Exhibit A

Brown AND Caldwell

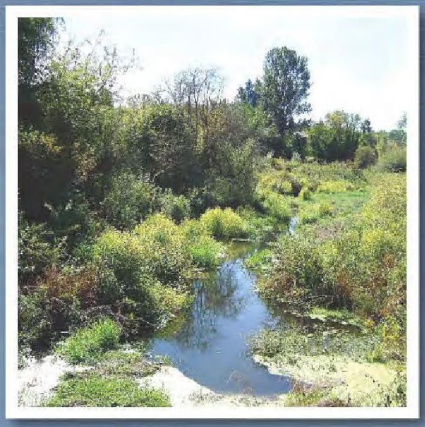
Prepared for City of Tualatin Oregon

City of Tualatin

Stormwater Master Plan

City of Tualatin

April 2019 | DRAFT-FINAL



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City of Tualatin

Stormwater Master Plan

Prepared for
City of Tualatin, Oregon
April 2019

DRAFT-FINAL

Brown AND Caldwell

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List of Abbreviations

1D	one-dimensional
2D	two-dimensional
AACE	Association for the Advancement of Cost Engineering
ac	acre
BC	Brown and Caldwell
BMP	best management practice
CB	catch basin
CCTV	closed-circuit television
CIP	capital improvement projects
City	City of Tualatin
COM	commercial zoning
CWA	Clean Water Act
CWS	Clean Water Services
DEQ	Department of Environmental Quality
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorophenyltrichloroethane
District	Clean Water Services District
EPA	U.S. Environmental Protection Agency
FTE	full-time equivalent
GI	green infrastructure
GIS	geographic information system
H/H	hydrologic and hydraulic
HSG	hydrologic soil groups
I-5	Interstate 5
I-205	Interstate 205
IGA	intergovernmental agreement
IND	industrial zoning
INS	institutional zoning
LIDA	low impact development applications
LiDAR	Light Detection and Ranging
LF	linear foot/feet
LOS	level of service
mg	milligram(s)
MH	manhole(s)
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
ODFW	Oregon Department of Fish and Wildlife
O&M	operations and maintenance
OSP	open space
PCB	polychlorinated biphenyl
Permit	NPDES Permit
Plan	2019 Tualatin Stormwater Master Plan
PW	City's Public Works Standards
ROW	right-of-way
R/R	repair and replacement
SBUH	Santa Barbara Urban Hydrograph
SDC	stormwater development charge
sf	square foot/feet
SMP	2019 Tualatin Stormwater Master Plan
SWMP	Stormwater Management Plan
TDC	Tualatin Development Code
TM	technical memorandum
TMDL	total maximum daily load
VAC	vacant development
WPA	Wetlands Protection Area
WQ	water quality
XPSWMM	XP-Storm Water Management Model

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Executive Summary

In 2016, the City of Tualatin (City) initiated development of a multi-objective stormwater master plan to guide stormwater project and program priorities over a 10-year planning period. Efforts were initiated due to the outdated nature of the City's previous stormwater plan (dated 1972), the changing regulatory environment for the City, new and redevelopment activities and annexations, and observed system deficiencies warranting additional study.

This 2019 Stormwater Master Plan (Plan or SMP) provides an overview of system improvements needed to address future growth, water quality, maintenance/system condition issues, and capacity issues.

The SMP development process included:

- Identifying and investigating known capacity and maintenance-related problem areas and water quality project opportunity areas.
- Developing hydrologic and hydraulic models to evaluate system capacity for targeted problem areas or systems.
- Evaluating stream channel conditions with respect to erosion and development impacts.
- Assessing current maintenance obligations and stormwater program needs to support identified problem areas.
- Developing an integrated stormwater system capital improvement program, including project and program recommendations and costs.
- Evaluating stormwater utility rates and stormwater development charges (SDC) to implement priority project and program recommendations.
- Developing a Master Plan document that is useful and easy to read, reference, and update.

Master Plan Technical Analyses

Developing this SMP included the following technical analyses to evaluate stormwater system deficiencies and define project and program needs.

Project Needs Identification. This effort included distributing surveys and questionnaires to City staff, GIS data review, site visits and, workshops. Information collected helped with developing a robust inventory of stormwater problem areas specific to stormwater infrastructure, stormwater facilities, outfalls, and natural systems. Stormwater 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 GIS to assess vacant/public lands, high pollutant-generating land use areas (i.e., industrial or commercial), and existing stormwater facility placement. Site visits were conducted in conjunction with identified water quality opportunity areas and identified stormwater problem areas to see if an integrated approach to stormwater management (i.e., installing water quality facilities to mitigate stormwater runoff) could help address the reported issue.

Targeted Stormwater 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 for both current and future development conditions.

Targeted Stream Assessment. A stream assessment was conducted to evaluate specific stream reaches in the city reported to have erosion, invasive vegetation, and hillslope stability issues. The assessment provided baseline information regarding existing physical stream conditions and informed project, program, and policy recommendations.

Maintenance Assessment. A maintenance assessment was conducted to evaluate current City maintenance obligations and maintenance-related stormwater problem areas likely addressed with increased maintenance efforts or activities. Conveyance system deficiencies and public/private water quality facility deficiencies were highlighted and used to support project and program recommendations.

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 general recommendations:

- 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 through water quality retrofits and enhancing the level of treatment provided.
- Conduct proactive maintenance of the City's stormwater infrastructure. Use system condition data currently collected (i.e., stormwater facility inspections, closed-circuit television [CCTV]) to evaluate needs and priorities.
- Consider the topographic limitations and flat grade of the City's conveyance network with regard to system maintenance activities. Sediment removal and vegetation management are key maintenance needs to ensure conveyance capacity.
- Continue coordination with Clean Water Services to ensure updates to the Tualatin Development Code (TDC) and Public Works (PW) Standards are in line with regulatory drivers and protect stream health.
- Ensure timely implementation of capital projects and programs by establishing updated funding mechanisms and rates. Additional funding is needed to adequately manage the drainage system as material costs increase, flows increase, and the drainage system deteriorates with age and use.

Capital Improvement Program Summary

Project and program recommendations represent an integrated strategy to address stormwater needs in the city. Recommendations include 21 capital projects and six programmatic efforts. Policy recommendations stemming from the stream assessment have also been identified.

Project Summary

Capital improvement projects (CIP) have been developed to address the following objectives:

- Increases capacity (flood control)
- Address erosion
- Increase water quality treatment (retrofit)
- Improve water quality (through existing site or facility modifications/restoration to address a pollutant source issue or improve treatment function)
- Address maintenance needs

Table ES-1 below summarizes the identified capital projects, estimated costs, and priorities. Figure ES-1 shows the location of the proposed CIPs, with priority projects identified. Detailed fact sheets for each CIP can be found in Appendix A.

Table ES-1. Capital Project Summary

Priority Project	CIP Number	CIP Name	Cost estimates
	1	Manhasset Storm System Improvements	$1,581,000
X (Phase 1)[a]	2	Nyberg Creek Stormwater Improvements	$3,412,000
	3	Sandalwood Water Quality Retrofit	$107,000
	4	Mohawk Apartments Stormwater Improvements	$295,000
X	5	Herman Road Storm System	$1,023,000
X	6	Blake St Culvert Replacement	$552,000
	7	Boones Ferry Railroad Conveyance Improvements	$515,000
	8	89th Avenue Water Quality Retrofit	$262,000
	9	125th Court Water Quality Retrofit	$206,000
	10	93rd Avenue Green Street	$224,000
X	11	Juanita Pohl Water Quality Retrofit	$156,000
X	12	Community Park Water Quality Retrofit	$158,000
X	13	Water Quality Facility Restoration - Venetia	$65,000
X	14	Water Quality Facility Restoration - Piute Court	$104,000
X	15	Water Quality Facility Restoration - Sequoia Ridge	$83,000
X	16	Water Quality Facility Restoration - Sweek Drive Pond	$103,000
	17	Siuslaw Water Quality Facility Retrofit	$454,000
X	18	Water Quality Facility Restoration - Waterford	$180,000
X	19	Saum Creek Hillslope Repair	$171,000
X	20	Hedges Creek Stream Repair	$327,000
X	21	Nyberg Water Quality Retrofit	$2,037,000
		Total	$12,015,000
		Total (Priority projects only)	$6,482,000

a. CIP 2, Nyberg Creek Stormwater Improvements includes three phases of development. Phase I implementation is considered priority.

Programmatic Summary

In addition to the identified capital projects, the following stormwater program needs and/or refinements have been identified to address ongoing maintenance deficiencies and proactively address long-term system replacement and water quality improvements:

- **Pipe Repair and Replacement (R/R) Program.** Establishes an annual funding mechanism to repair and replace piped stormwater infrastructure throughout the city over a 100-year planning period. Efforts will include evaluating CCTV results to prioritize locations requiring R/R.
- **Structure R/R Program.** Establishes an annual funding mechanism to repair and replace stormwater structures throughout the city over a 100-year planning period.
- **Public Water Quality Facility Maintenance Program.** Increases existing annual funding for public stormwater facility maintenance to address both routine and restorative maintenance activities. Efforts will prioritize locations identified during annual inspection efforts.
- **Public Water Quality Facility Retrofit Program.** Establishes an annual funding mechanism to identify and construct opportunistic water quality retrofits. Retrofits may include rehabilitating existing facilities to promote enhanced treatment or installing green streets in conjunction with transportation improvement projects.
- **Stream Vegetation Management.** Establishes an annual funding mechanism to conduct instream or riparian vegetation management activities to remove invasive vegetation and assess physical condition changes to stream channels.
- **Single Family LIDA Inspection Program.** Increases staff resources to support an expanded private stormwater facility inspection program targeting low impact development applications (LIDA) on single-family residential properties.

Policy Recommendations

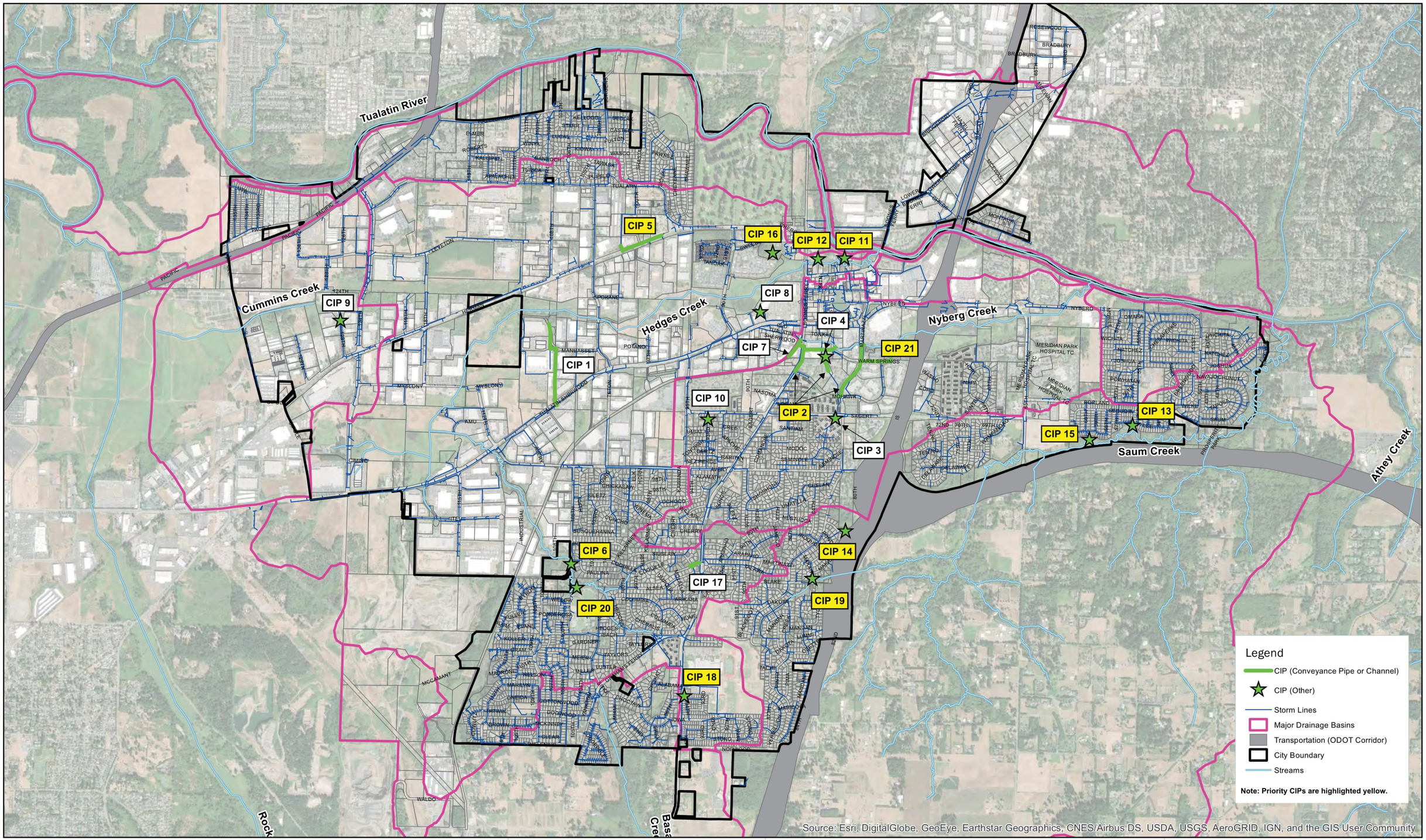
The Stream Assessment identified two policy recommendations the City may consider in order to improve instream channel health and mitigate the potential for localized flooding and erosion.

- **Flow Control Standards.** Protect select areas of the city with observed and/or reported instream erosion and hydromodification risk by requiring development to implement controls related to flow control. The City may incorporate flow control requirements in accordance with areas identified and experiencing channel erosion and incision through the adoption of Clean Water Services' (CWS) updated Design and Construction Standards, which include standards for water quantity control and hydromodification.
- **Beaver Management Guidelines.** Implement (via internal directive or codification) beaver management techniques to selectively encourage/discourage beaver activity based on the characteristics of the stormwater drainage systems, topography, and vegetation.

Implementation

Capital project and program cost information developed as part of this SMP were used to develop a financial plan for the City that outlines stormwater utility rate and SDCs necessary for the City to implement its stormwater capital improvement program while meeting other financial obligations. Capital project costs, program costs, and associated staffing needs were collectively used in the financial plan.

Implementing priority capital projects and programs associated with a 10-year planning period as outlined in this Plan will require a rate increases and adjustments to SDCs. The financial plan has not been directly included in this Plan, pending future City Council approval.



Brown AND Caldwell

City of Tualatin

City of Tualatin

Stormwater Master Plan

Date: April 2019
Project: Project 149233

N

0 2,050 4,100 Feet

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)

ES-1

Capital Project Location Overview

Section 1

Introduction

The City of Tualatin (City) developed this citywide Stormwater Master Plan (SMP or Plan) to guide stormwater capital project and program decisions over a 10-year planning period. This SMP addresses both water quantity and quality for constructed systems under the City's management.

The City manages approximately 93 miles of piped and open channel stormwater infrastructure. The City has experienced rapid growth and development over the last 20 years that thus has a relatively new collection and conveyance system. However, development rates and projections indicate that the stormwater system will require expansion and upgrades to accommodate future growth. The City needs a proactive plan to address capacity needs, replace failing infrastructure, and address regulatory drivers related to water quality improvement.

This Plan documents the process and methods used to evaluate the City's drainage infrastructure and natural systems. Results of the evaluation provide the City with projects and programmatic stormwater actions for implementation. The study area for this Plan includes all areas within the city limits and three planning areas (Northwest Concept Area, Southwest Concept Area, Basalt Creek Concept Area). Major receiving water bodies include Nyberg Creek, Hedges Creek, Saum Creek and the Tualatin River mainstem.

1.1 Stormwater Master Plan Objectives

The City's overarching goal for this SMP is to guide stormwater infrastructure improvements for the natural and built environment over a 10-year implementation period. Improvements must address future growth, water quality, maintenance/system condition issues, and capacity issues. Outcomes from this effort include a prioritized project list, subsequent program recommendations, and a financial analysis that includes rate recommendations to support the implementation of projects and programs.

Specific objectives related to development of this SMP include:

- Establishing a foundation for evaluating stormwater system needs in Tualatin and soliciting information from staff and stakeholders to inform the targeted and integrated identification of project needs and improvements.
- Identifying existing problem areas and providing project solutions related to collection, conveyance, treatment and detention. This includes:
  - Developing hydrologic and hydraulic (H/H) models to evaluate system capacity limitations and assess the frequency of nuisance flooding based on current system information as obtained from the City's GIS and survey.
  - Identifying water quality treatment opportunities throughout the city to be accomplished through water quality retrofits and existing system improvements.
  - Assessing stream health and physical conditions to develop a baseline condition assessment for future evaluations and identify project and program needs.
- Developing programs to support proactive maintenance of infrastructure.

- Reviewing current stormwater program funding, including rates and system development charges, and establishing an updated funding strategy and rates to manage the drainage system and construct recommended (priority) improvements.
- Establishing baseline cost estimates (Association for the Advancement of Cost Engineering [AACE] Class 5) for recommended stormwater improvements for use in planning and budgeting.

This Plan is intended to support regulatory directives under Clean Water Services' (CWS or District's) watershed-based National Pollutant Discharge Elimination System (NPDES) permit (Permit), of which the City is a co-implementor. The City is required to meet stormwater-related obligations and programs as documented in CWS' Stormwater Management Plan (SWMP) and referenced in intergovernmental agreements (IGA). Identifying water quality improvement and stormwater retrofits is a focus of the current (2016) Permit and SWMP.

In addition, the City values its natural systems and open spaces that are available to the community. Protecting natural systems (wetlands, stream channels, riparian corridors, and vegetated buffers) is important for maintaining a livable and healthy city. This Plan was also developed to support management of these natural resources and support their beneficial uses.

1.2 Background and Related Studies

The City's last stormwater master plan was completed in 1972 and does not reflect the current condition or configuration of the City's stormwater infrastructure. The City does not have a capital project list that directly reflects current development activities, population growth, and regulatory drivers. Updated project and program strategies included in this Plan represent priority needs for future budgeting.

The city is one of the fastest growing communities in Oregon, which has prompted the need to invest in infrastructure and consider long-range planning and policy decisions to support businesses and residential life. Copies of various planning-level reports and studies prepared since the last stormwater master plan were obtained to help inform areas of high growth potential and to identify stormwater system deficiencies and needs. Reports and studies reviewed and considered for this master plan update are detailed in Table 1-1.

Table 1-1. Existing Stormwater Planning Documentation and Reports

Report	Date	Summary and Application to the SMP
Tualatin Drainage Plan Report	1972	Provides background information and historic basis for the need to update the SMP.
Hedges Creek Wetlands Master Plan	2002	Provides stormwater management recommendations (culvert upsizing under Tualatin Road, sediment removal) related to the 29-acre Hedges Creek Wetlands.
Bridgeport Area Stormwater Master Plan	2005	Provides stormwater system information and a subbasin delineation in the Bridgeport Development Area.
Southwest Tualatin Concept Plan	2010	Provides guidance for industrial development in southwest Tualatin. Planning district/zoning designation is available.
Basalt Creek Existing Conditions Report	2014	Provides surrounding land use and demographic information for the Basalt Creek Planning Area. Does not provide official planning district/zoning designation or proposed transportation corridors.
Hedges Creek Stream Assessment	2018	Independent stream assessment from SW Ibach Street to SW 105th Avenue. Results were used to supplement the stream assessment conducted as part of this SMP.
Basalt Creek Concept Plan	2018	Provides preferred land use and recommends high-level concepts for transportation and infrastructure planning for the Basalt Creek Planning Area.

1.3 Stormwater Master Plan Development Process

The approach used to develop this Plan is provided in Figure 1-1.

This process leveraged City staff knowledge and existing data (see Planning Process in Figure 1-1) to conduct focused evaluations on areas/infrastructure where additional investigation is likely to inform capital projects and programs. This approach focused resources on the areas currently identified as problems. The overall process was implemented as follows:

1. Data reconnaissance and solicitation of input from City staff and stakeholders was conducted at the beginning of the project to identify stormwater problem areas (Planning Process). Targeted locations requiring modeling or stream assessment to inform project/program needs were identified.
2. A water quality assessment was conducted to identify water quality project opportunities and supplement stormwater problem areas and preliminary project needs (Planning Process).
3. A capacity evaluation (H/H modeling) and a stream assessment were completed to further define project and program solutions (Capacity Evaluation and Stream Assessment).
4. Project Opportunity Areas were defined geographically from identified stormwater problem areas and water quality opportunity areas and vetted based on evaluations/assessments, field visits, and workshops.
5. A maintenance assessment was conducted to define current maintenance obligations and programmatic activity needs (Maintenance Assessment).
6. Capital project and program descriptions and cost estimates were developed and vetted with City staff for inclusion in the Plan (Capital Improvement Program).
7. Staffing analysis, project prioritization, and development of other cost information to support the financial evaluation (rate and system development charges) were completed.
8. Documentation of the master planning approach and project and program descriptions and costs was completed at the end of the process.

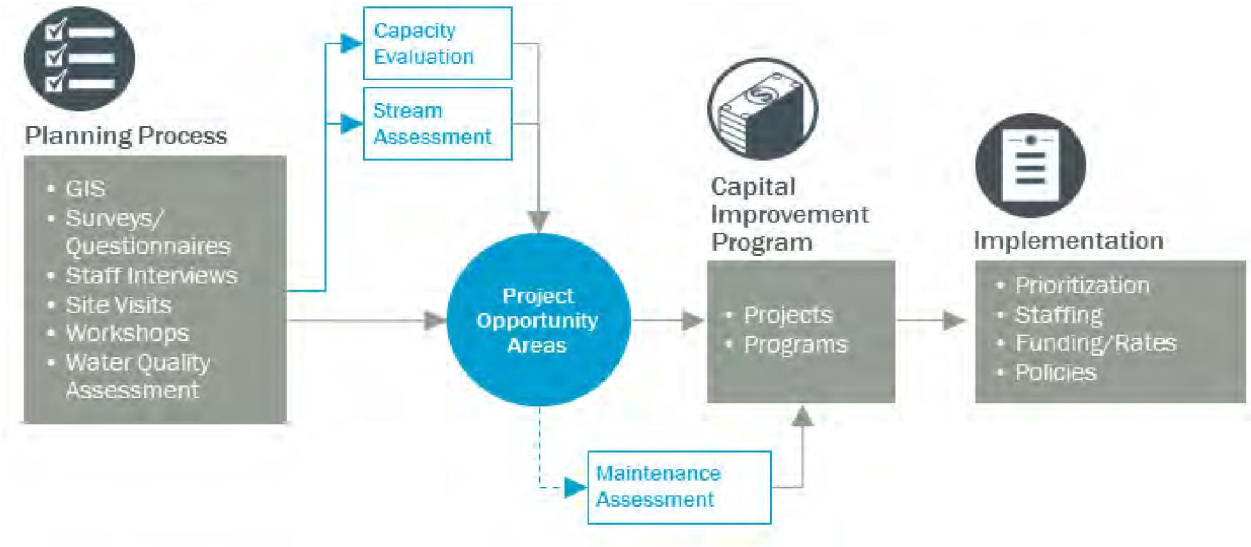


Figure 1-1. Stormwater Master Plan approach

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 planning process, which includes preliminary identification of problem areas, water quality opportunities, modeling needs, and stream assessment needs. Project Opportunity Areas stemming from the planning process are identified.
- Section 4 describes H/H modeling methods and results of the stormwater capacity evaluation and includes identifying capacity-related capital projects.
- Section 5 describes the stream assessment methods and results and identifies capital project, program, and policy recommendations stemming from field observations.
- Section 6 describes the maintenance assessment, including results of the Programmatic Activity Workshop. Capital project and program recommendations stemming from the maintenance assessment are identified.
- Section 7 summarizes the overall capital improvement program recommendations, including the final capital projects, programs and respective cost estimates.
- Section 8 provides an overview of the implementation elements of the capital improvement program, including a summary of staffing needs to support proposed projects and programs, the project prioritization process, level of service determination, and financial evaluation results.

Section 2

Study Area Characteristics

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

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

2.1 Location

The City of Tualatin is located 13 miles southwest of Portland, Oregon. Most of the city is in Washington County, with a small portion of area along the eastern city limits located in Clackamas County (Figure 2-1). Neighboring areas include the cities of Tigard, King City and Durham to the north; the City of Wilsonville to the south; unincorporated Washington County, including the Tualatin River National Wildlife Refuge, to the west; and unincorporated Clackamas County, commonly referred to as the Stafford Triangle, to the east.

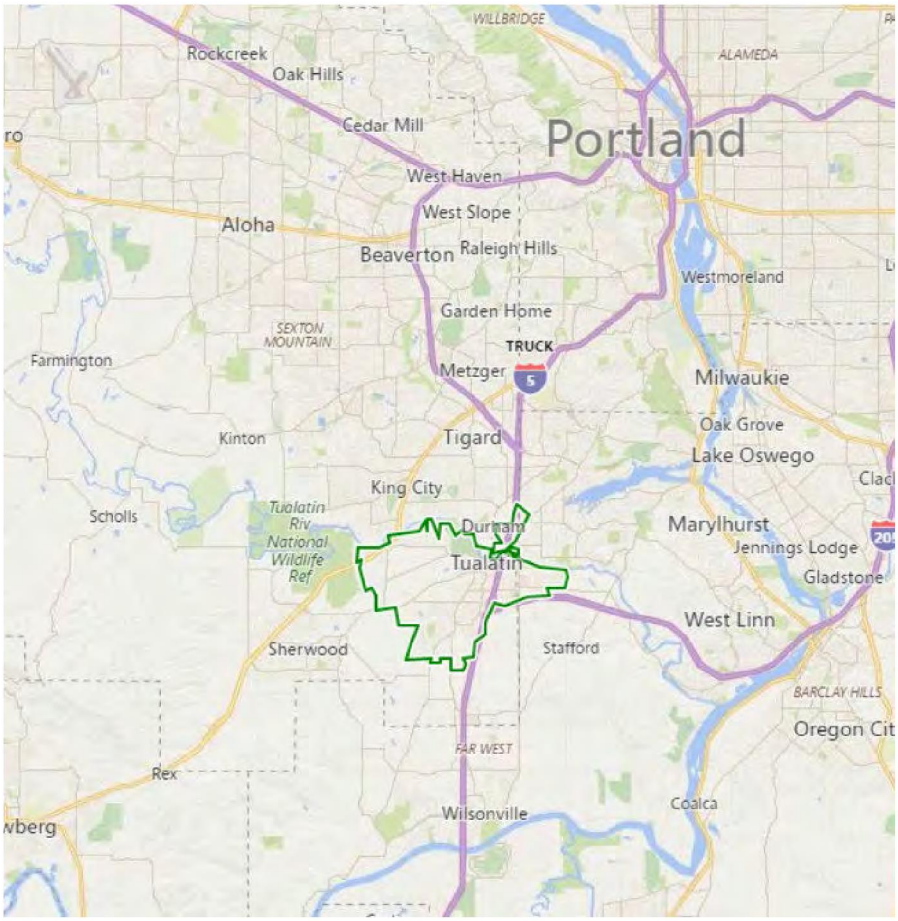


Figure 2-1. Location overview

Interstate 5 (I-5) runs north-south through the city, attributing to the large commercial corridor along the I-5 right-of-way (ROW). The intersection of I-5 and Interstate 205 (I-205) is in the southeast area of the city. Oregon Highway 99W intersects the City in the northwest corner. The city boasts a strong commercial and industrial economy, and prominent waterways access and parks, which make the city one of the most livable communities in the Portland metro area.

The city is approximately eight square miles in area, with an additional 1.2 square miles associated with planning areas outside of the city limits (Figure 2-2). The majority (approximately 97 percent) of the city discharges to the Tualatin River and tributaries. Major tributaries include Nyberg Creek, Hedges Creek, Cummins Creek, and Saum Creek. Area along the northern portion of the city discharges north directly to the Tualatin River, whereas the tributaries generally run east-west across the city before discharging into the Tualatin River. The remainder (approximately 3 percent) of the city discharges to Basalt Creek, a tributary located in the southern portion of the City, which runs south to Coffee Lake Creek in the City of Wilsonville before discharging to the Middle Willamette River.

2.2 Future Planning Areas

There are three future planning areas in the city: The Southwest Concept Plan Area, the Northwest Concept Plan Area and the Basalt Creek Planning Area (Figure 2-2).

Concept plans for these areas have been developed to guide future development and expansion as the City grows. These areas have yet to undergo significant development or redevelopment. Concept plans help facilitate communication with citizens and stakeholders by laying out how the area might be developed with respect to land use, transportation, natural resources and utility planning. Concept plans also aid in determining future financial implications and the level of potential investment required to develop and provide infrastructure throughout the planning area.

Detail related to these three future planning areas are as follows:

- **Southwest Concept Plan Area***:* The Southwest (SW) Concept Plan was completed in August 2005 to guide industrial development of a 614-acre area located south of Tualatin-Sherwood Road between SW 115th and 124th avenues. The area is near the Tigard Sand and Gravel Quarry. In 2011, the SW Concept Plan was updated and adopted into the Tualatin Development Code (TDC). The portion of the planning area within the urban growth boundary and north of Tonquin Road (approximately 431 acres) was included in this SMP.
- **Northwest Concept Plan Area:** The Northwest (NW) Tualatin Concept Plan was completed in March 2005 and incorporated into the City's Development Code in June 2005. The NW concept planning area is 14 acres, located in the northwest corner of the city, and mostly developed. This planning area was included in this SMP.
- **Basalt Creek Planning Area:** The Basalt Creek Concept Plan was adopted by City Council in August 2018. The Plan was developed as a joint effort between the cities of Tualatin and Wilsonville. The area is located between the southern boundary of the Tualatin and northern boundary of Wilsonville. The total planning area encompasses 847 acres. Tualatin's portion of the planning area (approximately 356 acres) was included in this SMP.

2.3 Topography

Tualatin's topography is characterized as relatively flat with gentle slopes (Figure 2-3). The elevation in the city varies from 368 feet at the highest point to 96 feet at the lowest point. The lowest elevation areas are along the northern border of the city at the Tualatin River. The highest elevation areas are near SW Boones Ferry Road and SW Norwood Road.

The flat topography results in limited slope in the stormwater collection system, which contributes to standing water in pipes, backwater conditions, and high sediment accumulation. The average slope in the stormwater collection system ranges from 0.5 percent to 6.5 percent. There are significant wetland areas within the city, particularly along Hedges Creek and the downstream portion of Nyberg Creek, further attributed to the flat topography, high groundwater levels, and proximity to the Tualatin River.

More significant grade changes are observed in the southeast portion of the city, north of Saum Creek, where a steep ridge defines the northern stream bank and the southwest part of the city, adjacent to the SW Concept Plan Area.

2.4 Soils

The National Resources Conservation Service (NRCS) Soil Survey online tool was used to gather soils information for Tualatin. 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. HSG conditions are reflected on Figure 2-3.

Most of the soils in Tualatin are HSG Type C soils with pockets of A, B, C/D and D type soils. Table 2-1 shows the NRCS hydrologic soils group by percent coverage within the city limits and planning areas.

Table 2-1. Soil Type within the City and Planning Areas

Hydrologic Soil Group	Acres	Percent
A	181	3
B	708	12
C	3,820	63
C/D	876	15
D	423	7
Total	6,008	100

There are saturated soils and wetland soil conditions along stream reaches and throughout the city. The City maintains a Wetlands Protection Area (WPA) GIS inventory that includes riparian areas along Hedges Creek, Nyberg Creek, and Saum Creek.

2.5 Land Use

Tualatin is a community that has experienced significant growth over the last 20 years. The population of Tualatin is approximately 27,500 as of July 1, 2017. The population has increased 5.2 percent between 2010 and 2017.

The city is primarily composed of industrial and residential land use, with significant areas of commercial development along the I-5 corridor and Tualatin-Sherwood Road. Large tracts of open space area (parks, greenways, natural areas, wetlands) are scattered throughout the city. Vacant lands with potential for development are located primarily in the western portion of the city.

Land use coverage was developed in GIS as part of this SMP to evaluate stormwater drainage conditions in the city. Land use coverage was based on City-provided GIS coverage of planning districts (zoning), open space areas, and developable lands. A detailed summary of the process to develop the City's land use coverage and associated impervious area estimates is provided in Technical Memorandum 1 (TM1), included in this SMP in Appendix B. Land use coverage is shown on Figure 2-4. Land use categories and impervious assumptions are reflected in Table 2-2.

Table 2-2. Land Use Categories and Impervious Percentages

Planning District Designation	Modeled Land Use Category	Impervious % (Existing)	Impervious % (Future)
Low-Density Residential	Low-density residential	43	53
Medium Low-Density Residential	Medium-density residential (MDR)	45	55
Medium High-Density Residential			
High-Density Residential	High-density residential	50	60
High-Density High Rise Residential			
General Commercial	Commercial (COM)	78	78
Central Commercial			
Medical Commercial			
Office Commercial			
Recreational Commercial			
General Manufacturing	Industrial (IND)	74	74
Light Manufacturing			
Manufacturing Business Park			
Manufacturing Park			
Institutional	Institutional (INS)	35	35
	Vacant, developable (VAC)[a]	5	Consistent with the underlying land use designation
	Open Space (OSP), undevelopable – Parks, greenways, natural areas, private [b]	5	5
	OSP, undevelopable – WPA, setbacks, Natural Resource Preservation Overlay, wetlands [b]	4	4
	Transportation (Oregon Department of Transportation corridor)	46	46
	Basalt Creek/rural residential	7	7

a. *Vacant land use reflects area with new or infill development potential. Future development conditions assume development of vacant lands consistent with their associated planning district designation.*

b. *Open space land use reflects area with no foreseeable development potential.*

Future growth for purposes of evaluating stormwater drainage infrastructure is based on projected development (i.e., vacant lands) (see Figure 2-4). Future industrial, primarily in the western half of the city, and commercial and multi-family residential development, is expected. Residential infill development is also anticipated. For the Basalt Creek planning area, future growth and development is expected but the timeframe is unknown. For purposes of this plan, future development conditions were not evaluated or assessed hydrologically for this area.

2.6 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.

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 be between a 50- and 100-year frequency event because of the intensity and nature of the rainfall. These "severe" events are expected to occur more frequently as the earth undergoes climate change.

2.7 Natural Systems

Tualatin drains to six major waterbodies: The Tualatin River, Cummins Creeks, Hedges Creek, Nyberg Creek, Saum Creek and Basalt Creek. These waterbodies and their associated drainage basins are shown on Figure 2-5. Cummins Creek, Hedges Creek, Nyberg Creek, and Saum Creek are tributaries to the Tualatin River. Basalt Creek is a tributary to the Willamette River. Contributing city area and planning area by drainage basin is summarized in Table 2-3.

Table 2-3. Major Drainage Basins and Contributing Drainage Area

Major Drainage Basin	City Area (ac)	Planning Area (ac)
Tualatin River (direct)	906	0
Cummins Creek	313	13
Hedges Creek	2,277	288
Nyberg Creek	863	0
Saum Creek	514	34
Basalt Creek	170	318

ac = acre

Each major waterbody has unique characteristics and is being impacted by development in different ways. In general, the natural systems within the city are considered highly modified. They have been affected by historic development activities conducted without the inclusion of stormwater management facilities to address water quality and increased flow and runoff volumes. An overview of stream channel conditions is provided in Section 5.

Ownership of the natural system has been identified based on adjacent property ownership (Figure 2-5). Ownership status limits activities the City can conduct to maintain and preserve the waterbody's integrity.

2.8 Stormwater Infrastructure System

The City manages approximately 93 miles (approximately 486,800 linear feet [LF]) of stormwater drainage pipe and 1.5 miles (7,700 LF) of roadside drainage ditches. There are six major receiving waters located throughout the city. As a result, most of the City's drainage infrastructure consists of small dispersed systems rather than large trunk lines. There are 386 mapped outfalls from the piped systems to receiving waters. The majority of pipe in the city is 12-inch concrete pipe.

Tables 2-4 and 2-5 summarize pipe characteristics and major drainage system features in the city as mapped in GIS. Major drainage features include manholes, catch basins, discharge points (outfalls), public water quality facilities (swales), public ponds (detention, dry ponds), and underground injection control wells. Figure 2-6 provides an overview of the stormwater collection and conveyance system.

Table 2-4. System Asset Inventory–Pipes and Open Channels, Public (mapped in GIS)

Diameter	Length (ft)
Not documented in GIS	11,684.1
0-6	27,891.1
8-12	244,648.3
14-18	102,535.4
20-24	57,762.1
27-30	21,681.0
36	14,519.0
42	1,146.2
48	3,952.9
54	0.0
60	728.4
66	0.0
72	229.2
Mapped Open Channels	7,735.3
Total (Pipe)	494,513.0

Table 2-5. Major Drainage Features (Counts)

Major Drainage Feature	Number)
Manholes	1,929
Catch basins	3,072
Outfalls	386
Public water quality facilities (swales)	32
Public ponds (detention, dry ponds)	52

Although most development in the city has occurred over the last 25 to 30 years, proactive system inspection and maintenance is needed to ensure continued performance. The City currently has limited information regarding underground utility condition and age. As the city continues to grow and expand, pipe and infrastructure will be added to the City's asset inventory that will need to be managed and maintained.

2.9 Water Quality and Regulatory Drivers

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 conducts permitting for activities that discharge to surface waters, 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 is a specific focus of this SMP.

2.9.1 National Pollutant Discharge Elimination System (NPDES) Permit Program

The NPDES Municipal Separate Storm Sewer 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 is a co-implementer on the CWS watershed-based NPDES permit, along with 12 other jurisdictions in Washington County, for managing stormwater runoff. CWS' NPDES permit was reissued in May 2016 for a 5-year permit term.

Implementation of CWS' NPDES permit is outlined in the CWS SWMP. Stormwater activities or best management practices (BMP) are outlined to address the elements of the permit including public education, public involvement, illicit discharge detection/elimination, construction site management, post-construction stormwater management, industrial/commercial facility inspections, good housekeeping practices for municipal operations, and operations and maintenance (O&M) activities for stormwater management facilities.

In addition to the permit elements listed above, the reissued NPDES permit requires CWS and co-implementers to prepare a stormwater retrofit strategy, prepare a hydromodification assessment (to address instream channel erosion and modifications), and develop TMDL pollutant load reduction benchmarks. These additional requirements prompted the City to incorporate stormwater retrofits for water quality improvement into its capital project development (see Section 3.1.1) and evaluate instream channel conditions to support future hydromodification assessments (see Section 5).

Coordination efforts between the City and CWS are identified in the SWMP and outlined in detail in IGAs between the City and CWA. The City maintains IGAs with CWS for erosion and sediment control and select system O&M activities.

2.9.2 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. DEQ develops this list for Oregon, which 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.

The Willamette and Tualatin rivers are the major receiving waters for Tualatin. 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. CWS is the identified discharge management agency in the Tualatin Subbasin and Willamette Basin TMDLs, and the City is identified as a contributing municipality associated with CWS. Table 2-6 summarizes the TMDL and 303(d) parameters relevant to the City.

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

Watershed/ Major Basin	Subbasin(s)	TMDL Year	Applicable TMDL parameters	TMDL surrogate parameters	Applicable 303(d) parameters [a]
Willamette River	Middle Willamette	2006	• Mercury • Bacteria (*E. coli*) • Temperature	• Effective shade (surrogate for temperature)	• Aldrin • Biological criteria • DDT/DDE • Dieldrin • Iron • Polychlorinated biphenyls (PCB)
Tualatin River	Tualatin	2001 and 2012 (update)	• Bacteria (*E. coli*) • Chlorophyll a • pH • Dissolved oxygen • Temperature	• Total phosphorus (surrogate for chlorophyll a and pH) • Total suspended solids (equivalent parameter for settleable volatile solids [SVS], a surrogate for dissolved oxygen) • Effective shade (surrogate for temperature)	• Ammonia • Biological criteria • Copper • Iron • Lead • Zinc

a. The 2016 303(d) list for Oregon was approved by DEQ in January 2019. It is the effective list for Oregon.

2.10 Stormwater Program Management

Stormwater program management includes maintenance, program operations, and program funding as described in the following subsections. This SMP includes an evaluation of maintenance activities and recommended program improvements to supplement capital project needs (see Section 6).

2.10.1 Maintenance Obligations

Maintenance of the City's assets is important to ensure that the full life expectancy is realized. The City allocates six, full-time equivalent (FTE) staff for utility system maintenance in the Public Works Department. Utility system maintenance includes stormwater system maintenance. Utility maintenance crews share responsibilities for multiple utility and infrastructure assets.

As mentioned, the City is a co-implementer on the CWS watershed-based NPDES permit for managing stormwater runoff. Maintenance obligations are outlined in the effective SWMP, dated 2016. Maintenance activities occur on a scheduled basis and in response to citizen and staff requests and are documented annually in the CWS stormwater annual report. Typical maintenance activities include:

- Pipeline inspection (CCTV) and cleaning
- Manhole repair
- Catch basin cleaning
- Public water quality facility inspection and maintenance (water quality manholes, vegetated stormwater facilities, proprietary filter systems). Public ponds are not routinely inspected and maintained by the City.
- Street sweeping

2.10.2 Program Operations

Programmatic stormwater activities are generally implemented to comply with NPDES permit requirements and may be conducted by utility maintenance staff or engineering staff in the Public Works Department.

The City employs two full-time equivalent staff engineers, three engineering associates, and two engineering technicians all responsible for a variety of engineering needs, including stormwater. Program implementation is documented annually in the CWS NPDES annual report. Program activities conducted by the City include:

- Private stormwater quality facility tracking and inspections. Annual notices are mailed to facility owners reminding them of their maintenance obligations.
- Stormwater development review.
- Illicit discharge detection and elimination, including spill response.
- Promotion of regional stormwater public outreach materials and campaigns.

CWS performs erosion control inspections and enforcement on the City's behalf in accordance with an IGA.

2.10.3 Staffing and Program Funding

The stormwater program is funded primarily through stormwater utility fees. Utility fee revenue for the 2019–2020 fiscal year is approximately $3.4 million. CWS serves as the lead storm utility agency and implements selected program activities on behalf of the city.

A financial evaluation was conducted as part of this master planning effort to determine an annual stormwater utility rate and stormwater development charge (SDC) increase to support the proposed capital improvement program and ensure adequate funding levels to support implementation needs (see Section 8).

Staffing levels to implement the City's stormwater program are considered adequate to implement current project and program needs; however, additional staff resources will be required to ensure timely project implementation and expanded program activities. Detail related to current and projected staffing needs is included in Section 8.1.

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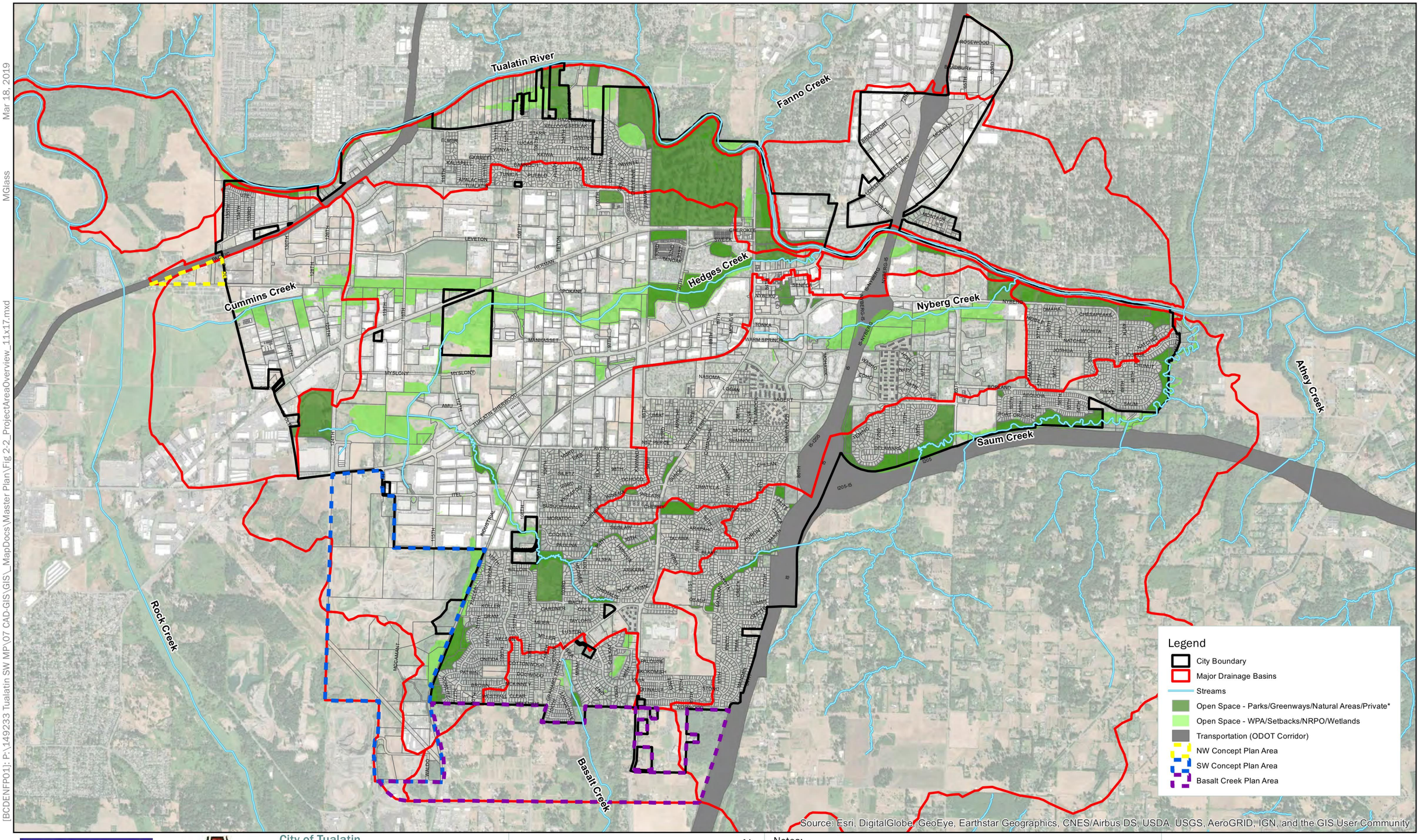


Brown AND Caldwell

City of Tualatin

City of Tualatin
Stormwater Master Plan

Date: April 2019
Project: Project 149233

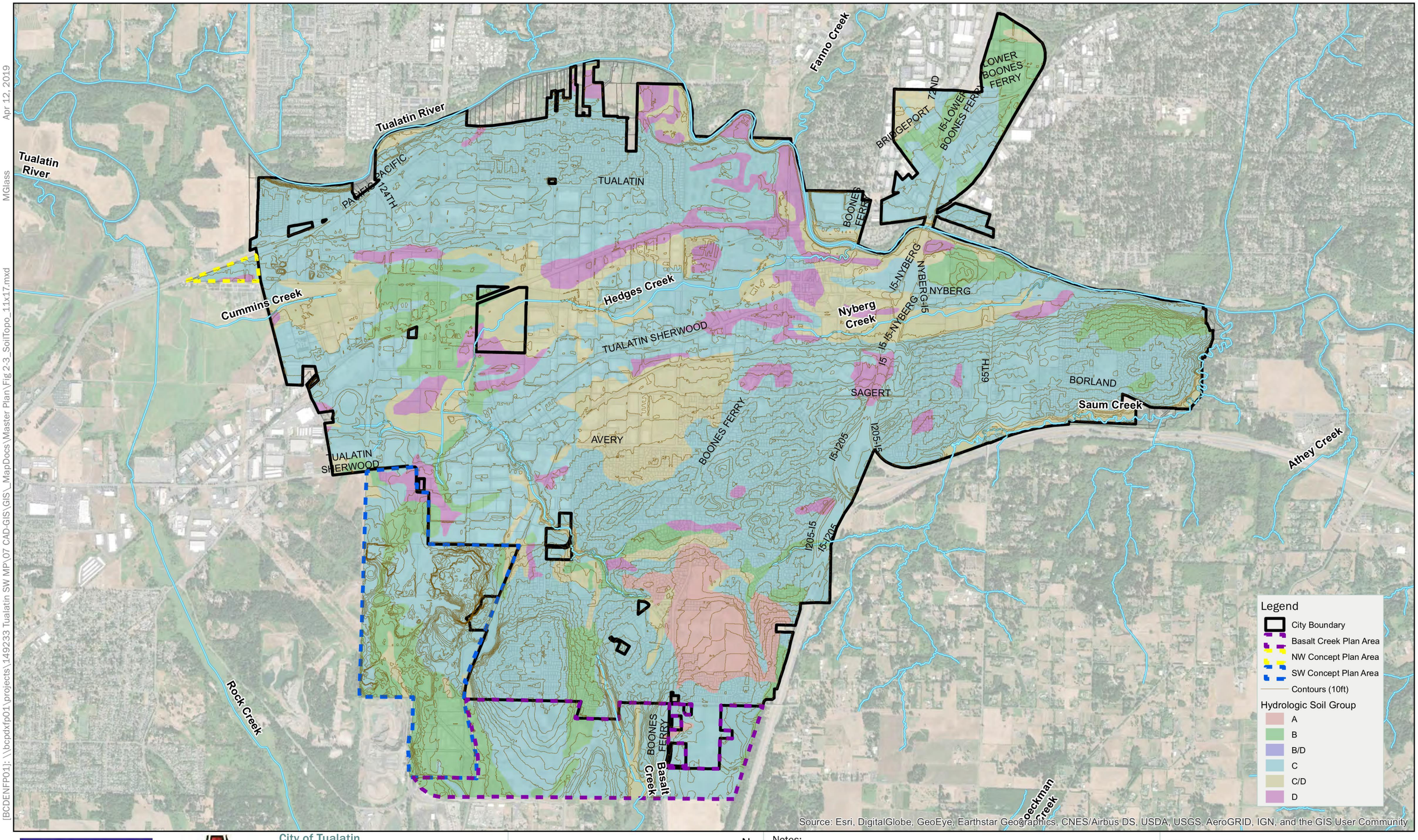
N

0 2,250 4,500 Feet

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)

Figure 2-2

Project Area Overview



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Brown AND Caldwell

City of Tualatin

City of Tualatin

Stormwater Master Plan

Date: April 2019
Project: Project 149233

N

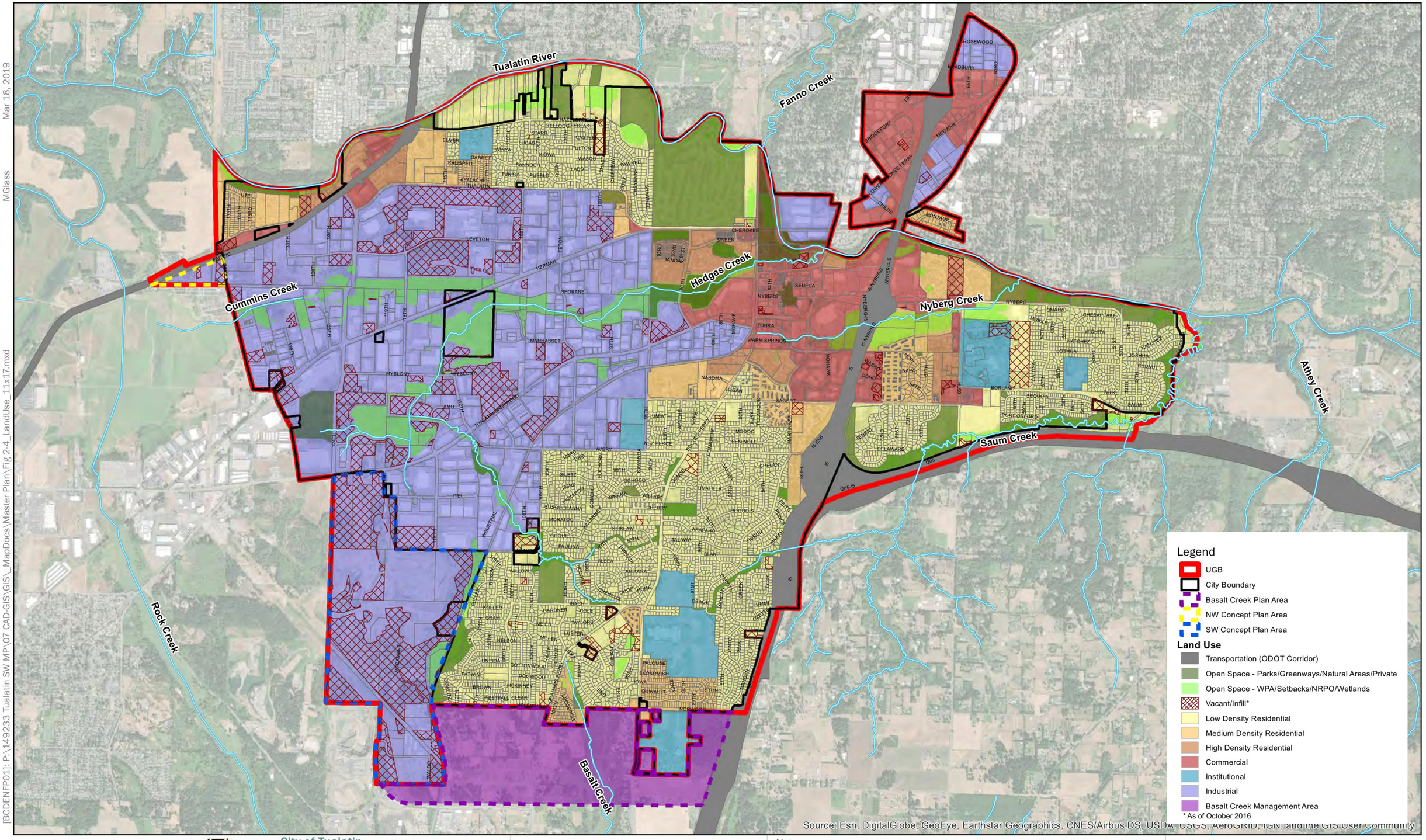
0 2,250 4,500 Feet

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)

Figure 2-3

Topography and Soils

[BCDENFP01]: P:\149233 Tualatin SW MP\07 CAD-GIS\GIS_MapDocs\Master Plan\Fig 2-4_LandUse_11x17.mxd MGlass Mar 18, 2019



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City of Tualatin

City of Tualatin

Stormwater Master Plan

Date: April 2019
Project: Project 149233

N

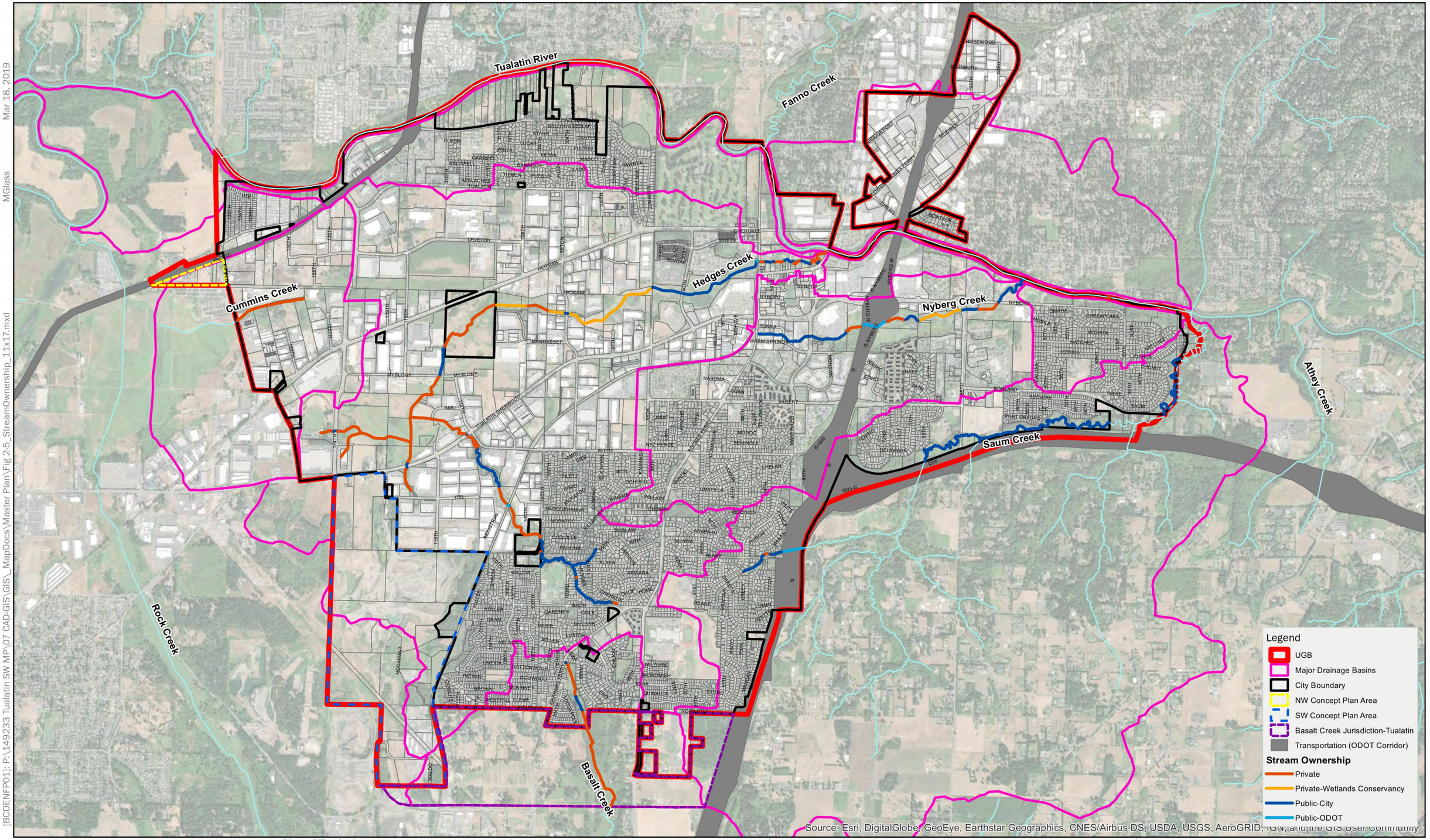
0 2,250 4,500 Feet

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)

Figure 2-4

Land Use

[BCDENFP01]: P:\149233 Tualatin SW MP\07 CAD-GIS\GIS_MapDocs\Master Plan\Fig 2-5_StreamOwnership_11x17.mxd MGlass Mar 18, 2019



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

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City of Tualatin

City of Tualatin

Stormwater Master Plan

Date: April 2019
Project: Project 149233

N

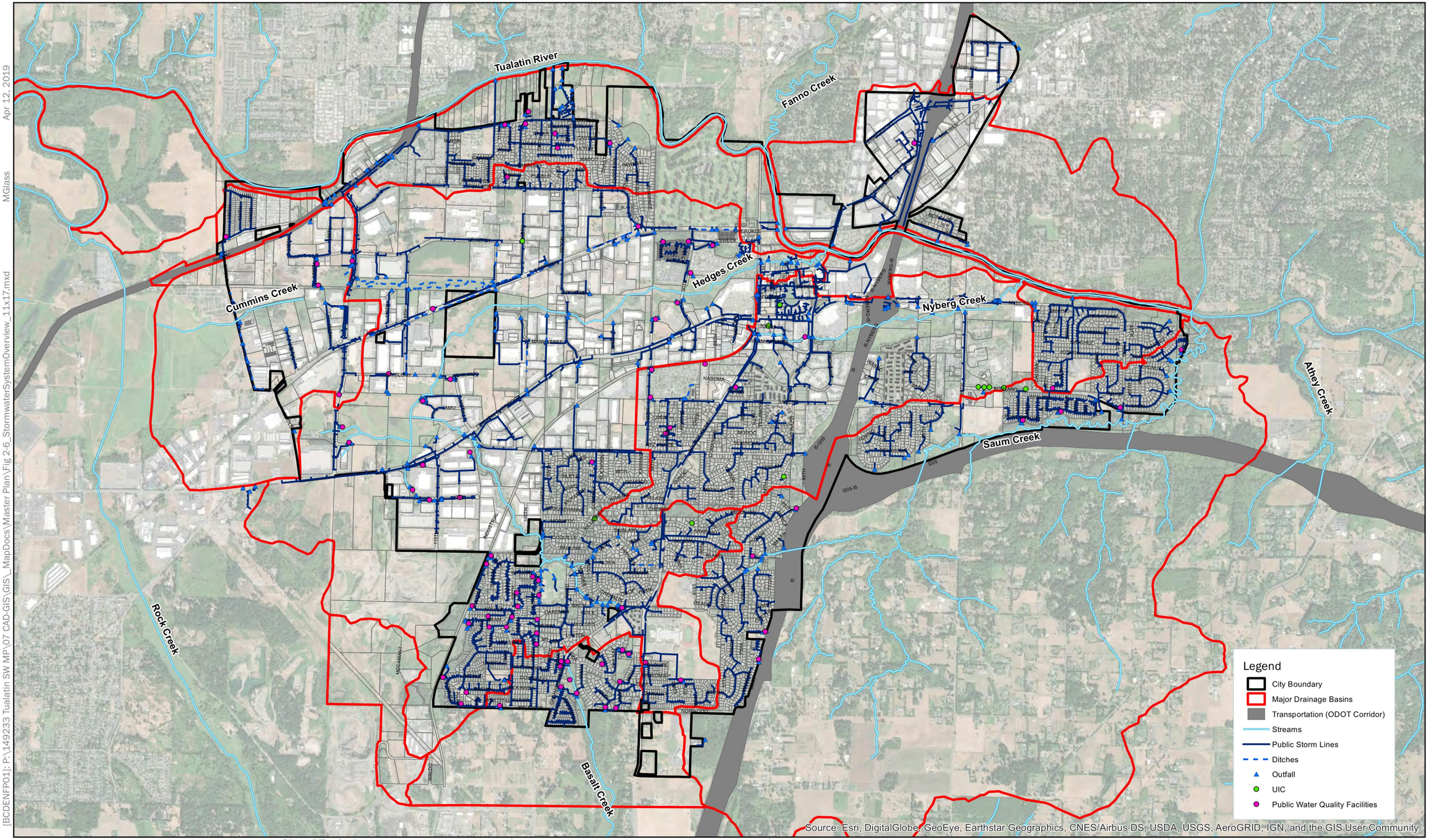
0 2,250 4,500 Feet

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)

Figure 2-5

Stream Ownership

[BCDENFP01]: P:\149233 Tualatin SW MP\07 CAD-GIS\GIS_MapDocs\Master Plan\Fig 2-6_StormwaterSystemOverview_11x17.mxd MGlass Apr 12, 2019



Brown AND Caldwell

City of Tualatin

City of Tualatin

Stormwater Master Plan

Date: April 2019
Project: Project 149233

N

0 2,250 4,500 Feet

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)

Figure 2-6

Stormwater System Overview

Section 3

Planning Process

This section provides background information related to the initial identification of Stormwater Project Opportunity Areas, which were used to inform capital project and program development efforts. As part of this preliminary effort, areas requiring additional evaluation, including H/H modeling and/or field investigations, were also identified.

Stormwater Project Opportunity Areas were identified based on a variety of data collection and field reconnaissance efforts. This process allowed the City to focus resources and develop information for areas and projects likely to be prioritized in a capital improvement program.

Additional detail related to this process is provided inTM1, included in this SMP as Appendix B. Table 3-1 and Figure 3-1, both at the end of this section, summarize the Stormwater Project Opportunity Areas.

3.1 Project Needs Identification

Stormwater project needs were initially identified through a collaborative process with the City's engineering, planning, and operations staff to assess known stormwater system problems and identify areas where infrastructure improvement, replacement, or retrofit could address observed issues.

From June through December 2016, reconnaissance efforts were conducted to identify current stormwater problems. Questionnaires were distributed to engineering and maintenance staff to document the type and location of reported and observed stormwater system deficiencies. The City's GIS inventory of reported drainage problems was reviewed. Two site visits were conducted to confirm the source of reported stormwater problems and validate whether the problems should be evaluated and addressed in the context of the SMP. Stormwater problem areas identified based on a stream capacity issue (bank overtopping) were generally omitted as a project opportunity, as stream capacity and natural system flooding was not an SMP objective.

Reported stormwater problems and project needs were consolidated by geographic area into defined Stormwater Project Opportunity Areas.

3.1.1 Water Quality Opportunities

Throughout this SMP planning process, expanded coverage of water quality treatment was a priority. An assessment of water quality project opportunities and potential water quality retrofits was conducted to supplement identified stormwater problem areas and project needs. Detail related to this effort is provided in Appendix B.

In the city and throughout the CWS NPDES permit coverage area there is increased emphasis on methods for improving stormwater quality. One method involves identifying opportunities to install water quality treatment facilities, particularly in developed areas of a city with high pollutant load potential (by land use) and limited potential for development and redevelopment (such that treatment requirements per development standards would be triggered). Such water quality retrofits can address stormwater regulatory requirements under the CWS NPDES permit and improve stream health and habitat citywide. identifying retrofit opportunities can be challenging, particularly in

developed areas where space is limited for installing above ground, vegetated treatment facilities as promoted in the NPDES permit.

The initial assessment of water quality project opportunity areas included a review of water-quality-related capital improvement projects per the City's 2017-2021 Capital Improvement Plan and review of available vacant/public lands that would support a new treatment facility. Available public lands are considered those not subject to the Tualatin City Charter, Chapter XI provisions, and generally included larger public parking areas or areas within the ROW[1]. Locations associated with high pollutant generating land use (i.e., industrial or commercial) and high imperviousness were prioritized for project development.

Reported capacity and maintenance-related stormwater problem areas were also reviewed to see if an integrated approach to stormwater management (i.e., installing water quality facilities to also mitigate stormwater runoff) could help address the reported issue (see Section 6).

Table 3-1 identifies Stormwater Project Opportunity Areas resulting from the assessment of water quality project opportunities. Water quality retrofit potential was identified for each opportunity area.

3.1.2 System Modeling Needs

Five stormwater problem areas were identified that required hydraulic modeling of the storm system to inform the source of capacity limitations and associated project development. These areas included:

1. Manhassat Drive (Stormwater Project Opportunity Area 4)
2. Boones Ferry Road at Tonka Road (Stormwater Project Opportunity Area 5)
3. Herman Road (Stormwater Project Opportunity Area 7)
4. Sagert Street at the Shenandoah Apartments (Stormwater Project Opportunity Area 9)
5. Mohawk Apartments at Warm Springs Road (Stormwater Project Opportunity Area 10)

Detail related to the H/H modeling methodology, model results, and associated project development is included in Section 4.

3.1.3 Stream Assessment Needs

Bank erosion, channel incision, sediment accumulation, and invasive vegetation are reported in reaches of the City's open channel conveyance system. To investigate these issues and develop a baseline assessment to evaluate stream condition in the future, a field stream assessment was initiated in September 2017.

The City identified and prioritized reaches of Suam Creek, Hedges Creek, and Nyberg Creek under "public ownership" (see Figure 2-5) that have not been previously evaluated but where there are reported problems.

Detail related to the stream assessment effort and associated project and program development is included in Section 5.

[1] Tualatin City Charter, Chapter XI limits the use of publicly owned parks, greenways, and natural areas to be used outside of their original intent without a public vote. The City has interpreted this provision to include using the property to facilitate installation of stormwater facilities.

3.2 Project Development Workshop

A project development workshop was held in October 2017 to finalize project development priorities and identify program needs/activities. Stormwater Project Opportunity Areas stemming from the preliminary project identification effort were presented and initial project concepts discussed.

Results from the hydraulic modeling effort were reviewed to confirm locations where flooding and surcharging have been observed. Project alternatives were discussed with the City to determine preferences related to routing and system configuration (i.e., piped versus open channel). Preliminary results from the stream assessment effort were also reviewed to validate project needs.

In some cases, an identified Stormwater Project Opportunity Area was determined to be better addressed as part of a routine maintenance activity instead of through implementing a standalone capital project. Relevant program needs for the City were discussed and included a pipe repair and replacement program, public water quality facility maintenance programs, and a stream vegetation management program. Section 6 addresses maintenance-related project and program needs.

During the workshop, City staff requested additional water quality-related project opportunities be considered and evaluated. As a result, the water quality opportunity areas were revisited, and additional public properties were identified, specifically parking lots, that could support water quality or LIDA facility installation. Site visits were conducted November 10 and December 17, 2017, to verify opportunities for additional water quality retrofit applications.

3.3 Results

Table 3-1 documents the list of final Stormwater Project Opportunity Areas used to develop capital projects and programs for this SMP. Figure 3-1 identifies each Stormwater Project Opportunity Area by ID (a numeric identifier) and primary project category—capacity/infrastructure need, erosion control, maintenance/condition assessment, and water quality. Multiple project categories may be relevant to one project opportunity, but the predominant category was used for mapping.

Twenty-six individual Stormwater Project Opportunity Areas and three citywide opportunities were identified, which reflects an expanded list of water quality retrofit locations following the project development workshop. Table 3-1 also includes a summary of the citywide preliminary project/program concepts.

It should be noted that not all Stormwater Project Opportunity Areas result in a capital project or program recommendation. Follow-up site visits conducted in November and December 2017 determined that two potential water quality retrofit locations were not viable for a facility installation. Additionally, City staff determined that the ability to retrofit select core parking areas of the City would require Board approval, and these areas should not be considered for proposed projects at this time.

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Table 3-1. City of Tualatin Stormwater Project Opportunities

SW Project Opportunity Area ID	Location	Basin/ Waterbody	Problem/ Project Category	Source	Water Quality (WQ) Retrofit Opportunity	Problem/Project Area Description	Preliminary Project Concepts and Observations (per site visits)	Additional Data Collection/City Input (following Project Development Workshop)	Project Development		
									Project Need	Programmatic Activity	No Project

1	Martinazzi Ave (near Tualatin-Sherwood Rd)
	Tualatin Sherwood Ave (near Martinazzi Ave)
		Nyberg Creek	• Maintenance/ Condition Assessment
			• Capacity (pipe grade)
				• Staff Questionnaire
				• City GIS
						• Over curb flooding in heavy rain events. Flooding originally thought to be a backwater issue from Nyberg Creek.
						• System includes high flow bypass pipe down Martinazzi to Izzy's Pond (12") and a low flow pipe (42") to the downstream end of culvert under Martinazzi that is almost fully submerged.
						• Anticipated to be addressed per current CWS project to remove sediment and improve capacity in Nyberg Creek.
							• Flat grade and submerged pipe attributes to sediment accumulation in the pipe down Martinazzi
							• Alternatives include:
							  • Pipe replacement (parallel pipe) or reconfiguration/rerouting.
							  • Development of an asset management/maintenance related CIP for continuous sediment removal.
								• Given orientation and current backwater, more frequent maintenance likely only means to address this problem area in the near term.
								• City requested expanded model development from Martinazzi to Nyberg Road along Nyberg Creek. Follow up modeling (initiated July 2018) conducted to determine project need.
								• Programmatic activities to be included in Master Plan and rate evaluation.
									TBD	X	

2	Venetia WQ Facility (Lee between 56th and 57th)	Saum Creek	• Maintenance/ Condition Assessment	• City GIS		• Facility overgrown with large bushes and trees but functional.
						• As-builts available. Facility design is a U-shaped swale with a total flowline of 172 LF and a slope of 1%. The bottom width of the swale is 4' with 4:1 side slopes. Top width is 15' and the water treatment level is 5.7".
						• Flow control MH installed directly upstream of the swale with a 24" bypass directly to the creek for high flow events.
							• No access to inlet/outlet.
							• Limited maintenance access; the existing access path is partially washed out.
							• Steep grade. High flow bypass outfall should be checked and repaired as needed
							• Project needs include:
							  • vegetation trim and thinning, removal of invasives
							  • replanting as needed
							  • regrading as needed
								Keep as a maintenance-related project.	X		

3	Blake St outfall at Saum Creek	Saum Creek	• Erosion Control
			• Maintenance (Debris accumulation)
				• City GIS		• Outfall experiences bank erosion (citizen complaints). Further erosion could impact the adjacent home.
						• Culvert under Blake may be undersized and cause backwater upstream.
							• The bank is steep and appears to be unstable and eroding.
							• Bank instability may not solely be due to the outfall. Adjacent bank instability and groundwater seepage was observed 100' downstream. Further geotechnical investigation may be warranted.
							• The upstream system appears in good order.
							• Project needed to retrofit existing outfall to creek, which is hanging out over the creek and exposed and minimize erosion of the channel.
							• Bank rehabilitation may include:
							  • rock buttress
							  • pillow wall with plantings to stabilize bank
							  • other based on geotechnical guidance
								• Storm pipe upstream of outfall requires replacement due to structural deficiencies.
								• Include outfall pipe replacement (existing failure) from road and private fence replacement in cost estimate.
								• Cost estimate to include geotechnical evaluation of stream reach.
									X		

4	Manhasset Dr (near 10550 SW Manhasset Dr)	Hedges Creek	• Capacity/ Infrastructure Need	• Staff Questionnaire- • Storm Area Hot Spots • City GIS • Stormwater CIP • WQ retrofit evaluation	X	• Frequent flooding of drainage channel between private properties from T-S Rd to Manhasset. • Drainage channel has limited capacity and observed debris accumulation. • Preliminary modeling indicates that the open channel is undersized for the contributing drainage area. • Some contributing pipes are undersized and surcharging during the 25-yr design storm. • Retrofit (WQ) opportunity - adjacent undeveloped land that has transportation and warehouse land draining to it. • No city easement exists along alignment.	• CIP needed to alleviate private property flooding and reconfigure collection system • System configuration options presented during the workshop include maintaining the open channel and piping the entire alignment.	• Modified system hydrology needed on upstream industrial parcel. The NE corner of the parcel does not discharge to the system. BC to evaluate with updated hydrology. • Piped system requires less maintenance and is preferred. • System surcharging is permissible due to flat grade and areas of backslope on the discharge pipe.	X		

Table 3-1. City of Tualatin Stormwater Project Opportunities

SW Project Opportunity Area ID	Location	Basin/ Waterbody	Problem/ Project Category	Source	Water Quality (WQ) Retrofit Opportunity	Problem/Project Area Description	Preliminary Project Concepts and Observations (per site visits)	Additional Data Collection/City Input (following Project Development Workshop)	Project Development		
									Project Need	Programmatic Activity	No Project

5	Boones Ferry Rd (19417 SW Boones Ferry Rd)	Nyberg Creek	• Capacity/ Infrastructure Need
			• Maintenance (gravel ballast)
				• Storm Area Hot Spots
				• City GIS
					X	• Problem location extends down Boones Ferry, the railroad culvert behind Jiffy Lube, and west along Tonka Avenue. Specific problem locations include:
						  • The inlet along the RR tracks (maintenance issue). Gravel is transported and redeposited downstream.
						  • StormFilter catchbasins along Boones Ferry are located at a roadway sag and clog, resulting in flooding.
						  • The conveyance system along Tonka, Warm Springs and Boones Ferry contributes to flooding.
							• CIP needed for source control and improved conveyance.
							• Gravel transportation mitigation needed to control railroad ballast.
							• Site visit confirmed two existing offline, single cartridge configuration of Storm Filter catchbasins. Additional sediment control or relocation may be needed to improve StormFilter performance.
							• Rerouting of conveyance on Warm Spring, Tonka and Boones Ferry may improve conveyance and alleviate flooding.
							• Preliminary modeling and system configuration alternatives presented during Workshop include revisions to the RR conveyance channel and Boones Ferry routing alternatives.
								• City requested expanded model development from Martinazzi to Nyberg Road along Nyberg Creek (initiated July 2018), which may impact project development.
								• StormFilter relocation needed.
								• Due to project size and scope, project development may require separate projects and/or phasing.
								• Follow up site visit 12/14/17 indicates the most viable option for a StormFilter is upstream along Boones Ferry.
									X		

6	Alsea/BF Rd 99th/Siuslaw Greenway	Hedges Creek	• Capacity/ Infrastructure Need • Water Quality	• Staff Questionnaire • WQ retrofit evaluation	X	• Dual corrugated pipe has the bottom rusted out. No apparent capacity deficiency. • High levels of sediment accumulation are observed. • Retrofit (WQ and FC) opportunity- This long linear greenway may provide an opportunity for WQ treatment for contributing drainage area (City confirms ok per charter).	• Project to include replacement of parallel pipes from Boones Ferry to MH upstream of parallel pipes • Project to include sediment trap. • Area is upstream of observed instream erosion at Alsea Ct. Regrading/amending channel between Siuslaw Ln and 98th Ave would improve downstream erosion issues.	• Include pipe replacement, sediment trap, and bioswale in cost estimate. • Project meets retrofit requirement and promotes stormwater infiltration/retention. • City to review upstream system to define upstream limit of replacement.	X		
7	Herman Rd	Hedges Creek	• Capacity/ Infrastructure Need	• Staff Questionnaire • WQ retrofit evaluation	X	• System has flat grade. Half the road drains to roadside ditch and the other half to a ditch along railroad ROW. • System lacks required drainage infrastructure. City wishes to install piped/below ground infrastructure. • Survey shows negative pipe slopes for the culverts passing under Herman Road. Survey also indicates pipes under RR are deep relative to upstream and downstream pipes. • Preliminary modeling indicates that culverts crossing Herman Road leads to backwater effects and flooding in the ditch/culvert system on the north side of Herman Road.	• CIP needed to install additional conveyance infrastructure. • Preliminary modeled alternatives suggest the system will backwater upstream of the railroad crossing. • Piping to be sized with maximum slope possible to limit sedimentation • Potential water quality retrofit locations at SE corner of Herman Road and 95th Avenue.	• Modified system hydrology needed. Golf course does not discharge to system. • Preferred configuration is piped system in middle of roadway. • Culverts under tracks are frequently maintained. • System surcharging is permissible due to flat grade. • No water quality treatment needed/not a retrofit opportunity now. Stormwater treatment will be accommodated as part of the roadway widening.	X		

8	Curves at Blake/105 and 108th	Hedges Creek	• Capacity/Infrastructure Need
			• Erosion
				• Staff Questionnaire		• Roadway lacks collection system and pedestrian access. City is currently in planning stages for roadway update (concept plan in place) but no budget for project yet.
						• Culvert alignment may play a role in design and cost estimate.
						• Current drainage from Coquille/Paulina and 105th is an open channel ditch to culvert inlet.
						• Specific problem locations include:
						  • Stream channel experiences 90° bends on both sides of culvert.
						  • Culvert is undersized
						  • Existing roadway embankments are steep and drainage updates are needed for the roadway.
							• Culvert design to incorporate a sizing and length based on the hydrology and ideal alignment.
							• Observed (during stream assessment) retaining wall deficiencies along the roadway. Assume improvements as part of roadway redesign and not culvert replacement.
								• Per Oregon Department of Fish and Wildlife (ODFW) feedback (1/25/17) culvert fish passage design not necessary.
								• Culvert sizing and construction estimate needed as part of the CIP. Roadway drainage to be addressed with roadway update.
								• Assume configuration of culvert to align with historic channel orientation and not current orientation.
								• Culvert to be sized based on 100-yr flows at point of inlet.
									X		

Table 3-1. City of Tualatin Stormwater Project Opportunities

SW Project Opportunity Area ID	Location	Basin/ Waterbody	Problem/ Project Category	Source	Water Quality (WQ) Retrofit Opportunity	Problem/Project Area Description	Preliminary Project Concepts and Observations (per site visits)	Additional Data Collection/City Input (following Project Development Workshop)	Project Development		
									Project Need	Programmatic Activity	No Project
9	Sagert St. - Shenandoah Apts (Sandalwood)	Nyberg Creek	• Erosion Control • Capacity/Infrastructure Need	• Storm Area Hot Spots • WQ retrofit evaluation	X	• Reported flooding during Oct and Dec 2015 storms. • Retrofit (WQ) opportunity by converting existing open channel to WQ facility. • Preliminary modeling indicates that the existing pipes upstream of the open channel are undersized and are surcharging during the 25-yr design storm, but no flooding is reported.	• System flooding may be due to debris from nearby tree limiting capacity of ditch inlet. • Limited pipe cover through greenspace. • Channel sloughing observed upstream of Sagert St. • WQ and detention should be incorporated into this project if possible (project location is upstream of WQ Opportunity Area #10).	• City easement exists. • CIP development to be completed independent of Nyberg system. Surcharging is acceptable. • Relocate ditch inlet (away from tree). • Maintain open channel conveyance options to qualify as a water quality retrofit.	X		

10	Mohawk Apts	Nyberg Creek	• Capacity/ Infrastructure Need
			• Maintenance/ Condition Assessment
				• Storm Area Hot Spots		• Conveyance capacity affecting Opportunity Area #5.
						• Inlet behind Mohawk Apts is inundated, resulting in overland flow through adjacent property and flooding Tonka and Warm Springs at the Elks Lodge.
						• City is unaware of any easements that may facilitate correcting the issue.
							• Limited freeboard available prior to overtopping at the inlet. Grate structure installed at inlet likely reducing capacity.
							• Alternatives include:
							  • Update/replace inlet and embankment to reduce/remove flooding
							  • Pipe open section through apartments and remove inlet
							  • Update both inlet and channel to enhance natural function/remove invasive vegetation
								• City unable to access pipe upstream of open channel for CCTV. Need to include CCTV cost into CIP development.
								• CIP to include installation of access locations (manholes) along piped system upstream of open channel.
								• CIP to include replacement of ditch inlet at downstream end of open channel and corrugated metal pipe downstream of open channel.
								• City to confirm easement along open channel alignment.
								• City prefers piping over maintaining open channel.
									X		

11	Piute Ct. WQ Facility	Saum Creek	• Maintenance/ Condition Assessment	• Storm Area Hot Spots		• Public WQ facility is failing. Sediment and invasive vegetation accumulation. • As-builts available. Facility design is approx. 7' deep, 400 square foot (sf) bottom, 3:1 side slope. • No access road. Easement status is unknown.	• Site visit was unable to locate outlet structure. System appears to discharge towards I-205. • Potential maintenance access along backside of facility. Installation of access road needed. • CIP to include facility regrading with sediment and vegetation removal and replanting. • Existing easement available between two houses on Piute Ct. but does not appear to be established or used.	• Keep as a maintenance project. • The outfall structure should be inspected and repaired as needed. • City owns easement between two private properties off Piute Ct. Assume construction of a permanent access road off Piute Ct.	X		

12	Sequoia Ridge WQ Facility	Saum Creek	• Maintenance/ Condition Assessment	• Stormwater CIP		• Facility is overgrown with malfunctioning outlet structure and standing water.
						• As-builts available. Facility design reflects pond volume of 14,250 cubic feet (cf) but was built to 15,500 cf. Pond bottom is approx. 4,000 sf and 5' deep with side slopes of 3:1. Facility was designed in 1997.
						• Outlet structure has a 2" orifice for low flow and a high flow inlet to bypass low flow orifice.
						• Trail connects facility to Saum Creek, resulting in increased public attention.
							• Large cottonwood trees need to be removed
							• Outfall structure needs engineering review.
							• Due to the standing water, there is little beneficial vegetation and will likely need to be fully replanted.
							• As-builts reference recommended maintenance requirements including sediment removal once it exceeds 6" in depth. Mow 2x/yr. Watering in times of drought. Inspections 3x/yr.
							• Project needs include:
							  • Replacement of outlet structure
							  • Removal of trees
							  • Amendment of soils
							  • Replanting of vegetation
								• Keep as a maintenance project.
								• The outfall structure should be inspected and repaired as needed.
									X		

13	Sweek Dr WQ Facility	Hedges Creek	• Maintenance/ Condition Assessment	• Stormwater CIP		• Facility is overgrown. • No as-builts available.	• Large cottonwood trees need to be removed, • No outlet structure observed, and facility appears to freely drain. • Project needs include: • Removal of trees	• Keep as a maintenance project.	X		

Table 3-1. City of Tualatin Stormwater Project Opportunities

SW Project Opportunity Area ID	Location	Basin/ Waterbody	Problem/ Project Category	Source	Water Quality (WQ) Retrofit Opportunity	Problem/Project Area Description	Preliminary Project Concepts and Observations (per site visits)	Additional Data Collection/City Input (following Project Development Workshop)	Project Development		
									Project Need	Programmatic Activity	No Project
							• Amendment of soils • Replanting of vegetation				

14	Waterford WQ Facility	Hedges Creek	• Maintenance/ Condition Assessment	• Stormwater CIP
				• WQ retrofit evaluation
					X	• Maintenance needed due to sediment build up and limited access to outlet structure.
						• As-builts available. Facility is approx. 4' deep, 2,500 sf bottom. Facility was designed in 1993. Original design included WQ swale graded around the pond for preliminary treatment.
						• The existing outlet structure in the pond needs to be removed and relocated so maintenance can be performed during high water events.
						• Facility is upstream of observed instream erosion, so flow/volume control may benefit.
							• The WQ swale no longer exists and needs to be regraded into the facility.
							• No vegetation is visible and high sediment accumulation observed.
							• The inlet riprap needs to be replaced.
							• Project needs include:
							  • Relocation and redesign of outfall structure to maximize flow control.
							  • Invasive removal.
							  • Excavate and regrade WQ swale. Include amended soils and replant
							  • Replace inlet structure.
								• Flow control/flow duration sizing to be referenced in project description.
								• Project to assume maintenance consistent with other public WQ facility.
									X		

15	89th Ave/Tualatin-Sherwood Rd Stormwater Outfall	Hedges Creek	• Water Quality	• Stormwater CIP • WQ retrofit evaluation	X	• Project identified in City's 2017-2021 CIP. Project is a WQ manhole (MH) installation to prevent debris from discharging into wetlands. • CWS retrofit program driver. Per review of CWS Permit and SWMP, appears to be viable as an outfall retrofit project.	• Limited opportunity for green infrastructure or any facility with drop requirement. Water surface elevation in adjacent wetlands prohibits use of any facility with large internal drop requirement. • Due to a small head drop across the structure conveyance pipe from the structure and a new outfall may need to be constructed.	• Facility sizing and installation to be included as project	X		
16	125th to Herman Rd	Cummins Creek	• Water Quality	• Stormwater CIP • WQ retrofit evaluation	X	• Project identified in City's 2017-2021 CIP. Project is a WQ MH installation to treat 143 ac contributing area with no upstream treatment. • CWS retrofit program driver. Per review of CWS Permit and SWMP, appears to be viable as an outfall retrofit project. • Identifying catchment area challenging due to the railway along south side of SW Herman Road and unknown conveyance pathways.	• Limited opportunity for green infrastructure or any facility with drop requirement. Water surface elevation in adjacent wetlands prohibits use of any facility with large internal drop requirement. • Due to a small head drop across the structure conveyance pipe from the structure and a new outfall may need to be constructed. • Catchment delineation and facility placement to be determined during detailed design due to private property constraints.	• Facility sizing and installation to be included as project	X		
17	93rd Ave	Nyberg Creek	• Water Quality • Infrastructure need	• Staff Questionnaire • WQ retrofit evaluation	X	• Potential for green street pilot project to provide treatment in roadside planters to Avery St. • GIS indicates collection system exists, so no new infrastructure required.	• Current conveyance is provided in street side ditch primarily on the west side of 93rd. • Project to include curb and gutter where 93rd is currently unimproved. Roadside planters to be incorporated and sized based on the catchment area draining to the north end of the road to Avery.	• New project opportunity area following Workshop. • Project extends on the west side of 93rd Avenue to SW Umiat St. and on the east side to SW Tonopah St (one inlet will need to be removed in front of 20232 SW 93rd)	X		
18	Green Parking Lot (approx. 18725 SW Boones Ferry Rd)	Hedges Creek	• Water Quality • Capacity (bank overtopping)	• City GIS • WQ retrofit evaluation	X	• Potential WQ retrofit. • Reported flooding of lot due to proximity to Hedges Creek and floodplain. Flooding due to stream capacity issue and not to be addressed by Master Plan. • Vegetated swale (unmaintained) already exists adjacent to Hedges Creek; collecting parking lot runoff. • Parking lot properties are considered public but are governed by a separate board that oversees improvements.	• Per site visit, there are several locations where existing planters could be retrofit for additional WQ treatment. Would require relocation of inlet and potentially lose a parking stall depending on facility sizing needs.	• New project opportunity area following Workshop. • Area is already being treated by a water quality facility. Maintenance of the swale is recommended. • Follow up from City in December 2017 indicates the need for board approval to retrofit core area parking will present an implementation challenge. No dedicated project need now.			X

Table 3-1. City of Tualatin Stormwater Project Opportunities

SW Project Opportunity Area ID	Location	Basin/ Waterbody	Problem/ Project Category	Source	Water Quality (WQ) Retrofit Opportunity	Problem/Project Area Description	Preliminary Project Concepts and Observations (per site visits)	Additional Data Collection/City Input (following Project Development Workshop)	Project Development		
									Project Need	Programmatic Activity	No Project
19	Yellow Parking Lot (Seneca and 84th)	Hedges Creek	• Water Quality	• WQ retrofit evaluation	X	• Potential WQ retrofit. • Parking lot properties are considered public but are governed by a separate board that oversees improvements.	• Per site visit, there are several locations where the existing planters could be retrofit for WQ treatment. Would require relocating inlet and potentially losing a parking stall depending on facility sizing needs. • There are light poles in the planters.	• New project opportunity area following Workshop. • Follow up from City in December 2017 indicates the need for board approval to retrofit core area parking will present an implementation challenge. No dedicated project need now.			X
20	Juanita Pohl Parking Lot	Hedges Creek	• Water Quality	• WQ retrofit evaluation	X	• Potential WQ retrofit at City-owned, parking lot. • Significant impervious surface area and limited existing WQ treatment.	• Per site visit, there are several locations where the existing islands that could be retrofit for WQ treatment. Would require relocation of inlet and potentially lose a parking stall depending on facility sizing needs.	• New project opportunity area following Workshop.	X		
21	White Parking Lot	Hedges Creek	• Water Quality	• WQ retrofit evaluation	X	• Potential WQ retrofit. • Parking lot properties are considered public but are governed by a separate board that oversees improvements.	• Per site visit, parking lot currently drains to middle ditch/swale that could be retrofit to provide significant treatment. Some light grading, soil augmentation and planting would be needed. Existing inlets would need to be removed.	• New project opportunity area following Workshop. • Follow up from City in December 2017 indicates the need for board approval to retrofit core area parking will present an implementation challenge. No dedicated project need now.			X
22	Community Park Parking Lot	Hedges Creek	• Water Quality	• Site Visit	X	• Potential WQ retrofit at City-owned, parking lot. • Significant impervious surface area and limited existing WQ treatment.	• Per site visit, there are several locations where the existing islands that could be retrofit for WQ treatment. Would require relocation of inlet and potentially lose a parking stall depending on facility sizing needs.	• New project opportunity area following Workshop.	X		
23	Blue Parking Lot (Boones Ferry Rd and Tualatin Rd)	Hedges Creek	• Water Quality • Capacity (bank overtopping)	• City GIS • WQ retrofit evaluation	X	• Potential WQ retrofit. • Reported flooding of lot due to proximity to Hedges Creek and floodplain. Flooding due to stream capacity issue and not to be addressed by Master Plan. • Properties are considered public but are governed by a separate board that oversees improvements.	• Hedges Creek floods the parking lot during routine rain events. • Per site visit, standing water onsite and parking lot is at grade with Hedges Creek. • Not a recommended opportunity to retrofit for WQ.	• New project opportunity area following Workshop. • Follow up from City in December 2017 indicates the need for board approval to retrofit core area parking will present an implementation challenge. No dedicated project need now.			X
24	City Operations Yard	Hedges Creek	• Water Quality	• WQ retrofit evaluation	X	• Potential WQ retrofit at City-owned, municipal property. • Significant impervious surface area.	• Per site visit, the parking lot adjacent to Herman Road currently has WQ treatment. The parking lot adjacent to the building does not, and access was limited. • Little opportunity for WQ retrofit at this location.	• New project opportunity area following Workshop. • No recommended project per follow up site visits.			X
25	Jurgens Park Parking Lot	Tualatin River	• Water Quality	• Site Visit	X	• Potential WQ retrofit at City-owned, parking lot.	• Per site visit, there is little opportunity for a water quality retrofit due to catch basin placement. The northern portion of the parking area is already paved with porous pavers.	• New project opportunity area following Workshop. • No recommended project per follow up site visits.			X
26	Hedges Creek at SW 106th Ave and Willow Str	Hedges Creek	• Erosion Control	• Stream Assessment		• Active stream bank erosion occurring adjacent to, upstream, and downstream of an exposed sanitary manhole. • Separate evaluation conducted by the Park Department (Hedges Creek Stream Assessment, February 2018) also observed active erosion in vicinity.	• Limited upstream flow control results in high runoff velocities that appear to have eroded the stream channel. • Results of the Stream Assessment (Section 5 and TM3 of the SMP) outline specific observed conditions in reach.	• New project opportunity area following Workshop. • Project scope and cost information to be based on recommendations outlined in the Hedges Creek Stream Evaluation, February 2018. • Ongoing vegetation maintenance program needs.	X	X	

Table 3-1. City of Tualatin Stormwater Project Opportunities

SW Project Opportunity Area ID	Location	Basin/ Waterbody	Problem/ Project Category	Source	Water Quality (WQ) Retrofit Opportunity	Problem/Project Area Description	Preliminary Project Concepts and Observations (per site visits)	Additional Data Collection/City Input (following Project Development Workshop)	Project Development		
									Project Need	Programmatic Activity	No Project
City wide	Repair and Replacement Program	City wide	• Capacity/ Infrastructure Need • Maintenance/ Condition Assessment	• Staff Questionnaire		• Select storm lines and infrastructure throughout City may need more frequent maintenance to ensure function. • There is no proactive pipe or structure replacement program.	• Development of repair and replacement program for infrastructure (pipes and structures) requiring increased maintenance frequency. Include proactive infrastructure replacement.	• Programmatic activities to be included in Master Plan and rate evaluation. May require multiple programmatic activities.		X	
City wide	Public WQ Facility Maintenance	City wide	• Maintenance/ Condition Assessment • Water Quality	• Staff Questionnaire • WQ retrofit evaluation		• City staff has been receiving complaints from homeowners unaware that a public WQ facility is near their residence. • Re-engineering and/or retrofit of existing WQ facilities may be required.	• Develop a program to review/investigate existing system design and function.	• Programmatic activities to be included in Master Plan and rate evaluation.		X	
City wide	Vegetation Management	City wide	• Water Quality • Maintenance	• Stream Assessment		• Excessive invasive vegetation reported along stream reaches throughout the City.	• Develop a program to remove invasive/replace/restore vegetation along stream channels. • Results of the Stream Assessment (Section 5 and TM3 of the SMP) outline specific observed conditions in reach.	• Programmatic activities to be included in Master Plan and rate evaluation.		X	

City Wide Stormwater Project Opportunities	
Program	**Category**
Repair and Replacement	Capacity/Infrastructure Need
Public Water Quality Facility Maintenance	Maintenance/Condition Assessment
Vegetation Management	Water Quality

Legend

Stormwater Project Opportunity Areas (by ID and predominate project category)

- Capacity/Infrastructure Need
- Erosion Control
- Maintenance/Condition Assessment
- Water Quality
- Removed from consideration
- Streams
- Transportation (ODOT Corridor)
- City Boundary

Refer to Table 3-1 for additional Stormwater Project Opportunity detail.

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

Brown AND Caldwell

City of Tualatin

City of Tualatin

Stormwater Master Plan

Date: April 2019
Project: Project 149233

0 2,250 4,500 Feet

N

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)

Figure 3-1

Stormwater Project Opportunity Areas

Section 4

Storm System Capacity Evaluation

Stormwater conveyance is the primary function of the City's stormwater infrastructure. This section outlines the H/H system modeling approach and results for select areas of the city that were used to inform observed capacity limitations and develop project solutions.

System modeling needs were identified as part of the project needs identification effort (Section 3.1.2) and reflect targeted areas of the city requiring hydraulic modeling to analyze existing and future system capacity. Capital project recommendations were developed for each modeled area after verifying capacity limitations and assessing project alternatives. A total of six capital project recommendations stemmed from results of the H/H modeling effort.

The system capacity evaluation is described in additional detail in TM2 and in TM3, included in this SMP as Appendix C and Appendix D, respectively. Model results and figures related to the capital project development are included in this SMP as Appendix E.

4.1 Modeling Approach

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

H/H modeling was predominately conducted in the downstream portions of the stormwater collection system that exhibit high flow but are relatively flat. A few areas do not discharge/outfall freely due to high tailwater conditions, resulting in backwater of the conveyance system and flooding. The City does not require detention for new and redevelopment, so as development occurs, there is typically an increase in stormwater flow and runoff volume, and as a result, existing infrastructure capacity may be insufficient to convey the increase in stormwater runoff.

For this SMP, the following modeling approach was used to evaluate stormwater 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 3.1.2)
2. Review available data (via GIS, as-builts, etc.) to identify data gaps and data required for model development and to inform survey needs
3. Conduct field survey work to supplement data gaps in the City's GIS for the targeted portions of the City's stormwater conveyance system
4. Delineate subbasins and develop a citywide hydrologic model to estimate stormwater runoff generated for existing and future development conditions
5. Develop targeted or system-specific hydraulic models
6. Validate modeled flooding using anecdotal information (photographs, City records)
7. Verify capacity constraints and identify potential sources or causes
8. Use the validated hydraulic models to simulate alternative conveyance system design and develop potential solutions to capacity problems.

4.2 Planning Criteria and Design Standards

Planning criteria related to the analysis of the City's stormwater collection system are documented in the City's Public Works Standards (PW) Standards (2013), the CWS Design and Construction Standards (2007), and the CWS LIDA Handbook (2009).

Planning criteria and design standards are used to identify system capacity limitations and establish the basis of design for water quality and capacity-related projects. A summary of applicable planning criteria and design standards is provided in Table 4-1. Please note that some deviation from established design standards occurs on a case-by-case basis, particularly where slope or pipe cover design constraints exist.

Table 4-1. Drainage Standards and Design Criteria

Criteria	Source	Value
Water Quality Facility Design	PW Standards (206.8)	Design to requirements of CWS Design and Construction Standards and CWS LIDA Handbook. Specific to the PW Standards, facilities are required to have 4' or 6' vinyl coated chain link fencing.
Water Quantity Facility Design	PW Standards (206.8) CWS Design and Construction Standards	Design to requirements of CWS Design and Construction Standards. Match pre- and post-development flow for the 2-, 10-, and 25-yr, 24-hr storm events.
Pipe, Culvert Design Storm[a]	PW Standards (206.3)	Design to the 25-yr storm event. Surcharge during the 25-yr is not permissible. [b]
Open Channel and Ditch Design Storm	PW Standards (206.3)	Design to the 25-yr storm event. Surcharge during the 25-yr is not permissible. [c]
Pipe Size	PW Standards (206.4)	10" minimum diameter for pipe from catch basins to the main in the public ROW. 12" minimum diameter for mains in the public ROW.
Manning's Roughness	PW Standards (Table 206-8)	Varies by material and shape.
Pipe Material	PW Standards (206.4)	Concrete, PVC, ductile iron, and aluminum spiral rib pipe.
Pipe Cover	CWS Design and Construction Standards	Table 5-2, varies by pipe material.
Structure Spacing	PW Standards (206.4)	250' maximum for 10" pipe; 400' maximum for 12" pipe.
Manhole Size	PW Standards (206.6)	48" diameter minimum.

a. *The City's PW standards reference the rational method for conveyance design. Santa Barbara Urban Hydrograph (SBUH) was an approved equivalent as discussed with the City during the July 28, 2016, meeting.*

b. *Per discussion with City staff, surcharge is acceptable for capital project design.*

c. *Due to the consequence of failure (potential road washout), capital project design for culverts used the 100-year peak flow.*

In conjunction with the reissued NPDES permit, CWS is in the process of updating its Design and Construction Standards. CWS released updated standards in April 2017 to address the size of development that requires water quality treatment (impervious area threshold) and the prioritization of LIDA and green infrastructure (GI) facilities to provide treatment. Additional updates were finalized in April 2019 to establish strategies and priorities for addressing effects of hydromodification. These updates have not affected the City's design of capital projects under this SMP.

Additional discussion of stream erosion in accordance with hydromodification risk is provided in Section 5.

4.3 Hydrologic Model Development and Results

A citywide hydrologic model was developed using XP-Storm Water Management Model (XPSWMM) version 2016.1. Within the model, the SBUH method was used to estimate hydrology. The input parameters for the SBUH method include subbasin areas, impervious percentages, pervious curve numbers, and time of concentration. The hydrology routine in XPSWMM converts rainfall into stormwater runoff as a function of the design storm parameters (e.g., volume and intensity of rainfall); subbasin characteristics including topography, land use, vegetation, and soil types.

The hydrology modeling effort, particularly the delineation of subbasin areas, considered locations where the hydrology input is needed for the hydraulic model, such as at system junctions, changes in system slope, or locations where there are changes in conveyance pipe or channel size.

Hydrologic model results are tabulated in TM2 (Appendix C). Results are displayed by subbasin as the maximum flow for each design storm, the change in peak flow, and the percent increase in peak flow between the existing and future development conditions. Overall, the hydrologic model results show minimal to no increases in future flows for subbasins that are fully developed, such as in the Nyberg Creek and Tualatin River (direct) watersheds. The largest increases in flow are in subbasins with larger amounts of vacant land, such as in the Hedges Creek watershed.

4.4 Hydraulic Model Development and Results

There are six Stormwater Project Opportunity Areas where hydraulic models were developed as part of this SMP:

1. Stormwater Project Opportunity Area 1, Martinazzi Avenue at Tualatin-Sherwood Road
2. Stormwater Project Opportunity Area 4, Manhassat Drive
3. Stormwater Project Opportunity Area 5, Boones Ferry Road at Tonka Road
4. Stormwater Project Opportunity Area 7, Herman Road
5. Stormwater Project Opportunity Area 9, Sagert Street at the Shenandoah Apartments
6. Stormwater Project Opportunity Area 10, Mohawk Apartments at Warm Springs Road

Five of the Stormwater Project Opportunity Areas (Nos. 4, 5, 7, 9, and 10) were identified during the project needs identification effort. Additional hydraulic modeling was initiated in July 2018 to evaluate lower Nyberg Creek and the contributing stormwater collection system east of Martinazzi Avenue (Stormwater Project Opportunity Area 1). Modeling efforts focused on capacity and backwater effects of Nyberg Creek on stormwater infrastructure (Lower Nyberg Creek System).

Due to proximity and connectivity of the proposed modeled system, three of the areas (Nos. 5, 9, and 10) were combined into one hydraulic model system (Upper Nyberg Creek System).

Hydraulic model extents, including contributing subbasins, are shown on Figure 4-1 at the end of this section.

4.4.1 Hydraulic Model Development

XPSWMM was used to simulate the hydraulic performance of the select pipe and open-channel systems to calculate peak flows, water surface elevations, and velocities for established design storms. The hydraulic model extents were established upstream and downstream of the identified problem areas to verify the extent and severity of the problem location and develop potential alternatives to correct or mitigate the deficiency.

One-dimensional (1D) XPSWMM hydraulic models were developed based on existing geographic information system (GIS) data provided by the City, field survey collected as part of this master

planning effort, and site visits. A two-dimensional (2D) XPSWMM model was developed for the Lower Nyberg Creek System, from Martinazzi Avenue east to Nyberg Lane, based on Light Detection and Ranging (LiDAR), field observations from stream walks, aerial photos, and survey data.

A description of each modeled system is provided below:

- **Manhassat Drive System:** The Manhassat Drive system includes Stormwater Project Opportunity Area 4. The City frequently responds to flooding of the open channel system, starting from Tualatin-Sherwood Road to Manhasset Drive. Based on field reconnaissance, feedback from City staff, and initial system review in GIS, the open channel system is capacity limited. The hydraulic model for the Manhassat Drive system includes the culvert under Tualatin-Sherwood Road and the piped and open channel system running north to the outfall into Hedges Creek.
- **Herman Road System:** The Herman Road system includes Stormwater Project Opportunity Area 7. City staff identified this area during completion of the stormwater surveys as frequently flooding. Based on field reconnaissance, feedback from City staff, and initial system review in GIS, the primary drainage issues include undersized drainage infrastructure and flat grade along Herman Road. The south side of Herman Road does not have a stormwater collection system, which results in standing water on the roadway. The hydraulic model for the Herman Road system includes the piped and open channel conveyance along Herman Road between Southwest Teton Avenue and Southwest Tualatin Road, as well as the open channel/piped system between Herman Road and the outfall at Sweek Pond.
- **Upper Nyberg Creek System:** The Upper Nyberg Creek system includes Stormwater Project Opportunity Areas 5, 9, and 10. All three areas were identified due to frequent flooding and the need for further assessment. Collectively, transport of sediment and gravel in this system, combined with the relatively flat grade of the system, results in reduced capacity of the stormwater collection system and backwater and flooding effects. The hydraulic model is extensive and includes the open channel system along the railroad tracks west of Boones Ferry Road, the piped drainage system on Boones Ferry Road, the culverts discharging east under Boones Ferry Road, the open channel system flowing east from Boones Ferry Road to Martinazzi Avenue, and the open channel and piped systems discharging north to Nyberg Creek from Seminole Trail Warms Springs Street.
- **Lower Nyberg Creek System:** The Lower Nyberg Creek system includes Stormwater Project Opportunity Area 1 and extends along Nyberg Creek from Martinazzi Avenue to Nyberg Lane. Both 1D and 2D modeling approaches were used to evaluate flooding extents, potential causes of flooding and comprehensively assess how modifications to Nyberg Creek influences upstream stormwater system The Upper Nyberg Creek model 1D model was extended to include the Nyberg Creek channel from Martinazzi Avenue to the culvert outfall at Nyberg Lane and portions of the stormwater collection system along Tualatin-Sherwood Road and Martinazzi Avenue. The 1D and 2D models are linked in XPSWMM and simulated as a single model of the channel and floodplain.

For the Manhassat, Herman Road, and Upper Nyberg Creek System, existing condition hydrology for the 25-year storm event was used to initially evaluate the capacity of the modeled systems and validate model results. Model results were compared to anecdotal flooding reports and City photographs taken during the December 2015 storm event (for the Manhasset Drive system). Model validation information 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 calibration were performed by adjusting hydraulic input parameters based on field observations to match reported flooding.

No recent model validation or calibration data were available for the Lower Nyberg Creek System.

Both existing and future condition hydrology were applied to the validated hydraulic model. This process enables the existing infrastructure to be assessed for future capacity needs.

4.4.2 Capacity Evaluation Results

The hydraulic model results showed minimal to no increases in future flows for the modeled areas that are fully developed. As expected, the largest projected flow increases were seen in areas with existing vacant lands. The hydraulic model results confirmed the flooding problem areas/capacity-limited areas as reported by City staff and provided additional information about potential sources of the problems.

Detailed hydraulic modeling results (tables and figures) are provided in Appendix C for the Manhassat, Herman Road, and Upper Nyberg Creek System. Hydraulic modeling results are provided for the Lower Nyberg Creek System in Appendix D.

A summary of the hydraulic modelling results by modeled system is provided below. Table 4-2 summarizes the general modeled flooding locations, the potential source of the capacity deficiencies, and whether a capital project was developed to address the flooding.

- **Manhasset Drive System:** The hydraulic model shows extensive flooding during the 2-year design storm in the stormwater system along Manhasset Drive, especially along the open channel portion where the open channel cross sections are non-symmetrical and limited in capacity. Proper open channel maintenance, including debris removal and regular mowing of channel vegetation, may alleviate some flooding; however, the channel is still undersized for the contributing flow. Because pipes further downstream (north of Manhassat Drive) experience surcharging they do not meet City design standards; however, the maximum water elevations are not above manhole rim elevations.
- **Herman Road System:** The hydraulic model shows extensive flooding in the open channel/culvert system along Herman Road between SW Teton Avenue and SW Tualatin Road. The open channel system north of Herman Road is further restricted by the two culverts across Herman Road. These culverts have a non-traditional layout, likely due to the ground clearance required beneath the railroad and have a negative or backslope. To the east, the parallel culverts south of the intersection of Tualatin Road and Herman Road begin surcharging at the 2-year event. Figures 4-3 and 4-4 show the extent of modeled flooding by conduit.
- **Upper Nyberg Creek System:** The hydraulic model shows widespread system flooding during the 2-year and 10-year design storms. One prevalent location of flooding is the open channel system along the railroad tracks west of Boones Ferry Road (19417 SW Boones Ferry Road). The open channel is overtopping, and the downstream pipes are surcharging, resulting in flooding of nearby businesses. Flow bypassing the system is discharging to Boones Ferry Road via overland flow, consistent with the flow patterns reported by city staff. Sediment accumulation further restricts conveyance across the parallel culverts at Boones Ferry Road.

  Additional area experiencing surcharge and flooding is the pipes north of Seminole Trail between Tillamook Court and Martinazzi Avenue, starting at the 10-year event. Modeling did not indicate flooding of the open channel system, but because any system upsize would impact the open channel, capital project development must include a comprehensive review of project needs in this area. Finally, the pipes near the intersection of SW Boones Ferry Road and SW Warm Springs Street and the intersection of SW Warm Springs Street and SW Tonka Street are surcharging beginning at the 10-year event.

- **Lower Nyberg Creek System:** The hydraulic model shows systemic flooding along Martinazzi Avenue and Tualatin-Sherwood Road. The flooding is due to the low elevation of roadways and parking lots, low gradient conveyance systems and the low gradient in the Nyberg Creek itself.

  As described in TM3 (Appendix D), larger regional events result in widespread flooding along Martinazzi Avenue from Nyberg Creek to Tualatin-Sherwood Road due to the backwater effects of the Tualatin River on Nyberg Creek. More frequent, nuisance flooding (evaluated based on a 5-year, 24-hour design storm) still occurs along Martinazzi Avenue and Tualatin-Sherwood Road, but is the result of limited capacity of the collection system to convey flow as opposed to backwater conditions.

Table 4-2. Capacity Evaluation Result Summary and Capital Project Development Approach

Modeled System	General Location	Conduit	Surcharging/ Flooding Scenario	Source of Capacity Deficiency	Capital Project Development (Y/N) [a]
Herman Road System	Open channel/culvert system on north side of Herman Road	Link32.1	Existing 10-yr	Existing culverts are undersized and have minimal slope. Multiple transitions from open channel to a piped system lead to high energy losses.	Y – CIP 8
		Link34.1	Existing 10-yr		
		322603	Existing 2-yr		
		322638.1	Existing 2-yr		
		333704.1	Existing 2-yr		
		333705.1	Existing 2-yr		
		333706.1	Existing 2-yr		
		333707.1	Existing 2-yr		
		334080.1	Existing 2-yr		
		Link33.1	Future 2-yr		
	Culvert across Herman Road	322643	Existing 2-yr	Culvert has minimal slope and nearby pipes show unusual change in inverts. Culvert is surcharging but not flooding. Follow up survey with detailed design recommended.	N
	Dual culvert south of intersection of Tualatin Road and Herman Road	322618	Existing 2-yr	Culvert has minimal slope. Culvert is surcharging but not flooding.	N
	Stormwater system at intersection of Tualatin Road and Herman Road	268371	Future 25-yr	Pipes is surcharging but not flooding. Refined hydrology during project design may refine project need.	N
Manhasset Drive System	Open channel along Manhasset Drive	Link9	Existing 2-yr	Open channel is undersized and not properly maintained.	Y – CIP 1
		Link10.1	Existing 2-yr		
		Link11.1	Existing 2-yr		
		Link12.1	Existing 2-yr		
		Link13.1	Existing 2-yr		
		Link14.1	Existing 2-yr		
	Piped system downstream of open channel on Manhasset Drive	266695	Existing 2-yr	Existing pipes are surcharging but not flooding due to minimal slope.	Y – CIP 1
		266697	Existing 2-yr		
		268265	Existing 2-yr		
Lower Nyberg Creek System	Piped system along Martinazzi Avenue and Tualatin-Sherwood Road	Link91	Existing 5-yr[b]	Nyberg Creek is surcharged to the outfall at Martinazzi Avenue. Backwater conditions result in system surcharging and localized flooding.	N
		Link102			
		Link103			
		Link93.1			
		Link100			

Table 4-2. Capacity Evaluation Result Summary and Capital Project Development Approach					
Modeled System	General Location	Conduit	Surcharging/ Flooding Scenario	Source of Capacity Deficiency	Capital Project Development (Y/N) [a]
		Link99			
		Link98			
		Link94			
		Link 136			
		Link74			
		267573_1			
		267573_2			
		267573_3			
		Link97			
		Link134			
		Link135			
		Link86			
		Link89			
Upper Nyberg Creek System	Open channel and pipe system behind Oil Can Henry's including junction of outfalls directly west of Boones Ferry Road	Link36	Existing 2-yr	Rock/gravel accumulation is limiting capacity. Project needs may include source control and maintenance.	Y – CIP 7
		Link43.1	Existing 2-yr		
		Link80	Existing 2-yr		
		277225	Future 2-yr		
	Piped system on Boones Ferry Road near Warm Springs Street	268293	Existing 10-yr	Existing open channels and pipes are undersized for the contributing drainage area. This system receives overland flow from the open channel behind Oil Can Henrys. System rerouting may help alleviate flooding.	Y – CIP2, Phase 3
		322832	Existing 10-yr		
		268296.1	Existing 25-yr		
		267215	Future 10-yr		
		268297.1	Future 25-yr		
	Piped system at intersection of Warm Springs Street and Tonka Street	264286	Existing 10-yr	Existing pipes have minimal slope and are undersized. System rerouting may alleviate flooding.	Y – CIP 2, Phase 2
		265109	Existing 2-yr		
	Piped system between Seminole Trail and Sagert Street	267910	Existing 10-yr	Existing pipes are undersized for contributing drainage area. Pipes are surcharged but not flooding. System is upstream of reported Sandalwood project opportunity area.	N
		267951	Existing 10-yr		
		264521	Future 10-yr		
	Sandalwood open channel	Link31	-	No flooding in model; however, flooding was reported during the December 2015 storm event. Channel is incised.	Y – CIP 3
	Open channel behind Mohawk Apartments	Link32	-	Open channel is not flooding in the model; however, flow is being restricted at the downstream ditch inlet, which has large hydraulic losses.	Y – CIP 4 and CIP 2, Phase 1
		Link 33	-		

a. *Capital projects are detailed in Section 7. Capacity deficiencies associated with system surcharging were not prioritized for project development (see Section 7.3).*

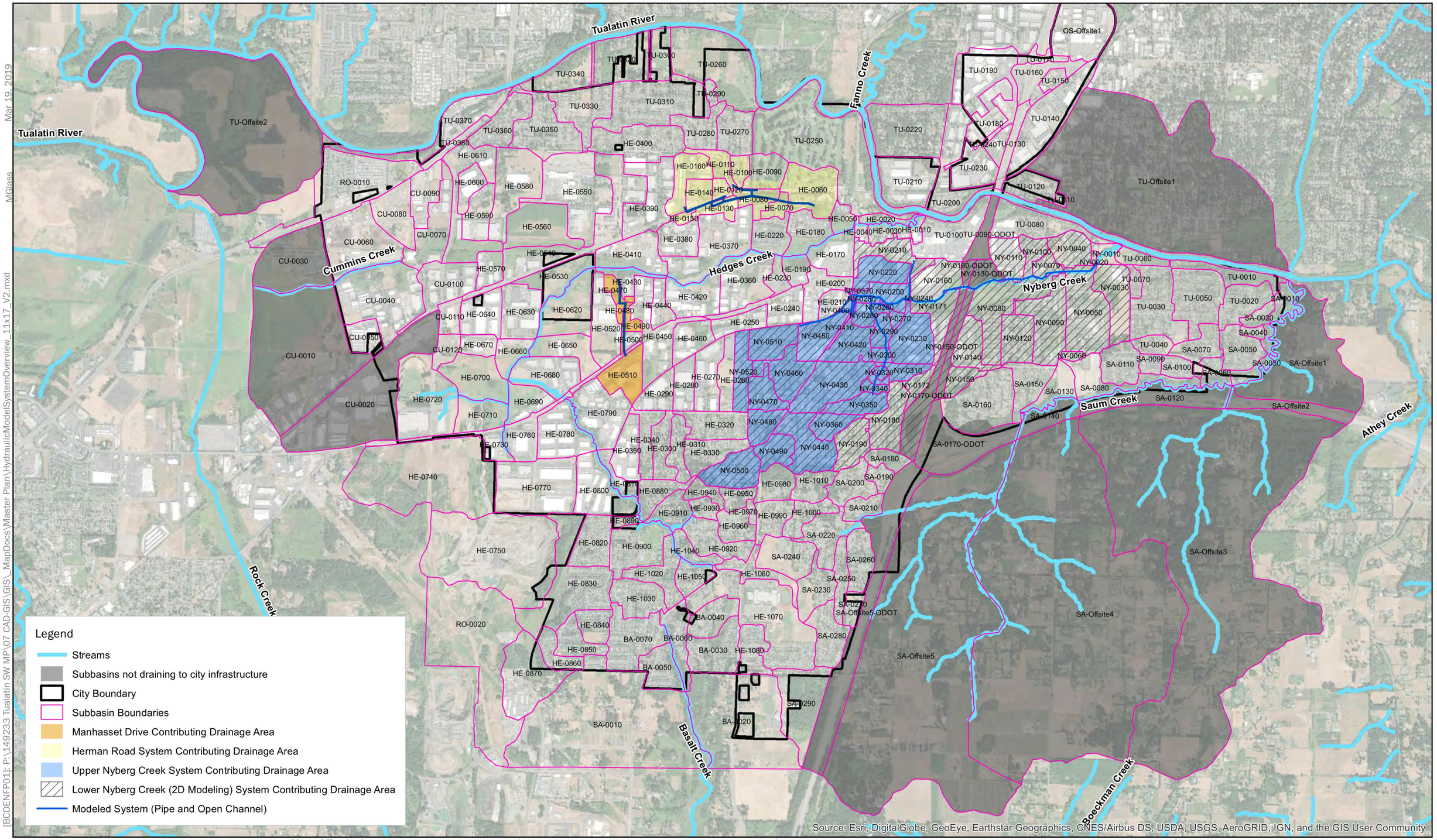
b. *The 5-year design storm was evaluated for this reach to reflect nuisance flooding. Significant instream channel modifications (widening or regrading) is needed to alleviate flooding.*

4.5 Capital Project Development

Based on the system capacity analysis, project alternatives were identified and evaluated to address modeled capacity issues. For some locations, multiple system configurations and sizing were tested to develop the preferred conceptual solution. Project alternatives were discussed with the City during the project development workshop (Section 3.2).

The preferred system configuration was developed into a capital project concept and a preliminary cost established based on the improvements required. For the Manhassat and Herman Road systems, one capital project was developed to address each system deficiency. Because the Upper Nyberg Creek System covered a large area and multiple stormwater project opportunities, a total of five capital projects were developed. Capital project fact sheets that included a project description, project considerations, and preliminary costs are included in Appendix A.

- Manhassat Storm System Improvements (CIP 1). This project addresses flooding due to an undersized conveyance channel and pipe system. This location is associated with Stormwater Project Opportunity Area 4.
- Nyberg Creek Stormwater Improvements (CIP 2). This project addresses undersized pipe pipes and ongoing maintenance issues along Boones Ferry Road, Warm Springs Street, and Martinazzi Avenue. This large project is split into three phases. This location is associated with Stormwater Project Opportunity Area 5.
- Sandalwood Water Quality Retrofit (CIP 3). This project addresses erosion and capacity concerns related to an open channel conveyance system. Water quality features are also incorporated. This location is associated with Stormwater Project Opportunity Area 9.
- Mohawk Apartment Stormwater Improvements (CIP 4). This project addresses limited capacity and system condition concerns and helps eliminate downstream flooding. This location is associated with Stormwater Project Opportunity Area 10.
- Herman Road Storm System (CIP 5). This project adds infrastructure to address frequent flooding. This location is associated with Stormwater Project Opportunity Area 7.
- Boones Ferry Railroad Conveyance Improvements (CIP 7). This project addresses ongoing maintenance issues, flooding, and backwater conditions along railroad ROW. This location is associated with Stormwater Project Opportunity Area 5.



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Mar 19, 2019

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City of Tualatin

City of Tualatin
Stormwater Master Plan

Date: April 2019
Project: Project 149233

N

0 2,250 4,500 Feet

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)

Figure 4-1

Model System Overview

Section 5

Stream Assessment

Tributary stream channels to the Tualatin and Willamette rivers are an important element of the overall stormwater collection and conveyance system in the city. Stream channels provide conveyance and storage of water and sediment and provide habitat for aquatic and terrestrial species.

This section outlines results of the stream assessment conducted for select stream reaches in the city to inform project, program, and policy recommendations. Stream assessment needs were identified as part of the project needs identification effort (Section 3.1.3), to evaluate stream reaches observed to have erosion, invasive vegetation and hillslope instability. The stream assessment is described in additional detail in TM4, included in this SMP as Appendix F.

A total of three capital project recommendations stemmed from results of the stream assessment effort. Program and policy recommendations were also proposed to protect and proactively benefit the stream system.

5.1 Stream System Overview

The City of Tualatin's geography and topography are unique. While the city is located adjacent to the Tualatin River, much of the city drains to smaller tributary streams, including Nyberg Creek, Saum Creek and Hedges Creek. The City is in the downstream, lower portion of the Tualatin River watershed, approximately five miles from its confluence with the Willamette River. As such, topography is relatively flat and tributary stream channels have low gradient and are relatively well connected to the surrounding floodplain. There are extensive wetlands that compose much of the Hedges Creek and Nyberg Creek stream corridors.

Below is a brief description of Tualatin River and five tributary stream channels in the city, including ownership characteristics and description of the associated drainage basins:

- The Tualatin River is located along the northwestern border of the City. Relatively limited city area directly discharges to it, and the contributing drainage area is composed of low-density residential and open space. Backwater conditions from the Tualatin River routinely affect stormwater drainage for property near the river, resulting in standing water and flooding on parking lots and roadways.
- Cummins Creek is in the northwest part of the city and is a tributary to Rock Creek and the Tualatin River. The contributing drainage is predominately industrial with some open space (wetland) areas. Cummins Creek is considered privately owned.
- Hedges Creek drains the majority (44 percent) of the city area, and its watershed is almost exclusively located in the city. Much of the waterbody is considered privately owned, including large areas owned by the Wetlands Conservancy. Contributing land use is predominately industrial and low-density residential. Hedges Creek is considered highly modified due to extensive, historic development activities with limited stormwater management that occurred in the watershed.

- Nyberg Creek crosses I-5 and is the primary receiving water for much of the commercial development areas along I-5 and Tualatin-Sherwood Road. Contributing land use is commercial, industrial and low-density residential. Nyberg Creek has extensive wetland complexes and on-going beaver activity. Like Hedges Creek, ownership is a combination of private (Wetlands Conservancy) and public (City and the Oregon Department of Transportation).
- Saum Creek is in the southeastern portion of the City. Contributing land use is low-density residential and open space. There are significant greenways and natural areas along the lower (downstream) portion of the stream channel, which helps limit encroachment and direct impacts to the channel resulting from development. Ownership is a combination of private and public (City).
- Basalt Creek runs north-south in the southern portion of the City. Much of the contributing land use is low-density and rural residential, but with pending adoption of the Basalt Creek Concept Plan concept plan, future development is anticipated to impact the contributing land use and stream condition. Ownership is currently private and public (City).

5.2 Objectives

The stream assessment focused on direct observations gained from conducting stream walks along priority reaches of Saum, Nyberg, and Hedges creeks. Objectives of the stream assessment were to:

- Provide a baseline assessment of existing physical stream conditions
- Identify existing problem areas, such as locations of channel instability or excessive erosion that may impact private or public infrastructure
- Assess the potential for changes and impacts to the stream channel
- Recommend capital, operational, maintenance or other solutions for issues identified

Objectives of the stream assessment were developed to support continued evaluation of stream channel conditions in the city. Information collected as part of this assessment should be referenced and used during future inspection efforts to help assess improvements and degradation.

5.3 Methodology

City staff identified nine priority reaches in the city based on ownership, history of staff or citizen complaints/concerns, and potential for additional stream flow due to new or redevelopment activities. Figure 5-1 at the end of this section identifies specific stream reaches investigated.

Stream walks were conducted between September 11, 2017, and September 15, 2017. A total of 10 reaches were evaluated, including all nine priority reaches plus Hedges Creek Reach 3A, an optional reach associated with Stormwater Project Opportunity Area 8 (see Table 3-1). A total of 23,225 linear feet of stream and riparian corridor was evaluated.

During the stream walks, photographs were taken to document stream characteristics and condition. Physical and biological stream conditions were noted and mapped and included:

- General vegetation condition, including presence of native and non-native vegetation
- In-stream and hillslope erosion processes (incision, aggradation and hillslope failures)
- Approximate bankfull stream channel widths and depths, measured at appropriate intervals when conditions change
- General aquatic habitat conditions (pools, riffles, large woody debris, flow)
- Location of stormwater outfalls, pipes and groundwater seeps
- Potential pollution sources

- General in-stream sediment distribution throughout the stream channel
- Wildlife activity (presence of beaver dams)

Photo logs and stream reach summary sheets were developed to identify cross section and physical condition characteristics for each reach at the time of the stream walk.

5.4 Findings and Results

Observations made during the stream walks were used to qualitatively identify current stream channel deficiencies and potential strategies for improvement. A detailed summary of stream channel condition by reach is provided in Appendix F. General reach characteristics are provided in Table 5-1.

Table 5-1. Summary of Stream Reach Conditions

Stream	Reach	Length (ft)	Average Gradient (%)	Average Valley Width (ft)	Contributing City Drainage Area (ac)	Contributing Existing Impervious (%)	Contributing Future Impervious (%)	Difference (%)
Saum	1	6,775	0.6	100-200	493	34	42	8
	2	4,950	0.4	150-175	460	37	44	7
	3	600	1.1 (upstream) 3.0 (downstream)	75-100	367	37	44	7
Nyberg	1	950	<0.1	300-400	816	46	57	11
	2	2,100	0.1	500-650	607	41	57	16
	3	1,400	0.3	30-60	399	36	57	21
Hedges	1	2,250	0.8	75 - 125	2,340	48	58	10
	2	1,900	0.2	125-250	754	41	51	10
	3A	1,740	<0.1	~150	608	36	47	11
	3B	560	3.7	~50	138	40	50	10

5.4.1 Vegetation

Stream reaches were found to contain significant amounts of invasive, non-native vegetation such as reed canary grass, Himalayan blackberry, jewel weed, and English Ivy within their riparian corridor. Invasive vegetation was observed in almost every investigated stream reach, although some reaches were heavily impacted. Invasive vegetation can limit native vegetation growth and constrain flow capacity and beneficial habitat. Evidence of beaver activity was prevalent as well.

Reaches did show a distinct lack of trash in and around the channel, which is positive and noteworthy given its urban/suburban setting.

5.4.2 Riparian Condition

Wide riparian corridors surround many of the stream channels. Preservation of wide riparian corridors and connection to floodplain is important, especially for low-gradient streams like those in the City because these reaches require space to maintain meandering characteristics and a stable channel form. This finding is positive and noteworthy given the urban/suburban setting.

The upstream/headwater stream reaches investigated were generally steeper and had more confined channels. There is very little in-channel or floodplain storage capacity in these areas to dissipate flows. Riparian vegetation in these areas is also limited. Riparian vegetation provides

channel stability and slope stability through water interception, water uptake, and soil reinforcement from roots. A limited riparian buffer combined with a steeper gradient makes these stream channels more susceptible to channel stability issues (see Section 5.4.3).

5.4.3 Channel Erosion and Incision

Stormwater runoff, particularly in urban areas, has the potential to impact stream conditions. Increases in impervious areas through development and redevelopment can alter runoff conditions and increase the timing and magnitude of flows to stream channels. Increased flow can alter stream channel conditions and result in flooding, bank erosion, bed incision, sediment production, and other impacts, commonly referred to as hydromodification. Physical stream channel conditions (i.e., riparian width, stream channel gradient, and channel confinement from development or topographic conditions) were documented and considered in conjunction with observed bank and bed erosion.

Instances of bed and bank erosion were most prevalent in the headwater stream reaches evaluated (e.g., Hedges Creek Reach Nos. 3A and 3B), which are exposed to the first effects of high flows conveyed from surrounding residential neighborhoods during rain events.

The future potential for bed and bank erosion can be observed in conjunction with the potential for development (and associated increases in impervious surface area) (Table 5-1). Upstream reaches, specifically in Nyberg Creek and Hedges Creek, are relatively narrow and show a greater potential for increases in runoff from impervious surface areas. Policies related to flow control may be warranted for select stream reaches to mitigate impacts of increased stormwater runoff.

5.5 Additional Investigations

Independent from the stream assessment conducted for this SMP, the City's Parks Department conducted a supplemental assessment of Hedges Creek from SW Ibach Street to SW 105th Avenue (Hedges Creek Stream Assessment, February 2018). Hedges Creek Reach Nos. 3A and 3B are included in this evaluation effort. In addition, this supplemental assessment extended west along the southern Hedges Creek tributary, adjacent to SW Ibach Street.

Potential project needs were identified and prioritized along Hedges Creek. Findings from this supplemental assessment generally corresponded with findings from the stream assessment where locations overlapped.

City staff reviewed the findings and qualified the identified stormwater project needs from this supplemental assessment, and selected project needs to include as part of this SMP.

5.6 Capital Project and Program Development

Findings from the stream assessment and supplemental Hedges Creek Stream Assessment were used to identify stormwater project and program needs. Identification of stormwater project needs was isolated to reaches under City ownership.

In addition, the City may consider policies to mitigate stormwater flow associated with new and redevelopment, particularly in headwater stream reaches with observed erosion and downcutting. The City may also consider beaver management efforts to maintain in-channel conveyance capacity and address localized flooding issues resulting from beaver activity.

5.6.1 Capital Project Needs

Three capital project needs were verified in conjunction with the stream assessment. Two locations were originally identified during preliminary stormwater project planning (Section 3.0) as Stormwater Project Opportunity Areas. Capital project fact sheets that include a project description, project considerations, and preliminary costs are included in Appendix A.

- **Blake Street Culvert Replacement (CIP 6).** This project addresses an undersized culvert and failing headwall along Hedges Creek. The stream assessment identified headwall deterioration and bank erosion due to the culvert's orientation. This location is associated with Stormwater Project Opportunity Area 8 and was also identified as a project need in the supplemental Hedges Creek Stream Assessment.
- **Saum Creek Hillslope Repair (CIP 19).** This project replaces a degraded outfall pipe and repairs the hillslope failure near the outfall. The stream assessment confirmed the perched outfall location and evaluated stream bank conditions immediately upstream and downstream of the outfall. This location is associated with Stormwater Project Opportunity Area 3.
- **Hedges Creek Stream Repair (CIP 20).** This project includes an outfall extension, bioengineered slopes, streambed fill, vegetation restoration and construction of a retaining wall to address observed instream channel erosion and protect infrastructure. This location was identified as a project need in the supplemental Hedges Creek Stream Assessment.

5.6.2 Program Needs

Results from the collective stream assessment efforts and preliminary project planning (Section 3.0) support the need for an annual program to conduct vegetation management along stream corridors. Efforts would be targeted at: 1) invasive vegetation removal, 2) planting and irrigation (as necessary) 3) installation of native riparian plants, and 4) ongoing inspections to refine future maintenance needs and compare overall stream channel conditions against results from this baseline evaluation.

Results from the stream assessment efforts prioritized the following reaches for vegetation management activities (Table 5-2). Cost assumptions related to the program efforts are detailed in Section 7.

Table 5-2. Priority Locations for Vegetation Management

Stream	Reach	Approximate Length (ft)	Location Description	Invasive Vegetation	Ownership
Saum	3	200	Upstream of SW Blake Street near a recent restoration project	Reed canary grass, Himalayan Blackberry	City
Nyberg	3	1,400	Entire reach	Reed canary grass	City (approximately 300' private)
Hedges	1	500	Tualatin Community Park	Reed canary grass	City
	2	1,900	Entire reach	Reed canary grass, Himalayan Blackberry	City
	Southern Tributary	200	Locations C, D, and F identified in the supplemental Hedges Creek Stream Assessment	Not specified	City

5.6.3 Policy Considerations

The following policy considerations may be incorporated into future updates to the Tualatin Public Works Construction Code, Tualatin Municipal Code (Title 03), or addressed through internal directives.

5.6.3.1 Detention/Flow Control Stormwater Design Standard

In April 2019, CWS adopted updated Design and Construction Standards with updated language in Chapter 4: Runoff Treatment and Control[2]. Updated language incorporates new design requirements related to water quantity and hydromodification control and builds on previous efforts from 2017 (see Section 3.2). New and redevelopment greater than 12,000 square feet of impervious surface will be required to conduct a Hydromodification Assessment and implement strategies commensurate with the receiving water Hydromodification Risk Level, Development Class, and Project Size.

Results from this stream assessment effort and additional investigations conducted by the City appear consistent CWS's published Hydromodification Risk Levels for receiving waters, which identify upper Hedges Creek and Saum Creek as moderate or high risk for hydromodification.

The City currently implements CWS's Design and Construction Standards for water quality. The City should consider adopting the updated CWS Design and Construction Standards, including standards that address water quantity control and hydromodification, in accordance with areas identified as experiencing channel erosion and incision.

5.6.3.2 Beaver Management Activities

The stream assessment effort identified significant beaver activity along investigated reaches. Beavers provide many benefits to stream ecology and habitat, but in urban areas, beaver activity can result in localized flooding and backwater effects in stream channels.

Beavers are classified as "Protected Furbearers" in Oregon, and thus excluded from take (Oregon Administrative Rule 498.012) (Portland 2010). The 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.

The City may choose to implement/codify beaver management techniques to selectively encourage/discourage beaver activity based on the characteristics of their stormwater drainage systems, topography and vegetation. Management techniques for consideration 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 and 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 be 2 to 4 feet high. Install fencing around inlets of culverts or spillways to prevent beavers from blocking inlets.
- **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.

[2] On November 12, 2019, CWS Board of Directors adopted the most recent amendments to the CWS' Design and Construction Standards. Such amendments included updates to standard engineering details, pump station standards, and minor changes to text for clarity. Implementation policies referenced in this Plan for development projects were adopted in April 2019 and remain in effect.

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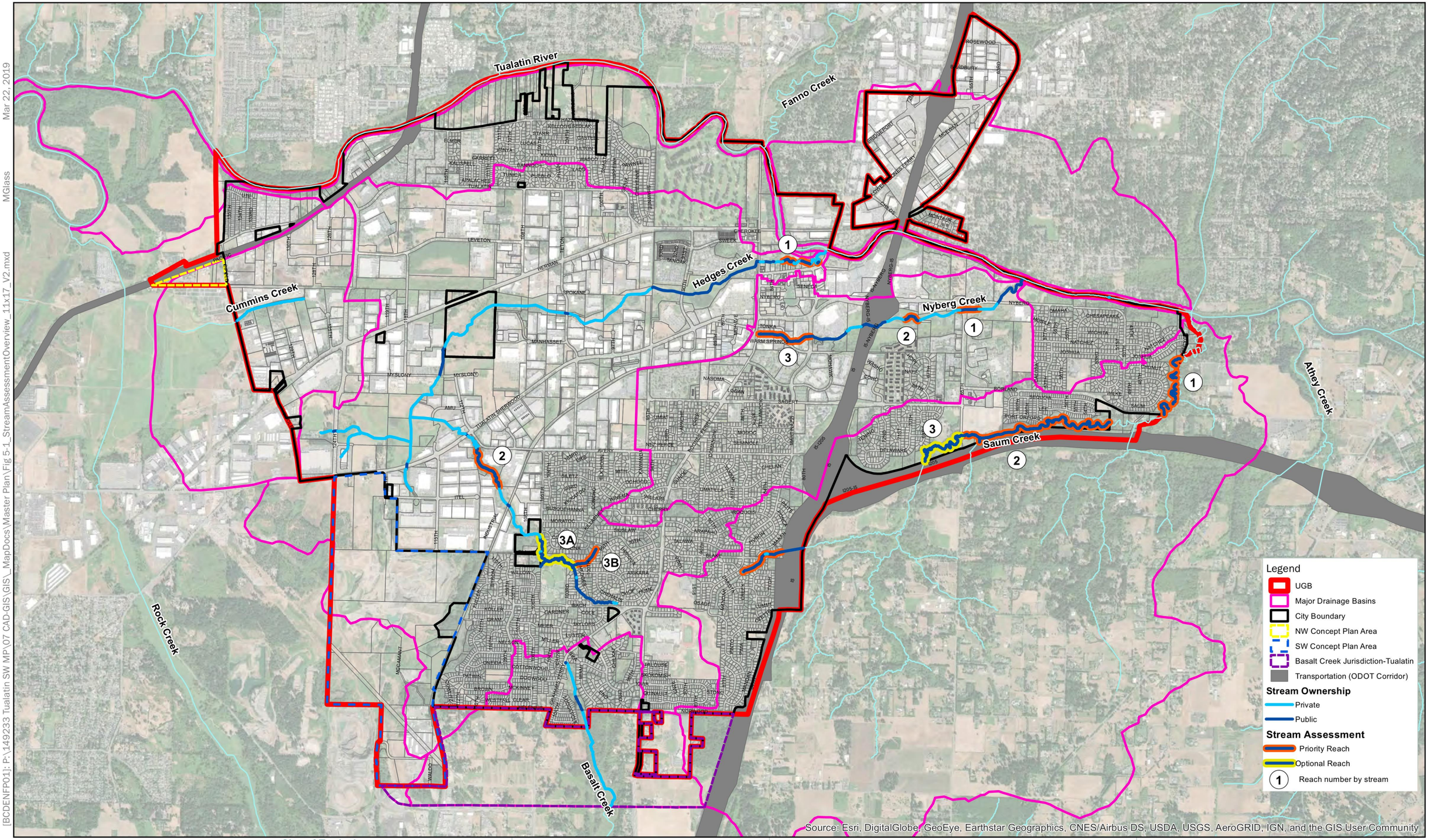

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City of Tualatin

Stormwater Master Plan

Date: April 2019
Project: Project 149233

N

0 2,250 4,500 Feet

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)

Figure 5-1

Stream Assessment Overview

Section 6

System Maintenance and Programmatic Assessment

This SMP includes projects and programs intended to support the City's long-term asset management efforts and supplement existing maintenance activities.

This section outlines maintenance-related project and program needs stemming from review of the City's current maintenance activities and costs, site visits, and staff feedback during a programmatic activity workshop. Project needs are considered a one-time planning and cost effort, whereas program activities are continuous and require annual funding. A detailed condition assessment of City infrastructure was not performed as part of this SMP, but activities to protect and preserve existing assets are proposed, based on the condition of the City's stormwater collection, conveyance, and treatment systems.

A total of six capital project recommendations are associated with condition or maintenance-related deficiencies. Additionally, four program strategies are proposed to maintain City infrastructure and/or provide ongoing water quality benefits.

6.1 Maintenance Overview

Maintenance is a necessary requirement for the long-term health and stability of the City's stormwater program. This includes the maintenance of piped conveyance systems, open-channel conveyance system, stormwater structures (manholes, catch basins, etc.), water quality facilities, outfalls and natural systems, and other elements of the stormwater system. Neglected systems perform at a lower level than maintained systems, and it is typically more expensive to fix a neglected system than to conduct preventive maintenance. Maintenance is recommended to be a priority for all elements of the City's stormwater system.

The City contracts out and internally conducts scheduled (routine) and unscheduled maintenance activities on stormwater infrastructure and facilities throughout the City. Many maintenance activities and frequencies are specified in conjunction with CWS's watershed-based NPDES permit. As a co-implementor of the NPDES permit, the City conducts and reports on maintenance activities annually for permit compliance.

Table 6-1 provides an overview of the City's current maintenance activities and obligations, along with an average estimate of staff time to perform the maintenance activity. Based on current NPDES annual reporting, the City can meet most maintenance targets, but public water quality facility maintenance is one area of needed improvement.

Table 6-1. City Maintenance Activities					
Activity	Frequency required	Annual Target [a]	Annual Effort [a]	Meeting target? (Y/N)	Staff/Division
TV inspection	8-year cycle	57,000 ft	57,000 ft	Y	Storm Division or contract
Pipeline cleaning	6-year cycle	75,000 ft	75,000+ ft	Varies	Storm Division
Ditch inspection/cleaning	--	--	--	--	Storm Division
CB cleaning (with sumps)	Annual	1,200	1,200	Y	Storm Division
CB cleaning (without sumps)	Annual	1,600	1,600	Y	Storm Division
Water quality MH cleaning	2x/year	126 (based on 63 MH)	140+	Y	Storm Division
MH cleaning	----	-----	-----	--	Storm Division
Street sweeping	12x/year	150 curb miles	150+ mi	Y	Storm Division or contract
Public water quality facility inspections [b]	4x/year	1,200 (based on 300 facilities)	1,200+	Y	Engineering
Public WQ facility maintenance	As needed	----	----	N	Contracted via Parks or Storm Division
Private WQ facility inspections[b]	25%/year	68	80+	Y (need for improved system tracking)	Engineering

a. Values provided are approximate based on the asset inventory documented per the CWS NPDES 2015-16 annual report.

b. Updated per email from Shawn Strasser 10/6/17.

6.2 Programmatic Activity Workshop

On April 19, 2018, City and BC staff met to review the City's existing stormwater maintenance-related efforts and discuss general stormwater program needs. Discussion included the City's current funding allocations for maintenance-related activities. A summary document was distributed to staff summarizing the City's asset inventory (from GIS) and maintenance obligations as detailed in CWS's effective SWMP. The goal of the workshop was to define additional programmatic efforts to include in this SMP, along with a dedicated annual funding commitment, to improve upon the City's current programs to protect and preserve assets.

Stormwater project needs identification (Section 3.1) efforts resulted in the identification of three citywide maintenance-related program needs, which formed the basis for discussion of programmatic activities. These citywide needs included:

- Repair and replacement program
- Public water quality facility maintenance program
- Vegetation management program

Current, dedicated funds to support maintenance related activities are limited and do not include a reserve to support variable system maintenance or replacement needs. Relevant program cost information based on the City's 2018-2019 budget is listed in Table 6-2 below.

Table 6-2. Existing Program Funding (2018-19)		
Relevant Activity	Annual Budget	Staff/Division
Repair of Stormlines/MH/CBs	$19,400	Storm Division
Line Repairs to System	$25,000	Storm Division
CCTV Inspection	$53,530	Storm Division or contract
Retrofit CBs (CWS requirement)	$45,500 [a]	Storm Division
Contract Landscape Services at 72 sites (reflects water quality facilities but also general landscaping needs)	$108,300 [b]	Contracted via Parks or Storm Division

a. For 2018-19, the annual $45,500 was doubled to account for unspent funds in 2017-18.

b. Assume $25,000 of annual budget is reserved for facility maintenance.

Program activities are defined and described below with respect to conveyance system condition deficiencies, and public/private water quality facilities. Program needs related to vegetation management were previously defined in conjunction with the stream assessment results (see Section 5.6.2).

6.2.1 Conveyance System Condition Deficiencies

A stormwater system condition assessment requires review of available, current stormwater system information to identify areas of failure, pending or imminent failure, and areas that are rapidly deteriorating.

Much of the City's infrastructure was constructed in the last 30 years in conjunction with private development trends. As such, the City's stormwater infrastructure (pipe and structures) should have several decades of service life remaining; however, pipe age is not currently tracked in the City's GIS. CCTV of the City's stormwater infrastructure is conducted to address NPDES permit requirements, but detailed evaluation of the CCTV results has not occurred. A condition assessment of buried stormwater infrastructure to confirm remaining service life has also not been conducted to date.

As part of this SMP effort, the City is looking to identify pipe and structure replacement needs and plan for long-term asset replacement, repair, and rehabilitation. Development of a repair and replacement (R/R) program is a critical component of this effort. An R/R program begins by establishing baseline condition data to track and address pipe and structure condition moving forward.

The City wishes to establish separate programs (and annual funding mechanisms) for R/R to address pipes and structures. These programs should first assess and track infrastructure health in conjunction with current CCTV inspections to establish a baseline condition assessment. Pipe and structure R/R can follow as needed. These programs are described further in Section 6.3.2.

6.2.2 Public/Private Water Quality Facility Inspection and Maintenance

In accordance with requirements of the CWS NPDES permit, there is increased emphasis on methods for improving stormwater quality. One method is through the tracking, inspection, and maintenance of existing public and private stormwater treatment facilities to ensure that function of these facilities is preserved.

Development of this SMP included a detailed look at existing public water quality facility conditions. The project needs assessment (Section 3.0) identified five project opportunities where the function of the stormwater treatment facilities was compromised. Based on site inspections, these locations require facility restoration as opposed to just maintenance. Restoration efforts include vegetation management and removal (including trees), sediment removal and regrading, installation of

amended soil to support plant growth, and rehab/replacement of inlet or outlet structures. These restoration needs are addressed with capital projects, as detailed in Section 6.3.1.

Preliminary project planning efforts also identified that ongoing (routine) public water quality facility maintenance does not regularly occur. Maintenance is conducted on an as-needed basis as time and funding allow. The City contracts out most of the stormwater facility maintenance activities, which can result in delays. The City regularly inspects facilities in accordance with efforts documented in Table 6-1. Recent inspection efforts identified the following priority locations that require maintenance to ensure functionality, although a stand-alone capital project need was not identified at this time:

- **Lakeridge Terrace Facility Maintenance.** Facility (pond) was constructed in 2001 to serve a 48-lot subdivision. Maintenance needs include sediment removal (facility and outlet structure), tree removal, and replanting.
- **Gertz Swale Redesign.** Facility was constructed in 2003. Stormwater currently short-circuits the facility and results in erosion. Maintenance needs include re-grading the facility, vector management, and installation of an impermeable membrane.
- **Shasta Trail Swale Maintenance.** Facility was constructed in 2004. Stormwater currently short-circuits the facility and results in erosion and discharge to neighboring property. Maintenance needs include re-grading the facility, vector management, and installation of an impermeable membrane.
- **Green Lot Swale Maintenance.** Facility was constructed in 2005. Maintenance needs include re-grading the facility, sediment removal, and vegetation management (removal and replanting)

As part of this SMP effort, the City identified the need for a program (and annual funding mechanism) for continual public water quality facility maintenance. The program can be used to conduct both routine maintenance activities and support larger system restoration or redesign needs. Efforts should prioritize facilities identified through annual inspection efforts, including those priority locations listed above.

Figure 6-1. Example of buried outlet control structure at the Green Lot Swale

(photo courtesy of City of Tualatin)

In addition, in conjunction with CWS's updated Design and Construction Standards, a lower impervious area development threshold for meeting design standards will result in more private water quality facility installations. The City wishes to expand its private stormwater facility inspection program to include low impact development applications (LIDA) on single family residential sites. This programmatic activity would be supported by an increase in staffing as opposed to an annual funding mechanism.

6.2.3 Water Quality Facility Retrofits

Per requirements of the CWS NPDES permit, another method for improving stormwater quality focuses on expanding of water quality treatment through the ongoing identification of water quality retrofit opportunities. Such efforts directly address current NPDES permit requirements related to the development and implementation of a retrofit strategy and the need for increased stormwater pollutant load reduction.

Water quality opportunity areas and water quality projects have been identified as part of the project planning process (Section 3.1.1). Additional project reconnaissance efforts conducted by the City and CWS (see Appendix I) identified the following additional retrofit opportunity locations, although a stand-alone capital project need was not identified at this time:

- **Boones Ferry Road and Iowa Street** (Green Street installation).
- **Boones Ferry Road across from Logan Lane** (Green Street installation).
- **125th Avenue to Herman Road** (Public-Private Partnership for a water quality facility installation during redevelopment).
- **SW 95th Avenue at SW Tualatin-Sherwood Road** (Public-Private Partnership for a water quality facility installation during redevelopment or a Green Street installation).
- **SW Teton Road and SW Herman Road Intersection** (regional facility).
- **SW Nyberg Street at SW 65th Avenue** (rehabilitation of an existing water quality facility).

As part of this SMP effort, the City also identified a need for an annual program to validate and construct opportunistic water quality retrofits, as additional opportunity areas are likely to be identified throughout the duration of this SMP's implementation. Such retrofits may include larger-scale regional facilities or installing green streets in conjunction with transportation improvement projects. Efforts should prioritize project opportunities identified through annual inspection efforts, including those priority locations listed above.

6.3 Capital Project and Program Development

Findings from the maintenance assessment, in conjunction with the programmatic activity workshop and supplemental site visits, were used to identify stormwater project and program needs in support of improved and proactive system maintenance.

6.3.1 Capital Project Needs

Six capital projects, originally identified during the project needs assessment (Section 3.1) and as Stormwater Project Opportunity Areas, were developed to address condition-related deficiencies with piped stormwater infrastructure and priority maintenance deficiencies with public water quality facilities.

Capital project fact sheets including project descriptions, project considerations, and preliminary costs are included in Appendix A.

- **Water Quality Facility Restoration-Venetia (CIP 13).** This project includes restoring a failing public water quality facility. Project activities include clearing brush and vegetation, removing sediment and regrading, installing amended soils, and replanting. This location is associated with Stormwater Project Opportunity Area 2.
- **Water Quality Facility Restoration-Piute Court (CIP 14).** This project includes restoring a failing public water quality facility. Project activities include installing a maintenance access road, clearing brush and vegetation, removing sediment and regrading, installing amended soils, replanting with a temporary irrigation system, and replacing the outlet structure. This location is associated with Stormwater Project Opportunity Area 11.
- **Water Quality Facility Restoration–Sequoia Ridge (CIP 15).** This project includes restoring a failing public water quality facility. Project activities include clearing trees and vegetation, removing sediment and regrading, installing amended soils, installing energy dissipation, replanting with a temporary irrigation system, and replacing the outlet structure. This location is associated with Stormwater Project Opportunity Area 12.

- **Water Quality Facility Restoration–Sweek Drive Pond (CIP 16).** This project includes restoring a failing public water quality facility. Project activities include clearing trees and vegetation, removing sediment, installing amended soils, installing an upstream water quality manhole, replanting with a temporary irrigation system, and installing an outlet control structure. This location is associated with Stormwater Project Opportunity Area 13.
- **Siuslaw Water Quality Facility Retrofit (CIP 17).** This project includes replacing 450 feet of failing stormwater pipe and adds water quality treatment at the outlet. This location is associated with Stormwater Project Opportunity Area 6.
- **Water Quality Facility Restoration–Waterford (CIP 18).** This project includes restoring a failing public water quality facility. Project activities include clearing vegetation, removing sediment and regrading, installing amended soils, replanting with a temporary irrigation system, and relocating and replacing the outlet control structure. This location is associated with Stormwater Project Opportunity Area 14.

6.3.2 Program Needs

Results from the project needs assessment (Section 3.1) and maintenance assessment indicate annual programs are needed to proactively address maintenance-related deficiencies.

Cost assumptions related to these programs are detailed in Section 7.

- **Pipe Repair and Replacement Program.** Establishes an annual funding mechanism for pipe R/R. Initial dedicated funds can support development of a baseline condition assessment, including review of existing CCTV in accordance with defined evaluation metrics, coding, and scoring. The National Association of Sewer Service Companies provides a consistent and standard evaluation process for pipes and underground structure conditions. Annual program cost obligations, in addition to staff resources, have been established.
- **Structure R/R Program**. Establishes an annual funding mechanism for structural facility (catch basins, ditch inlets, flow control structures, and manholes) R/R. Initial dedicated funds can support development of a baseline condition assessment. Annual program cost obligations, in addition to staff resources, have been established.
- **Public Water Quality Facility Maintenance Program.** Establishes an annual funding mechanism to conduct routine maintenance (vegetation removal, sediment removal) and restorative maintenance (sediment and regrading, addition of amended soils, replanting, new infrastructure) for public water quality facilities. Immediate needs should be based on annual inspection efforts. Annual program cost obligations, in addition to staff resources, have been established.
- **Public Water Quality Retrofit Program.** Establishes an annual funding mechanism expand water quality treatment throughout the City. Efforts would focus on rehabilitating or retrofitting existing public water quality facilities to promote additional infiltration and/or flow management, planning activities in support of regional water quality retrofit facility installations, and installation of green streets in conjunction with transportation improvement projects. Efforts may include developing a dedicated program, responding to public inquiries, preliminary facility sizing, and detailed design/construction. Annual program cost obligations have been established.
- **Single Family LIDA Inspection Program.** Dedicates staff resources to expand the existing private water quality facility inspection program to single-lot/single family LIDA applications. Annual staff resources have been established.

Section 7

Capital Improvement Plan

This section summarizes the capital project and program recommendations identified throughout the master planning process. Project and program recommendations stem from the water quality assessment (summarized in Section 3.1.1), capacity evaluation (Section 4), stream assessment (Section 5), and maintenance assessment (Section 6).

A total of 21 capital projects were identified to address current and future needs related to water quality, capacity/flooding, system condition and repair, maintenance, and stream health. Six program recommendations to address R/R, system maintenance, and ongoing water quality retrofits were also identified.

7.1 Summary of Recommended Actions

Projects, programs 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 through water quality retrofits and enhancing the level of treatment provided.
- Conduct proactive maintenance of the City's stormwater infrastructure. Utilize system condition data currently collected (i.e., stormwater facility inspections, CCTV) to evaluate needs and priorities.
- Consider the topographic limitations and flat grade of the City's conveyance network with regards to system maintenance activities. Sediment removal and vegetation management are key maintenance needs to ensure conveyance capacity, and an increase in maintenance activities may be warranted for select areas of the system.
- Continue coordination with CWS to ensure updates to the City's TDC and PW Standards are in line with regulatory drivers and protect stream health.
- Ensure timely implementation of capital projects and programs by establishing updated funding mechanisms and rates. Additional funding is needed to adequately manage the drainage system as material costs increase, flows increase, and the drainage system deteriorates with age and use.

7.2 Capital Project Recommendations

Table 7-1 summarizes the final capital projects list. Figure 7-1, at the end of this section provides an overview of project locations throughout the city. Project fact sheets are provided in Appendix A and include a project description, summary of design considerations, an overview figure, and cost summary.

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Table 7-1. City of Tualatin Stormwater Capital Project Summary

CIP #	Project Name	Project Summary	Project Objectives	Location	Basin/ Waterbody	Project Description	Total Estimated Cost	SDC Eligible Cost	WQ Retrofit	Project Timing		Associated SW Project Opportunity Area ID
										High Priority (2019-2029)	Lower Priority (Future)	
1	Manhasset Storm System Improvements	Project addresses flooding due to undersized channel and pipe system near Tualatin-Sherwood Road to Manhasset Drive.	• Increases System Capacity (Flood Control)	Manhasset Dr (near 10550 SW Manhasset Dr)	Hedges Creek	• Pipe the existing open channel conveyance and upsize select pipe segments. • Replaces the existing 1,050 linear feet (LF) of open channel and 180 LF of 21-inch-diameter pipe with 1,230 linear feet (LF) of 30-inch-diameter pipe. • Replaces the existing 750 LF of 27-inch-diameter pipe from Manhasset Drive to the outfall to Hedges Creek with 750 LF of 36-inch-diameter pipe. • Includes landscaping, nine new manholes and a new outfall to Hedges Creek.	$1,581,000	$237,000			X	4
2	Nyberg Creek Stormwater Improvements	Project addresses under sized pipes and ongoing maintenance issues near Nyberg Creek between Boones Ferry Road and Martinazzi Avenue.	• Increases System Capacity (Flood Control) • Increases WQ Treatment (Retrofit)	Boones Ferry Rd (19417 SW Boones Ferry Rd)	Nyberg Creek	• Upsize undersized pipe segments, relocating StormFilter catch basin units, and rerouting stormwater flow. • Project is broken up into three phases due to costs: • Phase 1: Install a new trunkline down Martinazzi Avenue from Mohawk Street to Nyberg Creek. • Phase 2: Install a 48-inch pipe along Warm Springs Street and a new outfall to Nyberg Creek. • Phase 3: Upsize storm system along Boones Ferry Road and divert flow to the new system on Warm Springs Street	Phase 1: $1,523,000 Phase 2: $1,252,000 Phase 3: $637,000	Phase 1: $289,000 Phase 2: $238,000 Phase 3: $121,000	X	X (Phase 1)	X (Phases 2 and 3)	5
3	Sandalwood Water Quality Retrofit	Project addresses erosion and capacity concerns related to an open channel conveyance system.	• Addresses Erosion • Increases WQ Treatment (Retrofit)	Sagert St. - Shenandoah Apts (Sandalwood)	Nyberg Creek	• Regrade the existing open channel conveyance. • Install planting for enhanced WQ treatment. • Widen and regrade the existing open channel conveyance, resulting in a 10' wide by 220' long swale. • Install outfall protection and check dams. • Install a new ditch to prevent debris accumulation. • Replace existing ditch inlet with a manhole and connect to new ditch.	$107,000	$25,000	X		X	9
4	Mohawk Apartments Stormwater Improvements	Project addresses limited capacity system at Mohawk Apts to eliminate downstream flooding.	• Increases System Capacity (Flood Control) • Addresses Maintenance Need	Mohawk Apartments	Nyberg Creek	• Install 1,000 LF of CCTV video inspection to determine/ verify the pipe condition, location, material and size. • Install three manholes along the pipe alignment for maintenance access.	$295,000	$59,000			X	10
5	Herman Road Storm System	Project addresses areas of frequent flooding due to limited grade and a lack of drainage infrastructure.	• Increases System Capacity (Flood Control)	Herman Rd	Hedges Creek	• Install 110 LF of 30-inch-diameter pipe • Install 960 LF of 36-inch-diameter pipe • Install 10 manholes, 4 connections to existing stormwater pipes/culverts, and 12 catch basins with an associated 420 LF of 12-inch inlet leads.	$1,023,000	$276,000		X		7
6	Blake St. Culvert Replacement	Project addresses undersized culvert and failing rock wall due to erosive flows.	• Increases System Capacity (Flood Control) • Addresses Erosion	Curves at Blake/105th and 108th	Hedges Creek	• Replace the existing culvert with an 84-inch culvert, along the natural stream alignment.	$552,000	$121,000		X		8
7	Boones Ferry Railroad Conveyance Improvements	Project addresses ongoing maintenance issue, flooding and backwater conditions.	• Addresses Maintenance Need • Increases System Capacity (Flood Control) • Addresses Erosion	RR Culvert behind former Oil Can Henrys		• Install large rock along the railroad ballast. • Upsize downstream pipe to increase flow capacity and improve maintenance access. • Remove existing gravel and ballast material along 150 ft of the open conveyance channel. • Install Class 100 rip-rap along the railroad ballast to reduce the potential for material transport. • Install a new ditch inlet to minimize hydraulic losses at the upstream end of the pipe. • Replace 480 LF of 36-inch-diameter pipe with 42-inch-diameter pipe. • Install a 72-inch manhole along pipe alignment for improved maintenance access. • Install a new outfall to the open channel area directly west of Boones Ferry Road. Add rip-rap for energy dissipation.	$515,000	$108,000			X	5
8	89th Avenue Water Quality Retrofit	Project adds pretreatment/ WQ treatment for Hedges Creek wetland and addresses requirement of the NPDES Permit	• Increases WQ Treatment (Retrofit)	89th Ave/Tualatin-Sherwood Rd Stormwater Outfall	Hedges Creek	• Install a Contech CDS hydrodynamic separator (Model CDS3025) with a treatment flow rate of 2.4 cfs. • Install 50 LF of 24-inch-diameter pipe and 100 LF of 48-inch-diameter pipe.	$262,000	-	X		X	15

Table 7-1. City of Tualatin Stormwater Capital Project Summary

CIP #	Project Name	Project Summary	Project Objectives	Location	Basin/ Waterbody	Project Description	Total Estimated Cost	SDC Eligible Cost	WQ Retrofit	Project Timing		Associated SW Project Opportunity Area ID
										High Priority (2019-2029)	Lower Priority (Future)	
9	125th Court Water Quality Retrofit	Project adds pretreatment/ WQ treatment for Hedges Creek wetland and addresses requirement of the NPDES Permit.	• Increases WQ treatment (Retrofit)	125th to Herman Rd	Cummins Creek	• Install a Contech™ CDS hydrodynamic separator (Model CDS3025), with a treatment flow rate of 2.4 cfs. • Install 50 LF of 24-inch-diameter pipe and 50 LF of 36-inch-diameter pipe to support connections to existing infrastructure.	$206,000	$74,000	X		X	16
10	93rd Avenue Green Street	Project addresses WQ retrofit objectives of the NPDES Permit through a pilot green street project.	• Increases WQ treatment (Retrofit)	93rd Ave	Nyberg Creek	• Install stormwater planters (with an underdrain and overflow) to treat approximately 15,000 sf of impervious surface from the roadway, sidewalks and property frontage along the unimproved right-of-way. • Install 550 LF of curb and gutter along 93rd Avenue to direct stormwater runoff to the WQ facilities. • Connect outlets of the WQ facilities to existing stormwater infrastructure on 93rd Avenue.	$224,000	-	X		X	17
11	Juanita Pohl Water Quality Retrofit	Project adds WQ treatment in a parking area that discharges to Hedges Creek.	• Increases WQ treatment (Retrofit)	Juanita Pohl Parking Lot	Hedges Creek	• Regrade existing landscape islands to install raingardens for WQ treatment. • Excavate and regrade landscape areas and back fill with drain rock and amended soils to support the WQ facility installation. • Install of check dams to minimize potential erosion. • Install curb and curb cuts to serve as inlets to the facilities and associated piping to connect the facility overflows to downstream structures (i.e., manholes). • Plant the facility with native vegetation suitable for a WQ facility. • Minor repaving of parking stalls near the facilities.	$156,000	-	X	X		20
12	Community Park Water Quality Retrofit	Project adds WQ treatment in a parking area associated with the Tualatin Community Park.	• Increases WQ treatment (Retrofit)	Community Park	Hedges Creek	• Regrade existing landscape islands to install raingardens for WQ treatment. • Excavate and regrade the landscape areas and back fill with drain rock and amended soils. • Address existing utilities, light pole, signage, etc. • Install curb and curb cuts to serve as inlets to the facilities and associated piping to connect the facility overflows to downstream structure (i.e., manhole). • Plant the facility with native vegetation suitable for a WQ facility.	$158,000	-	X	X		22
13	Water Quality Facility Restoration - Venetia	Project restores a failing WQ facility.	• Addresses maintenance need • Improves WQ	Venetia WQ Facility Failing (Lee between 56th and 57th)	Saum Creek	• Restore a public WQ facility. • Clear trees and large brush growing in the swale. • Remove accumulated sediment along swale bottom, regrade and replace with amended soils and mulch. • Replant facility with native vegetation suitable for a WQ facility.	$65,000	-		X		2
14	Water Quality Facility Restoration – Piute Court	Project restores a failing WQ facility.	• Addresses maintenance need • Improves WQ	Piute Ct. WQ Facility	Saum Creek	• Restore a public WQ facility. • Install 100 LF gravel access road in the easement located between homes on Piute Court. • Remove accumulated sediment and invasive vegetation, regrade the existing facility, and add amended soils and mulch. • Replant the bottom and sides of facility with riparian/wetland vegetation. Add temporary irrigation. • Install an energy dissipation pad at the pond inlet. • Replace the existing ditch inlet with an outfall control structure. • Install a WQ manhole upstream of the facility in Piute Court.	$104,000	-		X		11
15	Water Quality Facility Restoration – Sequoia Ridge	Project restores a failing public WQ facility.	• Addresses maintenance need • Improves WQ	Sequoia Ridge WQ Facility	Saum Creek	• Restore a public WQ facility. • Clear all cottonwood trees and other vegetation from the facility. • Remove accumulated sediment and invasive vegetation and add amended soils. • Replant the bottom and sides of facility with riparian/wetland vegetation suitable for a stormwater pond. Add temporary irrigation. • Install energy dissipation pad at pond inlet. • Redesign the outlet control structure to have functional low flow pipe and high flow overflow. • Remove the current cap and install an overflow plate.	$83,000	-		X		12

Table 7-1. City of Tualatin Stormwater Capital Project Summary

CIP #	Project Name	Project Summary	Project Objectives	Location	Basin/ Waterbody	Project Description	Total Estimated Cost	SDC Eligible Cost	WQ Retrofit	Project Timing		Associated SW Project Opportunity Area ID
										High Priority (2019-2029)	Lower Priority (Future)	
16	Water Quality Facility Restoration – Sweek Drive Pond	Project restores a failing public WQ facility.	• Addresses maintenance need • Improves WQ	Sweek Dr. WQ pond	Hedges Creek	• Restore a public WQ facility. • Install a new outlet control structure to better utilize storage. • Clear all cottonwood trees and other vegetation from the facility. • Remove accumulated sediment and invasive vegetation and add amended soils. • Replant the bottom and sides of the facility with native vegetation suitable for a stormwater pond. Add temporary irrigation. • Install a WQ manhole upstream of the pond to minimize sediment loading. • Install an energy dissipation pad at the pond inlet and outlet.	$103,000	-		X		13
17	Siuslaw Water Quality Facility Retrofit	Project replaces failing infrastructure and adds WQ treatment.	• Addresses maintenance need • Increases WQ treatment (Retrofit)	Alsea/BF Rd 99th/Siuslaw Greenway	Hedges Creek	• Replace stormwater conveyance system from Boones Ferry to the outfalls at the existing greenway. • Install 350 LF of 30-inch-diameter pipe and 100 LF of 48-inch-diameter pipe. • Install a flow splitter/WQ manhole. • Install or replace 3 catch basins, 2 manholes, and the installation of 5 check dams/energy dissipation. • Grade the existing open channel conveyance to serve as a 15-ft-wide by 500-ft-long bioswale.	$454,000	$104,000	X		X	6
18	Water Quality Facility Restoration - Waterford	Project restores a failing public WQ facility.	• Addresses maintenance need • Improves WQ	Waterford WQ Facility	Hedges Creek	• Restore a public WQ facility. • Clear invasive and unwanted vegetation from the facility. • Excavate and regrade as needed to maximize WQ function and restore to original design. • Remove accumulated sediment and replace with amended soils. • Replant the swale and bottom and sides of the pond facility with native vegetation suitable for a swale and WQ pond. Add temporary irrigation. • Relocate and replace the outlet control structure to the edge of pond for improved maintenance access. • Replace inlet rip rap for increased energy dissipation. • Install two WQ/flow splitter manholes upstream of facility to minimize sediment loading.	$180,000	-		X		14
19	Saum Creek Hillslope Repair	Project replaces infrastructure that is in poor condition and addresses existing slope instability.	• Addresses maintenance need • Addresses erosion	Recent outfall retrofit (Blake St at Saum Creek)	Saum Creek	• Replace the storm pipe from Makah Ct. to the outfall and outfall reconstruction and extension to the stream channel. • Conduct hillslope rehabilitation (rock buttresses or import new fill material) in conjunction with the pipe and outfall replacement to incorporate energy dissipation and be minimize future erosion and slope instability.	$171,000	-		X		3
20	Hedges Creek Stream Repair	Project addresses instream channel erosion and threatened public infrastructure.	• Addresses erosion	SW 106th Ave and Willow Street at Hedges Creek	Hedges Creek	• Site 'N': Install an outfall extension, bioengineered slopes, streambed fill and vegetation restoration. • Site 'M': Install an open channel excavation, stream bed fill, and installation of a retaining wall.	$327,000	-		X		N/A
21	Nyberg Creek Water Quality Facility	Project adds regional WQ treatment.	• Increases WQ treatment (Retrofit)	Warm Springs Street at City-owned parcel adjacent to Nyberg Creek	Nyberg Creek	• Clear invasive and unwanted vegetation; excavate and grade City-acquired property to support facility installation. • Install low flow bypass structure, 485 LF of 12-inch diameter pipe, and 275 LF of 24-inch-diameter pipe on Warm Springs Street between Martinazzi Avenue and the facility. • Install 4 manholes, 3 catch basins, and inlet leads along Warm Springs Street. • Install an approximately 1-acre tiered WQ facility with beehive overflows. A maintenance access road will also be needed. • Install a flow control structure and debris forebay in the WQ facility and a high-flow bypass channel around the facility. • Install a new open channel conveyance to outfall at Nyberg Creek.	$2,037,000	$265,000	X	X		N/A

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7.2.1 Integrated Project Development

Integrated project development refers to the selection and design of capital projects to address multiple objectives. Project objectives are reflected in Table 7-1 and include:

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

Projects identified to improve water quality are associated with existing site or facility modifications/restoration to address a pollutant source issue or improve treatment function and are, therefore, not considered a retrofit.

This SMP used an integrated approach for project identification and development efforts, starting with the initial identification of project needs and Stormwater Project Opportunity Areas and then the consolidation of Stormwater Project Opportunity Areas into single, multi-objective project concepts where possible (Section 3).

An integrated project development approach was specifically used during the water quality opportunity assessment (Section 3.1.1). Capacity and maintenance-related project needs were prioritized when considering opportunities for water quality enhancement and retrofit. As project concepts were developed and refined, continued opportunities for water quality elements were considered and incorporated. Integrated project examples that reflect the combination of capacity and water quality include CIP 2, Nyberg Creek Stormwater Improvements; CIP 3, Sandalwood Water Quality Retrofit; and CIP 17, Siuslaw Water Quality Facility Retrofit.

The maintenance assessment also recognized that certain capacity-related deficiencies may also be addressed through maintenance-related activities. Integrated project examples reflecting capacity and maintenance related project needs include CIP 4, Mohawk Apartment Stormwater Improvements; and CIP 7, Boones Ferry Railroad Conveyance Improvements.

7.2.2 Sizing and Design Assumptions

Capital project sizing and design assumptions were based on the type of improvement proposed. Sizing and design assumptions generally followed the City's Public Works Standards and/or CWS's Design and Construction Standards (2012) or LIDA Handbook (2009).

Project concepts are reflective of an approximate 10%design level. Conceptual layout and design considerations are included in the project fact sheets (Appendix A).

- **Capacity Projects**. Projects to construct new conveyance infrastructure or replace existing conveyance infrastructure were developed following the City's PW Standards. All capacity projects in this SMP were sized for the 25-year, 24-hour design event. Although system surcharging is not permissible per the City's design standards, given the flat grade of much of the existing City infrastructure, system surcharging was deemed permissible for capital projects.
- **Water Quality Projects**. Water quality projects were generally designed according to CWS's LIDA Handbook. Proprietary system vendors were contacted to verify sizing where proprietary treatment systems were proposed (i.e., CIP Nos. 2, 8, and 9). As select retrofit projects could not be reasonably sized within area constraints to manage the full water quality treatment flow/volume, facility sizing was based on maximizing water quality treatment within the available area (i.e., CIP 21).

- **New Infrastructure**. Several projects require new infrastructure in locations where no storm system exists. Conceptual layouts are illustrated in the project fact sheets (Appendix A) and reflect new infrastructure proposed in the public ROW only; however, detailed design must consider/allow for potential utility conflicts and realignment needs. Survey will be required to verify elevations and locations. Final design may require additional structures, an alternate alignment due to conflicts, or deeper or shallower pipes than assumed for the conceptual project design.

7.2.3 Cost Assumptions

Project costs are based on the total capital investment necessary to complete a project (i.e., engineering through construction). Costs are based on the proposed layout and general design assumptions as documented in the project fact sheets (Appendix A).

Unit prices for construction elements are based on recent bid tabs and previous local stormwater master planning efforts, adjusted for 2018 based on a historical cost index. The current RS Means *Book for Site Work and Landscaping* was referenced for material costs not previously identified. Cost estimates presented in this SMP are 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.

Preliminary cost estimates were based on the unit cost information for construction elements plus a 30 percent construction contingency and multipliers to account for mobilization/demobilization, traffic control and utility relocation, and erosion control. Engineering and permitting costs (15 to 35 percent) and construction administration costs (10 percent) were applied as a general percentage to the total construction cost with contingencies. The range in engineering and permitting costs were based on the anticipated permitting level of effort, including whether in-water work is anticipated, which would warrant environmental permitting efforts in conjunction with Section 404 of the CWA. For planning purposes, costs were rounded to the nearest $1,000.

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

Appendix G includes the unit cost table developed for this SMP and the planning-level cost estimates for each project. Staffing resource assumptions to implement these projects are described in Section 8.1.1.

7.3 Program Recommendations

Six program needs were identified to address water quality, stream health, system maintenance, and asset management of stormwater infrastructure.

During the programmatic activity workshop (Section 6.2), City staff reviewed cost assumptions associated with implementing the proposed programs. Program costs vary based on existing City funding levels and coverage or extent of activity anticipated. Table 7-2 summarizes the resulting program cost summary, accounting for the City's current annual funding obligations.

Table 7-2. Programmatic Activities and Cost Estimates				
Program Activity	Current Annual Obligation [a]	Proposed Program Cost	Project Duration Assumptions	Additional Program Funding (annual) [b]
Pipe R/R Program	$25,000	$125,000	100-years	$100,000
Structure R/R Program	$19,400	$120,000	100-years	$100,000
Public WQ Facility Maintenance Program	$25,000	$150,000	Ongoing	$125,000
Public WQ Facility Retrofit Program	N/A	$75,000	Ongoing	$75,000
Stream Vegetation Management	N/A	$100,000	Ongoing	$100,000
Single Family LIDA Inspection Program	N/A	N/A	10-year	N/A

a. Refer to Table 6-2.

b. Based on subtraction of the current annual obligation. Assumes that the current annual obligation will be maintained in the future.

Cost assumptions by program are detailed below. Staffing resources to implement these proposed programs are described in Section 8.1.2.

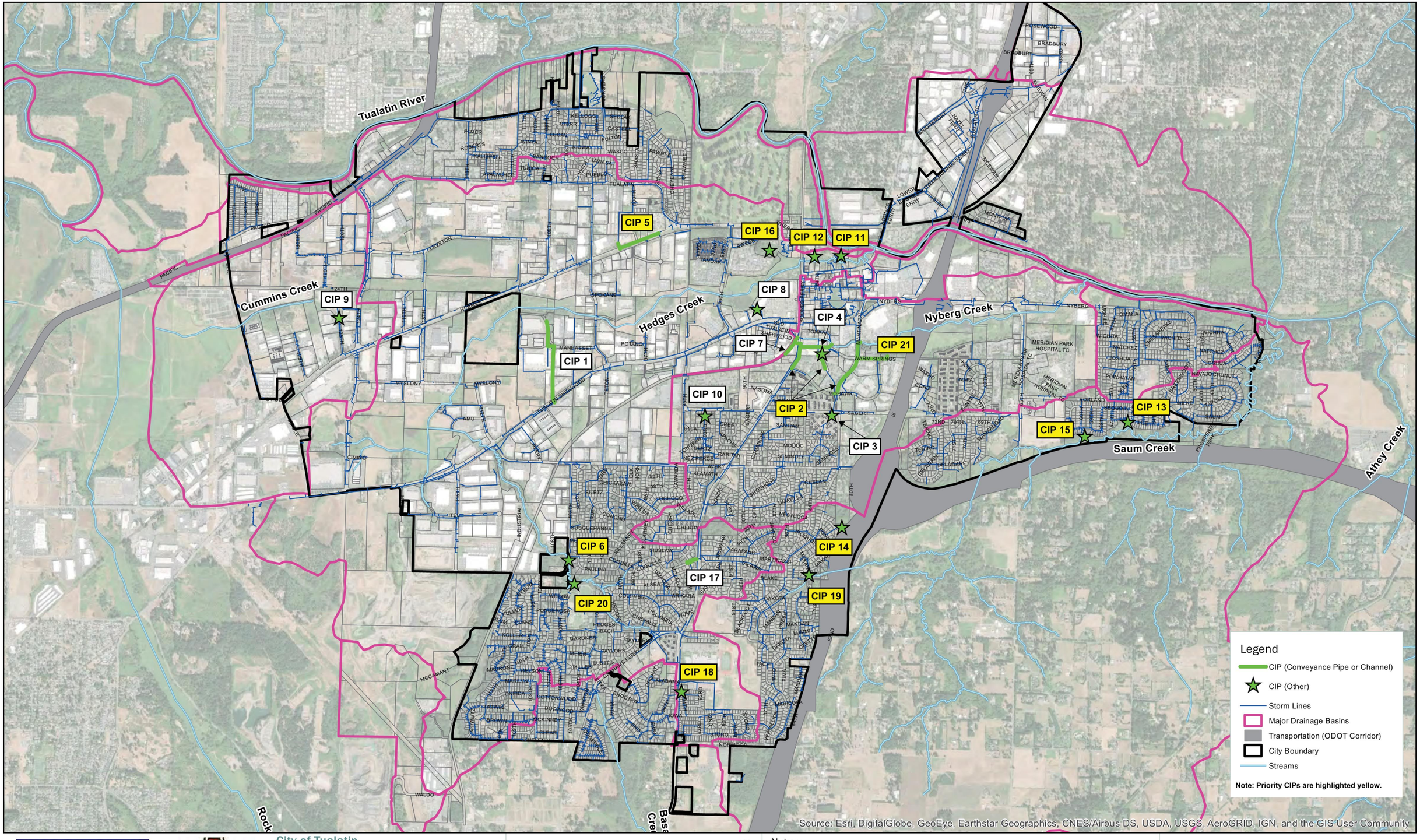
- **Pipe R/R Program.** Cost assumptions were based on replacing 486,000 LF of public storm line over a 100-year planning period (i.e., 1 percent of pipes replaced annually). Pipe replacement costs assumed a consistent size distribution as the current inventory. Present worth analysis indicated an annual cost between $1 million and $1.25 million would be required; however, due to ongoing pipe replacement efforts and unknowns related to lifespan, the City opted to allocate approximately 10 percent of the annually calculated amount ($125,000) for budgeting purposes. The additional annual allocation was $100,000, assuming a current annual allocation of $25,000.

  Efforts should first establish a baseline system condition from current CCTV results. R/R efforts should be prioritized based on condition assessment and reported deficiencies.
- **Structure Repair and Replacement Program.** Cost assumptions were based on replacing or restoring public catch basins, ditch inlets, flow control structures, and manholes over a 100-year planning period (i.e., 1 percent of structures replaced annually). Replacement costs assumed consistent facility distribution as reflected in the City's current asset inventory. Restoration costs assumed a lump sum of $2,000 per structure. Present worth analysis indicated an annual cost between $140,000 to $240,000 would be required; however, due to ongoing structure replacement efforts and unknowns related to lifespan, the City opted to allocate 50 percent of the maximum annually calculated amount for budgeting purposes ($120,000). The additional annual allocation is $100,000, assuming a current annual allocation of approximately $20,000.
- **Public Water Quality Facility Maintenance Program.** Cost assumptions considered both routine (minor) and restorative needs for public water quality facilities. Typical extensive/restorative facility maintenance ranges from $75,000 to $100,000 (based on cost estimates developed for projects as part of this Plan). Routine maintenance efforts can vary (assume $50,000). The total annual allocation proposed is $150,000. The additional annual allocation is $125,000, assuming a current annual allocation of $25,000.

  Efforts should prioritize facilities currently identified by staff as requiring maintenance (see Section 6.2.2).
- **Public Water Quality Retrofit Program.** Costs are based on anticipated annual efforts to identify potential retrofit opportunities annually, respond to public inquiries, conduct preliminary facility sizing, and provide oversight of detailed design/construction. Funds may be used internally or contracted externally. The total proposed annual allocation is $75,000 and should prioritize

locations currently identified by staff or additional retrofit opportunities identified by CWS during their review of this Plan (see Section 6.2.3 and Appendix I).

- **Stream Vegetation Management Program**. Cost assumptions were based on removing 0.5 acres of invasive vegetation per year at a unit cost of $4.60/square foot (sf). The total proposed annual allocation is $100,000. Funds may be used internally or contracted externally.
- **Single-Family LIDA Inspection Program**. Costs assumed an expanded number of private stormwater facility inspections (10 additional facilities with a 10 percent annual increase). Staff resources are required, and a proposed annual fund allocation is not included.



Brown AND Caldwell

City of Tualatin

City of Tualatin
Stormwater Master Plan

Date: April 2019
Project: Project 149233

N

0 2,050 4,100 Feet

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)

Figure 7-1

Capital Project Location Overview

Section 8

Implementation

This SMP includes a financial evaluation to determine rate adjustments required to implement projects and programs identified in this Plan.

This section provides an overview of staffing needs, project prioritization, operational costs and established levels of service (LOS) reflected in the stormwater utility rate and SDC evaluation. This section also summarizes results of the rate evaluation.

8.1 Staffing Analysis

The City's public works department includes seven FTEs in engineering and six FTEs in operations that currently support stormwater project and program needs. Current staffing levels are considered adequate to support existing commitments, project obligations, and program implementation, but an increase in staff resources is needed to implement capital projects and programs proposed under this SMP.

Appendix H, Table H-1 summarizes the comprehensive results of the staffing analysis for purposes of informing the financial evaluation. Staffing needs for capital projects were incorporated directly into the project cost, while staffing needs for programs were estimated for each individual program. A total of 0.6 FTEs (administration, engineering and maintenance staff) is required to implement all projects identified in this SMP over a 10-year implementation period. A total of 0.4 FTEs is required to implement proposed programs over the next 10-year implementation period. If the City intends to implement only priority projects over the next 10-year implementation period, a total of 0.7 FTEs is required to implement priority projects and all proposed programs (see Section 8.2 for discussion of priority project needs).

8.1.1 Capital Project Staffing Assumptions

For capital projects, additional staffing needs are anticipated to support capital project administration, project management, and the ongoing maintenance of new assets. Staffing estimates to support capital projects were based solely on the conversion of the construction administration cost to an FTE based on an annual salary (cost) equivalent of $150,000. The total FTE estimate to implement capital projects was then converted to an annual staff allocation based on a 10-year implementation period. Construction administration costs are estimated at 10 percent of the capital expense subtotal (see Appendix G for detailed cost estimates by project).

For reference purposes only, Table H-1 also includes an estimate of maintenance staff time, based on the new infrastructure proposed with the capital project, to support the capital project implementation. Although maintenance staff time was accounted for with the staffing calculation for capital projects described above, it is recognized that select capital projects may require maintenance outside of the City's current maintenance obligations and frequencies to ensure optimum performance, while other capital projects that include replacing existing infrastructure may not require additional maintenance activities, as the existing infrastructure would already be maintained.

Table 8-1 summarizes the maintenance-related cost assumptions used to summarize the estimated maintenance staff needs. The City does not currently track maintenance activities or log maintenance staff hours in time sheets or as part of an asset management program; therefore, maintenance staff time assumptions were based on typical rates and confirmed with City staff. Maintenance staffing resource needs are calculated in hours and converted to an FTE, based on a typical FTE workload of 2,080 hours.

Table 8-1. Maintenance Staff Time Summary

Maintenance Activity	Average Time Calculation	Maintenance Frequency
Pipe/open channel conveyance cleaning	20'/hour	Annual
Outfall debris removal	4 hours/outfall	Annual
Catch basin maintenance	1 hour/facility	Annual
Water quality facility (swale) maintenance	20'/hour	Annual
Water quality facility (StormFilter or CDS) maintenance	6 hours/facility	Annual
Water quality facility (planter or raingarden) maintenance	50 square feet/hour	Annual
Water quality facility (WQ manhole) maintenance	1 hour/facility	Biannual
Water quality facility inspections	1 hour/facility	Quarterly

Please note that engineering and permitting costs (estimated between 15 and 35 percent of the capital expense subtotal) were included in the capital project cost estimates but not reflected in the staffing costs. The City currently assumes that all engineering and permitting activities will be contracted, so additional staff time to perform engineering and permitting services is not reflected in the staffing analysis.

8.1.2 Program Staffing Assumptions

For select programs, there may also be an increase in engineering and/or maintenance staff needs; however, there are many considerations that would influence staffing levels.

Program-specific estimates of additional engineering and maintenance staff resource needs are listed in Table 8-2 and have been summarized in Appendix H, Table H-1. In general, maintenance and R/R programs require additional engineering staff to evaluate and identify project locations and needs, review maintenance/CCTV records, and contract needed repairs. Additional maintenance staff resources are needed to expand condition assessment efforts to structures.

Costs for implementing an expanded public water quality facility maintenance program, public water quality facility retrofit program, and vegetation management program are estimated as a lump sum that may be spent either on contracted or internal support. Thus, additional staff resources are limited to engineering support, and additional maintenance needs have not been separately identified. Implementing an expanded water quality facility inspection program for single-family LIDA is a staff activity, and the cost is solely accounted for in the staffing analysis.

Table 8-2. Annual Program Staffing Needs

Program Activity	Proposed Program Cost [a]	Additional Funding Need [a]	Additional Staffing Resources (Engineering)	Additional Staffing Resources (Maintenance)
Pipe R/R Program	$125,000	$100,000	• 0.10 FTE (review and evaluate pipe based on CCTV results, identify additional CCTV needs, PM and contract repairs). • Design and construction to be contracted per proposed program funding.	N/A
Structure R/R Program	$19,400	$100,000	• 0.10 FTE (review and evaluate structures based on condition assessment, PM and contract repairs). • Design and construction to be contracted per proposed program funding.	0.10 FTE (vactor in support of inspections, site prep, and coordination).
Public WQ Facility Maintenance Program	$25,000	$125,000	• 0.05 FTE (identify and document maintenance needs, PM and contract management). • Design and construction to be contracted per proposed program funding.	N/A (efforts to be contracted)
Public WQ Facility Retrofit Program	N/A	$75,000	N/A	N/A
Stream Vegetation Management	N/A	$100,000	N/A	N/A (efforts to be contracted)
Single Family LIDA Inspection Program	N/A	N/A	0.05 FTE (conduct additional inspections assuming 10% annual increase).	N/A

a. Refer to Table 7-2.

8.2 Project Prioritization

Project prioritization is an important component of the stormwater master planning process and can provide direction in terms of sequencing projects in accordance with City objectives.

The prioritization process was initiated during the programmatic activity workshop (Section 6-2). Example prioritization criteria and scoring methods (qualitative versus quantitative) were provided to City staff to guide their internal process. The City opted to focus prioritization efforts on defining priority projects to be funded over the next 10-year implementation period and not on numeric scoring and specific ranking of projects. Over time, the City may choose to add numeric scoring metrics or weighting factors to refine projects for scheduling or to place more emphasis on specific criteria as new project needs are identified and added to the capital improvement program. Table 8-3 summarizes the general prioritization criteria provided and used by the City as part of its prioritization process.

Table 8-3. Prioritization Criteria		
Criteria	Scoring Definition	
	High (H)	Lower (L)
Flooding Issue/ Safety Concern	• Addresses an area of known or significant capacity deficiency or erosion potential. • Was identified as flooding during existing conditions per targeted hydraulic modeling.	No reported flooding concerns or safety issues associated with project location.
WQ Improvement	• Project significantly improves water quality and wildlife habitat. • Project many be classified as a retrofit per CWS.	Project moderately improves or doesn't improve water quality and wildlife habitat.
Maintenance	• Project will reduce existing maintenance needs or complaints. • Project provides increased longevity for facility function.	Occasional maintenance needs or complaints occur in this area.
Concurrence	• Project is required or a prerequisite for other budgeted or inter-jurisdictional projects.	Project is stand-alone and does not affect implementation of other City projects.
Special Interest	• Project has City Council, City staff, or public interest/motivation.	Project has no public driver or interest.

City staff independently evaluated projects in conjunction with prioritization guidelines and criteria and determined those highest priority projects for implementation over the next 10 years. A summary of capital projects and costs, including an indication of those priority projects, is provided in Table 8-4.

Table 8-4. Capital Project Costs and Priorities			
Priority Project	CIP Number	CIP Name	Cost Estimates
	1	Manhassat Storm System Improvements	$1,581,000
X (Phase 1)	2	Nyberg Creek Stormwater Improvements (Phases 1-3)	$3,412,000
	3	Sandalwood Water Quality Retrofit	$107,000
	4	Mohawk Apartments Stormwater Improvements	$295,000
X	5	Herman Road Storm System	$1,023,000
X	6	Blake St Culvert Replacement	$552,000
	7	Boones Ferry Railroad Conveyance Improvements	$515,000
	8	89th Avenue Water Quality Retrofit	$262,000
	9	125th Court Water Quality Retrofit	$206,000
	10	93rd Avenue Green Street	$224,000
X	11	Juanita Pohl Water Quality Retrofit	$156,000
X	12	Community Park Water Quality Retrofit	$158,000
X	13	Water Quality Facility Restoration - Venetia	$65,000
X	14	Water Quality Facility Restoration - Piute Court	$104,000
X	15	Water Quality Facility Restoration - Sequoia Ridge	$83,000
X	16	Water Quality Facility Restoration - Sweek Drive Pond	$103,000
	17	Siuslaw Water Quality Facility Retrofit	$454,000
X	18	Water Quality Facility Restoration - Waterford	$180,000
X	19	Saum Creek Hillslope Repair	$171,000
X	20	Hedges Creek Stream Repair	$327,000
X	21	Nyberg Water Quality Retrofit	$2,037,000
		Total	$12,015,000
		Total (Priority projects only)	$6,482,000

8.3 Level of Service

Developing the stormwater rate evaluation requires the City to determine a level of service consistent with the expectations of the City's stormwater program and ratepayers.

Using project cost information, program cost information, and estimated operational funding expenditures, City staff identified the proposed LOS for stormwater-related services. The proposed LOS assumes construction of priority capital projects within a 10-year timeframe. Program expenditures are funded at recommended levels (see Table 7-2). Staffing needs are identified based on implementing priority projects only and all program elements. Operational costs were provided by City staff and account for vehicle replacement needs and rehabilitation of the City's operations building.

Table 8-5. Current and Recommended Level of Service (Criteria)

Criteria	Current LOS	Recommended LOS
Capital Project Implementation		
Stormwater Project Implementation (CIPs)	Implement stormwater capital projects in conjunction with City's 2017-2021 Capital Improvement Plan	Implement priority stormwater capital projects per this SMP in a 10-year planning window
Program Implementation (Annual Cost)		
Pipe R/R	Maintain current funding for repair needs	Expand repair efforts into an R/R program.
Structure R/R	Maintain current funding for repair needs	Expand repair efforts into an R/R program.
Public WQ Facility Maintenance Program	Conduct or contract out minor maintenance needs.	Expand maintenance program to include routine and restorative efforts.
Public WQ Facility Retrofit Program	N/A	Add program
Stream Vegetation Management	N/A	Add program
Equipment/Operational Costs (Annual Cost)		
Vehicle/Equipment Replacement [a]	Variable	Assume annual funding to replace vehicles (cost share with sanitary)
Operations Building Rehabilitation [b]	N/A	$50,000
Staffing (associated with priority capital projects and programs) (FTE)		
Staffing (engineering)	Maintain existing staffing resources	Increase engineering staffing resources by 0.52 FTE to support priority projects and programs.
Staffing (maintenance)	Maintain existing staffing resources	Increase maintenance staffing resources by 0.24 FTE to support priority projects and programs.

a. The vactor truck replacement is budgeted at $310,000 in FY 2019/20. Following FY 2019/20, vehicle replacement is budgeted at $75,000/year.

b. Annual cost provided by City.

8.4 Funding Evaluation

In conjunction with development of this Plan, a review of the City's stormwater utility rate and SDC was conducted. Documentation of the financial evaluation is provided in a separate TM.

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Section 9

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Section 10

Limitations

This document was prepared solely for City of Tualatin in accordance with professional standards at the time the services were performed and in accordance with the contract between City Tualatin and Brown and Caldwell dated April 14, 2016. This document is governed by the specific scope of work authorized by City of Tualatin; 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 Tualatin and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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