Brown AND Caldwell

FINAL REPORT | Prepared for
The City of Oregon City

Stormwater Master Plan

July 2019

Oregon City Stormwater Master Plan

Prepared for
City of Oregon City, Oregon
July 2019

March 18, 2020: Ordinance 19-1014
enacted which adopted the Plan

April 17, 2020: Effective date of
Ordinance 19-1014

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List of Abbreviations

BC	Brown and Caldwell
BMP	best management practice
CCTV	closed-circuit television
CIP	capital improvement project
City	City of Oregon City
CMP	corrugated metal pipe
CWA	Clean Water Act
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
EPA	U.S. Environmental Protection Agency
FTE	full-time equivalent
GIS	geographic information system
GOCWC	Greater Oregon City Watershed Council
H/H	hydrologic and hydraulic
I-205	Interstate 205
I/I	infiltration and inflow
L	liter(s)
LF	linear foot/feet
mg	milligram(s)
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
OCMC	Oregon City Municipal Code
ODOT	Oregon Department of Transportation
O&M	operations and maintenance
PCB	polychlorinated biphenyl
Plan	Stormwater Master Plan
R/R	rehabilitation and replacement
SWMP	Stormwater Management Plan
TMDL	total maximum daily load
UGB	Urban Growth Boundary

Executive Summary

The City of Oregon City (City) developed this citywide Stormwater Master Plan (Master Plan) to guide stormwater-related priorities and capital improvement projects (CIPs) over the next 10 to 15 years. The City is currently managing more than 174 miles of stormwater infrastructure, including significant areas of aging systems. At the same time, development rates and projections indicate that the stormwater system will require continued expansion to accommodate future growth. The City's previous Drainage Master Plan was completed in 1988 and is no longer relevant following nearly 30 years of development across the city.

The City needs a proactive plan to address immediate capacity needs, replace aging infrastructure, and provide regional solutions to larger flooding and water quality challenges. The updated CIP list and selected programmatic approaches included in this Master Plan will facilitate a prioritization of the City's resources and support future resource and financial planning.

Oregon City Stormwater Overview

Oregon City is the oldest city in Oregon with a rich history and strong community identity. In addition to its pioneer history, the city takes great pride in its connection to natural resources. The City's 11.92 square miles are drained by Abernethy Creek, Beaver Creek, the Clackamas River, and the Willamette River (see Figure ES-1). The eastern edge of the City borders Newell Canyon, which includes land that has been purchased by Metro for preservation. The City takes pride in being a gateway to Willamette Falls and is a partner in the Willamette Falls Legacy Project, which will provide public access to the falls and facilitate redevelopment of the historic Blue Heron Mill property.

The City manages more than 160 miles of piped stormwater infrastructure and 14 miles of roadside drainage ditches. Oregon City has some of the oldest utility infrastructure in the state, with some areas of underground infrastructure suspected to be more than 100 years old. The downtown area of the city and the Canemah neighborhood were once served by a combined sanitary sewer and storm system, which was separated in the 1980s and 1990s. The pipes that previously served the old combined system are still used for stormwater flows. The City currently has a growing database of information regarding underground utility conditions from closed circuit television (CCTV) surveys, allowing the City to make informed decisions on infrastructure improvements.

While significant areas of stormwater assets are aging, the city continues to grow and expand at the northern and southern ends of town, increasing the miles of pipes and infrastructure that need to be managed and maintained.

Providing stormwater conveyance to prevent flooding is the primary function of the City's stormwater infrastructure. The City has several drainage systems that are too small and unable to convey existing flows. As part of the master planning evaluations, a series of hydraulic models were developed to analyze the capacity of the conveyance infrastructure. The modeling was used to evaluate both existing conditions and future conditions when development expansion and infill is expected to increase flows to the conveyance system.

The City also has a robust program to address water quality through programmatic actions, such as illicit discharge investigations, construction site regulations, and stringent standards for new development and redevelopment. These water quality programs address water quality issues at the source because stormwater, unlike wastewater, does not drain to a centralized treatment facility.

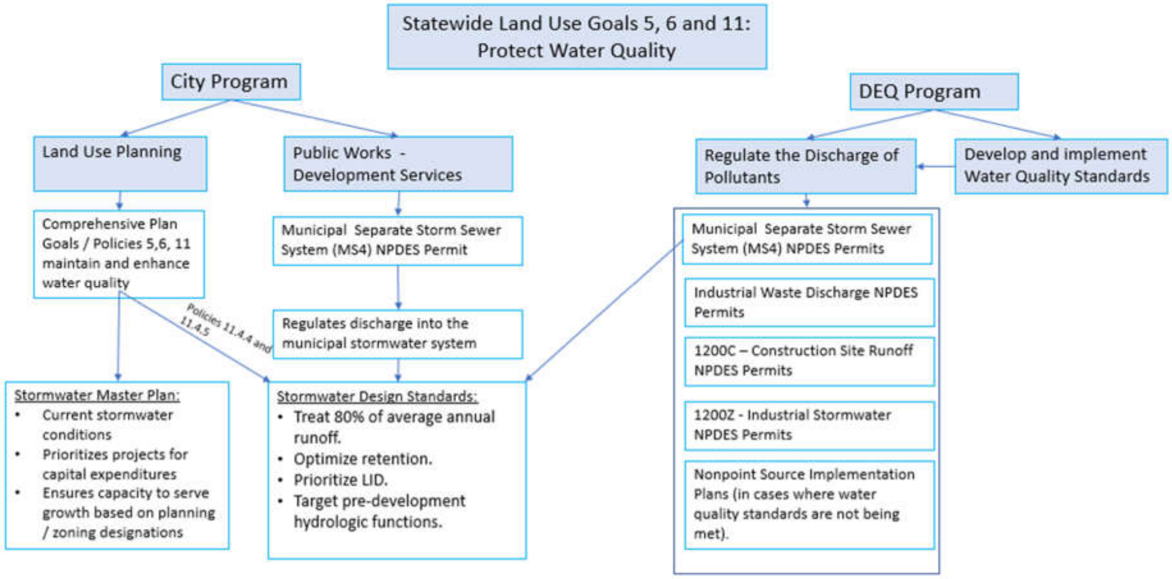
Improving water quality conditions through retrofit of existing stormwater infrastructure is an important element of the City's overall stormwater management program. The City's water quality concerns extend to Newell Creek Canyon where studies have shown an increased susceptibility for erosion and channel modification due to increasing flows.

Land Use Goals and Federal Permitting

When it comes to water quality, the City complies with the Statewide Land Use Goals by adopting comprehensive plan policies that call for protection of riparian resources through development restrictions, prioritized capital expenditures for infrastructure, and design standards regulating how stormwater is treated before it enters the municipal system. *Comp Plan Policy 11.4.7 – Provide stormwater management services and monitor, report and evaluate success of the services consistent with the NPDES MS4 permit requirements* provides clear direction to the City to utilize the NPDES MS4 permitting process for stormwater planning. Moreover, through this policy, the Comprehensive Plan recognizes that the City operates under an NPDES MS4 Permit issued by the Oregon DEQ.

The NPDES MS4 Permit is the means by which the State implements the Federal NPDES program required by the Clean Water Act. Oregon City's approach to conduct stormwater management planning according to the NPDES MS4 permit complies with both State water quality rules and Statewide Planning Goals. The City's Stormwater and Grading Design Standards implement the NPDES MS4 Permit requirements for new and re-development and provide additional clarity for developers.

Stormwater management is a critical component of the City's obligation to implement Statewide Planning Goals 5, 6 and 11. Statewide Planning Goals 5 and 6 call for the protection of certain resources, such as rivers and wetlands, as well as air and water quality. Statewide Planning Goal 11 calls for the provision of utilities. These goals are accomplished through the implementation of a Comprehensive Plan that explains the City's policies to achieve these objectives.



Planning Process

The planning process for this master plan included the following steps:

- Identify, investigate and study known problem areas.
- Create hydrologic and hydraulic models to evaluate system capacity for key problem areas or systems.
- Develop an integrated stormwater system capital improvement program to address storm system capacity needs and water quality.
- Evaluate stream channel conditions with respect to erosion and impacts from existing and future development.
- Identify implementation priorities and impacts to the program budget.
- Develop a Master Plan document that is useful and easy to read, reference, and up to date.

This Master Plan documents the means and methods used to evaluate the City's drainage infrastructure and natural systems. Results of the evaluations conducted provide the City with CIPs and programmatic stormwater actions for implementation. The study area for this Master Plan covers drainage areas to receiving water bodies including Abernethy Creek, the Clackamas River, Beaver Creek, and the Willamette River.

Master Plan Technical Analyses

Development of the Master Plan involved the following technical analyses to evaluate the stormwater infrastructure and related programs.

Problem Areas Survey. Meetings and interviews with City staff, compilation of public complaints, and site visits throughout the city provided a robust problem area list which included stormwater infrastructure, outfalls, and natural systems. The identified problems were then reviewed and studied to determine which areas needed further study through hydraulic modeling. Problem areas were classified into five categories: project opportunities, natural systems, maintenance concerns, deteriorating or missing infrastructure, and flooding. Problem area identification is discussed in Section 3.2.

Stormwater System Capacity Evaluation. Section 3 documents the development of the hydrologic and hydraulic models to simulate rainfall and runoff characteristics within the City. The models were used to simulate stormwater flows through pipe networks, drainage ditches, and culverts to identify areas of the system that are under capacity. The models were run to simulate both current conditions and the impacts of future development on stormwater flows.

Condition Assessment. Section 4 discusses the current state of the City's stormwater drainage system, as well as details the efforts currently underway via closed-circuit television surveys (CCTV). The condition of the system was analyzed in terms of its age, conveyance capacity, and state of repair based off of city records, construction documents (as-builts), and CCTV survey information.

Water Quality Retrofit. Section 5 discusses water quality improvement opportunities. In 2015, the City developed a Water Quality Retrofit Plan, which recommended that water quality retrofits be a focus of the Stormwater Master Plan. A city-wide assessment was completed to determine how water quality projects could be incorporated into previously urbanized areas or incorporated as an element of other proposed capital projects. Through the stormwater management municipal code, new development and redevelopment projects are required to provide water quality treatment.

Natural Systems Assessment. The focus of the natural systems assessment was to evaluate physical stream conditions to identify impacts from stormwater runoff. The City includes areas that are clearly susceptible to channel erosion and modification due to increases in flow from surface water runoff. Section 6 outlines the recommended infrastructure improvements and land use policies to address natural channel impacts from stormwater runoff.

Integrated Management Strategy

The City's stormwater program was formed around addressing drainage capacity and flooding problems. In the last decade, the program has shifted to include programs that address water quality needs, natural system impacts and the aging infrastructure. The recommendations in Sections 7 and 8 present an integrated strategy of programs and projects to address stormwater priorities across the City. The major recommendations include:

- Replace deteriorating and failing infrastructure, particularly in older areas of the City where stormwater infrastructure is reaching the end of the design life.
- Upsize existing infrastructure to reduce identified flooding issues.
- Upsize existing infrastructure to carry flows from projected future development and support future roadway improvements.
- Install new stormwater infrastructure systems in unserved neighborhoods (Rivercrest and Harding) to reduce stormwater inflow and infiltration into the sanitary sewer system.
- Implement outfall assessment program to systematically monitor and stabilize Newell Canyon outfalls.
- Increase water quality treatment through targeted actions and by integrating treatment features into planned capital projects.
- Expand programs to monitor stormwater infrastructure condition to identify pipes, culverts, and outfalls in degraded condition.
- Develop funding strategy and prioritized CIP implementation schedule.

Recommendations include twelve capital improvement projects and three programmatic actions. Capital Improvement Projects (CIPs) have been developed to address existing and predicted future conditions flooding problems, integrate water quality elements, and replace deteriorating pipe segments. Table ES-1 below summarizes the identified CIPs, estimated costs and priority ranking. Figure ES-1 shows the location of the proposed CIPs. Detailed fact sheets for each CIP can be found in Appendix F. Planning level cost estimates and prioritization scoring information are provided in Appendices H and I, respectively.

Table ES-1. Capital Improvement Projects and Prioritization

Prioritization Score [a]	# - Project Name		Conceptual Cost
18.5	#1	John Adams Basin Capacity Improvements	$8,555,000
15	#2	South End Road Stormwater Improvements	$3,209,000
12.5	#3	Division Street Infrastructure Improvements	$770,000
20.5	#4	Rivercrest Neighborhood Infrastructure Improvements	$2,428,000
26.5	#5	Harding Boulevard Sanitary Disconnect	$464,000
15	#6	Pebble Beach Pond Retrofit	$713,000
12.5	#7	Hiefield Court Culvert Improvements	$657,000
18.5	#8	The Cove Water Quality Improvements	$608,000
13	#9	Holcomb Boulevard Capacity Improvements	$3,893,000
13	#10	Coffee Creek Capacity Improvements	$1,096,000
22.5	#11	Scattering Canyon Stormwater Improvement	$521,000
24.5	#12	Newell Canyon Outfall Assessment (annual)	$100,000

a. *Prioritization scores range from 12.5 to 26.5, with the higher scores representing projects that are most closely aligned with the City's stormwater planning objectives.*

In addition to the identified capital projects, Section 8 identifies and recommends the following projects and studies:

- Closed Circuit Television (CCTV) of the entire stormwater system starting with the most aged areas of the Singer Basin (neighborhood in vicinity of Singer Creek), the John Adams Basin (McLoughlin neighborhood) and the Canemah neighborhood.
- Annual and ongoing Rehabilitation and Replacement (R/R) program to address failing infrastructure identified through the CCTV inspection program. The annual R/R budget is recommended between $300,000 and $750,000 per year depending on the extent of the R/R program.
- Ongoing outfall stabilization projects to upgrade and reconstruct outfalls around Newell Canyon, based on the recommendations from the outfall assessment in CIP #12.

Adoption and implementation of this Master Plan and the elements outlined within it are important for the City to move in a direction of preventive actions to minimize future and more expensive reactionary actions. Implementation of the CIPs and utilization of the prioritization matrix along with implementation of the programmatic recommendations will be critical to moving the City forward with respect to sound management of its stormwater infrastructure.

City of Oregon City

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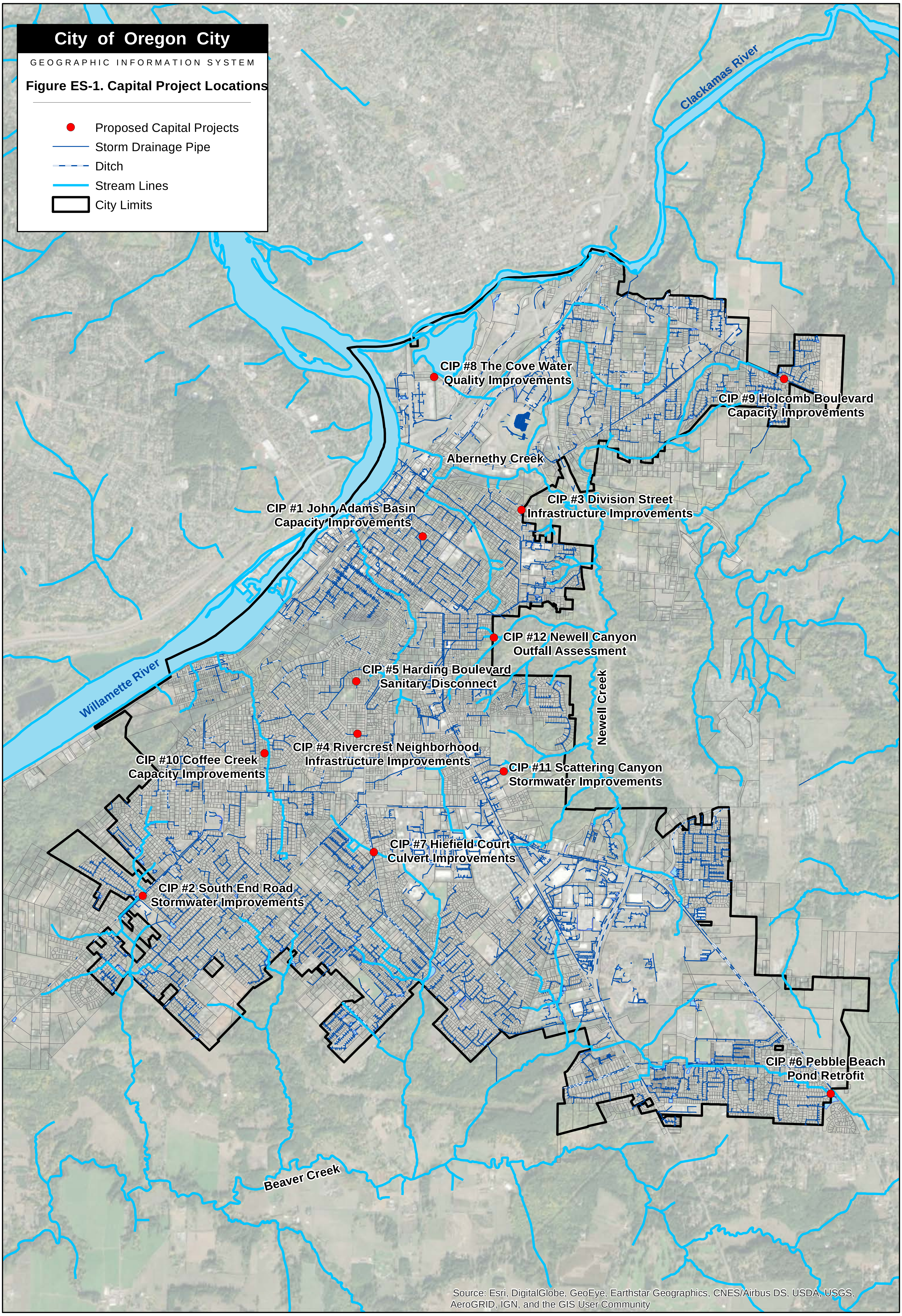
Figure ES-1. Capital Project Locations

● Proposed Capital Projects
Storm Drainage Pipe
Ditch
Stream Lines
▭ City Limits



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

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Map name: Figure 7-1 Capital Project Locations.mxd

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Section 1

Introduction

The City of Oregon City (City) developed this citywide Stormwater Master Plan (Master Plan) to guide stormwater-related priorities and capital improvement projects (CIPs) over the next 10 to 15 years. The City is currently managing more than 174 miles of stormwater infrastructure, including significant areas of aging systems. At the same time, development rates and projections indicate that the stormwater system will require continued expansion to accommodate future growth. The City's previous Drainage Master Plan was completed in 1988 and is no longer relevant following nearly 30 years of development across the city. The City needs a proactive plan to address immediate capacity needs, replace aging infrastructure, and provide regional solutions to larger flooding and water quality challenges. The updated CIP list and selected programmatic approaches included in this Master Plan will facilitate a prioritization of the City's resources and support future resource and financial planning.

This Master Plan documents the means and methods used to evaluate the City's drainage infrastructure and natural systems. Results of the evaluations conducted provide the City with CIPs and programmatic stormwater actions for implementation. The study area for this Master Plan covers drainage areas to receiving water bodies including Abernethy Creek, the Clackamas River, Beaver Creek, and the Willamette River.

1.1 Stormwater Master Plan Objectives

The goal of this Master Plan is to provide guidance in planning and designing stormwater conveyance and managing infrastructure to protect the natural and built environment for the next 10 to 15 years. The primary method for guidance is through a prioritized CIP list.

This Master Plan is intended to be used in conjunction with both the City's National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer system (MS4) permit, and Stormwater Grading and Design Standards, which outline the City's stormwater quality and quantity related obligations and programs. The NPDES MS4 permit requires the City to implement a Stormwater Management Plan (SWMP[1]) that outlines programmatic water quality best management practices (BMPs) to reduce pollutants in urban stormwater discharges to receiving waters. The City's Stormwater Grading and Design Standards require developers to address stormwater quality and quantity impacts associated with new development and redevelopment activities.

In addition to addressing aging infrastructure, future growth, water quality, flooding, and capacity issues, the City values the natural systems and spaces available to the community. Protecting and maintaining a healthy environment is important to maintaining a livable and healthy city. This Master Plan was developed to support the City's healthy management of these resources, including natural channel and riparian areas, habitat, and water bodies with beneficial uses such as fishing and recreation.

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[1] There is frequent acronym confusion between a the City's Stormwater Management Plan (SWMP) (a document required by the NPDES MS4 permit, focused on water quality programs) and the Stormwater Master Plan (this document). To ease this confusion, this document is referred to as the "Master Plan," without use of an acronym.

1.2 Background

Oregon City has a footprint of approximately 7,629 acres or 11.92 square miles. The City manages more than 160 miles of piped stormwater infrastructure and 14 miles of roadside drainage ditches. The city contributes runoff to four major water bodies: the Willamette River, Clackamas River, Abernethy Creek, and Beaver Creek. Each of these systems has unique needs that have been addressed through this planning process.

The Clean Water Act (CWA) of 1972 and the resulting NPDES permitting program require municipalities to develop and implement stormwater management plans to address water quality. Within the SWMP, the City committed to developing a Stormwater Master Plan to provide longer-term planning guidance in order to address requirements such as implementing a strategy to retrofit existing developments for better water quality, addressing total maximum daily load (TMDL) and 303(d) listed pollutants, and addressing hydromodification.

1.2.1 Previous Studies

Previous studies completed for the City address the built environment, the natural environment, and water quality. The following studies provide guidance for managing surface water in and around the City and were used as background information in the development of this Master Plan:

- **Oregon City Drainage Master Plan (1988):** In 1988 a Drainage Master Plan was completed for the City that largely addressed conveyance capacity concerns. CIPs resulting from the 1988 Drainage Master Plan primarily recommended culvert upsizing or pipe replacement. Some guidance was provided for open and closed channel maintenance activities, but water quality and the protection of natural resources were not specifically addressed.
- **Oregon City Hydromodification Assessment (2015):** The City completed a stream assessment in June 2015 to address one of the NPDES MS4 permit requirements. The hydromodification assessment included an evaluation of stream channels in the City to identify whether discharges from the municipal stormwater system have negatively impacted stream channels (i.e., caused downcutting, aggradation, or erosion), and how future development might contribute to additional impacts.
- **Oregon City Retrofit Plan (2015):** In July 2015 the City completed a Stormwater Quality Retrofit Plan to address another requirement of the NPDES MS4 permit. The retrofit plan documents the City’s retrofit strategy for reducing water quality impacts from existing developed areas. The objectives of the retrofit strategy include concepts for reducing pollutants of concern and reducing the identified hydromodification impacts.
- **Greater Oregon City Watershed Council Watershed Action Plan (2010):** This plan was developed to provide a long-term, science-based program to restore the greater Oregon City watersheds. Primary objectives for restoring watershed health included restoring streams, removing barriers to fish passage, and implementing near-channel water quality projects. The plan focuses on the larger watershed areas draining to Abernethy Creek and Beaver Creek, with few projects identified within the urban area of Oregon City.
- **Oregon City Stormwater and Grading Design Standards (2015):** To meet another NPDES MS4 permit requirement, the City adopted updated stormwater standards for new development and redevelopment in 2015. These standards require developers to prioritize low-impact development and they require new development and redevelopment projects to manage surface runoff from impervious areas to mimic natural patterns.

1.2.2 Regulatory Drivers

The CWA was enacted to protect waters of the United States and resulted in the establishment of water quality standards for surface waters and a permitting program to regulate discharges to surface waters. To address urban stormwater runoff, the U.S. Environmental Protection Agency (EPA) developed the NPDES MS4 permitting program.

The NPDES MS4 program requires municipalities to develop and implement SWMPs to address stormwater quality. Oregon City is a co-permittee on the Clackamas County NPDES MS4 permit. As a result, the City developed a SWMP that provides detailed information on how the NPDES MS4 permit requirements will be met. **The development of this Master Plan is one of the commitments identified in the City's SWMP.** Other commitments in the City's SWMP are mostly programmatic and are related to 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.

1.3 Planning Approach

The approach used to develop this Plan is provided in Figure 1-1. This process was established to first leverage City staff knowledge and existing data and then to conduct focused investigations leading to the development of CIPs. The investigation, including hydraulic modeling, focused on the problem areas rather than the whole city. This approach was used to minimize modeling and analysis costs and to focus on the areas identified as problems. The problem area identification, evaluation, CIP list development, and prioritization of CIPs were conducted in the following manner:

1. A kickoff workshop was conducted with City staff to identify potential stormwater and surface water problems in each of the City's 21 drainage basins.
2. Further problem area identification and data collection were conducted through meetings with maintenance and engineering staff to compile all available sources of problem areas and to define areas for focused data collection and evaluation.
3. Analysis and review of maps, plans, and record drawings, hydrologic and hydraulic (H/H) modeling, natural systems investigations, and additional field investigations were completed to further define problem areas and potential projects.
4. A workshop was conducted with City staff to refine the potential project list.
5. Additional H/H modeling following detailed data gathering, and evaluation resulted in a draft list of conceptual CIPs to review with City staff.
6. The development of CIP cost estimates, priorities, and a timeline for implementation were completed and vetted with City staff for inclusion in the draft Plan.
7. The Plan was developed to document the master planning approach, CIP list, and additional recommendations.

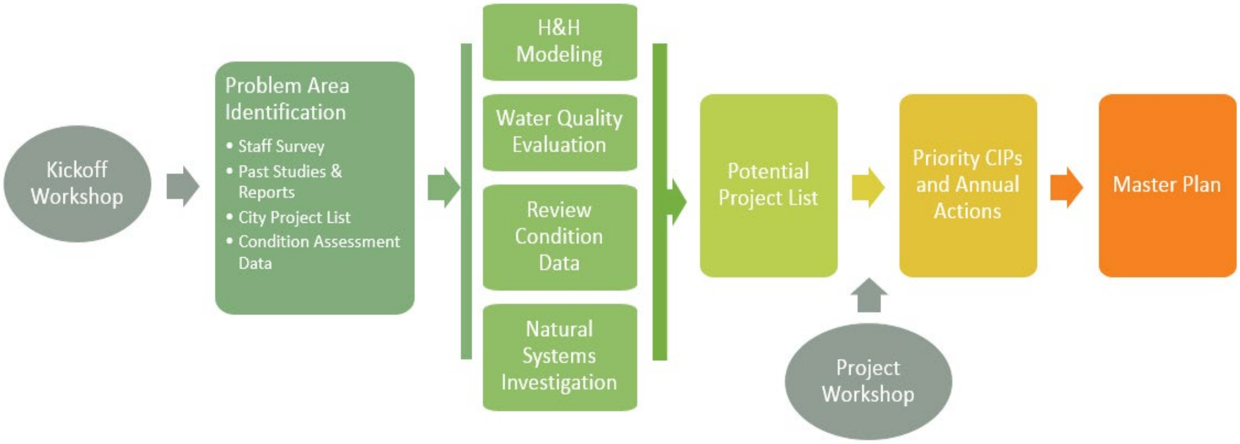

Figure 1-1. Stormwater Master Plan approach

City staff have provided input throughout every stage of the project process, starting with the kick-off workshop, where staff discussed known issues in each of the City’s 21 drainage basin and continuing through problem area analysis, project development, and final project prioritization.

Section 2

Study Area Characteristics

Oregon City is located adjacent to Willamette Falls, at the confluence of two of Oregon's major waterways: the Clackamas and Willamette rivers. Waterways and natural resources play a prominent part in the City's history and protection of these resources continues to be of high value for the City.

2.1 Location

The City of Oregon City is located 12 miles south of Portland, Oregon. Interstate 205 (I-205) and Pacific Highway 99E go through Oregon City and intersect in the northern portion of the city, as seen in Figure 2-1, below. The Willamette River bounds the city to the west and the Clackamas River bounds the city to the north. Unincorporated Clackamas County lands bound the eastern and southern city limits.

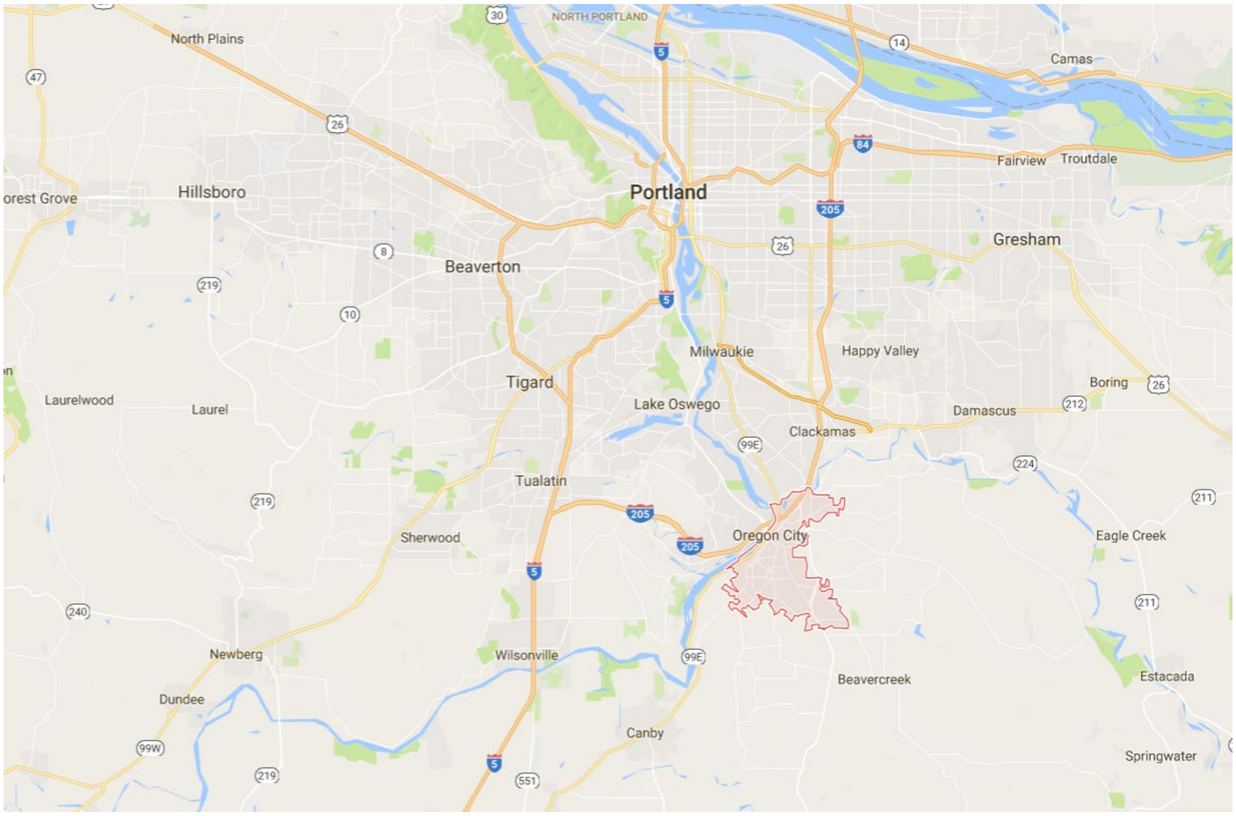

Figure 2-1. Location map

Oregon City is the oldest city in Oregon with a rich history and strong community identity. In addition to its pioneer history, the city takes great pride in its connection to natural resources. The City's 11.92 square miles are drained by Abernethy Creek, Beaver Creek, the Clackamas River, and the Willamette River.

The eastern edge of the City borders Newell Canyon, which includes land that has been purchased by Metro for preservation. Abernethy Creek and the Clackamas River enter the Willamette River near the northern end of the city. Beaver Creek joins the Willamette River south of the city near the intersection of South End Road and Highway 99E. The City takes pride in being a gateway to Willamette Falls and is a partner in the Willamette Falls Legacy Project, which will provide public access to the falls and facilitate redevelopment of the historic Blue Heron Mill property.

2.2 Topography

Oregon City's topography is characterized by a significant escarpment or bluff that parallels the Willamette River (see Figure 2-2). Above the bluff the city has moderate slopes up to the intersection of Linn Avenue, Warner Parrott Road, Warner Milne Road, Central Point Road, and Leland Road, which is located at a high point of the city.

The northern portion of the city, north of Abernethy Creek, is characterized by gentle slopes that rise to the east and drain primarily to the Clackamas River and Abernethy Creek. To the south of the high point the city slopes more gently to the south. These areas are upper tributaries of the Beaver Creek watershed.

The eastern edge of the city is characterized by numerous steep slopes and ravines that drain through protected forest land to Newell Creek, which is a tributary to Abernethy Creek.

2.3 Soils

The Natural Resources Conservation Service (NRCS) Soil Survey online tool was used to gather soils information for Oregon City. Soils are an important watershed characteristic for evaluating potential runoff rates and volumes. Soils are generalized into four categories or hydrologic soil units, 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. Oregon City generally has C type soils with pockets of A, B, and D type soils. See Figure 2-3 for a soils map of the city.

Newell Canyon is a unique area of the city because of the highly erodible soils along the slopes of the canyon. The discharges from stormwater outfalls along with natural processes such as landslides have posed some additional risks for this area as development encroaches on the steeper slopes. This area requires more care during development because of the unique soils and slope conditions. Figure 2-4 highlights the Newell Canyon area.

Table 2-1 below shows the soil types, NRCS map symbol, hydrologic soil group, and percent coverage within the city limits. This information is based on soil data from NRCS's Web Soil Survey and analysis done within Esri's ArcMap.

City of Oregon City

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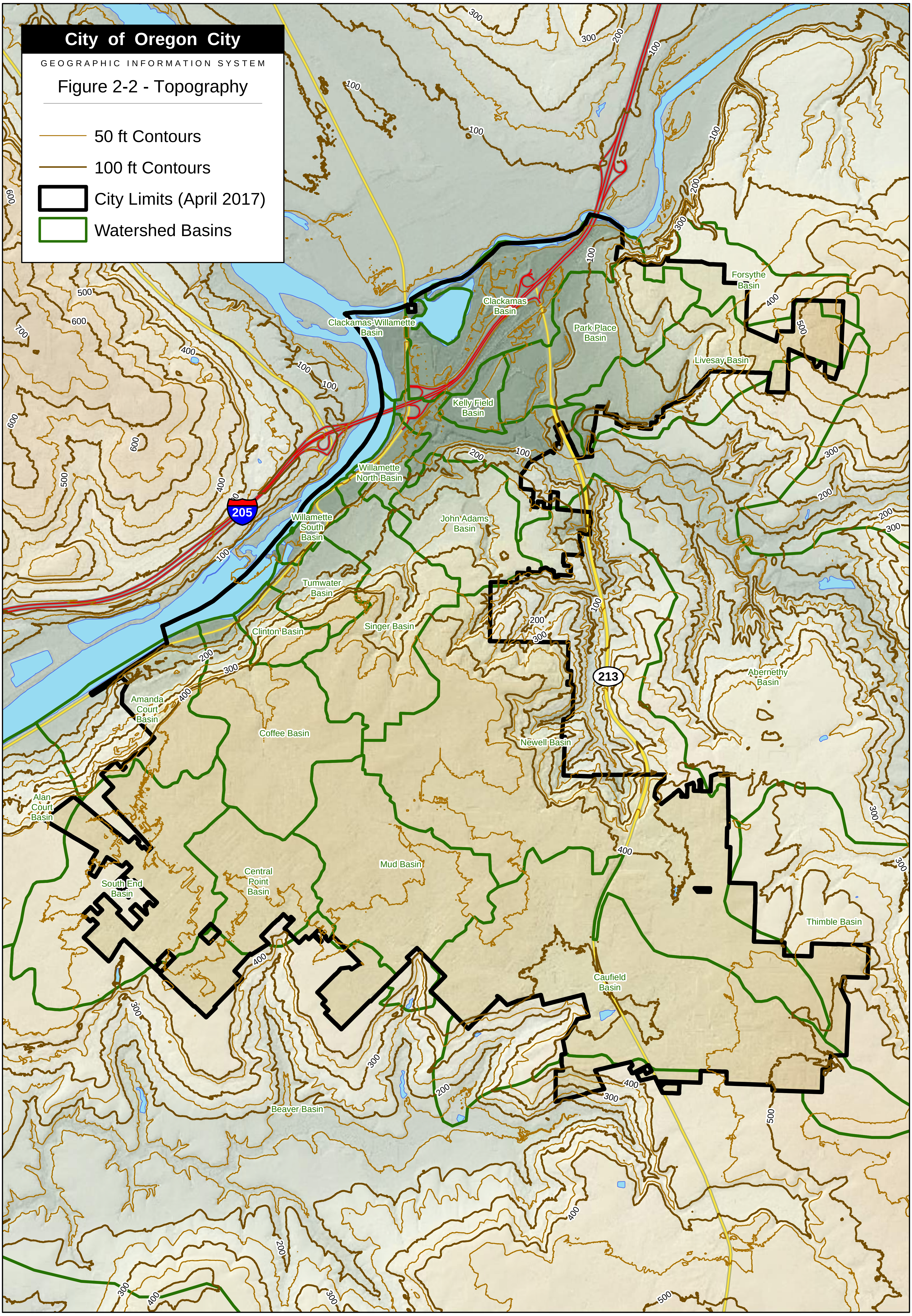
Figure 2-2 - Topography



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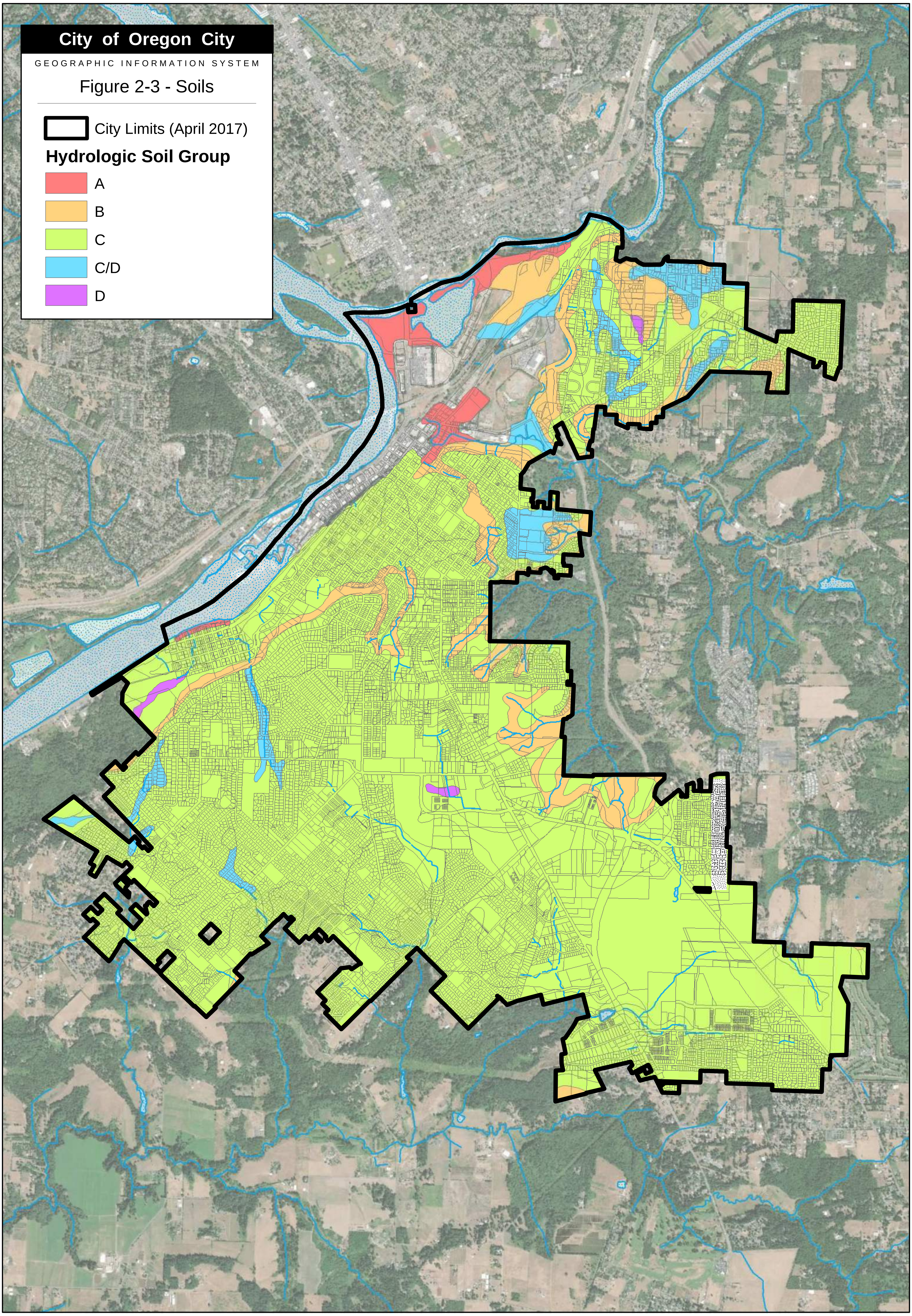

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Figure 2-3 - Soils

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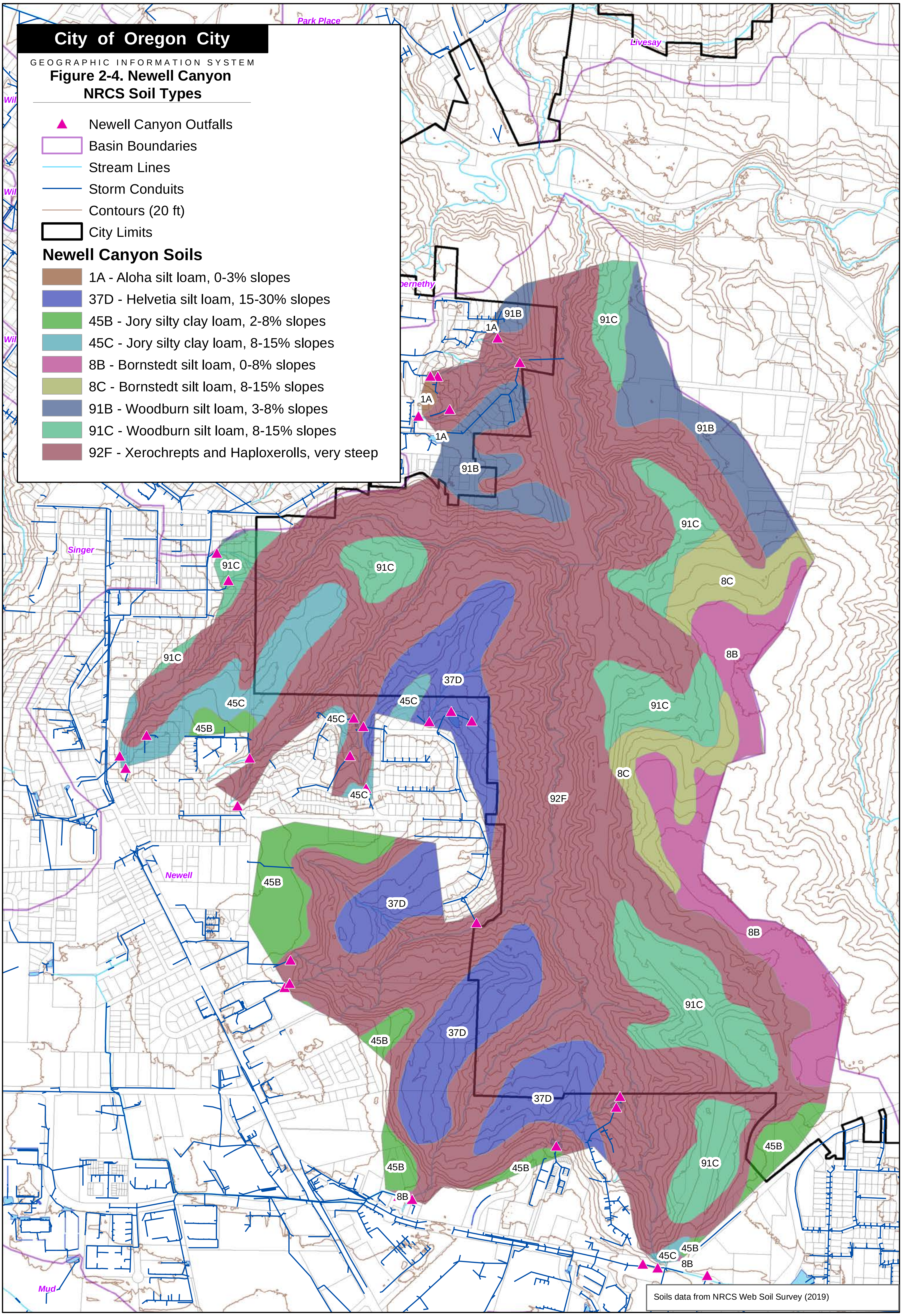
Figure 2-4. Newell Canyon NRCS Soil Types



Soils data from NRCS Web Soil Survey (2019)

The City of Oregon City makes no representations, express or implied, as to the accuracy, completeness and timeliness of the information displayed. This map is not suitable for legal, engineering, or surveying purposes. Notification of any errors is appreciated.

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Map name: Figure 2-4 Newell Canyon.mxd

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Table 2-1. Soil Types				
NRCS map symbol	NRCS soil types	Hydrologic soil group	Acres within city limits	Percent of land within city limits
11	Camas gravelly sandy loam	A	9.23	0.15
13C	Cascade silt loam, 8%–15% slopes	C	33.50	0.53
16	Chehalis silt loam	B	51.33	0.81
17	Clackamas silt loam	C/D	40.05	0.63
1A	Aloha silt loam, 0%–3% slopes	C/D	43.92	0.70
1B	Aloha silt loam, 3%–6% slopes	C/D	12.50	0.20
23D	Cornelius silt loam, 15%–30% slopes	C	0.49	0.01
24B	Cottrell silty clay loam, 2%–8% slopes	C	185.56	2.94
25	Cove silty clay loam	D	9.01	0.14
3	Amity silt loam	C/D	33.94	0.54
30C	Delena silt loam, 3%–12% slopes	C/D	55.92	0.89
36C	Hardscrabble silt loam, 7%–20% slopes	D	3.86	0.06
37B	Helvetia silt loam, 3%–8% slopes	C	11.06	0.18
37C	Helvetia silt loam, 8%–15% slopes	C	57.59	0.91
37D	Helvetia silt loam, 15%–30% slopes	C	74.58	1.18
41	Huberly silt loam	C/D	8.30	0.13
45B	Jory silty clay loam, 2%–8% slopes	C	1,052.74	16.67
45C	Jory silty clay loam, 8%–15% slopes	C	97.52	1.54
45D	Jory silty clay loam, 15%–30% slopes	C	17.74	0.28
45E	Jory silty clay loam, 30%–60% slopes	C	3.38	0.05
46B	Jory stony silt loam, 3%–8% slopes	C	345.80	5.48
46C	Jory stony silt loam, 8%–15% slopes	C	43.88	0.69
54B	Laurelwood silt loam, 3%–8% slopes	B	11.34	0.18
54E	Laurelwood silt loam, 30%–60% slopes	B	1.00	0.02
56	McBee silty clay loam	C	29.06	0.46
64B	Nekia silty clay loam, 2%–8% slopes	C	87.22	1.38
67	Newberg fine sandy loam	A	108.74	1.72
73	Riverwash		7.36	0.12
76B	Salem silt loam, 0%–7% slopes	B	67.53	1.07
78B	Saum silt loam, 3%–8% slopes	C	149.81	2.37
78C	Saum silt loam, 8%–15% slopes	C	141.37	2.24
78D	Saum silt loam, 15%–30% slopes	C	99.22	1.57
78E	Saum silt loam, 30%–60% slopes	C	10.54	0.17
7B	Borges silty clay loam, 0%–8% slopes	D	5.21	0.08
82	Urban land		345.94	5.48
84	Wapato silty clay loam	C/D	43.27	0.69
8B	Bornstedt silt loam, 0%–8% slopes	C	1,818.23	28.79
8C	Bornstedt silt loam, 8%–15% slopes	C	68.29	1.08

Table 2-1. Soil Types

NRCS map symbol	NRCS soil types	Hydrologic soil group	Acres within city limits	Percent of land within city limits
91A	Woodburn silt loam, 0%–3% slopes	C	31.49	0.50
91B	Woodburn silt loam, 3%–8% slopes	C	268.79	4.26
91C	Woodburn silt loam, 8%–15% slopes	C	116.96	1.85
92F	Xerochrepts and Haploxerolls, very steep	B	399.09	6.32
93E	Xerochrepts-Rock outcrop complex, moderately steep	C	146.35	2.32
W	Water		165.82	2.63
Total			**6,314.57**	**100**

2.4 Land Use

Oregon City is a community of both historic development and rapid growth. Most of the city's developed areas are residential lands of various densities. The oldest and newest parts of the city tend to have smaller lots. Large parcel residential areas on the east side of the city are slowly being replaced by partitions, adding residential homes. Areas along major highways are generally mixed-use with small businesses and commercial areas. This includes the corridors of Highway 99E, I-205, Highway 213, 7th Street, and Molalla Avenue. The land in the southeast corner of the city between Beavercreek Road and Molalla Avenue has the largest concentration of industrial and commercial land.

The population of Oregon City has increased by 25 percent from 2010 to 2015, as illustrated in Figure 2-5. Vacant lands are scattered in small pockets across the city. However, Oregon City is somewhat unique in its metro area, as the area has large parcels of undeveloped land within existing city limits. This has and will continue to allow for rapid development at the northeast and southeast edges of the city, as parcels do not need to be annexed prior to land use approval. The city also has large undeveloped areas within the Urban Growth Boundary (UGB) that is expected to allow a continued high pace of development into the foreseeable future.

Future growth will occur based on the projected development patterns shown in Figure 2-6, including new industrial and mixed-use areas, primarily in the southeast and northwest corners of the city. Significant residential growth is expected along the northeast and south borders of the city.

2.5 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 5.6 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 is just under 36 inches with an average of 4 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 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.

City of Oregon City

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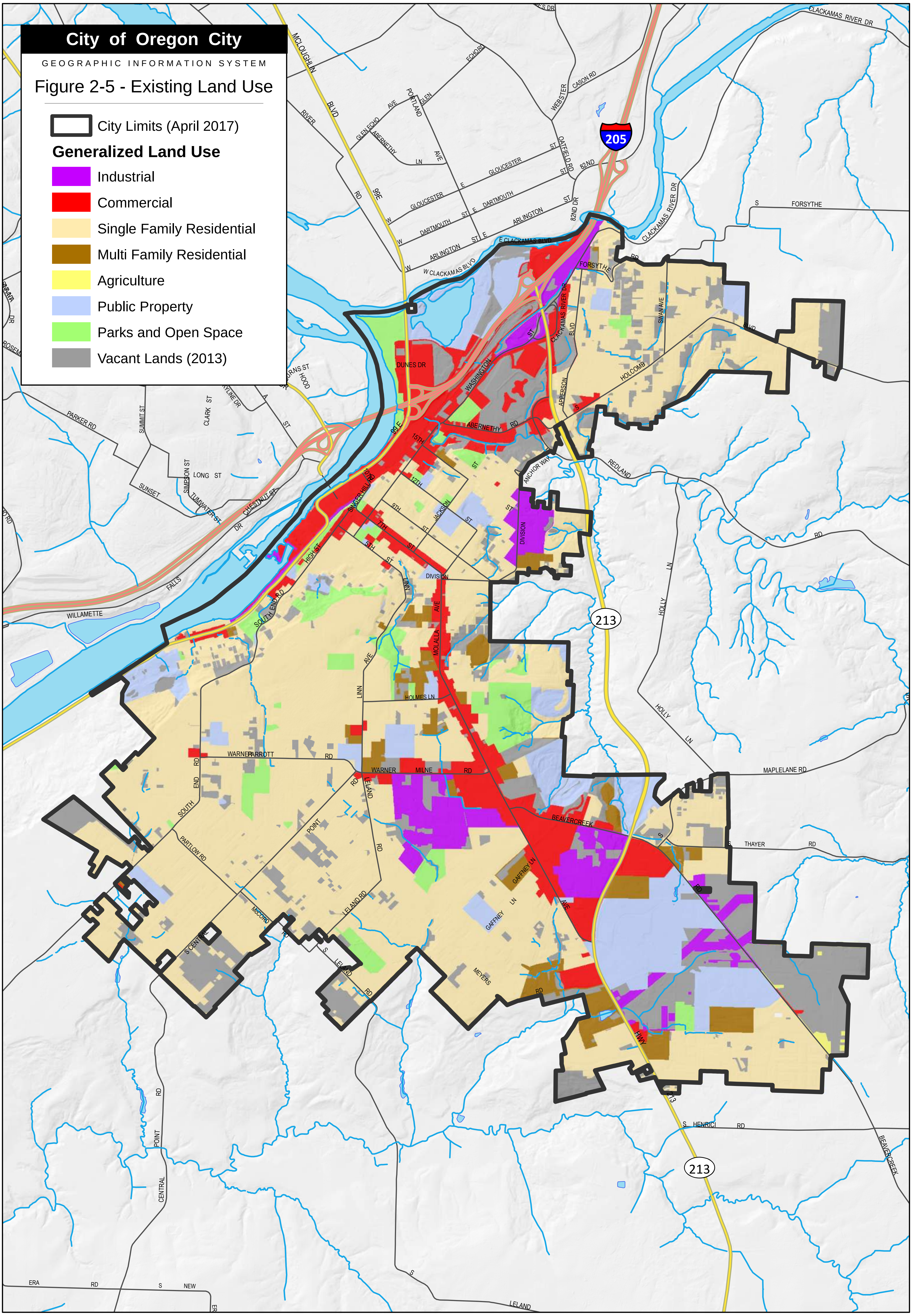
Figure 2-5 - Existing Land Use



- ▭ City Limits (April 2017)

Generalized Land Use

- 🟪 Industrial
- 🟥 Commercial
- 🟨 Single Family Residential
- 🟫 Multi Family Residential
- 🟨 Agriculture
- 🟦 Public Property
- 🟩 Parks and Open Space
- ⬛ Vacant Lands (2013)

0 0.5 1 2 Miles

0 5,000 10,000 Feet

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Map name: SWMP - Existing Land Use - 11x17P.mxd

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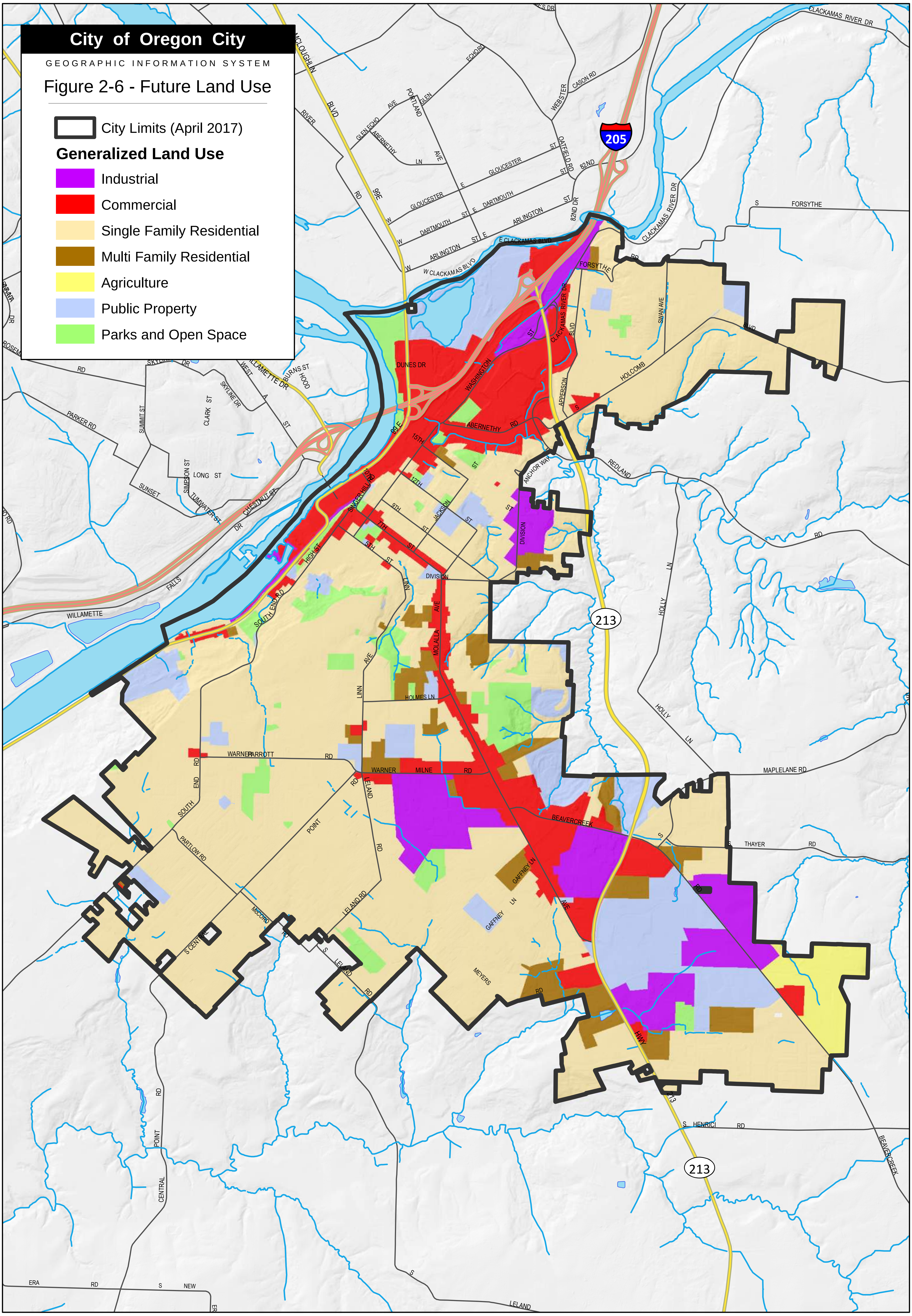
Figure 2-6 - Future Land Use



The City of Oregon City makes no representations, express or implied, as to the accuracy, completeness and timeliness of the information displayed. This map is not suitable for legal, engineering, or surveying purposes. Notification of any errors is appreciated.

Please recycle with colored office grade paper.

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2.6 Natural Systems

Oregon City land drains to three primary watersheds: the Willamette River, Abernethy Creek, and Beaver Creek. Relatively small portions of the city drain to the Clackamas River. Within these primary watershed areas, the City has identified 21 drainage areas, as shown in Figure 2-2. These drainage areas represent the drainage boundaries for smaller tributaries that contribute to the larger watersheds. Each of these systems has unique needs and is being impacted by development in different ways.

The area of Oregon City that drains directly to the Willamette River represents the older part of the City and is mostly developed. The land is primarily industrial, mixed use, parks, and residential. The natural systems within this area of the city are highly modified because of decades of development without stormwater management for water quality or flow control.

Beaver Creek is south of Oregon City with several tributaries to the creek originating within city limits. Many of these areas have seen significant residential development in the last few decades, and those developments have typically incorporated stormwater management as part of the development.

Abernethy Creek receives runoff from the east side of Oregon City. The land that drains to Abernethy Creek is a mix of residential, parks, public, commercial, and industrial.

Newell Creek or Newell Canyon, as it is referred to by the City, has several locations where erosion, bank sloughing, and landslides have occurred during and following storm events. The canyon is largely protected from development because of Metro ownership and protection. However, prior development of the drainage area contributing to Newell Canyon has resulted in some degradation of the natural systems.

2.7 Stormwater Infrastructure System

The City manages more than 160 miles (844,800 linear feet [LF]) of piped stormwater infrastructure and 14 miles (73,920 LF) of roadside drainage ditches. The topographic high point is generally at the center of the city and major receiving waters are located on all sides of the city. As a result, most of the City’s drainage infrastructure consists of small, dispersed pipe and culvert systems, rather than large trunk lines. The City has more than 248 mapped outfalls from piped systems. At the time of this report-writing, the City currently manages over 2300 manholes, over 2400 catch basins, as well as 87 detention ponds, 88 drainage swales, 5 infiltration basins, 2 rain gardens, and 26 detention tanks.[2]

Oregon City has some of the oldest utility infrastructure in the state, with some areas of underground infrastructure suspected to be more than 100 years old. The downtown area of the city and the Canemah neighborhood were once served by a combined sanitary sewer and storm system, which was separated in the 1980s and 1990s. The pipes that previously served the old combined system

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[2] For detailed information on the City’s infrastructure please see the City of Oregon’s online GIS portal at https://www.orcity.org/maps.

are still used for stormwater flows. The City currently has a growing database of information regarding underground utility conditions from CCTV surveys (see Section 4).

While significant areas of stormwater assets are aging, the city continues to grow and expand at the northern and southern ends of town, increasing the miles of pipes and infrastructure that need to be managed and maintained.

2.8 Recent Projects

The City regularly implements stormwater-related projects to address acute problems and correct system deficiencies. Projects may be CIPs funded through the City's capital program or smaller construction efforts, implemented by the City's maintenance staff. The City's recent stormwater infrastructure projects have included the following:

- **15th Street Stormwater Repair.** Along 15th Street between Main and Center Streets, the City replaced 500 LF of pipe and installed two 60-inch manholes, two curb inlets, and two catch basins with sumps. The project also included installing a manhole and pipe on 15th Street between John Adams Street and Jackson Street.
- **High Street Reconstruction Project.** Stormwater improvements were incorporated into this street project on High Street between 1st and 2nd Streets; installed a ditch inlet, two manholes and 290 LF of pipe.
- **Coffee Creek Culvert Rehabilitation.** Installed four manholes and 200 LF of pipe near Hedges Street and 3rd Avenue.
- **14th Street Storm Drain Improvements.** Extended the stormwater collection system with 450 LF of pipe and sumped catch basins.
- **OR99E, Clackamas River Bridge to Dunes Drive Improvements.** Installation of a water quality treatment rain garden, water quality manhole, and a 2,550 LF collection system.
- **Oregon City Pavement Improvements.** The City works to incorporate water quality improvements into pavement projects. The work often involves installing sumped catch basins or manholes, replacing deteriorated pipe, and/or extending the upstream point of an existing collection system in areas where paving projects are opening up the roadway section. Recent work has occurred on Molalla Avenue, between Beverly Drive intersections, Brighton Avenue between Summit and Creed Streets, and at 9th Street and Washington Street.

2.9 Future Planning Areas

Future planning areas include areas of growth and new development, as well as infill and redevelopment. To date, the City has adopted three concept plans with stormwater implications and is in the planning stages for redevelopment of the Willamette Falls Downtown District. The City may identify additional planning areas in the future.

2.9.1 Concept Plans

Concept plans for major planning areas have been developed to guide future development and expansion as the City grows. Concept plans address areas that are included in the City and urban growth boundary or adjacent areas but have yet to undergo significant development. The plans 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 throughout the planning area.

Three concept plans have been developed for the City of Oregon City which include:

- *South End Concept Plan* completed in March of 2014. This plan includes the areas along South End Road from Rose Road at the north end to S May Road. The concept area surrounds a tributary to Beaver Creek that drains south, away from the City core.
- *Beavercreek Road Concept Plan* completed in August of 2008. This plan includes the areas east of S Beavercreek Road, south of S Thayer Road and north of S Old Acres Lane. The concept area is west of Thimble Creek and generally drains east, away from the City's primary stormwater conveyance systems.
- *Park Place Concept Plan* completed in March of 2008. The areas roughly east of Hwy 213, south of Holcomb Boulevard, north of S Morton Road and west of S Edenwild Lane. Abernethy Creek drains through the middle of the Park Place concept area.

These concept plans outline basic assumptions for the type and quantities of stormwater infrastructure that may be required to develop the planning areas. These assumptions are useful for fiscal planning (see Section 8.4), but the eventual layout of the stormwater conveyance systems and management facilities will be crafted through the preliminary and final design process for each area.

This master plan is a conceptual evaluation of future conditions. More refined analysis will be needed for concept areas to evaluate projected runoff rates and develop the details of the required stormwater infrastructure. That analysis should consider roadway layout, detailed land use plans, open space areas, and opportunities to manage stormwater green facilities, as well as the traditional piped conveyance system.

2.9.2 Redevelopment Areas

The City is a partner in the Willamette Falls Legacy Project, which will provide public access to the falls and facilitate redevelopment of the historic Blue Heron Mill property. Redevelopment of the Willamette Falls Downtown District will require stormwater collection, conveyance, and water quality treatment. The area is exempt from flow control, due to the proximity to the Willamette River.

Stormwater management in the Willamette Falls Downtown District will require a unique approach, including public and private partnerships, regional facilities, treatment trades, and fee-in-lieu agreements. Together, these approaches will achieve the overall stormwater management objectives of water quality treatment and natural resource protection on a district scale.

2.9.3 The Cove Development

The area around Clackamette Cove is another area planned for redevelopment. The full build-out of the Waterfront Residences project will consist of upgraded roadways, a multi-use esplanade path, residential and mixed use buildings, and associated parking and landscaping. The project is anticipated to include stormwater management conveyance systems, facilities that enhance water quality treatment, and mitigation to restore riparian habitat and designate recreational access.

2.10 Stormwater Program Management

Stormwater program management includes maintenance, program operations, and program funding as described in the following subsections.

2.10.1 Maintenance Obligations

Maintenance of the City's assets is important to ensure that the full life expectancy of these assets is realized. The City allocates nine full-time equivalents (FTEs) per year for stormwater system maintenance. However, City maintenance crews share responsibilities for multiple utility and infrastructure assets. Maintenance activities occur on a scheduled basis and in response to citizen and staff requests. In the prior budget biennium (2015–17), major accomplishments included the following:

- Swept 9,131 curb miles and collected 3,254 cubic yards of debris and leaves.
- Corrected four sanitary to storm cross-connections.
- Maintained 75 detention ponds.
- Mowed and maintained 17 drainage ditches and bioswales (7,700 LF).
- Inspected and/or cleaned 1,460 catch basins and 45 pollution control manholes.
- CCTV inspected over 200,000 LF of pipes.
- Transitioned all underground utility locates to a paperless electronic system.

2.10.2 Program Operations

Programmatic stormwater activities are generally implemented in response to NPDES MS4 permit requirements. Program implementation is documented annually in the City’s NPDES MS4 permit annual report. Recent program highlights include:

- Continued stormwater quality sampling in coordination with Clackamas County Service District #1 and co-permittees.
- Completed more than 1,000 erosion control inspections.
- Developed and implemented a private stormwater quality facility inspection program.
- Developed and implemented a commercial/industrial inspection program.
- Completed quarterly water quality inspections of municipal operations facilities.

2.10.3 Program Funding

The stormwater program is funded primarily through stormwater utility fees (see Table 2-2). Utility fee revenue for 2017–18 and 2018–19 is projected to be approximately $2.65 million per year. In the past, the stormwater utility rate included an annual rate increase. At a rate increase of $0.30 per dwelling unit per month, the stormwater program revenue continued to grow each year. The annual increases are scheduled to lapse during the 2017–19 biennium. However, the City plans to complete a stormwater rate study that may result in a future adjustment to stormwater utility rates.

In addition to maintenance, staffing levels for the City’s stormwater program are currently at 9.0 FTE, exclusive of shared administrative and supervisory personnel. Staffing of the program accounts for approximately 37 percent of the annual stormwater budget to cover engineering, maintenance, and water quality staff. Approximately 26 percent of the budget is allocated to materials and services and approximately 17 percent (roughly $1.1M) per year is allocated to capital improvements. The remaining budget covers other transfers and contingency funds.

Table 2-2. Stormwater Operations Funding Summary, 2017-2019

Resources	
Beginning Fund Balance	$1,140,500
Charges for Services (Utility Fees)	$5,302,842
Licenses and Permits	-
Intergovernmental	$28,000
Interest Income	$6,000
Miscellaneous Income	-
Total Resources	$6,477,342
Requirements	
Personnel Services	$ 2,418,834
Materials & Services	$1,679,704
Capital Outlay	$1,105,000
Transfers Out	$810,000
Contingency	$463,804
Unappropriated Fund Balance	-
Total Requirements	**$6,477,342**

Section 3

Storm System Capacity Evaluation

Providing stormwater conveyance to prevent flooding is the primary function of the City's stormwater infrastructure. The City has several drainage systems that are too small and unable to convey existing flows. As part of the master planning evaluations, a series of hydraulic models were developed to analyze the capacity of the conveyance system.

The objectives of this storm system capacity evaluation included developing hydrologic and hydraulic (H/H) models. The hydrologic models estimate existing and future conditions flows across the city. Hydraulic modeling is used to analyze the conveyance system to verify problem areas, understand conveyance system complexities, and to analyze potential capital projects to alleviate problem areas and meet desired levels of service.

Developing a city-wide hydraulic model was determined to be cost-prohibitive, which led to the selection of 12 locations to analyze through focused hydraulic modeling. Key findings from the H/H model evaluation include:

- Central Point basin has an undersized conveyance system in the vicinity of Central Point Road that is further complicated by a series of irregular flow patterns and structure connections.
- The Coffee Creek area near Hazelwood Drive is an ongoing capacity concern that impacts private properties.
- The Holcomb Boulevard conveyance system is not large enough to accommodate current flows and expected to be further stressed by projected development in the Livesay basin.
- The John Adams basin has the greatest concentration of flooding stormwater structures, requiring significant capital investment to upsize existing infrastructure and relocate structures from private property into the public right-of-way.
- Existing culverts in the Park Place basin may not have capacity for current flows, but the drainage system is likely to be modified with future development.
- The conveyance systems through Singer Basin have inadequate capacity for peak storm events, and potential projects should be focused on replacing structures that are deteriorating due to age (See Section 4).
- The South End basin will need an upsized conveyance system to support future development and expansion of South End Road.
- The drainage system around Beavercreek Road and Molalla Avenue may pond in the roadways during peak events, as water is stored in underground detention tanks, which prevents higher flows to Newell Canyon.

The following section details how capacity issues were evaluated and discusses the development of models, and model results. The results of this evaluation led to a series of CIP recommendations to address both existing and future capacity constraints as outlined in Section 7.

Figure 3-1 below illustrates identified stormwater problem areas and Figure 3-2 shows the locations of hydraulic model. Figures 3-3 through 3-10 show the hydraulic model framework, as well as locations of flooded nodes. For information on proposed improvements in these areas, please see the CIP fact sheets, in Appendix F.

3.1 Capacity Evaluation Approach

Rather than constructing an expensive citywide hydraulic model, this study focused the City's limited resources to evaluate areas where flooding is known or suspected to be a problem. Most areas developed since the adoption of the City's Stormwater Flow and Detention Standards (1999) have been designed for full buildout of the surrounding drainage area and therefore have adequate capacity for stormwater conveyance. However, older infrastructure areas may have trunk lines that were installed without long-term planning. These areas were targeted by this evaluation as suspected locations for undersized infrastructure.

The approach to evaluating stormwater conveyance capacity included the following five steps:

1. Compile a list of known and suspected problem areas
2. Classify problems according to suspected causes and determine which areas should be evaluated through H/H modeling
3. Identify the levels of service required for the various types of conveyance throughout the city
4. Develop hydraulic models to verify capacity problems and evaluate potential causes
5. Use the hydraulic models to simulate alternative conveyance system designs to identify potential solutions to capacity problems

The identification of problem areas can come from multiple sources such as City staff or residents. Typically, this information is generated through a survey and workshops with City staff. Problem areas are identified and then reviewed and evaluated for the likely cause of the issue if not known. Those areas that are identified as areas with capacity problems are then further evaluated through hydraulic modeling to determine the cause and/or potential CIP solution.

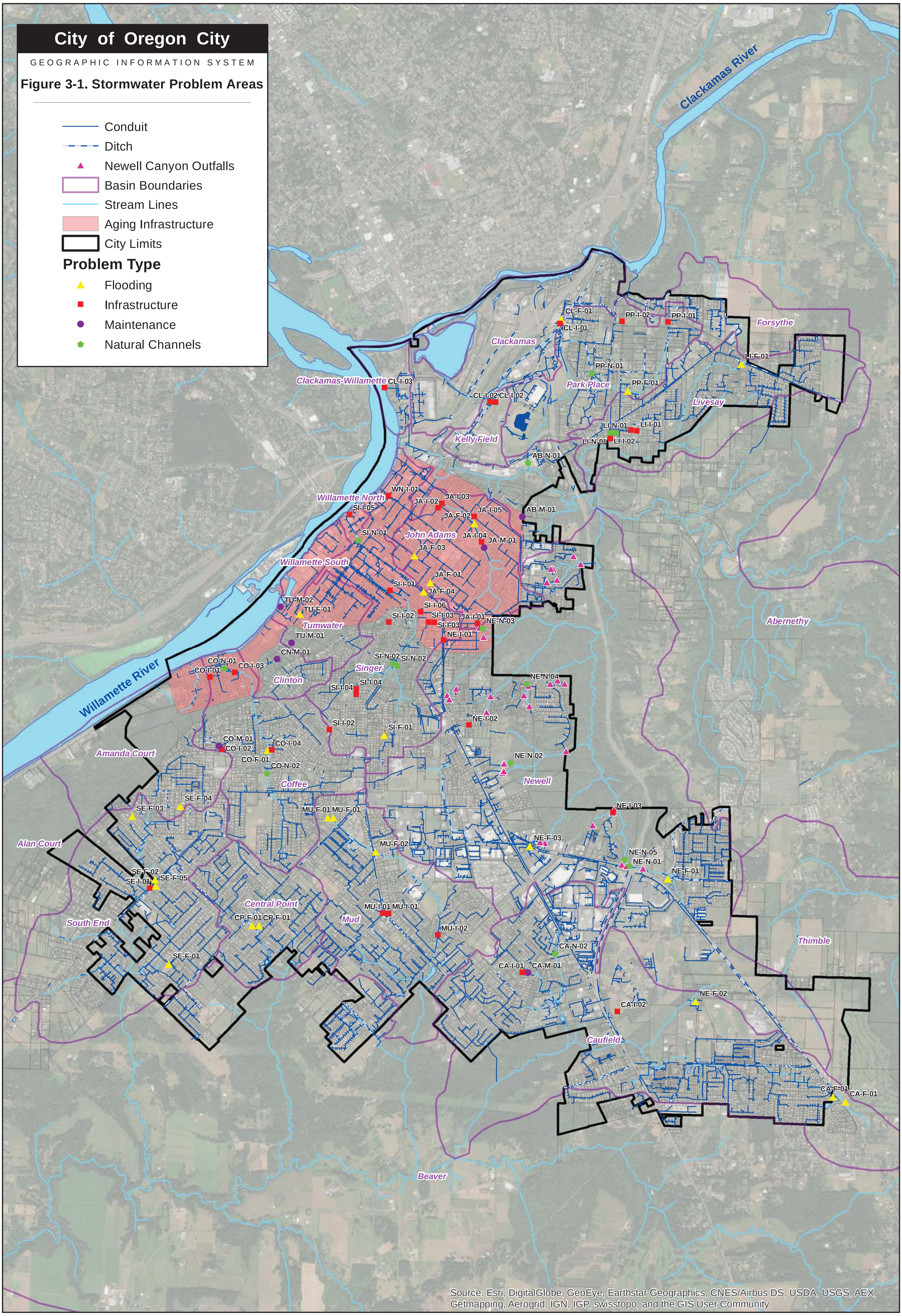
3.2 Problem Area Identification

Problem area identification is a synthesis of data and input from numerous sources to develop a master list of problem areas. This study followed this framework to develop a master list of problem areas, sorted by problem type and source. The identified problems are shown on Figure 3-1 and documented in a matrix provided in Appendix A.

Problem area data sources included the following:

- Watershed workshop with City staff
- City maintenance staff problem area maps and notes
- Citizen input at public meetings and events
- Previous technical studies and master plans

Winter storm events in 2015 and 2016 caused widespread flooding across the Portland Metro region. A driving assumption for this study was that recent storm events are good indicators of stormwater system capacity. Areas that did not experience significant flooding in 2015 or 2016 were assumed to have capacity for existing conditions flows.



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-1. Stormwater Problem Areas

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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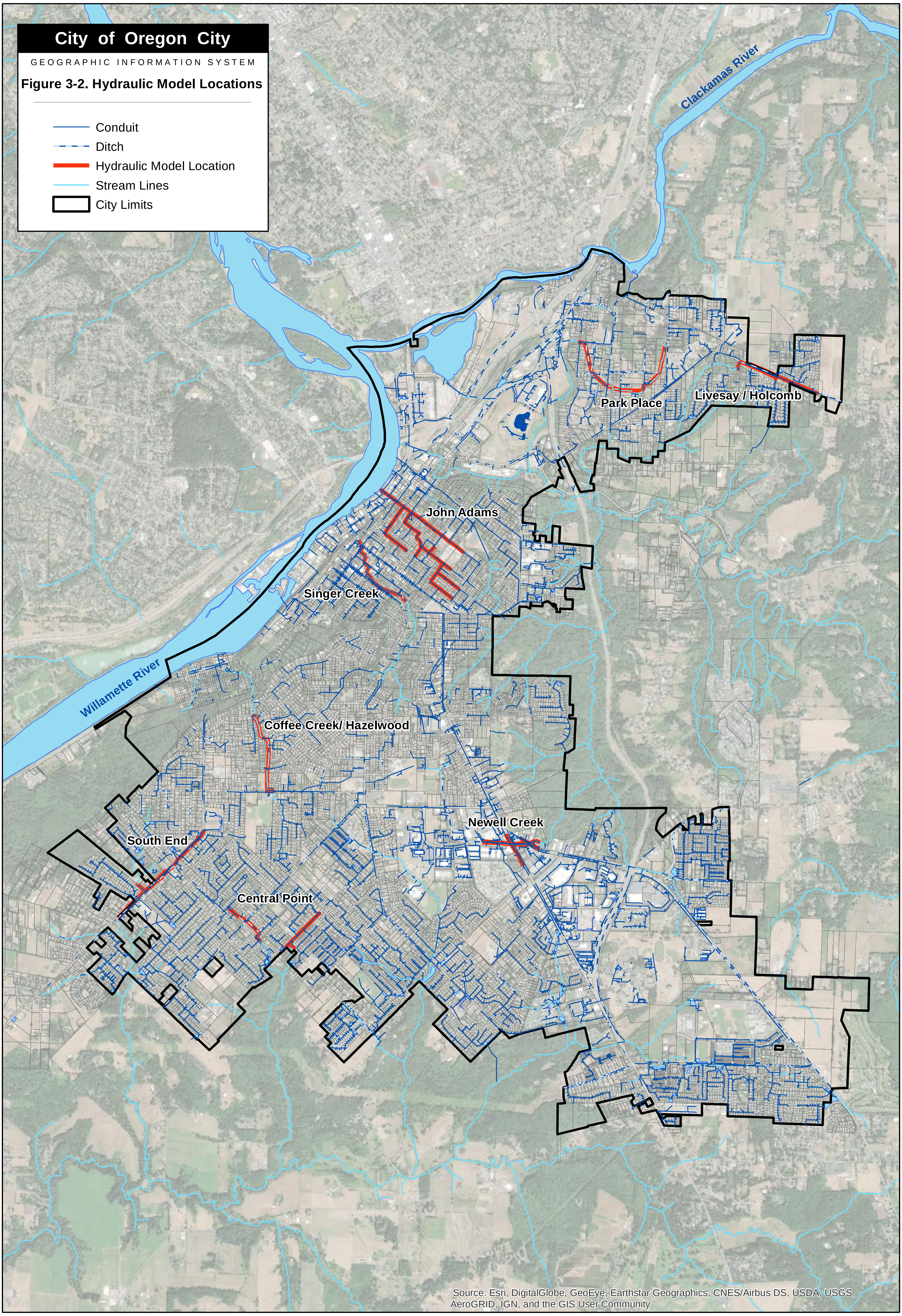
Plot name: Figure 3-1 Problem Areas.pdf
Map name: Figure 3-1 Problem Areas.mxd



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-2. Hydraulic Model Locations

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

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Plot date: June 22, 2017
Plot name: Figure 3-2 Hydraulic Model Locations.pdf
Map name: Figure 3-2 Hydraulic Model Locations.mxd

3.2.1 Watershed Review Workshop

The watershed workshop conducted in December 2015 provided the primary opportunity for City staff to inform the problem areas list. The workshop allowed City and consultant staff to discuss stormwater system conditions in each of the City's 21 watershed areas. Staff from engineering, maintenance, development review, and water quality all attended the workshop to provide insights regarding stormwater system problems and opportunities. For each watershed area, the group discussed the development history, major stormwater facilities, anticipated development and redevelopment areas, and planned future projects. The group also brainstormed known and suspected problems related to flooding, failing infrastructure, missing infrastructure, water quality, and other concerns.

Following the workshop, all attendees were given an opportunity to review the workshop minutes and expand on the list of problem areas identified.

3.2.2 Maintenance Maps

Following the workshop, City maintenance staff also developed a series of maps, using sticky notes to mark problem areas throughout the city. The marked problem areas included locations that staff have observed themselves, areas where citizens have called to report drainage problems, and problem areas recorded in the City's Lucity tracking system. These maps provided additional detail to the information gathered during the larger staff workshop, as each note included the location, severity, and nature of the problem.

Through this effort, maintenance staff also identified locations of "priority drains" that commonly have flooding problems. Maintenance staff conduct drive-by inspections of priority drains during storm events so that they can remove blockages or post high-water warnings.

3.2.3 Public Meetings and Events

The following four public outreach events were conducted:

- Citizen Involvement Committee meeting (February 2017)
- Natural Resources Committee meeting (February 2017 and April 2019)
- Neighborhood meeting with the Canemah neighborhood (February 2017)

Public notice was provided through posted meeting agendas and information on the City's website. Additional information about the project was provided during Planning Commission meetings and briefings to City Commission.

At each event, a presentation was conducted to share an overview of the Plan, and attendees were given the opportunity to make notes on printed maps regarding drainage problem areas and other stormwater-related concerns. Attendees were also encouraged to complete a stormwater infrastructure survey to provide written input to the master planning process.

3.2.4 Previous Plans

The project team reviewed existing technical studies and previously developed master plans to document previously identified problem areas and/or recommended projects. The plans reviewed included the following:

- Oregon City Drainage Master Plan, 1988
- Caufield Basin Master Plan, 1997 (planning area concept plan)
- South End Basin Master Plan, 1997 (planning area concept plan)
- Greater Oregon City Watershed Council, Watershed Action Plan, 2010

3.3 Problem Area Classification

While the stormwater problem area list is extensive, most of the reported problems have limited supporting data or specific documentation. The list of stormwater problem areas included descriptions based on one event, a citizen's phone call to City staff, or anecdotal evidence of flooding observed by maintenance crews working on another issue. Determining the source or cause of the reported problem can be challenging with such limited data, so additional investigation or modeling is required to evaluate the problem areas and investigate potential solutions.

Once the problem areas list was compiled and vetted with City staff, the master list was divided into problem types. For this study, the following five problem types were considered:

- **Flooding:** observed or reported capacity concerns in open channels or conveyance systems
- **Infrastructure:** locations of failing infrastructure or missing infrastructure, such as neighborhoods constructed without stormwater conveyance systems
- **Maintenance:** priority drains and other areas that require frequent maintenance attention
- **Natural systems:** erosion or water quality concerns in creeks and tributaries
- **Opportunities:** potential project areas, previously identified by other plans or staff observation

Duplicate entries were used for problem areas that fell into multiple categories. Duplicate entries were also used for problem areas that were reported by more than one source. This methodology resulted in some problem areas showing up multiple times in the problem areas list (Appendix A) and map (Figure 3-1).

Flooding or capacity problem areas were then further evaluated to determine if hydraulic modeling would be beneficial to better understand the problem or to develop a conceptual solution. Typically, the systems that require modeling are longer pipe segments that may have complex flow dynamics, larger catchments that have higher rates of flow, or areas where there are higher risks of impacts to infrastructure or private property if the problem is not addressed. City staff and the consultant team worked together to determine where hydraulic models should be developed as part of this storm system capacity evaluation.

3.4 Levels of Service

Levels of service are defined as the design storm (peak flow) that the conveyance infrastructure should carry downstream without surcharge or flooding. The level of service can vary depending on the location of the infrastructure and the drainage area. For instance, a pipe conveying flow from a residential neighborhood will require a level of service equal to the 25-year, 24-hour storm event. However, a culvert or pipe system conveying drainage from several neighborhoods may require that the level of service be equal to the 50 year, 24-hour storm event because of the consequences of failure for that culvert (road washout) as opposed to consequences of failure in a residential neighborhood (localized ponding).

For Oregon City, levels of service for the stormwater conveyance system are defined in the City's Stormwater and Grading Design Standards, February 2015. Table 3-1 documents the City's standard requirements, which were applied to this Master Plan. In most areas of the city, the municipal stormwater conveyance system should be designed for the 25-year, 24-hour storm event because contributing drainage areas are between 40 acres and 640 acres in area.

Table 3-1. Stormwater Conveyance System Levels of Service

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

Source: Oregon City Stormwater and Grading Design Standards.

3.5 Model Development Summary

The development of an H/H model typically includes two major steps. First, the hydrology (the relationship between rainfall and runoff) is developed for the catchment contributing to the problem area, which may include multiple subcatchments. The hydrology is also developed with consideration for the interest points where the hydrology input will be needed in the model such as at pipeline junctions, significant changes in system slope, or locations where there are changes in conveyance pipe or channel size. Second, the conveyance system is developed upstream and downstream of the identified problem areas to the extent that is necessary to appropriately assess the location hydraulics. The model is then used to verify the problem and develop alternatives to correct the deficiency.

There are eight locations (see Figure 3-2) where hydraulic models were developed as part of this master planning effort:

- **Central Point Basin:** Modeled from Vincent Drive to the outfall near Sunset Springs and McCord Road and from Crisp Drive to Pavilion Place down to Pease Road.
- **Coffee Creek Basin:** Modeled from Warner Parrot Road to Barker Road.
- **Livesay Basin:** Modeled Holcomb Blvd from Kittyhawk Avenue to the outfall on Oak Tree Terrace.
- **John Adams Basin:** Includes three conveyance systems that meet at Washington Street and 12th Street. The modeled segments start at 12th Street and Harrison, 8th Street and Taylor, and 9th Street and Madison Street.
- **Park Place Basin:** Modeled from Swan Avenue to the outfall at Apperson Blvd and La Rae Street.
- **Singer Creek Basin:** Modeled from 6th Street and Harrison Street to the outfall at Singer Hill and 7th Street.
- **South End Basin:** Modeled South End Road from S Gentry Way to the outfall between Salmonberry Drive and S Forest Ridge Road.
- **Newell Creek Basin:** Modeled the Warner Milne system from Beavercreek Road, across Molalla Avenue, to the outfall west of the Beavercreek Road/Molalla Avenue intersection.

One-dimensional XP-SWMM hydraulic models were developed based on existing geographic information system (GIS) data provided by the City, field survey collected as part of the master planning effort, and site visits conducted by consultant staff.

The existing hydrology for the 25-year storm event was used in the initial model built to evaluate the capacity of the existing infrastructure. Future hydrology is based on the future land use classifications outlined in City planning documentation. The hydrology for future conditions was applied to the existing-conditions hydraulic model. This process enables the future hydrology to be applied to the existing infrastructure and assessed for future capacity and other potential problems.

Limited model validation was performed by comparing the existing-conditions hydraulic modeling results to anecdotal flood reports. No model calibration was included with this study because of a lack of available flow data, images from storm events, or verbal descriptions of flooding.

Additional details related to H/H model development and analysis are included in Appendices B and C.

3.6 Model Results

The modeling shows flooding and capacity problems that are generally consistent with reported problem areas. The following sections summarize the model results and suspected causes of system capacity problems. Appendix C provides more detailed information and model results in a tabular format.

3.6.1 Central Point Basin

The hydraulic model results (see Figure 3-3 and Table 3-2) for the Central Point Basin show that the pipe at the downstream end of the open channel along South McCord Road between South Central Point Road and Sunset Springs Drive is undersized. This causes flooding to occur during the 25-year design event. This flooding simulated by the model is consistent with problems reported by City staff. In addition to undersized pipes, the system capacity is further reduced by several 90-degree bends in the drainage network. The roadway drainage discharges on the west side of Central Point Road near Kathaway Court, where it joins the main channel to flow back under Central Point Road to the east. The flooding is most problematic at 19451 Sunset Springs Drive.

The second area of modeling shows that the existing infrastructure on Pease Road is at capacity and water surface elevations are near the surface, but it has adequate capacity to carry future flows during the 25-year storm event.

City maintenance staff have recently modified the inlet/outlet structures near Kathaway Court to reduce losses and improve flow capacity. These modifications improved conditions and reduced flooding during the 2016/17 winter storm events. No capacity projects are recommended for the Central Point conveyance system at this time. The City will continue to monitor the drainage network to determine if any further improvements are needed.

Inlet to culvert under Central Point Road on private property.

Table 3-2. Central Point Basin Hydraulic Model Results for 25-yr Storm

Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
808424	42490_CP_0500	38777	444.58	448.68	443.97	440.61
803448	33962	35483	467.71	467.48	467.71	460.86
803449	35483	35481	467.48	450.42	460.86	444.94
803703	35630	35478	439.21	432.23	431.70	430.10
807429	37879_CP_0800	33962	468.84	467.71	477.46	467.71
808422	33002	39749	447.90	445.23	444.38	443.98
808427	39588	34501	438.46	438.50	434.54	434.27
808428	34502	39588	440.22	438.46	435.42	434.54
808653	38733_CP_0800	35630	440.18	439.21	432.43	431.70
808654	35481	38733_CP_0800	450.42	440.18	444.80	432.43
809337	34503	34502	441.35	440.22	436.83	435.42
809791	34248_CP_0100	35487	438.92	438.59	438.57	437.31
809793	35487	35484	438.59	437.00	437.31	435.23
812537	39749	42490_CP_0500	445.23	444.58	443.98	443.97
Link18	33700_CP_0600	33002	450.79	447.90	445.59	444.38
Link19	38888	30909_CP_0400	441.29	439.11	440.45	439.11
Link20	30909_CP_0400	34503	439.11	441.35	439.11	437.84
Link21	38777	38888	448.68	441.29	440.61	440.45
Link25	35484	35478	437.00	432.23	435.23	429.59
Link26	35478	40654	432.23	425.18	429.59	423.89
Link27	34501	33145	438.50	435.27	434.27	433.27

**Shaded rows indicate a flooded link during simulation of the 25-year design event.*

3.6.2 Coffee Creek Basin

The hydraulic model was used to evaluate the open-channel system along the Coffee Creek alignment. The system is mostly open channels with culverts at road crossings and other restrictive hydraulic features on private property.

The hydraulic model results (see Figure 3-4 and Table 3-3) for the Coffee Creek Basin show flooding around hydraulic constrictions beginning at the 10-year design storm. The water overtops the banks of the channel, flooding the backyards of residential homes. The flooding is most problematic near 939 Hazelwood Drive where the creek crosses Hazelwood Drive. The southeast corner of Hartke City Park and properties in the area flood because of a restriction built into the channel. An undersized rusted corrugated metal pipe (CMP) in the backyard of the home at 965 Hazelwood Drive is another restriction along the creek. The system also has multiple constrictions and modified culvert inlets that greatly reduce the capacity of the open-channel system.

City staff have been actively working with homeowners to address constrictions in the existing system. In terms of CIPs, a 24-inch high-flow bypass is being recommended as a possible course of action to mitigate flooding within the neighborhood. Modeling of this scenario show reduced flooding in the private residential areas. The project may also require expanding the existing crossing near 930 Hazelwood Drive (Node “CO_0300” in Figure 3-4) to fully convey the 25-year peak flow.

Table 3-3. Coffee Creek Basin Hydraulic Model Results for 25-yr Storm

Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
618.1	42534_CO_0500	42533	445.16	444.48	443.75	441.87
802016	40182_CO_0800	34657	456.03	456.54	455.71	453.97
808374.1	40182_CO_0800	34657	456.03	456.54	455.71	453.97
808377	42472_CO_0600	42473	453.69	454.24	452.54	450.47
808379.1	42475_CO_0400	42474	417.69	416.03	416.96	412.85
808379.2	42475_CO_0400	42474	417.69	416.03	416.96	412.85
808867	CO_0300	42552	433.21	432.52	433.21	430.25
Backyard	42534_CO_0500	42533	445.16	444.48	443.75	443.07
Link10	42552	42475_CO_0400	432.52	417.69	430.25	416.96
Link11	Node16	Node17	450.46	450.36	450.46	447.43
Link12	Node17	42534_CO_0500	450.36	445.16	447.43	443.75
Link13	42533	Node19	444.48	441.82	441.87	441.53
Link14	Node19	Node20	441.82	442.53	441.53	440.00
Link15	Node20	CO_0300	442.53	433.21	440.00	433.21
Link6	34657	40188_CO_0700	456.54	457.06	453.97	452.97
Link7	40188_CO_0700	42472_CO_0600	457.06	453.69	452.97	452.54
Link8	42473	Node16	454.24	450.46	450.47	450.46

**Shaded rows indicate a flooded link during simulation of the 25-year design event.*

3.6.3 Livesay Basin

The Livesay Basin model was built to assess reported flooding and verify capacity of the existing infrastructure to manage flows from future development, as well as assess system capacity from recent developments already built at Abernethy Landing. Model results revealed that much of the infrastructure along Holcomb Boulevard is undersized and will need to be replaced if future development is to occur within the drainage area. A future conditions model was developed that takes into account the development and drainage improvements made as a part of the Abernethy Landing project. The updated model shows flooding begins for the future flow scenario at the 2-year design event. The most significant flooding occurs at the transition between open channels and piped flow where the stormwater system from the north side of Holcomb Boulevard crosses to the south side, west of Oaktree Terrace. Additional flooding occurs downstream of this location before the drainage system turns south under Oaktree Terrace. Modifying the inlet structures to increase hydraulic efficiency and properly sizing the downstream infrastructure is likely needed to alleviate flooding. In addition to proper sizing of conduits, relief of flooding has the potential to increase flows downstream. The design of improvements to alleviate flooding will also need to assess impacts to natural systems due to increased flows and velocities at the outfall to the natural system.

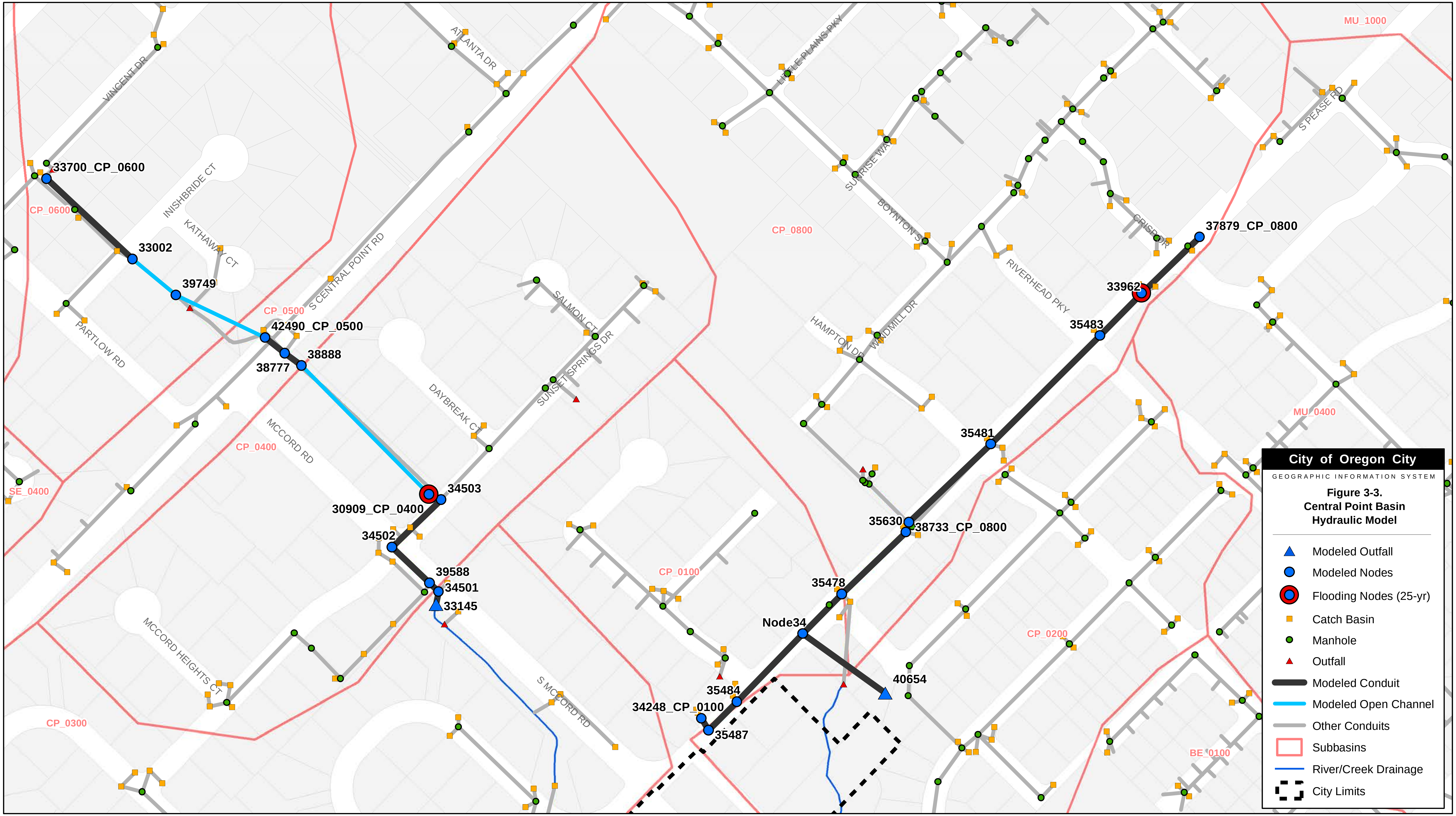
The Livesay Basin is an area of expected future development and the flooding problems are shown to be a result of increased flows as the basin is projected to increase in impervious surfaces. Projects to upsize the Holcomb Boulevard conveyance system should be constructed in conjunction with future development in the basin. The hydraulic model results for the Livesay Basin are shown in Table 3-4 with model extents shown on Figure 3-5.

Table 3-4. Livesay Basin Model Hydraulic Model Results for 25-yr Storm

Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
Link1	33740_LI_1200	33742	512.76	510.16	504.45	502.75
Link13	34160	42491	435.25	432.4	430.89	429.04
Link14	32573_LI_1100	34374_LI_1000	441.61	430.48	438.97	423.98
Link15	34374_LI_1000	35610	430.48	418.42	423.89	411.91
Link16	35610	35612	418.42	412.91	411.91	409.76
Link17	35612	35607	412.91	400.77	409.42	398.73
Link18	35607	35686	400.77	398.88	398.73	396.20
Link19	35686	39436	398.88	385.02	396.20	384.72
Link2	33742	34162_LI_1100	510.16	505.96	502.55	501.43
Link20	39436	34997	385.02	379.93	384.72	377.48
Link21	34997	30828_LI_0600	379.93	366.9	377.48	364.33
Link22	30828_LI_0600	39842	366.9	368.26	364.32	357.13
Link23	42491	39313_LI_1000	432.4	428	429.04	426.72
Link24	39313_LI_1000	Node25	428	403.39	426.12	403.03

Table 3-4. Livesay Basin Model Hydraulic Model Results for 25-yr Storm						
Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
Link25	Node25	35607	403.39	400.77	403.03	398.73
Link29	Node31	Node31.1	519.47	512.76	509.17	507.72
Link29.1	Node31.1	Node34	512.76	506.82	507.72	502.97
Link3	34162_LI_1100	34161	505.96	465.63	501.43	461.29
Link30	Node34	34162_LI_1100	506.82	505.96	502.97	501.73
Link4	34161	33066	465.63	453.44	461.29	450.27
Link5	33066	33065	453.44	438.65	450.22	436.36
Link6	33065	34160	438.65	435.25	436.36	430.89

**Shaded rows indicate a flooded link during simulation of the 25-year design event.*



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-3.
Central Point Basin Hydraulic Model

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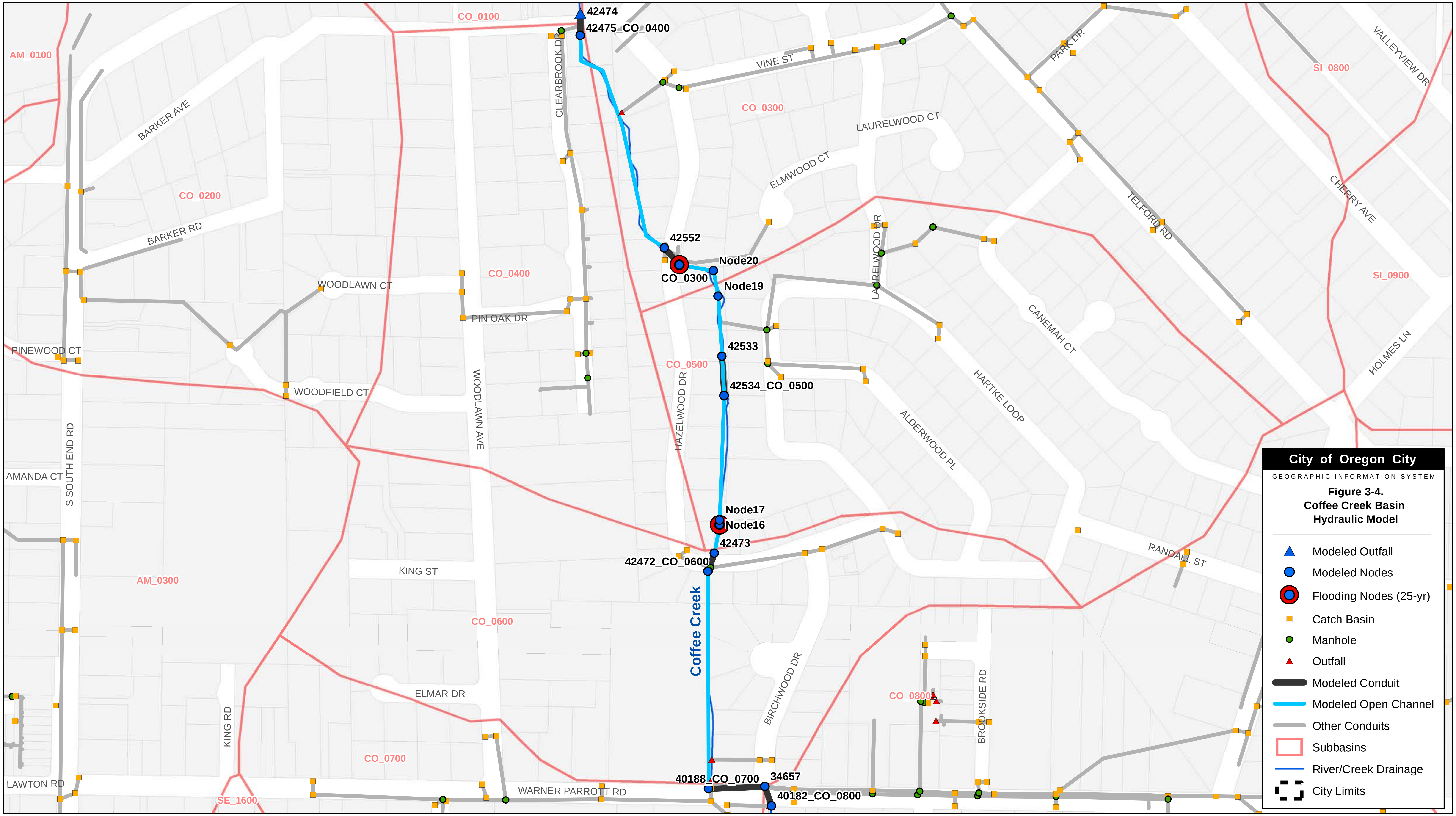
Plot date: June 20, 2017
Plot name: Figure 3-3 Central Point Basin.pdf
Map name: Figure 3-3 Central Point Basin.mxd



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-4.
Coffee Creek Basin
Hydraulic Model

N
W E
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0 250 500 1,000 1,500
Feet

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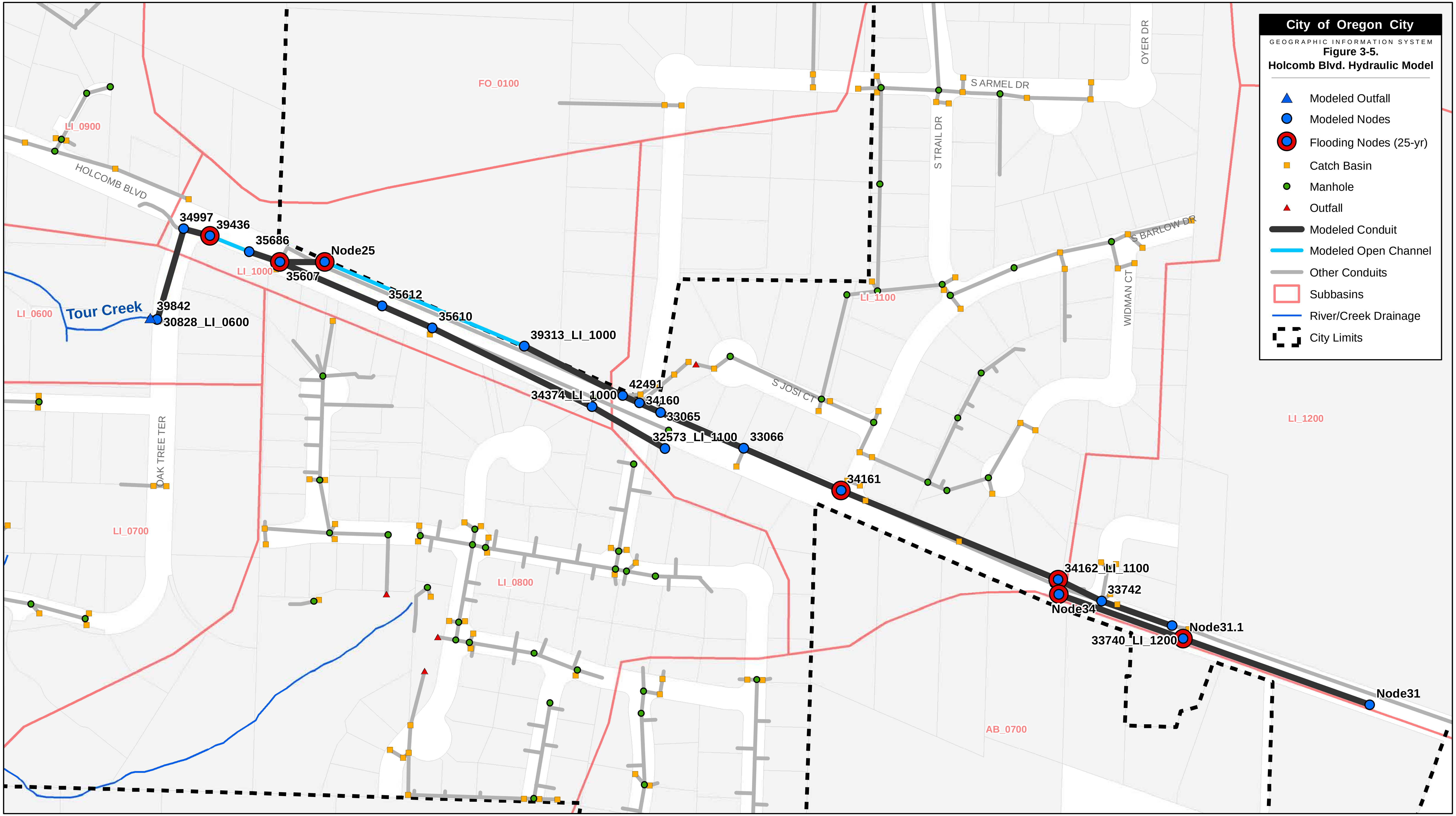
Plot date: June 20, 2017
Plot name: Figure 3-4 Coffee Creek Basin.pdf
Map name: Figure 3-4 Coffee Creek Basin.mxd

City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-5. Holcomb Blvd. Hydraulic Model



The City of Oregon City makes no representations, express or implied, as to the accuracy, completeness and timeliness of the information displayed. This map is not suitable for legal, engineering, or surveying purposes. Notification of any errors is appreciated.

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Plot date: June 20, 2017
Plot name: Figure 3-5 Livesay Basin.pdf
Map name: Figure 3-5 Livesay Basin.mxd

3.6.4 John Adams Basin

The results of the John Adams Basin analysis reveal several areas where the system is undersized and floods, especially in areas where the stormwater system transitions from larger-diameter to smaller-diameter pipes. Routine flooding has been reported at the intersections of 9th and John Adams Streets, 11th and John Adams Streets, and 11th and Madison Streets, among other locations. Model-predicted flooding occurs during the 2-year design event, which is consistent with the reported flooding frequency.

This area has some of the oldest infrastructure in the city and is complex, while undersized for the areas it drains. Much of this infrastructure is well past its design life, suggesting there may be locations where pipes are partially collapsed or have root growth or other conditions that further reduce capacity. The system has many 90-degree bends and structures that act as flow splitters, which further reduce conveyance efficiency.

In addition to the frequent flooding locations reported above, the hydraulic model shows flooding during the 25-year event (see Figure 3-6) along most conveyance trunk lines between 9th and 12th Streets and between Washington and Van Buren Streets, as shown in Table 3-5.

Table 3-5. John Adams Basin Hydraulic Model Results for 25-yr Storm

Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
800781	34313	33514	162.29	171.45	161.08	153.28
801568	33504	33474	261.10	254.51	261.10	254.51
801573	33473	34769	226.39	226.95	223.03	220.87
802603	33505_JA_1400	38651	316.50	286.90	310.38	281.42
802604	33566_JA_1600	34696	330.45	318.74	330.45	314.66
802606	34698	33504	289.22	261.10	283.03	261.10
804813	33520	43469	96.27	88.74	83.22	75.98
804814	33519	33520	99.89	96.27	93.02	87.25
804815	33521	34704_WN_0300	86.97	73.55	74.18	67.05
804841	33475_JA_1000	33473	243.58	226.39	243.58	223.03
804846	33469	33508	188.90	191.51	188.90	185.23
804848	33514	33515	171.45	153.00	153.03	145.34
804851	33515	34191_JA_0100	153.00	128.90	145.16	128.90
804860	33517_WN_0400	33516	185.10	179.60	182.36	179.60
804861	33523	33517_WN_0400	201.40	185.10	193.08	182.36
804867	34311_WN_0500	33523	207.50	201.40	200.31	193.42
804870	34767_JA_1100	34309	209.10	198.92	209.10	193.47
804934	38650_JA_1500	33475_JA_1000	269.84	243.58	269.84	243.58
804969	33513_JA_0300	33519	119.72	99.89	118.80	93.85
806396	37054	33513_JA_0300	162.35	119.72	159.31	118.80
806401	37059	37054	178.38	162.35	173.72	159.31
806402	37062	37059	208.79	178.38	206.49	173.73
806406	37064	37062	210.50	208.79	208.95	207.02

Table 3-5. John Adams Basin Hydraulic Model Results for 25-yr Storm

Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
806411	37070_JA_0500	34769	224.81	226.95	224.81	220.87
806471	37118	37139_WN_0100	57.70	53.08	57.70	53.08
806474	37139_WN_0100	37142	53.08	53.08	53.08	50.09
808623	37142	41009	53.08	52.70	50.09	48.32
808624	43300	43301	61.81	61.81	46.43	44.94
808704	33474	33475_JA_1000	254.51	243.58	254.51	243.58
808721	34309	33508	198.92	191.51	190.80	183.92
812475	36378	34534	168.58	167.42	168.58	166.00
812477	33516	36378	179.60	168.58	179.60	168.58
812478	34534	43051	167.42	163.93	166.00	160.78
812479	43051	43050	163.93	155.49	160.78	151.78
812692	41009	43300	52.70	61.81	48.32	46.43
812695	43301	39733	61.81	19.40	43.94	14.79
812816	43469	33521	88.74	86.97	75.98	74.18
Link43	38651	33474	286.90	254.51	281.04	254.51
Link44	34696	34698	318.74	289.22	314.00	283.21
Link45	34692_JA_1300	37087	250.94	248.38	368.43	248.38
Link46	37087	33491_JA_0200	248.38	234.43	248.38	234.43
Link47	33491_JA_0200	37064	234.43	210.50	234.43	208.95
Link48	34769	33469	226.95	188.90	220.87	188.90
Link49	33508	34313	191.51	162.29	180.16	161.08
Link54	34704_WN_0300	37118	73.55	57.70	67.05	57.70
Link55	43050	Node58	155.49	126.51	151.10	124.78
Link56	Node58	Node59	126.51	114.00	124.67	111.72
Link57	Node59	33521	114.00	86.97	111.57	84.64
Link58	34191_JA_0100	34192	128.90	120.42	128.90	120.42
Link59	34192	41014	120.42	109.91	120.42	109.50
Link60	41014	33519	109.91	99.89	109.50	93.13

**Shaded rows indicate a flooded link during simulation of the 25-year design event.*

The conveyance system is undersized and surcharged or flooding at numerous locations throughout the John Adams Basin. Much of this system is aged and may need replacement regardless of capacity.

3.6.5 Park Place Basin

The existing Park Place Basin model results showed no flooding at locations that were reported to be problem areas by residents and City staff. This inconsistency is suspected to be the result of private development changing the drainage patterns in these areas and reducing flows to the identified problem areas since the time staff and residents have observed problems. The hydraulic model extents for the Park Place Basin are shown on Figure 3-7.

The existing model does identify several other areas of flooding. The culvert crossing under Hiram Avenue shows flooding with the 2-year design event. Other locations show flooding during the 25-year, 24-hour storm, (see Table 3-6) including an undersized culvert near the intersection of Clear Street and Front Avenue, the transition from open channel to closed conveyance east of Hunter Avenue and south of Cleveland Street, and the culvert in the backyard of 16163 South Harley Avenue. These locations, identified as potential projects, should be on the City’s watch list. No capital projects are proposed for the Park Place basin at this time, as culverts and problem areas are likely to be modified as part of future development.

Table 3-6. Park Place Basin Hydraulic Model Results for 25-yr Storm

Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
801099	30675	30674	114.51	114.42	113.79	113.37
801520	34163	34164	201.5	194.73	190.96	188.49
801521	34164	34511	194.73	192.57	188.49	185.89
801522	34166	34163	195.75	201.5	192.45	191.37
804027	40789_PP_0800	40790	223.9	220.09	223.23	218.62
806132	30676	36849	116.68	115.17	114.92	114.29
806133	36849	30675	115.17	114.51	114.29	113.79
806138	36853	30676	134.95	116.68	133.01	114.92
806331	41420	37021	148.22	147.94	148.22	147.05
808078	30674	38518	114.42	113.64	113.37	112.85
808079	38518	PP_0500	113.64	113.49	112.85	112.41
809819	37021	41421_PP_0600	147.94	147.05	147.05	146.19
809820	41350	36853	133.49	134.95	133.49	133.01
812683	43287_PP_1000	43288_PP_0900	264.56	263.56	264.56	255.85
Link17	33393	34166	199.5	195.75	199.50	192.45
Link18	34511	PP_0700	192.57	192	183.25	182.06
Link20	40854	40855	103.38	98.5	103.38	96.03
Link21	41341	36790_PP_0300	93.79	90.65	92.65	82.32
Link22	36790_PP_0300	41342	90.65	80.85	82.32	69.12
Link23	43288_PP_0900	40789_PP_0800	263.56	223.9	255.85	223.23
Link24	40790	33393	220.09	199.5	218.62	199.50
Link27	41421_PP_0600	41350	147.05	133.49	146.19	133.49
Link28	PP_0500	40854	113.49	103.38	112.41	103.38
Link29	40855	41341	98.5	93.79	96.03	92.65
Link31	PP_0700	41420	192	148.22	182.06	148.22

**Shaded rows indicate a flooded link during simulation of the 25-year design event.*

3.6.6 Singer Creek Basin

No flooding or problem areas were identified for this area but City staff requested that a model be built and the system be assessed because of its age and alignment through private property. The modeled system shows no flooding, yet it is surcharged and the water surface during the 25-year design event (see Table 3-7 and Figure 3-8) is at or near the surface.

The drainage basin contributing to Singer Creek is mostly built out, but as densification and infill occurs, care should be taken to address any increase in peak flows. The infrastructure is some of the oldest in the city and will require regular inspections and assessment to ensure function. Additionally, the creek is aligned across private property and directly under structures in a few instances. No capital projects are proposed for Singer Creek basin at this time. However, the trunk line should be relocated into the public right-of-way and out of private property as infill development impacts the affected properties.

Table 3-7. Singer Creek Basin Hydraulic Model Results for 25-yr Storm

Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
800363	39390_SI_0500	33815	218.52	205.18	208.12	199.51
803639	34189	35537	174.46	174.00	173.05	171.26
803641	35540	34189	177.61	174.46	176.49	173.05
803643	SI_0300	35540	177.80	177.61	177.80	176.49
804123	35900	SI_0300	180.04	177.80	179.71	177.80
804124	35902	35900	180.96	180.04	180.96	179.71
804125	35903	35902	185.01	180.96	182.98	180.96
804126	34190	35903	189.08	185.01	185.11	182.98
804191	33815	35985	205.18	191.23	199.51	187.03
804192	35985	34190	191.23	189.08	187.03	185.11
804812	34187	35594	171.23	165.19	167.28	162.38
806469	37138	36507_SI_0400	164.15	159.74	160.12	155.12
806470	35594	37138	165.19	164.15	162.38	160.12
Link14	40796_SI_0600	40797	221.02	220.00	219.16	216.65
Link15	40797	Inlet	220.00	225.00	216.65	216.60
Link15.1	Inlet	40897	225.00	229.48	216.60	216.47
Link16	36023	39390_SI_0500	229.61	218.52	214.61	208.12
Link17	40897	36023	229.48	229.61	216.47	214.61
Link18	35537	34187	174.00	171.23	171.26	167.28
Link19	36507_SI_0400	42737	159.74	151.00	155.12	149.46

**Shaded rows indicate a flooded link during simulation of the 25-year design event.*

The hydraulic model extents for the Singer Creek Basin are shown on Figure 3-8.

3.6.7 South End Basin: South End Road

The South End conveyance system includes a mix of open channels and large and small pipes, which has resulted in an inefficient system. Based on model results (see Table 3-8), this system starts to flood during the 2-year event. The flooding starts near South Rose Road where the open-channel system enters a closed system. The entrance grate configuration and pipes are not sized sufficiently to convey the runoff. The system then decreases in pipe diameter and significantly increases in slope. The conveyance infrastructure floods farther down South End Road where a culvert capturing the open-channel flow is under capacity. The hydraulic model extents for the South End Basin are shown on Figure 3-9. A capital project is proposed to upgrade the conveyance system along South End Road to address existing capacity problems. The project should construct a closed stormwater conveyance system that could serve a future roadway expansion.

Table 3-8. South End Basin Hydraulic Model Results for 25-yr Storm

Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
2	39657	39658	433.30	433.56	431.72	431.11
681.1	39657	39658	433.30	433.56	431.72	431.11
800101	40224	38962	453.42	451.20	452.06	451.20
800102	38963	30628	450.92	450.12	450.13	450.12
800823	33801	33800	452.50	449.78	449.72	449.63
800824	30628	33801	450.12	452.50	450.12	449.72
801783	33800	42854	449.78	447.80	449.63	446.98
802067	33531_SE_1300	33530	461.95	459.99	460.89	458.34
802192	33899	40224	455.75	453.42	452.83	452.06
802326	32462_SE_1200	34366	440.93	447.02	437.82	437.31
802787	38962	38963	451.20	450.92	451.20	450.13
803617	35517_SE_1400	33531_SE_1300	465.59	461.95	465.59	460.89
807270	37785_SE_1000	33899	458.00	455.75	455.52	452.83
807271	37787	37785_SE_1000	459.02	458.00	456.16	455.52
808402	38973_SE_0800	39657	433.34	433.30	431.85	431.72
808415	39658	42487	433.56	431.11	431.11	431.11
808417	42487	39582	431.11	428.66	431.11	426.68
809300	33535_SE_1600	35517_SE_1400	468.36	465.59	468.34	465.59
809303	32769_SE_1500	33531_SE_1300	461.31	461.95	461.31	460.89
809312	33530	37788	459.99	459.22	458.34	456.92
809724	34366	34365_SE_1100	447.02	446.54	437.31	437.15
Link20	37788	37787	459.22	459.02	456.92	456.16
Link21	32798_SE_1000	34786	456.04	452.42	452.49	450.32
Link23	34786	Node65	452.42	450.47	450.32	448.86
Link24	Node65	Node66	450.47	448.92	448.70	447.66
Link25	Node66	Node67	448.92	448.55	447.66	447.17

Table 3-8. South End Basin Hydraulic Model Results for 25-yr Storm

Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
Link26	Node67	Node68	448.55	447.11	447.17	447.11
Link31	42854	34365_SE_1100	447.80	446.54	446.98	437.15
Link33	Node68	42854	447.11	447.80	447.11	446.98
Link36	34761_SE_0900	38973_SE_0800	438.14	433.34	435.10	431.85
Link37	34365_SE_1100	Node70	446.54	441.95	437.15	436.16
Link38	Node70	34761_SE_0900	441.95	438.14	436.16	435.10

**Shaded rows indicate a flooded link during simulation of the 25-year design event.*

3.6.8 Newell Creek Basin: Beavercreek Road and Molalla Avenue

The modeling has shown that pipes are under capacity at the Beavercreek Road crossing east of Molalla Avenue. One undersized pipe, across Beavercreek Road, is a restriction thought to be constructed to aid in filling upstream pipes as a form of detention. Regardless of the reason, the pipe is now a restriction and the cause of minor flooding starting with the 2-year design event. The pipes along Molalla Avenue that drain to Beavercreek Road have capacity while the smaller pipes along Beavercreek Road that contribute to the trunk line are surcharged for short periods of time during the 2-year event (see Table 3-9).

Replacement of the existing 40 feet of 12-inch-diameter pipe and 10 feet of 42-inch-diameter pipe, across Beavercreek Road, to match the upstream and downstream pipe sizes, which are 48 inches in diameter, will likely remove most of the capacity issues within the trunk line of this system. However, the flow restrictions in this system are likely serving as flow attenuation and mitigating peak flows downstream. This conveyance system is located upstream of Newell Canyon where erosion is a significant concern (see Section 6).

Upsizing the conveyance system will result in downstream erosion impacts that were determined to be of greater concern than the current flooding. For this reason, the capacity problem identified was not addressed in the potential project recommendations at this time. Instead, ongoing monitoring of the flooding in this area is recommended to determine the impacts to surrounding properties.

As opposed to upsizing conduits, and potentially causing further erosion issues, the City should investigate upstream opportunities to install green infrastructure or additional detention systems that would slow down the time-to-peak in the watershed. The retention systems can reduce flooding, improve water quality, and lower peak flows, which will in turn mitigate erosion issues.

Table 3-9. Newell Creek Basin Hydraulic Model Results for 25-yr Storm

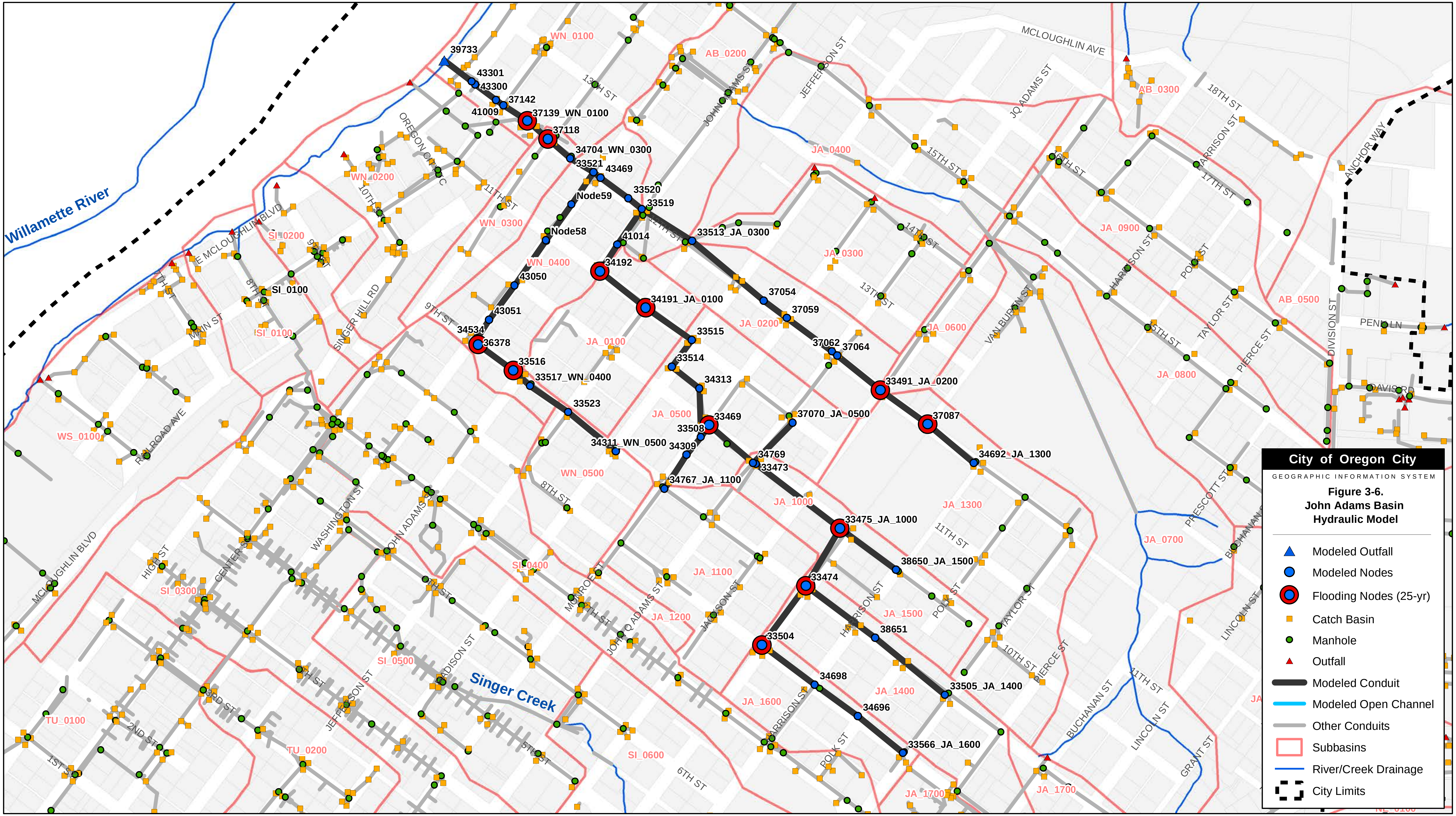
Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
800688	34994	39666	430.02	415.38	418.97	412.81
800690	34611	30023	429.34	430.16	429.34	426.31
800854	39740_NE_1900	34616	436.51	436.91	433.41	429.90
801962	34604	34603	441.90	437.52	439.19	433.95
801965	34605_NE_3100	34604	444.01	441.90	442.26	439.59
801981	30056_NE_3100	37259	439.36	433.77	436.07	432.43
803140	30021	30023	431.51	430.16	427.60	426.31
803172	30030_NE_2200	30027	434.39	433.37	434.39	432.69
803176	30027	30025	433.37	430.71	432.69	429.54
803179	30025	30024	430.71	430.26	429.54	427.50
803180	30024	30023	430.26	430.16	427.50	426.31
806619	37234	37235	433.20	433.20	429.40	429.40
806620	37234	30021	433.20	431.51	429.40	427.60
807452	37903	37901	427.94	430.44	427.94	426.94
807453	37238_NE_2200	37903	430.54	427.94	430.54	427.94
808393	39739_NE_1900	34615	436.49	436.91	434.75	430.93

Table 3-9. Newell Creek Basin Hydraulic Model Results for 25-yr Storm

Link ID	Node name		Ground elevation (ft)		Existing max water surface elevation (ft)	
	US	DS	US	DS	US	DS
Link18	34615	41521	436.91	432.42	430.86	429.46
Link19	41521	37235	432.42	433.20	429.46	429.40
Link20	37235	34611	433.20	429.34	429.40	429.34
Link21	30023	Node35	430.16	429.89	426.31	424.58
Link22	Node35	34994	429.89	430.02	424.58	418.97
Link23	37901	Node35	430.44	429.89	426.94	424.58
Link24	34603	42867	437.52	432.33	433.95	430.46
Link25	42867	41521	432.33	432.42	430.46	429.46
Link26	34616	35735_NE_1600	436.91	434.20	429.90	429.89
Link27	35735_NE_1600	41522	434.20	432.04	429.89	429.64
Link28	41522	37234	432.04	433.20	429.64	429.40
Link29	37259	41522	433.77	432.04	432.43	429.64

**Shaded rows indicate a flooded link during simulation of the 25-year design event.*

The hydraulic model extents for the Newell Creek Basin are shown on Figure 3-10.



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-6.
John Adams Basin
Hydraulic Model

- ▲ Modeled Outfall
- ● Modeled Nodes
- ◉ Flooding Nodes (25-yr)
- ■ Catch Basin
- ● Manhole
- ▲ Outfall
- ━ Modeled Conduit
- ━ Modeled Open Channel
- ━ Other Conduits
- ▭ Subbasins
- ━ River/Creek Drainage
- ⬚ City Limits

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Plot date: June 22, 2017
Plot name: Figure 3-6 John Adams Basin.pdf
Map name: Figure 3-6 John Adams Basin.mxd

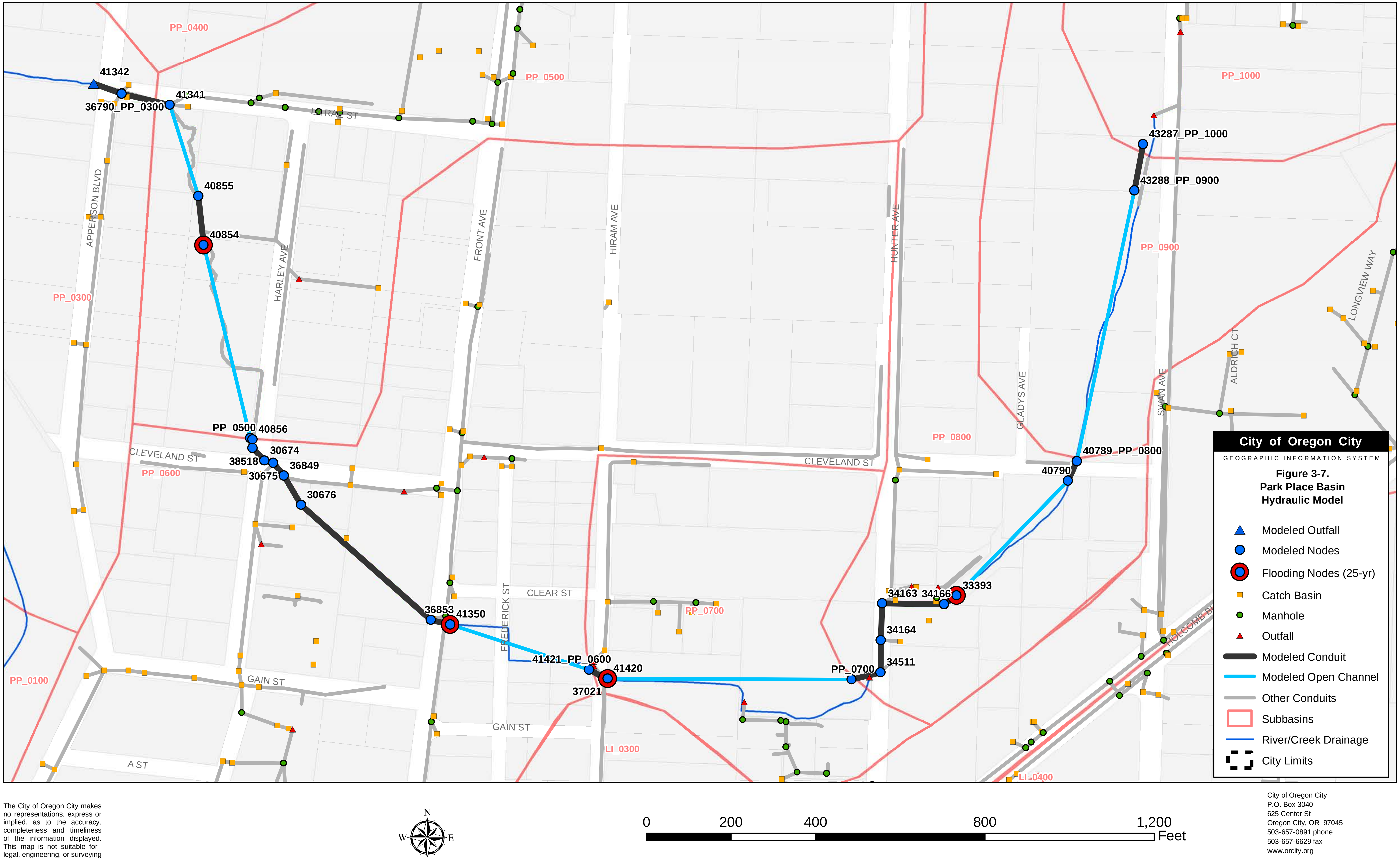

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**Figure 3-7.
Park Place Basin
Hydraulic Model**

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Plot date: June 20, 2017
Plot name: Figure 3-7 Park Placet Basin.pdf
Map name: Figure 3-7 Park Place Basin.mxd

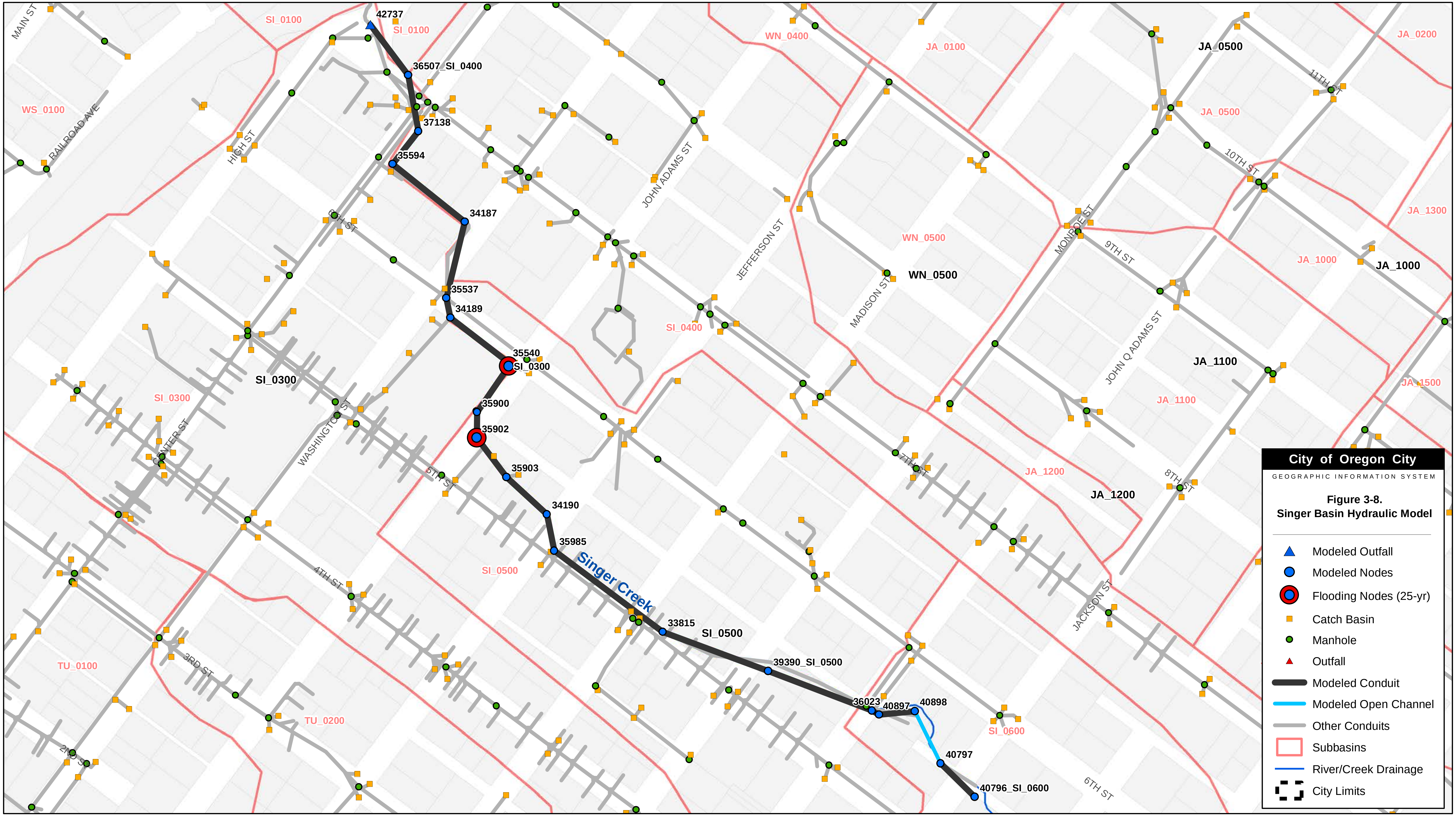

Figure 3-8.
Singer Basin Hydraulic Model

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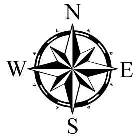

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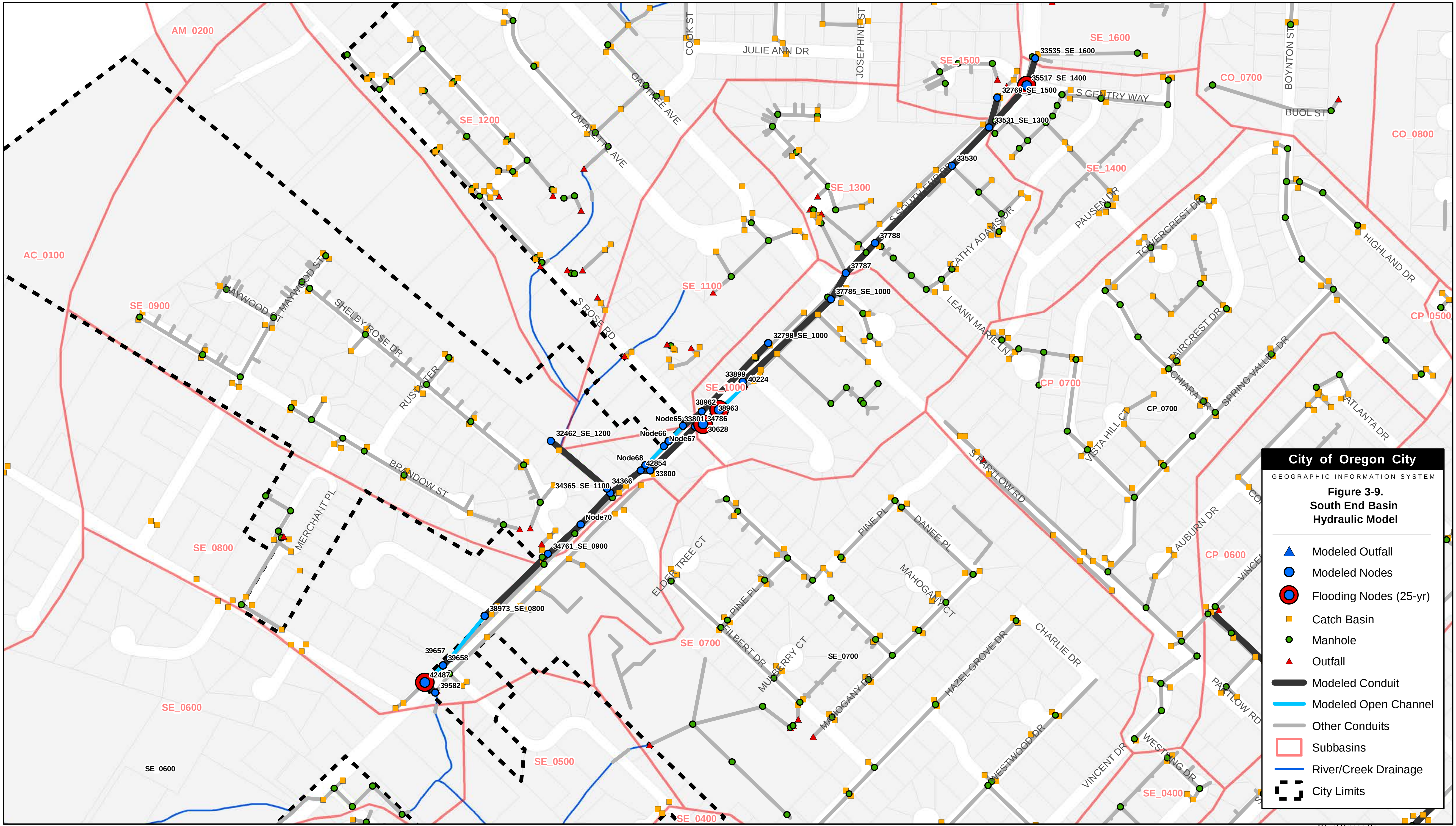
Plot date: June 20, 2017
Plot name: Figure 3-8 Singer Basin.pdf
Map name: Figure 3-7 Singer Basin.mxd



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-9.
South End Basin
Hydraulic Model

- ▲ Modeled Outfall
- ● Modeled Nodes
- ◉ Flooding Nodes (25-yr)
- ■ Catch Basin
- ● Manhole
- ▲ Outfall
- ▬ Modeled Conduit
- ▬ Modeled Open Channel
- ▬ Other Conduits
- ☐ Subbasins
- ― River/Creek Drainage
- ⬚ City Limits

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Plot date: June 20, 2017
Plot name: Figure 3-9 South End Basin.pdf
Map name: Figure 3-9 South End Basin.mxd

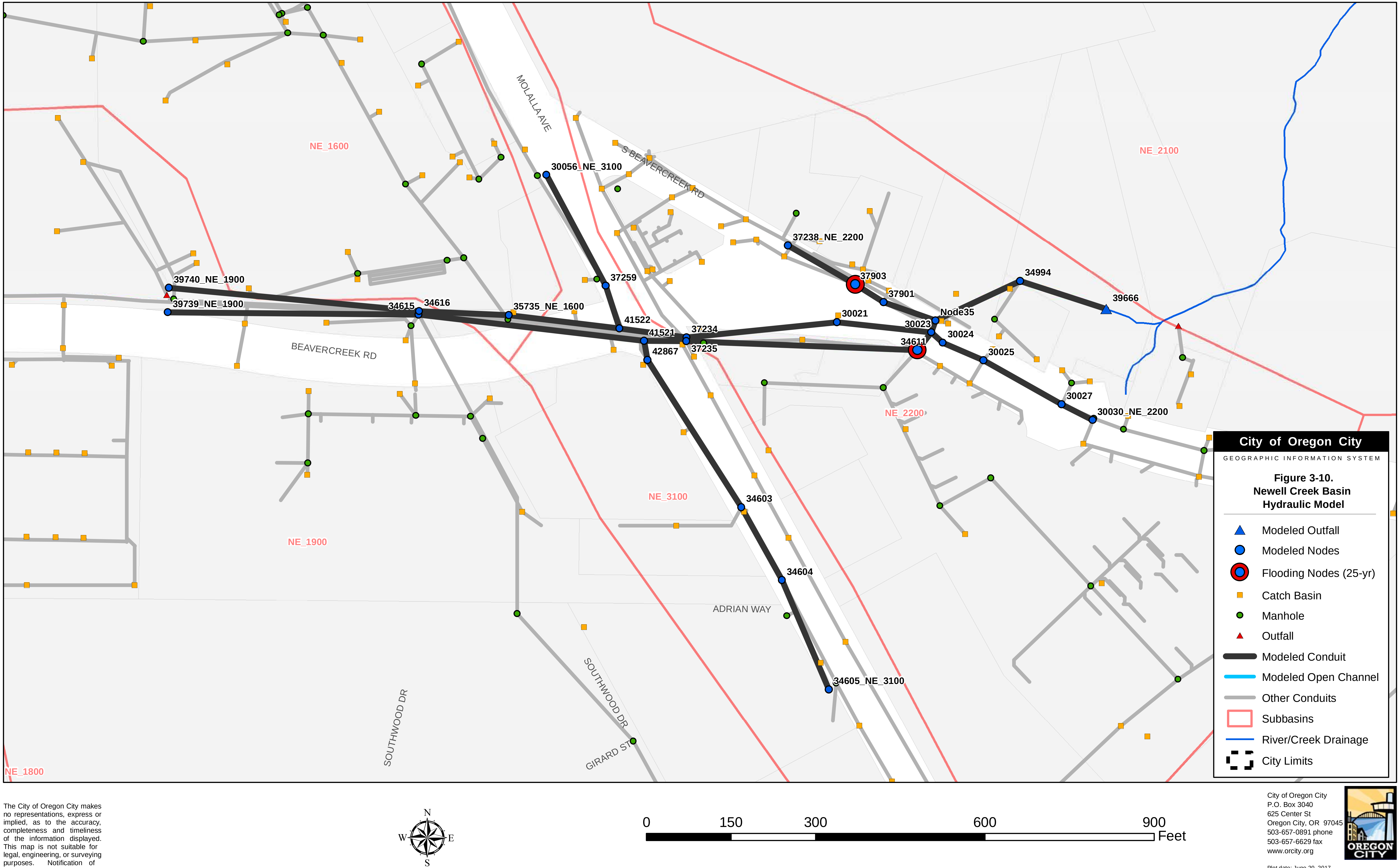

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Figure 3-10.
Newell Creek Basin
Hydraulic Model

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Plot date: June 20, 2017
Plot name: Figure 3-10 Newell Creek Basin.pdf
Map name: Figure 3-10 Newell Creek Basin.mxd

3.7 Capital Improvement Project Analysis

Based on the results of the system capacity analysis, two potential CIPs were identified to address capacity concerns. The John Adams and South End basins include multiple problem areas that could be addressed through modification of the stormwater conveyance infrastructure. In these areas, the hydraulic models were used to evaluate potential CIP alternatives and identify preferred conceptual solutions.

3.7.1 John Adams Infrastructure Replacement

The John Adams Basin is systemically undersized. Flooding was reported at multiple locations and the hydraulic model shows additional locations where the system is under capacity for the desired level of service. There is one location, at 9th Street and John Quincy Adams Street, where a manhole acts as a flow splitter directing incoming runoff down through two different pipes, which is an inefficient practice and is reflective of the challenges throughout this conveyance system. The storm alignment currently is routed through private property and around a home. The home is located at 1004 Madison Street. The pipe crosses through D.C. Latourette Tennis Courts Park and along the property line separating the park and home. The proposed CIP shifts the pipe alignment to the right-of-way and assumes the pipe through the park can be abandoned. The design engineer and contractor for this project should evaluate the drainage in this area to verify that no lateral connections exist in the sections of pipe that cross through the park and private property.

The CIP for this location recommends upsizing for every pipe that was modeled, except for two: the very last pipe in the system and one 24-inch-diameter pipe between 10th and 11th Streets along Madison Street. All remaining existing pipes are 18 inches in diameter or smaller, several of which are recommended for upsizing to 36-, 48-, and 54-inch-diameter pipes. The proposed improvement is anticipated to provide conveyance for the 25-year event (see Table 3-10) and is anticipated to remove flooding and surcharging of the system. During the 100-year event the system should not flood, but pipe surcharging into manholes may occur at four locations.

Table 3-10. John Adams Basin Hydraulic Model Parameters and Results for 25-yr Storm for Proposed Infrastructure

Link ID	Node name		Ground elevation (ft)		Future max water surface elevation (ft)	
	US	DS	US	DS	US	DS
800781	34313	33514	162.29	171.45	160.42	153.52
801568	33504	33474	261.10	254.51	258.03	244.78
801573	33473	34769	226.39	226.95	221.38	216.57
802603	33505_JA_1400	38651	316.50	286.90	310.38	281.42
802604	33566_JA_1600	34696	330.45	318.74	330.45	314.66
802606	34698	33504	289.22	261.10	283.02	258.63
804813	33520	43469	96.27	88.74	83.78	73.85
804814	33519	33520	99.89	96.27	93.86	87.68
804815	33521	34704_WN_0300	86.97	73.55	71.08	66.99
804841	33475_JA_1000	33473	243.58	226.39	237.13	221.88
804846	33469	33508	188.90	191.51	186.35	180.58
804848	33514	33515	171.45	153.00	153.50	145.67
804851	33515	34191_JA_0100	153.00	128.90	145.28	117.96
804860	33517_WN_0400	33516	185.10	179.60	179.81	175.85

Table 3-10. John Adams Basin Hydraulic Model Parameters and Results for 25-yr Storm for Proposed Infrastructure

Link ID	Node name		Ground elevation (ft)		Future max water surface elevation (ft)	
	US	DS	US	DS	US	DS
804861	33523	33517_WN_0400	201.40	185.10	193.08	179.81
804867	34311_WN_0500	33523	207.50	201.40	200.31	193.42
804870	34767_JA_1100	34309	209.10	198.92	209.10	193.47
804934	38650_JA_1500	33475_JA_1000	269.84	243.58	269.84	237.13
804969	33513_JA_0300	33519	119.72	99.89	116.37	93.86
806396	37054	33513_JA_0300	162.35	119.72	157.45	116.57
806401	37059	37054	178.38	162.35	174.49	157.53
806402	37062	37059	208.79	178.38	199.83	174.61
806406	37064	37062	210.50	208.79	203.46	199.94
806411	37070_JA_0500	34769	224.81	226.95	224.81	219.01
806471	37118	37139_WN_0100	57.70	53.08	52.19	49.93
806474	37139_WN_0100	37142	53.08	53.08	49.93	49.08
808623	37142	41009	53.08	52.70	49.08	48.27
808624	43300	43301	61.81	61.81	47.28	46.22
808704	33474	33475_JA_1000	254.51	243.58	244.78	237.26
808721	34309	33508	198.92	191.51	190.80	183.92
812475	36378	34534	168.58	167.42	165.35	163.55
812477	33516	36378	179.60	168.58	173.63	165.35
812478	34534	43051	167.42	163.93	163.55	160.17
812479	43051	43050	163.93	155.49	160.12	151.85
812692	41009	43300	52.70	61.81	48.27	47.28
812695	43301	39733	61.81	19.40	44.74	15.37
812816	43469	33521	88.74	86.97	73.85	71.08
Link43	38651	33474	286.90	254.51	280.95	244.78
Link44	34696	34698	318.74	289.22	314.00	283.21
Link45	34692_JA_1300	37087	250.94	248.38	246.56	240.16
Link46	37087	33491_JA_0200	248.38	234.43	239.67	229.72
Link47	33491_JA_0200	37064	234.43	210.50	228.90	203.46
Link48	34769	33469	226.95	188.90	216.57	186.35
Link49	33508	34313	191.51	162.29	180.55	160.42
Link54	34704_WN_0300	37118	73.55	57.70	66.67	52.19
Link55	43050	Node58	155.49	126.51	151.20	123.86
Link56	Node58	Node59	126.51	114.00	123.80	110.82
Link57	Node59	33521	114.00	86.97	110.68	83.74
Link58	34191_JA_0100	34192	128.90	120.42	117.96	110.98
Link59	34192	41014	120.42	109.91	110.50	101.99
Link60	41014	33519	109.91	99.89	101.99	93.86

**Shaded rows indicate a flooded upstream node during the 100-year storm event.*

A CIP fact sheet for this project is included in Appendix F.

3.7.2 South End Basin, South End Road

The South End conveyance system is a mix of open channels and large and small pipes, which results in an inefficient system. There is a conveyance system on both the north and south side of the roadway west of Filbert Drive. Near S Rose Road, the system on the south side of the road has an oversized pipe with a smaller pipe downstream just before the junction with the system on the north side of the road. Based on model results, this system starts to flood during the 2-year event. The flooding starts near S Rose Road where the open-channel system enters a closed system. The entrance grate configuration and pipes are not sized sufficiently to convey the runoff. The system then decreases in pipe diameter and significantly increases in slope. The conveyance infrastructure floods farther down South End Road where a culvert capturing the open-channel flow does not have sufficient capacity.

During the 25-year design event (see Table 3-11) the existing system also floods between S Forest Ridge Road and Salmonberry Drive where the open channels enter a culvert to cross under South End Road.

Alleviation of the flooding along South End Road will require a larger pipe from the outfall east to Long Standing Court. The Capital Project Fact Sheet in Appendix F provides a description of the improvements and a figure showing the extents and sizes of the upsized pipes. With the increase in capacity, the system is anticipated to provide 25-year level of service. During the 100-year event the system may be surcharged at several manholes with minor flooding near the intersection of Lafayette Avenue and South End Road. This is a significant improvement over current conditions.

Table 3-11. South End Basin Hydraulic Model Parameters and Results for 25-yr Storm for Proposed Infrastructure

Link ID	Node name		Ground elevation (ft)		Future max water surface elevation (ft)	
	US	DS	US	DS	US	DS
800101	40224	38962	453.92	452.20	452.82	452.20
800102	38963	30628	451.42	450.62	450.91	451.08
800823	33801	33800	452.50	449.78	447.91	442.35
800824	30628	33801	450.62	452.50	451.08	447.91
801783	33800	42854	449.78	447.80	442.35	440.88
802067	33531_SE_1300	33530	461.95	459.99	461.01	458.56
802192	33899	40224	455.75	453.92	453.37	452.82
802326	32462_SE_1200	34366	440.93	447.02	437.89	437.44
802787	38962	38963	452.20	451.42	452.20	450.91
803617	35517_SE_1400	33531_SE_1300	465.59	461.95	465.59	461.01
807270	37785_SE_1000	33899	458.00	455.75	455.85	453.37
807271	37787	37785_SE_1000	459.02	458.00	456.47	455.85
809300	33535_SE_1600	35517_SE_1400	468.36	465.59	468.36	465.59
809303	32769_SE_1500	33531_SE_1300	461.31	461.95	461.31	461.01
809312	33530	37788	459.99	459.22	458.56	457.20
809724	34366	34365_SE_1100	447.02	446.54	437.44	437.29

Table 3-11. South End Basin Hydraulic Model Parameters and Results for 25-yr Storm for Proposed Infrastructure

Link ID	Node name		Ground elevation (ft)		Future max water surface elevation (ft)	
	US	DS	US	DS	US	DS
Link20	37788	37787	459.22	459.02	457.20	456.47
Link21	32798_SE_1000	34786	456.04	452.42	452.49	450.32
Link23	34786	Node65	452.42	450.47	450.32	448.86
Link24	Node65	Node66	450.47	448.92	448.70	447.66
Link25	Node66	Node67	448.92	448.55	447.66	446.77
Link26	Node67	Node68	448.55	447.11	446.77	445.85
Link31	42854	34365_SE_1100	447.80	446.54	440.88	437.29
Link33	Node68	42854	447.11	447.80	445.85	445.01
Link41	34365_SE_1100	34761_SE_0900	446.54	438.14	437.29	434.22
Link42	34761_SE_0900	38973_SE_0800	438.14	433.60	434.22	431.78
Link43	38973_SE_0800	Node75	433.60	434.25	431.78	429.95
Link44	Node75	Node76	434.25	430.16	429.95	428.50

Section 4

Storm System Condition Assessment

Oregon City has some of the oldest infrastructure in the state of Oregon. The City needs a management strategy to identify needed pipe replacements and plan for long-term asset replacement, repair, and rehabilitation. The storm system condition assessment conducted for this Master Plan included an evaluation of existing infrastructure needs and recommends that a long-term rehabilitation and replacement (R/R) program be included as a critical element of the City's overall stormwater management program.

4.1 Background

Oregon City was established in 1829 and incorporated in 1844, which makes it the first city to be incorporated west of the Rocky Mountains.

While existing infrastructure is reaching its design life, the City's focus over the last several decades has been on providing new utility and roadway services for rapidly developing areas. Underground infrastructure problems are addressed on an as-needed basis when failures or flooding occur. The City is now working to establish a program to replace aging infrastructure, including roadways and utility systems. As a part of this effort, the city has acquired video inspection equipment and has begun Closed-Circuit Television (CCTV) inspections of the drainage system.

In addition to the review of pipe repair records, and as-builts from previous infrastructure projects, this visual inspection will be a valuable aid to the city in implementing a pipe replacement and prioritization system. While it is not unusual for stormwater pipes to remain viable for much longer than similar sanitary sewer systems, visual inspection by a trained individual can help differentiate levels of service in aging pipe segments.

4.2 System Assessment

The goal of a traditional stormwater system condition assessment is to review existing stormwater system information to identify areas of current or imminent failure as well as areas that are rapidly deteriorating. At the time of this study, the City had performed CCTV video inspections and developed rating scores for about one-fifth of the City's buried stormwater infrastructure. The work to date covers approximately 40 miles of pipe, primarily in the southern neighborhoods. As a part of each survey, CCTV recordings of pipes are made, and each segment is given a rating between one and five, in accordance with the Pipeline Assessment Certification Program (PACP). A score of "1" indicates a pipe is new and/or very unlikely to fail within its given design life, while a "5" indicates a pipe that has failed or is extremely likely to fail. With 20 percent of the city surveyed in three years, establishing citywide baseline data would take roughly 12 years, assuming the city can maintain the current pace of surveying. The goal of this master planning evaluation is to outline a strategy that the City can implement to start collecting condition data to optimize their system assessment and inform future CIP decisions.

4.2.1 Aging Infrastructure

As a result of early settlement, Oregon City has some of the oldest stormwater infrastructure in the region. The John Adams Basin, Canemah Neighborhood, and Singer Basin all likely have pipes and infrastructure that are more than 100 years old. Clay pipe was the most common material used before concrete pipes. Significant portions of the three basins likely have clay pipe. Clay pipe can last many decades but if disturbed is highly susceptible to failure.

The downtown area (John Adams Basin) had a combined sanitary sewer and storm collection system, which is approximately 70 years old. In the 1980s and 1990s a new sanitary sewer collection system was constructed. The former combined system remains in place, well past the expected life of the pipe, and continues to be used to manage stormwater.

In other areas of the city, pipe age was evaluated by looking at the dates of neighborhood development, since most stormwater infrastructure in residential areas is constructed as part of residential development. The areas south of downtown and north of roughly Warner Parrott Road and Warner Milne Road are made up of infrastructure constructed between 1940 and 1980. Areas south of Warner Parrott and Warner Milne roads are primarily built after 1980 and should have several decades of service remaining. This is also true for the portion of the city north of downtown, where infrastructure was constructed after 1990. See Figure 4-2 for a map detailing these areas.

Figure 4-1. Historic brick manhole along the Singer Creek alignment

4.2.2 Existing Condition Data

Because of the age of the infrastructure in the older portion of Oregon City there is little information with regard to its condition. The information available for the rest of the city is slightly more robust but still lacking in detail to inform an assessment program. The City has inspected approximately 20 percent of the piped conveyance system via closed-circuit television (CCTV) inspections, primarily in the southern portion of the city (See Figure 4-3).

As shown in Table 4-1, of the pipes inspected, approximately 77 percent received a score less than 2.0, indicating failure is extremely unlikely within the design life of the pipes, while approximately 6 percent received scores of 4 or higher, indicating poor condition, and a high probability of failure.

Table 4-1. CCTV Results to-Date (March 2019)

Score	Pipes Inspected LF	% of Total Inspected
1.0 – 1.9	166,785	77.3
2.0 – 2.9	23,736	11.0
3.0 – 3.9	11,934	5.5
4.0 – 4.9	7,617	3.5
5.0	5,753	2.7
Total Inspected	**215,824**	

Detailed review of the CCTV reports did not identify any pipe segments that are in immediate need of replacement. This highlights the need for a detailed engineering assessment to evaluate pipes with condition concerns, prior to prioritizing replacement projects.

Some limited amount of condition data is available from visual inspections. For example, the drainage network along the historic Singer Creek has been observed to be formed out of bedrock and concrete walls with aged manholes built out of bricks (see Figure 4-1). The primary creek channel appears to flow through a constructed channel that has been enhanced over the decades with concrete walls (in some places), and a top. The channel is similar in shape to a box culvert.

During visual inspections of structures, the Singer trunk line infrastructure appears aged but does not appear to need significant repair. However, CCTV inspection has been completed on three segments of the Singer trunk line, two of which scored a 4, warranting more assessment of this area. Based on modeling results (see Section 3) the system capacity is adequate for the desired level of service, but a review of the specific pipe inspections in this vicinity would be helpful to understand whether pipe replacement is warranted. Visual inspections of structures can effectively be paired with already completed CCTV to build a fuller picture of system health.

The City continues to track pipe and storm drain infrastructure using Lucity (now CentralSquare Technologies) as well as compiling information from the pipe surveying software Granite. Using these in tandem with their GIS geodatabase of infrastructure positions the City to make informed decisions on infrastructure improvements.

4.2.3 Sanitary Sewer System and Stormwater

Modern conveyance systems for storm and sanitary are separated so that the two do not mix. However, this is not always the case. There are portions of the city where no stormwater conveyance system was ever constructed and therefore runoff is routed to the sanitary system. The areas that lack storm conveyance infrastructure should be slated for storm system construction. This would likely require that private lateral connections be updated.

In the John Adams Basin, as mentioned previously, large portions of the conveyance infrastructure for storm and sanitary were combined at one time and the old combined system pipes are still used for stormwater conveyance. These old pipes are suspected of having areas that are deteriorating, compromised by tree roots, or otherwise damaged. While the public trunk lines are no longer serving combined sanitary and storm, several of these have been surveyed along 12th Avenue, and have scored in the fours and fives, suggesting further surveys may be warranted. It is also likely that private laterals, which remain from before the sewer separation, and that may manage roof runoff, foundation drains, and small area drains are still connected to the sanitary system.

The plans or as-builts of the separation of the storm and sanitary sewer infrastructure in the old portions of town may provide insights into how this separation was conducted and how the private and public laterals were handled. Some of the old infrastructure was constructed deeper than most traditional stormwater systems because of its former use as a combined system. The depth of the system may make replacement or rehabilitation more challenging.

4.2.4 Other Considerations

The City is in the process of establishing an inspection and replacement program for the sanitary system. To date, the work has included an infiltration and inflow (I/I) study in key neighborhoods as well CCTV inspections. The City has also conducted smoke testing to locate cross-connections between the sanitary and storm systems in the John Adams and Singer Basins. That work was completed in 2016/17 and reported in *I/I Abatement Program, Smoke Testing* (BC), February 10, 2017.

The City also has an ongoing pavement maintenance program, which includes reconstruction of roadways in older neighborhoods. Because these projects cause significant disruption to neighborhood residents, coordinating any needed underground utility improvements with pavement maintenance projects is desirable.

4.3 Rehabilitation and Replacement Program

R/R programs can be broadly described as a process of investigation, assessment, recommendations, and implementation. The implementation of CCTV inspections is the first step in establishing an R/R program to assess and evaluate the stormwater system. The City has also implemented an inspection and replacement program for the sanitary system as part of its 2014 Sanitary Sewer Master Plan, and has seen the value in systematic assessment and evaluation. A similar program is recommended for the storm system.

Conducting a citywide rehabilitation program that investigates all areas of the city on a rotating basis is likely cost-prohibitive, so the R/R program recommendations will utilize existing and on-going CCTV survey information for establishing priorities for focused inspections.

4.3.1 Aging Infrastructure Area

Oregon City is in a unique position locally in the Portland metropolitan area because of the excessive age of some portions of the city's buried infrastructure. However, the City also manages an ever-expanding network of new stormwater infrastructure, constructed to support rapid development. Rather than conduct a citywide R/R program, the R/R program alternatives described below are based on identifying a priority area for inspections.

The "aging infrastructure area" is defined as those areas of the city where the stormwater system is assumed to be at least 60 years old. Development records, as-builts, and anecdotal information provided by City staff were used to estimate pipe age across the city. The City's GIS inventory was then used to calculate the piped conveyance system assets. The aging infrastructure area encompasses most of the Singer and John Adams Basins, as well as the Canemah Neighborhood.

Table 4-2 compares the length of pipe inside the aging infrastructure area to the City's total piped infrastructure.

Table 4-2. Stormwater Asset Inventory

Asset type	Aging infrastructure area, LF	City total, LF
Pipe total	140,000+	760,000+
10–12 inch pipe	113,500	589,700
15–18 inch pipe	18,000	106,500
21–14 inch pipe	5,200	34,300
30–36 inch pipe	3,700	23,800
42+ inch pipe	300	6,100
Catch basins, all types	860	4,300
Manholes	420	2,400
Connected downspouts	Unknown	Unknown

4.3.2 Inspection Program

In 2016, Brown and Caldwell met with City staff to explore possible directions to go in when establishing an inspection program for the aging stormwater system. The inspection program will allow the City to collect quality data to guide decisions about infrastructure rehabilitation and replacement. Several alternative approaches were discussed with the City to determine whether the City would embark on a widespread CCTV inspection program or target inspections to highest risk areas. Subsequent to the initial alternatives meeting, the City embarked on a widespread CCTV inspection program that has inspected over forty miles of stormwater pipe, as described in Section 4.2.2. Collecting a significant amount of condition information prior to identifying R/R areas will allow projects to be focused on the areas of greatest need.

The City should continue CCTV inspections, focused on three areas: the aging infrastructure area, areas in the vicinity of high priority CIP projects, and roadways and neighborhoods that are scheduled for pavement replacement. Focusing in these areas will allow the City to identify acute problems that should be corrected during ongoing pavement maintenance projects and/or CIP projects. After inspections are completed in these areas, it is recommended that the City continue an ongoing cycle of CCTV inspections, with the aim of covering all public stormwater infrastructure in the City on a 10-year cycle. Depending on staffing levels, the long-term CCTV inspection could be completed by City maintenance crews.

4.3.3 Replacement Program

The City currently funds stormwater CIPs at approximately $500,000 per year, so widespread replacement of the aging infrastructure area is cost-prohibitive. Review of the CCTV inspection data collected to date identified that approximately six percent of the inspected pipes have scores of 4 or 5, indicating a condition concern. This percentage is expected to increase as the inspections move into older areas of the City. However, detailed review of the CCTV reports did not identify any pipe segments that are in immediate need of replacement. This highlights the need for a detailed engineering assessment to evaluate pipes with condition concerns, prior to prioritizing replacement projects.

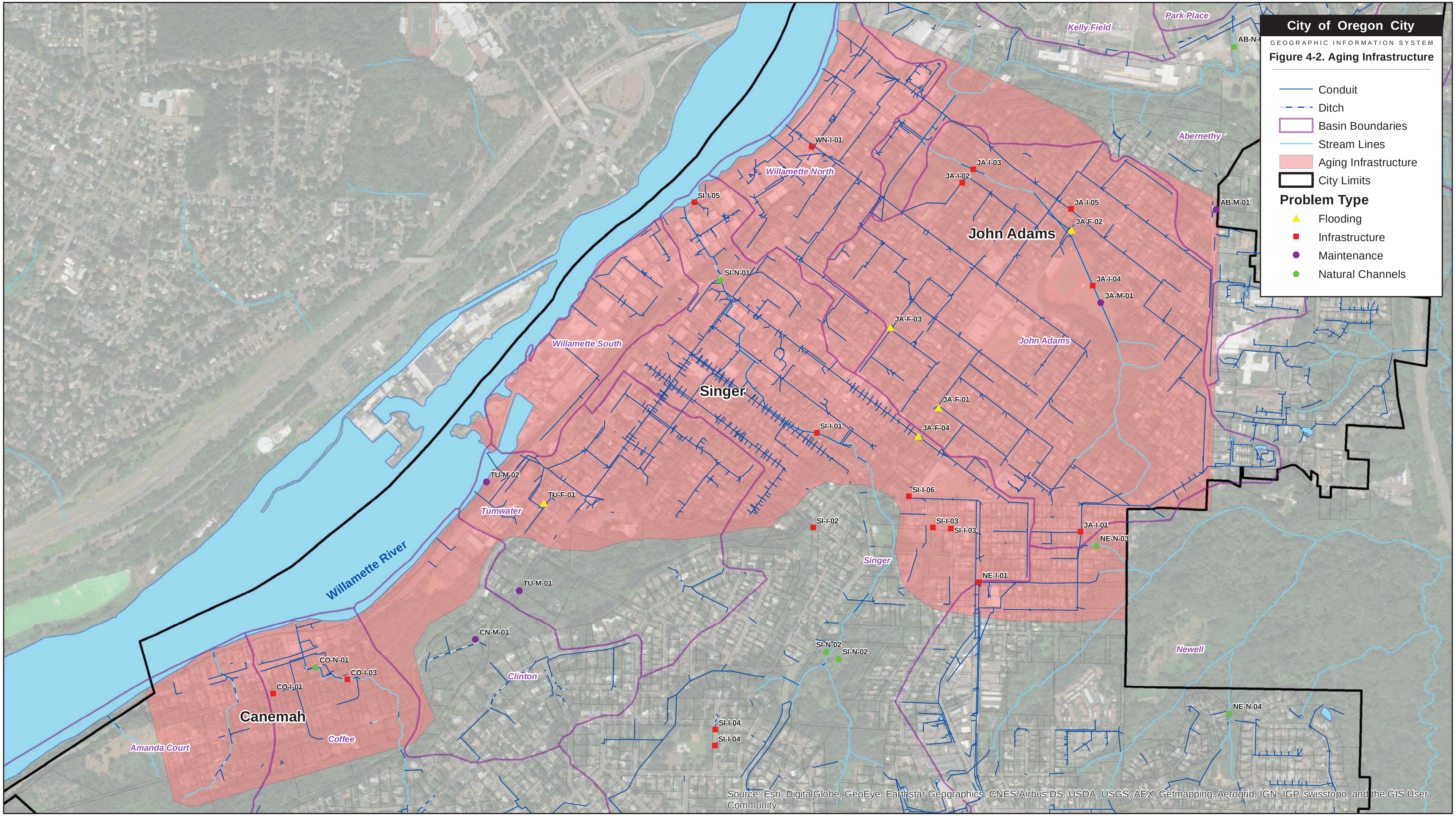
Continuing to utilize the completed and on-going CCTV information will allow the City to identify pipes in critical need of replacement and to focus capital construction resources in the areas of highest need, as well as coordinate with transportation improvement projects, and CIP projects. It is assumed that a higher percentage of pipes (20-25 percent) will require replacement in the aging infrastructure area, but that newer areas will require fewer replacements. For a planning assumption, the City should plan to replace 5 to 10 percent of the public infrastructure over the next 20 to 25 years. With over 150 miles of publicly managed stormwater pipe, the annual replacement cost would be between $300,000 and $750,000 per year, depending on the extent of pipe replacements, size of pipes, type of rehabilitation, and the speed at which the City wants to implement the program.

Pipe replacement projects would be in addition to the CIPs outlined in Section 7 and should be scored and prioritized in a similar manner, as the City determines where to direct stormwater program resources.

4.3.4 Additional Actions

The CCTV inspection program gives the City a long-term plan to investigate and rehabilitate aging stormwater infrastructure. However, it will likely be 5 to 10 years before any construction projects identified through the inspection program are completed (depending on funding).

In addition to the CCTV inspections and pipe replacement program, CIP 1: John Adams Basin Capacity Improvements include the planned replacement of 7,300 LF of pipe and associated drainage structures within the aging infrastructure area (see Section 7). This CIP meets multiple objectives through upsizing infrastructure to reduce flooding while also replacing aging infrastructure. The areas included in CIP 1 will not need to be included in the initial CCTV inspections, as all sections of pipe in the project area are planned for replacement to address capacity concerns.



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 4-2. Aging Infrastructure

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Feet

1 inch = 833 feet

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Plot date: June 20, 2017
Plot name: Figure 4-2 Aging Infrastructure.pdf
Map name: Figure 4-2 Aging Infrastructure.mxd

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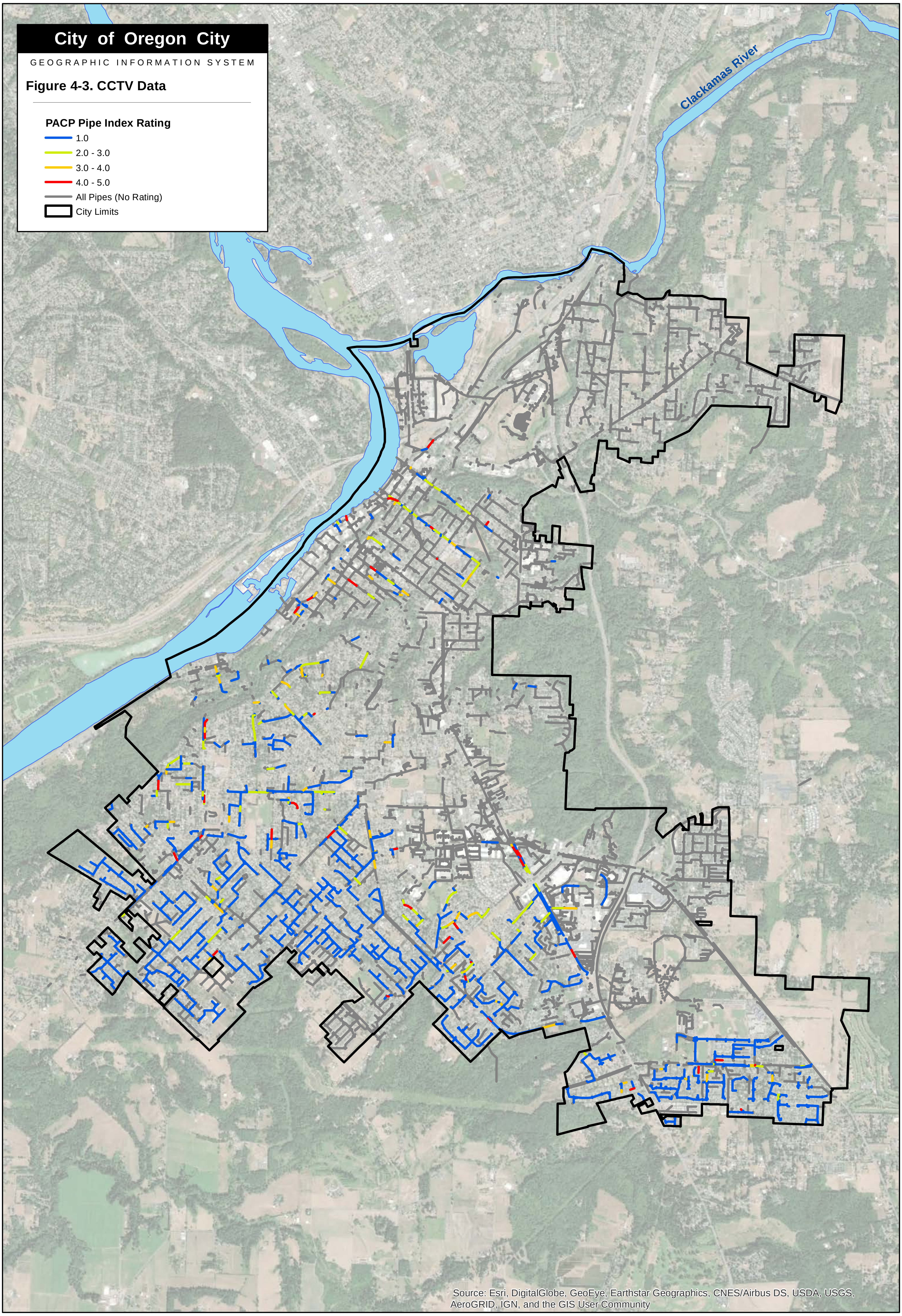
GEOGRAPHIC INFORMATION SYSTEM

Figure 4-3. CCTV Data



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

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Plot date: March 11, 2019
Plot name: Figure 4-3 CCTV Data.pdf
Map name: Figure 4-3 PipeInspectionAreas.mxd

Section 5

Water Quality/Retrofit Assessment

Improving water quality conditions through retrofit of existing stormwater infrastructure is an important element of the City's overall stormwater management program. The City has programs and projects to address water quality issues at the source because stormwater, unlike wastewater, does not drain to a centralized treatment facility. The primary objective for a stormwater retrofit program is to improve the overall level of water quality treatment in developed areas of the city. New development and redevelopment projects are required to add water quality treatment during development, but existing development that was constructed prior to treatment standards will receive treatment only through public retrofits.

5.1 Water Quality Priorities

There is a direct link between stormwater runoff and the City's surface water and groundwater quality and quantity. As land is developed, creation of new impervious surfaces and loss of vegetation increases stormwater runoff during rainfall events, altering the natural hydrologic cycle. Runoff that flows over roadways, parking areas, rooftops, and other impervious surfaces collects pollutants that are transported within the watershed to streams, rivers, and groundwater resources. Properly managing stormwater is vital to protecting the City's water resources for a great number of uses, including fish and wildlife habitat, recreation, and drinking water.

5.1.1 Regulatory Requirements

Oregon City is adjacent to several major water bodies including Abernethy Creek, Newell Creek, Beaver Creek, the Clackamas River, and the Willamette River. Regulatory requirements for these systems are driven primarily by the CWA and related regulations. As described in Section 1.2.2, the City is covered by an NPDES MS4 permit for stormwater discharges. In addition to ongoing programmatic requirements in the permit, the City was recently required to develop several plans to evaluate and assess stormwater programs and impacts. In 2015, the City was required to develop a Water Quality Retrofit Plan to evaluate existing water quality measures and outline a plan for long-term retrofit of developed areas. One of the recommended actions in the retrofit plan was to conduct retrofit planning as part of the master planning process. This water quality/retrofit assessment builds on the 2015 plan and incorporates recommendations from the City's Pollutant Load Reduction Evaluation and the Wasteload Allocation Attainment Assessment, both of which were additional requirements of the NPDES MS4 Permit.

5.1.2 Pollutants of Concern

Stormwater runoff is known to have negative impacts on receiving waters. The mixture of contaminants can vary by region and area within a city depending on the land use and inputs to runoff. However, across urbanized areas, the pollutants of concern and treatment approaches remain generally consistent.

As part of the water quality standards program, the Oregon Department of Environmental Quality is required to conduct a water quality assessment of the state's water bodies every 2 years. If a water body is found to have pollutant levels that exceed water quality standards, it is placed on what is referred to as a 303(d) list. Once on the 303(d) list, a water body is in line for the development of a

TMDL requirement. A TMDL requirement will specify limits on allowable loads from each discharger. Three TMDLs have been developed that apply to Oregon City. These include bacterial TMDLs for the Clackamas River, the Middle Willamette River Direct, and the Middle Willamette River tributaries.

In addition, several water bodies have been identified as water quality limited on the 303(d) list and are in line for TMDLs. 303(d) listed water bodies in Oregon City are provided in Table 5-1. These water quality issues were considered in the development of CIPs for this Master Plan.

Table 5-1. 2010 303(d) Parameters Applicable to Oregon City

Water body	River mile	Season	Parameter
Middle Willamette Subbasin			
Abernethy Creek	0.0–15.3	Year round	Biological criteria[a]
Willamette River	0.0–54.8	Summer	Chlorophyll a[a]
Willamette River	24.8–54.8	Year round	Aldrin
Willamette River	24.8–54.8	Year round	Biological criteria
Willamette River	24.8–54.8	Year round	DDT and DDT metabolite (DDE)
Willamette River	24.8–54.8	Year round	Dieldrin
Willamette River	24.8–54.8	Year round	Iron
Willamette River	24.8–54.8	Year round	PCBs
Clackamas River Subbasin			
Clackamas River	0.0–83.2	Year round	Biological criteria[a]
Clackamas River	0.0–8.8	October 15–May 15	Dissolved oxygen[a] (spawning: not <11. 0 mg/L or 95% of saturation)

a. Parameter added with the 2010 list.

5.2 Water Quality Treatment Overview

In 2015, the City developed a retrofit evaluation in response to NPDES permit requirements. The evaluation included a review of water quality treatment facilities across the city to identify areas where there may not be adequate treatment.

Areas of the city that have been developed in the last 20 years generally have included the implementation of water quality treatment facilities. This includes roughly the southern third of the city. The areas developed during the 1950s through the 1990s are less likely to include water quality treatment, as the City's design standards requiring treatment were adopted in 1999. The oldest portion of the city that was developed prior to 1950 does not include water quality treatment facilities. These untreated areas include most of the industrial and commercial areas north of downtown, in the vicinity of Abernethy Creek and the Clackamas River. Over time some of the areas not originally serviced with water quality facilities may have been retrofit with public facilities to meet regulatory guidelines, when public projects or private redevelopment projects were constructed, but those areas are small compared to the total drainage area.

The City's Wasteload Allocation Attainment Assessment, completed in 2016, identified the level of water quality treatment that would be required in order to achieve TMDL wasteload allocations for bacteria. That study showed that TMDL wasteload allocations may not be attainable goals. However, the wasteload allocation is currently representative of a target for only one pollutant (bacteria). There is still significant value in improving water quality over current conditions by addressing a wide range of pollutants of concern. Increasing the percentage of the city that receives water quality treatment remains an objective for the city and part of the NPDES permit requirements. Increasing treatment across the City will occur through various mechanisms including future development, redevelopment, and opportunities identified by the City to build water quality facilities.

5.3 Retrofit Evaluation

A citywide evaluation was performed to identify priority areas for water quality treatment. This evaluation considered existing areas of treatment, potential pollutant loads, and downstream resources that could benefit from improved water quality. Based on this evaluation, the area draining to the Clackamette Cove was identified as the focus for stormwater retrofit projects. Several potential CIP locations were identified for water quality retrofit facilities.

5.3.1 Priority Area

The Clackamette Cove is an area with strong development interest. Several new mixed-use development projects are in the planning or construction stage. These developments identify Clackamette Cove as an attractive water feature, with the potential for recreation and wildlife viewing. At the same time, Clackamette Cove is known to have water quality challenges with temperature and algal blooms. Clackamette Cove has only one connection to the Clackamas River and during low-flows, essentially behaves as a lake, as opposed to a part of the river, and does not experience enough mixing. Stagnant waters, higher temperatures, and high pollutant levels result in water quality problems.

Located at the confluence of the Willamette River and the Clackamas River, Clackamette Cove is an area with significant natural resources value. The Cove provides habitat for juvenile salmon, steelhead, and pacific lamprey, while the land around the cove provides habitat for deer, coyotes, minks, otters, and beavers. In addition to wildlife, the Cove is also host to various recreational activities for residents, and is a popular location for boating, swimming, fishing, and hiking. While these recreational activities have an impact on the Cove's habitability, so do groundwater and stormwater.

Studies conducted in this area have detected contamination from nearby sites from stormwater runoff, as well as migration from sites only connected through groundwater. Recent sediment testing of soils around former asphalt plants revealed contaminants such as diesel, petroleum, arsenic, and lead, with some of these also showing up along the Cove's eastern shoreline.

With respects to stormwater runoff, there are currently three major stormwater outfalls into the cove. One discharges from a fairly large drainage area to the east of the cove that includes land uses such as residential, transportation, commercial, and some light industrial. The second outfall is near the Oregon City Shopping Center, which drains transportation, commercial, and mixed land uses. The third outfall receives water from a drainage swale between a residential apartment complex and the Oregon City Shopping Center. These three outfalls convey runoff from large urban areas, and those drainage areas receive little water quality treatment prior to discharging into the cove. The City, through its National Pollutant Discharge Elimination System (NPDES) permit, is required to monitor and sample at these outfalls, the results of which consistently show the presence of dissolved copper, zinc and lead, which all have been linked to negative effects on salmon and steelhead. A map of the drainage area is included in Figure 5-1.

The combination of higher pollutant-generating land uses and important downstream natural resources makes the Clackamette Cove drainage area a logical focus for the City's water quality retrofit program.

5.3.2 Potential Project Locations

The drainage networks contributing to the three Clackamette Cove outfalls includes a mix of both public and private infrastructure. The conveyance systems are old, with complicated networks and areas of unknown connections. However, the disjointed development throughout this area has resulted in a series of underdeveloped properties and slivers of undevelopable land.

Using existing GIS data, land use data were investigated to locate publicly owned properties as well as underdeveloped properties where a property owner might become a willing partner in the implementation of a water quality retrofit project. Within the Clackamette Cove drainage area, the following three general opportunity areas were identified:

- The South Metro Transfer Station, which has an existing water quality treatment facility. This facility could be retrofitted to manage a larger drainage area and provide treatment for areas outside of the Metro property.
- Oregon City Shopping Center and the associated area drainage does not include any treatment at this time. A relatively large portion of the private property is undeveloped and adjacent to City-owned property to the north. This open space could provide a site for a water quality treatment facility to serve the entire shopping center and associated drainage.
- Several large pieces of property between I-205 and the railroad could include opportunity areas for a treatment facility. Some of this land is currently designated as wetland mitigation.

5.4 Water Quality/Retrofit Recommendations

Continuing to improve water quality within the city will require a combination of programmatic actions, opportunistic investments, and specific projects.

5.4.1 Water Quality Capital Improvement Projects

Based on the evaluation presented in Section 5.3, one water quality retrofit project has been included in the recommended CIP list. CIP 10 is proposed to install a water quality treatment facility north of the Oregon City Shopping Center. The facility has the potential to provide treatment for the entire shopping center and other additional impervious area that is currently untreated. This CIP was selected based on the simplicity and opportunity to retrofit existing infrastructure by redirecting flow to the new facility, and the availability of land for the construction of a water quality facility.

Implementation of this CIP will require close coordination with the existing property owner, as well as an easement to locate and maintain the facility on private property. With a heightened regional interest in improving water quality in Clackamette Cove, the CIP could also be well positioned to compete for grants and other competitive funding. See Section 7 for more information regarding this CIP.

Water quality features will also be incorporated into proposed capital projects at Pebble Beach Pond and Scattering Canyon. Over time, outfall improvements through Newell Canyon have the potential to improve water quality by reducing erosion and sediment contributions to Newell Creek. The City may also elect to evaluate water quality retrofit opportunities in conjunction with stormwater conveyance projects. Retrofits could include installing green streets or treatment swales as part of the upgraded conveyance system.

In the long term the City may also investigate the feasibility of constructing additional water quality retrofit facilities on the other properties listed in Section 5.3.2.

5.4.2 Water Quality Programs

In response to the NPDES permit requirements, the City already has a robust program to address water quality through programmatic actions. These programs address water quality at the source through illicit discharge investigations, construction site regulations, and stringent standards for new development and redevelopment.

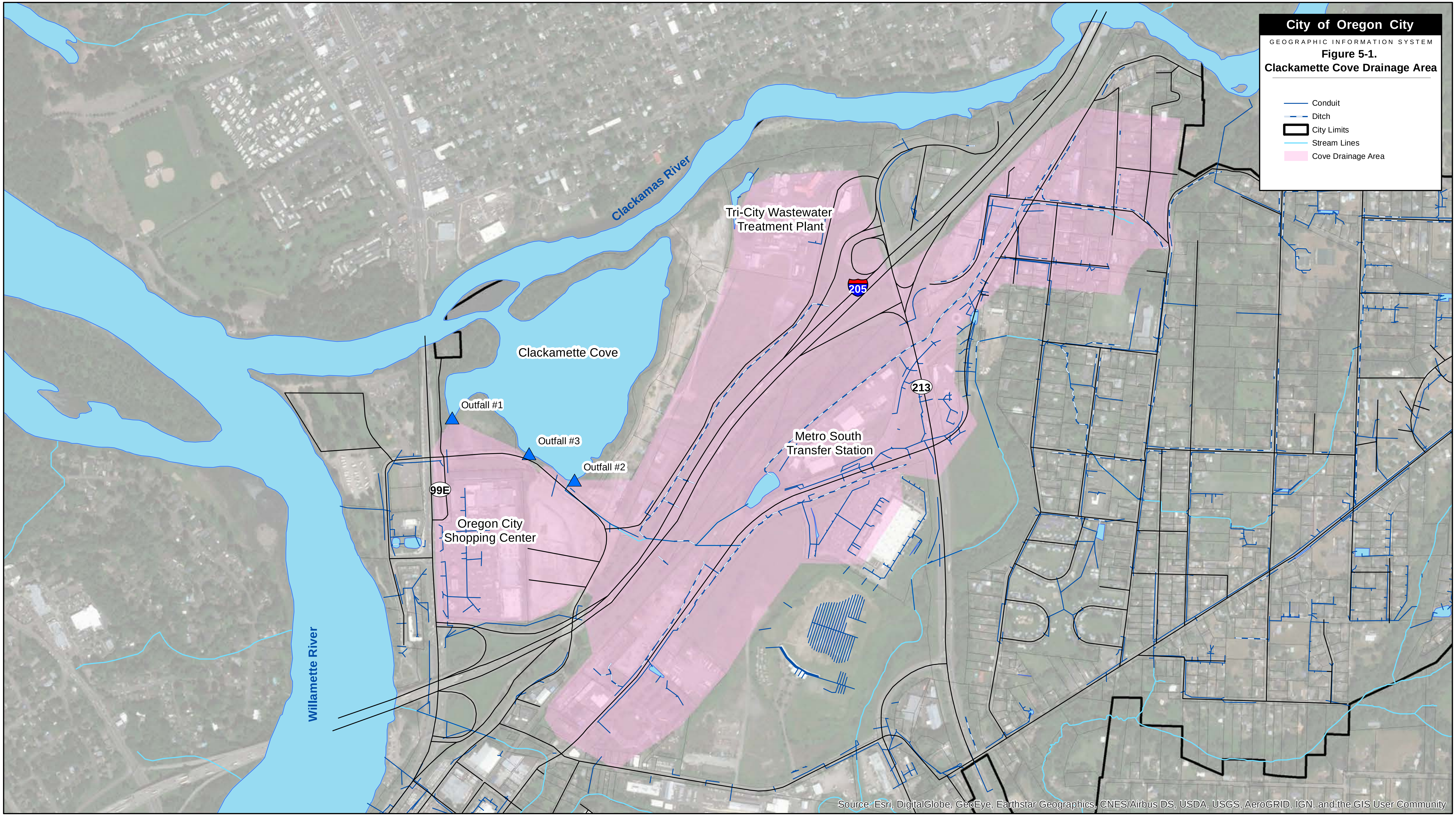
In addition to these existing programs, the City may investigate other focused water quality retrofit plans. Some examples include:

- Opportunistically incorporating water quality treatment into municipal projects, such as roadway improvements and building remodels.
- Implementing a green streets retrofit program for areas in need of additional treatment and opportunistically implementing along with roadway improvements by replacing landscape strips with stormwater planters to provide treatment for existing roadways and residential areas.
- Incorporating water quality enhancements at existing stormwater outfalls when outfall rehabilitations are constructed (see Section 6).
- Community outreach programs to encourage private property owners to install rain gardens, swales, or other treatment facilities on individual properties.
- Retrofitting existing facilities to enhance treatment. An example of this is the Pebble Beach CIP discussed in Section 7.

City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 5-1.
Clackamette Cove Drainage Area



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

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1 inch = 700 feet

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Plot date: June 20, 2017
Plot name: Figure 5-1 Cove Drainage Area.pdf
Map name: Figure 5-1 Cove Drainage Area.mxd

Section 6

Natural Systems Assessment

The focus of this natural systems assessment was to evaluate physical stream conditions to identify impacts from stormwater runoff. As Oregon City has developed over the decades the percentage of impervious area has increased, causing an increase in peak flows and a decrease in base flow. The result of this is channel erosion and modification that is not beneficial to the health of the stream and its ecosystem. Stormwater runoff also has significant potential to impact in-stream water quality and natural systems, as discussed in Section 5 of this Master Plan.

The City includes areas that are clearly susceptible to channel erosion and modification due to increases in flow from surface water runoff. It is recommended that proper stormwater infrastructure and land use policies be implemented by the City to address natural channel impacts from stormwater runoff.

6.1 Background

Oregon City's geography and topography are unique. While the city is located adjacent to the Willamette River, much of the city drains to smaller tributary streams, including tributaries to Newell Creek, Beaver Creek, and Abernethy Creek.

As an urbanized area, stormwater discharges generated in the city have the potential to impact stream conditions through hydromodification. Increasing impervious area through development and redevelopment activities alters runoff conditions and increases peak flow to stream channels, typically increasing stream energy and decreasing base flow. Increased stream energy can alter stream channels through flooding, bank erosion, bed incision, sediment production, and other impacts.

The City has been implementing stormwater management design standards for new development and redevelopment since 1999. Those standards have required developments to manage peak flows, resulting in numerous stormwater detention ponds constructed across the city. Further evaluation is needed to determine whether the facilities constructed during peak periods of development have been sufficient to offset impacts from increased stormwater runoff.

This natural systems assessment builds heavily upon the City's 2015 Hydromodification Assessment (described in Section 1.2.1) to identify citywide recommendations to address in-stream channel modification caused by surface water runoff.

6.2 2015 Hydromodification Study

The City's NPDES MS4 permit required the City to complete and submit a hydromodification assessment, which was completed in July 2015. The study was focused on evaluating hydromodification impacts associated with urbanization and discharges from the MS4. The assessment included a review of existing planning documents, a GIS desktop evaluation of watershed conditions, and targeted field assessments to identify hydromodification indicators. The assessment included an evaluation of stream channels in the city to determine whether discharges from the MS4 have impacted stream channels and whether future development patterns are likely to contribute to additional impacts.

Because of time constraints, field assessments in 2015 were focused on the Abernethy Creek tributaries, including Newell Canyon areas. Additional evaluation was still needed for Beaver Creek tributaries.

The assessment then identified strategies to address the hydromodification impacts. Partly in response to the hydromodification assessment, the City adopted new Stormwater and Grading Design Standards. These standards require new development and redevelopment projects to control both the peak flow and the volume of stormwater runoff to better protect natural systems.

The 2015 study identified key CIPs to address in-stream hydromodification problems. These CIPs included:

- Installing energy dissipation measures to address active erosion and incision problems on Newell Creek, downstream of Beavercreek Road and Highway 213
- Reconstructing the drainage channel to better manage current flows in Scattering Canyon, located in the Mountain View Cemetery
- Installing energy dissipation at the Livesay Creek culvert outfall downstream of Holcomb Boulevard
- Installing grade control structures and energy dissipation features in Park Place Creek downstream of Abernethy Road Culvert[3]

The 2015 study also recommended annual monitoring of known and potential problem areas to determine whether the City should take immediate corrective action. Some stream channels that look to be problematic may be showing signs of historical erosion that has since stabilized. Annual site visits to conduct visual monitoring will allow the City to identify active erosion problem areas. The sites identified for annual monitoring included:

- Newell Creek at Beavercreek Road and Highway 213 outfalls (site 004)
- Newell Creek tributary at Mountain View Cemetery, known as Scattering Canyon (site 012)
- Livesay Creek culvert downstream of Holcomb Boulevard (site 002)
- Park Place Creek downstream of Abernethy Road (site 001)
- Newell Creek tributary at stormwater system outfall downstream of Eluria Street near Logus Street (site 008)
- Stormwater system outfall channel adjacent to 17883 Peter Skene Way (site 013)

The 2016 field evaluations included site visits to these previously identified monitoring locations to assess hydromodification and general system conditions. The field evaluations and descriptions of the conditions are presented below in Sections 6.3 through 6.5.

6.3 2016 Field Evaluations

The purpose of the 2016 field evaluations was to expand and enhance the 2015 hydromodification assessment results. Field evaluations were conducted by the City and consultant staff on May 24, 2016.

The field assessment was qualitative in nature, and focused on documenting existing channel conditions. Locations for the 2016 field assessment were selected based on known problem areas, annual monitoring sites listed in Section 6.2 and locations throughout the Beaver Creek tributary subbasins that were not evaluated in 2015.

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[3] This CIP was subsequently removed from the potential CIP list, as a follow-up site visit in 2016 revealed little change in the channel conditions.

Nearly all the field observations could be made from public property. City staff identified field assessment locations with public access to the stream channels, including locations of road culverts, easements, and the Mountain View Cemetery. Metro also owns and manages 300 acres of property with access to Newell Creek. Table 6-1 lists the specific locations of field observations. Field observation locations for the 2015 hydromodification study and this Master Plan are identified on the map in Figure 6-1.

Table 6-1. Hydromodification Assessment Field Observation Locations

Site no.	Water body	Location	Description
001	Park Place Creek	Channel downstream of Abernethy Rd., behind property at 13530 Redland Rd.	• City-identified problem area due to minor incision and channel deepening • City water quality monitoring location
002	Livesay Creek	Storm outfall at 14010 Beemer Way, downstream of Holcomb Blvd.	• City-identified problem area due to severe channel incision at stormwater outfall
003	Newell Creek	Beavercreek Rd. and Hwy. 213, upstream and east of Hwy. 213	• Reference reach of channel conditions reflecting an urbanized area with upstream flow control • Approximately 500 feet upstream of site 004
004	Newell Creek	Beavercreek Rd. and Hwy. 213, downstream and west of Hwy. 213	• City-identified problem area due to severe erosion at stormwater outfalls
005	Tributary to Newell Creek	1635 Beavercreek Rd.	• City-identified problem area with possible outfall erosion and channel incision • Discharge location for drainage system from Warner Milne Rd.
006	Stormwater outfall in Newell Creek Basin	702 Hilltop Ave.	• City-identified problem area at stormwater outfall
007	Tributary to Newell Creek	Tributary in Newell Canyon, accessed from Hilltop Ave.	• Reference reach of tributary stream in Newell Canyon Metro property
008	Tributary to Newell Creek	Stormwater outfall and channel downstream of Eluria St. near 613 Logus St.	• City-identified problem area due to stormwater outfall causing bank erosion along channel adjacent to private property
009–010	High School Creek (John Adams Basin)	Culverts under Madison St. and Monroe St.	• City-identified problem area due to channel incision at stormwater outfalls
011	Stormwater system in Central Point Basin	11976 Kathaway Ct.	• City-identified stormwater system problem area • Potential future CIP to address conveyance issues associated with open-channel conveyance along private property
012	Tributary to Newell Creek	Scattering Canyon in Mountain View Cemetery	• City-identified problem area due to channel incision • Location of potential project identified by the GOCWC
013	Tributary to Newell Creek	17883 Peter Skene Way	• City-identified problem area due to channel incision
014	Coffee Creek	Canemah Neighborhood	• City-identified problem area due to various channel conditions through Canemah neighborhood • Potential future CIP to address conveyance needs including relocation of the conveyance system within the public ROW
200	Tributary to Caufield Creek	South of Meyers Rd. near Trails End Market Place	• City-identified problem area due to erosion issues at outfall • Minimal erosion witnessed during site visit
201/202	Caufield Creek	Downstream of Hwy. 213	• City-identified problem area due to erosion/incision issues
203	Mud Creek	Frontier Parkway near pump station	• Natural pond formed by beaver activity
204	Tributary to Beaver Creek	Orchard Grove Drive	• Stormwater ponds in Beaver Creek Basin
205	Coffee Creek	Hazelwood Drive	• Investigating conditions and flooding issues in Coffee Creek
206	Singer Creek	Singer Creek Park	• City-identified problem area due to bank stability • Western bank has slid off into creek but now appears stable

The field assessment was used to document hydromodification indicators by taking photographs at each site (see Appendix D) and completing Stream Channel Observation Forms for major observed reaches (see Appendix E).

6.4 Observations

Table 6-2 below, lists the hydromodification indicators observed during site visits in 2015 and 2016. General observations of the impacts to these systems due to the runoff generated within Oregon City are summarized below.

Newell Canyon. Newell Canyon has been established as a problem area that is characterized by steep slopes and erodible soils. The development that exists in this watershed is generally older and lacks water quality or flow control facilities. The combination of development without flow control and highly erodible soils has resulted in observed stream incision, erosion at the outfalls, and severely altered stream channels. Newell Canyon hillsides have also experienced sloughing and small landslides, though those problems cannot be attributed solely to stormwater runoff. Newell Creek has some areas of severe downcutting and incision in the upper reaches of the creek (site 003), but lower reaches of the creek seem to be well preserved (site 007). Several stormwater outfalls (sites 008 and 013) showed noticeable degradation between the 2015 and 2016 site visits.

Beaver Creek. The tributaries to Beaver Creek that are within the city are managed through manmade and natural features such as wetlands that appear to be managing the changes in hydrology caused by increased impervious surfaces. Newer development that has occurred since 1999 has been designed with the required water quality and flow control facilities that appear to be protecting the integrity of the tributaries and natural systems. Recent field visits to the tributaries of Beaver Creek show that the channels downstream of large residential developments appear to be stable and preserved in their natural state (sites 200, 201, and 202). Hydromodification does not appear to be occurring in these areas.

Abernethy Creek. Field investigations for Abernethy Creek were focused on stormwater outfalls from the urbanized area, as much of the Abernethy Creek watershed is located upstream of the city. Stormwater outfalls and culverts in Abernethy Creek tributaries are generally in poor condition. The soils in this watershed are loose, highly erodible, and susceptible to damage by changes in the hydrology of the watershed. Several of the outfalls inspected in 2015 had exposed bedrock, indicating severe downcutting (sites 001 and 002). However, follow-up visits in 2016 showed little change at these outfalls and culverts. It appears that the channel degradation occurred during older periods of development and the stream channels have since re-stabilized to the modified hydrology.

Clackamas River. The northern portion of the city discharges to the Clackamas River. Few observations have occurred in this area. There have been few reports from City staff of negative impacts to the system due to development.

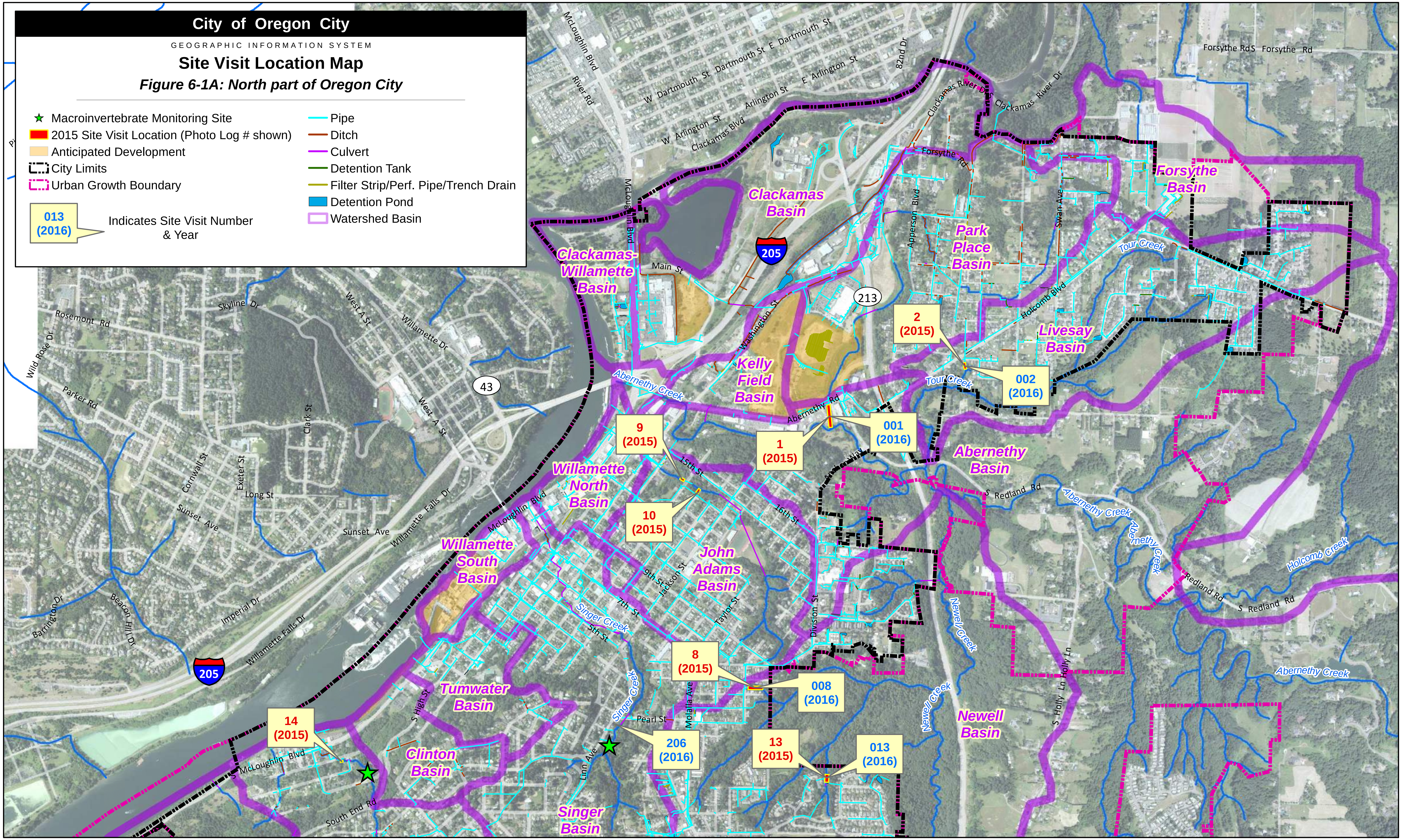
Willamette River. The Willamette River is impacted by the areas of the city that have been long established and developed. The results are long-established flow patterns. The areas of the city that drain to the Willamette River are naturally protected from the negative impacts of development by the rocky nature of the geology. No negative impacts from development have been observed in these areas.

City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Site Visit Location Map

Figure 6-1A: North part of Oregon City



Plot date: June 23, 2017; Plot name: SWMP - Site Visit Location Map - North - 11x17L - 20170623.pdf; Map name: SWMP - Site Visit Location Map - North - 11x17L.mxd

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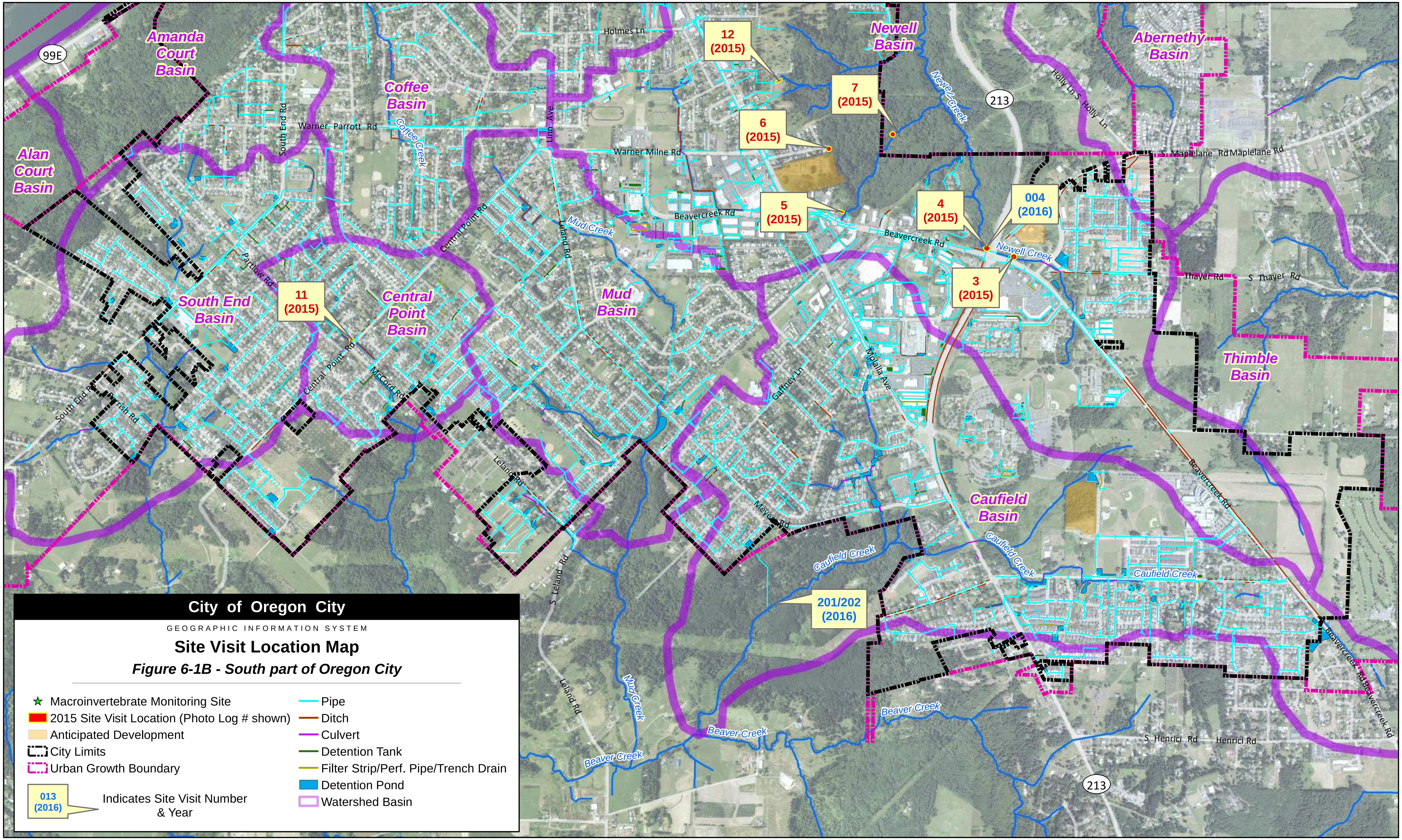

City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Site Visit Location Map

Figure 6-1B - South part of Oregon City

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Plot date: June 23, 2017; Plot name: SWMP - Site Visit Location Map - South - 11x17L - 20170623.pdf; Map name: SWMP - Site Visit Location Map - South - 11x17L.mxd

Table 6-2. Hydromodification Indicators in Oregon City Watersheds				
Indicators	Abernethy Creek and tributaries (Livesay Creek, High School Creek, Park Place Creek)	Newell Creek and tributaries	Willamette River tributaries (Coffee Creek, Singer Creek)	Beaver Creek tributaries (Caufield Creek, Mud, Central Point
Flooding	• None observed or reported during limited field observations. • Observed open-channel areas are typically in small canyons, limiting potential flooding.	• None observed or reported associated with stream channel discharges. • Localized flooding problems are associated with specific areas of the conveyance system.	• None observed or reported.	• None observed or reported.
Degradation/ bed incision	• Bed incision on Park Place Creek downstream of Abernethy Road (site 001) looks to be historical channel change. Culverts currently sit above the elevation of the lowered channel bed. • Significant bed incision on tributary to Livesay Creek downstream of Holcomb Boulevard (site 002). Past channel protections, including a large concrete outfall, are continuing to degrade.	• Most observed locations show little incision. • Significant bed incision at Beavercreek Road/Hwy. 213 outfalls (site 004) caused by multiple stormwater discharge pipes in single, steep channel. Portions of bed are armored with natural bedrock and boulders. • Active incision at Scattering Canyon tributary. Evidence of nick points and plunge pools forming between cobbles. • Bed stabilization projects on small tributaries (site 008) looks to be providing adequate protection.	• Observed portion of Coffee Creek Channel under private property has signs of historical incision. • Channel beds contain cobbles and larger material, providing natural resistance to incision.	• None observed or reported. Channels look to be retaining natural shape and connections to larger floodplains.
Bank erosion/widening	• Erosion around culvert outlets on observed tributaries. • Significant erosion of channel banks near outfall at site 002.	• Channel sections with sufficient setbacks have maintained floodplain connection and do not show signs of ongoing erosion. • Significant bank erosion at Beavercreek Road/Hwy. 213 outfalls (site 004) caused by multiple stormwater discharge pipes in single, steep channel. Portions of channel bed are naturally armored with boulders and cobbles. • Minor channel widening at Scattering Canyon tributary (site 012). • Localized erosion around stormwater outfalls.	• None observed or reported during limited field observations.	• None observed or reported.

Table 6-2. Hydromodification Indicators in Oregon City Watersheds

Indicators	Abernethy Creek and tributaries (Livesay Creek, High School Creek, Park Place Creek)	Newell Creek and tributaries	Willamette River tributaries (Coffee Creek, Singer Creek)	Beaver Creek tributaries (Caufield Creek, Mud, Central Point
Lack of riparian vegetation	• Development encroachment has reduced riparian vegetation in some areas. • Invasive species observed in urbanized channel areas. • High School Creek (site 009-010) is located in a deep canyon and has protected vegetated corridor through the urbanized area.	• Observed channel areas have good vegetative cover. • Protected areas of Newell Canyon are vegetated with natives. Little evidence of invasive species. • Development encroachment on smaller tributaries has potential to impact riparian vegetation.	• Development encroachment has reduced riparian vegetation in some areas, particularly in Coffee Creek Basin. • Singer Creek has protected riparian corridors around the stream channel.	• None observed or reported. Channels are in protected corridors with abundant natural vegetation.
Aggradation/sediment loads (evidence of increasing sediment loads without capacity to transport)	• None observed or reported during limited field observations.	• None observed or reported. • Stream channel observations show good gradation of channel bed materials, little siltation.	• None observed or reported during limited field observations.	• None observed or reported during limited field observations.
Other observed problems	NA	• Potential water quality concerns at Scattering Canyon (site 012). Hillside seepage and drainage pipes from old landfill could be source of pollutants.	• Limited open-channel areas in these drainage basins. • Some locations of the piped conveyance system are located on or under existing structures and/or private property. Limited potential to daylight channel or increase conveyance capacity.	NA
Unique features that may inform hydromodification strategies	• Future development areas in the UGB adjacent to Livesay Road and Redland Road have potential to impact Abernethy Creek and tributaries. • Future development of old landfill site could impact problem area at Park Place Creek downstream of Abernethy Road (site 001).	• Large portions of Newell Canyon are under Metro protection, limiting near-stream development and maintaining riparian and floodplain protection. • Future developments in headwaters areas have the potential to impact Newell Creek and Newell Creek tributaries. • GOCWC has been pursuing funding for a restoration project at Scattering Canyon. The City has also allocated funds for this project.	• Limited channel observations in this watershed. • Steep slopes and more limited upstream development potential in these basins.	• Development in this watershed has largely included stormwater management facilities. • Natural wetland areas at headwaters of tributaries provide natural attenuation for stormwater runoff.

Note: Representative conditions identified based on available data. Beaver Creek tributaries (Caufield, Mud, Central Point, and South End basins) not included in priority field assessments, though impacts are expected to be similar to those in the Newell and Abernethy basins.

6.5 Natural Systems Recommendations

The natural systems assessment builds upon the hydromodification assessment, completed by the City in 2015. Additional data collected in 2016 lead to the refinement of the CIP recommendations from the 2015 study.

Several of the program recommendations from the 2015 study were completed in conjunction with this Master Plan. This included collecting additional field data, completing a surface water master plan, conducting annual monitoring visits to problem areas, and developing a water quality retrofit program. In addition, the City is implementing the updated Stormwater and Grading Design Standards that include requirements for developments related to addressing hydromodification.

6.5.1 Capital Project Recommendations

Table 6-3 lists the potential in-stream CIPs that were identified in 2015 with additional information regarding the incorporation of those CIPs into the Master Plan. One additional CIP that was also identified in 2016 has been added to the table below.

Table 6-3. Potential In-stream Capital Improvement Project Locations

Basin	Site visit location	CIP location	Description	Potential hydromodification benefits	Implementation Plan
Newell Creek	004	Newell Creek downstream of Beavercreek Road and Highway 213	• Energy dissipation at existing outfalls and downstream channel improvements • Vegetation management associated with reconstructed channel and floodplain • Requires geotechnical evaluation to determine extent of roadway impacts and methods of armoring the stream channel in locations of the road subgrade	• Addresses active erosion and incision problems • Reduces stream energy and dissipates concentrated flows • Improves in-stream function • Enhances riparian zone	• This problem area is being addressed through a separate ODOT project.
Newell Creek	012	Scattering Canyon in Mountain View Cemetery	• Reconstruct drainage channel to accommodate current flow regime • Install energy dissipation features and reconnect floodplain for overbank peak flows • Vegetation management associated with reconstructed channel • Requires upstream investigation to determine source and extent of current flow contributions	• Addresses active erosion and incision problems • Reduces stream energy and dissipates concentrated flows • Improves in-stream function • Enhances riparian zone	• At the time of this Plan, this CIP is in the design phase.
Livesay Creek	002	Livesay Creek culvert outfall downstream of Holcomb Boulevard	• Energy dissipation at existing outfalls and downstream channel improvements • Vegetation management associated with reconstructed channel and floodplain • May require private property acquisition to reconstruct channel and floodplain	• Addresses active erosion and incision problems • Reduces stream energy and dissipates concentrated flows • Improves in-stream function • Enhances riparian zone	• 2016 site visit showed no ongoing degradation. CIP was removed from the priority list.

Table 6-3. Potential In-stream Capital Improvement Project Locations

Basin	Site visit location	CIP location	Description	Potential hydromodification benefits	Implementation Plan
Park Place Creek	001	Park Place Creek channel downstream of Abernethy Road culvert	• Enhance in-stream channel diversity and energy dissipation through vegetation management and installation of woody debris • Consider grade control structures to prevent further incision • Consider long-term property acquisition to restore floodplain connection • Coordinate with GOCWC on adjacent floodplain restoration project along Abernethy Creek	• Addresses ongoing incision • Potential to reconnect floodplain and reduce stream energy	• 2016 site visit showed no ongoing degradation. CIP was removed from the priority list.
Newell Canyon	008 and 013	Newell Canyon Outfalls	• Outfall investigation program to prioritize and evaluate Newell Canyon outfalls. • Stabilization projects to reduce erosion and bank sloughing at priority outfalls.	• Identifies and addresses active erosion and incision problems • Reduces stream energy and dissipates concentrated flows • Improves in-stream function • Enhances riparian zone	• Incorporated into this Plan as a CIP.

6.5.2 Outfall Assessment Recommendations

The 2016 site visits revealed a clear need for ongoing monitoring and in-depth investigation of stormwater outfalls in Newell Canyon (last row of Table 6-3). Sites 008 and 013 showed noticeable degradation in a 1-year time frame. The City has constructed outfall stabilization projects in the past, but a more comprehensive investigation is warranted.

To facilitate the necessary level of effort to continue to inspect and then repair or rehabilitate some of the outfalls and systems, a programmatic CIP has been developed. The outfall inspection program would include conducting widespread assessment of stormwater outfalls in Newell Canyon to identify and prioritize projects that would stabilize failing areas, reduce stream energy and enhance riparian areas. Projects identified through the outfall inspection program could be included as additions to the CIP list provided in Section 7 and should be scored and prioritized in a similar manner as the City determines where to direct CIP resources.

The City's first step in this process is to conduct a widespread outfall assessment to evaluate stormwater outfalls, identify significant problem locations, and develop concept plans to stabilize degrading systems. The assessment should include the following:

- Develop outfall evaluation criteria for a desktop evaluation and onsite evaluation.
- Conduct desktop evaluation using available mapping data and problem area reports to prioritize locations for onsite assessments.
- Based on the prioritization outcome, conduct outfall inspections at roughly 15-20 high priority outfalls. Inspections would evaluate outfall condition, stabilization measures, bank stability and degradation. Inspections would also evaluate construction opportunities and constraints for future stabilization projects.
- Develop a priority matrix of outfall stabilization projects and a recommended schedule for design and construction.

- Develop concept level designs and cost estimates for outfall stabilization measures at the highest priority project areas (approximately five outfalls).

Follow-up work is expected to include numerous outfall stabilization projects. Some projects may be completed by City crews, while others could require significant design and construction contracts. It is recommended that $100,000 per year be set aside for outfall stabilization projects identified through the outfall assessment study. The project implementation timeline will depend on the severity of degradation and potential risks of deterioration at each outfall. Future goals may include proactive work to stabilize lower priority outfalls before significant problems arise to avoid more costly emergency fixes down the road.

Section 7

Capital Improvement Project Development

This section describes the CIPs recommended to address the problem areas identified throughout this master planning process. These CIPs address current and future needs to address water quality issues, capacity/flooding, asset management, and natural systems health.

7.1 Project Identification

Potential CIP locations were identified by reviewing the problem areas matrix presented in Appendix A. The matrix includes problems reported by City staff, as well as problem areas identified through modeling (Section 3) and the natural systems assessment (Section 6).

After documenting the problem areas on a map and in a matrix, the problems were grouped into potential CIP areas. Many of the reported problems were identified as having a clearly identifiable solution. Examples of this include culvert upsizing to increase capacity, adding infrastructure in underserved areas, and construction of water quality treatment facilities for untreated urbanized areas. Other problem areas were identified as requiring additional investigation through modeling, site visits, or desktop assessment in order to recommend CIPs.

Appendix G includes a comprehensive matrix of potential CIPs resulting from the problem area review. This list includes far more CIPs than the City could reasonably implement during the planning period, but it provides an overview that helped to identify focus areas.

Using the potential CIPs matrix in Appendix G, Brown and Caldwell led a workshop with City staff to review, prioritize, and narrow the list of potential CIPs. During the workshop, each problem area was reviewed with respect to the nature of the problem, the severity of the problem, and how the problem or potential solution would benefit residents and private or public assets. CIP timing was also discussed as some CIPs were already under development and not appropriate for inclusion in this future planning document.

7.2 Recommended Capital Improvement Projects

Based on feedback from the strategy workshop the potential CIP list was prioritized and narrowed down to twelve CIPs for further evaluation and development. Six projects include water quality enhancements, five replace old and undersized infrastructure to address capacity issues, and three construct new infrastructure in areas currently lacking a system. Several projects address multiple objectives. These identified CIPs are listed in Table 7-1 below.

Table 7-1. Comprehensive CIP Summary				
CIP no.	CIP type	CIP name	CIP description	Estimated implementation cost
1	Capacity	John Adams Basin Capacity Improvements	Pipe capacity improvements	$8,555,000
2	Capacity Water quality	South End Road Stormwater Improvements	Pipe capacity improvements	$3,209,000
3	New infrastructure	Division Street Infrastructure Improvements	New conveyance infrastructure	$770,000
4	New infrastructure	Rivercrest Neighborhood Infrastructure Improvements	New infrastructure and existing pipe capacity improvements: sanitary disconnect	$2,428,000
5	New infrastructure	Harding Boulevard Sanitary Disconnect	New infrastructure and sanitary disconnect	$464,000
6	Water quality	Pebble Beach Pond Retrofit	Detention and water quality pond retrofit	$713,000
7	Capacity	Hiefield Court Culvert Improvements	Update culvert inlets to reduce losses and assess capacity of existing system	$657,000
8	Water quality	The Cove Water Quality Improvements	Construction of water quality facility and retrofit of existing conveyance system	$608,000
9	Capacity	Holcomb Boulevard Capacity Improvements	Pipe capacity improvements	$3,893,000
10	Capacity Water quality	Coffee Creek Stream Restoration	Daylighting and restoration of Coffee Creek through Hazelwood Drive neighborhood.	$1,096,000
11	Water quality	Scattering Canyon Stormwater Improvement	Enhance current outfall and channel at canyon to reduce erosion while enhancing water quality and aesthetics	$521,000
12	Water quality	Newell Canyon Outfall Assessment	Visit, assess and develop concept design for outfall repair	$100,000

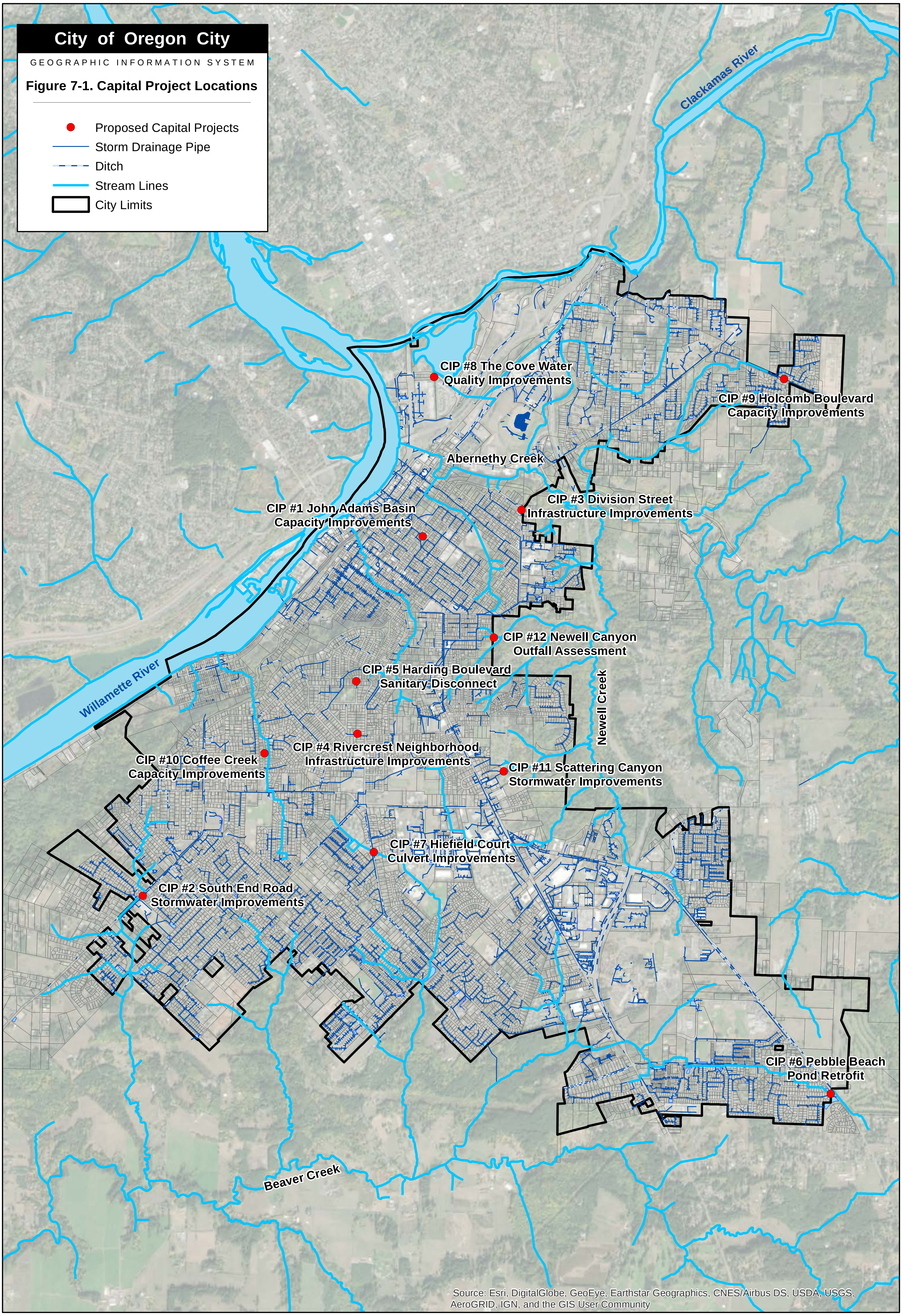
A map of CIP locations is included as Figure 7-1. Fact sheets for each of the CIPs are included in Appendix F.

7.3 Design Assumptions

This section includes a summary of the CIP sizing and conceptual design criteria based on the type of system improvements proposed. CIP design concepts include capacity projects, water quality projects, and new stormwater infrastructure. The design assumptions used to develop conceptual project solutions generally followed the City’s Stormwater and Grading Design Standards. CIP concepts were designed to an approximate 10 percent design level with preliminary concept sketches and cost estimates included in the CIP Fact Sheets in Appendix F.

Capacity Projects. CIP concepts that include construction of new conveyance infrastructure, or that replace existing conveyance infrastructure, were developed following the City design standards for sizing. All CIPs in this plan systems were sized for conveyance of the 25-year, 24-hour event. This is required for catchment areas between 40 and 640 acres.

Water Quality Projects. Six CIPs include elements that provide water quality benefits for the city. The conceptual facility at the Cove was sized using the City’s BMP Sizing Tool. The tool provides facility sizing for flow control and/or water quality. The Pebble Beach retrofit CIP will be sized using the tool when the time comes for detailed design. For the conceptual design, the assumption was made that increased water quality treatment will be provided within the existing facility footprint to the extent possible with the inclusion of new outlet structures. Other projects incorporate water quality enhancements to larger capacity focused projects or are opportunistic enhancements, based on the available land area.



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 7-1. Capital Project Locations

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

N
W E
S

0 0.5 1 2 Miles

0 5,000 10,000 Feet

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Plot date: December 14, 2017
Plot name: Figure 7-1 Capital Project Locations.pdf
Map name: Figure 7-1 Capital Project Locations.mxd

New Infrastructure. Several of the CIPs include new infrastructure to be constructed in locations where no previous storm systems existed. Concepts of these systems are illustrated in the CIP Fact Sheets in Appendix F with generalized locations provided in public rights-of-way. However, consideration for other utilities, conflicts, depth, and location of manholes and catch basins will all need to be investigated in more detail for final design. The actual design may need additional structures, may require an alternate alignment because of conflicts, or may be deeper or shallower than what was assumed for the conceptual CIP in this Master Plan.

7.4 Cost Estimates

The cost estimates generated for each CIP were based on the proposed layout and general design assumptions. The unit pricing was based on past CIP bid tabs adjusted for 2019 based on a historical cost index and recent construction bids in the Portland Metro area.

Preliminary CIP cost estimates were based on the unit cost information for construction elements plus a 30 percent contingency. Contingencies for permitting, surveying and design, and construction administration costs were based on a general percentage of the total construction cost. A market adjustment of 15 percent was also added to cost estimates, based on higher than usual construction costs in the Portland metropolitan area. Land acquisition costs were not included in the estimates.

Appendix H includes the unit cost tables that were used for this Master Plan, and the concept-level project cost estimate for each CIP.

7.5 Capital Improvement Project Prioritization

CIP prioritization is an important step in developing a plan for the City that provides an implementable path forward and direction in terms of sequencing CIPs. The prioritization process included a set of scoring categories or criteria and point values for CIP conditions associated with each criterion. Over time, the City may choose to add weighting factors to place more emphasis on a particular scoring category as new CIPs are added to the list and scored.

For Oregon City, a CIP prioritization meeting was conducted with City staff. Multiple CIP example scoring criteria were provided, and City staff identified the preferred criteria and scoring framework as shown in Table 7-2 below.

Table 7-2. Capital Improvement Project Prioritization Criteria

Scoring category	Weight	Rating level	Score
Capacity issue (safety/liability)	1.0	Significant flooding hazard; threat to life and limb and/or property	5
		Moderate safety hazard	3
		No flooding or safety hazard	1
Benefit to sanitary system	1.0	Significant benefit to sanitary system	5
		Moderate benefit to sanitary system	3
		No benefit to sanitary system	1
Cost	1.0	Small CIP (less than $500,000)	5
		Medium CIP (greater than $500,000 and less than $1,000,000)	3
		Large CIP (more than $1,000,000)	1
Environmental benefit	1.0	Significantly improves water quality	5
		Moderately improves water quality	3
		No improvement to water quality	1
Maintenance (long- and short-term)	1.0	CIP will significantly reduce ongoing maintenance requirements	5
		CIP will moderately reduce ongoing maintenance requirements	3
		CIP will not reduce ongoing maintenance requirements	1
Existing condition	0.5	System is failing or beyond its expected design life	5
		System appears to be in good working order and is not beyond expected design life	3
		System is in excellent shape and relatively new	1
Impact	1.0	Problem affects regionwide area with significant downstream and/or upstream impacts	5
		CIP will address multiple blocks or properties	3
		CIP will address a few properties	1

The prioritization criteria focus on system capacity and condition with consideration for cost, maintenance, and environmental benefit, which are included in Table 7-2. Unique to Oregon City, the scoring categories include consideration for a CIP’s potential benefit to the sanitary sewer system, as the City is facing challenges related to stormwater and sanitary sewer interconnections. All scoring criteria were weighted equally, with the exception of the “existing conditions” criterion, which was given half the weight of the other criteria. The maximum possible CIP score was 35.

The CIP scoring and the resulting ranking is included in Table 7-3 below. Prioritization scores range from 12.5 to 26.5, with the higher scores representing projects that are most closely aligned with the City’s stormwater planning objectives.

Table 7-3. Capital Improvement Project Prioritization

Score	CIP ranking	
26.5	1	Harding Blvd Sanitary Disconnect
24.5	2	Newell Canyon Outfall Assessment
22.5	3	Scattering Canyon Stormwater Improvements
20.5	4	Rivercrest Neighborhood Infrastructure Improvements
18.5	5	John Adams Basin Capacity Improvements
18.5	6	The Cove Water Quality Improvements
15.0	7	South End Road Stormwater Improvements
15.0	8	Pebble Beach Pond Retrofit
13.0	9	Holcomb Road Capacity Improvements
13.0	10	Coffee Creek Capacity Improvements
12.5	11	Hiefield Ct Culvert Improvements
12.5	12	Division Street Infrastructure Improvements

The full CIP prioritization scoring matrix is included in Appendix I.

Section 8

Integrated Stormwater Management Strategy

The City needs a proactive plan to address immediate capacity needs, replace aging infrastructure, and provide regional solutions to larger flooding and water quality challenges. This section provides a summary of recommendations to address existing storm system capacity deficiencies, future storm system needs, asset management, and water quality objectives.

8.1 Integrated Stormwater Management Overview

The management of a stormwater program is multifaceted and requires the integration of multiple elements. Ensuring that the conveyance infrastructure has adequate capacity and is managed to ensure long-term reliability forms the backbone of the stormwater system. The outfalls from the conveyance system and the natural systems that carry the resulting urban runoff require management that is aided through water quality treatment and flow control facilities incorporated into the urban stormwater infrastructure. Guiding the integration of the City's stormwater management strategy is City code, design standards, and state and federal management requirements.

The City's stormwater program was formed around addressing drainage capacity and flooding problems. In the last decade, the program has shifted to include programs that address water quality needs, natural system impacts and the aging infrastructure. The recommendations in Sections 7 and 8 present an integrated strategy of programs and projects to address stormwater priorities across the City. The major recommendations include:

- Replace deteriorating and failing infrastructure, particularly in older areas of the City where stormwater infrastructure is reaching the end of the design life.
- Upsize existing infrastructure to reduce identified flooding issues.
- Upsize existing infrastructure to carry flows from projected future development and support future roadway improvements.
- Install new stormwater infrastructure systems in unserved neighborhoods (Rivercrest and Harding) to reduce stormwater inflow and infiltration into the sanitary sewer system.
- Implement outfall assessment program to systematically monitor and stabilize Newell Canyon outfalls.
- Increase water quality treatment through targeted actions and by integrating treatment features into planned capital projects.
- Expand programs to monitor stormwater infrastructure condition to identify pipes, culverts, and outfalls in degraded condition.
- Develop funding strategy and prioritized CIP implementation schedule.

Recommendations include twelve capital improvement projects and three programmatic actions. Capital Improvement Projects (CIPs) have been developed to address existing and predicted future conditions flooding problems, integrate water quality elements, and replace deteriorating pipe segments.

8.2 Capital Improvement Projects

Implementation of the CIPs outlined in Section 7 will be important to continue to provide the necessary infrastructure for a healthy and well-maintained stormwater system. The CIPs provide a list of projects to enhance all aspects of the City's stormwater infrastructure and program.

The twelve recommended CIPs cover multiple objectives. Three CIPs install infrastructure in areas that are not currently served, six include water quality enhancements, five replace old or undersized infrastructure to improve conveyance capacity, and one programmatic project focuses on assessment of current conditions.

Based on priority rankings, the City's highest priority is to implement CIP #5 – Harding Boulevard Sanitary Disconnect to install new infrastructure in neighborhood without a stormwater system. Other high priorities include conducting systematic outfall assessments across Newell Canyon (CIP #12) and reconstructing the outfall channel in Scattering Canyon (CIP #11).

To support upcoming projects, it is recommended that the City begin investigating property acquisition for a water quality improvement near the Cove (CIP #8), and initiate coordination with private property owners to assess the viability of installing new stormwater systems for the Harding and Rivercrest neighborhoods.

The scheduling of CIPs will depend on funding sources and availability, as described in Section 8.4 below.

8.3 Programmatic Recommendations

In addition to the recommended CIPs, the following program recommendations would allow the City to improve understanding of the existing drainage infrastructure conditions and enhance stormwater-related services.

8.3.1 Stormwater R/R Program

The stormwater R/R program outlined in Section 4 includes two primary elements: annual inspections and ongoing pipe R/R projects.

This plan recommends continuing the CCTV inspections with a focus on the aging infrastructure area and areas of the City where pavement rehabilitation projects are planned in the next five years. After inspections are completed in the aging infrastructure area, it is recommended that the City continue an ongoing cycle of CCTV inspections, with the aim of covering all public stormwater infrastructure the City on a 10-year cycle. Depending on staffing levels, the long-term CCTV inspection could be completed by City maintenance crews.

Completing the inspection program will allow the City to identify pipes in critical need of replacement. Replacing deteriorating stormwater infrastructure could cost over $750,000 per year, depending on the extent of pipe replacements, size of pipes, type of rehabilitation, and the speed at which the City wants to implement the program. Pipe replacement projects would be in addition to the CIPs outlined in Section 7 and should be scored and prioritized in a similar manner as they are added to the list.

8.3.2 Outfall Stabilization Project

The outfall inspection assessment outlined in Section 6 and CIP #12 is focused on investigating stormwater outfalls in Newell Canyon to document changing (or stabilized) conditions at each City-owned outfall and identify areas where stabilization measures are needed.

Follow-up work is expected to include numerous outfall stabilization projects. Some projects may be completed by City crews, while others could require significant design and construction contracts. It is recommended that $100,000 per year be set aside for outfall stabilization projects identified through the outfall assessment study. The project implementation timeline will depend on the severity of degradation and potential risks of deterioration at each outfall. Future goals may include proactive work to stabilize lower priority outfalls before significant problems arise to avoid more costly emergency fixes down the road.

8.3.3 Additional Recommendations

Maintenance is a necessary requirement for the long-term health and stability of the City's stormwater program. This includes the maintenance of conveyance systems, flow control or detention facilities, water quality facilities, roadways and hard surfaces, 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.

8.4 Future Development Planning

The three concept plans for Beavercreek Road Concept Area, South End Concept Area and Park Place Concept Area all include financial evaluations to estimate the cost to construct transportation, utilities, and parks in the future planning areas. The financial details for the three plans have been completed at different time periods with different underlying assumptions. The costs associated with each of the concept plans for the necessary stormwater infrastructure associated with the area in the plan are provided below. Costs have been normalized to the cost per equivalent dwelling unit (EDU) or equivalent residential unit (ERU).

- Beavercreek Road Concept Plan: $14,206 per EDU for stormwater infrastructure only provided in 2007 dollars
- South End Concept Plan: $21,464 per ERU for all public facilities in 2014 dollars
- Park Place Concept Plan: $473 per EDU stormwater infrastructure only provided in 2008 dollars

The City is also a partner in the Willamette Falls Legacy Project, which will provide public access to the falls and facilitate redevelopment of the historic Blue Heron Mill property. Redevelopment of the Willamette Falls Downtown District will require an investment in infrastructure and utilities, including conveyance and water quality treatment facilities for stormwater.

Additional evaluation is needed to establish updated cost estimates for stormwater infrastructure in all of the planning areas and to determine which portions of the stormwater infrastructure (if any) should be paid for through SDCs. Updated cost estimates could be needed to support a future stormwater utility and SDC rate study as part of the Stormwater Master Plan implementation.

8.5 Stormwater Master Plan Fiscal Discussion

This Master Plan includes a recommendation for twelve capital projects and three programs. The total capital cost for the twelve CIPs is estimated at $20,335,000. The annual cost to fund these infrastructure CIPs over the next 15 years is $1,489,000. The two management programs (stormwater R/R program and outfall stabilizations) are estimated at $400,000 per year, assuming a smaller value and longer term R/R program. The annual budget to implement the twelve CIPs and two management programs outlined in this Master Plan is $1,889,000.

The City's current budget allocates roughly 17 percent of the stormwater program budget to capital improvements. This equates to roughly $550,000 per year. If the City were to address the CIPs outlined in this Master Plan using existing capital project allocations and neglected all other small stormwater project work, there would still be a significant budget shortfall. Given the importance of these CIPs, it is recommended that a stormwater utility rate study be completed as a follow-up to this Master Plan. The rate study can provide a deeper understanding of the financial implications and an opportunity to evaluate alternative funding mechanisms and plans.

In addition to the capital project costs noted above, the concept plans discussed in Section 8.4 could require a significant public investment in stormwater infrastructure. Costs for infrastructure in the concept plan areas should be incorporated into the City's financial analysis.

8.6 Stormwater Management Implementation Plan

Adoption and implementation of this Master Plan and the elements outlined within it are important for the City to move in a direction of preventive actions to minimize future and more expensive reactionary actions. Implementation of the CIPs and utilization of the prioritization matrix along with implementation of the programmatic recommendations will be critical to moving the City forward with respect to sound management of its stormwater infrastructure.

Following this study with a rate study and funding assessment will enable the City to address some of the funding challenges.

Establishing an annual program to inspect and assess the condition of the City's infrastructure will set the City up with a greater understanding of the system and the areas in need of imminent repair and replacement. Implementing design and construction of the listed CIPs will address the areas currently identified as problems. Current and future regulations and design standards will aid in ensuring that new development and redevelopment do not exacerbate any existing problems or place new stresses on the current system.

Section 9

Limitations

This document was prepared solely for Oregon City in accordance with professional standards at the time the services were performed and in accordance with the contract between Oregon City and Brown and Caldwell dated March 17, 2016. This document is governed by the specific scope of work authorized by Oregon City; 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 Oregon City and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

Section 10

References

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http://www.usclimatedata.com/climate/portland/oregon/united-states/usor0275

Appendices

Appendix A: Problem Area Matrix

Table A-1. Stormwater Problem Areas – Opportunities

Name/no.	Basin	Location	Problem type	Source	Site visit	Description	Comments/notes
LI-O-01	Livesay	Northeast corner of city	Opportunities	Staff workshop		Need master planning for future development near Holcomb and Winston and Oak Tree Ter.	
CA-O-02	Caufield	Andrea Lynn Ter.	Opportunities	City asset review		Evaluate Pond inflow/outflow – looks like it may overtop.	JM - low
CL-O-01	Clackamas/Kelly Field	Melinda St.	Opportunities	Staff workshop		Possibly redirect flow at Melinda/Forsythe toward Jughandle.	
CL-O-02	Clackamas/Kelly Field	Kelly Field	Opportunities	Staff workshop		Need master planning for future development near Kelly Field.	
CO-O-02	Coffee Creek	Linn Ave. at Mt Pleasant Apartments	Opportunities	City asset review		Large puddle forms at the entrance of apartments.	JM - low
MU-O-02	Mud	Existing ponds	Opportunities	Staff workshop		Potential to retrofit existing ponds for greater benefit.	
NE-O-01	Newell Creek	Newell Canyon outfalls	Opportunities	Staff workshop		Possible ongoing line item CIP to evaluate and stabilize outfalls discharging into Newell Canyon (ex. 42" outfall at Rocky Younger property).	
SE-O-01	South End	Basin wide	Opportunities	Staff workshop		Are there opportunities to add regional facilities and/or in-line facilities along creek corridor to serve future development?	Consider with WQ retrofit evaluation Need to review South End Concept Plan for potential projects.

Table A-2. Stormwater Problem Areas – Natural Systems

Name/no.	Basin	Location	Problem type	Source	Site visit	Description	Comments/notes
NE-N-04	Newell Creek	17883 Peter Skene Way	Natural channels	Natural systems investigation	013	City-installed rip-rap has stabilized stream bed however water seeping through bank is causing severe erosion. Source of water possibly from above detention/infiltration pond.	
NE-N-01	Newell Creek	Hwy 213 and Beavercreek Rd.	Natural channels	Natural systems investigation	004	Significant erosion and incision at Beavercreek Rd./Hwy 213 outfalls; potentially an ODOT issue.	City is starting coordination with ODOT EH - high priority
CO-N-02 (CO-P-01)	Coffee Creek	Between Hazelwood Dr. and Warner Parrott Rd.	Natural channels	City asset review		Stream bank eroding near foundation of house.	JM - high priority
LI-N-01	Livesay	Private property at 14040 Beemer Way (Jacobs Way and Holcomb Blvd.)	Natural channels	Natural systems investigation City asset review	002	Significant erosion; Concrete outfall structure conveying discharge from Holcomb Road to creek. Evidence of channel incision and high flows with boulders in channel bed. Eroding banks and exposed roots.	
AB-N-01	Abernethy Creek	13530 Redland Rd. (current dry weather monitoring location)	Natural channels	Natural systems investigation	001	Some bed erosion and stream incision.	
CO-N-01	Coffee Creek	Hedges St.	Natural channels	Staff workshop		Loose rocks in channel downstream of Hedges Ave.	
NE-N-02	Newell Creek	Scatter Canyon	Natural channels	Staff workshop		Channel erosion contributing to water quality concerns.	Project under development
NE-N-03	Newell Creek	Logus St. and Eluria St.	Natural channels	Natural systems investigation	008	Ongoing erosion on southern bank of tributary to Newell Creek. Limited vegetation is growing along this bank.	
PP-N-01	Park Place	Harley and Cleveland	Natural channels	Staff workshop		Erosion in large regional ditches.	
SI-N-01	Singer Creek	Singer Creek Falls	Natural channels	Staff workshop		Occasional observations of discoloration at outfall; unable to identify upstream source.	
SI-N-02	Singer Creek	Singer Creek Park	Natural channels	Natural systems investigation City asset review	206	Western bank has slid off into creek. Further bank stabilization may be required. Culvert evaluation needed.	May be an isolated incident. JM - low
CA-N-02 (CA-P-01)	Caufield	Char Diaz - outfall	Natural channels	City asset review		Erosion issues at outfall.	EH - high priority

Table A-3. Stormwater Problem Areas – Maintenance

Name/no.	Basin	Location	Problem type	Source	Site visit	Description	Comments/notes
CN-M-01	Clinton	512 Center and 517 Sunset	Maintenance	Staff workshop		Drainage from bluff to Center Street (asphalt channel) at 512 Center and 517 Sunset are both subject to grate clogging.	
CO-M-01	Coffee Creek	Woodly Ct.	Maintenance	Staff workshop		Roots plugging pipe downstream of Woodly Ct.	
JA-M-01	John Adams	High School Creek - Jackson St and upstream	Maintenance	City asset review		No access for maintenance of storm lines across high school field.	
TU-M-01	Tumwater	S. Center St. and Clinton St.	Maintenance	City asset review		Stormwater from Ogden stream runs down the bank and the inlet at Center and Clinton plugs.	JM - high priority
TU-M-02	Tumwater	Discharge pipe	Maintenance	Staff workshop		Broken discharge pipe to river at outfall.	Would like to understand the extent of damage and potential liability
CA-M-01	Caufield	Falcon Dr.	Maintenance	Staff workshop City asset review		Limited maintenance access and flooding into private areas. Need additional storm infrastructure - drainage issues at outfall to creek.	EH - medium priority

Table A-4. Stormwater Problem Areas – Infrastructure

Name/no.	Basin	Location	Problem type	Source	Site visit	Description	Comments/notes
CO-I-01	Coffee Creek	Canemah District	Infrastructure	Staff workshop		Historic channels are deteriorating and need repair. Pipes and channels through private property and under buildings.	Would like to see a Canemah District "Stormwater Restoration Project" that includes systematic upgrades to channels with historic preservation.
CO-I-04	Coffee Creek	965 Hazelwood Drive	Infrastructure	Staff workshop		Culvert is in poor condition and failing - needs replacement.	JM-high priority
JA-I-03	John Adams	Madison Street between 12th and 15th	Infrastructure	City asset review		Culvert needs inspection for potential replacement.	EH - high priority
JA-I-04	John Adams	High School Creek - Jackson St. and upstream	Infrastructure	City asset review		Video inspect and evaluate.	
JA-I-05	John Adams	15th and Van Buren to Jackson	Infrastructure	City asset review		Install additional storm line to pick up year round drainage.	EH - high priority
JA-I-01	John Adams	Eluria St., Willamette St.	Infrastructure	City asset review		Replace aged storm system, numerous structural issues.	EH - medium priority
LI-I-02	Livesay	Private property at 14040 Beemer Way (Jacobs Way and Holcomb Blvd)	Infrastructure	City asset review		Severe erosion at outfall - needs repair.	EH - High Priority
SI-I-01	Singer Creek	Old Singer Creek alignment	Infrastructure	Staff workshop		Failing infrastructure along old singer creek alignment. Concern for condition of pipes and locations of pipes under private property.	
SI-I-02	Singer Creek	Rivercrest neighborhood	Infrastructure	Staff workshop		No storm drain system; drains to sewer.	
SI-I-04	Singer Creek	Harding Boulevard	Infrastructure	Staff workshop City asset review		Planned project to add infrastructure on Harding Boulevard. Multiple CB's connected to sanitary.	Budgeted for 2017
SI-I-06	Singer Creek	Harrison St and Division	Infrastructure	City asset review		Drainage problem area.	EH - high priority
SE-I-01	South End	South End St. from Lafayette to Forest ridge	Infrastructure	City asset review		Storm system drains poorly.	EH - low priority
WN-I-01	Willamette North	Main and 12th	Infrastructure	Staff workshop		20" CMP needs replacement; pipe type changes to concrete in vacant lot.	
SE-F-01	South End	Hazelnut St.	Flooding/ infrastructure	Staff workshop		Culvert under Hazelnut upstream of Hazelgrove Park needs replacement; currently 18-inch pipe.	
TU-F-01	Tumwater	2nd and High St.	Flooding/ infrastructure	Staff workshop		Alley flooding between 1st and 2nd, at S 2nd and High St.; upstream erosion plugs system; potential pipe project.	

Table A-4. Stormwater Problem Areas – Infrastructure

Name/no.	Basin	Location	Problem type	Source	Site visit	Description	Comments/notes
CO-I-02	Coffee Creek	Woodfield Ct.	Infrastructure	City asset review		Storm line is in poor condition.	JM - medium priority
CO-I-03	Coffee Creek	Ganong St.	Infrastructure	City asset review		Coffee Creek is piped under house - consider realignment.	JM - low
CA-I-02	Caufield	Meyers Rd. extension	Infrastructure	Staff workshop		Meyers Rd. extension will need stormwater system.	Planned project
CL-I-01	Clackamas/ Kelly Field	Park Place Ct.	Infrastructure	Staff workshop		Old rail culvert is rusted through.	Operations is working to redirect flow
CL-I-02	Clackamas/ Kelly Field	Washington Street system	Infrastructure	Staff workshop City asset review		Culverts cross back and forth across roadway at Clackamas Landscape Supply; Home Depot intersection flows to I-205 culverts; need pipe system to replace culvert/ditch system.	EH - low priority
CL-I-03	Clackamas/ Kelly Field	Clackamette Park outfall	Infrastructure	Staff workshop		Outfall at Clackamette Park is submerged and possibly deteriorating.	
JA-I-02	John Adams	Madison Street between 12th and 15th	Infrastructure	City asset review		Change flow direction of pipe to flow towards High School Creek.	EH - medium priority
LI-I-01	Livesay	Between Hunter Ave. and S Jacobs Way	Infrastructure	Staff workshop City asset review		No connection between Hunter and Jacobs; stormwater system discharges onto private property. Homes along Jacobs Way flood out during large events.	EH - medium priority
MU-I-01	Mud	Leland/Meyers	Infrastructure	Staff workshop City asset review		Culvert/ditch system needs upgrade to serve future road improvements.	Low
NE-I-01	Newell Creek	Roosevelt and Molalla	Infrastructure	City asset review		MH lid blows off during large events.	NA
NE-I-02	Newell Creek	Hilda St. and Gleason St.	Infrastructure	City asset review		Need additional storm infrastructure.	EH - low priority
PP-I-01	Park Place	N. end of Swan Ave.	Infrastructure	City asset review		Upsize existing 8-inch pipe to 12-inch pipe.	EH - medium priority
PP-I-02	Park Place	N. end of Hiram St.	Infrastructure	City asset review		Inadequate storm infrastructure.	EH - low priority
SI-I-02	Singer Creek	1st and Jackson	Infrastructure	Staff workshop		Missing infrastructure.	Note that many roof drains are likely still connected to sewer laterals and contribute to sewer flows.
SI-I-03	Singer Creek	Willamette St. between Molalla and Holmes St.	Infrastructure	Staff workshop City asset review		No stormwater system on Willamette St; results in nuisance flooding on street and adjacent lots between Molalla and Holmes St.	EH - high priority
SI-I-05	Singer Creek	8th and 9th St. outfalls	Infrastructure	City asset review		Rusted outfalls need replacement.	EH
MU-I-02 (MU-P-01)	Mud	Mud Creek - Wassail Ln. to Meyers Rd.	Infrastructure	City asset review		Video and evaluate pipe.	EH - medium priority
AB-I-01	Abernethy Creek	Penn Ln., Anchor Way	Infrastructure	City asset review		Upgrade catch basin and storm drain system on Division.	EH - high priority

Table A-5. Stormwater Problem Areas – Flooding

Name/no.	Basin	Location	Problem type	Source	Site visit	Description	Comments/notes
CO-F-01	Coffee Creek	965 Hazelwood Dr.	Flooding	City asset review		Channel flooding on private property downstream of Hazelwood Drive; Private owners have constructed walls to contain channel. 24-inch CMP failed during Dec 2015 event.	What is City's obligation to address private property flooding?
JA-F-01	John Adams	8th and Van Buren	Flooding	Staff workshop		Manhole blow offs during flood events; roots growing into pipes; basement flooding; sections of clay pipe.	Need modeling evaluation.
JA-F-02	John Adams	Van Buren between 14th and 15th	Flooding	Staff workshop		Missing Infrastructure and drainage from high school field results in flooding at 1410 Van Buren.	
JA-F-03	John Adams	9th and Monroe	Flooding	Staff workshop		18-inch Pipe connects to 8-inch pipe.	Need modeling evaluation Recent project fixed adjacent problems on 7th.
CP-F-01	Central Point	Kathaway Court to Sunset Springs	Flooding	Staff workshop City asset review		Public system adjacent to private property regularly floods during peak events. Roadway drainage discharges to swale on private property before crossing Central Point Road. Problem stream corridor, fences etc., across stream.	City is working on solution for complicated drainage at Kathaway Court EH - high priority
SE-F-03 (SE-P-02)	South End	Oaktree Ct.	Potential project	City asset review		House flooded during storms - potentially from WQ facility uphill?	NA
SE-F-02	South End	Rose Rd	Flooding	Staff workshop		Rose Road culvert and roadside ditch are often surcharged with standing water.	Runoff is from County management area
MU-F-02	Mud	Hiefield Ct	Flooding	Staff workshop		Hiefield Court experiences flooding at culvert crossing; currently two, 30-inch culverts.	
NE-F-01	Newell Creek	14652 Thayer Ct	Flooding	Staff workshop		Low lying properties; ditch easily overtops; private pumps cannot manage current volumes	Area recently annexed from the County
NE-F-02	Newell Creek	"School District pond"	Flooding	Staff workshop		School district pond usually drains to Caufield, but overflows to Newell in heavy events; floods ball field/parking lot.	City wants to confirm that flows are following the intended configuration
JA-F-04 (JA-P-01)	John Adams	7th and Van Buren	Potential Project	City asset review		Drainage sheet flows from 7th to Van Buren and jumps a curb and then floods garage.	NA
CL-F-01	Clackamas/ Kelly Field	Park Place Ct	Flooding	Staff workshop		Flooding and maintenance issues on Park Place Ct.	Operations is working to redirect flow
MU-F-01	Mud	Round Tree Rd	Flooding	Staff workshop City asset review		Yard flooding at apartments downstream of Round Tree Rd., adjacent to natural system.	Low
PP-F-01	Park Place	Swan Ave to Apperson Ct	Flooding	Staff workshop		Culverts along channel downstream of Swan Ave. have some capacity problems.	

Table A-5. Stormwater Problem Areas – Flooding							
Name/no.	Basin	Location	Problem type	Source	Site visit	Description	Comments/notes
SE-F-04 (SE-P-03)	South End	Josephine and Bjerke	Flooding	City asset review		Poor drainage in area system.	JM - Medium Priority
SI-F-01 (SI-P-01)	Singer Creek	Holmes and Leonard	Flooding	City asset review		Flooding at the corner.	JM - low
CA-F-01 (CA-P-03)	Caufield	Beavercreek Rd	Flooding	City asset review		Flooding over Beavercreek during heaving rain events from golf course to SWQF pond.	EH
SE-F-05	South End	South End Rd	Flooding	H&H modeling			
NE-F-01	Newell Creek	Beavercreek Rd and Molalla Ave	Flooding	H&H modeling			
LI-F-01	Livesay	Holcomb Rd	Flooding	H&H modeling			

Appendix B: Hydrologic Modeling TM

Technical Memorandum

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Prepared for: City of Oregon City

Project Title: Stormwater Master Plan

Project No.: 149133

Technical Memorandum

Subject: Subcatchment Hydrology

Date: October 17, 2016

To: Jon Archibald, Project Engineer

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Copy to: Alissa Maxwell, P.E., Ryan Retzlaff, File

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Limitations:

This document was prepared solely for City Oregon City in accordance with professional standards at the time the services were performed and in accordance with the contract between City Oregon City and Brown and Caldwell dated March 16, 2016. This document is governed by the specific scope of work authorized by City Oregon City; 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 Oregon City and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

Section 1: Introduction

The City of Oregon City (City) is developing a stormwater master plan to update existing planning documents to guide surface and stormwater program decisions. The master plan will address both water quantity and quality for constructed and natural systems under the City's management. The master plan requires a clear understanding of existing and future runoff conditions across the city to identify long-term stormwater project needs.

This memorandum has been developed to document the methodology used to evaluate the hydrology, primarily as peak flows, generated by all subcatchments within the city for existing and anticipated future developed conditions. The modeling results show that peak flows are expected to remain fairly constant in watersheds such as South End and John Adams where most land area is currently built to maximum zoning allowances. The most significant flow increases are anticipated in the Park Place and Clackamas catchments because of significant vacant lands that are slated for future development.

The results of the hydrology model will be used to analyze the hydraulics of conveyance systems in key areas of concern. The hydrology results can also be used to identify natural system areas that may be more susceptible to channel erosion or channel impacts because of increasing flows.

Section 2: Hydrology Model Development

The hydrology model was developed using XP-Storm Water Management Model (SWMM) version 2016.1. The necessary parameters for the Santa Barbara Urban Hydrograph method include subcatchment areas, impervious percentages, pervious curve numbers, and times of concentration. This section includes detailed descriptions of the methodology used in determining each of the hydrology model parameters.

2.1 Basin Boundaries

The purpose of the basin boundary delineation is to define the major watershed boundaries or collection catchments within the city. The major collection catchments were then subdivided further to facilitate hydrologic evaluation.

Watershed boundaries for 23 watershed areas were provided by the City as a geographic information system (GIS) shapefile: Alan Court, Amanda Court, Central Point, South End, Mud, Clackamas-Willamette, Willamette South, Clinton, Coffee, Thimble, Livesay, Beaver, Tumwater, Singer, Park Place, Forsythe, Newell, Caufield, Kelly Field, Clackamas, Willamette North, Abernethy, and John Adams. These larger watershed boundaries are defined based on topography and conveyance system routing.

Sub-basin boundaries were defined using a combination of contour lines, streets, tax lots, stormwater conduits, and the City-provided watershed boundaries. As a starting point the sub-basins were hand drawn on large maps with a size ranging between 20 and 50 acres. Sub-basins are generally smaller in urbanized areas where the pipe network is more complex. The sub-basin delineation includes larger sub-basin areas in the outer areas of the city and in rural/agricultural areas that are not yet developed. In areas of discrepancy, basin boundary questions were resolved through the use of as-built records, GIS invert data, and City staff knowledge of the existing drainage system. A total of 185 sub-basins were defined, ranging in size from 1.0 to 194.0 acres with an average area of 39.8 acres. The watershed and sub-basin boundaries are shown in Figures 1 and 2.

Each sub-basin name was assigned a name in the format XX_####. The two-letter abbreviation was from the City-provided watershed name (e.g., AB for Abernethy). The numbers began at 0100 near the outlet of the sub-basin and increased in increments of 100. Sub-basin names are shown in Attachment A, Table A-1.

Sub-basin areas were calculated in ArcGIS and are also shown in Attachment A, Table A-1.

2.2 Time of Concentration

The methodology used to calculate the time of concentration for all sub-basins used three different methods. Rather than using the traditional approach of calculating the overland flow, shallow concentrated flow and channel or pipe flow, staff applied a streamlined method to the sub-basins based on land use and density of development. These are roughly divided into the categories of residential, commercial (COM), and rural/parks. The methods used are described in more detail in the narrative below.

The first method to be implemented selected 20 sub-basins with developed residential land use across Oregon City out of a total of 101 sub-basins. The longest pipe flow path to the outlet was measured for each subcatchment. A linear regression analysis was performed with subcatchment surface area in acres as the independent variable (x) and longest pipe flow length as the dependent variable (y), which yielded the following equation:

$$Y = 37.09x + 554.35 \ (R^2 = 0.73)$$

This regression equation was applied to the remaining 81 residential subcatchments, 101 in total, to determine the pipe flow lengths. An average velocity of 4 feet per second (ft/s) was used to calculate pipe travel time. We assumed a sheet flow length of 100 feet and no shallow concentrated flow. Slopes were measured using contour lines within ArcGIS derived from light detecting and ranging (LiDAR). From this information the time of concentration was quickly calculated for all sub-basins that are largely made up of residential land use.

The second time of concentration method calculation was implemented for more developed and densely populated areas (downtown, COM, and industrial [IND]). A shorter sheet flow length of 5 minutes was assumed because of the increased amount of impervious surfaces. The same regression equation from above was then used to calculate pipe flow lengths and average velocity within those pipes was assumed to be 4 ft/s. This methodology was applied to a total of 62 subcatchments.

For less developed areas the traditional approach was used. This includes identifying the longest flow path lines in ArcGIS then dividing the path into sheet flow, shallow concentrated flow, and pipe/channel flow. The maximum sheet flow length was set to 100 feet and the shallow concentrated flow length was used until reaching an open channel or pipe. The distance of pipe/open channel flow was measured in ArcGIS and the average velocity was assumed to be 4 ft/s. The remaining 22 sub-basin times of concentration were calculated in this way.

The times of concentration for the sub-basins ranged from 7.5 to 49.6 minutes with an average of 21.7 minutes.

Attachment A provides a data table that includes the time of concentration for each sub-basin. Attachment A also documents other parameters used within the model such as area, pervious curve number, and existing/future impervious percentages, which are all discussed in greater detail in the following sections.

2.3 Existing Conditions Land Use

During development of the 2015 *Pollutant Load Reduction Evaluation* the City generated an updated GIS layer to represent existing land use coverage (City 2015b). The land use coverage is based on the City's *Oregon City Comprehensive Plan* land use data and also incorporated vacant land data from Metro, which is based on 2013 aerial photos (City 2004). The land use categories from the *Oregon City Comprehensive Plan* were grouped into the land use modeling categories as shown in Figure 3. These updated GIS layers formed the basis of the existing condition land use analysis.

2.4 Future Conditions Land Use

For future conditions land use, it is assumed all vacant lands under existing conditions land use will be developed to match the City's comprehensive plan zoning. An additional shapefile was provided by the City for future land use, which is shown in Figure 4.

2.5 Impervious Coverage

The City calculated the impervious cover percentage for each modeled land use category in 2015. Each parcel in the city was assigned an impervious area percentage based on either Metro impervious area coverages or Clackamas County Assessor's data. Roads were assumed to have a 90 percent impervious coverage. The average impervious coverage for all parcels within each modeled land use category was then calculated as shown in Table 1.

Table 1. Modeled Land Use Categories

Comprehensive plan land use category	Modeled land use category	2015 modeled impervious percentage
Low-density residential (LR)	Single-family residential	45
Medium-density residential (MR)	Single-family residential	
High-density residential (HR)	Multi-family residential	57
Commercial (COM)	Commercial	74
Mixed-use corridor (MUC)	Commercial	
Mixed-use downtown (MUD)	Commercial	
Industrial (IND)	Industrial	63
Mixed-use employment (MUE)	Industrial	
Quasi-public	Public facility	34
Parks	Parks and open space	19
Future urban holding (FUH)	Agriculture [a]	48
All vacant	Vacant [b]	21

a. *The impervious percentage for agriculture is higher than expected because the only areas designated as agriculture are portions of small farms along Beavercreek Road in the southeast corner of Oregon City. The areas included in Oregon City limits are typically driveways and houses, which include the bulk of the impervious area for those properties.*

b. *Vacant lands include areas of all land use categories that are not currently developed or are not developed to the density indicated in the comprehensive plan (City 2004). Vacant land includes unused COM and IND land along the Oregon Highway 205 corridor.*

Impervious coverage within each sub-basin is dependent on its land use. There are a total of eight land use categories, which are all mapped in GIS and have assigned values of impervious percentage (see Table 1). The land use categories were overlaid with the sub-basin boundaries in GIS and area-weighted average impervious percentages were calculated for each sub-basin within GIS. A number of sub-basins had a portion of land area outside of city limits with no land use data available. It is assumed these regions are vacant with an impervious percentage of 21 percent. The impervious percentages for each sub-basin are shown in Attachment A, Table A-1.

2.6 Pervious Area Curve Number

The pervious area curve number is a dimensionless number that depends on hydrologic soil group, cover type, and antecedent moisture conditions. Runoff curve numbers for pervious areas were estimated from typical runoff curve number tables provided in the Soil and Conservation Service (SCS) Technical Release 55, titled *Urban Hydrology for Small Watersheds* (SCS 1986). Curve number values are shown in Table 2 and were selected based on hydrologic soil group for the pervious portions of each sub-basin. A map of hydrologic soil groups is shown in Figure 5. Aerial imagery was used to choose the correct land use description and associated pervious area curve number for sub-basins with large wooded parks. A curve number of 98 was assumed for impervious areas.

Table 2. Runoff Curve Numbers for Urban Areas

Land use descriptions	Curve numbers for hydrologic soil group			
	A	B	C	D
Fully developed urban areas (vegetation establish):				
Open space (lawns, parks, golf courses, cemeteries, etc.)				
Good condition (grass cover >75%)	39	61	74	80
Fair condition (grass cover 50–75%)	49	69	79	84
Poor condition (grass cover <50%)	68	79	86	89
Paved parking lots, roofs, driveways, etc.	98	98	98	98
Streets and roads:				
Paved; curbs and storm sewers (excluding rights-of-way)	98	98	98	98
Gravel (including rights-of-way)	76	85	89	91
Dirt (including rights-of-way)	72	82	87	89
Paved with open ditches (including rights-of-way)	83	89	92	93
Woods-grass combination:				
Poor condition	57	73	82	86
Fair condition	43	65	76	82
Good condition	32	58	72	79
Woods:				
Poor condition	45	66	77	83
Fair condition	36	60	73	79
Good condition	30	55	70	77

2.7 Design Storms

Design storms are precipitation patterns that are typically used to evaluate the capacity of storm drainage systems and design capital improvements for the desired level of service. Design storms evaluated for this study include the, 1.2-year, 2-year, 10-year, 25-year, 50-year, and 100-year recurrence intervals. The rainfall depths for most events were based on isopluvial maps published in the National Oceanic and Atmospheric Administration (NOAA) in Atlas 2, Volume X, which is referenced in the City's *Stormwater and Grading Design Standards* (City 2015a). The rainfall distribution for these design storms is based on the SCS 24-hour, Type IA distribution, which is applicable to western Oregon, Washington, and northwestern California.

Table 3 lists the precipitation depths from the NOAA Atlas 2, Volume X, used for design storms in the model.

Table 3. Design Storm Depths

Design storm event	Rainfall depth, inches
1.2-year, 24-hour	1.18
2-year, 24-hour	2.8
10-year, 24-hour	3.5
25-year, 24-hour	4.0
50-year, 24-hour	4.4
100-year, 24-hour	4.5

The 1.2-year rainfall depth is representative of the water quality design storm as documented in the technical memorandum *Selection of Representative Rainfall Volume and Rainfall Intensities to Result in Capture and Treatment of 80% of the Average Annual Runoff Volume* (BC 2010). According to a 2008 Oregon Department of Transportation (ODOT) study titled *Water Quantity (Flow Control) Design Storm Performance Standard*, 42 percent of the 2-year peak flow rate can be used as an analog for the 1.2-year peak flow rate (ODOT 2008).

Section 3: Hydrology Model Results

The XP-SWMM simulations were run for the 2-year, 10-year, 25-year, 50-year, and 100-year storm for both current and future development conditions. The model results show no/minimal increases in future flows for sub-basins that are fully developed and the largest increases for sub-basins with existing vacant land with planned development.

Results of the hydrologic simulations for all events and sub-basins are tabulated in Attachment B (Table B-1). Results are displayed as maximum flows within each sub-basin for each design storm.

The channel-forming event—1.2-year peak flow—is included in Attachment B, calculated based on the 2-year peak runoff as described in Section 2.7.

Attachment C, Table C-1 provides the change in peak discharge and percent increase between the existing and future conditions flows for each sub-basin.

Section 4: References

Brown and Caldwell (BC). 2010. *Selection of Representative Rainfall Volume and Rainfall Intensities to Result in Capture and Treatment of 80% of the Average Runoff Volume*. May 11.

City of Oregon City (City). 2004. *Oregon City Comprehensive Plan*. June.

City. 2015a. Storm*water and Grading Design Standards*. February.

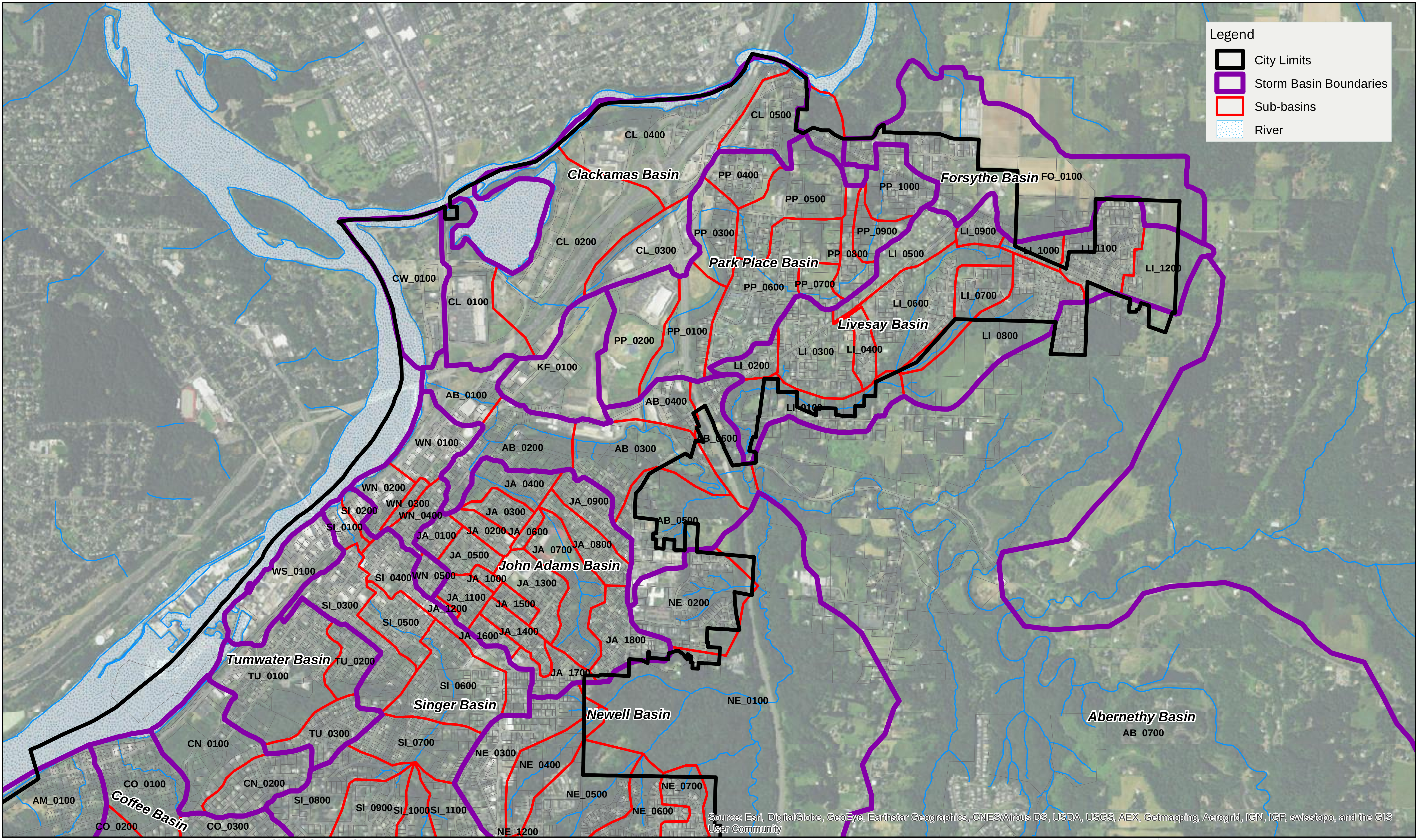
City. 2015b. *TMDL Pollutant Load Reduction Evaluation*. October.

National Oceanic and Atmospheric Administration (NOAA). 2010. Atlas 2, Volume X.

Oregon Department of Transportation (ODOT). 2008. *Water Quantity (Flow Control) Design Storm Performance Standard*.

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

Figures



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

[BCDENFP01]: P:\149133 Oregon City SWMP\CAD-GIS\MXD\Tech Memo\Hydrology\TM_Subbasins_North_11x17.mxd

mgrzegorzewski

Aug 10, 2016

Brown AND Caldwell

OREGON CITY

City of Oregon City

Stormwater Master Plan

Date: July 2016
Project: Project 149133

0 1,500 3,000 Feet

N

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

Figure 1

Northern Sub-basins

[BCDENFP01]: P:\149133 Oregon City SWMP\CAD-GIS\MXD\Tech Memo\Hydrology\TM_Subbasins_South_11x17.mxd

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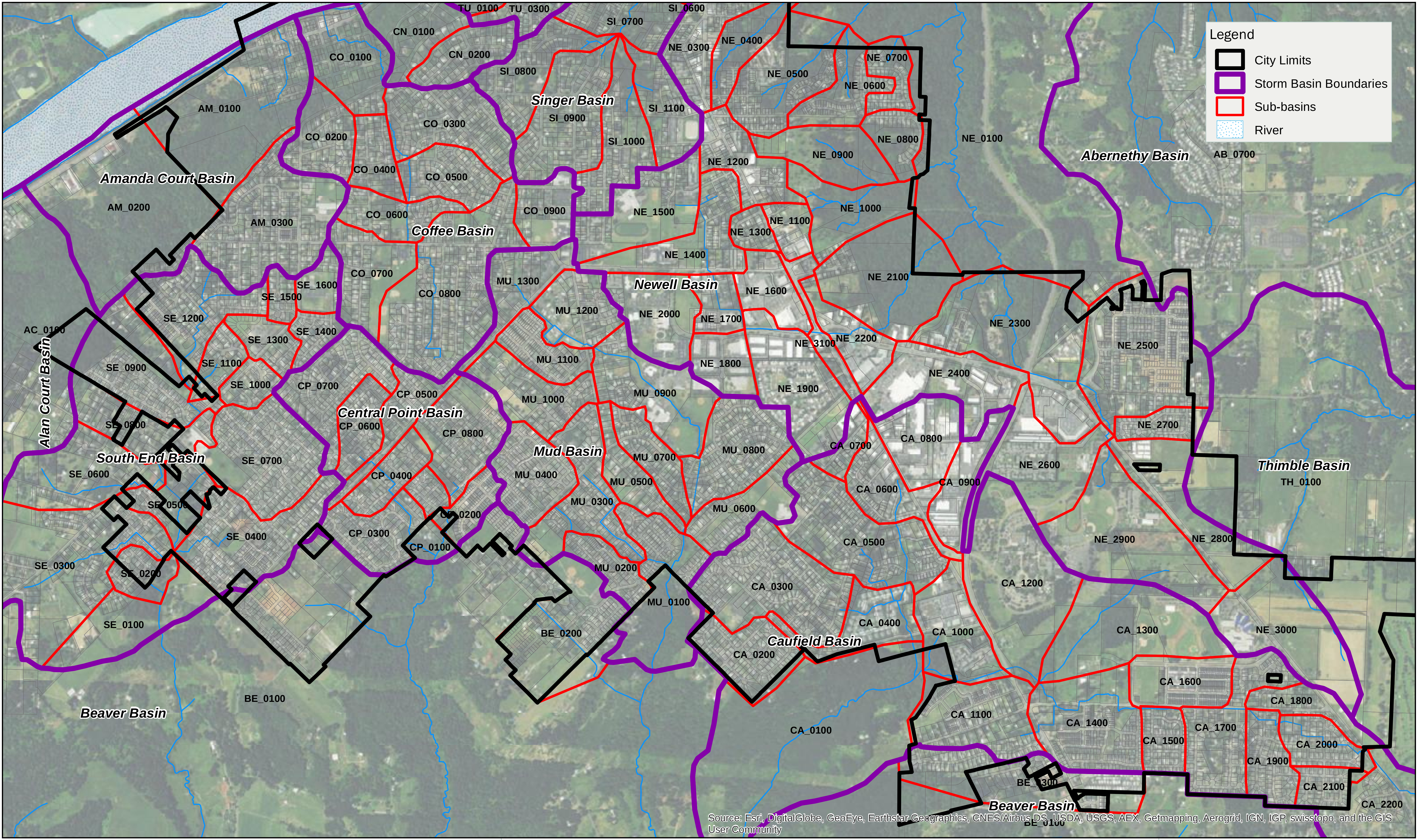

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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0 1,500 3,000
Feet

N

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

Figure 2

Southern Sub-basins

[BCDENFP01]: P:\149133 Oregon City SWMP\CAD-GIS\MXD\Tech Memo\Hydrology\TM_LandUse_17x11.mxd

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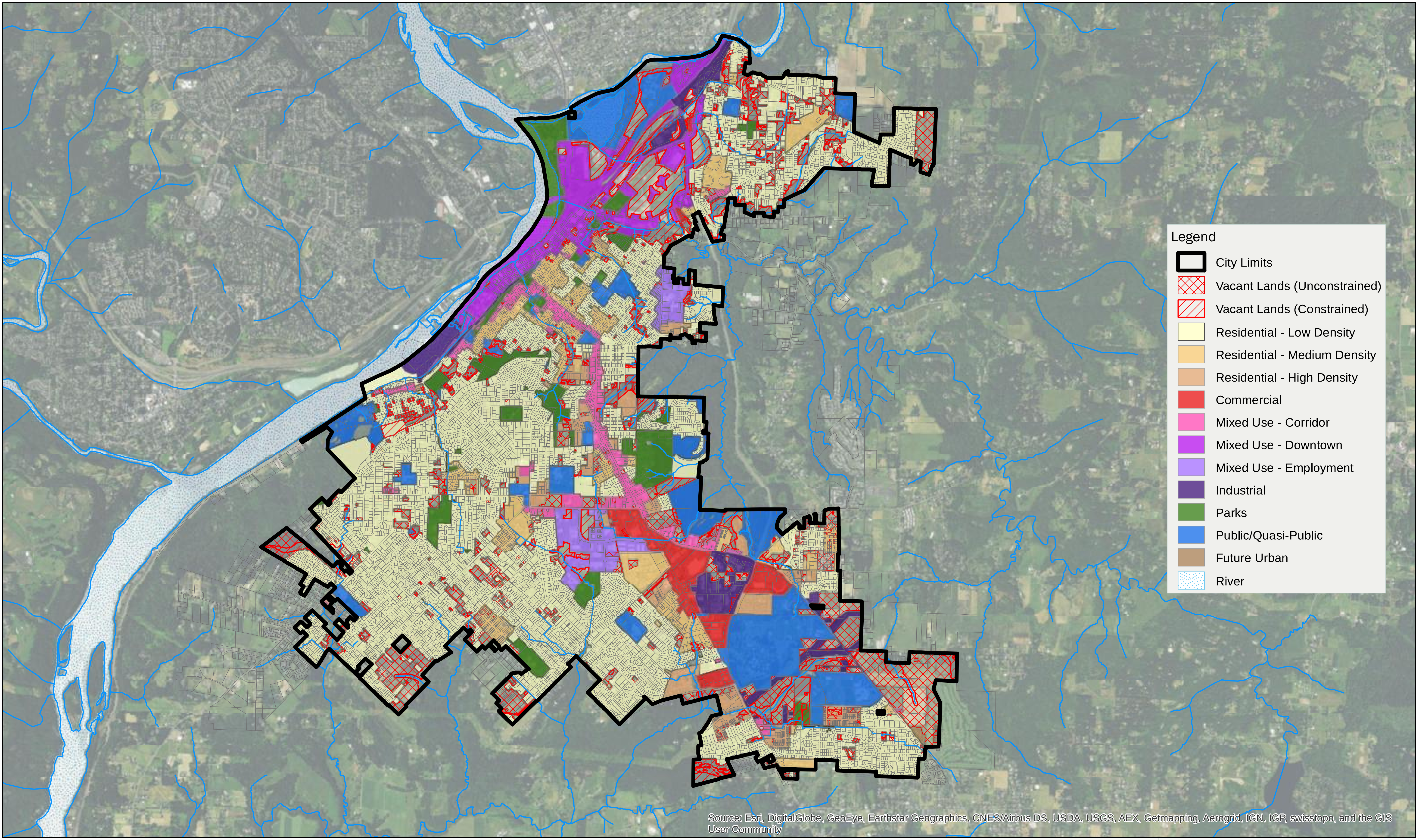

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Project: Project 149133

0 3,000 6,000 Feet

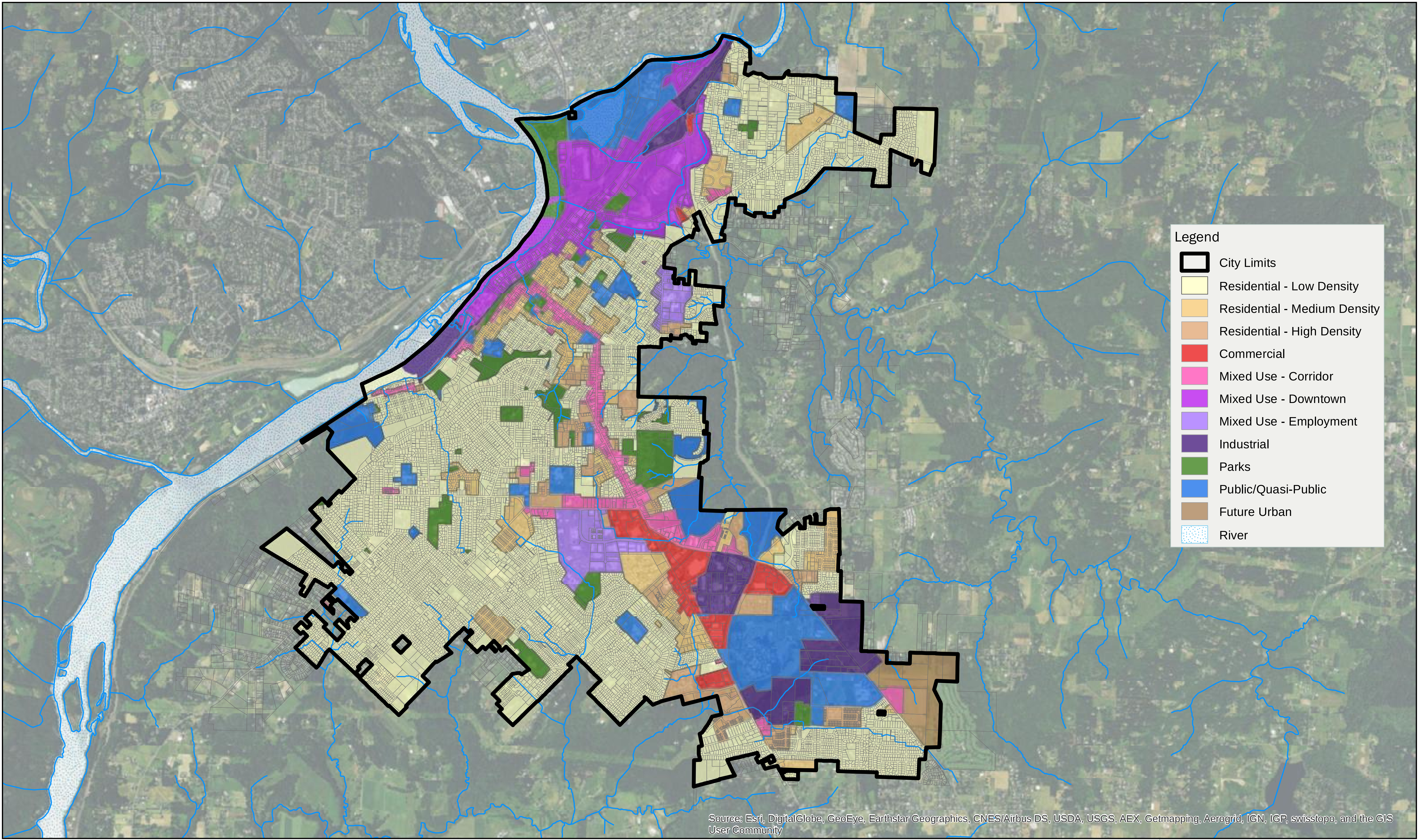
N

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

Figure 3

Existing Conditions Land Use

[BCDENFP01]: P:\149133 Oregon City SWMP\CAD-GIS\MXD\Tech Memo\HydrologyTM\HydrologyTM_LandUse_17x11.mxd mgrzegorzewski Aug 10, 2016



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Stormwater Master Plan

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Project: Project 149133

N

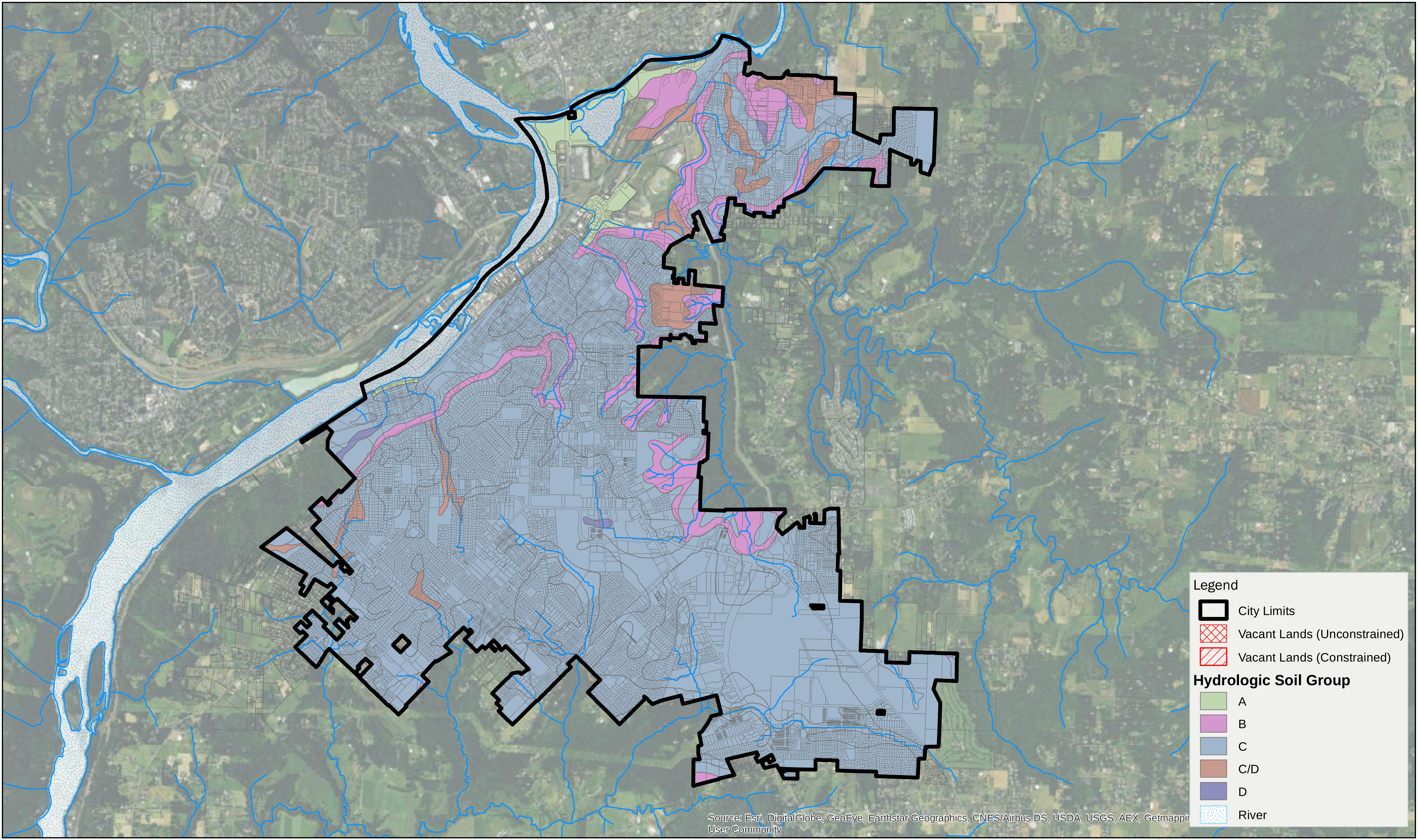
0 3,000 6,000 Feet

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

Figure 4

Future Conditions Land Use

[BCDENFP01]: P:\149133 Oregon City SWMP\CAD-GIS\MXD\Tech Memo\Hydrology\TM_Soil_17x11.mxd mgrzegorzewski Aug 10, 2016



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmappi
User Community

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Stormwater Master Plan

Date: July 2016
Project: Project 149133

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

Figure 5

Hydrologic Soil Group

Attachment A: Hydrology Model Results

Table A-1: Subcatchment Parameters					
Name	Area (acres)	Time of concentration (minutes)	Pervious CN	Existing impervious percentage	Future impervious percentage
Abernathy Creek Basin					
AB_0100	27	11.48	79	68.99	70.19
AB_0200	45	21.98	69	50.6	56.7
AB_0300	54	23.99	79	29.76	41.1
AB_0400	19	10.25	79	56.44	67.28
AB_0500	58	16.27	79	21.21	21.58
AB_0600	30	30.16	79	21.36	22.31
Alan Court Basin					
AC_0100	725	10	79	20.71	20.71
Amanda Court Basin					
AM_0100	116	19.74	73	33.38	34.64
AM_0200	136	10	79	19.94	19.95
AM_0300	86	38.82	79	44.42	44.97
Beaver Basin					
BE_0200	71	10	79	25.94	32.22
BE_0300	70	10	79	21.9	23.92
Caufield Basin					
CA_0100	194	31.3	73	20.59	20.6
CA_0200	39	25.93	79	36.77	36.77
CA_0300	80	29.63	79	43.41	44.53
CA_0400	35	27.46	79	46.31	50.94
CA_0500	75	37.12	79	42.15	44.57
CA_0600	34	12.56	79	55.1	55.61
CA_0700	11	9.01	79	55.35	55.35
CA_0800	43	13.96	79	61.83	64.68
CA_0900	28	11.64	79	68.4	68.82
CA_1000	44	14.11	79	45.44	49.82
CA_1100	56	27.06	79	42.52	44.19
CA_1200	95	21.99	79	35.63	39.67
CA_1300	79	19.52	79	28.25	47.49
CA_1400	63	29.64	79	44.1	49.46
CA_1500	18	22.69	79	44.28	44.99
CA_1600	34	30.78	79	47.55	47.63
CA_1700	51	27.79	79	42.56	43.93
CA_1800	21	28.77	79	41.76	45.67

Table A-1: Subcatchment Parameters					
Name	Area (acres)	Time of concentration (minutes)	Pervious CN	Existing impervious percentage	Future impervious percentage
CA_1900	26	20.39	79	44.71	44.97
CA_2000	24	20.98	79	40	41.08
CA_2100	15	24.37	79	39.83	39.83
CA_2200	108	49.63	79	21	21
Clackamas Basin					
CL_0100	52	15.35	79	56.1	63.34
CL_0200	106	23.69	69	38.77	52.37
CL_0300	35	12.72	79	55.02	67.01
CL_0400	96	22.15	69	49.41	52.37
CL_0500	31	19.82	79	42.43	48.86
Clinton Basin					
CN_0100	49	24.84	79	39.97	43.65
CN_0200	29	26.53	79	45	45
Coffee Basin					
CO_0100	47	21.77	79	42.86	48.66
CO_0200	33	30.63	79	43.48	45
CO_0300	53	33.72	79	44.84	45
CO_0400	21	23.15	79	43.66	45
CO_0500	31	30.32	79	43.11	43.41
CO_0600	27	29.7	79	40.38	44.61
CO_0700	39	36.93	74	34.96	37.14
CO_0800	103	48.86	79	41.46	42.9
CO_0900	25	11.17	79	45.97	46.71
Central Point Basin					
CP_0100	18	24.83	79	21.12	21.69
CP_0200	17	35.57	79	34.65	37.87
CP_0300	34	27.3	79	44.3	44.57
CP_0400	22	28.93	79	41.62	45
CP_0500	25	29.39	79	44.34	45
CP_0600	23	25.6	79	44.18	45
CP_0700	46	32.64	79	44.95	45
CP_0800	46	25.51	79	39.04	45
Clackamas-Willamette Basin					
CW_0100	61	22.32	43	28.47	29.43

Table A-1: Subcatchment Parameters					
Name	Area (acres)	Time of concentration (minutes)	Pervious CN	Existing impervious percentage	Future impervious percentage
Forsythe Basin					
FO_0100	190	10	79	18.07	18.55
John Adams Basin					
JA_0100	8	8.55	79	45	45
JA_0200	9	8.7	79	39.4	39.4
JA_0300	11	9.01	79	41.31	41.91
JA_0400	18	10.09	69	45.27	48.11
JA_0500	12	9.16	79	41.21	41.21
JA_0600	3	14.97	79	43.27	43.27
JA_0700	36	19.21	69	36.79	41.3
JA_0800	19	28.46	79	47.81	47.92
JA_0900	18	24.83	79	45.27	46.27
JA_1000	3	7.77	79	43.43	43.43
JA_1100	12	9.16	79	45.98	46.67
JA_1200	1	7.46	79	59.14	59.14
JA_1300	22	10.71	79	40.62	40.63
JA_1400	12	9.16	79	44.7	45
JA_1500	6	8.24	79	43.04	43.77
JA_1600	6	8.24	79	51.71	51.71
JA_1700	13	17.65	79	42.71	42.71
JA_1800	26	26.07	79	47.01	47.57
Kelly Field Basin					
KF_0100	55	15.81	79	37.91	66.05
Livesay Basin					
LI_0100	49	25.97	69	17.66	21.24
LI_0200	11	9.01	79	51.24	56.41
LI_0300	42	20.54	79	42.18	45
LI_0400	10	17.92	79	41	45
LI_0500	25	29.39	79	43.35	44.98
LI_0600	56	23.68	79	38.08	45
LI_0700	24	19.35	79	28.07	30.54
LI_0800	67	32.4	79	19.27	19.5
LI_0900	10	18.82	79	38.34	42.6
LI_1000	9	17.03	79	19.09	19.09
LI_1100	39	23.3	79	32.98	33.59

Table A-1: Subcatchment Parameters					
Name	Area (acres)	Time of concentration (minutes)	Pervious CN	Existing impervious percentage	Future impervious percentage
LI_1200	31	24.7	79	18.82	29.31
Mud Basin					
MU_0100	64	28.29	79	19.43	19.77
MU_0200	20	25.14	79	43	43
MU_0300	52	30.09	79	40.41	41.63
MU_0400	38	25.78	79	43.56	45
MU_0500	22	28.93	79	42.44	45
MU_0600	33	27.15	79	40.77	41.67
MU_0700	25	25.91	79	44.28	44.28
MU_0800	52	27.94	79	44.07	44.13
MU_0900	55	23.38	74	40.36	46.5
MU_1000	39	28.08	79	41.12	45
MU_1100	24	29.24	79	43.99	45
MU_1200	33	25	79	45.2	47.86
MU_1300	32	37.89	79	43.52	44.86
Newell Basin					
NE_0100	542	10	79	20.31	20.31
NE_0200	60	27.67	79	42.28	43.63
NE_0300	50	15.04	79	53.53	55.23
NE_0400	29	24.39	69	32.29	43.12
NE_0500	57	30.86	79	30.67	34.65
NE_0600	30	15.86	76	31.85	32.05
NE_0700	17	19.9	79	36.33	36.33
NE_0800	19	18.58	79	39.17	39.17
NE_0900	38	16.78	76	24.31	24.75
NE_1000	40	24.23	60	26.87	36.71
NE_1100	14	9.47	79	53.86	55.14
NE_1200	33	12.41	79	56.83	58.54
NE_1300	11	9.01	79	56.75	56.75
NE_1400	47	14.57	79	49.79	58.99
NE_1500	53	15.5	79	44.65	44.65
NE_1600	24	11.02	79	73.98	73.98
NE_1700	17	9.94	79	57	63.37
NE_1800	23	10.86	79	60	62.94
NE_1900	59	16.43	79	50.29	53.54

Table A-1: Subcatchment Parameters					
Name	Area (acres)	Time of concentration (minutes)	Pervious CN	Existing impervious percentage	Future impervious percentage
NE_2000	42	13.8	79	52.67	62.62
NE_2100	77	19.21	79	28.59	36.25
NE_2200	26	11.33	79	65.36	73.84
NE_2300	107	23.85	69	42.3	48.1
NE_2400	50	15.04	79	61.22	67.4
NE_2500	94	40.05	79	32.76	36.54
NE_2600	58	16.27	79	49.78	49.79
NE_2700	16	22.38	79	35.95	35.99
NE_2800	53	15.5	79	31.85	51.12
NE_2900	91	21.37	79	36.63	45.12
NE_3000	72	18.44	79	25.68	48.84
NE_3100	15	9.63	79	67.08	67.08
Park Place Basin					
PP_0100	34	12.56	69	41.4	66.71
PP_0200	46	14.42	79	44.34	74
PP_0300	25	25.91	69	45.09	61.16
PP_0400	20	18.73	79	41.66	46.3
PP_0500	45	20.6	69	35.15	43.44
PP_0600	62	14.09	76	40.66	43.03
PP_0700	10	15.19	79	34.93	45
PP_0800	14	22.07	79	41.5	45
PP_0900	13	17.65	79	36.37	45
PP_1000	25	36.81	79	40.16	45
South End Basin					
SE_0100	47	32.96	76	20.81	20.81
SE_0200	18	22.69	79	19.8	19.8
SE_0300	115	43.3	79	18.99	19.01
SE_0400	65	42.99	79	39.47	41.41
SE_0500	28	21.6	79	18.96	20.07
SE_0600	56	28.56	79	20.49	20.49
SE_0700	67	32.4	79	42.86	43.23
SE_0800	38	27.92	79	18.83	18.85
SE_0900	59	34.64	79	24.99	28.85
SE_1000	14	24.21	79	44.37	44.72
SE_1100	16	35.42	79	35.68	37.98

Table A-1: Subcatchment Parameters					
Name	Area (acres)	Time of concentration (minutes)	Pervious CN	Existing impervious percentage	Future impervious percentage
SE_1200	56	30.7	79	35.62	37.02
SE_1300	18	24.83	79	44.41	44.41
SE_1400	13	18.38	79	43.71	44.21
SE_1500	9	34.33	79	45	45
SE_1600	15	18.69	79	36.46	44.95
Singer Basin					
SI_0100	8	8.55	79	61.53	61.63
SI_0200	6	8.24	79	67.54	67.54
SI_0300	42	27.01	79	46.42	46.93
SI_0400	36	12.87	79	55.94	56.53
SI_0500	21	10.56	79	49.5	50.45
SI_0600	49	24.84	79	45.63	48.58
SI_0700	35	25.31	79	41.86	44.47
SI_0800	40	22.18	76	39.68	39.68
SI_0900	60	24.92	79	42.75	42.75
SI_1000	43	32.17	79	38.91	41.93
SI_1100	33	12.41	79	40.12	42.85
Thimble Basin					
TH_0100	945	10	79	19.22	19.46
Tumwater Basin					
TU_0100	71	12.98	73	38.64	40
TU_0200	17	24.68	79	40.6	41.38
TU_0300	23	36.5	79	44.09	44.4
Willamette North Basin					
WN_0100	27	11.48	79	64.93	68.39
WN_0200	15	9.63	79	64.12	65.82
WN_0300	4	7.93	79	50.66	51.75
WN_0400	12	9.16	79	46.91	46.91
WN_0500	7	8.39	79	46.79	46.79
Willamette South Basin					
WS_0100	41	13.65	79	68.83	69.16

Attachment B: Hydrology Results

Table B-1: Hydrology Model Results

Subbasin	Existing							Future						
	Impervious %	Max flow (cfs)						Impervious %	Max flow (cfs)					
		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
Abernethy Basin														
AB_0100	68.99	5.27	12.54	16.98	20.16	22.69	23.33	70.19	5.33	12.69	17.14	20.32	22.85	23.48
AB_0200	50.60	4.24	10.09	15.68	19.89	23.36	24.23	56.70	4.85	11.54	17.38	21.73	25.27	26.17
AB_0300	29.76	5.31	12.64	19.32	24.33	28.43	29.47	41.10	6.22	14.80	21.82	27.00	31.21	32.27
AB_0400	56.44	3.29	7.83	10.95	13.20	15.01	15.46	67.28	3.70	8.81	11.97	14.24	16.05	16.50
AB_0500	21.21	5.73	13.65	21.37	27.20	32.01	33.22	21.58	5.77	13.73	21.46	27.30	32.11	33.33
AB_0600	21.36	2.36	5.62	8.88	11.37	13.42	13.94	22.31	2.39	5.70	8.98	11.48	13.54	14.06
Alan Court Basin														
AC_0100	20.71	79.74	189.86	295.11	374.46	439.64	456.12	20.71	79.74	189.86	295.11	374.46	439.64	456.12
Amanda Court Basin														
AM_0100	33.38	9.37	22.31	36.27	46.95	55.81	58.06	34.64	9.63	22.93	37.01	47.77	56.68	58.93
AM_0200	19.94	14.79	35.22	54.89	69.74	81.93	85.02	19.95	14.79	35.22	54.90	69.74	81.94	85.03
AM_0300	44.42	8.48	20.19	29.58	36.50	42.12	43.53	44.97	8.54	20.34	29.75	36.68	42.30	43.72
Beaver Basin														
BE_0200	25.94	8.41	20.03	30.59	38.50	44.97	46.60	32.22	9.16	21.82	32.66	40.72	47.28	48.94
BE_0300	21.90	7.83	18.65	28.87	36.56	42.88	44.47	23.92	8.06	19.20	29.51	37.26	43.60	45.21
Caufield Basin														
CA_0100	20.59	9.56	22.77	40.37	54.23	65.89	68.90	20.60	9.57	22.78	40.37	54.24	65.90	68.91
CA_0200	36.77	4.11	9.78	14.63	18.23	21.17	21.91	36.77	4.11	9.78	14.63	18.23	21.17	21.91
CA_0300	43.41	8.73	20.79	30.53	37.72	43.55	45.02	44.53	8.86	21.10	30.89	38.09	43.94	45.41
CA_0400	46.31	4.10	9.75	14.18	17.43	20.07	20.73	50.94	4.35	10.36	14.85	18.13	20.79	21.45
CA_0500	42.15	7.31	17.41	25.66	31.76	36.77	38.03	44.57	7.55	17.98	26.31	32.47	37.50	38.77
CA_0600	55.10	5.61	13.35	18.76	22.68	25.83	26.62	55.61	5.64	13.43	18.85	22.77	25.92	26.71
CA_0700	55.35	1.91	4.55	6.37	7.69	8.75	9.01	55.35	1.91	4.55	6.37	7.69	8.75	9.01
CA_0800	61.83	7.49	17.83	24.64	29.54	33.47	34.45	64.68	7.73	18.40	25.23	30.14	34.07	35.05
CA_0900	68.40	5.42	12.90	17.49	20.78	23.41	24.06	68.82	5.44	12.95	17.55	20.84	23.46	24.12
CA_1000	45.44	6.30	15.00	21.68	26.58	30.54	31.53	49.82	6.65	15.83	22.60	27.54	31.52	32.52
CA_1100	42.52	6.27	14.93	21.95	27.14	31.34	32.40	44.19	6.41	15.27	22.33	27.54	31.76	32.82
CA_1200	35.63	10.48	24.96	37.36	46.59	54.10	56.00	39.67	11.07	26.37	38.98	48.31	55.88	57.79
CA_1300	28.25	8.18	19.49	29.83	37.58	43.93	45.53	47.49	10.60	25.25	36.40	44.59	51.20	52.86
CA_1400	44.10	6.94	16.52	24.21	29.88	34.48	35.64	49.46	7.45	17.73	25.57	31.30	35.94	37.11
CA_1500	44.28	2.21	5.25	7.66	9.43	10.86	11.23	44.99	2.23	5.30	7.71	9.49	10.92	11.28
CA_1600	47.55	3.86	9.18	13.33	16.37	18.83	19.45	47.63	3.86	9.19	13.34	16.38	18.85	19.46
CA_1700	42.56	5.65	13.46	19.79	24.47	28.27	29.22	43.93	5.76	13.71	20.08	24.77	28.58	29.53
CA_1800	41.76	2.27	5.40	7.97	9.87	11.41	11.80	45.67	2.39	5.69	8.30	10.22	11.77	12.16
CA_1900	44.71	3.32	7.91	11.50	14.14	16.28	16.82	44.97	3.33	7.94	11.53	14.18	16.32	16.85
CA_2000	40.00	2.86	6.80	10.04	12.43	14.37	14.86	41.08	2.90	6.90	10.15	12.54	14.49	14.98

Table B-1: Hydrology Model Results

Subbasin	Existing							Future						
	Impervious %	Max flow (cfs)						Impervious %	Max flow (cfs)					
		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
CA_2100	39.83	1.69	4.02	5.95	7.38	8.54	8.83	39.83	1.69	4.02	5.95	7.38	8.54	8.83
CA_2200	21.00	6.78	16.15	25.62	32.84	38.81	40.32	21.00	6.78	16.15	25.62	32.84	38.81	40.32
Clackamas Basin														
CL_0100	56.10	8.30	19.76	27.75	33.54	38.19	39.35	63.34	9.01	21.45	29.55	35.38	40.04	41.21
CL_0200	38.77	7.21	17.18	28.82	37.81	45.30	47.21	52.37	10.10	24.04	37.07	46.86	54.89	56.92
CL_0300	55.02	5.75	13.69	19.25	23.28	26.52	27.33	67.01	6.57	15.64	21.31	25.37	28.61	29.42
CL_0400	49.41	8.77	20.88	32.67	41.58	48.91	50.76	52.37	9.38	22.34	34.39	43.45	50.88	52.75
CL_0500	42.43	3.88	9.24	13.53	16.68	19.25	19.89	48.86	4.21	10.03	14.41	17.61	20.20	20.85
Clinton Basin														
CN_0100	39.97	5.48	13.06	19.32	23.96	27.73	28.67	43.65	5.76	13.71	20.07	24.75	28.54	29.49
CN_0200	45.00	3.38	8.05	11.75	14.47	16.67	17.23	45.00	3.38	8.05	11.75	14.47	16.67	17.23
Coffee Basin														
CO_0100	42.86	5.74	13.66	19.99	24.66	28.44	29.39	48.66	6.18	14.72	21.17	25.90	29.71	30.67
CO_0200	43.48	3.55	8.46	12.43	15.36	17.74	18.34	45.00	3.63	8.64	12.63	15.57	17.95	18.55
CO_0300	44.84	5.57	13.26	19.44	23.99	27.68	28.61	45.00	5.58	13.29	19.47	24.03	27.72	28.65
CO_0400	43.66	2.53	6.03	8.82	10.87	12.53	12.95	45.00	2.58	6.14	8.94	11.00	12.66	13.08
CO_0500	43.11	3.34	7.94	11.68	14.44	16.68	17.25	43.41	3.35	7.98	11.72	14.48	16.72	17.29
CO_0600	40.38	2.82	6.73	9.97	12.38	14.33	14.82	44.61	2.99	7.12	10.42	12.85	14.83	15.32
CO_0700	34.96	2.66	6.34	10.16	13.08	15.49	16.10	37.14	2.78	6.62	10.50	13.46	15.89	16.51
CO_0800	41.46	8.81	20.97	31.04	38.55	44.67	46.21	42.90	8.98	21.38	31.52	39.07	45.21	46.75
CO_0900	45.97	3.78	8.99	12.95	15.84	18.17	18.76	46.71	3.81	9.08	13.04	15.93	18.27	18.86
Central Point Basin														
CP_0100	21.12	1.53	3.65	5.76	7.36	8.68	9.01	21.69	1.55	3.68	5.80	7.40	8.72	9.06
CP_0200	34.65	1.52	3.62	5.46	6.84	7.97	8.26	37.87	1.59	3.79	5.65	7.05	8.20	8.48
CP_0300	44.30	3.88	9.25	13.53	16.68	19.23	19.88	44.57	3.90	9.28	13.57	16.72	19.28	19.92
CP_0400	41.62	2.37	5.64	8.32	10.31	11.92	12.32	45.00	2.48	5.90	8.62	10.62	12.24	12.65
CP_0500	44.34	2.77	6.60	9.67	11.92	13.75	14.21	45.00	2.80	6.66	9.73	11.99	13.83	14.29
CP_0600	44.18	2.69	6.41	9.37	11.54	13.31	13.75	45.00	2.72	6.48	9.44	11.63	13.39	13.84
CP_0700	44.95	4.91	11.70	17.13	21.13	24.38	25.19	45.00	4.92	11.71	17.14	21.14	24.39	25.20
CP_0800	39.04	5.03	11.98	17.79	22.09	25.59	26.47	45.00	5.45	12.97	18.91	23.28	26.82	27.71
Clackamas-Willamette Basin														
CW_0100	28.47	0.42	1.00	1.88	2.62	3.87	4.23	29.43	0.44	1.04	1.94	2.77	4.12	4.50
Forsythe Basin														
FO_0100	18.07	20.10	47.87	75.10	95.70	112.65	116.94	18.55	20.25	48.21	75.51	96.14	113.12	117.41
John Adams Basin														
JA_0100	45.00	1.24	2.95	4.25	5.19	5.96	6.15	45.00	1.24	2.95	4.25	5.19	5.96	6.15

Table B-1: Hydrology Model Results														
Subbasin	Existing							Future						
	Impervious %	Max flow (cfs)						Impervious %	Max flow (cfs)					
		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
JA_0200	39.40	1.30	3.09	4.52	5.58	6.43	6.64	39.40	1.30	3.09	4.52	5.58	6.43	6.64
JA_0300	41.31	1.62	3.86	5.61	6.90	7.94	8.20	41.91	1.63	3.88	5.64	6.93	7.98	8.24
JA_0400	45.27	1.86	4.42	6.98	8.92	10.51	10.92	48.11	1.98	4.71	7.32	9.29	10.91	11.32
JA_0500	41.21	1.76	4.19	6.10	7.51	8.64	8.93	41.21	1.76	4.19	6.10	7.51	8.64	8.93
JA_0600	43.27	0.41	0.98	1.43	1.76	2.02	2.09	43.27	0.41	0.98	1.43	1.76	2.02	2.09
JA_0700	36.79	2.52	6.01	10.16	13.37	16.05	16.73	41.30	2.84	6.77	11.09	14.40	17.15	17.85
JA_0800	47.81	2.24	5.32	7.71	9.46	10.87	11.23	47.92	2.24	5.33	7.72	9.47	10.88	11.24
JA_0900	45.27	2.16	5.15	7.50	9.22	10.62	10.97	46.27	2.19	5.22	7.57	9.30	10.70	11.05
JA_1000	43.43	0.46	1.10	1.58	1.94	2.23	2.30	43.43	0.46	1.10	1.58	1.94	2.23	2.30
JA_1100	45.98	1.87	4.44	6.38	7.80	8.94	9.23	46.67	1.88	4.48	6.42	7.84	8.99	9.27
JA_1200	59.14	0.18	0.44	0.61	0.73	0.83	0.85	59.14	0.18	0.44	0.61	0.73	0.83	0.85
JA_1300	40.62	3.13	7.46	10.90	13.43	15.48	15.99	40.63	3.13	7.46	10.90	13.43	15.48	15.99
JA_1400	44.70	1.84	4.38	6.31	7.72	8.86	9.15	45.00	1.84	4.39	6.32	7.74	8.88	9.17
JA_1500	43.04	0.91	2.17	3.14	3.85	4.42	4.57	43.77	0.92	2.19	3.16	3.87	4.45	4.59
JA_1600	51.71	1.01	2.40	3.40	4.12	4.70	4.84	51.71	1.01	2.40	3.40	4.12	4.70	4.84
JA_1700	42.71	1.69	4.03	5.89	7.26	8.37	8.65	42.71	1.69	4.03	5.89	7.26	8.37	8.65
JA_1800	47.01	3.13	7.46	10.82	13.28	15.28	15.78	47.57	3.16	7.52	10.88	13.35	15.34	15.84
Kelly Field Basin														
KF_0100	37.91	6.94	16.52	24.46	30.34	35.12	36.32	66.05	9.75	23.21	31.75	37.88	42.78	44.01
Livesay Basin														
LI_0100	17.66	1.63	3.87	7.90	11.20	14.09	14.83	21.24	1.86	4.43	8.65	12.10	15.07	15.84
LI_0200	51.24	1.82	4.34	6.15	7.46	8.52	8.78	56.41	1.93	4.61	6.43	7.75	8.81	9.07
LI_0300	42.18	5.18	12.34	18.08	22.31	25.74	26.60	45.00	5.37	12.80	18.59	22.85	26.30	27.17
LI_0400	41.00	1.27	3.02	4.43	5.48	6.33	6.54	45.00	1.33	3.18	4.61	5.67	6.52	6.74
LI_0500	43.35	2.74	6.51	9.57	11.82	13.65	14.11	44.98	2.80	6.66	9.73	11.99	13.82	14.28
LI_0600	38.08	6.22	14.81	22.03	27.38	31.73	32.83	45.00	6.82	16.24	23.65	29.10	33.51	34.62
LI_0700	28.07	2.49	5.92	9.07	11.43	13.36	13.85	30.54	2.58	6.14	9.32	11.70	13.64	14.13
LI_0800	19.27	4.95	11.79	18.74	24.08	28.51	29.64	19.50	4.97	11.83	18.79	24.14	28.57	29.70
LI_0900	38.34	1.21	2.87	4.25	5.28	6.11	6.32	42.60	1.28	3.04	4.44	5.48	6.31	6.53
LI_1000	19.09	0.85	2.02	3.19	4.08	4.81	5.00	19.09	0.85	2.02	3.19	4.08	4.81	5.00
LI_1100	32.98	4.06	9.67	14.61	18.30	21.32	22.08	33.59	4.09	9.75	14.71	18.41	21.42	22.18
LI_1200	18.82	2.55	6.07	9.67	12.40	14.66	15.24	29.31	2.99	7.12	10.92	13.76	16.09	16.68
Mud Basin														
MU_0100	19.43	5.01	11.93	19.03	24.42	28.88	30.01	19.77	5.04	12.00	19.10	24.51	28.97	30.10
MU_0200	43.00	2.32	5.52	8.10	10.00	11.54	11.93	43.00	2.32	5.52	8.10	10.00	11.54	11.93
MU_0300	40.41	5.41	12.89	19.11	23.72	27.47	28.41	41.63	5.50	13.10	19.36	23.98	27.74	28.68

Table B-1: Hydrology Model Results

Subbasin	Existing							Future						
	Impervious %	Max flow (cfs)						Impervious %	Max flow (cfs)					
		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
MU_0400	43.56	4.40	10.47	15.34	18.92	21.83	22.56	45.00	4.48	10.67	15.56	19.16	22.07	22.81
MU_0500	42.44	2.39	5.70	8.39	10.38	12.00	12.40	45.00	2.48	5.90	8.62	10.62	12.24	12.65
MU_0600	40.77	3.60	8.58	12.69	15.72	18.19	18.81	41.67	3.65	8.69	12.81	15.85	18.32	18.95
MU_0700	44.28	2.92	6.94	10.15	12.50	14.42	14.90	44.28	2.92	6.94	10.15	12.50	14.42	14.90
MU_0800	44.07	5.87	13.97	20.46	25.23	29.11	30.08	44.13	5.87	13.98	20.47	25.25	29.12	30.10
MU_0900	40.36	5.06	12.06	18.76	23.81	27.96	29.01	46.50	5.67	13.51	20.46	25.65	29.89	30.95
MU_1000	41.12	4.22	10.05	14.85	18.40	21.29	22.01	45.00	4.45	10.59	15.46	19.04	21.95	22.68
MU_1100	43.99	2.65	6.32	9.26	11.43	13.19	13.64	45.00	2.69	6.41	9.36	11.54	13.30	13.74
MU_1200	45.20	3.95	9.40	13.70	16.85	19.41	20.05	47.86	4.09	9.73	14.07	17.24	19.81	20.45
MU_1300	43.52	3.15	7.50	11.01	13.60	15.72	16.26	44.86	3.21	7.64	11.17	13.77	15.89	16.43
Newell Basin														
NE_0100	20.31	59.27	141.12	219.65	278.89	327.56	339.87	20.31	59.27	141.12	219.65	278.89	327.56	339.87
NE_0200	42.28	6.64	15.80	23.26	28.77	33.24	34.36	43.63	6.76	16.09	23.59	29.11	33.60	34.72
NE_0300	53.53	7.78	18.52	26.19	31.77	36.25	37.37	55.23	7.94	18.90	26.60	32.19	36.68	37.80
NE_0400	32.29	1.62	3.86	6.81	9.13	11.08	11.58	43.12	2.19	5.21	8.48	10.99	13.08	13.60
NE_0500	30.67	5.10	12.15	18.62	23.48	27.45	28.46	34.65	5.41	12.88	19.47	24.39	28.41	29.42
NE_0600	31.85	2.98	7.10	11.12	14.15	16.65	17.28	32.05	2.99	7.13	11.15	14.18	16.68	17.32
NE_0700	36.33	1.96	4.67	6.96	8.66	10.05	10.40	36.33	1.96	4.67	6.96	8.66	10.05	10.40
NE_0800	39.17	2.33	5.54	8.18	10.14	11.73	12.13	39.17	2.33	5.54	8.18	10.14	11.73	12.13
NE_0900	24.31	3.24	7.72	12.50	16.16	19.20	19.97	24.75	3.27	7.79	12.58	16.25	19.29	20.06
NE_1000	26.87	0.76	1.81	4.42	6.81	8.90	9.46	36.71	1.33	3.17	6.52	9.30	11.71	12.33
NE_1100	53.86	2.38	5.66	7.97	9.63	10.97	11.31	55.14	2.41	5.75	8.05	9.73	11.07	11.40
NE_1200	56.83	5.56	13.25	18.53	22.35	25.42	26.18	58.54	5.67	13.51	18.81	22.63	25.70	26.47
NE_1300	56.75	1.94	4.62	6.45	7.77	8.83	9.09	56.75	1.94	4.62	6.45	7.77	8.83	9.09
NE_1400	49.79	7.04	16.77	23.96	29.20	33.43	34.49	58.99	7.85	18.70	26.04	31.34	35.60	36.66
NE_1500	44.65	7.34	17.47	25.34	31.12	35.80	36.97	44.65	7.34	17.47	25.34	31.12	35.80	36.97
NE_1600	73.98	4.95	11.79	15.76	18.60	20.85	21.42	73.98	4.95	11.79	15.76	18.60	20.85	21.42
NE_1700	57.00	2.97	7.08	9.88	11.91	13.53	13.94	63.37	3.19	7.60	10.42	12.45	14.08	14.49
NE_1800	60.00	4.11	9.79	13.56	16.28	18.45	19.00	62.94	4.24	10.11	13.89	16.62	18.79	19.34
NE_1900	50.29	8.63	20.54	29.34	35.76	40.94	42.23	53.54	8.97	21.37	30.24	36.69	41.89	43.19
NE_2000	52.67	6.60	15.71	22.25	27.01	30.83	31.79	62.62	7.40	17.61	24.29	29.08	32.93	33.89
NE_2100	28.59	8.06	19.19	29.33	36.93	43.15	44.72	36.25	8.97	21.35	31.83	39.62	45.97	47.57
NE_2200	65.36	4.89	11.65	15.92	18.98	21.43	22.05	73.84	5.33	12.70	17.00	20.05	22.49	23.10
NE_2300	42.30	7.97	18.99	31.09	40.37	48.07	50.03	48.10	9.21	21.92	34.62	44.25	52.18	54.19
NE_2400	61.22	8.50	20.25	28.04	33.66	38.16	39.28	67.40	9.10	21.67	29.53	35.16	39.66	40.78
NE_2500	32.76	7.77	18.50	28.14	35.37	41.28	42.77	36.54	8.20	19.53	29.34	36.66	42.63	44.13

Table B-1: Hydrology Model Results

Subbasin	Existing							Future						
	Impervious %	Max flow (cfs)						Impervious %	Max flow (cfs)					
		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
NE_2600	49.78	8.45	20.12	28.78	35.10	40.19	41.47	49.79	8.45	20.12	28.78	35.10	40.20	41.47
NE_2700	35.95	1.76	4.20	6.28	7.82	9.08	9.40	35.99	1.76	4.20	6.28	7.83	9.09	9.40
NE_2800	31.85	6.19	14.75	22.25	27.84	32.40	33.55	51.12	7.95	18.93	26.96	32.81	37.52	38.70
NE_2900	36.63	10.28	24.48	36.52	45.46	52.73	54.56	45.12	11.51	27.40	39.83	48.96	56.35	58.20
NE_3000	25.68	7.32	17.43	26.89	34.00	39.85	41.33	48.84	10.00	23.81	34.20	41.79	47.93	49.46
NE_3100	67.08	2.94	6.99	9.51	11.30	12.74	13.10	67.08	2.94	6.99	9.51	11.30	12.74	13.10
Park Place Basin														
PP_0100	41.40	3.05	7.27	11.80	15.27	18.14	18.86	66.71	5.23	12.45	17.78	21.67	24.80	25.59
PP_0200	44.34	6.46	15.38	22.32	27.40	31.52	32.55	74.00	9.05	21.54	28.86	34.07	38.23	39.27
PP_0300	45.09	1.93	4.60	7.41	9.56	11.33	11.78	61.16	2.78	6.62	9.78	12.12	14.02	14.49
PP_0400	41.66	2.52	6.01	8.81	10.88	12.56	12.98	46.30	2.68	6.38	9.23	11.32	13.01	13.43
PP_0500	35.15	2.93	6.99	11.99	15.87	19.12	19.95	43.44	3.66	8.71	14.10	18.21	21.62	22.49
PP_0600	40.66	7.37	17.55	26.49	33.15	38.59	39.96	43.03	7.65	18.22	27.26	33.98	39.45	40.83
PP_0700	34.93	1.23	2.92	4.36	5.43	6.30	6.52	45.00	1.40	3.33	4.82	5.92	6.81	7.03
PP_0800	41.50	1.67	3.98	5.85	7.23	8.35	8.63	45.00	1.75	4.16	6.06	7.45	8.57	8.86
PP_0900	36.37	1.56	3.71	5.52	6.87	7.96	8.24	45.00	1.74	4.15	6.02	7.40	8.51	8.79
PP_1000	40.16	2.38	5.67	8.40	10.43	12.10	12.52	45.00	2.54	6.05	8.84	10.91	12.59	13.02
South End Basin														
SE_0100	20.81	2.87	6.84	11.39	14.91	17.84	18.59	20.81	2.87	6.84	11.39	14.91	17.84	18.59
SE_0200	19.80	1.56	3.70	5.86	7.50	8.86	9.20	19.80	1.56	3.70	5.86	7.50	8.86	9.20
SE_0300	18.99	7.45	17.74	28.29	36.41	43.13	44.83	19.01	7.46	17.75	28.29	36.42	43.14	44.84
SE_0400	39.47	5.73	13.63	20.31	25.27	29.32	30.34	41.41	5.88	14.00	20.74	25.73	29.79	30.82
SE_0500	18.96	2.43	5.80	9.19	11.77	13.90	14.44	20.07	2.48	5.90	9.31	11.91	14.04	14.58
SE_0600	20.49	4.44	10.57	16.79	21.52	25.42	26.41	20.49	4.44	10.57	16.79	21.52	25.42	26.41
SE_0700	42.86	6.98	16.62	24.49	30.30	35.03	36.21	43.23	7.01	16.70	24.58	30.40	35.13	36.32
SE_0800	18.83	2.96	7.06	11.28	14.49	17.14	17.82	18.85	2.97	7.06	11.28	14.49	17.15	17.82
SE_0900	24.99	4.63	11.03	17.19	21.84	25.70	26.68	28.85	4.91	11.68	17.96	22.70	26.61	27.60
SE_1000	44.37	1.68	3.99	5.83	7.18	8.27	8.55	44.72	1.69	4.01	5.85	7.20	8.30	8.57
SE_1100	35.68	1.45	3.46	5.21	6.51	7.59	7.86	37.98	1.50	3.58	5.34	6.66	7.74	8.01
SE_1200	35.62	5.40	12.86	19.38	24.24	28.20	29.20	37.02	5.51	13.12	19.68	24.55	28.53	29.53
SE_1300	44.41	2.14	5.09	7.43	9.15	10.55	10.90	44.41	2.14	5.09	7.43	9.15	10.55	10.90
SE_1400	43.71	1.69	4.03	5.88	7.24	8.34	8.61	44.21	1.70	4.06	5.91	7.27	8.37	8.64
SE_1500	45.00	0.94	2.24	3.28	4.05	4.67	4.83	45.00	0.94	2.24	3.28	4.05	4.67	4.83
SE_1600	36.46	1.77	4.21	6.27	7.80	9.04	9.36	44.95	1.98	4.70	6.83	8.40	9.66	9.98
Singer Basin														
SI_0100	61.53	1.50	3.56	4.91	5.87	6.65	6.84	61.63	1.50	3.57	4.91	5.88	6.65	6.84

Table B-1: Hydrology Model Results

Subbasin	Existing							Future						
	Impervious %	Max flow (cfs)						Impervious %	Max flow (cfs)					
		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr		1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
SI_0200	67.54	1.20	2.85	3.87	4.60	5.18	5.32	67.54	1.20	2.85	3.87	4.60	5.18	5.32
SI_0300	46.42	4.96	11.80	17.15	21.07	24.25	25.05	46.93	4.99	11.88	17.23	21.16	24.35	25.14
SI_0400	55.94	5.96	14.20	19.92	24.06	27.39	28.22	56.53	6.01	14.30	20.03	24.17	27.49	28.33
SI_0500	49.50	3.34	7.96	11.33	13.79	15.78	16.27	50.45	3.38	8.05	11.43	13.89	15.88	16.38
SI_0600	45.63	5.91	14.08	20.47	25.17	28.98	29.94	48.58	6.14	14.62	21.08	25.81	29.64	30.60
SI_0700	41.86	3.99	9.50	13.98	17.28	19.97	20.64	44.47	4.13	9.83	14.36	17.68	20.38	21.06
SI_0800	39.68	4.07	9.70	14.79	18.59	21.71	22.50	39.68	4.07	9.70	14.79	18.59	21.71	22.50
SI_0900	42.75	6.96	16.57	24.32	30.03	34.66	35.83	42.75	6.96	16.57	24.32	30.03	34.66	35.83
SI_1000	38.91	4.25	10.13	15.12	18.82	21.83	22.59	41.93	4.44	10.56	15.61	19.34	22.38	23.14
SI_1100	40.12	4.54	10.82	15.86	19.57	22.58	23.34	42.85	4.70	11.20	16.29	20.02	23.05	23.81
Thimble Basin														
TH_0100	19.22	101.70	242.15	378.36	481.25	565.85	587.25	19.46	102.06	243.00	379.37	482.35	567.00	588.42
Tumwater Basin														
TU_0100	38.64	7.25	17.25	27.09	34.53	40.66	42.21	40.00	7.44	17.72	27.64	35.13	41.29	42.85
TU_0200	40.60	1.92	4.58	6.76	8.38	9.69	10.02	41.38	1.94	4.63	6.82	8.44	9.75	10.08
TU_0300	44.09	2.32	5.52	8.08	9.99	11.54	11.93	44.40	2.33	5.54	8.11	10.02	11.57	11.96
Willamette North Basin														
WN_0100	64.93	5.05	12.02	16.44	19.62	22.16	22.79	68.39	5.23	12.46	16.90	20.08	22.62	23.25
WN_0200	64.12	2.85	6.78	9.29	11.08	12.52	12.88	65.82	2.90	6.90	9.41	11.21	12.65	13.01
WN_0300	50.66	0.67	1.59	2.25	2.73	3.12	3.21	51.75	0.68	1.61	2.27	2.75	3.14	3.24
WN_0400	46.91	1.89	4.49	6.44	7.86	9.00	9.29	46.91	1.89	4.49	6.44	7.86	9.00	9.29
WN_0500	46.79	1.11	2.64	3.78	4.62	5.29	5.46	46.79	1.11	2.64	3.78	4.62	5.29	5.46
Willamette South Basin														
WS_0100	68.83	7.74	18.42	24.99	29.69	33.45	34.39	69.16	7.76	18.49	25.06	29.76	33.51	34.45

Attachment C: Existing and Future Hydrology Comparison

Table C-1: Existing and Future Hydrology Comparison												
Subbasin	Absolute increase in maximum flow (cfs)						Percent increase in maximum flow (%)					
	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
Abernethy Basin												
AB_0100	0.07	0.15	0.16	0.16	0.16	0.15	1.24	1.24	0.93	0.78	0.68	0.66
AB_0200	0.61	1.46	1.70	1.83	1.92	1.94	14.42	14.42	10.85	9.21	8.21	7.99
AB_0300	0.91	2.17	2.50	2.67	2.77	2.80	17.15	17.15	12.92	10.96	9.75	9.49
AB_0400	0.41	0.98	1.02	1.04	1.04	1.04	12.46	12.46	9.35	7.85	6.91	6.70
AB_0500	0.03	0.08	0.09	0.10	0.10	0.10	0.56	0.56	0.42	0.36	0.32	0.31
AB_0600	0.03	0.08	0.10	0.11	0.12	0.12	1.46	1.46	1.15	0.98	0.88	0.85
Alan Court Basin												
AC_0100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Amanda Court Basin												
AM_0100	0.26	0.61	0.74	0.82	0.87	0.88	2.75	2.75	2.05	1.74	1.56	1.51
AM_0200	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
AM_0300	0.06	0.15	0.17	0.18	0.18	0.19	0.74	0.74	0.57	0.49	0.43	0.44
Beaver Basin												
BE_0200	0.75	1.79	2.07	2.22	2.32	2.34	8.94	8.94	6.78	5.77	5.15	5.02
BE_0300	0.23	0.55	0.64	0.69	0.73	0.73	2.93	2.93	2.22	1.90	1.70	1.65
Caufield Basin												
CA_0100	0.00	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.02	0.02	0.02	0.01
CA_0200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CA_0300	0.13	0.32	0.36	0.38	0.39	0.39	1.52	1.52	1.17	1.00	0.89	0.87
CA_0400	0.25	0.60	0.67	0.70	0.72	0.72	6.16	6.16	4.71	4.02	3.57	3.48
CA_0500	0.24	0.57	0.65	0.71	0.73	0.74	3.30	3.30	2.54	2.23	1.99	1.94
CA_0600	0.03	0.08	0.08	0.09	0.09	0.09	0.59	0.59	0.45	0.38	0.34	0.33
CA_0700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CA_0800	0.24	0.57	0.60	0.60	0.60	0.60	3.19	3.19	2.41	2.04	1.80	1.74
CA_0900	0.02	0.06	0.06	0.06	0.06	0.06	0.43	0.43	0.33	0.27	0.24	0.24
CA_1000	0.35	0.83	0.92	0.96	0.98	0.98	5.55	5.55	4.24	3.61	3.21	3.12
CA_1100	0.14	0.34	0.38	0.40	0.41	0.42	2.26	2.26	1.74	1.48	1.32	1.29
CA_1200	0.59	1.41	1.61	1.72	1.78	1.79	5.65	5.65	4.32	3.69	3.29	3.20
CA_1300	2.42	5.76	6.57	7.00	7.27	7.33	29.56	29.56	22.03	18.63	16.55	16.10
CA_1400	0.51	1.21	1.35	1.42	1.46	1.47	7.31	7.31	5.59	4.77	4.24	4.13
CA_1500	0.02	0.05	0.06	0.06	0.06	0.06	0.91	0.91	0.72	0.60	0.55	0.53
CA_1600	0.00	0.01	0.01	0.01	0.01	0.01	0.11	0.11	0.08	0.07	0.06	0.06
CA_1700	0.10	0.25	0.28	0.30	0.31	0.31	1.85	1.85	1.42	1.22	1.09	1.06
CA_1800	0.12	0.29	0.33	0.35	0.36	0.36	5.39	5.39	4.13	3.52	3.14	3.05
CA_1900	0.01	0.03	0.03	0.03	0.03	0.03	0.34	0.34	0.25	0.23	0.20	0.19

Table C-1: Existing and Future Hydrology Comparison

Subbasin	Absolute increase in maximum flow (cfs)						Percent increase in maximum flow (%)					
	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
CA_2000	0.04	0.10	0.11	0.12	0.12	0.12	1.46	1.46	1.11	0.95	0.85	0.82
CA_2100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CA_2200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clackamas Basin												
CL_0100	0.71	1.70	1.81	1.84	1.85	1.85	8.59	8.59	6.51	5.49	4.85	4.71
CL_0200	2.88	6.87	8.25	9.05	9.59	9.71	39.97	39.97	28.64	23.94	21.16	20.57
CL_0300	0.82	1.95	2.06	2.09	2.09	2.09	14.23	14.23	10.69	8.97	7.90	7.66
CL_0400	0.61	1.46	1.72	1.87	1.97	1.99	6.99	6.99	5.28	4.50	4.02	3.91
CL_0500	0.33	0.79	0.88	0.93	0.96	0.96	8.55	8.55	6.52	5.59	4.98	4.84
Clinton Basin												
CN_0100	0.28	0.66	0.75	0.79	0.82	0.82	5.05	5.05	3.87	3.30	2.94	2.86
CN_0200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coffee Basin												
CO_0100	0.44	1.06	1.18	1.24	1.28	1.28	7.75	7.75	5.91	5.03	4.48	4.36
CO_0200	0.07	0.17	0.20	0.21	0.22	0.22	2.07	2.07	1.59	1.36	1.21	1.18
CO_0300	0.01	0.03	0.03	0.03	0.04	0.04	0.21	0.21	0.17	0.14	0.13	0.12
CO_0400	0.04	0.11	0.12	0.13	0.13	0.13	1.76	1.76	1.36	1.16	1.04	1.01
CO_0500	0.01	0.03	0.04	0.04	0.04	0.04	0.40	0.40	0.32	0.27	0.24	0.23
CO_0600	0.17	0.40	0.45	0.48	0.49	0.50	5.90	5.90	4.51	3.85	3.45	3.35
CO_0700	0.12	0.29	0.35	0.38	0.40	0.41	4.51	4.51	3.40	2.90	2.60	2.52
CO_0800	0.17	0.41	0.48	0.52	0.53	0.54	1.98	1.98	1.56	1.34	1.20	1.17
CO_0900	0.03	0.08	0.09	0.10	0.10	0.10	0.91	0.91	0.70	0.60	0.53	0.52
Central Point Basin												
CP_0100	0.01	0.03	0.04	0.04	0.04	0.04	0.90	0.90	0.68	0.57	0.52	0.50
CP_0200	0.07	0.17	0.19	0.21	0.22	0.22	4.61	4.61	3.53	3.11	2.78	2.71
CP_0300	0.01	0.03	0.04	0.04	0.04	0.04	0.36	0.36	0.28	0.24	0.21	0.21
CP_0400	0.11	0.26	0.30	0.31	0.32	0.33	4.67	4.67	3.56	3.05	2.72	2.65
CP_0500	0.02	0.06	0.07	0.07	0.07	0.07	0.89	0.89	0.67	0.58	0.52	0.51
CP_0600	0.03	0.07	0.08	0.08	0.09	0.08	1.09	1.09	0.83	0.71	0.64	0.62
CP_0700	0.00	0.01	0.01	0.01	0.01	0.01	0.07	0.07	0.05	0.04	0.04	0.04
CP_0800	0.42	1.00	1.13	1.19	1.23	1.24	8.32	8.32	6.34	5.41	4.81	4.69
Clackamas-Willamette Basin												
CW_0100	0.02	0.04	0.06	0.15	0.26	0.27	4.40	4.40	3.24	5.80	6.62	6.34
Forsythe Basin												
FO_0100	0.14	0.34	0.41	0.44	0.46	0.47	0.71	0.71	0.54	0.46	0.41	0.40

Table C-1: Existing and Future Hydrology Comparison												
Subbasin	Absolute increase in maximum flow (cfs)						Percent increase in maximum flow (%)					
	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
John Adams Basin												
JA_0100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JA_0200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JA_0300	0.01	0.03	0.03	0.03	0.04	0.04	0.75	0.75	0.57	0.49	0.44	0.43
JA_0400	0.12	0.29	0.35	0.38	0.40	0.40	6.63	6.63	4.97	4.24	3.79	3.69
JA_0500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JA_0600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JA_0700	0.32	0.76	0.93	1.03	1.10	1.12	12.68	12.68	9.18	7.73	6.88	6.69
JA_0800	0.00	0.01	0.01	0.01	0.01	0.01	0.15	0.15	0.12	0.10	0.08	0.08
JA_0900	0.03	0.07	0.08	0.08	0.08	0.08	1.32	1.32	1.00	0.87	0.77	0.75
JA_1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JA_1100	0.02	0.04	0.04	0.04	0.04	0.04	0.83	0.83	0.64	0.55	0.49	0.48
JA_1200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JA_1300	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
JA_1400	0.01	0.02	0.02	0.02	0.02	0.02	0.37	0.37	0.27	0.25	0.21	0.21
JA_1500	0.01	0.02	0.02	0.02	0.02	0.02	0.88	0.88	0.67	0.57	0.52	0.50
JA_1600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JA_1700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JA_1800	0.02	0.05	0.06	0.06	0.07	0.07	0.74	0.74	0.55	0.48	0.43	0.41
Kelly Field Basin												
KF_0100	2.81	6.69	7.29	7.54	7.67	7.69	40.47	40.47	29.79	24.85	21.83	21.17
Livesay Basin												
LI_0100	0.23	0.55	0.76	0.90	0.99	1.01	14.22	14.22	9.60	8.06	7.01	6.79
LI_0200	0.11	0.26	0.28	0.29	0.30	0.30	6.06	6.06	4.62	3.91	3.46	3.36
LI_0300	0.19	0.46	0.52	0.54	0.56	0.57	3.73	3.73	2.86	2.44	2.18	2.13
LI_0400	0.07	0.16	0.18	0.19	0.20	0.20	5.30	5.30	4.08	3.47	3.10	3.01
LI_0500	0.06	0.14	0.16	0.17	0.18	0.18	2.21	2.21	1.69	1.45	1.30	1.26
LI_0600	0.60	1.43	1.62	1.72	1.77	1.79	9.68	9.68	7.37	6.27	5.59	5.44
LI_0700	0.09	0.21	0.25	0.27	0.28	0.28	3.60	3.60	2.73	2.35	2.10	2.05
LI_0800	0.02	0.04	0.05	0.06	0.06	0.06	0.36	0.36	0.28	0.24	0.21	0.21
LI_0900	0.07	0.17	0.19	0.20	0.21	0.21	5.75	5.75	4.42	3.79	3.37	3.29
LI_1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LI_1100	0.04	0.08	0.10	0.10	0.11	0.11	0.87	0.87	0.66	0.57	0.51	0.49
LI_1200	0.44	1.05	1.25	1.36	1.43	1.45	17.36	17.36	12.92	10.94	9.75	9.48
Mud Basin												
MU_0100	0.03	0.07	0.08	0.09	0.09	0.09	0.54	0.54	0.41	0.35	0.32	0.31

Table C-1: Existing and Future Hydrology Comparison

Subbasin	Absolute increase in maximum flow (cfs)						Percent increase in maximum flow (%)					
	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
MU_0200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MU_0300	0.09	0.22	0.25	0.26	0.27	0.27	1.68	1.68	1.30	1.11	0.99	0.97
MU_0400	0.08	0.20	0.23	0.24	0.25	0.25	1.92	1.92	1.48	1.26	1.12	1.09
MU_0500	0.08	0.20	0.23	0.24	0.24	0.25	3.51	3.51	2.68	2.29	2.04	1.99
MU_0600	0.04	0.11	0.12	0.13	0.13	0.13	1.24	1.24	0.95	0.81	0.72	0.70
MU_0700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MU_0800	0.00	0.01	0.01	0.01	0.01	0.01	0.08	0.08	0.06	0.05	0.05	0.05
MU_0900	0.61	1.45	1.70	1.83	1.92	1.94	12.03	12.03	9.06	7.70	6.87	6.69
MU_1000	0.23	0.54	0.61	0.64	0.66	0.67	5.34	5.34	4.09	3.50	3.12	3.03
MU_1100	0.04	0.09	0.10	0.10	0.10	0.11	1.36	1.36	1.05	0.89	0.80	0.78
MU_1200	0.14	0.33	0.37	0.39	0.40	0.40	3.51	3.51	2.69	2.30	2.05	1.99
MU_1300	0.06	0.14	0.15	0.16	0.17	0.17	1.81	1.81	1.40	1.20	1.09	1.07
Newell Basin												
NE_0100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NE_0200	0.12	0.29	0.33	0.35	0.36	0.36	1.83	1.83	1.41	1.20	1.07	1.05
NE_0300	0.16	0.38	0.41	0.42	0.43	0.43	2.03	2.03	1.56	1.32	1.18	1.14
NE_0400	0.57	1.35	1.68	1.87	2.00	2.03	34.93	34.93	24.60	20.43	18.03	17.52
NE_0500	0.31	0.73	0.85	0.91	0.95	0.96	5.98	5.98	4.55	3.89	3.47	3.38
NE_0600	0.01	0.03	0.03	0.03	0.03	0.04	0.35	0.35	0.27	0.23	0.20	0.20
NE_0700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NE_0800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NE_0900	0.03	0.06	0.08	0.09	0.09	0.09	0.83	0.83	0.62	0.53	0.47	0.46
NE_1000	0.57	1.36	2.09	2.49	2.81	2.87	75.10	75.10	47.33	36.60	31.56	30.37
NE_1100	0.03	0.08	0.09	0.09	0.09	0.09	1.47	1.47	1.12	0.96	0.85	0.82
NE_1200	0.11	0.26	0.28	0.28	0.29	0.29	1.96	1.96	1.50	1.27	1.13	1.09
NE_1300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NE_1400	0.81	1.92	2.08	2.14	2.17	2.18	11.46	11.46	8.68	7.34	6.49	6.31
NE_1500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NE_1600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NE_1700	0.22	0.51	0.54	0.55	0.55	0.55	7.23	7.23	5.46	4.60	4.07	3.95
NE_1800	0.13	0.32	0.34	0.34	0.34	0.34	3.26	3.26	2.47	2.09	1.85	1.79
NE_1900	0.35	0.82	0.90	0.94	0.95	0.95	4.02	4.02	3.07	2.61	2.32	2.26
NE_2000	0.80	1.90	2.03	2.08	2.09	2.10	12.09	12.09	9.13	7.69	6.79	6.60
NE_2100	0.91	2.17	2.51	2.69	2.82	2.84	11.28	11.28	8.54	7.28	6.53	6.36
NE_2200	0.44	1.05	1.08	1.07	1.06	1.05	9.05	9.05	6.75	5.63	4.93	4.78
NE_2300	1.23	2.94	3.54	3.88	4.12	4.17	15.46	15.46	11.38	9.62	8.56	8.33

Table C-1: Existing and Future Hydrology Comparison

Subbasin	Absolute increase in maximum flow (cfs)						Percent increase in maximum flow (%)					
	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
NE_2400	0.60	1.42	1.48	1.50	1.50	1.50	7.02	7.02	5.29	4.45	3.92	3.81
NE_2500	0.43	1.03	1.20	1.29	1.35	1.36	5.57	5.57	4.28	3.65	3.26	3.18
NE_2600	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
NE_2700	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.05	0.04	0.03	0.03
NE_2800	1.76	4.18	4.71	4.97	5.12	5.15	28.37	28.37	21.18	17.85	15.80	15.35
NE_2900	1.23	2.92	3.31	3.50	3.62	3.64	11.94	11.94	9.06	7.71	6.86	6.68
NE_3000	2.68	6.38	7.31	7.79	8.07	8.13	36.57	36.57	27.18	22.91	20.26	19.68
NE_3100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Park Place Basin												
PP_0100	2.17	5.17	5.98	6.40	6.67	6.73	71.15	71.15	50.65	41.94	36.77	35.66
PP_0200	2.59	6.16	6.54	6.67	6.71	6.71	40.06	40.06	29.33	24.34	21.29	20.62
PP_0300	0.85	2.02	2.37	2.56	2.68	2.71	43.99	43.99	31.99	26.79	23.67	23.00
PP_0400	0.15	0.37	0.42	0.44	0.45	0.45	6.14	6.14	4.73	4.03	3.59	3.49
PP_0500	0.72	1.73	2.11	2.34	2.50	2.54	24.70	24.70	17.61	14.74	13.07	12.71
PP_0600	0.28	0.67	0.77	0.83	0.86	0.87	3.82	3.82	2.92	2.49	2.23	2.17
PP_0700	0.17	0.41	0.46	0.49	0.51	0.51	14.05	14.05	10.65	9.05	8.05	7.83
PP_0800	0.08	0.19	0.21	0.22	0.23	0.23	4.68	4.68	3.59	3.07	2.73	2.65
PP_0900	0.19	0.44	0.50	0.53	0.55	0.56	11.98	11.98	9.13	7.76	6.92	6.74
PP_1000	0.16	0.38	0.43	0.47	0.49	0.49	6.76	6.76	5.16	4.53	4.05	3.95
South End Basin												
SE_0100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE_0200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE_0300	0.00	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.02	0.02	0.02	0.02
SE_0400	0.16	0.37	0.43	0.46	0.47	0.48	2.74	2.74	2.10	1.80	1.61	1.57
SE_0500	0.04	0.10	0.12	0.13	0.14	0.14	1.74	1.74	1.32	1.13	1.01	0.98
SE_0600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE_0700	0.04	0.09	0.09	0.10	0.10	0.10	0.51	0.51	0.39	0.33	0.30	0.29
SE_0800	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.02	0.02	0.02
SE_0900	0.28	0.66	0.78	0.86	0.91	0.92	5.96	5.96	4.52	3.94	3.54	3.45
SE_1000	0.01	0.02	0.02	0.02	0.02	0.02	0.45	0.45	0.36	0.29	0.27	0.26
SE_1100	0.05	0.11	0.13	0.14	0.15	0.15	3.26	3.26	2.50	2.21	1.96	1.92
SE_1200	0.11	0.26	0.30	0.32	0.33	0.33	2.01	2.01	1.54	1.32	1.18	1.15
SE_1300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE_1400	0.01	0.03	0.03	0.03	0.03	0.03	0.64	0.64	0.49	0.41	0.37	0.37
SE_1500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE_1600	0.21	0.50	0.57	0.60	0.62	0.62	11.79	11.79	9.02	7.68	6.83	6.65

Table C-1: Existing and Future Hydrology Comparison

Subbasin	Absolute increase in maximum flow (cfs)						Percent increase in maximum flow (%)					
	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr	1.2 yr	2 yr	10 yr	25 yr	50 yr	100 yr
Singer Basin												
SI_0100	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.08	0.07	0.06	0.06
SI_0200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SI_0300	0.03	0.08	0.09	0.09	0.09	0.10	0.67	0.67	0.51	0.44	0.39	0.38
SI_0400	0.04	0.10	0.10	0.11	0.11	0.11	0.68	0.68	0.52	0.44	0.39	0.38
SI_0500	0.04	0.09	0.10	0.10	0.10	0.10	1.13	1.13	0.87	0.74	0.66	0.64
SI_0600	0.23	0.55	0.61	0.64	0.65	0.66	3.89	3.89	2.98	2.54	2.26	2.20
SI_0700	0.14	0.34	0.38	0.40	0.41	0.42	3.53	3.53	2.71	2.31	2.06	2.01
SI_0800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SI_0900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SI_1000	0.18	0.43	0.49	0.53	0.55	0.55	4.28	4.28	3.27	2.80	2.50	2.44
SI_1100	0.16	0.38	0.43	0.45	0.47	0.47	3.53	3.53	2.71	2.31	2.06	2.01
Thimble Basin												
TH_0100	0.36	0.86	1.01	1.10	1.16	1.17	0.35	0.35	0.27	0.23	0.20	0.20
Tumwater Basin												
TU_0100	0.20	0.47	0.55	0.60	0.63	0.64	2.71	2.71	2.05	1.75	1.56	1.52
TU_0200	0.02	0.05	0.05	0.06	0.06	0.06	1.07	1.07	0.81	0.69	0.62	0.61
TU_0300	0.01	0.02	0.03	0.03	0.03	0.03	0.42	0.42	0.32	0.28	0.25	0.24
Willamette North Basin												
WN_0100	0.19	0.45	0.46	0.46	0.46	0.46	3.70	3.70	2.79	2.34	2.07	2.00
WN_0200	0.05	0.12	0.13	0.13	0.13	0.13	1.80	1.80	1.37	1.15	1.01	0.99
WN_0300	0.01	0.02	0.02	0.02	0.02	0.02	1.32	1.32	0.98	0.81	0.74	0.72
WN_0400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WN_0500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Willamette South Basin												
WS_0100	0.03	0.06	0.07	0.07	0.06	0.06	0.34	0.34	0.26	0.22	0.19	0.19

Appendix C: Hydraulic Modeling TM

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Technical Memorandum

Prepared for: City of Oregon City

Project title: Stormwater Master Plan

Project no.: 149133

Technical Memorandum

Subject: Hydraulic Models

Date: October 5, 2017

To: Jon Archibald, Project Engineer

From: Matt Grzegorzewski

Copy to: Alissa Maxwell, P.E., Ryan Retzlaff, File

Prepared by: Matt Grzegorzewski

Reviewed by: Alissa Maxwell, P.E.

Limitations:

This document was prepared solely for City Oregon City in accordance with professional standards at the time the services were performed and in accordance with the contract between City Oregon City and Brown and Caldwell dated March 16, 2016. This document is governed by the specific scope of work authorized by City Oregon City; 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 Oregon City 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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Section 1: Introduction

The City of Oregon City (City) is developing a stormwater master plan to update existing planning documents and guide surface water and stormwater decisions. The master plan will address both water quantity and quality for the constructed and natural storm drainage systems under the City's management. The master plan requires a clear understanding of existing and future infrastructure capacity across the city to identify long-term (10 to 20 years) stormwater project needs.

This technical memorandum (TM) has been developed to document the methodology used to analyze the hydraulics of stormwater conveyance systems in key areas of concern. The modeling results reveal system capacity problems consistent with City staff visual observations and input from citizens of Oregon City. The modeling shows significant flooding in the John Adams and Livesay basins along South End Road. Other areas, such as those in the Singer Creek and Central Point basins, show adequate capacity for design storms.

As a result of this analysis capital projects to increase infrastructure capacity in the John Adams neighborhood and along South End Road are recommended. An additional recommendation includes continued monitoring of recent infrastructure improvements along Coffee Creek and at Kathaway Court (Central Point Basin) to determine if further modifications may be necessary.

Section 2: Modeling Areas

Oregon City includes 23 major drainage basins. This project includes the development of hydraulic models to analyze the stormwater conveyance systems of greatest concern. Future efforts may expand the hydraulic modeling to include additional portions of the city.

City staff identified multiple areas of the city where there are known capacity or flooding issues. Some identified problem areas were considered to have a clear project solution such as those that are maintenance-related. Other areas were identified as in need of a more detailed hydraulic analysis to determine the cause of the flooding and/or develop a preferred solution. In a workshop setting with the City and Brown and Caldwell (BC), the identified problem areas were pared down to nine priority modeling locations. The extent of the modeled systems has been largely based on modeling the area upstream and downstream sufficiently to capture the problem. The outfall and downstream systems have been included as needed. The nine selected priority areas are described below.

While hydraulic modeling was limited to these nine priority areas, citywide hydrology modeling to document runoff patterns and rates was developed and documented in the *Subcatchment Hydrology* TM by BC, dated October 17, 2016.

2.1 Central Point Basin

The Central Point Basin has two reported flooding areas. Kathaway Court to Sunset Springs experiences flooding due to roadway drainage flooding over the roadway and causing localized flooding of homes. A hydraulic model was developed to include the storm system starting at Vincent Drive and following the system south to the outfall near S McCord Road.

The other location modeled starts with the storm system at Crisp Drive and follows Pease Road to an outfall near Pavilion Place.

The two modeled areas are shown in Figure 1.

2.2 Coffee Creek Basin

The Hazelwood neighborhood has been built up around Coffee Creek, which drains through the backyards of numerous homes. Coffee Creek has been channelized with significant modification to the drainage system. The system has multiple culverts and includes complicated entrance and exit conditions. One home has a culvert that is partially deteriorated, causing some localized flooding in the backyard of the property. The model for this storm system begins at Warner Parrott Road and follows the creek alignment under Hazelwood Drive, through a residential area to Barker Avenue. Barker Avenue was determined to be the end of the model due to no identified downstream problem areas and the channel showing no signs of downcutting or instability downstream of Barker Avenue.

The modeled area is shown in Figure 2.

2.3 Livesay Basin

The northeast corner of the city is expected to see significant future development, which may influence stormwater infrastructure capacity. The existing drainage systems along Holcomb Boulevard and Oaktree Terrace were modeled to identify existing and future sources of flooding and to determine how best to correct the flooding. A combination of pipes, open ditches, and culverts convey runoff west along Holcomb Boulevard, then south at Oaktree Terrace where the system outfalls to Tour Creek.

The modeled area is shown in Figure 3.

2.4 John Adams Basin

The John Adams Basin has some of the oldest infrastructure in the city. Many pipes are undersized, causing localized flooding throughout the basin. Flooding has been reported at the following locations:

- Intersection of 8th and Van Buren streets
- Van Buren Street between 14th Street and 15th Street
- Intersection of 9th and Monroe streets
- Intersection of 7th and Van Buren streets

Modeling for this basin is extensive compared to the other basins. The most upstream ends of the modeled system are at the intersection of 8th and Taylor streets and at the intersection of Harrison and 12th streets. A third modeled pipe segment starts at the intersection of 9th and Madison streets. The modeled system outfall is at the end of 12th Street.

The modeled area is shown in Figure 4.

2.5 Park Place Basin

The reported problems in the Park Place Basin include flooding near Swan Avenue, undersized culverts downstream of Swan Avenue to Apperson Boulevard, and some erosion near the intersection of Harley Avenue and Cleveland Street. The stormwater infrastructure in this basin is primarily aging culverts and pipe segments, following the original stream path. The City is concerned that the existing infrastructure would not support future development in the area. The model starts with the system west of Swan Avenue just south of Blue Mountain Way and follows the original stream path forming a half circle, which ends at the intersection of Apperson Boulevard and La Rae Street.

The modeled area is shown in Figure 5.

2.6 Singer Creek Basin

The concerns in the Singer Creek Basin are primarily due to aging infrastructure. The current alignment through the old portion of town includes brick, rock, and concrete channels and structures that have been paved and built on as the area developed. Portions of the system do not have a solid bottom and may be exfiltrating into underlying soils. The alignment also goes under several buildings. While capacity is not an immediate concern, understanding the limitations of the system is important to the City. The model starts with the system at Jackson Street between 5th and 6th streets and continues down to the Singer outfall at the corner of 7th Street, Singer Hill, and High Street.

The modeled area is shown in Figure 6.

2.7 South End Basin

South End Road has several pipes that are smaller than the upstream pipes. It is not clear whether these constrictions were intentional efforts at flow control, or design oversights. The constrictions are causing the system flooding of homes and streets in the areas around Oaktree Court, Rose Road, and the intersection of Josephine and Bjerke streets. This system also collects flow from a tributary creek near Filbert Drive that contributes significant discharge to the capacity-limited system. Starting at S Gentry Way the model then follows South End Road to the existing outfall between Salmonberry Drive and S Forest Ridge Road.

The modeled area is shown in Figure 7.

2.8 Newell Basin at Molalla Avenue and Beaver Creek Road

The City manages dozens of small stormwater systems that discharge to Newell Canyon or associated tributaries. This modeling effort included the evaluation of the most complicated drainage network in the vicinity of the S Beavercreek Road and Molalla Avenue intersection. Stormwater infrastructure is undersized in this system in several locations and has some critical erosion occurring at the outfall. The area also includes several underground detention pipes, installed to restrict downstream flows. The model extends east and west of Molalla Avenue along Beavercreek Road with north and south pipes along Molalla Avenue contributing to the Beavercreek Road system. The model outfall is just downstream of Beavercreek Road, toward a tributary to Newell Creek.

The modeled area is shown in Figure 8.

Section 3: Hydraulic Model Development

The hydraulic models were developed using XP Solutions, Storm Water Management Model (SWMM) version 2016.1. This section includes detailed descriptions of the inputs and methodology used to define the hydraulic characteristics of the modeled systems. Data sources to populate the hydraulic model included the City's geographic information system (GIS), field survey data collected in June 2017, and site visits performed by both BC and City staff. The design storms, survey, model naming conventions, and hydraulic model methods are described below.

3.1 Design Storms

The City's design event for conveyance systems depends on the size of the catchment draining to the infrastructure as follows:

- Catchment areas of less than 40 acres require a 10-year, 24-hour design event
- Catchment areas between 40 and 640 acres require a 25-year, 24-hour design event

- Catchment areas greater than 640 acres require a 50-year, 24-hour design event

New public and private conveyance systems are designed to carry the design event without surcharging. For analysis of existing systems, the design events are used to identify current and future capacity problems and then provide a target capacity for capital projects. To support these goals, each of the hydraulic models was used to simulate existing conditions for the 2-year, 10-year, 25-year, and 100-year, 24-hour design storms.

The 1.2-year rainfall depth is representative of the water quality design storm as documented in the technical memorandum *Selection of Representative Rainfall Volume and Rainfall Intensities to Result in Capture and Treatment of 80% of the Average Annual Runoff Volume* (BC 2010). According to a 2008 Oregon Department of Transportation (ODOT) study titled *Water Quantity (Flow Control) Design Storm Performance Standard*, 42 percent of the 2-year peak flow rate can be used as an analog for the 1.2-year peak flow rate (ODOT 2008). This event represents a depth of 1.18 inches of rainfall. The 1.2 year rainfall event is not included in the hydraulic results table in Attachment A because it does not impact capacity analyses of the conveyance system. However, it is an important consideration for water quality and bank forming events and is included in the city-wide hydrology analysis.

A hydrology model was developed for the 185 subbasins located within Oregon City prior to the hydraulic model. The Santa Barbara Urban Hydrograph (SBUH) was used to develop runoff hydrographs for multiple storm events. The necessary input parameters for estimating hydrology include subcatchment area, pervious and impervious percentages, pervious curve numbers, rainfall, and time of concentration. For more detailed descriptions of the methodology used in determining each of the hydrologic model parameters, see the *Subcatchment Hydrology* TM by BC, dated August 10, 2016.

Results from the hydrology model were used as input to the hydraulic models to simulate flows in the selected pipe networks. Hydrology input nodes were placed at hydraulic stormwater structures near the downstream ends of contributing subcatchments.

3.2 Conveyance Naming Convention

The naming convention for Oregon City's drainage system was provided via GIS by the City, which includes the links (pipes, open channels, culverts, etc.) and nodes (manholes, catch basins, etc.). Links have a unique six-digit facility identifier (ID) beginning with the number 800000, and nodes have a unique five-digit facility ID beginning with the number 30000. The naming convention used in the City's GIS was applied to the systems simulated in the XPSWMM model.

Links or nodes that were not found in the existing GIS database and that were added to the hydraulic models were named with the default nomenclature provided by XPSWMM (e.g., Link 34 and Node 23).

3.3 Input Parameters

The primary purpose of the modeling was to conduct a hydraulic analysis of select storm drainage systems to evaluate system capacity. Hydraulic input parameters included pipe name, upstream (US) node (name, invert elevation, rim elevation), downstream (DS) node (name, invert elevation, rim elevation), pipe length, pipe slope, pipe shape, pipe diameter, and Manning's roughness coefficient. Attachment A, Hydraulic Model Parameters and Results, includes all pipe and node data for each model. The following sections describe the parameters that were required for development of the models.

3.3.1 Upstream and Downstream Node Names

The upstream and downstream node names for each link were assigned based on the naming convention provided by the City's GIS, as explained in Section 3.2. Nodes in the hydraulic model that also include model hydrologic input information were renamed with the nomenclature *NodeName_SubbasinName_hydraulic-nodename* (e.g. 42534_CO_0500).

3.3.2 Length and Slope of Segment

The length of each link was provided by the City from the City's GIS. Lengths were extended or combined with other segments as necessary to ensure continuity in the system. Where the information provided in the GIS did not align with observations, other means to estimate the length of infrastructure were employed, such as a site visit, field survey, Google Earth measurement, or GIS measurement.

Segment slopes were calculated in XPSWMM using upstream and downstream node invert elevations and segment lengths.

3.3.3 Invert Elevations

Upstream and downstream invert elevations for each pipe segment were extracted from node data in GIS. If invert information was missing, the invert data were collected via field survey as is described in Section 3.4.

3.3.4 Rim Elevations

The rim elevation at each node location is necessary to simulate possible flooding of the drainage system. Many rim elevations were missing in the City' GIS database. Missing rim elevations were estimated using light detecting and ranging (LiDAR) data. Field survey was collected for structures where rim elevations were inconclusive from LIDAR.

3.3.5 Diameter and Shape

Existing pipe diameters for pipe segments were obtained from GIS or collected through field survey or site visits. For pipes where diameter data were not provided or could not be field-verified, the diameter was assumed to be the same size as the pipe segment immediately upstream. This assumption provides a conservative estimate of hydraulic system capacity.

Pipes were assumed to be circular in shape with the exception of conduits that convey flow from Singer Creek downstream of Node 33815 to the outfall at Node 42737. During a field visit conducted by BC staff on August 31, 2016, these pipe segments were observed to have a rectangular cross-section.

Open channels were assumed to be trapezoidal in shape with dimensions approximated based on measurements obtained during field visits by BC or City staff.

3.3.6 Manning's Roughness Coefficient

Manning's roughness coefficient "n" is dependent on the surface material of pipes and open channels. It was assumed that all pipes were composed of concrete with an associated roughness coefficient of 0.014. A roughness coefficient range of 0.014 to 0.040 was assigned to all open-channel surfaces based on observations from aerial photography and site visits. The low roughness of 0.014 for an open channel was applied to a concrete-lined open channel. Other vegetated, rock, or dirt channels with higher roughness had a Manning's "n" of up to 0.040.

3.4 Survey Needs

After determining the extent of area to be modeled for each problem area, missing invert elevations and pipe diameters within these areas were identified based on a query of GIS data in order to develop a data gaps list. A total of 126 structures were identified as needing a survey to supplement the existing GIS data. AKS Engineering & Forestry performed the survey in May 2016 to obtain the missing data necessary for modeling. Survey results were delivered in the form of a computer-aided design (CAD) file and an Excel spreadsheet. BC staff incorporated the updated elevations into the GIS database. Subsequently, the data were exported from GIS into XPSWMM.

3.5 Vertical Datum

To verify the vertical datum used in the GIS data provided by the City, ground elevations of nodes were extracted from LIDAR data and compared to rim elevations within the GIS database. Ground elevations from LIDAR, which was known to use the North American Vertical Datum of 1988 (NAVD88), were consistently 3.5 feet higher than the City-provided rim elevations. Based on this observation, it was assumed that a majority of the City data used the National Geodetic Vertical Datum of 1929 (NGVD29). There were a few exceptions where the difference between the elevations was near zero feet. These nodes were updated by the City more recently and most likely already use NAVD88. No adjustment was made to these nodes. The remaining nodes were adjusted using the datum shift between NAVD88 and NGVD29 for Oregon City, Oregon (3.52 feet) to bring the City GIS data to NAVD88.

3.6 Hydraulic Model Methods

To evaluate system capacity and flooding hazards, the XPSWMM computer model was used to simulate the hydraulic performance of the piped and open-channel systems. The hydrology routine in XPSWMM converts rainfall into stormwater runoff based on design storm parameters (e.g., volume and intensity of rainfall) and subbasin characteristics such as topography, land use, vegetation, and soil types. The hydraulics routine in the model then routes the stormwater runoff through the drainage system and enables estimates to be made of discharge through the conveyance system, water surface elevations, and velocities for design storms.

Problem areas identified by BC and City staff for modeling were based on known issues. These areas are shown in Figure 9.

To check model results and validate the hydrologic and hydraulic modeling, the results were compared to anecdotal problem area descriptions. Problem area descriptions provided by the City did not include specific flooding elevations or measured extents in any of the basins. A general model validation was performed to check that all the models are showing flooding in areas where flooding was reported by City staff.

3.7 Hydraulic Scenarios

Two scenarios were simulated using the hydraulic models: existing and future development conditions.

- The existing-conditions models were based on hydrology for the existing land use conditions as described in the *Subcatchment Hydrology* TM by BC, dated August 10, 2016. The hydraulics models were based on the infrastructure currently in place and represented in the GIS supplemented with surveyed data.
- The future-conditions models were based on hydrology for the future land use conditions as described in the *Subcatchment Hydrology* TM by BC, dated August 10, 2016. The future-conditions models typically resulted in higher flows due to increased impervious percentages associated with new development. These models were used to assess the ability of existing infrastructure to handle future flows and to identify locations where additional or new capacity problems might occur as a result of buildout.

In areas where flooding problems indicated a need for a modification of the drainage infrastructure, an additional hydraulic model was created. The proposed capital improvement project (CIP) hydraulic features were incorporated into the future conditions models to identify conceptual designs for the new infrastructure.

Section 4: Hydraulic Model Results

The XPSWMM simulations were run for the 2-year, 10-year, 25-year, and 50-year event for both current and future development conditions. The model results show no/minimal increases for future flows for the modeled areas that are already fully developed. As expected, the largest projected flow increases were seen in areas with existing vacant land that is slated for future development. The model results also provided validation of the problem areas as reported by City staff and they provided additional information about potential sources of the problems. When reviewing model results, flooding was considered to be a problem when the maximum water surface elevation at any modeled node was equal to or greater than the rim elevation of the node. Surcharging of the system was not considered to be a flooding problem.

A summary of the model results is described below. See Tables A-1 through A-4 in Attachment A for modeling result details.

4.1.1 Central Point Basin

The hydraulic model results for the Central Point Basin show that the pipe at the downstream end of the open channel along S McCord Road between S Central Point Road and Sunset Springs Drive is undersized and results in flooding during the 25-year design event. This flooding as simulated by the model is consistent with problems reported by City staff. In addition to undersized pipes, the system capacity is further reduced by several 90-degree bends in the drainage network. The roadway drainage discharges on the west side of Central Point Road near Kathaway Court, where it joins the main channel to flow back under Central Point Road to the east. The flooding is most problematic at 19451 Sunset Springs Drive. The modeling shows that the existing infrastructure on Pease Road has adequate capacity to carry future flows during the 25-year storm event.

City maintenance staff have recently modified the inlet/outlet structures near Kathaway Court to reduce losses and improve flow capacity. These modifications reduced flooding during the 2016/17 winter storm events. The City will continue to monitor the drainage network to determine if any further improvements are needed.

4.1.2 Coffee Creek Basin

The hydraulic model results for the Coffee Creek Basin show minor/significant flooding around hydraulic constrictions beginning at the 10-year design storm. This system is mostly open channel with a few culverts. The water overtops the banks of the channel, flooding the backyards of residential homes. The flooding is most problematic near the backyard of 965 Hazelwood Drive which has an undersized culvert that was installed by a private party. The system has multiple constrictions and modified culvert inlets that greatly reduce the capacity of the open channel.

City staff has been actively working with homeowners to address constrictions in the existing system. No capital projects are recommended for this basin at this time. However, the City may consider opportunities for small drainage improvements when other public projects are connected to the creek.

4.1.3 Livesay Basin

The Livesay Basin model was built to assess reported flooding and verify capacity of the existing infrastructure as the area is nearly fully developed. Model results revealed some deficiencies in the system where the reported flooding is occurring. Much of the infrastructure along Holcomb Boulevard is undersized and will need to be replaced if future development is to occur within the drainage area. Flooding begins for the future flow scenario beginning at the 2-year design event. The most significant flooding occurs at the transition between open channels and piped flow where the stormwater system from the north side of Holcomb Boulevard crosses to the south side, west of Oaktree Terrace. Modifying the inlet structures to increase hydraulic efficiency and properly sizing the downstream infrastructure is likely needed to alleviate flooding.

4.1.4 John Adams Basin

The results of the John Adams Basin analysis reveal several areas where the system is undersized and floods, especially in areas where the stormwater system transitions from larger-diameter to smaller-diameter pipe. This occurs at the intersections of 9th and John Adams streets, 11th and John Adams streets, and 11th and Madison streets, among others. Flooding has been observed in the field and has been confirmed with the existing-conditions model at these locations. The scope of the model built and areas modeled included areas identified as problems. Modeled flooding occurs during the 2-year design event, which is consistent with the reported flooding that is said to occur during routine events.

This area has some of the oldest infrastructure in the city and is complex while undersized for the areas it drains. Much of this infrastructure is well past its design life, suggesting there may be locations where pipes are partially collapsed or have root growth or other conditions that reduce capacity.

4.1.5 Park Place Basin

Reports of flooding in the Park Place neighborhoods are related to inconsistencies in the channelized system and abrupt changes in either flow direction or conveyance material.

The existing Park Place model results show flooding at the culvert crossing under Hiram Avenue starting with the 2-year design event. Other locations that flood during the 25-year, 24-hour storm include an undersized culvert farther downstream near the intersection of Clear Street and Front Avenue, the transition from open channel to closed east of Hunter Avenue and south of Cleveland Street, and the culvert that appears to be in the backyard of 16163 S Harley Avenue.

4.1.6 Singer Creek Basin

No flooding or problem areas were identified for this area but City staff requested that a model be built and the system be assessed because of its age and alignment through private property. The modeled system shows no flooding, yet it is surcharged and the water surface during the 25-year design event is at or near the surface. The system is running full during the 25-year design event and is surcharged. The drainage basin contributing to Singer Creek is mostly built out but as densification and infill occurs, care should be taken to assess impacts of any increase in discharge or peak flows. The infrastructure is some of the oldest in the city and will require regular inspections and assessment to ensure function. Additionally, the creek is aligned across private property and directly under structures in a few instances. As the system is updated the trunk line should be relocated into the public right-of-way and out of private property whenever possible.

4.1.7 South End Basin: South End Road

The South End conveyance system is a mix of open channels and large and small pipes, which results in an inefficient system. Based on model results, this system starts to flood during the 2-year event. The flooding starts near South Rose Road where the open-channel system enters a closed system. The entrance grate configuration and pipes are not sized sufficiently to convey the runoff. The existing entrance grate could also be an issue for debris accumulation. The system then decreases in pipe diameter and significantly increases in slope. The conveyance infrastructure floods farther down South End Road where a culvert capturing the open-channel flow does not have capacity.

4.1.8 Newell Creek Basin: Beavercreek Road and Molalla Avenue

The modeling has shown that pipes are under capacity at the Beavercreek Road crossing east of Molalla Avenue. One undersized pipe, across Beavercreek Road, looks to be an intentional restriction to create an underground detention system for stormwater management. The underground detention pipes may not be adequately sized for the expected peak flows and the pipe across Beavercreek Road is the cause of flooding starting with the 2-year design event. The pipes along Molalla Avenue that drain to Beavercreek Road have capacity while the smaller pipes along Beavercreek Road that contribute to the trunk line are surcharged during the 2-year event. Future monitoring for flooding in this area is recommended.

Replacement of the existing 40 feet of 12-inch-diameter pipe and 10 feet of 3.5-foot-diameter pipe, across Beavercreek Road, to match the upstream and downstream pipe size, which is 4.0 feet in diameter, will likely remove much of the capacity issues within the trunk line of this system.

Results of the hydraulic simulations for all events and locations are tabulated in Attachment A: Hydraulic Model Parameters and Results.

Section 5: References

Brown and Caldwell (BC). 2010. *Selection of Representative Rainfall Volume and Rainfall Intensities to Result in Capture and Treatment of 80% of the Average Runoff Volume*. May 11.

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Attachment A: Hydraulic Model Parameters and Results

Table A-1. Hydraulic Model Parameters and Results for 2-yr and 1.2-yr Storms

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water Surface Elevation (ft)		Future Max Water Surface Elevation (ft)		Max Flow (cfs)		1.2-yr Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future	Existing	Future
Central Point Basin																				
808424	57.6	Circular	36	3.44	42490_CP_0500	38777	441.58	439.60	444.58	448.68	443.13	440.27	443.15	440.27	12.86	13.00	5.40	5.46		
803448	135.1	Circular	12	1.58	33962	35483	461.35	459.21	467.71	467.48	462.44	459.99	463.01	460.06	3.97	4.29	1.67	1.80		
803449	349.8	Circular	12	4.26	35483	35481	459.01	444.12	467.48	450.42	459.59	444.67	459.62	444.70	3.97	4.29	1.67	1.80		
803703	202.6	Circular	30	0.59	35630	35478	429.72	428.53	439.21	432.23	431.03	429.64	431.10	429.69	11.87	12.85	4.99	5.39		
807429	182.8	Circular	12	0.77	37879_CP_0800	33962	463.41	462.00	468.84	467.71	466.05	462.85	466.70	463.01	3.98	4.30	1.67	1.81		
808422	128.1	Circular	36	0.71	33002	39749	443.14	442.23	447.90	445.23	443.93	443.17	443.94	443.18	6.39	6.46	2.68	2.71		
808427	28.5	Circular	36	0.04	39588	34501	432.78	432.77	438.46	438.50	434.54	434.27	434.54	434.27	17.05	17.05	7.16	7.16		
808428	118.5	Circular	36	1.05	34502	39588	434.03	432.78	440.22	438.46	435.42	434.54	435.42	434.54	17.05	17.05	7.16	7.16		
808653	18.7	Circular	30	2.20	38733_CP_0800	35630	430.33	429.92	440.18	439.21	431.68	431.03	431.75	431.10	11.88	12.85	4.99	5.40		
808654	259.3	Circular	12	4.75	35481	38733_CP_0800	443.92	431.60	450.42	440.18	444.49	432.13	444.52	432.16	3.97	4.29	1.67	1.80		
809337	155.2	Circular	36	0.95	34503	34502	435.50	434.03	441.35	440.22	436.83	435.42	436.83	435.42	17.05	17.06	7.16	7.16		
809791	34.0	Circular	15	0.00	34248_CP_0100	35487	430.72	430.73	438.92	438.59	432.07	431.73	432.08	431.74	3.64	3.67	1.53	1.54		
809793	91.2	Circular	15	0.27	35487	35484	430.53	430.28	438.59	437.00	431.73	431.05	431.74	431.05	3.64	3.67	1.53	1.54		
812537	128.1	Trapezoidal	30	0.71	39749	42490_CP_0500	442.23	441.58	445.23	444.58	443.17	443.13	443.18	443.15	6.32	6.40	2.66	2.69		
Link18	292.2	Circular	36	0.41	33700_CP_0600	33002	444.35	443.14	450.79	447.90	445.25	443.93	445.26	443.94	6.41	6.48	2.69	2.72		
Link19	447.2	Trapezoidal	30	0.49	38888	30909_CP_0400	438.79	436.61	441.29	439.11	440.07	439.11	440.08	439.11	12.80	12.95	5.37	5.44	YES	YES
Link20	33.0	Circular	27	0.62	30909_CP_0400	34503	436.61	436.40	439.11	441.35	439.11	437.84	439.11	437.84	17.05	17.05	7.16	7.16		
Link21	10.0	Circular	36	13.10	38777	38888	439.60	438.29	448.68	441.29	440.27	440.07	440.27	440.08	12.86	12.99	5.40	5.46		
Link25	341.0	Circular	15	0.55	35484	35478	430.08	428.20	437.00	432.23	431.01	429.15	430.95	429.18	3.63	3.66	1.53	1.54		
Link26	215.0	Circular	30	2.57	35478	40654	428.20	422.68	432.23	425.18	429.15	423.54	429.18	423.57	15.50	16.51	6.51	6.93		
Link27	38.5	Circular	36	1.30	34501	33145	432.77	432.27	438.50	435.27	434.27	433.27	434.27	433.27	17.05	17.05	7.16	7.16		
Coffee Creek Basin																				
618.1	116.9	Circular	24	0.58	42534_CO_0500	42533	440.66	439.98	445.16	444.48	443.58	441.51	443.59	441.53	14.95	14.95	6.28	6.28		
802016	56.9	Circular	24	1.63	40182_CO_0800	34657	453.03	452.10	456.03	456.54	454.64	452.87	454.67	452.88	8.40	8.63	3.53	3.62		
808374	56.9	Circular	24	1.63	40182_CO_0800	34657	453.03	452.10	456.03	456.54	454.64	452.87	454.67	452.88	8.40	8.63	3.53	3.62		
808377	62.4	Circular	48	1.07	42472_CO_0600	42473	448.69	448.02	453.69	454.24	451.07	449.49	451.13	449.54	31.25	32.31	13.13	13.57		
808379	68.6	Circular	30	2.90	42475_CO_0400	42474	413.69	411.70	417.69	416.03	416.77	412.79	416.78	412.79	25.54	25.60	10.73	10.75		
808379	68.6	Circular	30	2.90	42475_CO_0400	42474	413.69	411.70	417.69	416.03	416.77	412.79	416.78	412.79	25.54	25.60	10.73	10.75		
808867	76.2	Circular	36	0.91	CO_0300	42552	429.21	428.52	433.21	432.52	433.21	430.25	433.21	430.25	45.08	45.08	18.93	18.94		
Backyard	116.9	Trapezoidal	24	0.00	42534_CO_0500	42533	443.16	442.48	445.16	444.48	443.58	442.90	443.59	442.91	23.84	24.95	10.01	10.48		
Link10	686.1	Trapezoidal	48	2.16	42552	42475_CO_0400	428.52	413.69	432.52	417.69	430.25	416.77	430.25	416.78	45.08	45.08	18.93	18.93		
Link11	6.0	Rectangular	30	1.73	Node16	Node17	446.46	446.35	450.46	450.36	449.34	447.26	449.40	447.28	31.24	32.30	13.12	13.57		
Link12	329.2	Trapezoidal	48	1.73	Node17	42534_CO_0500	446.35	440.66	450.36	445.16	447.26	443.58	447.28	443.59	31.24	32.30	13.12	13.57		
Link13	180.0	Trapezoidal	24	0.58	42533	Node19	439.98	438.82	444.48	441.82	441.51	441.14	441.53	441.17	39.77	40.87	16.70	17.17		
Link14	50.0	Trapezoidal	36	0.58	Node19	Node20	438.82	438.53	441.82	442.53	441.14	439.73	441.17	439.75	39.76	40.87	16.70	17.16		
Link15	100.5	Trapezoidal	48	9.27	Node20	CO_0300	438.53	429.21	442.53	433.21	439.73	433.21	439.75	433.21	39.76	40.87	16.70	17.16	YES	YES
Link6	174.1	Circular	36	0.67	34657	40188_CO_0700	451.30	450.14	456.54	457.06	452.78	451.85	452.81	451.89	16.80	17.25	7.05	7.25		
Link7	587.5	Trapezoidal	60	0.25	40188_CO_0700	42472_CO_0600	450.14	448.69	457.06	453.69	451.85	451.07	451.89	451.13	24.87	25.57	10.44	10.74		
Link8	90.3	Trapezoidal	48	1.73	42473	Node16	448.02	446.46	454.24	450.46	449.49	449.34	449.54	449.40	31.24	32.31	13.12	13.57		

Table A-1. Hydraulic Model Parameters and Results for 2-yr and 1.2-yr Storms

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water Surface Elevation (ft)		Future Max Water Surface Elevation (ft)		Max Flow (cfs)		1.2-yr Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future	Existing	Future
Livesay Basin																				
Link1	169.8	Circular	1	1.00	33740_LI_1200	33742	504.45	502.75	512.76	510.16	512.35	506.09	505.61	505.61	5.86	0.00	2.46	0.00		
Link13	41.7	Circular	1.5	4.31	34160	42491	429.05	427.25	435.25	432.40	426.66	424.12	431.00	428.29	10.36	13.83	4.35	5.81		
Link14	185.2	Circular	1	8.09	32573_LI_1100	34374_LI_1000	438.68	423.70	441.61	430.48	434.71	423.87	438.90	423.92	0.73	0.96	0.31	0.40		
Link15	399.6	Circular	1	3.02	34374_LI_1000	35610	423.47	411.42	430.48	418.42	423.57	411.73	423.80	411.77	1.07	1.30	0.45	0.55		
Link16	124.8	Circular	1	1.67	35610	35612	411.36	409.27	418.42	412.91	411.73	409.61	411.77	409.65	1.07	1.30	0.45	0.55		
Link17	252.8	Circular	1	5.17	35612	35607	409.06	395.99	412.91	400.77	409.31	400.77	409.34	400.77	1.07	1.30	0.45	0.55	YES	YES
Link18	73.6	Circular	1	0.56	35607	35686	395.79	395.38	400.77	397.38	400.77	395.67	400.77	395.61	6.48	4.20	2.72	1.76		
Link19	96.2	Trapezoidal	2	14.41	35686	39436	395.38	381.52	397.38	383.52	395.67	383.52	395.61	383.52	6.48	4.20	2.72	1.76	YES	YES
Link2	106.9	Circular	1	1.91	33742	34162_LI_1100	502.55	500.51	510.16	505.96	506.09	501.92	505.61	505.60	5.86	0.00	2.46	0.00		
Link20	61.8	Circular	1	8.24	39436	34997	381.52	376.43	383.52	379.80	383.52	376.89	383.52	376.89	4.09	4.09	1.72	1.72		
Link21	218.2	Circular	1	5.92	34997	30828_LI_0600	376.23	363.31	379.80	366.90	376.78	363.82	376.78	363.82	4.09	4.09	1.72	1.72		
Link22	19.2	Circular	1	32.88	30828_LI_0600	39842	362.77	356.46	366.90	368.26	363.10	356.79	363.29	356.79	4.50	4.54	1.89	1.91		
Link23	198.9	Circular	2	0.88	42491	39313_LI_1000	426.75	425.00	432.40	427.01	424.12	417.72	428.29	426.24	10.38	13.83	4.36	5.81		
Link24	542.8	Trapezoidal	2	4.63	39313_LI_1000	Node25	425.00	399.89	427.01	401.89	417.72	401.89	425.93	401.89	11.94	15.51	5.02	6.51	YES	YES
Link25	125.0	Circular	2	3.12	Node25	35607	399.89	395.99	401.89	400.77	401.89	400.77	401.89	400.77	11.28	11.28	4.74	4.74	YES	YES
Link29	455.6	Circular	1.25	0.39	Node31	Node31.1	508.23	506.44	519.47	512.76	NA$_1$	NA$_1$	513.21	512.76	NA$_1$	1.82	NA$_1$	0.76		YES
Link29.1	296.1	Circular	1.25	1.70	Node31.1	Node34	506.24	501.21	512.76	506.82	NA$_1$	NA$_1$	512.76	506.82	NA$_1$	9.29	NA$_1$	3.90		YES
Link3	525.9	Circular	1.25	7.72	34162_LI_1100	34161	500.41	459.83	505.96	465.63	501.71	465.66	505.60	465.63	14.56	16.05	6.11	6.74	YES	YES
Link30	23.7	Circular	1.25	1.69	Node34	34162_LI_1100	501.01	500.61	506.82	505.96	NA$_1$	NA$_1$	506.82	505.60	NA$_1$	9.18	NA$_1$	3.86		
Link4	241.2	Circular	1.25	4.46	34161	33066	459.84	449.09	465.63	453.44	465.66	453.43	465.63	450.34	12.59	13.83	5.29	5.81		
Link5	206.8	Circular	1.25	6.95	33066	33065	449.09	434.71	453.44	438.65	453.43	435.98	450.21	436.48	10.36	13.83	4.35	5.81		
Link6	52.1	Circular	1.25	12.00	33065	34160	435.15	428.90	438.65	435.25	435.80	426.66	436.48	431.00	10.36	13.83	4.35	5.81		YES
John Adams Basin																				
800781	159.3	Circular	16	4.81	34313	33514	160.19	152.53	162.29	171.45	161.08	153.28	161.08	153.28	9.48	9.48	3.98	3.98		
801568	335.0	Circular	8	4.06	33504	33474	257.58	243.99	261.10	254.51	261.10	253.96	261.10	253.99	1.93	1.93	0.81	0.81		
801573	15.0	Circular	12	28.92	33473	34769	220.25	215.90	226.39	226.95	223.03	220.87	223.03	220.87	6.58	6.58	2.76	2.76		
802603	417.6	Circular	12	6.93	33505_JA_1400	38651	309.65	280.69	316.50	286.90	310.15	281.19	310.15	281.19	4.36	4.38	1.83	1.84		
802604	268.7	Circular	8	2.85	33566_JA_1600	34696	321.64	313.99	330.45	318.74	326.74	314.66	326.74	314.66	2.38	2.38	1.00	1.00		
802606	301.1	Circular	8	8.09	34698	33504	282.51	258.15	289.22	261.10	282.96	261.10	282.96	261.10	2.38	2.38	1.00	1.00	YES	YES
804813	157.0	Circular	18	6.34	33520	43469	82.29	72.34	96.27	88.74	83.21	75.92	83.21	75.92	12.63	12.63	5.31	5.30		
804814	78.8	Circular	18	7.00	33519	33520	92.03	86.51	99.89	96.27	93.02	87.25	93.02	87.25	12.61	12.61	5.30	5.30		
804815	124.1	Circular	18	2.66	33521	34704_WN_0300	68.67	65.37	86.97	73.55	74.12	66.87	74.12	66.87	19.03	19.03	7.99	7.99		
804841	513.2	Circular	12	2.94	33475_JA_1000	33473	235.76	220.69	243.58	226.39	243.58	223.03	243.58	223.03	6.58	6.58	2.76	2.76		
804846	64.5	Circular	12	1.18	33469	33508	185.00	184.24	188.90	191.51	188.90	185.23	188.90	185.23	6.27	6.27	2.63	2.63		
804848	150.6	Circular	24	5.05	33514	33515	152.33	144.73	171.45	153.00	153.03	145.34	153.03	145.34	9.48	9.48	3.98	3.98		
804851	256.1	Circular	18	8.38	33515	34191_JA_0100	144.53	123.08	153.00	128.90	145.16	128.90	145.16	128.90	9.48	9.48	3.98	3.98	YES	YES
804860	101.6	Circular	18	3.60	33517_WN_0400	33516	178.61	174.95	185.10	179.60	179.81	178.88	179.81	178.88	7.07	7.07	2.97	2.97		
804861	211.6	Circular	18	6.54	33523	33517_WN_0400	192.64	178.81	201.40	185.10	192.97	179.81	192.97	179.81	2.64	2.64	1.11	1.11		
804867	274.3	Circular	18	2.49	34311_WN_0500	33523	199.70	192.86	207.50	201.40	200.14	193.28	200.14	193.28	2.64	2.64	1.11	1.11		
804870	183.5	Circular	8	6.02	34767_JA_1100	34309	203.85	192.80	209.10	198.92	209.10	193.47	209.10	193.47	3.22	3.22	1.35	1.35		
804934	296.9	Circular	8	9.23	38650_JA_1500	33475_JA_1000	263.28	235.87	269.84	243.58	263.70	243.58	263.71	243.58	2.17	2.19	0.91	0.92	YES	YES
804969	247.9	Circular	8	8.24	33513_JA_0300	33519	113.61	93.18	119.72	99.89	118.80	93.85	118.80	93.85	3.55	3.55	1.49	1.49		
806396	444.2	Circular	8	8.37	37054	33513_JA_0300	151.18	114.01	162.35	119.72	159.31	118.80	159.31	118.80	3.55	3.55	1.49	1.49		
806401	131.5	Circular	8	16.53	37059	37054	173.12	151.38	178.38	162.35	173.72	159.31	173.72	159.31	3.58	3.58	1.50	1.51		
806402	255.5	Circular	10	12.82	37062	37059	206.06	173.32	208.79	178.38	206.49	173.73	206.49	173.73	3.55	3.55	1.49	1.49		
806406	30.6	Circular	10	2.72	37064	37062	207.09	206.26	210.50	208.79	208.95	207.02	208.95	207.02	3.55	3.55	1.49	1.49		

1. Existing model based on infrastructure in place in 2017. Future conditions model includes recently installed infrastructure.

Table A-1. Hydraulic Model Parameters and Results for 2-yr and 1.2-yr Storms

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water Surface Elevation (ft)		Future Max Water Surface Elevation (ft)		Max Flow (cfs)		1.2-yr Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future	Existing	Future
806411	253.8	Circular	8	1.92	37070_JA_0500	34769	223.30	218.42	224.81	226.95	224.81	220.87	224.81	220.87	1.40	1.40	0.59	0.59		
806471	131.0	Circular	18	3.17	37118	37139_WN_0100	50.10	45.95	57.70	53.08	57.70	53.08	57.70	53.08	15.12	15.12	6.35	6.35	YES	YES
806474	123.1	Circular	18	0.56	37139_WN_0100	37142	45.72	45.03	53.08	53.08	53.08	50.09	53.08	50.09	12.38	12.37	5.20	5.19		
808623	41.5	Circular	18	0.63	37142	41009	44.93	44.67	53.08	52.70	50.09	48.32	50.09	48.32	12.37	12.37	5.19	5.19		
808624	19.1	Circular	18	-0.52	43300	43301	43.51	43.61	61.81	61.81	46.43	44.94	46.43	44.94	12.37	12.37	5.19	5.19		
808704	305.9	Circular	12	2.42	33474	33475_JA_1000	243.75	236.34	254.51	243.58	253.96	243.58	253.99	243.58	6.02	6.03	2.53	2.53	YES	YES
808721	103.2	Circular	12	6.62	34309	33508	190.32	183.49	198.92	191.51	190.80	183.92	190.80	183.92	3.22	3.22	1.35	1.35		
812475	29.8	Circular	12	4.05	36378	34534	163.75	162.54	168.58	167.42	168.58	166.00	168.58	166.00	6.66	6.66	2.80	2.80		
812477	198.1	Circular	12	4.42	33516	36378	172.70	163.95	179.60	168.58	178.88	168.58	178.88	168.58	7.07	7.07	2.97	2.97	YES	YES
812478	100.6	Circular	12	3.01	34534	43051	162.24	159.21	167.42	163.93	166.00	160.78	166.00	160.78	6.65	6.65	2.79	2.79		
812479	194.4	Circular	12	4.18	43051	43050	159.11	150.99	163.93	155.49	160.78	151.78	160.78	151.78	6.48	6.48	2.72	2.72		
812692	119.5	Circular	18	0.80	41009	43300	44.57	43.61	52.70	61.81	48.32	46.43	48.32	46.43	12.37	12.37	5.19	5.19		
812695	158.3	Circular	54	18.38	43301	39733	43.51	14.40	61.81	19.40	43.94	14.79	43.94	14.79	12.37	12.37	5.19	5.19		
812816	39.8	Circular	18	8.12	43469	33521	72.10	68.87	88.74	86.97	75.92	74.12	75.92	74.12	12.71	12.72	5.34	5.34		
Link43	393.4	Circular	12	9.22	38651	33474	280.27	243.99	286.90	254.51	280.75	253.96	280.75	253.99	4.36	4.38	1.83	1.84		
Link44	240.8	Circular	8	12.78	34696	34698	313.57	282.80	318.74	289.22	313.96	283.17	313.96	283.17	2.38	2.38	1.00	1.00		
Link45	276.4	Circular	8	1.36	34692_JA_1300	37087	242.56	238.80	250.94	248.38	308.28	248.38	308.28	248.38	7.33	7.33	3.08	3.08	YES	YES
Link46	256.7	Circular	8	3.82	37087	33491_JA_0200	238.60	228.79	248.38	234.43	248.38	234.43	248.38	234.43	2.72	2.72	1.14	1.14	YES	YES
Link47	259.8	Circular	8	7.96	33491_JA_0200	37064	227.98	207.29	234.43	210.50	234.43	208.95	234.43	208.95	3.55	3.55	1.49	1.49		
Link48	262.9	Circular	12	13.33	34769	33469	220.25	185.20	226.95	188.90	220.87	188.90	220.87	188.90	7.94	7.94	3.34	3.34	YES	YES
Link49	225.3	Circular	16	8.60	33508	34313	179.51	160.14	191.51	162.29	180.16	161.08	180.16	161.08	9.48	9.48	3.98	3.98		
Link54	132.7	Circular	18	11.25	34704_WN_0300	37118	65.33	50.40	73.55	57.70	66.68	57.70	66.68	57.70	20.59	20.61	8.65	8.66	YES	YES
Link55	249.5	Circular	12	10.53	43050	Node58	150.49	124.22	155.49	126.51	151.10	124.78	151.10	124.78	6.48	6.48	2.72	2.72		
Link56	122.1	Circular	12	10.53	Node58	Node59	124.02	111.16	126.51	114.00	124.67	111.72	124.67	111.72	6.47	6.47	2.72	2.72		
Link57	257.4	Circular	12	10.44	Node59	33521	110.96	84.08	114.00	86.97	111.57	84.64	111.57	84.64	6.46	6.46	2.71	2.71		
Link58	291.0	Circular	15	2.29	34191_JA_0100	34192	116.25	109.60	128.90	120.42	128.90	120.42	128.90	120.42	9.89	9.89	4.16	4.16	YES	YES
Link59	121.6	Circular	12	6.76	34192	41014	109.22	101.00	120.42	109.91	120.42	109.50	120.42	109.50	9.20	9.25	3.87	3.88		
Link60	192.3	Circular	12	4.46	41014	33519	100.71	92.13	109.91	99.89	109.50	93.13	109.50	93.13	9.07	9.07	3.81	3.81		
Park Place Basin																				
801099	22.4	Circular	24	1.30	30675	30674	111.81	111.52	114.51	114.42	113.73	113.30	113.73	113.30	11.91	11.91	5.00	5.00		
801520	86.9	Circular	30	2.60	34163	34164	189.81	187.55	201.50	194.73	190.83	188.35	190.87	188.40	13.22	14.24	5.55	5.98		
801521	75.8	Circular	30	3.03	34164	34511	187.35	185.05	194.73	192.57	188.35	185.81	188.40	185.84	13.22	14.24	5.55	5.98		
801522	146.7	Circular	30	0.46	34166	34163	190.69	190.01	195.75	201.50	192.23	191.23	192.31	191.28	13.22	14.24	5.55	5.98		
804027	51.3	Circular	30	5.92	40789_PP_0800	40790	220.63	217.59	223.90	220.09	221.31	218.53	221.34	218.56	13.24	14.26	5.56	5.99		
806132	80.2	Circular	24	0.26	30676	36849	112.88	112.67	116.68	115.17	114.90	114.25	114.90	114.25	11.91	11.91	5.00	5.00		
806133	38.7	Circular	24	1.45	36849	30675	112.57	112.01	115.17	114.51	114.25	113.73	114.25	113.73	11.91	11.91	5.00	5.00		
806138	409.7	Circular	15	4.13	36853	30676	130.15	113.23	134.95	116.68	133.01	114.90	133.01	114.90	11.91	11.91	5.00	5.00		
806331	7.1	Circular	24	5.33	41420	37021	145.72	145.34	148.22	147.94	148.22	146.97	148.22	146.98	15.07	15.07	6.33	6.33		
808078	41.1	Circular	24	1.17	30674	38518	111.62	111.14	114.42	113.64	113.30	112.73	113.30	112.73	11.91	11.91	5.00	5.00		
808079	9.4	Circular	24	-1.39	38518	PP_0500	110.86	110.99	113.64	113.49	112.73	112.19	112.73	112.19	11.91	11.91	5.00	5.00		
809819	37.6	Circular	24	2.10	37021	41421_PP_0600	145.34	144.55	147.94	147.05	146.97	145.94	146.98	145.95	15.07	15.07	6.33	6.33		
809820	47.5	Circular	24	1.56	41350	36853	130.99	130.25	133.49	134.95	133.49	133.01	133.49	133.01	12.88	12.83	5.41	5.39		
812683	109.8	Circular	18	7.07	43287_PP_1000	43288_PP_0900	262.76	255.00	264.56	263.56	264.27	255.72	264.35	255.75	5.67	6.05	2.38	2.54		
Link17	32.9	Circular	24	16.70	33393	34166	197.00	191.50	199.50	195.75	197.57	192.23	197.59	192.31	13.22	14.25	5.55	5.98		
Link18	28.6	Circular	36	3.71	34511	PP_0700	182.06	181.00	192.57	192.00	183.09	181.93	183.14	181.95	13.22	14.24	5.55	5.98		
Link20	116.2	Circular	24	3.58	40854	40855	98.78	94.62	103.38	98.50	101.79	95.90	101.79	95.90	18.73	18.72	7.87	7.86		
Link21	114.7	Circular	30	7.12	41341	36790_PP_0300	89.66	81.50	93.79	90.65	92.01	82.18	92.01	82.18	18.72	18.71	7.86	7.86		

Table A-1. Hydraulic Model Parameters and Results for 2-yr and 1.2-yr Storms

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water Surface Elevation (ft)		Future Max Water Surface Elevation (ft)		Max Flow (cfs)		1.2-yr Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future	Existing	Future
Link22	69.7	Circular	36	18.65	36790_PP_0300	41342	81.50	68.50	90.65	80.85	82.18	69.03	82.18	69.03	18.72	18.71	7.86	7.86		
Link23	628.5	Trapezoidal	30	5.47	43288_PP_0900	40789_PP_0800	255.00	220.63	263.56	223.90	255.72	221.31	255.75	221.34	9.28	10.12	3.90	4.25		
Link24	389.1	Trapezoidal	30	5.29	40790	33393	217.59	197.00	220.09	199.50	218.53	197.57	218.56	197.59	13.22	14.25	5.55	5.98		
Link27	416.8	Trapezoidal	30	3.25	41421_PP_0600	41350	144.55	130.99	147.05	133.49	145.94	133.49	145.95	133.49	32.51	33.24	13.66	13.96	YES	YES
Link28	567.6	Trapezoidal	30	2.15	PP_0500	40854	110.99	98.78	113.49	103.38	112.19	101.79	112.19	101.79	18.84	18.83	7.91	7.91		
Link29	270.3	Trapezoidal	30	1.84	40855	41341	94.62	89.66	98.50	93.79	95.90	92.01	95.90	92.01	18.83	19.05	7.91	8.00		
Link31	718.8	Trapezoidal	30	5.60	PP_0700	41420	181.00	145.72	192.00	148.22	181.93	148.22	181.95	148.22	15.99	17.02	6.72	7.15	YES	YES
Singer Creek Basin																				
800363	257.5	Circular	36	3.20	39390_SI_0500	33815	206.45	198.22	218.52	205.18	207.67	199.07	207.69	199.09	21.66	22.29	9.10	9.36		
803639	45.1	Rectangular	30	0.55	34189	35537	167.56	167.31	174.46	174.00	170.68	169.63	170.81	169.73	33.35	34.08	14.01	14.31		
803641	165.3	Rectangular	30	2.81	35540	34189	172.21	167.56	177.61	174.46	173.91	170.68	173.95	170.81	33.36	34.08	14.01	14.31		
803643	10.1	Rectangular	30	1.58	SI_0300	35540	172.37	172.21	177.80	177.61	175.03	173.91	175.08	173.95	33.37	34.09	14.02	14.32		
804123	131.4	Rectangular	30	1.65	35900	SI_0300	174.74	172.37	180.04	177.80	176.23	175.03	176.27	175.08	21.65	22.28	9.09	9.36		
804124	57.9	Rectangular	30	2.02	35902	35900	175.91	174.74	180.96	180.04	177.45	176.23	177.49	176.27	21.65	22.29	9.09	9.36		
804125	114.9	Rectangular	30	2.34	35903	35902	178.60	175.91	185.01	180.96	179.85	177.45	179.88	177.49	21.66	22.29	9.10	9.36		
804126	124.7	Rectangular	30	2.57	34190	35903	181.81	178.60	189.08	185.01	182.98	179.85	183.01	179.88	21.66	22.29	9.10	9.36		
804191	308.3	Rectangular	30	4.28	33815	35985	198.22	185.02	205.18	191.23	199.07	186.08	199.09	186.11	21.66	22.29	9.10	9.36		
804192	84.1	Rectangular	30	3.82	35985	34190	185.02	181.81	191.23	189.08	186.08	182.98	186.11	183.01	21.66	22.29	9.10	9.36		
804812	212.8	Rectangular	30	2.11	34187	35594	165.13	160.43	171.23	165.19	166.81	162.00	166.84	162.02	33.31	34.05	13.99	14.30		
806469	153.9	Rectangular	30	3.91	37138	36507_SI_0400	158.98	152.96	164.15	159.74	159.88	154.52	159.89	154.54	33.31	34.04	13.99	14.30		
806470	94.8	Rectangular	30	1.32	35594	37138	160.43	158.98	165.19	164.15	162.00	159.88	162.02	159.89	33.31	34.05	13.99	14.30		
Link14	94.4	Circular	36	2.90	40796_SI_0600	40797	218.02	215.28	221.02	220.00	218.87	216.10	218.89	216.12	14.07	14.62	5.91	6.14		
Link15	156.0	Trapezoidal	36	0.55	40797	Inlet	215.28	214.42	220.00	225.00	216.10	215.76	216.12	215.80	14.05	14.60	5.90	6.13		
Link15.1	94.0	Circular	36	0.50	Inlet	40897	214.42	213.95	225.00	229.48	215.76	215.61	215.80	215.65	13.99	14.53	5.87	6.10		
Link16	240.5	Circular	36	2.89	36023	39390_SI_0500	213.41	206.45	229.61	218.52	214.27	207.67	214.29	207.69	13.98	14.52	5.87	6.10		
Link17	19.1	Circular	36	2.81	40897	36023	213.95	213.41	229.48	229.61	215.61	214.27	215.65	214.29	13.98	14.53	5.87	6.10		
Link18	192.9	Rectangular	30	1.13	35537	34187	167.31	165.13	174.00	171.23	169.63	166.81	169.73	166.84	33.31	34.05	13.99	14.30		
Link19	115.4	Rectangular	30	4.30	36507_SI_0400	42737	152.96	148.00	159.74	151.00	154.52	149.11	154.54	149.12	46.83	47.53	19.67	19.96		
South End Basin																				
2	40.1	Circular	30	0.30	39657	39658	428.74	428.62	433.30	433.56	431.31	431.11	431.32	431.11	28.25	28.93	11.86	12.15		
681.1	40.1	Circular	30	0.30	39657	39658	428.74	428.62	433.30	433.56	431.31	431.11	431.32	431.11	13.53	13.87	5.68	5.82		
800101	225.2	Trapezoidal	24	0.76	40224	38962	450.92	449.20	453.42	451.20	451.92	451.20	451.93	451.20	18.44	18.96	7.75	7.96	YES	YES
800102	53.6	Trapezoidal	24	2.42	38963	30628	448.92	448.12	450.92	450.12	450.10	450.12	450.10	450.12	9.30	9.32	3.91	3.91	YES	YES
800823	249.0	Circular	30	0.65	33801	33800	446.64	445.01	452.50	449.78	449.63	449.52	449.64	449.52	7.42	7.47	3.12	3.14		
800824	33.2	Circular	18	4.16	30628	33801	448.12	446.74	450.12	452.50	450.12	449.63	450.12	449.64	7.95	7.93	3.34	3.33		
801783	37.0	Circular	12	1.54	33800	42854	445.01	444.44	449.78	447.80	449.52	446.41	449.52	446.42	7.33	7.37	3.08	3.10		
802067	213.1	Circular	24	0.40	33531_SE_1300	33530	455.40	454.55	461.95	459.99	458.13	456.47	458.35	456.54	15.51	16.02	6.52	6.73		
802192	20.1	Circular	30	0.10	33899	40224	450.94	450.92	455.75	453.42	452.55	451.92	452.57	451.93	18.44	18.96	7.75	7.96		
802326	286.5	Circular	60	0.28	32462_SE_1200	34366	435.93	435.14	440.93	447.02	437.20	436.66	437.21	436.68	12.83	13.09	5.39	5.50		
802787	32.5	Circular	18	0.00	38962	38963	449.20	448.92	451.20	450.92	451.20	450.10	451.20	450.10	7.97	7.97	3.35	3.35		
803617	221.5	Circular	15	1.46	35517_SE_1400	33531_SE_1300	458.84	455.60	465.59	461.95	463.19	458.13	464.02	458.35	8.21	8.72	3.45	3.66		
807270	476.7	Circular	30	0.30	37785_SE_1000	33899	452.38	450.94	458.00	455.75	454.44	452.55	454.49	452.57	18.45	18.97	7.75	7.97		
807271	119.5	Circular	30	0.00	37787	37785_SE_1000	452.74	452.38	459.02	458.00	454.90	454.44	454.96	454.49	15.28	15.79	6.42	6.63		
808402	204.7	Trapezoidal	24	0.29	38973_SE_0800	39657	429.34	428.74	433.34	433.30	431.40	431.31	431.42	431.32	41.77	42.79	17.54	17.97		
808415	100.2	Trapezoidal	24	0.51	39658	42487	428.62	428.11	433.56	431.11	431.11	431.11	431.11	431.11	41.78	42.80	17.55	17.98	YES	YES
808417	58.9	Circular	36	4.16	42487	39582	428.11	425.66	431.11	428.66	431.11	426.68	431.11	426.68	31.29	31.29	13.14	13.14		
809300	116.5	Circular	15	1.52	33535_SE_1600	35517_SE_1400	460.81	459.04	468.36	465.59	464.01	463.19	465.04	464.02	4.19	4.68	1.76	1.97		

Table A-1. Hydraulic Model Parameters and Results for 2-yr and 1.2-yr Storms

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water Surface Elevation (ft)		Future Max Water Surface Elevation (ft)		Max Flow (cfs)		1.2-yr Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future	Existing	Future
809303	93.7	Circular	12	1.10	32769_SE_1500	33531_SE_1300	456.63	455.60	461.31	461.95	458.74	458.13	458.96	458.35	2.25	2.25	0.94	0.94		
809312	433.6	Circular	30	0.30	33530	37788	454.55	453.25	459.99	459.22	456.47	455.42	456.54	455.49	15.39	15.90	6.46	6.68		
809724	17.8	Circular	60	1.12	34366	34365_SE_1100	434.94	434.74	447.02	446.54	436.66	436.56	436.68	436.58	12.82	13.08	5.39	5.49		
Link20	166.2	Circular	30	0.31	37788	37787	453.25	452.74	459.22	459.02	455.42	454.90	455.49	454.96	15.29	15.80	6.42	6.64		
Link21	369.9	Circular	12	0.00	32798_SE_1000	34786	451.89	449.90	456.04	452.42	452.31	450.20	452.32	450.20	0.74	0.75	0.31	0.31		
Link23	84.9	Circular	12	1.68	34786	Node65	449.90	448.47	452.42	450.47	450.20	448.75	450.20	448.76	0.74	0.74	0.31	0.31		
Link24	92.2	Trapezoidal	24	1.68	Node65	Node66	448.47	446.92	450.47	448.92	448.63	447.41	448.63	447.41	0.74	0.74	0.31	0.31		
Link25	22.2	Circular	12	1.68	Node66	Node67	446.92	446.55	448.92	448.55	447.41	446.71	447.41	446.71	0.74	0.74	0.31	0.31		
Link26	85.9	Trapezoidal	24	1.68	Node67	Node68	446.55	445.11	448.55	447.11	446.71	446.45	446.71	446.46	0.74	0.74	0.31	0.31		
Link31	156.4	Circular	12	6.03	42854	34365_SE_1100	444.37	434.94	447.80	446.54	446.41	436.56	446.42	436.58	7.55	7.54	3.17	3.17		
Link33	52.5	Circular	12	1.02	Node68	42854	445.11	444.57	447.11	447.80	446.45	446.41	446.46	446.42	0.73	0.74	0.31	0.31		
Link36	322.9	Circular	48	1.10	34761_SE_0900	38973_SE_0800	432.88	429.34	438.14	433.34	434.45	431.40	434.47	431.42	34.73	35.75	14.59	15.01		
Link37	207.7	Circular	54	0.24	34365_SE_1100	Node70	434.74	434.24	446.54	441.95	436.56	435.63	436.58	435.64	23.71	24.07	9.96	10.11		
Link38	172.0	Circular	54	0.56	Node70	34761_SE_0900	434.04	433.08	441.95	438.14	435.61	434.45	435.62	434.47	23.71	24.07	9.96	10.11		
Newell Creek Basin at Molalla Avenue and Beaver Creek Road																				
800688	160.5	Circular	48	3.51	34994	39666	417.02	411.38	430.02	415.38	418.52	412.54	418.54	412.55	46.09	46.93	19.36	19.71		
800690	39.8	Circular	12	1.66	34611	30023	423.69	423.03	429.34	430.16	428.37	425.52	428.39	425.55	6.39	6.36	2.68	2.67		
800854	442.7	Circular	42	0.82	39740_NE_1900	34616	433.01	429.39	436.51	436.91	433.32	429.69	433.33	429.70	1.31	1.36	0.55	0.57		
801962	148.0	Circular	15	3.87	34604	34603	438.50	432.77	441.90	437.52	439.01	433.44	439.01	433.44	3.73	3.73	1.57	1.57		
801965	205.9	Circular	15	0.43	34605_NE_3100	34604	439.49	438.60	444.01	441.90	440.61	439.38	440.61	439.38	3.73	3.73	1.57	1.57		
801981	230.0	Circular	18	1.54	30056_NE_3100	37259	435.30	431.75	439.36	433.77	435.91	432.18	435.91	432.19	3.27	3.28	1.38	1.38		
803140	168.1	Circular	42	0.78	30021	30023	424.29	422.98	431.51	430.16	426.41	425.52	426.45	425.55	32.31	33.17	13.57	13.93		
803172	61.7	Circular	12	0.66	30030_NE_2200	30027	426.11	425.70	434.39	433.37	434.39	432.53	434.39	432.54	4.89	4.94	2.05	2.08		
803176	159.5	Circular	12	0.92	30027	30025	425.53	424.07	433.37	430.71	432.53	429.08	432.54	429.09	4.83	4.85	2.03	2.04		
803179	78.3	Circular	12	0.57	30025	30024	423.92	423.47	430.71	430.26	429.08	426.83	429.09	426.86	4.79	4.81	2.01	2.02		
803180	27.5	Circular	12	0.87	30024	30023	423.45	423.21	430.26	430.16	426.83	425.52	426.86	425.55	4.78	4.79	2.01	2.01		
806619	6.3	Circular	48	0.00	37234	37235	426.45	426.45	433.20	433.20	428.37	428.37	428.40	428.40	-16.60	-17.35	-6.97	-7.29		
806620	267.8	Circular	42	0.68	37234	30021	426.45	424.63	433.20	431.51	428.37	426.41	428.40	426.45	32.34	33.20	13.58	13.94		
807452	59.3	Circular	12	-4.99	37903	37901	423.40	426.36	427.94	430.44	427.94	426.90	427.94	426.90	2.84	2.84	1.19	1.19		
807453	135.4	Circular	12	2.29	37238_NE_2200	37903	428.50	425.40	430.54	427.94	430.54	427.94	430.54	427.94	4.04	4.04	1.70	1.70	YES	YES
808393	446.8	Circular	42	0.81	39739_NE_1900	34615	432.99	429.39	436.49	436.91	434.25	430.53	434.28	430.55	19.15	19.92	8.04	8.36		
Link18	394.5	Circular	48	0.49	34615	41521	428.89	426.95	436.91	432.42	430.25	428.50	430.28	428.53	19.14	19.91	8.04	8.36		
Link19	82.1	Circular	48	0.49	41521	37235	426.95	426.55	432.42	433.20	428.50	428.37	428.53	428.40	22.84	23.59	9.59	9.91		
Link20	410.9	Circular	48	0.67	37235	34611	426.45	423.69	433.20	429.34	428.37	428.37	428.40	428.39	8.68	8.49	3.65	3.56		
Link21	9.3	Circular	42	3.23	30023	Node35	423.03	422.73	430.16	429.89	425.52	424.16	425.55	424.17	43.25	44.09	18.16	18.52		
Link22	168.9	Circular	48	3.38	Node35	34994	422.73	417.02	429.89	430.02	424.16	418.52	424.17	418.54	46.09	46.93	19.36	19.71		
Link23	98.6	Circular	12	3.68	37901	Node35	426.36	422.73	430.44	429.89	426.90	424.16	426.90	424.17	2.84	2.85	1.19	1.19		
Link24	309.6	Circular	15	1.44	34603	42867	432.77	428.30	437.52	432.33	433.44	429.00	433.44	429.01	3.73	3.73	1.57	1.57		
Link25	45.0	Circular	15	2.77	42867	41521	428.20	426.95	432.33	432.42	429.00	428.50	429.01	428.53	3.73	3.73	1.56	1.56		
Link26	158.4	Circular	48	0.80	34616	35735_NE_1600	428.89	427.62	436.91	434.20	429.18	429.05	429.19	429.07	1.31	1.36	0.55	0.57		
Link27	203.9	Circular	48	0.34	35735_NE_1600	41522	427.62	426.93	434.20	432.04	429.05	428.67	429.07	428.69	12.96	13.05	5.44	5.48		
Link28	114.2	Circular	48	0.34	41522	37234	426.93	426.55	432.04	433.20	428.67	428.37	428.69	428.40	16.12	16.22	6.77	6.81		
Link29	85.4	Circular	15	5.64	37259	41522	431.75	426.93	433.77	432.04	432.18	428.67	432.19	428.69	3.27	3.27	1.37	1.37		

Table A-2. Hydraulic Model Parameters and Results for 10-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water Surface		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Central Point Basin																		
808424	57.6	Circular	36	3.44	42490_CP_0500	38777	441.58	439.60	444.58	448.68	443.63	440.48	443.64	440.48	18.81	18.96		
803448	135.1	Circular	12	1.58	33962	35483	461.35	459.21	467.71	467.48	465.52	460.16	466.23	460.20	5.89	6.26		
803449	349.8	Circular	12	4.26	35483	35481	459.01	444.12	467.48	450.42	459.79	444.84	459.84	444.87	5.89	6.25		
803703	202.6	Circular	30	0.59	35630	35478	429.72	428.53	439.21	432.23	431.43	429.93	431.51	429.99	17.63	18.74		
807429	182.8	Circular	12	0.77	37879_CP_0800	33962	463.41	462.00	468.84	467.71	472.13	465.52	473.58	466.23	5.90	6.27		
808422	128.1	Circular	36	0.71	33002	39749	443.14	442.23	447.90	445.23	444.17	443.64	444.18	443.65	9.33	9.40		
808427	28.5	Circular	36	0.04	39588	34501	432.78	432.77	438.46	438.50	434.54	434.27	434.54	434.27	17.05	17.05		
808428	118.5	Circular	36	1.05	34502	39588	434.03	432.78	440.22	438.46	435.42	434.54	435.42	434.54	17.05	17.05		
808653	18.7	Circular	30	2.20	38733_CP_0800	35630	430.33	429.92	440.18	439.21	432.12	431.43	432.21	431.51	17.64	18.75		
808654	259.3	Circular	12	4.75	35481	38733_CP_0800	443.92	431.60	450.42	440.18	444.68	432.29	444.73	432.32	5.88	6.25		
809337	155.2	Circular	36	0.95	34503	34502	435.50	434.03	441.35	440.22	436.83	435.42	436.83	435.42	17.06	17.06		
809791	34.0	Circular	15	0.00	34248_CP_0100	35487	430.72	430.73	438.92	438.59	435.06	434.26	434.72	433.91	5.74	5.78		
809793	91.2	Circular	15	0.27	35487	35484	430.53	430.28	438.59	437.00	434.26	432.95	433.91	432.58	5.73	5.77		
812537	128.1	Trapezoidal	30	0.71	39749	42490_CP_0500	442.23	441.58	445.23	444.58	443.64	443.63	443.65	443.64	9.26	9.33		
Link18	292.2	Circular	36	0.41	33700_CP_0600	33002	444.35	443.14	450.79	447.90	445.45	444.17	445.46	444.18	9.37	9.44		
Link19	447.2	Trapezoidal	30	0.49	38888	30909_CP_0400	438.79	436.61	441.29	439.11	440.31	439.11	440.31	439.11	18.78	18.93	YES	YES
Link20	33.0	Circular	27	0.62	30909_CP_0400	34503	436.61	436.40	439.11	441.35	439.11	437.84	439.11	437.84	17.05	17.05		
Link21	10.0	Circular	36	13.10	38777	38888	439.60	438.29	448.68	441.29	440.48	440.31	440.48	440.31	18.81	18.96		
Link25	341.0	Circular	15	0.55	35484	35478	430.08	428.20	437.00	432.23	432.95	429.41	432.58	429.45	5.73	5.77		
Link26	215.0	Circular	30	2.57	35478	40654	428.20	422.68	432.23	425.18	429.41	423.75	429.45	423.78	23.36	24.51		
Link27	38.5	Circular	36	1.30	34501	33145	432.77	432.27	438.50	435.27	434.27	433.27	434.27	433.27	17.05	17.05		
Coffee Creek Basin																		
618.1	116.9	Circular	24	0.58	42534_CO_0500	42533	440.66	439.98	445.16	444.48	443.73	441.82	443.73	441.82	14.98	14.98		
802016	56.9	Circular	24	1.63	40182_CO_0800	34657	453.03	452.10	456.03	456.54	455.29	453.40	455.33	453.44	13.07	13.34		
808374	56.9	Circular	24	1.63	40182_CO_0800	34657	453.03	452.10	456.03	456.54	455.29	453.40	455.33	453.44	13.07	13.34		
808377	62.4	Circular	48	1.07	42472_CO_0600	42473	448.69	448.02	453.69	454.24	451.93	450.47	451.99	450.47	47.67	48.90		
808379	68.6	Circular	30	2.90	42475_CO_0400	42474	413.69	411.70	417.69	416.03	416.91	412.82	416.91	412.82	26.94	27.00		
808379	68.6	Circular	30	2.90	42475_CO_0400	42474	413.69	411.70	417.69	416.03	416.91	412.82	416.91	412.82	26.94	27.00		
808867	76.2	Circular	36	0.91	CO_0300	42552	429.21	428.52	433.21	432.52	433.21	430.25	433.21	430.25	45.08	45.08		
Backyard	116.9	Trapezoidal	24	0.00	42534_CO_0500	42533	443.16	442.48	445.16	444.48	443.73	443.05	443.73	443.05	39.71	39.79		
Link10	686.1	Trapezoidal	48	2.16	42552	42475_CO_0400	428.52	413.69	432.52	417.69	430.25	416.91	430.25	416.91	45.08	45.08		
Link11	6.0	Rectangular	30	1.73	Node16	Node17	446.46	446.35	450.46	450.36	450.46	447.43	450.46	447.43	42.67	42.67		
Link12	329.2	Trapezoidal	48	1.73	Node17	42534_CO_0500	446.35	440.66	450.36	445.16	447.43	443.73	447.43	443.73	42.67	42.67		
Link13	180.0	Trapezoidal	24	0.58	42533	Node19	439.98	438.82	444.48	441.82	441.82	441.48	441.82	441.48	55.26	55.33		
Link14	50.0	Trapezoidal	36	0.58	Node19	Node20	438.82	438.53	441.82	442.53	441.48	439.96	441.48	439.96	55.25	55.32		
Link15	100.5	Trapezoidal	48	9.27	Node20	CO_0300	438.53	429.21	442.53	433.21	439.96	433.21	439.96	433.21	55.25	55.32	YES	YES
Link6	174.1	Circular	36	0.67	34657	40188_CO_0700	451.30	450.14	456.54	457.06	453.40	452.48	453.44	452.53	26.14	26.68		
Link7	587.5	Trapezoidal	60	0.25	40188_CO_0700	42472_CO_0600	450.14	448.69	457.06	453.69	452.48	451.93	452.53	451.99	38.26	39.09		
Link8	90.3	Trapezoidal	48	1.73	42473	Node16	448.02	446.46	454.24	450.46	450.47	450.46	450.47	450.46	47.67	48.91	YES	YES
Livesay Basin																		
Link1	169.75	Circular	1.00	1.00	33740_LI_1200	33742	504.45	502.75	512.76	510.16	512.35	508.95	505.98	505.97	5.88	0.00		
Link13	41.73	Circular	1.50	4.31	34160	42491	429.05	427.25	435.25	432.40	426.66	424.13	431.02	428.29	5.87	13.84		
Link14	185.23	Circular	1.00	8.09	32573_LI_1100	34374_LI_1000	438.68	423.7	441.61	430.48	434.77	423.93	438.96	423.97	17.20	1.45		
Link15	399.60	Circular	1.00	3.02	34374_LI_1000	35610	423.47	411.42	430.48	418.42	423.65	411.85	423.88	411.90	12.59	1.99		
Link16	124.78	Circular	1.00	1.67	35610	35612	411.36	409.27	418.42	412.91	411.85	409.71	411.90	409.75	10.36	1.98		
Link17	252.76	Circular	1.00	5.17	35612	35607	409.06	395.99	412.91	400.77	409.38	400.77	409.42	400.77	10.36	1.98	YES	YES
Link18	73.60	Circular	1.00	0.56	35607	35686	395.79	395.38	400.77	397.38	400.77	395.67	400.77	395.61	10.36	4.20		

Table A-2. Hydraulic Model Parameters and Results for 10-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water Surface		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Link19	96.21	Trapezoidal	2.00	14.41	35686	39436	395.38	381.52	397.38	383.52	395.67	383.52	395.61	383.52	1.18	4.20	YES	YES
Link2	106.92	Circular	1.00	1.91	33742	34162_LI_1100	502.55	500.51	510.16	505.96	508.95	506.72	505.97	505.96	10.39	0.00	YES	YES
Link20	61.79	Circular	1.00	8.24	39436	34997	381.52	376.43	383.52	379.80	383.52	376.89	383.52	376.89	1.71	4.09		
Link21	218.18	Circular	1.00	5.92	34997	30828_LI_0600	376.23	363.31	379.80	366.90	376.78	363.82	376.78	363.82	1.71	4.09		
Link22	19.19	Circular	1.00	32.88	30828_LI_0600	39842	362.77	356.46	366.90	368.26	363.11	356.80	363.31	356.80	12.90	4.75		
Link23	198.91	Circular	2.00	0.88	42491	39313_LI_1000	426.75	425	432.40	427.01	424.13	417.75	428.29	426.24	1.71	13.83		
Link24	542.80	Trapezoidal	2.00	4.63	39313_LI_1000	Node25	425	399.89	427.01	401.89	417.75	401.89	425.95	401.89	11.28	16.48	YES	YES
Link25	125.02	Circular	2.00	3.12	Node25	35607	399.89	395.991	401.89	400.77	401.89	400.77	401.89	400.77	6.48	11.28	YES	YES
Link29	455.63	Circular	1.25	0.39	Node31	Node31.1	508.23	506.44	519.47	512.76	NA$_1$	NA$_1$	513.93	512.76	NA$_1$	2.93		YES
Link29.1	296.12	Circular	1.25	1.70	Node31.1	Node34	506.24	501.21	512.76	506.82	NA$_1$	NA$_1$	512.76	506.82	NA$_1$	9.46		YES
Link3	525.87	Circular	1.25	7.72	34162_LI_1100	34161	500.41	459.83	505.96	465.63	506.72	465.66	505.96	465.63	6.48	16.15	YES	YES
Link30	23.69	Circular	1.25	1.69	Node34	34162_LI_1100	501.01	500.61	506.82	505.96	NA$_1$	NA$_1$	506.82	505.96	NA$_1$	9.04		YES
Link4	241.20	Circular	1.25	4.46	34161	33066	459.84	449.09	465.63	453.44	465.66	453.43	465.63	450.34	4.09	13.83		
Link5	206.81	Circular	1.25	6.95	33066	33065	449.09	434.71	453.44	438.65	453.43	435.98	450.21	436.49	4.09	13.83		
Link6	52.10	Circular	1.25	12.00	33065	34160	435.15	428.9	438.65	435.25	435.80	426.66	436.49	431.02	4.70	13.83		
John Adams Basin																		
800781	159.3	Circular	16	4.81	34313	33514	160.19	152.53	162.29	171.45	161.08	153.28	161.08	153.28	9.48	9.48		
801568	335.0	Circular	8	4.06	33504	33474	257.58	243.99	261.10	254.51	261.10	254.51	261.10	254.51	1.91	1.91	YES	YES
801573	15.0	Circular	12	28.92	33473	34769	220.25	215.90	226.39	226.95	223.03	220.87	223.03	220.87	6.58	6.58		
802603	417.6	Circular	12	6.93	33505_JA_1400	38651	309.65	280.69	316.50	286.90	310.28	281.32	310.28	281.32	6.29	6.31		
802604	268.7	Circular	8	2.85	33566_JA_1600	34696	321.64	313.99	330.45	318.74	330.45	314.66	330.45	314.66	2.78	2.78		
802606	301.1	Circular	8	8.09	34698	33504	282.51	258.15	289.22	261.10	283.03	261.10	283.03	261.10	2.78	2.78	YES	YES
804813	157.0	Circular	18	6.34	33520	43469	82.29	72.34	96.27	88.74	83.21	75.93	83.21	75.93	12.63	12.63		
804814	78.8	Circular	18	7.00	33519	33520	92.03	86.51	99.89	96.27	93.02	87.25	93.02	87.25	12.61	12.61		
804815	124.1	Circular	18	2.66	33521	34704_WN_0300	68.67	65.37	86.97	73.55	74.13	66.92	74.13	66.92	19.05	19.05		
804841	513.2	Circular	12	2.94	33475_JA_1000	33473	235.76	220.69	243.58	226.39	243.58	223.03	243.58	223.03	6.58	6.58		
804846	64.5	Circular	12	1.18	33469	33508	185.00	184.24	188.90	191.51	188.90	185.23	188.90	185.23	6.27	6.27		
804848	150.6	Circular	24	5.05	33514	33515	152.33	144.73	171.45	153.00	153.03	145.34	153.03	145.34	9.48	9.48		
804851	256.1	Circular	18	8.38	33515	34191_JA_0100	144.53	123.08	153.00	128.90	145.16	128.90	145.16	128.90	9.48	9.48	YES	YES
804860	101.6	Circular	18	3.60	33517_WN_0400	33516	178.61	174.95	185.10	179.60	181.46	179.60	181.46	179.60	10.21	10.21	YES	YES
804861	211.6	Circular	18	6.54	33523	33517_WN_0400	192.64	178.81	201.40	185.10	193.03	181.46	193.03	181.46	3.78	3.78		
804867	274.3	Circular	18	2.49	34311_WN_0500	33523	199.70	192.86	207.50	201.40	200.24	193.37	200.24	193.37	3.78	3.78		
804870	183.5	Circular	8	6.02	34767_JA_1100	34309	203.85	192.80	209.10	198.92	209.10	193.47	209.10	193.47	3.22	3.22		
804934	296.9	Circular	8	9.23	38650_JA_1500	33475_JA_1000	263.28	235.87	269.84	243.58	266.19	243.58	266.45	243.58	3.10	3.12	YES	YES
804969	247.9	Circular	8	8.24	33513_JA_0300	33519	113.61	93.18	119.72	99.89	118.80	93.85	118.80	93.85	3.55	3.55		
806396	444.2	Circular	8	8.37	37054	33513_JA_0300	151.18	114.01	162.35	119.72	159.31	118.80	159.31	118.80	3.55	3.55		
806401	131.5	Circular	8	16.53	37059	37054	173.12	151.38	178.38	162.35	173.72	159.31	173.72	159.31	3.55	3.55		
806402	255.5	Circular	10	12.82	37062	37059	206.06	173.32	208.79	178.38	206.49	173.73	206.49	173.73	3.55	3.55		
806406	30.6	Circular	10	2.72	37064	37062	207.09	206.26	210.50	208.79	208.95	207.02	208.95	207.02	3.55	3.55		
806411	253.8	Circular	8	1.92	37070_JA_0500	34769	223.30	218.42	224.81	226.95	224.81	220.87	224.81	220.87	1.40	1.40		
806471	131.0	Circular	18	3.17	37118	37139_WN_0100	50.10	45.95	57.70	53.08	57.70	53.08	57.70	53.08	15.12	15.12	YES	YES
806474	123.1	Circular	18	0.56	37139_WN_0100	37142	45.72	45.03	53.08	53.08	53.08	50.09	53.08	50.09	12.38	12.37		
808623	41.5	Circular	18	0.63	37142	41009	44.93	44.67	53.08	52.70	50.09	48.32	50.09	48.32	12.37	12.37		
808624	19.1	Circular	18	-0.52	43300	43301	43.51	43.61	61.81	61.81	46.43	44.94	46.43	44.94	12.37	12.37		
808704	305.9	Circular	12	2.42	33474	33475_JA_1000	243.75	236.34	254.51	243.58	254.51	243.58	254.51	243.58	6.19	6.19	YES	YES
808721	103.2	Circular	12	6.62	34309	33508	190.32	183.49	198.92	191.51	190.80	183.92	190.80	183.92	3.22	3.22		
812475	29.8	Circular	12	4.05	36378	34534	163.75	162.54	168.58	167.42	168.58	166.00	168.58	166.00	6.71	6.71		
812477	198.1	Circular	12	4.42	33516	36378	172.70	163.95	179.60	168.58	179.60	168.58	179.60	168.58	7.33	7.33	YES	YES

1. Existing model based on infrastructure in place in 2017. Future conditions model includes recently installed infrastructure.

Table A-2. Hydraulic Model Parameters and Results for 10-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water Surface		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
812478	100.6	Circular	12	3.01	34534	43051	162.24	159.21	167.42	163.93	166.00	160.78	166.00	160.78	6.66	6.66		
812479	194.4	Circular	12	4.18	43051	43050	159.11	150.99	163.93	155.49	160.78	151.78	160.78	151.78	6.49	6.49		
812692	119.5	Circular	18	0.80	41009	43300	44.57	43.61	52.70	61.81	48.32	46.43	48.32	46.43	12.37	12.37		
812695	158.3	Circular	54	18.38	43301	39733	43.51	14.40	61.81	19.40	43.94	14.79	43.94	14.79	12.37	12.37		
812816	39.8	Circular	18	8.12	43469	33521	72.10	68.87	88.74	86.97	75.93	74.13	75.93	74.13	12.70	12.70		
Link43	393.4	Circular	12	9.22	38651	33474	280.27	243.99	286.90	254.51	280.91	254.51	280.91	254.51	6.29	6.31	YES	YES
Link44	240.8	Circular	8	12.78	34696	34698	313.57	282.80	318.74	289.22	314.00	283.21	314.00	283.21	2.78	2.78		
Link45	276.4	Circular	8	1.36	34692_JA_1300	37087	242.56	238.80	250.94	248.38	343.79	248.38	343.79	248.38	10.74	10.74	YES	YES
Link46	256.7	Circular	8	3.82	37087	33491_JA_0200	238.60	228.79	248.38	234.43	248.38	234.43	248.38	234.43	2.72	2.72	YES	YES
Link47	259.8	Circular	8	7.96	33491_JA_0200	37064	227.98	207.29	234.43	210.50	234.43	208.95	234.43	208.95	3.55	3.55		
Link48	262.9	Circular	12	13.33	34769	33469	220.25	185.20	226.95	188.90	220.87	188.90	220.87	188.90	7.94	7.94	YES	YES
Link49	225.3	Circular	16	8.60	33508	34313	179.51	160.14	191.51	162.29	180.16	161.08	180.16	161.08	9.48	9.48		
Link54	132.7	Circular	18	11.25	34704_WN_0300	37118	65.33	50.40	73.55	57.70	66.92	57.70	66.92	57.70	21.29	21.32	YES	YES
Link55	249.5	Circular	12	10.53	43050	Node58	150.49	124.22	155.49	126.51	151.10	124.78	151.10	124.78	6.47	6.47		
Link56	122.1	Circular	12	10.53	Node58	Node59	124.02	111.16	126.51	114.00	124.67	111.72	124.67	111.72	6.47	6.47		
Link57	257.4	Circular	12	10.44	Node59	33521	110.96	84.08	114.00	86.97	111.57	84.64	111.57	84.64	6.43	6.44		
Link58	291.0	Circular	15	2.29	34191_JA_0100	34192	116.25	109.60	128.90	120.42	128.90	120.42	128.90	120.42	9.89	9.89	YES	YES
Link59	121.6	Circular	12	6.76	34192	41014	109.22	101.00	120.42	109.91	120.42	109.50	120.42	109.50	9.11	9.11		
Link60	192.3	Circular	12	4.46	41014	33519	100.71	92.13	109.91	99.89	109.50	93.13	109.50	93.13	9.07	9.07		
Park Place Basin																		
801099	22.4	Circular	24	1.30	30675	30674	111.81	111.52	114.51	114.42	113.76	113.34	113.76	113.34	11.91	11.91		
801520	86.9	Circular	30	2.60	34163	34164	189.81	187.55	201.50	194.73	190.96	188.49	190.96	188.49	16.26	16.26		
801521	75.8	Circular	30	3.03	34164	34511	187.35	185.05	194.73	192.57	188.49	185.89	188.49	185.89	16.26	16.26		
801522	146.7	Circular	30	0.46	34166	34163	190.69	190.01	195.75	201.50	192.45	191.37	192.45	191.37	16.26	16.26		
804027	51.3	Circular	30	5.92	40789_PP_0800	40790	220.63	217.59	223.90	220.09	222.96	218.57	223.03	218.58	18.36	19.08		
806132	80.2	Circular	24	0.26	30676	36849	112.88	112.67	116.68	115.17	114.91	114.27	114.91	114.27	11.91	11.91		
806133	38.7	Circular	24	1.45	36849	30675	112.57	112.01	115.17	114.51	114.27	113.76	114.27	113.76	11.91	11.91		
806138	409.7	Circular	15	4.13	36853	30676	130.15	113.23	134.95	116.68	133.01	114.91	133.01	114.91	11.91	11.91		
806331	7.1	Circular	24	5.33	41420	37021	145.72	145.34	148.22	147.94	148.22	147.01	148.22	147.02	15.07	15.07		
808078	41.1	Circular	24	1.17	30674	38518	111.62	111.14	114.42	113.64	113.34	112.80	113.34	112.80	11.91	11.91		
808079	9.4	Circular	24	-1.39	38518	PP_0500	110.86	110.99	113.64	113.49	112.80	112.32	112.80	112.32	11.91	11.91		
809819	37.6	Circular	24	2.10	37021	41421_PP_0600	145.34	144.55	147.94	147.05	147.01	146.09	147.02	146.10	15.07	15.07		
809820	47.5	Circular	24	1.56	41350	36853	130.99	130.25	133.49	134.95	133.49	133.01	133.49	133.01	12.25	12.22		
812683	109.8	Circular	18	7.07	43287_PP_1000	43288_PP_0900	262.76	255.00	264.56	263.56	264.56	255.81	264.56	255.83	7.05	7.05		
Link17	32.9	Circular	24	16.70	33393	34166	197.00	191.50	199.50	195.75	199.50	192.45	199.50	192.45	16.26	16.26		
Link18	28.6	Circular	36	3.71	34511	PP_0700	182.06	181.00	192.57	192.00	183.24	182.04	183.24	182.04	16.26	16.26		
Link20	116.2	Circular	24	3.58	40854	40855	98.78	94.62	103.38	98.50	102.85	95.98	102.85	95.98	23.23	23.22		
Link21	114.7	Circular	30	7.12	41341	36790_PP_0300	89.66	81.50	93.79	90.65	92.46	82.28	92.46	82.28	23.20	23.19		
Link22	69.7	Circular	36	18.65	36790_PP_0300	41342	81.50	68.50	90.65	80.85	82.28	69.10	82.28	69.10	23.20	23.19		
Link23	628.5	Trapezoidal	30	5.47	43288_PP_0900	40789_PP_0800	255.00	220.63	263.56	223.90	255.81	222.96	255.83	223.03	12.54	13.04		
Link24	389.1	Trapezoidal	30	5.29	40790	33393	217.59	197.00	220.09	199.50	218.57	199.50	218.58	199.50	18.35	19.06	YES	YES
Link27	416.8	Trapezoidal	30	3.25	41421_PP_0600	41350	144.55	130.99	147.05	133.49	146.09	133.49	146.10	133.49	41.48	42.25	YES	YES
Link28	567.6	Trapezoidal	30	2.15	PP_0500	40854	110.99	98.78	113.49	103.38	112.32	102.85	112.32	102.85	23.80	23.79		
Link29	270.3	Trapezoidal	30	1.84	40855	41341	94.62	89.66	98.50	93.79	95.98	92.46	95.98	92.46	23.23	23.22		
Link31	718.8	Trapezoidal	30	5.60	PP_0700	41420	181.00	145.72	192.00	148.22	182.04	148.22	182.04	148.22	20.59	20.59	YES	YES

Table A-2. Hydraulic Model Parameters and Results for 10-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water Surface		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Singer Creek Basin																		
800363	257.5	Circular	36	3.20	39390_SI_0500	33815	206.45	198.22	218.52	205.18	207.93	199.34	207.95	199.36	31.19	31.88		
803639	45.1	Rectangular	30	0.55	34189	35537	167.56	167.31	174.46	174.00	173.05	171.26	173.05	171.26	44.47	44.47		
803641	165.3	Rectangular	30	2.81	35540	34189	172.21	167.56	177.61	174.46	176.49	173.05	176.49	173.05	44.47	44.47		
803643	10.1	Rectangular	30	1.58	SI_0300	35540	172.37	172.21	177.80	177.61	177.80	176.49	177.80	176.49	44.47	44.47		
804123	131.4	Rectangular	30	1.65	35900	SI_0300	174.74	172.37	180.04	177.80	179.26	177.80	179.33	177.80	31.18	31.87	YES	YES
804124	57.9	Rectangular	30	2.02	35902	35900	175.91	174.74	180.96	180.04	180.23	179.26	180.34	179.33	31.18	31.87		
804125	114.9	Rectangular	30	2.34	35903	35902	178.60	175.91	185.01	180.96	181.59	180.23	181.76	180.34	31.18	31.87		
804126	124.7	Rectangular	30	2.57	34190	35903	181.81	178.60	189.08	185.01	183.55	181.59	183.62	181.76	31.18	31.87		
804191	308.3	Rectangular	30	4.28	33815	35985	198.22	185.02	205.18	191.23	199.34	186.48	199.36	186.51	31.20	31.89		
804192	84.1	Rectangular	30	3.82	35985	34190	185.02	181.81	191.23	189.08	186.48	183.55	186.51	183.62	31.19	31.89		
804812	212.8	Rectangular	30	2.11	34187	35594	165.13	160.43	171.23	165.19	167.28	162.38	167.28	162.38	44.47	44.47		
806469	153.9	Rectangular	30	3.91	37138	36507_SI_0400	158.98	152.96	164.15	159.74	160.12	155.00	160.12	155.01	44.47	44.47		
806470	94.8	Rectangular	30	1.32	35594	37138	160.43	158.98	165.19	164.15	162.38	160.12	162.38	160.12	44.47	44.47		
Link14	94.4	Circular	36	2.90	40796_SI_0600	40797	218.02	215.28	221.02	220.00	219.04	216.38	219.06	216.41	20.46	21.08		
Link15	156.0	Trapezoidal	36	0.55	40797	Inlet	215.28	214.42	220.00	225.00	216.38	216.23	216.41	216.28	20.37	20.98		
Link15.1	94.0	Circular	36	0.50	Inlet	40897	214.42	213.95	225.00	229.48	216.23	216.12	216.28	216.16	20.26	20.86		
Link16	240.5	Circular	36	2.89	36023	39390_SI_0500	213.41	206.45	229.61	218.52	214.47	207.93	214.49	207.95	20.25	20.85		
Link17	19.1	Circular	36	2.81	40897	36023	213.95	213.41	229.48	229.61	216.12	214.47	216.16	214.49	20.26	20.86		
Link18	192.9	Rectangular	30	1.13	35537	34187	167.31	165.13	174.00	171.23	171.26	167.28	171.26	167.28	44.48	44.48		
Link19	115.4	Rectangular	30	4.30	36507_SI_0400	42737	152.96	148.00	159.74	151.00	155.00	149.40	155.01	149.40	64.37	64.48		
South End Basin																		
2	40.1	Circular	30	0.30	39657	39658	428.74	428.62	433.30	433.56	431.52	431.11	431.53	431.11	40.88	41.75		
681.1	40.1	Circular	30	0.30	39657	39658	428.74	428.62	433.30	433.56	431.52	431.11	431.53	431.11	19.40	19.74		
800101	225.2	Trapezoidal	24	0.76	40224	38962	450.92	449.20	453.42	451.20	452.03	451.20	452.03	451.20	23.48	23.49	YES	YES
800102	53.6	Trapezoidal	24	2.42	38963	30628	448.92	448.12	450.92	450.12	450.12	450.12	450.12	450.12	9.98	9.96	YES	YES
800823	249.0	Circular	30	0.65	33801	33800	446.64	445.01	452.50	449.78	449.68	449.58	449.68	449.59	7.45	7.44		
800824	33.2	Circular	18	4.16	30628	33801	448.12	446.74	450.12	452.50	450.12	449.68	450.12	449.68	7.57	7.64		
801783	37.0	Circular	12	1.54	33800	42854	445.01	444.44	449.78	447.80	449.58	446.75	449.59	446.76	7.39	7.38		
802067	213.1	Circular	24	0.40	33531_SE_1300	33530	455.40	454.55	461.95	459.99	460.33	457.83	460.33	457.83	18.81	18.80		
802192	20.1	Circular	30	0.10	33899	40224	450.94	450.92	455.75	453.42	452.78	452.03	452.78	452.03	23.48	23.50		
802326	286.5	Circular	60	0.28	32462_SE_1200	34366	435.93	435.14	440.93	447.02	437.56	437.04	437.58	437.06	19.32	19.62		
802787	32.5	Circular	18	0.00	38962	38963	449.20	448.92	451.20	450.92	451.20	450.12	451.20	450.12	7.97	7.97		
803617	221.5	Circular	15	1.46	35517_SE_1400	33531_SE_1300	458.84	455.60	465.59	461.95	465.59	460.33	465.59	460.33	9.48	9.56		
807270	476.7	Circular	30	0.30	37785_SE_1000	33899	452.38	450.94	458.00	455.75	455.14	452.78	455.15	452.78	23.49	23.50		
807271	119.5	Circular	30	0.00	37787	37785_SE_1000	452.74	452.38	459.02	458.00	455.72	455.14	455.72	455.15	18.77	18.77		
808402	204.7	Trapezoidal	24	0.29	38973_SE_0800	39657	429.34	428.74	433.34	433.30	431.65	431.52	431.67	431.53	60.27	61.48		
808415	100.2	Trapezoidal	24	0.51	39658	42487	428.62	428.11	433.56	431.11	431.11	431.11	431.11	431.11	60.28	61.49	YES	YES
808417	58.9	Circular	36	4.16	42487	39582	428.11	425.66	431.11	428.66	431.11	426.68	431.11	426.68	31.29	31.29		
809300	116.5	Circular	15	1.52	33535_SE_1600	35517_SE_1400	460.81	459.04	468.36	465.59	467.37	465.59	467.70	465.59	6.27	6.83	YES	YES
809303	93.7	Circular	12	1.10	32769_SE_1500	33531_SE_1300	456.63	455.60	461.31	461.95	461.31	460.33	461.31	460.33	3.17	3.17		
809312	433.6	Circular	30	0.30	33530	37788	454.55	453.25	459.99	459.22	457.83	456.44	457.83	456.45	18.78	18.77		
809724	17.8	Circular	60	1.12	34366	34365_SE_1100	434.94	434.74	447.02	446.54	437.04	436.90	437.06	436.92	19.29	19.58		
Link20	166.2	Circular	30	0.31	37788	37787	453.25	452.74	459.22	459.02	456.44	455.72	456.45	455.72	18.77	18.77		
Link21	369.9	Circular	12	0.00	32798_SE_1000	34786	451.89	449.90	456.04	452.42	452.42	450.27	452.42	450.27	1.08	1.09		
Link23	84.9	Circular	12	1.68	34786	Node65	449.90	448.47	452.42	450.47	450.27	448.82	450.27	448.82	1.08	1.09		
Link24	92.2	Trapezoidal	24	1.68	Node65	Node66	448.47	446.92	450.47	448.92	448.67	447.56	448.67	447.56	1.08	1.09		
Link25	22.2	Circular	12	1.68	Node66	Node67	446.92	446.55	448.92	448.55	447.56	446.75	447.56	446.75	1.08	1.08		

Table A-2. Hydraulic Model Parameters and Results for 10-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water Surface		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Link26	85.9	Trapezoidal	24	1.68	Node67	Node68	446.55	445.11	448.55	447.11	446.75	446.83	446.75	446.84	1.08	1.08		
Link31	156.4	Circular	12	6.03	42854	34365_SE_1100	444.37	434.94	447.80	446.54	446.75	436.90	446.76	436.92	7.52	7.52		
Link33	52.5	Circular	12	1.02	Node68	42854	445.11	444.57	447.11	447.80	446.83	446.75	446.84	446.76	1.09	1.09		
Link36	322.9	Circular	48	1.10	34761_SE_0900	38973_SE_0800	432.88	429.34	438.14	433.34	434.83	431.65	434.86	431.67	49.09	50.29		
Link37	207.7	Circular	54	0.24	34365_SE_1100	Node70	434.74	434.24	446.54	441.95	436.90	435.92	436.92	435.94	31.91	32.34		
Link38	172.0	Circular	54	0.56	Node70	34761_SE_0900	434.04	433.08	441.95	438.14	435.92	434.83	435.94	434.86	31.91	32.33		
Newell Creek Basin at Molalla Avenue and Beaver Creek Road																		
800688	160.5	Circular	48	3.51	34994	39666	417.02	411.38	430.02	415.38	418.82	412.72	418.84	412.73	60.81	61.69		
800690	39.8	Circular	12	1.66	34611	30023	423.69	423.03	429.34	430.16	428.97	426.04	429.02	426.07	6.45	6.45		
800854	442.7	Circular	42	0.82	39740_NE_1900	34616	433.01	429.39	436.51	436.91	433.38	429.74	433.39	429.75	1.87	1.93		
801962	148.0	Circular	15	3.87	34604	34603	438.50	432.77	441.90	437.52	439.11	433.62	439.11	433.62	5.08	5.08		
801965	205.9	Circular	15	0.43	34605_NE_3100	34604	439.49	438.60	444.01	441.90	441.44	439.51	441.44	439.51	5.08	5.08		
801981	230.0	Circular	18	1.54	30056_NE_3100	37259	435.30	431.75	439.36	433.77	436.01	432.32	436.01	432.32	4.45	4.45		
803140	168.1	Circular	42	0.78	30021	30023	424.29	422.98	431.51	430.16	427.14	426.04	427.18	426.07	47.01	47.89		
803172	61.7	Circular	12	0.66	30030_NE_2200	30027	426.11	425.70	434.39	433.37	434.39	432.64	434.39	432.64	5.01	5.00		
803176	159.5	Circular	12	0.92	30027	30025	425.53	424.07	433.37	430.71	432.64	429.38	432.64	429.40	4.82	4.82		
803179	78.3	Circular	12	0.57	30025	30024	423.92	423.47	430.71	430.26	429.38	427.27	429.40	427.30	4.78	4.79		
803180	27.5	Circular	12	0.87	30024	30023	423.45	423.21	430.26	430.16	427.27	426.04	427.30	426.07	4.76	4.78		
806619	6.3	Circular	48	0.00	37234	37235	426.45	426.45	433.20	433.20	428.98	428.99	429.02	429.03	-25.85	-26.66		
806620	267.8	Circular	42	0.68	37234	30021	426.45	424.63	433.20	431.51	428.98	427.14	429.02	427.18	47.07	47.94		
807452	59.3	Circular	12	-4.99	37903	37901	423.40	426.36	427.94	430.44	427.94	426.92	427.94	426.93	2.87	2.87		
807453	135.4	Circular	12	2.29	37238_NE_2200	37903	428.50	425.40	430.54	427.94	430.54	427.94	430.54	427.94	4.04	4.04	YES	YES
808393	446.8	Circular	42	0.81	39739_NE_1900	34615	432.99	429.39	436.49	436.91	434.55	430.77	434.57	430.79	27.36	28.20		
Link18	394.5	Circular	48	0.49	34615	41521	428.89	426.95	436.91	432.42	430.59	429.05	430.63	429.09	27.33	28.17		
Link19	82.1	Circular	48	0.49	41521	37235	426.95	426.55	432.42	433.20	429.05	428.99	429.09	429.03	32.25	33.09		
Link20	410.9	Circular	48	0.67	37235	34611	426.45	423.69	433.20	429.34	428.99	428.97	429.03	429.02	7.82	7.83		
Link21	9.3	Circular	42	3.23	30023	Node35	423.03	422.73	430.16	429.89	426.04	424.43	426.07	424.45	57.94	58.82		
Link22	168.9	Circular	48	3.38	Node35	34994	422.73	417.02	429.89	430.02	424.43	418.82	424.45	418.84	60.81	61.69		
Link23	98.6	Circular	12	3.68	37901	Node35	426.36	422.73	430.44	429.89	426.92	424.43	426.93	424.45	2.87	2.87		
Link24	309.6	Circular	15	1.44	34603	42867	432.77	428.30	437.52	432.33	433.62	429.75	433.62	429.79	5.07	5.07		
Link25	45.0	Circular	15	2.77	42867	41521	428.20	426.95	432.33	432.42	429.75	429.05	429.79	429.09	5.05	5.06		
Link26	158.4	Circular	48	0.80	34616	35735_NE_1600	428.89	427.62	436.91	434.20	429.51	429.50	429.53	429.53	1.95	2.01		
Link27	203.9	Circular	48	0.34	35735_NE_1600	41522	427.62	426.93	434.20	432.04	429.50	429.22	429.53	429.26	17.35	17.44		
Link28	114.2	Circular	48	0.34	41522	37234	426.93	426.55	432.04	433.20	429.22	428.98	429.26	429.02	21.62	21.69		
Link29	85.4	Circular	15	5.64	37259	41522	431.75	426.93	433.77	432.04	432.32	429.22	432.32	429.26	4.45	4.45		

Table A-3. Hydraulic Model Parameters and Results for 25-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Central Point Basin																		
808424	57.6	Circular	36	3.44	42490_CP_0500	38777	441.58	439.60	444.58	448.68	443.97	440.61	443.98	440.61	23.14	23.29		
803448	135.1	Circular	12	1.58	33962	35483	461.35	459.21	467.71	467.48	467.71	460.86	467.71	460.86	7.02	7.02		
803449	349.8	Circular	12	4.26	35483	35481	459.01	444.12	467.48	450.42	460.86	444.94	460.86	444.94	6.79	6.79		
803703	202.6	Circular	30	0.59	35630	35478	429.72	428.53	439.21	432.23	431.70	430.10	431.76	430.13	21.39	22.18		
807429	182.8	Circular	12	0.77	37879_CP_0800	33962	463.41	462.00	468.84	467.71	477.46	467.71	478.47	467.71	7.34	7.74	YES	YES
808422	128.1	Circular	36	0.71	33002	39749	443.14	442.23	447.90	445.23	444.38	443.98	444.38	443.99	11.46	11.54		
808427	28.5	Circular	36	0.04	39588	34501	432.78	432.77	438.46	438.50	434.54	434.27	434.54	434.27	17.05	17.05		
808428	118.5	Circular	36	1.05	34502	39588	434.03	432.78	440.22	438.46	435.42	434.54	435.42	434.54	17.05	17.05		
808653	18.7	Circular	30	2.20	38733_CP_0800	35630	430.33	429.92	440.18	439.21	432.43	431.70	432.49	431.76	21.45	22.21		
808654	259.3	Circular	12	4.75	35481	38733_CP_0800	443.92	431.60	450.42	440.18	444.80	432.43	444.80	432.49	6.80	6.80		
809337	155.2	Circular	36	0.95	34503	34502	435.50	434.03	441.35	440.22	436.83	435.42	436.83	435.42	17.06	17.06		
809791	34.0	Circular	15	0.00	34248_CP_0100	35487	430.72	430.73	438.92	438.59	438.57	437.31	437.96	436.68	7.33	7.37		
809793	91.2	Circular	15	0.27	35487	35484	430.53	430.28	438.59	437.00	437.31	435.23	436.68	434.56	7.32	7.36		
812537	128.1	Trapezoidal	30	0.71	39749	42490_CP_0500	442.23	441.58	445.23	444.58	443.98	443.97	443.99	443.98	11.37	11.45		
Link18	292.2	Circular	36	0.41	33700_CP_0600	33002	444.35	443.14	450.79	447.90	445.59	444.38	445.59	444.38	11.54	11.62		
Link19	447.2	Trapezoidal	30	0.49	38888	30909_CP_0400	438.79	436.61	441.29	439.11	440.45	439.11	440.45	439.11	23.11	23.26	YES	YES
Link20	33.0	Circular	27	0.62	30909_CP_0400	34503	436.61	436.40	439.11	441.35	439.11	437.84	439.11	437.84	17.05	17.05		
Link21	10.0	Circular	36	13.10	38777	38888	439.60	438.29	448.68	441.29	440.61	440.45	440.61	440.45	23.14	23.28		
Link25	341.0	Circular	15	0.55	35484	35478	430.08	428.20	437.00	432.23	435.23	429.59	434.56	429.61	7.31	7.36		
Link26	215.0	Circular	30	2.57	35478	40654	428.20	422.68	432.23	425.18	429.59	423.89	429.61	423.91	28.65	29.53		
Link27	38.5	Circular	36	1.30	34501	33145	432.77	432.27	438.50	435.27	434.27	433.27	434.27	433.27	17.05	17.05		
Coffee Creek Basin																		
618.1	116.9	Circular	24	0.58	42534_CO_0500	42533	440.66	439.98	445.16	444.48	443.75	441.87	443.75	441.87	14.98	14.98		
802016	56.9	Circular	24	1.63	40182_CO_0800	34657	453.03	452.10	456.03	456.54	455.71	453.97	455.74	454.04	16.61	16.90		
808374	56.9	Circular	24	1.63	40182_CO_0800	34657	453.03	452.10	456.03	456.54	455.71	453.97	455.74	454.04	16.61	16.90		
808377	62.4	Circular	48	1.07	42472_CO_0600	42473	448.69	448.02	453.69	454.24	452.54	450.47	452.61	450.47	59.94	61.26		
808379	68.6	Circular	30	2.90	42475_CO_0400	42474	413.69	411.70	417.69	416.03	416.96	412.85	416.97	412.85	27.97	28.03		
808379	68.6	Circular	30	2.90	42475_CO_0400	42474	413.69	411.70	417.69	416.03	416.96	412.85	416.97	412.85	27.97	28.03		
808867	76.2	Circular	36	0.91	CO_0300	42552	429.21	428.52	433.21	432.52	433.21	430.25	433.21	430.25	45.08	45.08		
Backyard	116.9	Trapezoidal	24	0.00	42534_CO_0500	42533	443.16	442.48	445.16	444.48	443.75	443.07	443.75	443.07	42.66	42.71		
Link10	686.1	Trapezoidal	48	2.16	42552	42475_CO_0400	428.52	413.69	432.52	417.69	430.25	416.96	430.25	416.97	45.08	45.08		
Link11	6.0	Rectangular	30	1.73	Node16	Node17	446.46	446.35	450.46	450.36	450.46	447.43	450.46	447.43	42.67	42.67		
Link12	329.2	Trapezoidal	48	1.73	Node17	42534_CO_0500	446.35	440.66	450.36	445.16	447.43	443.75	447.43	443.75	42.67	42.67		
Link13	180.0	Trapezoidal	24	0.58	42533	Node19	439.98	438.82	444.48	441.82	441.87	441.53	441.87	441.54	58.09	58.13		
Link14	50.0	Trapezoidal	36	0.58	Node19	Node20	438.82	438.53	441.82	442.53	441.53	440.00	441.54	440.00	58.07	58.11		
Link15	100.5	Trapezoidal	48	9.27	Node20	CO_0300	438.53	429.21	442.53	433.21	440.00	433.21	440.00	433.21	58.07	58.11	YES	YES
Link6	174.1	Circular	36	0.67	34657	40188_CO_0700	451.30	450.14	456.54	457.06	453.97	452.97	454.04	453.02	33.21	33.80		
Link7	587.5	Trapezoidal	60	0.25	40188_CO_0700	42472_CO_0600	450.14	448.69	457.06	453.69	452.97	452.54	453.02	452.61	48.32	49.21		
Link8	90.3	Trapezoidal	48	1.73	42473	Node16	448.02	446.46	454.24	450.46	450.47	450.46	450.47	450.46	59.94	61.26	YES	YES
Livesay Basin																		
Link1	169.8	Circular	1	1.00	33740_LI_1200	33742	504.45	502.75	512.76	510.16	512.35	508.95	506.04	506.00	5.86	0.00		
Link13	41.7	Circular	1.5	4.31	34160	42491	429.05	427.25	435.25	432.40	426.66	424.12	431.01	428.29	10.36	13.83		
Link14	185.2	Circular	1	8.09	32573_LI_1100	34374_LI_1000	438.68	423.70	441.61	430.48	434.81	423.97	438.99	424.00	1.52	1.82		
Link15	399.6	Circular	1	3.02	34374_LI_1000	35610	423.47	411.42	430.48	418.42	423.71	411.93	423.93	411.99	2.20	2.50		
Link16	124.8	Circular	1	1.67	35610	35612	411.36	409.27	418.42	412.91	411.93	409.78	411.99	409.82	2.20	2.50		
Link17	252.8	Circular	1	5.17	35612	35607	409.06	395.99	412.91	400.77	409.45	400.77	409.48	400.77	2.20	2.50	YES	YES

Table A-3. Hydraulic Model Parameters and Results for 25-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Link18	73.6	Circular	1	0.56	35607	35686	395.79	395.38	400.77	397.38	400.77	395.67	400.77	395.61	6.48	4.20		
Link19	96.2	Trapezoidal	2	14.41	35686	39436	395.38	381.52	397.38	383.52	395.67	383.52	395.61	383.52	6.48	4.20	YES	YES
Link2	106.9	Circular	1	1.91	33742	34162_LI_1100	502.55	500.51	510.16	505.96	508.95	506.72	506.00	505.96	5.88	0.00	YES	YES
Link20	61.8	Circular	1	8.24	39436	34997	381.52	376.43	383.52	379.80	383.52	376.89	383.52	376.89	4.09	4.09		
Link21	218.2	Circular	1	5.92	34997	30828_LI_0600	376.23	363.31	379.80	366.90	376.78	363.82	376.78	363.82	4.09	4.09		
Link22	19.2	Circular	1	32.88	30828_LI_0600	39842	362.77	356.46	366.90	368.26	363.12	356.80	363.32	356.81	4.85	4.90		
Link23	198.9	Circular	2	0.88	42491	39313_LI_1000	426.75	425.00	432.40	427.01	424.12	417.78	428.29	426.24	10.38	13.83		
Link24	542.8	Trapezoidal	2	4.63	39313_LI_1000	Node25	425.00	399.89	427.01	401.89	417.78	401.89	425.97	401.89	13.62	17.22	YES	YES
Link25	125.0	Circular	2	3.12	Node25	35607	399.89	395.99	401.89	400.77	401.89	400.77	401.89	400.77	11.28	11.28	YES	YES
Link29	455.6	Circular	1.25	0.39	Node31	Node31.1	508.23	506.44	519.47	512.76	NA$_1$	NA$_1$	514.84	512.76	NA$_1$	3.92		YES
Link29.1	296.1	Circular	1.25	1.70	Node31.1	Node34	506.24	501.21	512.76	506.82	NA$_1$	NA$_1$	512.76	506.82	NA$_1$	9.43		YES
Link3	525.9	Circular	1.25	7.72	34162_LI_1100	34161	500.41	459.83	505.96	465.63	506.72	465.66	505.96	465.63	17.20	16.15	YES	YES
Link30	23.7	Circular	1.25	1.69	Node34	34162_LI_1100	501.01	500.61	506.82	505.96	NA$_1$	NA$_1$	506.82	505.96	NA$_1$	9.16		YES
Link4	241.2	Circular	1.25	4.46	34161	33066	459.84	449.09	465.63	453.44	465.66	453.43	465.63	450.34	12.59	13.83		
Link5	206.8	Circular	1.25	6.95	33066	33065	449.09	434.71	453.44	438.65	453.43	435.98	450.21	436.49	10.36	13.83		
Link6	52.1	Circular	1.25	12.00	33065	34160	435.15	428.90	438.65	435.25	435.80	426.66	436.49	431.01	10.36	13.83		
John Adams Basin																		
800781	159.3	Circular	16	4.81	34313	33514	160.19	152.53	162.29	171.45	161.08	153.28	161.08	153.28	9.48	9.48		
801568	335.0	Circular	8	4.06	33504	33474	257.58	243.99	261.10	254.51	261.10	254.51	261.10	254.51	1.88	1.88	YES	YES
801573	15.0	Circular	12	28.92	33473	34769	220.25	215.90	226.39	226.95	223.03	220.87	223.03	220.87	6.58	6.58		
802603	417.6	Circular	12	6.93	33505_JA_1400	38651	309.65	280.69	316.50	286.90	310.38	281.42	310.38	281.42	7.70	7.72		
802604	268.7	Circular	8	2.85	33566_JA_1600	34696	321.64	313.99	330.45	318.74	330.45	314.66	330.45	314.66	2.78	2.78		
802606	301.1	Circular	8	8.09	34698	33504	282.51	258.15	289.22	261.10	283.03	261.10	283.03	261.10	2.78	2.78	YES	YES
804813	157.0	Circular	18	6.34	33520	43469	82.29	72.34	96.27	88.74	83.22	75.98	83.22	76.01	12.63	12.63		
804814	78.8	Circular	18	7.00	33519	33520	92.03	86.51	99.89	96.27	93.02	87.25	93.02	87.25	12.61	12.61		
804815	124.1	Circular	18	2.66	33521	34704_WN_0300	68.67	65.37	86.97	73.55	74.18	67.05	74.20	67.08	19.06	19.06		
804841	513.2	Circular	12	2.94	33475_JA_1000	33473	235.76	220.69	243.58	226.39	243.58	223.03	243.58	223.03	6.58	6.58		
804846	64.5	Circular	12	1.18	33469	33508	185.00	184.24	188.90	191.51	188.90	185.23	188.90	185.23	6.27	6.27		
804848	150.6	Circular	24	5.05	33514	33515	152.33	144.73	171.45	153.00	153.03	145.34	153.03	145.34	9.48	9.48		
804851	256.1	Circular	18	8.38	33515	34191_JA_0100	144.53	123.08	153.00	128.90	145.16	128.90	145.16	128.90	9.48	9.48	YES	YES
804860	101.6	Circular	18	3.60	33517_WN_0400	33516	178.61	174.95	185.10	179.60	182.36	179.60	182.36	179.60	12.46	12.46	YES	YES
804861	211.6	Circular	18	6.54	33523	33517_WN_0400	192.64	178.81	201.40	185.10	193.08	182.36	193.08	182.36	4.61	4.61		
804867	274.3	Circular	18	2.49	34311_WN_0500	33523	199.70	192.86	207.50	201.40	200.31	193.42	200.31	193.42	4.61	4.61		
804870	183.5	Circular	8	6.02	34767_JA_1100	34309	203.85	192.80	209.10	198.92	209.10	193.47	209.10	193.47	3.22	3.22		
804934	296.9	Circular	8	9.23	38650_JA_1500	33475_JA_1000	263.28	235.87	269.84	243.58	269.84	243.58	269.84	243.58	3.44	3.44	YES	YES
804969	247.9	Circular	8	8.24	33513_JA_0300	33519	113.61	93.18	119.72	99.89	118.80	93.85	118.80	93.85	3.55	3.55		
806396	444.2	Circular	8	8.37	37054	33513_JA_0300	151.18	114.01	162.35	119.72	159.31	118.80	159.31	118.80	3.55	3.55		
806401	131.5	Circular	8	16.53	37059	37054	173.12	151.38	178.38	162.35	173.72	159.31	173.72	159.31	3.55	3.55		
806402	255.5	Circular	10	12.82	37062	37059	206.06	173.32	208.79	178.38	206.49	173.73	206.49	173.73	3.55	3.55		
806406	30.6	Circular	10	2.72	37064	37062	207.09	206.26	210.50	208.79	208.95	207.02	208.95	207.02	3.55	3.55		
806411	253.8	Circular	8	1.92	37070_JA_0500	34769	223.30	218.42	224.81	226.95	224.81	220.87	224.81	220.87	1.40	1.40		
806471	131.0	Circular	18	3.17	37118	37139_WN_0100	50.10	45.95	57.70	53.08	57.70	53.08	57.70	53.08	15.12	15.12	YES	YES
806474	123.1	Circular	18	0.56	37139_WN_0100	37142	45.72	45.03	53.08	53.08	53.08	50.09	53.08	50.09	12.37	12.37		
808623	41.5	Circular	18	0.63	37142	41009	44.93	44.67	53.08	52.70	50.09	48.32	50.09	48.32	12.37	12.37		
808624	19.1	Circular	18	-0.52	43300	43301	43.51	43.61	61.81	61.81	46.43	44.94	46.43	44.94	12.37	12.37		
808704	305.9	Circular	12	2.42	33474	33475_JA_1000	243.75	236.34	254.51	243.58	254.51	243.58	254.51	243.58	6.19	6.19	YES	YES
808721	103.2	Circular	12	6.62	34309	33508	190.32	183.49	198.92	191.51	190.80	183.92	190.80	183.92	3.22	3.22		

1. Existing model based on infrastructure in place in 2017. Future conditions model includes recently installed infrastructure.

Table A-3. Hydraulic Model Parameters and Results for 25-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
812475	29.8	Circular	12	4.05	36378	34534	163.75	162.54	168.58	167.42	168.58	166.00	168.58	166.00	6.66	6.66		
812477	198.1	Circular	12	4.42	33516	36378	172.70	163.95	179.60	168.58	179.60	168.58	179.60	168.58	7.33	7.33	YES	YES
812478	100.6	Circular	12	3.01	34534	43051	162.24	159.21	167.42	163.93	166.00	160.78	166.00	160.78	6.65	6.65		
812479	194.4	Circular	12	4.18	43051	43050	159.11	150.99	163.93	155.49	160.78	151.78	160.78	151.78	6.49	6.49		
812692	119.5	Circular	18	0.80	41009	43300	44.57	43.61	52.70	61.81	48.32	46.43	48.32	46.43	12.37	12.37		
812695	158.3	Circular	54	18.38	43301	39733	43.51	14.40	61.81	19.40	43.94	14.79	43.94	14.79	12.37	12.37		
812816	39.8	Circular	18	8.12	43469	33521	72.10	68.87	88.74	86.97	75.98	74.18	76.01	74.20	12.67	12.67		
Link43	393.4	Circular	12	9.22	38651	33474	280.27	243.99	286.90	254.51	281.04	254.51	281.04	254.51	7.70	7.72	YES	YES
Link44	240.8	Circular	8	12.78	34696	34698	313.57	282.80	318.74	289.22	314.00	283.21	314.00	283.21	2.78	2.78		
Link45	276.4	Circular	8	1.36	34692_JA_1300	37087	242.56	238.80	250.94	248.38	368.43	248.38	368.43	248.38	13.26	13.26	YES	YES
Link46	256.7	Circular	8	3.82	37087	33491_JA_0200	238.60	228.79	248.38	234.43	248.38	234.43	248.38	234.43	2.72	2.72	YES	YES
Link47	259.8	Circular	8	7.96	33491_JA_0200	37064	227.98	207.29	234.43	210.50	234.43	208.95	234.43	208.95	3.55	3.55		
Link48	262.9	Circular	12	13.33	34769	33469	220.25	185.20	226.95	188.90	220.87	188.90	220.87	188.90	7.94	7.94	YES	YES
Link49	225.3	Circular	16	8.60	33508	34313	179.51	160.14	191.51	162.29	180.16	161.08	180.16	161.08	9.48	9.48		
Link54	132.7	Circular	18	11.25	34704_WN_0300	37118	65.33	50.40	73.55	57.70	67.05	57.70	67.08	57.70	21.77	21.79	YES	YES
Link55	249.5	Circular	12	10.53	43050	Node58	150.49	124.22	155.49	126.51	151.10	124.78	151.10	124.78	6.46	6.46		
Link56	122.1	Circular	12	10.53	Node58	Node59	124.02	111.16	126.51	114.00	124.67	111.72	124.67	111.72	6.47	6.47		
Link57	257.4	Circular	12	10.44	Node59	33521	110.96	84.08	114.00	86.97	111.57	84.64	111.57	84.64	6.44	6.44		
Link58	291.0	Circular	15	2.29	34191_JA_0100	34192	116.25	109.60	128.90	120.42	128.90	120.42	128.90	120.42	9.89	9.89	YES	YES
Link59	121.6	Circular	12	6.76	34192	41014	109.22	101.00	120.42	109.91	120.42	109.50	120.42	109.50	9.09	9.10		
Link60	192.3	Circular	12	4.46	41014	33519	100.71	92.13	109.91	99.89	109.50	93.13	109.50	93.13	9.07	9.07		
Park Place Basin																		
801099	22.4	Circular	24	1.29638	30675	30674	111.81	111.52	114.51	114.42	113.79	113.37	113.79	113.37	11.908	11.91		
801520	86.9	Circular	30	2.60048	34163	34164	189.81	187.55	201.5	194.73	190.96	188.49	190.96	188.49	16.256	16.26		
801521	75.8	Circular	30	3.0327	34164	34511	187.35	185.05	194.73	192.57	188.49	185.89	188.49	185.89	16.256	16.26		
801522	146.7	Circular	30	0.46347	34166	34163	190.69	190.01	195.75	201.5	192.45	191.37	192.45	191.37	16.256	16.26		
804027	51.3	Circular	30	5.92212	40789_PP_0800	40790	220.63	217.59	223.9	220.09	223.23	218.62	223.31	218.64	21.076	21.83		
806132	80.2	Circular	24	0.2617	30676	36849	112.88	112.67	116.68	115.17	114.92	114.29	114.92	114.29	11.909	11.91		
806133	38.7	Circular	24	1.44651	36849	30675	112.57	112.01	115.17	114.51	114.29	113.79	114.29	113.79	11.908	11.91		
806138	409.7	Circular	15	4.12944	36853	30676	130.15	113.23	134.95	116.68	133.01	114.92	133.01	114.92	11.909	11.91		
806331	7.1	Circular	24	5.32735	41420	37021	145.72	145.34	148.22	147.94	148.22	147.05	148.22	147.05	15.065	15.07		
808078	41.1	Circular	24	1.16689	30674	38518	111.62	111.14	114.42	113.64	113.37	112.85	113.37	112.85	11.908	11.91		
808079	9.4	Circular	24	-1.39037	38518	PP_0500	110.86	110.99	113.64	113.49	112.85	112.41	112.85	112.41	11.91	11.91		
809819	37.6	Circular	24	2.09989	37021	41421_PP_0600	145.34	144.55	147.94	147.05	147.05	146.19	147.05	146.21	15.067	15.07		
809820	47.5	Circular	24	1.55773	41350	36853	130.99	130.25	133.49	134.95	133.49	133.01	133.49	133.01	12.088	12.17		
812683	109.8	Circular	18	7.0674	43287_PP_1000	43288_PP_0900	262.76	255	264.56	263.56	264.56	255.85	264.56	255.86	7.046	7.05		
Link17	32.9	Circular	24	16.7021	33393	34166	197	191.5	199.5	195.75	199.50	192.45	199.50	192.45	16.256	16.26		
Link18	28.6	Circular	36	3.70629	34511	PP_0700	182.06	181	192.57	192	183.25	182.06	183.25	182.06	16.256	16.26		
Link20	116.2	Circular	24	3.57911	40854	40855	98.78	94.62	103.38	98.5	103.38	96.03	103.38	96.03	25.192	25.19		
Link21	114.7	Circular	30	7.11669	41341	36790_PP_0300	89.66	81.5	93.79	90.65	92.65	82.32	92.65	82.32	25.192	25.19		
Link22	69.7	Circular	36	18.646	36790_PP_0300	41342	81.5	68.5	90.65	80.85	82.32	69.12	82.32	69.12	25.191	25.19		
Link23	628.5	Trapezoidal	30	5.46849	43288_PP_0900	40789_PP_0800	255	220.63	263.56	223.9	255.85	223.23	255.86	223.31	13.878	14.41		
Link24	389.1	Trapezoidal	30	5.29183	40790	33393	217.59	197	220.09	199.5	218.62	199.50	218.64	199.50	21.059	21.81	YES	YES
Link27	416.8	Trapezoidal	30	3.25375	41421_PP_0600	41350	144.55	130.99	147.05	133.49	146.19	133.49	146.21	133.49	48.13	48.96	YES	YES
Link28	567.6	Trapezoidal	30	2.15128	PP_0500	40854	110.99	98.78	113.49	103.38	112.41	103.38	112.41	103.38	27.66	27.65	YES	YES
Link29	270.3	Trapezoidal	30	1.8352	40855	41341	94.62	89.66	98.5	93.79	96.03	92.65	96.03	92.65	25.191	25.19		
Link31	718.8	Trapezoidal	30	5.60378	PP_0700	41420	181	145.72	192	148.22	182.06	148.22	182.06	148.22	21.654	21.65	YES	YES

Table A-3. Hydraulic Model Parameters and Results for 25-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Singer Creek Basin																		
800363	257.5	Circular	36	3.20	39390_SI_0500	33815	206.45	198.22	218.52	205.18	208.12	199.51	208.14	199.52	38.11	38.83		
803639	45.1	Rectangular	30	0.55	34189	35537	167.56	167.31	174.46	174.00	173.05	171.26	173.05	171.26	44.47	44.47		
803641	165.3	Rectangular	30	2.81	35540	34189	172.21	167.56	177.61	174.46	176.49	173.05	176.49	173.05	44.47	44.47		
803643	10.1	Rectangular	30	1.58	SI_0300	35540	172.37	172.21	177.80	177.61	177.80	176.49	177.80	176.49	44.47	44.47		
804123	131.4	Rectangular	30	1.65	35900	SI_0300	174.74	172.37	180.04	177.80	179.71	177.80	179.71	177.80	35.57	35.57	YES	YES
804124	57.9	Rectangular	30	2.02	35902	35900	175.91	174.74	180.96	180.04	180.96	179.71	180.96	179.71	35.57	35.57		
804125	114.9	Rectangular	30	2.34	35903	35902	178.60	175.91	185.01	180.96	182.98	180.96	183.06	180.96	38.11	38.82	YES	YES
804126	124.7	Rectangular	30	2.57	34190	35903	181.81	178.60	189.08	185.01	185.11	182.98	185.27	183.06	38.11	38.82		
804191	308.3	Rectangular	30	4.28	33815	35985	198.22	185.02	205.18	191.23	199.51	187.03	199.52	187.13	38.12	38.84		
804192	84.1	Rectangular	30	3.82	35985	34190	185.02	181.81	191.23	189.08	187.03	185.11	187.13	185.27	38.11	38.82		
804812	212.8	Rectangular	30	2.11	34187	35594	165.13	160.43	171.23	165.19	167.28	162.38	167.28	162.38	44.47	44.47		
806469	153.9	Rectangular	30	3.91	37138	36507_SI_0400	158.98	152.96	164.15	159.74	160.12	155.12	160.12	155.12	44.48	44.48		
806470	94.8	Rectangular	30	1.32	35594	37138	160.43	158.98	165.19	164.15	162.38	160.12	162.38	160.12	44.47	44.47		
Link14	94.4	Circular	36	2.90	40796_SI_0600	40797	218.02	215.28	221.02	220.00	219.16	216.65	219.18	216.69	25.16	25.81		
Link15	156.0	Trapezoidal	36	0.55	40797	Inlet	215.28	214.42	220.00	225.00	216.65	216.60	216.69	216.65	24.99	25.62		
Link15.1	94.0	Circular	36	0.50	Inlet	40897	214.42	213.95	225.00	229.48	216.60	216.47	216.65	216.52	24.82	25.45		
Link16	240.5	Circular	36	2.89	36023	39390_SI_0500	213.41	206.45	229.61	218.52	214.61	208.12	214.63	208.14	24.81	25.44		
Link17	19.1	Circular	36	2.81	40897	36023	213.95	213.41	229.48	229.61	216.47	214.61	216.52	214.63	24.82	25.45		
Link18	192.9	Rectangular	30	1.13	35537	34187	167.31	165.13	174.00	171.23	171.26	167.28	171.26	167.28	44.49	44.49		
Link19	115.4	Rectangular	30	4.30	36507_SI_0400	42737	152.96	148.00	159.74	151.00	155.12	149.46	155.12	149.47	68.50	68.62		
South End Basin																		
2	40.1	Circular	30	0.30	39657	39658	428.74	428.62	433.30	433.56	431.72	431.11	431.74	431.11	50.61	51.42		
681.1	40.1	Circular	30	0.30	39657	39658	428.74	428.62	433.30	433.56	431.72	431.11	431.74	431.11	23.61	24.10		
800101	225.2	Trapezoidal	24	0.76	40224	38962	450.92	449.20	453.42	451.20	452.06	451.20	452.06	451.20	24.79	24.81	YES	YES
800102	53.6	Trapezoidal	24	2.42	38963	30628	448.92	448.12	450.92	450.12	450.13	450.12	450.13	450.12	10.14	10.15	YES	YES
800823	249.0	Circular	30	0.65	33801	33800	446.64	445.01	452.50	449.78	449.72	449.63	449.72	449.63	7.33	7.36		
800824	33.2	Circular	18	4.16	30628	33801	448.12	446.74	450.12	452.50	450.12	449.72	450.12	449.72	7.43	7.46		
801783	37.0	Circular	12	1.54	33800	42854	445.01	444.44	449.78	447.80	449.63	446.98	449.63	446.99	7.31	7.34		
802067	213.1	Circular	24	0.40	33531_SE_1300	33530	455.40	454.55	461.95	459.99	460.89	458.34	460.89	458.34	19.11	19.10		
802192	20.1	Circular	30	0.10	33899	40224	450.94	450.92	455.75	453.42	452.83	452.06	452.84	452.06	24.79	24.82		
802326	286.5	Circular	60	0.28	32462_SE_1200	34366	435.93	435.14	440.93	447.02	437.82	437.31	437.84	437.33	24.16	24.47		
802787	32.5	Circular	18	0.00	38962	38963	449.20	448.92	451.20	450.92	451.20	450.13	451.20	450.13	7.97	7.97		
803617	221.5	Circular	15	1.46	35517_SE_1400	33531_SE_1300	458.84	455.60	465.59	461.95	465.59	460.89	465.59	460.89	9.49	9.56		
807270	476.7	Circular	30	0.30	37785_SE_1000	33899	452.38	450.94	458.00	455.75	455.52	452.83	455.53	452.84	24.80	24.82		
807271	119.5	Circular	30	0.00	37787	37785_SE_1000	452.74	452.38	459.02	458.00	456.16	455.52	456.17	455.53	19.07	19.07		
808402	204.7	Trapezoidal	24	0.29	38973_SE_0800	39657	429.34	428.74	433.34	433.30	431.85	431.72	431.88	431.74	74.20	75.51		
808415	100.2	Trapezoidal	24	0.51	39658	42487	428.62	428.11	433.56	431.11	431.11	431.11	431.11	431.11	74.22	75.52	YES	YES
808417	58.9	Circular	36	4.16	42487	39582	428.11	425.66	431.11	428.66	431.11	426.68	431.11	426.68	31.29	31.29		
809300	116.5	Circular	15	1.52	33535_SE_1600	35517_SE_1400	460.81	459.04	468.36	465.59	468.34	465.59	468.36	465.59	7.80	7.84	YES	YES
809303	93.7	Circular	12	1.10	32769_SE_1500	33531_SE_1300	456.63	455.60	461.31	461.95	461.31	460.89	461.31	460.89	3.31	3.31		
809312	433.6	Circular	30	0.30	33530	37788	454.55	453.25	459.99	459.22	458.34	456.92	458.34	456.93	19.10	19.09		
809724	17.8	Circular	60	1.12	34366	34365_SE_1100	434.94	434.74	447.02	446.54	437.31	437.15	437.33	437.17	24.13	24.43		
Link20	166.2	Circular	30	0.31	37788	37787	453.25	452.74	459.22	459.02	456.92	456.16	456.93	456.17	19.08	19.08		
Link21	369.9	Circular	12	0.00	32798_SE_1000	34786	451.89	449.90	456.04	452.42	452.49	450.32	452.49	450.32	1.33	1.34		
Link23	84.9	Circular	12	1.68	34786	Node65	449.90	448.47	452.42	450.47	450.32	448.86	450.32	448.86	1.33	1.34		
Link24	92.2	Trapezoidal	24	1.68	Node65	Node66	448.47	446.92	450.47	448.92	448.70	447.66	448.70	447.66	1.33	1.34		

Table A-3. Hydraulic Model Parameters and Results for 25-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Link25	22.2	Circular	12	1.68	Node66	Node67	446.92	446.55	448.92	448.55	447.66	447.17	447.66	447.17	1.33	1.34		
Link26	85.9	Trapezoidal	24	1.68	Node67	Node68	446.55	445.11	448.55	447.11	447.17	447.11	447.17	447.11	3.32	4.57	YES	YES
Link31	156.4	Circular	12	6.03	42854	34365_SE_1100	444.37	434.94	447.80	446.54	446.98	437.15	446.99	437.17	7.53	7.54		
Link33	52.5	Circular	12	1.02	Node68	42854	445.11	444.57	447.11	447.80	447.11	446.98	447.11	446.99	1.33	1.32		
Link36	322.9	Circular	48	1.10	34761_SE_0900	38973_SE_0800	432.88	429.34	438.14	433.34	435.10	431.85	435.13	431.88	59.85	61.15		
Link37	207.7	Circular	54	0.24	34365_SE_1100	Node70	434.74	434.24	446.54	441.95	437.15	436.16	437.17	436.18	38.03	38.48		
Link38	172.0	Circular	54	0.56	Node70	34761_SE_0900	434.04	433.08	441.95	438.14	436.16	435.10	436.18	435.13	38.03	38.47		
Newell Creek Basin at Molalla Avenue and Beaver Creek Road																		
800688	160.5	Circular	48	3.51	34994	39666	417.02	411.38	430.02	415.38	418.97	412.81	418.97	412.81	68.55	68.64		
800690	39.8	Circular	12	1.66	34611	30023	423.69	423.03	429.34	430.16	429.34	426.31	429.34	426.31	6.59	6.59		
800854	442.7	Circular	42	0.82	39740_NE_1900	34616	433.01	429.39	436.51	436.91	433.41	429.90	433.41	429.90	2.30	2.35		
801962	148.0	Circular	15	3.87	34604	34603	438.50	432.77	441.90	437.52	439.19	433.95	439.19	433.96	6.04	6.04		
801965	205.9	Circular	15	0.43	34605_NE_3100	34604	439.49	438.60	444.01	441.90	442.26	439.59	442.26	439.59	6.04	6.04		
801981	230.0	Circular	18	1.54	30056_NE_3100	37259	435.30	431.75	439.36	433.77	436.07	432.43	436.07	432.43	5.29	5.29		
803140	168.1	Circular	42	0.78	30021	30023	424.29	422.98	431.51	430.16	427.60	426.31	427.60	426.31	54.70	54.79		
803172	61.7	Circular	12	0.66	30030_NE_2200	30027	426.11	425.70	434.39	433.37	434.39	432.69	434.39	432.69	4.95	4.85		
803176	159.5	Circular	12	0.92	30027	30025	425.53	424.07	433.37	430.71	432.69	429.54	432.69	429.55	4.79	4.78		
803179	78.3	Circular	12	0.57	30025	30024	423.92	423.47	430.71	430.26	429.54	427.50	429.55	427.51	4.76	4.77		
803180	27.5	Circular	12	0.87	30024	30023	423.45	423.21	430.26	430.16	427.50	426.31	427.51	426.31	4.75	4.76		
806619	6.3	Circular	48	0.00	37234	37235	426.45	426.45	433.20	433.20	429.40	429.40	429.41	429.41	-30.46	-30.83		
806620	267.8	Circular	42	0.68	37234	30021	426.45	424.63	433.20	431.51	429.40	427.60	429.41	427.60	54.74	54.85		
807452	59.3	Circular	12	-4.99	37903	37901	423.40	426.36	427.94	430.44	427.94	426.94	427.94	426.94	2.88	2.88		
807453	135.4	Circular	12	2.29	37238_NE_2200	37903	428.50	425.40	430.54	427.94	430.54	427.94	430.54	427.94	4.04	4.04	YES	YES
808393	446.8	Circular	42	0.81	39739_NE_1900	34615	432.99	429.39	436.49	436.91	434.75	430.93	434.78	430.95	33.35	34.22		
Link18	394.5	Circular	48	0.49	34615	41521	428.89	426.95	436.91	432.42	430.86	429.46	430.89	429.47	33.37	34.22		
Link19	82.1	Circular	48	0.49	41521	37235	426.95	426.55	432.42	433.20	429.46	429.40	429.47	429.41	39.56	40.35		
Link20	410.9	Circular	48	0.67	37235	34611	426.45	423.69	433.20	429.34	429.40	429.34	429.41	429.34	11.41	12.07	YES	YES
Link21	9.3	Circular	42	3.23	30023	Node35	423.03	422.73	430.16	429.89	426.31	424.58	426.31	424.58	65.67	65.76		
Link22	168.9	Circular	48	3.38	Node35	34994	422.73	417.02	429.89	430.02	424.58	418.97	424.58	418.97	68.55	68.64		
Link23	98.6	Circular	12	3.68	37901	Node35	426.36	422.73	430.44	429.89	426.94	424.58	426.94	424.58	2.88	2.88		
Link24	309.6	Circular	15	1.44	34603	42867	432.77	428.30	437.52	432.33	433.95	430.46	433.96	430.47	6.03	6.03		
Link25	45.0	Circular	15	2.77	42867	41521	428.20	426.95	432.33	432.42	430.46	429.46	430.47	429.47	6.03	6.03		
Link26	158.4	Circular	48	0.80	34616	35735_NE_1600	428.89	427.62	436.91	434.20	429.90	429.89	429.90	429.90	2.45	2.49		
Link27	203.9	Circular	48	0.34	35735_NE_1600	41522	427.62	426.93	434.20	432.04	429.89	429.64	429.90	429.65	20.87	21.01		
Link28	114.2	Circular	48	0.34	41522	37234	426.93	426.55	432.04	433.20	429.64	429.40	429.65	429.41	26.22	26.35		
Link29	85.4	Circular	15	5.64	37259	41522	431.75	426.93	433.77	432.04	432.43	429.64	432.43	429.65	5.29	5.29		

Table A-4. Hydraulic Model Parameters and Results for 100-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water Surface		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Central Point Basin																		
808424	57.6	Circular	36	3.44	42490_CP_0500	38777	441.58	439.60	444.58	448.68	444.30	440.73	444.32	440.74	27.50	27.66		
803448	135.1	Circular	12	1.58	33962	35483	461.35	459.21	467.71	467.48	467.71	460.86	467.71	460.86	7.00	7.01		
803449	349.8	Circular	12	4.26	35483	35481	459.01	444.12	467.48	450.42	460.86	444.94	460.86	444.94	6.79	6.80		
803703	202.6	Circular	30	0.59	35630	35478	429.72	428.53	439.21	432.23	431.93	430.21	432.00	430.24	24.30	25.13		
807429	182.8	Circular	12	0.77	37879_CP_0800	33962	463.41	462.00	468.84	467.71	481.28	467.71	482.45	467.71	8.80	9.21	YES	YES
808422	128.1	Circular	36	0.71	33002	39749	443.14	442.23	447.90	445.23	444.62	444.31	444.63	444.33	13.60	13.68		
808427	28.5	Circular	36	0.04	39588	34501	432.78	432.77	438.46	438.50	434.54	434.27	434.54	434.27	17.05	17.05		
808428	118.5	Circular	36	1.05	34502	39588	434.03	432.78	440.22	438.46	435.42	434.54	435.42	434.54	17.05	17.05		
808653	18.7	Circular	30	2.20	38733_CP_0800	35630	430.33	429.92	440.18	439.21	432.68	431.93	432.77	432.00	24.33	25.16		
808654	259.3	Circular	12	4.75	35481	38733_CP_0800	443.92	431.60	450.42	440.18	444.80	432.68	444.80	432.77	6.79	6.78		
809337	155.2	Circular	36	0.95	34503	34502	435.50	434.03	441.35	440.22	436.83	435.42	436.83	435.42	17.06	17.06		
809791	34.0	Circular	15	0.00	34248_CP_0100	35487	430.72	430.73	438.92	438.59	438.92	437.63	438.92	437.52	7.55	7.87		
809793	91.2	Circular	15	0.27	35487	35484	430.53	430.28	438.59	437.00	437.63	435.49	437.52	435.19	7.46	7.79		
812537	128.1	Trapezoidal	30	0.71	39749	42490_CP_0500	442.23	441.58	445.23	444.58	444.31	444.30	444.33	444.32	13.50	13.58		
Link18	292.2	Circular	36	0.41	33700_CP_0600	33002	444.35	443.14	450.79	447.90	445.74	444.62	445.74	444.63	13.73	13.81		
Link19	447.2	Trapezoidal	30	0.49	38888	30909_CP_0400	438.79	436.61	441.29	439.11	440.57	439.11	440.58	439.11	27.48	27.63	YES	YES
Link20	33.0	Circular	27	0.62	30909_CP_0400	34503	436.61	436.40	439.11	441.35	439.11	437.84	439.11	437.84	17.05	17.05		
Link21	10.0	Circular	36	13.10	38777	38888	439.60	438.29	448.68	441.29	440.73	440.57	440.74	440.58	27.50	27.66		
Link25	341.0	Circular	15	0.55	35484	35478	430.08	428.20	437.00	432.23	435.49	429.68	435.19	429.72	7.46	7.79		
Link26	215.0	Circular	30	2.57	35478	40654	428.20	422.68	432.23	425.18	429.68	423.96	429.72	423.99	31.72	32.87		
Link27	38.5	Circular	36	1.30	34501	33145	432.77	432.27	438.50	435.27	434.27	433.27	434.27	433.27	17.05	17.05		
Coffee Creek Basin																		
618.1	116.9	Circular	24	0.58	42534_CO_0500	42533	440.66	439.98	445.16	444.48	443.78	441.91	443.78	441.92	14.98	14.97		
802016	56.9	Circular	24	1.63	40182_CO_0800	34657	453.03	452.10	456.03	456.54	456.40	454.86	456.47	454.99	20.27	20.60		
808374	56.9	Circular	24	1.63	40182_CO_0800	34657	453.03	452.10	456.03	456.54	456.40	454.86	456.47	454.99	20.27	20.60		
808377	62.4	Circular	48	1.07	42472_CO_0600	42473	448.69	448.02	453.69	454.24	453.16	450.50	453.22	450.50	72.48	73.86		
808379	68.6	Circular	30	2.90	42475_CO_0400	42474	413.69	411.70	417.69	416.03	417.03	412.87	417.03	412.87	29.01	29.07		
808379	68.6	Circular	30	2.90	42475_CO_0400	42474	413.69	411.70	417.69	416.03	417.03	412.87	417.03	412.87	29.01	29.07		
808867	76.2	Circular	36	0.91	CO_0300	42552	429.21	428.52	433.21	432.52	433.21	430.25	433.21	430.25	45.08	45.08		
Backyard	116.9	Trapezoidal	24	0.00	42534_CO_0500	42533	443.16	442.48	445.16	444.48	443.78	443.10	443.78	443.10	45.59	45.63		
Link10	686.1	Trapezoidal	48	2.16	42552	42475_CO_0400	428.52	413.69	432.52	417.69	430.25	417.03	430.25	417.03	45.08	45.08		
Link11	6.0	Rectangular	30	1.73	Node16	Node17	446.46	446.35	450.46	450.36	450.46	447.43	450.46	447.43	42.67	42.67		
Link12	329.2	Trapezoidal	48	1.73	Node17	42534_CO_0500	446.35	440.66	450.36	445.16	447.43	443.78	447.43	443.78	42.67	42.67		
Link13	180.0	Trapezoidal	24	0.58	42533	Node19	439.98	438.82	444.48	441.82	441.91	441.59	441.92	441.59	60.89	60.93		
Link14	50.0	Trapezoidal	36	0.58	Node19	Node20	438.82	438.53	441.82	442.53	441.59	440.03	441.59	440.03	60.87	60.91		
Link15	100.5	Trapezoidal	48	9.27	Node20	CO_0300	438.53	429.21	442.53	433.21	440.03	433.21	440.03	433.21	60.87	60.91	YES	YES
Link6	174.1	Circular	36	0.67	34657	40188_CO_0700	451.30	450.14	456.54	457.06	454.86	453.48	454.99	453.54	40.53	41.17		
Link7	587.5	Trapezoidal	60	0.25	40188_CO_0700	42472_CO_0600	450.14	448.69	457.06	453.69	453.48	453.16	453.54	453.22	58.64	59.58		
Link8	90.3	Trapezoidal	48	1.73	42473	Node16	448.02	446.46	454.24	450.46	450.50	450.46	450.50	450.46	72.48	73.87	YES	YES
Livesay Basin																		
Link1	169.8	Circular	1	1.00	33740_LI_1200	33742	504.45	502.75	512.76	510.16	512.35	508.96	506.13	506.06	5.87	0.00		
Link13	41.7	Circular	1.5	4.31	34160	42491	429.05	427.25	435.25	432.40	426.66	424.12	431.00	428.29	10.36	13.83		
Link14	185.2	Circular	1	8.09	32573_LI_1100	34374_LI_1000	438.68	423.70	441.61	430.48	434.85	424.00	439.03	424.03	1.88	2.19		
Link15	399.6	Circular	1	3.02	34374_LI_1000	35610	423.47	411.42	430.48	418.42	423.76	412.02	423.99	412.09	2.71	3.02		
Link16	124.8	Circular	1	1.67	35610	35612	411.36	409.27	418.42	412.91	412.02	409.85	412.09	409.89	2.70	3.02		
Link17	252.8	Circular	1	5.17	35612	35607	409.06	395.99	412.91	400.77	409.51	400.77	409.54	400.77	2.70	3.02	YES	YES
Link18	73.6	Circular	1	0.56	35607	35686	395.79	395.38	400.77	397.38	400.77	395.67	400.77	395.61	6.48	4.20		

Table A-4. Hydraulic Model Parameters and Results for 100-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water Surface		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Link19	96.2	Trapezoidal	2	14.41	35686	39436	395.38	381.52	397.38	383.52	395.67	383.52	395.61	383.52	6.48	4.20	YES	YES
Link2	106.9	Circular	1	1.91	33742	34162_LI_1100	502.55	500.51	510.16	505.96	508.96	506.72	506.06	505.96	5.86	0.00	YES	YES
Link20	61.8	Circular	1	8.24	39436	34997	381.52	376.43	383.52	379.80	383.52	376.89	383.52	376.89	4.09	4.09		
Link21	218.2	Circular	1	5.92	34997	30828_LI_0600	376.23	363.31	379.80	366.90	376.78	363.82	376.78	363.82	4.09	4.09		
Link22	19.2	Circular	1	32.88	30828_LI_0600	39842	362.77	356.46	366.90	368.26	363.12	356.81	363.34	356.81	5.00	5.05		
Link23	198.9	Circular	2	0.88	42491	39313_LI_1000	426.75	425.00	432.40	427.01	424.12	417.80	428.29	426.24	10.37	13.83		
Link24	542.8	Trapezoidal	2	4.63	39313_LI_1000	Node25	425.00	399.89	427.01	401.89	417.80	401.89	425.99	401.89	14.37	17.98	YES	YES
Link25	125.0	Circular	2	3.12	Node25	35607	399.89	395.99	401.89	400.77	401.89	400.77	401.89	400.77	11.28	11.28	YES	YES
Link29	455.6	Circular	1.25	0.39	Node31	Node31.1	508.23	506.44	519.47	512.76	NA$_1$	NA$_1$	516.07	512.76	NA$_1$	4.97		YES
Link29.1	296.1	Circular	1.25	1.70	Node31.1	Node34	506.24	501.21	512.76	506.82	NA$_1$	NA$_1$	512.76	506.82	NA$_1$	9.12		YES
Link3	525.9	Circular	1.25	7.72	34162_LI_1100	34161	500.41	459.83	505.96	465.63	506.72	465.66	505.96	465.63	17.20	16.15	YES	YES
Link30	23.7	Circular	1.25	1.69	Node34	34162_LI_1100	501.01	500.61	506.82	505.96	NA$_1$	NA$_1$	506.82	505.96	NA$_1$	8.84		YES
Link4	241.2	Circular	1.25	4.46	34161	33066	459.84	449.09	465.63	453.44	465.66	453.43	465.63	450.34	12.59	13.83		
Link5	206.8	Circular	1.25	6.95	33066	33065	449.09	434.71	453.44	438.65	453.43	435.98	450.21	436.48	10.36	13.83		
Link6	52.1	Circular	1.25	12.00	33065	34160	435.15	428.90	438.65	435.25	435.80	426.66	436.48	431.00	10.36	13.83		
John Adams Basin																		
804870	183.5	Circular	8	6.02	34767_JA_1100	34309	203.85	192.80	209.10	198.92	209.10	193.47	209.10	193.47	3.22	3.22		
800781	159.3	Circular	16	4.81	34313	33514	160.19	152.53	162.29	171.45	161.08	153.28	161.08	153.28	9.48	9.48		
801568	335.0	Circular	8	4.06	33504	33474	257.58	243.99	261.10	254.51	261.10	254.51	261.10	254.51	1.88	1.88	YES	YES
801573	15.0	Circular	12	28.92	33473	34769	220.25	215.90	226.39	226.95	223.03	220.87	223.03	220.87	6.58	6.58		
802603	417.6	Circular	12	6.93	33505_JA_1400	38651	309.65	280.69	316.50	286.90	314.75	285.04	314.93	285.14	9.05	9.07		
802604	268.7	Circular	8	2.85	33566_JA_1600	34696	321.64	313.99	330.45	318.74	330.45	314.66	330.45	314.66	2.78	2.78		
802606	301.1	Circular	8	8.09	34698	33504	282.51	258.15	289.22	261.10	283.03	261.10	283.03	261.10	2.78	2.78	YES	YES
804813	157.0	Circular	18	6.34	33520	43469	82.29	72.34	96.27	88.74	83.28	77.10	83.28	77.12	12.64	12.64		
804814	78.8	Circular	18	7.00	33519	33520	92.03	86.51	99.89	96.27	93.02	87.25	93.02	87.25	12.61	12.61		
804815	124.1	Circular	18	2.66	33521	34704_WN_0300	68.67	65.37	86.97	73.55	75.31	68.13	75.33	68.15	19.21	19.24		
804841	513.2	Circular	12	2.94	33475_JA_1000	33473	235.76	220.69	243.58	226.39	243.58	223.03	243.58	223.03	6.58	6.58		
804846	64.5	Circular	12	1.18	33469	33508	185.00	184.24	188.90	191.51	188.90	185.23	188.90	185.23	6.27	6.27		
804848	150.6	Circular	24	5.05	33514	33515	152.33	144.73	171.45	153.00	153.03	145.34	153.03	145.34	9.48	9.48		
804851	256.1	Circular	18	8.38	33515	34191_JA_0100	144.53	123.08	153.00	128.90	145.16	128.90	145.16	128.90	9.48	9.48	YES	YES
804860	101.6	Circular	18	3.60	33517_WN_0400	33516	178.61	174.95	185.10	179.60	183.43	179.60	183.43	179.60	14.73	14.73	YES	YES
804861	211.6	Circular	18	6.54	33523	33517_WN_0400	192.64	178.81	201.40	185.10	193.12	183.43	193.12	183.43	5.45	5.45		
804867	274.3	Circular	18	2.49	34311_WN_0500	33523	199.70	192.86	207.50	201.40	200.37	193.48	200.37	193.48	5.45	5.45		
804934	296.9	Circular	8	9.23	38650_JA_1500	33475_JA_1000	263.28	235.87	269.84	243.58	269.84	243.58	269.84	243.58	3.44	3.44	YES	YES
804969	247.9	Circular	8	8.24	33513_JA_0300	33519	113.61	93.18	119.72	99.89	118.80	93.85	118.80	93.85	3.55	3.55		
806396	444.2	Circular	8	8.37	37054	33513_JA_0300	151.18	114.01	162.35	119.72	159.31	118.80	159.31	118.80	3.55	3.55		
806401	131.5	Circular	8	16.53	37059	37054	173.12	151.38	178.38	162.35	173.72	159.31	173.72	159.31	3.55	3.55		
806402	255.5	Circular	10	12.82	37062	37059	206.06	173.32	208.79	178.38	206.49	173.73	206.49	173.73	3.55	3.55		
806406	30.6	Circular	10	2.72	37064	37062	207.09	206.26	210.50	208.79	208.95	207.02	208.95	207.02	3.55	3.55		
806411	253.8	Circular	8	1.92	37070_JA_0500	34769	223.30	218.42	224.81	226.95	224.81	220.87	224.81	220.87	1.40	1.40		
806471	131.0	Circular	18	3.17	37118	37139_WN_0100	50.10	45.95	57.70	53.08	57.70	53.08	57.70	53.08	15.12	15.12	YES	YES
806474	123.1	Circular	18	0.56	37139_WN_0100	37142	45.72	45.03	53.08	53.08	53.08	50.09	53.08	50.09	12.38	12.38		
808623	41.5	Circular	18	0.63	37142	41009	44.93	44.67	53.08	52.70	50.09	48.32	50.09	48.32	12.37	12.37		
808624	19.1	Circular	18	-0.52	43300	43301	43.51	43.61	61.81	61.81	46.43	44.94	46.43	44.94	12.37	12.37		
808704	305.9	Circular	12	2.42	33474	33475_JA_1000	243.75	236.34	254.51	243.58	254.51	243.58	254.51	243.58	6.19	6.19	YES	YES
808721	103.2	Circular	12	6.62	34309	33508	190.32	183.49	198.92	191.51	190.80	183.92	190.80	183.92	3.22	3.22		
812475	29.8	Circular	12	4.05	36378	34534	163.75	162.54	168.58	167.42	168.58	166.00	168.58	166.00	6.69	6.69		
812477	198.1	Circular	12	4.42	33516	36378	172.70	163.95	179.60	168.58	179.60	168.58	179.60	168.58	7.33	7.33	YES	YES

1. Existing model based on infrastructure in place in 2017. Future conditions model includes recently installed infrastructure.

Table A-4. Hydraulic Model Parameters and Results for 100-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water Surface		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
812478	100.6	Circular	12	3.01	34534	43051	162.24	159.21	167.42	163.93	166.00	160.78	166.00	160.78	6.66	6.66		
812479	194.4	Circular	12	4.18	43051	43050	159.11	150.99	163.93	155.49	160.78	151.78	160.78	151.78	6.47	6.47		
812692	119.5	Circular	18	0.80	41009	43300	44.57	43.61	52.70	61.81	48.32	46.43	48.32	46.43	12.37	12.37		
812695	158.3	Circular	54	18.38	43301	39733	43.51	14.40	61.81	19.40	43.94	14.79	43.94	14.79	12.37	12.37		
812816	39.8	Circular	18	8.12	43469	33521	72.10	68.87	88.74	86.97	77.10	75.31	77.12	75.33	12.71	12.72		
Link43	393.4	Circular	12	9.22	38651	33474	280.27	243.99	286.90	254.51	285.04	254.51	285.14	254.51	9.02	9.04	YES	YES
Link44	240.8	Circular	8	12.78	34696	34698	313.57	282.80	318.74	289.22	314.00	283.21	314.00	283.21	2.78	2.78		
Link45	276.4	Circular	8	1.36	34692_JA_1300	37087	242.56	238.80	250.94	248.38	393.18	248.38	393.18	248.38	15.81	15.81	YES	YES
Link46	256.7	Circular	8	3.82	37087	33491_JA_0200	238.60	228.79	248.38	234.43	248.38	234.43	248.38	234.43	2.72	2.72	YES	YES
Link47	259.8	Circular	8	7.96	33491_JA_0200	37064	227.98	207.29	234.43	210.50	234.43	208.95	234.43	208.95	3.55	3.55		
Link48	262.9	Circular	12	13.33	34769	33469	220.25	185.20	226.95	188.90	220.87	188.90	220.87	188.90	7.94	7.94	YES	YES
Link49	225.3	Circular	16	8.60	33508	34313	179.51	160.14	191.51	162.29	180.16	161.08	180.16	161.08	9.48	9.48		
Link54	132.7	Circular	18	11.25	34704_WN_0300	37118	65.33	50.40	73.55	57.70	68.13	57.70	68.15	57.70	22.26	22.28	YES	YES
Link55	249.5	Circular	12	10.53	43050	Node58	150.49	124.22	155.49	126.51	151.10	124.78	151.10	124.78	6.48	6.48		
Link56	122.1	Circular	12	10.53	Node58	Node59	124.02	111.16	126.51	114.00	124.67	111.72	124.67	111.72	6.46	6.46		
Link57	257.4	Circular	12	10.44	Node59	33521	110.96	84.08	114.00	86.97	111.57	84.64	111.57	84.64	6.45	6.45		
Link58	291.0	Circular	15	2.29	34191_JA_0100	34192	116.25	109.60	128.90	120.42	128.90	120.42	128.90	120.42	9.89	9.89	YES	YES
Link59	121.6	Circular	12	6.76	34192	41014	109.22	101.00	120.42	109.91	120.42	109.50	120.42	109.50	9.09	9.09		
Link60	192.3	Circular	12	4.46	41014	33519	100.71	92.13	109.91	99.89	109.50	93.13	109.50	93.13	9.07	9.07		
Park Place Basin																		
801099	22.4	Circular	24	1.30	30675	30674	111.81	111.52	114.51	114.42	113.82	113.41	113.82	113.41	11.91	11.91		
801520	86.9	Circular	30	2.60	34163	34164	189.81	187.55	201.50	194.73	190.96	188.49	190.96	188.49	16.26	16.26		
801521	75.8	Circular	30	3.03	34164	34511	187.35	185.05	194.73	192.57	188.49	185.89	188.49	185.89	16.26	16.26		
801522	146.7	Circular	30	0.46	34166	34163	190.69	190.01	195.75	201.50	192.45	191.37	192.45	191.37	16.26	16.26		
804027	51.3	Circular	30	5.92	40789_PP_0800	40790	220.63	217.59	223.90	220.09	223.50	218.68	223.58	218.70	23.83	24.61		
806132	80.2	Circular	24	0.26	30676	36849	112.88	112.67	116.68	115.17	114.94	114.31	114.94	114.31	11.91	11.91		
806133	38.7	Circular	24	1.45	36849	30675	112.57	112.01	115.17	114.51	114.31	113.82	114.31	113.82	11.91	11.91		
806138	409.7	Circular	15	4.13	36853	30676	130.15	113.23	134.95	116.68	133.01	114.94	133.01	114.94	11.91	11.91		
806331	7.1	Circular	24	5.33	41420	37021	145.72	145.34	148.22	147.94	148.22	147.09	148.22	147.10	15.07	15.07		
808078	41.1	Circular	24	1.17	30674	38518	111.62	111.14	114.42	113.64	113.41	112.91	113.41	112.91	11.91	11.91		
808079	9.4	Circular	24	-1.39	38518	PP_0500	110.86	110.99	113.64	113.49	112.91	112.49	112.91	112.49	11.91	11.91		
809819	37.6	Circular	24	2.10	37021	41421_PP_0600	145.34	144.55	147.94	147.05	147.09	146.29	147.10	146.30	15.07	15.07		
809820	47.5	Circular	24	1.56	41350	36853	130.99	130.25	133.49	134.95	133.49	133.01	133.49	133.01	12.21	12.18		
812683	109.8	Circular	18	7.07	43287_PP_1000	43288_PP_0900	262.76	255.00	264.56	263.56	264.56	255.89	264.56	255.90	7.05	7.05		
Link17	32.9	Circular	24	16.70	33393	34166	197.00	191.50	199.50	195.75	199.50	192.45	199.50	192.45	16.26	16.26		
Link18	28.6	Circular	36	3.71	34511	PP_0700	182.06	181.00	192.57	192.00	183.25	182.09	183.25	182.09	16.26	16.26		
Link20	116.2	Circular	24	3.58	40854	40855	98.78	94.62	103.38	98.50	103.38	96.03	103.38	96.03	25.19	25.19		
Link21	114.7	Circular	30	7.12	41341	36790_PP_0300	89.66	81.50	93.79	90.65	92.65	82.32	92.65	82.32	25.19	25.19		
Link22	69.7	Circular	36	18.65	36790_PP_0300	41342	81.50	68.50	90.65	80.85	82.32	69.12	82.32	69.12	25.19	25.19		
Link23	628.5	Trapezoidal	30	5.47	43288_PP_0900	40789_PP_0800	255.00	220.63	263.56	223.90	255.89	223.50	255.90	223.58	15.24	15.80		
Link24	389.1	Trapezoidal	30	5.29	40790	33393	217.59	197.00	220.09	199.50	218.68	199.50	218.70	199.50	23.82	24.60	YES	YES
Link27	416.8	Trapezoidal	30	3.25	41421_PP_0600	41350	144.55	130.99	147.05	133.49	146.29	133.49	146.30	133.49	54.93	55.79	YES	YES
Link28	567.6	Trapezoidal	30	2.15	PP_0500	40854	110.99	98.78	113.49	103.38	112.49	103.38	112.49	103.38	31.72	31.71	YES	YES
Link29	270.3	Trapezoidal	30	1.84	40855	41341	94.62	89.66	98.50	93.79	96.03	92.65	96.03	92.65	25.19	25.19		
Link31	718.8	Trapezoidal	30	5.60	PP_0700	41420	181.00	145.72	192.00	148.22	182.09	148.22	182.09	148.22	22.74	22.74	YES	YES

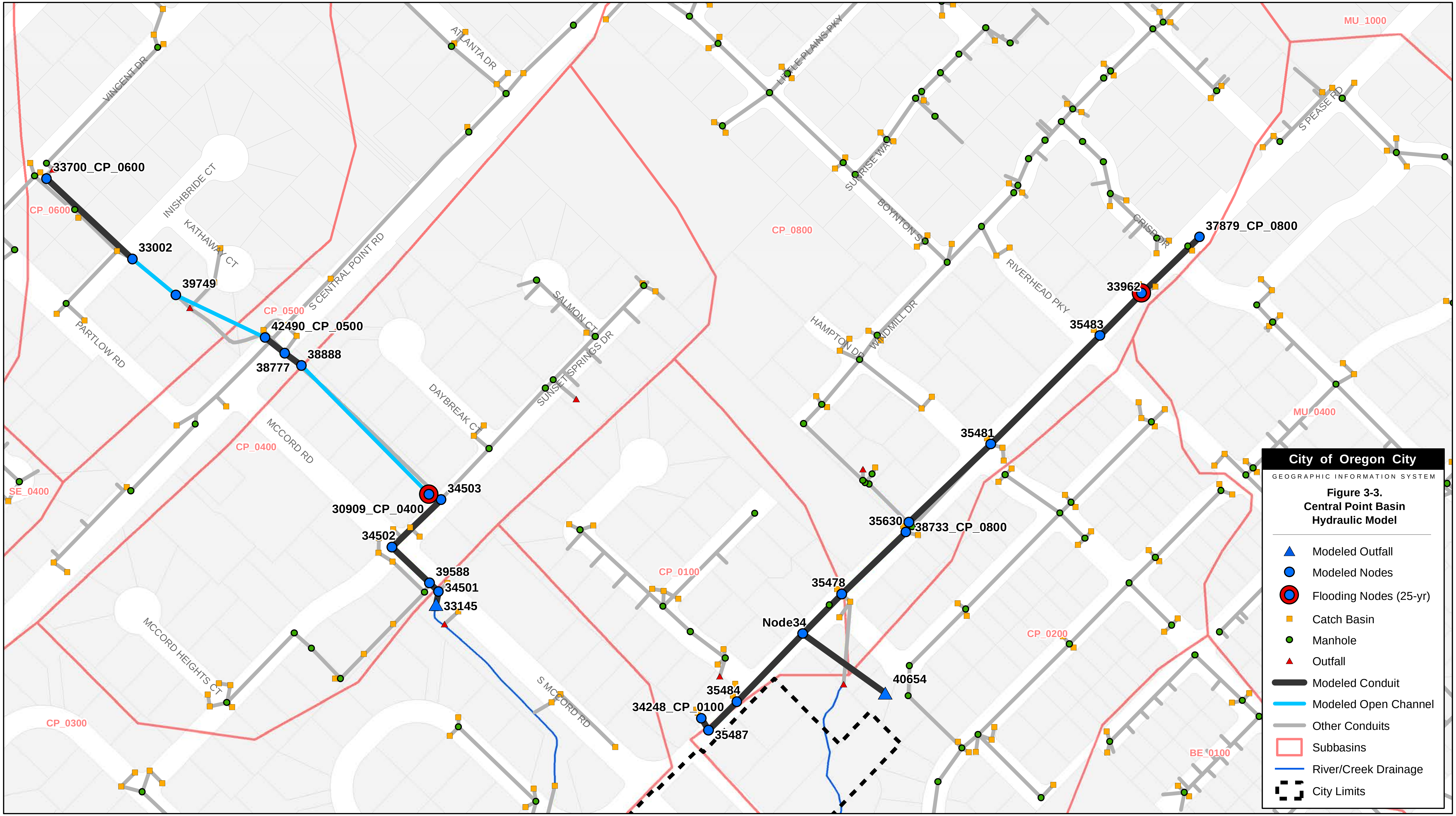
Table A-4. Hydraulic Model Parameters and Results for 100-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water Surface		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Singer Creek Basin																		
800363	257.5	Circular	36	3.20	39390_SI_0500	33815	206.45	198.22	218.52	205.18	208.25	199.81	208.14	199.52	45.05	38.83		
803639	45.1	Rectangular	30	0.55	34189	35537	167.56	167.31	174.46	174.00	173.05	171.26	173.05	171.26	44.47	44.47		
803641	165.3	Rectangular	30	2.81	35540	34189	172.21	167.56	177.61	174.46	176.49	173.05	176.49	173.05	44.48	44.47		
803643	10.1	Rectangular	30	1.58	SI_0300	35540	172.37	172.21	177.80	177.61	177.80	176.49	177.80	176.49	44.48	44.47		
804123	131.4	Rectangular	30	1.65	35900	SI_0300	174.74	172.37	180.04	177.80	179.71	177.80	179.71	177.80	35.57	35.57	YES	YES
804124	57.9	Rectangular	30	2.02	35902	35900	175.91	174.74	180.96	180.04	180.96	179.71	180.96	179.71	35.57	35.57		
804125	114.9	Rectangular	30	2.34	35903	35902	178.60	175.91	185.01	180.96	183.78	180.96	183.06	180.96	45.04	38.82	YES	YES
804126	124.7	Rectangular	30	2.57	34190	35903	181.81	178.60	189.08	185.01	186.74	183.78	185.27	183.06	45.04	38.82		
804191	308.3	Rectangular	30	4.28	33815	35985	198.22	185.02	205.18	191.23	199.81	189.13	199.52	187.13	45.04	38.84		
804192	84.1	Rectangular	30	3.82	35985	34190	185.02	181.81	191.23	189.08	189.13	186.74	187.13	185.27	45.04	38.82		
804812	212.8	Rectangular	30	2.11	34187	35594	165.13	160.43	171.23	165.19	167.28	162.38	167.28	162.38	44.47	44.47		
806469	153.9	Rectangular	30	3.91	37138	36507_SI_0400	158.98	152.96	164.15	159.74	160.12	155.26	160.12	155.12	44.51	44.48		
806470	94.8	Rectangular	30	1.32	35594	37138	160.43	158.98	165.19	164.15	162.38	160.12	162.38	160.12	44.48	44.47		
Link14	94.4	Circular	36	2.90	40796_SI_0600	40797	218.02	215.28	221.02	220.00	219.29	216.99	219.18	216.69	29.92	25.81		
Link15	156.0	Trapezoidal	36	0.55	40797	Inlet	215.28	214.42	220.00	225.00	216.99	216.98	216.69	216.65	29.62	25.62		
Link15.1	94.0	Circular	36	0.50	Inlet	40897	214.42	213.95	225.00	229.48	216.98	216.82	216.65	216.52	29.40	25.45		
Link16	240.5	Circular	36	2.89	36023	39390_SI_0500	213.41	206.45	229.61	218.52	214.74	208.25	214.63	208.14	29.39	25.44		
Link17	19.1	Circular	36	2.81	40897	36023	213.95	213.41	229.48	229.61	216.82	214.74	216.52	214.63	29.40	25.45		
Link18	192.9	Rectangular	30	1.13	35537	34187	167.31	165.13	174.00	171.23	171.26	167.28	171.26	167.28	44.47	44.49		
Link19	115.4	Rectangular	30	4.30	36507_SI_0400	42737	152.96	148.00	159.74	151.00	155.26	149.53	155.12	149.47	72.61	68.62		
South End Basin																		
2	40.1	Circular	30	0.30	39657	39658	428.74	428.62	433.30	433.56	432.07	431.10	432.11	431.10	59.96	60.81		
681.1	40.1	Circular	30	0.30	39657	39658	428.74	428.62	433.30	433.56	432.07	431.10	432.11	431.10	28.47	28.98		
800101	225.2	Trapezoidal	24	0.76	40224	38962	450.92	449.20	453.42	451.20	452.09	451.20	452.09	451.20	26.12	26.13	YES	YES
800102	53.6	Trapezoidal	24	2.42	38963	30628	448.92	448.12	450.92	450.12	450.13	450.12	450.13	450.12	10.21	10.25	YES	YES
800823	249.0	Circular	30	0.65	33801	33800	446.64	445.01	452.50	449.78	449.72	449.63	449.72	449.63	7.41	7.40		
800824	33.2	Circular	18	4.16	30628	33801	448.12	446.74	450.12	452.50	450.12	449.72	450.12	449.72	7.57	7.54		
801783	37.0	Circular	12	1.54	33800	42854	445.01	444.44	449.78	447.80	449.63	447.01	449.63	447.01	7.37	7.38		
802067	213.1	Circular	24	0.40	33531_SE_1300	33530	455.40	454.55	461.95	459.99	461.27	458.68	461.27	458.68	19.29	19.25		
802192	20.1	Circular	30	0.10	33899	40224	450.94	450.92	455.75	453.42	452.90	452.09	452.90	452.09	26.12	26.13		
802326	286.5	Circular	60	0.28	32462_SE_1200	34366	435.93	435.14	440.93	447.02	438.08	437.58	438.10	437.60	29.09	29.42		
802787	32.5	Circular	18	0.00	38962	38963	449.20	448.92	451.20	450.92	451.20	450.13	451.20	450.13	7.97	7.97		
803617	221.5	Circular	15	1.46	35517_SE_1400	33531_SE_1300	458.84	455.60	465.59	461.95	465.59	461.27	465.59	461.27	9.46	9.54		
807270	476.7	Circular	30	0.30	37785_SE_1000	33899	452.38	450.94	458.00	455.75	455.81	452.90	455.82	452.90	26.12	26.13		
807271	119.5	Circular	30	0.00	37787	37785_SE_1000	452.74	452.38	459.02	458.00	456.47	455.81	456.47	455.82	19.17	19.17		
808402	204.7	Trapezoidal	24	0.29	38973_SE_0800	39657	429.34	428.74	433.34	433.30	432.16	432.07	432.19	432.11	88.43	89.80		
808415	100.2	Trapezoidal	24	0.51	39658	42487	428.62	428.11	433.56	431.11	431.10	431.11	431.10	431.11	88.43	89.80	YES	YES
808417	58.9	Circular	36	4.16	42487	39582	428.11	425.66	431.11	428.66	431.11	426.68	431.11	426.68	31.29	31.29		
809300	116.5	Circular	15	1.52	33535_SE_1600	35517_SE_1400	460.81	459.04	468.36	465.59	468.36	465.59	468.36	465.59	7.84	7.84	YES	YES
809303	93.7	Circular	12	1.10	32769_SE_1500	33531_SE_1300	456.63	455.60	461.31	461.95	461.31	461.27	461.31	461.27	3.37	3.37		
809312	433.6	Circular	30	0.30	33530	37788	454.55	453.25	459.99	459.22	458.68	457.24	458.68	457.24	19.18	19.18		
809724	17.8	Circular	60	1.12	34366	34365_SE_1100	434.94	434.74	447.02	446.54	437.58	437.39	437.60	437.41	29.05	29.39		
Link20	166.2	Circular	30	0.31	37788	37787	453.25	452.74	459.22	459.02	457.24	456.47	457.24	456.47	19.18	19.17		
Link21	369.9	Circular	12	0.00	32798_SE_1000	34786	451.89	449.90	456.04	452.42	452.56	450.36	452.56	450.36	1.59	1.59		
Link23	84.9	Circular	12	1.68	34786	Node65	449.90	448.47	452.42	450.47	450.36	448.89	450.36	448.90	1.59	1.59		
Link24	92.2	Trapezoidal	24	1.68	Node65	Node66	448.47	446.92	450.47	448.92	448.72	447.77	448.72	447.77	1.59	1.59		
Link25	22.2	Circular	12	1.68	Node66	Node67	446.92	446.55	448.92	448.55	447.77	447.18	447.77	447.19	1.58	1.59		

Table A-4. Hydraulic Model Parameters and Results for 100-yr Storm

					Node Name		Invert Elevation (ft)		Ground Elevation (ft)		Existing Max Water		Future Max Water Surface		Max Flow (cfs)		Flooding at DS Node	
Link ID	Length (ft)	Shape	Diameter/Height (in)	Slope (%)	US	DS	US	DS	US	DS	US	DS	US	DS	Existing	Future	Existing	Future
Link26	85.9	Trapezoidal	24	1.68	Node67	Node68	446.55	445.11	448.55	447.11	447.18	447.11	447.19	447.11	4.97	5.04	YES	YES
Link31	156.4	Circular	12	6.03	42854	34365_SE_1100	444.37	434.94	447.80	446.54	447.01	437.39	447.01	437.41	7.52	7.52		
Link33	52.5	Circular	12	1.02	Node68	42854	445.11	444.57	447.11	447.80	447.11	447.01	447.11	447.01	1.31	1.32		
Link36	322.9	Circular	48	1.10	34761_SE_0900	38973_SE_0800	432.88	429.34	438.14	433.34	435.39	432.16	435.43	432.19	70.84	72.22		
Link37	207.7	Circular	54	0.24	34365_SE_1100	Node70	434.74	434.24	446.54	441.95	437.39	436.40	437.41	436.43	44.22	44.69		
Link38	172.0	Circular	54	0.56	Node70	34761_SE_0900	434.04	433.08	441.95	438.14	436.40	435.39	436.43	435.43	44.21	44.68		
Newell Creek Basin at Molalla Avenue and Beaver Creek Road																		
800688	160.5	Circular	48	3.51	34994	39666	417.02	411.38	430.02	415.38	418.99	412.82	418.99	412.83	69.66	69.78		
800690	39.8	Circular	12	1.66	34611	30023	423.69	423.03	429.34	430.16	429.34	426.35	429.34	426.36	6.61	6.61		
800854	442.7	Circular	42	0.82	39740_NE_1900	34616	433.01	429.39	436.51	436.91	433.44	430.07	433.44	430.08	2.71	2.77		
801962	148.0	Circular	15	3.87	34604	34603	438.50	432.77	441.90	437.52	439.41	435.81	439.41	435.82	6.99	6.99		
801965	205.9	Circular	15	0.43	34605_NE_3100	34604	439.49	438.60	444.01	441.90	443.16	439.66	443.16	439.66	7.00	7.00		
801981	230.0	Circular	18	1.54	30056_NE_3100	37259	435.30	431.75	439.36	433.77	436.14	432.53	436.14	432.53	6.13	6.13		
803140	168.1	Circular	42	0.78	30021	30023	424.29	422.98	431.51	430.16	427.70	426.35	427.72	426.36	55.86	55.99		
803172	61.7	Circular	12	0.66	30030_NE_2200	30027	426.11	425.70	434.39	433.37	434.39	432.70	434.39	432.70	4.79	4.79		
803176	159.5	Circular	12	0.92	30027	30025	425.53	424.07	433.37	430.71	432.70	429.57	432.70	429.57	4.76	4.78		
803179	78.3	Circular	12	0.57	30025	30024	423.92	423.47	430.71	430.26	429.57	427.54	429.57	427.54	4.75	4.76		
803180	27.5	Circular	12	0.87	30024	30023	423.45	423.21	430.26	430.16	427.54	426.35	427.54	426.36	4.75	4.76		
806619	6.3	Circular	48	0.00	37234	37235	426.45	426.45	433.20	433.20	429.49	429.49	429.50	429.51	-31.61	-31.97		
806620	267.8	Circular	42	0.68	37234	30021	426.45	424.63	433.20	431.51	429.49	427.70	429.50	427.72	55.90	56.04		
807452	59.3	Circular	12	-4.99	37903	37901	423.40	426.36	427.94	430.44	427.94	426.94	427.94	426.94	2.88	2.88		
807453	135.4	Circular	12	2.29	37238_NE_2200	37903	428.50	425.40	430.54	427.94	430.54	427.94	430.54	427.94	4.04	4.04	YES	YES
808393	446.8	Circular	42	0.81	39739_NE_1900	34615	432.99	429.39	436.49	436.91	434.95	431.08	434.99	431.11	39.39	40.37		
Link18	394.5	Circular	48	0.49	34615	41521	428.89	426.95	436.91	432.42	431.08	429.58	431.11	429.60	39.37	40.30		
Link19	82.1	Circular	48	0.49	41521	37235	426.95	426.55	432.42	433.20	429.58	429.49	429.60	429.51	46.39	47.31		
Link20	410.9	Circular	48	0.67	37235	34611	426.45	423.69	433.20	429.34	429.49	429.34	429.51	429.34	20.47	21.29	YES	YES
Link21	9.3	Circular	42	3.23	30023	Node35	423.03	422.73	430.16	429.89	426.35	424.60	426.36	424.60	66.78	66.90		
Link22	168.9	Circular	48	3.38	Node35	34994	422.73	417.02	429.89	430.02	424.60	418.99	424.60	418.99	69.66	69.78		
Link23	98.6	Circular	12	3.68	37901	Node35	426.36	422.73	430.44	429.89	426.94	424.60	426.94	424.60	2.88	2.88		
Link24	309.6	Circular	15	1.44	34603	42867	432.77	428.30	437.52	432.33	435.81	430.93	435.82	430.94	6.99	6.99		
Link25	45.0	Circular	15	2.77	42867	41521	428.20	426.95	432.33	432.42	430.93	429.58	430.94	429.60	6.99	6.99		
Link26	158.4	Circular	48	0.80	34616	35735_NE_1600	428.89	427.62	436.91	434.20	430.07	430.07	430.08	430.08	2.89	2.95		
Link27	203.9	Circular	48	0.34	35735_NE_1600	41522	427.62	426.93	434.20	432.04	430.07	429.78	430.08	429.80	23.95	24.08		
Link28	114.2	Circular	48	0.34	41522	37234	426.93	426.55	432.04	433.20	429.78	429.49	429.80	429.50	30.05	30.12		
Link29	85.4	Circular	15	5.64	37259	41522	431.75	426.93	433.77	432.04	432.53	429.78	432.53	429.80	6.12	6.12		

Figures



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-3.
Central Point Basin Hydraulic Model

- ▲ Modeled Outfall
- ● Modeled Nodes
- ◉ Flooding Nodes (25-yr)
- ■ Catch Basin
- ● Manhole
- ▲ Outfall
- ━ Modeled Conduit
- ━ Modeled Open Channel
- ━ Other Conduits
- ☐ Subbasins
- ─ River/Creek Drainage
- ⬚ City Limits

N
W E
S

0 200 400 800 1,200 Feet

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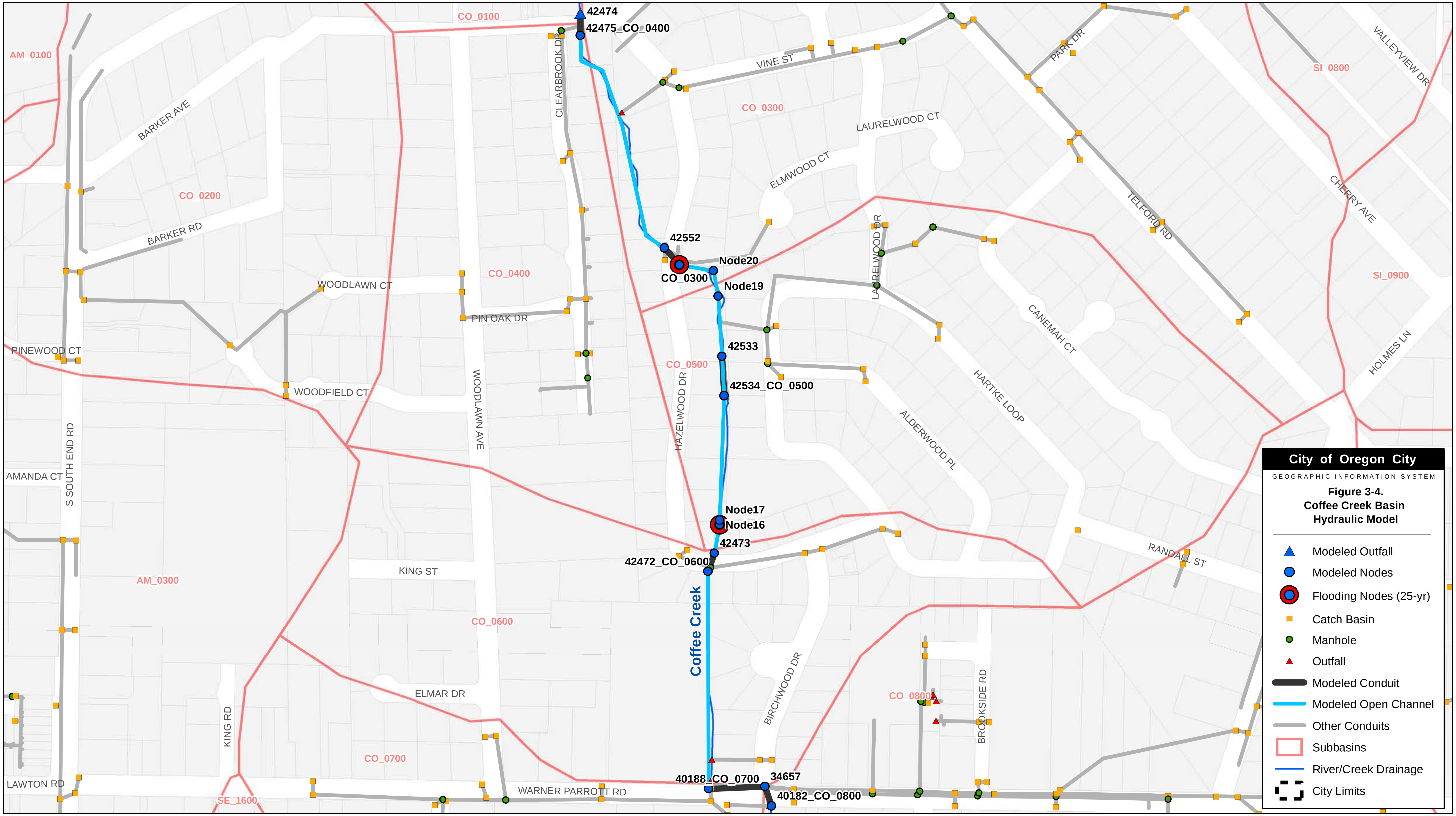
Plot date: June 20, 2017
Plot name: Figure 3-3 Central Point Basin.pdf
Map name: Figure 3-3 Central Point Basin.mxd



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-4.
Coffee Creek Basin
Hydraulic Model

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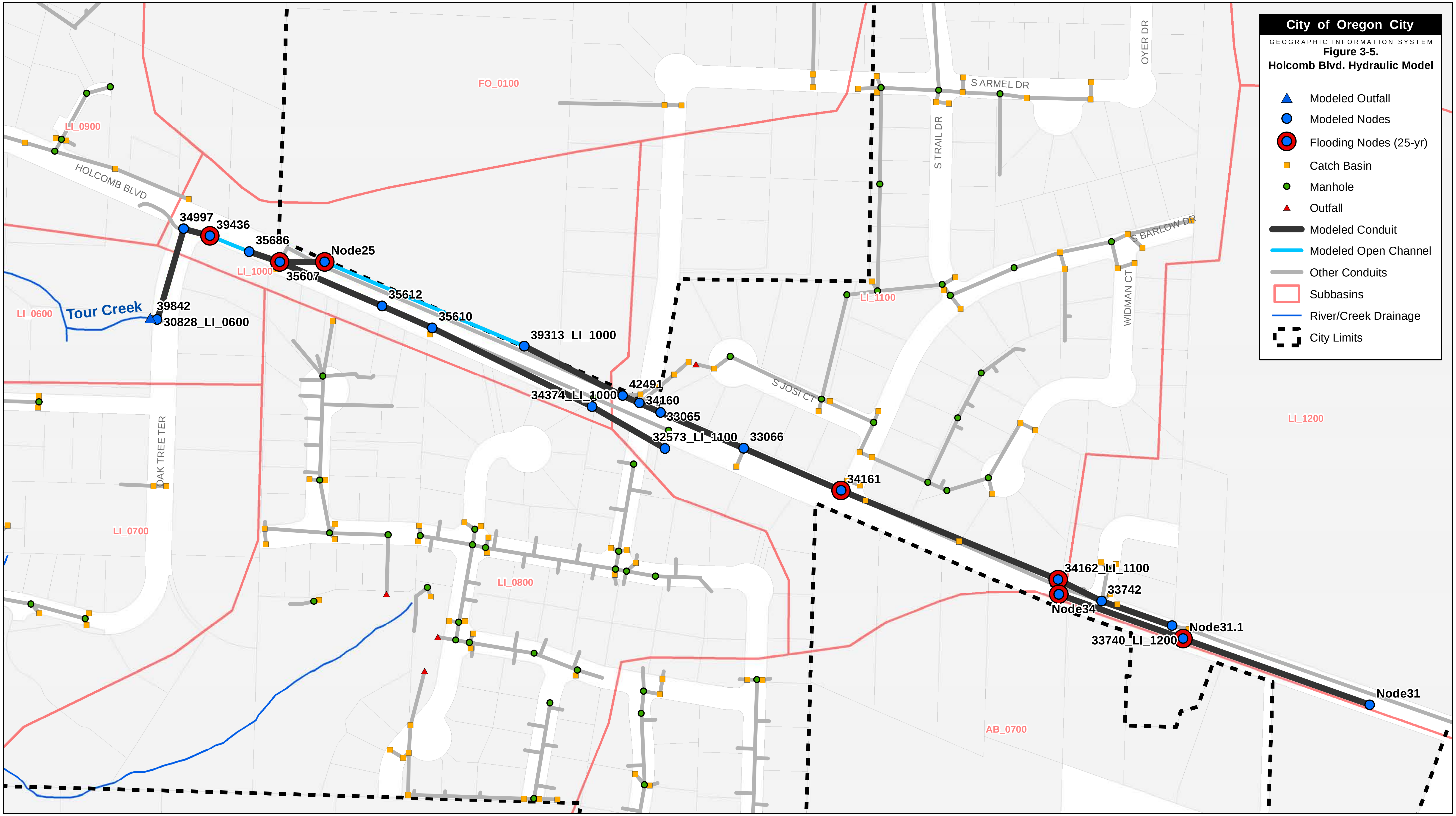
Plot date: June 20, 2017
Plot name: Figure 3-4 Coffee Creek Basin.pdf
Map name: Figure 3-4 Coffee Creek Basin.mxd



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GEOGRAPHIC INFORMATION SYSTEM

Figure 3-5.
Holcomb Blvd. Hydraulic Model

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Plot date: June 20, 2017
Plot name: Figure 3-5 Livesay Basin.pdf
Map name: Figure 3-5 Livesay Basin.mxd

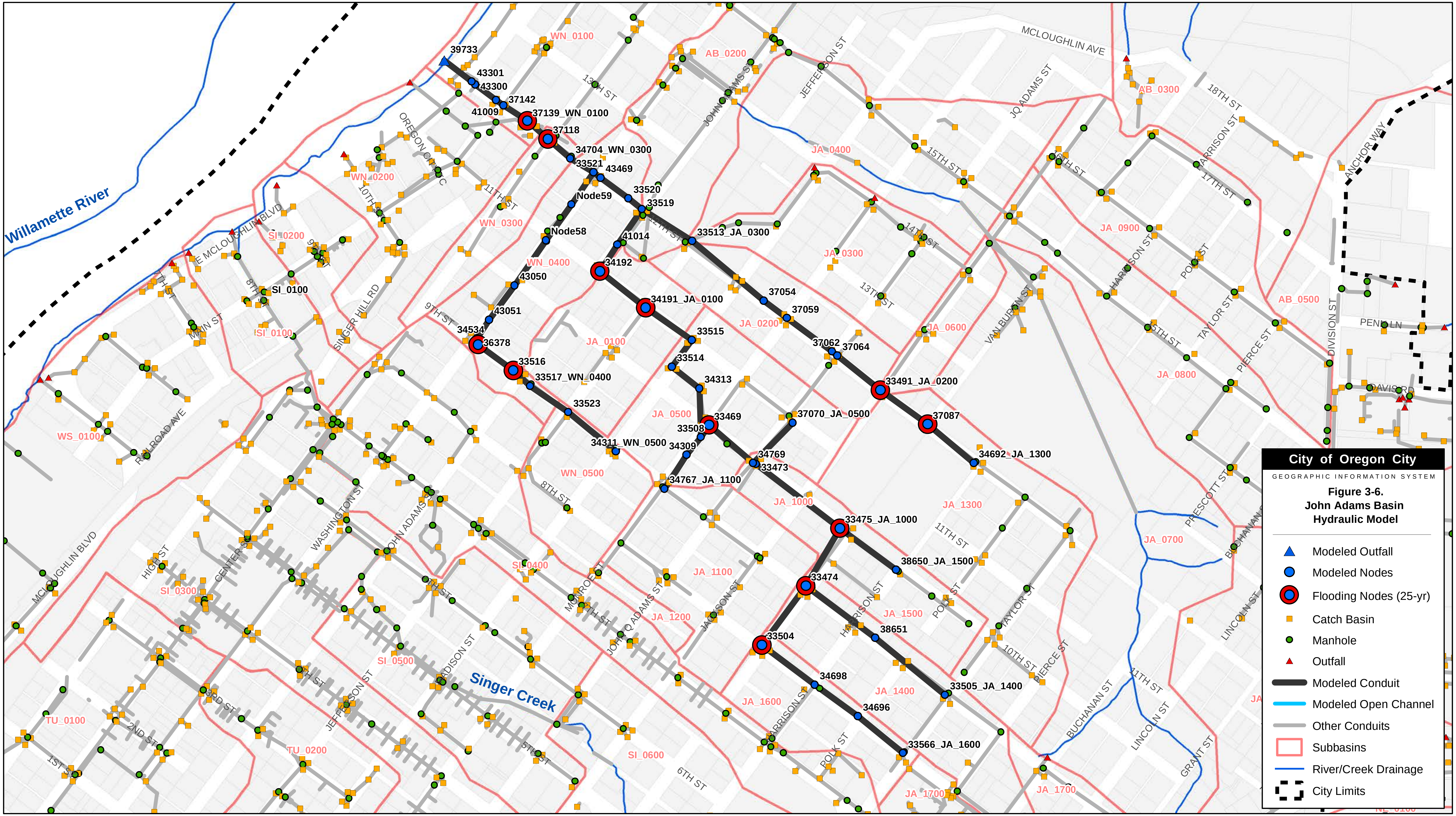
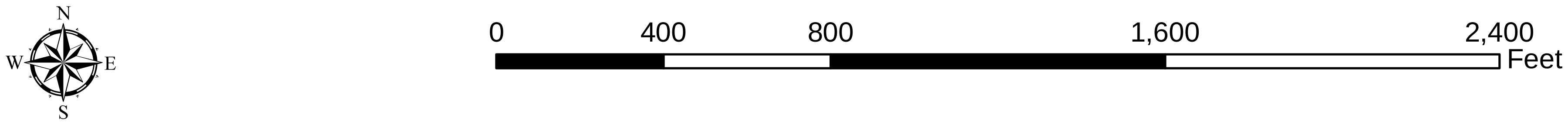


Figure 3-6.
John Adams Basin Hydraulic Model



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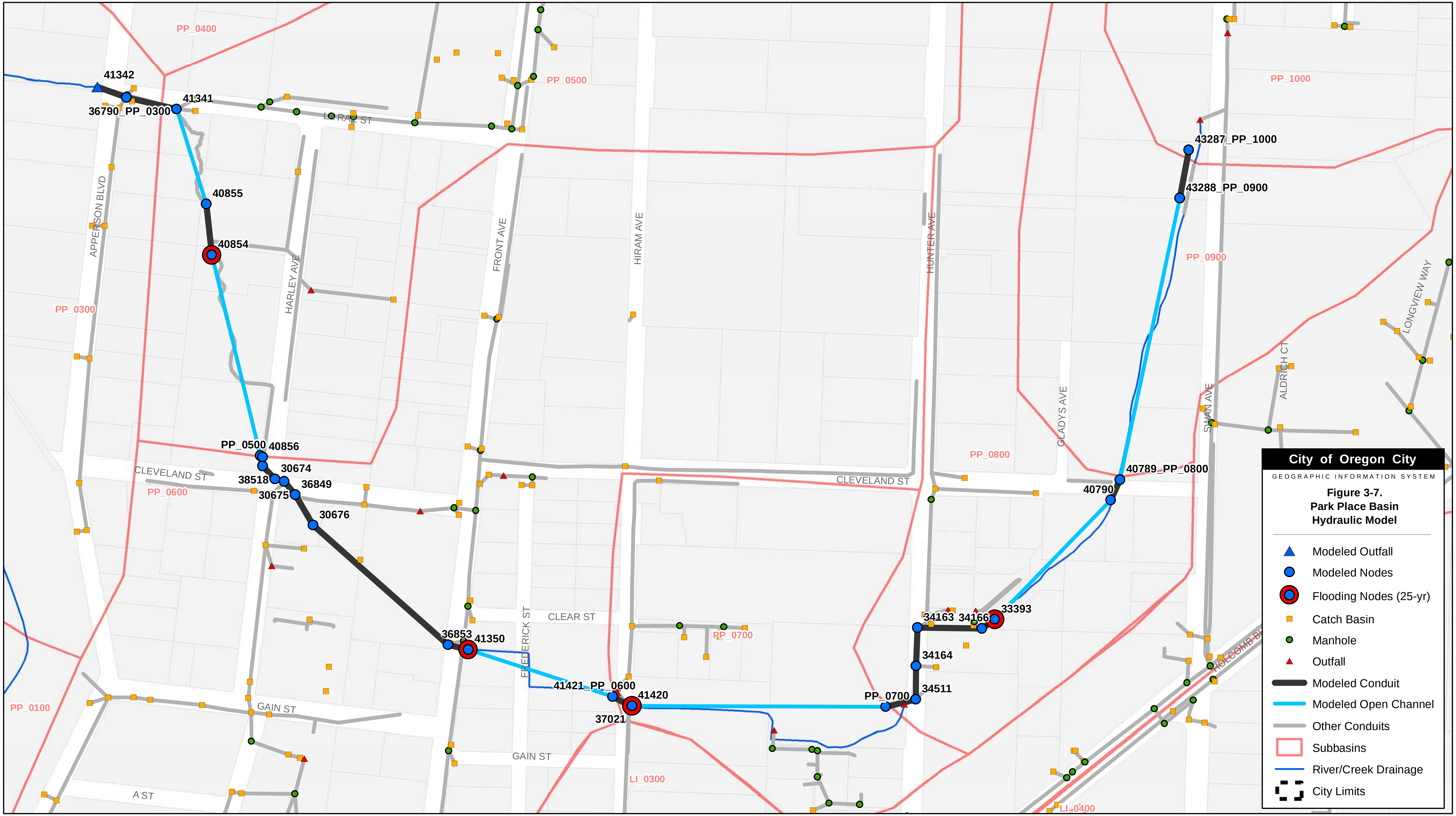
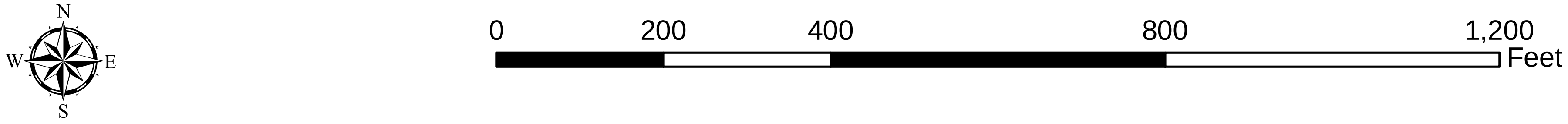
Plot date: June 22, 2017
Plot name: Figure 3-6 John Adams Basin.pdf
Map name: Figure 3-6 John Adams Basin.mxd



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-7.
Park Place Basin
Hydraulic Model



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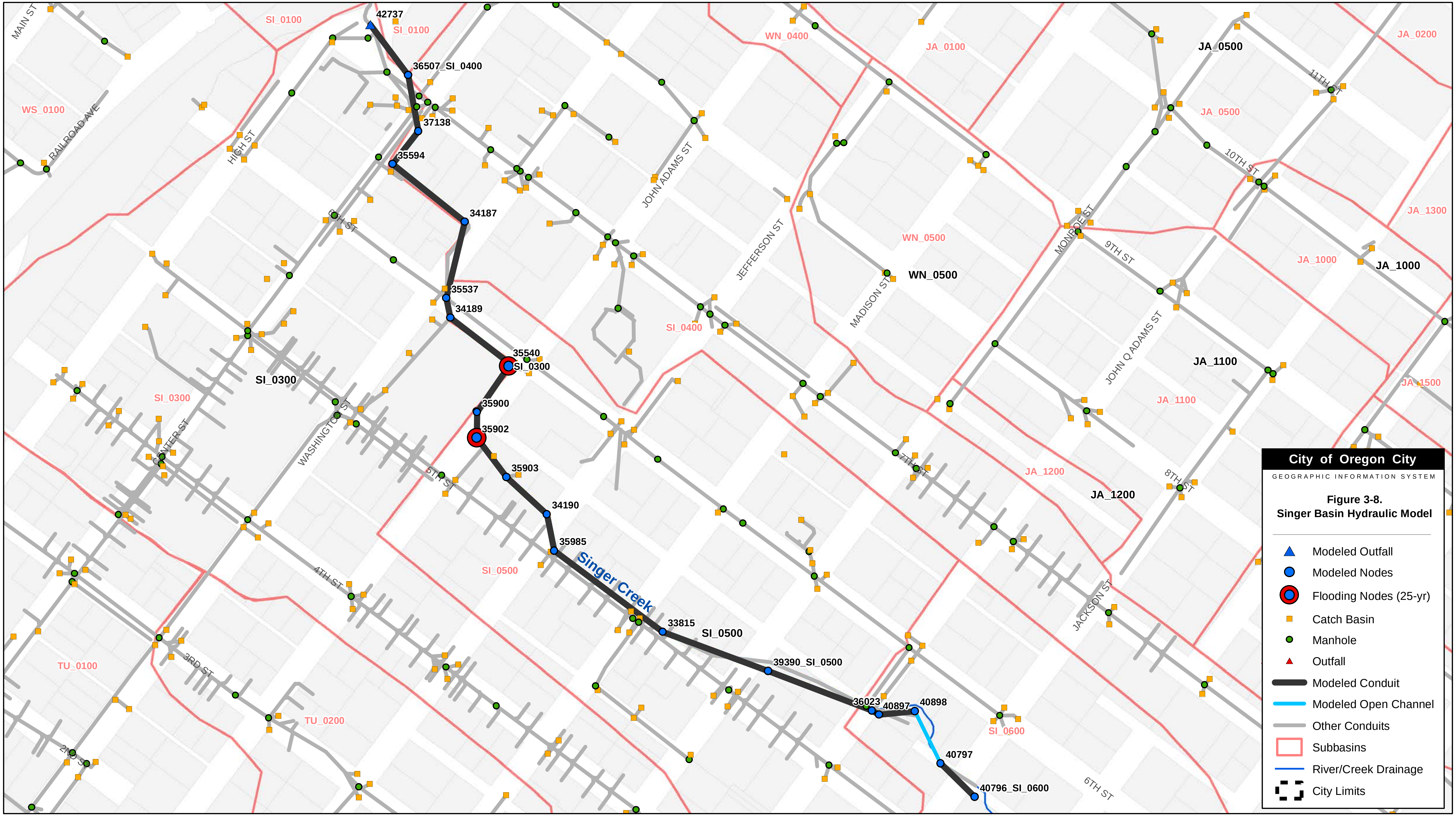
Plot date: June 20, 2017
Plot name: Figure 3-7 Park Placet Basin.pdf
Map name: Figure 3-7 Park Place Basin.mxd



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-8.
Singer Basin Hydraulic Model

N
W E
S

0 200 400 800 1,200
Feet

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Plot date: June 20, 2017
Plot name: Figure 3-8 Singer Basin.pdf
Map name: Figure 3-7 Singer Basin.mxd

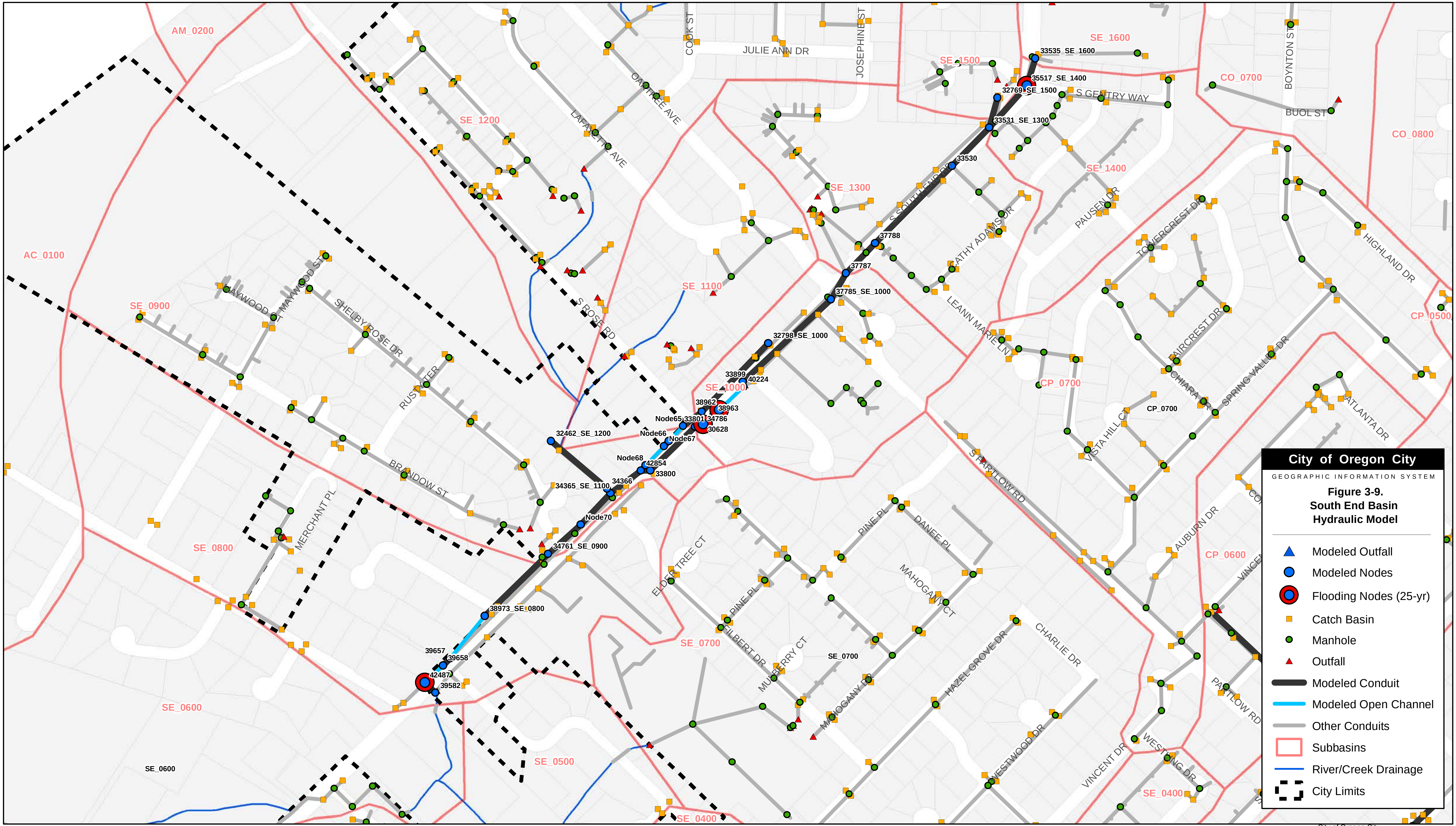

Figure 3-9.
South End Basin
Hydraulic Model

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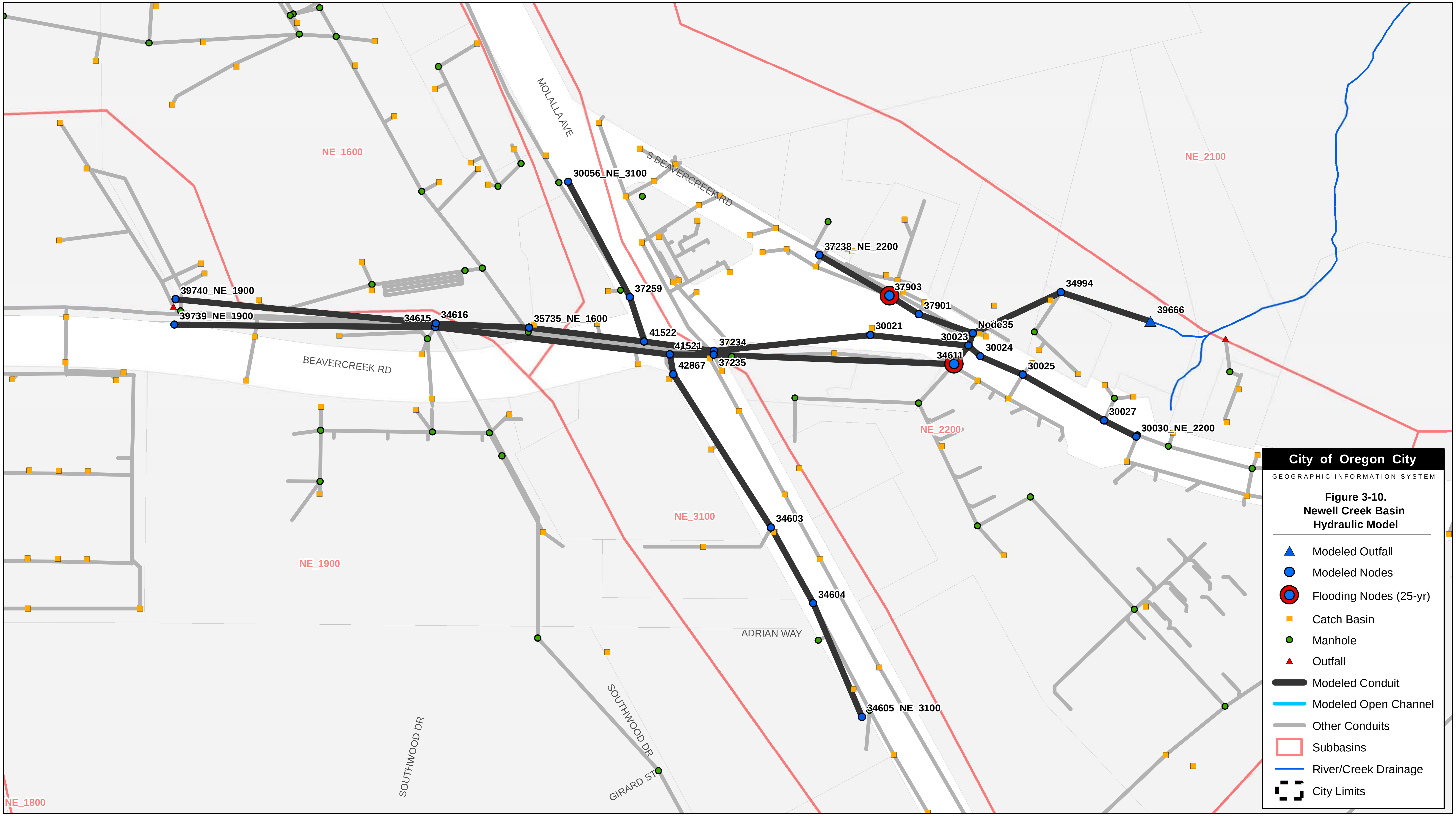
Plot date: June 20, 2017
Plot name: Figure 3-9 South End Basin.pdf
Map name: Figure 3-9 South End Basin.mxd



City of Oregon City

GEOGRAPHIC INFORMATION SYSTEM

Figure 3-10.
Newell Creek Basin Hydraulic Model

N
W E
S

0 150 300 600 900
Feet

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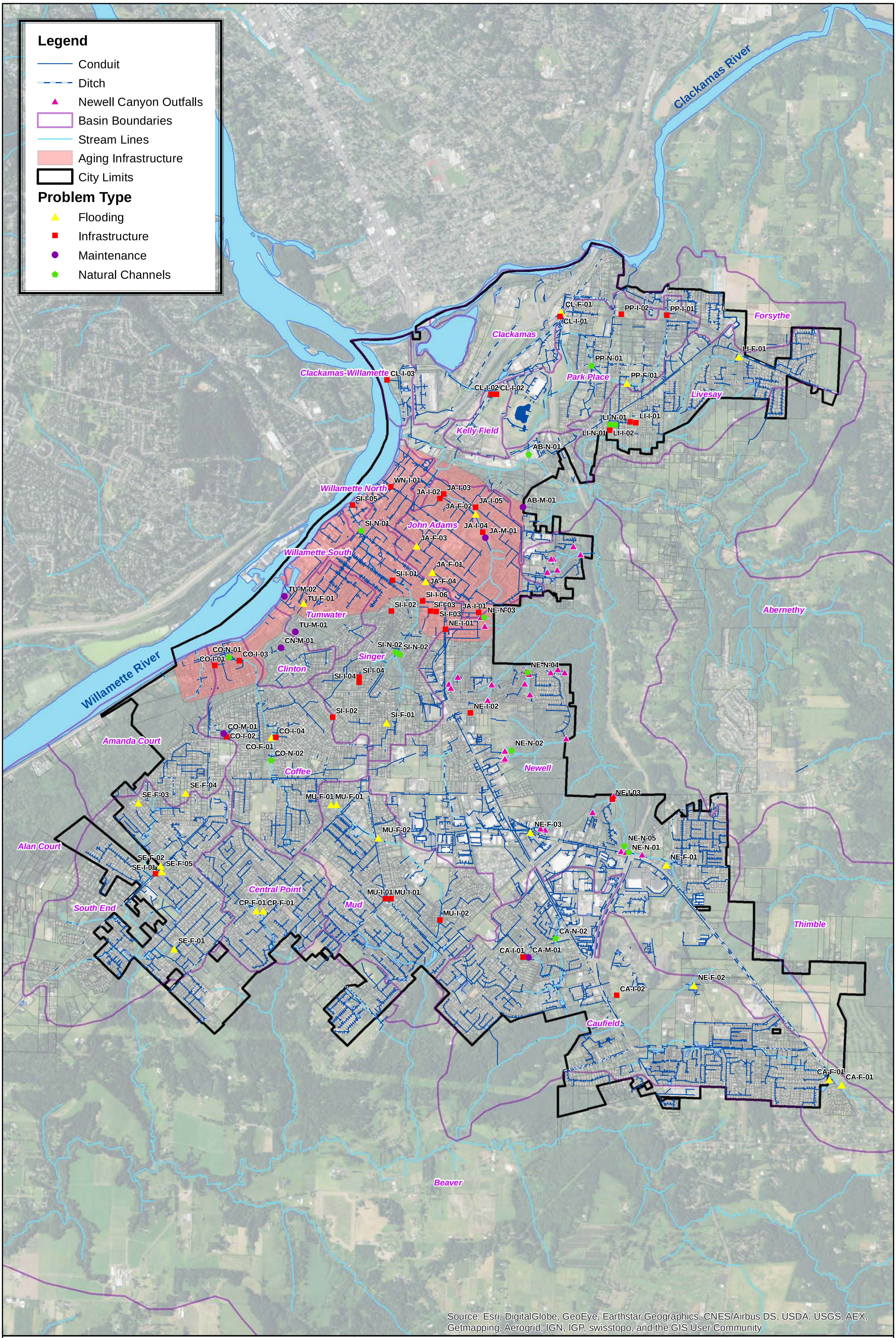
www.orcity.org

Plot date: June 20, 2017
Plot name: Figure 3-10 Newell Creek Basin.pdf
Map name: Figure 3-10 Newell Creek Basin.mxd



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Brown AND Caldwell

OREGON CITY

City of Oregon City
Stormwater Master Plan

Date: May 2017
Project:149133

Notes:
1. Projection: NAD 1983 State Plane Oregon North (feet)
2. Refer to Hydrology Tech Memo (Date 8/10/2016) for subbasin delineation

0 1,250 2,500 5,000 Feet

N

Figure 9

Problem Areas

Appendix D: Field Observation Photo Log

Appendix D

Field Observation Photo Log

Photographs and descriptions of the field investigation (by site) are provided on the following pages.

Waterbody:	**Park Place Creek (tributary to Abernethy)**
Reach description:	**13530 Redland Road (current dry weather monitoring location)**
Site locations:	**001**

Site location:	001
Photo number:	IMG_1461
Description:	Piped discharge from Abernethy Rd. to Park Place Creek at 13530 Redland Road.

Site location:	001
Photo number:	IMG_1455
Description:	Approximately 200’ downstream from photo IMG_1461. Silty bed sediment with large boulders. Unconsolidated bed material.

Site location:	001
Photo number:	IMG_1452
Description:	Overhead view of photo IMG_1455. Stormwater water quality testing site.

Waterbody:	**Unnamed tributary to Livesay Creek**
Reach description:	**Private property at 14040 Beemer Way**
Site locations:	**002**

Site location:	002
Photo number:	IMG_1442
Description:	Concrete outfall structure conveying discharge from Holcomb Road to creek. Evidence of channel incision and high flows with boulders in channel bed.

Site location:	002
Photo number:	IMG_1446
Description:	Side view of channel. Approximately 15' channel depth. Limited vegetation (ivy) along channel bank and side slopes.

Site location:	002
Photo number:	IMG_1450
Description:	Zoomed in view of eroding bank and exposed roots.

Waterbody:	**Newell Creek**
Reach description:	**Beavercreek Rd and Highway 213, west of Highway 213**
Site location:	**004**

Site location: 004

Photo number: IMG_1449

Description: Significant contributing flow from adjacent roadway and commercial development.

Site location: 004

Photo number: IMG_1501

Description: Significant bank erosion. City identified location as area of concern.

Site location:	004
Photo number:	IMG_1510
Description:	Approximately 30' downstream of outfalls; observed channel incision and exposed bedrock.

Site location:	004
Photo number:	IMG_1511
Description:	Approximately 50' downstream of outfalls facing downstream. Unknown concrete pipe visible in left portion of image. Cobbles and boulders in streambed.

Waterbody:	**Unnamed tributary to Newell Creek**
Reach description:	Intersection of Logus Street and Eluria Street (approximate address 613 Logus St.)
Site locations:	008

Site location:	008
Photo number:	IMG_1477
Description:	Spring/groundwater flowing into tributary. Bed appears stable with gravel and cobble.

Site location:	008
Photo number:	IMG_1470
Description:	Side view of channel. Southern (left) bank has minimal vegetation, indicative of ongoing erosion. Northern (right) bank contains established ivy.

Waterbody:	**Unnamed tributary to Newell Creek**
Reach description:	**17883 Peter Skene Way**
Site location:	**013**

Site location:	013
Photo number:	IMG_1482
Description:	Outfall from Peter Skeene Way

Site location:	013
Photo number:	IMG_1480
Description:	Downstream of outfall. Steep channel grade. City installed rip rap along channel segment

Site location: 013

Photo number: IMG_1483

Description: Approximately 50’ downstream from outfall. Channel deepens. Bed composed of cobble and boulders.

Site location: 013

Photo number: IMG_1486

Description: Bank along right side of channel visible in photo IMG_1483. Water seeping through soil causing heavy erosion.

Site location:	013
Photo number:	IMG_1487
Description:	Looking downstream from photo IMG_1486. Heavy vegetation along channel.

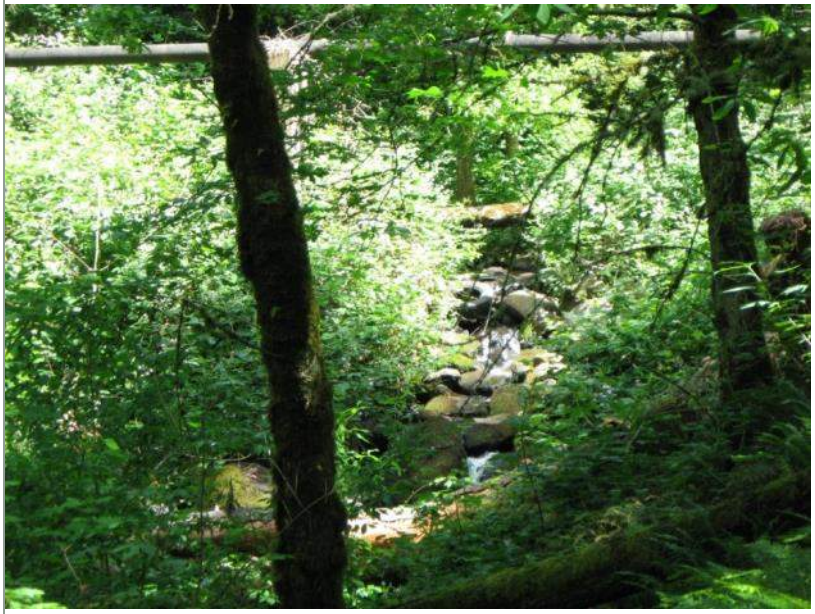
Waterbody:	**Tributary to Caufield Creek**
Reach description:	**South of Meyers Rd. near Trails End Market Place**
Site location:	**200**

Site location:	200
Photo number:	IMG_1519
Description:	Stream bed of tributary where it crosses access trail. Bed composed of cobble and boulders. Minimal erosion.

Site location:	200
Photo number:	IMG_1523
Description:	Approximately 40' upstream from photo IMG_1519. Stream flowing along access trail with minimal erosion. Bed has silty composition with some gravel and cobble.

Site location:	200
Photo number:	IMG_1529
Description:	Small pool located approximately 100’ upstream from IMG_1523. Stream bed is silt and gravel. Water is discharged from Trails End Market Place.

Waterbody:	**Caufield Creek**
Reach description:	**Downstream of 213**
Site location:	**201/202**

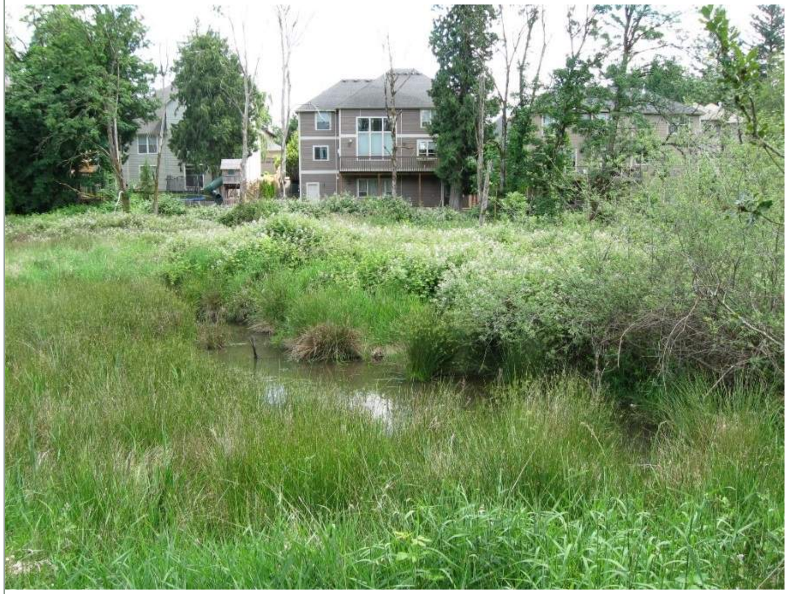


Site location:	201
Photo number:	IMG_1534
Description:	Streambed primarily boulders.

Site location:	202
Photo number:	IMG_1540
Description:	Caufield Creek approximately 1000' downstream from photo IMG_1449. Minimal incision/erosion.

Site location:	202
Photo number:	IMG_1542
Description:	Bridge crossing over Caufield Creek. Streambed composed of compacted silt with some gravel and cobble.

Waterbody:	**Mud Creek**
Reach description:	**Frontier Parkway near pump station**
Site location:	**203**



Site location: 203

Photo number: IMG_1555

Description: Natural pond formed from beaver activity and downed vegetation. Provides flow control along Mud Creek.

Site location: 203

Photo number: IMG_1553

Description: Dense vegetation along pond composed of tall grasses, bushes, and blackberries.

Waterbody:	**Tributary to Beaver Creek**
Reach description:	**Orchard Grove Drive**
Site location:	**204**

Site location: 204

Photo number: IMG_1557

Description: Smaller Pond and inlet on private property at South McCord Road and Orchard Grove Drive

Site location: 204

Photo number: IMG_1559

Description: Larger pond on City property. Pond collecting sediment and filling in. Major maintenance overhaul may be required.

Waterbody:	**Coffee Creek**
Reach description:	**Hazelwood Drive**
Site location:	**205**

Site location: 205

Photo number: IMG_1562

Description: Ditch in Chapin City Park. No erosion visible.

Site location: 206

Photo number: IMG_1572

Description: 36" outfall to open ditch north of Warner Parrot Road.

Site location: 205

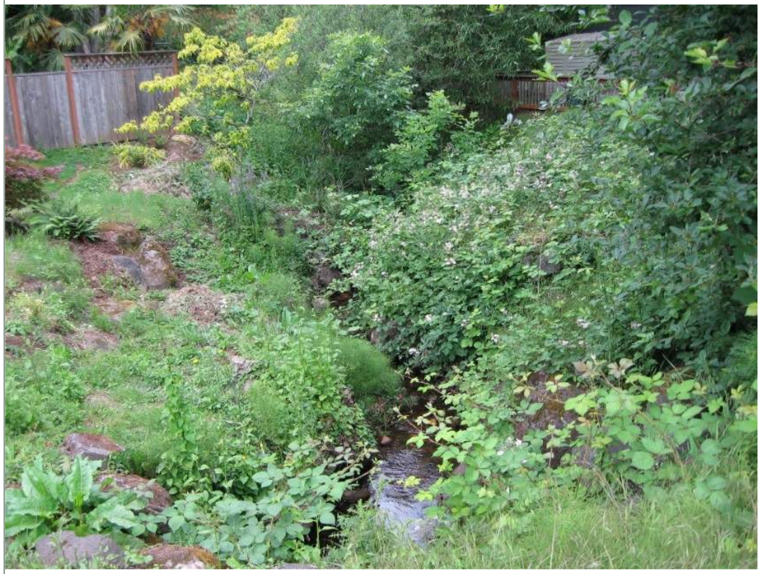
Photo number: IMG_1574

Description: Open channel near 1013 Hazelwood Drive. Channel bed formed of large rocks. No incision/erosion.

Site location: 205

Photo number: IMG_1575

Description: Coffee Creek channel just east of crossing with Hazelwood Drive at 939 Hazelwood Drive. This location is just downstream of natural spring that contributes base flow to Coffee Creek year-round. Creek bed in this location composed of large boulders.



Site location:	205
Photo number:	IMG_1580
Description:	Approximately 50' downstream of IMG_1574. Silty bed with large boulders. Minimal erosion.

Site location:	205
Photo number:	IMG_1581
Description:	Coffee Creek near 418 Barker Avenue. Streambed composed of silt, rocks, and boulders. Minor incision evident.

Waterbody:	**Singer Creek**
Reach description:	**Singer Creek Park**
Site location:	**206**

Site location:	206
Photo number:	IMG_1594
Description:	Deep channel (10-15'). Soil along western (left) bank has slid off into creek. Abandoned water line visible in image.

Site location:	206
Photo number:	IMG_1591
Description:	Silt, gravel, and cobble in streambed.

Site location:	206
Photo number:	IMG_1600
Description:	Streambed 100' upstream of IMG_1591. Primarily gravel. Minimal erosion/incision.

Appendix E: Stream Channel Observation Forms

Channel Stability Observation Form

Water Body:	Park Place Creek	**Date:**	5/24/16
Site/Location:	13530 Redland Rd. #001	**Time:**	9AM
		Crew:	GJ, JP, AM, MG
Photos:		**Weather:**	SUN
Channel Size:	4' wide	**Observed problems:**	A. Flooding B. Degradation C. Bank Erosion D. Lack of Vegetation E. Sediment Loads
Channel Pattern:	Meandering [✓ Straight] Braided Channelized/Altered		

A. Flooding

Describe observed/known flooding problems:	N/A

B. Degradation/Bed Incision

Primary Bed Material:	Bedrock Boulders Cobbles Gravel Sand [✓ Silt] Clay	
Degree of incision*	0-25% 26-50% 51-75% [✓ 76-100%]	
Exposed Roots	None [✓ Mild] Moderate Severe	
Head cutting or nick points	Describe: Naturally stabilized	

C. Bank Erosion/Widening

Primary Bank Materials	Bedrock Boulders Gravel/Sand [✓ Silt/Clay]	
Bank Protection	[✓ None] Left Bank Right Bank	
Streambank Erosion	Left Bank: [✓ None] Fluvial Mass Wasting	No widening from 2015
	Right Bank: [✓ None] Fluvial Mass Wasting	
Streambank Instability (% each bank failing)	Left Bank: [✓ 0-25%] 26-50% 51-75% 76-100%	
	Right Bank: [✓ 0-25%] 26-50% 51-75% 76-100%	
Vegetation Impacts	Exposed Roots Leaning Trees J-shaped Trees	N/A

D. Lack of Vegetation

Established riparian woody-vegetative cover	Left Bank: 0-25% 26-50% [✓ 51-75%] 76-100%	Bushes/Invasives
	Right Bank: 0-25% 26-50% [✓ 51-75%] 76-100%	

E. Sediment Loads

Aggradation	☐ Fresh sediment deposition: channel bar near structure overbank ☒ Unconsolidated bed ☐ Embedded Cobbles
Turbidity/ Siltation	Describe: Lots of silt

Other

Known or observed problems **Unique features** **Field notes**	Minimal change from 2015. Appears stable. No project required.

* Degree of incision = relative elevation of the "normal" low water compared to the floodplain/terrace. Normal water equal to the floodplain/terrace represents 100%.

Channel Stability Observation Form

Water Body:	Livesay Creek	Date:	5/24/16
Site/Location:	Outfall @ 14040 Beemer Way #002	Time:	230 AM
		Crew:	GJ, JP, AM, MG, JA
Photos:		Weather:	SUN
Channel Size:	Deep Ravine (20' deep × 5' Wide)	Observed problems:	A. Flooding [✓ B. Degradation] [✓ C. Bank Erosion] D. Lack of Vegetation E. Sediment Loads
Channel Pattern:	[✓ Meandering] Straight Braided Channelized/Altered		

A. Flooding

Describe observed/known flooding problems:	N/A

B. Degradation/Bed Incision

Primary Bed Material:	Bedrock [✓ Boulders] Cobbles [✓ Gravel] Sand [✓ Silt] Clay
Degree of incision*	0-25% 26-50% 51-75% [✓ 76-100%]
Exposed Roots	None Mild Moderate [✓ Severe]
Head cutting or nick points	Describe: Concrete outfall for protection

C. Bank Erosion/Widening

Primary Bank Materials	Bedrock [✓ Boulders] [✓ Gravel/Sand] [✓ Silt/Clay]
Bank Protection	[✓ None] Left Bank Right Bank
Streambank Erosion	Left Bank: [✓ None] Fluvial Mass Wasting
	Right Bank: None Fluvial [✓ Mass Wasting]
Streambank Instability (% each bank failing)	Left Bank: [✓ 0-25%] 26-50% 51-75% 76-100%
	Right Bank: 0-25% 26-50% [✓ 51-75%] 76-100%
Vegetation Impacts	[✓ Exposed Roots] [✓ Leaning Trees] J-shaped Trees

D. Lack of Vegetation

Established riparian woody-vegetative cover	Left Bank: 0-25% 26-50% 51-75% [✓ 76-100%]
	Right Bank: 0-25% 26-50% 51-75% [✓ 76-100%]

E. Sediment Loads

Aggradation	☐ Fresh sediment deposition: channel bar near structure overbank ☐ Unconsolidated bed ☐ Embedded Cobbles N/A
Turbidity/ Siltation	Describe: N/A

Other

Known or observed problems Unique features Field notes	Heavy erosion on right bank unchanged from 2015, Tree growth in channel indicates stream stabilization.

* Degree of incision = relative elevation of the "normal" low water compared to the floodplain/terrace. Normal water equal to the floodplain/terrace represents 100%.

Channel Stability Observation Form

Water Body:	Newell Creek	**Date:**	5/24/16
Site/Location:	Beavercreek Rd/ Hwy 213 #004	**Time:**	10 AM
		Crew:	GJ, JP, AM, MG, JA
Photos:		**Weather:**	SUN
Channel Size:	4-10' wide	**Observed problems:**	A. Flooding [✓ B. Degradation] [✓ C. Bank Erosion] D. Lack of Vegetation E. Sediment Loads
Channel Pattern:	[✓ Meandering] Straight Braided Channelized/Altered		

A. Flooding

Describe observed/known flooding problems:	N/A

B. Degradation/Bed Incision

Primary Bed Material:	Bedrock	[✓ Boulders]	[✓ Cobbles]	[✓ Gravel]	Sand	Silt	Clay
Degree of incision*	0-25%	26-50%	[✓ 51-75%]	76-100%			
Exposed Roots	None	Mild	Moderate	[✓ Severe]			
Head cutting or nick points	Describe: Major headcutting + nick points @ outfall						

C. Bank Erosion/Widening

Primary Bank Materials	Bedrock	[✓ Boulders]	Gravel/Sand	Silt/Clay	
Bank Protection	[✓ None]	Left Bank	Right Bank		
Streambank Erosion	Left Bank:	None	Fluvial	[✓ Mass Wasting]	Only @ outfall
	Right Bank:	None	Fluvial	[✓ Mass Wasting]	
Streambank Instability (% each bank failing)	Left Bank:	[✓ 0-25%]	26-50%	51-75%	76-100%
	Right Bank:	[✓ 0-25%]	26-50%	51-75%	76-100%
Vegetation Impacts	[✓ Exposed Roots]	[✓ Leaning Trees]	J-shaped Trees		

D. Lack of Vegetation

Established riparian woody-vegetative cover	Left Bank:	0-25%	26-50%	51-75%	[✓ 76-100%]	ds of outfall
	Right Bank:	0-25%	26-50%	51-75%	[✓ 76-100%]	

E. Sediment Loads

Aggradation	☐ Fresh sediment deposition: channel bar near structure overbank ☐ Unconsolidated bed ☐ Embedded Cobbles N/A
Turbidity/ Siltation	Describe: N/A

Other

Known or observed problems **Unique features** **Field notes**	still major wash out @ outfall, possibly worse than 2015. Cracks in concrete retaining walls above outfalls, City to coordinate with ODOT.

* Degree of incision = relative elevation of the "normal" low water compared to the floodplain/terrace. Normal water equal to the floodplain/terrace represents 100%.

Brown and Caldwell

Channel Stability Observation Form

Water Body:	Tributary to Newell Creek	**Date:**	5/24/16
Site/Location:	Elvira St. near 613 Locust St. #008	**Time:**	11 AM
		Crew:	GJ, JP, AM, MG, JA
Photos:		**Weather:**	Sun
Channel Size:	3-5' wide, 3' deep low flow	**Observed problems:**	A. Flooding [✓ B. Degradation] [✓ C. Bank Erosion] D. Lack of Vegetation E. Sediment Loads
Channel Pattern:	[✓ Meandering] Straight Braided Channelized/Altered		

A. Flooding	
Describe observed/known flooding problems:	N/A
B. Degradation/Bed Incision	
Primary Bed Material:	Bedrock Boulders Cobbles [✓ Gravel] [✓ Sand] Silt Clay
Degree of incision*	0-25% 26-50% [✓ 51-75%] 76-100%
Exposed Roots	None [✓ Mild] Moderate Severe
Head cutting or nick points	Describe: Minor @ outfall
C. Bank Erosion/Widening	
Primary Bank Materials	Bedrock Boulders Gravel/Sand [✓ Silt/Clay]
Bank Protection	[✓ None] Left Bank Right Bank
Streambank Erosion	Left Bank: None [✓ Fluvial] Mass Wasting Right Bank: None [✓ Fluvial] Mass Wasting
Streambank Instability (% each bank failing)	Left Bank: 0-25% 26-50% [✓ 51-75%] 76-100% ← more erosion than 2015 Right Bank: 0-25% [✓ 26-50%] 51-75% 76-100%
Vegetation Impacts	Exposed Roots Leaning Trees J-shaped Trees N/A
D. Lack of Vegetation	
Established riparian woody-vegetative cover	Left Bank: 0-25% 26-50% 51-75% [✓ 76-100%] Ivy & Ferns Right Bank: 0-25% 26-50% 51-75% [✓ 76-100%]
E. Sediment Loads	
Aggradation	☐ Fresh sediment deposition: channel bar near structure overbank ☐ Unconsolidated bed ☐ Embedded Cobbles N/A
Turbidity/ Siltation	Describe:
Other	
Known or observed problems **Unique features** **Field notes**	Minor changes (more incision/erosion) compared to 2015. Private properties use tarps for stabilization.

* Degree of incision = relative elevation of the "normal" low water compared to the floodplain/terrace. Normal water equal to the floodplain/terrace represents 100%.

Channel Stability Observation Form

Water Body:	Tributary to Newell Cr.	**Date:**	5/24/16
Site/Location:	17883 Peter Skene Way #013	**Time:**	1130AM
		Crew:	GJ, JP, AM, MG, JA
Photos:		**Weather:**	SUN
Channel Size:	3'-5' wide 2-3' deep	**Observed problems:**	A. Flooding [✓ B. Degradation] [✓ C. Bank Erosion] D. Lack of Vegetation E. Sediment Loads
Channel Pattern:	[✓ Meandering] < ds of riprap Straight Braided [✓ Channelized/Altered] culverts/riprap added to stabilize		

A. Flooding

Describe observed/known flooding problems:	N/A

B. Degradation/Bed Incision

Primary Bed Material:	Bedrock Boulders Cobbles Gravel Sand [✓ Silt] ← downstream Clay riprap u.s.
Degree of incision*	0-25% 26-50% [✓ 51-75%] 76-100%
Exposed Roots	None [✓ Mild] Moderate Severe
Head cutting or nick points	Describe: u.s. portion stabilized w/ riprap

C. Bank Erosion/Widening

Primary Bank Materials	Bedrock Boulders Gravel/Sand [✓ Silt/Clay]
Bank Protection	[✓ None] Left Bank Right Bank
Streambank Erosion	Left Bank: None [✓ Fluvial] Mass Wasting Right Bank: None [✓ Fluvial] Mass Wasting
Streambank Instability (% each bank failing)	Left Bank: 0-25% 26-50% [✓ 51-75%] 76-100% Right Bank: 0-25% 26-50% [✓ 51-75%] 76-100% ← due to seepage from uphill stormwater facility
Vegetation Impacts	Exposed Roots Leaning Trees J-shaped Trees

D. Lack of Vegetation

Established riparian woody-vegetative cover	Left Bank: 0-25% 26-50% 51-75% [✓ 76-100%] Right Bank: 0-25% 26-50% 51-75% [✓ 76-100%] Heavy vegetation d.s. of rip-rap

E. Sediment Loads

Aggradation	☐ Fresh sediment deposition: channel bar near structure overbank ☐ Unconsolidated bed ☐ Embedded Cobbles N/A
Turbidity/ Siltation	Describe:

Other

Known or observed problems **Unique features** **Field notes**	Incision increases downstream of rip rap. Observable changes from 2015. Needs stabilization project.

* Degree of incision = relative elevation of the "normal" low water compared to the floodplain/terrace. Normal water equal to the floodplain/terrace represents 100%.

Channel Stability Observation Form

Water Body:	Tributary to Caufield Creek	**Date:**	5/24/16
Site/Location:	S. Meyers Rd. near Trails End Market Place #200	**Time:**	1 PM
		Crew:	GJ, JP, AM, MG
Photos:		**Weather:**	SUN
Channel Size:	2'-3' wide 6" deep	**Observed problems:**	A. Flooding B. Degradation C. Bank Erosion D. Lack of Vegetation E. Sediment Loads
Channel Pattern:	[✓ Meandering] Straight Braided Channelized/Altered		

A. Flooding

Describe observed/known flooding problems:	N/A

B. Degradation/Bed Incision

Primary Bed Material:	Bedrock [✓ Boulders] [✓ Cobbles] Gravel Sand [✓ Silt] Clay
Degree of incision*	[✓ 0-25%] 26-50% 51-75% 76-100%
Exposed Roots	None [✓ Mild] Moderate Severe
Head cutting or nick points	Describe: None

C. Bank Erosion/Widening

Primary Bank Materials	Bedrock Boulders Gravel/Sand [✓ Silt/Clay]
Bank Protection	[✓ None] Left Bank Right Bank
Streambank Erosion	Left Bank: [✓ None] Fluvial Mass Wasting Right Bank: [✓ None] Fluvial Mass Wasting
Streambank Instability (% each bank failing)	Left Bank: [✓ 0-25%] 26-50% 51-75% 76-100% Right Bank: [✓ 0-25%] 26-50% 51-75% 76-100%
Vegetation Impacts	Exposed Roots Leaning Trees J-shaped Trees N/A

D. Lack of Vegetation

Established riparian woody-vegetative cover	Left Bank: 0-25% 26-50% 51-75% [✓ 76-100%] Right Bank: 0-25% 26-50% 51-75% [✓ 76-100%]

E. Sediment Loads

Aggradation	☐ Fresh sediment deposition: channel bar near structure overbank ☐ Unconsolidated bed ☐ Embedded Cobbles N/A
Turbidity/ Siltation	Describe: N/A

Other

Known or observed problems **Unique features** **Field notes**	No incision or erosion observed.

* Degree of incision = relative elevation of the "normal" low water compared to the floodplain/terrace. Normal water equal to the floodplain/terrace represents 100%.

Channel Stability Observation Form

Water Body:	Canfield Creek	**Date:**	8/24/16
Site/Location:	Downstream of Hwy 213 #201/202	**Time:**	2 PM
		Crew:	GJ, JP, AM, MG
Photos:		**Weather:**	SUN
Channel Size:	6'-8' wide 2'-3' deep	**Observed problems:**	A. Flooding B. Degradation C. Bank Erosion D. Lack of Vegetation E. Sediment Loads
Channel Pattern:	[✓ Meandering] Straight Braided Channelized/Altered		

A. Flooding

Describe observed/known flooding problems:	N/A

B. Degradation/Bed Incision

Primary Bed Material:	Bedrock [✓ Boulders] [✓ Cobbles] Gravel Sand [✓ Silt] Clay
Degree of incision*	[✓ 0-25%] 26-50% 51-75% 76-100%
Exposed Roots	None [✓ Mild] Moderate Severe
Head cutting or nick points	Describe: N/A

C. Bank Erosion/Widening

Primary Bank Materials	Bedrock Boulders Gravel/Sand [✓ Silt/Clay]
Bank Protection	[✓ None] Left Bank Right Bank
Streambank Erosion	Left Bank: [✓ None] Fluvial Mass Wasting
	Right Bank: None [✓ Fluvial] Mass Wasting
Streambank Instability (% each bank failing)	Left Bank: [✓ 0-25%] 26-50% 51-75% 76-100%
	Right Bank: [✓ 0-25%] 26-50% 51-75% 76-100% ← Minor erosion
Vegetation Impacts	Exposed Roots Leaning Trees J-shaped Trees N/A

D. Lack of Vegetation

Established riparian woody-vegetative cover	Left Bank: 0-25% 26-50% 51-75% [✓ 76-100%]
	Right Bank: 0-25% 26-50% 51-75% [✓ 76-100%]

E. Sediment Loads

Aggradation	☐ Fresh sediment deposition: channel bar near structure overbank ☐ Unconsolidated bed ☐ Embedded Cobbles N/A
Turbidity/ Siltation	Describe: N/A

Other

Known or observed problems **Unique features** **Field notes**	Very minor erosion observed

* Degree of incision = relative elevation of the "normal" low water compared to the floodplain/terrace. Normal water equal to the floodplain/terrace represents 100%.

Channel Stability Observation Form

Water Body:	Mud Creek	**Date:**	5/24/16
Site/Location:	Frontier Parkway @ pump station #203	**Time:**	230 PM
		Crew:	GJ, JP, AM, MG
Photos:		**Weather:**	SUN
Channel Size:	Main channel ~5' wide	**Observed problems:**	A. Flooding B. Degradation C. Bank Erosion D. Lack of Vegetation E. Sediment Loads
Channel Pattern:	[✓ Meandering] Straight Braided Channelized/Altered		

A. Flooding

Describe observed/known flooding problems:	N/A

B. Degradation/Bed Incision

Primary Bed Material:	Bedrock	Boulders	Cobbles	Gravel	Sand	[✓ Silt]	Clay
Degree of incision*	[✓ 0-25%]	26-50%	51-75%	76-100%			
Exposed Roots	[✓ None]	Mild	Moderate	Severe			
Head cutting or nick points	Describe: N/A						

C. Bank Erosion/Widening

Primary Bank Materials	Bedrock	Boulders	Gravel/Sand	[✓ Silt/Clay]	
Bank Protection	[✓ None]	Left Bank	Right Bank		
Streambank Erosion	Left Bank:	[✓ None]	Fluvial	Mass Wasting	
	Right Bank:	[✓ None]	Fluvial	Mass Wasting	
Streambank Instability (% each bank failing)	Left Bank:	[✓ 0-25%]	26-50%	51-75%	76-100%
	Right Bank:	[✓ 0-25%]	26-50%	51-75%	76-100%
Vegetation Impacts	Exposed Roots	Leaning Trees	J-shaped Trees	N/A	

D. Lack of Vegetation

Established riparian woody-vegetative cover	Left Bank:	0-25%	26-50%	51-75%	[✓ 76-100%]	Blackberry bushes,
	Right Bank:	0-25%	26-50%	51-75%	[✓ 76-100%]	tall grasses, reeds

E. Sediment Loads

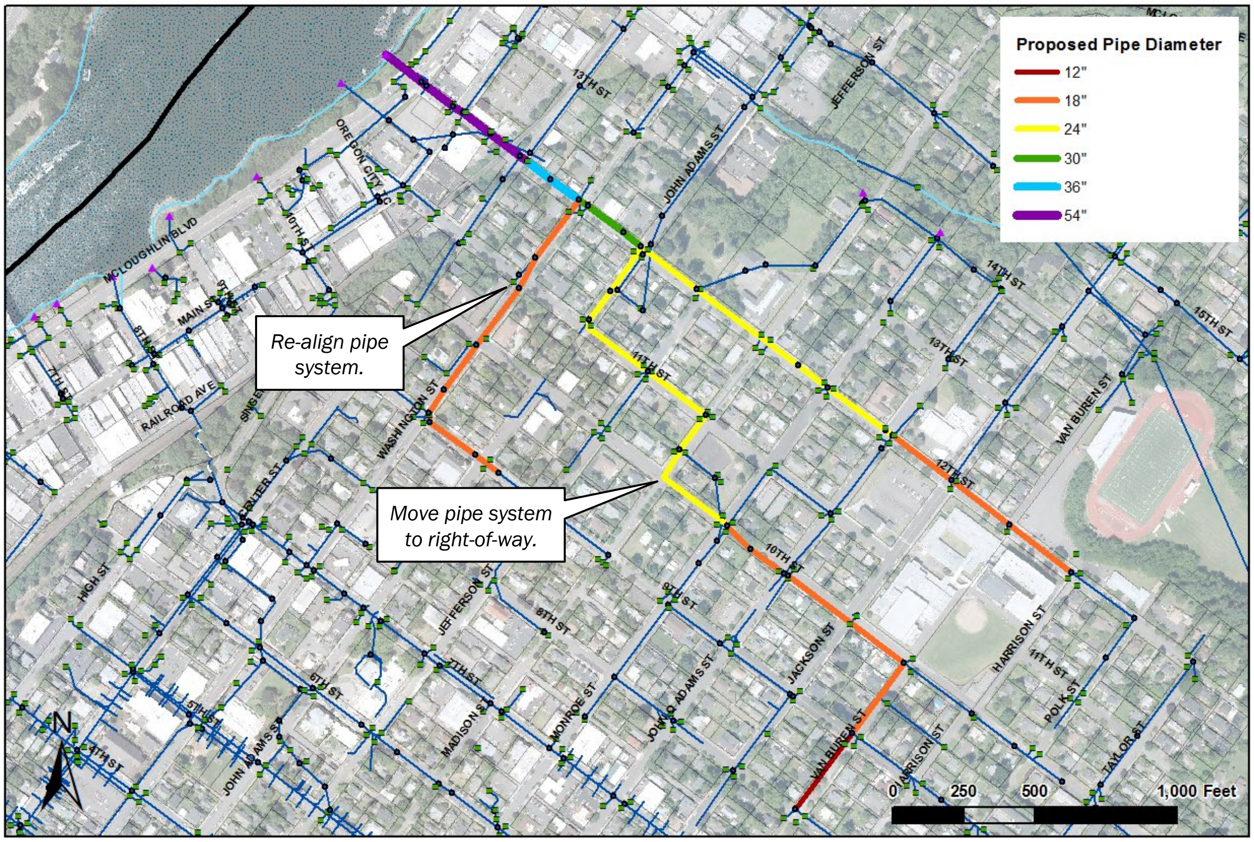
Aggradation	☐ Fresh sediment deposition: channel bar near structure overbank ☐ Unconsolidated bed ☐ Embedded Cobbles N/A
Turbidity/ Siltation	Describe: N/A

Other

Known or observed problems **Unique features** **Field notes**	Natural pond formed by beavers and downed vegetation. Natural & manmade wetlands are attenuating flow.

* Degree of incision = relative elevation of the "normal" low water compared to the floodplain/terrace. Normal water equal to the floodplain/terrace represents 100%.

Appendix F: CIP Fact Sheets



Project Identifier	CIP 1
Project Name	John Adams Basin Capacity Improvements
Detailed Location	Taylor Street to Main Street between 8th Street and 12th Street
Model File	Model FU3_JA2.xp
Objective(s) Addressed	Flood Reduction, Aging Infrastructure

Project Background

The primary problems identified in the John Adams basin are flooding and infrastructure age. Secondary problems include mismatched infrastructure and pipes located in private property. Areas near 9th and Monroe Streets and 8th and Van Buren have reported to have flooding in the past. There are several locations where downstream pipe segments are smaller than upstream pipes leading to surcharging and flooding. Modeling of the storm system revealed significant flooding beginning at the 2-year storm event. Pipe sections are currently undersized and will require replacement to alleviate flooding issues.

In addition, the storm pipes in this basin are among the oldest in the City and well past the expected life. Portions of the stormwater system were previously part of a combined stormwater/sanitary system which will be removed.

Project Description

Upsize drainage system in the John Adams Basin by installing 340 LF of 12-inch pipe, 4,000 LF of 18-inch pipe, 2,300 LF of 24-inch pipe, 240 LF of 30-inch pipe, 300 LF of 36-inch pipe, 130 LF of 48-inch pipe (represented as 54-inch in the figure), and 460 LF of 54-inch pipe. Pipe sizing recommendations are based on providing capacity for 25-year peak flows under full build-out conditions. The project includes the installation of an estimated 40 manhole structures, 21 connections to existing structures and 78 catch basins.

It is suspected that much of this basin does not have private stormwater laterals connected to the existing conveyance system. Stormwater runoff from roof drains may be contributing to the sanitary sewer collection system. Existing private stormwater laterals should be connected to the new stormwater system. Properties without stormwater laterals or downspout disconnection may have a combined lateral (sanitary and storm together) which may be addressed through coordination with the sanitary I/I abatement program. The number and cost for private lateral connection is unknown and therefore is not included in the cost estimate but is recommended as part of the CIP.

Design Considerations

Drainage system installation should be coordinated with roadway reconstruction projects to avoid multiple impacts to the same roadway segments. Detailed topographic survey is needed to conduct final engineering evaluation to determine the appropriate invert elevations and pipe diameters to maintain necessary cover depth in this flat terrain. Investigative work prior to design is necessary to determine appropriate handling of private laterals. Planning level design assumes most proposed structures are located near or at the same location as existing structures.

Comprehensive design effort across all four project phases is suggested to maintain continuity in design.

Phase 1 Planning-level Cost Estimate (Outfall to 12th/John Adams)	
Capital Expense Total (including contingency)	$1,656,000
Engineering and Permitting (40%)	$663,000
Market Climate (10%)	$166,000
Construction Administration (15%)	$248,000
Capital Project Implementation Cost Total*	**$2,733,000**

Phase 2 Planning-level Cost Estimate (12th/John Adams to 12th/Harrison)	
Capital Expense Total (including contingency)	$1,271,000
Engineering and Permitting (15%)	$191,000
Market Climate (10%)	$127,000
Construction Administration (15%)	$191,000
Capital Project Implementation Cost Total*	**$1,780,000**

Phase 3 Planning-level Cost Estimate (12th/John Adams to 8th/Van Buren)	
Capital Expense Total (including contingency)	$1,928,000
Engineering and Permitting (15%)	$289,000
Market Climate (10%)	$193,000
Construction Administration (5%)	$289,000
Capital Project Implementation Cost Total*	**$2,699,000**

Phase 4 Planning-level Cost Estimate (12th/Washington to 9th/John Adams)	
Capital Expense Total (including contingency)	$959,000
Engineering and Permitting (15%)	$144,000
Market Climate (10%)	$96,000
Construction Administration (5%)	$144,000
Capital Project Implementation Cost Total*	**$1,343,000**

**Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand. Project cost does not include property or easement acquisitions.*

Additional Project Information

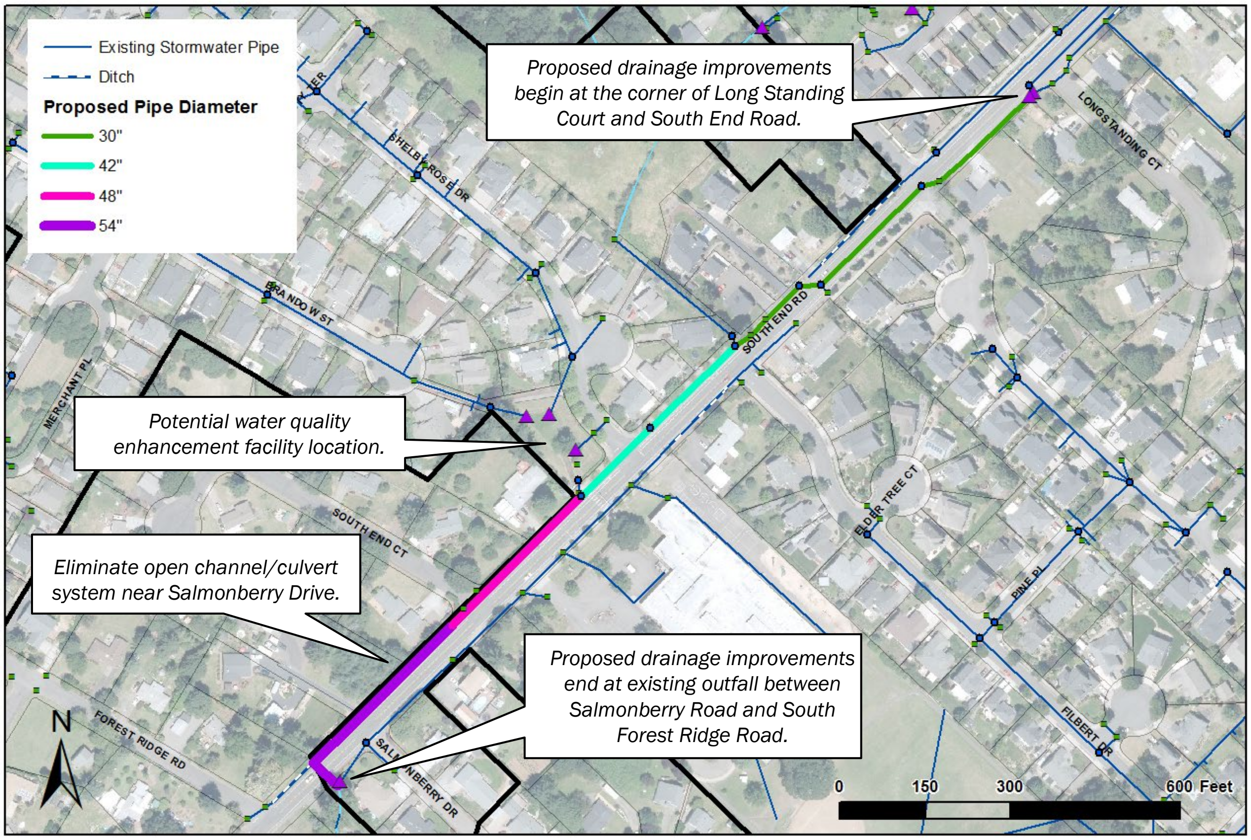
The table below is provided to show the details of the planning level design and estimates for pipe size and invert elevations (this information should be considered planning level only and a formal design and analysis is needed). The table is color coded based on proposed pipe diameter.

Planning Level Infrastructure Data

Link	Existing Diameter (in)	Proposed Diameter (in)	Proposed Length (ft)	US Node	DS Node	US Invert (ft)	DS Invert (ft)
Phase 1							
804813	12	30	157.0	33520	43469	82.29	72.34
804814	18	30	78.8	33519	33520	92.03	86.51
804815	18	36	124.1	33521	34704_WN_0300	68.67	65.37
806471	18	48	131.0	37118	37139_WN_0100	50.10	45.95
806474	18	54	123.1	37139_WN_0100	37142	45.72	45.03
808623	18	54	41.5	37142	41009	44.93	44.67
808624	18	54	19.1	43300	43301	43.51	43.61
812692	18	54	119.5	41009	43300	44.57	43.61
812695	18	54	158.3	43301	39733	43.51	14.40
812816	18	36	39.8	43469	33521	72.10	68.87
Link54	18	36	132.7	34704_WN_0300	37118	65.33	50.40
Phase 2							
804969	8	24	247.9	33513_JA_0300	33519	115.62	92.23
806396	8	24	444.2	37054	33513_JA_0300	156.65	115.82
806401	8	24	131.5	37059	37054	173.67	156.85
806402	8	24	255.5	37062	37059	199.01	173.87
806406	8	24	30.6	37064	37062	202.22	199.21
Link45	N/A	18	276.4	34692_JA_1300	37087	242.56	238.80
Link46	N/A	18	256.7	37087	33491_JA_0200	238.60	228.79
Link47	N/A	18	259.8	33491_JA_0200	37064	227.98	202.42

Planning Level Infrastructure Data

Link	Existing Diameter (in)	Proposed Diameter (in)	Proposed Length (ft)	US Node	DS Node	US Invert (ft)	DS Invert (ft)
Phase 3							
800781	18	24	159.3	34313	33514	159.19	152.53
801568	8	12	335.0	33504	33474	257.58	243.99
801573	12	18	15.0	33473	34769	220.25	215.90
804841	12	18	513.2	33475_JA_1000	33473	235.76	220.69
804846	12	18	64.5	33469	33508	185.00	179.71
804848	24	24	150.6	33514	33515	152.33	144.73
804851	18	24	256.1	33515	34191_JA_0100	144.53	116.45
808704	12	18	305.9	33474	33475_JA_1000	243.75	236.34
Link48	12	18	262.9	34769	33469	215.75	185.20
Link49	12	18	225.3	33508	34313	179.51	159.14
Link58	18	24	291.0	34191_JA_0100	34192	116.25	109.60
Link59	12	24	121.6	34192	41014	109.22	101.00
Link60	12	24	192.3	41014	33519	100.71	92.13
Phase 4							
804860	12	18	101.6	33517_WN_0400	33516	178.61	174.95
804861	12	18	211.6	33523	33517_WN_0400	192.64	178.81
804867	12	18	274.3	34311_WN_0500	33523	199.70	192.86
812475	12	18	29.8	36378	34534	163.75	162.54
812477	12	18	198.1	33516	36378	172.70	163.95
812478	12	18	100.6	34534	43051	162.24	159.21
812479	12	18	194.4	43051	43050	159.11	150.99
Link55	12	18	249.5	43050	Node58	150.49	123.22
Link56	12	18	122.1	Node58	Node59	123.02	110.16
Link57	12	18	257.4	Node59	33521	109.96	83.08



Proposed drainage improvements begin at the corner of Long Standing Court and South End Road.

Potential water quality enhancement facility location.

Eliminate open channel/culvert system near Salmonberry Drive.

Proposed drainage improvements end at existing outfall between Salmonberry Road and South Forest Ridge Road.

Project Identifier	CIP 2
Project Name	South End Road Stormwater Improvement
Detailed Location	South End Road between Rose Road and South Forest Ridge Road Structures 33535 to 39582
Model File	Model FU3_SE4.xp
Objective(s) Addressed	Flood Reduction

Project Background

Flooding issues along South End Road were identified during the watershed problem identification workshop and as part of the City asset review. Near Rose Road, the existing pipe system transitions from a 30 Inch pipe down to a 12 Inch pipe, possibly as a prior flow control mechanism. Modeling of the storm system revealed significant flooding, especially in areas where downstream pipe segments were smaller than upstream pipes. Flooding occurs in the open channels when modeled with the 2-year storm event.

Project Description

Replace the existing open channel/culvert system with a closed pipe from Rose Road to the outfall between Salmonberry Drive and South Forest Ridge Road. Upsize and extend the drainage system to convey the 25-year peak flows for full buildout. The project will eliminate the existing open channel/culvert system near Salmonberry Drive.

Planning level design assumes proposed structures will be placed in the same locations as the existing manholes, spaced no more than 400 feet apart. The project includes installation of 800 LF of 30 inch pipe, 380 LF of 42 inch pipe, 325 LF of 48 inch pipe, and 400 LF of 54 inch pipe. The project includes 7 manhole structures, 2 are proposed and 5 existing manholes will be utilized. The project also assumes installation of 7 catch basins with a total of 140 feet of 12-inch connecting laterals to accommodate future road widening.

Design Considerations

South End Road is identified as an area for future roadway improvements. The drainage system installation should be planned as part of roadway reconstruction project or drainage system design should account for future roadway widths and curb/sidewalk locations. Detailed topographic survey is needed to conduct final engineering evaluation to determine the appropriate invert elevations and pipe diameters to maintain necessary cover depth in this flat terrain.

The downstream open channel, south of South End Road will require a capacity assessment prior to upsizing. Due to the existing undersized pipe system, the open channel is currently not experiencing peak flows and may need additional stabilization to manage peak flows.

This project has also been identified as a possible location for a water quality enhancement facility, which has been included in the cost estimate as a lump sum item. The enhancement could include an upgrade to the tract adjacent to South End Road or the installation of dispersed facilities along the roadway alignment.

Planning-level Cost Estimate

Capital Expense Total (including contingency)	$2,292,000
Engineering and Permitting (15%)	$344,000
Market Climate (10%)	$229,000
Construction Administration (15%)	$344,000
Capital Project Implementation Cost Total*	**$3,209,000**

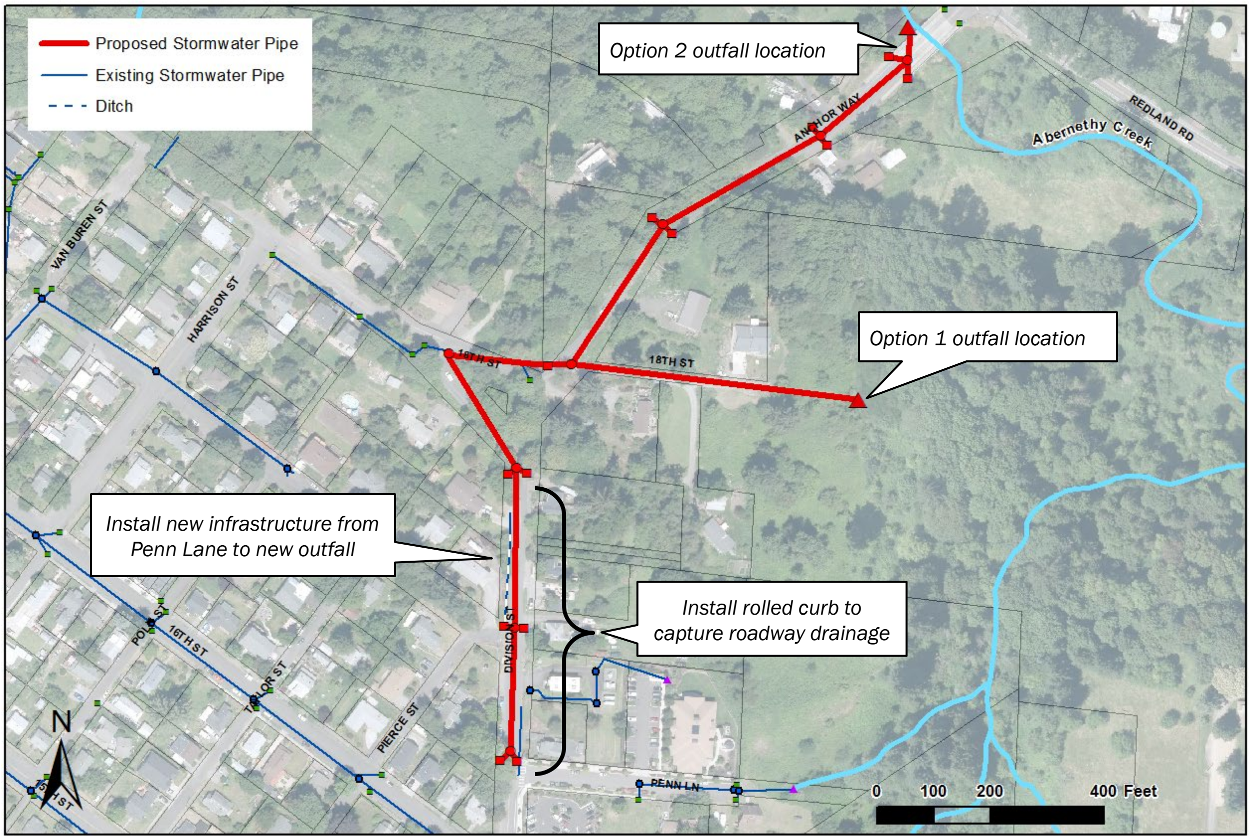
* *Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand. Project cost does not include property or easement acquisitions.*

Additional Project Information

The table below is provided to show the details of the planning level design and estimates for pipe size and invert elevations (this information should be considered planning level only and a formal design and analysis is needed).

Planning Level Infrastructure Data

Link	Existing Diameter (in)	Proposed Diameter (in)	Proposed Length (ft)	US Node	DS Node	US Invert (ft)	DS Invert (ft)
800101	Open Channel	30	220	38963	30628	450.92	449.2
800102	Open Channel	30	60	40224	28962	448.92	448.12
800823	30	30	250	33801	33800	446.64	440.73
800824	18	30	35	30628	33801	448.12	446.74
801783	12	30	40	33800	42854	440.52	439.65
802787	18	30	35	38962	38963	449.2	448.92
Link31	12	30	160	42854	34365_SE_1100	439.45	435.74
Link41	54	42	380	34365_SE_1100	34761_SE_0900	434.74	431.57
Link42	48	48	325	34761_SE_0900	38973_SE_0800	431.07	428.38
Link43	Open Channel	54	340	38973_SE_0800	Node75	427.88	426.16
Link44	36	54	60	Node75	Node76	425.95	425.66



Project Identifier	CIP 3
Project Name	Division Street Infrastructure Improvements
Detailed Location	Division Street from Penn Lane to S Anchor Way
Model Connection	N/A
Objective(s) Addressed	Insufficient Infrastructure

Project Background

The City has identified insufficient infrastructure along Division Street near Penn Lane. Roadway drainage is currently managed through a series of ditches and culverts routing flow northward down Division Street, Anchor Way and 18th Street. Roadways occasionally experience flooding.

Project Description

The proposed project would pipe runoff from Division, Anchor Way and the associated catchments to one of two potential outfall locations toward Abernethy Creek. Both options include the same proposed infrastructure from Penn Lane downstream to the intersection of 18th Street and Anchor Way.

From the 18th Street and Anchor Way intersection, the Option 1 outfall location routes the storm system east of Anchor Way along 18th Street towards Abernethy Creek. 18th Street is an unimproved easement or existing right-of-way which will enable pipe and outfall to be constructed. Site conditions at the east end of 18th Street appear favorable for an outfall location. With this option, the proposed infrastructure will include the installation of approximately 1400 LF of 12-inch pipe, 7 catch basins with an associated 140 LF of inlet leads, 4 manholes, and an outfall structure. The project will require installation of rolled asphalt curbs along both sides of Division Street from Penn Lane to 18th Street.

The Option 2 outfall location routes the storm system northeast along Anchor Way towards the outfall at Abernethy Creek. In addition to the infrastructure necessary for option 1, this option will require the installation of an additional 500 LF of 12-inch pipe, 6 catch basins with an associated 120 LF of inlet leads, and 3 manholes.

Design Considerations

Option 1 would require slope stability analysis to verify that the proposed outfall would not contribute to hillside erosion. Option 2 is the preferred option because it uses an existing right-of-way alignment. Option 2 could also include improvements to address drainage concerns and pavement condition along Anchor Way.

Only preliminary calculations have been performed to identify conceptual pipe sizing. Design should verify pipe capacity needs, pipe location in right of way, outfall location and limits of rolled curb.

Detailed topographic survey is needed to conduct final engineering evaluation to determine the appropriate invert elevations and pipe diameters to maintain necessary cover depth.

Planning-level Cost Estimate (Option 1 Outfall Location)	
Capital Expense Total (including contingency)	$550,000
Engineering and Permitting (15%)	$82,000
Market Climate (10%)	$56,000
Construction Administration (15%)	$82,000
Capital Project Implementation Cost Total*	**$770,000**

Planning-level Cost Estimate (Option 2 Outfall Location)	
Capital Expense Total (including contingency)	$701,000
Engineering and Permitting (15%)	$105,000
Market Climate (10%)	$70,000
Construction Administration (15%)	$105,000
Capital Project Implementation Cost Total*	**$981,000**

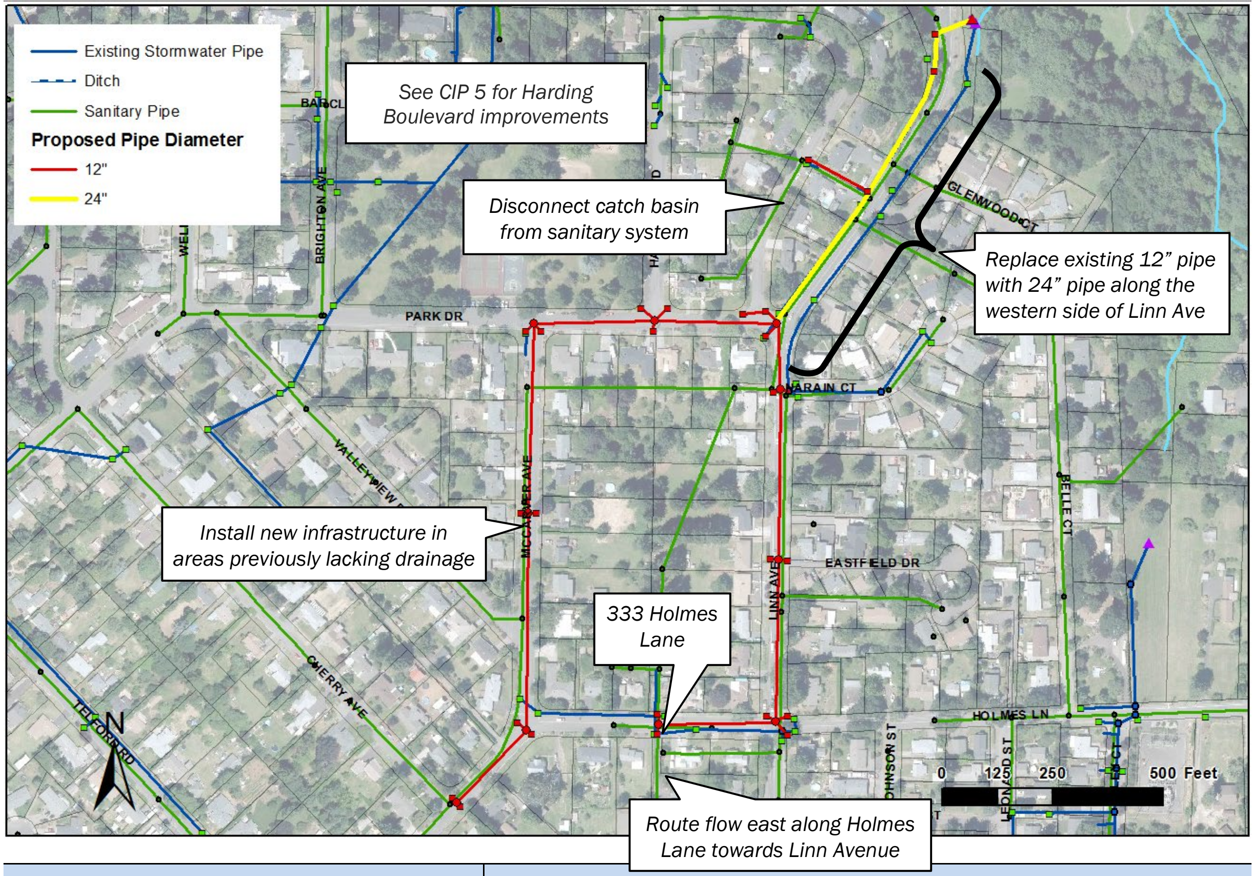
* *Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand. Does not include property or easement acquisitions.*

Additional Project Information

Images of the study area are included below.

Figure 1: Option 1 outfall location

Figure 2: View from Option 2 outfall location west towards Anchor Way



Project Identifier	CIP 4
Project Name	Rivercrest Neighborhood Infrastructure Improvements
Detailed Location	Linn Avenue between Holmes Lane and Park Drive
Model File	N/A
Objective(s) Addressed	Insufficient Infrastructure

Project Background

Portions of the Rivercrest Neighborhood lack a storm drain system. Drainage along Holmes Lane between McCarver and Linn Avenue currently discharges to an open channel near the northwest corner of 333 Holmes Lane. This open channel flows, to the north, through multiple backyards approximately along the existing sanitary sewer line and terminates near the intersection of Linn Ave and Park Drive. Two existing 12-inch stormwater pipes, providing stormwater conveyance along Linn Avenue north of Park Drive do not have capacity for the catchment based on modeling results.

Project Description

New storm infrastructure is proposed along Linn Ave, McCarver Avenue, Holmes Lane and Park Drive. The drainage discharging at 333 Holmes Lane will be rerouted east along Holmes Lane to a structure at the intersection with Linn Avenue where it will flow north towards Park Drive. The existing conveyance line in Linn Avenue will be replaced with a single, larger pipe along the west side of the road which will discharge into Singer Creek. The western side of Linn Avenue is the preferred drainage route because it has the wider roadway shoulder.

In addition, the single catch basin on Harding Blvd will be disconnected from the sanitary sewer and routed south east between the two homes to Linn Avenue.

The project includes 2,800 LF of 12-inch pipe along McCarver Avenue, Park Drive, Holmes Ln, and Linn Avenue and 900 LF of 24-inch pipe on Linn Avenue north of Park Drive. A total of 10 manhole structures will be installed, with the manhole at the intersection of Linn Avenue and Holmes Ln reaching a depth of approximately 15-20 feet. 27 catch basins and 440 feet of 12-inch inlet leads will also be installed.

Design Considerations

Only planning level calculations have been performed to identify conceptual sizing. Detailed topographic survey is needed to conduct final engineering evaluation to determine the appropriate invert elevations and pipe diameters to maintain necessary cover depth in this flat terrain.

Outfall inspections may be necessary for the proposed 24” pipe across Linn Avenue due to the increased flow associated with the additional infrastructure. A more suitable outfall location may be considered if the current proposed location is not stable enough to accommodate the larger peak flows.

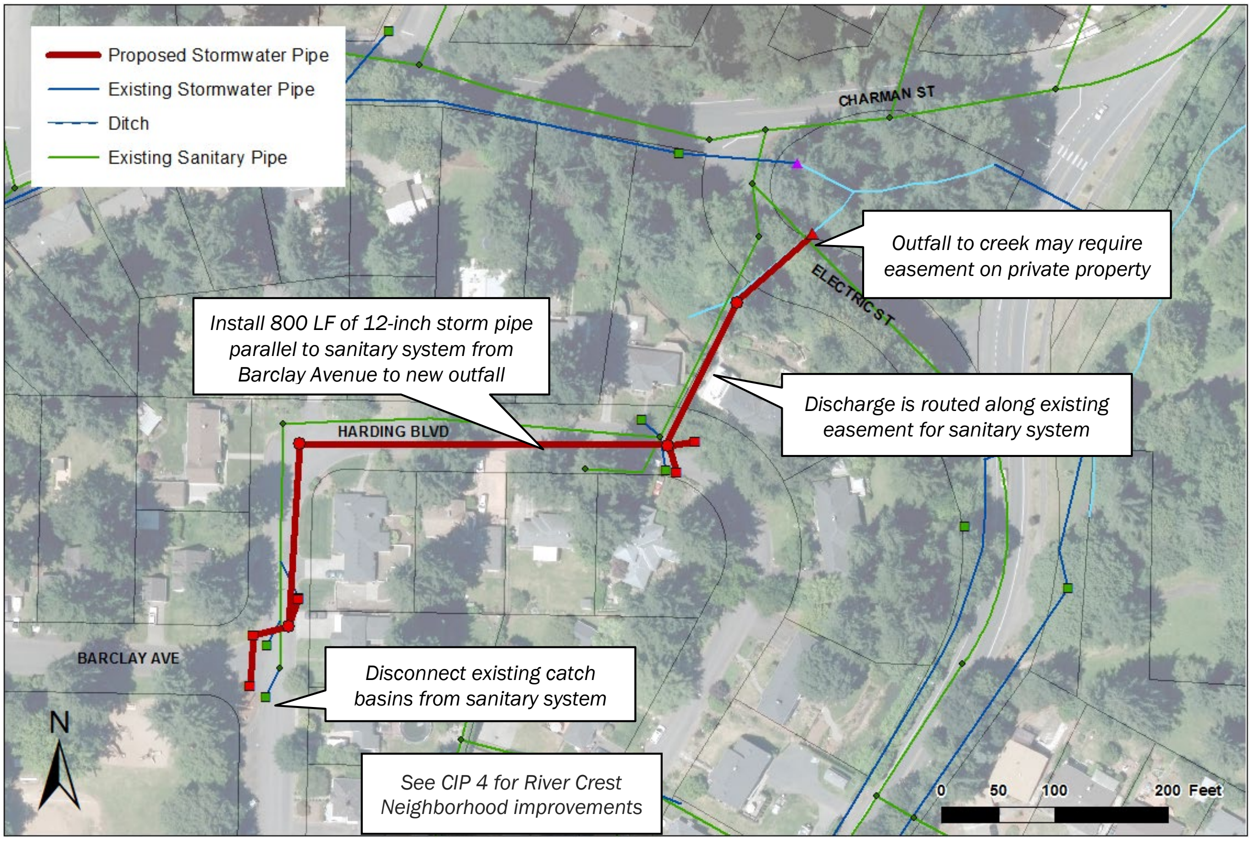
Coordination with the SS Master Plan is recommended to avoid utility conflicts and multiple impacts to the same roadway segments.

Planning-level Cost Estimate	
Capital Expense Total (including contingency)	$1,734,000
Engineering and Permitting (15%)	$260,000
Market Climate (10%)	$174,000
Construction Administration (15%)	$260,000
Capital Project Implementation Cost Total*	$2,428,000

* *Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand. Project cost does not include property or easement acquisitions.*

Additional Project Information

Figure 1: Drainage outfall location behind 333 Holmes Lane



Outfall to creek may require easement on private property

Install 800 LF of 12-inch storm pipe parallel to sanitary system from Barclay Avenue to new outfall

Discharge is routed along existing easement for sanitary system

Disconnect existing catch basins from sanitary system

See CIP 4 for River Crest Neighborhood improvements

Project Identifier	CIP 5
Project Name	Harding Boulevard Sanitary Disconnect
Detailed Location	Harding Blvd from Barclay Ave to Linn Ave
Model File	N/A
Objective(s) Addressed	Disconnect stormwater from sanitary collection system

Project Background

Five catch basins are currently connected to the sanitary system along Harding Boulevard north of Barclay Avenue. This area has been identified as a contributor to sanitary sewer infiltration and inflow. This area is adjacent to CIP 4, which includes the installation of new stormwater infrastructure in the River Crest Neighborhood.

Project Description

Five catch basins will be disconnected from the sanitary collection system, redirecting roadway runoff and associated drainage to a proposed stormwater conveyance system with an outfall to Singer Creek. 800 LF of 12-inch will be installed parallel to the existing sanitary system. The project will include 4 manholes and assumes installation of 5 inlet structures with a total of 100 LF of 12-inch connecting laterals.

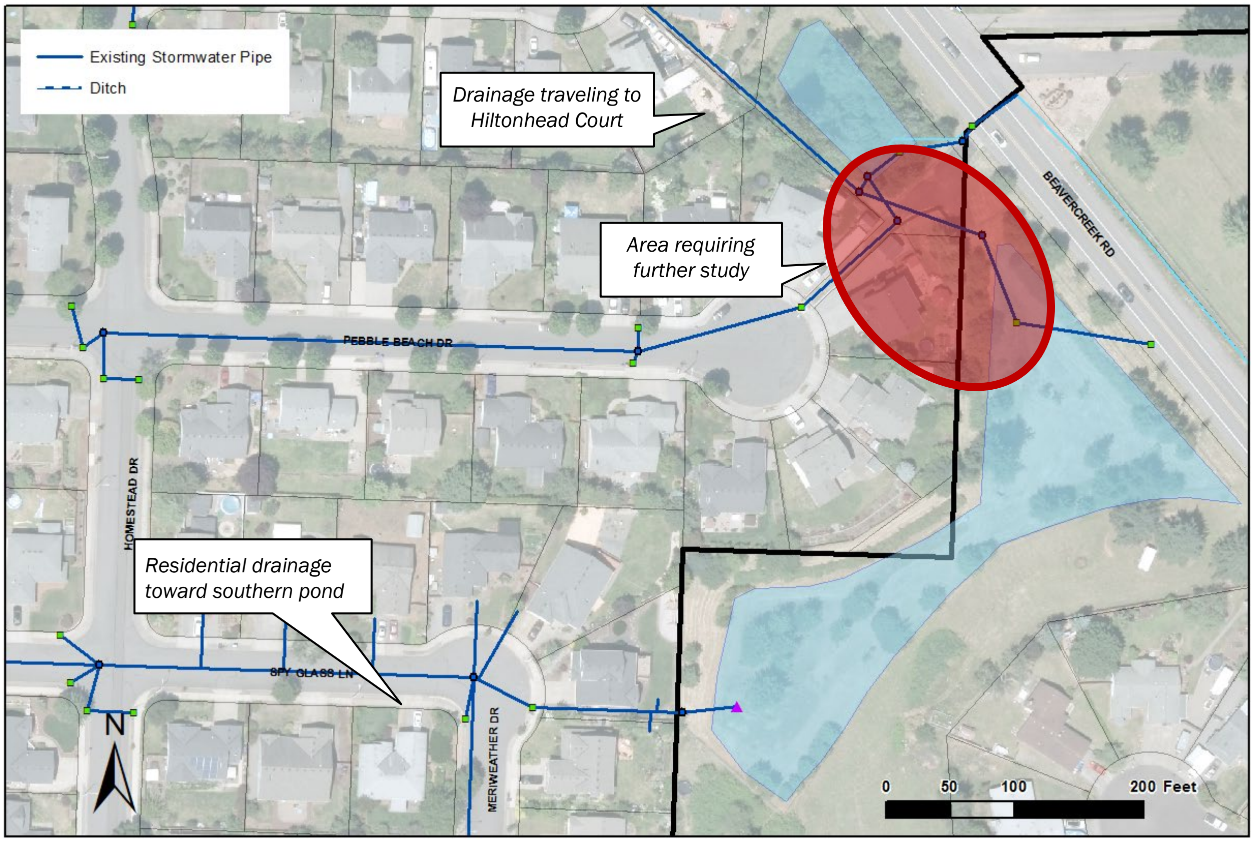
Design Considerations

The outfall will discharge to private property at the corner of Electric St and Linn Ave. An easement exists between 170 Harding Blvd and 178 Harding Blvd for the sanitary system which will be used for the new stormwater pipes, However, a new easement may be needed for the outfall at Electric St. A new easement may be necessary for the private property outfall north of Electric Street.

Detailed topographic survey is needed to conduct final engineering evaluation to determine the appropriate invert elevations and pipe diameters to maintain necessary cover depth in this flat terrain. Final design will need to address potential utility conflicts and proposed catch basin locations.

Planning-level Cost Estimate	
Capital Expense Total (including contingency)	$331,000
Engineering and Permitting (15%)	$50,000
Market Climate (10%)	$33,000
Construction Administration (15%)	$50,000
Capital Project Implementation Cost Total*	**$464,000**

**Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand. Does not include property or easement acquisitions.*



Project Identifier	CIP 6
Project Name	Pebble Beach Pond Retrofit
Detailed Location	Near 15083 Pebble Beach Road
Model Connection	N/A
Objective(s) Addressed	Flooding

Project Background

Two stormwater management ponds are located near Thayer Court, adjacent to Beavercreek Road. During the watershed problem identification workshop, City staff indicated that the ponds are not working as intended with only one pond filling during storm events. During a site visit in March 2017, the small pond appeared to have a plugged outlet, as the water elevation was high and the emergency overflow was moving water into the outlet structure. The larger pond did not have any standing water and does not appear to provide detention or flow control.

Residential stormwater from the south contributes to the larger pond and from one inlet along Beavercreek Road. Most Beavercreek Road runoff contributes to the smaller pond. A portion of residential stormwater from Pebble Beach Drive discharges to the outfall structure of the small pond and therefore receives no treatment via the pond. The two ponds are isolated hydraulically but share a manhole, downstream of each pond, prior to being conveyed northwest toward Hiltonhead Court. Both ponds have deep risers in the emergency overflow structure with an orifice at the bottom.

Project Description

These two ponds could be optimized/retrofit to improve water quality treatment and flow control. The goals of optimization include: better utilization of storage for flow control, increase water quality treatment capacity and improve maintenance access.

Further study is recommended for these ponds to determine the nature of the inputs and existing infrastructure to appropriately inform a design that would increase water quality treatment, reduce flooding, reduce maintenance and provide some flow control by updating the orifice structures.

Design Considerations

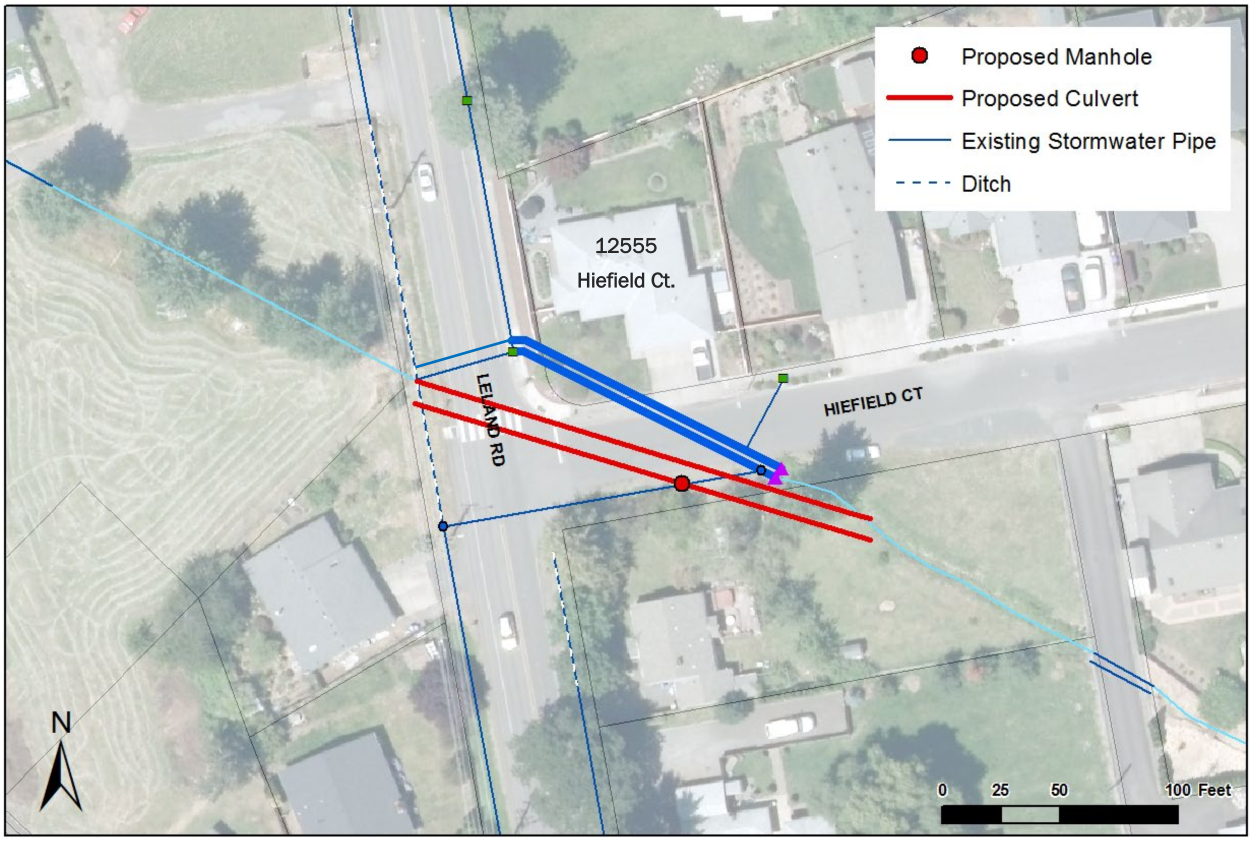
There are no design recommendations.

Planning-level Cost Estimate

Capital Expense Total (including contingency)	$460,000
Engineering and Permitting (30%)**	$138,000
Market Climate (10%)	$46,000
Construction Administration (15%)	$69,000
Capital Project Implementation Cost Total*	**$713,000**

* *Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand. Cost does not include property or easement acquisitions.*

** *Engineering and Permitting is 30% to allow for hydrologic and hydraulic assessment prior to engineering.*



Project Identifier	CIP 7
Project Name	Hiefield Court Culvert Improvements
Detailed Location	Culvert crossing at Hiefield Court and Leland Road
Model File	N/A
Objective(s) Addressed	Localized flooding

Project Background

The two existing culverts across Hiefield Court and Leland Road are prone to flooding at the inlet along Leland Road. The dual culvert begins on the west side of Leland Road with two 24” pipes. The culverts appear to have very low slope and minimal cover.

The north 24” inch drains to a large structure at the east side of Leland Road where the system transitions to 30”. The 30” pipe conveys runoff under the corner of the adjacent private lot to the outfall on the south side of Hiefield Court. The south 24” pipe drains to an inlet structure and is parallel to the north line. A 30” pipe exits the inlet structure and parallels the north line to the outlet. Just before the outlet a 24” pipe enters the southern 30” as shown in the figure above.

The inlet of the two 24” culverts is not optimized to reduce inlet losses and the sharp bend in the structure on the east side of Leland Road does not optimize the movement of water downstream. Updating the channel alignment and reducing entrance/structure losses may alleviate the flooding currently occurring along the west side of Leland Road.

Project Description

Potential improvements include:

- Updating the inlet with wing walls to reduce head loss and reworking the pipe alignment such that the channel is in line with the culverts to facilitate the movement of water downstream,
- Adjusting the location of the 24” pipe that connects to the 30” such that the pipe has a separate outfall to the open channel drainage system.
- Replacing existing culverts with upsized culverts as shown in figure above.

The project should include a detailed hydrologic and hydraulic analysis (model) of this culvert system to determine the existing capacity and the optimal configuration and ensure that the proposed design can convey the design event for the contributing catchment.

Design Considerations

Any overtopping of the culverts should be directed to Hiefield Court and away from the home at 12555 Hiefield Court. Limited cover over the culvert may be a considerable design constraint.

Planning-level Cost Estimate

Capital Expense Total (including contingency)**	$460,000
Engineering and Permitting (25%)	$138,000
Market Climate (10%)	$46,000
Construction Administration (15%)	$69,000
Capital Project Implementation Cost Total*	$713,000

* *Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand. Does not include property or easement acquisitions.*

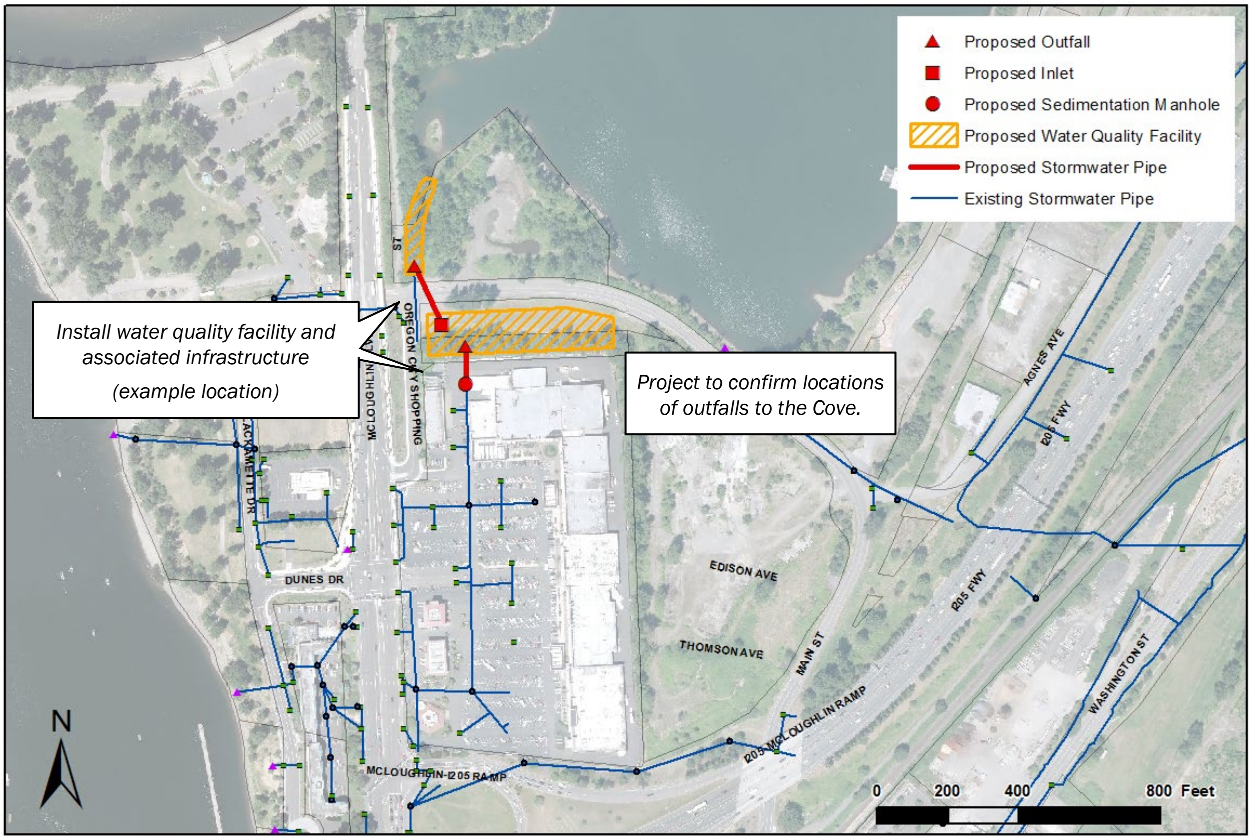
** *Cost estimate based on culvert replacement.*

Additional Project Information

Images of the study area are included below.

Figure 1: Downstream end of culverts south of Hiefield Court

Figure 2: Inlet of culverts west of Leland Road



Project Identifier	CIP 8
Project Name	The Cove Water Quality Improvements
Detailed Location	Linn Avenue between Holmes Lane and Park Drive
Model File	N/A
Objective(s) Addressed	Water Quality

Project Background

Stormwater entering Clackamette Cove is primarily runoff from industrial, commercial and other land use that can generate high pollutant loads. The areas were developed prior to water quality requirements, so the discharge entering the cove is primarily untreated.

Previous studies have identified significant water quality concerns in the cove, including algal blooms. Limited connection to the Clackamas River results in little circulation and turnover which contributes to the water quality concerns.

The area surrounding the cove is of high interest for development and redevelopment, due to the proximity to the rivers and large land parcels. As the surrounding property redevelops, more attention is placed on this water body and its use for recreation and habitat enhancement. Improving water quality from the contributing catchments has become a priority.

Project Description

Water quality treatment of Oregon City Shopping Center, located at the intersection of Mcloughlin Blvd and Dunes Dr., will be the primary goal of this project. Treatment may occur along the north sides of the shopping center and/or to the north, across Main Street, prior to the outfall into Clackamette Cove. Preliminary water quality facility sizing, utilizing the BMP sizing tool, for the entire shopping center results in a treatment area of 11,000 square feet.

The water quality area shown in the figure above is not intended to show this size but to provide potential areas for facility placement. Existing onsite drainage infrastructure should be determined prior to formal adoption of where treatment will occur. Treatment of the parking lot drainage will be key to making significant change to the effluent water quality discharging to The Cove, which should be the priority for treatment and rerouting of existing storm infrastructure to the proposed water quality facility.

Design Considerations

The location and depth of existing stormwater infrastructure will be critical to the success of rerouting runoff to a treatment facility. Survey will be required. Wetland delineation and permitting may be needed for the area north of Main St. if wetlands exist in the area identified for a water quality facility.

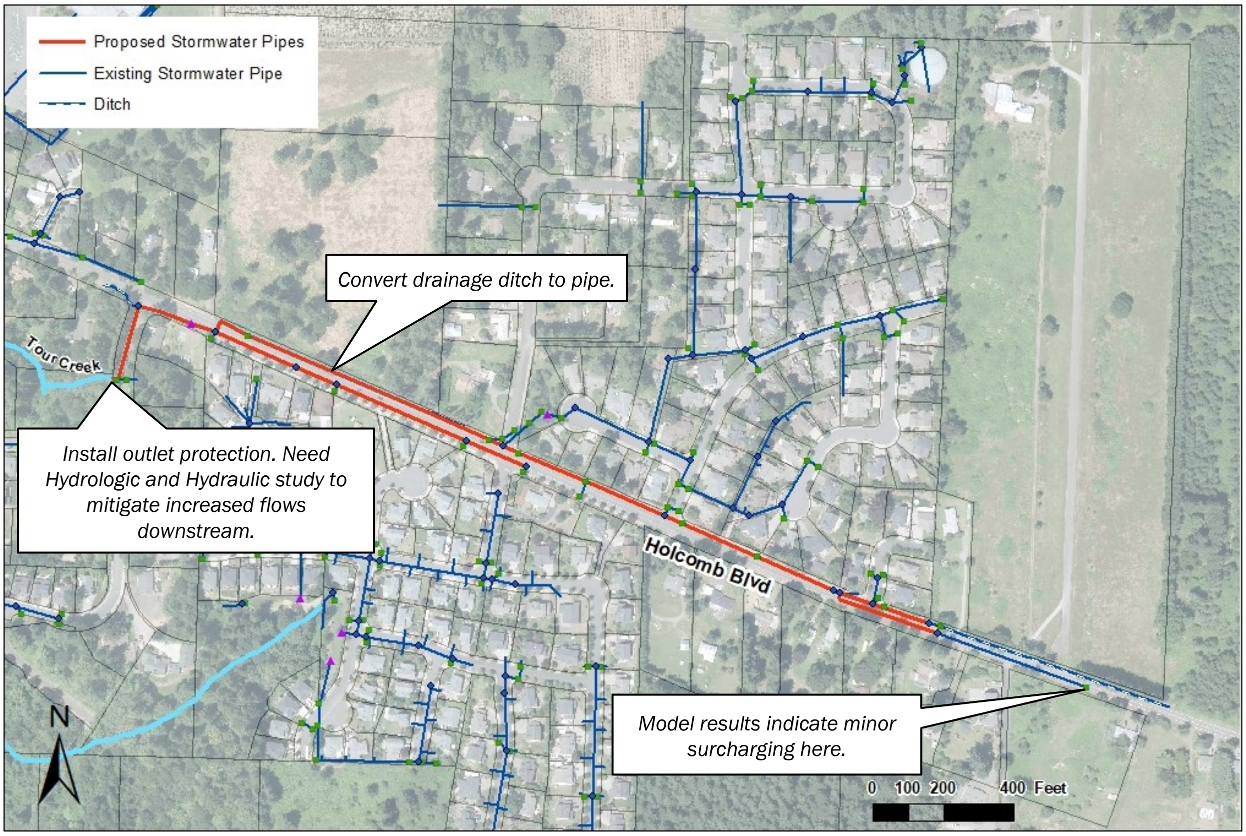
The specific design for the water quality retrofit could include a large regional facility as shown above. Other options include dispersed treatment filters throughout the parking area, a smaller rain garden or planters throughout the contributing drainage basin, or a combination of these. The area shown above is one such concept, developed to establish a cost estimate.

Planning-level Cost Estimate

Capital Expense Total (including contingency)*	$406,000
Engineering and Permitting (25%)	$101,000
Market Climate (10%)	$40,000
Construction Administration (15%)	$61,000
Capital Project Implementation Cost Total**	**$608,000**

**Includes hydrologic & hydraulic modeling and survey. Does not include property or easement acquisitions.*

***Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand.*



Convert drainage ditch to pipe.

Install outlet protection. Need Hydrologic and Hydraulic study to mitigate increased flows downstream.

Model results indicate minor surcharging here.

Project Identifier	CIP 9
Project Name	Holcomb Boulevard Capacity Improvements
Detailed Location	Holcomb Blvd from Kittyhawk Ave to Outfall at Tour Creek
Model File	FU3_HO1_v2019_25yr.xp
Objective(s) Addressed	Provide conveyance for the 25-year storm event and mitigate for future development

Project Background

Private development at Abernethy Landing recently made stormwater improvements to this stretch of Holcomb, adding a parallel conveyance line tied into the existing drainage system. Hydrologic and Hydraulic analysis of this area has revealed deficiencies in both the recently installed segments, as well as with existing infrastructure to the west. This area has projected future development and potential connections from Park Place Concept area. The Holcomb Boulevard system culminates with discharge to Tour Creek.

Project Description

The project includes the upsizing of approximately 4000 linear feet of pipe, as well as outlet and channel protection for Tour Creek., The new conveyance system will range from 24-inch pipe east of Jada Way and increase to 42-inch pipe at the outlet, as well as upsizing to the drainage line on the south side of Holcomb, from 12- to 15-inches. The project would replace approximately 550 LF of open channel with a closed conveyance system, allowing for future upgrades to Holcomb Boulevard. Portions of the drainage system between Jada Way, and the previously open channel segment are steep (between 4.5 and 12%), causing the upper end of the watershed to drain quickly, but putting added conveyance needs on the lower, flatter, portion of the system.

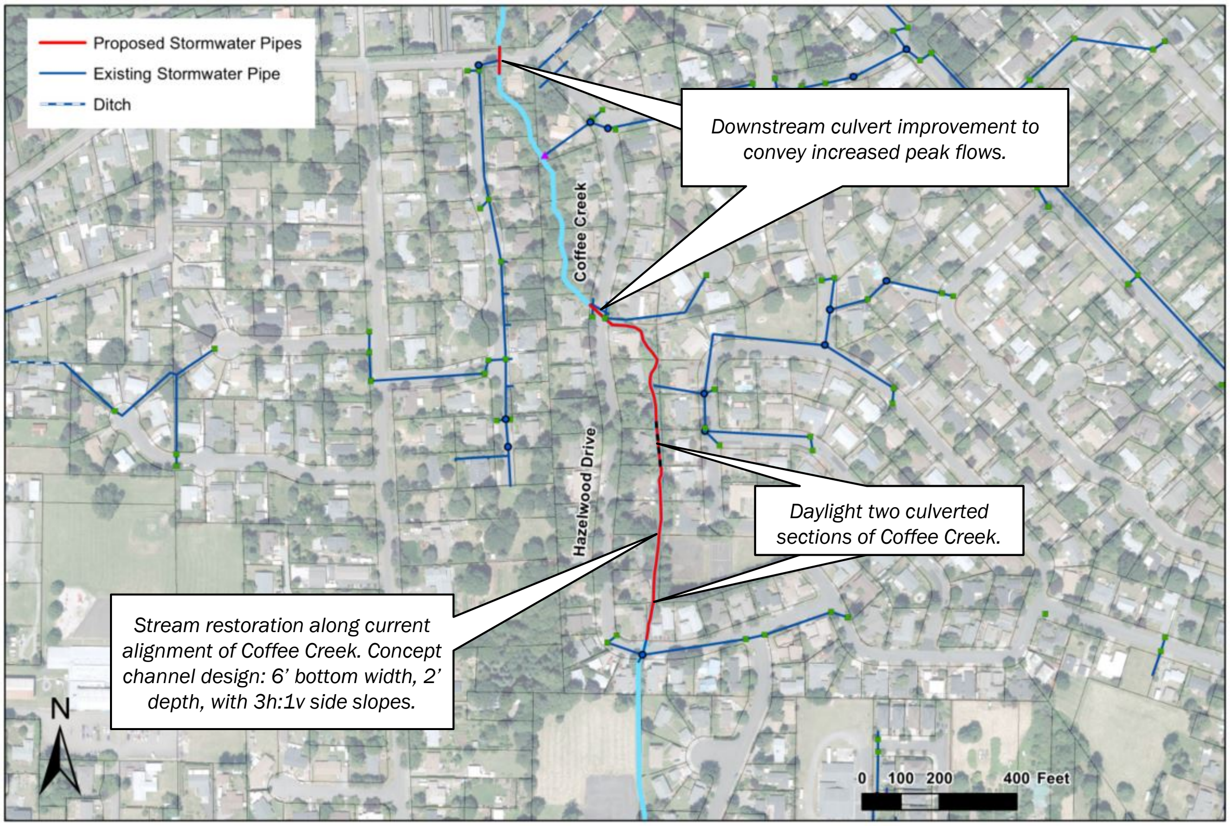
Design Considerations

Preliminary model results indicate a significant increase to the peak flow to Tour Creek, which warrants further study in order to confirm these results, as well as to provide a basis for mitigating the downstream impacts of the project. Project design should include detailed hydrologic evaluation to predict flow volumes and velocities for the design of outlet/erosion control measures.

Modeling results indicated minor surcharging at most upstream node along south-side main line on Holcomb (see callout) during 25-year event. This segment can be upsized from 15” to 18” to eliminate this surcharging and meet Oregon City design standards for a cost of approximately $90,000. Final design of system should consider refining pipe size, material, slopes, and depth to find most cost-effective solution to meet design objectives.

Planning-level Cost Estimate	
Capital Expense Total (including contingency)	$2,781,000
Engineering and Permitting (15%)	$417,000
Market Climate (10%)	$278,000
Construction Administration (15%)	$417,000
Capital Project Implementation Cost Total*	**$3,893,000**

**Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand. Does not include property or easement acquisitions.*



Downstream culvert improvement to convey increased peak flows.

Daylight two culverted sections of Coffee Creek.

Stream restoration along current alignment of Coffee Creek. Concept channel design: 6' bottom width, 2' depth, with 3h:1v side slopes.

Project Identifier	CIP 10
Project Name	Coffee Creek Stream Restoration
Detailed Location	Coffee Creek through Hazelwood Drive neighborhood between two Hazelwood Drive culverts.
Model File	FU3_CO1_Alt3_v05.xp
Objective(s) Addressed	Restore stream for improved water quality and stream stability. Provide additional conveyance during larger storm events to mitigate flooding issues on residential properties.

Project Background

Residents in the Hazelwood neighborhood have regularly complained of flooding issues during storm events. Due to prior development around Coffee Creek, the stream is routed through a series of pipes, culverts, and man-made channels of varying size. The existing system is located on private property, and is constricted through culverts twice within this stretch, creating uncertainty around maintenance responsibility and access. The system ranges from 48-inches in diameter at the upstream (southern) culvert crossing Hazelwood Drive, down to 24-inches at some points, causing chokepoints and localized flooding. The existing system has several unique drainage structures that are susceptible to debris accumulation.

In order to provide some relief for residents in this vicinity, the City is proposing a stream restoration project through the existing Coffee Creek alignment to provide additional channel capacity, stabilize the creek, and improve water quality.

Project Description

The project includes the removal of two culverts along the Coffee Creek alignment on private property with a combined length of approximately 120 feet. The preliminary concept design is based on installation of a uniform channel cross section, sized to have a 6 foot bottom width, 2 foot depth, and 3h:1v side slopes. Final design should include adjustments to channel cross section to match individual lot topography and create a varied and meandering channel.

The project includes approximately 870 linear feet of stream restoration, as well as downstream improvements to increase culvert sizes at the Hazelwood and Barker Ave crossings.

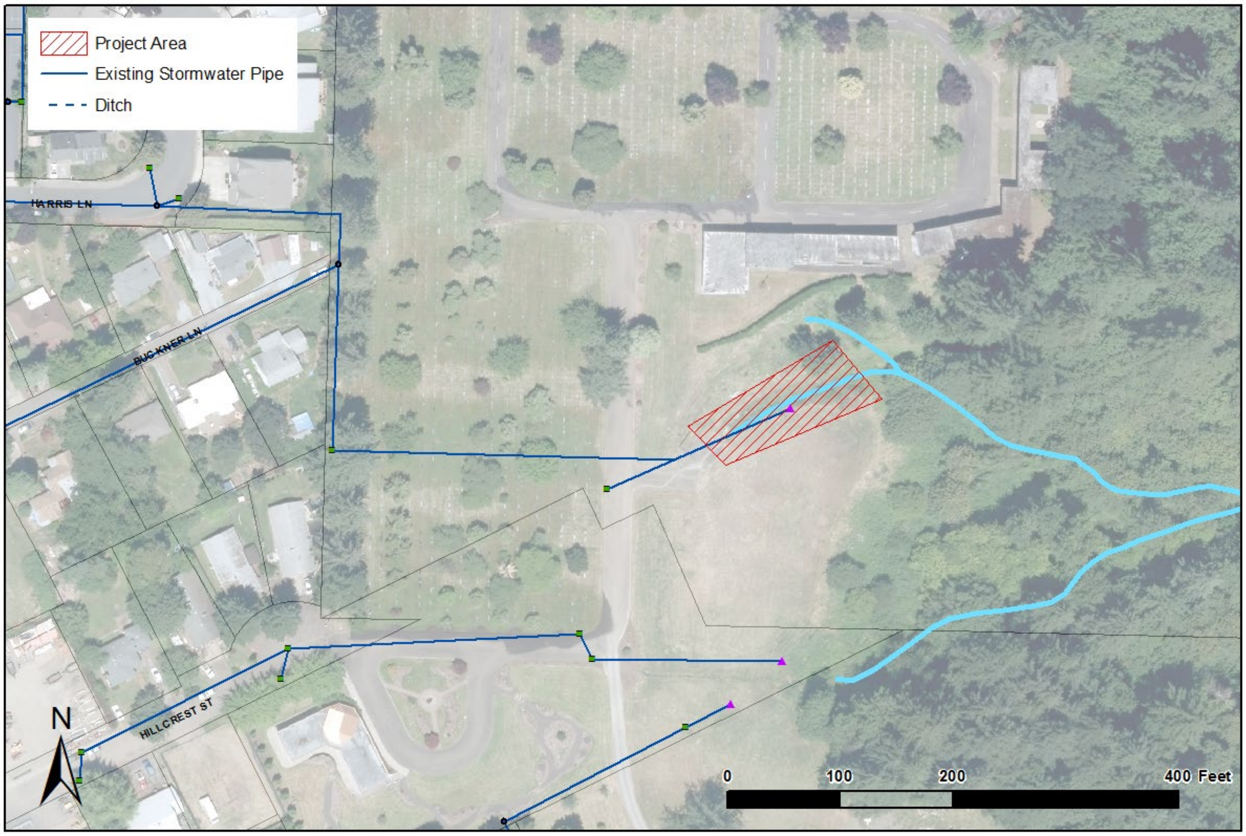
Design Considerations

The concept channel designed here is sized to provide conveyance for the 25-year design storm. A complete design is contingent upon survey of the area and space constraints. Buy-in from local residents will be necessary to complete construction on private property. Downstream impacts from an increased peak flow rate will need to be mitigated through upstream green infrastructure, up-sizing of downstream infrastructure, the installation of in-line flood storage, or a combination of these. Previous sanitary system work on Hazelwood Drive should provide valuable information on local geology that may impact construction costs and methods.

Planning-level Cost Estimate

Capital Expense Total (including contingency)	$783,000
Engineering and Permitting (15%)	$117,000
Market Climate (10%)	$79,000
Construction Administration (15%)	$117,000
Capital Project Implementation Cost Total*	**$1,096,000**

**Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand. Does not include property or easement acquisitions.*



Project Identifier	CIP 11
Project Name	Scattering Canyon Stormwater Improvement
Detailed Location	Mountain View Cemetery (500 Hilda Street)
Model File	N/A
Objective(s) Addressed	Erosion, Infrastructure Needs, Water Quality

Project Background

Scattering Canyon is located along a tributary to Newell Creek in the Mountain View Cemetery property. This area is often a place where ashes are scattered in the creek and is used by family and friends of the deceased. The creek has been experiencing hydromodification in the form of severe incision near the outfall and erosion further downstream resulting in a less than desirable setting. The pipe outfall at the start of the tributary conveys stormwater from roads and residential areas upstream.

Project Description

The project will consist of multiple improvements to Scattering Canyon. The current eroding channel will be modified to provide water quality treatment with 195 LF of 6-inch perforated underdrain pipe in the canyon to enhance water quality treatment. A diversion structure and pollution control manhole will direct water quality flows to the swale and divert high flows to an outfall further downstream via a new stormwater conveyance system consisting of two manholes and 250 LF of 12-inch pipe. Large boulders and vegetation will be placed near the existing outfall to prevent further incision. Multiple boulder check dams or steps will be installed in the swale for flow control to reduce erosive energy and provide a more approachable setting for visitors. The existing dirt road will have some minor regrading and will be paved with geo-grid grass pavers. Native trees and vegetation will also be planted with temporary irrigation as part of this project.

Design Considerations

Only 30% level design has been performed to identify conceptual plans. Detailed topographic survey and hydraulic modeling is needed to conduct final engineering evaluation to determine the appropriate invert elevations and verify pipe diameters to maintain necessary cover and convey the design event for the stormwater system.

Planning-level Cost Estimate

General Requirements	$60,000
Earthwork	$170,000
Storm Utilities	$65,000
Landscaping/Irrigation	$65,000
Site Furniture	$19,000
10% Contingency	$38,000
Capital Project Implementation Cost Total*	**$417,000**
Engineering and Permitting (20%)	$83,000
Construction Administration (5%)	$21,000
Capital Project Implementation Cost Total*	**$521,000**

**Planning level cost estimates estimated in 2019 dollars, rounded to the nearest thousand. Project cost does not include property or easement acquisitions.*

Additional Project Information

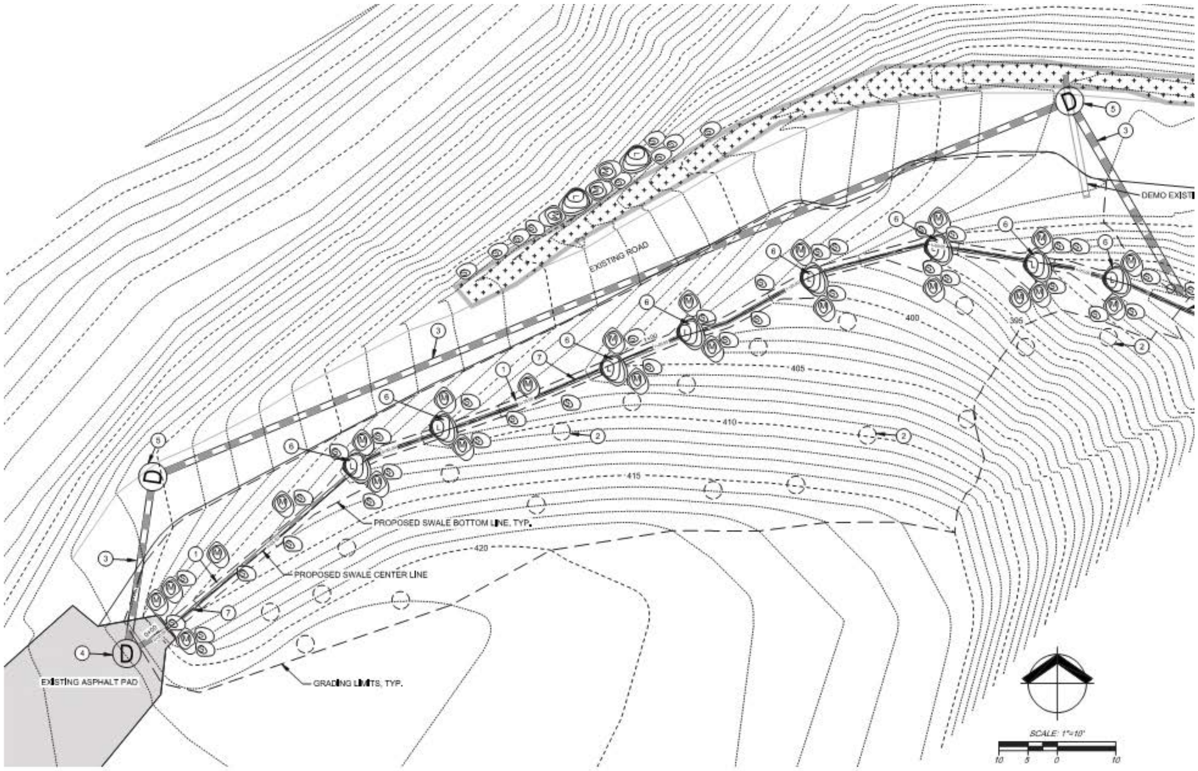
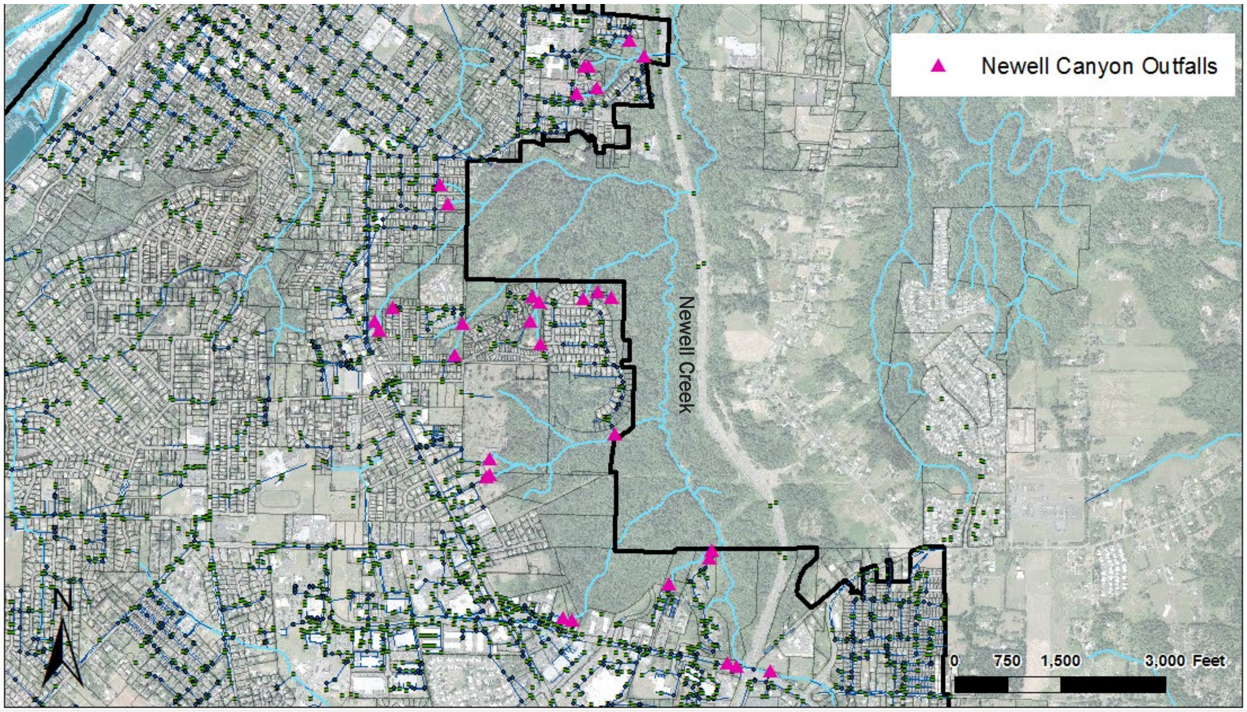


Image 1. Conceptual plan for Scattering Canyon



Project Identifier	CIP 12
Project Name	Newell Canyon Outfall Assessment
Detailed Location	Newell Creek
Model File	N/A
Objective(s) Addressed	Natural Systems, Infrastructure

Project Background

The area around Newell Creek, commonly referred to as Newell Canyon, has several locations where erosion, bank sloughing, and landslides have occurred during and following storm events. The canyon is largely protected from development because of Metro ownership and protection. However, prior development of the drainage area contributing to Newell Canyon has resulted in some degradation of the natural systems.

Newell Canyon has been established as a problem area that is characterized by steep slopes, erodible soils, and numerous stormwater outfalls and small drainage tributaries. The development in this watershed is generally lacks stormwater management facilities. The combination of development without flow control and highly erodible soils has resulted in observed stream incision, erosion at the outfalls, and severely altered stream channels. Newell Canyon hillsides have also experienced sloughing and small landslides, though those problems cannot be attributed solely to stormwater runoff. Newell Creek has some areas of severe downcutting and incision in the upper reaches of the creek but lower reaches of the creek through the base of the canyon seem to be well preserved.

Stream surveys and site visits in 2015 and 2016 by Brown and Caldwell staff documented areas where stormwater outfalls showed noticeable degradation. Outfalls showed visible increases in erosion and degradation over the course of 12 months. There is concern that ongoing degradation may lead to more significant bank and hillside stability problems.

Project Description

Further study is needed to evaluate the stormwater outfalls in the Newell Canyon area. This project includes conducting a widespread outfall assessment to evaluate stormwater outfalls, identify significant problem locations, and develop concept plans to stabilize degrading systems. The assessment should include the following:

- Develop outfall evaluation criteria for a desktop evaluation and onsite evaluation.
- Conduct desktop evaluation using available mapping data and problem area reports to prioritize locations for onsite assessments.
- Based on the prioritization outcome, conduct outfall inspections at roughly 15-20 high priority outfalls. Inspections would evaluate outfall condition, stabilization measures, bank stability and degradation. Inspections would also evaluate construction opportunities and constraints for future stabilization projects.
- Develop a priority matrix of outfall stabilization projects and a recommended schedule for design and construction.
- Develop concept level designs and cost estimates for outfall stabilization measures at the highest priority project areas (approximately 5 outfalls).

The planning level cost estimate includes the development of evaluation criteria, 15-20 site visits, and concept design for up to 5 locations.

Planning-level Cost Estimate	
Capital Project Implementation Cost Total	**$100,000**

Additional Project Information

Image 1. Degrading outfall location near Peter Skene Way

Image 2. Sloughing bank downstream of outfall location near Eluria Street

Appendix G: Potential Project Matrix

Table G-1. Potential Projects (as of April 2017)

				Project type		Project benefits					
Project no.	Project area/name	Problem areas addressed	Project description	Individual	Programmatic	Capacity	Asset upgrade/replacement	Water quality	Habitat/channel restoration	Erosion prevention/repair	Other
Project Recommendations											
1	John Adams Basin Capacity Improvements	JA-F-01 JA-F-02 JA-F-03 JA-F-04 JA-I-01 JA-I-03 JA-I-04 JA-I-05	Upsize pipes and/or re-route flow to address capacity problems and replace aging infrastructure.	X		X	X				
2	Infrastructure Inspection and Rehabilitation	JA… SI-I-01 CO-I-01	Program to conduct video inspection for aging infrastructure. Areas to include John Adams Basin, older parts of Singer Basin, and the Canemah District in the Coffee Creek Basin. Infrastructure replacement based on inspection results.		X		X				
3	Outfall Inspection and Stabilization	NE-N-04 LI-N-01 LI-I-02	Programmatic inspections and repairs to stabilize outfalls in Newell Canyon and other tributaries to Abernethy. Examples: Peter Skene Way, 14040 Beemer Way		X					X	X
4	South End Rd near Rose Rd	SE-F-02 SE-I-01	Upsize undersized pipes in South End Road and extend closed drainage system to outfall near S Salmonberry Drive.	X		X					
5	Division near Penn	AB-I-01	Upgrade catch basins and storm system along west side of Division, starting at 19th/Anchor Way and extending to Penn.	X		X	X				
6	Rivercrest Neighborhood	SI-I-02	Install storm drainage system to disconnect from sanitary system.	X			X				X
7	Harding Blvd	SI-I-04	Install storm drainage system to disconnect from sanitary system.	X			X				X
8	Pebble Beach Pond	CA-F-01	Retrofit existing ponds to improve operations/storage and increase water quality treatment	X		X		X			

Table G-1. Potential Projects (as of April 2017)

Project no.	Project area/name	Problem areas addressed	Project description	Project type		Project benefits					
				Individual	Programmatic	Capacity	Asset upgrade/replacement	Water quality	Habitat/channel restoration	Erosion prevention/repair	Other
Additional Potential Projects to Consider											
ODOT project	Hwy 213 and Beavercreek Rd	NE-N-01	Channel and outfall stabilization based on geotechnical investigation.	x						x	
Low priority	Kathaway Ct to Sunset Springs	CP-F-01	Extend pipes to collect drainage from Partlow and adjust outfall accordingly.	x		x					
Maintenance project	Harrison St & Division	SI-I-06	Maintenance upgrade to replace existing pipe and add berm, curb, or CB.	x			x				
Opportunity with other infrastructure priorities	Coffee Creek Culverts near Hazelwood	CO-F-01 CO-I-04	Replace aging culvert or re-grade and rehabilitate natural channel to improve capacity.	x		x					
	Hiefield Court	MU-F-02	Upsize existing culvert crossing Leland Rd to address flooding.	X		X					
	Livesay	NA	Holcomb Blvd from outfall at Oak Tree Ter upstream to roadside ditch on north side of road is undersized. System may require improvements/upsizing associated with development.	x		x					
	Park Place	NA	Several culverts may be undersized and contribute to flooding. Improvements to the system may be needed.	x		x					
	Newell Creek	NE-F-01	existing in line detention system may be contributing to localized flooding at the intersection of Beavercreek Rd and Molalla Ave.	x		x				x	

Appendix H: CIP Cost Estimates

Oregon City 2019 SWMP
Unit Cost Table
Recommended unit cost for Oregon City 2019 SWMP.
Costs based on RS Means, collected bid tabs, and recent master planning efforts.

ITEM	UNIT	2019 Recommended Unit Costs
Water Quality Facility Installation		
General Earthwork/ Excavation	CY	20
Dewatering/flow bypass	LS	20,000
Embankment	CY	9
Clear and Grub brush including stumps	AC	8,200
Amended Soils and Mulch	CY	45
Jute Matting, Biodegradeable	SY	6
Geomembrane	SY	30
Energy dissapation pad - Rip-Rap, Class 50	CY	66
Drain Rock	CY	101
Pond Outflow Control Structure	EA	6,100
Pond Inlet Structure	EA	4,500
Water Quality Facility Plantings with Trees	SF	6
Rain Garden	SF	27
Stormwater Planter	SF	40
Gravel Access Road	SF	5
Beehive Overflow	EA	1,500
Structure Installation		
Precast Concrete Manhole (48", 0-8' deep)	EA	5,600
Precast Concrete Manhole (48", 9-12' deep)	EA	6,600
Precast Concrete Manhole (48", 13-20' deep)	EA	10,200
Precast Concrete Manhole (60", 0-8' deep)	EA	7,600
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700
Precast Concrete Manhole (72", 0-8' deep)	EA	9,700
Precast Concrete Manhole (72", 9-12' deep)	EA	12,200
Drywell (48", 20-25' deep)	EA	12,200
Curb Inlet	EA	1,300
Catch Basin, all types	EA	2,000
Concrete Fill - UIC Decomissioning	EA	10,200
Connection to Existing Lateral	EA	1,200
Connection to Existing Structure, standard	EA	2,000
Connection to Existing Stone Structure	EA	7,500
Pipe Demo and Disposal	FT	70
Abandon Existing Pipe, no excavation (12")	FT	10
Abandon Existing Pipe, no excavation (15"-18")	FT	20
Abandon Existing Pipe, no excavation (21"-24")	FT	25
Abandon Existing Pipe, no excavation (27"-36")	FT	35
Abandon Existing Structure	EA	1,000
Remove Manhole Structure	EA	1,000
Plug Existing Pipe	EA	505
Outfall Improvements	EA	3,000-10,000
Restoration/ Resurfacing		
Non-Water Quality Facility Landscaping	AC	15,300
Riparian/Wetland Planting (Non-irrigated)	AC	20,300
Riparian/Wetland Planting (w/ temporary irrigation)	AC	32,500
4-foot Chain Link Fence	LF	22
Split Rail Fence	LF	25
Hydroseed, large quantities	AC	2,500
Seeding, small quantities	SF	6
Concrete Curbs	FT	40
Pipe Unit Cost		
Underdrain, 6" perforated HDPE	LF	56
HDPE Inlet Lead (12", 2-5' Deep)	FT	91
HDPE Pipeline w/ asphalt resurfacing (12", 5-10' Deep)	FT	140
HDPE Pipeline w/ asphalt resurfacing (12", 10-15' Deep)	FT	160
HDPE Pipeline w/ asphalt resurfacing (15", 10-15' Deep)	FT	180
HDPE Pipeline w/ asphalt resurfacing (18", 5-10' Deep)	FT	200
HDPE Pipeline w/ asphalt resurfacing (21", 5-10' Deep)	FT	240
HDPE Pipeline w/ asphalt resurfacing (24", 5-10' Deep)	FT	275
HDPE Pipeline w/ asphalt resurfacing (30", 5-10' Deep)	FT	325
HDPE Pipeline w/ asphalt resurfacing (36", 5-10' Deep)	FT	405
HDPE Pipeline w/ asphalt resurfacing (42", 5-10' Deep)	FT	485
HDPE Pipeline w/ asphalt resurfacing (48", 5-10' Deep)	FT	570
HDPE Pipeline w/ asphalt resurfacing (60", 5-10' Deep)	FT	820
Extra depth pipe	FT	51
Construction Contingencies and Multipliers		
Mobilization/Demobilization	LS	10%
Traffic Control/Utility Relocation	LS	10-15%
Erosion Control	LS	2%
Construction Contingency	LS	30%
Engineering and Permitting (%)	LS	15-40%
Construction Administration (%)	LS	15%
Market Climate (%)	LS	10%

Oregon City 2019 SWMP

Stormwater Master Plan Project Cost Summary

July 2019

CIP ID	Project Title	Total Cost (rounded)
CIP-1	John Adams Basin Capacity Improvements (all phases)	$8,555,000
CIP-2	South End Road Stormwater Improvement	$3,209,000
CIP-3	Division Street Infrastructure (Option 1)	$770,000
CIP-4	Rivercrest Sanitary Disconnect	$2,428,000
CIP-5	Harding Boulevard Sanitary Disconnect	$464,000
CIP-6	Pebble Beach Pond Retrofit	$713,000
CIP-7	Hiefield Court Culvert Improvements	$657,000
CIP-8	The Cove Water Quality Improvements	$608,000
CIP-9	Holcomb Boulevard Capacity Improvements	$3,893,000
CIP-10	Coffee Creek Capacity Improvements	$1,096,000
CIP-11	Scattering Canyon Stormwater Improvement	$521,000
Programmatic Activities		**Annual Cost**
CIP-12	Newell Canyon Outfall Assessment (annual)	$100,000
	Stormwater Short Term Repair Budget (annual)	TBD
	Stormwater Infrastructure Rehabilitation (annual)	TBD
	CIPs Total Cost:	**$23,014,000**

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #1
John Adams Basin Capacity Improvements
Outfall to 12th/John Adams

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Water Quality Facility Installation				
Energy dissapation pad - Rip-Rap, Class 50	CY	66	90	$5,940
Structure Installation				
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700	12	$116,400
Catch Basin, all types	EA	2,000	15	$30,000
Connection to Existing Structure, standard	EA	2,000	5	$10,000
Pipe Demo and Disposal	FT	70	1140	$79,800
Remove Manhole Structure	EA	1,000	12	$12,000
Outfall Improvements	EA	3,000-10,000	10000	$10,000
Pipe Unit Cost				
HDPE Inlet Lead (12", 2-5' Deep)	FT	91	300	$27,300
HDPE Pipeline w/ asphalt resurfacing (36", 5-10' Deep)	FT	405	540	$218,700
HDPE Pipeline w/ asphalt resurfacing (60", 5-10' Deep)	FT	820	600	$492,000
Extra depth pipe	FT	51	820	$41,820
Project Sub-Total				$1,044,000
Constructtion Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$104,400
Traffic Control/Utility Relocation	LS	10%		$104,400
Erosion Control	LS	2%		$20,880
Construction Cost Subtotal				$1,274,000
Construction Contingency	LS	30%		$382,200
Capital Expense Total				$1,656,200
Engineering and Permitting (%)	LS	40%		$662,480
Market Climate (%)	LS	10%		$165,620
Construction Administration (%)	LS	15%		$248,430
			TOTAL	$2,733,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #1

John Adams Basin Capacity Improvements

12th/John Adams to 12th/Harrison

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Structure Installation				
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700	8	$77,600
Catch Basin, all types	EA	2,000	21	$42,000
Connection to Existing Structure, standard	EA	2,000	4	$8,000
Pipe Demo and Disposal	FT	70	1900	$133,000
Remove Manhole Structure	EA	1,000	9	$9,000
Pipe Unit Cost				
HDPE Inlet Lead (12", 2-5' Deep)	FT	91	420	$38,220
HDPE Pipeline w/ asphalt resurfacing (18", 5-10' Deep)	FT	200	800	$160,000
HDPE Pipeline w/ asphalt resurfacing (24", 5-10' Deep)	FT	275	1100	$302,500
Project Sub-Total				$770,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$77,000
Traffic Control/Utility Relocation	LS	15%		$115,500
Erosion Control	LS	2%		$15,400
Construction Cost Subtotal				$978,000
Construction Contingency	LS	30%		$293,400
Capital Expense Total				$1,271,400
Engineering and Permitting (%)	LS	15%		$190,710
Market Climate (%)	LS	10%		$127,140
Construction Administration (%)	LS	15%		$190,710
			TOTAL	$1,780,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #1
John Adams Basin Capacity Improvements
12th/John Adams to 8th/Van Buren

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Structure Installation				
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700	12	$116,400
Catch Basin, all types	EA	2,000	30	$60,000
Connection to Existing Structure, standard	EA	2,000	9	$18,000
Pipe Demo and Disposal	FT	70	3500	$245,000
Abandon Existing Pipe, no excavation (12")	FT	10	340	$3,400
Remove Manhole Structure	EA	1,000	13	$13,000
Pipe Unit Cost				
HDPE Inlet Lead (12", 2-5' Deep)	FT	91	600	$54,600
HDPE Pipeline w/ asphalt resurfacing (12", 5-10' Deep)	FT	140	340	$47,600
HDPE Pipeline w/ asphalt resurfacing (18", 5-10' Deep)	FT	200	1400	$280,000
HDPE Pipeline w/ asphalt resurfacing (24", 5-10' Deep)	FT	275	1200	$330,000
Project Sub-Total				$1,168,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$116,800
Traffic Control/Utility Relocation	LS	15%		$175,200
Erosion Control	LS	2%		$23,360
Construction Cost Subtotal				$1,483,000
Construction Contingency	LS	30%		$444,900
Capital Expense Total				$1,927,900
Engineering and Permitting (%)	LS	15%		$289,185
Market Climate (%)	LS	10%		$192,790
Construction Administration (%)	LS	15%		$289,185
			TOTAL	$2,699,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #1

John Adams Basin Capacity Improvements

12th/Washington to 8th/John Adams

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Structure Installation				
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700	8	$77,600
Catch Basin, all types	EA	2,000	12	$24,000
Connection to Existing Structure, standard	EA	2,000	3	$6,000
Pipe Demo and Disposal	FT	70	1200	$84,000
Remove Manhole Structure	EA	1,000	8	$8,000
Pipe Unit Cost				
HDPE Inlet Lead (12", 2-5' Deep)	FT	91	240	$21,840
HDPE Pipeline w/ asphalt resurfacing (18", 5-10' Deep)	FT	200	1800	$360,000
Project Sub-Total				$581,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$58,100
Traffic Control/Utility Relocation	LS	15%		$87,150
Erosion Control	LS	2%		$11,620
Construction Cost Subtotal				$738,000
Construction Contingency	LS	30%		$221,400
Capital Expense Total				$959,400
Engineering and Permitting (%)	LS	15%		$143,910
Market Climate (%)	LS	10%		$95,940
Construction Administration (%)	LS	15%		$143,910
			TOTAL	$1,343,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #2
South End Road Stormwater Improvement

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Water Quality Facility Installation				
Water Quality Enhancement	LS	150,000	1	$150,000
Structure Installation				
Precast Concrete Manhole (48", 9-12' deep)	EA	6,600	3	$19,800
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700	2	$19,400
Precast Concrete Manhole (72", 9-12' deep)	EA	12,200	2	$24,400
Catch Basin, all types	EA	2,000	7	$14,000
Abandon Existing Pipe, no excavation (12")	FT	10	200	$2,000
Abandon Existing Pipe, no excavation (15"-18")	FT	20	35	$700
Abandon Existing Pipe, no excavation (27"-36")	FT	35	1100	$38,500
Remove Manhole Structure	EA	1,000	7	$7,000
Outfall Improvements	EA	3,000-10,000	1	$3,000
Restoration/ Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	0.5	$10,150
Pipe Unit Cost				
HDPE Inlet Lead (12", 2-5' Deep)	FT	91	140	$12,740
HDPE Pipeline w/ asphalt resurfacing (36", 5-10' Deep)	FT	405	800	$324,000
HDPE Pipeline w/ asphalt resurfacing (48", 5-10' Deep)	FT	570	705	$401,850
HDPE Pipeline w/ asphalt resurfacing (60", 5-10' Deep)	FT	820	400	$328,000
Project Sub-Total				$1,356,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$135,600
Traffic Control/Utility Relocation	LS	15%		$203,400
Erosion Control	LS	5%		$67,800
Construction Cost Subtotal				$1,763,000
Construction Contingency	LS	30%		$528,900
Capital Expense Total				$2,291,900
Engineering and Permitting (%)	LS	15%		$343,785
Market Climate (%)	LS	10%		$229,190
Construction Administration (%)	LS	15%		$343,785
			TOTAL	$3,209,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #3

Division Street Infrastructure Improvements

Option 1

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Water Quality Facility Installation				
Energy dissapation pad - Rip-Rap, Class 50	CY	66	60	$3,960
Structure Installation				
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700	4	$38,800
Catch Basin, all types	EA	2,000	7	$14,000
Outfall Improvements	EA	3,000-10,000	3000	$3,000
Restoration/ Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	0.5	$10,150
Seeding, small quantities	SF	6	1000	$6,000
Concrete Curbs	FT	40	1000	$40,000
Pipe Unit Cost				
HDPE Inlet Lead (12", 2-5' Deep)	FT	91	140	$12,740
HDPE Pipeline w/ asphalt resurfacing (12", 5-10' Deep)	FT	140	1400	$196,000
Project Sub-Total				$325,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$32,500
Traffic Control/Utility Relocation	LS	15%		$48,750
Erosion Control	LS	5%		$16,250
Construction Cost Subtotal				$423,000
Construction Contingency	LS	30%		$126,900
Capital Expense Total				$549,900
Engineering and Permitting (%)	LS	15%		$82,485
Market Climate (%)	LS	10%		$54,990
Construction Administration (%)	LS	15%		$82,485
			TOTAL	$770,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #3

Division Street Infrastructure Improvements

Option 2

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Water Quality Facility Installation				
Energy dissapation pad - Rip-Rap, Class 50	CY	66	60	$3,960
Structure Installation				
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700	7	$67,900
Catch Basin, all types	EA	2,000	13	$26,000
Outfall Improvements	EA	3,000-10,000	3000	$3,000
Restoration/ Resurfacing				
Concrete Curbs	FT	40	1000	$40,000
Pipe Unit Cost				
HDPE Inlet Lead (12", 2-5' Deep)	FT	91	260	$23,660
HDPE Pipeline w/ asphalt resurfacing (12", 5-10' Deep)	FT	140	1900	$266,000
Project Sub-Total				$431,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$43,100
Traffic Control/Utility Relocation	LS	10%		$43,100
Erosion Control	LS	5%		$21,550
Construction Cost Subtotal				$539,000
Construction Contingency	LS	30%		$161,700
Capital Expense Total				$700,700
Engineering and Permitting (%)	LS	15%		$105,105
Market Climate (%)	LS	10%		$70,070
Construction Administration (%)	LS	15%		$105,105
			TOTAL	$981,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #4
Rivercrest Neighborhood Infrastructure Improvements

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Water Quality Facility Installation				
Energy dissapation pad - Rip-Rap, Class 50	CY	66	60	$3,960
Structure Installation				
Precast Concrete Manhole (48", 13-20' deep)	EA	10,200	1	$10,200
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700	9	$87,300
Catch Basin, all types	EA	2,000	27	$54,000
Abandon Existing Pipe, no excavation (15"-18")	FT	20	1500	$30,000
Outfall Improvements	EA	3,000-10,000	3000	$3,000
Restoration/ Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	0.5	$10,150
Pipe Unit Cost				
HDPE Inlet Lead (12", 2-5' Deep)	FT	91	440	$40,040
HDPE Pipeline w/ asphalt resurfacing (12", 5-10' Deep)	FT	140	2800	$392,000
HDPE Pipeline w/ asphalt resurfacing (12", 10-15' Deep)	FT	160	700	$112,000
HDPE Pipeline w/ asphalt resurfacing (24", 5-10' Deep)	FT	275	900	$247,500
Extra depth pipe	FT	51	700	$35,700
Project Sub-Total				$1,026,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$102,600
Traffic Control/Utility Relocation	LS	15%		$153,900
Erosion Control	LS	5%		$51,300
Construction Cost Subtotal				$1,334,000
Construction Contingency	LS	30%		$400,200
Capital Expense Total				$1,734,200
Engineering and Permitting (%)	LS	15%		$260,130
Market Climate (%)	LS	10%		$173,420
Construction Administration (%)	LS	15%		$260,130
			TOTAL	$2,428,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #5

Harding Boulevard Sanitary Disconnect

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Water Quality Facility Installation				
Energy dissapation pad - Rip-Rap, Class 50	CY	66	60	$3,960
Structure Installation				
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700	4	$38,800
Catch Basin, all types	EA	2,000	5	$10,000
Abandon Existing Pipe, no excavation (12")	FT	10	160	$1,600
Abandon Existing Structure	EA	1,000	5	$5,000
Plug Existing Pipe	EA	505	5	$2,525
Outfall Improvements	EA	3,000-10,000	3000	$3,000
Restoration/ Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	0.5	$10,150
Pipe Unit Cost				
HDPE Inlet Lead (12", 2-5' Deep)	FT	91	100	$9,100
HDPE Pipeline w/ asphalt resurfacing (12", 5-10' Deep)	FT	140	800	$112,000
Project Sub-Total				$196,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$19,600
Traffic Control/Utility Relocation	LS	15%		$29,400
Erosion Control	LS	5%		$9,800
Construction Cost Subtotal				$255,000
Construction Contingency	LS	30%		$76,500
Capital Expense Total				$331,500
Engineering and Permitting (%)	LS	15%		$49,725
Market Climate (%)	LS	10%		$33,150
Construction Administration (%)	LS	15%		$49,725
			TOTAL	$464,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #6
Pebble Beach Pond Retrofit

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Water Quality Facility Installation				
General Earthwork/ Excavation	CY	20	400	$8,000
Amended Soils and Mulch	CY	45	2000	$90,000
Pond Outflow Control Structure	EA	6,100	2	$12,200
Pond Inlet Structure	EA	4,500	2	$9,000
Structure Installation				
Precast Concrete Manhole (60", 9-12' deep)	EA	9,700	3	$29,100
Outfall Improvements	EA	3,000-10,000	3000	$3,000
Restoration/ Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	0.5	$10,150
Riparian/Wetland Planting (w/ temporary irrigation)	AC	32,500	1.2	$39,000
Pipe Unit Cost				
HDPE Pipeline w/ asphalt resurfacing (24", 5-10' Deep)	FT	275	300	$82,500
Project Sub-Total				$283,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$28,300
Traffic Control/Utility Relocation	LS	10%		$28,300
Erosion Control	LS	5%		$14,150
Construction Cost Subtotal				$354,000
Construction Contingency	LS	30%		$106,200
Capital Expense Total				$460,200
Engineering and Permitting (%)	LS	30%		$138,060
Market Climate (%)	LS	10%		$46,020
Construction Administration (%)	LS	15%		$69,030
			TOTAL	$713,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #7

Hiefield Court Culvert Improvements

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Modeling				
Hydrology and hydraulic assessment	EA	30,000	1	$30,000
Water Quality Facility Installation				
General Earthwork/ Excavation	CY	20	100	$2,000
Inlet structure	LS	1,500	1	$15,000
Structure Installation				
Precast Concrete Manhole (60", 0-8' deep)	EA	7,600	1	$7,600
Pipe Demo and Disposal	FT	70	210	$14,700
Outfall Improvements	EA	3,000-10,000	3000	$3,000
Restoration/ Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	0.5	$10,150
Seeding, small quantities	SF	6	2500	$15,000
Pipe Unit Cost				
HDPE Pipeline w/ asphalt resurfacing (36", 5-10' Deep)	FT	405	400	$162,000
Project Sub-Total				$259,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$25,900
Traffic Control/Utility Relocation	LS	15%		$38,850
Erosion Control	LS	5%		$12,950
Construction Cost Subtotal				$337,000
Construction Contingency	LS	30%		$101,100
Capital Expense Total				$438,100
Engineering and Permitting (%)	LS	25%		$109,525
Market Climate (%)	LS	10%		$43,810
Construction Administration (%)	LS	15%		$65,715
			TOTAL	$657,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #8

The Cove Water Quality Improvements

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Survey				
Survey	EA	20,000	1	$20,000
Modeling				
Hydrology and hydraulic assessment	EA	20,000	1	$20,000
Water Quality Facility Installation				
General Earthwork/ Excavation	CY	20	1700	$34,000
Amended Soils and Mulch	CY	45	450	$20,250
Energy dissapation pad - Rip-Rap, Class 50	CY	66	200	$13,200
Structure Installation				
Catch Basin, all types	EA	2,000	4	$8,000
Outfall Improvements	EA	3,000	3	$9,000
Restoration/ Resurfacing				
Water Quality Facility Planting with Irrigation	SF	2	11000	$22,000
Pipe Unit Cost				
HDPE Pipeline w/ asphalt resurfacing (24", 5-10' Deep)	FT	275	400	$110,000
Project Sub-Total				$256,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$25,600
Traffic Control/Utility Relocation	LS	10%		$25,600
Erosion Control	LS	2%		$5,120
Construction Cost Subtotal				$312,000
Construction Contingency	LS	30%		$93,600
Capital Expense Total				$405,600
Engineering and Permitting (%)	LS	25%		$101,400
Market Climate (%)	LS	10%		$40,560
Construction Administration (%)	LS	15%		$60,840
			TOTAL	$608,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #9

Holcomb Boulevard Capacity Improvements

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Structure Installation				
Precast Concrete Manhole (60", 0-8' deep)	EA	7,600	16	$121,600
Abandon Existing Structure	EA	1,000	4	$4,000
Pipe Demo and Disposal	FT	70	3750	$262,500
Outfall Improvements	EA	3,000-10,000	3000	$10,000
Restoration/ Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	0.5	$10,150
Seeding, small quantities	SF	6	2500	$15,000
Pipe Unit Cost				
HDPE Pipeline w/ asphalt resurfacing (15", 10-15' Deep)	FT	180	980	$176,400
HDPE Pipeline w/ asphalt resurfacing (24", 5-10' Deep)	FT	275	300	$82,500
HDPE Pipeline w/ asphalt resurfacing (30", 5-10' Deep)	FT	325	1070	$347,750
HDPE Pipeline w/ asphalt resurfacing (36", 5-10' Deep)	FT	405	800	$324,000
HDPE Pipeline w/ asphalt resurfacing (42", 5-10' Deep)	FT	485	600	$291,000
Project Sub-Total				$1,645,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$164,500
Traffic Control/Utility Relocation	LS	15%		$246,750
Erosion Control	LS	5%		$82,250
Construction Cost Subtotal				$2,139,000
Construction Contingency	LS	30%		$641,700
Capital Expense Total				$2,780,700
Engineering and Permitting (%)	LS	15%		$417,105
Market Climate (%)	LS	10%		$278,070
Construction Administration (%)	LS	15%		$417,105
			TOTAL	$3,893,000

Oregon City 2019 SWMP

CIP Cost Estimate

CIP #10

Coffee Creek Capacity Improvements

ITEM	UNIT	Recommended Unit Cost	Quantity	Total Cost
Water Quality Facility Installation				
General Earthwork/ Excavation	CY	20	800	$16,000
Dewatering/Flow bypass	LS	20,000	1	$20,000
Clear and Grub brush including stumps	AC	8,200	0.5	$4,100
Jute Matting, Biodegradeable	SY	6	1200	$7,200
Energy dissapation pad - Rip-Rap, Class 50	CY	66	10	$660
Rip-Rap, Class 100	CY	80	900	$72,000
Drain Rock	CY	101	300	$30,300
Water Quality Facility Plantings with Trees	SF	6	16200	$97,200
Inlet structure	LS	1,500	1	$15,000
Structure Installation				
Pipe Demo and Disposal	FT	70	300	$21,000
Outfall Improvements	EA	3,000-10,000	3000	$3,000
Restoration/ Resurfacing				
Riparian/Wetland Planting (Non-irrigated)	AC	20,300	0.5	$10,150
Seeding, small quantities	SF	6	2500	$15,000
Pipe Unit Cost				
HDPE Pipeline w/ asphalt resurfacing (48", 5-10' Deep)	FT	570	80	$45,600
HDPE Pipeline w/ asphalt resurfacing (60", 5-10' Deep)	FT	820	70	$57,400
Extra depth pipe*	FT	51	950	$48,450
Project Sub-Total				$463,000
Contingencies and Multipliers				
Mobilization/Demobilization	LS	10%		$46,300
Traffic Control/Utility Relocation	LS	15%		$69,450
Erosion Control	LS	5%		$23,150
Construction Cost Subtotal				$602,000
Construction Contingency	LS	30%		$180,600
Capital Expense Total				$782,600
Engineering and Permitting (%)	LS	15%		$117,390
Market Climate (%)	LS	10%		$78,260
Construction Administration (%)	LS	15%		$117,390
			TOTAL	$1,096,000

Appendix I: Project Prioritization Scoring Matrix

Table I-1. Project Prioritization Scoring Matrix

Criteria	Weight	Rating Criteria Definition		
		5	3	1
1. Capacity Issue (safety/liability) *Are existing/future capacity and safety/liability issues addressed?*	1.0	Significant flooding hazard; Threat to life and limb and/or property	Moderate flooding safety hazard	No flooding safety hazard
2. Benefit to Sanitary System *Does the project address storm and sanitary infrastructure needs?*	1.0	Significant benefit to sanitary system	Moderate benefit to sanitary system	No benefit to sanitary system
3. Cost *What is the expected capital investment?*	1.0	Small capital project (less than $500,000)	Medium capital project (greater than $500,000 and less than $1,000,000)	Large capital project (more than $1,000,000)
4. Environmental Benefit (sustainability/livability) *Does the project address water quality, other environmental benefits?*	1.0	Significantly improves water quality	Moderately improves water quality	No improvement to water quality
5. Maintenance (long-/short-term) *Will this cause a long term maintenance burden?*	1.0	Project will significantly reduce ongoing maintenance requirements	Project will moderately reduce ongoing maintenance requirements	Project will not reduce ongoing maintenance requirements
6. Existing Condition *How close is the system to its expected design life or is it failing?*	0.5	System is failing or beyond its expected design life	System appears to be in average working order and is not beyond expected design life	System is in good shape and relatively new
7. Impact *How large an area and/or how many people does the problem impact?*	1.0	Problem affects regionwide area with significant downstream and/or upstream impacts	Project will address multiple blocks or properties	Project will address a few properties

CIP Scoring Criteria						CIP Project Scoring									
	Criteria	Weight	Rating Criteria Definition			1	2	3	4	5	6	7	8	9	10
			5	3	1	John Adams	South End Rd	Division St	River Crest	Harding Blvd	Pebble Beach	Hiefield Ct	The Cove	Newell Canyon	Scatter Canyon
1	Capacity Issue	1.0	Significant hazard	Moderate hazard	No hazard	3	3	1	3	5	1	3	1	3	3
2	Benefit to Sanitary System	1.0	Significant benefit	Moderate benefit	No benefit	1	1	1	5	5	1	1	1	1	1
3	Cost	1.0	Small capital project	Medium capital project	Large capital project	1	1	3	1	5	3	3	3	5	5
4	Environmental Benefit	1.0	Significantly improves water quality	Moderately improves water quality	No improvement to water quality	1	1	1	3	3	5	3	5	3	3
5	Maintenance	1.0	Significant reduction	Moderate reduction	No reduction	5	3	3	3	3	3	1	3	5	5
6	Existing Condition	0.5	poor	average	good	2.5	1.5	2.5	2.5	2.5	1.5	0.5	0.5	2.5	2.5
7	Impact	1.0	Regionwide impact	10-15 years	Short term	5	5	1	3	3	1	1	3	5	3
Totals						**18.5**	**15.5**	**12.5**	**20.5**	**26.5**	**15.5**	**12.5**	**16.5**	**24.5**	**22.5**
					Rank	**6**	**8**	**10**	**4**	**1**	**7**	**9**	**5**	**2**	**3**

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