

Initial Draft

CITY OF DUVALL WATERSHED PLAN

Prepared for
City of Duvall

January 30, 2015



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TABLE OF CONTENTS

CHAPTER 1.	Watershed Plan Overview.....	1-1
1.1	Purpose and Background	1-1
1.2	Public Planning Process.....	1-2
1.3	Plan Purpose and Organization.....	1-4
1.4	Duvall Landscape Setting	1-5
CHAPTER 2.	Key Watershed Analysis Results	2-1
2.1	Watershed and Basin Conditions.....	2-1
2.2	Watershed Characterization.....	2-12
2.3	Subbasin Management Group Framework	2-16
CHAPTER 3.	Watershed Goals and Policies.....	3-1
3.1	Goals and Policies.....	3-1
3.2	Implementation	3-4
CHAPTER 4.	Subbasin Folio	4-1
4.1	Understanding the Folio.....	4-1
4.2	Cherry Creek Basin.....	4-3
4.3	Duvall Tributaries Basin.....	4-3
4.4	Weiss Creek Basin.....	4-4
CHAPTER 5.	Watershed Strategies for Development Standards	5-1
5.1	Development Regulations Strategies Overview	5-1
	Objectives	5-1
	Subbasin Prioritization Based on Watershed Analysis Results.....	5-1
5.2	Implementing Watershed Approach for Development Standards	5-1
	Zoning.....	5-1
	Landscaping	5-1
	Tree Protection.....	5-1
	Subdivision	5-1
5.3	Outcomes of Watershed Approach.....	5-1
CHAPTER 6.	Watershed Strategies for Stormwater Management.....	6-1
6.1	Stormwater Strategies Overview	6-1
	Stormwater Management Objectives	6-1
	Subbasin Prioritization Based on Watershed Analysis Results.....	6-1
6.2	Implementing Watershed Approach for Stormwater Management	6-1
	On-site strategies.....	6-1
	Centralized/Municipal Strategies	6-1
	Additional Strategies.....	6-1
6.3	Outcomes of Watershed Approach.....	6-1
CHAPTER 7.	Watershed Strategies for Sensitive Areas Management	7-1
7.1	Sensitive Areas Strategies Overview	7-1
	Objectives	7-1
	Subbasin Prioritization Based on Watershed Analysis Results.....	7-1
7.2	Implementing Watershed Approach for Sensitive Area Standards	7-1
	Wetlands	7-1
	Fish and Wildlife Habitats (including streams and habitat corridors).....	7-1
	Geologic Hazards.....	7-1

7.3	Outcomes of Watershed Approach.....	7-1
CHAPTER 8.	Land Use Strategies for Urban Growth Areas	8-1
8.1	UGA Land Use Strategies Overview.....	8-1
	Objectives	8-1
	Areas Studied.....	8-1
8.2	North UGA	8-1
	Existing Conditions.....	8-1
	Watershed Priorities.....	8-1
	Land Use Recommendations.....	8-1
8.3	East UGA Reserve – Northern Portion.....	8-1
	Existing Conditions.....	8-1
	Watershed Priorities.....	8-1
	Land Use Recommendations.....	8-1
8.4	East UGA Reserve – Southern Portion.....	8-1
	Existing Conditions.....	8-1
	Watershed Priorities.....	8-1
	Land Use Recommendations.....	8-2
8.5	South of City – Eastern Portion	8-2
	Existing Conditions.....	8-2
	Watershed Priorities.....	8-2
	Land Use Recommendations.....	8-2
8.6	South of City – Western Portion.....	8-2
	Existing Conditions.....	8-2
	Watershed Priorities.....	8-2
	Land Use Recommendations.....	8-2
8.7	Outcomes of Watershed-based Planning for Urban Growth Areas	8-2
CHAPTER 9.	References.....	10-1

LIST OF APPENDICES

Appendix A: Duvall Days Survey Results Memorandum

Appendix B: Data Sources, Methods, and Detailed Analysis Results

Appendix C: Low Impact Development Manual for Residential Projects

Appendix D: Data Sources List

LIST OF FIGURES

Figure 1-1. Project Study Area and Watershed Position.....	1-7
Figure 2-1. Landscape Processes that Maintain Key Aquatic Resources in the Puget Sound Lowlands (adapted from Stanley et al., 2005 and ESA, 2011)	2-3
Figure 2-2. Wetlands and Streams	2-9
Figure 2-3. Primary Results – Watershed Characterization Overall Water Flow	2-13
Figure 2-4. Secondary Results – Subbasin Management Recommendations	2-17
Figure 4-1 Example Folio Sheets.....	4-2

LIST OF TABLES

Table 2-1. Basins of Duvall.....	1
Table 2-2. Summary of Landscape Processes – Controls, Mechanisms and Important Areas (adapted from ESA, 2011).....	2-5
Table 2-3. Project Assessment Unit (PAU) Summary.....	2-15
Table 3-1. Watershed Actions [PLACEHOLDER].....	3-5
Table 4-1. PAU Folio Sheets in Cherry Creek Subbasins	4-3
Table 4-2. PAU Folio Sheets in Duvall Tributaries Subbasins.....	4-3

ACKNOWLEDGMENTS

PLACEHOLDER

GLOSSARY AND ACRONYMS

This is a work in progress. Final list to be provided for next draft

Term/Acronym	Description
Aquifer	Any geological formation containing or conducting ground water, especially one that supplies the water for wells, springs, etc.
Basin	The catchment area of a particular river and its tributaries.
BMP	Best Management Practices
Channel Morphology	The shapes of river channels and how they change over time.
Depressional Wetlands	Wetlands which occur in topographic depressions that allow the accumulation of surface water.
DEM	Digital Elevation Model
DMC	Duvall Municipal Code
Effective impervious surface	Impervious surface that is connected to the storm water drainage system.
Groundwater & Base Flow Management	
IP	Intrinsic Potential
LID	Low Impact Development
LWD	Large Woody Debris
Mainstem	The main course of a river or stream.
NRCS	Natural Resources Conservation Service
PAU	Project Assessment Unit
Reach	
Sediment export potential	A model of analysis which examines sources and sinks of sediment by looking at three processes: surface erosion, mass wasting, and stream channel erosion based on attributes of the watershed.
Slope Wetlands	Wetlands which occur along sloping land and are caused by the discharge of groundwater to the land surface and precipitation.
SSHAP	Salmon and Steelhead Habitat Inventory and Assessment Program
Stream sinuosity	A stream's tendency to move back and forth across its floodplain, in an S-shaped pattern, over time.
Subbasin	A geologic feature whereupon a depression in the earth's surface forms within a larger depression in the earth's surface.
Surface Storage	Water from rainfall that is temporarily retained and doesn't immediately add to a stream's flow. (Rain that "soaks into" the ground, rain that sits in puddles or ponds, rain that is retained or held back by any means is considered to be in

Term/Acronym	Description
	"surface storage".)
TESC	Temporary Erosion and Sediment Control
Tributary impoundment	
UGA	Urban Growth Area
UGAR	Urban Growth Area Reserve
WDFW	Washington Department of Fish and Wildlife
WDFW intrinsic model	
Windthrow	Trees uprooted or broken by wind.
WRIA	Water Resource Inventory Area

CHAPTER 1. WATERSHED PLAN OVERVIEW

1.1 Purpose and Background

Like many communities on the urban fringe, the City of Duvall is striving to promote economic growth and development without sacrificing its rural character and environmental assets that are at the heart of the community’s “small town – real life” identity. This Watershed Plan has been prepared by the consulting company Environmental Science Associates (ESA) to support the City in achieving this goal. The Plan provides a watershed-based framework to:

- Inform the 2015 Comprehensive Plan Update;
- Focus future development based on a comprehensive understanding of watershed processes;
- Maintain and improve forest cover and open space;
- Enhance the City’s approach to stormwater management and salmon recovery; and
- Strengthen sensitive area regulations to provide enhanced protection for important resources.

The Plan is based upon a detailed characterization of Duvall’s subbasins¹ using methods established by the Washington State Department of Ecology (Ecology) Puget Sound Watershed Characterization (Stanley et al., 2011). This Plan was developed with funding provided by the Environmental Protection Agency (EPA) through a National Estuary Program grant (PC-00J20101), and City matching dollars.

*The term **watershed characterization** refers to the process of evaluating geology, soils, hydrology, precipitation, topography, land cover and other information to describe the condition of the landscape. The characterization considered how natural processes have been altered by current conditions, including the addition of impervious surfaces throughout the city. This analysis will support decisions about future land use and stormwater planning within the city.*

¹ Drainage basins drain into other drainage basins in a hierarchical pattern, with smaller sub-drainage basins (or subbasins) combining into larger drainage basins.

1.2 Public Planning Process

The City convened a Watershed Planning Advisory Group to inform the process (see Acknowledgements section for a list of members). King County's Snoqualmie Watershed Forum worked closely with the City as a partner, including participating in Advisory Group activities. In addition, the City engaged the public in the planning process through a series of public events and activities:

1. **May 8, 2014 - Advisory Group Kick-off Meeting:** This was the first meeting with the Advisory Group and included introduction of ESA, City staff, and Advisory Group team members. ESA provided a project overview, and identified preliminary project basins, key data sources, and methodology.
2. **May 31, 2014 - Duvall Days:** The City set up a project booth for Duvall Days to educate the public about the Watershed Planning project. The booth was staffed by ESA, Sound Salmon Solutions, Mountains to Sound Greenway, and Stewardship Partners. In addition to interactive games, informational handouts, and posters, there was a survey that was available for the public to electronically fill out. The results of the survey are included in Appendix A.
3. **June 17, 2014 - Advisory Group Meeting #2:** ESA described the initial watershed modeling scores and subbasin boundaries (called Project Assessment Units or PAUs). The Advisory Group provided feedback on the types of watershed processes that should be studied in Duvall and the approach to creating management categories that would group subbasins based on the quality of their watershed processes.
4. **July 29, 2014 - Advisory Group Meeting #3:** ESA described the results of the primary and secondary watershed modeling scores (see Chapter 2 and Appendix B for more detail) and identified subbasin management categories along with a corresponding list of management tools that the City could use to protect or restore watershed processes. The Advisory Group began providing feedback on the management tools, adjusting them to better fit into Duvall's setting. The group provided more extensive feedback on the



City Booth at Duvall Days

management tools via an online survey by assigning each tool to a subbasin management category and prioritizing the tool based on its level of importance or relevance to the City.

5. **September 2, 2014 - Advisory Group Meeting #4:** ESA presented the final results of the primary and secondary analysis of the watershed models, the approach to incorporating aquatic habitat data into the models, and the final 5 subbasin management categories. ESA also provided a Project Assessment Unit two-sheet folio template (see Chapter 4) for review and feedback.
6. **October 14, 2014 - Advisory Group Meeting #5:** The group walked through the survey results of the management tools to obtain consensus on priority and appropriate management categories.
7. **November 18, 2014 - Advisory Group Meeting #6:** The group continued to work through the survey results of the management tools, focusing on the stormwater-related tools. Final feedback on the Project Assessment Unit two-sheet folio template was provided.
8. **February 18, 2015 - Advisory Group Meeting #7:** Chapters 1-4 of this Watershed Plan were presented to the Advisory Group for their feedback.
9. **March XX, 2015 - Advisory Group Meeting #8:** Chapters 5-8 and Appendices of this Watershed Plan were presented to the Advisory Group for their feedback.
10. **Planning Commission Meetings -** The initial draft of the Plan was presented to the Planning Commission on February 18th and XX, 2015. The Planning Commission held public hearings on the Plan on XX and XX, 2015. On XX, the Planning Commission recommended the Plan for approval by the City Council.
11. **City Council Meetings -** The plan was distributed to the City Council

CRITICAL AREAS				
#	Management Tool	Appropriate for:	Prioritization:	Discussion:
		1 2 3 4 5	1 2 3 4 5	
34	Further integrate tree protection standards into stream and wetland buffer standards	Initial response: • City-wide • Emphasis on District 2, 24, and 28	Initial response: 2.8 Most common: 2	
35	Increase steep slope and erosion hazard area buffers	Initial response: • District 1, 24, and 28	Initial response: 2.8 Most common: 2	1 - Impact - Not a program
36	Decrease allowances to modify or reduce critical areas buffers	Initial response: • City-wide	Initial response: 2.8 Most common: 2.8	4 - No need - No need - No need - No need
37	Increase buffers for depressional wetlands	Initial response: • All but Group 2 • City-wide • Not appropriate for District	Initial response: 2.8 Most common: 2	4 - Consider - Full is big - Consider - Consider - Consider
Other tools?				
ZONING REGULATIONS				
#	Management Tool	Appropriate for:	Prioritization:	Discussion:
		1 2 3 4 5	1 2 3 4 5	
50	Reduce maximum impervious surface limits	Initial response: • District 1 and 24 • District 24, 28, 27, 27, City-wide	Initial response: 2.8 Most common: 2	4 - Change - Change - Change - Change
51	Increase maximum impervious surface limits	Initial response: • District 1 • District 24, 28, 24, 27, City-wide • Not appropriate for District	Initial response: 2.8 Most common: 1	
52	Increase residential/commercial density	Initial response: • District 1 • District 27, City-wide	Initial response: 2.8 Most common: 2	4
55	Allowed shared parking for commercial uses	Initial response: • District 2 • District 27, City-wide	Initial response: 2.8 Most common: 2	2
56	Allow small decentralized parking lots rather than individual garages for townhomes, cottage housing, multi-family	Initial response: • District 27, City-wide • District 24	Initial response: 2.8 Most common: 2 & 3	4 - Not - Not - Not - Not
58	Establish landscaping standards for single-family residential (native plants, maximum lawn area)	Initial response: • District 1, 24, and 28 • District 27, City-wide	Initial response: 2.8 Most common: 2 & 4	4 - Change - Change - Change - Change
59	Establish soil standards for landscaping	Initial response: • City-wide • District 24, 28, and 27	Initial response: 2.8 Most common: 2 & 4	4 - Government - Government - Government - Government
Other tool?				

Advisory Group Management Tool Poster

for the XX, 2015 meeting. Public hearings were held on XX and XX, 2015. The plan was approved by the City Council on XX, 2015.

1.3 Plan Purpose and Organization

This Plan is intended to be a technical document that identifies existing watershed characteristics in and immediately surrounding Duvall. The goals, policies, and actions identified in Chapter 3 are based on the findings of this watershed characterization and provide the City with a roadmap to improving watershed protections and focusing future development in appropriate areas within the city and its urban growth area.

The Watershed Plan is organized as follows:

1. **Chapter 1 Watershed Plan Overview** - (this chapter) describes the purpose of this Plan, the planning process that led to the adoption of this Plan, and the Duvall landscape setting.
2. **Chapter 2 Key Watershed Analysis Results** - summarizes existing watershed and subbasin conditions, as well as the watershed analysis results and subbasin management approach that informs the remainder of the Plan.
3. **Chapter 3 Watershed Goals, Policies, and Objectives** - identifies goals and polices that address the findings of the watershed characterization and seek to direct future development. Chapter 3 also introduces the strategies and actions that the City can take to meet this Plan's objectives.
4. **Chapter 4 Subbasin Folio** - provides a two-page folio sheet that identifies watershed analysis results for each Project Assessment Unit in the city and urban growth area, with corresponding management priorities to ensure ongoing protection and improvement of important watershed processes.
5. **Chapters 5 Watershed Strategies for Development Standards** - identifies objectives and actions consistent with goals and policies provided in Chapter 3 to improve watershed protections in the City's zoning and subdivision code. The chapter also identifies voluntary approaches.
6. **Chapter 6 Watershed Strategies for Stormwater Management** - similar to Chapter 5, except actions are targeted towards stormwater management.
7. **Chapter 7 Watershed Strategies for Sensitive Areas Management** - similar to Chapter 5, except actions are targeted towards the City's sensitive areas ordinance.

8. **Chapter 8 Land Use Strategies for Urban Growth Areas** - because most foreseeable future development is likely to occur in urban growth areas located to the north, east and south of the City's current city limits, this chapter presents information on environmental constraints for these areas, as well as recommendations on where future development is appropriate based on watershed analysis results.
9. **Chapter 9 References** - includes references cited in this Plan.

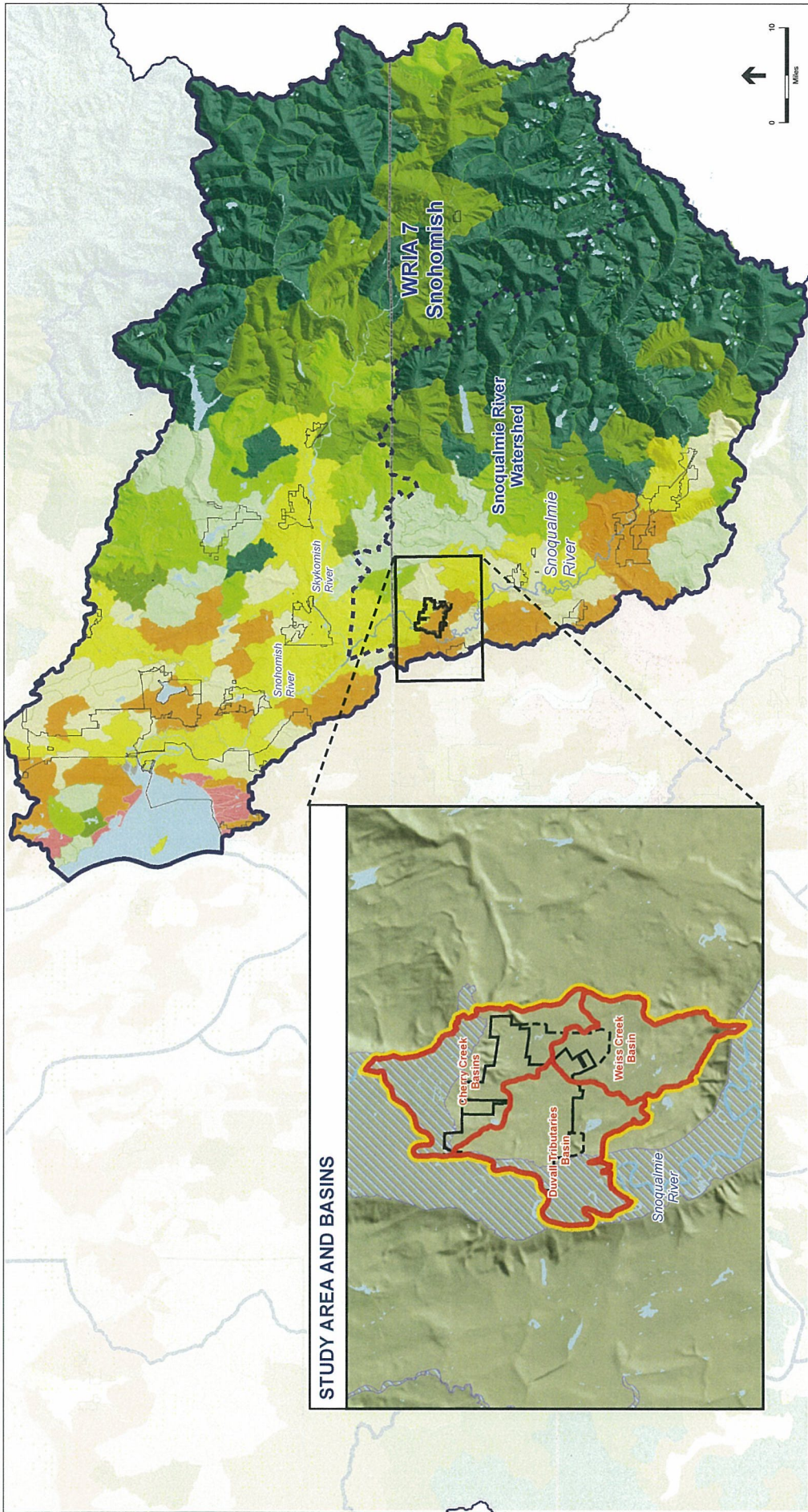
1.4 Duvall Landscape Setting

The City of Duvall is located on west- and north-facing hillsides in the lower Snoqualmie River valley. The mainstem Snoqualmie River forms in the headwaters of the North, Middle, and South Forks of the Snoqualmie River. The mainstem Snoqualmie River extends south and east from the city through unincorporated King County, the City of Carnation, the community of Fall City, and (above Snoqualmie Falls) the Cities of Snoqualmie and North Bend (see Figure 1-1).

The north-facing hillsides along the northern edge of the city slope down to the Cherry Creek valley, which converges with the Snoqualmie River just downstream of Duvall (to the northeast of the city). Cherry Creek is the lowest significant tributary of the Snoqualmie River, and the only significant tributary that drains areas in the city. The mainstem of Cherry Creek does not pass through the city or urban growth area; tributaries to Cherry Creek drain the northeastern portion of the city.

The Snoqualmie River continues north from Duvall for approximately 9 miles before joining the Skykomish River to form the Snohomish River. The Snohomish River drains to Puget Sound in the City of Everett. These three rivers—Snohomish, Skykomish, and Snoqualmie—and their tributaries together drain a watershed (Water Resource Inventory Area 7) of 1,856 square miles located in both Snohomish and King Counties (Snohomish County, 2006).

The geology of western King County, including the lowland areas of the Snoqualmie River, consists of bedrock underneath layers of sediments deposited by glaciers, as well as sand and gravel (alluvium) deposited recently by modern rivers (Krukeberg, 1991). The region has a temperate, maritime climate. Winters are cool and wet, while there is typically a drought period in the summer and early fall. The climate is influenced by Puget Sound to the west and the Cascade Mountains to the east. Average annual precipitation ranges from approximately 30 inches near Puget Sound to 90 inches in the Cascade foothills, with the area surrounding Duvall averaging nearly 50 inches.



City of Duvall Watershed Planning - 130674
Figure 1-1: Project Study Area and Watershed Position
 Duvall, King County, Washington

Over 80 percent of the population of King County lives in cities and urban growth areas, with less than 20 percent in rural areas (King County, 2008). This trend continues throughout the Snoqualmie watershed, with the majority of the population focused in designated urban growth areas and incorporated cities. Moderate population densities in the Snoqualmie River watershed are focused within and around Duvall, Carnation, Fall City, Snoqualmie and North Bend. Outside of these urban areas, the Snoqualmie River valley consists primarily of agricultural production districts rural residential areas, forest production districts, and open spaces (preserved lands) (King County DDES, 2009).

The Snoqualmie River watershed contains a wide range of vegetation types from wetland scrub/shrub and emergent areas in the valley floodplain to forests in the Cascade foothills. In general, the high elevations are largely undeveloped, while lower areas tend to be the most urbanized.

Prior to European settlement, the Snoqualmie River valley was used by several Coast Salish Indian tribes, including the Tulalip, Pilchuck, Snohomish, and Snoqualmie. Large, permanent winter villages were located along the Snoqualmie and Snohomish Rivers where people thrived by fishing for salmon, hunting mammals over land, and gathering native fruits, vegetables, and berries (City of Duvall, 2006).

Early Euro-American settlers were first drawn to the Duvall vicinity of the Snoqualmie River valley in the 1870s by vast timber resources, both in areas of the valley and the surrounding hills. Homesteading occurred in the region, primarily by Civil War veterans with homestead rights. The Duvall area was homesteaded and named after two brothers, Francis and James Duvall. The original town site, named Cherry Valley, occurred to the north of the existing town center, near the convergence of Cherry Creek with the Snoqualmie River. The Snoqualmie and Snohomish Rivers were used to transport logs to major downstream population centers, including Everett.

The Snoqualmie River watershed and the entire Water Resource Inventory Area 7 support a variety of fish and wildlife species. Wildlife habitat types that are common in the vicinity include freshwater aquatic areas and associated riverine habitats; wetlands and associated riparian areas; lowland conifer-hardwoods; and agricultural and pasture areas. The Snoqualmie River watershed supports Chinook, chum, coho, and pink salmon; bull trout and Dolly Varden; cutthroat, steelhead, rainbow, and brook trout. All of these species use the mainstem Snoqualmie River at the city's western edge at some point in their life histories, and salmonid use is also abundant in the mainstem and tributaries of Cherry Creek. Coho and steelhead use the lower reaches of tributary streams extending into Duvall, including Cherry Creek Tributary A, Coe-Clemmons Creek, Thayer Creek, and reaches of Weiss Creek and other Cherry Creek tributaries downstream of the city.

The river remained the primary means of transportation until the 1890s, at which time the construction of railroad lines to the town of Snohomish allowed a more intensive timber industry to become established in the immediate area. In the following decades, bridges over the Snoqualmie River and roads linking Duvall to Lake Sammamish and Lake Washington were constructed. Bridges and roadways were also built on fill berms in the floodplain, in most instances stretching east-west across the valley. The developed transportation infrastructure led to rapid population growth in Duvall, as well as other valley communities. The growth of the timber industry and the expanded population brought about rapid changes in vegetative cover (forest to agricultural fields and rural residential uses) and vegetative character (old growth forest to second growth forest) during this period. Population growth continued throughout the 1920s, after which the decline of the timber industry in the area minimized the need for laborers.

In the last 50 years, modern roadways and expanding suburban growth from the Seattle metropolitan area has led to additional growth in the city and the valley – with the majority of this growth occurring in the last 20 years. Agricultural activities remain a significant regional economy, with cattle and dairy operations, produce and crop farms, and greenhouse operations extending up and down the valley. However, residential housing and associated service businesses have come to characterize Duvall and other urbanized areas of the watershed.

CHAPTER 2. KEY WATERSHED ANALYSIS RESULTS

2.1 Watershed and Basin Conditions

The City of Duvall (1,594 acres) is situated in the Snoqualmie River watershed (442,880 acres), located on the east side of the lower Snoqualmie River valley and bordered on the west by the mainstem river (see Chapter 1, Figure 1-1). Unincorporated areas of King County extend through the floodplain to the south, east, and north. There are four smaller watersheds or basins that are tributaries to the Snoqualmie River, and they are located in or partially within the city or urban growth area boundary: Thayer Creek, Coe-Clemmons Creek, Cherry Creek and Weiss Creek (Table 2-1). Cherry Creek is the lowest significant tributary of the Snoqualmie River and the only significant tributary that drains areas of the city. The mainstem of Cherry Creek never passes into the city or urban growth area; tributaries to Cherry Creek drain the northeastern portion of the city.

Table 2-1. Basins of Duvall

Stream Name	Total Watershed Area (acres)	Area within Study Area (acres)	% Total Watershed Area
Thayer Creek	235	235	100%
Coe-Clemons Creek	371	371	100%
Cherry Creek	32,000	2,185	6.8%
Weiss Creek	2,169	2,067	95%

Historic Changes to Land Cover

Hydrology and ecology of the study area have been shaped by the historical uses of the landscape. Starting in the 1870s, European settlers were drawn to the area by timber resources, using the Snoqualmie River to transport logs downstream. In the 1890s, the railroad was constructed along the east side of the river, adjacent to Duvall's Main Street, on a 12- to 15-foot-tall fill berm that stretches along the river valley. In the following decades, bridges over the Snoqualmie River and roads linking through to Lake Sammamish and Lake Washington were constructed, also built on fill berms in the floodplain. The growth of the timber industry and the expanded population brought about rapid changes in vegetative cover (forest to agricultural fields) and vegetative character (old growth forest to second growth forest) during this period. Population growth continued through the 1920s, after

which the decline of the timber industry in the area minimized the need for laborers.

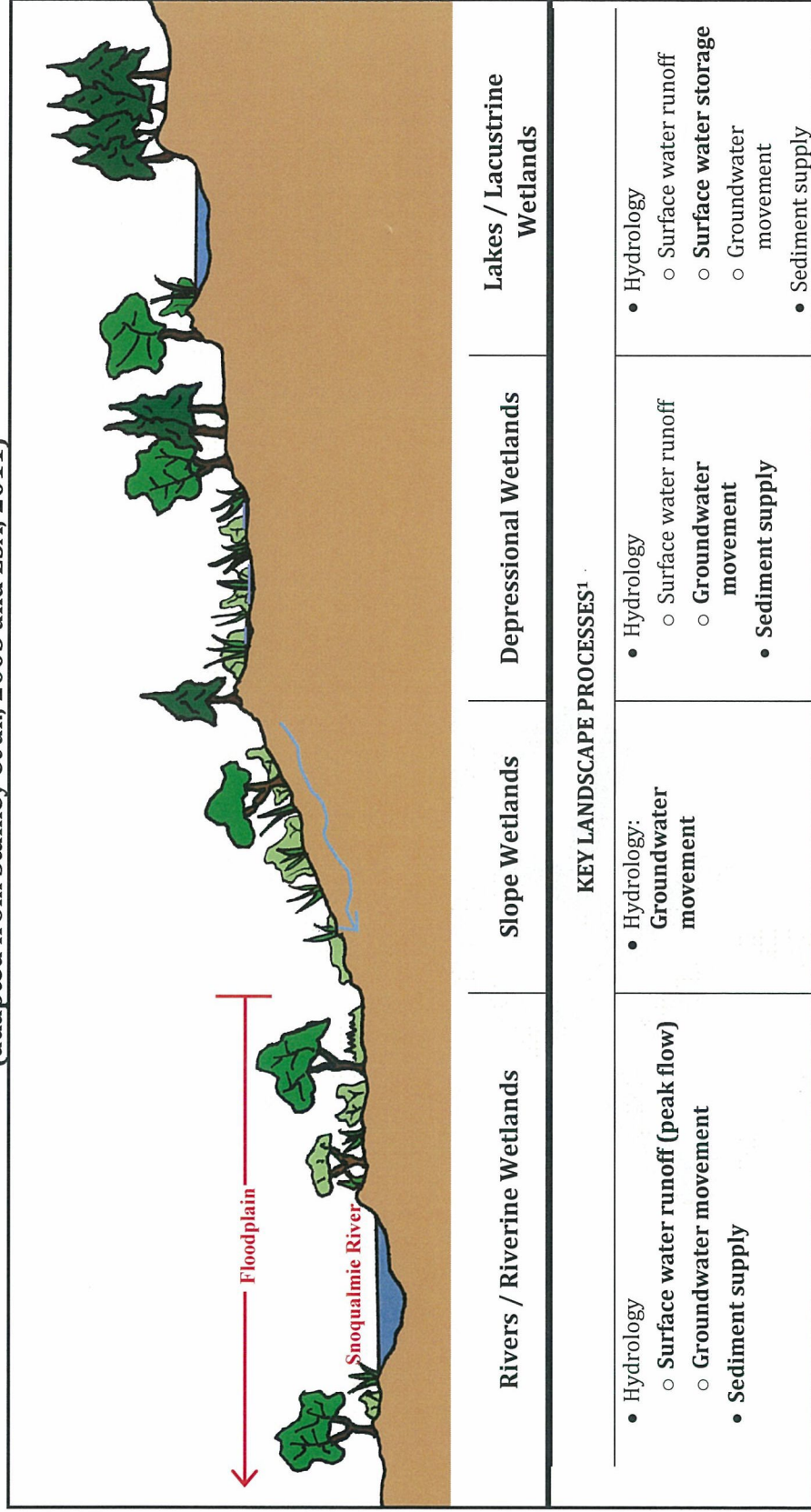
After the 1920s the pattern of alterations to the valley landscape was characterized by clearing of native shrub and riparian vegetation, ditching of streams and land to create pasture, and bank hardening along the Snoqualmie River. In the last 50 years, modern roadways and expanding suburban growth from the Seattle has led to additional growth in Duvall and throughout the valley. Significant population growth in Duvall has primarily occurred in the last 20 years. Agricultural activities are an important component of the Snohomish Valley the economy and floodplain-wide land use, with cattle and dairy operations, produce and crop farms, and greenhouse operations extend up and down the valley. However, residential housing and associated service businesses have come to characterize Duvall and other urbanized areas of the watershed.

A number of recent studies describe the current conditions in Duvall's watersheds. A Landscape Analysis was developed for Duvall to support the City's last sensitive area ordinance update, completed in 2006 (Parametrix, 2005). Other watershed studies and plans with background information useful in understanding watershed processes developed in the last ten years include the [Snoqualmie Watershed Water Quality Synthesis Report](#) (Kaje, 2009); the [Snohomish Basin Ecological Analysis for Salmonid Conservation](#) (SBSRTC, 2005), developed as part of the [Snohomish River Basin Salmon Conservation Plan](#) (SBSRTC, 2005); and the [City of Duvall Shoreline Master Program Update](#) (ESA, 2011). King County included both Cherry Creek and Weiss Creek watersheds as example watersheds in their analysis of Hydrologic Control Index (HCI) (Luchetti, 2014).

Watershed Processes

Watershed processes control the physical form of the landscape and the types of habitats that occur throughout the ecosystem. Watershed processes are characterized in this study based on Ecology's Puget Sound Watershed Characterization (Stanley et al., 2011) and are generally related to water flow. , Water flow processes, such as surface water storage and groundwater movement, vary based on landscape position (Figure 2-1, Table 2-2) and play a substantial role in shaping how habitats such as wetlands and stream function. Important areas in Duvall and the surrounding vicinity for water flow processes and habitat processes were summarized in the City of Duvall Shoreline Master Program Inventory and Characterization Report (ESA, 2011) and are provided in Table 2-2.

Figure 2-1. Landscape Processes that Maintain Key Aquatic Resources in the Puget Sound Lowlands
 (adapted from Stanley et al., 2005 and ESA, 2011)



¹Processes in bold are most important for maintaining the integrity of aquatic resources such as wetlands and streams.

Table 2-2. Summary of Landscape Processes – Controls, Mechanisms and Important Areas (adapted from ESA, 2011)

Process	Natural Controls	Mechanisms	Types of Important Areas ¹	Description of Important Areas in Duval and Vicinity		
Hydrology (surface and ground water)	<ul style="list-style-type: none"> Climate and precipitation patterns Timing of snowmelt Soils and geology Vegetation 	Infiltration/recharge	Permeable soils, <i>riparian areas, floodplains</i>	Moderate levels of infiltration and recharge occur primarily within the Cherry Valley floodplain, as well as within the Snoqualmie River floodplain at lower levels.	Entire Duval floodplain area serves as storage during overbank flood events.	Areas of significant infiltration and recharge are located in the vicinity of Fall City and above the Snoqualmie Falls.
		Surface water storage	<i>Depressional wetlands, lakes, floodplains</i>	As Thayer, Coe-Clemons, and Cherry Creek tributaries reach the floodplain, surface flows spread across the valley and surface water is stored in several large depressional wetlands.		One small lake is located within the Cherry Creek basin of Duval; other moderately sized wetlands are also mapped in Duval.
		Peak flows	<i>Impervious surfaces, rain-on-snow (ROS) zone, forest cover</i>	Impervious surfaces are minimal within Snoqualmie River floodplain; however, rapid development throughout Duval over the last 2 decades has converted agricultural and forest land to commercial and residential development which has increased the amount/extent of impervious surface.		Heightened levels of impervious surface correspond with reduced forest cover – a mechanism change that primarily occurred through logging and agricultural conversion between 1880 and 1950.
		Groundwater movement (baseflow)	<i>Permeable deposits, fissured bedrock</i>	Groundwater moves through the hillside near the surface, expressing as seeps and slope wetlands near the break between the hillside and the Snoqualmie River floodplain.		Detailed assessment of bedrock conditions has not occurred in Duval.
Sediment Supply	<ul style="list-style-type: none"> Topography Soil erodibility Vegetation cover 	Erosion	<i>Erodible soils (especially on steep slopes), Channel Migration Zones (CMZs)</i>	Potential erosion areas along the Snoqualmie River west of the Snoqualmie Valley Trail. Review of historical mapping and aerial photography suggest that mainstem channel migration occurs relatively slowly within the lower Snoqualmie River valley.		Erodible soils along steep slopes occur along the reach of Coe-Clemons Creek immediately east of Main Street. Active bank failure is noted within this reach, causing downstream sedimentation.
		Mass wasting	<i>Slopes prone to landslides</i>	Steep slopes susceptible to landslides occur along the reach of Coe-Clemons Creek immediately east of Main Street.		Steep slope areas occur along the northern boundary of the city, where tributary streams to Cherry Creek cut through the hillside to the valley to the north.
Habitat	<ul style="list-style-type: none"> Water energy Riparian vegetation Soil erodibility Topography Climate Biotic interactions 	Riparian vegetation	<i>Riparian zones, forested CMZs</i>			Riparian cover along tributary streams provides moderate organic input function, including along Coe-Clemons Creek, however these sources of LWD are disconnected from the Snoqualmie River by undersized culverts (Main Street, Snoqualmie Valley Trail, and other transportation and trail infrastructure).
		Large woody debris (LWD) recruitment	<i>Riparian zones, forested CMZs, landslide hazard areas</i>	Riparian vegetation generally consists of a narrow band of mixed forest backed by herbaceous and shrub vegetation communities. Existing development along the Snoqualmie River does prohibit or hinder potential future enhancement of riparian habitats.		

Source: Summarized from Stanley et al. (2005) and Parametrix (2005)

¹Important areas in bold are those areas found within the Duval vicinity. Important areas also in italics are found within the Duval Snoqualmie River floodplain.

Infiltration and Recharge

Two major geologic formations in the Snoqualmie watershed create conditions for hydrologic infiltration and groundwater recharge: porous soils (outwash) above relatively impermeable subsurface strata; and alluvium along major streams. Deep recharge occurs in areas where bedrock is fissured, including areas within and adjacent to the Snoqualmie River and tributary floodplains (Turney et al., 1995, Adolfson Associates, 2004, King County Groundwater Protection Program, 2004). Along major tributaries, including Cherry Creek, areas of high recharge extend out of the river floodplain into contributing basins. The entire area of the city is mapped as having a high or moderate level of recharge (primarily moderate). Areas of high recharge in Duvall are focused within the Snoqualmie River floodplain and the Snoqualmie / Cherry Creek floodplain extending along the north side of the city. Compared to rates in upstream areas (as high as 90 inches annually), recharge rates throughout much of Duvall are low (10 to 20 inches annually).

Groundwater Flows

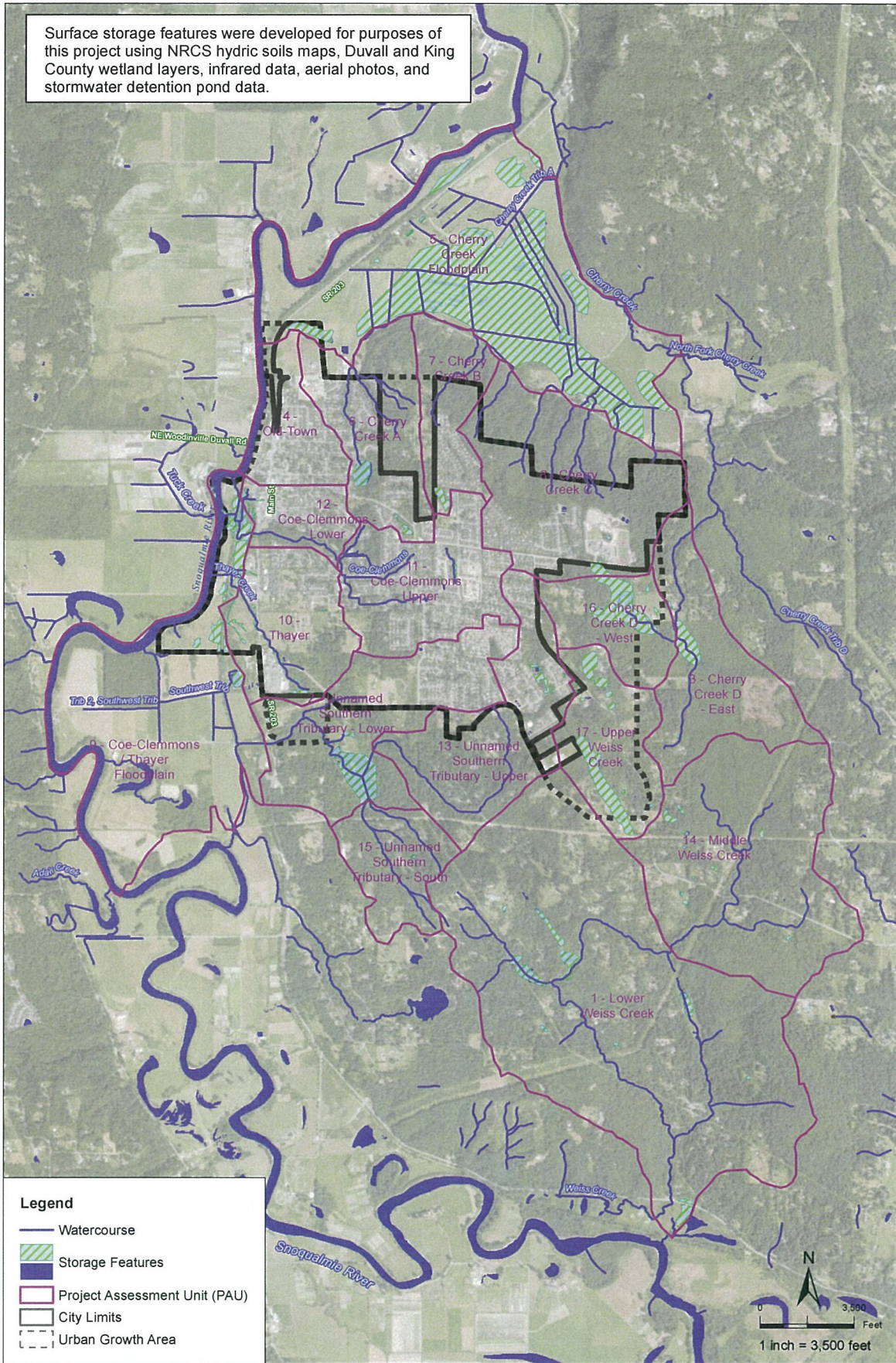
Recharge replenishes deep groundwater (aquifers) with surface water and shallow groundwater. Two large aquifers have been mapped in the Snoqualmie River valley, the largest of which (the Snoqualmie Aquifer) lies well upstream of Duvall. Risks of contamination to Snoqualmie watershed aquifers are most severe in areas of high infiltration located to the south and east of Duvall, although the relatively shallow groundwater table (approximately 40 feet above mean sea level within the floodplain) and higher rates of recharge in the city's floodplain areas warrant protection to prevent groundwater contamination (Turney et al., 1995, Parametrix, 2005).

Throughout Duvall, groundwater has been mapped as intermediate to shallow. Relatively impermeable soils through the hillside of the city (above the floodplain) impede infiltration and keep groundwater relatively shallow. Groundwater at intermediate to shallow levels generally follows surface topography. There are a number of hillside seeps in Duvall where shallow groundwater seeps out at topographical breaks. (Turney et al., 1995).

Surface Water Storage

The Snoqualmie River flows carries large volumes of water compared to quantities contributed by the Duvall area basins. The floodplain provides storage for river waters only during flood events. Wetlands, Rasmussen Lake, ponds and other depressional features store smaller amounts (approximately 5.3 acres) of water throughout the year (see Figure 2-2).

Surface storage features were developed for purposes of this project using NRCS hydric soils maps, Duvall and King County wetland layers, infrared data, aerial photos, and stormwater detention pond data.



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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013; King County, 2014

City of Duvall Watershed Planning · 130674

Figure 2-2
Wetlands and Streams

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Habitat

Out of 107 miles of riparian area surveyed in the Snohomish basin, Pentec (1999) found that nearly two-thirds of the riparian vegetation consisted of grass, brush, or sparse trees. The loss of riparian vegetation within the city has impacted salmonid habitat by reducing the food supply for fry, increasing solar heating of the water, and reducing cover and refuge habitat. Fish habitat features such as complex channels, overhanging cover, and pools have declined in the lower Snoqualmie watershed, including contributing basins. This is due in part to the loss of large wood in the river, which has reduced the amount of wood available to create pools and to collect sediment and gravels.

Terrestrial wildlife is also affected by the loss of riparian vegetation because many species depend on wetlands and riparian zones. For example, riparian forests are used by songbirds for nesting and foraging, by big game for forage and calving areas, and by other forest species as movement corridors between rivers and upland habitats (Pentec, 1999).

Sediment Export

Under natural conditions, sediment reaches aquatic ecosystems through surface erosion, mass wasting, and erosion from within the stream channel. Sediment is generally transported through high gradient (steeply sloping) streams and deposited in lower gradient reaches. Other areas where erosion naturally occurs at high rates include transitions from plateaus to terraces, alluvial fans, and upland ravines formed by streams. Excess sediment can result from human activities that expose soils and increase runoff without providing adequate erosion control measures. Bank erosion above a natural background level can indicate hydrologic or sediment conditions that are out of balance. Areas of sediment supply and deposition within and in the vicinity of Duvall include the Coe-Clemons Creek riparian corridor and areas of the Cherry Creek basin along the northern edge of the city.

Degradation of Processes

Degradation of processes is linked to changes in land use and increases in impervious surfaces associated with the urban development. Alterations to hydrologic processes in the Snoqualmie watershed include decreased infiltration/recharge, channelization, and disconnection of streams from their floodplains; decreased storage capacity due to bank armoring, channelization, and wetland loss; increased peak flows resulting from vegetation clearing, and an increase in impervious surface; and groundwater withdrawals and groundwater contamination (Parametrix, 2005, Solomon and Boles, 2002, Collins and Sheikh, 2003). Additionally, Herrera Environmental Consultants (2002) assessed stream habitat in Thayer, Coe-Clemons, and two Cherry Creek tributaries within the city limits and identified reaches for all of these streams with deeply incised channels and bank

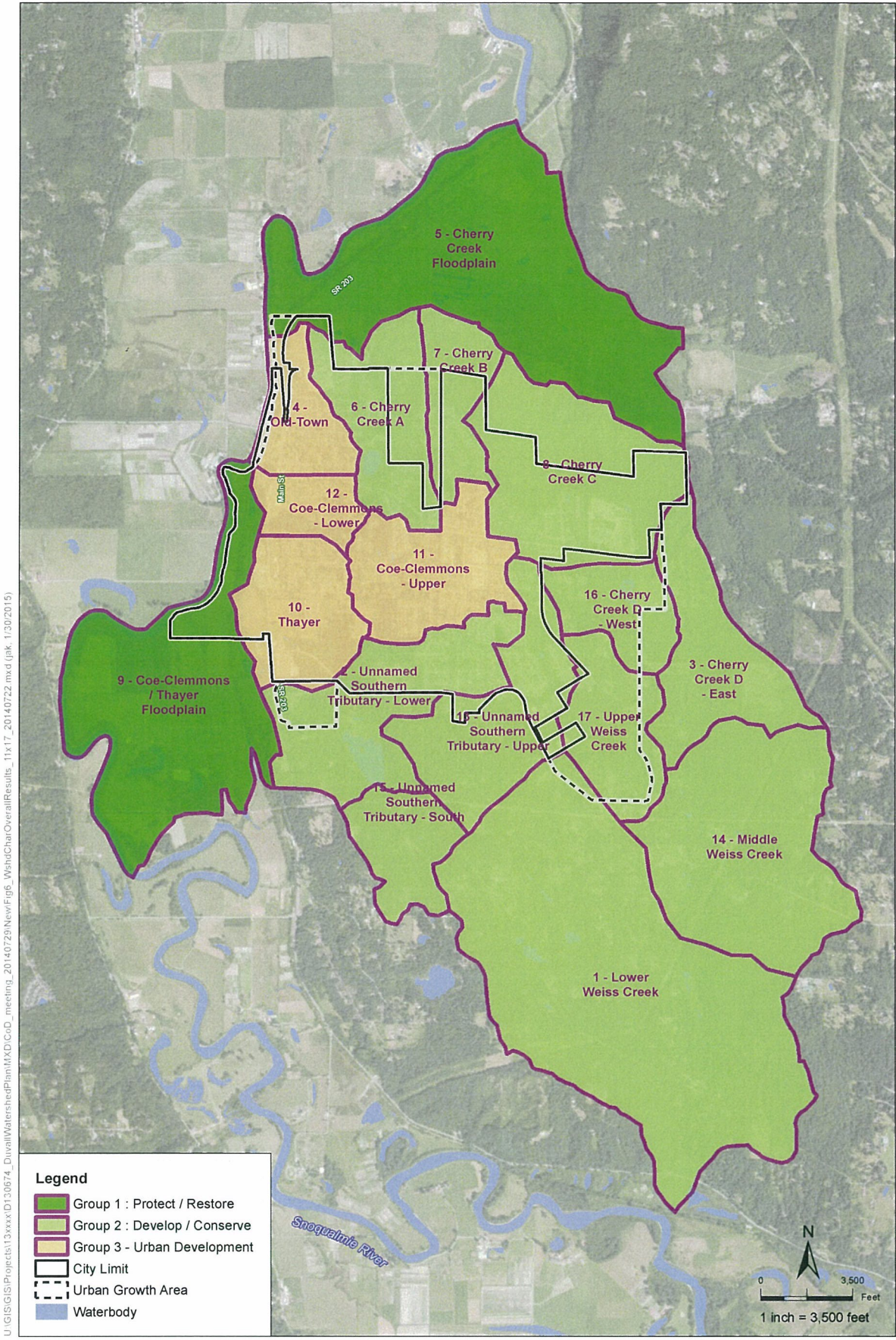
failures caused by altered runoff patterns. Excessive sedimentation was also seen in reaches of Thayer Creek and the Cherry Creek Tributary B system.

2.2 Watershed Characterization

Summary of Duvall Subbasins

Ecology identified three Assessment Units (AUs) within the study area (see Chapter 1, Figure 1-1). The AUs include the Cherry Creek basin (extending north of the city), Duvall tributaries direct to the Snoqualmie River (making up the majority of the city), and the Weiss Creek basin (extending to the south of the city) (see Chapter 1, Figure 1-1). These AUs range in size from 1 to 10 square miles.

To characterize watershed conditions in Duvall more precisely, the city delineated 17 subbasins or project assessment units (PAUs) (see Appendix B for more detail on methods and Figure 2-3). PAUs range from 98 to 1,273 acres and generally correspond to 1st order streams and specific landscape positions (Table 2-3).



SOURCE: BHC Consultants, 2013; USDA NAIP, 2013; King County, 2014

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Table 2-3. Project Assessment Unit (PAU) Summary

PAU Name	PAU #	Landscape Position	Area (acres)	Percent of Subbasin within City	Percent Forest Cover	Percent Impervious Surface
Cherry Creek Tributary Basin						
Cherry Creek Floodplain	5	Floodplain	865	1%	5%	3%
Cherry Creek A	6	Slope / Ravine	264	55%	44%	24%
Cherry Creek B	7	Slope / Ravine	158	46%	62%	15%
Cherry Creek C	8	Slope / Ravine	457	59%	71%	11%
Cherry Creek D – East	3	Slope / Ravine	288	< 1%	56%	4%
Cherry Creek D – West	16	Terrace	166	< 1%	55%	6%
Coe-Clemmons / Thayer / Unnamed Tributary Basin						
Old Town	4	Slope / Ravine	146	88%	11%	43%
Coe-Clemmons – Lower	12	Slope / Ravine	98	100%	27%	43%
Coe-Clemmons – Upper	11	Terrace	273	100%	26%	43%
Thayer	10	Slope / Ravine	235	92%	24%	29%
Coe-Clemmons / Thayer Floodplain	9	Floodplain	663	13%	7%	3%
Unnamed Southern Tributary – Lower	2	Slope / Ravine	373	42%	40%	17%
Unnamed Southern Tributary – South	15	Slope / Ravine	158	0%	70%	7%
Unnamed Southern Tributary – Upper	13	Terrace	327	36%	54%	18%
Weiss Creek Basin						
Weiss Creek – Upper	17	Terrace	207	4%	42%	11%
Weiss Creek – Middle	14	Slope / Ravine	587	0%	54%	8%
Weiss Creek – Lower	1	Slope / Ravine	1273	0%	63%	7%

Subbasin Importance and Degradation Scores

The goal of the Duvall watershed analysis was to evaluate the importance of watershed processes and the level to which these watershed processes are intact within the study area. Water flow processes were assessed and scored using Puget Sound Watershed Characterization data (Stanley et al., 2011). Scores represent the relative importance and degradation of each process (see Appendix B for more information). The score for Water Flow importance reflects the underlying, pre-development physical conditions (geology, landscape position, etc.). The score for Water Flow degradation reflects the amount of change to land cover. Each PAU was

also rated for sediment export potential, forest cover, and aquatic habitat. Appendix B provides detailed methods for how importance and degradation scores were calculated.

2.3 Subbasin Management Group Framework

Subbasins are ranked based on the relative importance of their watershed processes to the overall watershed and on the extent of degradation these processes have sustained as a result of past human practices (e.g., converting forested lands to impervious surfaces). The subbasins are ranked according to the following five subbasin management categories (see Figure 2-4):

Group 1 – Protect / Restore

- Applies to Snoqualmie River/Cherry Creek floodplains (PAUs 5 and 9).
- Assigned to subbasins that are of highest importance to multiple watershed processes and are a high priority for protection and restoration.

Group 2A – Highest Conservation

- Applies to 6 subbasins along east and south edges of the city (PAUs 8, 16, 3, 14, 1 and 15).
- Assigned to subbasins that are the highest priority for conservation and are likely not appropriate for much additional development. Assessment results show moderate importance to multiple watershed processes that are also highly intact.

Group 2B – Moderate Conservation

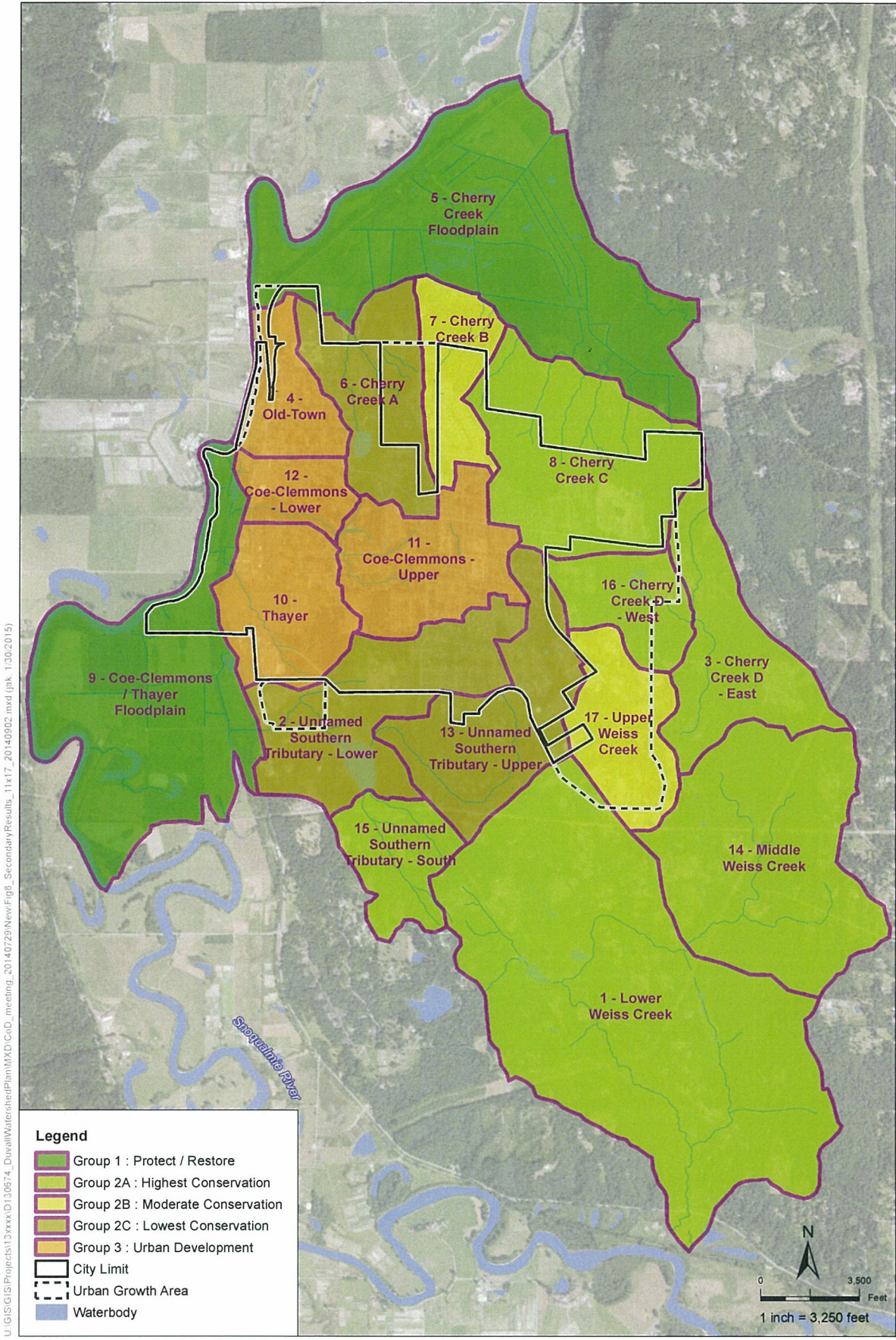
- Applies to Cherry Creek B (PAU 7) and Upper Weis Creek (PAU 17).
- Assigned to subbasins that may be appropriate for some additional development, but also require protection of areas important for remaining watershed processes.

Group 2C – Lowest Conservation

- Applies to three subbasins including North urban growth area (PAU 6) and southeast City / South urban growth area (PAUs 2 and 13).
- Assigned to subbasins where more intense development is appropriate. The remaining resources and areas important to watershed processes would benefit from protection.

Group 3 – Urban Development

- Applies to four subbasins in historic downtown Duvall (PAUs 4, 10, 11, and 12).
- Assigned to subbasins where more intense development should be focused. Subbasins are below average for water flow importance and have the highest existing degradation.



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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013; King County, 2014

City of Duwall Watershed Planning · 130674

Figure 2-4

Secondary Results - Subbasin Management Recommendations

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CHAPTER 3. WATERSHED GOALS AND POLICIES

3.1 Goals and Policies

This chapter identifies goals and policies based on the findings of the watershed characterization described in Chapter 2 Key Watershed Analysis Results. The goals and policies provided here can be incorporated into the Sustainability and Environment Element of the 2015 Comprehensive Plan. All policies apply city-wide unless otherwise noted.

WATERSHED GOAL 1

Change land use patterns, development practices and infrastructure systems to meet the City's growth objectives while improving important watershed processes and functions over time.

Policies:

- W1.1 Protect watershed processes by establishing new zoning, subdivision, sensitive areas, and storm drainage standards that are appropriate for each subbasin management group.
- W1.2 Update zoning, subdivision, sensitive areas, and storm drainage standards and other development standards consistent with the subbasin management group framework established in the Watershed Plan. Standards should afford more protection for subbasins that are important for watershed processes and allow for higher density development in subbasins of lower importance.
- W1.3 Revise the City's urban growth area and urban growth area reserve boundaries to exclude subbasins in the Highest Conservation management group (Group 2A) where feasible.
- W1.4 Work with King County to adjust their urban growth area and urban growth area reserve boundaries to include subbasins with Moderate and Lowest Conservation management groups (Groups 2B and 2C).
- W1.5 When pre-designating urban growth areas and urban growth area reserves with Comprehensive Plan designations and zoning districts, consider the findings of the Watershed Plan.
- W1.6 Minimize impervious surfaces from new developments by encouraging or requiring innovative subdivision layout and multi-family residential designs, including decentralized parking lots instead of individual driveways and garages, shared driveways, clustering properties and buildings, and courtyard access lots.

WATERSHED GOAL 2**Improve watershed processes by investing in stormwater infrastructure, parks, open spaces, and restoration using the City's capital improvement program.**

Policies:

- W2.1 Use the findings of the Watershed Plan to identify and prioritize park improvements that achieve multiple benefits (e.g., restore wetlands and create a trail network).
- W2.2 Partner with King County to leverage their expertise and resources to implement subbasin management priorities and objectives identified in the Watershed Plan.
- W2.3 Partner with conservation groups, other government agencies, not-for-profit organizations, businesses and other partners, to restore habitat and watershed processes within the city limits.
- W2.4 Identify and prioritize stormwater retrofits that impaired watershed processes and reduce effective impervious surface areas based on the findings of the Watershed Plan.
- W2.5 Build and maintain centralized stormwater facilities in subbasin management Group 2 in the urban growth area to off-set on-site detention requirements.
- W2.6 Identify and target grant monies and other funding sources for restoration address protection and restoration of watershed processes in subbasin management groups 1, 2A, and 2B.
- W2.7 Work with private property owners to acquire land with intact forest cover and/or high value natural resources, especially land that is prioritized for protection or restoration by existing City plans (for example, Duvall's Shoreline Master Program Restoration Plan) in subbasin management groups 1, 2A, and 2B. Purchased land should be set aside as open space.

WATERSHED GOAL 3**Preserve and enhance Duvall's tree canopy cover through effective education and outreach, innovative partnerships, and pragmatic implementation strategies.**

Policies:

- W5.1. Create an urban forestry plan that documents existing conditions, identifies incentives and programs, and recommends revisions to code requirements to protect and increase forest cover.
- W5.2. Partner with non-profit organizations to promote a voluntary tree planting program that provides Duvall's residents and businesses with opportunities to plant trees in the street right-of-way planter strip and on private property. Outreach and education should be a component of this program.

- W3.1. Information about King County's Public Benefit Rating System, a tax reduction program, should be shared with Duvall property owners to encourage conservation of forested properties.
- W3.2. Promote conservation of healthy, native forests in large tracts as part of new subdivision development in subbasin management groups 1 and 2.
- W3.3. Amend the significant tree requirements to increase the percentage of trees preserved at the time properties develop and to require preservation of stands of trees. Trees to be saved should be in locations and of a species type to allow maximum opportunity for retention (*Existing Comprehensive Policy LU-1.8*).
- W3.4. Expand tree mitigation standards in Chapter 14.40 of the Duvall Municipal Code to include standards on tree type, location, and monitoring.

WATERSHED GOAL 4

Improve city-wide stormwater systems to maintain and enhance water flow and water quality processes through implementation of low impact development techniques.

Policies:

- W4.1. Create a stormwater strategies plan that outlines approaches to improve stormwater management based on the findings of the Watershed Plan. The plan should identify:
 - a. Low impact development best management practices applicable to Duvall, including both city-wide and subbasin-specific, that should be required for new development activities.
 - b. Guidance and direction on application of low impact development best management practices.
 - c. Incentive programs and organizational framework for creating and implementing such programs.
 - d. Recommendations for using existing low impact development certifications (e.g., Salmon Safe, Sustainable Sites, Living Futures).
 - e. Green infrastructure standards for public roadways that are subbasin-specific, along with guidance and direction on application of such standards.
 - f. Flow-control exemption program for subbasin management groups 2C and 3.
- W4.2. Encourage property owners to install low impact development best management practices for improved stormwater systems by establishing voluntary programs, partnering with not-for-profit organizations and governmental agencies, and incorporating incentives in Duvall's municipal code.
- W4.3. Create an educational outreach program that includes workshops, informational handouts, and links to additional resources on amended soils, rain gardens, native

landscaping and rainwater harvesting, landscaping management best practices, and environmental stewardship.

WATERSHED GOAL 5

Improve long-term management of sensitive areas by updating standards that address watershed processes into the City's Sensitive Areas Ordinance.

Policies:

- W5.1. Identify, designate, and protect habitat corridors between streams, wetlands, and geologic hazard areas in subbasin management groups 1 and 2.
- W5.2. Restrict wetland and stream buffer reduction allowances in the Duvall Municipal Code for subbasin management groups 1 and 2.
- W5.3. Increase regulatory protections for depressional wetlands in subbasin management groups 1 and 2.
- W5.4. Incorporate standards in the Sensitive Areas Ordinance that limit modifications to wetland and stream buffers which would result in tree loss.

WATERSHED GOAL 6

Avoid mass clearing and grading associated with new development that results in large amounts of tree loss and changes in topography.

Policies:

- W6.1. Limit clearing of mature or native vegetation in subbasin management group 2 as new development occurs by integrating open space subdivision standards with sensitive area standards.
- W6.2. Limit extensive grading and retaining walls for large subdivisions in subbasin management group 2.

3.2 Implementation

Table 3-1 identifies actions that the City of Duvall can take to implement the goals and policies identified in Section 3.1. The table identifies the watershed processes that would benefit from each action, the subbasin management group in which the action would be implemented, the chapter in the Watershed Plan that provides more detail on the action, and the policies that each action would address.

TABLE PROVIDED BELOW AS A PLACEHOLDER PENDING FURTHER DISCUSSION WITH THE CITY

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Table 3-1. Watershed Actions [PLACEHOLDER]

Actions	Watershed Processes that would Benefit				Applicable Subbasin Management Group	More Detail Provided in:				Watershed Policies Addressed
	Surface Storage	Groundwater / Base Flow Maintenance	Fish & Wildlife Habitat	Water Quality		Chapter 5 – Watershed Strategies for Development Standards	Chapter 6 – Watershed Strategies for Stormwater Management	Chapter 7 – Watershed Strategies for Sensitive Areas Management	Chapter 8 - Urban Growth Area Land Use Strategies Overview	
Land Use										
Reevaluate urban growth area boundaries consistent with the findings of the Watershed Plan	X	X	X	X	Groups 1, 2A, 2B and 2C				X	Policies 1.3 and 1.4
Redesignate urban growth areas consistent with the findings of the Watershed Plan	X	X	X	X	Groups 1, 2A, 2B and 2C				X	Policy 1.4
Etc.										

CHAPTER 4. SUBBASIN FOLIO

4.1 Understanding the Folio

To develop an understanding of watershed conditions in and around the City of Duvall, each subbasin or project assessment unit (PAU) was evaluated in terms of four key processes: 1) surface storage, 2) groundwater and base flow maintenance, 3) fish and wildlife habitat, and 4) water quality. Each PAU was scored according to the relative importance of the processes and the relative degree of degradation. Each PAU was then placed in a subbasin management group based on its score. Additional information on these steps is provided in Chapter 2 Key Watershed Analysis Results and Appendix B. A description of each PAU is provided in a two-page “folio sheet.” Figure 4-1 is an example folio sheet that identifies the key information included.

The folio sheets are grouped according to the tributaries the PAU drains to, and include Cherry Creek, Duvall Tributaries, and Weiss Creek basins. PAUs: 1, 3, 5, 14 and 15 are not included in this chapter because they are located almost entirely outside of Duvall city and urban growth area (UGA) limits, and therefore would not be under the jurisdiction of the City of Duvall at any future time. See Figure 2-4 in Chapter 2 for location of PAUs.

Figure 4-1 Example Folio Sheets

SUBBASIN:
Name of Subbasin and PAU #
BASIN: Basin the subbasin belongs to

Management Recommendation:
Recommended management group

What Does this Management Recommendation Mean?
 Description of what development is appropriate for the given management recommendation

Why is this the Management Recommendation?
 Justification of Management Recommendation.

Map identifying the location of the PAU in Duvall

Management Recommendations

Protect/Restore	Lowest Conservation
Highest Conservation	Urban Development
Moderate Conservation	

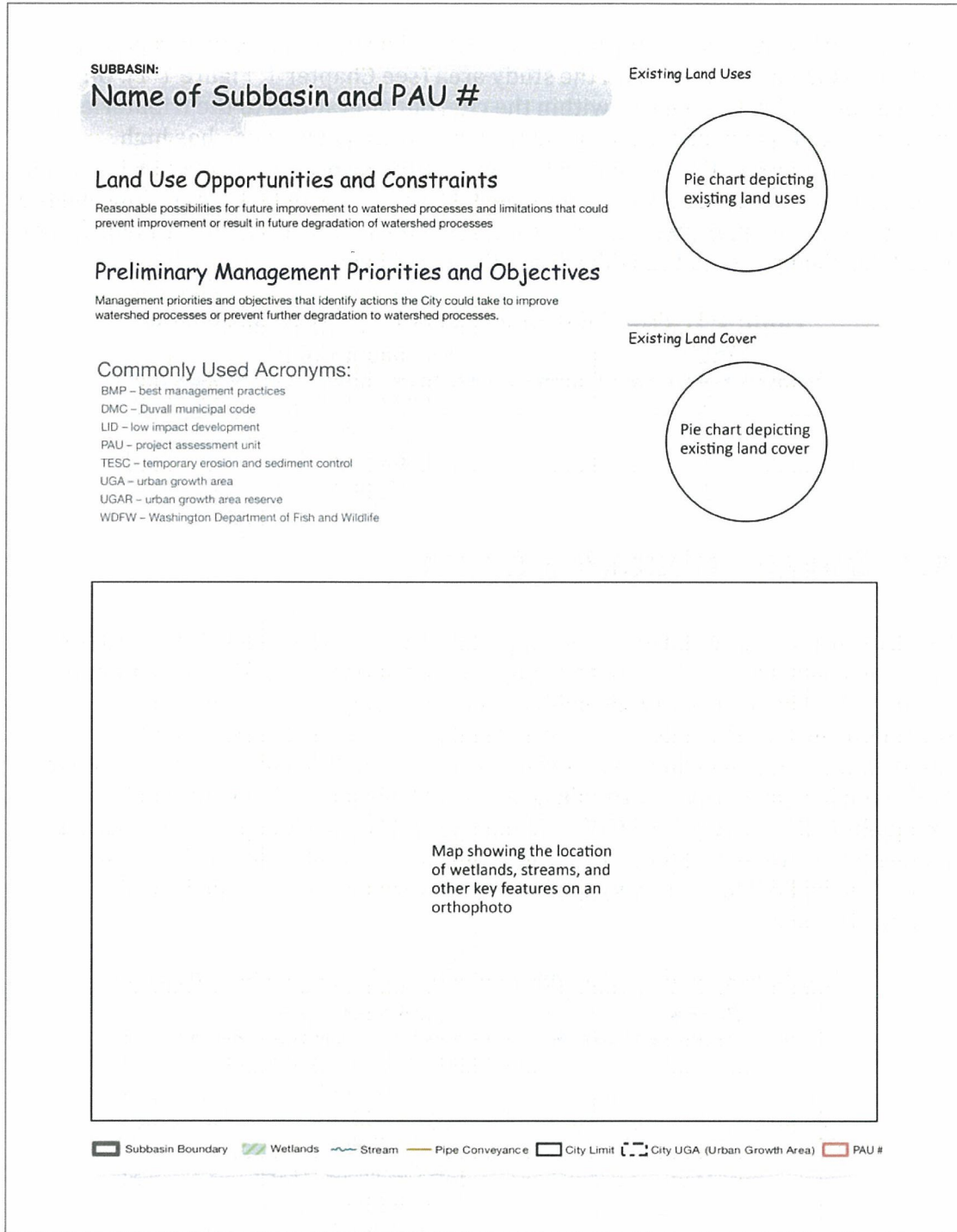
A in the table below describes of the current relative health (referred to as either intact watershed processes or degraded processes) of each watershed process. Broad management priorities are identified for each watershed process

Surface Storage	
Groundwater and Base Flow Maintenance	
Fish and Wildlife Habitat	
Water Quality	

SUBBASIN STATS
 Statistical information on PAU size, existing land use, existing land cover, presence of streams and rivers, and other key data.

The landscape position of each PAU and its relationship to other PAUs

(Figure 4-1 Continued)



4.2 Cherry Creek Basin

Cherry Creek watershed is approximately 32,000 acres, but less than seven percent of the total watershed is within the study area (see Chapter 1, Figure 1-1). Only tributaries to Cherry Creek lie within the city, but alterations to the tributaries can impact the mainstem and alter the floodplain downstream which has high conservation value. High to moderate degradation is observed in tributaries A and B, where development is more extensive. Tributaries C and D still have low levels of development and many watershed processes are still intact. Table 4-1 identifies the PAU folio sheets associated with Cherry Creek subbasins.

Table 4-1. PAU Folio Sheets in Cherry Creek Subbasins

PAU #	Subbasin Name
6	Cherry Creek A
7	Cherry Creek B
8	Cherry Creek C
16	Cherry Creek D - West

4.3 Duvall Tributaries Basin

The Duvall Tributaries basin covers approximately 2,500 acres within the study area and discharges into or are tributaries of the Snoqualmie River (see Chapter 1, Figure 1-1). The majority of the subbasins are developed, thus processes are heavily degraded. Surface storage, groundwater and base flow, and water quality importance tends to be low to moderate. Fish and wildlife habitat is moderate to high, which is primarily due to salmonid use of tributaries that feed into the Snoqualmie River. Only PAU 9 (Coe Clemmons / Thayer Floodplain) retains the majority of watershed processes because it is largely undeveloped. Table 4-2 identifies the PAU folio sheets associated with the subbasins in the Duvall Tributaries basin.

Table 4-2. PAU Folio Sheets in Duvall Tributaries Subbasins

PAU #	Subbasin Name
2	Unnamed Southern Tributary - Lower
4	Old-Town
9	Coe Clemmons/Thayer Floodplain
10	Thayer
11	Coe Clemmons - Upper
12	Coe Clemmons - Lower
13	Unnamed Southern Tributary - Upper

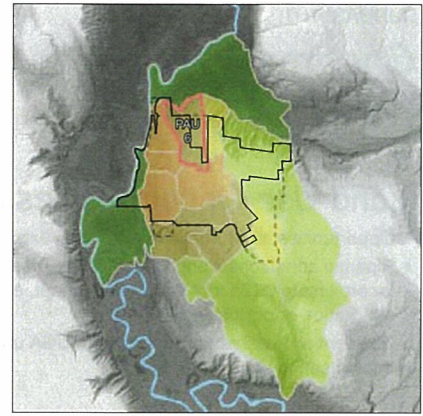
4.4 Weiss Creek Basin

Weiss Creek discharges into the Snoqualmie River upstream of the city (see Chapter 1, Figure 1-1). The majority of the basin has low to moderate development and watershed processes are moderately intact. Of the 2,169 acres in the study area, only Upper Weiss Creek (PAU 17) is within the city and UGA boundaries.

SUBBASIN:

Cherry Creek A (PAU 6)

BASIN: Cherry Creek Tributaries



Management Recommendation: Lowest Conservation

What Does this Management Recommendation Mean?

This subbasin is appropriate for more intense development but as development occurs the resources and areas most important for watershed processes should be conserved.

Why is this the Management Recommendation?

The subbasin scored relatively low for importance and high for degradation. New development, including in the North UGA would have less impact on processes compared to other subbasins and may create opportunities to improve important areas (Cherry Creek Tributary A riparian corridor, Lake Rasmussen). Analysis results are detailed below:

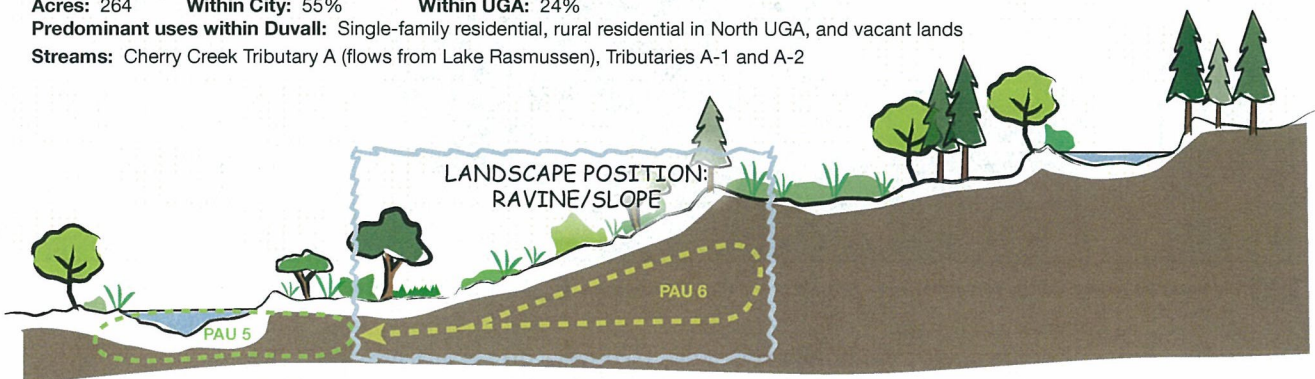
Management Recommendations

- Protect/Restore
- Lowest Conservation
- Highest Conservation
- Urban Development
- Moderate Conservation

<p>Surface Storage</p>	<p>Lake Rasmussen and other depressional wetlands in upper basin provide moderate levels of surface storage during storm events, reducing downstream erosion:</p> <ul style="list-style-type: none"> • 3% wetlands and other surface storage features • Lake Rasmussen (5.5 acres) within the upper portion of subbasin <p>Storage processes minimally degraded despite existing intensity of development due to retention of existing wetlands and Lake Rasmussen.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Limit sediment discharge to Lake Rasmussen • Conserve depressional wetlands • Restore wetlands to increase storage capacity
<p>Groundwater and Base Flow Maintenance</p>	<p>Subbasin features are moderately important for groundwater recharge processes; however, are less important for maintaining stream base flows:</p> <ul style="list-style-type: none"> • 1% permeable soils (supports recharge) • Few slope wetlands <p>Infiltration to groundwater degraded due to high impervious surface cover (less so within North UGA area). Base flow maintenance processes are more intact, especially around Cherry Creek Tributaries A-1 and A-2.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Establish impervious surface limits and other strategies to maintain infiltration • Maintain wetland and riparian areas around subbasin streams
<p>Fish and Wildlife Habitat</p>	<p>The subbasin is moderately to highly important for fish and wildlife habitat:</p> <ul style="list-style-type: none"> • Documented coho presence in Cherry Creek Tributaries A extending above NE Cherry Valley Rd; reach extending towards Lake Rasmussen also has potential to support steelhead • Forested areas are generally contiguous within subbasin (and to larger forested tracts to the east) <p>Salmon habitat impaired by riparian encroachment and stream crossings. Roadway interruption between subbasin and floodplain habitats in north.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Improve Tributary A channel conditions • Conserve riparian area and associated wetlands around subbasin streams • Limit tree loss within contiguous forested area
<p>Water Quality</p>	<p>This subbasin has moderate to high sediment export potential:</p> <ul style="list-style-type: none"> • Lake Rasmussen and depressional wetlands within subbasin provide filtration and sediment deposition for runoff • Steep slope areas in northern subbasin have high export potential for phosphorus and sediment <p>Runoff from developed areas has likely increased pollutant inputs to subbasin and downstream areas, as well as channel erosion.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Identify stormwater retrofit actions • Address Lake Rasmussen pollutant input • Maintain depressional wetlands • Encourage stormwater management for North UGA (implications for steep slopes)

SUBBASIN STATS

Acres: 264 **Within City:** 55% **Within UGA:** 24%
Predominant uses within Duvall: Single-family residential, rural residential in North UGA, and vacant lands
Streams: Cherry Creek Tributary A (flows from Lake Rasmussen), Tributaries A-1 and A-2



SUBBASIN:

Cherry Creek A (PAU 6)

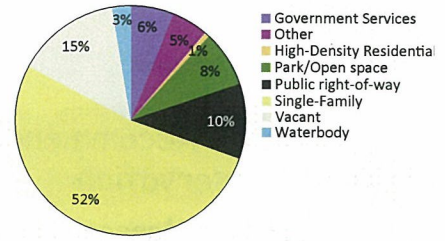
Land Use Opportunities and Constraints

- Opportunities for stormwater retrofits in existing developed areas
- Riparian conditions along Cherry Creek Tributary A vary; however, corridor is present (approximately 125 foot width) throughout, except for four road crossings. Channel and riparian restoration opportunities exist
- Residential development in the North UGA upon annexation presents an opportunity for implementing stormwater BMPs

Preliminary Management Priorities and Objectives

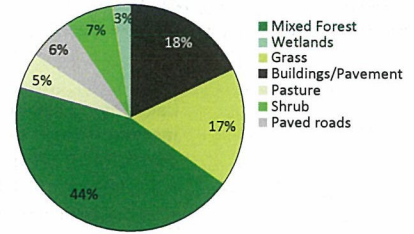
- Protect existing riparian corridor and wetlands, especially those along tributary streams and Lake Rasmussen
- Require use of LID approaches for water quality and water flow as new development occurs in North UGA
- Limit runoff from developed areas with increased pollutant loads discharging into Lake Rasmussen

Existing Land Uses

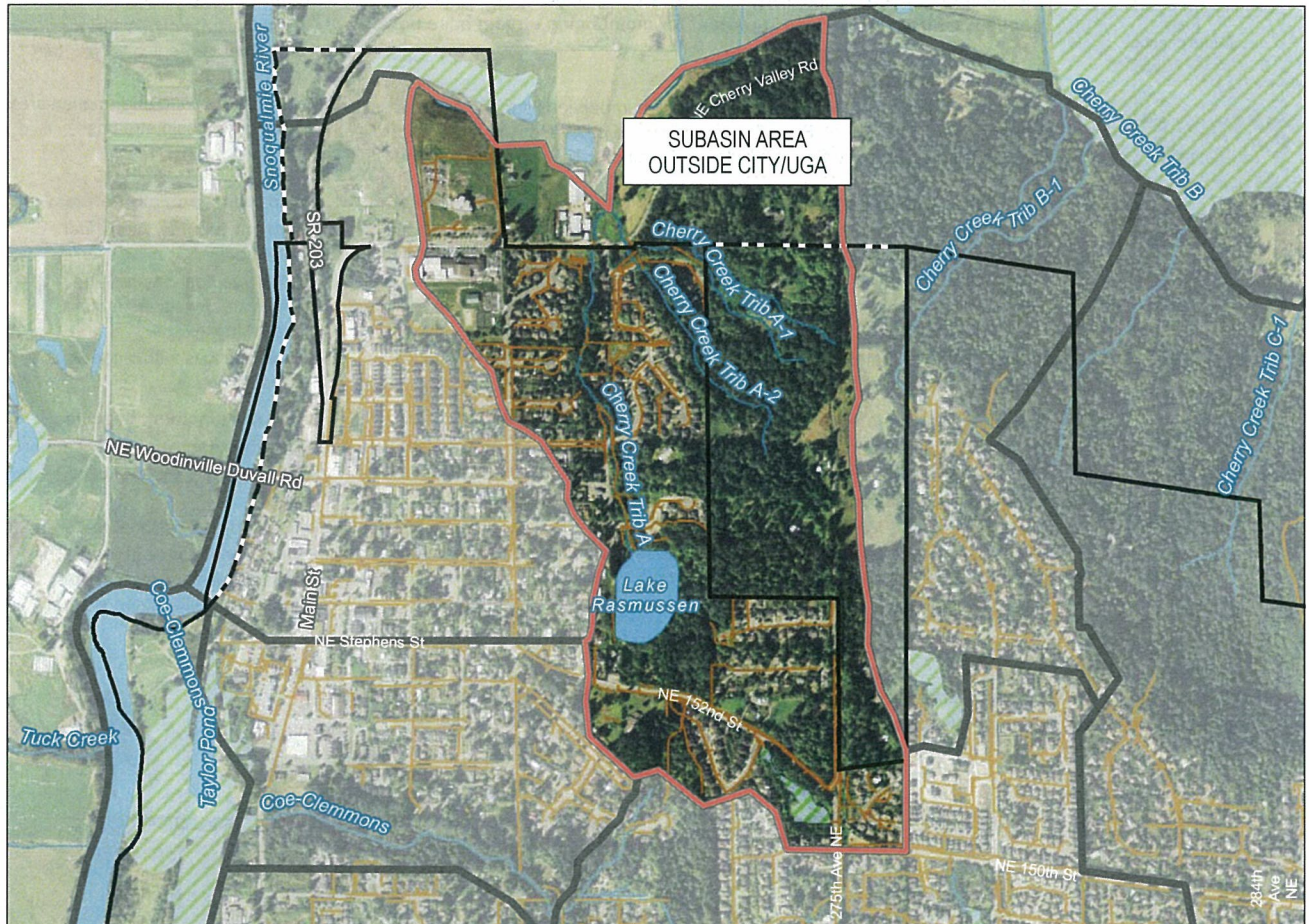


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



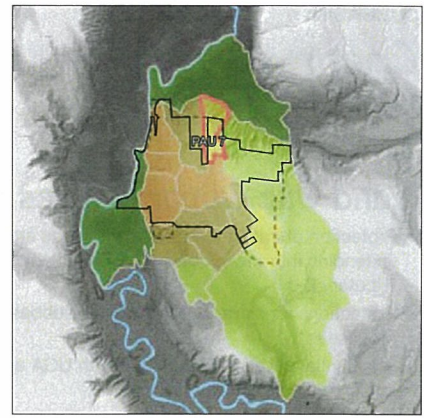
Subbasin Boundary
 Wetlands
 Stream
 Pipe Conveyance
 City Limit
 City UGA (Urban Growth Area)
 PAU 6

**ALL RECOMMENDATIONS APPLICABLE TO DUVALL CITY LIMITS AND UGA ONLY;
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SUBBASIN:

Cherry Creek B (PAU 7)

BASIN: Cherry Creek Tributaries



Management Recommendation: Moderate Conservation

What Does this Management Recommendation Mean?

While this subbasin may be appropriate for some additional development, care should be taken to protect areas important for remaining watershed processes, especially recharge, discharge and habitat processes.

Why is this the Management Recommendation?

This subbasin scored relatively low to moderate for importance and moderate for degradation. Some important areas for maintaining watershed processes remain intact, including forested slopes / slope wetlands and tributary channels. These areas should be conserved; however, overall results suggest there are areas appropriate for new development. Analysis results are detailed below:

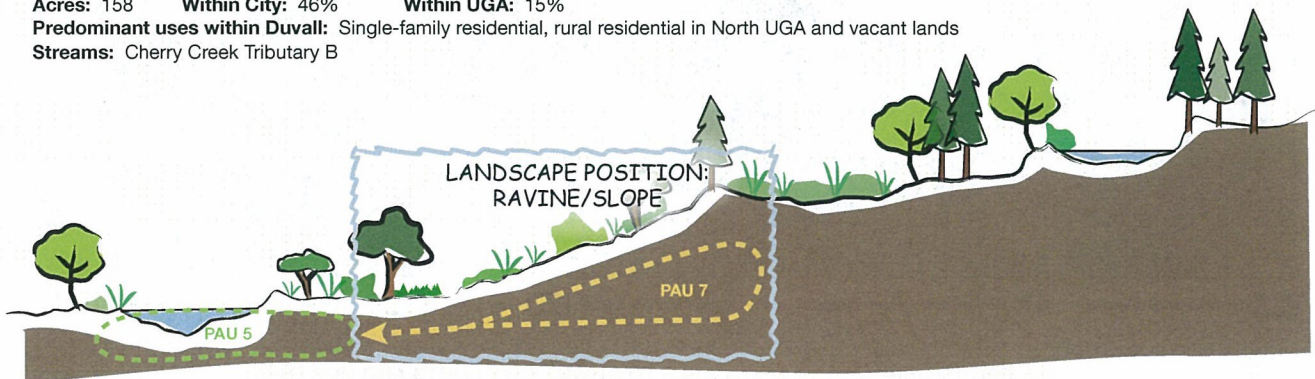
Management Recommendations



<p>Surface Storage</p>	<p>The subbasin is of lower importance for surface storage processes:</p> <ul style="list-style-type: none"> Limited storage opportunity due to steep slopes and lack of wetlands <p>Surface storage that is provided (depressional wetland at southern edge of subbasin) is minimally degraded.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Conserve depressional wetlands Limit concentrated stormwater discharges to steep slope areas (consideration for both quantity and timing)
<p>Groundwater and Base Flow Maintenance</p>	<p>Subbasin is very important for groundwater recharge and base flow maintenance processes:</p> <ul style="list-style-type: none"> 7% permeable soils (support recharge) Slope wetlands in forested areas <p>Groundwater infiltration degraded due to high impervious surface cover. Base flow maintenance processes are likely to be more intact, occurring primarily in forested subbasin areas.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Establish impervious surface limits, mass grading restrictions, and other strategies to maintain infiltration Identify and protect slope wetlands along streams
<p>Fish and Wildlife Habitat</p>	<p>The subbasin is of moderate importance for fish and wildlife habitat:</p> <ul style="list-style-type: none"> No documented salmonid presence; Cherry Creek Tributary B-1 has low to moderate potential for Coho and Steelhead Forested areas are generally contiguous within subbasin (and to larger tracts to east) <p>Existing roadways interrupt habitats within the subbasin and floodplain habitats to north.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Coordinate with County to improve connectivity across Cherry Valley Road Limit tree loss within contiguous forested area
<p>Water Quality</p>	<p>High sediment export potential indicates water quality importance:</p> <ul style="list-style-type: none"> Large depressional wetland at southern edge of subbasin provides filtration and retains sediment Extensive steep slope areas in northern subbasin have high potential to export phosphorus and sediment <p>Stormwater infrastructure in recently developed areas (large residential subdivision) likely provides adequate water quality treatment; but may not fully address water quantity and flow control</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Assess the need for stormwater retrofit actions Maintain depressional wetlands Minimize new development and forest loss within northern forested area

SUBBASIN STATS

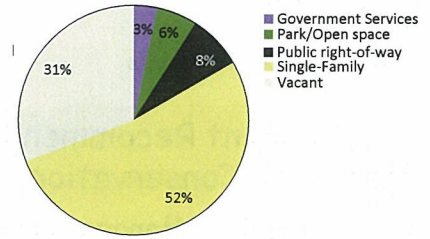
Acres: 158 **Within City:** 46% **Within UGA:** 15%
Predominant uses within Duvall: Single-family residential, rural residential in North UGA and vacant lands
Streams: Cherry Creek Tributary B



SUBBASIN:

Cherry Creek B (PAU 7)

Existing Land Uses



Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

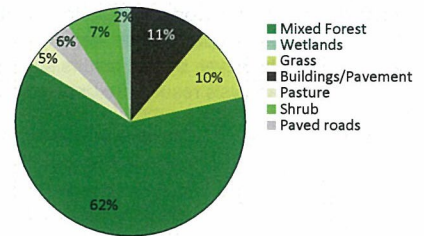
Land Use Opportunities and Constraints

- Protection of contiguous forest and slope areas to the north and east of existing development (extending into the subbasin to the east), including intact riparian forest along Cherry Creek Tributary B-1
- Protections for slope wetlands within subbasin to maintain important and intact recharge processes
- Residential development in the North UGA upon annexation presents an opportunity for implementing stormwater BMPs

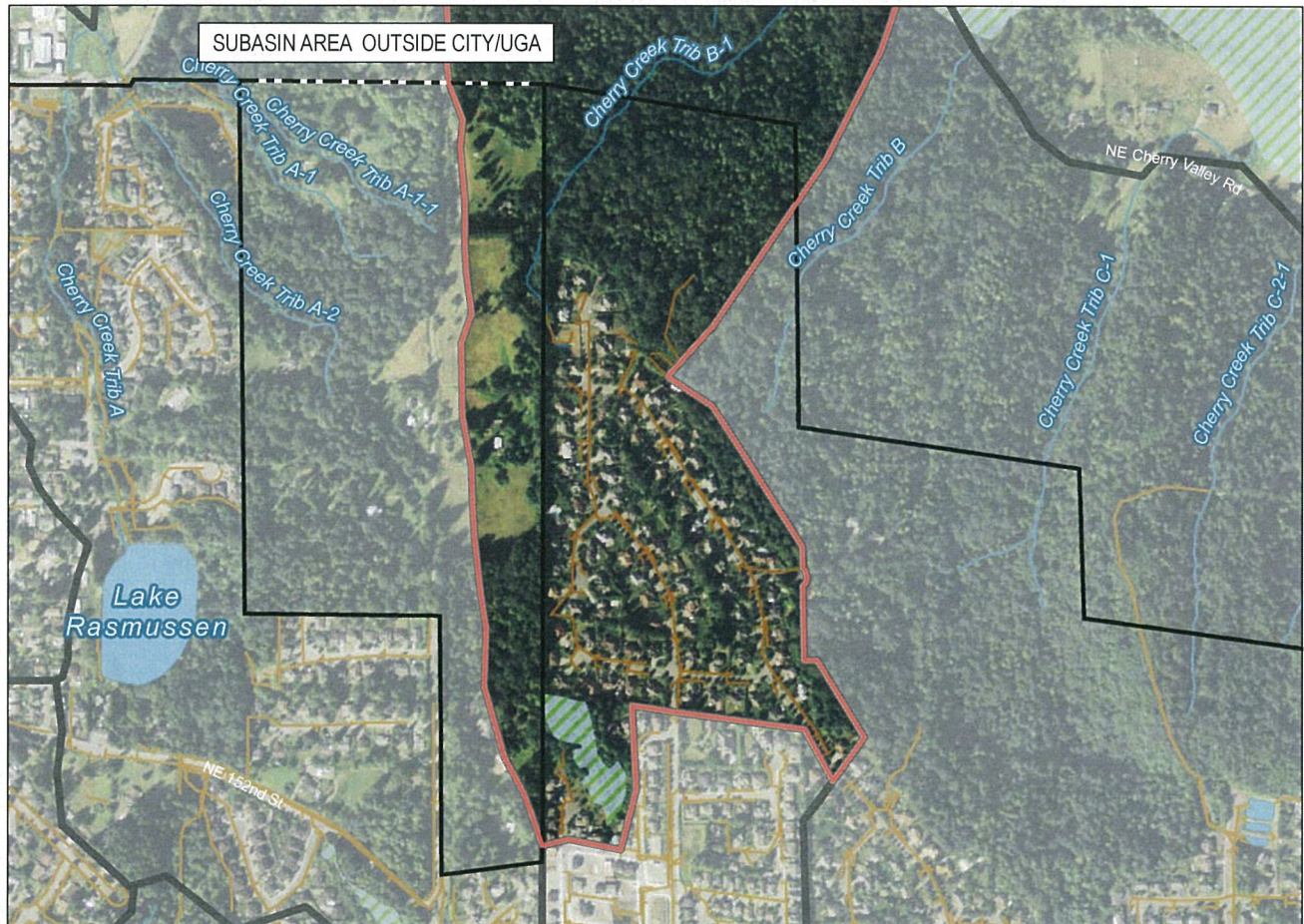
Preliminary Management Priorities and Objectives

- Require use of LID approaches, especially those encouraging infiltration as new development occurs in North UGA
- Protect existing contiguous forest and slope areas along riparian corridor, including along Cherry Creek Tributary B-1
- Maintain depressional wetlands, especially the large wetland at the south edge of the subbasin

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



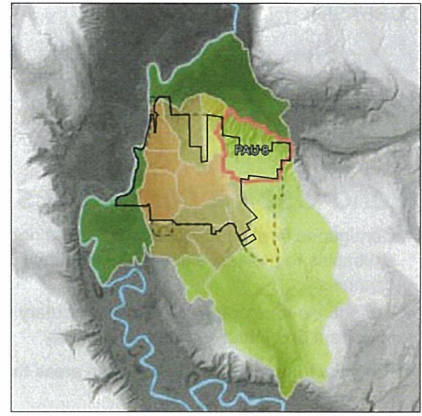
Legend: Subbasin Boundary, Wetlands, Stream, Pipe Conveyance, City Limit, City UGA (Urban Growth Area), PAU 7

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SUBBASIN:

Cherry Creek C (PAU 8)

BASIN: Cherry Creek Tributaries



Management Recommendation: Highest Conservation

What Does this Management Recommendation Mean?

This subbasin is highly important for multiple watershed processes and should be a high priority for protection and restoration.

Why is this the Management Recommendation?

The subbasin scored moderate for importance and low for degradation. Important areas for maintaining watershed processes and habitat remain intact, including forested slopes / slope wetlands and tributary channels across the northern edge of the city. These areas have generally been protected from past development, and conservation should continue into the future. Analysis results are detailed below:

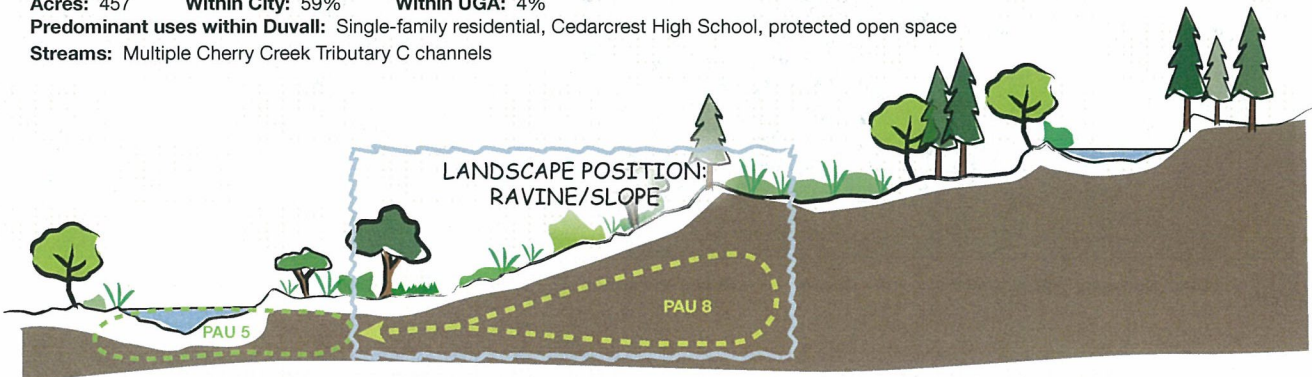
Management Recommendations



<p>Surface Storage</p>	<p>The subbasin is of low importance for surface storage processes:</p> <ul style="list-style-type: none"> Only 1% wetlands / other surface storage features Steep slopes predominant <p>Surface storage that was historically provided (depressional wetland at northern end of subbasin) are largely degraded by surrounding development.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Conserve any remaining depressional wetlands Limit concentrated stormwater discharge to steep slopes Monitor existing stormwater outfalls (identify / address erosion issues)
<p>Groundwater and Base Flow Maintenance</p>	<p>Subbasin is highly important for groundwater recharge processes:</p> <ul style="list-style-type: none"> 36% permeable soils (support recharge) Slope wetlands in forested areas <p>Infiltration to groundwater moderately degraded due to high impervious surface cover within southern portion; however this process remains intact throughout undeveloped slope areas. Base flow maintenance processes are of lower importance.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Establish impervious surface limits, mass grading restrictions, or other strategies to maintain infiltration Protect forested slopes and slope wetlands
<p>Fish and Wildlife Habitat</p>	<p>The subbasin is moderately important for fish and wildlife habitat:</p> <ul style="list-style-type: none"> No documented salmonid presence; WDFW rated multiple Cherry Creek Tributary C channels as having low to moderate intrinsic potential for Coho and Steelhead Forested areas are generally contiguous within subbasin (and to larger forested tracts to the east and west) <p>Existing roadways interrupt habits within the subbasin and floodplain habitats to the north.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Coordinate with County for improved connectivity across Cherry Valley Road Limit tree loss within contiguous forested areas
<p>Water Quality</p>	<p>The subbasin has relatively high sediment export potential:</p> <ul style="list-style-type: none"> Extensive steep slope areas in northern subbasin have high export potential for phosphorus and sediment Export potential is due to erodibility of slopes and tributary channels <p>More recently developed areas (large residential subdivisions; Cedarcrest High School) likely provide adequate water quality treatment; however impact flow quantity and timing.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Assess the need for retrofit actions (monitoring subbasin slopes for erosion) Protect contiguous forested areas (especially within erosion hazard areas)

SUBBASIN STATS

Acres: 457 Within City: 59% Within UGA: 4%
 Predominant uses within Duvall: Single-family residential, Cedarcrest High School, protected open space
 Streams: Multiple Cherry Creek Tributary C channels



SUBBASIN:

Cherry Creek C (PAU 8)

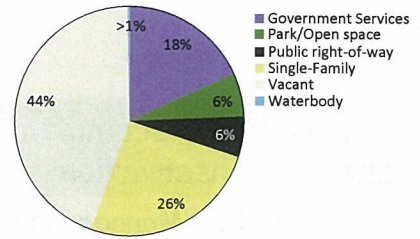
Land Use Opportunities and Constraints

- Contiguous forest and slope areas to the north of existing development (extending into the subbasins to the east and west), including intact riparian forest along Cherry Creek Tributary C channels
- Protections for slope wetlands and tributary stream channels within subbasin to maintain important and intact recharge processes
- Potential for additional forest loss in areas that do not have very steep slopes

Preliminary Management Priorities and Objectives

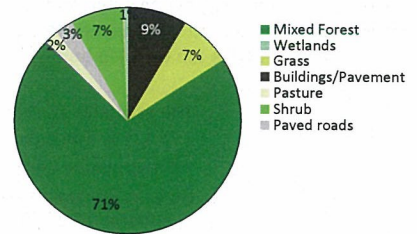
- Protect forested slope areas to the north of existing development, including intact riparian forest along Cherry Creek Tributary C channels.
- Manage and control stormwater discharges to steep slope areas (consideration of both quantity and timing)
- Monitor existing stormwater outfalls to identify and address slope erosion issues

Existing Land Uses



Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



Legend: Subbasin Boundary, Wetlands, Stream, Pipe Conveyance, City Limit, City UGA (Urban Growth Area), PAU 8

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SUBBASIN:

Cherry Creek D - West (PAU 16)

BASIN: Cherry Creek Tributaries

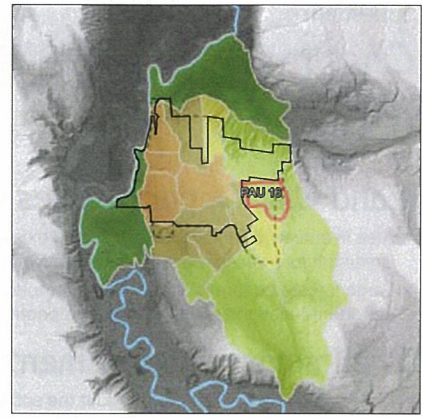
Management Recommendation: Highest Conservation

What Does this Management Recommendation Mean?

This subbasin is highly important to multiple watershed processes and should be a high priority for protection and restoration.

Why is this the Management Recommendation?

The subbasin scored moderate for importance and low for degradation. Important areas for maintaining watershed processes remain intact, including forested depressional wetlands in a headwater landscape to the south of NE 150th Street (the northern portion of the UGAR). These areas should be conserved; urban development may not be appropriate in this subbasin. Analysis results are detailed below:



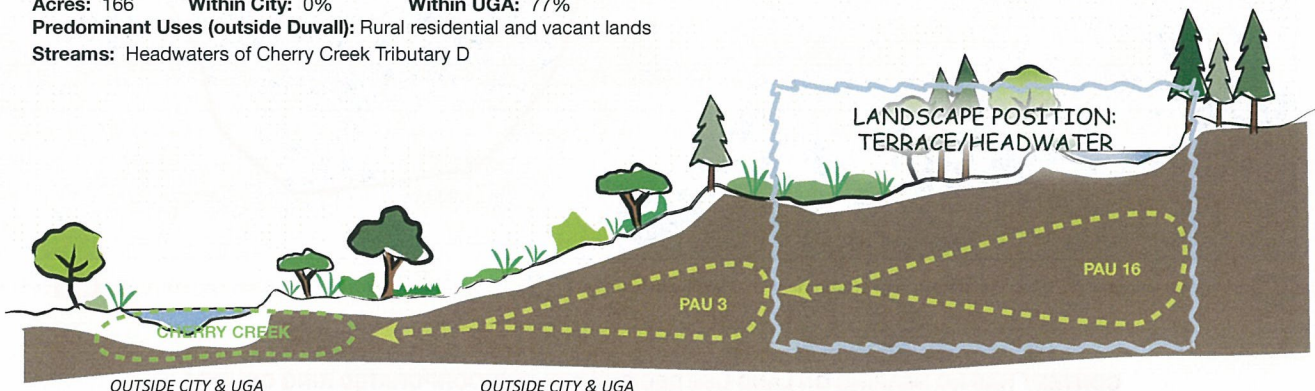
Management Recommendations

- Protect/Restore
- Lowest Conservation
- Highest Conservation
- Urban Development
- Moderate Conservation

<p>Surface Storage</p>	<p>Subbasin provides high levels of surface storage within a headwater landscape position:</p> <ul style="list-style-type: none"> • 23% wetlands and other surface storage features • Large forested depressional wetland complex to the south of NE 150th Street. <p>Water storage processes have been minimally degraded, as there are low levels of existing development</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Limit future development (consider removing from UGAR) • Protect depressional wetlands • Maintain downstream flow pathways
<p>Groundwater and Base Flow Maintenance</p>	<p>Subbasin is moderately important for base flow maintenance; less important for recharge:</p> <ul style="list-style-type: none"> • No areas of mapped permeable soils • Wetlands drain to Cherry Creek Tributary D channels <p>Groundwater and base flow processes have been minimally degraded because there is little existing development. Low impervious surface cover and high forest cover throughout the subbasin support processes.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Limit future development (consider removing from UGAR) • Protect depressional wetlands • Maintain downstream flow pathways
<p>Fish and Wildlife Habitat</p>	<p>The subbasin is moderately important for fish and wildlife habitat:</p> <ul style="list-style-type: none"> • No documented salmonid presence; although there is downstream presence of coho and steelhead within Cherry Creek Tributary D • Forested wetland areas provide habitat for the numerous bird, amphibian, and mammal species • Forested connection to larger undeveloped tracts to the east <p>Rural development has resulted in some forest loss.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Limit future development • Protect large forested wetland complex • Maintain habitat corridor to the east
<p>Water Quality</p>	<p>The headwater landscape of the subbasin supports sediment deposition and water filtration processes:</p> <ul style="list-style-type: none"> • Extensive areas of depressional wetlands suggest that the subbasin is a sediment and phosphorus sink • Wetlands provide water quality filtration before discharge to Cherry Creek Tributary D <p>Water quality processes are relatively intact due to low levels of development throughout subbasin, especially areas surrounding large forested wetland complex.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Limit future development • Protect large forested wetland complex

SUBBASIN STATS

Acres: 166 Within City: 0% Within UGA: 77%
 Predominant Uses (outside Duvall): Rural residential and vacant lands
 Streams: Headwaters of Cherry Creek Tributary D



SUBBASIN:

Cherry Creek D - West (PAU 16)

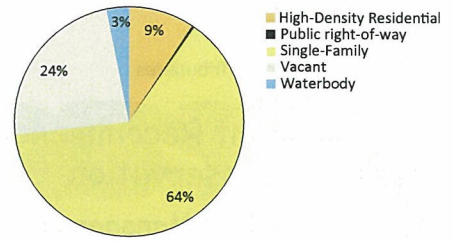
Land Use Opportunities and Constraints

- Area is entirely within the UGAR; limited existing development potential under County zoning (limiting future development is consistent with watershed management recommendation)
- Large forested depressional wetland complex in headwater landscape setting provides multiple important functions which should be a priority for protection

Preliminary Management Priorities and Objectives

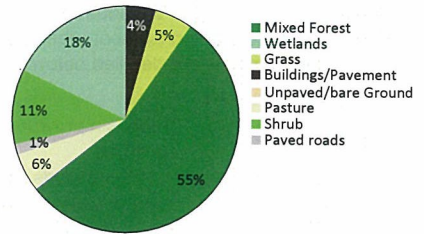
- Limit future development throughout the subbasin by removing from the UGAR or putting wetland areas (with substantial buffers) in conservation easement
- Maintain forested habitat corridors to the east, including downstream flow pathways from wetland complex to Cherry Creek Tributary D streams

Existing Land Use



Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



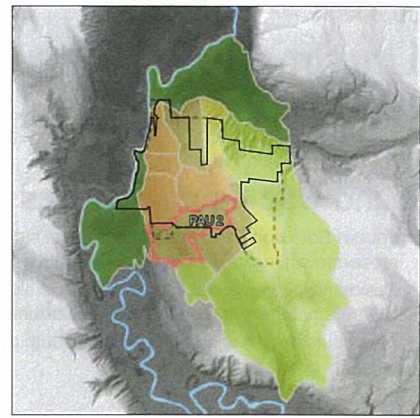
Subbasin Boundary
 Wetlands
 ~ Stream
 Pipe Conveyance
 City Limit
 City UGA (Urban Growth Area)
 PAU 16

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SUBBASIN:

Unnamed Southern Tributary - Lower (PAU 2)

BASIN: Southern Tributaries



Management Recommendation: Lowest Conservation

What Does this Management Recommendation Mean?

This subbasin is appropriate for more intense development; but as development occurs the resources and areas most important for watershed processes should be conserved.

Why is this the Management Recommendation?

The subbasin scored relatively low for importance and high for degradation. New development, including in the South UGA and along the Big Rock Road corridor, could occur with less severe effects on processes compared to other subbasins, and may generate opportunities to improve important areas (wetlands and riparian corridors, Loutsis Dam pond). Analysis results are detailed below:

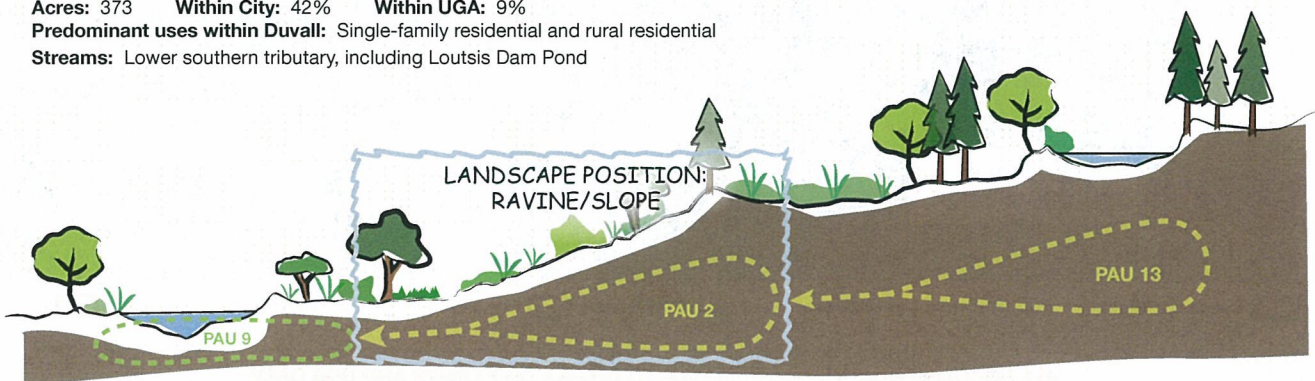
Management Recommendations

- Protect/Restore
- Lowest Conservation
- Highest Conservation
- Urban Development
- Moderate Conservation

<p>Surface Storage</p>	<p>Subbasin provides moderate levels of surface storage during storm events, reducing downstream erosion:</p> <ul style="list-style-type: none"> 6% wetlands and other surface storage features (primarily Loutsis Dam pond) <p>These processes remain largely intact, and should be protected</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Conserve / restore depressional wetlands / Loutsis Dam pond Limit stormwater discharges to steep slope areas, especially adjacent to streams
<p>Groundwater and Base Flow Maintenance</p>	<p>Subbasin is relatively low importance to groundwater and base flow maintenance processes:</p> <ul style="list-style-type: none"> No mapped permeable soils Few mapped slope wetlands; although these likely occur along riparian corridors <p>Processes are minimally degraded due to low levels of existing development and wide, forested riparian corridor.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Preserve forest cover Preserve slope wetlands along stream corridors
<p>Fish and Wildlife Habitat</p>	<p>The subbasin is moderately important for fish and wildlife habitat:</p> <ul style="list-style-type: none"> No documented salmonid presence; downstream presence mapped west of State Route 203 Forested riparian and contiguous wetland areas, including surrounding Loutsis Dam pond, provide habitat for numerous bird, amphibian, and mammal species, as well as connections to subbasins to the east <p>Northeastern portion of subbasin highly developed with single family residential. Rural development along Big Rock Road corridor has resulted in some forest loss.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Provide adequate stream and wetland buffers Maintain habitat corridors to the east
<p>Water Quality</p>	<p>This subbasin has low sediment export potential:</p> <ul style="list-style-type: none"> Sediment sources primarily channel erosion, due to soil erodibility and channel bank conditions Sediment sinks include Loutsis Dam Pond and other depressional wetlands <p>Low levels of existing development suggest most water quality processes intact. Higher impervious surface levels in contributing subbasins likely increased channel erosion.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Require use of LID approaches for water quality and water flow Maintain remaining wetlands

SUBBASIN STATS

Acres: 373 **Within City:** 42% **Within UGA:** 9%
Predominant uses within Duvall: Single-family residential and rural residential
Streams: Lower southern tributary, including Loutsis Dam Pond



SUBBASIN:

Unnamed Southern Tributary - Lower (PAU 2)

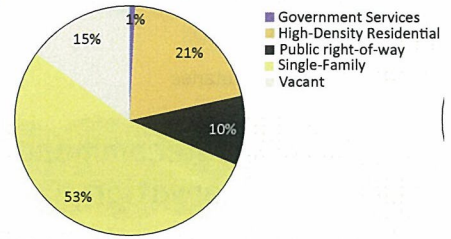
Land Use Opportunities and Constraints

- Loutsis Dam pond and riparian corridors, including ravine at lower end of subbasin, provide moderate ecological functions and should be protected
- Residential, commercial and industrial development along Big Rock Road corridor and South UGA upon annexation presents an opportunity for implementing stormwater BMPs
- Areas outside of city and UGA, to the south of Big Rock Road, may be appropriate for higher intensity development in the future

Preliminary Management Priorities and Objectives

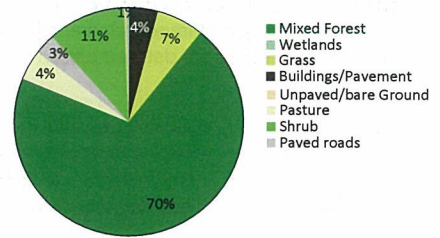
- Protect intact riparian forest along stream channels and surrounding Loutsis Dam pond
- Maintain slope wetlands adjacent to streams, and protect remaining depressional wetlands
- Require use of LID approaches for water quality and water flow as new development occurs

Existing Land Uses

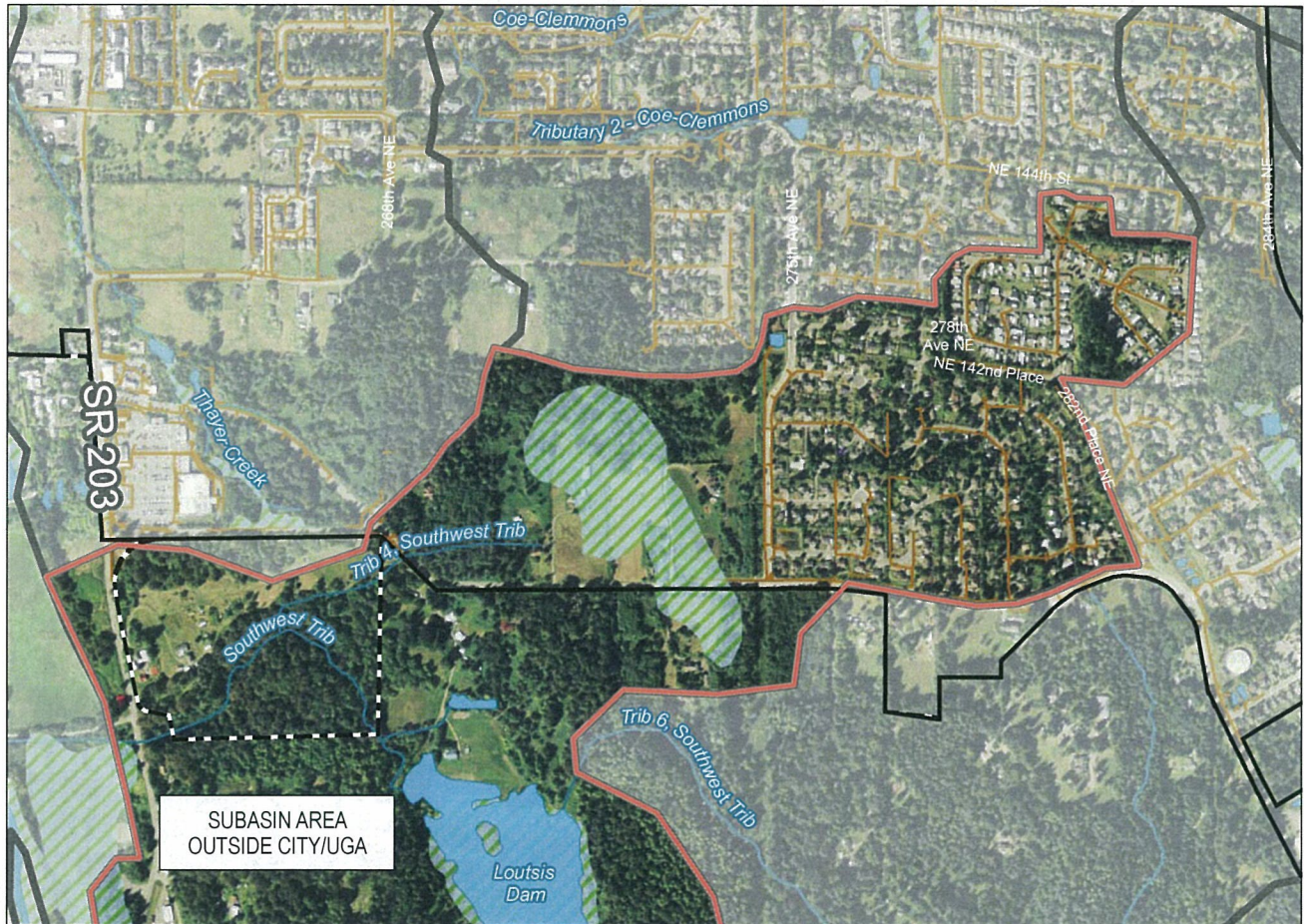


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



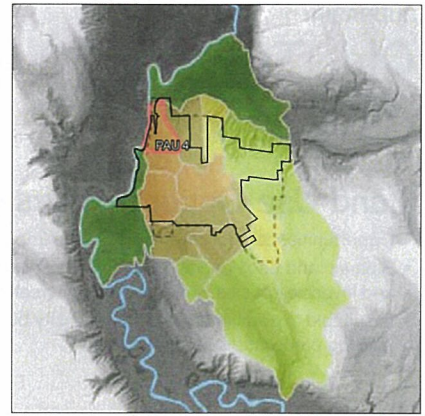
 Subbasin Boundary
 Wetlands
 ~ Stream
 Pipe Conveyance
 City Limit
 City UGA (Urban Growth Area)
 PAU 2

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SUBBASIN:

Old - Town (PAU 4)

BASIN: Duvall Tributaries – Direct to Snoqualmie River



Management Recommendation: Urban Development

What Does this Management Recommendation Mean?

This subbasin is an area of lowest importance to watershed processes and can be targeted for intense urban development.

Why is this the Management Recommendation?

Compared to other areas of the city, this subbasin scored lowest for importance and highest for level of degradation (high impervious surface cover and altered conveyance of surface flows). As new development / redevelopment in the subbasin occurs, it should be paired with targeted restoration focused on improving Snoqualmie River conditions. Analysis results are detailed below:

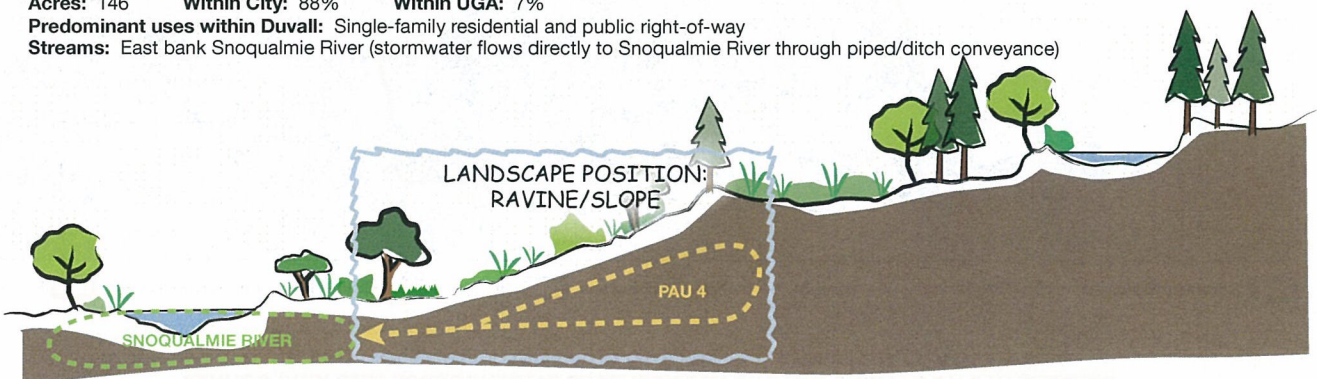
Management Recommendations

- Protect/Restore
- Lowest Conservation
- Highest Conservation
- Urban Development
- Moderate Conservation

<p>Surface Storage</p> 	<p>The subbasin has low importance for surface storage processes:</p> <ul style="list-style-type: none"> Almost no wetlands or other surface storage features, outside of narrow Snoqualmie River floodplain at western edge Previous development has resulted in piped / ditched conveyance directly to River <p>Limited opportunity for storage enhancement due to slopes and existing development / infrastructure patterns.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Limit new floodplain development Reduce effective impervious surface Eliminate flow control standard to encourage high density development (when consistent with DMC 19.06)
<p>Groundwater and Base Flow Maintenance</p> 	<p>Historically, subbasin features were moderately important for groundwater recharge and base flow maintenance processes; however these processes have been highly degraded:</p> <ul style="list-style-type: none"> 14% permeable soils (supports recharge) Very few wetlands <p>Process degradation due to high impervious surface cover and altered flow pathways.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Prohibit floodplain development Increase infiltration by reducing effective impervious surface Identify retrofit opportunities that provide infiltration
<p>Fish and Wildlife Habitat</p> 	<p>The subbasin is moderately important for fish and wildlife habitat:</p> <ul style="list-style-type: none"> Importance tied to salmonid presence within the Snoqualmie River, along western subbasin edge Remaining subbasin highly impervious with no open channel or forest habitats <p>Forest loss and development within Snoqualmie River riparian corridor has degraded habitat quality and armories along river banks.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Prohibit further encroachment into Snoqualmie River riparian corridor Restore riparian and river bank conditions Identify retrofits to improve water quality functions
<p>Water Quality</p> 	<p>The subbasin has moderate sediment export potential and direct discharge to Snoqualmie River indicates:</p> <ul style="list-style-type: none"> Sediment sources primarily surface erosion due to soil erodibility and subbasin slopes <p>Impervious surface cover and stormwater conveyance (pipe and ditch) infrastructure has likely reduced export potential; however increases water quality issues related to runoff from developed areas has increased.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Identify retrofit actions focused on water quality Ensure adequate Temporary Erosion and Sediment Control (TESC) BMPs during clearing and grading activities

SUBBASIN STATS

Acres: 146 Within City: 88% Within UGA: 7%
 Predominant uses within Duvall: Single-family residential and public right-of-way
 Streams: East bank Snoqualmie River (stormwater flows directly to Snoqualmie River through piped/ditch conveyance)



SUBBASIN:

Old -Town
(PAU 4)

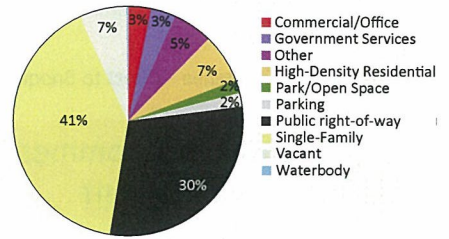
Land Use Opportunities and Constraints

- Opportunities for stormwater retrofits to improve water quality
- Riparian and bank conditions along the Snoqualmie River are degraded, with narrow corridor and invasive species within understory creating opportunity for restoration
- Is suitable fo additional residential density but redevelopment opportunity constrained by existing parcel and build-out pattern

Preliminary Management Priorities and Objectives

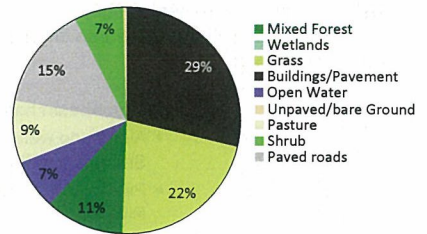
- Encourage high density development by eliminating flow control requirements (with enhanced water quality treatment) when consistent with DMC 19.06
- Reduce effective impervious surface by disconnecting non-pollution generating impervious areas (for example roofs, sidewalks)
- Prohibit further encroachment into Snoqualmie River riparian corridor / floodplain and restore habitat conditions
- Improve water quality functions throughout subbasin through redevelopment incentives and retrofit actions

Existing Land Uses

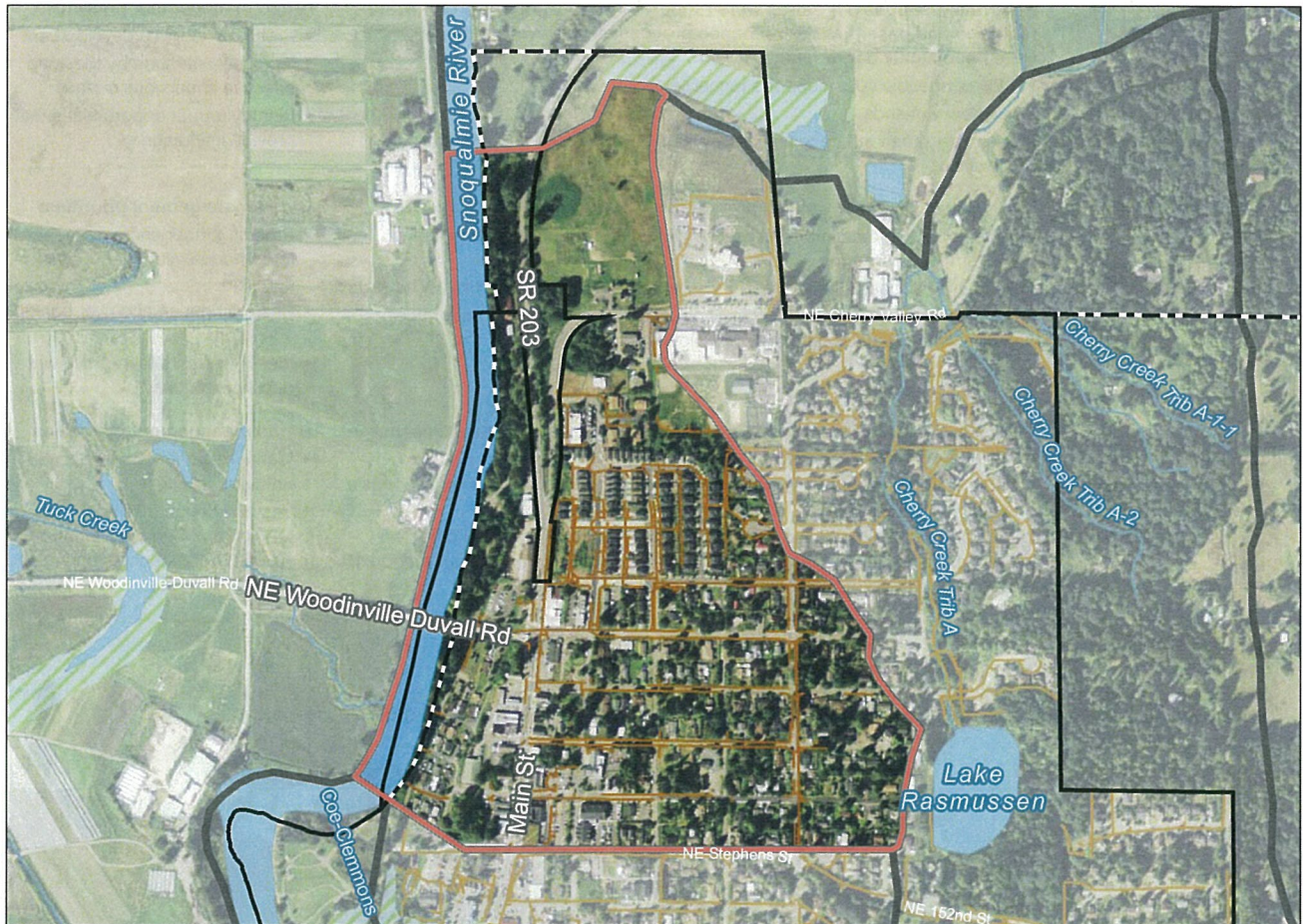


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



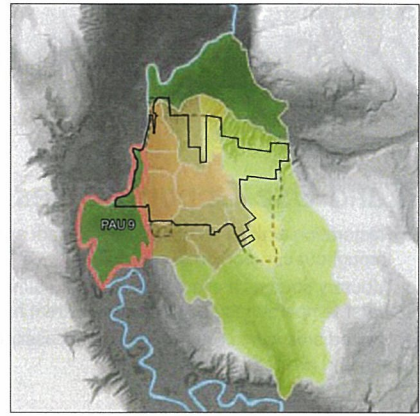
Subbasin Boundary
 Wetlands
 Stream
 Pipe Conveyance
 City Limit
 City UGA (Urban Growth Area)
 PAU 4

ALL RECOMMENDATIONS APPLICABLE TO DUVALL CITY LIMITS AND UGA ONLY;
CONTENT HAS NO BEARING ON LAND USE DECISIONS IN UNINCORPORATED KING COUNTY.

SUBBASIN:

Coe Clemmons/Thayer Floodplain (PAU 9)

BASIN: Duvall Tributaries - Coe-Clemmons/Thayer Creeks



Management Recommendation: Protect/Restore

What Does this Management Recommendation Mean?

This subbasin is highly important to multiple watershed processes and should be a high priority for protection and restoration.

Why is this the Management Recommendation?

The subbasin, which occurs within the Snoqualmie River floodplain, includes many features that support important water flow, water quality, and habitat processes. Degradation to these features is also relatively high, indicating that restoration should be prioritized. Analysis results are detailed below:

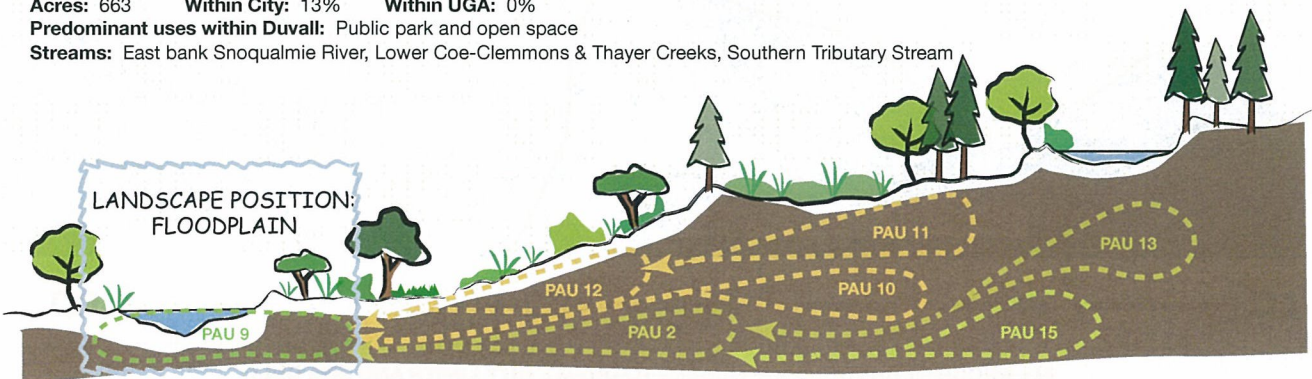
Management Recommendations

- Protect/Restore
- Lowest Conservation
- Highest Conservation
- Urban Development
- Moderate Conservation

<p>Surface Storage</p>	<p>Subbasin provides high levels of surface storage during floods, reducing hazards and providing refuge for salmon:</p> <ul style="list-style-type: none"> • 4% wetlands and other surface storage features • 100% floodplain (flooding from Snoqualmie River and tributaries) <p>These processes are very degraded due to past agricultural uses (ongoing outside city limits) that resulted in stream and wetland loss. Conditions partially restored within the city limits.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Wetland creation • Wetland restoration focused on increasing storage capacity • Improve stream sinuosity of tributaries
<p>Groundwater and Base Flow Maintenance</p>	<p>Subbasin is important for maintaining agricultural and domestic water supplies as well as Snoqualmie River water temperature:</p> <ul style="list-style-type: none"> • 90% permeable soils within the floodplain (supports recharge) • Low levels of impervious surface <p>Infiltration to groundwater largely intact due to low impervious surface cover. However, conversion of permeable/forested floodplain to park and agricultural uses has degraded processes.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Increase forest cover • Limit new impervious surfaces
<p>Fish and Wildlife Habitat</p>	<p>The subbasin is highly important for fish and wildlife habitat.</p> <ul style="list-style-type: none"> • Extensive salmonid use within Snoqualmie River and tributary streams (coho, steelhead) • Large open space tract contiguous with surrounding pasture/riparian habitats <p>Salmon habitat is impaired by stream channelization and crossings, and lack of riparian cover. Wildlife habitat is impaired by roadways, utility corridors, surrounding development, and habitat simplification.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Improve tributary stream habitat/connectivity • Increase Snoqualmie River riparian cover • Prohibit most new development • Increase forest cover throughout
<p>Water Quality</p>	<p>Floodplain and wetland landscape supports sediment deposition, water filtration, and shade processes:</p> <ul style="list-style-type: none"> • High wetland coverage / floodplain landscape • Permeable soils with low impervious surface cover <p>Changes in land use have depleted forest and increased input of pollutants to subbasin, including metals (roadway runoff from upstream subbasins). Elevated water temperatures due to riparian forest loss and tributary impoundment.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Increase forest cover • Manage stormwater from upstream subbasins • Limit new impervious surfaces

SUBBASIN STATS

Acres: 663 Within City: 13% Within UGA: 0%
 Predominant uses within Duvall: Public park and open space
 Streams: East bank Snoqualmie River, Lower Coe-Clemmons & Thayer Creeks, Southern Tributary Stream



SUBBASIN:

Coe Clemmons/Thayer Floodplain (PAU 9)

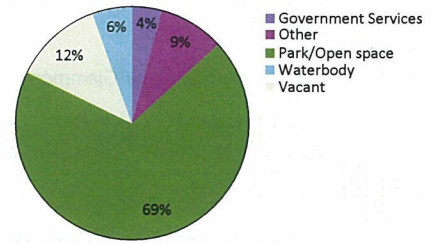
Land Use Opportunities and Constraints

- Restoration actions on publicly owned park and open space lands could improve conditions throughout city-portion of subbasin
- Tributary streams are impaired by Snoqualmie Valley Trail, potentially contributing to increased water temperatures and degraded instream habitat
- Limited area within City jurisdiction necessitates coordination with County to maximize protection and restoration opportunities

Preliminary Management Priorities and Objectives

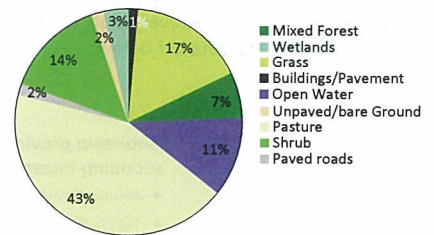
- Limit new impervious surfaces and increase forested cover in floodplain
- Protect existing wetlands and create or restore wetlands degraded by agricultural practices
- Prohibit new development and manage stormwater from upstream sources

Existing Land Uses



Depicts existing land uses for areas within the City. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



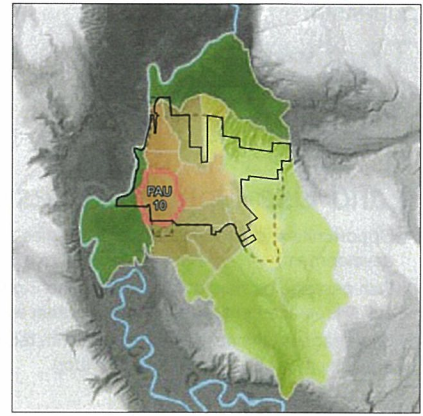
Subbasin Boundary
 Wetlands
 ~ Stream
 Pipe Conveyance
 City Limit
 City UGA (Urban Growth Area)
 PAU 9

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SUBBASIN:

Thayer (PAU 10)

BASIN: Duvall Tributaries – Thayer Creek



Management Recommendation: Urban Development

What Does this Management Recommendation Mean?

This subbasin is an area of lowest importance to watershed processes and is suitable for more intense urban development.

Why is this the Management Recommendation?

Compared to other areas in the City, the subbasin scored amongst the lowest for importance and highest for level of degradation (high impervious surface cover and altered conveyance of surface flows). As new development / redevelopment in the subbasin occurs it should be paired with restoration along the Thayer Creek corridor. Analysis results are detailed below:

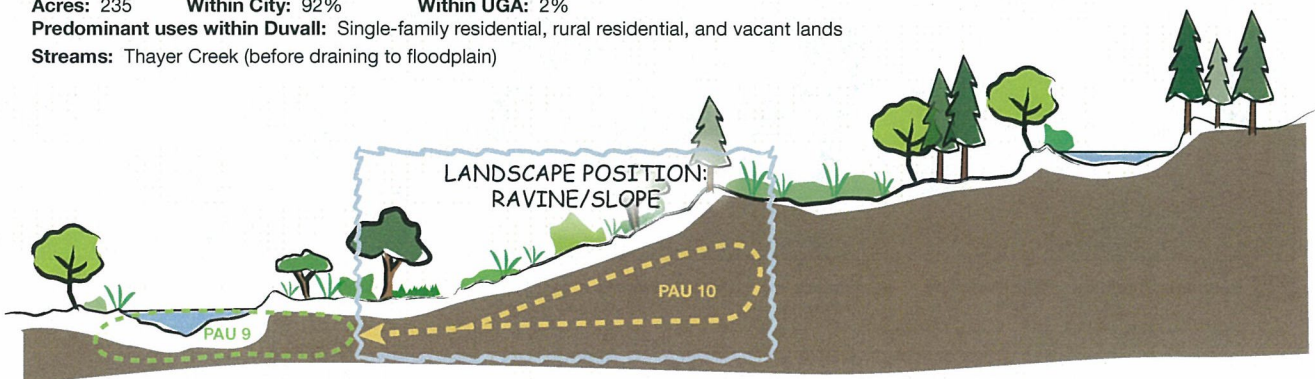
Management Recommendations

- Protect/Restore
- Urban Development
- Moderate Conservation
- Highest Conservation
- Lowest Conservation

<p>Surface Storage</p> 	<p>The subbasin is of low importance for surface storage processes:</p> <ul style="list-style-type: none"> • Only 2% wetlands / other surface storage features • Previous development has resulted in piped / ditched conveyance directly to Snoqualmie River floodplain <p>Limited opportunity for enhancing storage due to steep slopes and existing development / infrastructure patterns.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Reduce effective impervious surface • Eliminate flow control standard (when consistent with Duvall Municipal Code 19.06) to encourage high density development
<p>Groundwater and Base Flow Maintenance</p> 	<p>Subbasin has relatively low importance to groundwater and base flow maintenance processes:</p> <ul style="list-style-type: none"> • 4% permeable soils (supports recharge) • Slope wetlands along Big Rock Road corridor <p>Process degradation due to high impervious surface cover and altered flow pathways.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Increase infiltration by reducing effective impervious surface (where feasible) • Preserve slope wetlands along stream corridors
<p>Fish and Wildlife Habitat</p> 	<p>The subbasin is moderately important for fish and wildlife habitat:</p> <ul style="list-style-type: none"> • Documented coho presence in lower Thayer Creek, extending above Main Street and Big Rock Road (although culverts at these roads are partial fish passage barriers) <p>Salmon habitat impaired by riparian encroachment from surrounding development and stream crossings. Low amounts of remaining forest canopy across subbasin.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Improve Thayer Creek channel and riparian conditions • Remove fish passage barriers
<p>Water Quality</p> 	<p>The subbasin has moderate sediment export potential and discharge to lower Thayer Creek / Snoqualmie floodplain:</p> <ul style="list-style-type: none"> • Sediment sources associated with surface and channel erosion, including soil erodibility and subbasin / channel slopes <p>Stormwater runoff directed to Thayer Creek affects channel erosion and water quality. Urban runoff is likely polluted with metals and other contaminants.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Identify and implement retrofit actions focused on water quality • Control sediment sources

SUBBASIN STATS

Acres: 235 **Within City:** 92% **Within UGA:** 2%
Predominant uses within Duvall: Single-family residential, rural residential, and vacant lands
Streams: Thayer Creek (before draining to floodplain)



SUBBASIN:

Thayer (PAU 10)

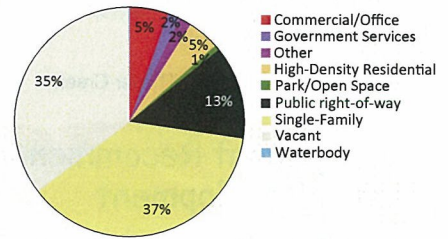
Land Use Opportunities and Constraints

- Opportunities for stormwater LID strategies focused on water quality (primarily for new development)
- Fish passage barriers at Main Street and Big Rock Road limit aquatic habitat; opportunity for culvert replacement and channel / riparian enhancement
- Encourage additional density in area with relatively low ecological functions (significant opportunity along 143rd Street corridor)

Preliminary Management Priorities and Objectives

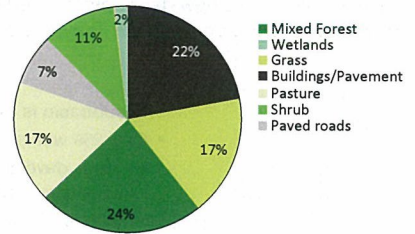
- Encourage high density development by eliminating flow control requirements (with enhanced water quality treatment) when consistent with DMC 19.06
- Reduce effective impervious surface by disconnecting non-pollution generating impervious areas (for example roofs, sidewalks)
- Restore Thayer Creek channel and riparian conditions downstream of Big Rock Road

Existing Land Uses



Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



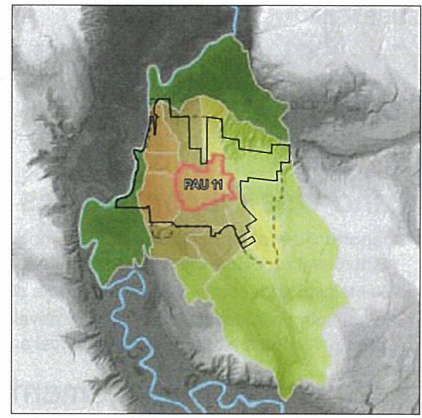
Subbasin Boundary
 Wetlands
 ~ Stream
 Pipe Conveyance
 City Limit
 City UGA (Urban Growth Area)
 PAU 10

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SUBBASIN:

Coe-Clemmons - Upper (PAU 11)

BASIN: Duvall Tributaries – Coe Clemmons Creek



Management Recommendation: Urban Development

What Does this Management Recommendation Mean?

This subbasin is an area of lowest importance to watershed processes and is suitable for more intense urban development.

Why is this the Management Recommendation?

Compared to other areas in the city, this subbasin scored lowest for importance and highest for level of degradation (high impervious surface cover, wetland loss and altered conveyance of surface flows). As new development / redevelopment in the subbasin occurs it should be paired with targeted protection/restoration focused on remaining wetlands, stream and habitat corridors and improving surface storage. Analysis results are detailed below:

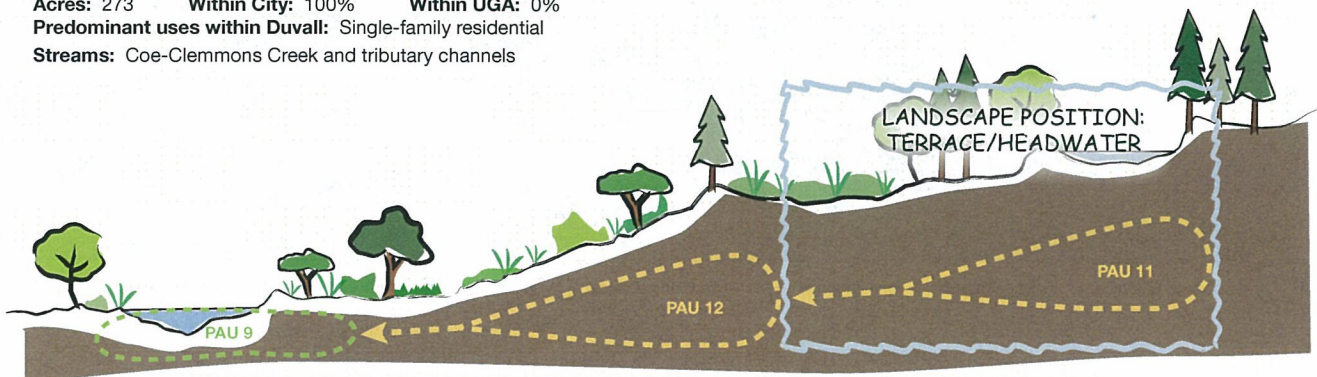
Management Recommendations



<p>Surface Storage</p>	<p>This subbasin is moderately important for surface storage processes and is highly degraded:</p> <ul style="list-style-type: none"> Only 1% wetlands / other surface storage features Previous development has resulted in piped / ditched conveyance with inadequate flow control <p>Significant opportunity for storage process enhancement through retrofits and other actions.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Maintain remaining wetlands Reduce effective impervious surface Identify and implement stormwater retrofits that provide addition detention
<p>Groundwater and Base Flow Maintenance</p>	<p>Subbasin was historically moderately important for groundwater recharge; however this process has been highly degraded:</p> <ul style="list-style-type: none"> Many slope wetland areas along tributary channels <p>Degradation of processes due to high impervious surface cover and altered flow pathways. Base flow maintenance processes are of lower importance.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Increase infiltration by reducing effective impervious surface Identify retrofit opportunities that provide infiltration (where feasible)
<p>Fish and Wildlife Habitat</p>	<p>The subbasin is moderately important for fish and wildlife habitat:</p> <ul style="list-style-type: none"> No documented salmonid presence; Reaches at the edge of the subbasin have moderate potential for Coho and Steelhead Coe-Clemmons Creek riparian corridor interrupted by multiple road crossings Wetland habitat loss from past development <p>Wildlife habitat impaired by riparian encroachment and stream crossings (partial barriers downstream).</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Focus on water flow and water quality functions to improve downstream habitat conditions Maintain and enhance remaining moderate value habitat
<p>Water Quality</p>	<p>The subbasin has low sediment export potential; and potential contributions to lower Coe-Clemmons Creek (with known erosion issues):</p> <ul style="list-style-type: none"> Sediment sources associated with channel erosion, including soil erodibility and channel bank conditions <p>Degradation related to impervious runoff has likely increased channel erosion and peak flows. Additionally, urban runoff is likely polluted with metals and other pollutants.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Identify and implement stormwater retrofit actions for water quality and surface storage Maintain remaining wetlands (sediment sinks)

SUBBASIN STATS

Acre: 273 Within City: 100% Within UGA: 0%
 Predominant uses within Duvall: Single-family residential
 Streams: Coe-Clemmons Creek and tributary channels



SUBBASIN:

Coe-Clemmons - Upper (PAU 11)

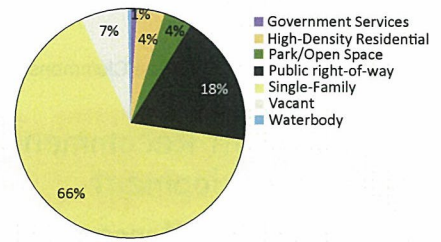
Land Use Opportunities and Constraints

- Opportunities for stormwater retrofit to improve water quality and water flow to downstream resources (lower Coe-Clemmons and Snoqualmie River floodplain)
- Maintaining and restoring habitat corridors along upper Coe-Clemmons tributary channels
- Encouraging additional density as new development and redevelopment occurs; redevelopment opportunity constrained by existing parcel and build-out pattern

Preliminary Management Priorities and Objectives

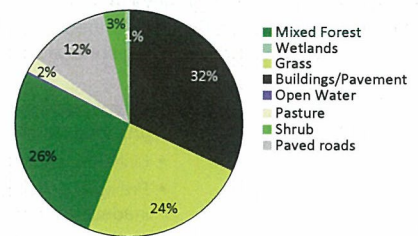
- Increase infiltration by reducing effective impervious surface (disconnect non-pollution generating impervious areas)
- Maintain and restore remaining wetlands (especially depressional wetlands, which serve as sediment sinks) and Coe-Clemmons tributary corridors
- Identify and implement stormwater retrofit actions for both water quality and surface storage; monitor retrofit results by assessing downstream conditions.

Existing Land Uses

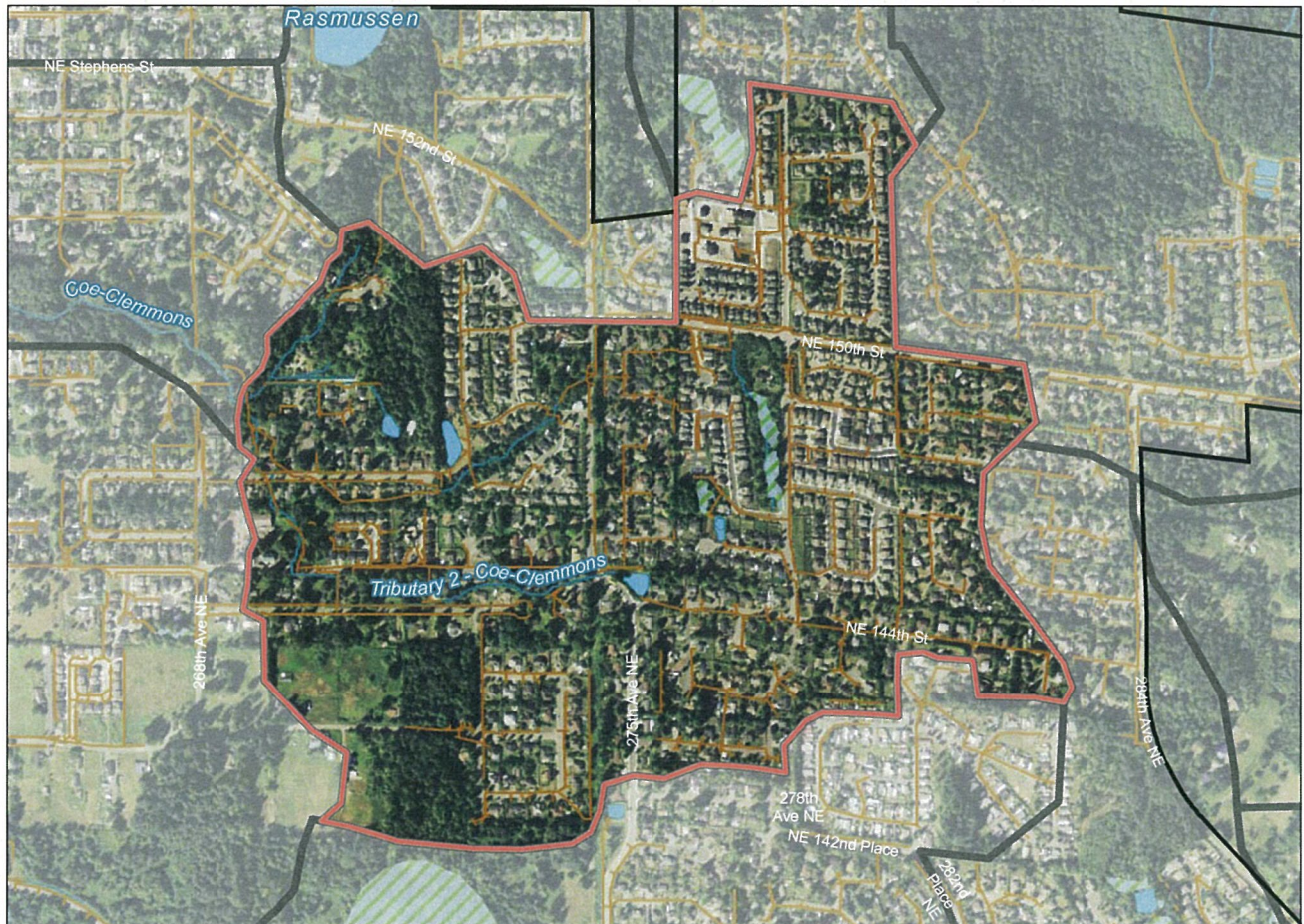


Depicts existing land uses for areas within the City. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



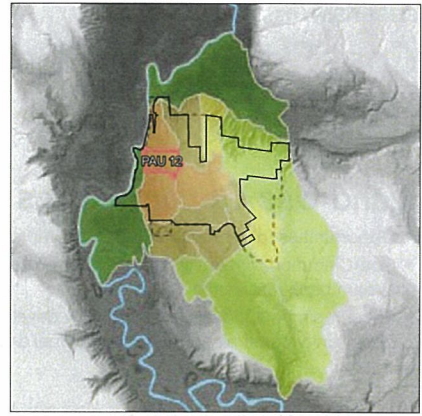
Subbasin Boundary
 Wetlands
 ~ Stream
 — Pipe Conveyance
 City Limit
 City UGA (Urban Growth Area)
 PAU 11

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SUBBASIN:

Coe-Clemmons - Lower (PAU 12)

BASIN: Duvall Tributaries – Coe Clemmons Creek



Management Recommendation: Urban Development

What Does this Management Recommendation Mean?

This subbasin is an area of lowest importance to watershed processes and is suitable for more intense urban development.

Why is this the Management Recommendation?

Compared to other areas in the city, this subbasin scored lowest for importance and highest for level of degradation (high impervious surface cover and altered conveyance of surface flows). As new development / redevelopment in the subbasin occurs it should be paired with targeted restoration focused on improving lower Coe-Clemmons riparian corridor conditions. Analysis results are detailed below:

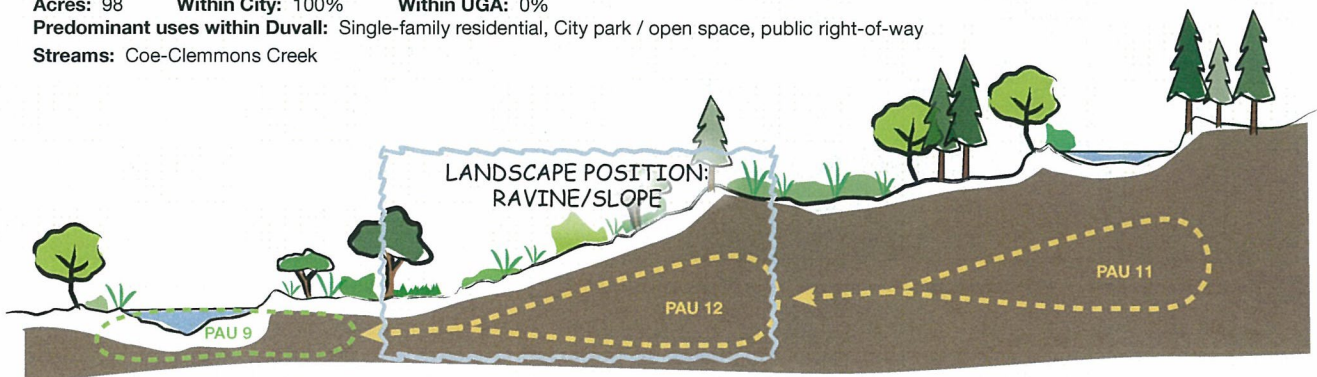
Management Recommendations



<p>Surface Storage</p>	<p>The subbasin is of low importance for surface storage processes:</p> <ul style="list-style-type: none"> Only 2% wetlands / other surface storage features Previous development has resulted in piped / ditched conveyance directly to Snoqualmie River floodplain <p>Limited opportunity for storage enhancement due to slopes and existing development / infrastructure patterns.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Reduce effective impervious surface Implement upstream flow control retrofits Eliminate flow control standard (when consistent with Duvall Municipal Code 19.06) to encourage high density development
<p>Groundwater and Base Flow Maintenance</p>	<p>Subbasin was historically moderately important for groundwater recharge; however, this process has been highly degraded:</p> <ul style="list-style-type: none"> 8% permeable soils (supports recharge) Slope wetlands along Coe-Clemmons Creek ravine <p>Degradation of processes due to high impervious surface cover and altered flow pathways. Base flow maintenance processes are of lower importance.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Increase infiltration by reducing effective impervious surface Identify retrofit opportunities that provide infiltration (where feasible)
<p>Fish and Wildlife Habitat</p>	<p>The subbasin is moderately to high important for fish and wildlife habitat:</p> <ul style="list-style-type: none"> Documented coho presence in Coe-Clemmons Creek, extending just above Main Street; Reaches have potential for Coho and Steelhead extending to top of subbasin Intact forested areas around Coe-Clemmons Creek (Taylor Park) <p>Salmon habitat impaired by riparian encroachment and stream crossings (partial barriers downstream). Roadway interruption (Main Street) between subbasin and floodplain habitats to the west.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Improve Coe-Clemmons Creek channel and riparian conditions Conserve riparian area and associated wetlands
<p>Water Quality</p>	<p>The subbasin has moderate sediment export potential and discharge to lower Coe-Clemmons Creek (with known erosion issues):</p> <ul style="list-style-type: none"> Sediment sources associated with surface and channel erosion, including soil erodibility and subbasin / channel slopes <p>Impervious surface cover and stormwater conveyance infrastructure directly to Snoqualmie floodplain has likely reduced export potential. Runoff from upstream areas (PAU 11) has increased channel erosion. Additionally, urban runoff is likely polluted with metals.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Identify and implement retrofit actions focused on water quality (within subbasin and upstream areas) Control sediment sources (including within PAU 11)

SUBBASIN STATS

Acres: 98 **Within City:** 100% **Within UGA:** 0%
Predominant uses within Duvall: Single-family residential, City park / open space, public right-of-way
Streams: Coe-Clemmons Creek



SUBBASIN:

Coe-Clemmons - Lower (PAU 12)

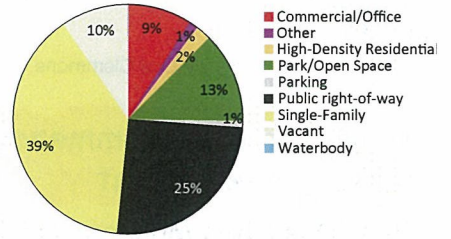
Land Use Opportunities and Constraints

- Opportunities for stormwater retrofit to improve water quality
- Coe-Clemmons Creek riparian corridor protected within Taylor Park; opportunity for riparian and stream bank restoration
- Encouraging additional density as new development and redevelopment occurs; redevelopment opportunity constrained by existing parcel and build-out pattern

Preliminary Management Priorities and Objectives

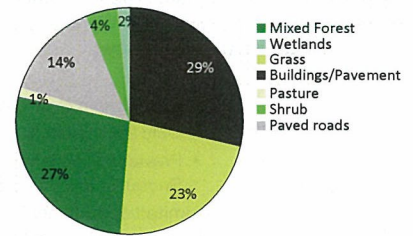
- Encourage high density development by eliminating flow control requirements (with enhanced water quality treatment) when consistent with DMC 19.06
- Reduce effective impervious surface by disconnecting non-pollution generating impervious areas (for example roofs, sidewalks)
- Restore Coe-Clemmons Creek channel and riparian conditions within Taylor Park

Existing Land Uses



Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin.



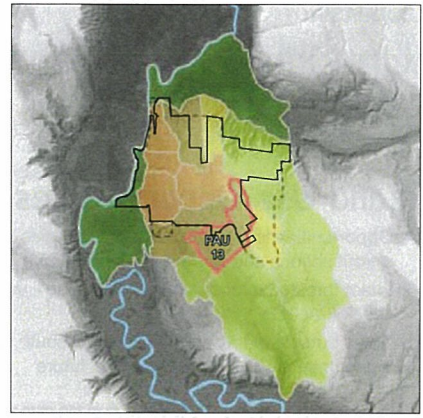
Subbasin Boundary
 Wetlands
 ~ Stream
 Pipe Conveyance
 City Limit
 City UGA (Urban Growth Area)
 PAU 12

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SUBBASIN:

Unnamed Southern Tributary - Upper (PAU 13)

BASIN: Southern Tributaries



Management Recommendation: Lowest Conservation

What Does this Management Recommendation Mean?

This subbasin is appropriate for more intense development; but as development occurs the resources and areas most important for watershed processes should be conserved.

Why is this the Management Recommendation?

The subbasin scored relatively low for importance and high for degradation. New development could likely occur with less effect on processes compared to other basins, although development opportunity appears to primarily occur within rural areas south of the city. Analysis results are detailed below:

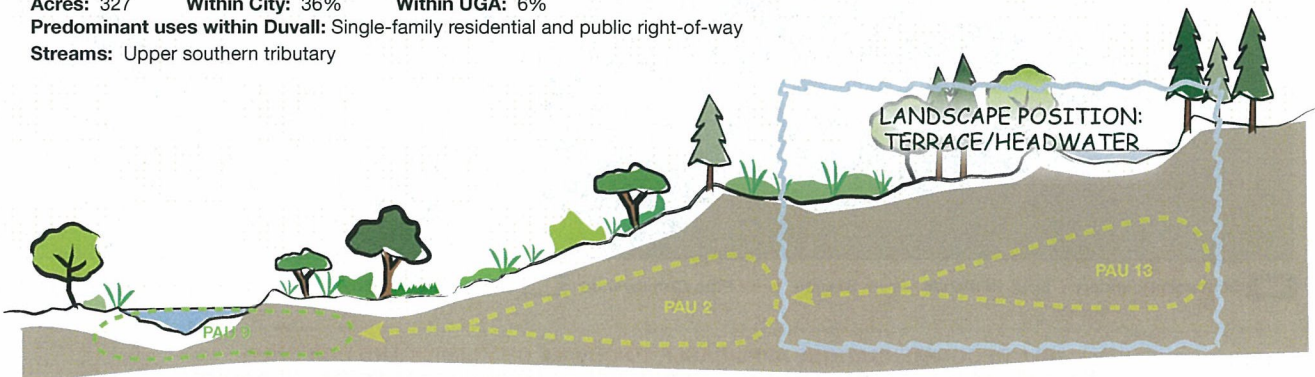
Management Recommendations

- Protect/Restore
- Lowest Conservation
- Highest Conservation
- Urban Development
- Moderate Conservation

<p>Surface Storage</p>	<p>Subbasin is of low importance for surface storage processes:</p> <ul style="list-style-type: none"> Only 1% wetlands / other surface storage features Previous development in NE portion (within city limits) has reduced storage <p>Surface storage that is provided is minimally degraded, especially in areas outside of city limits.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Conserve depressional wetlands Encourage or require LID approaches for new development Limit stormwater discharges to steep slope areas, especially adjacent to streams
<p>Groundwater and Base Flow Maintenance</p>	<p>Subbasin has relatively low importance to groundwater and base flow maintenance processes:</p> <ul style="list-style-type: none"> No mapped permeable soils Few mapped slope wetlands; although these likely occur along riparian corridors <p>Processes are minimally degraded due to low levels of existing development and wide, forested riparian corridors.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Preserve forest cover Preserve slope wetlands along stream corridors
<p>Fish and Wildlife Habitat</p>	<p>The subbasin is moderately important for fish and wildlife habitat:</p> <ul style="list-style-type: none"> No documented salmonid presence; nearest downstream presence is within Snoqualmie River floodplain Forested riparian corridor provides habitat for numerous bird, amphibian, and mammal species, as well as connections to subbasins to the east (PAUs 12 and 16), south and west <p>Rural development has resulted in some forest loss, primarily along Big Rock Road corridor.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Provide adequate stream buffers Maintain riparian and upland habitat corridors to surrounding subbasins
<p>Water Quality</p>	<p>The subbasin has low sediment export potential; contributions to downstream channel (within ravine before crossing Snoqualmie floodplain):</p> <ul style="list-style-type: none"> Sediment sources associated with soil erodibility and subbasin slopes Sediment sinks include depressional wetlands <p>Degradation related to impervious surface runoff has likely increased channel erosion and peak flows in downstream areas. Additionally, urban runoff is likely polluted with metals and other pollutants.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> Identify and implement retrofit actions Require use of LID approaches for water quality and water flow Maintain remaining wetlands

SUBBASIN STATS

Acres: 327 Within City: 36% Within UGA: 6%
 Predominant uses within Duvall: Single-family residential and public right-of-way
 Streams: Upper southern tributary



SUBBASIN:

Unnamed Southern Tributary - Upper (PAU 13)

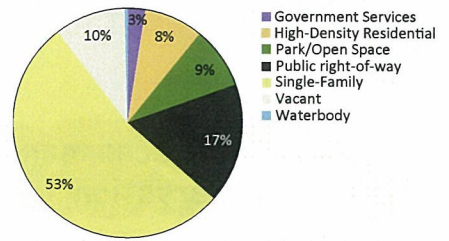
Land Use Opportunities and Constraints

- Opportunities for stormwater LID strategies focused on water flow and water quality (both as retrofit actions and for new development)
- Intact forested riparian corridors provide linkages in all directions, including to Upper Weiss Creek (PAU 17)
- Areas outside of city and UGA, to the south of Big Rock Road, may also be appropriate for higher intensity development in the future

Preliminary Management Priorities and Objectives

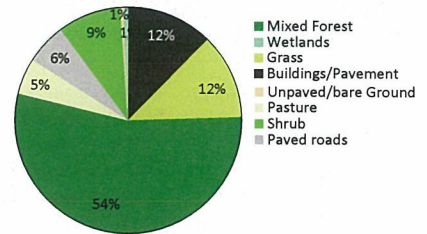
- Protect slope wetlands adjacent to streams, and maintain functions of remaining depressional wetlands
- Identify and implement stormwater retrofit actions to improve water flow and water quality to downstream resources
- Require use of LID approaches for water flow and water quality as new development occurs

Existing Land Use

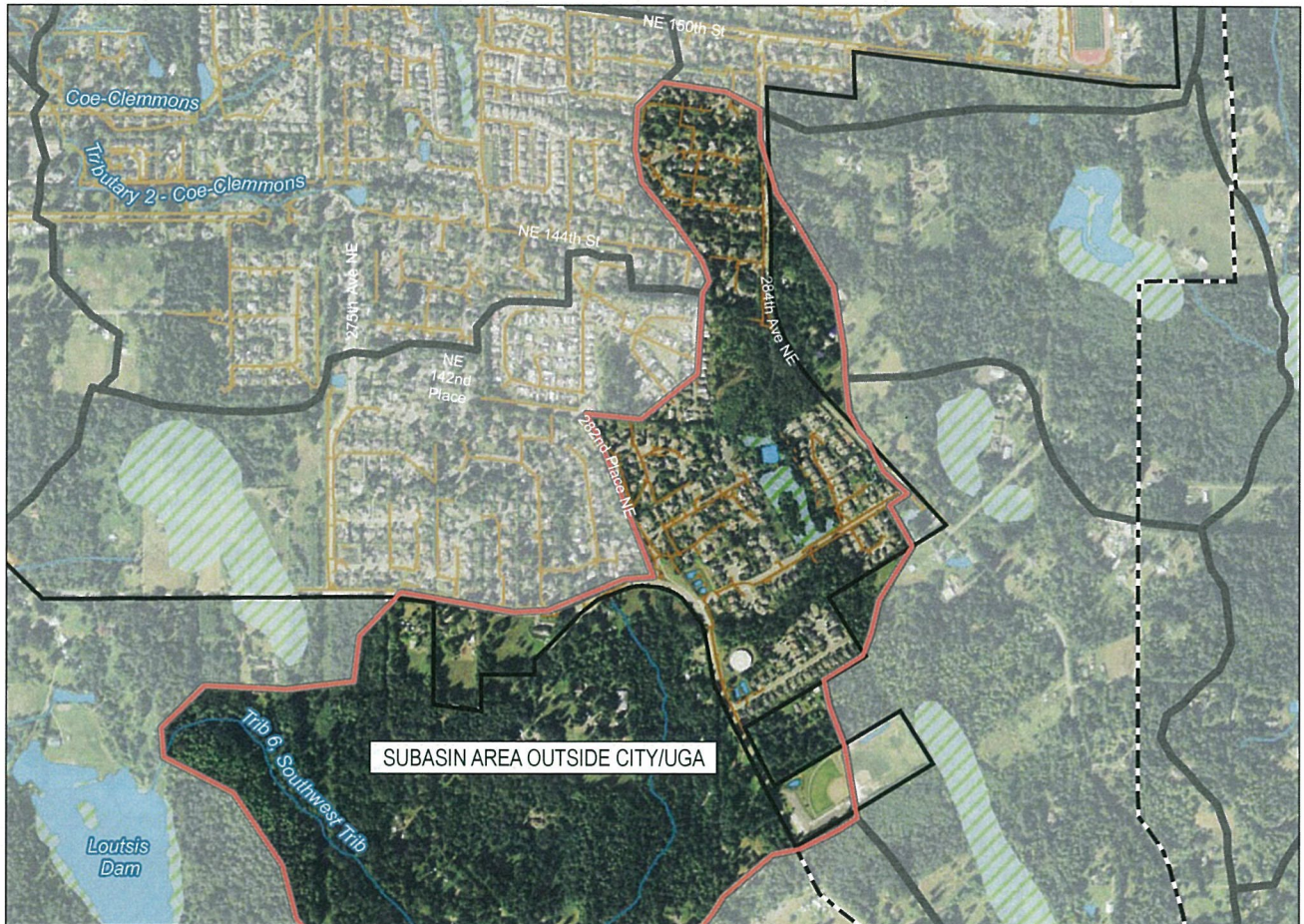


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



 Subbasin Boundary
 Wetlands
 ~ Stream
 Pipe Conveyance
 City Limit
 City UGA (Urban Growth Area)
 PAU 13

SUBBASIN:

Upper Weiss Creek (PAU 17)

BASIN: Southern Tributaries - Weiss Creek

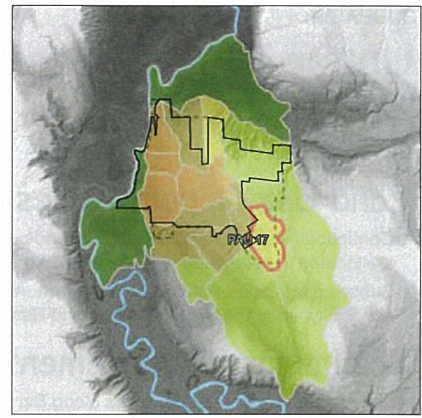
Management Recommendation: Moderate Conservation

What Does this Management Recommendation Mean?

While this subbasin may be appropriate for some additional development, care should be taken to protect areas important for remaining watershed processes, especially delivery, discharge and habitat processes.

Why is this the Management Recommendation?

The subbasin scored low to moderate for importance and moderate for degradation. Some important areas for maintaining watershed processes remain intact, including extensive forested areas that include several large depressional wetlands. These areas should be conserved; however, overall results suggest there are other areas that may be appropriate for additional development. Analysis results are detailed below:



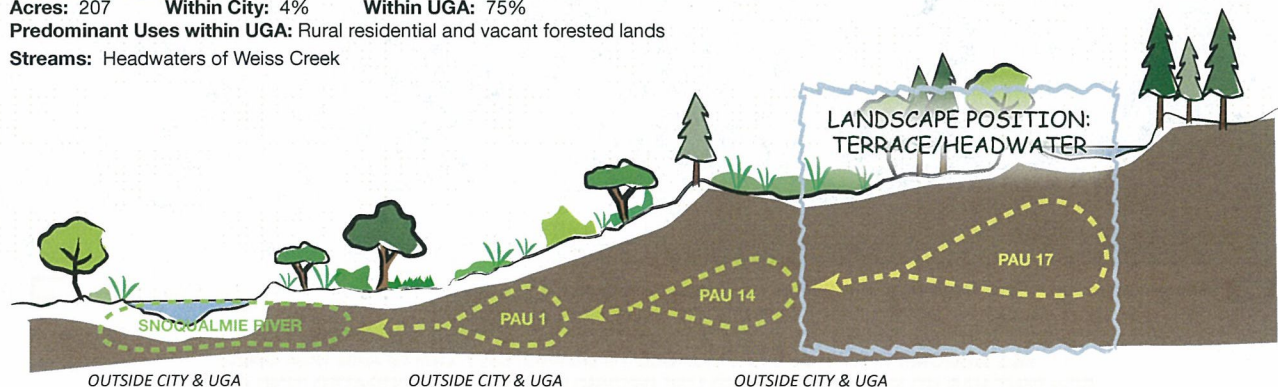
Management Recommendations

- Protect/Restore
- Highest Conservation
- Moderate Conservation
- Lowest Conservation
- Urban Development

<p>Surface Storage</p> 	<p>Subbasin features provide moderate levels of surface storage within a headwater landscape position:</p> <ul style="list-style-type: none"> • 13% wetlands and other surface storage features • Large forested depressional wetland complex within UGAR, to the NE of Big Rock Ball Fields Park <p>Storage processes are generally intact because there is little existing development.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Protect depressional wetlands • Maintain downstream flow pathways
<p>Groundwater and Base Flow Maintenance</p> 	<p>Subbasin is moderately important for base flow maintenance processes; however less important for recharge:</p> <ul style="list-style-type: none"> • No areas of mapped permeable soils • Large headwater wetlands for Weiss Creek <p>These processes have been minimally degraded, as there are generally low levels of existing development. Low impervious surface cover and high forest cover (especially within wetlands) support processes.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Limit future development • Protect depressional wetlands • Maintain downstream flow pathways
<p>Fish and Wildlife Habitat</p> 	<p>The subbasin is of moderately important for fish and wildlife habitat:</p> <ul style="list-style-type: none"> • No documented salmonid presence; although there is extensive downstream presence of coho within Weiss Creek (PAUs 14 and 1) • Forested wetland areas provide significant habitat for numerous bird, amphibian, and mammal species • Forested connection to larger undeveloped tracts to the north (PAU 16), west (PAU 13), south and east <p>Rural development has resulted in some forest loss, primarily along Big Rock Road corridor.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Limit future development to areas along Big Rock Road and Batten Road • Protect large forested wetland complex • Maintain habitat corridors
<p>Water Quality</p> 	<p>The headwater landscape of the subbasin supports sediment deposition and water filtration processes:</p> <ul style="list-style-type: none"> • Extensive areas of depressional wetlands suggest that the overall subbasin is a sediment and phosphorus sink • Wetlands provide water quality filtration before discharging to Weiss Creek <p>Water quality processes are relatively intact due to limited development throughout subbasin, especially areas surrounding the large forested wetland complex.</p>	<p>Broad management priorities:</p> <ul style="list-style-type: none"> • Limit future development, and require use of LID approaches for water flow and water quality wherever development occurs • Protect forested wetland complex

SUBBASIN STATS

Acres: 207 **Within City:** 4% **Within UGA:** 75%
Predominant Uses within UGA: Rural residential and vacant forested lands
Streams: Headwaters of Weiss Creek



SUBBASIN:

Upper Weiss Creek (PAU 17)

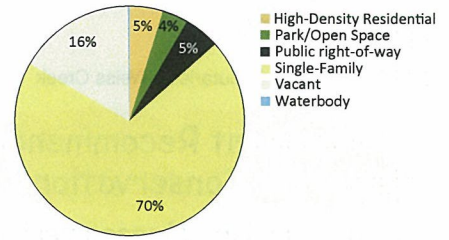
Land Use Opportunities and Constraints

- Contiguous wetlands and forested uplands extend throughout central portion of subbasin, and are located in headwater landscape position for Weiss Creek
- Subbasin is within existing UGAR; any future annexation would increase development pressure, especially along the Big Rock Road and Batten Road corridors

Preliminary Management Priorities and Objectives

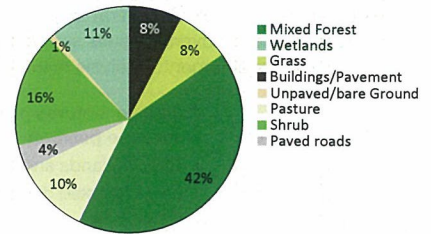
- Limit future development to areas along Big Rock Road and Batten Road, well away from forested depressional wetland complex
- Require use of LID approaches for water flow and water quality wherever development occurs.
- Maintain forested habitat corridors in all directions, including downstream flow pathways from wetland complex to Weiss Creek

Existing Land Use



Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



 Subbasin Boundary
 Wetlands
 ~ Stream
 Pipe Conveyance
 City Limit
 City UGA (Urban Growth Area)
 PAU 17

**ALL RECOMMENDATIONS APPLICABLE TO DUVALL CITY LIMITS AND UGA ONLY;
CONTENT HAS NO BEARING ON LAND USE DECISIONS IN UNINCORPORATED KING COUNTY.**

CHAPTER 5. WATERSHED STRATEGIES FOR DEVELOPMENT STANDARDS

PLACEHOLDER - DRAFT TO BE PROVIDED FEBRUARY 27TH

OUTLINE INCLUDED BELOW FOR REFERENCE

5.1 Development Regulations Strategies Overview

Objectives

Subbasin Prioritization Based on Watershed Analysis Results

5.2 Implementing Watershed Approach for Development Standards

Zoning

Landscaping

Tree Protection

Subdivision

5.3 Outcomes of Watershed Approach

CHAPTER 6. WATERSHED STRATEGIES FOR STORMWATER MANAGEMENT

PLACEHOLDER - DRAFT TO BE PROVIDED FEBRUARY 27TH

OUTLINE INCLUDED BELOW FOR REFERENCE

6.1 Stormwater Strategies Overview

Stormwater Management Objectives

Subbasin Prioritization Based on Watershed Analysis Results

6.2 Implementing Watershed Approach for Stormwater Management

On-site strategies

Residential Redevelopment on Existing Lots

New Subdivisions and Commercial Development

Direct Discharge Development (Flow Control Exempt)

Centralized/Municipal Strategies

Additional Strategies

6.3 Outcomes of Watershed Approach

CHAPTER 7. WATERSHED STRATEGIES FOR SENSITIVE AREAS MANAGEMENT

PLACEHOLDER - DRAFT TO BE PROVIDED FEBRUARY 27TH

OUTLINE INCLUDED BELOW FOR REFERENCE

7.1 Sensitive Areas Strategies Overview

Objectives

Subbasin Prioritization Based on Watershed Analysis Results

7.2 Implementing Watershed Approach for Sensitive Area Standards

Wetlands

Fish and Wildlife Habitats (including streams and habitat corridors)

Geologic Hazards

7.3 Outcomes of Watershed Approach

CHAPTER 8. LAND USE STRATEGIES FOR URBAN GROWTH AREAS

PLACEHOLDER - DRAFT TO BE PROVIDED FEBRUARY 27TH

OUTLINE INCLUDED BELOW FOR REFERENCE

8.1 UGA Land Use Strategies Overview

Objectives

Areas Studied

8.2 North UGA

Existing Conditions

Watershed Priorities

Land Use Recommendations

8.3 East UGA Reserve – Northern Portion

Existing Conditions

Watershed Priorities

Land Use Recommendations

8.4 East UGA Reserve – Southern Portion

Existing Conditions

Watershed Priorities

Land Use Recommendations

8.5 South of City – Eastern Portion

Existing Conditions

Watershed Priorities

Land Use Recommendations

8.6 South of City – Western Portion

Existing Conditions

Watershed Priorities

Land Use Recommendations

8.7 Outcomes of Watershed-based Planning for Urban Growth Areas

CHAPTER 9. REFERENCES

PLACEHOLDER - DRAFT TO BE PROVIDED FEBRUARY 27TH

Chapter 1 Watershed Plan Overview

King County, 2008

King County DDES, 2009

Krukeberg, 1991

Snohomish County, 2006

Stanley et al., 2011

Chapter 2 Key Watershed Analysis Results

Adolfson Associates, 2004

Collins and Sheikh, 2003

ESA 2011

Herrera Environmental Consultants, 2002

Kaje 2009

King County Groundwater Protection Program, 2004

Luchetti, G. 2014. Assessing Land Use Effects and Regulatory Effectiveness on Streams in Rural Watersheds of King County, Washington. King County.

Parametrix 2005

SBSRTC, 2005

Solomon and Boles, 2002

Stanley et al. 2005

Stanley et al., 2011

Stanley et al., 2013

Turney et al., 1995

Chapter 3 Watershed Goals and Policies

No references

Chapter 4 Subbasin Folio

No references

Chapter 5 Watershed Strategies for Development Standards

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Chapter 6 Watershed Strategies for Stormwater Management

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Chapter 7 Watershed Strategies for Sensitive Areas Management

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Chapter 8 Land Use Strategies for Urban Growth Areas

PLACEHOLDER

APPENDIX A

DUVALL DAYS SURVEY RESULTS MEMORANDUM



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Suite 200
Seattle, WA 98107
206.789.9658 phone
206.789.9684 fax

www.esassoc.com

memorandum

date June 12, 2014

to Lara Thomas, City of Duvall
Watershed Advisory Group

from Reema Shakra and Casey Rogers, ESA

subject City of Duvall Watershed Planning - Duvall Days Survey Results

On Saturday May 31, 2014, a survey was conducted at the watershed booth during the Duvall Days Festival, in Duvall, WA. The booth was hosted by the City of Duvall Department of Planning and Community Development, City of Duvall Public Works Department, Environmental Science Associates (ESA), Sound Salmon Solutions, Mountains to Sound Greenway, and Stewardship Partners. The purpose of the survey was to identify:

- Concerns Duvall community members have regarding the health of their watershed;
- Regulatory and voluntary approaches community members think the City should pursue to protect or improve the health of their watershed; and
- Actions that community members are already taking to preserve watershed functions and values.

The survey was also a tool to inform Duvall community members about approaches to protect or restore watershed processes. The survey was conducted electronically via Survey Monkey using an iPad and as hard copy handouts (see attachment 1). The survey consisted of 7 questions and solicited a total of 34 respondents. The majority of the respondents were residents (82 percent). People were encouraged to take the survey as a prerequisite to entering the rain barrel raffle drawing as a technique to increase participation.

Key findings of the survey are identified as follows:

- In response to question #3, which asked people to indicate their level of concern for watershed issues, loss of fish and wildlife habitat and forest habitat were ranked as the highest concern.
- In response to question #4, which asked people to identify activities they have done to protect their watershed, more than 50 percent indicated that they had picked up and disposed pet waste, planted trees and washed their cars at car washes.
- In response to question #5, which asked people to identify actions they would like to see implemented, all actions listed were almost evenly selected, with planting trees ranked as the most popular action.
- In response to question #6, which asked people to select City actions that should be done, 67 percent (20 respondents) indicated that they would like the City to provide additional incentives for developers to build housing units with smaller footprints (cottages, townhouses, condos).

The survey results should not be construed as representing a broad range of opinions held by Duvall community members because of the limited number of respondents compared to the total population and the approach used to

solicit participation. These results simply provide an overview of a select group of individuals' attitude towards the Duvall watershed. See attachment for more detailed survey results.

Attachments:

1. Survey Handout
2. Survey Results, Tabulated (question #7 contains personal information and is not included)

DUVALL WATERSHED CHARACTERIZATION PROJECT SURVEY

(Survey Intended For Duvall Residents Only)

1. What is your affiliation(s) in the community?

- Duvall Resident
- Business Owner
- Student
- Non-profit Group
- Riverview School District Faculty/Staff
- Other _____

2. Please tell us your zip code (as it applies to the affiliation listed above) _____

3. Please indicate your level of concern for each of these issues

	Not Concerned	Somewhat Concerned	Concerned	Very Concerned	N/A
Flooding and erosion in our rivers and streams	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water quality in our rivers and streams	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Loss of fish and wildlife habitat and natural areas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Loss of forest habitat	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Loss of agricultural lands	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. In the past two years which of the following have you (or someone in your household) done to protect your watershed (check all that apply)?

- Installed rain garden
- Installed rain barrel
- Planted stream bank vegetation
- Planted native landscaping
- Planted trees
- Serviced septic tanks every 3-5 years
- Washed car on grass
- Washed car at car wash
- Picked up and properly disposed of pet waste

5. What actions would you want to see implemented in your area (check all that apply)?

- Conserve land for public use
- Conserve land for natural vegetation and habitat
- Install rain gardens
- Install rain barrels
- Replace impervious surface with pervious pavers
- Plant river and stream bank vegetation
- Plant native landscaping
- Plant trees
- Educational stormwater signage

(Survey Continued on Back)

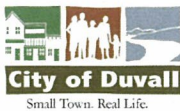
6. What regulations or voluntary programs would you like the City to implement (check all that apply)?

- Additional limits on impervious surfaces in City code
- Create narrower public streets with less pavement
- Conduct additional educational workshops on best practices for managing stormwater
- Provide additional incentives for developers to build housing units with smaller footprints (cottages townhouses, condos)
- Increase restrictions on tree removal in City code

7. Would you be interested in hearing more about the Watershed Land Use Planning Grant?

- Yes
- No

If yes, please provide your email address below.



Department of Commerce
Innovation is in our nature.



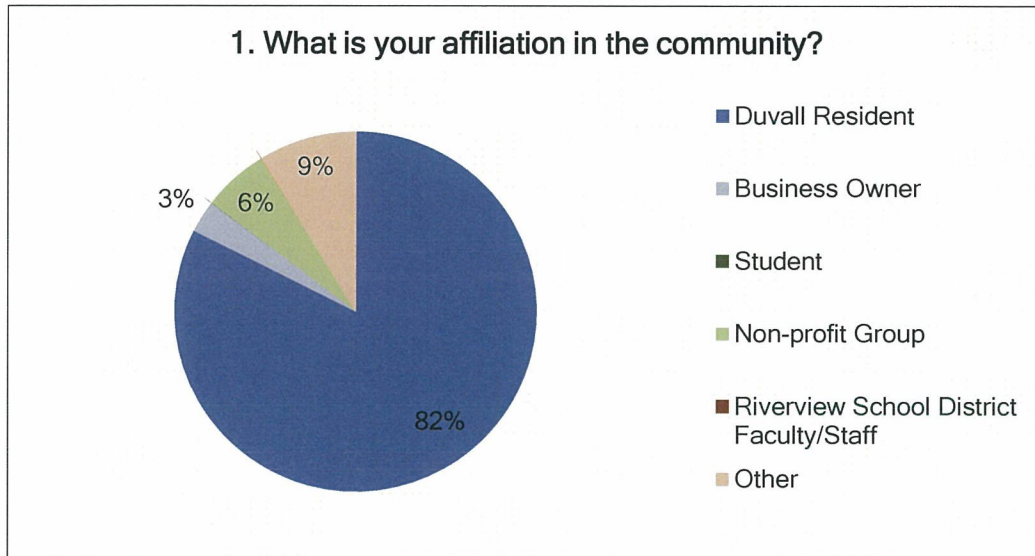
For More Information Contact Lara Thomas (425) 788 -2779

Attachment 2
 City of Duvall Watershed Planning - Duvall Days Survey Results
 June 2014

Duvall Watershed Characterization Project

1. What is your affiliation in the community?

Answer Options	Response Percent	Response Count
Duvall Resident	82.4%	28
Business Owner	2.9%	1
Student	0.0%	0
Non-profit Group	5.9%	2
Riverview School District Faculty/Staff	0.0%	0
Other	8.8%	3
<i>answered question</i>		34
<i>skipped question</i>		0

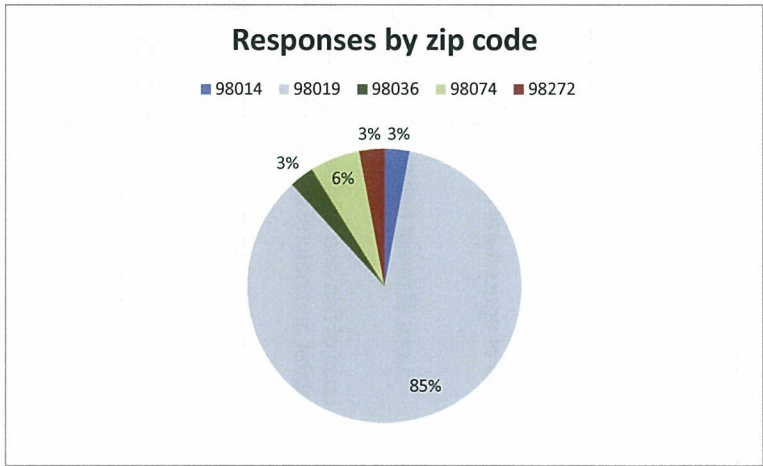


Duvall Watershed Characterization Project

2. Please tell us your zip code (as it applies to the affiliation listed above)

Answer Options	Response Count
	34
<i>answered question</i>	34
<i>skipped question</i>	0

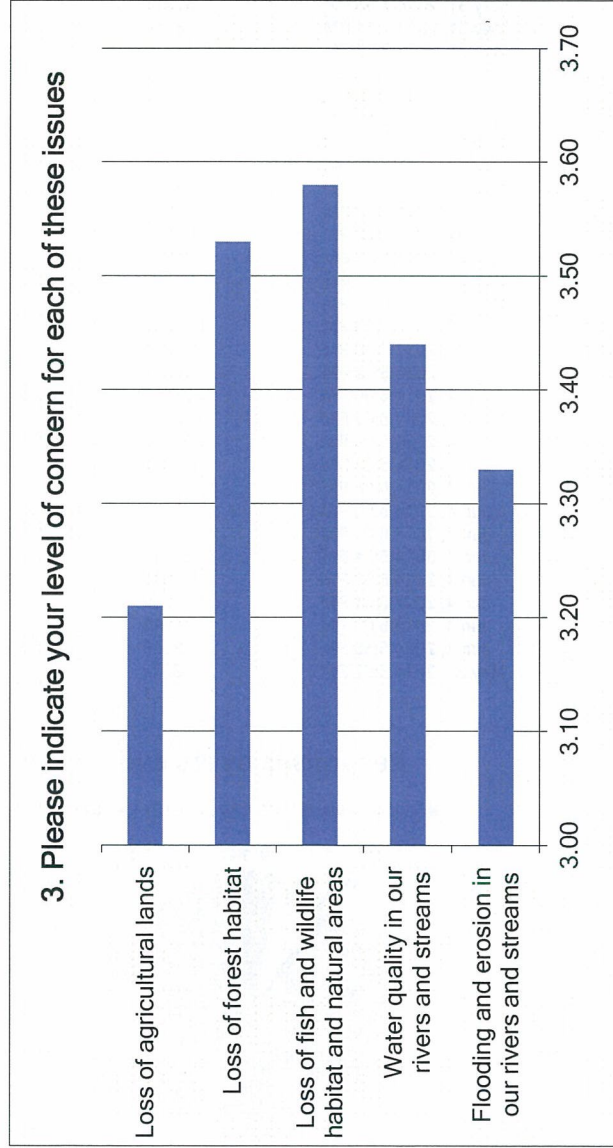
Number	Response Date	Response Text	Categories	Zip Code	Count	Percent
25	May 31, 2014 6:06 PM		98014			
13	May 31, 2014 8:08 PM		98019			
14	May 31, 2014 8:01 PM		98019			
15	May 31, 2014 7:56 PM		98019			
16	May 31, 2014 7:53 PM		98019			
17	May 31, 2014 7:14 PM		98019			
18	May 31, 2014 7:02 PM		98019			
20	May 31, 2014 6:39 PM		98019			
21	May 31, 2014 6:26 PM		98019			
22	May 31, 2014 6:15 PM		98019			
23	May 31, 2014 6:12 PM		98019			
24	May 31, 2014 6:09 PM		98019			
26	May 31, 2014 6:04 PM		98019			
28	May 31, 2014 5:57 PM		98019			
29	May 31, 2014 5:40 PM		98019			
32	May 31, 2014 5:06 PM		98019			
33	May 31, 2014 4:51 PM		98019			
34	May 31, 2014 4:35 PM		98019			
19	May 31, 2014 6:55 PM		98036			
30	May 31, 2014 5:15 PM		98074			
31	May 31, 2014 5:12 PM		98074			
1	Jun 4, 2014 6:09 PM		98019			
2	Jun 4, 2014 6:09 PM		98019			
3	Jun 4, 2014 6:08 PM		98019	98014	1	3%
4	Jun 4, 2014 6:07 PM		98019	98019	29	85%
5	Jun 4, 2014 6:06 PM		98019	98036	1	3%
6	Jun 4, 2014 6:05 PM		98019	98074	2	6%
7	Jun 4, 2014 6:04 PM		98019	98272	1	3%
8	Jun 4, 2014 6:04 PM		98019	total	34	100%
9	Jun 4, 2014 6:02 PM		98019			
10	Jun 4, 2014 6:01 PM		98019			
11	Jun 4, 2014 6:00 PM		98019			
12	Jun 4, 2014 5:59 PM		98019			
27	May 31, 2014 6:02 PM		98272			



Duvall Watershed Characterization Project

3. Please indicate your level of concern for each of these issues

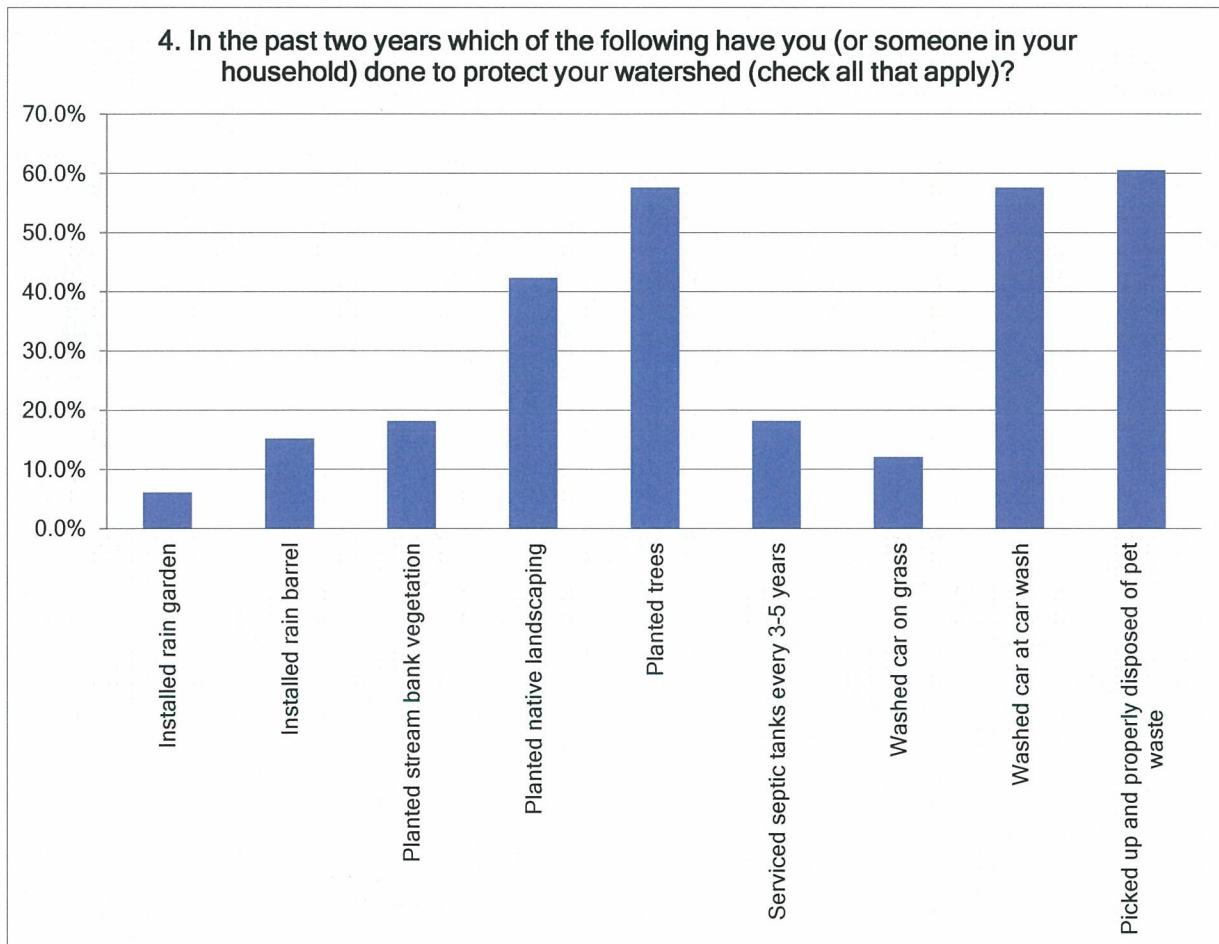
Answer Options	Not Concerned	Somewhat Concerned	Concerned	Very Concerned	N/A	Rating Average	Response Count
Flooding and erosion in our rivers and streams	1	5	9	18	0	3.33	33
Water quality in our rivers and streams	1	4	8	21	0	3.44	34
Loss of fish and wildlife habitat and natural areas	1	2	7	23	0	3.58	33
Loss of forest habitat	2	2	6	24	0	3.53	34
Loss of agricultural lands	2	5	10	16	0	3.21	33
<i>answered question</i>							34
<i>skipped question</i>							0



Duvall Watershed Characterization Project

4. In the past two years which of the following have you (or someone in your household) done to protect your watershed (check all that apply)?

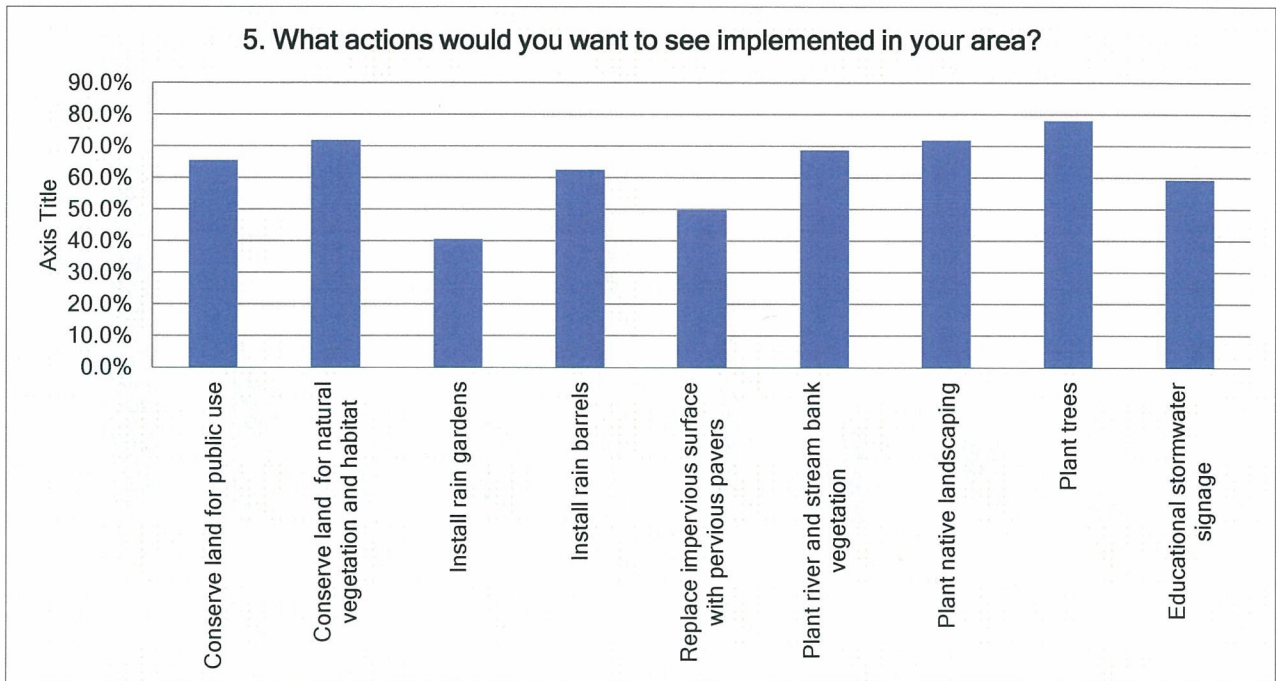
Answer Options	Response Percent	Response Count
Installed rain garden	6.1%	2
Installed rain barrel	15.2%	5
Planted stream bank vegetation	18.2%	6
Planted native landscaping	42.4%	14
Planted trees	57.6%	19
Serviced septic tanks every 3-5 years	18.2%	6
Washed car on grass	12.1%	4
Washed car at car wash	57.6%	19
Picked up and properly disposed of pet waste	60.6%	20
<i>answered question</i>		33
<i>skipped question</i>		1



Duvall Watershed Characterization Project

5. What actions would you want to see implemented in your area?

Answer Options	Response Percent	Response Count
Conserve land for public use	65.6%	21
Conserve land for natural vegetation and habitat	71.9%	23
Install rain gardens	40.6%	13
Install rain barrels	62.5%	20
Replace impervious surface with pervious pavers	50.0%	16
Plant river and stream bank vegetation	68.8%	22
Plant native landscaping	71.9%	23
Plant trees	78.1%	25
Educational stormwater signage	59.4%	19
<i>answered question</i>		32
<i>skipped question</i>		2

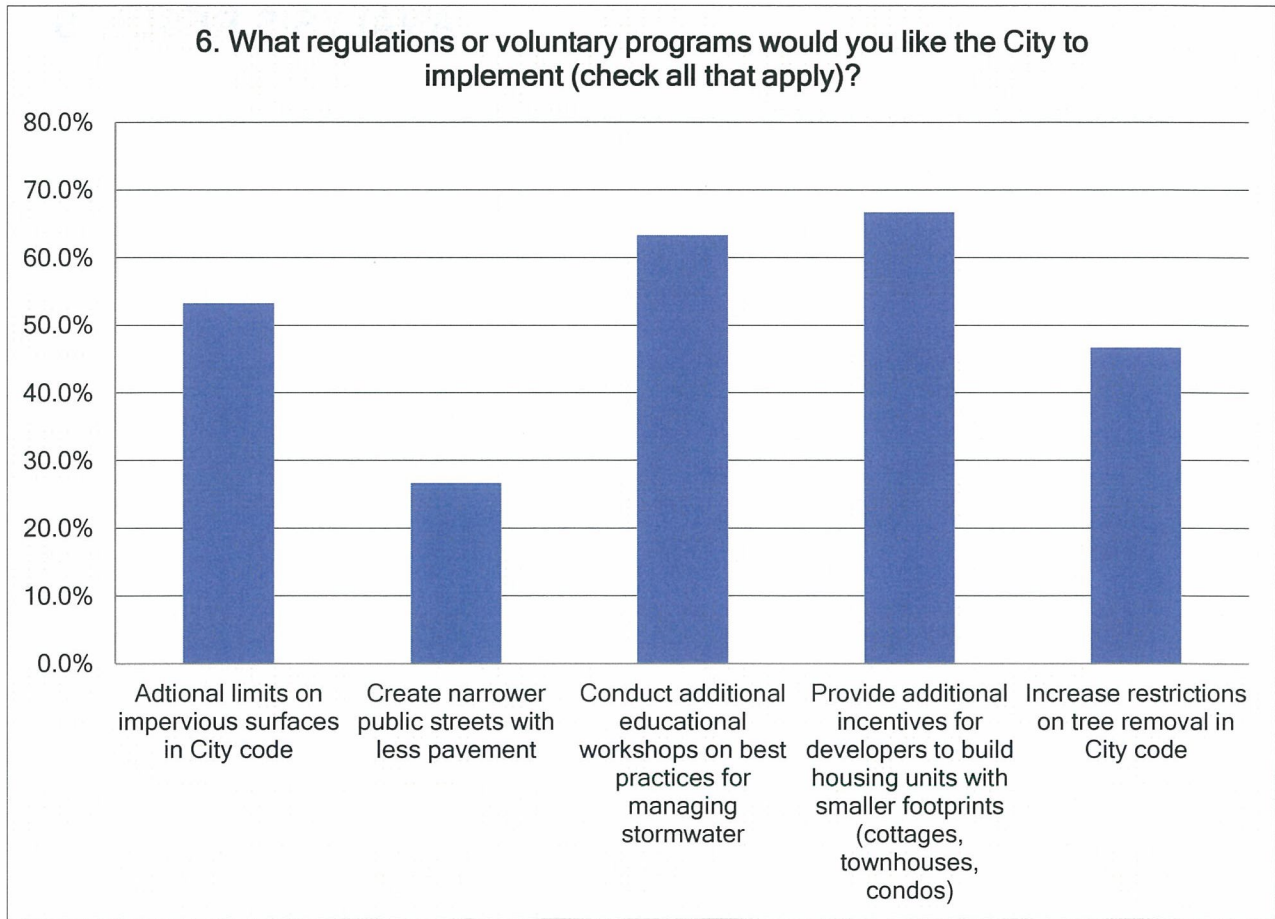


Attachment 2
 City of Duvall Watershed Planning - Duvall Days Survey Results
 June 2014

Duvall Watershed Characterization Project

6. What regulations or voluntary programs would you like the City to implement (check all that apply)?

Answer Options	Response Percent	Response Count
Adtional limits on impervious surfaces in City code	53.3%	16
Create narrower public streets with less pavement	26.7%	8
Conduct additional educational workshops on best practices for managing stormwater	63.3%	19
Provide additional incentives for developers to build housing units with smaller footprints (cottages, townhouses, condos)	66.7%	20
Increase restrictions on tree removal in City code	46.7%	14
<i>answered question</i>		30
<i>skipped question</i>		4



APPENDIX B

DATA SOURCES, METHODS AND DETAILED ANALYSIS RESULTS



APPENDIX B. DATA SOURCES, METHODS AND DETAILED ANALYSIS RESULTS

This appendix presents underlying data layers, information sources, and assessment methods used to complete the watershed analysis and provides detailed watershed analysis results. Methods are based on an assessment approach established by the Ecology Puget Sound Watershed Characterization (Stanley et al. 2011)¹. The Puget Sound Characterization is a regional-scale model that highlights the most important areas to protect and restore, and those more suitable for development. The characterization developed for Duvall builds on Ecology's characterization model, but was down-scaled to make the results more specific to Duvall. As is true for the Duvall project, Ecology's characterization model was funded by an Environmental Protection Agency grant and developed as a collaboration between Ecology, the Puget Sound Partnership, and Washington Department of Fish and Wildlife.

B.1 Spatial Data Sources

A number of key spatial datasets were used for this analysis (see Appendix D). Water Flow and Water Quality were assessed using Puget Sound Watershed Characterization data. Examples of data used in this effort include water flow, precipitation, land use/land cover, soils, road density, and Washington Department of Fish and Wildlife freshwater habitat assessment results.

Data sources providing more detailed, higher resolution data (primarily from City and King County sources) were used to refine the Ecology model results. These data enable quantitative assessment of:

- Percent impervious (total impervious area) by subbasin
- Areas of depressional wetlands and other surface storage features (including integration of City stormwater infrastructure data)
- Percent forest cover by subbasin
- Linear feet of aquatic habitat
- Salmonid presence
- Potential salmonid presence (intrinsic potential) from Washington Department of Fish and Wildlife models
- Infiltration capacity, as measured by soil types

¹ See http://www.ecy.wa.gov/puget_sound/characterization/ for more information on the Ecology Puget Sound Watershed Characterization.

Additional data sources were acquired from City staff, including from the Planning and Public Works departments, for use in qualitative evaluation of the watershed

B.2 Project Assessment Unit (PAU) Delineation

Ecology identified three Assessment Units (AUs) within the study area (see Chapter 1, Figure 1-1). These AUs were delineated using the data from the WDFW Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) in partnership with the Northwest Indian Fisheries Commission.

To better represent variability at the study area, the City divided the three AUs into 17 project assessment units (PAUs) using a combination of high resolution LiDAR digital elevation model, hydrology, and stormwater infrastructure maps. In some cases, the boundary of the Ecology AU was adjusted to match the more detailed topographic and drainage information. PAUs range from 98 to 1,273 acres (average size is 385 acres) and generally correspond to 1st order streams and specific landscape positions (Table B-1).

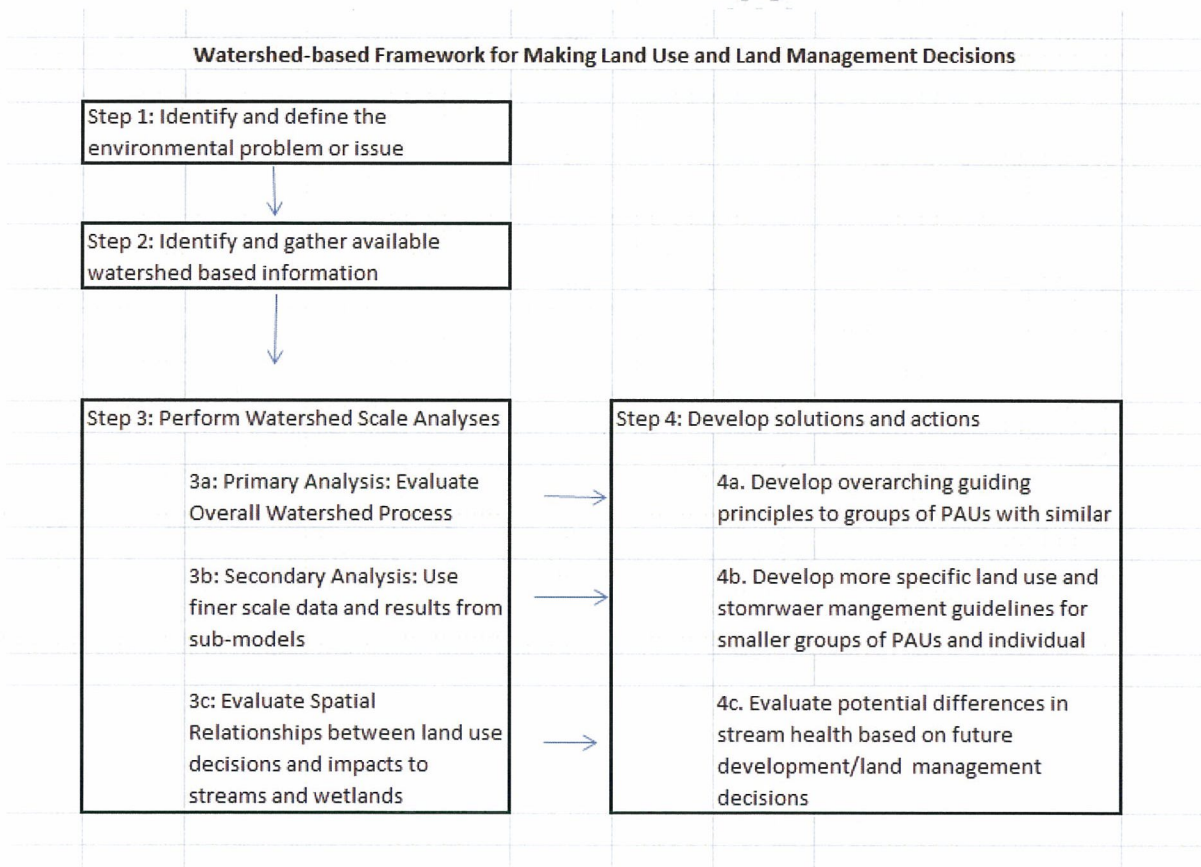
Table B-1. Project Assessment Unit (PAU) summary table

PAU Name	PAU Number	Area (acres)	Within City		Within UGA	
			Acres	% of Subbasin	Acres	% of Subbasin
Cherry Creek Basin						
Cherry Creek Floodplain	5	865	8	1%	5	1%
Cherry Creek A	6	264	146	55%	64	24%
Cherry Creek B	7	158	72	46%	23	15%
Cherry Creek C	8	457	272	59%	20	4%
Cherry Creek D – East	3	288	1	< 1%	5	2%
Cherry Creek D – West	16	166	0.3	< 1%	129	77%
Duvall Tributaries Basin						
Old Town	4	146	129	88%	10	7%
Coe-Clemmons – Lower	12	98	98	100%	0	0%
Coe-Clemmons – Upper	11	273	273	100%	0	0%
Thayer	10	235	215	92%	5	2%
Coe-Clemmons / Thayer Floodplain	9	663	84	13%	0	0%
Unnamed Southern Tributary - Lower	2	373	156	42%	35	9%
Unnamed Southern Tributary – South	15	158	0	0%	0	0%
Unnamed Southern Tributary - Upper	13	327	117	36%	19	6%
Weiss Creek Basin						
Weiss Creek – Upper	17	207	7	4%	156	75%
Weiss Creek – Middle	14	587	0	0%	0	0%
Weiss Creek – Lower	1	1273	0	0%	0	0%

B.3 Methods Overview

The goal of the Duvall watershed analysis is to evaluate the importance of watershed processes and the level to which these watershed processes are intact within the study area in order to inform land use planning decisions (Stanley et al. 2011) (Figure B-1).

Figure B-1. Framework for using Watershed Analysis across multiple scales to inform land use and stormwater management decisions (from Stanley et al. 2011)



The Puget Sound Watershed Characterization model was developed to be applied at larger spatial scales; therefore, the assessment was re-run for Duvall’s PAUs. In this project, we used the results of the regional characterization, normalized to our study area, to evaluate watershed processes at a local scale.

Analysis was performed at three spatial scales (Step 3 in Figure B-1). Using a variety of spatial scales allows the City to make general and more specific land use, stormwater and sensitive areas management strategies.

B.4 Primary Analysis

Primary analysis is the evaluation of watershed processes at the PAU scale. Relative importance and degradation of watershed processes are assigned, and PAUs with similar importance and degradation levels are organized into general subbasin management groups.

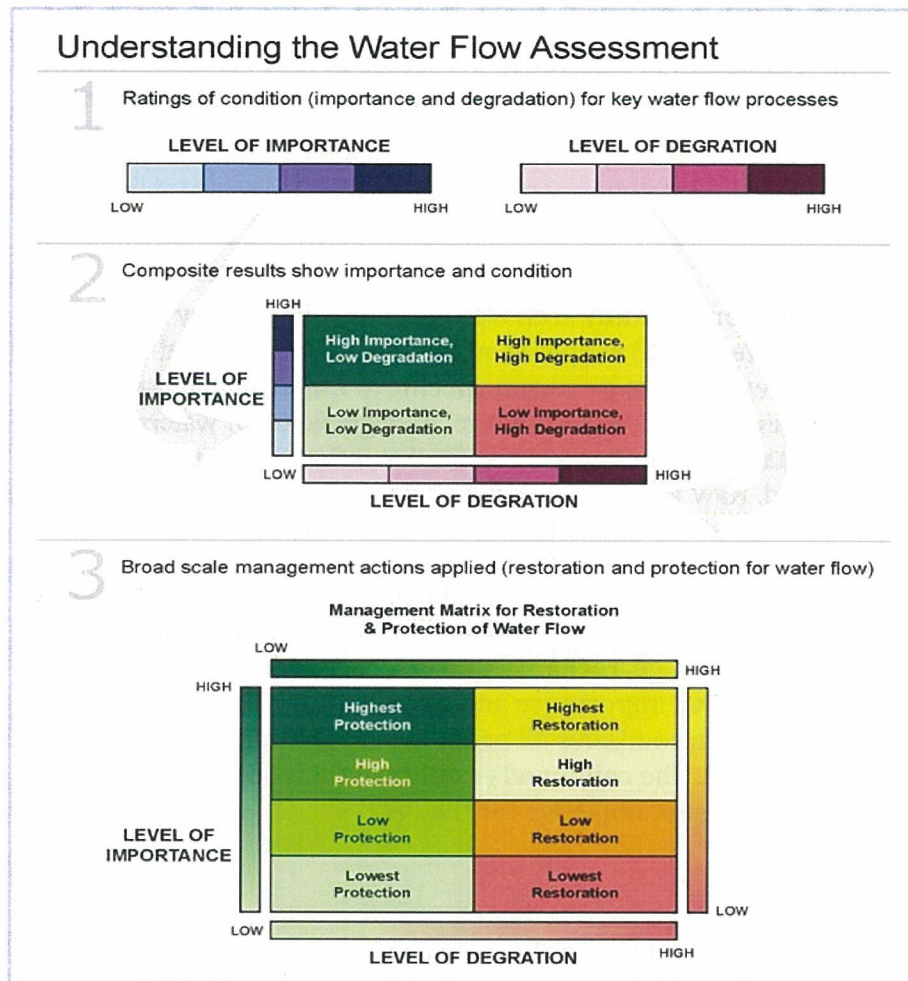
Methods

Seventeen PAUs delineated for the study area were provided to Ecology as a geographic information system (GIS) shapefile, allowing the Puget Sound Characterization water flow model to be re-run specific to Duvall's landscape setting. The model evaluates the importance and level of degradation of watershed processes based on GIS data of key landscape elements that influence the movement of water through the watershed. Raw importance and degradation scores from model runs were normalized relative to the study area, allowing for more variation in results.

The Water Flow assessment component of the model was used for this study. Water Flow assessment includes watershed characterization results for key water flow processes – delivery, surface storage, recharge, and discharge (Table B-2). The assessment evaluates the relative importance and degradation within each PAU and provides an overall result which combines all processes and results for each individual process (Figure B-2). The combined results can then be used to determine the overall management objective for the PAU.

Table B-2. Flow Variables

Process	Importance Score – an assessment of relative importance based on pre-developed conditions	Degradation Score – an assessment of relative process alteration based on existing conditions
Delivery	Precipitation Rain on snow areas (N/A in Duvall)	Impervious Surface Forest Loss
Surface Storage	Depressional wetlands Low gradient floodplain	Loss of wetlands and floodplains (urban/rural development)
Recharge	High permeability deposits Low permeability deposits	Development (impervious surface) over high/low permeability deposits
Discharge	Geology, soils, topography Slope wetlands near streams	Road density Groundwater well density

Figure B-2. Water Flow assessment method, from Stanley et al. (2013).

The Water Flow process is characterized by precipitation delivered (primarily as rain in Duvall) and the physical features that control its surface and subsurface movement within a subbasin. Features describing the process of water flow and used in the assessment include land cover, storage areas (i.e., wetlands and floodplains), areas of higher permeability and recharge, and areas that discharge groundwater.

Water Flow importance results are based on underlying, pre-development physical conditions.

Water Flow degradation results identify the amount of change to land cover indicators that maintain or are indicative of water flow processes. For example, degradation to water flow delivery processes is represented by features such as percent impervious cover and percent of forest cover loss that control how quickly

precipitation moves to downstream areas. Other indicators for water flow process degradation include alteration to storage areas and the number of groundwater extraction wells.

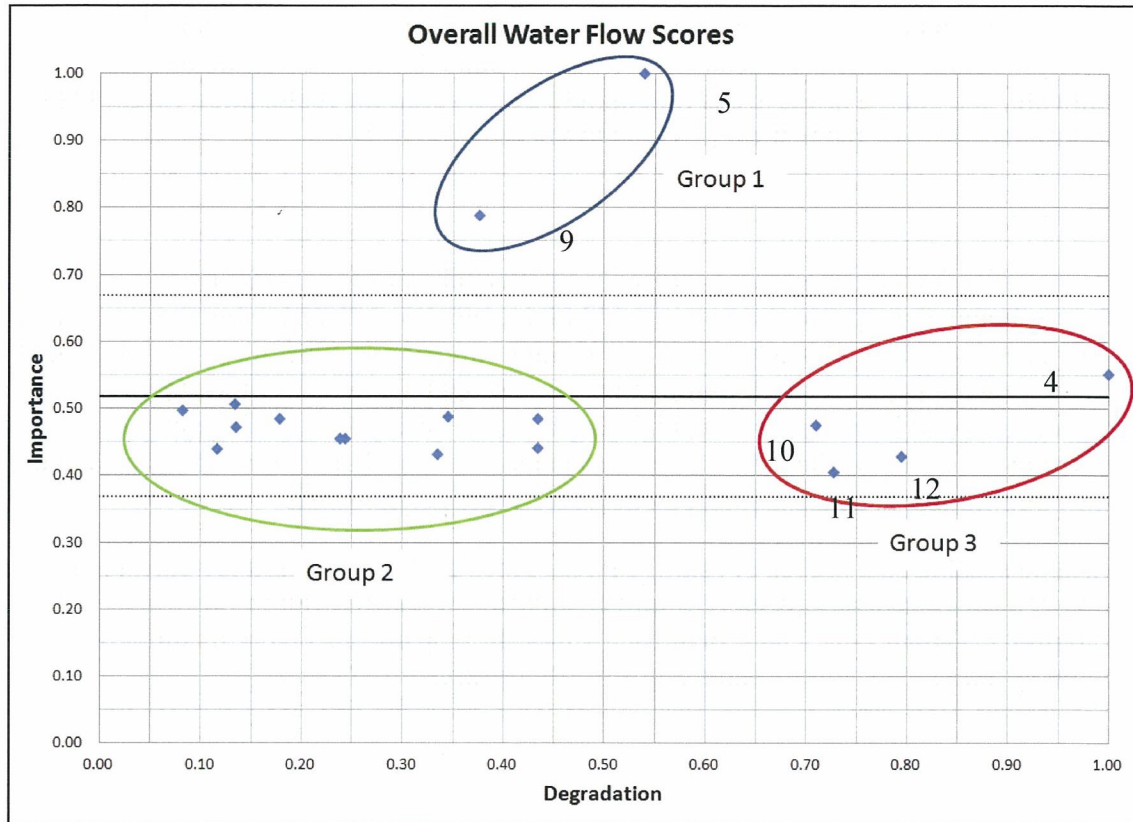
The approach identified each PAU's relative importance and degradation for water flow processes. Composite results (combining importance and degradation) indicate, at a coarse scale, areas that should be targeted for restoration (highest to lowest priority) or protection (highest to lowest priority).

Results

PAU results from Ecology were presented with each subbasin assigned to one of four primary management categories: 1) high protection (for high importance / low degradation PAUs); 2) low protection (for low importance / low degradation PAUs), 3) high restoration (for high importance, high degradation PAUs), and 4) low restoration (for low importance, high degradation PAUs). Results are derived by binning an equal number of PAUs into each category, and are provided for all water flow submodels in **Table X [PLACEHOLDER FOR NEXT DRAFT]**.

After assessing raw scores of relative importance and degradation for each PAU, only three distinct groups were found within the study area (Figure B-3, also see Chapter 2, Figure 2-3). The scores for each of these groupings were examined to identify management strategies appropriate for each.

Figure B-3. Plotted PAU results for process importance and degradation from Ecology's overall water flow model (primary analysis results); PAU numbers are shown for Groups 1 and 3 only



Management Groups

Group 1: PAUs 5 and 9

PAU 5 and 9 were grouped together because they had overall importance scores significantly higher than the other PAUs within the study area and only have moderate levels of degradation. The general management theme for Group 1 areas is “Protect/Restore” due to intact water flow processes in these PAUs. PAUs 5 and 9 are located within the Snoqualmie River/Cherry Creek Floodplains and generally have low levels of urban/suburban development.

Group 2: PAUs 1, 2, 3, 6, 7, 8, 13, 15, 16, 17

The PAUs in Group 2 generally have little variation in overall importance scores. Importance scores are similar to the PAUs in Group 3; however, all of these PAUs exhibit low to moderate levels of degradation when compared to Group 3 PAUs. “Develop / Conserve” is the management theme for Group 2 areas, and as development occurs in these less degraded areas, intact processes should be maintained.

Group 3: PAUs 4, 10, 11, and 12

The overall scores for these PAUs are at or below average for water flow importance and indicate the highest degradation levels for Duvall. These PAUs are generally located in the historic downtown areas of Duvall with a management theme of “Urban Development.”

B.5 Secondary Analysis

At completing the primary analysis, ten out of sixteen PAUs were sorted into Group 2. These ten PAUs include most of the city and urban growth area/urban growth area reserve, covering an area with substantial differences in existing land use and land cover types. To provide a more useful characterization for guiding land use decisions, Group 2 was further evaluated and subdivided.

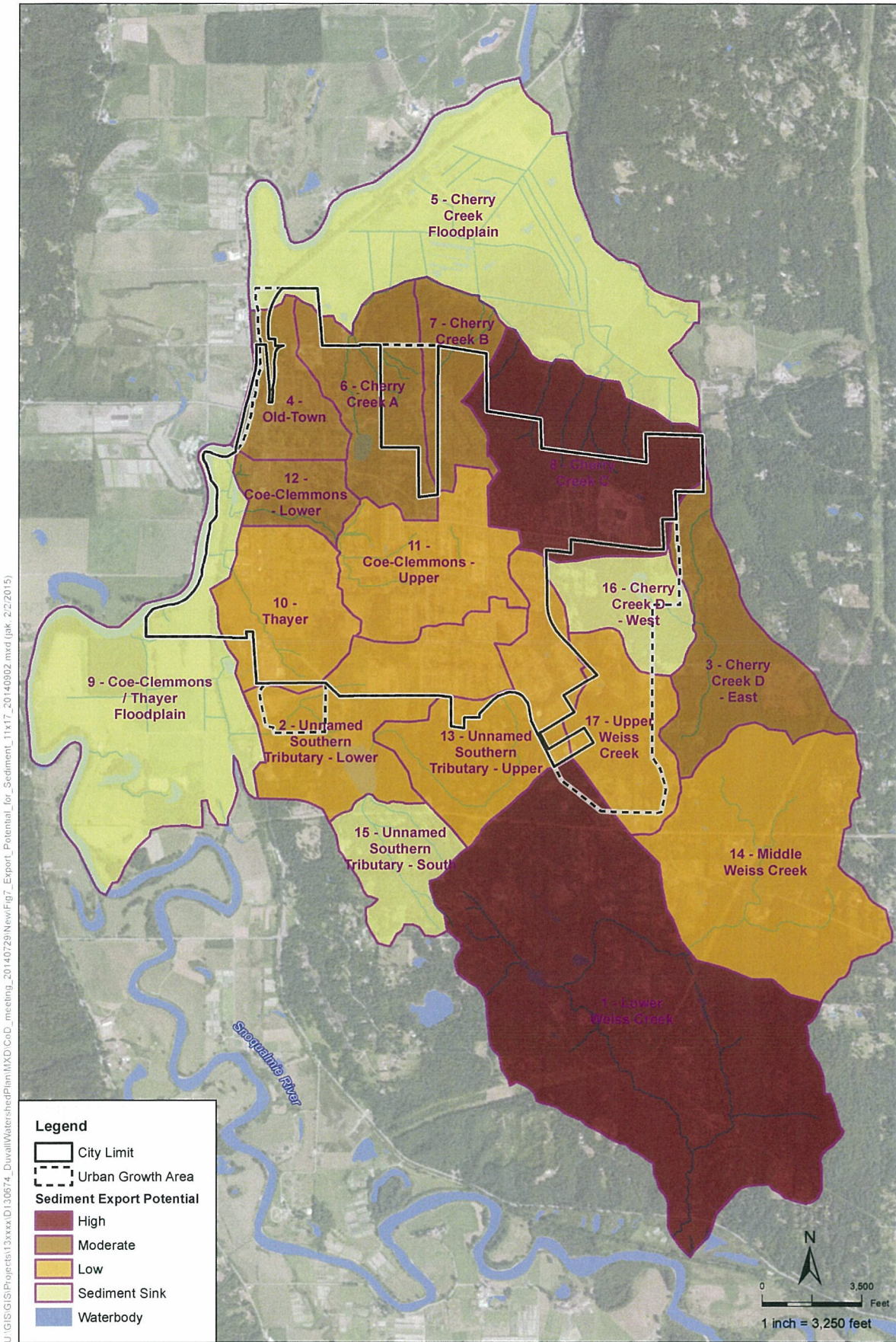
Methods

The Advisory Group identified four additional watershed processes for evaluation and finer resolution data that could be used for a secondary analysis of watershed importance:

- Ecology Sediment Export Potential Model
- Modified Storage
- Forest Cover
- Aquatic Habitat

Additionally, a new measure of degradation, impervious cover, was developed. Secondary analyses were performed on Group 2 PAUs only. More detail on methods for analyzing the measures is provided below.

For each of the four additional measures of importance, PAU scores were normalized and weighted equally to determine one value for importance. Results of this analysis were used to develop recommendations for land use management that balance economic development goals with conservation of watershed processes.



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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013; King County, 2014

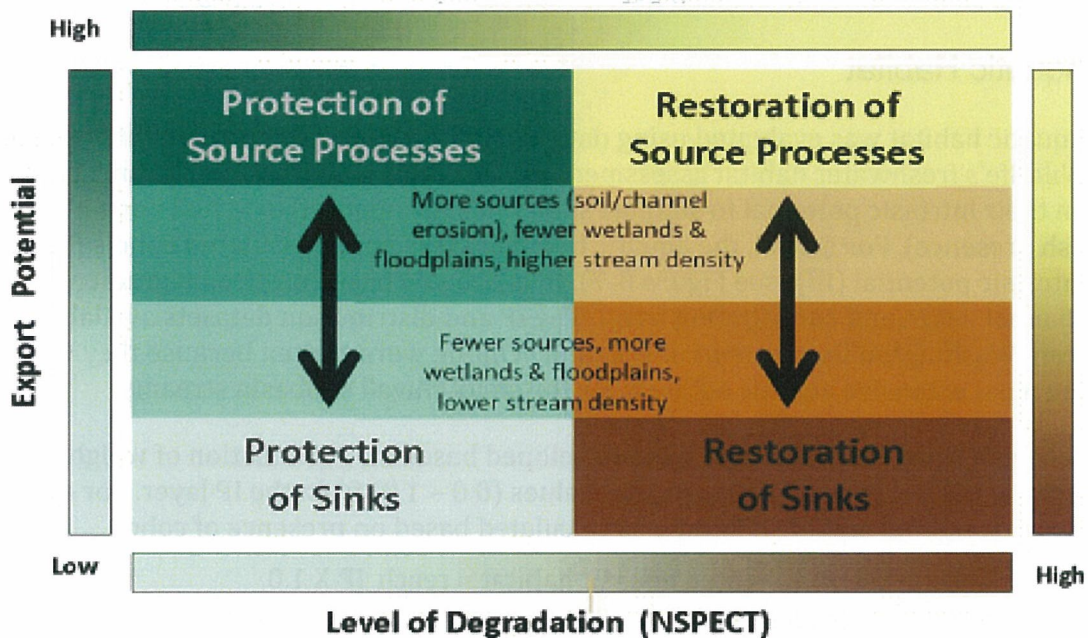
City of Duwall Watershed Planning - 130674
Figure B-4
 Export Potential of Sediment

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Ecology Sediment Export Potential Model

Erosion in the ravines and sedimentation in the lower stream reaches is a problem throughout and surrounding Duvall. The Ecology Sediment Export Potential model analyzed natural sources and sinks of sediment by looking at three processes based on attributes of the watershed: surface erosion, mass wasting, and stream channel erosion (Stanley et al. 2011). The results of the Ecology Sediment Export Potential model were calculated for each PAU in Group 2 and normalized within the study area (see Figure B-4). In the model, sediment export potential was evaluated in terms of protection and restoration of available sediment sources (e.g., channel or slope erosion) or sinks (e.g., wetlands and floodplains) (Figure B-5). High sediment export potential scores represent a naturally high potential for the PAU to deliver sediment, indicating a high risk of surface erosion, landslides or slope failures, or channel erosion. PAUs in Group 2 with a high score were given a higher priority for implementation of stormwater management strategies to reduce the risk associated with erosion and sedimentation.

Figure B-5. . Water Quality matrix for sediment, from Stanley et al. (2013).



Modified Storage

Primary analysis of surface water storage processes yielded storage scores that were uniform and near zero for all PAUs in Group 2. More variability was expected based on field observations and knowledge of the study area, indicating a need for additional analysis using local data. A more detailed storage data layer was created for this project using National Resources Conservation Service hydric soils maps, City and County wetland data layers, infrared data, aerial photos, field reconnaissance, and City detention pond data (see Chapter 2, Figure 2-2). The density of storage features was calculated for each PAU and the scores were normalized within Group 2.

Forest Cover

Although not a watershed process, the Advisory Group agreed that upland habitat conditions were an important indicator of watershed health. Upland habitat land cover data is not available for the study area; therefore, forest cover was used as a proxy. Forest cover was defined using land cover classifications, infrared imagery and ortho-imagery in GIS. The density of forest cover in each PAU was calculated and the scores were normalized for PAUs in Group 2 (see Figure B-6).

Aquatic Habitat

Aquatic habitat was evaluated using data from Washington Department of Fish and Wildlife's freshwater habitat assessment model. Their model scores streams based on their intrinsic potential to support salmonids (as opposed to actual documented fish presence). For Duvall, the aquatic habitat assessment considered coho salmon intrinsic potential (IP) (see Figure B-7). IP is broadly based on stream gradient, channel width and contributing basin. The IP and distribution datasets available from Washington Department of Fish and Wildlife were chosen because they were the most extensive aquatic datasets for the small Duvall subbasin streams.

Secondary importance scores were developed based on a calculation of weighted aquatic habitat (linear feet) using the values (0.0 – 1.0) from the IP layer. For each reach, weighted aquatic habitat was calculated based on presence of coho:

- Coho present: weighted aquatic habitat = reach_IP X 1.0
- No coho present: weighted aquatic habitat = reach_IP X 0.5

Scores were calculated as a per acre value and normalized by PAU.

Refined Degradation Score

Additional analysis was completed to determine a refined measure for level of degradation. Using the same approach as described above for forest cover, high resolution aerial photography was used to identify impervious surface cover (see

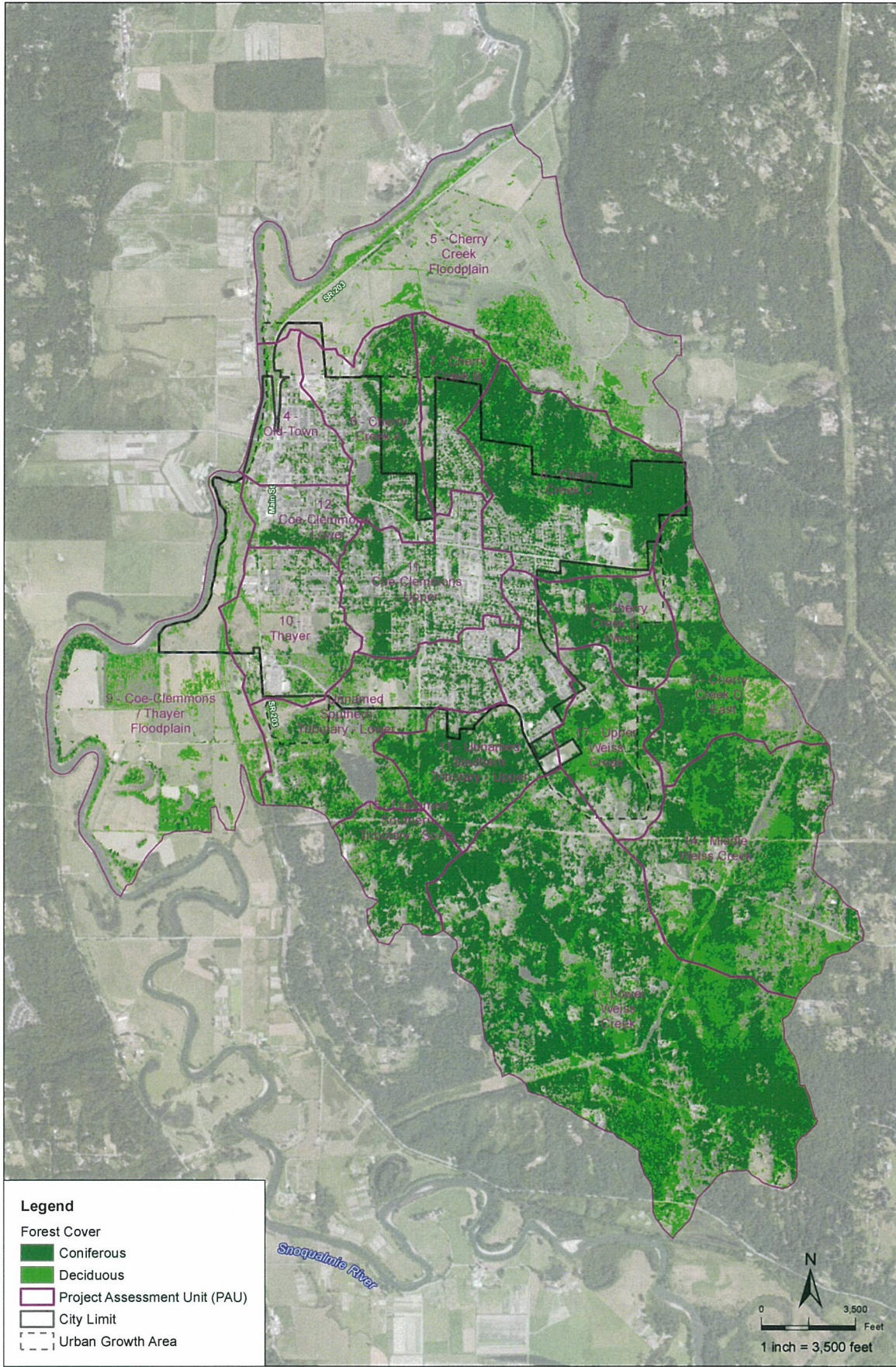
Figure B-8). The refined degradation score was determined as the ratio of impervious surface cover to forest cover for each subbasin.

Results

The results of each secondary analysis data set were rolled into one value (Secondary Importance Score) and plotted against the refined measure for level of degradation (Table B-3, Figure B-9). The scores are based on a scale of 0 to 1, where 1 is the highest possible score



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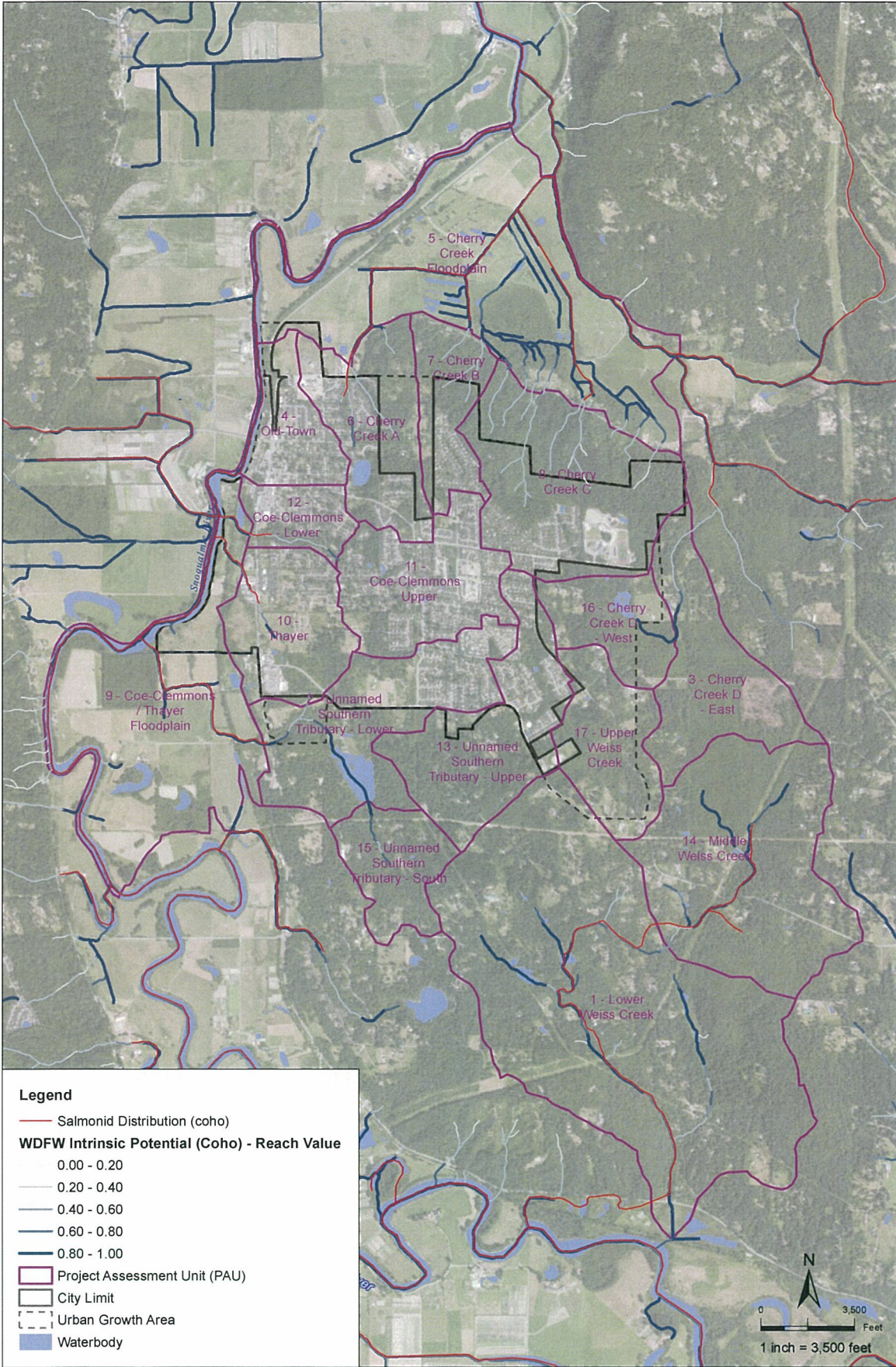
SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

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Figure B-6
Forest Cover

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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

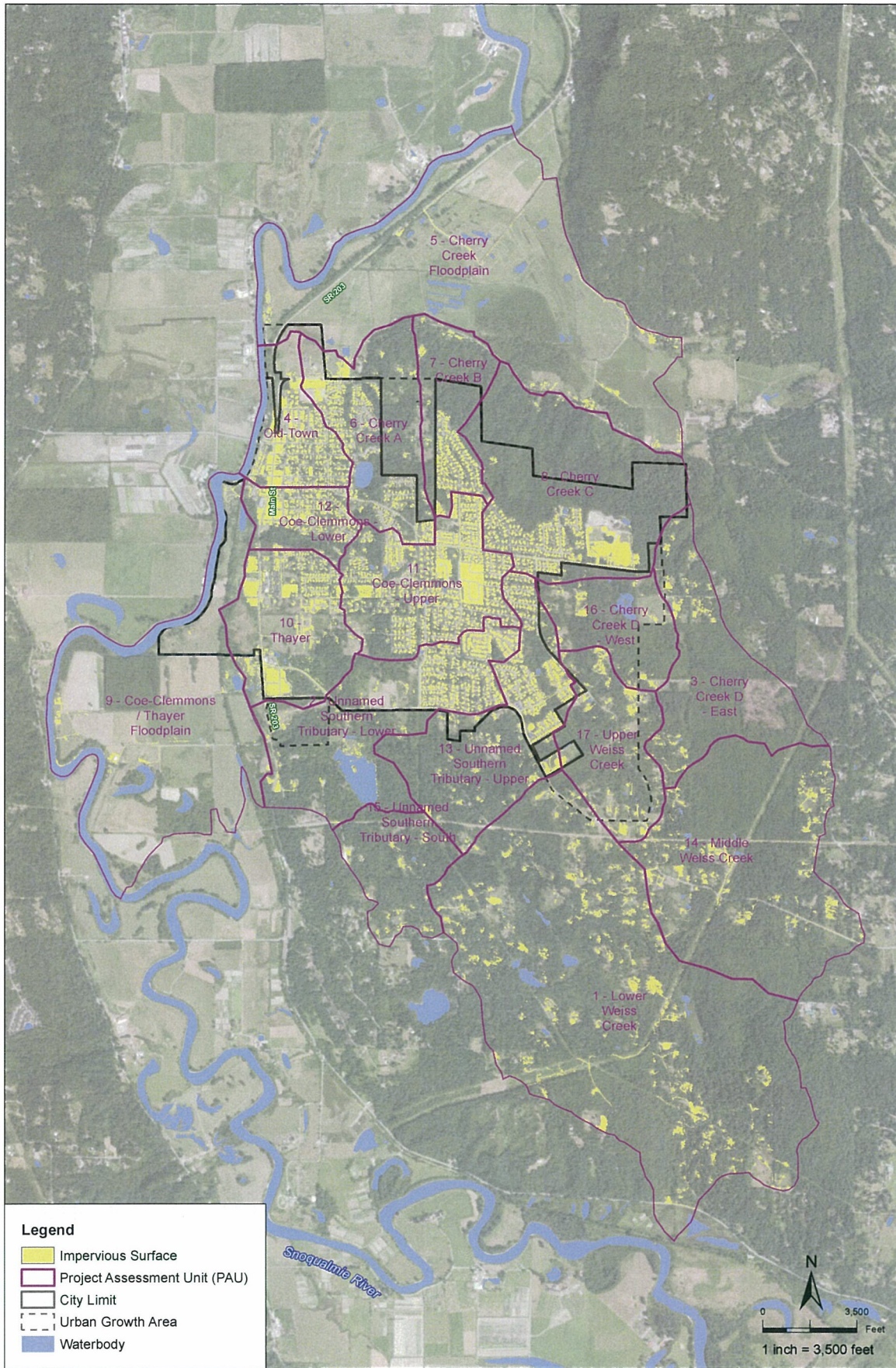
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Figure B-7

Coho Distribution and Intrinsic Overall Water Flow

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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013; King County, 2014

City of Duvall Watershed Planning - 130674
Figure B-8
Impervious Surface

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Table B-3. Secondary analysis results

PAU Name	PAU #	Sediment Export Potential	Wetland Density	% Forest Cover	Aquatic Habitat	Secondary Importance Score	Degradation
Sub-Group 2A: Highest Conservation							
Lower Weiss Creek	1	0.61	0.06	0.99	1.00	0.66	0.10
Cherry Creek D - East	3	0.40	0.14	1.00	0.24	0.45	0.06
Cherry Creek C	8	0.99	0.03	0.97	0.44	0.61	0.15
Cherry Creek D - West	16	-0.01	1.00	0.91	0.32	0.55	0.08
Sub-Group 2B: Moderate Conservation							
Cherry Creek B	7	0.43	0.07	0.88	0.34	0.43	0.22
Middle Weiss Creek	14	0.29	0.03	0.89	0.89	0.53	0.12
Unnamed Southern Tributary - South	15	0.27	0.02	0.95	0.33	0.39	0.10
Upper Weiss Creek	17	-0.07	0.50	0.75	0.00	0.30	0.20
Sub-Group 2C: Lowest Conservation							
Unnamed Southern Tributary - Lower	2	0.27	0.23	0.54	0.45	0.37	0.41
Cherry Creek A	6	0.36	0.11	0.62	0.54	0.41	0.52
Unnamed Southern Tributary - Upper	13	0.20	0.03	0.79	0.00	0.25	0.30

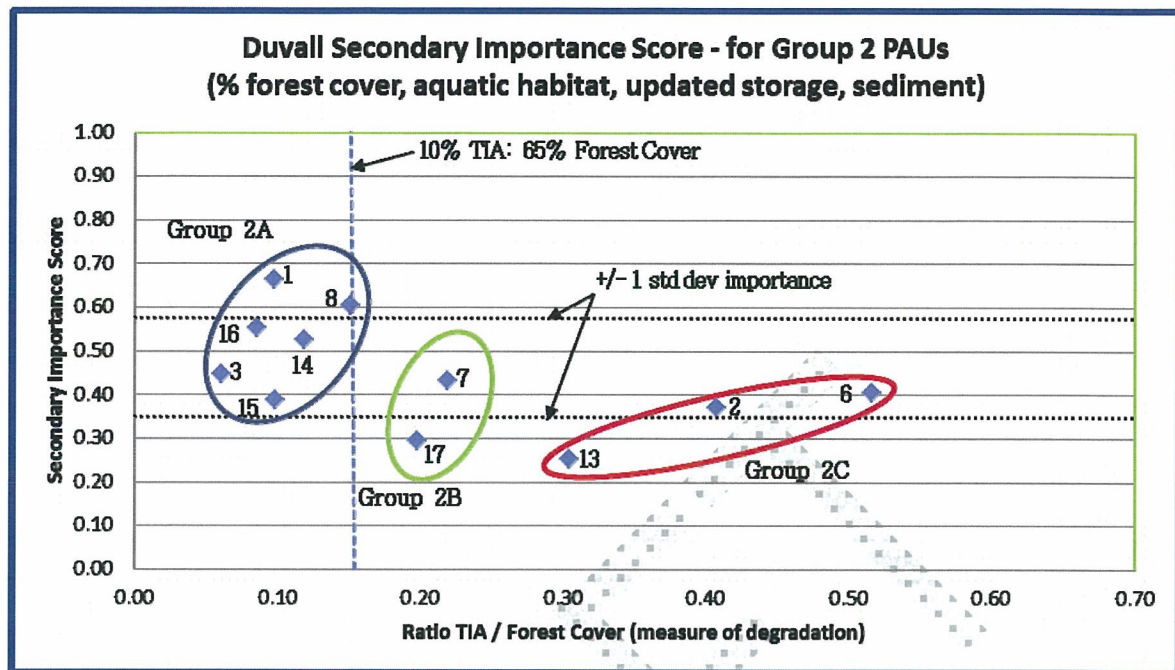


Figure B-9. Plotted secondary analysis results for Group 2 PAUs

Based on analysis results, three sub-management groups were identified within Group 2 (see Chapter 2, Figure 2-4). These sub-management groups still have an overarching prioritization for development and conservation to protect remaining watershed functions; however, with results from the secondary analysis, more specific land use and stormwater management decisions can be made.

Sub-Group 2A: Highest Conservation

- PAUs 1, 3, 8, and 16
- Scores for these PAUs are above average for importance and indicate lower levels of relative degradation.

Sub-Group 2B: Moderate Conservation

- PAUs 7, 14, 15, and 17
- Scores for these PAUs are average for importance and indicate lower to moderate levels of relative degradation.

Sub-Group 2C: Lowest Conservation

- PAUs 2, 6, 13
- Scores for these PAUs are average for importance and indicate higher levels of relative degradation.

Once management groups were defined for groups and sub-groups, results of the characterization, along with local knowledge, were used to develop more specific management recommendations for individual PAUs. Details of the management recommendations are provided on the subbasin folio sheets in Chapter 4. On each of the subbasin folio sheets, analysis results are provided along with management priorities for each watershed process, land use opportunities and constraints, and preliminary management priorities and objectives for the subbasin.

B.6 Sources Cited

Stanley et al. 2011

Stanley et al. 2013

APPENDIX C

LOW IMPACT DEVELOPMENT MANUAL FOR RESIDENTIAL PROJECTS

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APPENDIX D

DATA SOURCES LIST

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