity Areas 13

List of Tables

Table 1. Existing Stormwater Planning Documentation and Reports 2
Table 2. Applicable TMDL and 303(d) Parameters 4

Section 1: Introduction

The City of West Linn (City) is developing a Storm Drainage Master Plan (SMP) to improve understanding of stormwater system characteristics and infrastructure in the city. The SMP will support the prioritization of capital improvement projects (CIPs) and programmatic activities to address conveyance, capacity, and water quality for both existing and future development.

This Technical Memorandum #2 (TM#2) has been developed to document the following:

- Regulatory background and framework related to the development of CIPs and programs
- Methods and outcomes from the preliminary identification of stormwater problem areas and stormwater modeling needs
- Methods and outcomes from the identification of water quality opportunity areas
- Identification of proposed stormwater project opportunity areas for further consideration and refinement as CIPs or programmatic activities in the SMP

Through data collection and planning efforts to date, a total of 44 project opportunity areas have been identified for possible project development as part of this master planning effort. The stormwater project opportunity matrix (Attachment A, Table A-1) will be used to prioritize project development efforts and cost estimation needs for those project opportunities that are needed to ensure an acceptable level of service is maintained for West Linn residents.

Planning criteria and applicable stormwater design standards related to the sizing and design of stormwater infrastructure has been previously documented under TM#1: Stormwater Basis of Design and Code Review.

1.1 Objectives and Background

Key objectives of the City's SMP and associated stormwater project development efforts are to resolve known areas of stormwater drainage problems and flooding; enhance and expand water quality treatment; and identify programmatic opportunities to address stormwater needs on a city-wide scale.

The City opted to develop their SMP using a collaborative approach with engineering and maintenance staff to initially assess known stormwater problem areas and identify areas where infrastructure addition, replacement, or retrofit is needed to address an issue. Problem areas were identified through a combination of public and City staff surveys, interviews with City engineering and maintenance staff, site visits, literature review, and project workshops. A separate water quality assessment was conducted to ensure that water quality-related project opportunities were also identified. Portions of the stormwater system requiring a modeling approach to evaluate capacity limitations and project concepts were identified through this process.

This overall process allowed the City to focus resources and develop information for areas and projects most likely to be prioritized in a capital improvement program.

1.2 Data Compilation and Review

In May 2016, Brown and Caldwell (BC) provided a list of data needs to the City to initiate the SMP effort. Data needs included geographic information system (GIS) information, background data and reports, City organizational information, and maintenance program information and procedures. Data needs were reviewed and discussed in detail during the project kick-off meeting (May 25, 2017) and clarification was provided as necessary.

BC's data request was primarily fulfilled over the course of 6 months (July through December 2017) as part of 12 separate data packages.

One primary data gap that was identified was the availability of the hydrologic and hydraulic modeling files used in development of the 2006 *Surface Water Management Plan* (2006 Plan). However, GIS shapefiles reflecting subbasin delineations, select model input parameters (i.e., lag time, effective impervious area, etc.) and output results (i.e., modeled flows for defined design storms) were available for use and referenced in the development of new models for this SMP.

1.2.1 GIS Data Compilation and Preliminary Mapping

Most GIS data were provided to BC between July and August 2017. GIS data were provided as both individual shapefiles and geodatabases. Data reflect existing city limits, basin and subbasin boundaries, zoning and natural areas/parks coverage, stormwater collection system features (pipes, culverts, manholes), and water quality and flood control facilities.

Limited stormwater collection system attribute data (i.e., inverts, rim elevations, pipe diameters, age) were available. Approximately 77 percent of the stormwater collection system inverts and 68 percent of the rim elevations were not reflected in the GIS. Pipe sizes were missing for about 16 percent of the piped collection system. Open channel system dimensions (i.e., cross sections) were unavailable. As a result, a targeted modeling approach to address specific areas of known conveyance or capacity limitations was proposed. A targeted modeling approach requires less survey work to collect missing data.

In conjunction with review of the GIS system data, BC prepared preliminary maps identifying study area extents, topography and soils, land use, and stormwater drainage system features. The effective date of mapped system information is August 2017. Preliminary mapping is included in Attachment B and was used to support the identification of stormwater project opportunity areas discussed in this TM.

1.2.2 Existing Planning Documentation and Reports

The City's last stormwater master plan was completed in 2006 (2006 Plan). Since 2006, identified CIPs have not consistently been implemented. The identified projects were solely based on modeled system capacity deficiencies, specifically culverts. Projects were not prioritized, nor were validated by City staff in conjunction with observed deficiencies or City maintenance objectives. Project needs identified in the 2006 Plan are considered outdated due to the limited City feedback and qualification of project locations in conjunction with development of the 2006 Plan and the lack of reported capacity deficiencies associated with the modeled system since the 2006 Plan was developed.

BC obtained copies of various planning-level reports and studies prepared since the 2006 Plan to help inform areas of observed stormwater problems and potential stormwater project needs. Reports and studies reviewed and considered for this SMP are listed in Table 1. Additional detail related to the content and use of selected reports is included in Sections 3 and 4.

Table 1. Existing Stormwater Planning Documentation and Reports

Report	Date	Summary and application to the SMP
West Linn Surface Water Management Plan	2006	Provides background information and historic basis for the need to update the SMP.
Stormwater Retrofit Plan for the City of West Linn	2015	Provides documentation of the City's retrofit strategy, which includes proposed stormwater pond retrofits and culvert retrofits.
Hydromodification Assessment	2015	Provides a summary of instream channel conditions and hydromodification indicators. Field notes and photo logs documenting system conditions are included. Project and policy needs are identified.
West Linn Transportation System Plan	2016	Identifies transportation improvement project needs including pedestrian improvements that may be coordinated with stormwater infrastructure or green street development activities.

Section 2: Regulatory Background

One objective of the City's SMP is to enhance and expand water quality treatment. The City's National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer (MS4) permit, as well as the provisions of the total maximum daily load (TMDL) program and current 303(d) listings for receiving waters, provide a regulatory framework to guide project development.

2.1.1 NPDES MS4 Permit

The City is a co-permittee on the Phase 1 Clackamas County NPDES MS4 permit, along with 12 other jurisdictions in Clackamas County, for the management of stormwater runoff. The City's effective NPDES MS4 permit was issued in 2012 and expired in March 2017. The permit is currently under administrative extension until the Oregon Department of Environmental Quality (DEQ) reissues the permit. During administrative extension, jurisdictions are required to continue implementing their expired permit via their effective Stormwater Management Plan (SWMP).

The City's effective SWMP was developed in 2012, and describes the stormwater activities or best management practices (BMPs) designed to address the following permit elements:

- Illicit Discharge Detection and Elimination
- Industrial and Commercial Facilities
- Construction Site Runoff Control
- Education and Outreach
- Public Involvement and Participation
- Post-Construction Stormwater Management
- Pollution Prevention for Municipal Operations
- Stormwater Management Facilities Operation and Maintenance Activities

In addition to the permit elements listed above, the 2012 NPDES MS4 permit also required the City to prepare a stormwater retrofit strategy, prepare a hydromodification assessment (to address instream channel erosion and channel modifications), and develop TMDL pollutant load reduction benchmarks. These technical assessments were documented and submitted to DEQ and included program, policy, and/or project recommendations.

Current SWMP implementation and results of these technical assessments have been considered in the identification of project opportunities documented in this TM. Resulting water quality projects and identified program modifications may be used by the City to address anticipated future permit requirements.

2.1.2 TMDL and 303(d) Applicability

The city of West Linn is located in the Willamette River watershed, adjacent to both the Willamette and Tualatin Rivers. A majority of the city (approximately 85 percent) discharges to the Willamette River and its tributaries including Arbor Creek, Robinwood Creek, Trillium Creek, Tanner Creek, and Salamo Creek. Approximately 15 percent of the city's drainage area, located in the southwest portion of the city, discharges directly to the Tualatin River, which flows to the Willamette River at the city's southern boundary.

Water quality impairment and exceedance of water quality standards in the Willamette and Tualatin Rivers have prompted these rivers and corresponding tributaries to be placed on the State 303(d) list for various parameters of concern. TMDLs have been developed to address specific sources of pollutant loading for select parameters. TMDLs have been developed for pollutants with direct links to stormwater runoff (e.g., metals, nutrients) and pollutants not typically associated with urban stormwater runoff in the Willamette Valley (e.g., temperature). Table 2 outlines the TMDL and 303(d) parameters applicable to the City.

Addressing TMDL and 303(d) parameters will be considered with development of stormwater project concepts. Implementation of water quality projects and programs will allow the City to document progress toward TMDL pollutant load reduction benchmarks and fulfill obligations under the City's TMDL Implementation Plan for the Willamette and Tualatin watersheds.

Table 2. Applicable TMDL and 303(d) Parameters

Waterbody	TMDL Parameters	303(d) Parameters (2012)
Tualatin River	Bacteria (*E. coli*) Total phosphorus DO (TSS as a surrogate) Temperature Mercury	Ammonia [a] Biological criteria Copper [a] Iron Lead [a] Manganese Dissolved oxygen (spawning beneficial use) Zinc [a]
Willamette River (Lower Willamette subbasin)	Bacteria (*E. coli*) Temperature Mercury	Chlorophyll a Aldrin [b] Biological criteria Chlordane [b] Copper [a] Cyanide DDT and DDT metabolite (DDE) [b] Dieldrin [b] Hexachlorobenzene [b] Iron Lead [a] Manganese PCBs Pentachlorophenol Polynuclear aromatic hydrocarbons (PAH)
Willamette River (Middle Willamette subbasin)	Bacteria (*E. coli*) Temperature Mercury	Aldrin [b] Biological criteria Copper [a] DDT and DDT metabolite (DDE) [b] Dieldrin [b] Iron Lead [a] PCBs

a. *Parameter added in 2012.*

b. *Organochlorine compound.*

Section 3: Identification of Stormwater Problem Areas

As described previously, the City opted to develop their SMP by initially assessing known stormwater problem areas and identifying those areas where infrastructure improvement, addition, replacement, or retrofit is needed to address the problems. The City historically receives limited complaints regarding stormwater system capacity deficiencies. The City also anticipates limited growth (annexations) and new development over the SMP planning period (i.e., 10 years). As such, a qualitative effort to evaluate identified problem areas was used to validate the need for system improvements. City-wide hydraulic modeling, as conducted for the previous master planning effort, to inform stormwater project development is not proposed. Targeted system modeling will be conducted, however, to evaluate select infrastructure or drainage basins where modeling can help inform observed deficiencies and needed improvements.

From September 2017 to March 2018, BC and City staff reviewed anecdotal data (see Section 3.1 below) to identify locations (i.e., stormwater problem areas) with observed or reported performance issues for additional review and evaluation under this SMP. Typical performance issues were related to conveyance system function and operation, conveyance system capacity, water quality impairment, maintenance needs (due to system clogging, etc.), and erosion.

3.1 Data Sources

Data sources used in the identification of stormwater problem areas included the following:

- Public and City staff surveys
- Hydromodification Assessment (2015)
- Previous CIP List (per the City's 2006 West Linn Surface Water Management Plan)

More detail regarding each of these three information sources is described in in the following subsections.

3.1.1 Public and City Staff Surveys

In June 2017, BC and City staff prepared questionnaires (surveys) for distribution to the public and to City staff. The public survey reflected general questions about observed stormwater-related problems in respective neighborhoods. The City survey reflected more detailed questions targeting specific locations of reported capacity deficiencies, system condition issues, and frequent maintenance needs. Surveys were distributed to the public and City staff in July 2017.

The public survey closed after 6 weeks (September 7, 2017). A total of 40 responses were received. Typical problems reported in the public survey included ponding water (resulting from a lack of existing stormwater infrastructure) and locations where catch basins should be installed or relocated. Two City surveys were received between August and September 2017, one from Public Works staff and one from Parks staff. The survey received from Public Works identified areas with system configuration issues and reported flooding on private property. The survey received from Parks reflected areas of known instream erosion. The survey identified potential stream restoration project opportunities in conjunction with conceptual planning activities that are in progress on Parks property.

The City met internally on October 18, 2017, to review the public and City staff survey responses and discuss identified locations in conjunction with goals of the SMP and CIP development. Key findings and assumptions included:

- Installation of a stormwater collection system within the public right-of-way where one does not already exist may be a reasonable approach to address areas of ponding on private property. However, stormwater system improvements would likely be driven by the Transportation System Plan (TSP) and the need for pedestrian access (i.e., installation of curb and sidewalk). The TSP should be referenced and considered when prioritizing stormwater infrastructure needs.

- The City is currently implementing a strict interpretation of Chapter 46 (Parks Charter) and proposed projects on park property may need to go to a public vote. Such policy may constrain project development.
- Many reported problem areas associated with the need for catchbasin relocation or installation are already being addressed by Public Works.

The public and City survey resulted in the identification of 43 individual problem areas to be further evaluated as stormwater project opportunities.

3.1.2 Hydromodification Assessment

A hydromodification assessment was completed in June 2015 to address a NPDES MS4 permit requirement. The objective of the hydromodification assessment was to evaluate whether the City's stream channels were susceptible to hydromodification impacts associated with urbanization and MS4 discharges. Policy, program, and project needs were proposed to address areas of observed impacts. The assessment relied on a combination of desktop (GIS) analysis and field observations.

For West Linn, the hydromodification assessment resulted in a finding that most observed stream channels are composed of bed and bank materials that appear to provide a natural resistance to hydromodification. There were minor hydromodification impacts observed in locations of concentrated flow (i.e., at culverts and at discharges from stormwater outfalls).

The hydromodification assessment resulted in the identification of six potential project locations to address localized hydromodification impacts. The proposed projects included stream stabilization, retrofit of an existing flow control facility, and/or outfall reinforcement efforts. One location (019) is on private property and was thus excluded from consideration under this SMP. The other five locations were carried forward for additional follow up (i.e., site visits) and consideration as stormwater project opportunities.

3.1.3 2006 Plan CIP List Review

The City's 2006 Plan identified 79 project needs, generally pipe or culvert segments requiring upsizing to meet current or future modeled flows. As mentioned, there is no accompanying prioritization or detailed description of the project needs or cost assumptions in the 2006 Plan. Limited coordination with City staff occurred during the 2006 Plan development so there is limited historic reference related to the relevance or need for the projects. There is also no record of which proposed projects have been constructed in accordance with findings of the 2006 Plan.

In December 2017, BC and City engineering and operations staff reviewed the 79 project needs and compared them with current GIS information to determine which proposed projects had been constructed since 2006 to address the modeled capacity deficiency identified in the 2006 Plan. The review included comparison with public and City staff survey results and hydromodification assessment results to identify any overlap with current, reported problem areas. City staff also discussed, based on routine maintenance activities conducted to date, whether the original project needs were still warranted. Of those original 79 project needs:

- 10 projects had been "completed" (based on GIS review)
- 27 projects were deemed unnecessary by City staff (no observed flooding or maintenance related)
- 14 projects had potential ownership issues (i.e., ODOT, PGE), and would likely be addressed in conjunction with future Highway 43 roadway improvements (and were proposed not to be considered as stormwater project opportunities for this SMP)
- 9 projects overlapped with existing problem areas, and would therefore be carried forward for evaluation and consideration as stormwater project opportunities
- 19 project locations were added to the existing problem area list

3.1.4 Documentation of Findings

Stormwater problem areas based on results of the public and City staff surveys, the hydromodification assessment and the 2006 Plan CIP List were compiled into an initial matrix and mapped to help inform site visit needs.

A total of 65 problem areas were compiled and categorized as follows:

- Capacity - Areas experiencing flooding or backwater conditions due to existing stormwater conveyance capacity
- System Configuration - Existing stormwater system needs to be redesigned or reconfigured to promote drainage
- Infrastructure Needs - Areas lacking stormwater infrastructure (i.e., stormwater main, catch basins, inlets) and experiencing ponding or drainage impacts to private property
- Erosion - Areas with reported instream erosion (i.e., failing slopes, channel incision)
- Water Quality - Existing water treatment facilities that appear to be failing
- Maintenance - Areas of regular or frequent maintenance needs (i.e., clogged catch basins)
- System Condition - Areas with reported aging infrastructure at risk of failure (i.e., failing pipes, rusted pipes)

Figure 1 reflects identified stormwater problem areas in accordance with the categories listed above. Each location is identified by a Location ID number, carried forward for the documentation of stormwater project opportunities in Attachment A, Table A-1.

3.2 Site Visits (November 2017 and March 2018)

BC and City staff conducted two site visits to verify stormwater problem areas and assess potential project concepts and approaches. Each site visit began with a meeting to finalize site visit locations, verify schedule, and discuss accessibility constraints. Maps were distributed detailing the upstream and downstream stormwater conveyance systems. Site visits were documented via field notes and photo logs.

The first site visit was held November 30, 2017. A total of 13 problem areas were visited. These locations were prioritized during an initial 2-hour meeting with City operations and engineering staff prior to the site visit. Locations experiencing regular capacity deficiencies and areas with infrastructure needs were targeted during this site visit. During this initial meeting, 22 of the 65 initial stormwater problem areas were removed from consideration as project opportunities (and thus from the site visit schedule), due to the fact that efforts were currently being conducted to address the reported problem, or the problem was related to an instream conveyance issue outside of the scope for this SMP.

A follow up site visit was conducted March 6, 2018, to review capacity limited stormwater problem areas potentially requiring modeling. These locations were identified following the Stormwater Modeling Needs Workshop (Section 3.3).

3.3 Stormwater Modeling Needs Workshop

BC met with the City on February 15, 2018, to review data compilation efforts and the identification of 65 stormwater problem areas. The objective of the workshop was to refine problem areas by CIP development approach and discuss locations where modeling would be warranted to better understand an identified problem.

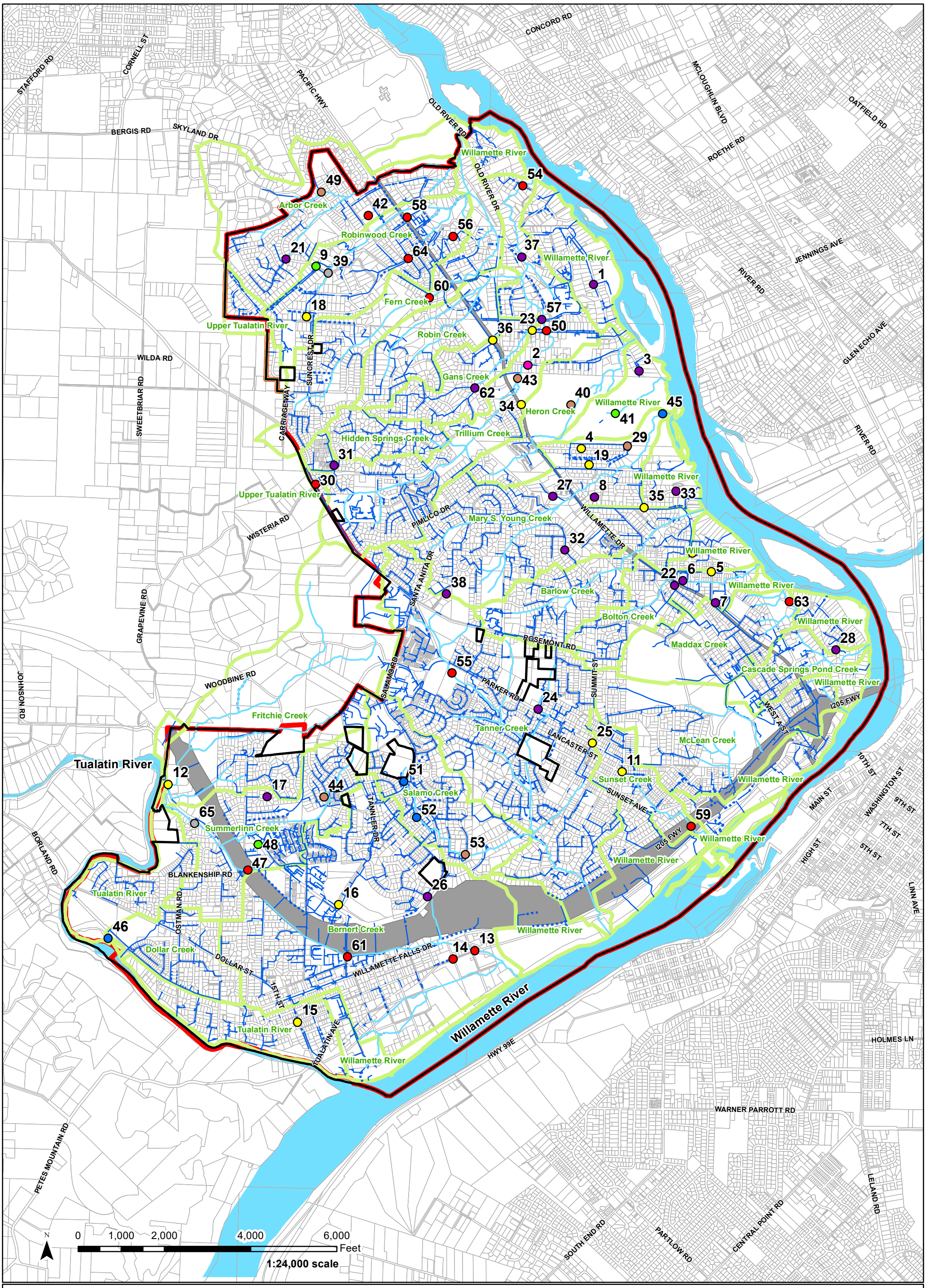
Four modeling approaches were presented to City staff reflecting varying levels of effort and survey needs. This allowed staff to consider schedule and cost implications related to obtaining data with the abilities and benefits of a model to reduce uncertainty regarding reported problems. Because some stormwater project opportunities could be developed without a detailed model, the City could prioritize locations where survey and a hydraulic model would provide additional benefit to the City. Based on need, problem areas were sorted into the following four categories:

- Category 1. Detailed hydraulic modeling is needed. Hydraulic modeling is required to determine the problem sources and solutions. Survey is needed to obtain system information upstream and downstream of the problem location.
- Category 2. Hydrology modeling to inform system sizing. Hydrology modeling will be used to size new infrastructure (i.e., pipes). These locations generally include those areas without existing infrastructure to evaluate. No survey is required.
- Category 3. Limited hydraulic modeling need. Hydraulic modeling is required to evaluate culvert or pipe capacity in areas with reported capacity deficiencies. Survey is needed to verify existing culvert/ pipe size and slope.
- Category 4. No modeling required.

Each stormwater problem area was discussed in conjunction with the defined categories. Two locations (Location ID 47 and 56) were identified for detailed hydraulic modeling (Category 1). Five locations (Location ID 13, 55, 59, 60, and 63) were identified for limited hydraulic modeling (Category 3).

As an outcome of the workshop, the City identified the need to hydraulically evaluate all stormwater system crossings along Highway 43 to confirm capacity (Category 3) and determine whether upsizing is needed in conjunction with the future Highway 43/ ODOT roadway widening project. There are 24 identified crossings. Results from this modeling effort will be documented in the SMP independent from CIP needs.

Stormwater problem areas and proposed modeling approaches are documented in the final stormwater project opportunity matrix (Attachment A, Table A-1), described in Section 5. Originally identified problem areas that upon additional review and discussion with the City are not anticipated to translate to a project opportunity have been maintained in the matrix for reference.



CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 1: Storm Drainage Problem Areas

- Stormwater Pipe
- Open Channel
- Streams
- Major Basin Boundaries
- ODOT ROW
- City Limits
- UGB

Stormwater Problem Areas (by Location ID)

- Capacity
- System Configuration
- Infrastructure Needs
- Erosion
- Water Quality
- Maintenance
- System Condition
- Other

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: June 2018 Produced by Brown and Caldwell

9/13/2019

Section 4: Water Quality Assessment

As a Phase I NPDES MS4 permit holder, retrofit of the stormwater system to improve water quality is a primary objective for this SMP. In accordance with the City's Stormwater Retrofit Plan (2015), stormwater retrofits, specifically the installation of water quality treatment in areas not otherwise treated, will allow the City to reduce TMDL and 303(d) pollutants, show continued progress towards meeting TMDL benchmarks, and improve water quality in the Willamette and Tualatin watersheds. Future NPDES MS4 permit requirements are anticipated to include additional focus on water quality treatment and facility installation.

BC conducted a separate water quality assessment to identify additional water quality project opportunities for consideration in the City's SMP. Objectives of the water quality assessment were to expand coverage of stormwater treatment facilities and improve the function of existing stormwater treatment facilities. Low impact development (LID) or green infrastructure applications were targeted, as they promote infiltration and runoff volume reduction in addition to treatment.

4.1 Water Quality Assessment Strategies

BC developed four strategies to help categorize identified water quality project opportunities in accordance with objectives of the water quality assessment:

- Strategy1a. Green Infrastructure in the public right-of-way as a standalone project (i.e., replacing bubblers and adding in a collection system).
- Strategy 1b. Green Infrastructure in the public right-of-way as part of a programmatic activity (i.e., to be completed with larger TSP).
- Strategy 2. Installation of new water quality facilities on public properties to provide treatment for areas that have no treatment. Strategy 2 directly addresses the City's water quality assessment objectives, and evaluation was limited to existing, developed public properties.
- Strategy 3. Installation of new water quality facilities to manage runoff associated with Highway 43 improvements.
- Strategy 4. Retrofit existing public stormwater ponds to increase capacity or treatment capabilities. This strategy would include the retrofit of ponds constructed solely for detention in order to add treatment and increase capacity.

Strategy 1 (green infrastructure in the public ROW) was subdivided into those areas where a standalone project would be initiated (Strategy 1a) as opposed to areas where green infrastructure could be added, but likely because of a larger TSP-initiated project (Strategy 1b). City staff confirmed that areas with existing curb and gutter should be classified as Strategy 1a, and areas without existing curb and gutter should be classified as Strategy 1b. A programmatic initiative would likely be funded to address Strategy 1b.

Strategy 3 stems from the fact that water quality treatment will be required in conjunction with the future Highway 43 roadway improvements. City charter (West Linn Charter, Chapter 11, Section 46) limits use of park property for any "nonauthorized" use without voter approval to be used for construction of utilities, which could limit the use of parks property for large regional stormwater detention facilities. However, the City has received voter approval for stormwater management, grading and drainage associated with Highway 43 improvements as an authorized use, and therefore park property may be used to site stormwater facility installations for this purpose. In addition, parks and open space are key locations for water quality as improved water quality is one of the primary functions of park and open space areas.

4.2 Methodology

A combination of a desktop GIS assessment and a site visit was used to develop and refine water quality opportunity areas in conjunction with the strategies listed above.

4.2.1 Desktop Assessment

A desktop GIS evaluation was conducted to comprehensively look at locations of high pollutant load generation (based on land use) and opportunistic areas (i.e., vacant, public, or undeveloped areas) where treatment facilities could potentially be located. Preliminary mapping (Attachment B) was used to support this effort. As part of the desktop assessment, the following data was reviewed:

- **Existing Land Use**–Existing land use was evaluated for areas of higher pollutant loading (i.e., commercial and industrial lands). See Attachment B, Figure B-3
- **Vacant Lands**–Vacant lands were reviewed to identify potential areas for easement or property acquisition to construct regional water quality treatment facilities. Vacant lands in conjunction with Highway 43 alignment were specifically targeted.
- **Public Facilities** (i.e., City Hall, Public Works Maintenance Facility, public parking lots at parks)–Parking areas associated with public facilities and parks properties were reviewed to evaluate whether water quality facility coverage already exists or could be expanded. See Attachment B, Figure B-1.
- **Existing Stormwater Problem Areas**–Mapped stormwater problem areas (Figure 1) were reviewed to evaluate whether a water quality project could be implemented to address an identified stormwater problem area. Locations with identified infrastructure needs were targeted, as there is the potential to incorporate green infrastructure into the streetscape in these areas to address reported drainage problems.
- **Public Parks**–Existing park property downstream (east) of Highway 43 was reviewed to evaluate potential treatment locations in conjunction with the Highway 43 roadway improvements.
- **Water Quality Facilities**–Existing water quality facility locations and associated drainage areas were reviewed to identify areas lacking existing facility coverage. See Attachment B, Figure B-4.

Stormwater ponds, contained within the City's GIS water quality facility shapefile, were evaluated independently to address Strategy 4. Pond attributes were reviewed to identify ownership (public, private), installation date, configuration (online vs offline), and the potential for future development to occur upstream for each pond. City staff provided as-built information and recent inspection feedback to support identification of public ponds that may be targeted for retrofit. The City currently has 53 public stormwater ponds recorded in their inventory. Thirty public ponds were installed prior to 2004 (the date associated with NPDES MS4 permit requirements targeting maintenance of water quality facilities), and 8 public ponds are located inline and downstream of vacant property. Two existing public ponds met both the installation date and proximity to vacant property objectives and were identified for consideration as stormwater quality project opportunities (see Table A-3 for reference).

The desktop assessment identified a total of 21 water quality opportunity areas, 10 of which overlap with identified stormwater problem areas. Figure 2 shows the water quality opportunity area locations in conjunction with identified stormwater problem areas. Locations are mapped by Water Quality Opportunity ID (see Table A-2 for reference).

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 2: Water Quality Opportunity Areas

Water Quality Opportunity Areas (by WQ Opportunity ID)

Stormwater Problem Areas

Stormwater Pipe

Open Channel

Vacant

Public Property

Streams

City Limits

UGB

N

0 1,000 2,000 4,000 6,000 Feet

1:24,000 scale

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: June 2018 Produced by Brown and Caldwell

10/9/2019

The Water Quality Assessment Matrix (Attachment A, Table A-2) documents each water quality opportunity area and provides a description of the project concept, rationale, and associated strategy number per Section 4.1. Relevant background information (i.e., soil type, land use) is also provided. In summary, the following water quality opportunity areas were identified in accordance with defined strategies:

- Two Strategy 1a projects
- Seven of Strategy 1b projects
- Seven Strategy 2 projects
- Two Strategy 3 projects
- Three Strategy 4 projects

A summary of the pond inventory, conducted in support of the overall Water Quality Assessment effort, is provided in Attachment A, Table A-3.

4.2.2 Site Visit

On June 21, 2018, BC and City staff conducted a site visit to confirm the configuration of select stormwater quality opportunity areas. Eight areas were visited to identify site conditions and discuss project/solution details. Results of the site visit are documented in Table A-2. Following the site visit, six areas were removed from consideration as future stormwater project opportunities. Namely, identified vacant properties near Highway 43 were removed given significant site constraints and limited retrofit potential.

4.3 Results

City staff provided final input and verification of stormwater quality opportunity areas that should be maintained for consideration.

Of the 21 stormwater quality opportunities identified, 10 overlapped with existing stormwater problem areas, and water quality will have to be integrated into the project development process. Five stormwater quality opportunity areas were added as potential new projects (see Section 5 for more details). Six areas were removed from consideration due to site constraints, limited potential for retrofit or land acquisition, or water quality had already been addressed for the area.

Section 5: Stormwater Project Opportunity Areas

Identified stormwater problem areas (Section 3) and stormwater quality opportunity areas (Section 4) were compiled into a comprehensive stormwater project opportunity matrix (Attachment A, Table A-1). This matrix documents preliminary project concepts that will be carried forward in the development of CIPs and city-wide programmatic activities under this SMP.

There are a total of 27 potential standalone CIP locations and 17 locations anticipated to be addressed as part of a city-wide programmatic effort. Five CIP locations are identified as “Project (Highway 43 Evaluation)”. Drainage problems associated with these locations will likely be addressed in conjunction with the Highway 43 roadway project. Capacity modeling to inform these Highway 43 crossings may support project development if warranted.

As mentioned, 23 stormwater problem areas are referenced in this matrix but have been shaded in gray and are not considered as opportunities to carry forward due to initial input from City staff during the November 30, 2017 site visit.

Information contained in the matrix includes the project objective(s), project source, and project background and summary of problem (if applicable). Project development status including proposed modeling approach, site visit status, and survey needs are also included. Locations are identified by Location ID, which is consistent with the numbering used to identify stormwater problem areas in Figure 1. Locations are mapped in Figure 3 in accordance with their "Location ID".

5.1 Programmatic Opportunities

Five city-wide programmatic activities, covering 17 identified stormwater project opportunity areas per Table A-1, were identified to support ongoing assessment and maintenance of existing infrastructure and water quality. Identification of these activities as a programmatic opportunity means that an annual budget allocation (as opposed to a one-time budget allocation) will be needed to support these efforts. The identified programmatic opportunities include:

- Beaver Management Initiative (Location ID 12) - This program would involve ongoing management efforts to mitigate beaver dam construction to eliminate flooding in susceptible areas with public safety concerns.
- Fish Passage Evaluation (Location ID 54, 57) - This program would involve a larger study to evaluate culvert replacement needs to address fish passage. Coordination with state and federal agencies may be required to confirm whether fish are inhabiting selected stream reaches. This initiative may also be defined as a standalone project (planning study).
- Green Street Pilot Program (Location ID 11, 15, 18, 19, 23, 25, 35) - This program would target public right-of-way areas without curbs, sidewalks, and gutters where improvements in accordance with the TSP may be initiated. Funding could be set aside for installation of green street features associated with roadway improvements.
- Inlet Replacement and Installation Program (Location ID 20, 28, 32, 37, 42, 48) - This program would add or replace inlets throughout the city in areas experiencing localized drainage issues. Efforts may include replacement of grated inlets with curb inlets, the addition of new inlets, or relocation of inlets in conjunction with grading or tree coverage (where leaves routinely clog the inlet).
- Pipe Replacement Program (Location ID 16) - This program would include replacing pipes with condition deficiencies. Asset age is not widely documented in the City's GIS (only 18 percent of the features are populated with an as-built year). The City could establish a system lifetime age and assume city-wide replacement/rehabilitation of piped infrastructure over a defined timeframe.

Additional programmatic opportunities may include, but are not limited to, a public pond maintenance program or an annual pipe inspection program (CCTV inspections).

If these programmatic initiatives are confirmed by the City, the scope and scale can be further refined and annual costs developed during the CIP development process.

5.2 Modeling Status

BC and City staff met March 7, 2018, to finalize survey needs for locations identified as requiring detailed or limited hydraulic modeling (see Table A-1). Data collection tables reflecting required storm structure information (rim elevations, invert elevations, and size) were distributed for each modeling location. For open channel portions of the conveyance system, the data collection tables included cross section information needs including surveyed points reflecting the bottom width of the channel and the top width of the channel. Stormwater system features and cross section locations requiring survey were presented in maps.

Highway 43 crossings (24 crossings total) are considered part of the limited hydraulic modeling needs and survey information is required for those locations as well (locations are not reflected in Table A-1).

City staff completed survey, QA/QC, and documentation on July 18, 2018, and provided the information to BC as a geodatabase for incorporation into the XP-SWMM model. Model assumptions and results will be documented in TM #3.

5.3 Next Steps

Stormwater project development will occur based on the preliminary project concepts outlined in Table A-1.

City staff will participate in a workshop following completion of the hydraulic modeling efforts. The workshop will be used to review preliminary results from the hydraulic modeling effort and facilitate discussion of the proposed project concepts including programmatic concepts. The outcome from this workshop will include a final stormwater project matrix for costing and inclusion in the SMP.

This page left intentionally blank.

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure 3: Storm Drainage Project Opportunity Areas

Project Opportunity Category (by Location ID)

- Proposed Project
- Proposed Project (Hwy 43)
- Proposed Programmatic
- Removed from Consideration

- Stormwater Pipe
- Open Channel
- Streams
- Watershed Boundaries
- ODOT ROW
- City Limits
- UGB

N

0 1,000 2,000 4,000 6,000 Feet

1:24,000 scale

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: July 2018 Produced by Brown and Caldwell

9/13/2019

Attachment A: Matrices

This page intentionally left blank.

Table A-1: Stormwater Project Opportunity Areas

							Project Development					
Opportunity Category	Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Modeling Approach	WQ Opportunity	Site Visit	Survey	TSP Driver	Notes
Project	1	Improve System Configuration	Staff Summary	18780 Nixon	Willamette River	Public storm pipe under house (garage) required relocation. Potential to move pipe to the southern location with easement. No survey required.	Hydrology to inform system sizing		Still Required	NA		
Project	4	Add Infrastructure Water Quality Retrofit	Staff Summary Public Survey	Mark Lane	Mary S. Young Creek	Poor drainage and reported flooding. No infrastructure and City uses bubblers, which City wants to discontinue. High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.	Hydrology to inform system sizing	Y	Y (6-26-18)	NA		See Water Quality Opportunity ID #3
Project	5	Add Infrastructure Water Quality Retrofit	Staff Summary Public Survey	Buck Street/ Upper Buck Street	Bolton Creek	Poor drainage and reported flooding. No infrastructure and City uses bubblers, which City wants to discontinue. City maintenance staff installed a new curb inlet at end of Buck St to alleviate flooding, which has helped but not eliminated flooding. Downstream outfall erosion observed. Project scope may include trunkline down Buck Street from fire station to outfall and green street facilities.	Hydrology to inform system sizing	Y	Y (11-30-17)	NA		See Water Quality Opportunity ID #2
Project	10	Add Infrastructure	Staff Summary Staff Survey	Sunset Avenue (between 4345 and 2413)	Sunset Creek	Deep ditches along road are eroding. Current eye sore. Flooding is generally not a concern but the geometry of the ditches is a safety concern. Steep grade may prohibit green infrastructure. Trunkline proposed for installation with road repairs. High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.	Hydrology to inform system sizing		Y (11-30-17)	NA	High	
Project	13	Increase System Capacity (Flood Control, 40" Concrete) Improve System Configuration	Staff Summary 2005 CIP	5th Avenue culvert	Bernert Creek	Undersized culvert identified in 2005 MP. Site visit 11-30-17 indicates debris and exposed corrugated metal sanitary line. City installed a concrete overlay on County-owned sanitary SMP that could present a safety concern. Culvert orientation results in 90 degree bend in channel. CIP may require reorienting culvert inline with channel configuration. Potential utility conflicts. Not anticipated to be a fish bearing waterway in proximity.	Capacity Check		Y (11-30-17)	Y		
Project	40	Erosion Prevention	Staff Survey	Mary S Young Park	Heron Creek	Reported land slides and erosion trail/bridge washout in Mary S Young Park. Project opportunity to add in stream bank erosion measures to minimize the trail and bridge washout in the park.			Still Required	NA		
Project	41	Address Maintenance Need Repair Infrastructure	Staff Survey	Turkey Creek in Mary S Young Park	Willamette River	Replace culvert at Turkey Creek in Mary S Young Park and rebuild the trail that has been washed out. Design measure to slow down the stormwater runoff in this area to avoid further erosion of trail. Continue ongoing maintenance of culverts to ensure no blockage.			Maybe Needed	NA		
Project	43	Erosion Prevention Water Quality Retrofit	Staff Survey	Trillium Creek in Mary S Young Park	Trillium Creek	Demonstration project opportunity at Trillium Creek in Mary S Young Park to restore channel incision with large woody debris and other creek stabilization measures.		Y (stream restoration)	Still Required	NA		Project location in area where sanitary system is having issues with calibration.
Project	45	Water Quality Retrofit	Staff Survey	Mary S Young Creek	Mary S. Young Creek	Remove culvert at Mary S. Young Creek to improve water quality and provide fish restoration measures in the creek in accordance with the Mary S Young Creek Restoration Concept Plan.		Y (stream restoration)	Still Required	NA		
Project	47	Increase System Capacity (Flood Control)	Staff Survey 2005 CIP	Blankenship Road under I-205 overpass	Summerlinn Creek	Blankenship Road consistently floods, even with recent site improvements to the swale and ditch along Blankenship. Area is flat. The 12-inch concrete pipe in Blankenship Drive near the intersection with Johnson Road was specifically mentioned in the 2005 CIP. Drainage infrastructure and drainage patters seems inconsistent with mapped GIS (recent surveying confirms need for subbasin delineation). Northern side of Blankenship under the overpass is unimproved and drains to a ditch inlet in middle of filled-in ditch. Inlet elevation is too high to function properly. Site visit 3-6-18 reveals a lack of inlets along Debok RD and upper Blankenship. Survey extents expanded to account for questions on drainage patterns and contributing area.	Detailed		Y (11-30-17, 3-16-18)	Y	High	
Project	49	Erosion Prevention	Hydromodification Assessment (009)	Downstream of Arbor Creek culvert at Hillside Drive, near Skye Parkway	Arbor Creek	Scour hole at culvert outlet resulting in bank erosion was observed during hydromod assessment. Project needs may include stream stabilization project to reduce channel drop or outfall reinforcement.			Maybe Needed	NA		
Project	52	Water Quality Retrofit	Hydromodification Assessment (007)	In-line stormwater facility upstream of Remington Drive	Bernert Creek	Potential opportunity to increase storage and flow control and enhance water quality treatment was observed during hydromod assessment.		Y	Maybe Needed	NA		See Water Quality Opportunity ID #19

Table A-1: Stormwater Project Opportunity Areas

							Project Development					
Opportunity Category	Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Modeling Approach	WQ Opportunity	Site Visit	Survey	TSP Driver	Notes
Project	55	Increase System Capacity (Flood Control, 15" CMP)	2005 CIP	Tanner Creek Park	Tanner Creek	Reported capacity deficiency in 2005 MP (should be 30"). There have been multiple complaints by park staff as the culvert is located under the walking path.	Capacity Check		Maybe Needed	Y		
Project	56	Increase System Capacity (Flood Control, 12" Concrete) Improve System Configuration	2005 CIP	Fairview Way to Vista Ct	Fern Creek	City previously replaced failing 12" pipe that crosses Fairview Way. The new 15" appears to have corrected the flooding problem, but may have relocated issue. All upstream pipes are 12" based on GIS and should be modeled prior to HWY 43 work. Project extents from node RW-CB-0144 on west side of HWY 43 to outfall RW-OF-0122 as DS pipe is 18". GIS updates needed.	Detailed		Y (3-16-18)	Y		
Project	59	Increase System Capacity (Flood Control, 24" Concrete)	2005 CIP	Sunset Creek at I-205 (2005 MP indicated under Willamette Falls Dr)	Willamette River	Reported capacity deficiency in 2005 MP (should be 30"). High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.	Capacity Check		Maybe Needed	Y		
Project	60	Increase System Capacity (Flood Control, 24" CMP and Concrete)	2005 CIP	Kantara Way	Fern Creek	Reported capacity deficiency in 2005 MP (should be 30"). There is a water line crossing near this location and the culvert was connected to a piped creek so the water line could be installed.	Capacity Check		Maybe Needed	Y		
Project	63	Increase System Capacity (Flood Control, 21" CMP)	2005 CIP	Maddox Creek at River Street	Maddox Creek	Flooding reported at this location. 2005 MP recommends 36" diameter pipe installed.	Capacity Check		Maybe Needed	Y		
Project	66	Water Quality Retrofit	BC Water Quality Assessment	Willamette Park Parking Lot Retrofit	Willametter River	Limited water quality treatment in vicinity. Opportunity to treat a large square footage of impervious area on public property. City prefers use of pervious pavers, consistent with overflow lots.		Y	Y (6-26-18)	NA		
Project	67	Water Quality Retrofit	BC Water Quality Assessment	Mary S. Young Park Parking Lots Retrofit	Willametter River	Limited water quality treatment in area. Opportunity to treat a large square footage of impervious area on public property. City prefers use of pervious pavers, consistent with overflow lots at other parks.		Y	Y (6-26-18)	NA		
Project	68	Water Quality Retrofit	BC Water Quality Assessment	West Linn Public Works Department	Tanner Creek	Opportunity to incorporate water quality treatment to treat additional area not currently being treated. City identified opportunity to install a small rain garden along Norfolk Street frontage for parking lot at front of building. Project location referenced in Retrofit Assessment (2015).		Y	Y (6-26-18)	NA		
Project	69	Water Quality Retrofit	BC Water Quality Assessment	Public Pond #18 (BC ID)	Bernert Creek	Retrofit existing public pond to enhance water quality treatment in areas of the City. This pond was installed in 1997, which is pre-2004 which was when the NPDES MS4 Permit Requirements for pond maintenance began. This pond is also located downstream of a vacant site. Retrofit in conjunction with development of adjacent parcel.		Y	Y (6-26-18)	NA		
Project	70	Water Quality Retrofit	BC Water Quality Assessment	Public Pond # 22 (BC ID), 25545 Katherine Court	Tualatin River	Retrofit existing public pond to enhance water quality treatment in areas of the City that are not currently being treated. This pond was installed in 1999, which is pre-2004 which was when the NPDES MS4 Permit Requirements for pond maintenance began. This pond is also located downstream of vacant sites. Pond located upstream of outfall to the Willamette River.		Y	Y (6-26-18)	NA		
Project (Highway 43 Evaluation)	7	Improve System Configuration	Staff Summary 2005 CIP	Bolton Primary School	Bolton Creek	Localized flooding/ runoff from Hwy 43 causes flooding. Steep slope and embankment to existing parking area. Complaints occur when freezing temperatures result in icy conditions. The 27-inch concrete pipe from Hwy 43 to the Holmes St outfall to Bolton Creek was specifically mentioned in the 2005 CIP. Problem likely addressed with Hwy 43 improvements. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location may not be warranted.	Capacity Check		Y (6-26-18)	Y (Hwy 43)	High	See Water Quality Opportunity ID #18 for more detail on site.
Project (Highway 43 Evaluation)	22	Improve System Configuration	Public Survey	Hwy 43/ A Street	Bolton Creek	Ponding on road during rain events. Problem likely addressed with Hwy 43 improvements. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location may not be warranted.	Capacity Check		N	Y (Hwy 43)	High	
Project (Highway 43 Evaluation)	36	Add Infrastructure Improve System Configuration	Public Survey	Hwy 43 at Hidden Springs	Gans Creek	Ponding on road during rain events. Problem likely addressed with Hwy 43 improvements. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location may not be warranted.	Capacity Check		N	Y (Hwy 43)		Project location in area where sanitary system is having issues with calibration.

Table A-1: Stormwater Project Opportunity Areas

							Project Development					
Opportunity Category	Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Modeling Approach	WQ Opportunity	Site Visit	Survey	TSP Driver	Notes
Project (Highway 43 Evaluation)	58	Increase System Capacity (Flood Control, 27" Concrete) Improve System Configuration	2005 CIP	Robinwood Creek at Shady Hallow Drive	Robinwood Creek	Flooding has been reported at this location in the past. Two drainage ditches converge at this location and enter a culvert. It is unclear if the issue is maintenance of the ditches or culvert capacity. Site visit 3-6-18 indicates three pipes: 18" and 24" culverts and a 12" pipe that originate near HWY 43 (actual location could not be verified). No flooding reported in original problem area location. The culvert under HWY 43 discharges to ODOT ROW and daylights. Sand bags and a corrigated plastic pipe redirect the water south where a junction redirects the water via another corrigated plastic pipe. The outfall of the plastic pipe is unknown but appears to discharge to a space between two homes. Problem area is associated with Hwy 43 crossing. Problem likely addressed with Hwy 43 improvements. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location may not be warranted.	Capacity Check		Y (3-16-18)	Y (Hwy 43)		
Project (Highway 43 Evaluation)	64	Increase System Capacity (Flood Control, 18" Concrete)	2005 CIP	Lower Marylhurst Drive from Lower Midhill	Robinwood Creek	Reported capacity deficiency in 2005 MP. Current GIS indicates 24" CMP crossing at Highway 43 so may need to confirm pipe size. Problem likely addressed with Hwy 43 improvements. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location may not be warranted.	Capacity Check		N	Y (Hwy 43)		
Programmatic (Beaver Management)	12	Address Maintenance Need	Staff Summary Staff Survey 2005 CIP	23350 Johnson Road; 23212 Johnson Road	Fritchie Creek	Flooding issues reported by City Staff and identified in the 2005 CIP list. The 2005 CIP list specially mentioned the 15 and 36-inch pair of concrete culverts along Johnson Road. There is no existing stormwater system. Site visit 11-30-17 identified beaver dams observed in culvert under Johnson Road and upstream (north) on Fritchie that appear to cause the flooding.			Y (11-30-17)	NA	Medium	
Programmatic (Fish Passagability Evaluation)	54	Increase System Capacity Improve System Configuration	2005 CIP	Trillium Creek Crossing Under Calaroga Drive	Trillium Creek	The 2005 CIP list indicated a capacity deficiency at the Trillium Creek crossing under Calaroga Drive. City staff reports need for fish passagable culvert. Seperate planning effort proposed to coordinate with ODFW and determine fish passageability need.			Maybe Needed	NA		
Programmatic (Fish Passagability Evaluation)	57	Improve System Configuraiton	2005 CIP	Trillium Creek at Cedar Oak Drive	Trillium Creek	The 2005 CIP list indicated three culverts under Cedar Oak Drive area fish crossings. City staff reports need for fish passagable culvert. Seperate planning effort proposed to coordinate with ODFW and determine fish passageability need.			Maybe Needed	NA		
Programmatic (Green Street)	11	Add Infrastructure Water Quality Retrofit	Staff Summary	Exeter St, Lancaster St	Sunset Creek	Poor drainage and reported flooding. No curb and gutter in a majority of the ROW. Piped conveyance to Sunset Creek through private parcel (not in ROW). High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.		Y	Y (11-30-17)	NA	High	See Water Quality Opportunity ID #5
Programmatic (Green Street)	15	Add Infrastructure	Staff Summary	Willamette Neighborhood	Bernert Creek	Limited water quality treatment in area. Wide Right-of-Way. No existing curb and sidewalk. Opportunity for a green street project. Target locations 14-16th Avenues.		Y	Y (11-30-17)	NA	Medium/High	See Water Quality Opportunity ID #1
Programmatic (Green Street)	18	Add Infrastructure Water Quality Retrofit	Public Survey	Suncrest, Valleyview Dr, and Hillcrest between Suncrest and Marylhurst Drive	Robinwood Creek	Reported stormwater flooding down Suncrest, Valley View Drive and Hill Crest between Suncrest and Marylhurst Drive. There are existing open drainage ditches and no curb or side walk. There are no signs of visible signs of erosion. A local resident hand dug a small trench to direct flow from a spring in front of 1779 Hillcrest Dr. (approx. address). Project opportunity to build a green street infrastructure project or a new piped stormwater conveyance system to mitigate stormwater flooding on the roadways. During design evaluate the downstream capacity of the stormwater system.		Y	Y (11-30-17)	NA	High	See Water Quality Opportunity ID #7
Programmatic (Green Street)	19	Add Infrastructure Water Quality Retrofit	Public Survey Staff Survey	LaFave Street, Jolie Point Road, Munger Drive, Lowell Avenue	Mary S. Young Creek	Poor drainage and reported flooding. System currently composed of driveway culverts and ditches. No curb and gutter. High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.		Y	N	NA		See Water Quality Opportunity ID #4
Programmatic (Green Street)	23	Add Infrastructure Water Quality Retrofit	Public Survey 2005 CIP	Kenthorpe Way	Trillium Creek	No existing stormwater system (uneven ditches) near the Fire Station and along Kenthrope Way. Public stormwater runoff is flooding private yards in the area. There is a pair of culverts along Gans Creek at Kenthrope Way were identified in the 2005 CIP List as a project need. Project opportunity to add in a new piped stormwater conveyance system near the Fire Station and on Kenthrope Way to mitigate flooding. Upsize/replace the culverts at Gans Creek.		Y		NA		See Water Quality Opportunity ID #9

Table A-1: Stormwater Project Opportunity Areas

							Project Development					
Opportunity Category	Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Modeling Approach	WQ Opportunity	Site Visit	Survey	TSP Driver	Notes
Programmatic (Green Street)	25	Add Infrastructure Water Quality Retrofit	Public Survey	Cornwell Road and York Street	Tanner Creek	No infrastructure and City uses bubblers, which City wants to discontinue. High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.		Y	Y (11-30-17)	NA	High	See Water Quality Opportunity ID #6
Programmatic (Green Street)	35	Add Infrastructure Water Quality Retrofit	Public Survey	Dillow Drive at Larson	Barlow Creek	Limited water quality treatment in area. Ponding water possibly due to undersized ditch inlet. Project opportunity to add additional inlets and potential green street improvements. Only partially curbed street. Opportunity for Highway 43 management if green street installed. High I&I reported in area (significant R value) in the public survey, indicating that high proportion of precipitation enters sanitary system. This could be caused by an undersized ditch inlet.		Y	Y (11-30-17, 6-26-18)	NA		See Water Quality Opportunity ID #8
Programmatic (Inlet Replacement/ Installation)	20	Infrastructure Need	Public Survey	6343 Failing Street	Willamette River	The public survey identified no stormwater system near 6343 Failing Street and stormwater runoff enters yards. Homes sit below grade which results in yards flooding. Roadway has steep slopes Potential projects to solve flooding include increased inlets with a trench drain system upstream of the yards that are being flooded.			Y (11-30-17)	NA		
Programmatic (Inlet Replacement/ Installation)	28	Improve System Configuration	Public Survey	5550 Sinclair Street	Cascade Springs Pond Creek	The existing storm drain inlet near 5550 Sinclair Street is not located at the low point. Project opportunity to remove existing inlet and install a new inlet at the low spot near the address noted.			N	NA		
Programmatic (Inlet Replacement/ Installation)	32	Improve System Configuration	Public Survey	Summit Street between Apollo and Causey	Mary S. Young Creek	Reported stormwater bypass from catchbasins on Apollo. Per site visit 11-30-18, catch basin spacing seems adequate but high leaf accumulation. May consider replacement with curb inlets for debris control.			Y (11-30-17)	NA	High	
Programmatic (Inlet Replacement/ Installation)	37	Improve System Configuration	Public Survey	Elmran Dr near Old River Road	Fern Creek	Ponding water reported at Elmran Dr near Old River Road. This problem will be addressed with new curb inlets to alleviate ponding.			N	NA	Medium	
Programmatic (Inlet Replacement/ Installation)	42	Improve System Configuration	Staff Survey	Near Midhill Park	Arbor Creek	Reported sheet flows from lower portion of Midhill Park results in downstream flooding of neighbors. City follow up identified drainage issues on Lower Midhill Road (inadequate catchbasins).			N	NA		
Programmatic (Inlet Replacement/ Installation)	48	Improve System Configuration Address Maintenance Need	Staff Survey	Rose Linn Care Center (2330 Debok Rd)	Summerlinn Creek	Staff survey reports Debok Road floods the bike lane when it rains. Flooding is due to clogged catch basins. May consider replacement with curb inlets for debris control.			N	NA		
Programmatic (Pipe Replacement)	16	Add Infrastructure	Staff Summary, Public Survey	Tannler open ditch	Bernert Creek	The public identified a closed stormwater system at Tannler Creek adjacent to Tannler Drive (2425/2445 Tannler) that may be an opportunity to daylight the pipe for aesthetics and water quality. The Creek is very deep in this location which would present structural and geotechnical design challenges if daylighted. May consider project opportunity if pipe condition deteriorates.			N	NA	Medium	
	2	Improve System Condition	Staff Summary	3843 Mapleton	Trillium Creek	The staff summary indicates a corrigated metal pipe in poor condition. This pipe is privately owned but conveys Trillium Creek. Per City staff, this is a private property issue. Environmental overlays at the site would require fix with development. No project need.			N	NA		Project location in area where sanitary system is having issues with calibration.
	3	Improve System Configuration	Staff Summary, Public Survey	Mapleton Drive/ S side of Mapleton	Willamette River	The public survey and staff summary identified poor drainage and lack of infrastructure that causes house to floods t the end of the cul-de-sac at Mapleton Drive. Per City staff, issue recently addressed. No project need.			N	NA		

Table A-1: Stormwater Project Opportunity Areas

							Project Development					
Opportunity Category	Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Modeling Approach	WQ Opportunity	Site Visit	Survey	TSP Driver	Notes
	6	Improve System Configuration	Staff Summary 2005 CIP	Bolton Fire Station (old)	Bolton Creek	Sinkhole developed along Bolton Creek downstream of crossing under Hwy 43. Per site visit, sinkhole appeared disconnected from culvert conveyance. The 24-inch concrete pipe from Hwy 43 to the Failing St outfall to Bolton Creek was specifically mentioned in the 2005 CIP. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location is not warranted. No project need.			Y (11-30-17)	NA	Medium	
	8	Improve System Configuration	Staff Summary	Magone Ln, Tulane Street	Mary S. Young Creek	The staff summary indicates that runoff from Hwy 43 causes flooding on a private street (Magone Lane). Per City staff, given private road issue, no project need. High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.			N	NA		
	9	Address Maintenance Need	Staff Summary	Marylhurst headwall (near 1694 Skye Parkway)	Robinwood Creek	The staff summary identifies a headwall is needed upstream of the portion of a culvert under Marylwood Ct for trash and debris control. Per City staff, location is not high risk. No project need.			Y (11-30-17)	NA		
	14	Increase System Capacity	Staff Summary	4th Street culvert	Bernert Creek	The staff summary identifies an undersized culture at 4th Street (same locations as the 5th Avenue culvert - see Location ID 13). No project need.			N	NA		
	17	Improve System Configuration	Staff Summary	Donegal Ct	Summerlinn Creek	The staff summary indicates a home floods at the end of a cul-de-sac. The home was built below the road grade and there is no existing catch basin on the property. Per City staff, improvements are in progress. No project need.			N	NA		
	21	Improve System Configuraiton	Public Survey 2005 CIP	Skye Parkway and Stonehaven Drive	Arbor Creek	The public survey and the 2005 CIP list identified this location as an area of poor drainage. The 18-inch concrete pipe section upstream of Braemar Court was specifically mentioned in the 2005 CIP list. Per discussions with City staff, the stormwater conveyance system issues will be addressed as an inhouse project to install new curb inlets. No project need.			N	NA		
	24	Improve System Configuration	Public Survey	Chinook Ct and Parker Rd (4709 Chinook Ct)	Tanner Creek	The Public Survey indicates ponding water near Chinook Ct and Parker Road. The roof drain associated with Chinook Court property is undersized. Per City staff, this is deemed a private property issue. No project need.			N	NA	Medium	
	26	Improve System Configuration	Public Survey	Greene Street and Salamo Road	Bernert Creek	Identified flooding issue due to infrequent/ undersized catchbasins on Greene Street and Salamo Street. This issue will be resolved through the Salamo Road project (per City staff), which is in progress. No project need.			N	NA	High	
	27	Improve System Configuration	Public Survey	Pimlico between Hwy 43 and Summit	Mary S. Young Creek	The public survey indicated that there is a serious of poorly located catchbasins on Pimlico between Hwy 43 and Summit. Per City staff, there is a future sidewalk project in area and drainage will be evaluated then. No project need.			Y (11-30-17)	NA	Medium	
	29	Erosion Prevention	Public Survey	Mary S Young Park at Mark Ln.	Mary S. Young Creek	The public survey reported stormwater runoff from Mark Lane is causing significant erosion above Mary's Creek. Project opportunity to retain/ infiltrate runoff and/or add in a new stormwater pipe to bypass some of the stormwater from Mark Lane downstream of Mary's Creek. Project need addressed per Location ID #4. No additional project need.			Y (6-26-18)	NA		See Water Quality Opportunity ID #3
	30	Increase System Capacity	Public Survey	Hidden Springs Rd near Rosemont	Upper Tualatin River	Public survey results indicate poor drainage at Hidden Springs Road near Rosemont, possible due to undersized infrastructure. City staff have no reports of flooding. No project need.			N	NA	Medium	
	31	Improve System Configuration	Public Survey	Suncrest Dr and Aztec Ct	Trillium Creek	The public survey indicates there is a deficiency in the number of catch basins at Suncrest Dr and Aztec Court. Per City staff, this is being addressed via an in house project. No project need.			N	NA		
	33	Improve System Configuration	Public Survey	End of Maple Terrace cul-de-sac	Willamette River	The public survey indicates there are poorly located catchbasins at the end of Maple Terrace cul-de-sac. Per City staff, this is being addressed via an in house project. No project need.			N	NA		

Table A-1: Stormwater Project Opportunity Areas

							Project Development					
Opportunity Category	Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Modeling Approach	WQ Opportunity	Site Visit	Survey	TSP Driver	Notes
	34	Improve System Configuration	Public Survey	Hwy 43/ Mary S Young Park entrance and Pimlico/ Hwy 43	Trillium Creek	The public survey indicates pond water at the entrance of Mary S Young Park near Pimlico and Hwy 43. Per City staff, there is a future sidewalk project in area and drainage will be evaluated then. No project need.			N	NA		
	38	Improve System Configuration	Public Survey	1255 Rosemont	Mary S. Young Creek	The public survey indicated that water doesn't flow into the catch basins located near 1255 Rosemont. Per City staff, Rosemont Road improvements will be resolving the issue. No project need.			N	NA		
	39	Improve System Configuration	Public Survey	1715 and 1694 Marylhurst Drive	Robinwood Creek	The public survey indicates there was an alteration of the stormwater system at Robinwood Street corridor adjacent to a private property owner. The private property owner has encroached on the channel downstream of Location ID #9. Per City staff, deemed an enforcement issue. No project need.			Y (11-30-17)	NA	High	
	44	Erosion Prevention	Staff Survey	2181 Alpine Dr (Tanner Open Space)	Summerlinn Creek	The staff survey indicates the upper portion of Summerlinn Creek is channelized near the Tanner Open Space. Per City staff, the channel is normalizing and channel adjustment is not problematic. No project need.			N	NA		
	46	Water Quality Retrofit	Staff Survey	821 Willamette Falls Drive	Tualatin River	The staff survey indicates that the existing causeways trap water near 821 Willamette Falls Drive and result in elevated temperatures during summer low flows. Per City staff, increased temperature is not a stormwater master planning objective. No project need.			N	NA		
	50	Increase System Capacity Erosion Prevention	Hydromodification Assessment (017) 2005 CIP	Trillium Creek at Kenthorpe Way	Trillium Creek	The hydromodification assessment (017) and the 2005 CIP list identified bank erosion and limited channel capacity/culvert capacity at Trillium Creek at Kenthrope Way. Per City staff, there was a recent roadway project conducted in location and no project would be necessary in the near term. No project need.			N	NA		
	51	Water Quality Retrofit	Hydromodification Assessment (006)	Stormwater pond at Bland Circle	Salamo Creek	The hydromodification assessment (006) results showed a potential opportunity to increase storage and flow control and enhance water quality treatment at a stormwater pond at Bland Circle. Per City staff, pond was recently retrofit with new development. No project need.		Y	N	NA	Medium	
	53	Erosion Prevention Increase System Capacity	Hydromodification Assessment (008)	Culvert at Theresa's Vineyard	Salamo Creek	The hydromodification assessment (008) results showed a bridge was not installed correctly and doesn't align with flow patterns at Theresa's vineyard. Per City staff, channel is normalizing and project is on private property. No project need.		Y (stream restoration)	N	NA		
	61	Increase System Capacity	2005 CIP	10th Street	Bernert Creek	The 2005 CIP list identified this as a project location; however there is no known flooding in the this area. The terrain is very flat and pipe ownership is unknown. Further issues may existing because of the close proximity to the road base. Per City staff, given ownership questions and no reported flooding, no project need.			N	NA		
	62	Increase System Capacity (18" Concrete) Improve System Configuration	2005 CIP	Cottonwood Court	Gans Creek	The 2005 CIP list indicated a capacity deficiency (need for 24" pipe). Per discussion with City staff, system was reconfigured about 10 years ago to not be located under a house. An overflow was constructed in an existing manhole to reduce backwater conditions. No current issues. No project need.			Y (3-6-18)	NA		Project location in area where sanitary system is having issues with calibration.
	65	Increase System Capacity	2005 CIP	Culvert Under Meadowview Court	Summerlinn Creek	The 2005 CIP List indicates the location of this project is downstream of the Johnson and Blankenship, which may warrant evaluation. No capacity deficiencies of the 60" CMP were reported in 2005. Per City staff, no separate project need.			N	NA		May tie into upstream model

Strategies

1a. Green Infrastructure in the public right-of-way (ROW) as a standalone project (i.e., replacing bubblers and adding in a collection system).
1b. Green Infrastructure in the public ROW in conjunction a programmatic basis/a TSP (i.e., no curb and gutter, completed with larger TSP).
2. Install New Water Quality (WQ) Facilities on Public Properties to provide treatment to areas that have no treatment.
3. Install New Regional WQ Facilities to Treatment on Hwy 43 (reviewed vacant lands and pipe system in conjunction with Hwy 43 alignment).
4. Retrofit Existing Public Stormwater Pond Locations (reviewed vacant lands and pond locations) to increase capacity or treatment capabilities.

Table A-2: Water Quality Assessment Matrix

WQ Opportunity ID	Project Name	Project Concept and Location	Project Rationale	Strategy # (See above)	Identified Problem Area (Y/N)	Soil Type	Land Use	Site Visit Notes and Findings	City Input	WQ Project Recommended (Y/N)?	WQ Project Description	Location ID	Other Notes
1	Willamette Neighborhood Green Street	Install green street in existing ROW in the Willamette Neighborhood between 14th-16th Aves.	Limited WQ treatment in area. Wide Right-of-Way. No existing curb and sidewalk. Opportunity for a green street project. Target locations 14-16th Aves.	1b	Y	Type C Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Low and Medium Density Residential. Not a high pollutant loading area.	11-30-17 - Windshield survey conducted. No curb and sidewalk. Wide ROW. Opportunity for green infrastructure. Target locations 14-16th Aves.	Pair with Street Improvement Project.	Y	Green Street	15	Programmatic Opportunity
2	Buck Street/ Upper Buck Street Green Street	Add a stormwater trunkline down Buck Street and green street facilities to provide WQ treatment.	Limited WQ treatment in area. Poor drainage. Needs storm main installed from Fire Station to end, outfall repairs. Cbs are bubblers with no connection to main. City wants to discontinue use of bubblers.	1a	Y	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Medium Density Residential	11-30-17 - Bubblers are ineffective. Public confirmed flooding due to leaf accumulation during site visit. City maintenance staff installed a new curb inlet at end of Buck St to alleviate flooding, which has helped but not eliminated flooding. Downstream outfall erosion observed. Project scope may include trunkline down Buck Street and Green Street facilities.	Standalone Green Street Project.	Y	Green Street	5	Project extents are from the fire station to outfall on Buck Street.
3	Mark Lane Green Street	Add stormwater trunkline down Mark Lane and green street facilities to provide WQ treatment.	Limited WQ treatment in area. Green street facilities and new piped infrastructure to remove bubblers as they are connected to the main.	1a	Y	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Low Density Residential	6-21-18 - Curb and sidewalk on both sides of street. Wide ROW. Per City, benefit to narrowing street for speed control (many kid signs). Green street opportunities along both sides of street (no crown) and full length, to minimize parking impacts. Bubblers located at intersection of Lowell Ave (location for curb bump out).	Standalone Green Street Project.	Y	Green Street	4	Project extents along full Mark Lane alignment
4	LaFave Street, Jolie Point Road, Munger Drive, Lowell Avenue Green Street	Green street facilities and new piped infrastructure (as applicable) to remove bubblers.	Limited WQ treatment in area. Poor drainage - system currently composed of driveway culverts and ditches. No existing curb and gutter.	1b	Y	Type C/D Soils. Infiltration Capacity should be confirmed, if infiltration is used for WQ treatment.	Low Density Residential	No further action required.	Pair with Street Improvement Project.	Y	Green Street	19	Programmatic Opportunity
5	Exeter St, Lancaster St Green Street	Green street facilities and new piped infrastructure.	Limited WQ treatment in area. Flooding Issue. Limited curb and sidewalk and grated catch basins get plugged routinely. Piped conveyance to Sunset Creek through private parcel (not in ROW), steep slope - need to verify easement. No existing curb and gutter.	1b	Y	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Low and Medium Density Residential	11-30-17 - No curb and sidewalk in a majority of the ROW. Potential for green street improvements in conjunction with roadway improvements. No further action required.	Pair with Street Improvement Project.	Y	Green Street	11	Programmatic Opportunity
6	Cornwall Street and York Street Green Street	Green street facilities and new piped infrastructure to remove bubblers.	Limited WQ treatment in area. No storm improvements in neighborhood. Cbs are bubblers with no connection to a main. City wants to discontinue use of bubblers. No existing curb and gutter.	1b	Y	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Medium Density Residential	11-30-17 - No curb and sidewalk in a majority of the ROW. Potential for green street improvements in conjunction with roadway improvements. No further action required.	Pair with Street Improvement Project.	Y	Green Street	25	Programmatic Opportunity
7	Suncrest, Valleyview Dr, and Hillcrest between Suncrest and Marylhurst Drive Green Street	Green street facilities and new piped infrastructure (as applicable).	Limited WQ treatment in area. High volume of water flowing down roadways, property erosion from open drainage ditches. No existing curb and gutter.	1b	Y	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Low Density Residential	11-30-17 - Windshield survey conducted. No curb and sidewalk. Wide ROW. Opportunity for green infrastructure with infrastructure install. Local resident hand dug small trench to direct flow from a spring in front of 1779 Hillcrest Drive (approximate address). No visible signs of erosion along roadway further downstream. No further action required.	Pair with Street Improvement Project.	Y	Green Street	18	Programmatic Opportunity

Strategies

1a. Green Infrastructure in the public right-of-way (ROW) as a standalone project (i.e., replacing bubblers and adding in a collection system).
1b. Green Infrastructure in the public ROW in conjunction a programmatic basis/a TSP (i.e., no curb and gutter, completed with larger TSP).
2. Install New Water Quality (WQ) Facilities on Public Properties to provide treatment to areas that have no treatment.
3. Install New Regional WQ Facilities to Treatment on Hwy 43 (reviewed vacant lands and pipe system in conjunction with Hwy 43 alignment).
4. Retrofit Existing Public Stormwater Pond Locations (reviewed vacant lands and pond locations) to increase capacity or treatment capabilities.

Table A-2: Water Quality Assessment Matrix

WQ Opportunity ID	Project Name	Project Concept and Location	Project Rationale	Strategy # (See above)	Identified Problem Area (Y/N)	Soil Type	Land Use	Site Visit Notes and Findings	City Input	WQ Project Recommended (Y/N)?	WQ Project Description	Location ID	Other Notes
8	Dillow Drive at Larson Ave Green Street	Green street facilities	Limited WQ treatment in area. Ponding water possibly due to undersized ditch inlet. Additional inlets and potential green street improvements. Only partially curbed street. Opportunity for Hwy 43 management.	1b and 3	Y	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Low Density Residential	11-30-17 - Windshield survey conducted. Curb and catch basins only located on one side of street with entire street width sloped to curbed side. 6-21-18 - No curb and sidewalk from Hwy 43 to Lowry (programmatic or opportunity to manage Hwy 43 runoff). Partial curb and sidewalk with infill from Lowry to Will View Ct. Steep slope after Will View Ct. Cbs are piped together which could reduce green street costs (overflow to tie into pipe).	Pair with Street Improvement Project.	Y	Green Street	35	Programmatic Opportunity. Project extents from Hwy 43 to Lowry and from Lowry to Willamette View Ct. Note: If Hwy 43 runoff routed to Dillow Drive, may present opportunity to treat Hwy 43 runoff.
9	Kenthorpe Way Green Street	Green street facilities and new piped infrastructure (as applicable).	Add in WQ treatment along Kenthorpe Way where no existing stormwater system or WQ treatment existing. No existing curb and gutter. Fire Station east down the road .No existing ditches on both sides of the street to take runoff. No stormwater system along Kenthorpe. Water flows off side of road into front yards. Green street installation as part of a programmatic or targeted green street pilot project.	1b	Y	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Low Density Residential	No further action required. Recent roadway projects conducted. Active neighborhood citizen group that would want input. City confirmed that area would not have a project in the near term.	Pair with Street Improvement Project.	Y	Green Street	23	Programmatic Opportunity. Note: The pair of culverts along Gans Creek at Kenthorpe Way were specifically mentioned in the 2005 CIP.
10	Willamette Park Parking Lot Retrofit	Add stormwater WQ treatment to the parking lot.	Limited WQ treatment in vicinity. Treat a large square footage of impervious area on public property.	2	N	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Parks	6-21-18 - Flat parking area with observed pavement cracks. Without regrading, may be difficult to divert runoff to specific locations (potential swale between car and trailer parking stalls). Option to use pervious pavers (similar to overflow parking areas).	Standalone Water Quality Retrofit project.	Y	New Water Quality Facility	66	City prefers use of pervious pavers, consistent with overflow lots.
11	Mary S. Young Park Parking Lots Retrofit	Add stormwater WQ treatment to the two parking lots.	Limited WQ treatment in area. Treat a large square footage of impervious area on public property.	2	N	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Parks	6-21-18 - Large parking area graded towards NE corner of lot (no observed catchbasins) except in NE corner. Pavement cracking observed. Option to install raingarden in corner of property (removes ~ 5 parking stalls) or use pervious pavers. Additional potential for swales along driveway approach.	Standalone Water Quality Retrofit project.	Y	New Water Quality Facility	67	City prefers use of pervious pavers, consistent with overflow lots.
12	West Linn City Hall	Add stormwater WQ facility on public property to treat additional area not currently being treated on the West Linn City Hall property.	Limited WQ treatment in area. Treat a large square footage of impervious area on public property. Could be a showcase project for the City to show that City Hall is promoting the use of green infrastructure.	2	N	Type C Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Commercial	6-21-18 - Parking lot drains to two catchbasins and manhole located along adjacent trail. Limited opportunity to daylight pipe in trail. Potential option to reconfigure parking lot and incorporate swales between parking stalls or retrofit catchbasins with filter cartridge CBs. Adjacent property owners complain of city visitors parking on their portion of lot so parking reconfiguration may be a benefit. Roofdrains appear to discharge directly off back side of property. Parking lot runoff discharges offsite to Bland Circle (pond #11), Roof drains discharge offsite to pond #19.	Drainage area already treated by facilities. No project recommended.	N	N/A	N/A	

Strategies

1a. Green Infrastructure in the public right-of-way (ROW) as a standalone project (i.e., replacing bubblers and adding in a collection system).
1b. Green Infrastructure in the public ROW in conjunction a programmatic basis/a TSP (i.e., no curb and gutter, completed with larger TSP).
2. Install New Water Quality (WQ) Facilities on Public Properties to provide treatment to areas that have no treatment.
3. Install New Regional WQ Facilities to Treatment on Hwy 43 (reviewed vacant lands and pipe system in conjunction with Hwy 43 alignment).
4. Retrofit Existing Public Stormwater Pond Locations (reviewed vacant lands and pond locations) to increase capacity or treatment capabilities.

Table A-2: Water Quality Assessment Matrix

WQ Opportunity ID	Project Name	Project Concept and Location	Project Rationale	Strategy # (See above)	Identified Problem Area (Y/N)	Soil Type	Land Use	Site Visit Notes and Findings	City Input	WQ Project Recommended (Y/N)?	WQ Project Description	Location ID	Other Notes
13	West Linn Public Works Department	Add stormwater WQ facility on public property to treat additional area not currently being treated on the West Linn Public Works Department property.	Ensure WQ treatment is provided for all pollutant generating impervious surface at the West Linn Public Works Facility. Ensure all components of the City's municipal and storage BMPs are in place.	2	N	Type C Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Medium Density Residential	Not visited.	City has identified opportunity to install a small rain garden along Norfolk Street frontage for parking lot at front of building	Y	New Water Quality Facility	68	
14	West Linn Police Station	There are no additional opportunities for WQ treatment at this site.	This site was reviewed to ensure no additional WQ opportunities were available at this location.	2	N	Type C Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Commercial	No further action required.	There is a nearby vacant land that was reviewed as an opportunity depending on drainage patterns/slopes in the area; however, there are no additional opportunities for WQ treatment in the area. See as-built drawings for more information.	N	N/A	N/A	
15	West Linn Public Library	There are no additional opportunities for WQ treatment at this site.	This site was reviewed to ensure no additional WQ opportunities were available at this location.	2	N	Type C Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Commercial	No further action required.	Parking lots to NE is made of permeable pavers. Main parking areas uses mechanical treatment. Limited opportunity for additional WQ treatment due to creek proximity.	N	N/A	N/A	
16	Fields Bridge Park Parking Lot Retrofit	There are no additional opportunities for WQ treatment at this site.	This site was reviewed to ensure no additional WQ opportunities were available at this location.	2	N	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Parks	No further action required.	The parking lot was constructed with permeable pavers. No further opportunities are available at this site.	N	N/A	N/A	
17	Mary S. Young Park - Hwy 43 Treatment	Construct a WQ facility along the eastside of Hwy 43 between Trillium Creek and Hernon Creek to mitigate new/replaced impervious surface from Hwy 43.	Water quality treatment facility (i.e. WQ swale or WQ treatment pond) would be constructed during the Hwy 43 construction project to provide treatment of impervious surface.	3	N	Type C and C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Parks	6-21-18 - Site visit included walking trail alignment along Hwy 43. Area is at crest of Hwy 43 and most has steep slope from Hwy 43 shoulder. Reviewed outfall locations. Potential retrofit (vegetation management) at furthest north outfall location and at entrance to Mary S Young Park. However, limited space for regional solution. No large project opportunities in this area.	Grade issues and limited available area without tree removal. No project recommended at this location.	N	N/A	N/A	The City has approved Mary S. Young Park a location for WQ treatment facility for HWY 43 runoff.
18	Hwy 43 Treatment near Failing Street	Install a small WQ treatment facility (swale or raingarden) to treat a small portion of Hwy 43 on an existing vacant land (0.054 acres) located on the eastside of Hwy 43.	Water quality treatment facility (i.e. WQ swale or WQ treatment pond) would be constructed during the Hwy 43 construction project to provide treatment of impervious surface.	3	N	Type C/D Soils. Infiltration Capacity should be confirmed if infiltration is used for WQ treatment.	Low Density Residential	6-21-18 - Small parcel downslope, close to Bolton elementary school. Location is too small for regional detention and too low below road grade to provide Hwy 43 treatment without compromising road bank stability. May be used to provide treatment or drainage for Bolton Elementary driveway (Problem Area #7).	Property acquisition required. Grade issues and limited available area. No project recommended at this location.	N	N/A	N/A	
19	Stormwater Facility Upstream of Remington Drive	Retrofit in-line stormwater facility upstream of Remington Drive. Add storage or treatment capacity to existing facility.	Opportunity to increase storage and flow control and enhance WQ treatment to an existing facility.	4	Y	Type C, Infiltration capacity should be confirmed if infiltration is used for WQ treatment.	Low Density Residential	Site visit still required.	Maintain as an opportunity pending site visit.	Y	Existing Public Facility Retrofit	52	Confirm cross streets and area available for expansion. Project opportunity identification per hydromodification assessment.

Strategies

1a. Green Infrastructure in the public right-of-way (ROW) as a standalone project (i.e., replacing bubblers and adding in a collection system).
1b. Green Infrastructure in the public ROW in conjunction a programmatic basis/a TSP (i.e., no curb and gutter, completed with larger TSP).
2. Install New Water Quality (WQ) Facilities on Public Properties to provide treatment to areas that have no treatment.
3. Install New Regional WQ Facilities to Treatment on Hwy 43 (reviewed vacant lands and pipe system in conjunction with Hwy 43 alignment).
4. Retrofit Existing Public Stormwater Pond Locations (reviewed vacant lands and pond locations) to increase capacity or treatment capabilities.

Table A-2: Water Quality Assessment Matrix

WQ Opportunity ID	Project Name	Project Concept and Location	Project Rationale	Strategy # (See above)	Identified Problem Area (Y/N)	Soil Type	Land Use	Site Visit Notes and Findings	City Input	WQ Project Recommended (Y/N)?	WQ Project Description	Location ID	Other Notes
20	Public Pond #18 (BC ID)	Opportunity to retrofit existing public stormwater pond #18 for new or additional WQ treatment. This pond was installed in 1997, which is pre-2004 which was when the NPDES MS4 Permit Requirements for pond maintenance began. This pond is also located downstream of a vacant site. Pond is located at 2240 Willamette Falls Drive.	Use existing publicly owned pond to enhance WQ treatment in areas of the City that are not currently being treated.	4	N	Type C, Infiltration capacity should be confirmed if infiltration is used for WQ treatment.	Commercial	6-21-18 - Access to location is limited. Redevelopment (Shari's Restaurant) will be occurring and will have to provide additional onsite treatment. Location is next to a hoarder property and contributing open channel is covered with invasives.	Maintain as an opportunity pending site visit. Retrofit opportunity in conjunction with development of adjacent parcel.	Y	Existing Public Facility Retrofit	69	
21	Public Pond # 22 (BC ID)	Opportunity to retrofit existing public stormwater pond #22 for new or additional WQ treatment. This pond was installed in 1999, which is pre-2004 which was when the NPDES MS4 Permit Requirements for pond maintenance began. This pond is also located downstream of a vacant site. Pond is located at 25545 Katherine Court.	Use existing publicly owned pond to enhance WQ treatment in areas of the City that are not currently being treated.	4	N	Type C, Infiltration capacity should be confirmed if infiltration is used for WQ treatment.	Low Density Residential	6-21-18 - Access to pond is good. Trees are growing in the pond and should be removed. Neighboring resident indicates pond functions during rainfall events. Potentially incorporate swale in pond bottom for WQ and conduct pond maintenance to remove trees.	The neighborhood where the pond is located is mostly developed with two upstream vacant parcels (redevelopment). May be good location to add WQ treatment to an existing pond to treat the neighborhood before the outfall to the Willamette River.	Y	Existing Public Facility Retrofit	70	

Table A-3. Pond Inventory and Review Matrix

City of West Linn
Public Pond Inventory Review - Water Quality Assessment
Prepared by Brown and Caldwell, J. Christofferson
Last Updated: May 8, 2018

Review Criteria	**Totals**
1. Priortize Ponds installed pre-2004 (NPDES MS4 Permit Requirements - Began in 2004.)	**30**
2. Ponds is downstream of a vacant property. Ponds may be retrofitted to address new development.	**8**
3. Criteria 1 and Criteria 2	**2**
4. Identify other constraints for Ponds in Category 3.	

				Initial Public Pond Review Water Quality Assessment Notes (3/14/18)			**City Assessment Review (5/3/18)**	**Criteria Category (5/8/18)**
BC_ID	**TYPE**	**DESC_**	**OWNER**	**Vacant Land in Proximity**	**Pond is Downstream or Upstream of Vacant Property**	**Other Notes**	**Year Installed**	
29	WETLAND	18418 River Woods PL	PUB	Yes	Upstream	Upstream of two private ponds (27, 28). Pond 27 is on private property. Wetland existing in 1990 plat	1990	1
23	WETLAND	Tualatin River Bluff - Near 1312 Evah Lane	PUB	Yes	N/A		1992	1
1	DT/TREATMENT	Near 3558 VistaRidge DR	PUB	No	N/A		1994	1
56	DT/TREATMENT	Cascade Summit #6 - 3390 Beacon Hill	PUB	No	N/A	Pond is located in a park in line with Ponds 56, 57 and 63.	1994	1
57	DT/TREATMENT	Cascade Summit #6	PUB	No	N/A	Pond is located in a park in line with Ponds 56, 57 and 63.	1994	1
63	DT/TREATMENT	Cascade Summit #6	PUB	No	N/A	Pond is located in a park in line with Ponds 56, 57 and 63.	1994	1
65	DT/TREATMENT	Cascade Summit #3 - near 3349 Coeur D'Alene Dr	PUB	No	N/A	Pond is located in a park.	1994	1
24	WETLAND	2070 (M) Volpp ST (Park)	PUB	No	N/A	In City park just upstream of Willamette River. Identified as existing in 1994 as-builts	1994	1
35	DT/TREATMENT	2115 Windham Oaks CT	PUB	No	N/A		1995	1
68	WETLAND	Remington DR & Rogue Way	PUB	Yes	N/A	Pond 94 is partially on a vacant lot. Ponds 67 and 68 are downstream of Pond 94.	1995	1
8	DT/TREATMENT	Tanner Creek Estates -near 2125 Fairhaven Ct	PUB	Yes	Upstream		1997	1
12	DT/TREATMENT	Near 2655 CouerDAlene DR	PUB	Yes	Upstream		1997	1
13	DT/TREATMENT	Near 2355 Tannler DR	PUB	Yes	Upstream	On City Property	1997	1
18	DT/TREATMENT	2240 Willamette Falls DR	PUB	Yes	On Vacant Property		1997	3
50	DT/TREATMENT	Parker Summit - 4700 Parker Rd	PUB	No	N/A		1997	1
37	WETLAND	4400 (M) Horton RD	PUB	No	N/A	1997 enhancement project (City)	1997	1
9	DT/TREATMENT	Near 2345 Rogue WAY	PUB	No	N/A		1998	1
49	DT/TREATMENT	Cascade Summit Apts - 22910 Weatherhill Rd	PUB	Yes	Upstream	Public Pond on Private Property. Vacant Lot in closer proximity.	1998	1
7	DT/TREATMENT	3000 Kensington CT	PUB	No	N/A		1999	1
22	DT/TREATMENT	25545 Katherine CT	PUB	Yes	Downstream	Just upstream of a Willamette River Outfall	1999	3
46	DT/TREATMENT	3100 Parker RD	PUB	No	N/A	Near Tanner Creek Park	1999	1

Table A-3. Pond Inventory and Review Matrix

				Initial Public Pond Review Water Quality Assessment Notes (3/14/18)			City Assessment Review (5/3/18)	Criteria Category (5/8/18)
BC_ID	**TYPE**	**DESC_**	**OWNER**	**Vacant Land in Proximity**	**Pond is Downstream or Upstream of Vacant Property**	**Other Notes**	**Year Installed**	
54	DT/TREATMENT	Sabo LN & Beacon Hill LN	PUB	Yes	Upstream	Numerous other ponds in the area (6, 47, 48, 5, 19, 52, 54 and 55). Pond 55 is on vacant land.	1999	1
67	DT/TREATMENT	Near 3051 Kensington CT	PUB	Yes	N/A	Pond 94 is partially on a vacant lot. Ponds 67 and 68 are downstream of Pond 94.	2000	1
47	WETLAND	Maxfield - near 3128 Winkel Way	PUB	Yes	Upstream	Numerous other ponds in the area (6, 47, 48, 5, 19, 52, 54 and 55). Pond 55 is on vacant land. 2000 mitigation project.	2000	1
43	DT/TREATMENT	Between Rosemont Salamo	PUB	Yes	Upstream	Just upstream of Wetland 42 (Private) which is on a vacant land. Water Quality treatment provided by Wetland?	2001	1
45	DT/TREATMENT	Rosemont Summit 3 - near 3821 Wild Rose	PUB	Yes	Upstream	Vacant Lot is just downstream and Tanner Creek runs through the lot.	2001	1
64	DT/TREATMENT	Near 2688 Beacon Hill LN	PUB	No	N/A		2001	1
48	DT/TREATMENT	Near 3258 Sabo LN	PUB	Yes	Upstream	Numerous other ponds in the area (6, 47, 48, 5, 19, 52, 54 and 55). Pond 55 is on vacant land.	2003	1
52	DT/TREATMENT	Near 3017 Sabo LN	PUB	Yes	Upstream	Numerous other ponds in the area (6, 47, 48, 5, 19, 52, 54 and 55). Pond 55 is on vacant land.	2003	1
66	DT/TREATMENT	23160 (M) Bland CIR	PUB	No	N/A		2003	1
39	DT/TREATMENT	Gegory Estates - 5149 Gregory Ct	PUB	Yes	Downstream	Downstream of Vacant Land, no real opportunity here.	2004	2
14	DT/TREATMENT	Fields Park	PUB	Yes	Upstream		2005	
69	DT/TREATMENT	FieldsParkNo2	PUB	Yes	Upstream	Upstream of Pond 14 and a nearby vacant lot.	2005	
2	DT/TREATMENT	4738 (M) Gardner LN	PUB	Yes	Downstream	Downstream of Vacant Land, but just upstream of Tanner Creek.	2006	2
3	DT/TREATMENT	4774 (M) Coho LN	PUB	On Vacant Prop	On Vacant Property		2006	2
4	DT/TREATMENT	2720 (M) Ridge LN	PUB	Yes	Upstream		2006	
19	DT/TREATMENT	2091 Winkel WAY	PUB	Yes	Upstream	Numerous other ponds in the area (6, 47, 48, 5, 19, 52, 54 and 55). Pond 55 is on vacant land.	2006	
5	DT/TREATMENT	Near 3010 Winkel WAY	PUB	Yes	Upstream	Numerous other ponds in the area (6, 47, 48, 5, 19, 52, 54 and 55). Pond 55 is on vacant land.	2007	
6	DT/TREATMENT	Maxfield	PUB	Yes	Upstream	Numerous other ponds in the area (6, 47, 48, 5, 19, 52, 54 and 55). Pond 55 is on vacant land.	2007	
20	DT/TREATMENT	SiennasEstates - Near 4713 Parker	PUB	No	N/A		2008	
21	DT/TREATMENT	SiennasEstates - Near 4703 Parker	PUB	No	N/A		2008	
70	DT/TREATMENT	ArborCove -1024 Epperly Way	PUB	Yes	Upstream	Adajent and downstream of a vacant lot.	2008	
71	DT/TREATMENT	Near 1848 Manchester CT	PUB	No	N/A		2008	
72	DT/TREATMENT	RosemontCrossing - Corner of Rosemont/Salamo	PUB	No	N/A		2008	
81	DT/TREATMENT	Debok Estates	PUB	Yes	Upstream	Upstream of large amount of vacant lots.	2011	
82	DT/TREATMENT	Parker_Road_Subdivision: Near Chinook Ct?	PUB	Yes	Downstream	Adajent and downstream of a vacant lot.	2011	2
83	DT/TREATMENT	2811 Coeur D Alene Dr	PUB	No	N/A		2012	

Table A-3. Pond Inventory and Review Matrix

				Initial Public Pond Review Water Quality Assessment Notes (3/14/18)			City Assessment Review (5/3/18)	Criteria Category (5/8/18)
BC_ID	**TYPE**	**DESC_**	**OWNER**	**Vacant Land in Proximity**	**Pond is Downstream or Upstream of Vacant Property**	**Other Notes**	**Year Installed**	
84	DT/TREATMENT	1025 Rosemont Rd	PUB	No	N/A		2013	
	DT/TREATMENT	23150 (M) Bland CIR	PUB		N/A	Adjacent to pond 29	2015	
10	DT/TREATMENT	Tanner Creek Estates	PRIV					
11	DT/TREATMENT	2030 Tanner Creek LN	PRIV					
15	DT/TREATMENT	1855 Blankenship RD	PRIV					
16	EFFLUENT	West Linn Paper WFD	PRIV					
17	DT/TREATMENT	1990 8TH AVE	PRIV					
25	WETLAND	1236 14th ST	PRIV					
26	EFFLUENT	Blue Heron Paper 4th ST	PRIV					
27	LANDSCAPE	18200 River Edge CT	PRIV					
28	WETLAND	18400 Old River Landing	PRIV					
30	FISH	North end of Nixon Ave	PRIV					
31	DT/TREATMENT	18850 Willamette DR	PRIV					
33	WETLAND	3845 Mapleton DR	PRIV					
34	WETLAND	1850 Carriage WAY	PRIV					
36	FISH	21305 Shannon Ln	PRIV	Yes				
38	DT/TREATMENT	6283 Haverhill CT	PRIV					
40	DT/TREATMENT	RRMS 20001 Salamo RD	PRIV					
41	DT/TREATMENT	RRMS 20001 Salamo RD	PRIV					
42	WETLAND	Between Rosemont Salamo	PRIV	Yes				
44	POND	3637 Parker RD	PRIV					
51	DT/TREATMENT	WLHS 5290 West A	PRIV					
53	DT/TREATMENT	WLHS 5290 West A	PRIV					
55	FISH	4340 S Parker RD	PRIV	Yes				
58	FISH	4340 S Parker RD	PRIV	Yes				
59	DT/TREATMENT	6200 SummerLinn WAY	PRIV	Yes	Downstream			
60	DT/TREATMENT	6000 SummerLinn WAY	PRIV	Yes	Downstream			
61	DT/TREATMENT	5800 SummerLinn WAY	PRIV	Yes	Downstream			
62	DT/TREATMENT	5600 SummerLinn WAY	PRIV	Yes	Downstream			
73	DT/TREATMENT	19066 Willamette Dr	PRIV					
74	DT/TREATMENT	3153 S Brandywine DR	PRIV					
75	DT/TREATMENT	3153 S Brandywine DR	PRIV					
77	DT/TREATMENT	1800 Valley View Dr	PRIV					
78	DT/TREATMENT	1800 Valley View Dr	PRIV					
79	DT/TREATMENT	Douglas Park (Park)	PRIV					
80	DT/TREATMENT	Douglas Park (Park)	PRIV					
32	WETLAND	Near Island Way	PUB	No	N/A	In Cedaroak Boat Ramp Park. This pond is just upstream of the Willamette River.		
85	WETLAND	Camassia Natural Area	PRIV					
86	WETLAND	Camassia Natural Area	PRIV					
76	DT/TREATMENT	64 Dollar ST	PUB	Yes	Downstream			2
88	DT/TREATMENT	CedaroakParkSchool	PRIV					
87	LANDSCAPE	12th & Volpp in the park	PUB	No	N/A	Just upstream of the Willamette River and located in a park.		
90					N/A			
91					N/A			

Table A-3. Pond Inventory and Review Matrix

				Initial Public Pond Review Water Quality Assessment Notes (3/14/18)			City Assessment Review (5/3/18)	Criteria Category (5/8/18)
BC_ID	**TYPE**	**DESC_**	**OWNER**	**Vacant Land in Proximity**	**Pond is Downstream or Upstream of Vacant Property**	**Other Notes**	**Year Installed**	
92					N/A			
93					N/A			
89	DT/TREATMENT	22111 Bland Dir	PUB	No	N/A			
94	DT/TREATMENT	Bland CIR & Salamo RD	PUB	Yes	Downstream	Pond 94 is partially on a vacant lot. Ponds 67 and 68 are downstream of Pond 94.		2

Attachment B: Preliminary Maps

This page intentionally left blank.

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure B-1: Storm Drainage System Overview

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: July 2018 Produced by Brown and Caldwell

N 0 1,000 2,000 4,000 6,000 Feet

1:24,000 scale

- Public Property
- Parks & Open Spaces
- Stormwater Pipe
- Open Channel
- Streams
- Watershed Boundaries
- ODOT ROW
- City Limits
- UGB

10/9/2019

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure B-2: Soils and Topography

Hydrologic Soil Group
- A
- B
- B/D
- C
- C/D
- D

- Contours (50 ft)
- Streams
- ODOT ROW
- City Limits
- UGB

N

0 1,000 2,000 4,000 6,000 Feet

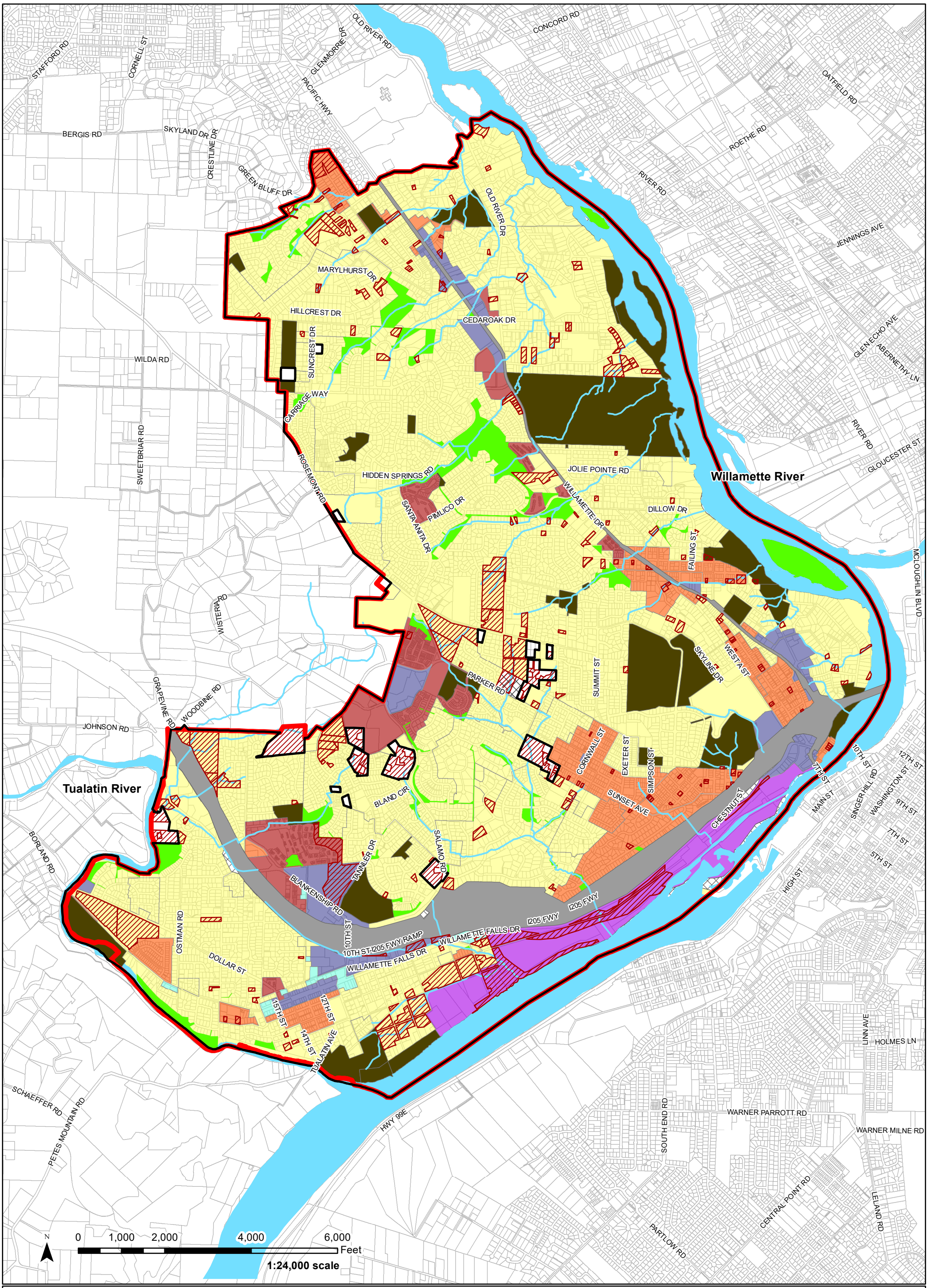
1:24,000 scale

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

10/9/2019



CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure B-3: Existing Land Use

- Commercial
- Industrial
- Residential (Low Density)
- Residential (Medium Density)
- Residential (High Density/Multi-family)
- Mixed Use
- No Zoning (Unzoned)
- Vacant
- Parks
- Open Spaces
- Streams
- ODOT ROW
- City Limits (2017)
- UGB

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

10/9/2019

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure B-4: Storm Drainage Treatment Facilities and Drainage Areas

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

9/13/2019

- Private Ponds
- Public Ponds
- Swale
- Wetlands
- Water Quality Facility Drainage Areas[1]
- Streams
- ODOT ROW
- City Limits
- UGB

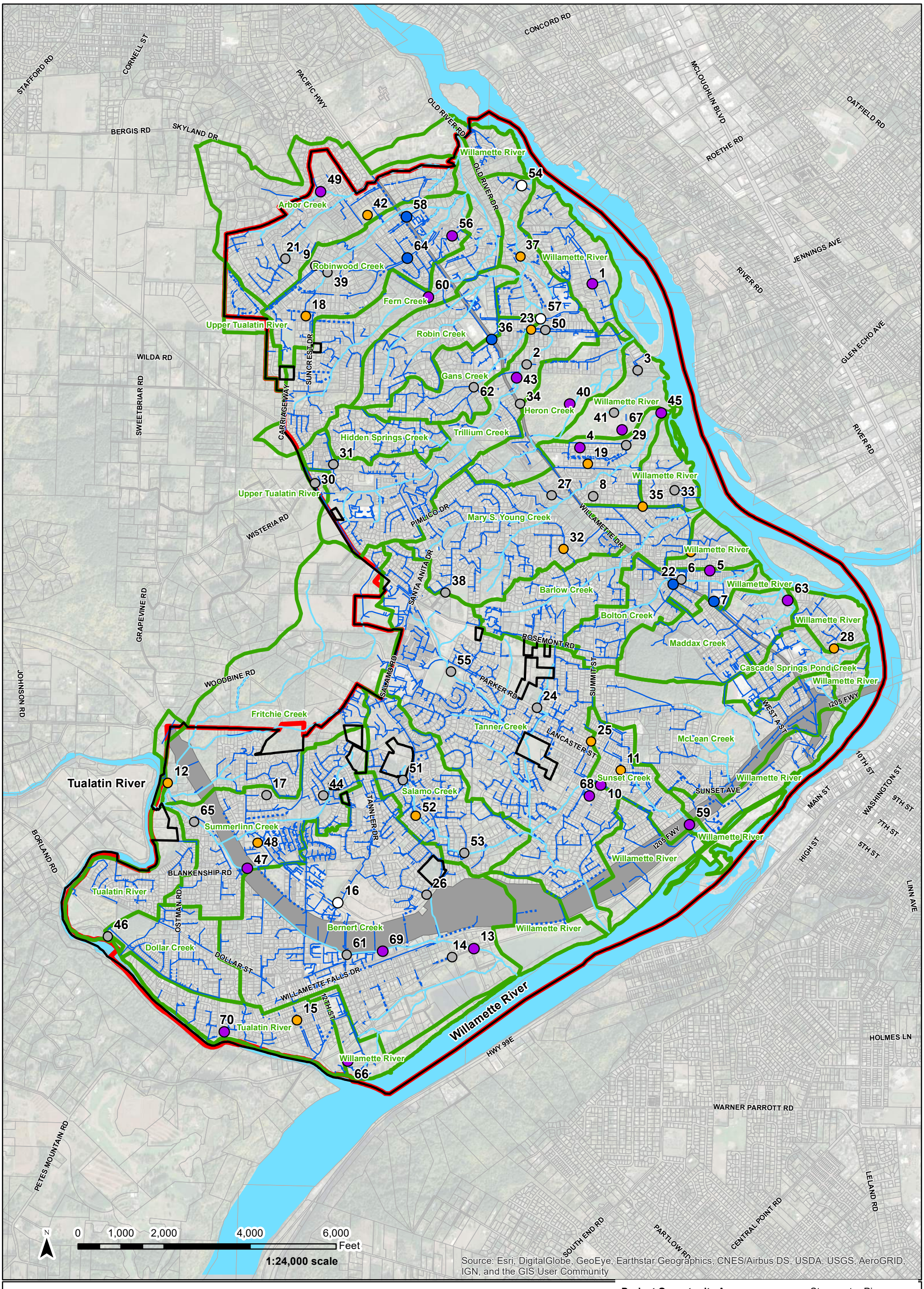
1. Other water quality facilities (i.e. rain gardens, planters, porous pavement) not individually mapped are reflected in this coverage.

N

0 1,000 2,000 4,000 6,000 Feet

1:24,000 scale

Appendix C: Final Stormwater Project Opportunity Areas



CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure C-1: Storm Drainage Project Opportunity Areas

Project Opportunity Areas (by Location ID)

- Proposed Project (Capital)
- Proposed Project (Planning)
- Proposed Program
- Project Need associated with Hwy 43
- Removed from Consideration

- Stormwater Pipe
- Open Channel
- Streams
- Watershed Boundaries
- ODOT ROW
- City Limits
- UGB

Note: Numbering corresponds to the identified Location ID.

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: August 2019 Produced by Brown and Caldwell

8/29/2019

Table C-1. Stormwater Project Opportunity Matrix

Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Project Prioritization Information								Capital Improvement Plan Development				
						Flooding Issue	Hydraulic Modeling Need	TSP or Transportation-Related Driver	Recurring Maintenance Need	Special Interest	Private Property Considerations	Hwy 43 Impacts[a]	WQ Opportunity	Project (Capital)	Project (Planning/ Study)	Program	Policy Change	No Project/ Associated Program
1	Improve System Configuration	Staff Summary	18780 Nixon	Willamette River	Public storm pipe under house (garage) required relocation. Potential to move pipe to the southern location with easement. No survey required.				X					X				
4	Add Infrastructure Water Quality Retrofit	Staff Summary Public Survey	Mark Lane	Mary S. Young Creek	Poor drainage and reported flooding. No infrastructure and City uses bubblers, which City wants to discontinue. High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.	X		X	X				X	X				
5	Add Infrastructure Water Quality Retrofit	Staff Summary Public Survey	Buck Street/Upper Buck Street	Bolton Creek	Poor drainage and reported flooding. No infrastructure and City uses bubblers, which City wants to discontinue. City maintenance staff installed a new curb inlet at end of Buck St to alleviate flooding, which has helped but not eliminated flooding. Downstream outfall erosion observed. Project scope may include trunkline down Buck Street from fire station to outfall and green street facilities.			X	X				X	X				
7	Improve System Configuration	Staff Summary 2006 CIP	Bolton Primary School	Bolton Creek	Localized flooding/runoff from Hwy 43 causes flooding. Steep slope and embankment to existing parking area. Complaints occur when freezing temperatures result in icy conditions. The 27-inch concrete pipe from Hwy 43 to the Holmes St outfall to Bolton Creek was specifically mentioned in the 2006 CIP. Problem likely addressed with Hwy 43 improvements. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location may not be warranted.	X		X	X			X							
10	Add Infrastructure	Staff Summary Staff Survey	Sunset Avenue (between 4345 and 2413)	Sunset Creek	Deep ditches along road are eroding. Current eye sore. Flooding is generally not a concern but the geometry of the ditches is a safety concern. Steep grade may prohibit green infrastructure. Trunkline proposed for installation with road repairs. High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.			X	X					X				
11	Add Infrastructure Water Quality Retrofit	Staff Summary	Exeter St, Lancaster St	Sunset Creek	Poor drainage and reported flooding. No curb and gutter in a majority of the ROW. Piped conveyance to Sunset Creek through private parcel (not in ROW). High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.	X		X	X				X			X		
12	Address Maintenance Need	Staff Summary Staff Survey 2006 CIP	23350 Johnson Road; 23212 Johnson Road	Fritchie Creek	Flooding issues reported by City Staff and identified in the 2006 CIP list. The 2006 CIP list specially mentioned the 15 and 36-inch pair of concrete culverts along Johnson Road. There is no existing stormwater system. Site visit 11-30-17 identified beaver dams observed in culvert under Johnson Road and upstream (north) on Fritchie that appear to cause the flooding.	X			X							**X (Beaver Management)**	
13	Increase System Capacity (Flood Control, 40" Concrete) Improve System Configuration	Staff Summary 2006 CIP	5th Avenue culvert	Bernert Creek	Undersized culvert identified in 2006 MP. Site visit 11-30-17 indicates debris and exposed corrugated metal sanitary line. City installed a concrete overlay on County-owned sanitary SMP that could present a safety concern. Culvert orientation results in 90 degree bend in channel. CIP may require reorienting culvert inline with channel configuration. Potential utility conflicts. Not anticipated to be a fish bearing waterway in proximity.	X	X							X				
15	Add Infrastructure	Staff Summary	Willamette Neighborhood	Bernert Creek	Limited water quality treatment in area. Wide Right-of-Way. No existing curb and sidewalk. Opportunity for a green street project. Target locations 14-16th Avenues.			X					X			X		
16	Add Infrastructure	Staff Summary, Public Survey	Tannler open ditch	Bernert Creek	The public identified a closed stormwater system at Tannler Creek adjacent to Tannler Drive (2425/2445 Tannler) that may be an opportunity to daylight the pipe for aesthetics and water quality. The Creek is very deep in this location which would present structural and geotechnical design challenges if daylighted. May consider project opportunity if pipe condition deteriorates.					X			X		X			

Table C-1. Stormwater Project Opportunity Matrix

Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Project Prioritization Information								Capital Improvement Plan Development				
						Flooding Issue	Hydraulic Modeling Need	TSP or Transportation-Related Driver	Recurring Maintenance Need	Special Interest	Private Property Considerations	Hwy 43 Impacts[a]	WQ Opportunity	Project (Capital)	Project (Planning/ Study)	Program	Policy Change	No Project/ Associated Program
18	Add Infrastructure Water Quality Retrofit	Public Survey	Suncrest, Valleyview Dr, and Hillcrest between Suncrest and Marylhurst Drive	Robinwood Creek	Reported stormwater flooding down Suncrest, Valley View Drive and Hill Crest between Suncrest and Marylhurst Drive. There are existing open drainage ditches and no curb or side walk. There are no signs of visible signs of erosion. A local resident hand dug a small trench to direct flow from a spring in front of 1779 Hillcrest Dr. (approx. address). Project opportunity to build a green street infrastructure project or a new piped stormwater conveyance system to mitigate stormwater flooding on the roadways. During design evaluate the downstream capacity of the stormwater system.	X		X	X				X			X		
19	Add Infrastructure Water Quality Retrofit	Public Survey Staff Survey	LaFave Street, Jolie Point Road, Munger Drive, Lowell Avenue	Mary S. Young Creek	Poor drainage and reported flooding. System currently composed of driveway culverts and ditches. No curb and gutter. High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.	X		X	X		X		X			X		
20	Infrastructure Need	Public Survey	6343 Failing Street	Willamette River	The public survey identified no stormwater system near 6343 Failing Street and stormwater runoff enters yards. Homes sit below grade which results in yards flooding. Roadway has steep slopes Potential projects to solve flooding include increased inlets with a trench drain system upstream of the yards that are being flooded.				X							X		
22	Improve System Configuration	Public Survey	Hwy 43/A Street	Bolton Creek	Ponding on road during rain events. Problem likely addressed with Hwy 43 improvements. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location may not be warranted.	X						X						
23	Add Infrastructure Water Quality Retrofit	Public Survey 2006 CIP	Kenthorpe Way	Trillium Creek	No existing stormwater system (uneven ditches) near the Fire Station and along Kenthorpe Way. Public stormwater runoff is flooding private yards in the area. There is a pair of culverts along Gans Creek at Kenthorpe Way were identified in the 2006 CIP List as a project need. Project opportunity to add in a new piped stormwater conveyance system near the Fire Station and on Kenthorpe Way to mitigate flooding. Upsize/replace the culverts at Gans Creek.	X		X	X		X		X			X		
25	Add Infrastructure Water Quality Retrofit	Public Survey	Cornwell Road and York Street	Tanner Creek	No infrastructure and City uses bubblers, which City wants to discontinue. High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.			X	X				X			X		
28	Improve System Configuration	Public Survey	5550 Sinclair Street	Cascade Springs Pond Creek	The existing storm drain inlet near 5550 Sinclair Street is not located at the low point. Project opportunity to remove existing inlet and install a new inlet at the low spot near the address noted.				X							X		
32	Improve System Configuration	Public Survey	Summit Street between Apollo and Causey	Mary S. Young Creek	Reported stormwater bypass from catchbasins on Apollo. Per site visit 11-30-18, catch basin spacing seems adequate but high leaf accumulation. May consider replacement with curb inlets for debris control.			X	X							X		
35	Add Infrastructure Water Quality Retrofit	Public Survey	Dillow Drive at Larson	Barlow Creek	Limited water quality treatment in area. Ponding water possibly due to undersized ditch inlet. Project opportunity to add additional inlets and potential green street improvements. Only partially curbed street. Opportunity for Highway 43 management if green street installed. High I&I reported in area (significant R value) in the public survey, indicating that high proportion of precipitation enters sanitary system. This could be caused by an undersized ditch inlet.	X		X	X				X			X		
36	Add Infrastructure Improve System Configuration	Public Survey	Hwy 43 at Hidden Springs	Gans Creek	Ponding on road during rain events. Problem likely addressed with Hwy 43 improvements. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location may not be warranted.	X						X						
37	Improve System Configuration	Public Survey	Elmran Dr near Old River Road	Fern Creek	Ponding water reported at Elmran Dr near Old River Road. This problem will be addressed with new curb inlets to alleviate ponding.	X		X								X		

Table C-1. Stormwater Project Opportunity Matrix

Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Project Prioritization Information								Capital Improvement Plan Development				
						Flooding Issue	Hydraulic Modeling Need	TSP or Transportation-Related Driver	Recurring Maintenance Need	Special Interest	Private Property Considerations	Hwy 43 Impacts[a]	WQ Opportunity	Project (Capital)	Project (Planning/ Study)	Program	Policy Change	No Project/ Associated Program
40	Erosion Prevention	Staff Survey	Mary S Young Park	Heron Creek	Reported land slides and erosion trail/bridge washout in Mary S Young Park. Project opportunity to add in stream bank erosion measures to minimize the trail and bridge washout in the park.					X				X				
42	Improve System Configuration	Staff Survey	Near Midhill Park	Arbor Creek	Reported sheet flows from lower portion of Midhill Park results in downstream flooding of neighbors. City follow up identified drainage issues on Lower Midhill Road (inadequate catchbasins).	X			X							X		
43	Erosion Prevention Water Quality Retrofit	Staff Survey	Trillium Creek in Mary S Young Park	Trillium Creek	Demonstration project opportunity at Trillium Creek in Mary S Young Park to restore channel incision with large woody debris and other creek stabilization measures.								X (stream restoration)	X				
45	Water Quality Retrofit	Staff Survey	Mary S Young Creek	Mary S. Young Creek	Remove culvert at Mary S. Young Creek to improve water quality and provide fish restoration measures in the creek in accordance with the Mary S Young Creek Restoration Concept Plan.								X (stream restoration)	X				
47	Increase System Capacity (Flood Control)	Staff Survey 2006 CIP	Blankenship Road under I-205 overpass	Summerlinn Creek	Blankenship Road consistently floods, even with recent site improvements to the swale and ditch along Blankenship. Area is flat. The 12-inch concrete pipe in Blankenship Drive near the intersection with Johnson Road was specifically mentioned in the 2006 CIP. Drainage infrastructure and drainage patters seems inconsistent with mapped GIS (recent surveying confirms need for subbasin delineation). Northern side of Blankenship under the overpass is unimproved and drains to a ditch inlet in middle of filled-in ditch. Inlet elevation is too high to function properly. Site visit 3-6-18 reveals a lack of inlets along Debok RD and upper Blankenship. Survey extents expanded to account for questions on drainage patterns and contributing area.	X	X	X	X					X				
48	Improve System Configuration Address Maintenance Need	Staff Survey	Rose Linn Care Center (2330 Debok Rd)	Summerlinn Creek	Staff survey reports Debok Road floods the bike lane when it rains. Flooding is due to clogged catch basins. May consider replacement with curb inlets for debris control.	X			X							X		
49	Erosion Prevention	Hydromodification Assessment (009)	Downstream of Arbor Creek culvert at Hillside Drive, near Skye Parkway	Arbor Creek	Scour hole at culvert outlet resulting in bank erosion was observed during hydromod assessment. Project needs may include stream stabilization project to reduce channel drop or outfall reinforcement.				X					X				
52	Water Quality Retrofit	Hydromodification Assessment (007)	In-line stormwater facility upstream of Remington Drive	Bernert Creek	Potential opportunity to increase storage and flow control and enhance water quality treatment was observed during hydromod assessment.								X			X		
54	Increase System Capacity Improve System Configuration	2006 CIP	Trillium Creek Crossing Under Calaroga Drive	Trillium Creek	The 2006 CIP list indicated a capacity deficiency at the Trillium Creek crossing under Calaroga Drive. City staff reports need for fish passagable culvert. Seperate planning effort proposed to coordinate with ODFW and determine fish passageability need.					X					X			
56	Increase System Capacity (Flood Control, 12" Concrete) Improve System Configuration	2006 CIP	Fairview Way to Vista Ct	Fern Creek	City previously replaced failing 12" pipe that crosses Fairview Way. The new 15" appears to have corrected the flooding problem, but may have relocated issue. All upstream pipes are 12" based on GIS and should be modeled prior to HWY 43 work. Project extents from node RW-CB-0144 on west side of HWY 43 to outfall RW-OF-0122 as DS pipe is 18". GIS updates needed.	X	X	X	X					X				
57	Improve System Configuraiton	2006 CIP	Trillium Creek at Cedar Oak Drive	Trillium Creek	The 2006 CIP list indicated three culverts under Cedar Oak Drive area fish crossings. City staff reports need for fish passagable culvert. Seperate planning effort proposed to coordinate with ODFW and determine fish passageability need.					X					X			

Table C-1. Stormwater Project Opportunity Matrix

Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Project Prioritization Information								Capital Improvement Plan Development				
						Flooding Issue	Hydraulic Modeling Need	TSP or Transportation-Related Driver	Recurring Maintenance Need	Special Interest	Private Property Considerations	Hwy 43 Impacts[a]	WQ Opportunity	Project (Capital)	Project (Planning/ Study)	Program	Policy Change	No Project/ Associated Program
58	Increase System Capacity (Flood Control, 27" Concrete) Improve System Configuration	2006 CIP	Robinwood Creek at Shady Hallow Drive	Robinwood Creek	Flooding has been reported at this location in the past. Two drainage ditches converge at this location and enter a culvert. It is unclear if the issue is maintenance of the ditches or culvert capacity. Site visit 3-6-18 indicates three pipes: 18" and 24" culverts and a 12" pipe that originate near HWY 43 (actual location could not be verified). No flooding reported in original problem area location. The culvert under HWY 43 discharges to ODOT ROW and daylights. Sand bags and a corrigated plastic pipe redirect the water south where a junction redirects the water via another corrigated plastic pipe. The outfall of the plastic pipe is unknown but appears to discharge to a space between two homes. Problem area is associated with Hwy 43 crossing. Problem likely addressed with Hwy 43 improvements. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location may not be warranted.	X			X			X						
59	Increase System Capacity (Flood Control, 24" Concrete)	2006 CIP	Sunset Creek at I-205 (2006 MP indicated under Willamette Falls Dr)	Willamette River	Reported capacity deficiency in 2006 MP (should be 30"). High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.	X	X							X				
60	Increase System Capacity (Flood Control, 24" CMP and Concrete)	2006 CIP	Kantara Way	Fern Creek	Reported capacity deficiency in 2006 MP (should be 30"). There is a water line crossing near this location and the culvert was connected to a piped creek so the water line could be installed.	X	X							X				
63	Increase System Capacity (Flood Control, 21" CMP)	2006 CIP	Maddox Creek at River Street	Maddox Creek	Flooding reported at this location. 2006 MP recommends 36" diameter pipe installed.	X	X							X				
64	Increase System Capacity (Flood Control, 18" Concrete)	2006 CIP	Lower Marylhurst Drive from Lower Midhill	Robinwood Creek	Reported capacity deficiency in 2006 MP. Current GIS indicates 24" CMP crossing at Highway 43 so may need to confirm pipe size. Problem likely addressed with Hwy 43 improvements. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location may not be warranted.	X						X						
66	Water Quality Retrofit	BC Water Quality Assessment	Willamette Park Parking Lot Retrofit	Willametter River	Limited water quality treatment in vicinity. Opportunity to treat a large square footage of impervious area on public property. City prefers use of pervious pavers, consistent with overflow lots.								X	X				
67	Water Quality Retrofit	BC Water Quality Assessment	Mary S. Young Park Parking Lots Retrofit	Willametter River	Limited water quality treatment in area. Opportunity to treat a large square footage of impervious area on public property. City prefers use of pervious pavers, consistent with overflow lots at other parks.								X	X				
68	Water Quality Retrofit	BC Water Quality Assessment	West Linn Public Works Department	Tanner Creek	Opportunity to incorporate water quality treatment to treat additional area not currently being treated. City identified opportunity to install a small rain garden along Norfolk Street frontage for parking lot at front of building. Project location referenced in Retrofit Assessment (2015).								X	X				
69	Water Quality Retrofit	BC Water Quality Assessment	Public Pond #18 (BC ID)	Bernert Creek	Retrofit existing public pond to enhance water quality treatment in areas of the City. This pond was installed in 1997, which is pre-2004 which was when the NPDES MS4 Permit Requirements for pond maintenance began. This pond is also located downstream of a vacant site. Retrofit in conjunction with development of adjacent parcel.								X	X				
70	Water Quality Retrofit	BC Water Quality Assessment	Public Pond # 22 (BC ID), 25545 Katherine Court	Tualatin River	Retrofit existing public pond to enhance water quality treatment in areas of the City that are not currently being treated. This pond was installed in 1999, which is pre-2004 which was when the NPDES MS4 Permit Requirements for pond maintenance began. This pond is also located downstream of vacant sites. Pond located upstream of outfall to the Willamette River.								X	X				
2	Improve System Condition	Staff Summary	3843 Mapleton	Trillium Creek	The staff summary indicates a corrigated metal pipe in poor condition. This pipe is privately owned but conveys Trillium Creek. Per City staff, this is a private property issue. Environmental overlays at the site would require fix with development. No project need.													X
3	Improve System Configuration	Staff Summary, Public Survey	Mapleton Drive/S side of Mapleton	Willamette River	The public survey and staff summary identified poor drainage and lack of infrastructure that causes houses to floods at the end of the cul-de-sac at Mapleton Drive. Per City staff, issue recently addressed. No project need.													X

Table C-1. Stormwater Project Opportunity Matrix

Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Project Prioritization Information								Capital Improvement Plan Development				
						Flooding Issue	Hydraulic Modeling Need	TSP or Transportation-Related Driver	Recurring Maintenance Need	Special Interest	Private Property Considerations	Hwy 43 Impacts[a]	WQ Opportunity	Project (Capital)	Project (Planning/ Study)	Program	Policy Change	No Project/ Associated Program
6	Improve System Configuration	Staff Summary 2006 CIP	Bolton Fire Station (old)	Bolton Creek	Sinkhole developed along Bolton Creek downstream of crossing under Hwy 43. Per site visit, sinkhole appeared disconnected from culvert conveyance. The 24-inch concrete pipe from Hwy 43 to the Failing St outfall to Bolton Creek was specifically mentioned in the 2006 CIP. Evaluation to confirm capacity of crossings under Hwy 43 to be conducted, but specific CIP need in this location is not warranted. No project need													X
8	Improve System Configuration	Staff Summary	Magone Ln, Tulane Street	Mary S. Young Creek	The staff summary indicates that runoff from Hwy 43 causes flooding on a private street (Magone Lane). Per City staff, given private road issue, no project need. High I&I reported in area (significant R value), indicating that high proportion of precipitation enters sanitary system.													X
9	Address Maintenance Need	Staff Summary	Marylhurst headwall (near 1694 Skye Parkway)	Robinwood Creek	The staff summary identifies a headwall is needed upstream of the portion of a culvert under Marylwood Ct for trash and debris control. Per City staff, location is not high risk. No project need.													X
14	Increase System Capacity	Staff Summary	4th Street culvert	Bernert Creek	The staff summary identifies an undersized culture at 4th Street (same locations as the 5th Avenue culvert - see Location ID 13). No project need.													X
17	Improve System Configuration	Staff Summary	Donegal Ct	Summerlinn Creek	The staff summary indicates a home floods at the end of a cul-de-sac. The home was built below the road grade and there is no existing catch basin on the property. Per City staff, improvements are in progress. No project need.													X
21	Improve System Configuraiton	Public Survey 2006 CIP	Skye Parkway and Stonehaven Drive	Arbor Creek	The public survey and the 2006 CIP list identified this location as an area of poor drainage. The 18-inch concrete pipe section upstream of Braemar Court was specifically mentioned in the 2006 CIP list. Per discussions with City staff, the stormwater conveyance system issues will be addressed as an inhouse project to install new curb inlets. No project need.													X
24	Improve System Configuration	Public Survey	Chinook Ct and Parker Rd (4709 Chinook Ct)	Tanner Creek	The Public Survey indicates ponding water near Chinook Ct and Parker Road. The roof drain associated with Chinook Court property is undersized. Per City staff, this is deemed a private property issue. No project need.													X
26	Improve System Configuration	Public Survey	Greene Street and Salamo Road	Bernert Creek	Identified flooding issue due to infrequent/undersized catchbasins on Greene Street and Salamo Street. This issue will be resolved through the Salamo Road project (per City staff), which is in progress. No project need.													X
27	Improve System Configuration	Public Survey	Pimlico between Hwy 43 and Summit	Mary S. Young Creek	The public survey indicated that there is a serious of poorly located catchbasins on Pimlico between Hwy 43 and Summit. Per City staff, there is a future sidewalk project in area and drainage will be evaluated then. No project need.													X
29	Erosion Prevention	Public Survey	Mary S Young Park at Mark Ln.	Mary S. Young Creek	The public survey reported stormwater runoff from Mark Lane is causing significant erosion above Mary's Creek. Project opportunity to retain/infiltrate runoff and/or add in a new stormwater pipe to bypass some of the stormwater from Mark Lane downstream of Mary's Creek. Project need addressed per Location ID #4. No additional project need.													X
30	Increase System Capacity	Public Survey	Hidden Springs Rd near Rosemont	Upper Tualatin River	Public survey results indicate poor drainage at Hidden Springs Road near Rosemont, possible due to undersized infrastructure. City staff have no reports of flooding. No project need.													X
31	Improve System Configuration	Public Survey	Suncrest Dr and Aztec Ct	Trillium Creek	The public survey indicates there is a deficiency in the number of catch basins at Suncrest Dr and Aztec Court. Per City staff, this is being addressed via an in house project. No project need.													X
33	Improve System Configuration	Public Survey	End of Maple Terrace cul-de-sac	Willamette River	The public survey indicates there are poorly located catchbasins at the end of Maple Terrace cul-de-sac. Per City staff, this is being addressed via an in house project. No project need.													X

Table C-1. Stormwater Project Opportunity Matrix

Location ID	Project Objectives	Project Source	Location	Major Basin	Project Background	Project Prioritization Information								Capital Improvement Plan Development				
						Flooding Issue	Hydraulic Modeling Need	TSP or Transportation-Related Driver	Recurring Maintenance Need	Special Interest	Private Property Considerations	Hwy 43 Impacts[a]	WQ Opportunity	Project (Capital)	Project (Planning/ Study)	Program	Policy Change	No Project/ Associated Program
34	Improve System Configuration	Public Survey	Hwy 43/Mary S Young Park entrance and Pimlico/Hwy 43	Trillium Creek	The public survey indicates pond water at the entrance of Mary S Young Park near Pimlico and Hwy 43. Per City staff, there is a future sidewalk project in area and drainage will be evaluated then. No project need.													X
38	Improve System Configuration	Public Survey	1255 Rosemont	Mary S. Young Creek	The public survey indicated that water doesn't flow into the catch basins located near 1255 Rosemont. Per City staff, Rosemont Road improvements will be resolving the issue. No project need.													X
39	Improve System Configuration	Public Survey	1715 and 1694 Marylhurst Drive	Robinwood Creek	The public survey indicates there was an alteration of the stormwater system at Robinwood Street corridor adjacent to a private property owner. The private property owner has encroached on the channel downstream of Location ID #9. Per City staff, deemed an enforcement issue. No project need.													X
41	Address Maintenance Need Repair Infrastructure	Staff Survey	Turkey Creek in Mary S Young Park	Willamette River	Replace culvert at Turkey Creek in Mary S Young Park and rebuild the trail that has been washed out. Design measure to slow down the stormwater runoff in this area to avoid further erosion of trail. Continue ongoing maintenance of culverts to ensure no blockage. Per Parks Department, repair is complete. No project need.													X
44	Erosion Prevention	Staff Survey	2181 Alpine Dr (Tanner Open Space)	Summerlinn Creek	The staff survey indicates the upper portion of Summerlinn Creek is channelized near the Tanner Open Space. Per City staff, the channel is normalizing and channel adjustment is not problematic. No project need.													X
46	Water Quality Retrofit	Staff Survey	821 Willamette Falls Drive	Tualatin River	The staff survey indicates that the existing causeways trap water near 821 Willamette Falls Drive and result in elevated temperatures during summer low flows. Per City staff, increased temperature is not a stormwater master planning objective. No project need.													X
50	Increase System Capacity Erosion Prevention	Hydromodification Assessment (017) 2006 CIP	Trillium Creek at Kenthorpe Way	Trillium Creek	The hydromodification assessment (017) and the 2006 CIP list identified bank erosion and limited channel capacity/culvert capacity at Trillium Creek at Kenthrope Way. Per City staff, there was a recent roadway project conducted in location and no project would be necessary in the near term. No project need.													X
51	Water Quality Retrofit	Hydromodification Assessment (006)	Stormwater pond at Bland Circle	Salamo Creek	The hydromodification assessment (006) results showed a potential opportunity to increase storage and flow control and enhance water quality treatment at a stormwater pond at Bland Circle. Per City staff, pond was recently retrofit with new development. No project need.													X
53	Erosion Prevention Increase System Capacity	Hydromodification Assessment (008)	Culvert at Theresa's Vineyard	Salamo Creek	The hydromodification assessment (008) results showed a bridge was not installed correctly and doesn't align with flow patterns at Theresa's vineyard. Per City staff, channel is normalizing and project is on private property. No project need.													X
55	Increase System Capacity (Flood Control, 15" CMP)	2006 CIP	Tanner Creek Park	Tanner Creek	Reported capacity deficiency in 2006 MP (should be 30"). There have been multiple complaints by park staff as the culvert is located under the walking path. Per Parks Department, repair is complete. No project need.													X
61	Increase System Capacity	2006 CIP	10th Street	Bernert Creek	The 2006 CIP list identified this as a project location; however there is no known flooding in the this area. The terrain is very flat and pipe ownership is unknown. Further issues may existing because of the close proximity to the road base. Per City staff, given ownership questions and no reported flooding, no project need.													X
62	Increase System Capacity (18" Concrete) Improve System Configuration	2006 CIP	Cottonwood Court	Gans Creek	The 2006 CIP list indicated a capacity deficiency (need for 24" pipe). Per discussion with City staff, system was reconfigured about 10 years ago to not be located under a house. An overflow was constructed in an existing manhole to reduce backwater conditions. No current issues. No project need.													X
65	Increase System Capacity	2006 CIP	Culvert Under Meadowview Court	Summerlinn Creek	The 2006 CIP List indicates the location of this project is downstream of the Johnson and Blankenship, which may warrant evaluation. No capacity deficiencies of the 60" CMP were reported in 2006. Per City staff, no separate project need.													X

Note: Gray highlighted rows reflect initially identified project needs that were determined after review by the City to be no longer applicable and do not warrant development of a project or program.

a. Project Opportunity Area may be affected by the OR43 Multimodal Transportation Project. Although project needs are confirmed, completion of the Project may impact project needs and solutions so no project is identified for this area.

Appendix D: TM3: Hydrology and Hydraulic Modeling Methods and Results

Technical Memorandum

6500 SW Macadam Avenue, Suite 200
Portland, OR 97239

T: 503.244.7005

Prepared for: City of West Linn

Project Title: Storm Drainage and Sanitary Sewer Master Plan

Project No.: 150752

Technical Memorandum #3

Subject: Hydrology and Hydraulic Modeling Methods and Results

Date: December 14, 2018 (Original)

March 5, 2019 (Updated)

To: Amy Pepper, P.E.

From: Ryan Retzlaff

Angela Wieland, P.E.

Prepared by: _____
Ryan Retzlaff

Reviewed by: _____
Angela Wieland, P.E.

This page intentionally left blank.

Table of Contents

Section 1: Introduction 1
Section 2: Stormwater Design Standards and Criteria 1
Section 3: Hydrologic Model Development 2
3.1 Subbasin Refinement 3
3.2 Width and Slope 4
3.3 Infiltration Conditions 4
3.4 Land Use and Impervious Percentage 4
3.5 Design Storms 5
Section 4: Hydraulic Model Development 6
4.1 Detailed Hydraulic Modeling Areas 6
4.1.1 Blankenship Road 6
4.1.2 Fairview Way 7
4.2 Capacity Evaluation Modeling Areas 7
4.3 Conveyance Naming Convention 8
4.4 Datum 8
4.5 Survey Needs 9
4.6 Hydraulic Input Parameters 9
4.6.1 Node Data 9
4.6.2 Conduit Data 9
4.6.3 Two-Dimensional (2-D) Model Input 10
4.6.4 System Routing 10
Section 5: Model Refinement and Results 10
5.1 Model Refinement 10
5.2 Hydrologic Model Results 11
5.3 Hydraulic Model Results 11
5.3.1 Capacity Hydraulic Modeling Evaluation 11
5.3.2 Detailed Hydraulic Modeling Evaluation 11
5.4 Proposed Capital Project Development 13
Section 6: References 14
Attachment A: Hydrologic and Hydraulic Model Results A-1
Attachment B: Figures B-1

List of Tables

Table 1. Drainage Criteria and Design Standards 2
Table 2. Major Watersheds Within West Linn 3
Table 3. Model Input Parameters for Horton Infiltration Method 4
Table 4. Modeled Land Use Categories and Impervious Percentages 5
Table 5. Design Storm Depths 6

List of Figures

Figure 1. Existing system analysis showing 2-D flooding for the 2-year 24-hour event 12
Figure 2. Existing system analysis showing 2-D flooding for the 10-year 24-hour event 12
Figure 3. Existing system analysis showing 2-D flooding for the 25-year 24-hour event 12

Section 1: Introduction

The City of West Linn (City) is developing a Storm Drainage Master Plan (SMP) to guide future stormwater program decisions. When finalized, the SMP will address both water quantity and quality issues for the constructed and natural systems under the City's management. Having a clear understanding of existing and future runoff conditions to identify long-term stormwater project needs will be essential.

This Technical Memorandum #3 (TM3) documents the methodology used to model hydrology and hydraulics for specific areas of concern in the city. TM3 is organized as follows:

Section 2: Outlines applicable stormwater design standards and criteria used to evaluate the performance of the storm drainage system.

Section 3: Outlines hydrologic model development.

Section 4: Outlines hydraulic model development.

Section 5: Outlines results of the modeling efforts, including proposed locations for the development of capital projects (CP).

The hydrology model was developed to evaluate peak flows generated by all subbasins within the city under existing and anticipated future development conditions. The hydrologic modeling results show that peak flows are expected to remain relatively constant in watersheds across the city, as most of the city is built out with limited areas of new development or expansion anticipated. The most significant flow increases are anticipated in the Bernert Creek watershed, where runoff is expected to increase by over 10 percent in select subbasins.

The hydraulic model results indicate flooding is expected in each system evaluated, starting at a 2-year design storm event. Specific locations modeled, including Blankenship Road, culvert crossings under Highway 43, and culverts identified by the City, are potentially problematic based upon historic complaints and/or identification completed as part of the City's 2006 Surface Water Master Plan (2006 Plan). The SMP will include capital projects to address system flooding identified in this TM.

Section 2: Stormwater Design Standards and Criteria

Brown and Caldwell (BC) reviewed the City's current Public Works Design Standards (PWDS) (Section 2, Storm Drain Requirements) to establish planning criteria relevant to the analysis of the City's stormwater system. The City's current standards went into effect October 2018 and reflect recommendations from Technical Memorandum 1 (TM1): Stormwater Basis of Design and Code Review.

While these planning criteria are typically applied to new infrastructure, they can also be used as the basis of design for the SMP. Table 1 lists the applicable planning criteria used to identify areas where West Linn's stormwater system has capacity limitations.

For additional details and background information on the City's design standards and planning criteria, refer to Section 2.2 of TM1.

Table 1. Drainage Criteria and Design Standards		
Criteria	**Source**	**Standard**
Water Quality Facility Design	PWDS 2.0013	• All water quality facilities shall meet the design requirements of the current edition of the City of Portland Stormwater Management Manual (SWMM).
	NPDES Phase I Permit, A.4.f.i	• Capture and treat 80% of the annual average runoff volume, identified in Clackamas County as the 1" over 24-hour design storm.
Water Quantity Facility Design	PWDS 2.0013	• Design to provide storage up to the 25-year storm event with safe overflow conveyance for the 100-year storm event. • Use a unit hydrograph method to evaluate existing and proposed conditions and restrict post-development discharge rates to pre-development discharge rates for the 2-, 10-, 25-, and 100-year events. • Minimum orifice size of 1.0".
Conveyance Piping Design	PWDS 2.0013	• Design to convey the 10-year storm event. • Minimum slope of 0.0055 (0.55%). • Minimum velocity of 2 feet per second, when flowing full. • Pipe roughness design coefficient shall not be less than 0.013.
Culvert Design	PWDS 2.0014	• Design to convey the 25-year storm event such that the headwater does not exceed 1.5 times the culvert diameter, or remains at least 1 foot below the roadway subgrade, whichever is lower. • 100-year storm event shall not overtop the roadway. • Allow for fish passage as required by the Oregon Division of State Lands, Army Corps of Engineers, and Oregon Division of Fish and Wildlife and/or the National Marine Fisheries Service. • Bottomless culverts shall be used whenever feasible.
Open Channel Design	PWDS 2.0013	• No design storm identified. • Control discharge so that the average velocity during the 10-year event is below the erosive velocity of the channel.
Pipe Size	PWDS 2.0012 PWDS 2.0033	• 12" minimum diameter for mains in the public right-of-way. • 10" minimum diameter for laterals to catch basins and other inlets. • Minimum 4" in diameter for service laterals.
Pipe Material	PWDS 2.0012	• Concrete, PVC, HDPE smooth interior/corrugated exterior are allowable. • Ribbed PVC is preferred for storm drains up to 24" in diameter. • Reinforced concrete is preferred for storm drains over 24" in diameter. • Ductile iron is allowed in areas where additional strength is required.
Pipe Cover	PWDS 2.0023	• Minimum cover shall be 30" above the top of the bell of the pipe in paved areas and 36" in all other locations. When minimum cover cannot be provided, implement additional strength measures.
Structure Spacing	PWDS 2.0031-2.0033	• Maximum of 500 feet between manholes. • Maximum of 400 feet between gutter inlets.

In addition to the design standards outlined in Table 1, the City's PWDS (2.0010) identifies that storm drain systems should be designed for ultimate development of all upstream tributary areas.

Section 3: Hydrologic Model Development

The hydrologic model was developed using XP-Storm Water Management Model (XPSWMM) version 2016.1. Within the model, the RUNOFF method was used to estimate hydrology. The necessary parameters for the RUNOFF Method include subbasin area, slope, width, infiltration conditions, and impervious percentage. The hydrology routine in XPSWMM converts rainfall into stormwater runoff based on design storm parameters

(e.g., volume and intensity of rainfall), the input parameters listed above, and the infiltration conditions of the soils, which are determined from soil type.

This section includes detailed descriptions of the methodology used in determining each of the hydrology model input parameters.

3.1 Subbasin Refinement

The purpose of the subbasin refinement effort is to update the City-provided major watershed and subbasin boundaries. This refinement was completed by using information collected during field surveys (see Section 4.5), updated conveyance information (based on city-provided Geographic Information System [GIS] mapping), and topography data (using LiDAR).

Watershed boundaries for 24 major watersheds, listed in Table 2, were provided by the City as a GIS shapefile.

Table 2. Major Watersheds Within West Linn

Arbor Creek	Mary S. Young Creek
Barlow Creek	McLean Creek
Bernert Creek	Robin Creek
Bolton Creek	Robinwood Creek
Cascade Springs Pond Creek	Salamo Creek
Dollar Creek	Summerlinn Creek
Fern Creek	Sunset Creek
Fritchie Creek	Tanner Creek
Gans Creek	Trillium Creek
Heron Creek	Tualatin River
Hidden Springs Creek	Upper Tualatin River
Maddax Creek	Willamette River

These watershed boundaries were defined based on topography and conveyance system routing. The watershed boundaries were refined using GIS to correlate with subbasin refinement, as described below. Watersheds range in size from 40 and 612 acres.

The City provided an initial subbasin delineation in GIS used for hydrologic modeling as part of the 2006 Plan. These subbasins generally correlated with the major watershed boundaries, except for a few areas. The initial subbasin delineation was refined based on as-built records, City staff feedback, and current GIS data indicating changes to the conveyance infrastructure since 2006. Select subbasins were also further subdivided to support detailed hydraulic modeling efforts (see Section 4.1). A total of 284 subbasins are defined for the city, ranging in size from 1.3 to 117 acres with an average area of 18.6 acres. The watershed and subbasin boundaries are shown in Attachment B, Figure B-1.

Each subbasin is named based on the City-provided watershed name. This naming convention is consistent with the initial subbasin delineation provided by the City. In cases where an existing subbasin was subdivided, a suffix of "-#" is added to the original name. For example, subbasin TAE was subdivided into subbasins TAE-1 and TAE-2. Subbasin names and subbasin areas calculated in GIS are listed in Attachment A, Table A-1.

3.2 Width and Slope

The RUNOFF method simplifies each subbasin into a rectangular shape based on the measured area, width and slope. To calculate width, BC generated longest flow path lines for each subbasin in GIS using contour lines, aerial imagery, and existing stormwater infrastructure layout. Subbasin areas were divided by the length of the longest flow path lines to obtain values for subbasin width.

Subbasin slopes were determined using ground elevations derived from LiDAR data. The difference between the maximum and minimum elevations along each longest flow path line was divided by the length to calculate slopes.

Use of the Santa Barbara Urban Hydrograph (SBUH) method was initially considered to estimate hydrology for the SMP, utilizing hydrologic data and assumptions developed for the 2006 Plan. However, little correlation was found between standard lag time (as calculated in the 2006 Plan) and time of concentration (as required for the SBUH method). Therefore, the RUNOFF method was selected to develop model hydrology. The RUNOFF method was selected due to relatively simple data needs, which could be determined based on the available data and relatively consistent results, when compared with SBUH.

3.3 Infiltration Conditions

Infiltration is largely dependent on the soil type of the subbasin and, to a lesser degree, on vegetation cover. West Linn soils are primarily comprised of hydrologic soil group C and D, which have low to minimal infiltration. The Horton infiltration method was used to estimate infiltration for each subbasin. The input parameters for this method have been determined based on the soil types and published average values.

A sensitivity analysis was conducted to determine how soil type affects runoff rates based on the Horton infiltration method. Subbasins with predominately Type B soils were observed to generate less runoff that subbasins with predominately C, C/D, and D soils. Two infiltration conditions, one reflecting Type B soils and one reflecting Type C, C/D, and D soils were established. Subbasins were classified based on the predominate soil type. The model input values used for the Horton method for West Linn are included in Table 3.

Table 3. Model Input Parameters for Horton Infiltration Method

Input Parameter	Type C, C/D, D Soils	Type B Soils
Maximum Infiltration (in/hr)	1.0	1.7
Minimum Infiltration (in/hr)	0.1	0.225
Decay (1/sec)	0.0015	0.0015
Maximum Infiltration Volume (in)	1	2

Figure B-2 in TM2 shows the topography and soils of the West Linn area.

3.4 Land Use and Impervious Percentage

The City does not maintain current land use coverage in GIS. Through coordination with the City, BC developed existing and future land use coverage based on zoning coverage, developable (vacant) lands coverage, and (undevelopable) parks and open space coverage.

The City provided GIS data representing City zoning coverage within the city limits. Zoning categories include commercial, industrial, low density residential, medium density residential, medium-high density residential, and mixed use. GIS data representing undevelopable open space including city parks, state parks, and

sensitive lands were merged with zoning coverage. Metro's 2016 vacant lands coverage and the City's 2013 buildable lands coverage were also merged with zoning to reflect vacant area with potential for development. The Oregon Department of Transportation (ODOT) corridor along Interstate 205 and Highway 43 was defined separately as transportation land use coverage.

City staff reviewed and refined the developable lands (vacant properties) based on current development conditions. The land use coverage was finalized in October 2017. A map reflecting land use coverage is available in TM2, Figure B-3.

To represent future land use conditions, all vacant lands are assumed to be developed in accordance with the City's zoning designation. Vacant area outside of the city limits without an established zoning designation are assigned a future land use category based on the comprehensive plan designation.

Impervious coverage by land use was provided by City staff based on values assumed in the 2006 Plan and compared with values used by neighboring jurisdictions. The provided impervious percentages by land use were verified by BC using aerial imagery for ten sample parcels. Impervious coverage for the ODOT corridor along Interstate 205 and Highway 43 was estimated by BC based on review of aerial imagery. Impervious percentage by land use is shown in Table 4.

Table 4. Modeled Land Use Categories and Impervious Percentages

Modeled Land Use Category	Impervious Percentage
Commercial	85
Industrial	85
Vacant	3
Open Space/Park	0
Mixed Use	85
Residential (High/Multi-family)	50
Residential (Medium)	35
Residential (Low)	30
Transportation (ODOT Corridor)	35

An area-weighted average impervious percentage by subbasin was calculated for both existing and future development conditions based on the contributing land use and associated impervious percentage. The existing and future impervious percentage for each subbasin is listed in Attachment A, Table A-1.

3.5 Design Storms

Design storms are precipitation patterns typically used to evaluate the capacity of storm drainage systems and design capital improvements for the desired level of service.

Design storms used for this study included the 2-, 10-, and 25-year recurrence interval 24-hour events. The rainfall depths were taken from Clean Water Services (CWS') *Design & Construction Standards*, Standard Detail Drawing No. 1280. Specific design storm depth is not codified in the City's PWDS. Given the proximity of CWS' jurisdiction to the city and more conservative values of the CWS design storms than defined design storms in neighboring jurisdictions, the CWS storm depths were used. The rainfall distribution for these design storms is based on a SCS Type IA, 24-hour distribution, which is applicable to western Oregon, Washington, and northwestern California.

Table 5 lists the design storm rainfall depths used in the hydrology model.

Table 5. Design Storm Depths

Design storm event	Rainfall depth, inches
2-year, 24-hour	2.50
10-year, 24-hour	3.45
25-year, 24-hour	3.90

Section 4: Hydraulic Model Development

To evaluate flood hazards and capacity limitations of stormwater infrastructure, the XPSWMM computer model was used to simulate the hydraulic performance of select pipe and open-channel systems to calculate peak flow, water surface elevation, and velocities within the modeled infrastructure for select design storms. The hydraulic model extents were discussed and verified with City staff on March 7, 2018.

Hydraulic model development is split into two categories: detailed hydraulic modeling and capacity hydraulic modeling. This section includes a summary of the two model categories, the hydraulic modeled areas, and input parameters used to characterize the hydraulic conditions of the modeled system. The location and extent of the hydraulic models are provided in Attachment B, Figures B-2 through B-5.

4.1 Detailed Hydraulic Modeling Areas

Detailed modeling refers to hydraulic modeling with multiple nodes and links, to evaluate performance of a collection system network. Hydraulic assessment of these areas also aids with development of capital projects (CIPs).

As described in TM2, two areas were identified as those that would benefit from a detailed hydraulic modeling assessment. These included Blankenship Road (Location ID 47) and Fairview Way (Location ID 56).

These areas were identified based on City- and stakeholder-reported flooding and the need for additional information to understand the potential cause of flooding.

4.1.1 Blankenship Road

City staff identified this location in staff surveys completed in September 2017. It was also included in the 2006 Plan CIP List. This area experiences frequent flooding. There is often standing water under the I-205 overpass on Blankenship Road during routine winter rainfall events. City Public Works staff frequently respond to flooding of the piped and open channel collection system and often place signage during the winter months alerting drivers to the potential for standing water during rain events.

The drainage system along Blankenship Road and under I-205 consists of a relatively flat pipe that conveys a large upstream drainage area from Blankenship Road, Debok Road, the Summerlinn apartment homes, and the east side of I-205. The hydraulic model developed for the Blankenship Road system includes the piped and open channel conveyance from Summerlinn Apartment Homes to the open channel along Johnson Road. Due to the reported flooding along Blankenship Road, a two-dimensional (2-D) model has been integrated along Blankenship Road to describe the roadway flooding. The 2-D model helps determine where the flooding is occurring, the extent of flooding, and how the flooding re-enters the collection system.

Starting from Debok Road, the conveyance system consists of 15-inch pipes to the I-205 underpass, transitioning to 24-inch pipes that drain to the outfall on the west side of I-205. At the transition from 15- to 24-inch pipe, an open channel draining the east side of the I-205 embankment connects to the piped system at Blankenship Road just east of I-205. At this same location, the slope of the drainage system flattens, and the existing collection system does not have sufficient capacity to convey the runoff, Runoff surcharges the piped collection system and exits the system from manholes and inlets, resulting in roadway flooding. There is a narrow open conveyance channel along the north side of Blankenship Road, under the I-205 overpass, which provides some relief capacity once the piped system begins to flood. However, due to varying grade and with limited capacity, the channel quickly becomes inundated and does not significantly alleviate the roadway flooding. All drainage along Blankenship Road discharges into a larger open channel conveyance along Johnson Road.

Attachment B, Figure B-5 shows the drainage area and hydraulic modeling extents specific for this area.

4.1.2 Fairview Way

City staff identified this location as having capacity and system configuration issues in staff surveys completed in September 2017. The drainage system along the east side of Highway 43 is characterized by ditches and closed conveyance systems, which drain east toward Robinwood Creek.

Based on field reconnaissance, feedback from City staff, and an initial system review in GIS, the primary drainage issues include undersized infrastructure and an unconventional system configuration that is primarily outside of public right-of-way. City maintenance staff recently completed repair work in this area, which includes replacing the 12-inch stormwater pipe crossing at Fairview Way with a 15-inch pipe.

The hydraulic model for the Fairview Way system includes the piped crossing under Highway 43 and the piped and open channel conveyance between Highway 43 and the crossing at Fairview Way. Attachment B, Figure B-2 shows the drainage area and hydraulic modeling extents specific for this area.

4.2 Capacity Evaluation Modeling Areas

Capacity evaluation modeling refers to the modeling of specific culverts, accounting for contributing upstream drainage areas but not modeling the upstream collection system. As described in TM2, five areas were identified as those that would benefit from a limited hydraulic modeling evaluation. These areas are summarized below.

Location ID 13–5th Avenue Culvert. This location consists of an undersized 36-inch culvert at 5th Avenue. The culvert conveys Bernert Creek, a tributary to the Willamette River in the southern portion of the city. This location was identified in staff surveys completed in September 2017 and it was included in the 2006 Plan CIP List.

The culvert has a sharp 90-degree bend just upstream of the entrance which creates hydraulic losses at the upstream end of the culvert. Downstream of the culvert, elevated flow velocities appear to be contributing to erosion of the channel banks, and there is an exposed sanitary force main operated by Water Environment Services (WES). The location of this culvert is provided in Attachment B, Figure B-5.

Location ID 59–Sunset Creek at Willamette Falls Drive. This location consists of an undersized 18-inch culvert at Willamette Falls Drive. City staff have not reported flooding in this location, but it was identified in the 2006 Plan CIP List. Most of the contributing drainage area is north of I-205 and predominantly residential. Runoff is routed under I-205 and then to Willamette Falls Drive via pipe and open channels. The culvert at Willamette Falls Drive is reported to be under capacity. The location of this culvert is provided in Attachment B, Figure B-4.

Location ID 60–Fern Creek at Kantara Way. This location consists of two 24-inch culverts and open channel conveyance in the northern portion of the City. The problem location is west of Highway 43 and has a relatively large contributing drainage area. City staff have not reported flooding in this location, but it was identified in the 2006 Plan CIP List. The culverts are configured in series and convey Fern Creek. Each culvert has a relatively small amount of freeboard and are separated by a short pool or open channel and have been reinforced with rip rap.

The system is steep and therefore experiences relatively high velocities. Due to the high velocity and resulting entrance loss, the culverts are undersized and overtop the freeboard. The location of the culverts is provided in Attachment B, Figure B-2.

Location ID 63–Maddox Creek at River Street. This location consists of an 18-inch and 24-inch culvert at River Street. City staff have not reported flooding in this location, but it was identified in the 2006 Plan CIP List. Additionally, the City's GIS information for this location is outdated. The GIS reflects an 18-inch culvert crossing, but based on field visits, a 24-inch culvert has been constructed more recently but information has not been updated in GIS.

The original 18-inch concrete culvert is full of sediment and appears inactive. The newer 24-inch culvert intercepts flow from further upstream in the open channel, resulting in a culvert much longer than the original 18-inch culvert. The 24-inch culvert has a headwall at the inlet and a splash block at the outlet. The newer culvert has been modeled to ensure there is capacity at this location. The approximate location of these culverts is provided in Attachment B, Figure B-3.

Highway 43 Crossings. Highway 43 (Willamette Drive) has 24 culvert crossings to convey drainage from the west side of the road to the east side, prior to discharge in the Willamette River. These crossings are labeled A-X in the Attachment B, Figures B-2 through B-5. The culverts vary in material, cover, and general condition. Some of the culverts convey tributary streams directly under Highway 43 while others convey local drainage and are connected to roadside ditches. The highway is generally unimproved with roadside ditches and segments with curb and gutter. As a result, some of the culverts have become filled or partially filled with sediment or blocked with debris.

The City and ODOT are initiating efforts to begin a roadway widening project on Highway 43. The City requested a capacity evaluation of existing culvert crossings to help inform project design and cost. For purposes of this evaluation, crossings have been divided into Phase 1 (culverts A through M) and Phase 2 (culverts N through X) in conjunction with the schedule for the roadway widening project.

4.3 Conveyance Naming Convention

Storm structures, including manholes, catch basins, ditch inlets, outfalls, tees, flow structures, and clean outs, are identified in the City's GIS database by their asset ID. The asset ID nomenclature includes XX-XX and a four-digit number. Typically, the first two characters in the ID are 'SL' while the second two are a description of the structure such as CB for catch basin or MH for manhole. The structure ID in the model is identical to the asset ID in the City's GIS database. The model links representing the conveyance system (pipes and open channels) do not follow the City's GIS naming convention.

Based on field survey results, and to accommodate flow routing and hydraulic modeling, links or nodes were added that did not previously exist in the City's GIS database. For these added features, and the links within the model, the default XPSWMM naming convention was used (e.g., Link43, Node68).

4.4 Datum

All data from the City including GIS, survey, as-builts, etc., are assumed to be in NAVD88.

4.5 Survey Needs

BC and City staff met March 7, 2018, to finalize survey needs for locations identified as requiring detailed or limited hydraulic modeling. Data collection tables reflecting required storm structure information (rim elevations, invert elevations, and size) were distributed for each modeling location. For open channel portions of the conveyance system, the data collection tables included cross section information needs including surveyed points reflecting the bottom width of the channel and the top width of the channel. Stormwater system features and cross section locations requiring surveying were presented in maps.

City staff completed the field surveys, QA/QC activities, and documentation on July 18, 2018; the information was provided to BC as a geodatabase for incorporation into the XP-SWMM model.

4.6 Hydraulic Input Parameters

Hydraulic input parameters include conduit (pipe or open channel) name, upstream (US) and downstream (DS) node information (name, invert elevation, rim elevation), conduit length, conduit slope, conduit shape, and pipe diameter. The following sections describe the model input parameters that were required for development of the hydraulic models.

Refer to Tables A-2 and A-3 in Attachment A to this TM3 for all conduit and node data applicable to each system model.

4.6.1 Node Data

Model node data including manholes, catch basins, outfalls, and other junction points, as defined in the City's GIS, were used to develop the models. The US and DS node names for each conduit were assigned using the naming convention provided by the City's GIS standards.

The rim elevation at each node location was assigned based on the City's GIS. Several rim elevations were missing in the City's GIS database and values were estimated based on LiDAR data. Field survey included the collection of rim elevations for structures where rim elevations were inconclusive from LiDAR or considered to be a critical data point.

US and DS invert elevations were extracted from node and conduit data in GIS. If invert information was missing or conflicting between the node and conduit attribute data, the invert data were collected via field survey.

4.6.2 Conduit Data

Modeled conduits include pipes, culverts, and open channels. The length of each modeled conduit was originally provided in the City's GIS. Because conduits were extended or combined with other segments as necessary to ensure continuity in the system, revised conduit lengths were directly calculated using GIS.

Conduit slopes were calculated in XPSWMM using the upstream and downstream node invert elevations and refined segment lengths.

Pipe diameters were obtained from the City's GIS or collected during field survey. For pipes where pipe diameters were not provided in GIS or could not be field-verified during the survey work, the diameter was assumed to be the same size as the pipe segment immediately upstream. This assumption provides a conservative estimate of hydraulic system capacity. Pipes were assumed to be circular in shape.

Most open channel cross-sections were obtained by field survey. Open channel segments not surveyed or used for flow routing purposes were assumed to be trapezoidal in shape with dimensions approximated based on measurements obtained during field visits or via aerial imagery.

Manning's roughness coefficient "n" is dependent on the surface material of pipes and open channels. All modeled pipes were concrete and assigned a roughness coefficient of 0.014. A roughness coefficient range of 0.027 to 0.045 was assigned to open-channel conduits based on field observations from aerial imagery. Open channels lined with shorter vegetation and dirt had lower roughness while open channels lined with large rocks and thick vegetation had values of Manning's "n" up to 0.045.

4.6.3 Two-Dimensional (2-D) Model Input

As described in Section 4.1.1, a 2-D hydraulic model was developed for Location ID47, Blankenship Road. The 2-D model was built with a base 1-D model, with inputs as described above to define the conveyance infrastructure. The 2-D model builds on this data to determine where water moves once out of the defined infrastructure. Additional input parameters necessary to define the 2-D model include following:

- LiDAR and a surface generated from the LiDAR
- Aerial imagery to define surface roughness
- Survey of specific locations within the 2-D hydraulic model boundary to ensure the constructed surface and 1-D hydraulic model elements are the same
- Site/field visits to understand the topography and localized drainage patterns.

4.6.4 System Routing

Only select portions of the City's conveyance system were hydraulically modeled to evaluate system flooding. To account for upstream subbasins that do not directly enter the modeled conveyance system but still contribute runoff to the modeled system, a simplified system routing was used. A simple pipe or open channel network was incorporated into the hydraulic model to mimic the upstream conveyance system and route flow downstream to the modeled system.

This approach was used for most of the modeled areas. The simple pipe network geometry is based on available GIS information and invert elevations as available and assumes a constant conveyance slope based on surface elevations. The hydraulic model results for the simple pipe networks and simplified routing are not included in model results tables.

Section 5: Model Refinement and Results

XPSWMM was used to simulate the 2-year, 10-year, and 25-year, 24-hour design events for current and future development conditions. Results of the hydrologic and hydraulic model simulations are tabulated in Attachment A, Table A-1 (for hydrology) and Tables A-2 and A-3 (for hydraulics).

5.1 Model Refinement

The hydrologic and hydraulic models were developed, and initial model results compared to City-reported flooding locations and field observations. Model validation information was anecdotal and general in nature and did not include specific flows or water surface elevations at structures within each of the hydraulic model areas. Therefore, model refinements instead of a model validation were performed by comparing initial model results with reported flooding areas and adjusting model parameters based on field observations to match reported flooding.

Due to limited information regarding the flooding extents and nature of the problem areas reported to or by city staff, small changes to the hydraulic models were made to align the modeled system with field observations where the system configuration based on GIS data does not match field observation.

5.2 Hydrologic Model Results

The hydrologic model results show minimal to no increases in future flows for subbasins that are nearly fully developed, such as those in the Arbor Creek, Barlow Creek, Fern Creek, McLean Creek and Tanner Creek watersheds. The watersheds with the largest increases in flow were, Fritchie Creek and Bernert Creek, as the contributing subbasins had more significant coverage of vacant land.

Results of the hydrologic simulations for all events and subbasins are tabulated in Attachment A, Table A-1. Results are displayed as maximum flows within each subbasin for each design storm. Attachment A, Table A-1 also provides the change in peak flow and percent increase in peak flow between the existing and future development conditions for each subbasin.

5.3 Hydraulic Model Results

The hydraulic model results show very little increases in future flows for the modeled areas that are fully developed. The model results confirm the problem areas/capacity limited areas identified by City staff or identified in the 2006 Plan and provide additional information about potential sources of the problems.

Hydraulic modeling results are tabulated in Attachment A, Tables A-2 and A-3. Results are displayed as the maximum water surface elevation and maximum peak flows for existing and future conditions for each modeled conduit.

5.3.1 Capacity Hydraulic Modeling Evaluation

The limited hydraulic model results are summarized in Attachment A, Table A-2. Model results include the maximum water surface elevation and flow at each design event. Flooding was identified for culverts based on whether the headwater is above 1.5 times the culvert diameter (see Table 1). The secondary design criteria (headwater is less than 1 foot below the roadway subgrade) was evaluated, but not used to determine system deficiencies due to questionable survey results reflecting the roadway profile. Instead, if culverts were identified as deficient based on the secondary design criteria, the culverts were analyzed to determine if they were free-flowing or inlet controlled. If free-flowing, no hydraulic deficiency was identified.

Each culvert evaluated for capacity limitations (excluding the Highway 43 culverts) are deficient for the 2-year existing design storm. 13 of the 24 Highway 43 culverts are deficient for the 2-year, 10-year, or 25-year design events.

The design storm and design criteria reflecting the modeled flooding is identified in Attachment A, Table A-2. Model results for the Highway 43 culverts are provided in Attachment B, Figures B-8 and B-9.

5.3.2 Detailed Hydraulic Modeling Evaluation

The detailed hydraulic model results are summarized in Attachment A, Table A-3. Model results include the maximum water surface elevation and flow at each design event. For the pipe system, flooding was identified when water exits the closed conveyance system. In the open channel system, flooding was identified when the maximum water surface elevation at any modeled node was equal to or greater than the ground elevation of the node, which implies that flow is overtopping the bank. In areas where flooding occurs and stormwater would exit a pipe or overtop an open channel, the model was configured to ensure no system losses, and that all water exiting the system would be routed back into the system immediately downstream of the flooded location. This modeling approach more accurately simulates real-world channel and pipe conditions and eliminates water loss from the system.

A summary of the detailed hydraulic model results by system is described below.

5.3.2.1 Blankenship Road at I-205 – Location ID 47

The hydraulic model shows that the piped and open channel conveyance system is under capacity, resulting in flooding west of the intersection of Blankenship Road and Debok Road.

Figures 1, 2, and 3 show the extent of system flooding during the 2-, 10- and 25-year event. These figures reflect the 2-D model output. The model results show flow leaving the system and flowing across Blankenship Road to the entrance of the Willamette Terrace Apartments and continuing downhill. This drainage pattern has not been reported by City staff.

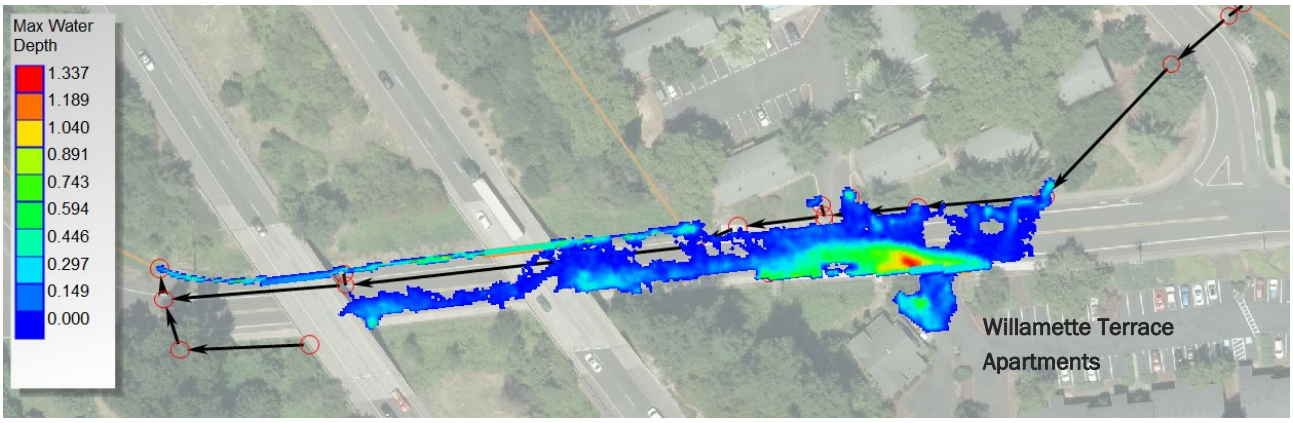


Figure 1. Existing system analysis showing 2-D flooding for the 2-year 24-hour event

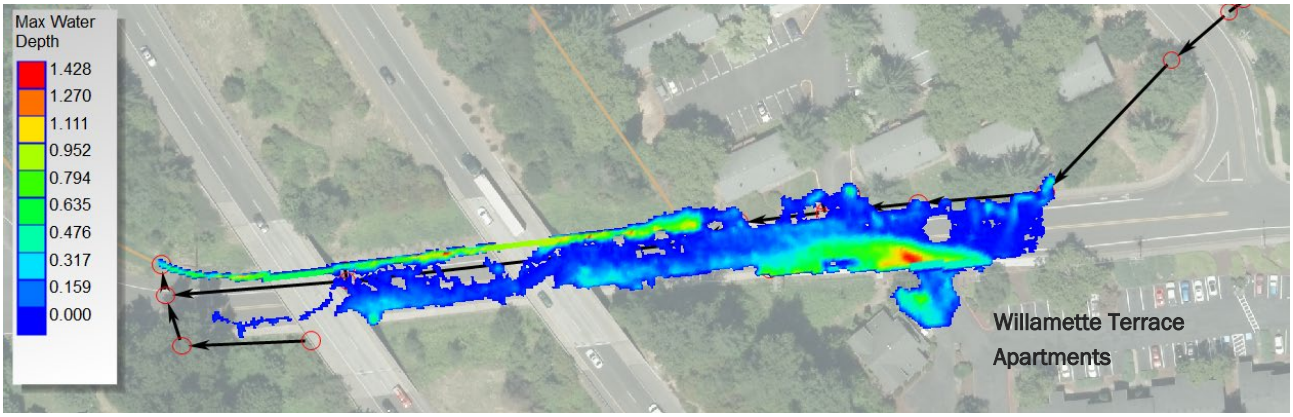


Figure 2. Existing system analysis showing 2-D flooding for the 10-year 24-hour event

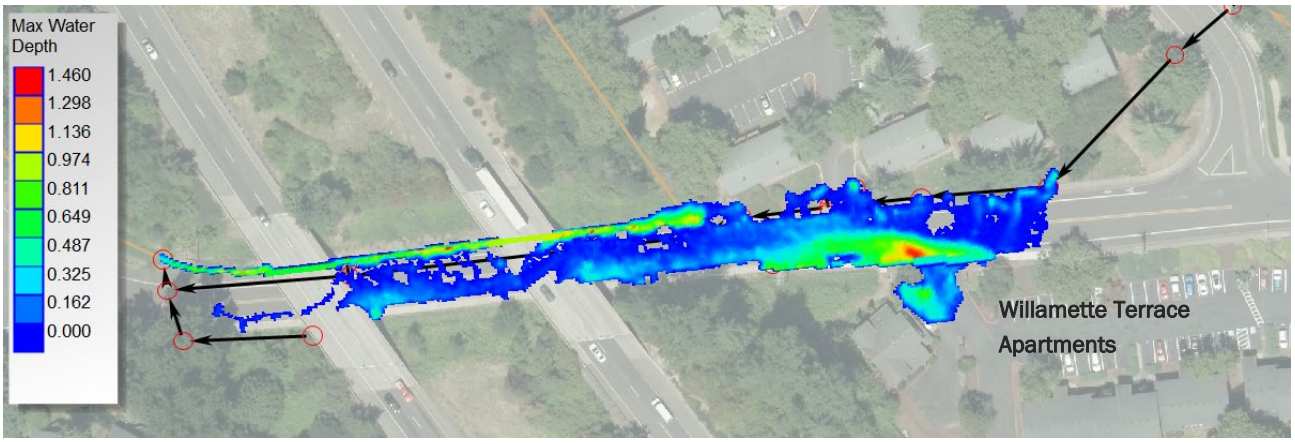


Figure 3. Existing system analysis showing 2-D flooding for the 25-year 24-hour event

The piped collection system remains surcharged to the west side of Interstate 205 where it discharges into an open channel. As seen in the figures below, Blankenship Road experiences flooding during each design event. The surface flows drain to the shallow channel on the north side of the Blankenship Road prior to discharge in the downstream open channel along Johnson Road. Model results along Blankenship in the proximity of Interstate 205 correspond to reported flooding by City staff. Flooding is due to the piped system being under capacity and the relatively flat grade until the west side of I-205 where the conveyance system is surcharged but not flooding.

The design storm and design criteria reflecting the modeled flooding is identified in Attachment A, Table A-3. In a few locations, the model is showing negative max flow values, which are related to the minor reversals of flow due to the system flooding and surcharge and are not reflective of the ongoing or actual flow occurring in the system. Notable instances are footnoted in Table A-3.

5.3.2.2 Fairview Way – Location ID 56

The hydraulic model shows flooding in select pipes in this system beginning at the 10-year design event.

The overall system has adequate slope (average of approximately 4 percent). However, model results indicate velocities in the piped system approaching 10 ft/sec, which can result in hydraulic loses when the conveyance system transitions to or from open channels to pipe. Flooding is reported in Link 3, which is the transition from open channel to pipe under Vista Court. The open channel (Link 2) and pipe (Link 3) are relatively shallow and there is not enough capacity in the pipe or freeboard at the entrance to the pipe, resulting in system flooding. Downstream, the piped system does not have capacity despite the relatively high slopes and velocities. At Link 11 the system empties into an open channel which is much deeper than the upstream system. From this point downstream, the system does not appear to have any capacity issues.

The design storm and design criteria reflecting the modeled flooding is identified in Attachment A, Table A-3.

5.4 Proposed Capital Project Development

For the culverts evaluated as part of the capacity hydraulic modeling evaluation, capital projects will be developed to address capacity deficiencies where the hydraulic model reflects flooding under existing development conditions. As an exception, a capital project will not be developed for Location ID 60. This area was reviewed with the City and given that this system is located in a ravine with no reported flooding or potential for property damage, a capital project is not proposed.

For the Blankenship Road area (Location ID 47), capital project alternatives will be developed to address capacity deficiencies within this modeled system. Site constraints affecting CP development include the significant I-205 overpass abutments and the shallow system configuration.

For the Fairview Way area (Location ID 56), a capital project will be developed to address capacity deficiencies within this modeled system. The capital project will address capacity deficiencies and realign the system in public right of way.

Section 6: References

City of West Linn Transportation System Plan. March 2016.

Brown and Caldwell. 2015. *Hydromodification Assessment prepared for the City of West Linn*. June.

Clean Water Services. Storm*water and Grading Design Standard*s. March 2017.

ODOT. Region 1 District 2B. Oswego Highway No. 3. Culvert Inventory

Soil Conservation Service (SCS). 1986. *Urban Hydrology for Small Watersheds*, Technical Release 55. June.

West Linn Community Development Code (CDC), Chapter 55 Design Review, Chapter 56 Parks and Natural Area Design Review, and Chapter 92 Required Improvements

West Linn Municipal Code (WLMC), Chapter 4 Utilities, Chapter 5 Nuisances, and Chapter 8.105 Building Permittee Responsible for Erosion Prevention and Sediment Control

West Linn Public Works Design Standards (PWDS), Section 2, Storm Drain Requirements. September 2018.

West Linn Public Works Standard Construction Specifications, Division 6, Storm Drain Technical Requirements

West Linn. *Retrofit Plan.* July 2015.

West Linn. *Transportation System Plan*. March 2016.

Misc Contracts and Agreements No. 32379. Cooperative Maintenance Agreement.

Misc Contracts and agreements No. 32348. Local Agency Agreement. July 2017

Attachment A: Hydrologic and Hydraulic Model Results

This page intentionally left blank.

Attachment A. Table A-1: Hydrology Parameters and Model Results																		
Basin ID	Area (acres)	Width (ft)	Slope (ft/ft)	Existing Impervious Percentage	Future Impervious Percentage	Existing Land Use			Future Land Use			Future Land Use			Future Land Use		
						Maximum Flow (cfs)			Maximum Flow (cfs)			Absolute Increase in Maximum			Percent Increase in Maximum Flow		
						2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr
Arbor Creek																	
AR1	1.9	264.3	0.04	30.0	30.0	0.9	1.4	1.6	0.9	1.4	1.6	0.0	0.0	0.0	0.0	0.1	0.0
AR2	15.3	365.4	0.05	30.0	30.0	4.6	9.6	11.4	4.6	9.6	11.4	0.0	0.0	0.0	0.0	0.0	0.0
AR2S	9.5	474.6	0.07	30.0	30.0	3.7	6.7	7.8	3.7	6.7	7.8	0.0	0.0	0.0	0.0	0.0	0.0
AR2S1	10.6	472.2	0.05	29.6	30.0	3.9	7.3	8.5	3.9	7.3	8.5	0.0	0.0	0.0	0.5	0.2	0.2
AR3	15.8	458.4	0.06	24.3	24.3	4.7	10.0	11.8	4.7	10.0	11.8	0.0	0.0	0.0	0.0	0.0	0.0
AR3N1	2.2	412.0	0.10	30.0	30.0	1.1	1.7	1.9	1.1	1.7	1.9	0.0	0.0	0.0	0.0	0.0	0.0
AR3N2	19.4	527.1	0.11	21.8	31.8	6.1	12.7	14.9	7.0	13.2	15.4	0.9	0.5	0.5	15.0	4.3	3.3
AR3N3	7.8	538.2	0.20	29.9	30.0	3.6	5.8	6.6	3.6	5.8	6.6	0.0	0.0	0.0	0.1	0.1	0.0
AR4	7.1	236.0	0.08	34.1	34.4	2.7	4.9	5.7	2.7	4.9	5.7	0.0	0.0	0.0	0.3	0.1	0.1
AR5	15.9	439.7	0.19	24.6	30.8	5.7	10.9	12.7	6.1	11.1	13.0	0.4	0.2	0.3	7.4	2.2	2.2
AR5N	4.9	319.6	0.10	33.1	34.7	2.2	3.6	4.2	2.2	3.7	4.2	0.0	0.0	0.0	1.1	0.4	0.4
AR5N1	10.3	395.9	0.18	28.0	28.8	4.2	7.4	8.5	4.2	7.4	8.5	0.0	0.0	0.0	0.6	0.2	0.2
AR5N1W1	49.9	816.4	0.13	29.7	29.8	15.2	31.6	37.4	15.2	31.6	37.4	0.0	0.0	0.0	0.2	0.1	0.0
AR5N2	3.6	247.3	0.21	16.9	25.4	1.6	2.6	3.0	1.6	2.7	3.1	0.1	0.0	0.0	4.9	1.8	1.5
AR5N3	16.1	773.4	0.12	23.9	23.9	6.4	11.4	13.2	6.4	11.4	13.2	0.0	0.0	0.0	0.0	0.0	0.0
AR5N4	20.0	639.1	0.08	25.9	25.9	6.6	13.3	15.5	6.6	13.3	15.5	0.0	0.0	0.0	0.0	0.0	0.0
AR6	8.3	349.1	0.24	11.9	24.5	3.1	5.7	6.7	3.5	6.0	6.9	0.4	0.2	0.2	11.5	4.0	3.2
AR7	12.6	488.7	0.10	23.8	25.2	4.5	8.6	10.0	4.6	8.7	10.1	0.1	0.0	0.1	1.7	0.5	0.5
AR7N	3.5	139.7	0.12	29.8	29.8	1.4	2.5	2.9	1.4	2.5	2.9	0.0	0.0	0.0	0.0	0.0	0.0
AR8	11.3	529.2	0.07	29.8	29.8	4.4	7.9	9.2	4.4	7.9	9.2	0.0	0.0	0.0	0.0	0.0	0.0
AR9	21.3	501.2	0.06	27.0	27.0	6.2	13.3	15.8	6.2	13.3	15.8	0.0	0.0	0.0	0.0	0.0	0.0
Barlow Creek																	
BA1	1.7	130.4	0.08	29.4	29.4	0.8	1.3	1.5	0.8	1.3	1.5	0.0	0.0	0.0	0.0	0.0	0.0
BA2	18.7	426.3	0.08	27.6	28.3	5.7	11.9	14.1	5.8	12.0	14.2	0.1	0.1	0.0	1.2	0.4	0.3
BA2S	18.8	482.9	0.10	30.1	30.4	3.3	6.6	9.5	3.4	6.7	9.5	0.1	0.1	0.0	3.0	1.5	0.0
BA3	15.0	416.0	0.03	30.3	30.6	4.2	9.0	10.8	4.3	9.0	10.8	0.0	0.0	0.0	0.5	0.2	0.1
BA4	9.6	474.7	0.21	25.9	28.4	4.2	7.0	8.1	4.2	7.1	8.1	0.1	0.0	0.0	1.7	0.6	0.5
BA4-1	6.1	339.5	0.02	30.0	30.0	2.1	4.1	4.8	2.1	4.1	4.8	0.0	0.0	0.0	0.0	0.0	0.0
BA5	9.2	481.3	0.15	19.0	19.7	1.0	3.5	5.3	1.1	3.5	5.3	0.1	0.0	0.0	10.0	0.0	0.0
BA6	27.7	516.6	0.09	28.6	28.6	8.2	17.4	20.6	8.2	17.4	20.6	0.0	0.0	0.0	0.0	0.0	0.0
BA7	16.0	453.6	0.13	21.4	21.4	5.2	10.7	12.4	5.2	10.7	12.4	0.0	0.0	0.0	0.0	0.0	0.0
BA7S1	7.2	275.9	0.07	28.9	29.8	2.6	4.9	5.7	2.7	5.0	5.8	0.0	0.0	0.0	1.2	0.3	0.4
BA8	32.1	582.5	0.04	22.8	30.0	7.4	17.3	21.3	8.5	18.4	22.4	1.2	1.2	1.1	15.9	6.6	5.1
Bernert Creek																	
BE1	18.00	404.23	0.05	28.09	59.34	5.05	10.89	13.05	7.59	12.70	14.67	2.54	1.81	1.62	50.34	16.65	12.41
BE2	51.24	1003.06	0.02	42.88	62.27	15.67	30.59	36.70	19.60	33.72	39.42	3.93	3.14	2.72	25.06	10.25	7.40
BE2W1	70.14	1154.06	0.04	24.83	31.12	16.25	37.38	46.10	18.46	39.62	48.21	2.21	2.23	2.11	13.58	5.98	4.58
BE3	18.55	499.86	0.10	32.32	40.70	6.61	12.60	14.66	7.31	13.01	15.06	0.71	0.40	0.40	10.68	3.21	2.73
BE3N1	48.65	934.42	0.11	33.97	34.67	16.37	32.13	37.69	16.53	32.25	37.79	0.16	0.11	0.10	1.00	0.35	0.27
BE3N2	34.06	578.77	0.07	23.89	28.33	8.47	19.40	23.59	9.25	20.11	24.24	0.78	0.71	0.66	9.18	3.67	2.79
BE4-1	32.03	416.17	0.03	49.99	51.30	9.59	18.07	21.81	9.74	18.23	21.95	0.15	0.15	0.14	1.61	0.85	0.63
BE4-2	9.33	334.67	0.03	32.96	32.96	3.03	6.06	7.14	3.03	6.06	7.14	0.00	0.00	0.00	0.00	0.00	0.00
BE4N1	6.91	271.41	0.14	26.21	26.21	2.69	4.86	5.64	2.69	4.86	5.65	0.00	0.00	0.00	0.00	0.00	0.02
BE5	26.76	563.36	0.14	25.16	25.40	8.47	17.48	20.53	8.50	17.50	20.55	0.03	0.02	0.02	0.38	0.12	0.09
BE5S1	20.01	357.12	0.02	74.40	74.46	8.03	13.06	15.16	8.03	13.06	15.16	0.00	0.00	0.00	0.05	0.02	0.01

Attachment A. Table A-1: Hydrology Parameters and Model Results																	
Basin ID	Area (acres)	Width (ft)	Slope (ft/ft)	Existing Impervious Percentage	Future Impervious Percentage	Existing Land Use			Future Land Use			Future Land Use			Future Land Use		
						Maximum Flow (cfs)			Maximum Flow (cfs)			Absolute Increase in Maximum			Percent Increase in Maximum Flow		
						2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr
BE5W	21.46	862.53	0.03	56.19	56.19	9.37	15.47	17.78	9.37	15.47	17.78	0.00	0.00	0.00	0.00	0.00	0.00
BE5W1	23.58	631.68	0.06	32.24	32.24	7.82	15.52	18.21	7.82	15.52	18.21	0.00	0.00	0.00	0.00	0.01	0.00
BE5W1N1	7.87	423.89	0.05	84.69	84.69	4.29	6.16	7.02	4.29	6.16	7.02	0.00	0.00	0.00	0.00	0.00	0.00
BE5W1N1W	9.50	210.81	0.05	66.69	66.69	4.27	6.82	7.84	4.27	6.82	7.84	0.00	0.00	0.00	0.00	0.00	0.00
BE5W1N2-1	15.77	363.01	0.07	34.26	48.79	5.18	10.27	12.09	6.23	10.98	12.72	1.05	0.70	0.63	20.36	6.85	5.23
BE5W1N2-2	8.98	361.75	0.15	68.66	84.98	4.73	7.03	8.01	5.02	7.13	8.11	0.29	0.10	0.10	6.18	1.39	1.21
BE5W1S	21.41	550.38	0.04	31.82	31.95	6.44	13.34	15.87	6.45	13.35	15.88	0.01	0.01	0.01	0.22	0.09	0.06
BE5W1S1	22.68	464.81	0.02	31.11	31.67	5.77	12.42	15.20	5.83	12.48	15.26	0.06	0.06	0.06	1.06	0.50	0.39
BE5W2	11.96	526.59	0.02	43.29	43.29	4.61	8.29	9.61	4.61	8.29	9.61	0.00	0.00	0.00	0.00	0.00	0.00
BE5W3	21.99	632.15	0.06	30.71	30.71	7.27	14.49	17.00	7.27	14.49	17.00	0.00	0.00	0.00	0.00	0.00	0.00
BE6	28.38	505.71	0.13	21.24	48.79	7.75	17.42	20.79	11.48	19.97	23.08	3.73	2.54	2.29	48.17	14.60	11.01
BE7	15.60	291.98	0.08	29.67	30.21	4.57	9.64	11.50	4.61	9.68	11.53	0.04	0.04	0.03	0.94	0.36	0.28
BE8	25.60	534.32	0.10	28.95	28.96	8.04	16.52	19.48	8.04	16.52	19.48	0.00	0.00	0.00	0.01	0.00	0.01
BE9	8.75	313.98	0.09	29.73	29.73	3.26	6.05	7.04	3.26	6.05	7.04	0.00	0.00	0.00	0.00	0.00	0.00
BE9N	3.60	252.10	0.11	30.00	30.00	1.60	2.65	3.05	1.60	2.65	3.05	0.00	0.00	0.00	0.00	0.00	0.00
Bolton Creek																	
BO1	14.30	417.48	0.09	25.42	28.48	4.71	9.50	11.10	4.92	9.62	11.22	0.21	0.13	0.11	4.42	1.33	1.03
BO2	14.35	520.28	0.08	36.27	37.39	5.69	10.11	11.75	5.76	10.16	11.79	0.07	0.05	0.04	1.19	0.46	0.37
BO3	6.71	302.28	0.06	31.84	32.46	2.55	4.66	5.42	2.57	4.67	5.43	0.02	0.01	0.01	0.71	0.19	0.20
BO3S1	4.64	563.72	0.25	28.38	30.85	2.28	3.49	4.00	2.31	3.50	4.01	0.03	0.02	0.01	1.14	0.46	0.38
BO4	15.40	454.25	0.14	31.79	33.00	5.90	10.73	12.49	5.98	10.78	12.54	0.08	0.06	0.05	1.36	0.52	0.42
BO5	12.47	523.04	0.16	31.54	31.68	2.30	5.50	7.80	2.40	5.50	7.80	0.10	0.00	0.00	4.35	0.00	0.00
BO6	13.53	310.87	0.10	30.00	30.00	4.44	8.90	10.44	4.44	8.90	10.44	0.00	0.00	0.00	0.00	0.00	0.00
BO7	8.91	385.28	0.11	25.09	25.09	3.43	6.25	7.25	3.43	6.25	7.25	0.00	0.00	0.00	0.00	0.00	0.00
BO8	13.32	457.55	0.10	30.00	30.00	4.98	9.21	10.71	4.98	9.21	10.71	0.00	0.00	0.00	0.00	0.00	0.00
Cascade Springs Pond Creek																	
CS1	1.77	157.47	0.06	25.36	29.99	0.76	1.29	1.49	0.79	1.31	1.50	0.03	0.02	0.01	3.28	1.24	1.01
CS2	16.54	390.84	0.05	39.60	40.74	5.60	10.79	12.71	5.69	10.86	12.77	0.09	0.07	0.06	1.57	0.61	0.47
CS2N1	16.50	482.55	0.07	65.01	65.01	7.93	12.25	14.08	7.93	12.25	14.08	0.00	0.00	0.00	0.00	0.00	0.00
CS3	5.47	282.05	0.07	41.27	41.89	2.41	4.03	4.63	2.42	4.03	4.64	0.01	0.01	0.01	0.50	0.20	0.15
CS4	20.45	499.57	0.05	32.10	32.36	6.29	12.91	15.32	6.32	12.93	15.34	0.03	0.02	0.02	0.41	0.16	0.13
Dollar Creek																	
DO1	3.75	119.44	0.06	30.02	30.13	1.25	2.48	2.91	1.25	2.49	2.91	0.00	0.00	0.00	0.16	0.04	0.03
DO1N	24.53	508.68	0.04	18.07	29.91	5.20	12.97	16.05	6.71	14.42	17.40	1.51	1.45	1.35	29.07	11.15	8.40
DO2	10.85	368.67	0.02	34.97	34.97	3.30	6.72	8.01	3.30	6.72	8.01	0.00	0.00	0.00	0.00	0.00	0.00
DO2S	21.52	398.94	0.02	29.97	30.26	5.06	11.04	13.68	5.09	11.07	13.71	0.03	0.03	0.03	0.59	0.29	0.23
DO3	23.72	642.92	0.01	30.00	30.00	5.89	12.83	15.75	5.89	12.83	15.75	0.00	0.00	0.00	0.00	0.00	0.00
DO3N	8.00	209.29	0.02	29.94	30.00	2.13	4.59	5.57	2.13	4.60	5.57	0.00	0.00	0.00	0.09	0.07	0.04
Fern Creek																	
FN1	31.74	437.01	0.05	30.00	30.00	7.98	17.36	21.27	7.98	17.36	21.27	0.00	0.00	0.00	0.00	0.00	0.00
FN2	9.27	408.46	0.05	29.52	29.52	3.33	6.33	7.35	3.33	6.33	7.35	0.00	0.00	0.00	0.00	0.00	0.00
FN3	13.99	418.88	0.04	16.37	16.37	3.27	8.03	9.75	3.27	8.03	9.75	0.00	0.00	0.00	0.00	0.00	0.00
FN4	11.60	328.13	0.03	29.67	30.00	3.26	6.97	8.37	3.28	6.99	8.38	0.02	0.02	0.02	0.58	0.24	0.18
FN4N	13.46	372.26	0.05	38.80	38.80	4.85	9.11	10.62	4.85	9.11	10.62	0.00	0.00	0.00	0.00	0.00	0.00
FN5	3.66	169.57	0.03	82.17	82.17	1.91	2.75	3.14	1.91	2.75	3.14	0.00	0.00	0.00	0.00	0.00	0.00
FN6	18.67	520.42	0.08	30.34	33.15	6.39	12.51	14.60	6.64	12.66	14.74	0.25	0.15	0.14	3.90	1.22	0.94

Attachment A. Table A-1: Hydrology Parameters and Model Results																	
Basin ID	Area (acres)	Width (ft)	Slope (ft/ft)	Existing Impervious Percentage	Future Impervious Percentage	Existing Land Use			Future Land Use			Future Land Use			Future Land Use		
						Maximum Flow (cfs)			Maximum Flow (cfs)			Absolute Increase in Maximum			Percent Increase in Maximum Flow		
						2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr
FN7	25.66	536.99	0.13	16.97	16.97	6.92	15.89	18.91	6.92	15.89	18.91	0.00	0.00	0.00	0.00	0.00	0.00
FN8	24.16	557.72	0.13	27.01	27.59	7.93	15.98	18.71	8.00	16.03	18.75	0.07	0.04	0.04	0.86	0.27	0.21
FN9	27.72	708.19	0.13	28.10	28.10	9.61	18.72	21.79	9.61	18.72	21.79	0.00	0.00	0.00	0.00	0.00	0.00
FNA	44.40	928.46	0.05	27.46	27.46	12.10	26.40	31.78	12.10	26.40	31.78	0.00	0.00	0.00	0.00	0.00	0.00
Fritchie Creek																	
FR1	1.36	171.01	0.01	19.45	30.00	0.48	0.93	1.08	0.54	0.96	1.12	0.06	0.04	0.04	12.24	3.99	3.61
FR1S1	9.19	319.27	0.05	30.23	32.19	3.08	6.10	7.14	3.17	6.16	7.19	0.09	0.06	0.05	2.79	0.92	0.70
FR1S2	29.27	477.86	0.12	21.35	30.20	7.64	17.49	21.02	8.96	18.55	21.98	1.33	1.06	0.96	17.35	6.05	4.58
FR1S3	32.94	550.47	0.11	26.29	30.00	9.33	20.23	24.15	9.95	20.72	24.60	0.62	0.49	0.45	6.62	2.44	1.86
FR2	17.20	557.96	0.06	31.29	32.48	5.89	11.51	13.44	5.99	11.57	13.50	0.10	0.06	0.06	1.66	0.54	0.42
FR3	47.64	694.24	0.06	27.56	30.04	12.00	26.65	32.51	12.59	27.22	33.05	0.59	0.58	0.54	4.93	2.17	1.66
FR3N1	10.73	534.26	0.21	30.00	30.00	4.78	7.91	9.09	4.78	7.91	9.09	0.00	0.00	0.00	0.00	0.00	0.00
FR3S	22.50	390.34	0.08	21.22	30.17	5.51	12.92	15.68	6.55	13.82	16.50	1.04	0.90	0.83	18.83	6.98	5.28
FR3S1	29.61	654.83	0.15	22.61	30.01	9.23	19.31	22.67	10.28	19.96	23.26	1.05	0.66	0.59	11.40	3.39	2.60
FR3S2	11.31	422.01	0.06	45.67	49.10	4.77	8.12	9.40	4.93	8.21	9.49	0.16	0.10	0.09	3.29	1.18	0.95
FR4	48.48	1083.96	0.19	30.00	30.00	17.47	33.13	38.46	17.47	33.13	38.46	0.00	0.00	0.00	0.00	0.00	0.00
FR5	59.75	956.26	0.07	30.00	30.00	16.52	35.39	42.63	16.52	35.39	42.63	0.00	0.00	0.00	0.00	0.00	0.00
ST1	31.47	537.06	0.08	30.00	30.00	9.16	19.34	23.09	9.16	19.34	23.09	0.00	0.00	0.00	0.00	0.00	0.00
ST2	42.84	699.80	0.04	30.00	30.00	10.79	23.49	28.76	10.79	23.49	28.76	0.00	0.00	0.00	0.00	0.00	0.00
Gans Creek																	
GS1	6.28	238.39	0.05	30.00	30.00	2.19	4.24	4.94	2.19	4.24	4.94	0.00	0.00	0.00	0.00	0.00	0.00
GS2	9.87	307.42	0.04	32.83	33.23	3.21	6.41	7.55	3.22	6.43	7.57	0.02	0.01	0.01	0.59	0.22	0.17
GS3	5.69	378.22	0.08	65.71	65.71	2.99	4.46	5.08	2.99	4.46	5.08	0.00	0.00	0.00	0.00	0.00	0.00
GS3N1	18.37	429.81	0.14	37.03	37.03	6.99	12.74	14.76	6.99	12.74	14.76	0.00	0.00	0.00	0.00	0.00	0.00
GS4	20.90	678.11	0.20	29.27	29.27	8.39	14.88	17.23	8.39	14.88	17.23	0.00	0.00	0.00	0.00	0.01	0.00
GS4S1	7.37	368.84	0.14	30.00	30.00	3.15	5.37	6.18	3.15	5.37	6.18	0.00	0.00	0.00	0.00	0.00	0.00
GS5	21.11	458.97	0.08	29.25	29.25	6.54	13.51	15.96	6.54	13.51	15.96	0.00	0.00	0.00	0.00	0.00	0.00
Heron Creek																	
HE1	13.97	444.08	0.06	12.39	21.59	3.52	8.50	10.16	4.17	8.95	10.56	0.65	0.45	0.40	18.42	5.30	3.98
HE2	19.11	454.33	0.06	28.66	29.98	5.78	12.09	14.33	5.90	12.18	14.41	0.13	0.10	0.09	2.18	0.79	0.61
HE3	46.84	812.66	0.05	1.05	1.05	6.66	19.94	26.04	6.66	19.94	26.04	0.00	0.00	0.00	0.00	0.00	0.00
HE4	19.98	587.13	0.17	25.99	29.67	7.35	13.75	16.01	7.66	13.94	16.22	0.31	0.19	0.21	4.28	1.40	1.29
HE5	14.49	446.36	0.14	18.69	18.78	4.79	9.69	11.29	4.80	9.69	11.30	0.01	0.00	0.00	0.13	0.03	0.03
Hidden Springs Creek																	
HS1	11.30	500.76	0.07	28.08	28.08	4.19	7.79	9.07	4.19	7.79	9.07	0.00	0.00	0.00	0.00	0.00	0.00
HS2	12.38	460.85	0.05	27.17	27.17	4.09	8.21	9.61	4.09	8.21	9.61	0.00	0.00	0.00	0.00	0.00	0.00
HS3	32.84	596.36	0.04	25.38	25.38	7.81	17.81	21.88	7.81	17.81	21.88	0.00	0.00	0.00	0.00	0.00	0.00
McLean Creek																	
MC1	10.74	333.95	0.08	36.96	36.96	4.06	7.44	8.61	4.06	7.44	8.61	0.00	0.00	0.00	0.00	0.00	0.00
MC2	12.07	395.60	0.06	42.24	42.69	4.74	8.45	9.77	4.77	8.46	9.78	0.02	0.01	0.01	0.51	0.17	0.12
MC2S	13.20	309.21	0.03	35.07	35.07	4.00	8.14	9.71	4.00	8.14	9.71	0.00	0.00	0.00	0.00	0.00	0.00
MC3	16.76	324.10	0.03	38.05	38.25	4.94	9.96	11.98	4.96	9.98	11.99	0.01	0.01	0.01	0.30	0.14	0.11
MC3N	9.51	665.58	0.04	50.21	50.79	4.53	7.20	8.25	4.55	7.21	8.25	0.02	0.01	0.01	0.38	0.14	0.11
MC3W1	23.19	493.72	0.11	33.82	34.60	8.03	15.53	18.15	8.11	15.59	18.20	0.09	0.06	0.05	1.07	0.36	0.28
MC3W2	25.83	645.11	0.10	9.92	10.42	6.13	15.43	18.52	6.20	15.48	18.57	0.06	0.05	0.04	1.06	0.31	0.23
MC3W3	22.94	457.28	0.08	24.99	24.99	6.33	13.94	16.69	6.33	13.94	16.69	0.00	0.00	0.00	0.00	0.00	0.00

Attachment A. Table A-1: Hydrology Parameters and Model Results																	
Basin ID	Area (acres)	Width (ft)	Slope (ft/ft)	Existing Impervious Percentage	Future Impervious Percentage	Existing Land Use			Future Land Use			Future Land Use			Future Land Use		
						Maximum Flow (cfs)			Maximum Flow (cfs)			Absolute Increase in Maximum			Percent Increase in Maximum Flow		
						2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr
MC4	12.64	336.97	0.04	20.96	20.96	3.22	7.46	8.99	3.22	7.46	8.99	0.00	0.00	0.00	0.00	0.00	0.01
MC5	24.17	541.09	0.12	20.20	20.20	6.95	15.29	18.10	6.95	15.29	18.10	0.00	0.00	0.00	0.00	0.00	0.00
MC6	9.26	302.00	0.06	29.33	29.33	3.14	6.19	7.23	3.14	6.19	7.23	0.00	0.00	0.00	0.00	0.00	0.01
MC7	22.69	501.35	0.08	13.69	13.69	5.27	13.18	15.95	5.27	13.18	15.95	0.00	0.00	0.00	0.00	0.00	0.00
MC8	21.54	526.67	0.07	29.52	29.52	6.83	13.95	16.43	6.83	13.95	16.43	0.00	0.00	0.00	0.00	0.00	0.00
Maddax Creek																	
MX1	6.62	328.74	0.11	10.76	10.76	0.40	1.90	3.20	0.40	1.90	3.20	0.00	0.00	0.00	0.00	0.00	0.00
MX1N1	11.01	377.66	0.09	14.35	14.76	3.23	7.11	8.36	3.25	7.12	8.37	0.02	0.01	0.01	0.65	0.18	0.14
MX2	18.21	379.88	0.06	42.13	42.53	6.38	12.05	14.14	6.42	12.07	14.16	0.03	0.02	0.02	0.53	0.21	0.16
MX3	16.10	486.12	0.16	28.13	29.30	6.07	11.16	13.00	6.15	11.22	13.05	0.08	0.06	0.05	1.32	0.50	0.40
MX3S	27.97	630.34	0.10	31.11	31.96	9.26	18.44	21.63	9.38	18.52	21.70	0.12	0.08	0.07	1.25	0.42	0.33
MX3S1	21.16	552.85	0.14	6.14	6.20	5.24	13.01	15.49	5.24	13.02	15.50	0.01	0.00	0.00	0.11	0.03	0.03
MX3S2	9.81	326.29	0.11	2.00	2.00	2.39	6.04	7.18	2.39	6.04	7.18	0.00	0.00	0.00	0.00	0.00	0.00
MX4	8.10	220.07	0.12	27.02	29.95	1.30	2.80	4.10	1.40	3.00	4.30	0.10	0.20	0.20	7.69	7.14	4.88
MX5	18.63	601.29	0.13	2.88	3.37	4.77	11.67	13.81	4.81	11.69	13.84	0.04	0.03	0.02	0.90	0.21	0.17
Mary S. Young Creek																	
MY1	8.49	277.74	0.10	0.00	0.00	0.40	1.60	2.70	0.40	1.60	2.70	0.00	0.00	0.00	0.00	0.00	0.00
MY2	7.61	261.42	0.08	20.96	20.96	1.00	2.30	3.50	1.00	2.30	3.50	0.00	0.00	0.00	0.00	0.00	0.00
MY2N	29.04	496.05	0.06	22.56	22.66	6.90	16.13	19.72	6.91	16.14	19.73	0.01	0.01	0.01	0.13	0.06	0.04
MY3	33.71	951.55	0.07	29.83	30.00	11.20	22.31	26.13	11.23	22.33	26.15	0.03	0.02	0.02	0.25	0.08	0.06
MY4	57.52	1154.42	0.09	27.08	28.49	17.05	36.17	42.93	17.46	36.48	43.21	0.41	0.31	0.28	2.40	0.86	0.66
MY4N1	30.85	568.55	0.07	29.51	29.51	8.82	18.77	22.47	8.82	18.77	22.47	0.00	0.00	0.00	0.00	0.00	0.00
MY4S1	27.00	564.31	0.08	29.73	30.00	8.21	17.08	20.24	8.25	17.10	20.27	0.04	0.03	0.02	0.44	0.16	0.12
MY4S2	26.71	690.91	0.11	20.25	30.00	7.99	17.19	20.25	9.25	17.99	20.97	1.26	0.80	0.72	15.78	4.65	3.54
MY4S3	17.44	514.99	0.07	26.79	30.00	5.55	11.39	13.38	5.82	11.57	13.54	0.27	0.18	0.16	4.92	1.59	1.22
MY5	23.78	455.43	0.10	27.96	28.31	7.19	15.08	17.86	7.23	15.11	17.88	0.04	0.03	0.03	0.57	0.21	0.16
MY6	35.82	580.81	0.06	26.55	26.55	9.00	20.14	24.56	9.00	20.14	24.56	0.00	0.00	0.00	0.00	0.00	0.00
Robin Creek																	
RB1	4.62	413.24	0.03	28.70	30.00	1.86	3.29	3.81	1.89	3.31	3.83	0.02	0.02	0.01	1.23	0.46	0.37
RB2	23.91	827.69	0.07	49.51	50.06	10.47	17.39	20.08	10.52	17.42	20.11	0.05	0.03	0.03	0.50	0.18	0.14
RB2S1	22.80	833.24	0.08	41.06	41.06	9.51	16.38	18.95	9.51	16.38	18.95	0.00	0.00	0.00	0.00	0.00	0.00
RB2S2	13.85	300.05	0.13	24.15	24.63	4.27	8.96	10.55	4.30	8.98	10.57	0.03	0.02	0.02	0.77	0.25	0.18
RB2S3	9.76	269.68	0.11	29.96	29.96	3.47	6.64	7.72	3.47	6.64	7.72	0.00	0.00	0.00	0.00	0.00	0.00
RB3	17.19	423.29	0.15	23.92	25.17	5.68	11.44	13.37	5.78	11.50	13.42	0.10	0.06	0.05	1.80	0.52	0.40
RB4	22.42	538.94	0.14	28.89	29.97	7.82	15.16	17.65	7.93	15.22	17.70	0.11	0.07	0.06	1.45	0.44	0.33
Robinwood Creek																	
RW1	21.64	535.23	0.06	20.24	20.68	5.62	12.97	15.57	5.67	13.01	15.61	0.05	0.04	0.04	0.89	0.31	0.24
RW1S1-1	3.32	218.83	0.05	46.28	54.30	1.53	2.48	2.85	1.61	2.53	2.90	0.09	0.05	0.04	5.63	1.89	1.58
RW1S1-2	3.85	345.78	0.03	30.00	30.00	1.60	2.77	3.20	1.60	2.77	3.20	0.00	0.00	0.00	0.00	0.00	0.00
RW1S1-3	1.31	181.66	0.04	29.67	29.67	0.60	0.97	1.11	0.60	0.97	1.11	0.00	0.00	0.00	0.00	0.00	0.00
RW1S2	7.24	204.30	0.07	35.95	35.95	2.61	4.92	5.73	2.61	4.92	5.73	0.00	0.00	0.00	0.00	0.00	0.00
RW1W1	13.29	336.66	0.09	38.31	38.91	4.93	9.12	10.60	4.97	9.14	10.62	0.04	0.02	0.02	0.75	0.24	0.18
RW1W2	17.27	550.56	0.15	32.60	35.25	6.89	12.24	14.20	7.07	12.37	14.31	0.19	0.12	0.12	2.69	1.00	0.81
RW1W3	25.83	558.35	0.17	29.18	30.00	8.94	17.41	20.29	9.04	17.47	20.34	0.10	0.06	0.05	1.11	0.34	0.27
RW2	11.24	346.83	0.09	30.09	30.45	4.02	7.66	8.90	4.04	7.67	8.91	0.02	0.01	0.01	0.45	0.13	0.10
RW3	4.67	210.90	0.09	12.36	17.95	1.51	3.11	3.62	1.62	3.17	3.68	0.11	0.06	0.06	7.43	1.80	1.63

Attachment A. Table A-1: Hydrology Parameters and Model Results																	
Basin ID	Area (acres)	Width (ft)	Slope (ft/ft)	Existing Impervious Percentage	Future Impervious Percentage	Existing Land Use			Future Land Use			Future Land Use			Future Land Use		
						Maximum Flow (cfs)			Maximum Flow (cfs)			Absolute Increase in Maximum			Percent Increase in Maximum Flow		
						2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr
RW4	19.05	510.96	0.17	29.07	30.00	7.05	13.13	15.27	7.13	13.17	15.33	0.08	0.04	0.05	1.11	0.31	0.34
RW5	12.29	525.96	0.10	28.99	30.00	4.79	8.64	10.03	4.84	8.68	10.07	0.05	0.04	0.03	1.07	0.41	0.33
RW6	20.80	494.23	0.07	29.29	29.58	6.43	13.30	15.72	6.46	13.32	15.74	0.03	0.02	0.02	0.47	0.17	0.13
RW6N1	6.55	204.32	0.04	30.00	30.00	2.09	4.25	5.00	2.09	4.25	5.00	0.00	0.00	0.00	0.00	0.00	0.00
RW7	9.95	359.08	0.03	5.97	5.97	2.00	5.51	6.75	2.00	5.51	6.75	0.00	0.00	0.00	0.00	0.00	0.00
Salamo Creek																	
SA1	14.34	299.57	0.10	29.64	29.65	4.58	9.32	10.97	4.58	9.32	10.97	0.00	0.00	0.00	0.00	0.01	0.01
SA2	19.95	724.10	0.07	28.20	29.98	7.05	13.56	15.75	7.21	13.65	15.84	0.16	0.09	0.08	2.30	0.67	0.53
SA3	7.25	378.76	0.10	29.93	30.00	3.03	5.24	6.05	3.04	5.24	6.05	0.00	0.00	0.00	0.03	0.02	0.02
SA4	9.33	493.89	0.07	30.00	30.00	3.76	6.65	7.70	3.76	6.65	7.70	0.00	0.00	0.00	0.00	0.00	0.00
SA5	11.22	591.30	0.03	30.00	30.00	3.95	7.61	8.85	3.95	7.61	8.85	0.00	0.00	0.00	0.00	0.00	0.00
SA5N1	20.91	462.45	0.06	27.78	27.78	6.09	12.98	15.46	6.09	12.98	15.46	0.00	0.00	0.00	0.00	0.00	0.00
SA6	8.69	423.29	0.08	24.50	24.50	3.25	6.02	7.01	3.25	6.02	7.01	0.00	0.00	0.00	0.00	0.00	0.00
SA7	13.69	428.34	0.05	28.74	28.76	4.37	8.91	10.48	4.37	8.91	10.48	0.00	0.00	0.00	0.02	0.01	0.01
SA7W	23.52	536.62	0.05	21.66	30.01	5.98	13.81	16.67	6.99	14.65	17.44	1.01	0.84	0.77	16.86	6.11	4.62
SA8	10.93	317.60	0.05	30.09	30.09	3.47	7.07	8.33	3.47	7.07	8.33	0.00	0.00	0.00	0.00	0.00	0.00
SA9	21.99	580.19	0.04	53.76	53.76	8.93	15.38	17.81	8.93	15.38	17.81	0.00	0.00	0.00	0.00	0.00	0.00
Summerlinn Creek																	
SL1	16.79	454.53	0.05	29.57	30.93	5.11	10.62	12.59	5.22	10.71	12.67	0.11	0.09	0.08	2.23	0.83	0.63
SL2	15.08	467.95	0.03	30.44	30.44	4.58	9.51	11.28	4.58	9.51	11.28	0.00	0.00	0.00	0.00	0.00	0.00
SL3-1	6.59	380.54	0.01	34.98	34.98	2.14	4.26	5.02	2.14	4.26	5.02	0.00	0.00	0.00	0.00	0.00	0.00
SL3-2	6.06	590.13	0.03	41.94	41.94	2.75	4.51	5.18	2.75	4.51	5.18	0.00	0.00	0.00	0.00	0.00	0.00
SL3-3	1.35	80.35	0.02	34.57	34.57	0.50	0.93	1.08	0.50	0.93	1.08	0.00	0.00	0.00	0.00	0.00	0.00
SL3-4	4.85	304.37	0.05	30.69	30.69	1.96	3.46	4.01	1.96	3.46	4.01	0.00	0.00	0.00	0.00	0.00	0.00
SL3-5	1.53	69.17	0.02	44.01	44.01	0.57	1.04	1.21	0.57	1.04	1.21	0.00	0.00	0.00	0.00	0.00	0.00
SL3E1	13.17	601.86	0.08	43.46	43.46	5.83	9.71	11.17	5.83	9.71	11.17	0.00	0.00	0.00	0.00	0.00	0.00
SL3S1	30.58	587.29	0.03	29.14	30.00	7.47	16.42	20.19	7.60	16.55	20.32	0.13	0.13	0.13	1.71	0.82	0.63
SL4	16.41	444.29	0.02	31.74	31.83	4.56	9.65	11.64	4.56	9.66	11.65	0.01	0.01	0.01	0.15	0.07	0.06
SL5-1	6.39	134.23	0.05	50.00	50.00	2.44	4.36	5.08	2.44	4.36	5.08	0.00	0.00	0.00	0.00	0.00	0.00
SL5-2	5.47	294.96	0.05	43.52	43.52	2.41	4.02	4.63	2.41	4.02	4.63	0.00	0.00	0.00	0.00	0.00	0.00
SL5N1	10.56	482.42	0.07	27.99	27.99	4.00	7.34	8.55	4.00	7.34	8.55	0.00	0.00	0.00	0.00	0.00	0.00
SL6	5.70	392.46	0.07	28.38	29.28	2.39	4.12	4.76	2.41	4.13	4.77	0.02	0.01	0.01	0.75	0.27	0.21
SL7	7.51	395.25	0.20	15.89	16.02	3.03	5.34	6.18	3.03	5.35	6.18	0.00	0.00	0.00	0.10	0.04	0.03
SL7N	3.49	190.72	0.10	30.00	30.00	1.47	2.53	2.92	1.47	2.53	2.92	0.00	0.00	0.00	0.00	0.00	0.00
SL8	7.49	320.72	0.19	10.26	10.26	2.66	5.10	5.95	2.66	5.10	5.95	0.00	0.00	0.00	0.00	0.00	0.00
SL8S1	5.18	267.03	0.08	29.25	29.25	2.09	3.70	4.28	2.09	3.70	4.28	0.00	0.00	0.00	0.00	0.00	0.02
SL9	16.51	410.73	0.11	27.85	29.78	5.49	10.97	12.83	5.65	11.07	12.92	0.15	0.10	0.09	2.77	0.87	0.67
SL9E1	6.77	363.32	0.16	23.26	39.16	2.83	4.88	5.63	3.16	5.08	5.82	0.33	0.20	0.19	11.56	4.08	3.37
SL9W	4.30	194.23	0.05	29.48	29.48	1.58	2.96	3.43	1.58	2.96	3.43	0.00	0.00	0.00	0.00	0.00	0.00
SLA	5.81	334.92	0.10	26.82	31.44	2.42	4.19	4.84	2.51	4.25	4.89	0.09	0.06	0.05	3.85	1.38	1.12
SLB	7.89	260.88	0.10	14.66	33.21	2.34	5.11	6.00	3.02	5.49	6.38	0.67	0.38	0.38	28.68	7.40	6.30
Sunset Creek																	
SS1	8.46	377.64	0.11	71.38	73.45	4.49	6.63	7.55	4.52	6.64	7.57	0.03	0.01	0.01	0.74	0.21	0.19
SS2	5.48	178.07	0.11	55.61	55.61	2.60	4.12	4.73	2.60	4.12	4.73	0.00	0.00	0.00	0.00	0.00	0.00
SS3	13.84	404.05	0.12	34.83	35.00	5.35	9.66	11.23	5.36	9.66	11.23	0.01	0.00	0.01	0.19	0.05	0.05
SS4	5.75	450.70	0.08	33.11	35.00	2.59	4.26	4.90	2.62	4.28	4.91	0.03	0.02	0.02	1.24	0.45	0.37

Attachment A. Table A-1: Hydrology Parameters and Model Results																	
Basin ID	Area (acres)	Width (ft)	Slope (ft/ft)	Existing Impervious Percentage	Future Impervious Percentage	Existing Land Use			Future Land Use			Future Land Use			Future Land Use		
						Maximum Flow (cfs)			Maximum Flow (cfs)			Absolute Increase in Maximum			Percent Increase in Maximum Flow		
						2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr
SS5	6.49	372.87	0.10	34.60	34.62	2.85	4.78	5.49	2.85	4.78	5.50	0.00	0.00	0.00	0.00	0.00	0.02
SS6	11.33	410.04	0.09	31.93	31.93	4.33	7.88	9.17	4.33	7.88	9.17	0.00	0.00	0.00	0.00	0.00	0.00
SS6W1	7.65	265.11	0.05	31.99	31.99	2.63	5.13	5.99	2.63	5.13	5.99	0.00	0.00	0.00	0.00	0.00	0.02
SS6W1W	9.00	356.54	0.07	34.36	34.77	3.50	6.29	7.32	3.51	6.30	7.33	0.02	0.01	0.01	0.46	0.17	0.14
SS7	9.34	324.11	0.05	32.29	32.30	3.28	6.31	7.35	3.28	6.31	7.35	0.00	0.00	0.00	0.00	0.00	0.00
Tanner Creek																	
TA1	13.72	452.07	0.17	44.75	61.80	6.20	10.19	11.71	6.93	10.58	12.08	0.73	0.39	0.37	11.83	3.80	3.16
TA2	10.63	590.64	0.04	32.85	32.87	4.09	7.41	8.62	4.09	7.41	8.62	0.00	0.00	0.00	0.02	0.01	0.00
TA3	5.61	246.26	0.04	28.23	28.23	1.94	3.79	4.41	1.94	3.79	4.41	0.00	0.00	0.00	0.00	0.00	0.00
TA3E	9.15	392.77	0.09	33.95	33.95	3.72	6.54	7.57	3.72	6.54	7.57	0.00	0.00	0.00	0.00	0.00	0.00
TA3E1	20.85	571.90	0.05	33.55	33.55	6.87	13.63	16.03	6.87	13.63	16.03	0.00	0.00	0.00	0.00	0.00	0.00
TA3W	5.45	202.91	0.07	31.43	32.47	2.00	3.74	4.34	2.03	3.76	4.36	0.02	0.01	0.02	1.25	0.37	0.41
TA4	16.90	595.24	0.09	29.55	29.55	6.18	11.61	13.49	6.18	11.61	13.49	0.00	0.00	0.00	0.00	0.00	0.00
TA4E	7.92	244.73	0.08	29.99	29.99	2.75	5.34	6.22	2.75	5.34	6.22	0.00	0.00	0.00	0.00	0.02	0.00
TA4E1	9.30	209.24	0.07	30.55	30.55	2.90	5.95	7.04	2.90	5.95	7.04	0.00	0.00	0.00	0.00	0.00	0.00
TA4W	8.17	233.95	0.11	29.48	29.48	2.91	5.56	6.47	2.91	5.56	6.47	0.00	0.00	0.00	0.00	0.00	0.00
TA5	14.63	475.49	0.06	24.70	24.70	4.56	9.50	11.17	4.56	9.50	11.17	0.00	0.00	0.00	0.00	0.01	0.00
TA5E1	12.62	489.30	0.11	26.52	30.23	4.72	8.74	10.18	4.92	8.87	10.30	0.20	0.14	0.13	4.15	1.56	1.26
TA5E2	14.53	476.98	0.04	36.44	36.56	5.15	9.80	11.43	5.16	9.80	11.44	0.01	0.01	0.00	0.16	0.06	0.03
TA6	33.54	661.83	0.09	26.43	30.32	9.75	20.91	24.88	10.41	21.42	25.33	0.66	0.50	0.46	6.74	2.41	1.83
TA6W1	5.19	289.95	0.17	23.69	28.95	2.22	3.77	4.34	2.30	3.82	4.39	0.08	0.05	0.05	3.70	1.30	1.08
TA6W1N	11.83	339.65	0.09	29.30	29.30	4.09	7.97	9.29	4.09	7.97	9.29	0.00	0.00	0.00	0.00	0.00	0.00
TA7	5.48	201.08	0.11	28.79	28.79	2.10	3.82	4.45	2.10	3.82	4.45	0.00	0.00	0.00	0.00	0.00	0.00
TA7W1	12.90	484.51	0.09	26.29	26.29	4.67	8.84	10.28	4.67	8.84	10.28	0.00	0.00	0.00	0.00	0.00	0.00
TA7W2	17.10	552.46	0.07	28.90	28.90	5.80	11.44	13.35	5.80	11.44	13.35	0.00	0.00	0.00	0.00	0.00	0.00
TA8	33.22	671.71	0.05	26.01	30.00	8.75	19.46	23.50	9.43	20.06	24.05	0.67	0.60	0.55	7.70	3.07	2.33
TA8E1	25.71	541.98	0.06	30.16	30.19	7.53	15.86	18.92	7.54	15.86	18.92	0.00	0.00	0.00	0.05	0.02	0.02
TA8E2	32.01	595.94	0.05	25.78	30.00	8.04	18.11	22.04	8.72	18.75	22.64	0.69	0.64	0.60	8.52	3.56	2.72
TA8W1-1	7.41	229.94	0.03	39.06	39.06	2.47	4.80	5.67	2.47	4.80	5.67	0.00	0.00	0.00	0.00	0.00	0.00
TA8W1-2	4.91	205.07	0.05	31.50	31.50	1.78	3.36	3.91	1.78	3.36	3.91	0.00	0.00	0.00	0.00	0.00	0.00
TA8W2	21.90	562.02	0.04	41.60	41.60	7.59	14.41	16.93	7.59	14.41	16.93	0.00	0.00	0.00	0.00	0.00	0.00
TA8W3	16.54	483.60	0.05	72.56	72.56	8.18	12.29	14.05	8.18	12.29	14.05	0.00	0.00	0.00	0.00	0.01	0.00
TA9	19.69	526.08	0.06	26.67	27.03	5.89	12.47	14.77	5.93	12.49	14.79	0.04	0.03	0.03	0.61	0.22	0.17
TA9E1	21.71	668.55	0.09	8.93	22.33	5.44	13.32	15.87	6.87	14.24	16.70	1.43	0.93	0.83	26.26	6.97	5.22
TA9E2	8.47	425.21	0.09	30.52	30.52	3.45	6.06	7.01	3.45	6.06	7.01	0.00	0.00	0.00	0.00	0.00	0.00
TA9E3	16.18	706.55	0.05	27.72	30.00	5.58	10.90	12.70	5.75	11.00	12.79	0.17	0.10	0.09	3.08	0.92	0.71
TAA	18.84	475.34	0.05	34.27	35.42	6.18	12.27	14.44	6.29	12.34	14.51	0.11	0.08	0.07	1.70	0.62	0.48
TAB	15.54	638.14	0.07	13.64	32.99	4.55	10.03	11.79	5.93	10.81	12.57	1.38	0.78	0.77	30.33	7.74	6.56
TAC	11.96	606.48	0.06	23.95	30.07	4.34	8.20	9.55	4.65	8.40	9.75	0.31	0.20	0.20	7.11	2.39	2.13
TAD	13.43	487.94	0.04	37.44	38.84	4.88	9.14	10.64	4.97	9.20	10.69	0.09	0.05	0.05	1.78	0.59	0.45
TAE-1	10.54	312.78	0.02	31.83	31.83	2.86	6.08	7.36	2.86	6.08	7.36	0.00	0.00	0.00	0.00	0.00	0.00
TAE-2	3.02	170.80	0.04	30.00	30.00	1.13	2.08	2.43	1.13	2.08	2.42	0.00	0.00	0.00	0.00	0.00	0.00
TAF	22.90	513.12	0.03	30.00	30.00	6.30	13.51	16.29	6.30	13.51	16.29	0.00	0.00	0.00	0.00	0.00	0.00

Attachment A. Table A-1: Hydrology Parameters and Model Results																		
Basin ID	Area (acres)	Width (ft)	Slope (ft/ft)	Existing Impervious Percentage	Future Impervious Percentage	Existing Land Use			Future Land Use			Future Land Use			Future Land Use		
						Maximum Flow (cfs)			Maximum Flow (cfs)			Absolute Increase in Maximum			Percent Increase in Maximum Flow		
						2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr	2-yr	10-yr	25-yr
Trillium Creek																	
TR1	35.18	572.50	0.04	30.00	30.00	8.93	19.41	23.74	8.93	19.41	23.74	0.00	0.00	0.00	0.00	0.00	0.00
TR2	10.38	375.56	0.03	29.18	30.00	3.25	6.68	7.88	3.29	6.71	7.91	0.04	0.03	0.03	1.29	0.45	0.36
TR2S1	21.15	462.88	0.01	29.24	30.00	4.44	9.68	12.20	4.51	9.76	12.29	0.07	0.09	0.09	1.60	0.89	0.71
TR3	20.40	634.90	0.04	29.62	30.00	6.45	13.19	15.55	6.49	13.22	15.57	0.04	0.03	0.03	0.59	0.20	0.16
TR4	3.32	223.29	0.03	30.00	30.00	1.27	2.32	2.69	1.27	2.32	2.69	0.00	0.00	0.00	0.00	0.00	0.00
TR5	24.82	746.04	0.05	27.07	30.00	7.53	15.81	18.70	7.89	16.08	18.94	0.36	0.26	0.24	4.82	1.66	1.27
TR6	15.97	585.63	0.06	15.53	15.54	4.49	10.12	11.96	4.49	10.12	11.96	0.00	0.00	0.00	0.02	0.00	0.00
TR7	37.76	790.30	0.18	19.10	20.43	11.29	24.35	28.67	11.53	24.51	28.81	0.24	0.16	0.14	2.17	0.64	0.49
TR8	35.25	528.78	0.10	28.12	28.12	9.76	21.13	25.39	9.76	21.13	25.39	0.00	0.00	0.00	0.00	0.00	0.00
TR9	18.93	442.71	0.07	34.27	34.27	6.33	12.45	14.62	6.33	12.45	14.62	0.00	0.00	0.00	0.00	0.01	0.00
TR9N	10.28	305.38	0.06	29.50	29.50	3.37	6.77	7.94	3.37	6.77	7.94	0.00	0.00	0.00	0.00	0.00	0.00
TRA	24.36	487.33	0.06	30.00	30.00	7.04	14.89	17.80	7.04	14.89	17.80	0.00	0.00	0.00	0.00	0.00	0.00
TRB	9.05	291.66	0.03	30.00	30.00	2.69	5.64	6.71	2.69	5.64	6.71	0.00	0.00	0.00	0.00	0.00	0.00
TRBS	29.89	704.05	0.04	30.00	30.00	8.58	18.19	21.77	8.58	18.19	21.77	0.00	0.00	0.00	0.00	0.00	0.00
TRC	14.14	549.46	0.07	29.45	29.45	5.16	9.70	11.27	5.16	9.70	11.27	0.00	0.00	0.00	0.00	0.00	0.00
Upper Tualatin River																	
UT1	33.84	812.04	0.06	29.71	30.00	10.27	21.37	25.34	10.32	21.41	25.38	0.05	0.04	0.04	0.50	0.18	0.14
UT2	6.57	467.72	0.07	30.00	30.00	2.81	4.78	5.51	2.81	4.78	5.51	0.00	0.00	0.00	0.00	0.02	0.00
Willamette River																	
WR1	30.71	1000.64	0.08	28.35	29.96	10.55	20.66	24.08	10.79	20.80	24.21	0.23	0.14	0.12	2.20	0.67	0.51
WR10	19.54	1333.21	0.12	85.00	85.00	11.19	15.71	17.84	11.19	15.71	17.84	0.00	0.00	0.00	0.00	0.00	0.00
WR2	88.86	2748.45	0.06	27.06	27.31	28.06	57.76	67.95	28.16	57.84	68.02	0.11	0.07	0.07	0.39	0.13	0.10
WR3	63.23	1892.20	0.06	4.00	4.86	13.14	35.86	43.65	13.31	36.08	43.84	0.17	0.22	0.19	1.27	0.60	0.44
WR4	43.46	901.47	0.10	23.60	23.75	12.55	27.26	32.36	12.58	27.29	32.39	0.03	0.03	0.02	0.26	0.09	0.07
WR5	34.51	1174.03	0.10	19.11	19.22	11.03	22.82	26.68	11.05	22.83	26.69	0.02	0.01	0.01	0.16	0.04	0.03
WR6	6.32	742.50	0.21	8.56	8.56	0.30	2.90	4.10	0.30	2.90	4.10	0.00	0.00	0.00	0.00	0.00	0.00
WR7	40.58	428.45	0.06	29.91	29.93	9.40	20.52	25.49	9.40	20.52	25.49	0.00	0.00	0.00	0.04	0.02	0.02
WR8	16.49	836.66	0.07	23.91	24.71	6.12	11.39	13.27	6.17	11.43	13.31	0.05	0.04	0.04	0.90	0.33	0.27
WR9-1	113.44	600.17	0.05	26.81	31.14	19.19	41.40	53.40	21.09	43.96	56.10	1.90	2.55	2.71	9.89	6.17	5.07
WR9-2	116.93	2551.08	0.09	36.69	47.04	41.15	78.53	91.74	46.65	81.94	94.80	5.50	3.41	3.06	13.36	4.34	3.34
WR9-3	109.96	1125.85	0.08	31.10	31.56	27.30	58.90	72.41	27.54	59.16	72.66	0.24	0.25	0.24	0.88	0.43	0.34
WR9-4	84.01	2573.99	0.11	43.19	54.47	35.44	60.51	70.00	39.07	62.63	71.97	3.63	2.12	1.97	10.24	3.50	2.81
WR9-5	68.20	1072.99	0.16	60.68	63.30	30.72	49.53	56.85	31.37	49.80	57.09	0.64	0.27	0.24	2.09	0.54	0.42

This page intentionally left blank.

Attachment A. Table A-2. Capacity Evaluation Hydraulic Model Parameters and Results

Link ID	Length (ft)	Shape	Diameter/ Height (ft)	Slope (%)	Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing 2 yr Max Water Surface Elevation (ft)		Future 2 yr Max Water Surface Elevation (ft)		Existing 10 yr Max Water Surface Elevation (ft)		Future 10 yr Max Water Surface Elevation (ft)		Existing 25 yr Max Water Surface Elevation (ft)		Future 25 yr Max Water Surface Elevation (ft)		2 yr Max Flow (cfs)		10 yr Max Flow (cfs)		25 yr Max Flow (cfs)		Applicable Culvert Design Criteria[1]	When Hydraulically Deficient
					US	DS	US	DS	US	DS	US	DS	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future	Existing	Future		
Location ID 13																														
Link25	43	Circular	3	1.7	BE-HW-0008	BE-OF-0006	78.95	78.20	84.92	84.68	87.69	79.66	87.78	79.67	89.37	79.75	89.38	79.75	89.72	79.77	89.73	79.77	93.98	94.58	105.06	105.17	107.26	107.34	Criteria 1	Ex. 2-year
Location ID 59																														
Link8	92	Circular	1.5	2.9	SS-CB-0012	SS-OF-0010	235.82	233.19	239.42	234.69	238.78	233.45	238.79	233.45	239.81	233.48	239.81	233.48	240.10	233.49	240.10	233.49	12.69	12.70	15.68	16.42	16.42	14.60	Criteria 1	Ex. 2-year
Location ID 60																														
Link6	28	Circular	2	6.8	FN-HW-0048	FN-OF-0046	225.97	224.06	234.00	227.00	234.37	227.44	234.39	227.45	236.76	228.79	236.76	228.80	237.15	229.11	237.15	229.11	36.30	36.35	41.77	41.77	42.60	42.61	Criteria 1	Ex. 2-year
Location ID 63																														
Link5	165	Circular	2	3.4	MX_HW_0008	MX-OF-0006	47.00	41.36	50.00	44.19	50.19	42.46	50.19	42.46	51.99	42.78	51.99	42.78	52.37	42.84	52.37	42.84	22.75	22.76	33.06	33.06	34.87	34.87	Criteria 1	Ex. 2-year
Highway 43																														
Crossing A	76	Circular	3	4.1	AR-IS-0008	AR-OF-0006	176.65	173.55	188.10	188.29	184.10	175.97	184.34	175.99	190.31	176.40	190.34	176.40	190.91	176.44	190.93	176.44	72.67	74.13	104.58	104.71	107.14	107.22	Criteria 1	Ex. 2-year
Crossing B	67	Circular	2	28.6	RW-IS-0016	RW-OF-0014	200.44	181.14	203.54	183.54	203.68	181.89	203.70	181.89	205.49	181.99	205.50	181.99	205.86	182.01	205.87	182.01	21.90	21.58	27.57	27.60	28.74	28.76	Criteria 1	Ex. 2-year
Crossing C	51	Circular	1	10.6	RW-IS-0240	RW-OF-0238	186.22	180.86	188.42	182.86	188.15	181.28	188.16	181.28	188.94	181.33	188.94	181.33	189.15	181.34	189.15	181.34	3.99	4.01	4.98	4.98	5.22	5.22	Criteria 1	Ex. 2-year
Crossing D	81	Circular	0.83	17.4	RW-CB-0380	RW-OF-0376	178.46	164.33	180.34	180.14	179.05	164.69	179.06	164.69	180.80	164.74	180.79	164.74	181.04	164.75	181.03	164.75	4.91	4.94	6.43	6.43	6.50	6.50	Criteria 1	Ex. 10-year
Crossing E	64	Circular	2	9.5	RW-CB-0076	RW-OF-0074	175.91	169.88	179.32	172.48	176.83	170.54	176.84	170.55	177.38	170.82	177.39	170.82	177.62	170.90	177.63	170.90	15.64	15.93	29.52	29.67	34.30	34.48	NA	NA
Crossing F	152	Circular	1	7.6	RW-CB-0144	RW-CB-0140	178.84	167.35	181.54	172.35	179.25	167.68	179.25	167.68	179.46	167.81	179.46	167.81	179.54	167.84	179.54	167.84	2.59	2.59	4.91	4.91	5.72	5.72	NA	NA
Crossing G	84	Circular	3.67	6.0	FN-MH-0034	FN-MH-0032	173.13	168.13	181.38	182.38	174.52	169.28	174.53	169.28	175.51	169.84	175.51	169.84	175.86	170.01	175.87	170.01	42.31	42.61	88.97	89.16	105.37	105.54	NA	NA
Crossing H	78	Circular	1.167	4.6	RB-IS-0086	RB-OF-0084	173.84	170.27	180.76	182.90	180.88	170.83	180.91	170.83	182.40	170.86	182.41	170.86	182.72	170.87	182.73	170.87	11.54	11.57	12.83	12.84	13.09	13.09	Criteria 1	Ex. 2-year
Crossing I	93	Circular	5	0.6	RB-HW-0020	RB-VA-0018	165.06	164.50	171.66	184.00	166.07	165.08	166.07	165.08	166.40	165.28	166.40	165.28	166.49	165.34	166.49	165.34	17.02	17.06	31.81	31.83	36.94	36.96	NA	NA
Crossing J	74	Circular	3	0.6	GS-MH-0030	GS-OF-0028	181.84	181.41	191.24	184.71	183.93	182.17	183.93	182.17	185.35	182.44	185.35	182.44	186.47	182.52	186.47	182.52	27.62	27.62	50.36	50.36	58.65	58.65	Criteria 1	Ex. 25-year
Crossing K	43	Circular	1.167	2.6	TR-CB-0492	TR-OF-0490	203.14	202.04	206.74	205.00	203.51	202.22	203.51	202.22	203.61	202.26	203.61	202.26	203.66	202.27	203.66	202.27	1.03	1.03	1.61	1.61	1.84	1.84	NA	NA
Crossing L	109	Circular	2	3.7	TR-HW-0506	TR-OF-0504	190.79	186.75	193.79	190.00	193.81	187.04	193.85	187.06	200.26	187.21	199.71	187.23	203.39	187.26	202.50	187.27	20.85	23.11	46.00	48.56	54.14	56.81	Criteria 1	Ex. 2-year
Crossing M	88	Circular	2	2.5	TR-HW-0068	TR-OF-0064	188.22	186.04	204.19	203.38	193.81	186.42	193.85	186.44	200.26	186.54	199.71	186.56	203.39	186.58	202.50	186.60	33.19	36.50	52.76	56.18	59.99	63.44	Criteria 1	Ex. 2-year
Crossing N	26	Circular	3	6.1	HE-CB-0026	HE-MH-0024	254.59	252.98	259.79	260.23	255.43	253.86	255.45	253.87	255.92	254.31	255.93	254.31	256.08	254.44	256.09	254.45	12.02	12.34	23.43	23.59	27.21	27.41	NA	NA
Crossing O	110	Circular	5	6.8	MY-HW-0020	MY-OF-0018	242.57	235.06	248.82	241.31	243.63	237.62	243.65	237.66	247.75	238.90	247.79	238.93	248.49	239.23	248.52	239.25	62.61	64.60	134.87	136.24	160.91	162.16	Inlet Controlled	Ex. 10-year
Crossing P	126	Circular	2	27.8	BA-HW-0030	BA-OF-0028	259.66	224.59	262.26	230.29	263.19	225.37	263.29	225.37	264.87	225.48	264.91	225.48	265.23	225.50	265.25	225.50	25.15	25.65	32.72	32.85	34.12	34.19	Criteria 1	Ex. 2-year
Crossing Q	86	Circular	3	12.5	BO-MH-0034	BO-OF-0032	208.63	197.83	212.93	202.78	209.54	198.68	209.55	198.68	210.00	199.00	210.00	199.00	210.15	199.10	210.16	199.10	28.49	28.61	51.86	51.94	60.39	60.46	NA	NA
Crossing R	104	Circular	2	2.9	MX-MH-0032	MX-MH-0030	152.68	149.64	160.58	154.64	153.81	150.35	153.82	150.35	155.68	150.71	155.72	150.72	157.11	150.83	157.15	150.83	13.37	13.60	28.19	28.33	33.01	33.13	Criteria 1	Ex. 25-year
Crossing S	46	Circular	2	3.6	MX-CB-0100	MX-MH-0098	150.77	149.13	154.57	154.53	152.16	150.07	152.16	150.08	154.84	150.64	154.85	150.64	155.42	150.74	155.43	150.74	16.61	16.73	34.13	34.17	36.51	36.54	Criteria 1	Ex. 10-year
Crossing T	43	Circular	2	11.9	CS-CB-0082	CS-MH-0078	145.71	140.61	147.91	148.11	146.30	141.06	146.30	141.06	146.49	141.17	146.49	141.17	146.57	141.21	146.57	141.21	7.92	7.92	12.25	12.25	14.07	14.07	NA	NA
Crossing U	67	Circular	3	20.9	CS-CB-0016	CS-MH-0014	128.08	114.09	132.28	130.49	128.41	114.49	128.41	114.49	128.58	114.65	128.58	114.65	128.63	114.70	128.63	114.70	6.23	6.26	12.87	12.89	15.28	15.30	NA	NA
Crossing V	301	Circular	1.5	2.3	MC-MH-0184	MC-MH-0006	114.04	107.18	124.39	122.98	114.54	108.14	114.55	108.14	114.72	108.58	114.73	108.58	114.80	108.63	114.80	108.63	3.61	3.63	6.18	6.19	7.13	7.14	NA	NA
Crossing W	109	Circular	3	8.2	MC-MH-0008	MC-MH-0006	116.05	107.18	122.63	122.98	117.78	108.14	117.78	108.14	122.91	108.58	122.90	108.58	124.10	108.63	124.10	108.63	55.62	55.54	114.35	114.34	120.35	120.34	Criteria 1	Ex. 10-year
Crossing X	456	Circular	2.5	1.2	MC-MH-0070	MC-MH-0006	112.56	107.18	119.86	122.98	113.08	108.14	113.08	108.14	113.31	108.58	113.31	108.58	113.39	108.63	113.39	108.63	3.95	3.95	8.07	8.07	9.65	9.65	NA	NA

[1] *Criteria 1 = Headwater is above 1.5 times the culvert diameter; Criteria 2 = Headwater is less than 1' below roadway subgrade; Pipe Criteria = Water exceeds spillcrest elevation*

Attachment A. Table A-3. Detailed Hydraulic Model Parameters and Results

Link ID	Length (ft)	Shape	Diameter/ Height (ft)	Slope (%)	Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing 2 yr Max Water Surface Elevation (ft)		Future 2 yr Max Water Surface Elevation (ft)		Existing 10 yr Max Water Surface Elevation (ft)		Future 10 yr Max Water Surface Elevation (ft)		Existing 25 yr Max Water Surface Elevation (ft)		Future 25 yr Max Water Surface Elevation (ft)		2 yr Max Flow (cfs)[2]		10 yr Max Flow (cfs)[2]		25 yr Max Flow (cfs)[2]		Applicable Culvert Design Criteria[1]	When Hydraulically Deficient
					US	DS	US	DS	US	DS	US	DS	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future	Existing	Future		
Location ID 47																														
Link47	346	Circular	3.0	6.2	SL-IS-0032	SL-HW-0030	161.63	140.19	164.63	143.75	163.80	141.08	163.82	141.08	164.27	141.09	164.28	141.09	164.37	141.11	164.37	141.11	29.94	29.44	29.34	29.41	30.83	30.87	Criteria 2	Ex. 2-year
Link35	40	Circular	2.0	1.9	SL-IS-0208	SL-MH-1602	152.00	151.25	154.10	155.04	152.86	152.86	152.87	152.87	153.26	153.23	153.26	153.23	153.37	153.33	153.37	153.33	1.85	1.81	3.43	3.43	3.96	3.97	NA	NA
Link38	190	Circular	1.0	1.8	SL-MH-0198	SL-OF-0196	175.10	171.59	178.63	173.97	178.83	172.56	178.83	172.56	179.76	173.32	179.76	173.32	179.97	173.53	179.97	173.53	5.52	5.52	5.99	5.99	6.08	6.08	Pipe	Ex. 2-year
Link39[3]	87	Natural	0.0	2.0	SL-OF-0196	SL-IS-0194	171.59	169.83	173.97	172.21	172.56	172.39	172.56	172.39	173.32	172.91	173.32	172.91	173.53	173.06	173.53	173.06	10.31	10.31	-36.29	-36.29	-47.75	-47.75	NA	NA
Link44	12	Trapezoidal	3.0	0.0	SL-OF-0372	SL-HW-0036	171.65	171.65	175.00	174.65	174.39	174.39	174.45	174.45	175.62	175.62	175.64	175.64	175.95	175.95	175.97	175.97	-0.43	0.73	-7.01	-6.27	-9.01	-8.57	NA	NA
Link27	138	Circular	1.3	7.2	SL-MH-0182	SL-MH-0181	164.10	154.11	170.70	158.36	164.88	158.62	164.88	158.62	164.95	158.69	164.95	158.69	164.98	158.71	164.98	158.71	7.93	7.93	8.84	8.84	9.15	9.15	NA	NA
Link29	45	Circular	1.3	0.1	SL-MH-0180	SL-MH-0180.1	153.25	153.19	156.80	155.46	157.04	156.63	157.04	156.64	157.08	156.79	157.08	156.79	157.08	156.78	157.09	156.80	5.18	5.18	5.18	5.18	5.15	5.15	Pipe	Ex. 2-year
Link26	57	Circular	1.3	0.4	SL-MH-0184	SL-MH-0182	164.44	164.20	169.19	170.70	167.07	165.29	167.07	165.29	167.43	165.32	167.43	165.32	167.52	165.33	167.52	165.33	7.57	7.57	8.27	8.27	8.44	8.44	NA	NA
Link40	13	Circular	1.0	3.5	SL-IS-0194	SL-OF-0192	169.83	169.38	172.21	170.38	172.39	169.70	172.39	169.70	172.91	169.71	172.91	169.71	173.06	169.72	173.06	169.72	4.76	4.76	5.33	5.33	5.49	5.49	Criteria 2	Ex. 2-year
Link41	137	Natural	0.0	2.2	SL-OF-0192	SL-CB-0188	169.38	166.38	170.38	168.03	169.70	168.17	169.70	168.17	169.71	168.73	169.71	168.73	169.72	168.88	169.72	168.88	4.75	4.75	5.32	5.32	5.47	5.47	NA	NA
Link48	267	Circular	2.0	2.4	SL-MH-0274	SL-OF-0034	170.05	163.63	175.27	166.63	170.55	164.63	170.55	164.65	170.81	164.97	170.81	164.98	170.91	165.05	170.91	165.05	4.52	4.52	9.62	9.62	11.62	11.62	NA	NA
Link30	36	Circular	1.3	0.2	SL-MH-0179	SL-MH-1608	153.06	153.00	155.57	156.00	156.06	155.92	156.11	156.00	156.68	157.55	156.68	157.57	156.66	157.39	156.72	157.89	6.26	6.26	6.30	6.30	6.30	-6.89	Pipe	Ex. 2-year
Link45	239	Circular	3.0	3.4	SL-HW-0036	SL-OF-0034	171.65	163.63	174.65	166.63	174.39	164.63	174.45	164.65	175.62	164.97	175.64	164.98	175.95	165.05	175.97	165.05	31.13	31.95	50.64	50.92	54.78	55.00	Pipe	Ex. 10-year
Link46	25	Trapezoidal	2.0	5.4	SL-OF-0034	SL-IS-0032	163.63	162.28	166.63	164.63	164.63	163.80	164.65	163.82	164.97	164.27	164.98	164.28	165.05	164.37	165.05	164.37	35.51	36.33	59.51	59.79	65.26	65.49	NA	NA
Link25	14	Circular	1.3	2.4	SL-CB-0188	SL-MH-0184	165.03	164.69	168.03	169.19	168.17	167.07	168.17	167.07	168.73	167.43	168.73	167.43	168.88	167.52	168.88	167.52	7.57	7.57	8.27	8.27	8.44	8.44	Pipe	Ex. 2-year
Link24	195	Natural	1.5	3.7	SL-OF-0190	SL-CB-0188	173.47	166.28	174.97	168.03	173.74	168.17	173.74	168.17	173.78	168.73	173.78	168.73	173.78	168.88	173.78	168.88	4.41	4.41	6.22	6.22	6.20	6.20	NA	NA
Link49	33	Natural	0.0	2.9	SL-HW-0030	Node335	140.06	139.11	143.75	143.00	141.01	140.06	141.01	140.06	141.09	140.14	141.09	140.14	141.11	140.16	141.11	140.16	38.29	37.64	47.48	47.58	49.87	49.94	NA	NA
Link42	259	Circular	3.0	0.0	SL-PC-0376	SL-PC-0692	175.93	175.93	199.27	187.82	184.18	184.17	184.18	184.17	188.74	188.72	188.74	188.72	189.05	189.04	189.05	189.04	-1.18	-1.18	1.49	1.49	2.76	2.76	NA	NA
Link43	208	Circular	1.5	2.1	SL-PC-0376	SL-OF-0372	175.93	171.65	199.27	175.00	176.70	174.66	176.70	174.66	177.30	174.66	177.30	174.66	178.62	174.66	178.62	174.66	4.89	4.89	9.68	9.68	11.68	11.68	NA	NA
Link37	148	Circular	1.0	0.2	SL-PC-0692	SL-MH-0198	175.93	175.68	187.82	178.63	184.17	178.83	184.17	178.83	188.72	179.76	188.72	179.76	189.04	179.97	189.04	179.97	5.79	5.79	7.82	7.82	7.92	7.92	Pipe	Ex. 10-year
Link36	551	Circular	3.0	0.5	SL-MH-0764	SL-PC-0692	182.43	179.74	190.13	187.82	184.20	184.17	184.20	184.17	188.77	188.72	188.77	188.72	189.09	189.04	189.09	189.04	5.43	5.43	9.70	9.70	11.16	11.16	NA	NA
Link21	120	Circular	2.0	14.8	BE-MH-1878	BE-MH-1864	282.63	264.78	290.23	275.98	282.99	265.22	282.99	265.22	283.13	265.55	283.13	265.55	283.17	265.67	283.17	265.67	5.17	5.17	10.27	10.27	12.09	12.09	NA	NA
Link22	19	Circular	2.0	5.3	BE-MH-1864	BE-MH-1304	265.03	264.01	275.98	274.31	265.22	264.18	265.22	264.18	265.55	264.42	265.55	264.42	265.67	264.49	265.67	264.49	0.72	0.72	4.24	4.24	5.97	5.97	NA	NA
Link23	599	Circular	0.8	15.2	BE-MH-1864	SL-OF-0190	264.68	173.47	275.98	174.97	265.22	173.74	265.22	173.74	265.55	173.78	265.55	173.78	265.67	173.78	265.67	173.78	4.42	4.42	6.22	6.22	6.22	6.22	NA	NA
Link28	97	Circular	1.3	0.7	SL-MH-0181	SL-MH-0180	153.94	153.25	158.36	156.80	158.62	157.04	158.62	157.04	158.69	157.08	158.69	157.08	158.71	157.08	158.71	157.09	6.34	6.32	6.36	6.36	6.38	6.38	Pipe	Ex. 2-year
Link31	267	Circular	2.0	0.7	SL-MH-1608	SL-MH-1604	152.90	150.91	156.00	155.08	155.92	154.06	156.00	154.10	157.55	154.91	157.57	154.92	157.39	154.92	157.89	154.94	14.92	15.09	17.88	17.91	17.59	18.90	Pipe	Ex. 10-year
Link32	139	Circular	2.0	-0.1	SL-MH-1604	SL-MH-1602	150.71	150.78	155.08	155.04	154.06	152.86	154.10	152.87	154.91	153.23	154.92	153.23	154.92	153.33	154.94	153.33	14.93	15.09	17.89	17.91	17.59	18.04	NA	NA
Link33	23	Circular	2.0	3.8	SL-MH-1602	SL-OF-0177	151.21	150.36	155.04	154.05	152.86	151.85	152.87	151.86	153.23	152.06	153.23	152.06	153.33	152.08	153.33	152.10	16.23	16.41	19.83	19.85	20.74	20.75	NA	NA
Link34	150	Natural	0.0	-0.3	SL-OF-0177	Node350	150.36	150.81	154.05	155.00	151.85	151.71	151.86	151.72	152.06	151.91	152.06	151.91	152.08	151.92	152.10	151.94	17.01	17.27	25.85	25.82	26.56	27.54	NA	NA
Link50	349	Trapezoidal	2.9	0.4	Node336	SL-MH-1608	154.42	153.05	157.42	156.00	156.09	155.92	156.15	156.00	157.59	157.55	157.60	157.57	157.42	157.39	157.92	157.89	15.03	15.43	35.36	35.58	40.66	40.70	NA	NA
Link65	173	Trapezoidal	2.5	2.0	Node350	Node355	150.81	147.30	155.00	153.00	151.71	147.94	151.72	147.95	151.91	148.05	151.91	148.05	151.92	148.06	151.94	148.07	16.97	17.22	25.78	25.82	26.55	27.51	NA	NA
Link66	150	Circular	1.0	0.3	Node351	SL-IS-0208	152.42	152.00	154.60	154.10	152.86	152.86	152.88	152.87	153.26	153.26	153.27	153.26	153.37	153.37	153.38	153.37	-0.16	-0.15	-0.20	-0.19	-0.20	-0.19	NA	NA
Link67	10	Circular	1.0	13.2	SL-DI-1606	SL-MH-1604	152.53	151.21	154.93	155.08	154.06	154.06	154.10	154.10	154.91	154.91	154.92	154.92	154.92	154.92	154.93	154.94	-0.64	-0.63	-0.62	-0.63	-1.41	-1.36	NA	NA
Link68	38	Circular	0.7	-0.3	SL-CB-1612	SL-MH-0179	153.87	153.98	155.35	155.57	155.84	156.06	155.85	156.11	155.96	156.68	155.96	156.68	155.96	156.66	155.97	156.72	1.41	1.41	-1.57	-1.58	-1.55	-1.61	Pipe	Ex. 2-year
Link51	370	Trapezoidal	3.0	2.3	Node354	Node336	163.00	154.42	166.50	157.42	163.76	156.09	163.78	156.15	164.18	157.59	164.18	157.60	164.26	157.42	164.27	157.92	14.68	15.25	34.04	34.26	39.07	39.25	NA	NA
Link69	50	Trapezoidal	3.0	2.7	Node354	SL-IS-0032	163.00	161.63	166.50	164.63	163.76	163.80	163.78	163.82	164.18	164.27	164.18	164.28	164.26	164.37	164.27	164.37	14.75	15.32	34.05	34.28	39.10	39.28	NA	NA
Link70	195	Trapezoidal	2.5	3.7	Node355	SL-HW-0030	147.30	140.06	153.00	143.75	147.94	141.01	147.95	141.01	148.05	141.09	148.05	141.09	148.06	141.11	148.07	141.11	13.45	13.61	18.65	18.67	19.09	19.69	NA	NA
Link29.1	25	Circular	1.3	0.1	SL-MH-0180.1	SL-MH-0180.1.1	153.19	153.15	155.46	155.51	156.63	156.40	156.64	156.43	156.79	156.74	156.79	156.74	156.78	156.73	156.80	156.77	5.18	5.18	5.18	5.18	5.15	5.15	Pipe	Ex. 2-year
Link29.1.1	65	Circular	1.3	0.1	SL-MH-0180.1.1	SL-MH-0179	153.15	153.07	155.51	155.57	156.40	156.06	156.43	156.11	156.74	156.68	156.74	156.68	156.73	156.66	156.77	156.72	5.18	5.18	5.17	5.17	5.15	5.15	Pipe	Ex. 2-year
Link73	13	Circular	1.0	0.1	Private2	SL-MH-0180.1	153.20	153.19	156.10	155.46	156.62	156.63	156.63	156.64	156.75	156.79	156.75	156.79	156.74	156.78	156.76	156.80	-0.66	-0.74	-1.85	-1.86	-1.80	-1.99	Pipe	Ex. 2-year
Link74	10	Circular	0.2	0.1	Private1	SL-MH-0180.1.1	153.16	153.15	156.30	155.51	156.40	156.40	156.41	156.43	156.44	156.74	156.44	156.74	156.44	156.73	156.44	156.77	0.04	0.04	-0.05	-0.05	-0.05	-0.05	Pipe	Ex. 2-year
Location ID 56																														
Link1	151	Circular	1.00	2.22	RW-CB-0144	RW-CB-0140	178.84	175.48	181.54	180.63	179.44	175.92	179.44	175.93	180.67	176.20	180.65	176.20	181.56	176.31	181.56	176.31	2.60	2.60	4.92	4.92	5.49	5.49	Pipe	Ex. 25-year
Link2	438	Natural	1.50	4.56	RW-OF-0138	RW-CB-0130	166.22	146.21	167.72	148.96	166.43	147.68	166.43	147.75	166.48	149.41	166.48	149.42	166.49	149.63	166.49	149.64	4.05	4.14	7.33	7.37	8.33	8.37	NA	NA
Link3	76	Circular	1.00	1.14	RW-CB-0130	RW-CB-0128	146.21	145.35	148.96	147.35	147.68	146.17	147.75	145.94	149.41	147.44	149.42	147.44	149.63	147.56	149.64	147.56	3.75	3.82	5.14	5.15	5.24	5.24	Pipe	Ex. 10-year
Link4	258	Circular	1.00	4.69	RW-CB-0128	RW-CB-0126	145.25	133.15	147.35	136.95	145.92	135.01	145.94	135.26	147.44	137.10	147.44	137.10	147.56	137.15	147.56	137.16	5.17	5.25	6.21	6.21	6.24	6.24	Pipe	Ex. 10-year
Link5	132	Circular	1.00	3.65	RW-CB-0126	RW-CB-0124	133.00	128.17	136.95	131.09	135.01	129.85	135.26	129.91	137.10	130.38	137.10	130.38	137.15	130.39	137.16	130.39	5.73	5.85	6.61	6.61	6.64	6.64	Pipe	Ex. 10-year
Link6	61	Circular	1.25	4.72	RW-CB-0124	RW-OF-0122	127.47	124.60	131.09	131.47	129.85	128.82	129.91	128.84	130.38	129.00	130.38	129.00	130.39	129.00	130.39	129.00	5.73	5.85	6.61	6.61	6.64	6.64	NA	NA
Link7	20	Circular	1.00	46.30	RW-CB-0140	RW-OF-0138	175.48	166.22	180.63	167.72	175.92	166.43	175.93	166.43	176.20	166.48	176.20	166.48	176.31	166.49	176.31	166.49	4.12	4.21	7.34	7.37	8.34	8.38	NA	NA
Link11	58	Trapezoidal	4.00	-5.22	RW-OF-0122	RW-IS-0120	124.60	127.63	131.47	137.13	128.82	128.82	128.84	128.84	129.00	129.00	129.00	129.00	129.00	129.00	129.00	129.00	5.66	5.77	6.61	6.61	6.64	6.64	NA	NA
Link12	69	Circular	1.50	4.52	RW-IS-0120	RW-OF-0118	127.43	124.31	137.13	137.01	128.82	124.85	128.84	124.49	129.00	124.89	129.00	124.52	129.00	124.89	129.00	124.52	5.65	5.76	6.61	6.61	6.64	6.64	NA	NA
Link13	100	Trapezoidal	4.00	5.00	RW-OF-0118	Node296	124.21	119.21	137.07	125.21	124.49	119.46	124.49	119.47	124.52	119.49	124.52	119.49	124.52	119.49	124.52	119.49	5.65	5.75	6.61	6.61	6.63	6.64	NA	NA

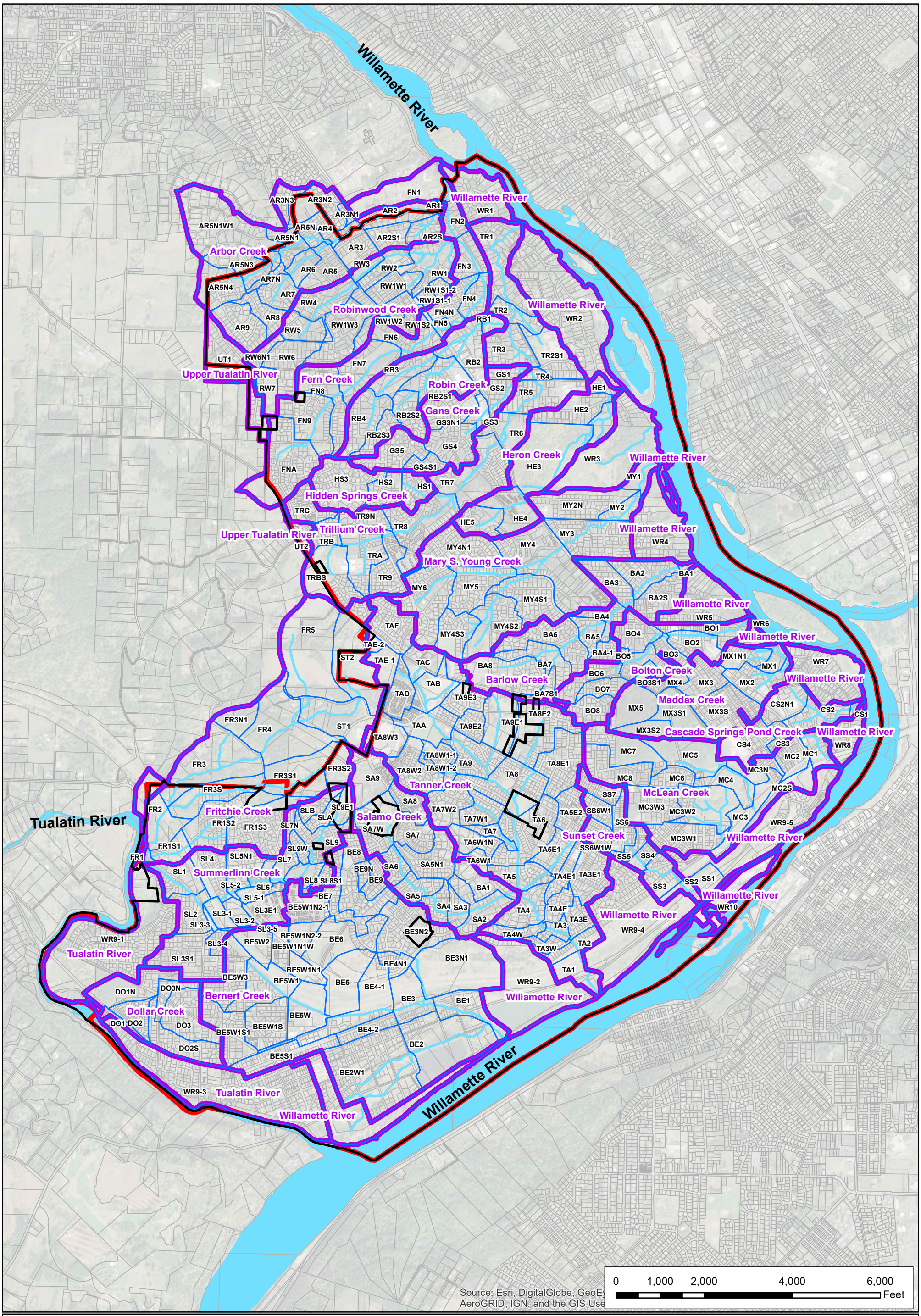
[1] *Criteria 1 = Headwater is above 1.5 times the culvert diameter; Criteria 2 = Headwater is less than 1' below roadway subgrade; Pipe Criteria = Water exceeds spillcrest elevation*

[2] *Negative max flow values are due to system surcharging and flooding and are not indicative of link capacity*

[3] *Negative flow values in this link are due to some minor model instability at this link only. Values are not indicative of the true discharge.*

Attachment B: Figures

This page intentionally left blank.



1:24,000 scale

N

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure B-1: Stormwater Subbasins

City Boundary
UGB
Subbasins
Watershed Boundaries
Streams

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: November 2018 Produced by Brown and Caldwell

10/7/2019

Legend

Hydraulic Modeling Location
- Detailed
- Capacity Check
- Hwy 43 Crossings
- Hydraulic Model Extent (Detailed Only)

Contributing Subbasins to Hydraulic Modeling Locations
- 13
- 47
- 56
- 59
- 60
- 63

- Stormwater Pipe
- Open Channel
- Streams
- Subbasins
- Watershed Boundaries
- City Limits
- UGB
- ODOT ROW
- Catch Basin
- Inlet
- Manhole
- Outfall

0 400 800 1,600 2,400 Feet

1:9,600 scale

N

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure B-2: Hydraulic Modeling Overview (North)

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: November 2018 Produced by Brown and Caldwell

10/7/2019

Legend

Hydraulic Modeling Location
- Detailed
- Capacity Check
- Hwy 43 Crossings
- Hydraulic Model Extent (Detailed Only)

Contributing Subbasins to Hydraulic Modeling Locations
- 13
- 47
- 56
- 59
- 60
- 63

- Stormwater Pipe
- Open Channel
- Streams
- Subbasins
- Watershed Boundaries
- City Limits
- UGB
- ODOT ROW
- Catch Basin
- Inlet
- Manhole
- Outfall

0 400 800 1,600 2,400 Feet

1:9,600 scale

N

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure B-3: Hydraulic Modeling Overview (Central)

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: November 2018 Produced by Brown and Caldwell

10/7/2019

Legend

Hydraulic Modeling Location
- Detailed
- Capacity Check
- Hwy 43 Crossings
- Hydraulic Model Extent (Detailed Only)

Contributing Subbasins to Hydraulic Modeling Locations
- 13
- 47
- 56
- 59
- 60
- 63

- Stormwater Pipe
- Open Channel
- Streams
- Subbasins
- Watershed Boundaries
- City Limits
- UGB
- ODOT ROW
- Catch Basin
- Inlet
- Manhole
- Outfall

Mary S. Young Creek
Barlow Creek
Bolton Creek
Willamette River
Maddax Creek
Cascade Springs Pond Creek
Tanner Creek
McLean Creek
Summerlinn Creek
Salamo Creek
Sunset Creek
Bernert Creek
I205 FWY
I205 FWY RAMP
63
59
0 400 800 1,600 2,400 Feet

1:9,600 scale

N

CITY OF WEST LINN, OREGON

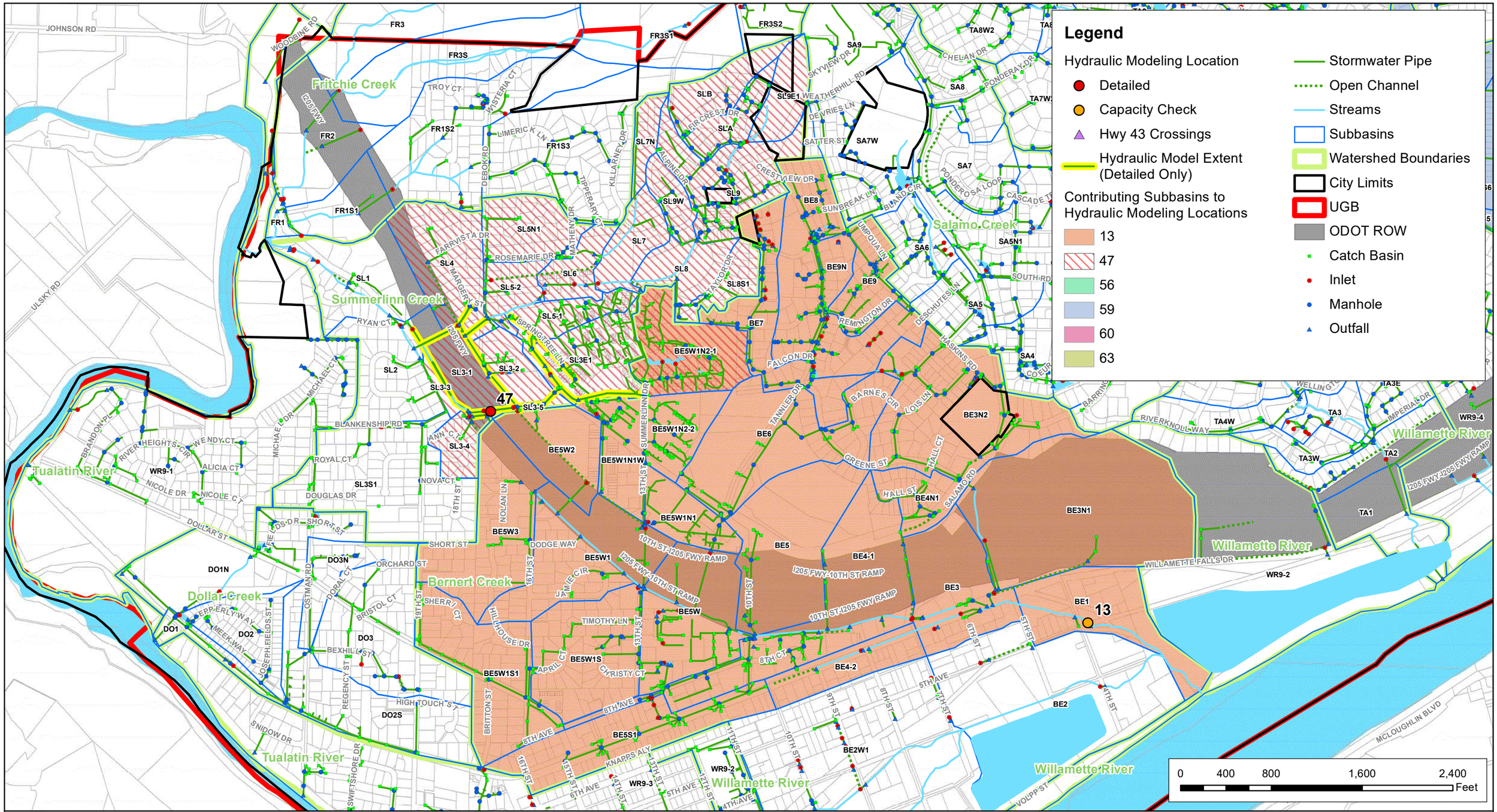
Storm Drainage and Sanitary Master Plan 2019

Figure B-4: Hydraulic Modeling Overview (South)

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: November 2018 Produced by Brown and Caldwell

10/7/2019



1:9,600 scale

N

CITY OF WEST LINN, OREGON

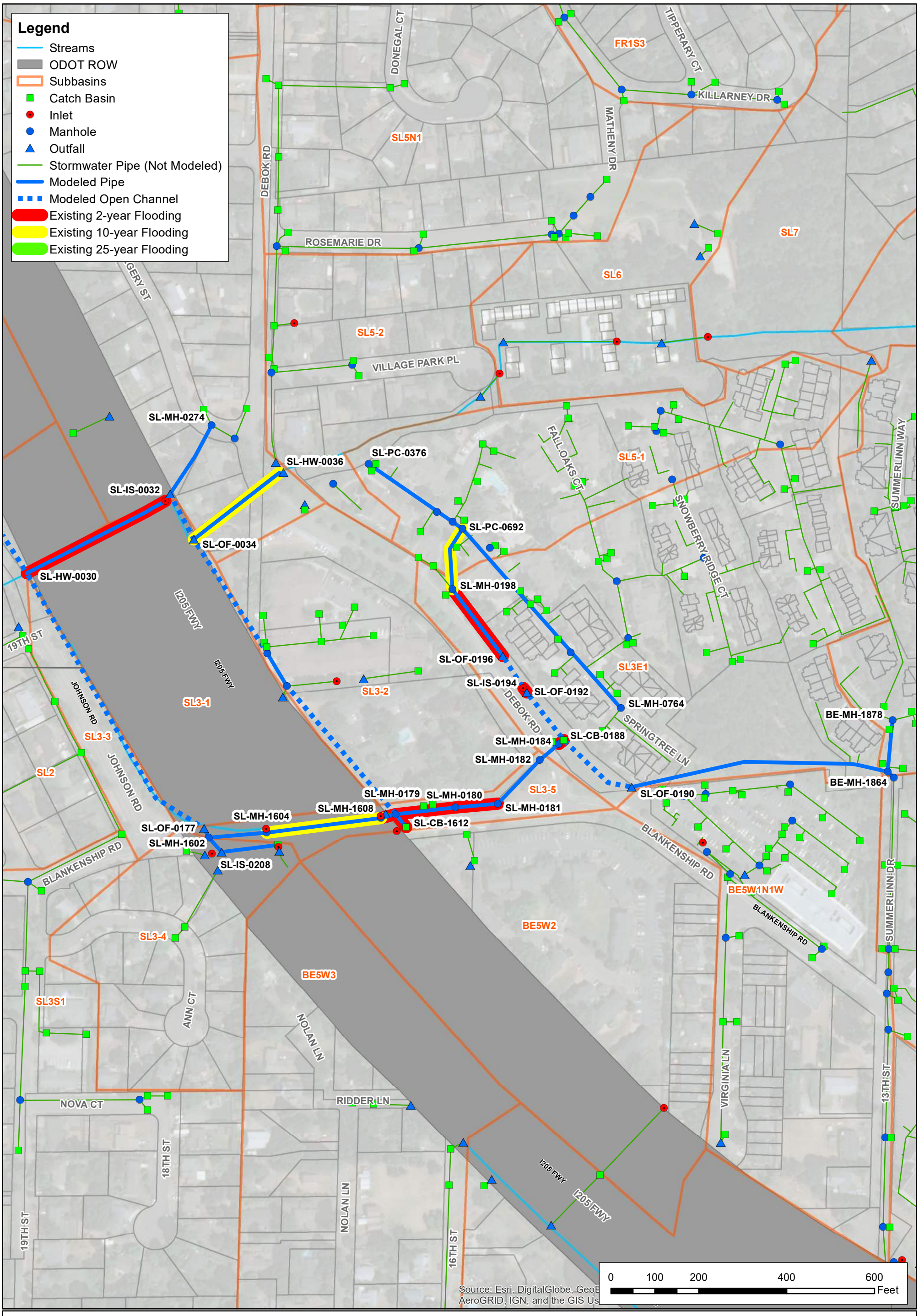
Storm Drainage and Sanitary Master Plan 2019

Figure B-5: Hydraulic Modeling Overview (Southwest)

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: November 2018 Produced by Brown and Caldwell

10/7/2019



1:2,400 scale

N

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

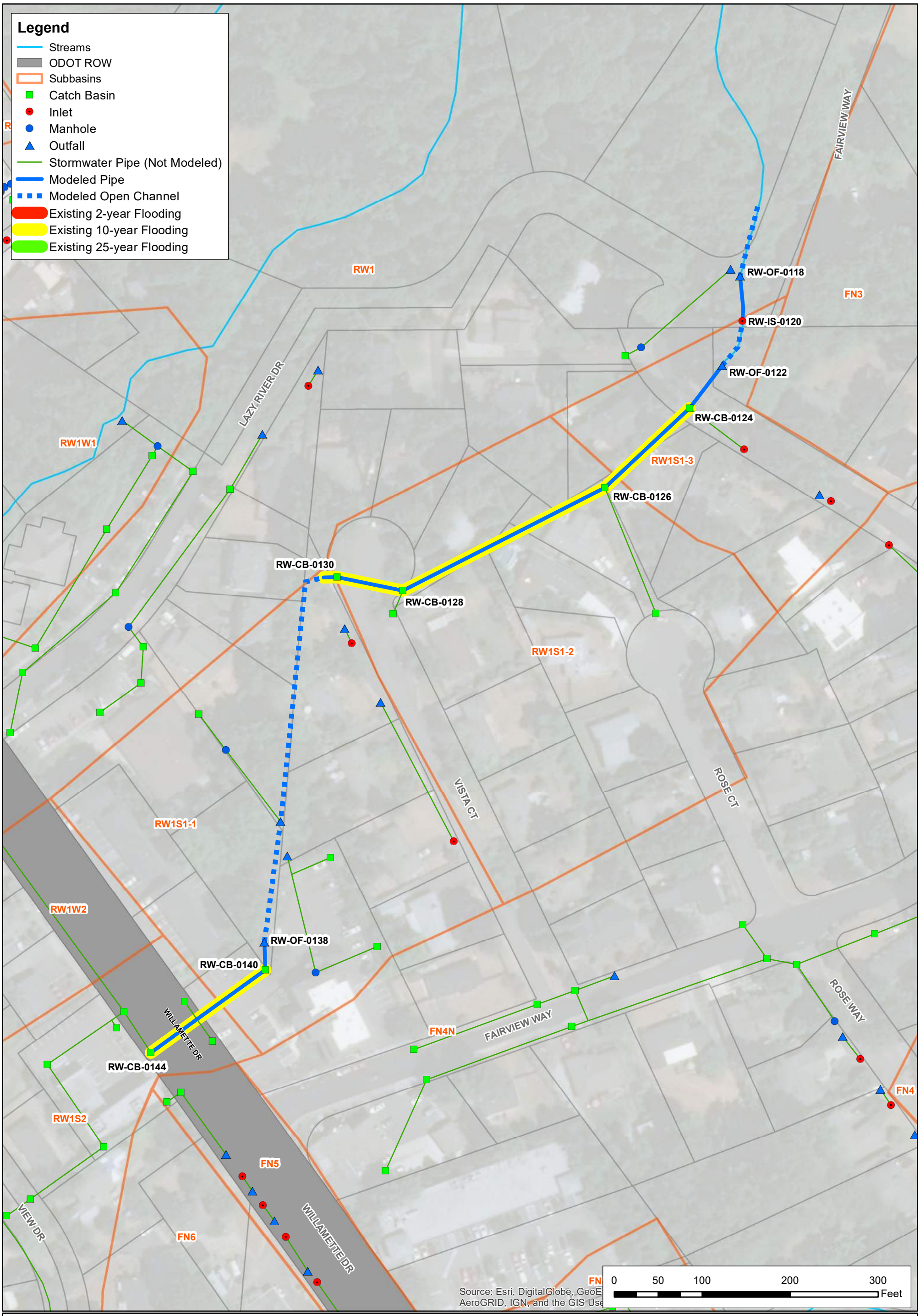
Figure B-6: Location 47 Hydraulic Modeling Results

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: November 2018 Produced by Brown and Caldwell

10/7/2019



1:1,200 scale

N

CITY OF WEST LINN, OREGON

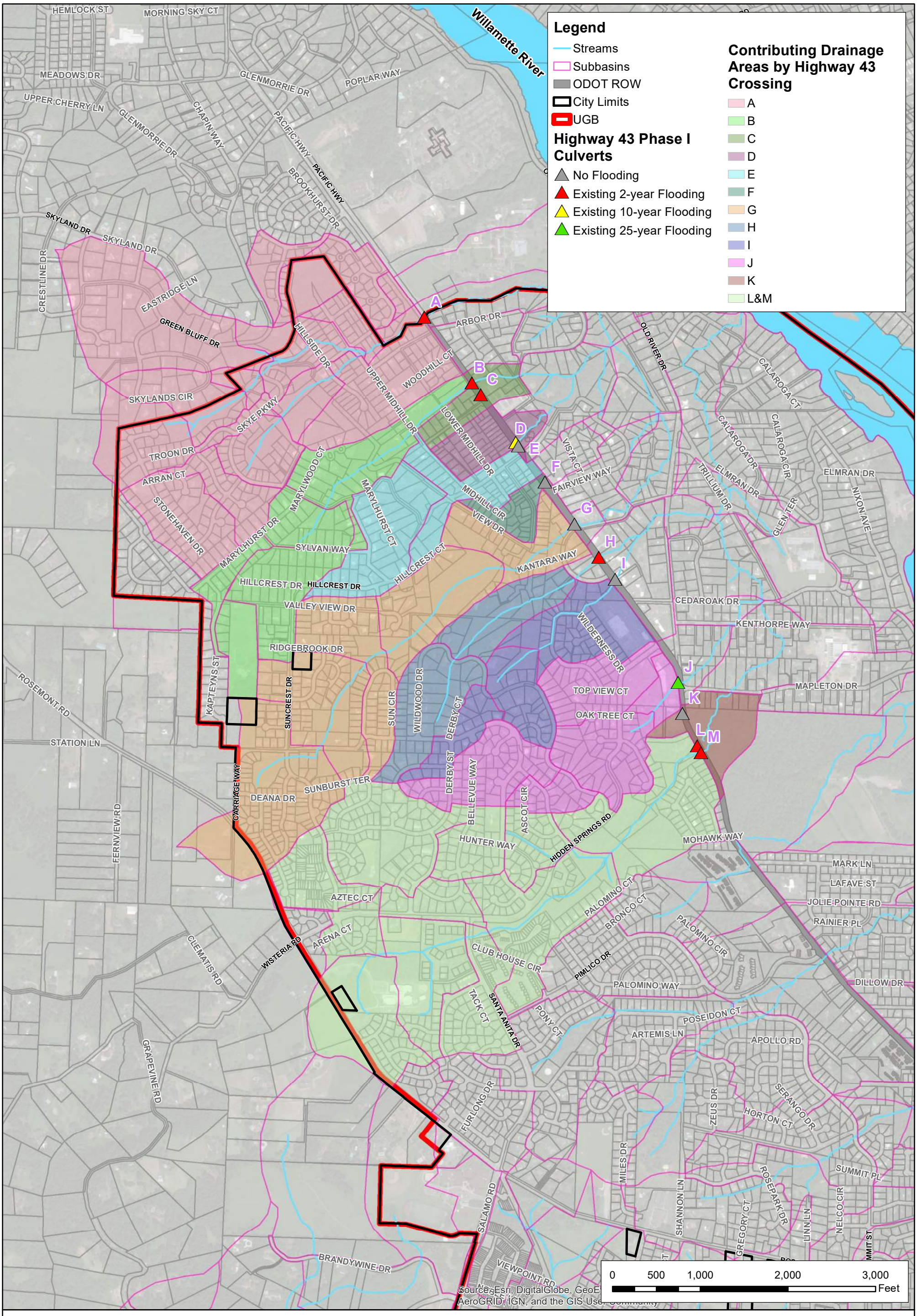
Storm Drainage and Sanitary Master Plan 2019

Figure B-7: Location 56 Hydraulic Modeling Results

Data Source: City of West Linn GIS and Metro RLIS

Map Publication/Print Date: November 2018 Produced by Brown and Caldwell

10/7/2019



1:12,000 scale

N

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary master Plan 2019

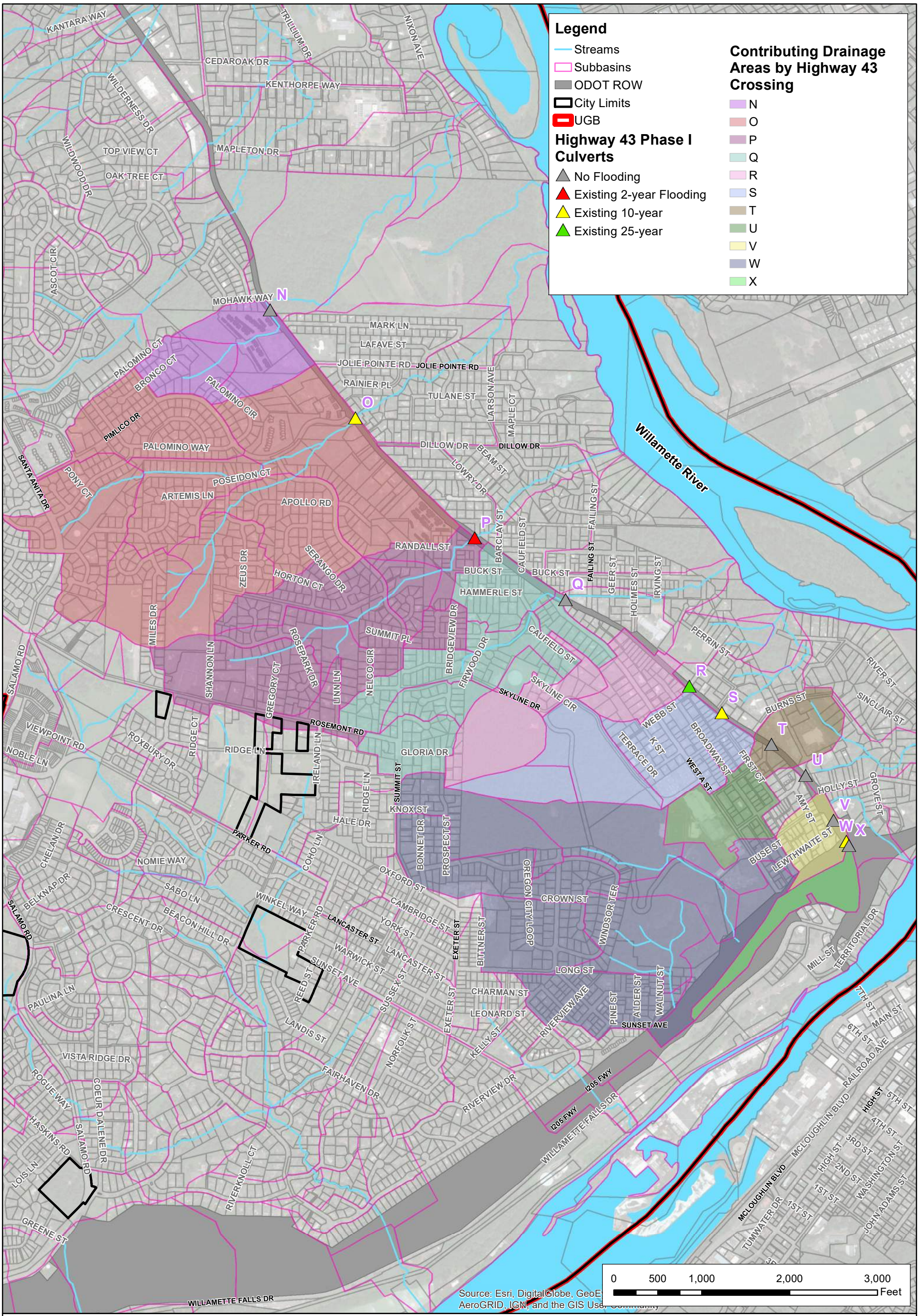
Figure B-8: Highway 43 Phase I Modeling Results

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: November 2018 Produced by Brown and Caldwell

10/7/2019



1:12,000 scale

N

CITY OF WEST LINN, OREGON

Storm Drainage and Sanitary Master Plan 2019

Figure B-9: Highway 43 Future (Phase II) Phase Modeling Results

Data Source: City of West Linn GIS and Metro RLIS

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Map Publication/Print Date: November 2018 Produced by Brown and Caldwell

10/7/2019

This page intentionally left blank.

Appendix E: Detailed Cost Estimates

Unit Cost Table

Costs based on RS Means, collected bid tabs, and recent master planning efforts, adjusted to 2018 prices.

Item	Unit	Unit Cost (2018)
Inspection		
Mainline Video Inspection	FT	3.50
Earthwork		
General Earthwork/Excavation	CY	20
Embankment	CY	9
Clear and Grub brush including stumps	AC	8,200
Amended Soils and Mulch	CY	45
Jute Matting, Biodegradeable	SY	6
Tree removal	EA	300
Geomembrane	SY	30
Geotextile	SY	3
Energy dissapation pad - Rip-Rap, Class 50	CY	66
Energy dissapation pad - Rip-Rap, Class 100	CY	81
Energy dissapation pad - Rip-Rap, Class 200	CY	96
Dewatering/Bypass	LS	20,000
Drain Rock	CY	101
Water Quality Facility Installation		
Pond Outflow Control Structure	EA	6,100
Pond Inlet Structure	EA	4,500
Water Quality Facility Plantings with Trees	SF	6
Rain Garden	SF	27
Stormwater Planter	SF	40
Gravel Access Road	SF	5
Beehive Overflow	EA	1,500
Structure Installation		
Field Ditch Inlet	EA	4,000
Precast Concrete Manhole (48", 0-8' deep)	EA	5,600
Precast Concrete Manhole (48", 9-12' deep)	EA	6,600
Precast Concrete Manhole (48", 13-20' deep)	EA	10,200
Precast Concrete Manhole (60", 0-8' deep)	EA	7,600
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700
Precast Concrete Manhole (72", 0-8' deep)	EA	9,700
Precast Concrete Manhole (72", 9-12' deep)	EA	12,200
Flow Splitter/WQ Manhole (72", all depths)	EA	12,300
Contech CDS (Model CDS3025, 72")	EA	28,800
StormFilter (2-cartridge catch basin unit, 18" cartridges)	EA	10,100
Drywell (48", 20-25' deep)	EA	12,200
Curb Inlet	EA	1,300
Catch Basin, all types	EA	2,000
Concrete Fill - UIC Decomissioning	EA	10,200
Connection to Existing Lateral	EA	1,200
Connection to Existing Structure, standard	EA	2,000
Abandon Existing Pipe, no excavation (12")	FT	10
Abandon Existing Pipe, no excavation (15"-18")	FT	20
Abandon Existing Pipe, no excavation (21"-24")	FT	25
Abandon Existing Pipe, no excavation (27"-36")	FT	35
Abandon Existing Structure	EA	1,000
Demo pipe	LF	71
Remove existing pavement	SY	10
Remove structure	EA	1,000
Plug Existing Pipe	EA	505
Check dams	EA	505
Stem wall check dam	LF	66
Headwall with wingwalls, larger than 48" pipe	EA	14,000
Headwall with wingwalls, up to 48" pipe	EA	8,000
Outfall Improvements	EA	3,000-10,000
Restoration/Resurfacing		
Non-Water Quality Facility Landscaping	AC	15,300
Riparian/Wetland Planting (Non-irrigated)	AC	20,300

Unit Cost Table

Costs based on RS Means, collected bid tabs, and recent master planning efforts, adjusted to 2018 prices.

Item	Unit	Unit Cost (2018)
Riparian/Wetland Planting (w/temporary irrigation)	AC	32,500
Planting and Bioengineered Restoration	SY	40
4-foot Chain Link Fence	LF	22
Split Rail Fence	LF	25
Hydroseed, large quantities	AC	2500
Seeding, small quantities (< 5,000 sf)	SF	6
Sidewalk Installation	SF	7
Trench resurfacing, Permanent ACP, 6-Inch Depth	SY	71
Permeable Paver Installation	SF	12
Concrete Curbs	FT	40
Pipe Unit Cost		
Underdrain Pipe, 4"	LF	29
Underdrain, 6" perforated HDPE	LF	56
HDPE Inlet Lead (12", 2-5' deep)	FT	91
HDPE Pipeline w/asphalt resurfacing (12", 5-10' deep)	FT	140
HDPE Pipeline (12", 5-10' deep)	FT	125
HDPE Pipeline w/asphalt resurfacing (12", 10-15' deep)	FT	160
HDPE Pipeline w/asphalt resurfacing (18", 5-10' deep)	FT	200
HDPE Pipeline w/asphalt resurfacing (24", 5-10' deep)	FT	275
HDPE Pipeline w/asphalt resurfacing (30", 5-10' deep)	FT	325
HDPE Pipeline (30", 5-10' deep)	FT	240
HDPE Pipeline w/asphalt resurfacing (36", 5-10' deep)	FT	405
HDPE Pipeline (36", 5-10' deep)	FT	265
HDPE Pipeline (36", 10-15' deep)	FT	305
HDPE Pipeline w/asphalt resurfacing (42", 5-10' deep)	FT	485
HDPE Pipeline (42", 5-10' deep)	FT	345
HDPE Pipeline w/asphalt resurfacing (48", 5-10' deep)	FT	570
HDPE Pipeline (48", 5-10' deep)	FT	430
HDPE Pipeline w/asphalt resurfacing (60", 5-10' deep)	FT	820
HDPE Pipeline (60", 5-10' deep)	FT	680
CMP Pipeline w/asphalt resurfacing (84", 5-10' deep)	FT	1145
CMP Pipeline (84", 5-10' deep)	FT	935
Extra depth pipe	FT	51
RCP Pipeline w/ asphalt resurfacing (12", 5-10' deep)	FT	230
RCP Pipeline w/ asphalt resurfacing (24", 5-10' deep)	FT	400
RCP Pipeline w/ asphalt resurfacing (30", 5-10' deep)	FT	525
RCP Pipeline w/ asphalt resurfacing (36", 5-10' deep)	FT	650
RCP Pipeline w/ asphalt resurfacing (48", 5'-10' deep)	FT	850
RCP Pipeline w/ asphalt resurfacing (60", 5'-10' deep)	FT	1200
RCP Pipeline w/ asphalt resurfacing (72",5'-10' deep)	FT	1500
RCP Pipeline w/ asphalt resurfacing (84", 5'-10' deep)	FT	1700
Box Culvert (160 LF, 4' x 9')	LS	102000
Box Culvert Installation	FT	890
Contingencies (applied to construction subtotals)		
Traffic Control/Utility Relocation	LS	5-10%
Erosion Control	LS	2%
Planning Contingency	LS	20%
Construction Contingency	LS	30%
Multipliers (applied to capital expense total including contingencies)		
Engineering and Permitting (%)	LS	15-35%
Construction Administration (%)	LS	10%

CIP #: C-1

Phase I Highway 43 Culvert Replacements

DESIGN ASSUMPTIONS

Water quality to address new/ replaced impervious to be determined with detailed design. Water quality facilities are not reflected in project description or cost estimate.

Crossings may require upstream drop structures due to lack of adequate cover for upsized pipes.
Concrete headwalls or a new manhole will be installed on the downstream ends of each new culvert.

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	160	$3,200
Embankment	CY	9	160	$1,440
Structure Installation				
Precast Concrete Manhole (60", 0-8' deep)	EA	7,600	1	$7,600
Precast Concrete Manhole (48", 0-8' deep)	LF	5,600	1	$5,600
Demo pipe	EA	71	720	$51,120
Field Ditch Inlet	EA	4,000	6	$24,000
Headwall with wingwalls, up to 48" pipe	EA	8,000	8	$64,000
Pipe Unit Cost				
HDPE Pipeline w/asphalt resurfacing (24", 5-10' deep)	FT	275	135	$37,125
HDPE Pipeline w/asphalt resurfacing (36", 5-10' deep)	FT	405	190	$76,950
HDPE Pipeline w/asphalt resurfacing (42", 5-10' deep)	FT	485	235	$113,975
HDPE Pipeline w/asphalt resurfacing (60", 5-10' deep)	FT	820	80	$65,600
Project Sub-Total				$451,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$90,200
Traffic Control/Utility Relocation	LS	10%		$45,100
Erosion Control	LS	2%		$9,020
Construction Cost Subtotal				$595,000
Construction Contingency	LS	30%		$178,500
Capital Expense Total				$774,000
Engineering and Permitting (%)	LS	25%		$193,500
Construction Administration (%)	LS	10%		$77,400
			TOTAL	$1,045,000

CIP #: C-2

5th Avenue Culvert Replacement

DESIGN ASSUMPTIONS

Due to limited cover, box culvert will be required to meet traffic rating.

An existing sanitary force main, owned and operated by WES, is aligned along the south side of 5th Ave and above the outfall of the existing culvert outfall. The force main is exposed and may require protection from the creek.

Utility conflicts, sanitary, water, gas, franchise utilities, are likely for this crossing due to the increased size.

Roadway improvements may be necessary following culvert replacement.

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	100	$2,000
Structure Installation				
Demo pipe	LF	71	45	$3,195
Headwall with wingwalls, larger than 48" pipe	EA	14,000	2	$28,000
Dewatering/Bypass	LS	20,000	1	$20,000
Remove existing pavement	SY	10	320	$3,200
Trench resurfacing, Permanent ACP, 6-Inch Depth	SY	71	230	$16,330
Restoration/Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	1	$20,300
Hydroseed, large quantities	AC	2,500	1	$2,500
Pipe Unit Cost				
Box Culvert (160 LF, 4' x 9')	LS	102,000	1	$102,000
Box Culvert Installation	FT	890	160	$142,400
Project Sub-Total				$340,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$68,000
Traffic Control/Utility Relocation	LS	10%		$34,000
Erosion Control	LS	2%		$6,800
Construction Cost Subtotal				$449,000
Construction Contingency	LS	30%		$134,700
Capital Expense Total				$584,000
Engineering and Permitting (%)	LS	35%		$204,400
Construction Administration (%)	LS	10%		$58,400
			TOTAL	$847,000

CIP #: C-3

Sunset Creek Willamette Falls Drive Culvert at I-205

DESIGN ASSUMPTIONS

Cover is limited in this location so small parallel culverts are required.

Conveyance of system across private property downstream of culvert is unknown. Additional culvert capacity may require additional updates to private system to the Willamette River.

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	40	$800
Structure Installation				
Demo pipe	LF	71	95	$6,745
Headwall with wingwalls, up to 48" pipe	EA	8,000	4	$32,000
Restoration/Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	1	$20,300
Pipe Unit Cost				
HDPE Pipeline w/asphalt resurfacing (30", 5-10' deep)	FT	325	95	$30,875
HDPE Pipeline w/asphalt resurfacing (30", 5-10' deep)	FT	325	95	$30,875
Project Sub-Total				$122,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$24,400
Traffic Control/Utility Relocation	LS	10%		$12,200
Erosion Control	LS	2%		$2,440
Construction Cost Subtotal				$161,000
Construction Contingency	LS	30%		$48,300
Capital Expense Total				$209,000
Engineering and Permitting (%)	LS	25%		$52,250
Construction Administration (%)	LS	10%		$20,900
			TOTAL	$282,000

CIP #: C-4

Maddox Creek Culvert at River Street

DESIGN ASSUMPTIONS

Configuration of existing culvert is not well known. Inverts and cover are estimates and are not based on survey or as-built records.

A full hydraulic assessment including a detailed survey of existing culverts, other utilities and roadway elevations should be completed prior to any final design at this location.

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	40	$800
Structure Installation				
Demo pipe	LF	71	165	$11,715
Restoration/Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	1	$20,300
Pipe Unit Cost				
HDPE Pipeline w/asphalt resurfacing (36", 5-10' deep)	FT	405	165	$66,825
HDPE Pipeline w/asphalt resurfacing (36", 5-10' deep)	FT	405	165	$66,825
Project Sub-Total				$166,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$33,200
Traffic Control/Utility Relocation	LS	10%		$16,600
Erosion Control	LS	2%		$3,320
Construction Cost Subtotal				$219,000
Construction Contingency	LS	30%		$65,700
Capital Expense Total				$285,000
Engineering and Permitting (%)	LS	25%		$71,250
Construction Administration (%)	LS	10%		$28,500
			TOTAL	$385,000

CIP #: I-1

Blankenship Road under I-205 Overpass Improvements

DESIGN ASSUMPTIONS

Some proposed pipes have limited depth and cover but are largely outside driving lanes. The alignment should be shifted toward the curb as much as possible to reduce the need for reinforced structural pipe.

XPSWMM modeling assumes no stormflow contribution to the project area from the ODOT culvert to the north/NW (see accompanying figure). The City of West Linn and ODOT will need to coordinate how conveyance system should be modified.

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	20	$400
Structure Installation				
Precast Concrete Manhole (48", 0-8' deep)	EA	5,600	2	$11,200
Precast Concrete Manhole (60", 0-8' deep)	EA	7,600	4	$30,400
Precast Concrete Manhole (72", 9-12' deep)	EA	12,200	2	$24,400
Field Ditch Inlet	EA	4,000	2	$8,000
Headwall with wingwalls, up to 48" pipe	EA	8,000	1	$8,000
Connection to Existing Structure, standard	EA	2,000	5	$10,000
Outfall Improvements	EA	5,000	1	$5,000
Restoration/Resurfacing				
Non-Water Quality Facility Landscaping	AC	15,300	1	$15,300
Pipe Unit Cost				
HDPE Pipeline w/asphalt resurfacing (18", 5-10' deep)	FT	200	45	$9,000
HDPE Pipeline w/asphalt resurfacing (24", 5-10' deep)	FT	275	275	$75,625
HDPE Pipeline w/asphalt resurfacing (30", 5-10' deep)	FT	325	430	$139,750
HDPE Inlet Lead (12", 2-5' deep)	FT	91	25	$2,275
Demo pipe	LF	71	430	$30,530
Project Sub-Total				$370,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$74,000
Traffic Control/Utility Relocation	LS	10%		$37,000
Erosion Control	LS	2%		$7,400
Construction Cost Subtotal				$488,000
Construction Contingency	LS	30%		$146,400
Capital Expense Total				$634,000
Engineering and Permitting (%)	LS	25%		$158,500
Construction Administration (%)	LS	10%		$63,400
			TOTAL	$856,000

CIP #: I-2

Mark Lane Improvements

DESIGN ASSUMPTIONS

Property and easement acquisition is not included in the cost estimate

Stormwater Planter footprint is conceptual and is to be established based on available ROW

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	1100	$22,000
Water Quality Facility Installation				
Stormwater Planter	SF	40	5000	$200,000
Beehive Overflow	EA	1,500	11	$16,500
Structure Installation				
Connection to Existing Structure, standard	EA	2,000	1	$2,000
Precast Concrete Manhole (48", 0-8' deep)	EA	5,600	7	$39,200
Curb Inlet	EA	1,300	11	$14,300
Pipe Unit Cost				
HDPE Pipeline w/asphalt resurfacing (12", 5-10' deep)	FT	140	1,400	$196,000
Project Sub-Total				$490,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$98,000
Traffic Control/Utility Relocation	LS	5%		$24,500
Erosion Control	LS	2%		$9,800
Construction Cost Subtotal				$622,000
Construction Contingency	LS	30%		$186,600
Capital Expense Total				$809,000
Engineering and Permitting (%)	LS	25%		$202,250
Construction Administration (%)	LS	10%		$80,900
			TOTAL	$1,092,000

CIP #: I-3

Buck Street Improvements

DESIGN ASSUMPTIONS

Property and easement acquisition is not included in the cost estimate

Stormwater planter footprint is conceptual and is to be established based on available ROW

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	830	$16,600
Water Quality Facility Installation				
Stormwater Planter	SF	40	3750	$150,000
Beehive Overflow	EA	1,500	8	$12,000
Structure Installation				
Precast Concrete Manhole (48", 0-8' deep)	EA	5,600	6	$33,600
Curb Inlet	EA	1,300	8	$10,400
Connection to Existing Structure, standard	EA	2,000	2	$4,000
Abandon Existing Pipe, no excavation (12")	FT	10	365	$3,650
Remove structure	EA	1,000	8	$8,000
Outfall Improvements	EA	5,000	1	$5,000
Restoration/Resurfacing				
Concrete Curbs	FT	40	100	$4,000
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	0.1	$2,030
Pipe Unit Cost				
HDPE Pipeline w/asphalt resurfacing (12", 5-10' deep)	FT	140	1100	$154,000
Project Sub-Total				$403,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$80,600
Traffic Control/Utility Relocation	LS	5%		$20,150
Erosion Control	LS	2%		$8,060
Construction Cost Subtotal				$512,000
Construction Contingency	LS	30%		$153,600
Capital Expense Total				$666,000
Engineering and Permitting (%)	LS	35%		$233,100
Construction Administration (%)	LS	10%		$66,600
			TOTAL	$966,000

CIP #: I-4

Fairview Way Pipe Relocation

DESIGN ASSUMPTIONS

Reinforced concrete pipes will be required for two pipe segments between Node304 and Node306 due to limited cover at the Fairview Way low point where the roadway turns to the northwest possibly others once a detailed survey is completed.

Local drainage along Fairview Avenue will be collected by a new storm sewer alignment

The roadway may be redesigned in conjunction with these storm line improvements. Associated stormwater collection improvements associated with roadway update should be coordinated with trunk line design.

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	40	$800
Structure Installation				
Precast Concrete Manhole (48", 0-8' deep)	EA	5,600	6	$33,600
Precast Concrete Manhole (60", 0-8' deep)	EA	7,600	5	$38,000
Abandon Existing Pipe, no excavation (12")	FT	10	215	$2,150
Outfall Improvements	EA	5,000	1	$5,000
Dewatering/Bypass	LS	20,000	1	$20,000
Demo pipe	LF	71	310	$22,010
Headwall with wingwalls, up to 48" pipe	EA	8,000	3	$24,000
Connection to Existing Structure, standard	EA	2,000	1	$2,000
Catch Basin, all types	EA	2,000	3	$6,000
Restoration/Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	1	$20,300
Pipe Unit Cost				
HDPE Pipeline w/asphalt resurfacing (18", 5-10' deep)	FT	200	1175	$235,000
RCP Pipeline w/ asphalt resurfacing (30", 5-10' deep)	FT	525	255	$133,875
HDPE Pipeline w/asphalt resurfacing (36", 5-10' deep)	FT	405	275	$111,375
HDPE Pipeline (36", 10-15' deep)	FT	305	50	$15,250
HDPE Pipeline (42", 5-10' deep)	FT	345	60	$20,700
HDPE Inlet Lead (12", 2-5' deep)	FT	91	100	$9,100
Project Sub-Total				$699,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$139,800
Traffic Control/Utility Relocation	LS	10%		$69,900
Erosion Control	LS	2%		$13,980
Construction Cost Subtotal				$923,000
Construction Contingency	LS	30%		$276,900
Capital Expense Total				$1,200,000
Engineering and Permitting (%)	LS	25%		$300,000
Construction Administration (%)	LS	10%		$120,000
			TOTAL	$1,620,000

CIP #: I-5

Nixon Avenue Pipe Relocation

DESIGN ASSUMPTIONS

Property and easement acquisition is not included in the cost estimate

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
Clear and Grub brush including stumps	AC	8,200	0.5	$4,100
Energy dissapation pad - Rip-Rap, Class 50	CY	66	10	$660
Structure Installation				
Precast Concrete Manhole (48", 0-8' deep)	EA	5,600	1	$5,600
Catch Basin, all types	EA	2,000	1	$2,000
Connection to Existing Structure, standard	EA	2,000	1	$2,000
Abandon Existing Pipe, no excavation (12")	FT	10	300	$3,000
Abandon Existing Structure	EA	1,000	2	$2,000
Outfall Improvements	EA	5,000	1	$5,000
Restoration/Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	0.1	$2,030
Pipe Unit Cost				
HDPE Pipeline (12", 5-10' deep)	FT	125	325	$40,625
HDPE Pipeline w/asphalt resurfacing (12", 5-10' deep)	FT	140	75	$10,500
Project Sub-Total				$78,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$15,600
Traffic Control/Utility Relocation	LS	5%		$3,900
Erosion Control	LS	2%		$1,560
Construction Cost Subtotal				$99,000
Construction Contingency	LS	30%		$29,700
Capital Expense Total				$129,000
Engineering and Permitting (%)	LS	25%		$32,250
Construction Administration (%)	LS	10%		$12,900
			TOTAL	$174,000

CIP #: I-6

Sunset Avenue Improvements

DESIGN ASSUMPTIONS

Project to be constructed in tandem with transportation project, which will provide curb/gutter, bike lane and sidewalk along Sunset Ave.

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	20	$400
Structure Installation				
Precast Concrete Manhole (48", 0-8' deep)	EA	5,600	18	$100,800
Catch Basin, all types	EA	2,000	10	$20,000
Connection to Existing Structure, standard	EA	2,000	8	$16,000
Abandon Existing Pipe, no excavation (12")	FT	10	915	$9,150
Pipe Unit Cost				
HDPE Pipeline w/asphalt resurfacing (12", 5-10' deep)	FT	140	3770	$527,800
HDPE Inlet Lead (12", 2-5' deep)	FT	91	150	$13,650
Project Sub-Total				$688,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$137,600
Traffic Control/Utility Relocation	LS	10%		$68,800
Erosion Control	LS	2%		$13,760
Construction Cost Subtotal				$908,000
Construction Contingency	LS	30%		$272,400
Capital Expense Total				$1,180,000
Engineering and Permitting (%)	LS	25%		$295,000
Construction Administration (%)	LS	10%		$118,000
			TOTAL	$1,593,000

CIP #: R-1

Public Pond #22 Retrofit

DESIGN ASSUMPTIONS

Inlet/ outlet piping has not been accounted for in the cost estimate

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	600	$12,000
Clear and Grub brush including stumps	AC	8,200	0.1	$820
Tree removal	EA	300	10	$3,000
Energy dissapation pad - Rip-Rap, Class 50	CY	66	2	$132
Water Quality Facility Installation				
Amended Soils and Mulch	CY	45	240	$10,800
Structure Installation				
Pond Outflow Control Structure	EA	6,100	1	$6,100
Restoration/Resurfacing				
Riparian/Wetland Planting (w/temporary irrigation)	AC	32,500	0.1	$3,250
Planting and Bioengineered Restoration	SY	40	100	$4,000
Project Sub-Total				$40,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$8,000
Traffic Control/Utility Relocation	LS	5%		$2,000
Erosion Control	LS	2%		$800
Construction Cost Subtotal				$51,000
Construction Contingency	LS	30%		$15,300
Capital Expense Total				$66,000
Engineering and Permitting (%)	LS	25%		$16,500
Construction Administration (%)	LS	10%		$6,600
			TOTAL	$89,000

CIP #: R-2

Mary S. Young Park Parking Lot Retrofit

DESIGN ASSUMPTIONS

Additional parking lot features (striping, signage, etc.) are not included in the cost estimate.
Infiltration testing should be conducted with design to confirm subgrade dimensions

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	2,500	$50,000
Structure Installation				
Connection to Existing Structure, standard	EA	2,000	1	$2,000
Remove existing pavement	SY	10	7,450	$74,500
Restoration/Resurfacing				
Permeable Paver Installation	SF	12	67,000	$804,000
Project Sub-Total				$931,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$186,200
Traffic Control/Utility Relocation	LS	5%		$46,550
Erosion Control	LS	2%		$18,620
Construction Cost Subtotal				$1,182,000
Construction Contingency	LS	30%		$354,600
Capital Expense Total				$1,537,000
Engineering and Permitting (%)	LS	25%		$384,250
Construction Administration (%)	LS	10%		$153,700
			TOTAL	$2,075,000

CIP #: R-3

West Linn Public Works Department Planters

DESIGN ASSUMPTIONS

Property and easement acquisition is not included in the cost estimate

Stormwater Planter footprint is conceptual and is to be established based on available ROW and onsite area

ITEM	UNIT	Unit Cost (2018)	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	20	260	$5,200
Water Quality Facility Installation				
Stormwater Planter	SF	40	1175	$47,000
Beehive Overflow	EA	1,500	2	$3,000
Structure Installation				
Curb Inlet	EA	1,300	2	$2,600
Connection to Existing Structure, standard	EA	2,000	2	$4,000
Abandon Existing Structure	EA	1,000	1	$1,000
Pipe Unit Cost				
HDPE Pipeline w/asphalt resurfacing (12", 5-10' deep)	FT	140	110	$15,400
Project Sub-Total				$78,000
Contingencies and Multipliers				
Planning Contingency	LS	20%		$15,600
Traffic Control/Utility Relocation	LS	5%		$3,900
Erosion Control	LS	2%		$1,560
Construction Cost Subtotal				$99,000
Construction Contingency	LS	30%		$29,700
Capital Expense Total				$129,000
Engineering and Permitting (%)	LS	25%		$32,250
Construction Administration (%)	LS	10%		$12,900
			TOTAL	$174,000

CIP Cost Summary

Funded Project Summary

CIP ID	Project Title	Capital Expense Total (including contingency)	Engineering and Permitting	Construction Administration	Other fees	Capital Project Implementation Cost Total[a]	SDC Eligibility[b]	SDC Percentage	SDC Eligible Cost[b]
C-1	Phase I Highway 43 Culvert Replacements	$774,000	$193,500	$77,400		**$1,045,000**	100%	3.0%	$ 31,000
C-2	5th Avenue Culvert Replacement	$584,000	$204,400	$58,400		**$847,000**	100%	12.6%	$ 106,000
C-3	Sunset Creek Willamette Falls Drive Culvert at I-205	$209,000	$52,250	$20,900		**$282,000**	100%	0.7%	$ 2,000
C-4	Maddox Creek Culvert at River Street	$285,000	$71,250	$28,500		**$385,000**	100%	1.7%	$ 7,000
I-1	Blankenship Road under I-205 Overpass Improvements	$634,000	$158,500	$63,400		**$856,000**	100%	11.3%	$ 97,000
I-2	Mark Lane Improvements	$809,000	$202,250	$80,900		**$1,092,000**	100%	0.4%	$ 5,000
I-3	Buck Street Improvements	$666,000	$233,100	$66,600		**$966,000**	100%	9.2%	$ 89,000
I-4	Fairview Way Pipe Relocation	$1,200,000	$300,000	$120,000		**$1,620,000**	100%	2.4%	$ 40,000
I-5	Nixon Avenue Pipe Relocation	$129,000	$32,250	$12,900		**$174,000**	100%	0.9%	$ 2,000
I-6	Sunset Avenue Improvements	$1,180,000	$295,000	$118,000		**$1,593,000**	100%	2.0%	$ 32,000
R-1	Public Pond #22 Retrofit	$66,000	$16,500	$6,600		**$89,000**	100%	1.5%	$ 1,000
R-2	Mary S. Young Park Parking Lot Retrofit	$1,537,000	$384,250	$153,700		**$2,075,000**	0%	0.4%	$ -
R-3	West Linn Public Works Department Planters	$129,000	$32,250	$12,900		**$174,000**	0%	0.0%	$ -
P-1	Tannler Open Ditch Feasibility Study	---	---	---	$20,000	**$20,000**	0%	0.0%	$ -
P-2	Fish Passage Evaluation	---	---	---	$20,000	**$20,000**	0%	0.0%	$ -
P-3	Surface Water Master Plan Update	---	---	---	$300,000	**$300,000**	0%	0.0%	$ -
P-4	Asset Management Program	---	---	---	$150,000	**$150,000**	0%	0.0%	$ -
P-5	Stormwater System Survey	---	---	---	$300,000	**$300,000**	0%	0.0%	$ -

a. Total costs are based on unrounded subtotals

b. SDC Eligibility applies to projects that increase capacity or treatment coverage. Maintenance-related projects to correct an existing deficiency are not eligible

Capital Project TOTAL (One-time Cost)	**$11,988,000**	**$ 412,000**
Capacity	$2,559,000	$146,000
Infrastructure	$6,301,000	$265,000
Retrofit	$2,338,000	$1,000
Planning	$790,000	$0
Program TOTAL (Annual Cost)	**$ 1,269,000**	**$0**

Appendix F: Capital Project Descriptions and Figures

CIP name	C-1. Phase I Highway 43 Culvert Replacements
Objective addressed	Increase system capacity
Contributing drainage area	930 acres
Statement of need	• Multiple culvert crossings under Highway 43 are capacity deficient and require upsizing. • Culvert replacement will likely be necessary as part of future Highway 43 improvements.
Project description	• City is partnering with ODOT on widening and pedestrian improvements along Highway 43. Capacity deficient culvert crossings will be upsized in conjunction with the planned roadway improvements. o Crossing A–Remove and replace 80' of existing 36" diameter culvert with 60" diameter HDPE pipe. o Crossing B–Remove and replace 70' of existing 24" diameter culvert with 42" diameter HDPE pipe. o Crossing C–Remove and replace 50' of existing 12" diameter culvert with 24" diameter HDPE pipe. o Crossing D–Remove and replace 85' of existing 10" diameter culvert with 24" diameter HDPE pipe. o Crossing H–Remove and replace 80' of existing 14" diameter culvert with 36" diameter HDPE pipe. o Crossing J – Remove and replace 75’ of existing 36” diameter culvert with 42” diameter HDPE pipe. o Crossing L–Remove and replace 110' of existing 24" diameter culvert with 36" diameter HDPE pipe. o Crossing M–Remove and replace 90' of existing 24" diameter culvert with 42" diameter HDPE pipe.
Estimated total project cost	$ 1,045,000
Design assumptions	• Phase I extends from Arbor Dr. to Hidden Springs Rd. • Water quality to address new/replaced impervious associated with the Highway 43 improvements to be determined with detailed design. Water quality facilities are not reflected in project description or cost estimate. • Highway 43 improvements will result in changes to roadway elevations and grade. Crossings may require upstream drop structures due to lack of adequate cover for upsized pipes. Cost estimate assumes manhole drop structure for Crossings B and H; ditch inlet for other crossings. • Concrete headwalls or a new manhole will be installed on the downstream ends of each new culvert. • Final pipe material selection and configuration will be dependent on the Highway 43 improvement project and resulting roadway alignment. • For crossing locations, refer to Figure 5-2.

CIP name	C-2. 5th Avenue Culvert Replacement
Objective addressed	Increase system capacity; improve system configuration; erosion prevention
Contributing drainage area	461 acres
Statement of need	• Capacity deficient culvert identified in the 2006 Stormwater Master Plan. • Culvert orientation results in an undesirable 90-degree bend in channel, contributing to bank erosion.
Project description *(Figure below illustrates proposed improvements)*	• Remove and dispose of approximately 43' of 30" diameter culvert. • Install 160' of 4' x 9' reinforced concrete box culvert and relocate existing utilities as needed. • Align new box culvert with existing stream alignment to eliminate unnecessary 90-degree bend in existing conditions.
Estimated total project cost	$ 847,000
Design assumptions	• Due to limited cover, a traffic-rated box culvert is proposed. Box culvert pricing includes transportation cost and conseal gasket. • An existing sanitary force main, owned and operated by Clackamas Water Environment Services, is aligned along the south side of 5th Ave and above the outfall of the existing culvert outfall. The force main is exposed and may require additional protection from the creek. • Utility (sanitary, water, gas, etc.) conflicts are likely for this crossing due to the increased size of the culvert. • Due to the potential for in-water work, an increased multiplier of 35% was used to account for engineering and permitting costs. • Roadway improvements may be necessary following culvert replacement and have not been assumed in the project cost.

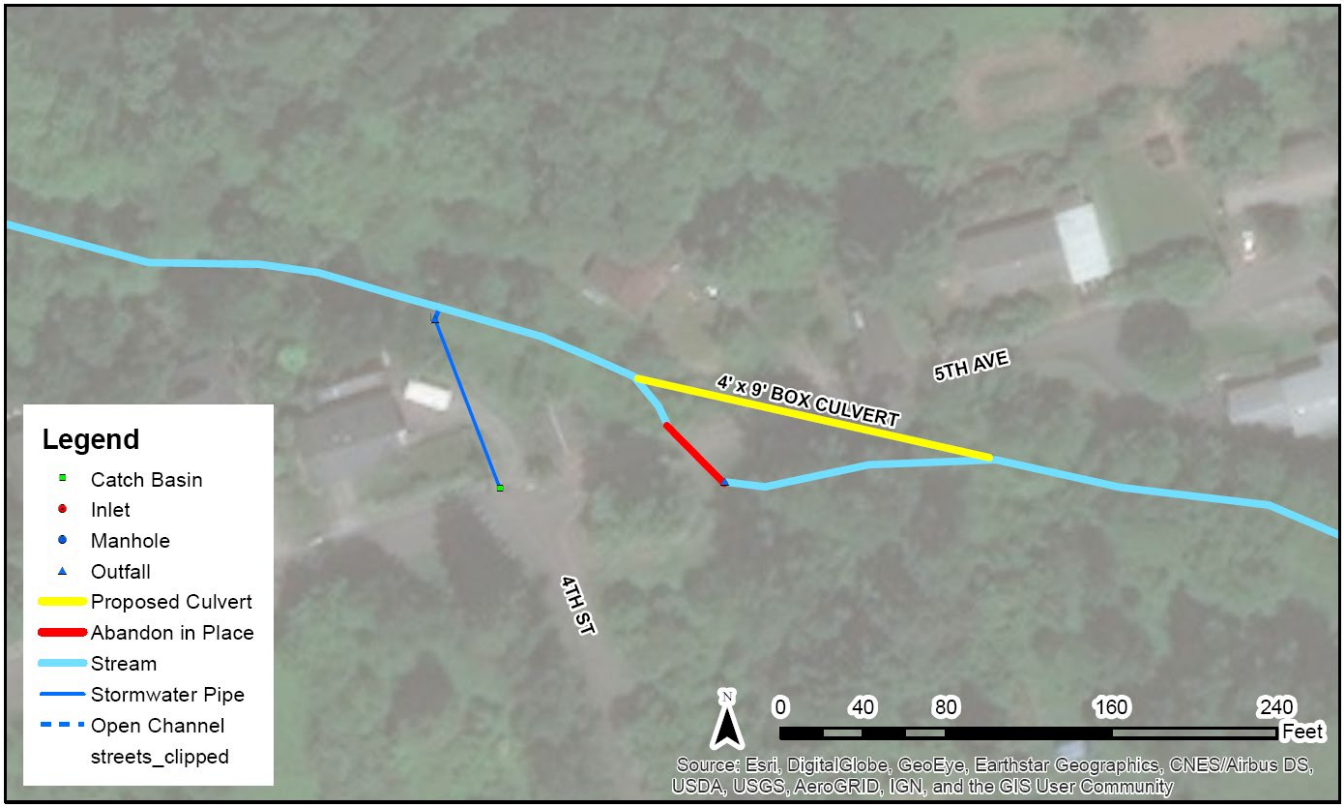


Figure F-1. Project C-2. 5th Avenue Culvert Replacement (Proposed alignment)

CIP name	C-3. Sunset Creek at Willamette Falls Drive Culvert Replacement
Objective addressed	Increase system capacity
Contributing drainage area	69 acres
Statement of need	• Capacity deficient culvert as identified in the 2006 Master Plan. • High I&I reported in area.
Project description	• Remove and replace approximately 95' of existing 18" diameter culvert with two parallel 30" diameter HDPE pipes. • Replacement begins at the ditch between Interstate 205 and Willamette Falls Dr. and extends approximately 30 feet southeast from the Willamette Falls Dr. edge of pavement.
Estimated total project cost	$ 282,000
Design assumptions	• Cover is limited in this location so parallel culverts are required. • The new drainage infrastructure will maintain existing drainage patterns and point of discharge. The downstream conveyance extends across private property and capacity is unknown. The increased conveyance capacity associated with this project may require additional upgrades to private system southeast to the Willamette River.

CIP name	C-4. Maddox Creek at River Street Culvert Replacement
Objective addressed	Increase system capacity
Contributing drainage area	84 acres
Statement of need	• Reported flooding at this location. • Existing culvert is undersized. A second culvert in the location is abandoned and full of sediment. • Current system configuration is inconsistent with City GIS.
Project description	• Remove and replace approximately 165' of existing 18" diameter pipe with two parallel 36" diameter HDPE pipes. • Replacement begins behind the structure, which appears to be a pump station, located across the street from 5757 River St. The alignment, crosses under River St., and ends approximately 10 feet north of the existing River St. edge of pavement. • The new drainage infrastructure will maintain existing drainage patterns and point of discharge. The increased conveyance capacity associated with this project may require additional upgrades to the downstream system.
Estimated total project cost	$ 385,000
Design assumptions	• Configuration of the existing culverts is not well known. Invert and ground elevations are estimates and are not based on survey or as-built records. • A detailed survey of existing culverts, other utilities, and roadway elevations should be completed prior to final design.

CIP name	I-1. Blankenship Road Improvements
Objective addressed	Increase system capacity; improve system configuration
Contributing drainage area	159 acres
Statement of need	• Frequent nuisance flooding along Blankenship Rd. • Hydraulic model results suggest regular roadway flooding, impacting adjacent properties. • Previous efforts to correct roadway flooding have had limited success.
Project description	• Install approximately 275' of 24" diameter HDPE storm line parallel to existing alignment on Blankenship Rd east of Highway 205 between manhole SL-MH-0181 and SL-MH-1608. • Remove and replace approximately 40' of existing 24" diameter storm line with 30" diameter HDPE storm pipe between SL-MH-1608 and Node 366. • Remove and replace approximately 365' of existing 24" diameter storm line with 30" diameter HDPE storm pipe between manhole Node 366 and SL-MH-1602. • Install new field ditch inlet in the ditch north of Blankenship Rd and east of Highway 205 at Node365 • Install approximately 45' of 18" diameter HDPE storm line to convey flow to the upsized 30" storm line between Node 365 and Node 366. • Remove and replace approximately 25' of 24" diameter storm pipe at the outfall north of SL-MH-1602 with 30" diameter HDPE. • Install approximately 25' of 12" diameter HDPE inlet storm line from SL-CB-1612 to Node363. • Reset and rotate ditch inlet, SL-DI-1606, to ensure grate is at grade and facing east. • See Figure 6-2 for the proposed alignment and design detail.
Estimated total project cost	$ 856,000
Design assumptions	• Some proposed pipes have limited depth and cover but are largely outside driving lanes. The alignment should be shifted toward the curb as much as possible to reduce the need for reinforced structural pipe. • Hydraulic modeling assumes no stormflow contribution to the project area from the ODOT culvert to the north/NW (see Figure 6-2).

CIP name	I-2. Mark Lane Improvements
Objective addressed	Add infrastructure; increase water quality treatment (retrofit)
Contributing drainage area	6.2 acres (area of adjacent parcels along Mark Lane)
Statement of need	• A lack of drainage infrastructure along this section of Mark Lane has resulted in reported roadway flooding. • High I&I reported in area.
Project description *(Figure below illustrates proposed improvements)*	• Install approximately 1050' of 12" diameter HDPE pipe along Mark Lane. • Install 5,000 ft² of stormwater planters with underdrain along Mark Lane right-of-way to improve drainage and water quality treatment for properties along Mark Lane. • Install approximately 350' of 12" diameter HDPE laterals to convey stormwater planter overflow to main line. • Install 7 manholes along proposed Mark Lane main line to connect to proposed stormwater planters via laterals and existing downstream infrastructure at the bottom of Mark Lane.
Estimated total project cost	$1,092,000
Design assumptions	• Property and easement acquisition is not included in the cost estimate. • Stormwater planter sizing is based on the contributing drainage area, associated percent impervious (single-family residential), and a 6% sizing factor. • Stormwater planter locations are conceptual and to be established based on available right-of-way.

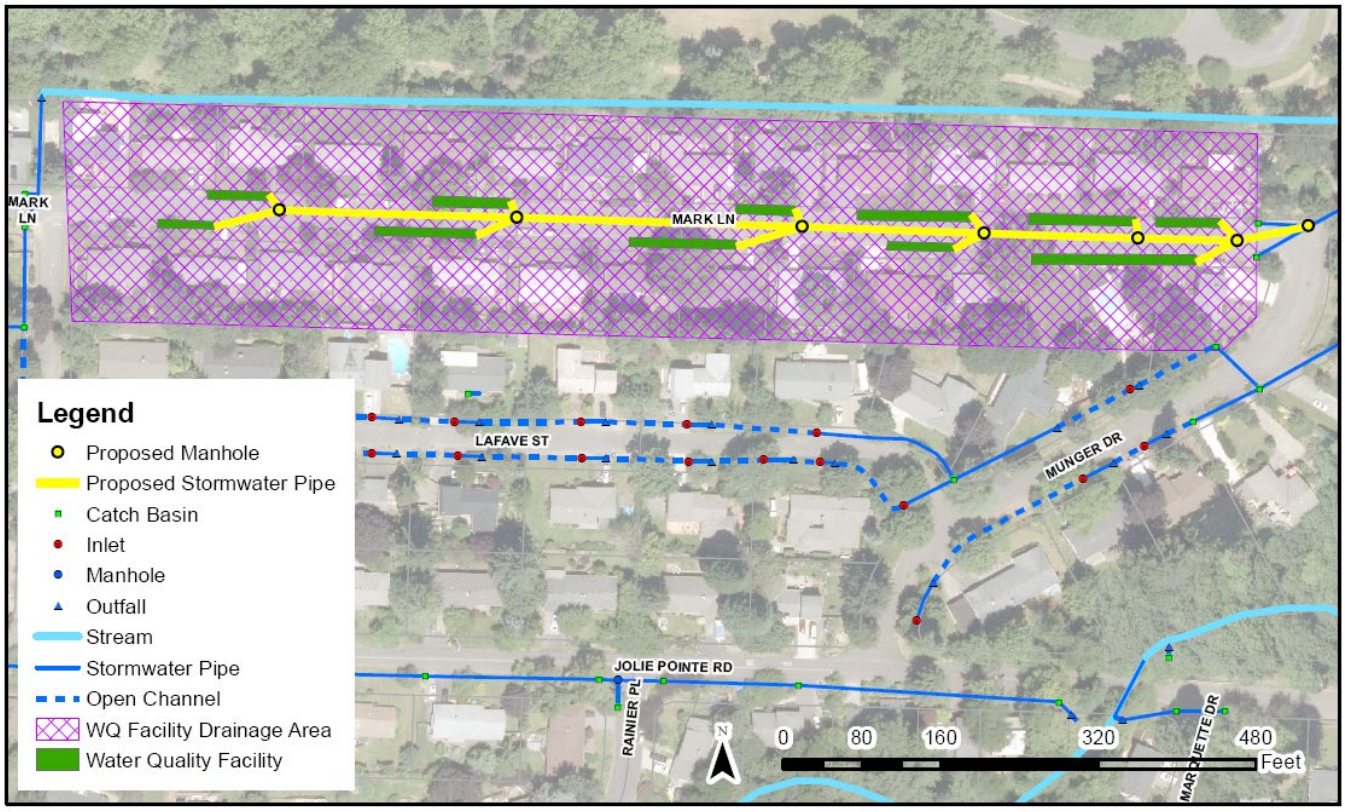


Figure F-2. Project I-2. Mark Lane Improvements (Proposed configuration)

CIP name	I-3. Buck Street Improvements
Objective addressed	Add infrastructure; increase water quality treatment (retrofit); erosion prevention
Contributing drainage area	4.7 acres (area of adjacent parcels along Buck St.)
Statement of need	• A lack of drainage infrastructure along this section of Buck St. has resulted in reported roadway flooding. • City policy to remove bubblers as stormwater infrastructure. • Erosion of the downstream outfall.
Project description *(Figure below illustrates proposed improvements)*	• Install approximately 750' of 12" diameter HDPE pipe along Buck St. • Install 3,750 ft² of stormwater planters with underdrain along Buck St. right-of-way to improve drainage and water quality treatment for properties along Buck St. • Install approximately 350' of 12" diameter HDPE laterals to convey stormwater planter overflow to main line. • Install approximately 100' of curb and gutter system along the unimproved section of Buck St. (northwestern section). • Install 6 manholes along proposed Buck St. main line to connect to proposed stormwater planters via laterals and existing infrastructure. • Upstream existing infrastructure connection is to catch basin located at southwest intersection of Greer St. and Buck St. Downstream existing infrastructure connection is to the catch basin located at the cul-de-sac at the eastern end of Buck. • Abandon approximately 365' of 8" diameter storm pipe and remove associated catch basins and bubblers along Buck St. • Replace existing outfall and provide outlet protection.
Estimated total project cost	$966,000
Design assumptions	• Property and easement acquisition is not included in the cost estimate. • Stormwater planter sizing is based on the contributing drainage area, percent impervious (single-family residential), and a 6% sizing factor. • Stormwater planter locations are conceptual and to be established based on available right-of-way. • Due to the potential for in-water work, a multiplier of 35% was used to account for engineering and permitting costs.

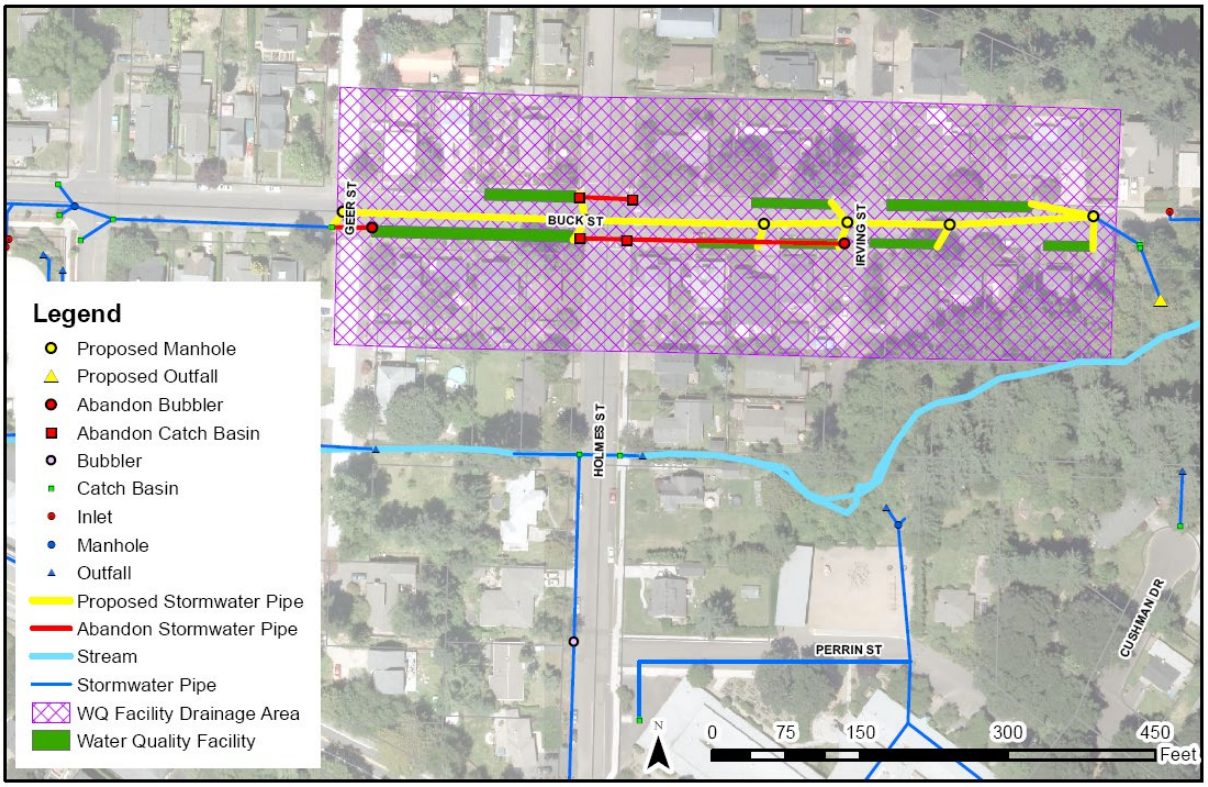


Figure F-3. Project I-3. Buck Street Improvements (Proposed configuration)

CIP name	I-4. Fairview Way Pipe Relocation
Objective addressed	Infrastructure improvements (configuration) and increase system capacity
Contributing drainage area	29 acres
Statement of need	• Capacity issues in existing storm pipes result in surcharging under design storms. • Existing pipes are corrugated metal and likely in poor condition. • System is configured outside of the public right of way or easement.

Project description	• Abandon in place 100' of 12" diameter storm pipe downstream of manhole RW-CB-0144.1 and approximately 115' of existing 10"/12" diameter storm pipe crossing Fairview Way.
	• Leave existing conveyance system downstream of abandoned pipe at manhole RW-CB-0140 intact to collect local drainage.
	• Install new storm pipe alignment along Fairview Way that conveys flow from manhole RW-CB-0144.1 to manhole RW-CB-0126.1 and ultimately discharges to Robinwood Creek at existing discharge location (RW-OF-0122). Specific project features are as follows:
	  • Install approximately 365' of 18" diameter HDPE between RW-CB-0144 and Node300
	  • Remove approximately 200' of existing 10" diameter pipe along north side of Fairview Way downstream of Node300.
	  • Install approximately 810' of 18" diameter HDPE between Node300 and Node304
	  • Install approximately 255' of 30" diameter RCP between Node304 and Node306
	  • Install approximately 275' of 36" diameter HDPE between Node306 and RW-CB-0126.1.
	  • Remove and replace 60' of 12" diameter pipe downstream of RW-CB-0126.1 with 42" diameter HDPE pipe.
	  • Install 100' of 12" diameter HDPE inlet leads to collect local drainage along Fairview Way.
	  • Install 11 manholes associated with the proposed conveyance in Fairview Way.
	• Remove and replace 50' of the 18" culvert upstream of Robinwood Creek, between RW-IS-0120 and RW-OF-0118, with 36" diameter HDPE pipe.
	• See Figure 6-3 for the proposed alignment and design detail.

Estimated total project cost	$ 1,620,000
Design assumptions	• Reinforced concrete pipes (RCP) will be required for two pipe segments between Node304 and Node306 due to limited cover at the Fairview Way low point where the roadway turns to the northwest. Due to limited cover, additional pipe segments may need to be RCP pending detailed survey of the area. • Local drainage along Fairview Avenue will be collected by the new storm sewer alignment; new inlets and laterals have been included in this cost estimate. • Roadway improvements (Fairview Way) may be conducted in conjunction with these stormwater improvements. Associated stormwater collection improvements associated with roadway update should be coordinated with trunk line design.

CIP name	I-5. Nixon Avenue Pipe Relocation
Objective addressed	Improve system configuration
Contributing drainage area	9.5 acres
Statement of need	• Public stormwater pipe currently located on private property underneath a structure. • City policy is to relocate storm pipe in the right-of-way where possible.
Project description *(Figure below illustrates proposed improvements)*	• Install approximately 75' of 12" diameter HDPE pipe along Nixon Ave. right-of-way. • Install approximately 250' of 12" diameter HDPE pipe between 18730 and 18740 Nixon Ave. properties. • Install new outfall structure. • Abandon in place 240' of 12" storm pipe under resident's garage and associated outfall. • Install one manhole and one catch basin along Nixon Ave. in conjunction with pipe realignment.
Estimated total project cost	$174,000
Design assumptions	Property and easement acquisition is not included in the cost estimate.

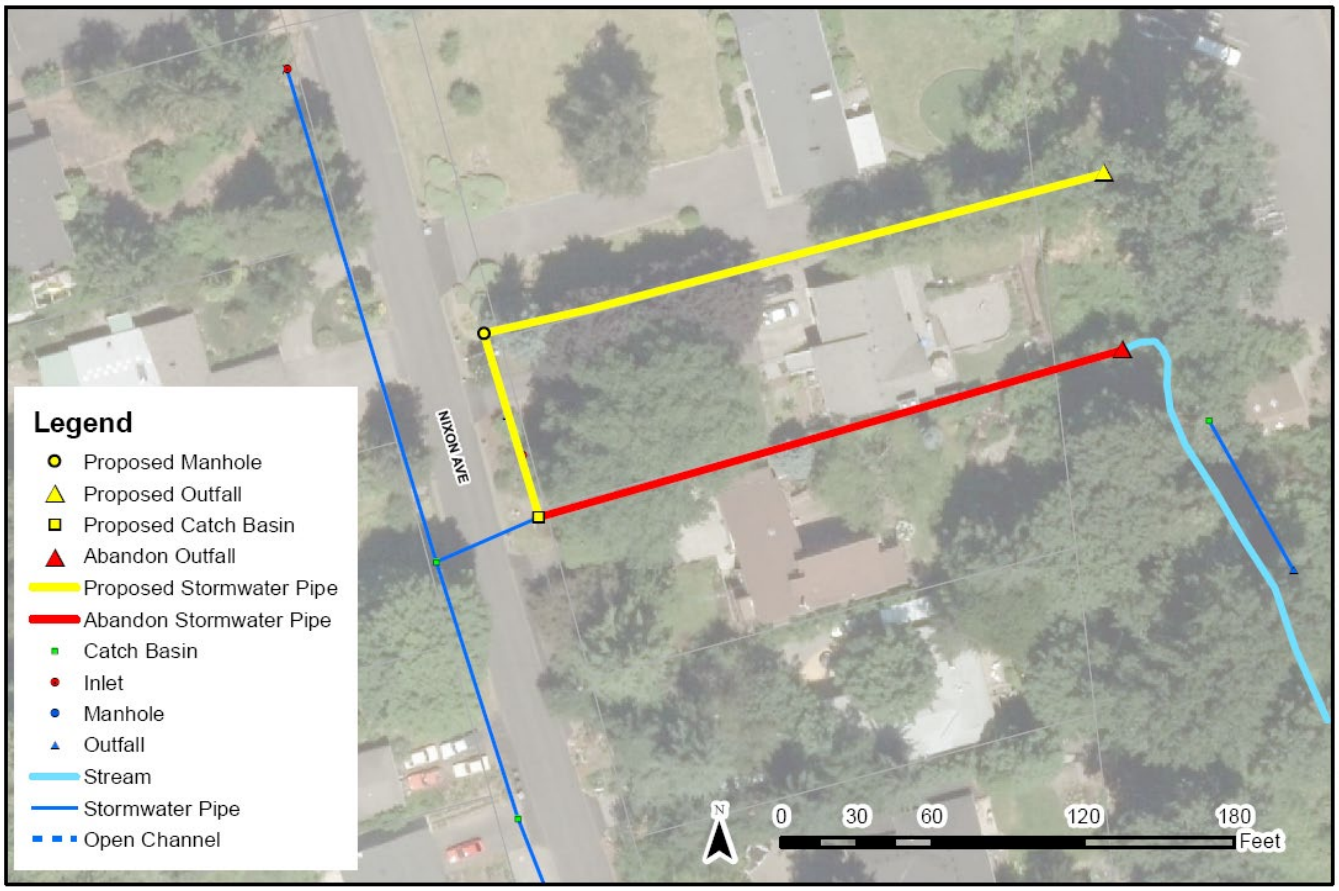


Figure F-4. Project I-5. Nixon Avenue Pipe Relocation (Proposed configuration)

CIP name	I-6. Sunset Avenue Improvements
Objective addressed	Infrastructure improvements
Contributing drainage area	35 acres
Statement of need	• A lack of drainage infrastructure along Sunset Avenue has resulted in reported roadway flooding and erosion of the adjacent roadside ditch. • High I&I reported in area
Project description *(Figures below illustrate proposed improvements)*	• Install approximately 3620' of 12" diameter HDPE along Sunset Ave. right-of-way. • Install approximately 150' of 12" diameter HDPE inlet leads to convey stormwater from catch basins to mainline. • Install 10 catch basins and 18 manholes along mainline pipe alignment. • Abandon in place 915' of existing pipe along the mainline pipe alignment. • Primary connections to existing infrastructure are anticipated at Riverview Ave., Sunset Ct., and Walnut St.
Estimated total project cost	$1,593,000
Design assumptions	• Project to be constructed in conjunction with transportation system improvement project which will install curb/gutter, bike lane, and sidewalk along Sunset Ave. • Water quality to address new/replaced impervious to be determined with detailed design. Water quality facilities are not reflected in project description or cost estimate. • Manholes are located every 300 LF and at pipe bends/connections for purposes of the cost estimate.

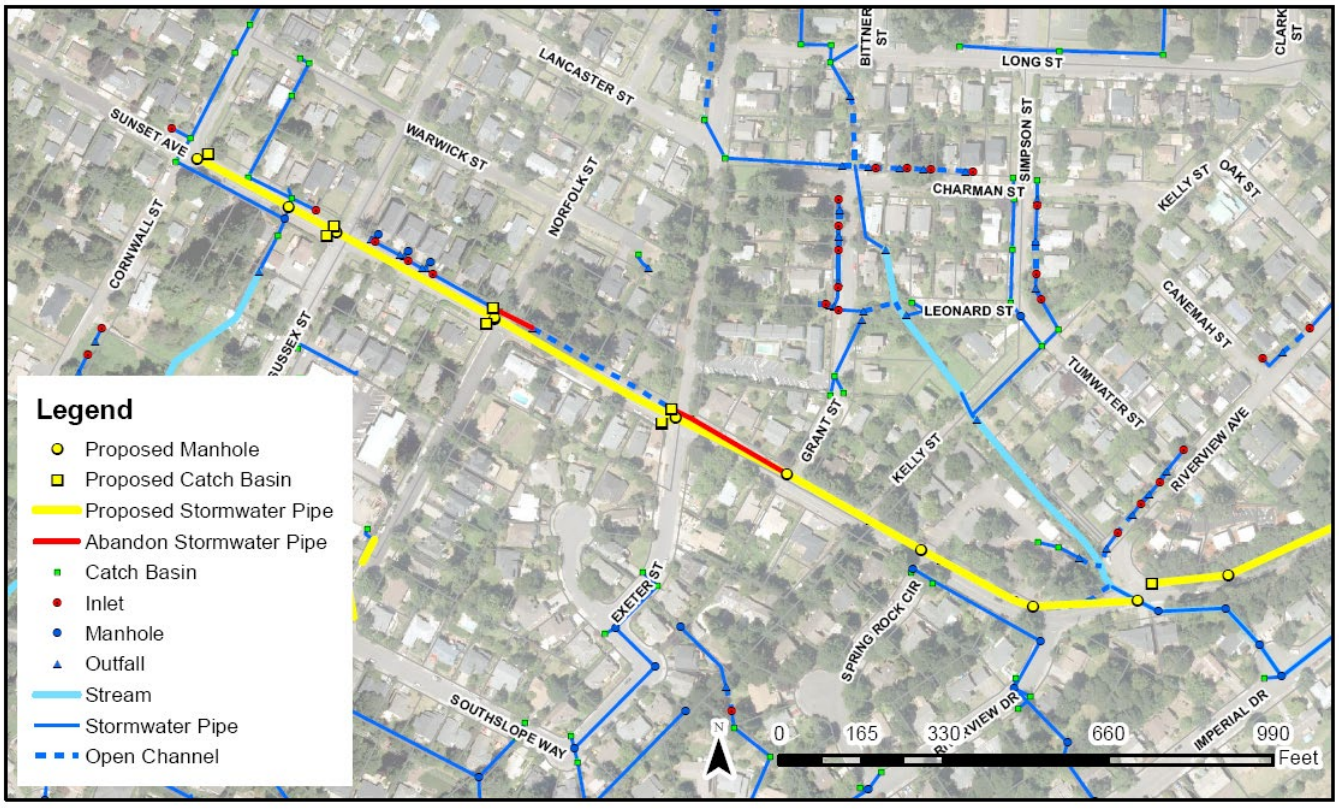


Figure F-5. Project I-6. Sunset Avenue Improvements–West (Proposed configuration)

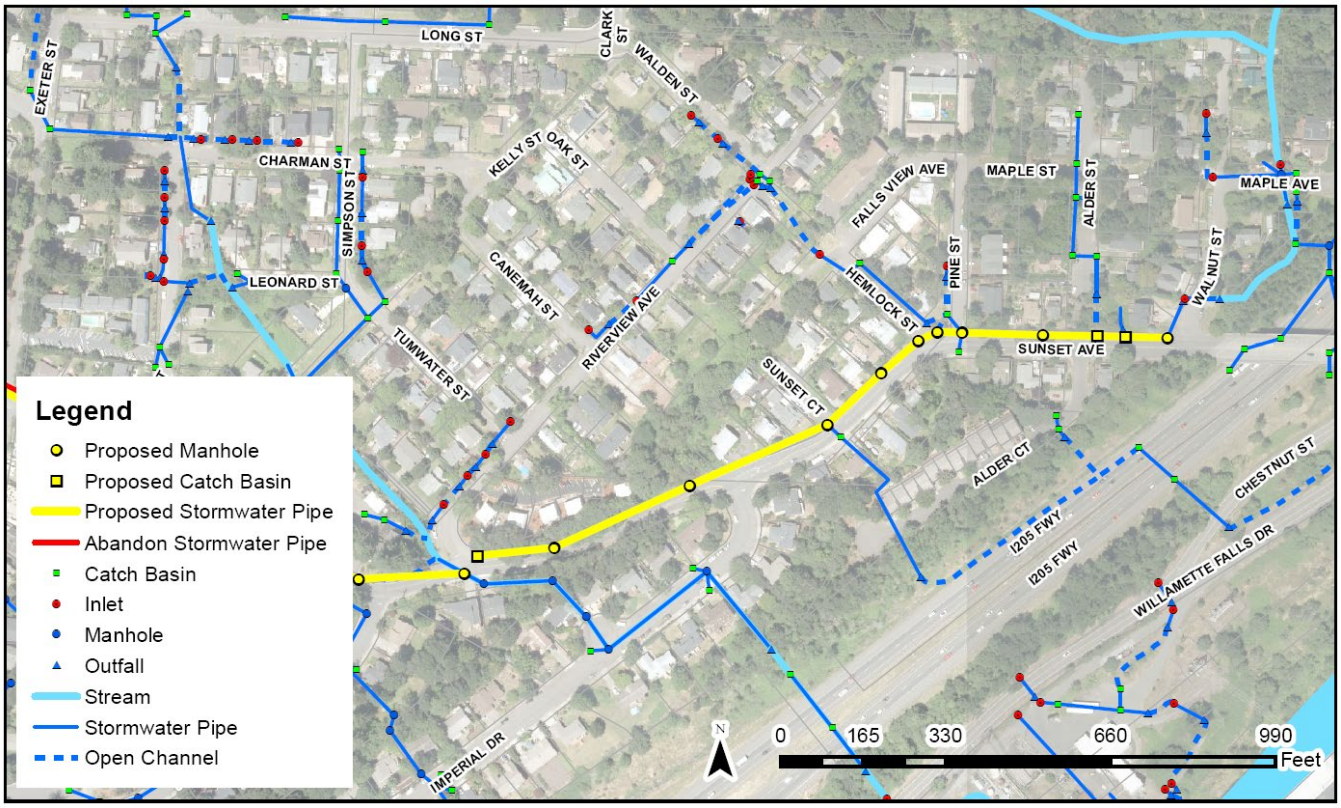


Figure F-6. Project I-6. Sunset Avenue Improvements–East (Proposed configuration)

CIP name	R-1. Public Pond #22 Retrofit (Katherine Court)
Objective addressed	Water quality retrofit
Contributing drainage area	8.1 acres
Statement of need	• Pond installed prior to 2004 when NPDES MS4 permit requirements for stormwater facility maintenance began. • Opportunity to add water quality treatment at an existing detention pond.
Project description *(Figure below illustrates proposed improvements)*	• Remove trees and invasive vegetation within pond footprint (estimated as 3,250 ft²). • Excavate accumulated sediment/debris and regrade pond. • Install 2' layer of amended soils and mulch. Revegetate/reseed pond area. • Replace the pond outflow structure.
Estimated total project cost	$89,000
Design assumptions	• Replacement of the pond outflow control structure has been included in the project cost; however, an inspection to determine if replacement is warranted should be conducted first. • Inlet and outlet piping to/from the pond has not been accounted for in the cost estimate. • Expansion of existing pond footprint may allow facility to address water quality needs for upstream developing areas.

Figure F-7. Project R-1. Public Pond #22 (Katherine Court) Retrofit

CIP name	R-2. Mary S. Young Park Parking Lot Retrofit
Objective addressed	Water quality retrofit
Contributing drainage area	1.5 acres (estimated as footprint of current parking lot)
Statement of need	• Limited water quality treatment in area. • Pavement is in poor condition. • Ponding occurs in corner of parking lot.
Project description *(Figure below illustrates proposed improvements)*	• Remove 67,000 ft² of existing impervious parking lot. • Excavate and grade parking lot subgrade. • Install 67,000 ft² of permeable pavers.
Estimated total project cost	$2,075,000
Design assumptions	• Additional parking lot features such as signage, wheel stops, and striping are not included in cost estimate. • Existing soil type and depth will inform paver subgrade needs.

Figure F-8. Project R-2. Mary S. Young Parking Lot Retrofit

CIP name	R-3. West Linn Public Works Department Planters
Objective addressed	Water quality retrofit
Contributing drainage area	1.2 acres (estimated as the portion of parcel draining east towards Norfolk St.)
Statement of need	• Limited water quality treatment in area. • Project opportunity identified as part of retrofit strategy development (NPDES MS4 requirement)
Project description *(Figure below illustrates proposed improvements)*	• Install 1,175 ft² of stormwater planters with underdrain to improve drainage and water quality treatment for the West Linn Public Works Department (PWD) property. • One stormwater planter may be located on West Linn PWD property to treat the northern portion of the site. • One stormwater planter may be located along Norfolk Street right-of-way to treat the southern portion of the site. • Remove existing bubbler in southern corner of property and connect existing piping to the downstream planter via new 12" HDPE pipe. Connect overflow of downstream planter to existing catch basin along Norfolk Street via new 12" HDPE piping.
Estimated total project cost	$174,000
Design assumptions	• Property and easement acquisition is not included in the cost estimate. • Planter sizing is based on estimated area available along Norfolk St. and on the PWD yard and not on a sizing factor. • Stormwater planter sizing based on contributing drainage area (commercial) and a 6% sizing factor would require 2,750 ft² of water quality treatment facility along Norfolk St. • Stormwater planter locations are conceptual and to be established based on available right-of-way.

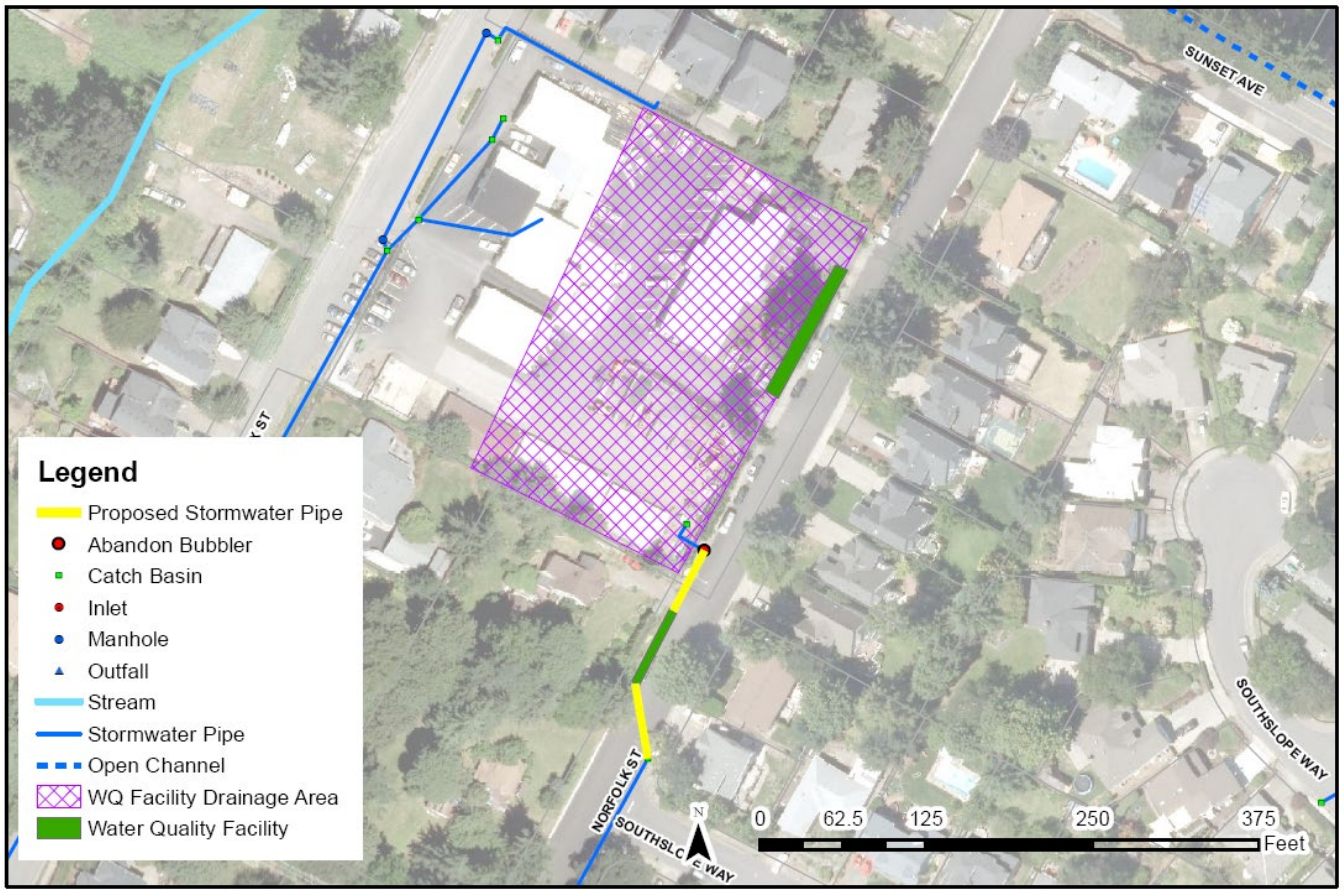


Figure F-9. Project R-3. West Linn Public Works Department Planters