CITY OF SAMMAMISH
WASHINGTON
RESOLUTION NO. R2011-470

A RESOLUTION OF THE CITY OF SAMMAMISH, WASHINGTON, ADOPTING THE CITY OF SAMMAMISH INGLEWOOD AND THOMPSON SUB-BASIN PLANS

WHEREAS, the City has developed sub-basin plans for the Inglewood and Thompson Sub-Basins; and

WHEREAS, there has been extensive public participation through the SEPA process and a series of six public meetings; and

WHEREAS, both the draft and final versions of the Plans have been available for public review and comment;

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF SAMMAMISH, WASHINGTON, DO RESOLVE AS FOLLOWS:

Section 1. Adoption of Inglewood and Thompson Sub-Basin Plans. The City hereby adopts the Inglewood and Thompson Sub-Basin Plans, attached hereto as Attachment "A" and Attachment "B" and incorporated herein by reference.

Section 2. Additional Action. The Inglewood and Thompson Sub-Basin Plans will be included in the Environmentally Critical Areas - Best Available Science update process. Staff will provide adequate public notice to property owners potentially affected by recommendations in the Plan and a public hearing will be held as part of the process for the adoption of the Critical Areas Ordinance.

Section 3. Severability. Should any section, paragraph, sentence, clause or phrase of this Resolution, or its application to any person or circumstance, be declared unconstitutional or otherwise invalid for any reason, or should any portion of this Resolution be pre-empted by state or federal law or regulation, such decision or pre-emption shall not affect the validity of the remaining portions of this Resolution or its application to other persons or circumstances.

PASSED BY THE CITY COUNCIL AT A REGULAR MEETING THEREOF ON THE 6th DAY DECEMBER, 2011.

CITY OF SAMMAMISH

Mayor Donald J. Gerend

ATTEST/AUTHENTICATED:

Melonie Anderson, City Clerk

Approved as to form:

Bruce L. Disend, City Attorney

Filed with the City Clerk:	November 30, 2011
Passed by the City Council:	December 6, 2011
Resolution No.:	R2011-470

Inglewood Sub-basin Plan Addendum

Prepared for

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CITATION

City of Sammamish. 2011. Inglewood Sub-basin Plan Addendum. Prepared by Parametrix, Bellevue, Washington, in association with WindWard Environmental, Seattle, Washington. September 2011.

CERTIFICATION

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

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ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
CAO	Critical Areas Ordinance
CIP	Capital Improvement Project
City	City of Sammamish
DEIS	Draft Environmental Impact Statement
Ecology	Washington State Department of Ecology
GMA	Growth Management Act
gpm	gallons per minute
KCC	King County Code
LID	Low Impact Development
msl	mean sea level
NPDES	National Pollutant Discharge Elimination System
RCW	Revised Code of Washington
SEPA	State Environmental Policy Act
SMC	Sammamish Municipal Code
UGA	urban growth area
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish and Wildlife

EXECUTIVE SUMMARY

This plan provides an update to a previous basin planning effort conducted in 2005. The Inglewood Sub-basin is one of two basins located at the headwaters of the proposed Sammamish Town Center. The purpose of this basin update is to improve existing natural and built conditions that may have changed since 2005 and to consider potential impacts resulting from development of the Town Center. Previous studies have included this basin, beginning in 1995 with King County's East Lake Sammamish Basin and Nonpoint Action Plan, and again in 2005 with the completion of the Inglewood Sub-basin Plan.

The Inglewood Sub-basin is in fair condition with respect to some characteristics, such as quality of wetlands and riparian forest adjacent to George Davis Creek, and large areas of recessional outwash geology that serves as an underground reservoir and collection system for surface water runoff. However, it is impaired with respect to fish habitat and access. There are three fish passage barriers located within 1/2 mile of Lake Sammamish that prevent fish use of upstream habitat.

Specific features that define the Inglewood Sub-basin and are important considerations in the development of projects and strategies are as follows:

Geology—The underlying geology in the Inglewood Sub-basin consists of compacted till and highly infiltrative recessional glacial outwash. The outwash serves a very important function in this basin, serving as a gigantic subsurface reservoir that recharges deeper groundwater aquifers and supplies flow to George Davis Creek and associated wetlands. It is important to minimize development of impervious surfaces on these highly infiltrative areas to protect the groundwater recharge capacity.

Wetland—There are very high quality, large wetlands in the Inglewood Sub-basin that provide hydrologic functions of storing water and attenuating flood flows, as well as providing diverse habitat for birds and other wildlife species. It is important to protect these areas for their critical functions.

Fish Passage Barriers—There are at least three fish passage barriers on George Davis Creek within the first 1/2 mile of Lake Sammamish. Despite relatively good fish habitat, these barriers represent a costly and unlikely restoration of anadromous fish populations to the lower reaches of George Davis Creek. For this reason, the removal of these barriers is not recommended as part of this plan.

The projects and strategies recommended herein are designed to preserve ecological function in areas that are currently functioning well, solve existing problems, and prevent future degradation as the Inglewood Sub-basin is further developed (Table ES-1). The cost of these projects is about $350,000, not including property acquisition, if required.

Table ES-1. Matrix of Recommended Projects

Strategy	Project Identification	Type of Strategy: Planning	Type of Strategy: Education	Type of Strategy: Capital	Description	Potential Partners	Cost	Priority
Conduct Wetland Tours	Ed-1		X		Sponsor wetland tours to foster appreciation and stewardship of Sammamish wetlands	Audubon Society, non-profit environmental groups	$6,000	Low
NE 217th Street Road Drainage Modification	CIP-1			X	Improve road drainage to reduce flooding to neighboring residence.	None	$59,000	Low
228th Avenue NE Stormwater Discharge Modification	CIP-2			X	Modify stormwater outfall discharge from 228th Avenue NE to reduce erosion and saturated conditions.	None	$55,000 to $78,000	Medium
NE 2nd Street Culvert Replacement	CIP-3			X	Replace culverts at NE 2nd Street driveway.	None	$40,000	Medium

1. INTRODUCTION

This plan provides an update to a previous basin planning effort conducted in 2005. The Inglewood Sub-basin is one of two basins located at the headwaters of the proposed Sammamish Town Center (Figure 1). The purpose of this basin update is to improve existing natural and built conditions that may have changed since 2005 and to consider potential impacts resulting from development of the Town Center. Previous studies have included this basin, beginning in 1995 with King County's East Lake Sammamish Basin and Nonpoint Action Plan, and again in 2005 with the completion of the Inglewood Sub-basin Plan.

1.1 BASIN PLANNING CONTEXT

The goals of this basin plan are to identify stormwater and surface water-related projects and strategies that (1) protect existing natural resources, (2) restore or enhance ecological or surface water functions where they are impaired, and (3) prevent future degradation of natural resources from future development. The City's Comprehensive Plan (City of Sammamish 2003) provides the impetus for completing basin plans:

> "The City shall provide Basin Plans for all areas of the City by either adopting existing plans or creating new ones, to assure that permitted development will not degrade the surface or ground water resources." (Goal ECP-1.27)

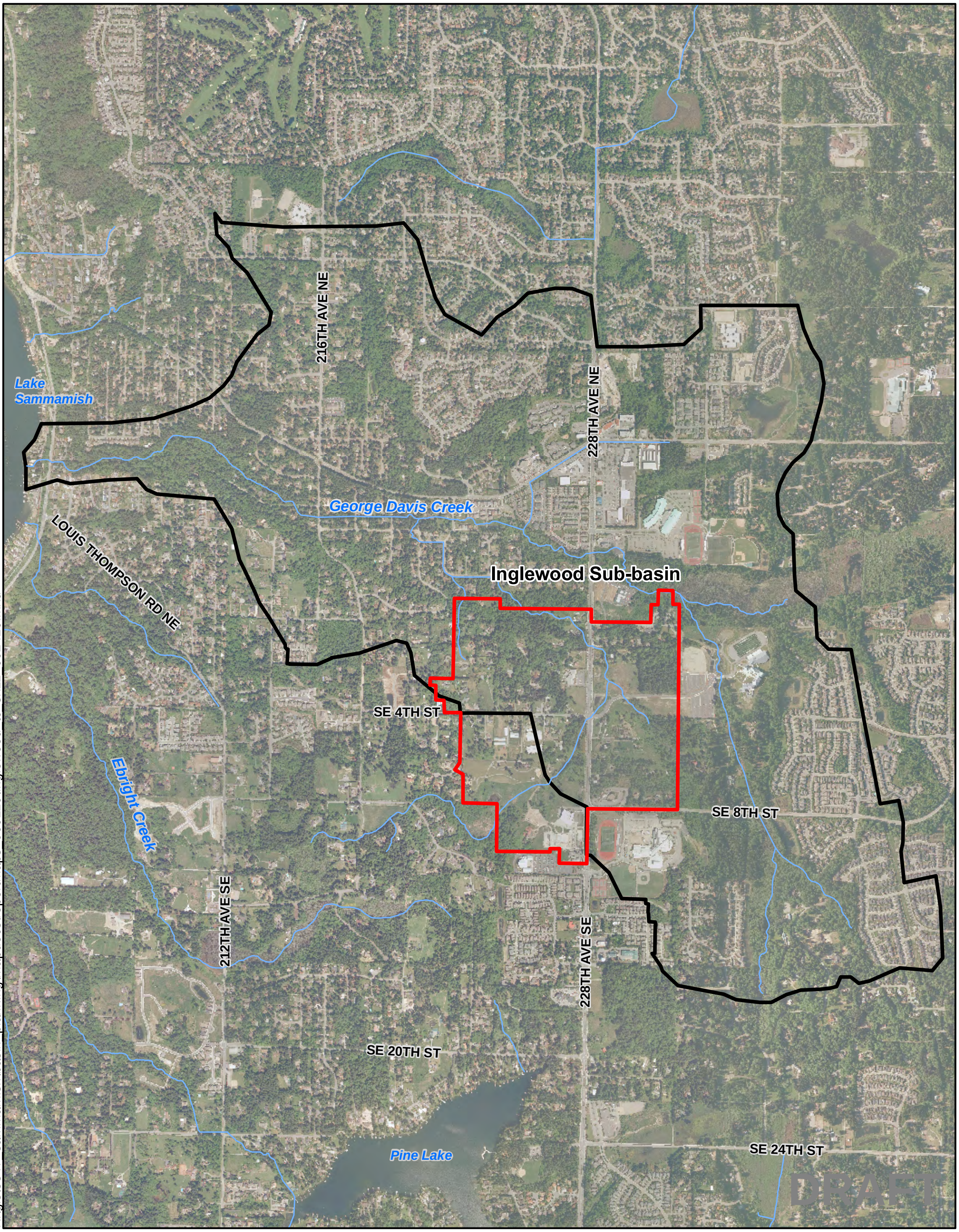
Additionally, the City has many environmental goals in the Comprehensive Plan (City of Sammamish 2003) that relate directly to basin planning efforts, including:

> **"**Preserve and enhance the natural features and historic, cultural and archeological resources of the community." (Goal LUG-9)

> **"**Preserve trees and other natural resources as integral components of the community's overall design." (Goal LUG-10)

> **"**Practice environmental stewardship by protecting, enhancing, and promoting the natural environment in and around the City." (Goal EC-1)

> **"**Maintain a surface water and groundwater system that serves the community, enhances the quality of life, and protects the environment." (Goal EC-3)



Parametrix

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Scale in Feet

Inglewood Sub-basin

Sammamish Town Center

Figure 1
Inglewood Sub-basin

These City goals, as well as regulatory directives, such as the City's National Pollutant Discharge Elimination System (NPDES) Phase II permit, and public safety issues such as flooding and access to clean water, provide the framework for development of the Inglewood Sub-basin plan (Figure 2).

Figure 2. Basin Plan Framework

In general, this basin plan is organized into sections based on the community and regulatory framework and what is known (review of previous documentation, results of the Parametrix field investigation and hydrologic modeling), followed by recommendations that are consistent with the City's goals and policies to address existing and potential future watershed concerns. Specific projects and strategies to address watershed concerns were developed into stand-alone projects that can be implemented through the City's Capital Improvement Project (CIP) program.

2. COMMUNITY AND REGULATORY FRAMEWORK

The City of Sammamish governs land use, stormwater, and the use of natural resources through codes and ordinances that are specific to the City or dictated by overarching state and federal regulations. These regulations, along with the City's vision to "blend small town atmosphere with suburban character" and maintain "quality neighborhoods, vibrant natural features, and outstanding recreational opportunities," result in several overlapping policies and goals regarding the management of stormwater and natural resources in the Inglewood Sub-basin. Table 1 summarizes existing federal, state, and local regulations related to stormwater runoff and natural resources and the relevance of these regulations to the Inglewood Sub-basin.

Table 1. Regulatory Framework of Surface Water Management in the Inglewood Sub-basin

Law	Implementing Entity	Regulatory Programs	Intent and Specifics	Relevance to Inglewood Sub-basin
Clean Water Act	Washington State Department of Ecology	NPDES Phase II Municipal Separate Storm Sewer System Permit	Eliminate discharge of pollutants into the nation's water, and achieve water quality levels that are protective of beneficial uses	The City of Sammamish is a NPDES Phase II permittee and must comply with conditions of the permit.
	Washington State Department of Ecology	Surface Water Quality Standards	Protect and regulate the quality of surface water in Washington State through (1) sustaining designated uses, (2) meeting numeric water quality criteria, and (3) implementing antidegradation policies	George Davis creek is listed on the state's 303(d) Category 5 list for water quality impairment by fecal coliform bacteria because of non-compliance with numeric water quality standards.
	Washington State Department of Ecology and U.S. Army Corps of Engineers	Sections 401 and 404	Requires a permit for activities classified by the U.S. Army Corps of Engineers for dredge or discharge of fill material to Waters of the United States	George Davis Creek and associated wetlands and tributaries, including Lake Sammamish, are considered Waters of the United States. In-water activities that meet minimum dredge and fill limits require a permit.
Tribal Agreements and Related Case Law	Muckleshoot Tribe or Snoqualmie Tribe		Protect fish populations in traditional fishing grounds of Native American tribes	Snoqualmie and Muckleshoot Tribes are party to SEPA review of development proposals and programs within the Inglewood watershed.
Endangered Species Act	United States Fish and Wildlife Service and NOAA Fisheries in consultation with lead federal agencies		Prevent further decline of listed terrestrial and aquatic species, including Puget Sound Chinook salmon, steelhead trout, marbled murrelet, and other species	Unknown status of endangered species in Inglewood Sub-basin.
State Environmental Policy Act (SEPA)	The City of Sammamish conducts reviews and issues SEPA determinations on proposed projects within its jurisdiction		Identify and require mitigation of the environmental impacts of proposals and programs	SEPA is used to address impacts on projects in the Inglewood Sub-basin that are not covered in other City code requirements.
Shoreline Management Act	City of Sammamish Shoreline Master Plan		Protect use and functions (economic, ecological, aesthetic) of shoreline areas	Only the part of the Inglewood Sub-basin that borders Lake Sammamish is included in the City's Shoreline Master Plan.

Table 1. Regulatory Framework of Surface Water Management in the Inglewood Basin (continued)

Law	Implementing Entity	Regulatory Programs	Intent and Specifics	Relevance to Inglewood Sub-basin
Washington State Hydraulic Code	Washington State Department of Fish and Wildlife (WDFW)		Sets requirements for placement of culverts and other hydraulic devices that may affect fish use	Projects within ordinary high water mark of streams must obtain a Hydraulic Project Approval permit from WDFW. Culverts must be fish passable where fish are present.
Growth Management Act (GMA)	City of Sammamish implements GMA	City of Sammamish Comprehensive Plan, Sammamish Town Center Plan	Regulate land use to meet growth targets while providing necessary services and protecting sensitive environmental resources	The Inglewood Sub-basin is located in a designated urban growth area (UGA) within the city of Sammamish.

2.1 CITY OF SAMMAMISH SURFACE WATER CODE AND REQUIREMENTS

The City's surface water code (Sammamish Municipal Code [SMC] §15.05.010), through adoption of King County's 1998 Surface Water Design Manual and code (King County Code [KCC] §9.12.035), outlines stormwater management requirements for new development and redevelopment projects that meet certain size thresholds within the City's jurisdiction. This is the primary regulatory mechanism for managing stormwater. The City is in the process of updating its code to include adoption of the latest King County Surface Water Design Manual (2009) or the Washington State Department of Ecology (Ecology) 2005 Stormwater Management Manual for Western Washington (2005 Ecology Manual), as required by the City's Phase II NPDES permit.

The City of Sammamish adopted a Low Impact Development (LID) Ordinance (02008-236) in 2008. This ordinance is based on incentives and encourages development proposals to incorporate LID techniques in exchange for increased density, signage, publicity, and other incentives.

In addition to adoption of a stormwater management manual that is consistent with the 2005 Ecology Manual, the City's NPDES Phase II permit outlines several stormwater management requirements related to water quality, including:

- Public education;
- Illicit discharge detection and elimination programs;
- Public involvement and participation;
- Construction and development runoff control; and
- Municipal operation and maintenance.

The City already has many of these stormwater management components in place and is currently updating its stormwater management approach to comply with NPDES Phase II permit requirements. The NPDES program requirements will affect the Inglewood Sub-basin in the following ways: updated stormwater management requirements for new development; opportunities for developers to obtain special allowances in exchange for utilizing LID techniques; increased maintenance frequency for City stormwater infrastructure; and continued public involvement and education regarding stormwater issues.

2.2 CITY OF SAMMAMISH COMPREHENSIVE PLAN

The Comprehensive Plan was adopted in 2003 and updated in 2006. It was developed in accordance with the state Growth Management Act's planning goals (Revised Code of Washington [RCW] 36.70A.020), which includes encouraging growth in urban areas where City services will be provided, limiting sprawl, protecting the environment and natural areas, and encouraging the involvement of citizens in the planning process. The Inglewood Sub-basin is located entirely within the city of Sammamish UGA. The Comprehensive Plan outlines several goals associated with each planning element. The goals related to surface water management and basin planning are summarized in Table 2 showing how these goals relate to existing City regulations.

Table 2. Relationship of Comprehensive Plan Goals to Existing City Regulations and Programs

	Elements of Comprehensive Plan Goals Related to Stormwater Management									
City Codes and Regulations	Preservation of Natural Environment/Open Space	Encourage Non-traditional Alternatives to Stormwater Management	Environmental Education	Protect Surface and Ground Water Resources	Minimize Impervious Surfaces	Integrated Water Resources Management	Use Incentives, Regulations and Programs to Manage Water Resources	Enhance Water Quality	Protect Ground Water Recharge Quantity and Quality	Maintain Ecologic and Hydrologic Functioning of Natural Systems
Critical Areas Ordinance	√			√					√	√
Growth Management Act	√									
LID Ordinance		√			√		√			
City/Town Center Stormwater Code		√		√	√	√				√
Shoreline Management Act	√									
NPDES Phase II Permit			√					√		

2.2.1 Town Center Plan

The Sammamish Town Center Plan was adopted in June 2008, outlining elements related to the development of 240 acres of property along 228th Avenue SE at the headwaters of the Thompson and Inglewood sub-basins. The elements in the Town Center Plan that relate to this basin plan include land use, open space, natural systems, and capital facilities and utilities. The Town Center Plan cites opportunities to "employ an integrated strategy to managing storm water and enhance the ecology" through "LID techniques to more closely emulate the natural hydrology" and "coordinate storm water management through an integrated regional system." A separate Comprehensive Stormwater Master Plan was prepared for the Town Center (Parametrix 2009a); design strategies for the Town Center will also be briefly discussed in this plan.

2.2.2 Critical Areas Ordinance

Several designated critical areas are located within the Inglewood Sub-basin, including landslide and erosion hazard areas on the flanks of George Davis Creek on the west slope of the Sammamish Plateau, wetlands, streams, wildlife corridors, and critical aquifer recharge areas (Figure 3). Approximately one-half of the entire basin is designated as a critical area. The City's Critical Areas Ordinance (No. 02005-193) and Environmentally Critical Areas Code (SMC Chapter 21A.50) specify activities allowed and prohibited in these areas, as well as requirements for mitigating impacts to critical areas. In addition to the Critical Areas Code that applies to the entire city, a special wetland overlay area has additional requirements and include portions of the Inglewood Sub-basin. The Critical Areas Code is important to basin planning because it outlines requirements related to surface water runoff and management through development restrictions adjacent to erosion hazard areas, limitations on impervious surface construction in critical aquifer recharge areas, and wetland and stream buffers to keep riparian areas and wildlife corridors intact.

2.3 CITY OF SAMMAMISH SHORELINE MASTER PROGRAM

The city's waterbodies that are considered shorelines of the state include Lake Sammamish, Pine Lake, and Beaver Lake. None of the streams located within the basin limits, including George Davis Creek, is large enough to be included in the Shoreline Master Program. The Inglewood Sub-basin does include a very small portion of the Lake Sammamish shoreline. Parametrix did not evaluate shoreline conditions and implications of the Shoreline Master Program for the Inglewood Sub-basin.

2.4 SEATTLE AND KING COUNTY PUBLIC HEALTH DEPARTMENT

The Seattle and King County Public Health Department regulate drinking water sources, including surface water developed for water supply, and drilled wells using groundwater as a source of potable water. Additionally, the health department helps to ensure that septic systems are installed and operating properly. The commercial area in the Inglewood Sub-basin at the intersection of Inglewood Hill Road and 228th Avenue SE receives sanitary sewer service from the Sammamish Plateau Water and Sewer District; however, most of the basin still relies on private septic systems. Parametrix did not investigate whether there have been any water quality or quantity concerns from private well owners, or whether private sewer systems are properly functioning.

2.5 WATER AND SEWER DISTRICTS

Most of the Inglewood Sub-basin is within the Sammamish Plateau Water and Sewer District service area; however, a very small portion on the north side is in the Northeast Sammamish Sewer and Water District service area. As mentioned above, large areas of the basin are still on private sewer systems, but the District's plan is to construct future mains and lift stations to service the basin (Sammamish Plateau Water and Sewer District 2003). As the area is redeveloped, new water lines will also likely service those residents that are currently on private well systems.

The District operates 13 municipal water wells in the vicinity of the city limits. These wells range in depth from 134 feet below ground surface (bgs) to 955 feet bgs for a total capacity of approximately 7,000 gallons per minute (gpm) (WSDOH 2011).

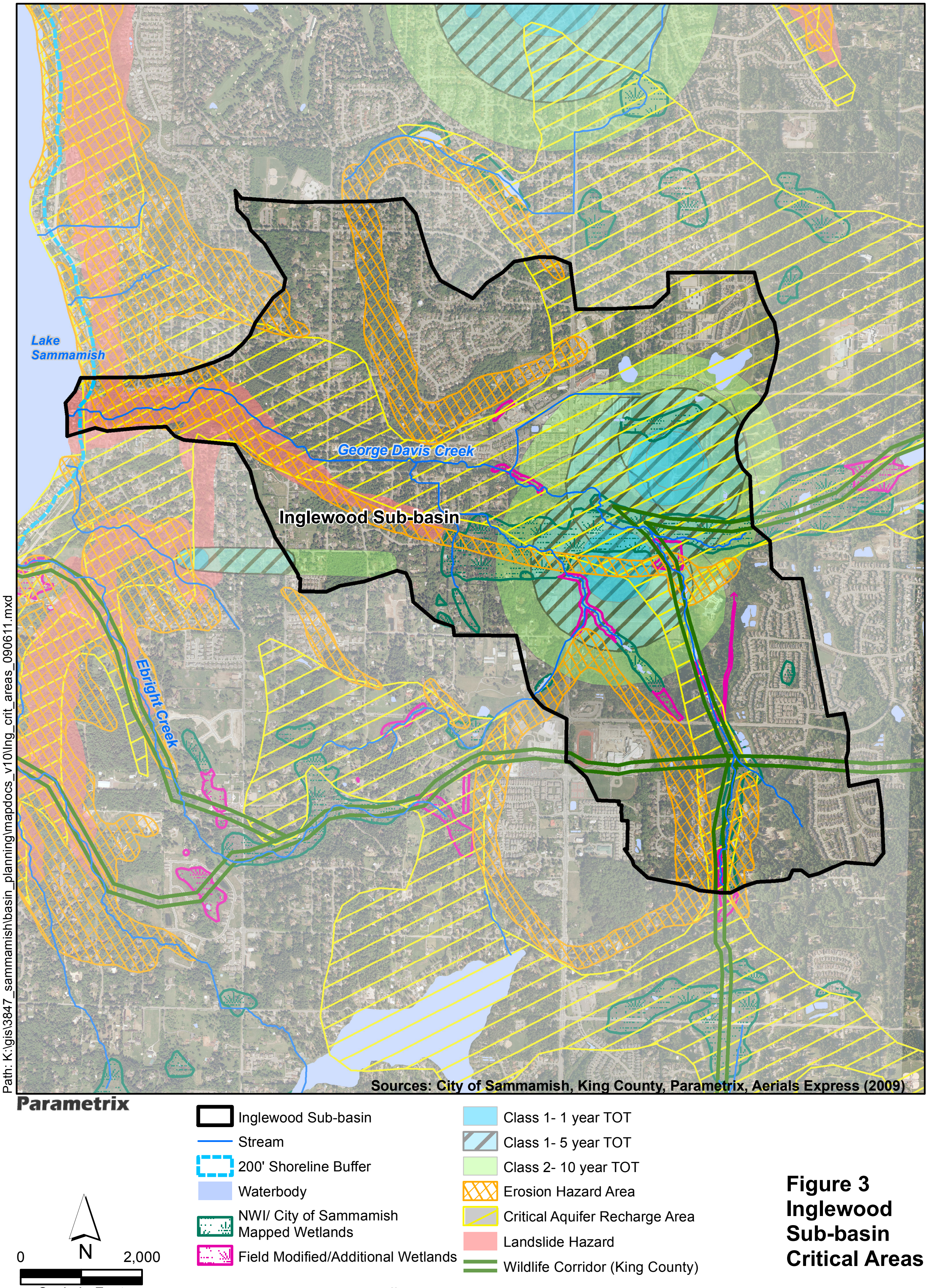


Figure 3 Inglewood Sub-basin Critical Areas

3. WATERSHED CHARACTERISTICS

Existing watershed characteristics were evaluated through review of previous studies and documentation, aerial photographs, maps, and field reconnaissance that included walking the stream channels and visiting wetlands in the basin. Additionally, supplemental information was obtained from residents at public meetings held in December 2008 and March 2009. Physical stream channel attributes collected in the field, along with existing land use, future zoning, and geologic data, were used to develop a hydrologic model of the basin to evaluate existing and future surface water flow conditions.

The Inglewood Sub-basin is in fair condition with respect to some characteristics, such as quality of wetlands and riparian forest adjacent to George Davis Creek, and large areas of recessional outwash geology that serves as an underground reservoir and collection system for surface water runoff. However, the basin is impaired with respect to fish habitat and access. There are three fish passage barriers located within 1/2 mile of Lake Sammamish that prevent fish use of upstream habitat. Table 3 summarizes existing conditions, potential future impacts, and existing regulatory measures in place to ensure protection of natural resources.

The watershed threats in the Inglewood Sub-basin are primarily related to the conversion of land to rural and suburban uses, particularly development over areas of recessional outwash. If the basin is built out to its full zoning potential, this could represent an increase in impervious surfaces from 15 percent to 32 percent.

3.1 PHYSICAL SETTING

The Inglewood Sub-basin is located on the east side of Lake Sammamish in east King County, Washington. The sub-basin is approximately 2.6 square miles, with an elevation range of 615 feet above mean sea level at the top of the Sammamish Plateau, to an elevation of 40 feet above mean sea level at the mouth of George Davis Creek (also known as Inglewood Creek) in Lake Sammamish. George Davis Creek is the primary drainage feature in the Inglewood sub-basin. Approximately 32 percent of the sub-basin is forested, with much of the forested area located in the riparian corridor adjacent to George Davis Creek. Impervious surface is roughly 15 percent of the total area based on average assumed impervious surface coverage for the different land types in the sub-basin. Road density in the basin is about 10.4 miles per square mile, which is fairly high for the level of development in the basin.

Table 3. Summary of Existing Conditions and Future Impacts

	Watershed Characteristic	Existing Conditions	Potential Future Impacts	Existing Regulatory Measures to Ensure Protection
Biological Characteristics	**Fisheries**	Aquatic habitat is in fair condition, but limited by stream flow and access. Stream flow is present in the winter months; much of George Davis Creek is dry during the summer and fall.	Unlikely that future development will significantly affect habitat. Flows are attenuated through infiltration into the recessional outwash.	Critical Areas Ordinance (CAO)—150-foot stream buffer on George Davis Creek.
		Complete fish passage barriers exist downstream of East Lake Sammamish Trail, at East Lake Sammamish Parkway, and upstream at an old concrete dam located about 1/2 mile upstream of the parkway.		CAO—Subdivisions must place wildlife corridors (such as George Davis Creek) in a contiguous permanent open-space tract.
		Large woody debris has been placed in the channel as restoration, which is likely to prevent sediment movement rather than create fish habitat.		
	Wetlands	Several large depressional wetlands, with groundwater hydrology and seasonal flooding. Some wetlands and buffers are degraded from residential development; others are in fairly good shape.	Vegetation and hydroperiod changes from increased stormwater runoff or infiltration; encroachment from urbanization.	CAO—Wetland buffers vary from 50 to 215 feet depending on wetland category.
		Many wetlands in the Inglewood Sub-basin have been encroached upon by development and have resulted in wetland fragmentation.		CAO—Wetland special district overlay (180) requires a maximum impervious surface area of 8% in areas zoned R-1 within a special overlay area. Some portions of Inglewood sub-basin are within this overlay.
		Wetlands receive more flow now with increased development (anecdotal information). Trees have been dying due to longer periods of saturation in some areas.		CAO—Surface water discharges are allowed in wetlands and their buffers only if the discharge does not increase rate of flow, decrease water quality, or change plant composition.
	Riparian Corridor	Fairly good condition in vicinity of George Davis Creek.	Encroachment from development, change in size and type of vegetation (smaller trees, less dense).	CAO—Wetland and stream buffers (see above) and vegetation management plan for clearing done in critical areas
				50% of sites must retain trees or re-vegetate with trees in areas zoned R-1 within wetland special overlay area.
Chemical Characteristics	**Water Quality**	George Davis Creek is on 303(d) list as a Category 5 impaired waterbody for fecal coliform bacteria.	Unknown; there is not a continuous flow of water in the creek, and infiltration of surface water likely removes fecal coliform bacteria.	

Table 3. Summary of Existing Conditions and Future Impacts (continued)

	Watershed Characteristic	Existing Conditions	Potential Future Impacts	Existing Regulatory Measures to Ensure Protection
Physical Characteristics	**Groundwater Hydrology**	Several domestic groundwater wells in the Inglewood Sub-basin.	Reduction in groundwater elevations in shallower aquifers due to more impervious surfaces and less groundwater recharge.	CAO—Much of Inglewood sub-basin is located within critical aquifer recharge areas. 75% of on-site stormwater generated from new development must be infiltrated in these areas, unless not feasible.
		Groundwater recharge occurs in undeveloped portions of the basin at quite high rates depending on surface geologic conditions.		CAO—Some activities are prohibited in critical aquifer recharge areas to protect groundwater quality.
	Surface Hydrology	Surface water hydrological conditions are relatively intact. Much of the Inglewood Sub-basin has very high infiltration rates in the recessional outwash, which attenuates flows in the stream channel.	Increased flows, durations, and volumes from new development could overwhelm capacity of outwash or affect wetlands.	King County Title 9—Surface water management code adopted by City of Sammamish, Level 3 flow control match 100-year peak for predeveloped forest conditions.
	Hillslope Geomorphology	Lower reaches of George Davis Creek are within an erosion hazard area. Many landslides were observed adjacent to George Davis Creek; some may be due to residential surface water discharges.	Removal of vegetation or discharge of stormwater near the slopes of George Davis Creek could compromise slope conditions and cause additional landslides.	
Built Environment	**Impervious Surface Coverage**	Currently, approximately 15% total impervious surface in basin.	Impervious surface estimates for future land use is 32% of basin.	CAO—Wetland overlay limits impervious surface to 8% in areas zoned R-1.

3.2 LAND USE AND POPULATION

Population on the Sammamish Plateau grew by nearly 600 percent between 1970 and 2001 (City of Sammamish 2003). Parametrix reviewed historical aerial photographs from 1944, 1970, 1979, 1996, 2002, and 2009. The 1979, 1996, 2002, and 2009 photographs are shown in Figures 4 through 7. The basin was very rural and mostly forested in the 1979 aerial photograph. Some residential and commercial development took place in the north portion of the basin (north of Inglewood Hill Road and at the intersection of Inglewood Hill Road and 228th Avenue SE) between 1979 and 1996. Significant land conversions have occurred since 1996 with the construction of two large high schools on 228th Avenue SE and several residential communities in the southeast part of the basin.

The Inglewood Sub-basin is not built out based on existing zoning (Figure 8). The proposed Town Center includes more than 150 acres in the Inglewood Sub-basin, some of which will be converted to dense development. Additionally, there are some areas zoned R-4 and R-6 (four and six dwelling units per acre, respectively) that are currently forested or developed at a rural density. These areas could be built out and result in stormwater and surface water impacts, particularly in those areas adjacent to wetlands, such as near Eastside Catholic High School, and steep slopes adjacent to George Davis Creek on the west slope of the plateau (in the vicinity of NE 6th Place).

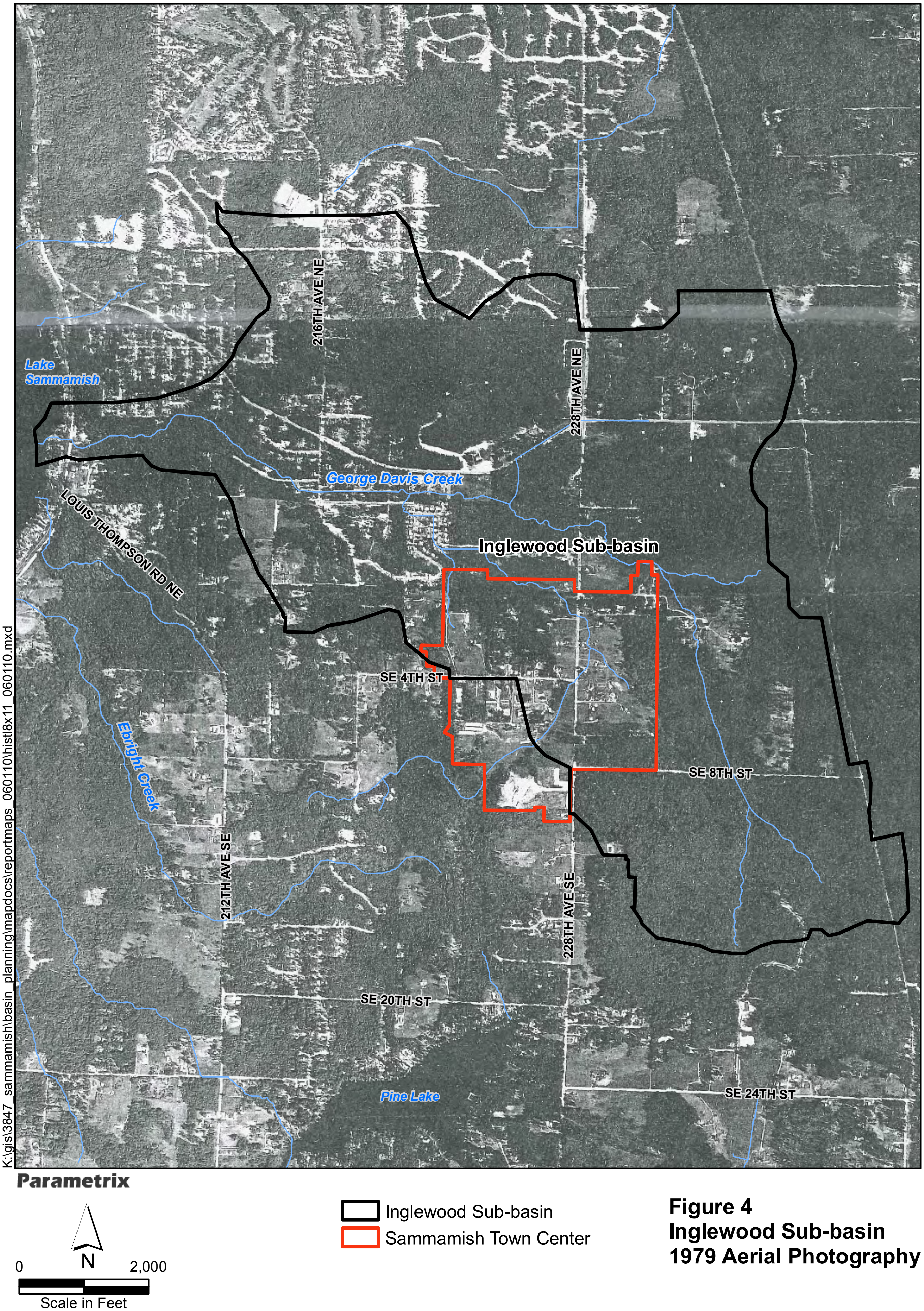
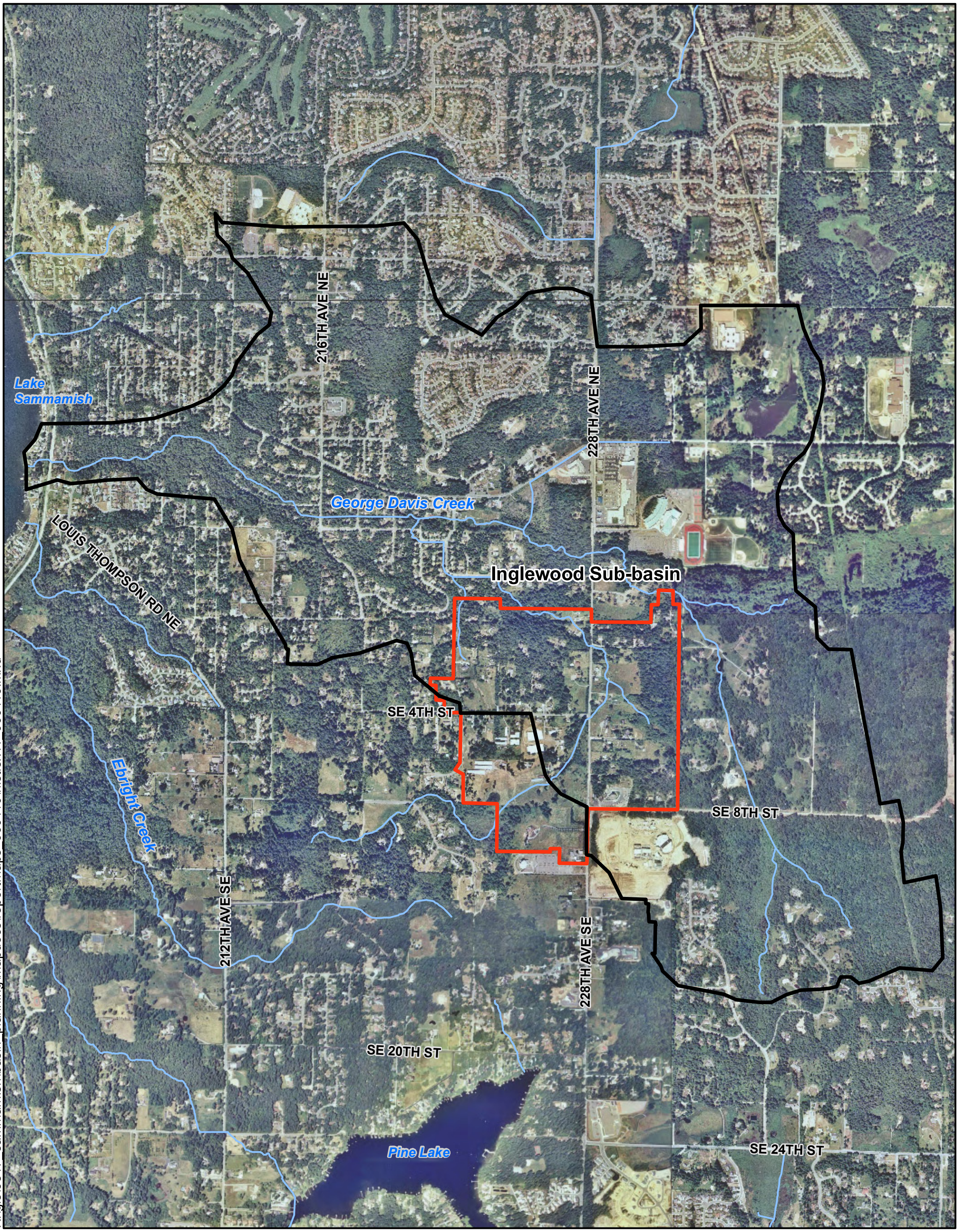


Figure 4
Inglewood Sub-basin
1979 Aerial Photography



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Scale in Feet

Inglewood Sub-basin

Sammamish Town Center

Figure 5
Inglewood Sub-basin
1996 Aerial Photography

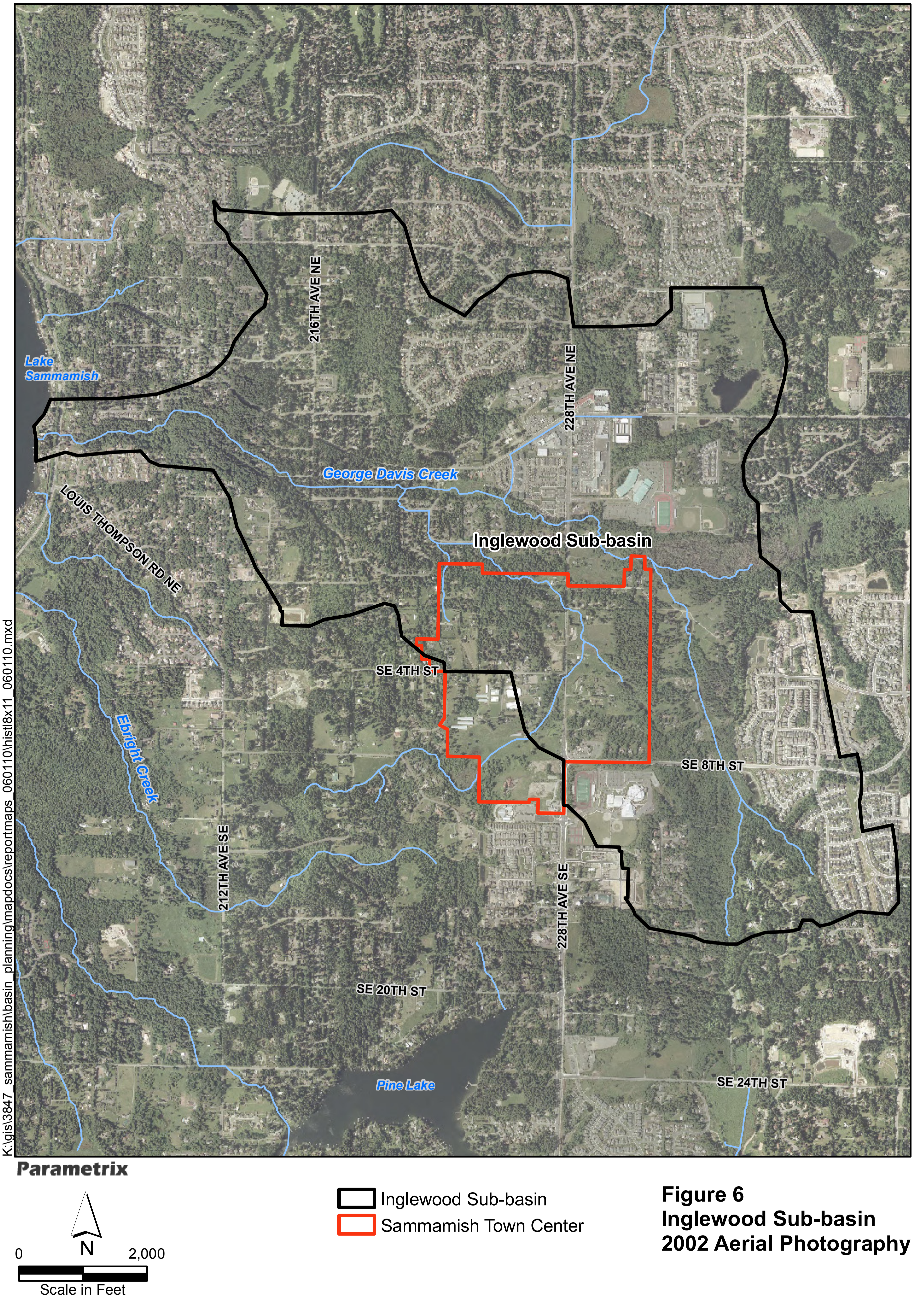
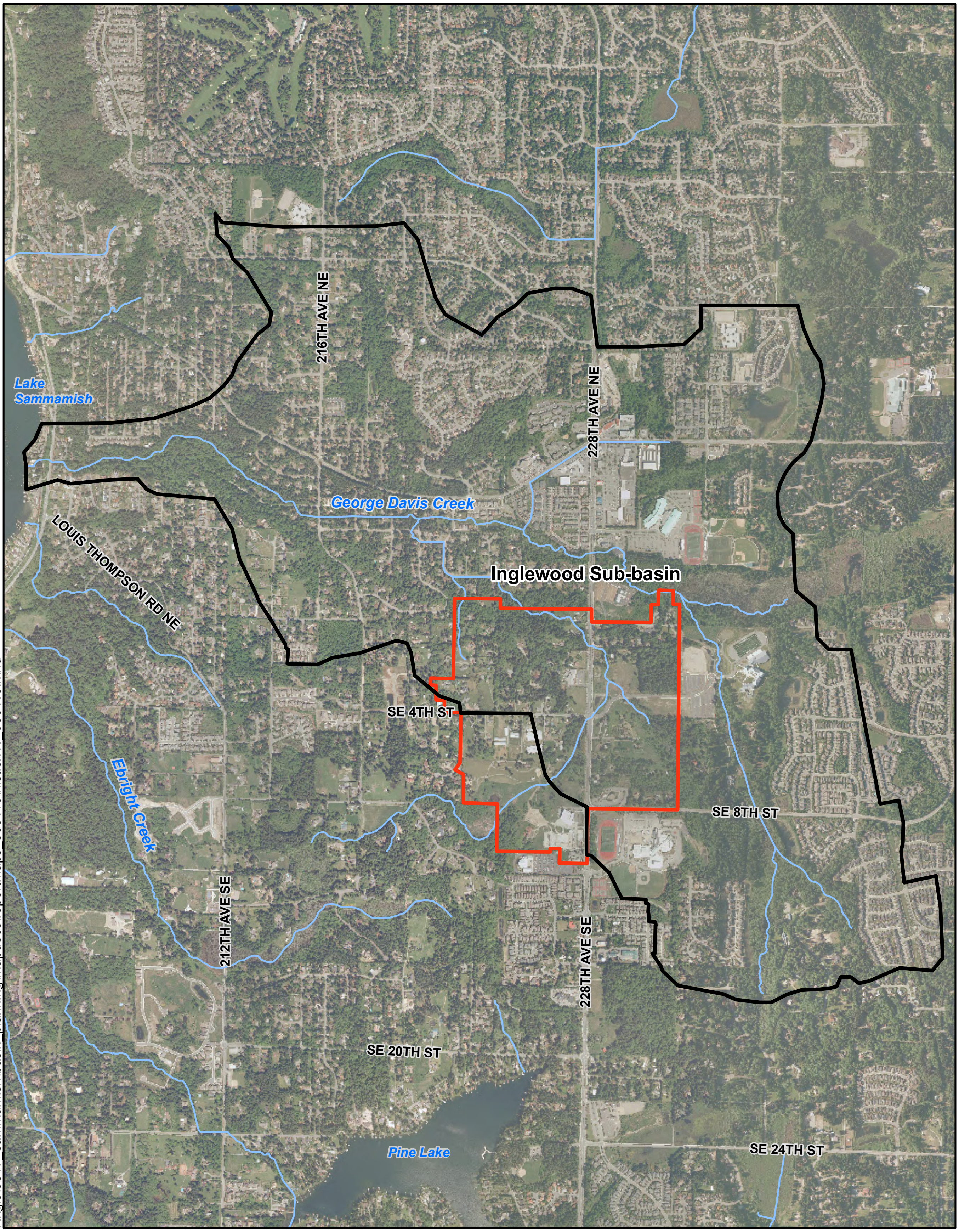


Figure 6
Inglewood Sub-basin
2002 Aerial Photography



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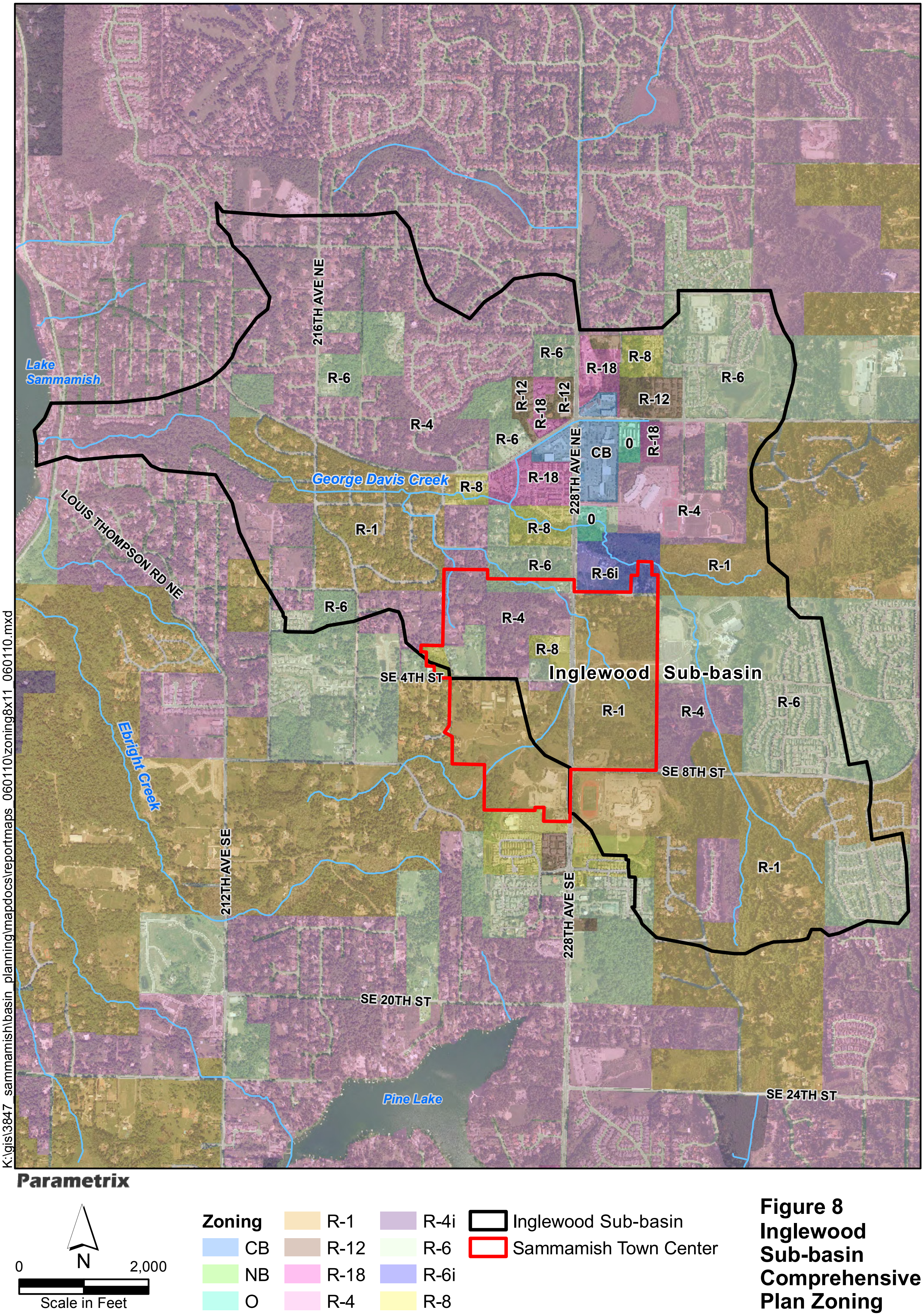
Scale in Feet

Inglewood Sub-basin

Sammamish Town Center

Figure 7
Inglewood Sub-basin
2009 Aerial Photography



Zoning
CB
NB
O
R-1
R-12
R-18
R-4
R-4i
R-6
R-6i
R-8
Inglewood Sub-basin
Sammamish Town Center

Figure 8
Inglewood Sub-basin Comprehensive Plan Zoning

3.3 GEOLOGY AND GROUNDWATER

3.3.1 Geology

The geological features of the East Lake Sammamish Plateau have been mapped by Derek B. Booth and others at the U.S. Geological Survey (USGS 2006). A map of the basin surface geology is presented in Figure 9. Cross sections showing approximate subsurface geologic conditions were developed based on water well logs obtained from Ecology and geotechnical studies available in unpublished reports (Hong West and Associates 1996; Nelson and Associates 1987; Terra Associates 1995, 1998, 1999). These cross sections are shown in Figures 10 and 11. The geological features are characterized by the following general sequence of unconsolidated glacial deposits from the surface downward:

- Vashon recessional outwash (Qvr);
- Vashon till (Qvt);
- Vashon advance outwash (Qva); and
- Pre-Vashon undifferentiated unconsolidated deposits—glacial and non-glacial (Qpf).

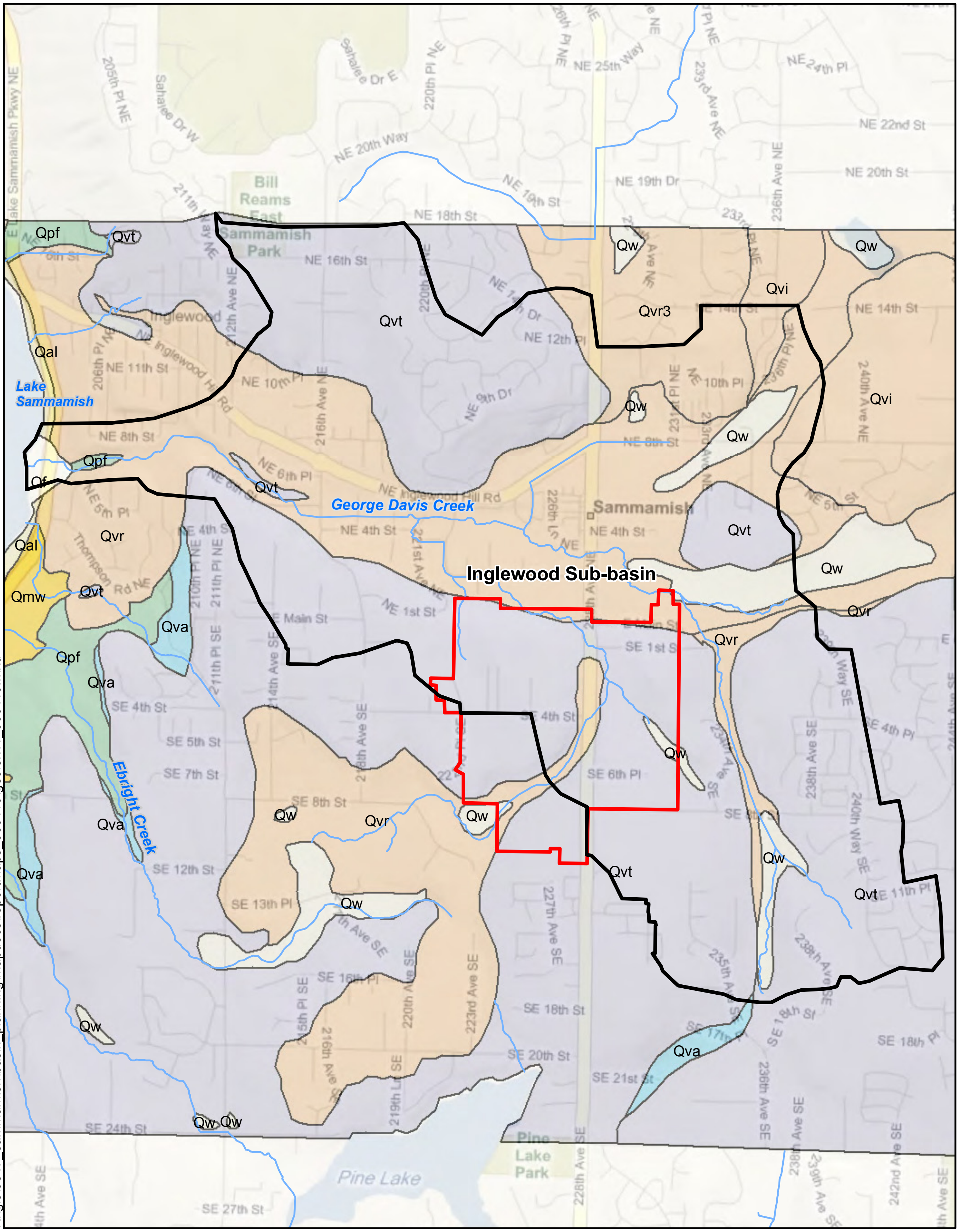
Most of the upland areas of the Sammamish Plateau and the Inglewood Sub-basin are mantled by Vashon Till (Qvt), a densely compacted poorly sorted mixture of boulders, cobbles, gravel, and sand in a matrix of silt and clay, often identified in driller's logs as "hardpan." The till is up to about 150 to 200 feet thick in some upland areas of the Sammamish Plateau based on a review of well records in the vicinity. The presence of till is an important consideration for stormwater management techniques because it is more difficult to infiltrate stormwater in these areas due to the compact nature and low permeability of the till.

The Vashon Till is locally overlain by Vashon Recessional Outwash deposits (Qvr)—a poorly sorted to well sorted, light gray, stratified gravel and sand with minor amounts of silt and clay deposited behind the receding glacier. The recessional outwash deposits are relatively thin on the south side of the Inglewood Sub-basin (less than 20 feet) but get thicker toward the north (up to 50 feet or more). The recessional outwash is the surficial geologic unit present throughout the George Davis Creek corridor. It plays an important role in stormwater management in that it serves as a large underground reservoir for water and stormwater readily infiltrates where recessional outwash is present.

The Vashon Till is underlain by Vashon Advance Outwash (Qva) that consist of variably compacted sand and gravel deposited by streams and rivers ahead of the advancing glacier. Vashon Advance Outwash is typically variable in grain size, varying from silt to gravel and in sorting from well sorted to unsorted. The advance outwash is not exposed in the Inglewood Sub-basin.

Pre-Vashon glacial deposits underlying the Vashon Advance Outwash include both glacial and non-glacial units. Two finer-grained and three coarser-grained units have been defined within these undifferentiated deposits.

Most of the surficial soils in the upland areas of the Inglewood Sub-basin are mapped as Alderwood Series (Soil Conservation Service 1973) developed in the weathered Vashon Till and Everett soils developed in the recessional glacial outwash. The Alderwood soils are very gravelly sandy loam to very gravelly fine sandy loam and are typically moderately well drained, moderately deep, and are formed in glacial tills in upland areas. The Everett soils are somewhat excessively drained and gravelly.



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Parametrix Data Source: USGS

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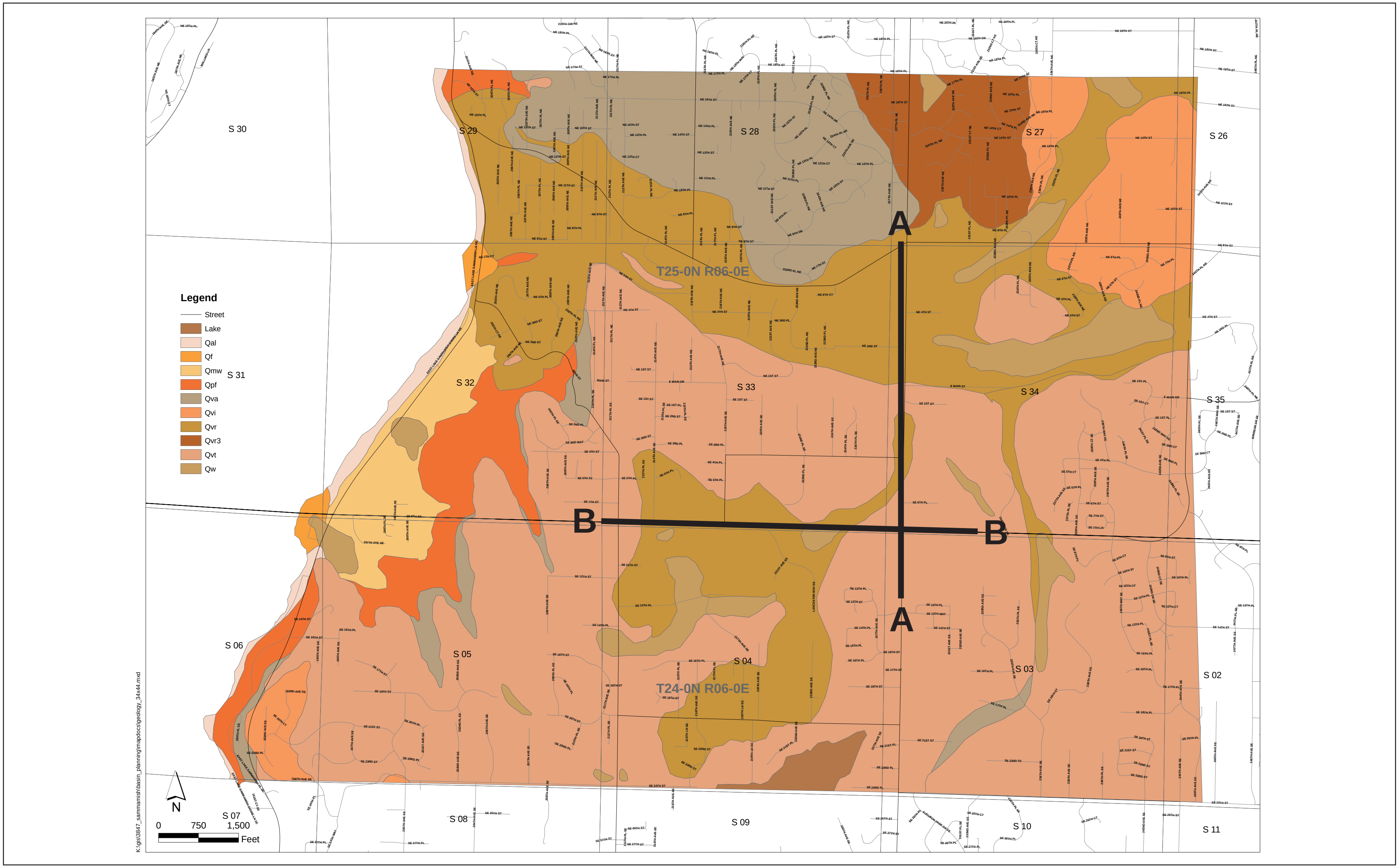
Scale in Feet

- Inglewood Sub-basin
- Sammamish Town Center
- Alluvium (Qal)
- Mass Wastage Deposits (Qmw)
- Wetland Deposits (Qw)
- Vashon Recessional Outwash (Qvr, Qvr3, Qvi)
- Vashon Till (Qvt)
- Vashon Advance Outwash (Qva)
- Pre-Vashon Undifferentiad Deposits (Qpf)

Figure 9
Inglewood Sub-basin Geology



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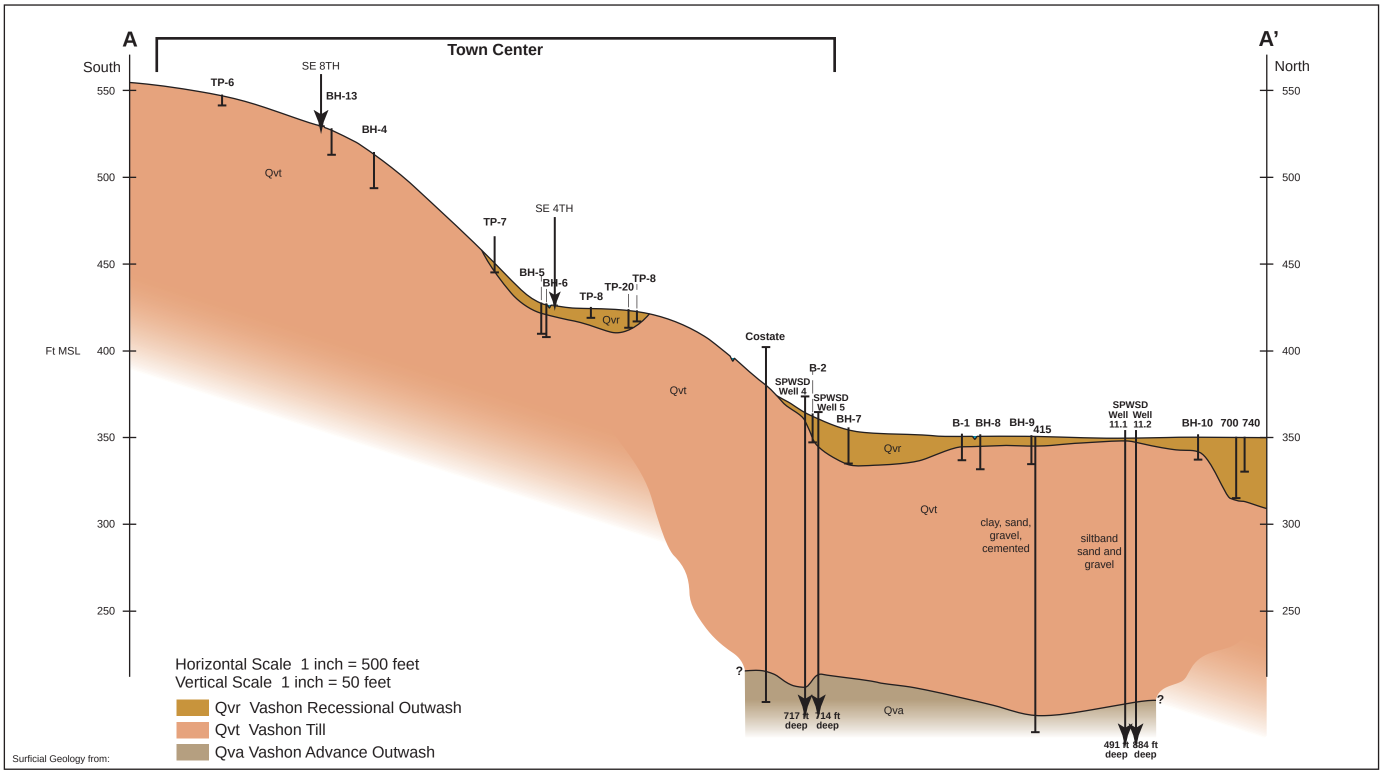
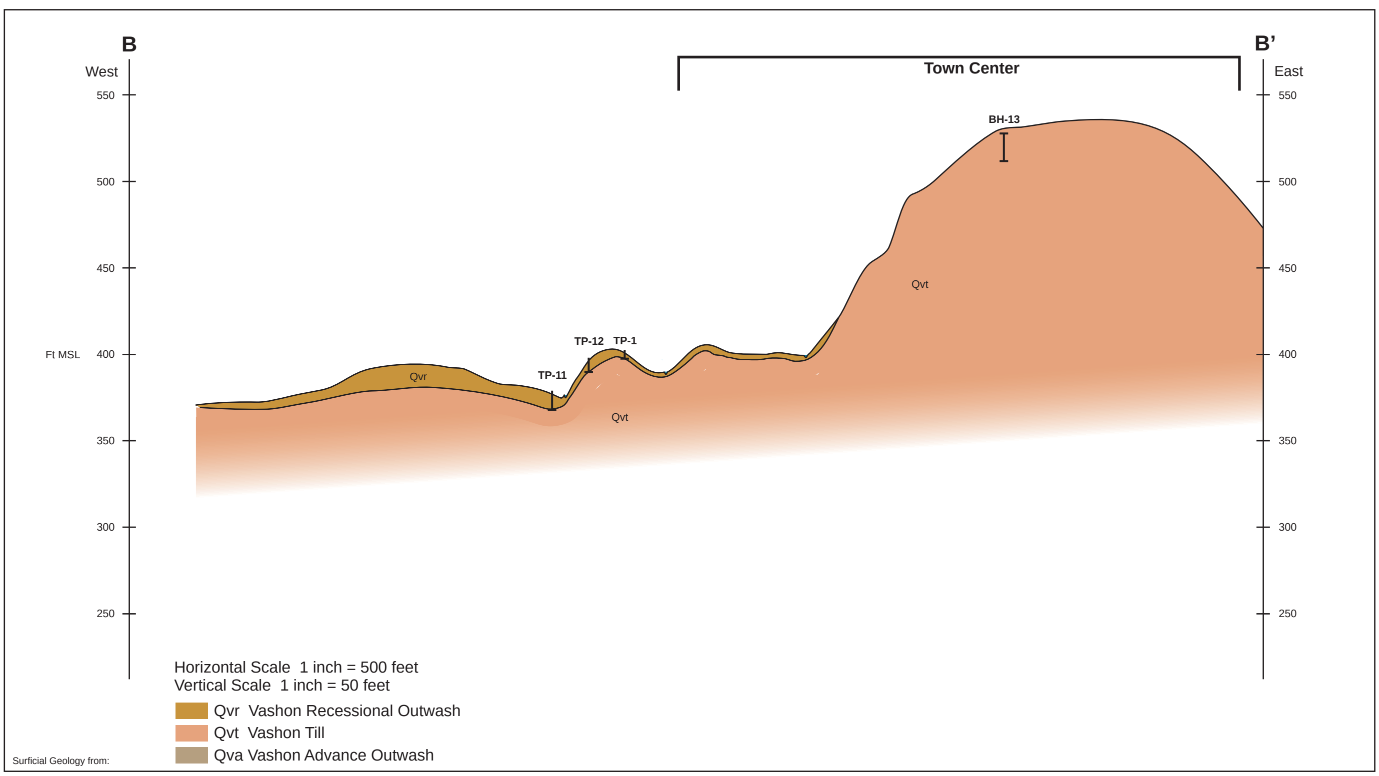
SCALE IN FEET

Figure 10
General Geology and Location of Geologic Cross Sections



Geologic Cross Section Along 228th Ave
City of Sammamish Town Center



Geologic Cross Section Along NE 8th Street
City of Sammamish Town Center

Figure 11
Geologic Cross Sections A-A' and B-B'

More recent surficial units mapped within the Inglewood Sub-basin include:

- Alluvium (Qal);
- Wetland deposits (Qw); and
- Mass-wastage deposits (Qmw).

Wetland deposits (Qw) are mapped along small portions of the upper reaches of George Davis Creek, and are described as peat and alluvium, poorly drained and intermittently wet.

3.3.2 Groundwater Occurrence

Groundwater resources of the Sammamish Plateau are described in Turney et al. (1995) and Leisch et al. (1963). Precipitation provides the source of recharge to shallow aquifers in the upland areas of the Sammamish Plateau. Recharge in the project vicinity is estimated to be 10 to 20 inches per year in the till, and 21 to 30 inches per year in the recessional outwash (Turney et al. 1995). Groundwater flow in the upper units is locally influenced by variations in lithology. Deeper aquifers are recharged by downward movement from shallow aquifers and by lateral flow from regional recharge areas to the east. In the upper aquifers of the project vicinity, overall groundwater flow is westward toward Lake Sammamish.

Areas of the Inglewood Sub-basin with recessional outwash mapped at the surface are designated as critical aquifer recharge areas in the Critical Areas Ordinance due to the permeable nature of these deposits. Although permeable, the relatively limited depths of the recessional outwash are not adequate to yield significant quantities of groundwater to wells. However, infiltration of precipitation through the recessional outwash provides an important source of recharge to underlying aquifers.

The upper part of the Vashon Till is typically more permeable than the lower part, and perched or semi-perched groundwater occurs locally within sand and gravel lenses. Wells completed in the till may yield small quantities of water that are adequate for domestic supply. The Vashon Advance Outwash yields a more reliable source of groundwater to some domestic wells in upland areas of the Sammamish Plateau completed at depths of approximately 100 to 300 feet.

Unconsolidated Pre-Vashon deposits underlying the Vashon Advance Outwash in the project vicinity provide the source of water supply to the City of Sammamish wells, completed at depths ranging from about 350 to 700 feet bgs, and elevations from 100 to less than -350 feet mean sea level (msl). Four wells are located in the Inglewood Sub-basin along 228th Avenue (Wells 4, 5, 11.1, and 11.2), completed at approximate depths from 500 to over 700 feet bgs. Wellhead protection areas are designated in accordance with the Critical Areas Ordinance for each of the City wells. Water wells along East Lake Sammamish Parkway are typically less than 100 feet deep and many have artesian flow.

3.4 SURFACE WATER HYDROLOGY

The surface water hydrology of the Inglewood Sub-basin is governed by rainfall rates, vegetative conditions (forest vs. grass), surface geology (permeable vs. impermeable geologic units), topography, and land development. Surface flow in the upper portion of George Davis Creek is seasonal, largely fed by groundwater supplied by the shallow recessional outwash aquifer. In the winter when water levels in the recessional outwash are high enough, local springs flow to George Davis Creek. Generally, the lower part of George Davis Creek (from about 212th Avenue NE to the mouth) flows year-round. There are several large wetlands bisecting 228th Avenue SE; these wetlands serve to store a significant amount of surface water. The presence of the highly infiltrative recessional outwash and large wetlands likely attenuates flows to the stream channel.

Currently, the basin is approximately 15 percent impervious. There was only one localized runoff-related problem identified in this basin. Runoff from 228th Avenue NE is currently discharged through an outfall near the top of the slope on the west side of 228th Avenue NE immediately north of SE 8th Street. This discharge has caused erosion and also may be contributing to saturated conditions that have resulted in the death of several large fir trees in this area (Photograph 1). Additionally, two other drainage issues were identified:

- Residential flooding on NE 217th Street; and
- Damaged culverts on NE 2nd Street.

The NE 217th Street flooding was brought to the City's attention by a local resident who experiences flooding from road runoff. The damaged culverts were identified during field visits by Parametrix. Capital projects to address these issues are described further in the recommended strategies in Section 4.

Photograph 1. Dying trees associated with saturated conditions on west side of 228th Avenue NE

3.4.1 Hydrologic Modeling

The surface hydrology of the Inglewood Sub-basin was modeled using MGS Flood, an HSPF-based (Hydrologic Simulation Program Fortran) continuous hydrologic model. The basin was divided into 17 sub-basins for the purposes of modeling (Figure 12). Existing and future hydrologic conditions were modeled to evaluate existing and potential future impacts related to increased flow rates. Additionally, the existing and future flows were compared to conditions that would have existed in a pre-developed (forested) condition. Current City of Sammamish stormwater regulations require new development to match pre-developed conditions for the 2-year and 100-year peak flow rates. The modeling results indicate that with future stormwater mitigation, pre-developed peak flow conditions can be met with application of these stormwater management techniques. Figure 13 shows existing, forested, and future mitigated flows for the 2-year, 10-year, and 100-year peak flow rates. The complete modeling results are provided in Appendix A.

Current stormwater requirements require management of flow rates and durations to minimize erosive forces in sensitive stream channels; however, they do not address increased stormwater volumes, which could affect wetland hydrology.

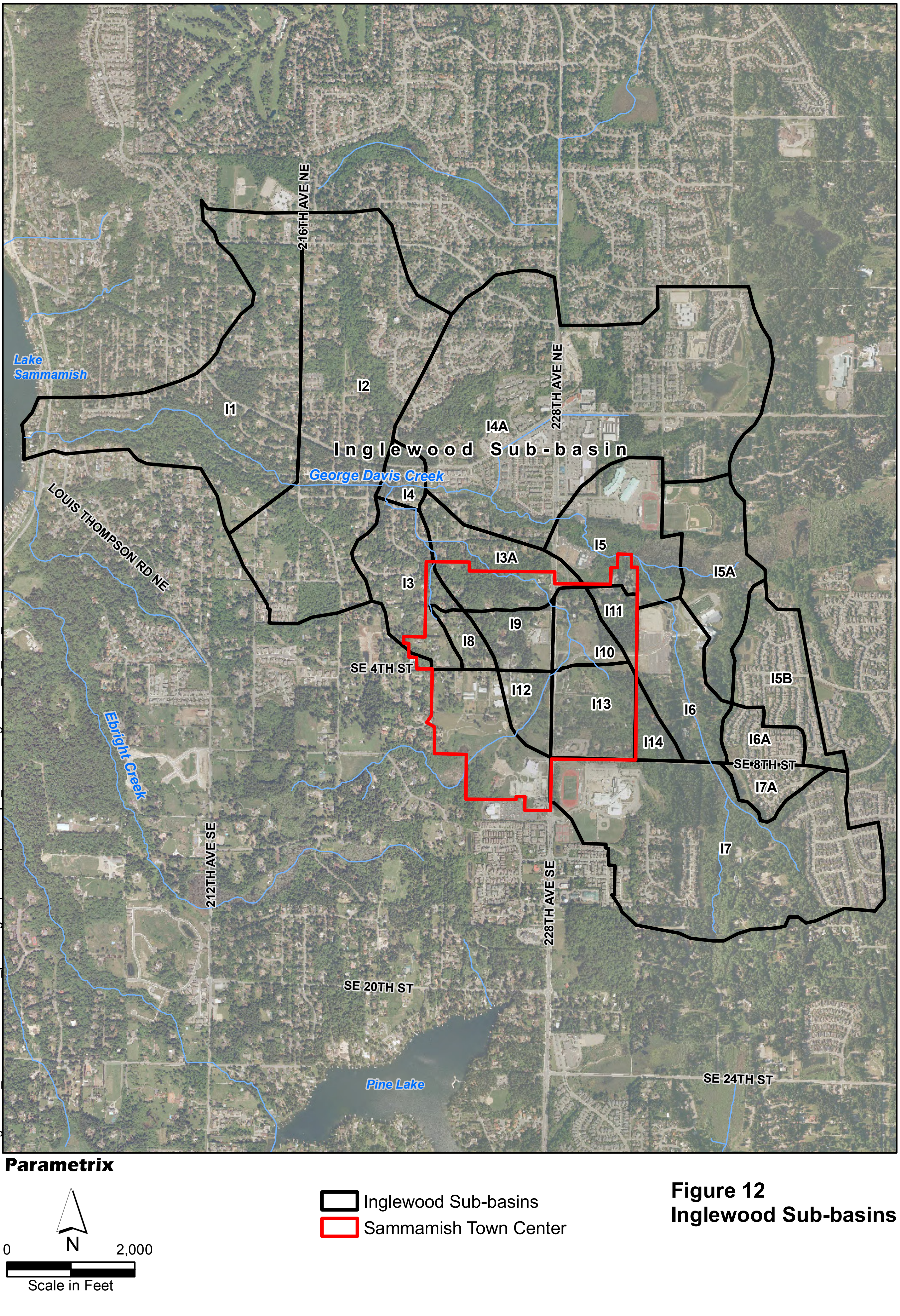
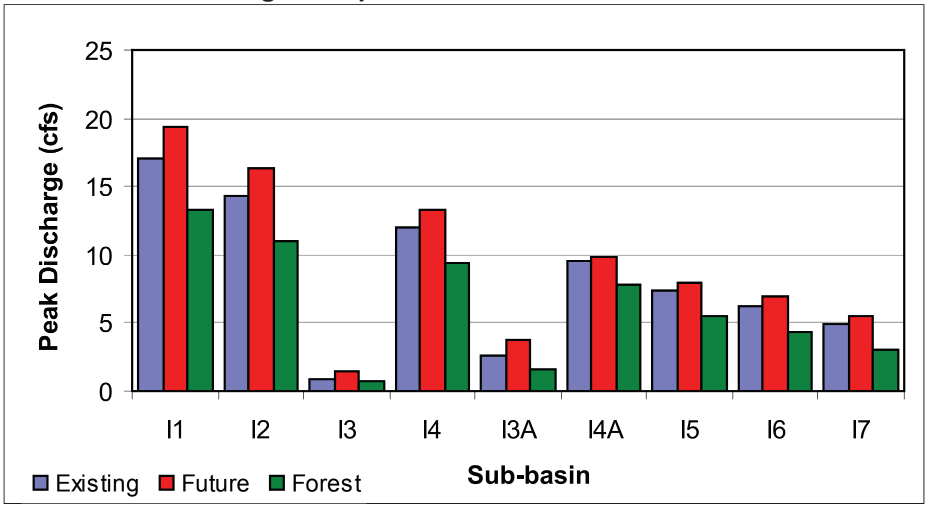
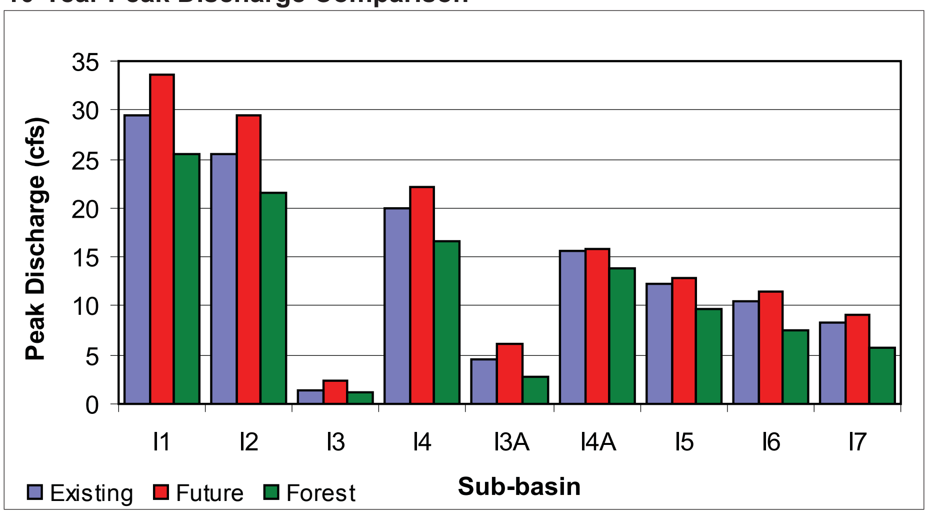


Figure 12
Inglewood Sub-basins

2-Year Peak Discharge Comparison



10-Year Peak Discharge Comparison



100-Year Peak Discharge Comparison

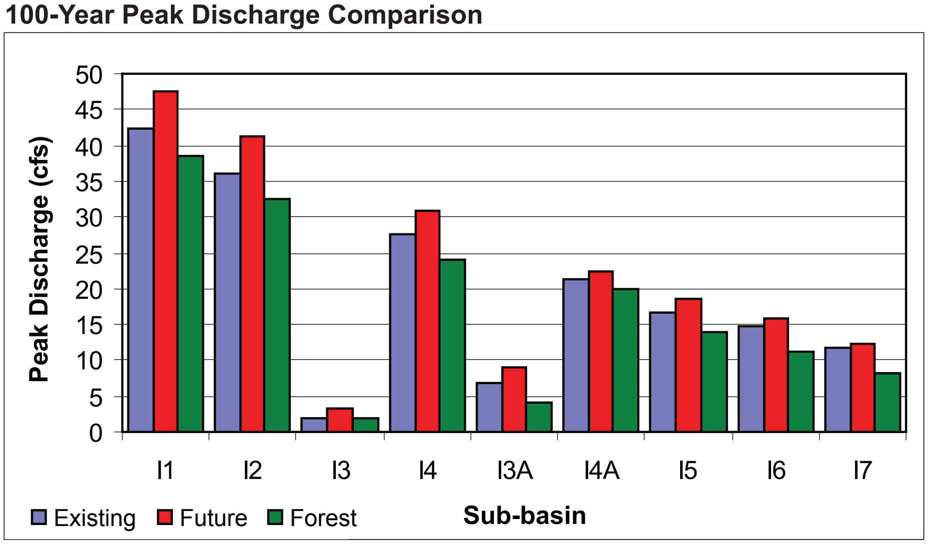


Figure 13
Inglewood Sub-basin Hydrological Modeling Results

3.5 WETLANDS

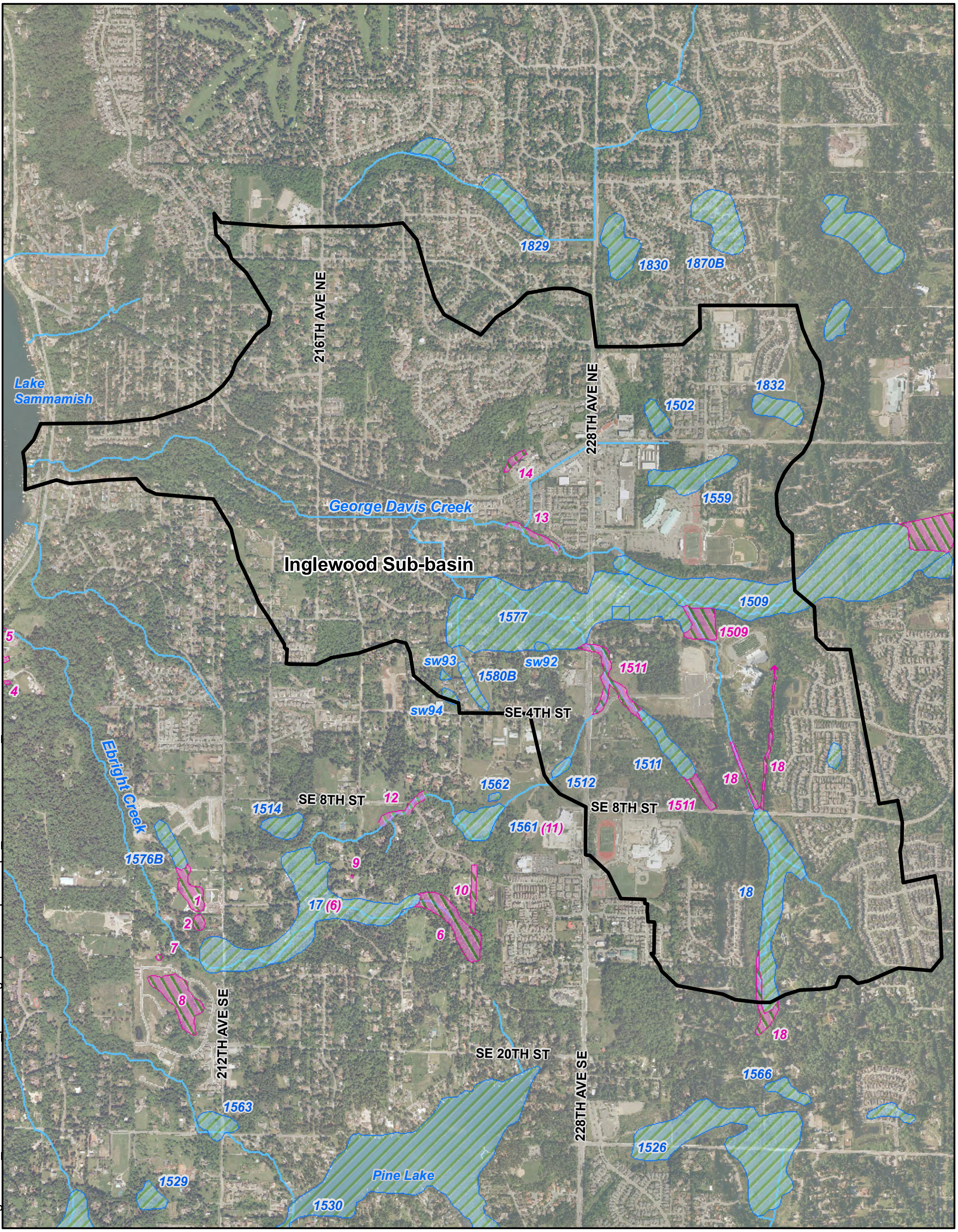
Wetlands in the Inglewood Sub-basin were evaluated during a limited field investigation from publicly accessible sites. Wetlands were assessed in the field using a quick assessment method; a proper delineation would be necessary to confirm wetland classifications and ratings. Wetland data forms are provided in Appendix B. Prior to the field visit the following documents were reviewed:

- Inglewood Sub-basin Plan (City of Sammamish 2005);
- City of Sammamish Town Center Sub-Area Plan Draft Environmental Impact Statement (DEIS) (City of Sammamish 2007);
- Sammamish Stormwater Comprehensive Plan (City of Sammamish 2001);
- Wetland data on the City of Sammamish Web site; and
- National Wetland Inventory Maps.

The eastern portion of the Inglewood Sub-basin is located within the Town Center Special Study area. Most of the wetlands in the Inglewood Sub-basin are located in the eastern portion of the sub-basin; therefore, most of the wetlands have been delineated and rated as part of the Town Center Sub-Area Plan. Wetland locations are shown in Figure 14. As stated in the Town Center Sub-Area Plan DEIS, there may be unmapped wetlands on private properties. Wetlands in the Inglewood sub-basin are listed in Table 4 below; however, they are described in more detail in the Town Center Sub-Area Plan (City of Sammamish 2007).

The Inglewood Sub-basin contains numerous wetlands and is dominated by a large wetland complex, which begins in the Bear-Evans Creek Sub-Basin and continues west to approximately 222nd Avenue just north of Main Street. As stated in the Town Center Sub-Area Plan DEIS (City of Sammamish 2007), this wetland complex is important for groundwater recharge, erosion and flood protection, and maintaining downstream water quality and fish habitat. Wetland 1509, the primary wetland in this complex, is a Category I wetland and contains forested, scrub-shrub, and emergent vegetation classes as well as a bog or fen. Wetland 1511 is also rated a Category I wetland. This wetland contains forested, scrub-shrub, emergent, and aquatic bed vegetation classes and provides excellent habitat due to its size, diversity, and interspersion of habitats (Table 4).

Wetlands 13, 18, 1511, 1512, 1580B, 1509, SW 91, and SW 96 are all connected by George Davis Creek or its tributaries. Other wetlands in the basin may also be connected but their connections were not seen during the limited site visits. Most of the smaller wetlands in the basin are depressional. Many of the wetlands are affected by residential and other large developments.



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Scale in Feet

Inglewood Sub-basin

Field Modified/Additional Wetlands

NWI/ City of Sammamish Mapped Wetlands

Figure 14
Inglewood Sub-basin Wetlands

Table 4. Inglewood Sub-basin Wetlands

Wetland Name[a]	Approximate Size (acres)	Characteristics	Cowardin Classification	Hydrogeomorphic Classification	Hydrology	Impacts	Mitigation Opportunities	Current Buffers	City of Sammamish (Quick Rating)
1509 (East Lake Sammamish 1509)	150	Wetland complex with bog; headwater tributary to George Davis Creek; high value wildlife habitat; partially in the Bear-Evans Basin	Forested, scrub-shrub, emergent	Depressional	Surface water, seasonally flooded/saturated, permanently flooded/saturated	Residential development, pipeline	Enhancement	Forested and grass lawn; Sammamish buffer is 215 feet	Category I (High)
1511 (East Lake Sammamish 11)	4.4	Wetland at headwater intermittent tributary to George Davis Creek; several man-made ponds	Forested, scrub-shrub, emergent, aquatic bed	Depressional, slope	Surface water	Residential development	Restoration	Forested, herbaceous-native, grass lawn; Sammamish buffer is 150 feet.	Category I (Moderate)
1577 (East Lake Sammamish 77)	1.6	Includes two headwater intermittent tributaries to George Davis Creek; site may be used by pileated woodpecker	Forested, scrub-shrub, emergent	Depressional, riverine, slope	Surface water, seasonally flooded/saturated	Road		Forested, herbaceous-native, grass lawn; Sammamish buffer is 100 feet.	Category I (special characteristics), Category II (functions) (Moderate)
1580B	1.1	Associated with intermittent tributary to George Davis Creek	Emergent	Depressional, riverine, slope	Surface water	Residential development, grazing/agriculture	Restore buffer	No buffer; Sammamish buffer is 50 feet	Category IV (Low)
SW91	0.03	Provides moderate habitat and water quality functions but no hydrologic functions	Emergent	Slope	Not assessed	Not assessed	Not assessed	Sammamish buffer is 50 feet	Category IV
SW92	0.3	Has a diversity of habitats and possibly provides habitat for pileated woodpecker	Forested, scrub-shrub, emergent	Depressional	Not assessed	Not assessed	Not assessed	Sammamish buffer is 50 feet	Category III
SW93	0.06	Provides moderate habitat value because of diversity of hydroperiods and vegetation. Part of a wetland complex associated with an intermittent stream.	Forested, scrub-shrub, emergent	Depressional	Not assessed	Not assessed	Not assessed	Sammamish buffer is 50 feet	Category III
SW94	0.4	Provides moderate habitat, water quality, and hydrologic functions.	Forested, scrub-shrub, emergent	Depressional	Not assessed	Not assessed	Not assessed	Sammamish buffer is 50 feet	Category III
SW96	0.01	Associated with intermittent stream	Forested, scrub-shrub, emergent	Depressional	Not assessed	Not assessed	Not assessed	Sammamish buffer is 100 feet	Category II
1502	>2	Provides excellent water quality functions and moderate habitat functions	Forested, scrub-shrub, emergent	Depressional	Groundwater	Residential development	Restoration	Forested and lawn grass for most of its circumference; Sammamish buffer is 100 feet.	Category II (Moderate)
1559 (East Lake Sammamish 59)	6.3	Provides moderate water quality, hydrologic, and habitat functions.	Forested, scrub-shrub	Depressional	Seeps, seasonally flooded/saturated	Residential development	Minimal	Forested for 1/2 of its circumference; Sammamish buffer is 75 feet.	Category II (Low)
1832 (Evans Creek #32, Llama Lake)		Provides moderate water quality and hydrologic functions and low habitat functions	Emergent, open water	Depressional	Groundwater, seasonally flooded/saturated	Residential development	Restoration	Forested and lawn grass; Sammamish buffer is 50 feet.	Category III (Low)
13		May be a stormwater feature created from construction of condos. South of Inglewood Hill Road	Emergent	Depressional					
14		At base of slope near Presbyterian Church north of Inglewood Hill Road	Emergent	Depressional	Seep, runoff	Residential development		Forested for 1/2 of its circumference	(Low)
18	17.2	Headwater tributary to George Davis Creek	Forested, scrub-shrub, emergent	Riverine	Surface water	Residential development	Restore artificial ponds; replant lawn with native vegetation	Buffer for 1/2 of its circumference	(High)

[a] If the wetland was previously named, this name was used. If the wetland was not named, wetlands were numbered beginning with 1 and ending with 18. Previous wetland names (e.g., Wetland 17) were not used to avoid two wetlands having the same name.

3.6 STREAM AND HILLSLOPE GEOMORPHOLOGY

In the early 1990s King County conducted field studies of George Davis Creek and the Inglewood Sub-basin. Results of these efforts are documented in the King County Basin and Nonpoint Action Plan for the East Lake Sammamish Basin (King County 1994) as well as the East Lake Sammamish Basin Conditions Report—Preliminary Analysis (King County 1990). The 2008 field efforts of Parametrix were compared to field notes collected by King County in the early 1990s. The King County evaluation occurred after a very large storm event in January 1990 that flooded East Lake Sammamish Parkway and caused extensive damage to the George Davis Creek channel downstream of 216th Avenue NE. The channel in this area is located in a forested ravine with very steep-sided slopes. Evidence of several landslides was observed by King County, and again by Parametrix, particularly on the south side of the ravine. In the intervening years since the King County study, a large restoration effort was conducted, with large woody debris and root wad structures installed in the stream channel at approximate 50- to 100-foot intervals. It appears that these structures serve to minimize downstream sediment movement from landslides and high flows.

One 12-inch-diameter stormwater discharge pipe was observed on the north hillside of George Davis Creek. This pipe has been tightlined down the hill and is equipped with an energy dissipator. Other smaller stormwater pipes were observed from individual residences on the south hillside. These pipes have all been tightlined to the stream channel to prevent hillslope erosion.

George Davis Creek flows intermittently and is fed by both surface flow and groundwater seepage. The channel appears to be in fairly stable condition, with the exception of an area just upstream of East Lake Sammamish Parkway adjacent to several residences. The creek is incised in this area ranging from 2.5 to 6 feet (Photograph 2).

Photograph 2. Incised stream channel adjacent to residence

Upstream of 216th Avenue NE, George Davis Creek and its tributaries consist of stream channels that are alternately straightened channels located adjacent to roads or residences and undefined channels associated with wetlands. The stream channel segments upstream of 216th Avenue NE are dry most of the year (Photograph 3).

Photograph 3. Dry streambed upstream of 216th Avenue NE

Appendix C summarizes conditions observed in 1990 and 2008, documented downstream to upstream. Appendix D provides a sequence of photographs of George Davis Creek, starting at the mouth and proceeding upstream. The photographs are representative of the general stream conditions in the various portions of the stream. Overall, the riparian buffers appear to be functioning properly and the stream channel is generally stable.

3.7 FISH HABITAT AND USE

George Davis Creek historically served as habitat for coho and sockeye salmon according to A Catalog of Washington Streams and Salmon Utilization (Williams et al. 1975). Aquatic habitat conditions were assessed by fish biologists during field reconnaissance surveys conducted on December 3 and 4, 2008. In general, habitat conditions between East Lake Sammamish Parkway and NE 6th Street could be considered good. This area has a very good riparian corridor, good supply of large woody debris (partially due to restoration efforts), and good quality of stream gravel. However, there are multiple fish passage barriers that prevent anadromous fish from using this reach and the supply of water is intermittent. The most downstream fish barrier is near the mouth of Lake Sammamish, where George Davis Creek is conveyed through a house in a concrete box structure. The downstream end of this barrier has been removed, with reconstruction of the house; however, the upstream pipe that conveys flow through another residential lot will not be replaced. The East Lake Sammamish Parkway crossing is also a fish passage barrier, consisting of several stormwater manholes and culverts. Just upstream of East Lake Sammamish Parkway is a 3.5-foot-tall concrete water diversion dam (no longer operational) that conveys water through holes in the wall (Photograph 4).

Photograph 4. George Davis Creek flow through old water supply diversion dam upstream of East Lake Sammamish Parkway

3.8 WATER QUALITY

No recent water quality samples have been collected for George Davis Creek. In the 2005 Inglewood Sub-basin Plan (Entranco 2005), it was reported that George Davis Creek is on Ecology's 303(d) Category 5 list for impaired waters due to elevated levels of fecal coliform bacteria. George Davis Creek is still on the 2008 303(d) list for fecal coliform bacteria (Ecology 2008).

4. RECOMMENDED STRATEGIES

Specific features that define the Inglewood Sub-basin and are important considerations in the development of projects and strategies are as follows:

Geology—The underlying geology in the Inglewood Sub-basin consists of compacted till and highly infiltrative recessional glacial outwash. The outwash serves a very important function in this basin, serving as a gigantic subsurface reservoir that recharges deeper groundwater aquifers and supplies flow to George Davis Creek and associated wetlands. It is important to minimize development of impervious surfaces on these highly infiltrative areas to protect the groundwater recharge capacity.

Wetlands—There are very high quality, large wetlands in the Inglewood Sub-basin that provide hydrologic functions of storing water and attenuating flood flows as well as providing diverse habitat for birds and other wildlife species. It is important to protect these areas for their critical functions.

Fish Passage Barriers—There are at least three fish passage barriers on George Davis Creek within the first 1/2 mile of Lake Sammamish. Despite relatively good fish habitat, these barriers represent a costly and unlikely restoration of anadromous fish populations to the lower reaches of George Davis Creek. In the 2005 Inglewood Sub-basin Plan, replacement of just one barrier at the East Lake Sammamish Parkway crossing was estimated to cost $1.5 million, with the availability of vacant parcels. Since 2005, the vacant parcels have been developed and there are no parcels available for stream realignment to allow for fish passage. The cost today to do this work would be significantly more and is not feasible. For this reason, the removal of these barriers is not recommended as part of this plan.

The projects and strategies recommended below are designed to preserve ecological function in areas that are currently functioning well, solve existing problems, and prevent future degradation as the Inglewood Sub-basin is further developed. Specific projects identified are presented in more detail in Appendix E.

4.1 PRESERVATION AND ENHANCEMENT OF ECOLOGICAL FUNCTION

The natural areas (George Davis Creek and associated wetlands) in the Inglewood Sub-basin are now largely protected through existing ordinances; however, past actions and developments have resulted in fish passage barriers and loss or degradation of wetlands. Still, the George Davis Creek riparian corridor and many of the associated wetlands are in very good condition. Through the City's Critical Areas Ordinance, areas adjacent to stream corridors and wetlands are protected with buffers up to 215 feet. It is important to enforce this ordinance and prevent encroachment of development into stream and wetland buffers to prevent future degradation.

The 2005 Inglewood Sub-basin Plan (Entranco 2005) recommended making the mouth of George Davis Creek fish passable. Given the extent of barriers in George Davis Creek and the availability of year-round flow, it is probably not worth the expense of providing fish passage in this stream when there are other projects that would result in greater benefits to fish and the natural resources.

Table 5 lists some strategies to preserve and enhance existing ecological function in the Inglewood Sub-basin. Full descriptions and planning level cost estimates are provided in Appendix E.

Table 5. Strategies to Preserve or Enhance Ecological Function in the Inglewood Sub-basin

Strategy	Project Identification	Type of Strategy: Planning	Education	Capital	Description	Potential Partners
Enhance Wetland 1509	Enh-1			X	Restore/enhance pasture area in Wetland 17	Private property owners, developers in need of potential mitigation, conservancy groups
Conduct wetland tours	Ed-1		X		Sponsor wetland tours to foster appreciation and stewardship of Sammamish wetlands	Audubon Society, non-profit environmental groups

4.1.1 Capital Project

4.1.1.1 Implement Wetland Enhancement

Washington State and federal regulatory agencies require that mitigation efforts follow the prescribed sequence below:

- Avoiding the impacts altogether by not taking a certain action or parts of an action.
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts.
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- Compensating for the impact by replacing, enhancing, or providing substitute resources or environments.
- Monitoring the impact and taking appropriate corrective measures.

In light of these requirements, preservation of existing wetlands is recommended, especially the wetland complex consisting of Wetlands 1509 and 1577. This can be done through enforcement of existing critical areas regulations (SMC 21A.50), outright purchase of properties, or establishment of conservation easements. Outright purchase of these properties is likely cost prohibitive; however, the City could consider using funds from their critical areas mitigation fee program (SMC 21A.50.360) to secure properties consistent with a watershed-based mitigation strategy. Alternatively, these projects could act as stand-alone watershed management projects. Mitigation opportunities are limited in the Inglewood sub-basin primarily because so much of it has recently been developed with inadequate protection of the wetlands and their buffers. Entire subdivisions and schools would need to be removed to make significant improvements to the watershed, which is impractical. In addition, due to the recent development a number of the wetlands and their buffers have been affected and mitigation has occurred. The areas that have already been subject to mitigation cannot be used for mitigation again. The City should also focus their efforts on ensuring these mitigation areas are successful, as well as effective enforcement of existing regulations including monitoring, contingency measures, and collection of bonds (SMC 21A.50.140 to 21A.50.190).

Because mitigation opportunities are limited, only one potential mitigation project is suggested. The proposed project is based on limited field observations from publicly accessible sites and photographic interpretation. Other mitigation opportunities likely exist. The proposed mitigation option would require a wetland delineation and further evaluation of the wetland for mitigation potential. Mitigation would require either purchase of the property, establishment of a conservation easement, and cooperation of the landowner.

4.1.2 Educational Strategy

4.1.2.1 Conduct Wetland Tours (Ed-1)

The Inglewood Sub-basin has some high quality wetlands that provide important ecological functions, including attenuation of stormwater runoff and habitat for terrestrial and aquatic species. One of the best ways to educate citizens about stewardship of their natural environment is to show them. Wetland tours that feature Wetlands 1509, 1511, and 1577 in the Inglewood Sub-basin, as well as other unique wetland environments on the Sammamish Plateau would be one way to promote environmental stewardship and increase understanding of the importance of wetlands.

4.2 REDUCE EFFECTS OF ONGOING STORMWATER DISCHARGES FROM EXISTING DEVELOPMENT

Three stormwater drainage problems were identified during this basin planning effort. Aside from these issues, there does not appear to be any significant flooding, stream channel erosion, or wetland elevation changes associated with stormwater discharges in the Inglewood Sub-basin. This may be due in part to the presence of highly infiltrative recessional outwash.

Table 6 lists projects to reduce the effects of ongoing stormwater discharges in Inglewood Sub-basin. Full descriptions and planning level cost estimates are provided in Appendix E.

Table 6. Projects to Reduce Ongoing Stormwater Impacts

Strategy	Project Identification	Type of Strategy			Description	Potential Partners
		Planning	Education	Capital		
NE 217th Street Road Drainage Modification	CIP-1			X	Modify road drainage to prevent flooding at adjacent residence.	None
228th Avenue NE Drainage Modification	CIP-2A or 2B			X	Modify discharge of stormwater runoff from road outfall to prevent downstream erosion and saturated conditions that appear to be causing trees to die.	None
NE 2nd Street Culvert Replacement	CIP-3			X	Replace damaged culverts at driveway crossing to prevent possible roadway flooding.	Property owner

4.2.1 Capital Strategies

4.2.1.1 NE 217th Street Road Drainage Modification (CIP-1)

This project involves modifying the drainage features on NE 217th Street, including installation of a curb to the road shoulder to direct water away from the residence that experiences flooding. Catch basins and pipes would be installed to collect and convey water from the east side of the road to the existing detention facility located downstream.

4.2.1.2 228th Avenue NE Drainage Modification (CIP-2)

This project involves modifying an existing drainage outfall located on the west side of 228th Avenue NE. Currently, the outfall discharges to an open channel on a steep slope and conveys water to the base of the hill where it pools and has resulted in saturated conditions that have killed several trees. This project consists of tightlining the stormwater runoff from the outfall to an existing pond.

4.2.1.3 NE 2nd Street Culvert Replacement (CIP-3)

This project involves the replacement of two 24-inch culverts and a 12-inch culvert that conveys George Davis Creek under a driveway on NE 2nd Street. The culverts are damaged and could result in flooding on NE 2nd. The culverts are sized appropriately and could be replaced with similar culverts of equivalent capacity.

4.3 PLAN FOR FUTURE IMPACTS AND MINIMIZE EFFECTS

The Inglewood Sub-basin will likely undergo changes in the next several decades, including development of the proposed Town Center and conversion of forested parcels to denser development in accordance with current zoning. Most of the parcels that can be expected to be developed over the next several decades are located in critical areas or within the Town Center. In these areas there are regulations and standards in place to require responsible management of stormwater to protect the resources. Stormwater management techniques and strategies are constantly evolving; currently, the regional emphasis is on low impact development to minimize the effects of stormwater runoff. This is the recommended approach for the Town Center (Parametrix 2009a), and is one of the only ways to mitigate stormwater volume resulting from land conversion.

The Town Center Comprehensive Stormwater Plan recommended using the LID techniques listed in Table 7 to mitigate stormwater runoff.

Table 7. Summary of Stormwater Treatment Requirements and Preferred Choices

Type of Impervious Surface	Treatment Required		First Choice	Second Choice	Third Choice
	Water Quality	Flow Control			
Rooftops		√	Rainwater Harvesting and Reuse	Green Roofs	Bioretention
Roads and Parking Lots	√	√	Minimize Surfaces	Bioretention	Pervious Pavement
Sidewalks and Patios		√	Pervious Pavement	Full Dispersion	Bioretention

The City of Sammamish has adopted an LID ordinance in which LID is provided incentives for new development. There has been little opportunity to test the effectiveness of this ordinance for encouraging use of LID because the economic slowdown of 2009 to 2010 has resulted in little to no development in the city. Whereas the LID ordinance is voluntary, LID will likely be mandatory (to the extent practical) in the Town Center (City of Sammamish Town Center Draft Comprehensive Stormwater Plan, 2010).

In addition to the use of technical methods to accomplish stormwater management goals, such as LID, there are other implementation mechanisms that could be explored in the future. Some of these implementation strategies are described in the Draft Non-Traditional Stormwater Approaches Memorandum (Parametrix 2009b).

Maintenance of the recessional outwash infiltration area is important because this helps ensure a stable flow regime in George Davis Creek. The critical aquifer recharge areas designated in the Critical Areas Ordinance coincide with these outwash areas. The ordinance requires that 75 percent of stormwater volume generated from development in these areas is infiltrated. This requirement should be enforced through the development review process.

Several programmatic strategies were recommended in the 2005 Inglewood Sub-basin Plan (Entranco 2005), including the following:

- Maintain Current Detention Standards;
- Encourage Widespread Use of Low Impact Development Techniques;
- Maintain Hydraulic Connectivity to Infiltration Areas;
- Map Infiltration Areas;
- Identify Potentially Flood-Prone Properties;
- Improve Wetland Maps;
- Preserve Infiltration Areas as a Natural Resource;
- Encourage Public Education and Outreach Programs;
- Reduce Phosphorus to Lake Sammamish;
- Remove Solids for Protection of Infiltration Areas;
- Limit Livestock Access to Creeks;
- Install Flow Gauges in the Upper Basin; and
- Investigate Sources of Fecal Coliform Bacteria.

An assessment of these strategies and current recommendations is shown in Table 8. No additional strategies or projects are recommended at this time to address future impacts.

Table 8. Previously Recommended Strategies to Plan for and Reduce Effects of Future Stormwater Runoff

Strategy	Purpose	Current Relevance	Concur with Recommendation?
Maintain Current Detention Standards	Reduce flooding potential throughout the basin, limit impacts to stream channels.	Although there are few flooding problems and little evidence of stream channel erosion due to high flows, current flow control standards should be maintained so that problems do not arise if the infiltration	Yes

Table 8. Previously Recommended Strategies to Plan for and Reduce Effects of Future Stormwater Runoff (continued)

Strategy	Purpose	Current Relevance	Concur with Recommendation?
		capacity of the outwash soils is exceeded.	
Encourage Widespread Use of Low Impact Development Techniques	Use on-site infiltration techniques to reduce sizes of traditional facilities and recharge aquifers.	The City is encouraging the widespread use of LID techniques through its LID ordinance, and demonstration projects such as the use of pervious pavement at City Hall.	Yes
Maintain Hydraulic Connectivity to Infiltration Areas	Provide opportunities for infiltration by maximizing use of open conveyance systems that are unlined.	Much of the stormwater infrastructure in the Inglewood Sub-basin consists of open conveyance systems. Continue using open systems where possible.	Yes
Map Infiltration Areas	Understanding the best infiltration areas will facilitate better protection and/or use of these areas for stormwater management.	Areas of existing infiltration areas are based on geologic maps prepared by the USGS. Geotechnical reports for projects in the area match geologic units mapped by the U.S. Geological Survey (USGS). This level of detail should be sufficient for planning-level stormwater management. Site-specific investigations should be done at the time of project development.	No
Identify Potentially Flood-Prone Properties	Know in advance what properties are likely to flood due to exceedance of infiltration capacity in outwash.	Unless there have been specific problems associated with infiltration capacities being exceeded, this would be difficult to evaluate without a detailed subsurface evaluation.	No
Reduce Phosphorus to Lake Sammamish	Improve water quality in Lake Sammamish through enhanced stormwater treatment that removes phosphorus	Phosphorus removal should be more focused on the lower portion of the basin, because much of the stormwater runoff in the upper part of the basin infiltrates and effectively removes phosphorus.	Yes
Remove Solids for Protection of Infiltration Areas	Removal of large sediment from runoff will help preserve beneficial function of outwash soils for infiltration.	Construction requirements for temporary sediment and erosion control and stormwater facility pre-treatment requirements target removal of sediment. Regular inspection of construction sites and stormwater facilities should be done to identify and correct problems.	No, already done
Limit Livestock Access to Creeks	Limit livestock access to stream channels to prevent sedimentation and fecal coliform bacteria pollution.	Very few livestock were observed in this basin. Confirm if this is a current problem.	No, unless this is still a problem
Install Flow Gauges in the Upper Basin	Recording flows in the outwash area will provide a better understanding of infiltration capacity.	Gauges have not been installed, but would add valuable information.	Yes
Investigate Sources of Fecal Coliform Bacteria	Identification of fecal coliform sources will help target reductions.	It is not known whether fecal coliform bacteria is still a problem in George Davis Creek because the water quality data are old. Source tracing is costly and unreliable.	No
Improve Wetland Maps	More accurate wetland maps are important for	The wetland maps should be updated because delineations are only valid	Yes

Table 8. Previously Recommended Strategies to Plan for and Reduce Effects of Future Stormwater Runoff (continued)

Strategy	Purpose	Current Relevance	Concur with Recommendation?
	enforcement of CAO requirements and protection of these resources.	for 5 years and the existing wetland information appears to be out of date.	
Preserve Infiltration Areas as a Natural Resource	Protection of the infiltration capacity of the outwash in the basin will preserve this natural resource and help maintain moderate flows to downstream reaches.	Most of the undeveloped infiltration areas are also designated as critical areas that have additional requirements for stormwater management. The City should evaluate whether the areas identified in the 2005 Inglewood Sub-basin Plan are adequately protected with ordinances.	Yes, unless adequate protection already exists
Encourage Public Outreach and Education Programs	Work with land owners to achieve a positive outcome beneficial to George Davis Creek.	The City is required to do public outreach and education as part of its NPDES Phase II permit. Inglewood Sub-basin could be targeted for certain types of education.	Yes

5. PROJECT PRIORITIZATION

The projects recommended above represent solutions to existing problems in the Inglewood Sub-basin. Many of the recommended projects would be eligible for grant funding. Parametrix prioritized the projects using several criteria, including (1) likelihood of success at achieving the desired outcome, (2) degree to which project meets multiple objectives, (3) degree to which project alleviates threats to wildlife and habitat or property, and (4) cost.

5.1 CRITERIA

Table 9 lists the criteria and rank the scores associated with a high, medium, or low ranking for each criterion.

Table 9. Criteria and Scoring for Project Prioritization

	Rank scores		
Criteria	**High (5 points)**	**Medium (3 points)**	**Low (1 point)**
Likelihood of Success	Proven in other cases	Mixed results in other cases	Unproven
Number of Issues Addressed	More than three	Two to three	One
Protection of Habitat	Protects both habitat and property	Protects habitat or property	Protects neither
Cost Category (first 5 years)	< $20,000	($20,000 – $50,000)	(> $50,000)

The combined scores of individual criteria were ranked according to the following scores:

Low priority (6 to 8 total points)

Medium priority (10 to 12 total points)

High priority (over 12 total points)

5.2 MATRIX OF PROJECTS

Table 10 lists the recommended projects that would preserve ecological function, provides proposed costs, and ranks the priority for project implementation.

Table 10. Matrix of Recommended Projects

Strategy	Project Identification	Type of Strategy: Planning	Type of Strategy: Education	Type of Strategy: Capital	Description	Potential Partners	Cost	Project Criteria: Likelihood of Success	Project Criteria: Number of Issues Addressed	Project Criteria: Protects Habitat	Project Criteria: Cost	Priority
Conduct Wetland Tours	Ed-1		X		Sponsor wetland tours to foster appreciation and stewardship of Sammamish wetlands.	Audubon Society, non-profit environmental groups	$6,000	L	L	L	H	Low
NE 217th Street Road Drainage Modification	CIP-1			X	Improve road drainage to reduce flooding to neighboring residence.	None	$59,000	H	L	L	L	Low
228th Avenue NE Stormwater Discharge Modification	CIP-2			X	Modify stormwater outfall discharge from 228th Avenue NE to reduce erosion and saturated conditions.	None	$55,000 - $78,000	H	M	M	L	Medium
NE 2nd Street Culvert Replacement	CIP-3			X	Replace culverts at NE 2nd Street driveway.	None	$40,000	H	L	L	H	Medium

6. REFERENCES

City of Sammamish. 2003. City of Sammamish Comprehensive Plan. Adopted September 16, 2003. Updated August 2006 per Ordinance No. 02003-130.

City of Sammamish. 2007. City of Sammamish Town Center Sub-Area Plan DEIS.

City of Sammamish. 2009. City of Sammamish Town Center Draft Comprehensive Stormwater Plan. Prepared by Parametrix. October 2009.

Ecology (Washington State Department of Ecology). 2008. Water Quality Assessment 303(d) list approved by EPA on January 29, 2009. Accessed at: http://www.ecy.wa.gov/programs/wq/303d/2008/index.html.

Entranco. 2005. City of Sammamish Inglewood Sub-basin Plan. Bellevue, Washington. February 2005.

Hong West and Associates, Inc. 1996. Geotechnical Study: Proposed 228th Avenue Issaquah-Pine Lake Road, King County, Washington. Prepared for Tams Consultants Inc. Available from Geomap NW.

King County. 1990. East Lake Sammamish Basin Conditions Report—Preliminary Analysis. King County Surface Water Management Division. Seattle, Washington. September 1990.

King County. 1994. Final East Lake Sammamish Basin and Nonpoint Action Plan. Report prepared by the Issaquah/East Lake Sammamish Watershed Management Committee. King County Lead Agency.

King County. 1995. East Lake Sammamish Basin and Nonpoint Action Plan Annual Report, 1994 water year. King County Department of Public Works, Surface Water Management Division. Seattle, Washington.

Leisch, B.A., C.E. Price, and Kenneth L. Walters. 1963. Geology and Groundwater Resources of Northwestern King County, Washington. Washington Division of Water Resources Water Supply Bulletin No. 20. Prepared in cooperation with U.S. Geological Survey.

Nelson, David, and Associates, Inc. 1987. Geotechnical Evaluation, Lancaster Ridge, King County, Washington. Prepared for Lakeridge Development Corporation, Bellevue, Washington. Available from Geomap NW.

Parametrix. 2009a. Comprehensive Stormwater Master Plan. Prepared for the City of Sammamish. Bellevue, Washington.

Parametrix. 2009b. Draft Non-traditional Stormwater Approaches Memorandum. Bellevue, Washington.

Sammamish Plateau Water and Sewer District. 2003. Wastewater Comprehensive Plan. Volume 1 Report. Draft Approved for Distribution. October 2003.

Soil Conservation Service. 1973. Soil Survey of King County Area, Washington.

Terra Associates, Inc. 1995. Geotechnical Report—Site No. 61, Elementary School, Lake Washington School District #414, King County, Washington. Prepared for Lake Washington School District. Available from Geomap NW.

Terra Associates, Inc. 1998. Preliminary Geotechnical Report—Lein Plat, 228th Avenue SE and SE 3rd Street Right-of-way, King County, Washington. Prepared for Doneshvar & Associates, Kirkland, Washington. Available from Geomap NW.

Terra Associates, Inc. 1999. Subsurface Exploration, Skinner North Gravity Interceptor, Sammamish, Washington. Prepared for Pacific Properties, Inc., Bellevue, Washington. Available from Geomap NW.

Turney, G.L., S.C. Kahle, and N.P. Dion. 1995. Geohydrology and Ground-water Quality of East King County, Washington. Water Resources Investigations Report 94-4082. Prepared in cooperation with Seattle-King County Department of Public Health, Tacoma, Washington.

USGS (U.S. Geological Survey). 2006. Geologic Map of the Issaquah 7.5' Quadrangle, King County, Washington by Derek B. Booth, Timothy J. Walsh, Kathy Goetz Troost, and Scott A. Shimel.

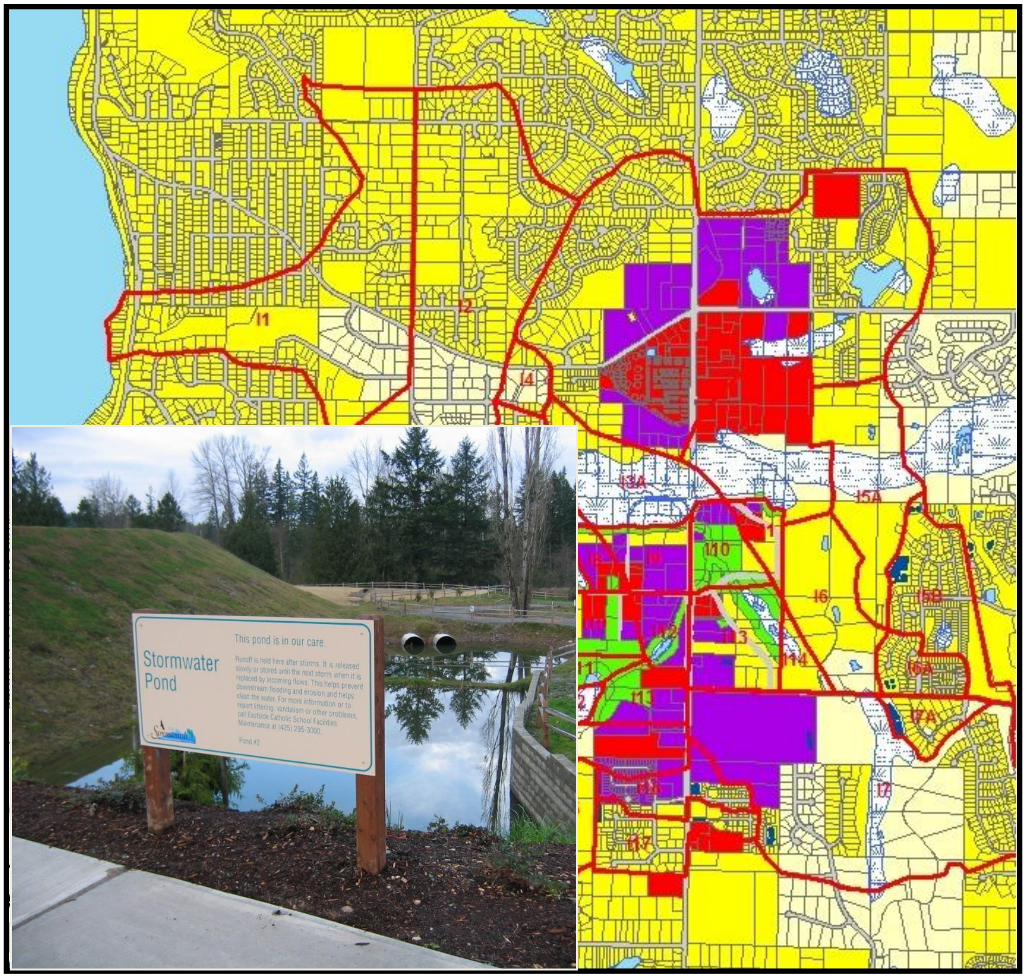
Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A Catalog of Washington Streams and Salmon Utilization. Volume 1—Puget Sound. Washington Department of Fish and Wildlife. Olympia, Washington.

WSDOH (Washington State Department of Health). 2011. Water Facilities Inventory (WFI) Form. System ID No. 409009, System Name: Sammamish Plateau Water & Sewer.

APPENDIX A

Hydrologic Modeling Report

Hydrologic Analysis of the Inglewood Basin, Thompson Basin and Sammamish Town Center Using the HSPF Model



Prepared for

The City of Sammamish

by

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December 8, 2009

Hydrologic and Hydraulic Analysis of Inglewood Basin, Thompson Basin, and Sammamish Town Center Using the HSPF Model

Prepared for

The City of Sammamish

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The engineering analyses and technical material presented in this report were prepared under the supervision and direction of the undersigned professional engineer.

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Bruce Barker

Bruce Barker, P.E.

EXECUTIVE SUMMARY

This report documents the development of hydrologic models used in the analysis of the Inglewood Basin, Thompson Basin, and Sammamish Town Center. The models were developed to quantify the runoff conditions in the two principal streams; George Davis and Ebright creeks under historic, current, and future land use. In addition, the models were used to analyze the effectiveness of stormwater controls at mitigating the increased runoff associated with future development in the basins.

Two hydrologic models were used in the analysis; the Hydrological Simulation Program-Fortran (HSPF) model and MGSFlood. HSPF has been used extensively in the Puget Sound region over the past 20 years for stormwater analysis. The HSPF model input was originally developed by King County as part of East Lake Sammamish Basin Plan in the mid 1980's and subsequently updated by the City of Sammamish for the Inglewood Basin Plan in 2004. The model input was updated and refined for the current study and recalibrated to streamflow data collected over a 20 month period from October 2001 through May 2003. HSPF model input and calibrated parameters were used in MGSFlood to analyze mitigation alternatives that included stormwater detention and Low Impact Development (LID).

The Inglewood Basin encompasses approximately 1640 acres (2.6 square miles) of suburban land in the City of Sammamish tributary to George Davis Creek. The geology in the central portion of the watershed is composed of highly infiltrative glacial outwash deposits. The outwash infiltrates the majority of surface flow produced in the upper parts of the watershed and results in little or no flow in the stream immediately upstream of the ravine. The stream intersects the groundwater table in the ravine and receives the majority of flow via groundwater discharge in this area. The groundwater discharge also produces year around base flow in the lower reaches of the stream. The outwash deposit infiltrates and stores runoff from the upper watershed and is equivalent to approximately 7,000 acre-feet of stormwater detention storage. Flows in the lower stream reaches are relatively low (attenuated) during floods because of the storage that occurs in the outwash deposit.

The Thompson Basin is located adjacent to the Inglewood basin and drains 800 acres (1.3 square miles) of suburban land via Ebright Creek. The Thompson Basin does not have the same infiltrative outwash deposit as the Inglewood basin, but does have a large wetland (Wetland 17) situated at the top of the ravine. This 30 acre wetland provides substantial flood attenuation and buffering of flows entering from the uplands before discharging to the ravine.

Historic (forested), existing, and future build-out conditions were simulated with the hydrologic models, and flood peak and flow duration statistics were computed. Little or no increases in runoff rates relative to existing conditions were predicted under the mitigated future land use scenario for the Inglewood Basin. In the Thompson Basin, future peak flow rates were predicted to decrease relative to existing conditions. These results show that stormwater mitigation designed according to the City's stormwater detention standard, which seeks to control runoff rates and durations to forested conditions, is effective at mitigating increased runoff associated with development. Because of this, the rates of erosion and flooding should not increase in the future and in most areas of the Thompson Basin, may actually decrease provided that the facilities are properly designed, constructed, and maintained.

The report includes the following recommendations to maintain a stable flow regime to ensure the health of the stream system in the future:

- Maintenance of Outwash Infiltration Areas – The glacial outwash deposit in the central part of the Inglewood Basin is currently infiltrating the majority of surface runoff from the upper watershed. Maintaining the infiltration function of this area is critical to ensuring a stable flow regime and the health of the stream. In addition, infiltration of urban runoff should be encouraged wherever feasible in the Thompson watershed.

- On-Site Detention Standard – The City's proposed detention standard, which is consistent with the 2005 Ecology Stormwater Management Manual, is effective at mitigating the increased potential for flooding and erosion associated with development. Stormwater detention facilities designed according to this standard are large and often expensive to construct. Low Impact Development (LID) methods provide a means to reduce the rate and volume of runoff associated with development, and increases the amount of potential groundwater recharge. LID methods can reduce the size of detention facilities, or replace them altogether. LID methods should be encouraged to the greatest extent practical for new construction in the Inglewood and Thompson Basins.

- Streamflow Monitoring – Streamflow gages have been operated and maintained by a private contractor in the past at the mouth of George Davis and Ebright creeks. These gages should be reestablished and the data collected from them quality checked and validated on an on-going basis.

TABLE OF CONTENTS

Hydrologic Analysis of the Inglewood Basin, Thompson Basin, and Sammamish Town Center

INTRODUCTION

This report presents findings of a hydrologic analysis of the Inglewood and Thompson Basins in the City of Sammamish. The analysis was performed using the Hydrological Simulation Program Fortran[1] (HSPF) and MGSFlood[2] hydrologic models. The purpose of the analysis was to determine streamflow magnitude-frequency and flow duration statistics at locations of interest in the watersheds under existing and future land use, and determine the effectiveness of mitigation alternatives.

The proposed Sammamish Town Center project, which consists of approximately 208 acres of residential and commercial development, straddles the Thompson/Inglewood basin divide. MGSFlood model and input was developed for historic, existing and future land use. MGSFlood includes routines for quickly analyzing mitigation alternatives including detention and Low Impact Development (LID) techniques.

HSPF MODEL ANALYSIS APPROACH

SUBBASIN DELINEATION INGLEWOOD BASIN/GEORGE DAVIS CREEK

The Inglewood Basin encompasses approximately 1640 acres (2.6 square miles) of suburban land in the City of Sammamish. The principal stream in the Inglewood Basin is named George Davis Creek. The creek originates at a wetland area on the Sammamish plateau and drops approximately 400 feet in three miles to Lake Sammamish (Figure 1).

HSPF model input for the watershed was developed by the USGS[3] and utilized by King County as part of the 1991 East Lake Sammamish Basin Plan[4]. The model was updated in 2004 for the Inglewood Basin Plan Update[5]. The model input was modified in the current analysis to reflect changes in land use that have occurred since 2004, and additional subbasins were added for the analysis of the Sammamish Town Center.

SUBBASIN DELINEATION THOMPSON BASIN/EBRIGHT CREEK

The Thompson Basin is located south of Inglewood and receives runoff from approximately 800 acres (1.25 square miles) of suburban land. The principal stream is Ebright Creek, which originates on the Sammamish plateau and discharges to Lake Sammamish (Figure 1).

HSPF model input for the watershed was developed by the USGS[3] and utilized by King County as part of the 1991 East Lake Sammamish Basin Plan[4]. The model was updated as part of the current analysis to reflect changes in land use, include additional subbasins, and update routing hydraulics.

SUBBASIN DELINEATION TOWN CENTER

The proposed Sammamish Town Center is a commercial and residential development that encompasses approximately 208 acres in the headwaters of both the Thompson and Inglewood basins (Figure 1). Decisions on flow control standards and mitigation alternatives will affect the streams and wetlands in both the Thompson and Inglewood Basins. The subbasin delineation for the Town Center was based on local topography and the 2008 Town Center Plan[5], which defined land use throughout the Town Center Complex. Subbasins delineated for the Town Center are shaded in Figure 1.

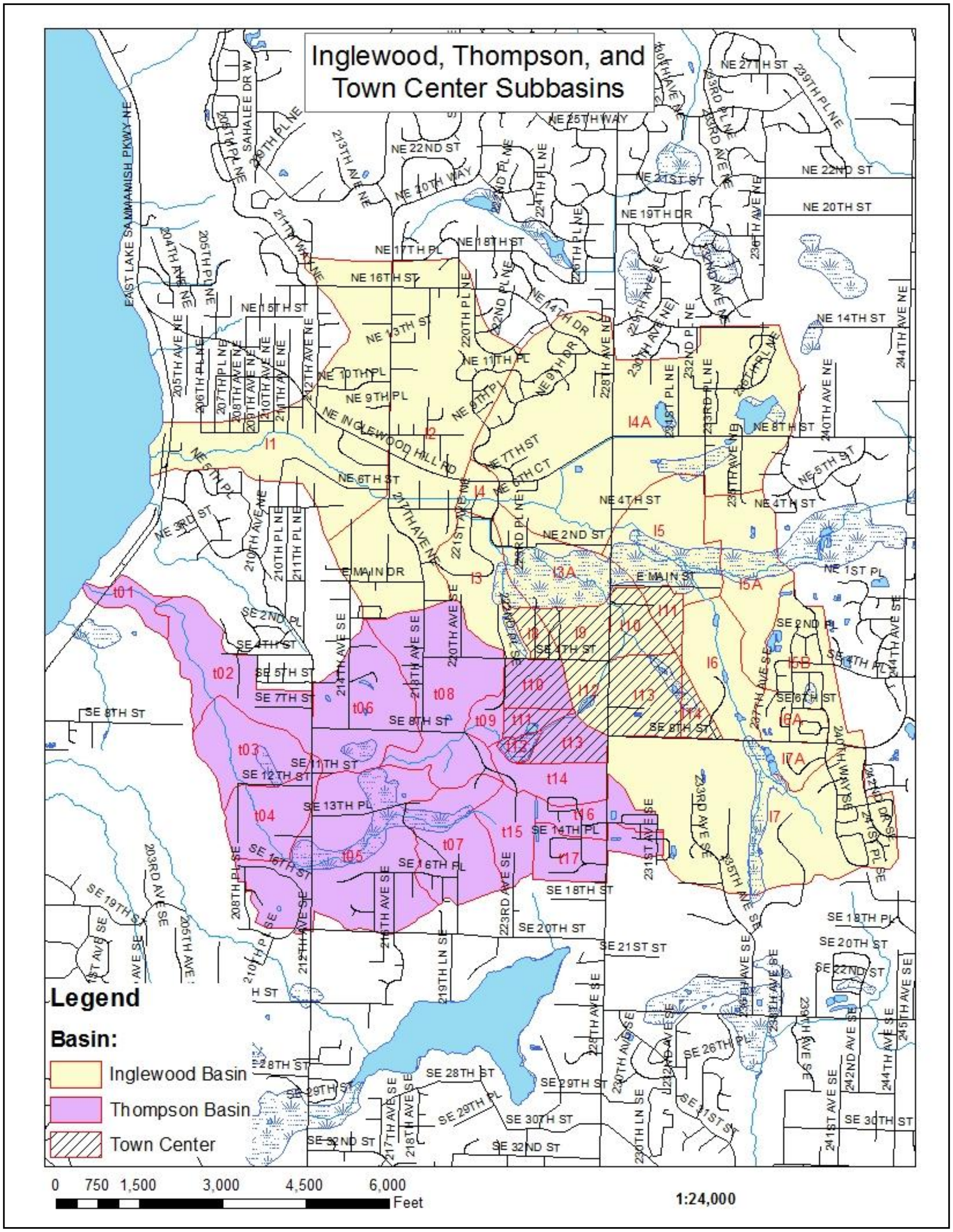


Figure 1 – Inglewood Basin, Thompson Basin and Town Center Subbasins

LAND USE SCENARIOS ANALYZED

Three land use scenarios were analyzed; historic conditions, existing land use, and future build-out. Each scenario is summarized in the sections below.

Historic Land Use

Historic land use was analyzed to provide an assessment of conditions in the watershed prior to any development or land use alterations by humans. The scenario was developed by replacing all land covers except for wetlands in the existing land use scenario with forest. All constructed stormwater control facilities are also assumed to be removed. This scenario is useful for estimating what the hydrologic conditions were that led to the formation of the streams.

Existing Land Use

Existing land use was developed based on aerial photos taken in 2006. Land use was defined based on the categories shown in Table 1. The existing land use coverage is shown in Figure 2. Significant existing stormwater detention facilities were included in this scenario. In addition, this scenario was used in hydrologic model calibration to ensure that simulated runoff matched recorded data.

Future Land Use

The future land use scenario was developed based on current zoning and the Town Center Plan[5]. Each land use zone was assigned to one of the hydrologic land uses defined in Table 1 resulting in the Future Land Use Coverage shown in Figure 3. This scenario represents future build-out conditions in the watershed and is the most severe hydrologic condition. Stormwater flow control measures were included for areas that increased in development density relative to existing conditions.

Land Cover Categories

Four land cover categories were considered in analyzing the watershed hydrology: forest, grass, wetland, and impervious. The percentage of each cover allocated to the mapped land uses are shown in Table 1. The effective impervious surface areas were determined based on relationships with mapped impervious surface developed by Sutherland[6] and Dinicola[7].

Table 1 – Land use and Percentage of HSPF Cover Categories

Land Use Code	Land Use	Effective Impervious	Grass	Forest	Wetland
C	Commercial/Industrial	85%	15%	0%	0%
MF	Multi-Family	48%	52%	0%	0%
H	High Density Residential	23%	75%	0%	0%
L	Low Density Residential	10%	90%	0%	0%
RF	Rural Residential Forest	4%	0%	96%	0%
RG	Rural Residential Grass	4%	0%	0%	0%
G	Grass	0%	100%	0%	0%
F	Forest	0%	0%	100%	0%
W	Wetlands/Open Water	0%	0%	0%	100%

The area within each subbasin was classified into areas of common land cover and geologic/soil type, called *PERLNDS*. The HSPF and MGSFlood models compute the hydrologic response of each PERLND within a subbasin on a per-unit-area basis and proportions the amount of surface runoff, interflow and groundwater entering the stream within each subbasin consistent with the PERLND area total for the subbasin.

The area of each category under forested, existing, and future build-out conditions for each basin is summarized in Appendix A.

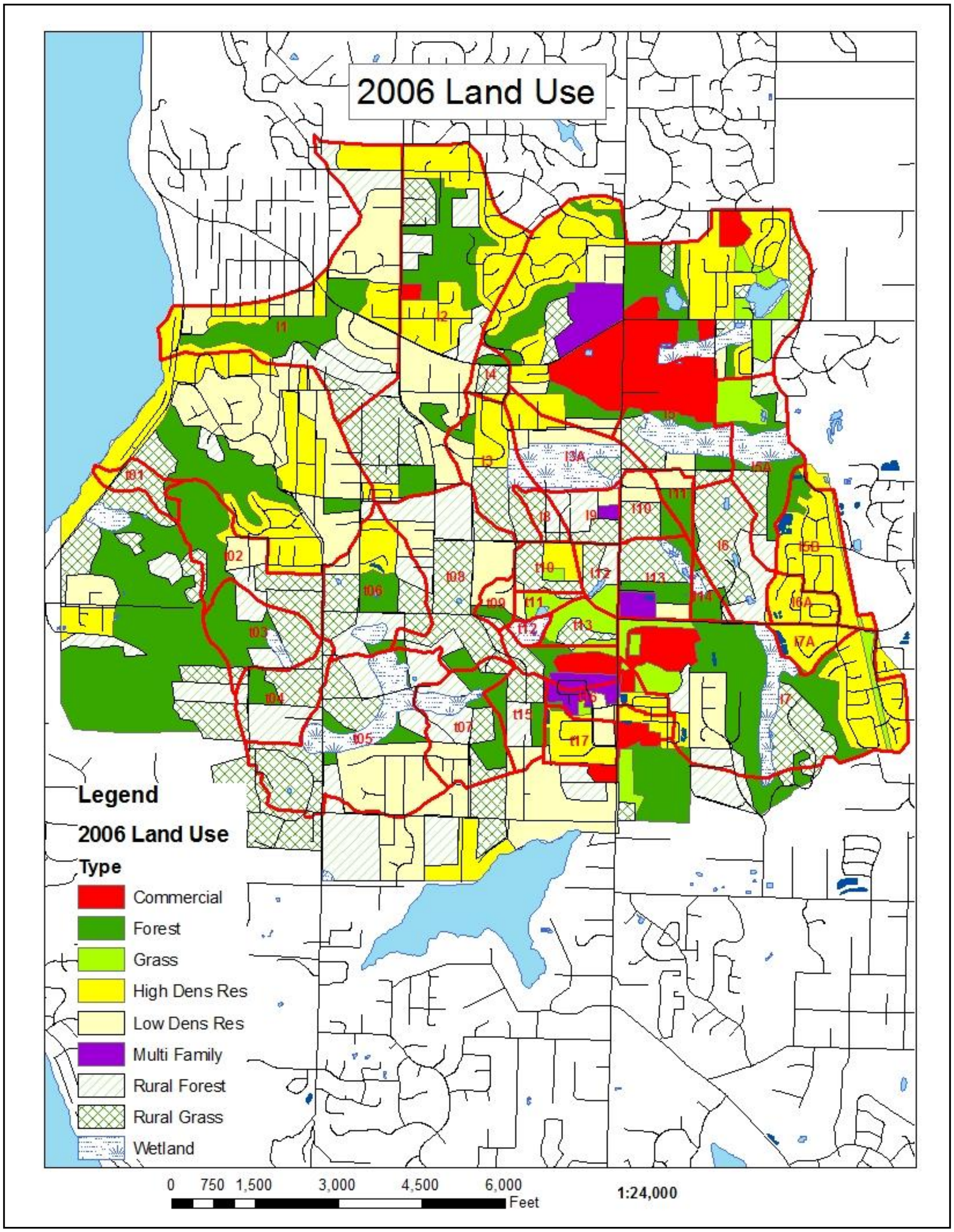


Figure 2 – Inglewood and Thompson Basins, Existing Land Use (2006)

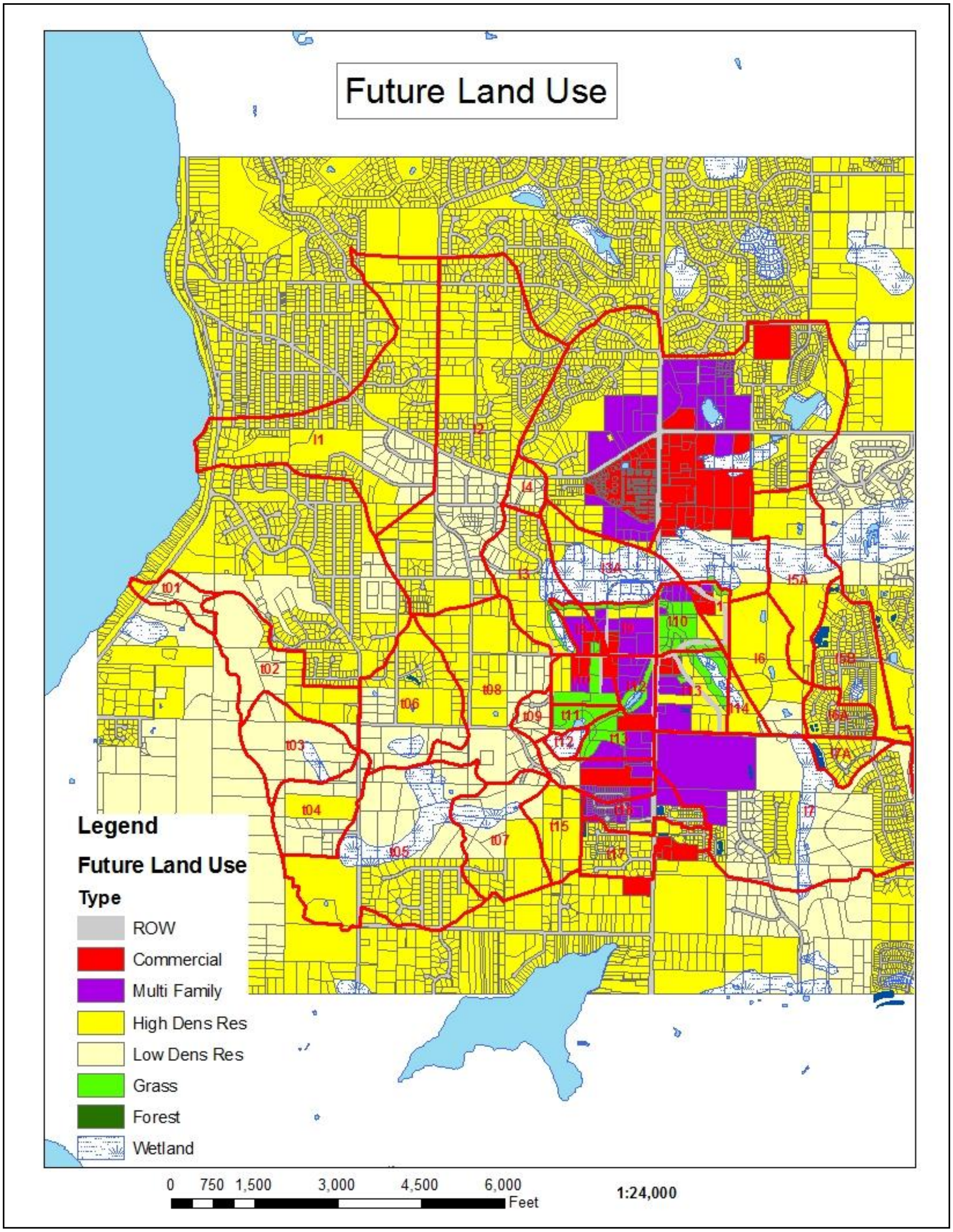


Figure 3 – Inglewood and Thompson Basins, Future Land Use, Developed from City of Sammamish Zoning and Town Center Plan

GEOLOGY

The Inglewood Basin consists of a broad till-capped plateau drained by gently sloping channels. The watershed geology was obtained from King County Department of Natural Resources[8] (Figure 4). The main stream channel flows across recessional outwash deposits incised into the till. Runoff generated on the adjacent till areas must migrate through the outwash before reaching the stream channel. In locations where the perched water table remains near the surface, several wetlands have formed. In the central portion of the watershed (Subbasins I2, I3, and I4), the groundwater is relatively deep, and the stream channel remains dry the majority of the time. Downstream of this point, the stream flows through an incised ravine and drops approximately 300 feet in less than a mile to Lake Sammamish. The lower stream reaches in Subbasin I1 receive discharge from the regional groundwater, which provides a reliable source of base flow to the stream throughout the year.

The Thompson basin is similar to Inglewood in that it originates in uplands of the Sammamish Plateau and drains through a ravine to Lake Sammamish. The lower reaches of the stream also intersect the regional groundwater table, which supports a nearly constant base flow. The Thompson Basin differs geologically from Inglewood in that it does not have a deep outwash deposit that infiltrates runoff upstream of the ravine. The runoff response in Ebright Creek is dominated by a surface and interflow response, similar to many other watersheds in the Puget Lowland that are underlain by glacial till .

For hydrologic modeling purposes, each geologic association in the watershed was assigned to one of three categories; till, outwash, or wetland according to the HSPF modeling methodology developed by the USGS[3,7]. These were combined with surface cover categories consisting of urban grass, forest, wetland/saturated soils, and impervious to form the PERLND groups shown in Table 2.

Table 2 – HSPF Land Cover/Geology (PERLND) Combinations

HSPF PERLND	Land Characteristics
Till Forest	Glacial till soils mature cover, all slopes
Till Urban Grass	Glacial till soils urban grass, all slopes Includes impervious surfaces not directly connected to the drainage network.
Outwash Forest	Glacial outwash soils mature cover, all slopes
Outwash Urban Grass	Glacial outwash soils urban grass, all slopes. Includes impervious surfaces not directly connected to the drainage network.
Wetland/Saturated Soils	Wetlands or areas with saturated soils
Impervious (HSPF IMPLND)	Impervious surfaces that are directly connected to the drainage network.

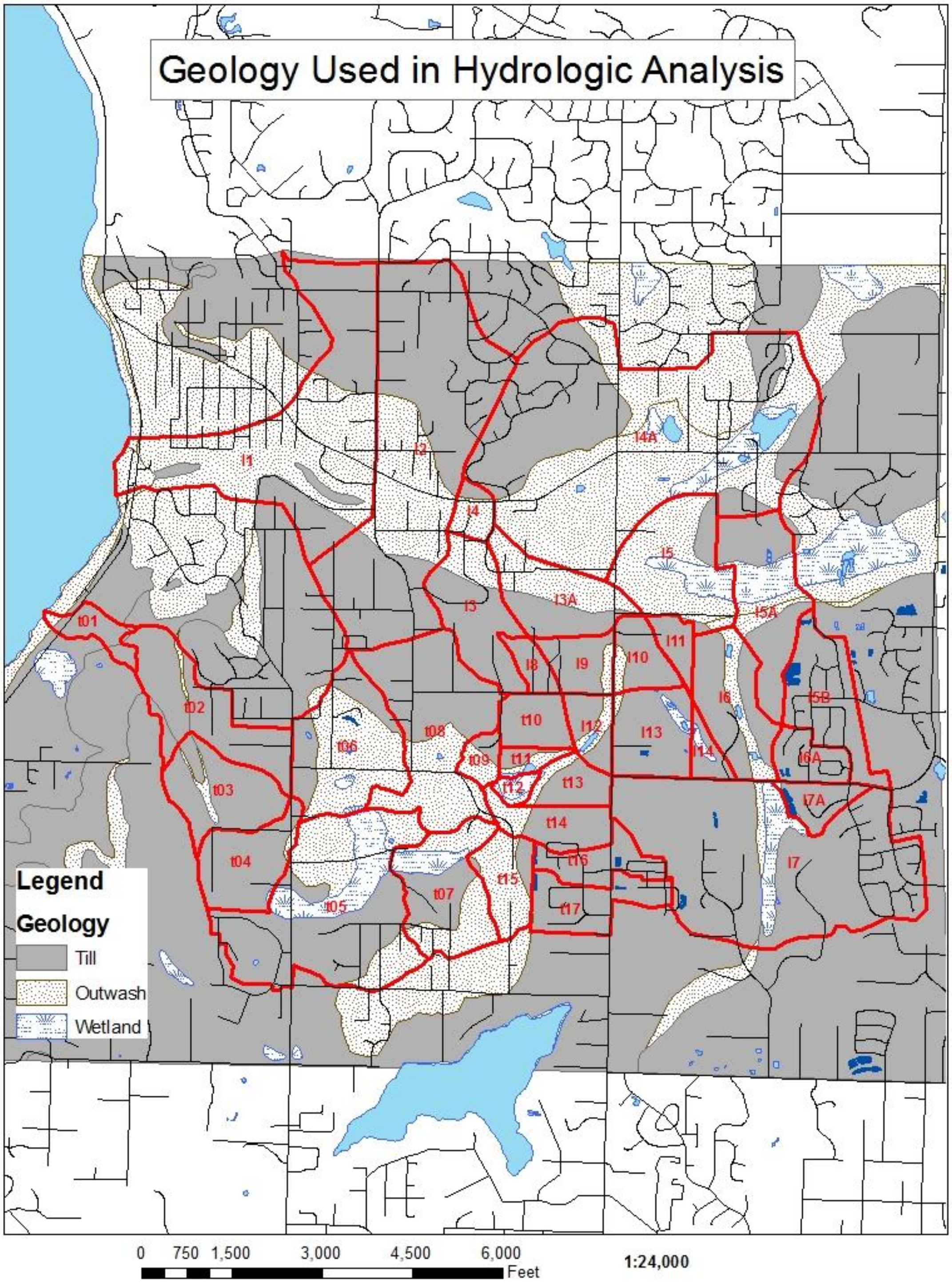


Figure 4 – Inglewood and Thompson Basins Geology as Defined for HSPF and MGSFlood Models

HSPF MODEL CONFIGURATION

INGLEWOOD BASIN

The geology of the Inglewood Basin consists of till in the uplands with glacial outwash in the ravine that carries the stream channel. Surface runoff and interflow produced in the upland till areas is infiltrated as it flows across the outwash deposit and results in a markedly attenuated runoff response from the watershed.

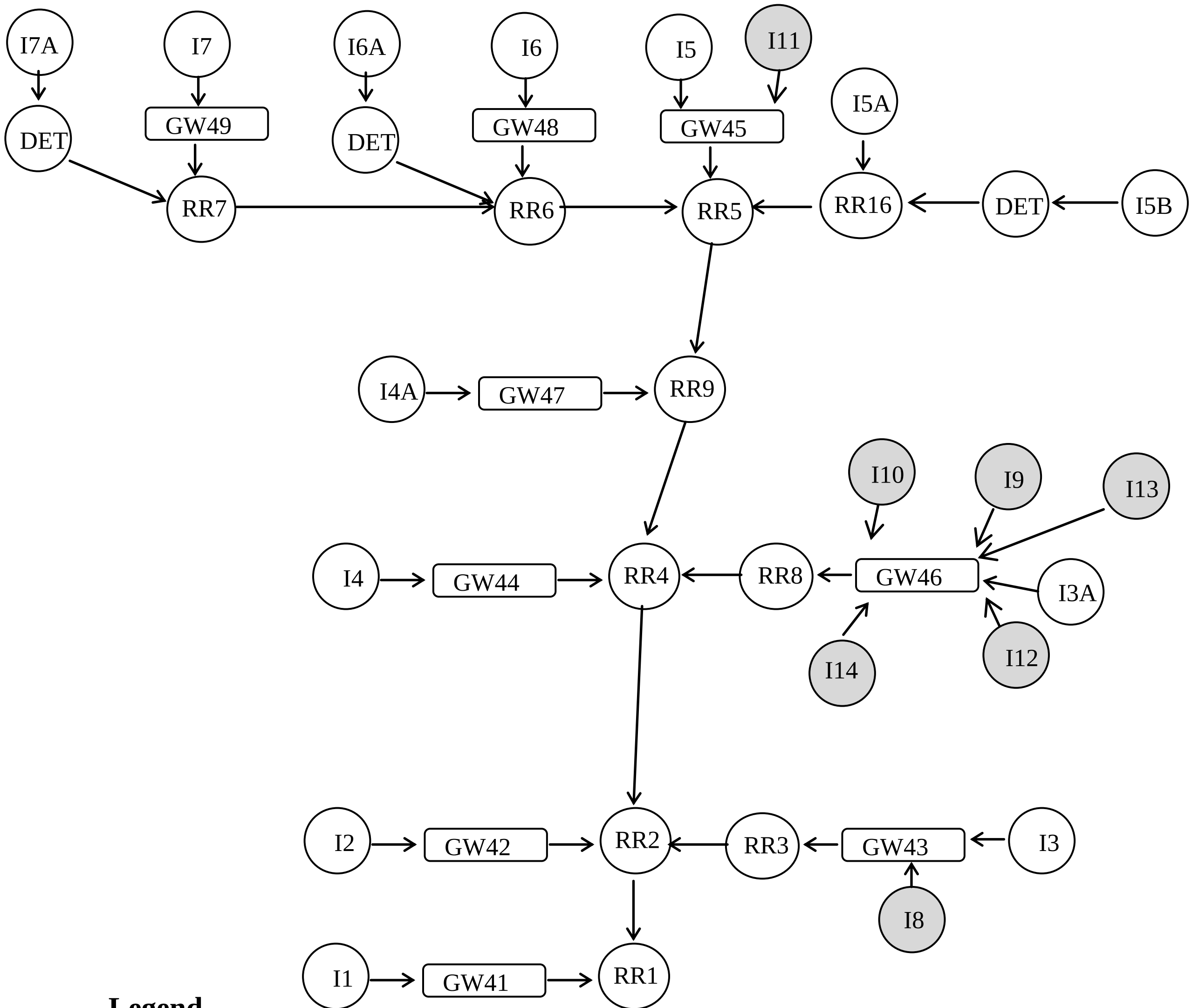
To mimic the infiltration of runoff from the uplands into the outwash deposit as they flow through George Davis Creek, a separate outwash Pervious Land Segment (PERLND) was defined for each subbasin that represents moisture inputs from both precipitation falling on the surface of the outwash and from lateral inflow from the till uplands. The area of these groundwater PERLNDS is equal to the area of outwash within the subbasin. The surface runoff and interflow from the adjacent upland till areas were then connected to each groundwater PERLND which were then connected to the stream channel.

Several large residential developments were constructed in the upper watershed in the time since the King County East Lake Sammamish Basin Plan was completed. The stormwater detention facilities associated with these developments were included in the HSPF model developed for the present analysis. Subbasin I5B, I6A, and I7A were added and define the tributary area to each stormwater pond associated with the new residential development. The ponds were designed according to the King County[9] Level 2 standard and HSPF routing tables (FTABLES) were developed for each subbasin such that they represented the detention pond discharge characteristics in the subbasin. A schematic of the Inglewood Basin HSPF model configuration is shown in Figure 5.

The USGS calibrated the HSPF model to the Inglewood Basin as part of a study to develop and validate regionalized parameters for the HSPF model for use in western Washington[3,7]. The USGS simulated the flow attenuation caused by the outwash using the HSPF channel routing (RCHRES) routine. They added flood storage volume to the stream reaches in each subbasin until the simulated and gaged streamflows matched. This approach produced a reasonable calibration but was not used in the present analysis because it was thought to be less physically representative of the watershed than the approach used (described above). The flood storage volume in the USGS model totaled approximately 7,000 acre-feet, which indicates that 7,000 acre-feet of stormwater detention storage would be required to replicate the flood storage and attenuation provided naturally by the outwash deposit.

Because of the high level of flood attenuation provided by the outwash deposit, the flow attenuation resulting from on-site detention in the future land use scenario would be indistinguishable after routing through the outwash deposit. In addition, connecting upstream stormwater ponds to the downstream groundwater PERLNDS can produce erroneous results in HSPF. Therefore, on-site detention mitigation was only included for the Town Center subbasins in the HSPF model. This does not mean that on-site detention should not be required in future developments in the Inglewood Basin; on the contrary, on-site detention should be required for future developments to ensure that discharge rates reaching the outwash do not increase to the point where they overwhelm the infiltration rate of the outwash deposit. This would result in a dramatic increase in the discharge rate in George Davis Creek as surface runoff in excess of the outwash infiltration rate discharged downstream.

The MGSFlood model was developed with routing reaches to account for the infiltration into the groundwater. The hydraulic characteristics of the routing reaches were defined to produce a response similar to the groundwater PERLNDS developed for the HSPF model. This approach allowed for detention to be included in all subbasins in the MGSFlood Inglewood model. For this reason, peak flow and duration results in the future land use scenario are slightly lower in the MGSFlood model than the HSPF model.



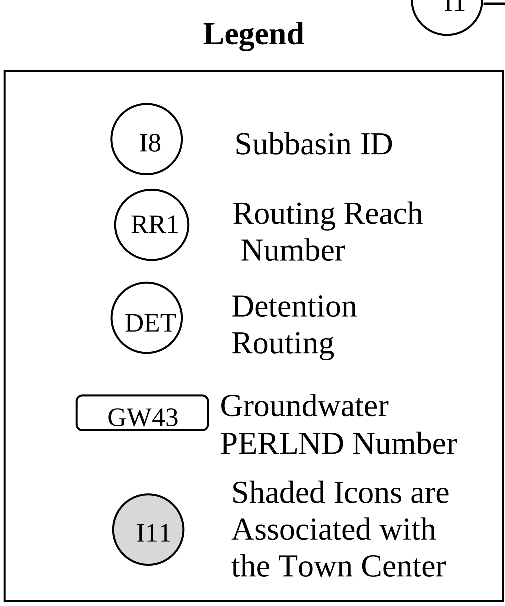
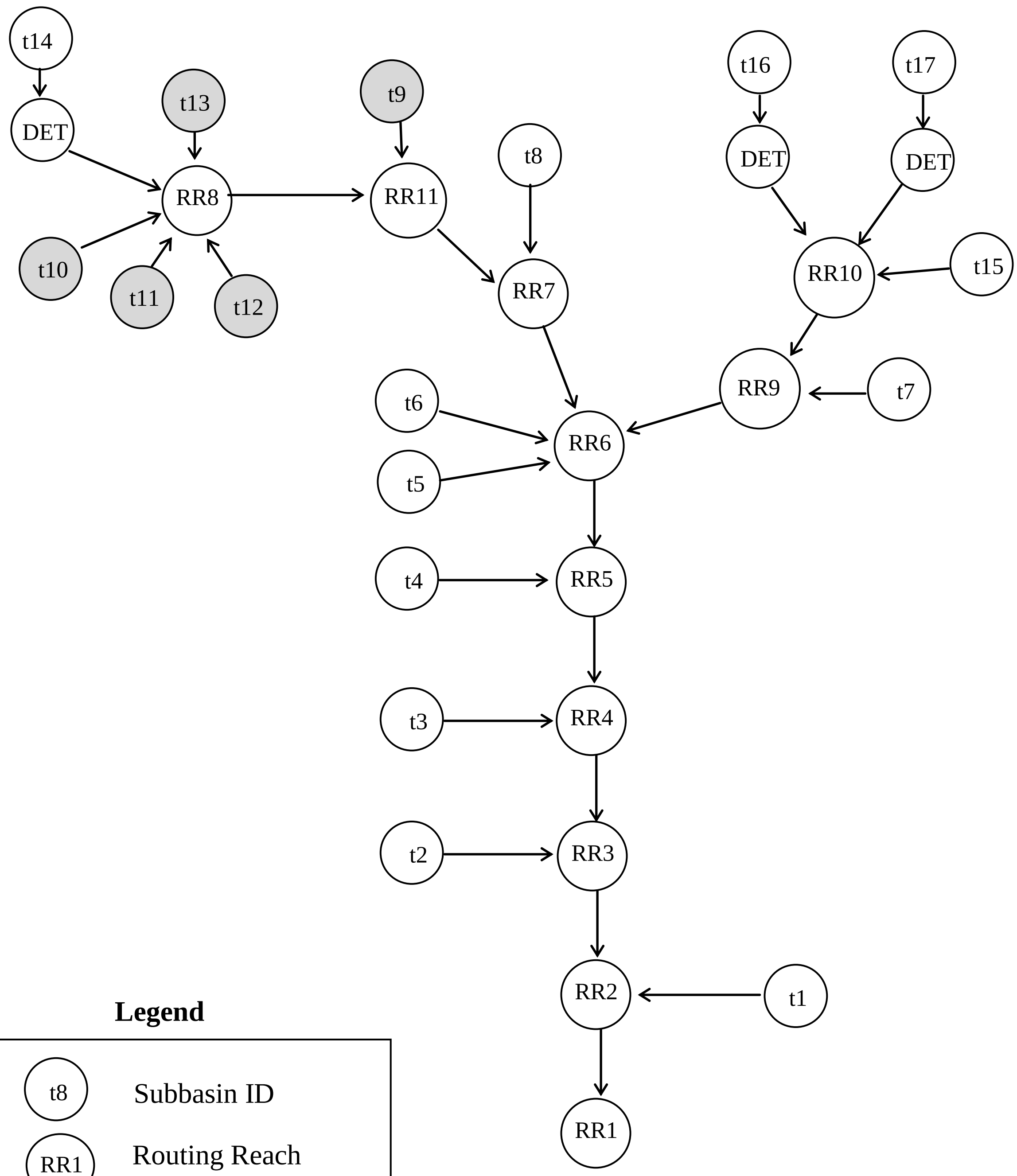


Figure 5 – Inglewood Basin HSPF Model Schematic

THOMPSON BASIN

The Thompson Basin is similar to Inglewood in that it originates in uplands of the Sammamish Plateau and drains through a ravine to Lake Sammamish. The Thompson Basin differs geologically from Inglewood in that it does not have a deep outwash deposit that infiltrates runoff upstream of the ravine. The runoff response in Ebright Creek is similar to many other watersheds in the Puget Lowland that are underlain by glacial till. Thus, routing through the outwash deposit was not included for this basin. While Ebright Creek does not possess the natural infiltration and storage of the outwash, it does have a large wetland (Wetland 17) situated at the top of the ravine. This 30-acre wetland provides substantial flood attenuation and buffering of flows entering from the uplands before discharging to the ravine.

Several existing developments in the upper washed were broken out as separate subbasins (Subbasins t16 and t17) and detention was included using the King County[9] Level 2 standard. A schematic of the Thompson Basin HSPF model configuration is shown in Figure 6.



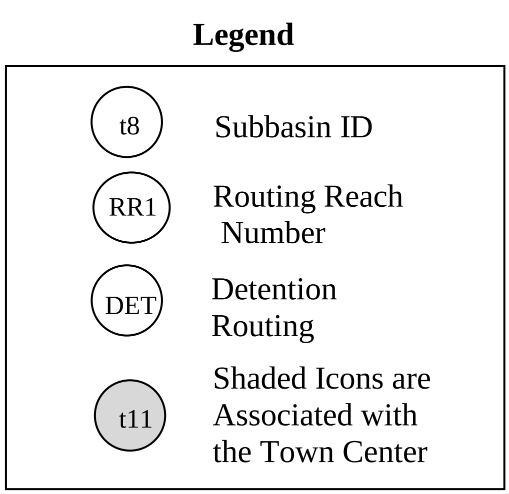


Figure 6 – Thompson Basin HSPF Model Schematic

STORMWATER DETENTION SIMULATION

Future land use was simulated with detention according to the City's proposed on-site detention standard. This standard is based on the current King County design manual[10], which requires that the post development runoff duration is controlled to the predeveloped forest duration from ½ of the predeveloped 2-year to the 50-year. Two detention ponds were included for each subbasin; one for areas on glacial till and one for areas on outwash. The outwash areas were sized as infiltration basins and only the overflow was connected to the receiving stream.

To account for uncertainty due to design, construction, and maintenance, detention mitigation simulated with the future land use scenario was assumed to be 90-percent effective. This was accomplished by sizing detention for only 90-percent of the developed area and routing 90-percent of the area to the pond. The remaining 10-percent of the developed area bypassed the pond. The exception was in the Town Center area where the bypass was not applied because this is a master planned development, and the design, construction, and maintenance will likely be more reliable than a typical development.

HSPF MODEL CALIBRATION

INTRODUCTION

Calibration of the HSPF model was performed to ensure that the hydrologic processes simulated by the model were representative of the conditions in the watershed. Calibration is the process whereby the model input parameters are adjusted until simulated and recorded discharge data match to the greatest extent possible.

CALIBRATION DATA

The model parameters were refined through calibration using streamflow data collected near the mouth of George Davis Creek and concurrent precipitation collected near the headwaters (City of Sammamish Gage 18Y) for the period October 2001-May 2003. Daily evaporation data were developed from data collected at the Puyallup 2 West Experimental Station (station number 45-6803). Flow data at the mouth of Ebright Creek were not of sufficient quality to use in model calibration.

Streamflow data for Ebright Creek was collected at a gage operated by commercial firm, Geotivity under contract to the City of Sammamish. Geotivity went bankrupt several years ago, and maintenance of the gage and quality checking of the data ceased at that time. The flow gage consisted of a sensor that tracked, among other things, the flow depth and velocity. Flow rate was computed using a functional relationship that included the recorded depth and velocity. This metering approach is commonly used in storm and sanitary sewers where the velocity varies across the flow area in a predictable manner. In stream channels, the cross section is irregular in shape and the velocity varies in a much less predictable manner.

The relationship used by Geotivity to derive streamflow from the depth and velocity measurements was not known. The data were analyzed and several relationships were tried to convert the depth and velocity measurements to discharge. The resulting flow data did not appear reasonable when compared with precipitation data recorded in the watershed.

An apparent shift in the depth recordings was also noted following a large storm that occurred in December 2007. Following the storm, the base flow depth recorded by the meter was higher, and resulted in a 1-2 cfs increase in the flow data than prior to the storm.

Because of the issues cited above, the recorded streamflow at the mouth of Ebright Creek were not used to calibrate the models. Parameters derived from the Inglewood Basin calibration were used for the Thompson Basin. Plots comparing simulated and recorded streamflow at the Ebright Creek gage are presented in the next section. The flow rate at the Ebright gage was derived by multiplying the recorded velocity times the cross sectional area corresponding to the recorded depth.

HSPF Model Calibration Results

Existing land use (year 2006) was used for model calibration. Model parameters for the pervious land segments (PERLNDS) were adopted from the 2004 Inglewood Basin Plan update[11]. Hourly streamflow data recorded by the City of Sammamish from October 2001-May 2003 near the outlet of George Davis Creek was used to verify that the current model with updated land use and subbasins produced results similar to the original calibration.

A comparison of simulated and recorded discharge at the outlet of George Davis Creek during water years 2002 and 2003 is shown in Figure 7. In general, the simulated and recorded magnitude and timing of discharge compared well. The general shape of simulated winter storm flows and the magnitude of summer base flows matched well with the recorded streamflow for this period. Several large runoff spikes in the streamflow record (December 2001, October 2002, and March 2003) were attributed to gage malfunction or poor quality data and were discounted in the model calibration. The streamflow record was not of sufficient quality to compute runoff volume or other statistics. The calibration was therefore judged qualitatively by the goodness of fit between simulated and recorded streamflow shown in Figure 7.

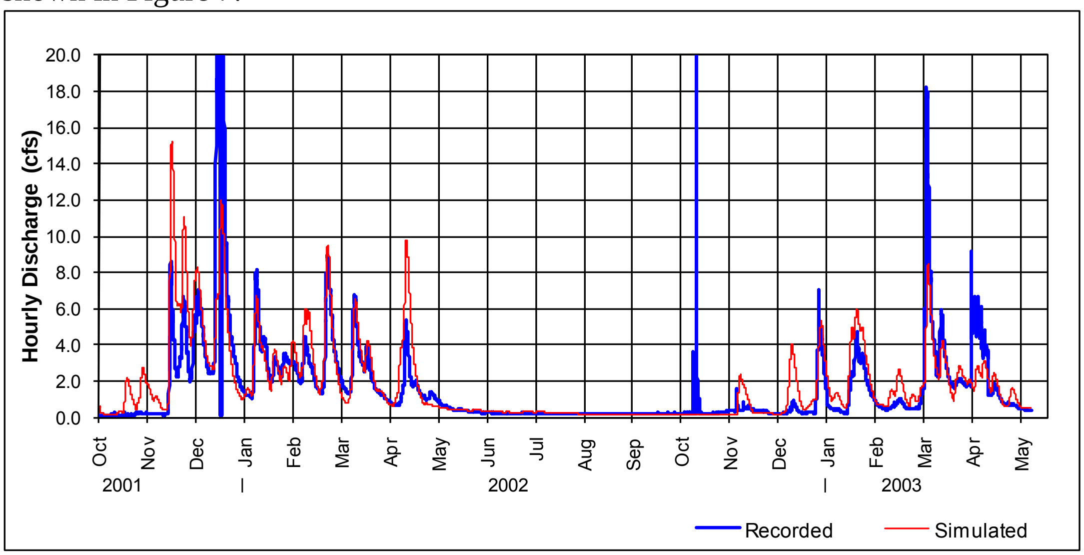


Figure 7 – HSPF Model Calibration, George Davis Creek

As discussed in the previous section, flow data at the mouth of Ebright Creek were deemed of insufficient quality to warrant use in the model calibration. Despite the uncertainty with the recorded streamflow data, there is a fairly close correspondence between the simulated and recorded flows (Figure 8), especially the storm that occurred in December 2007 (Figure 9).

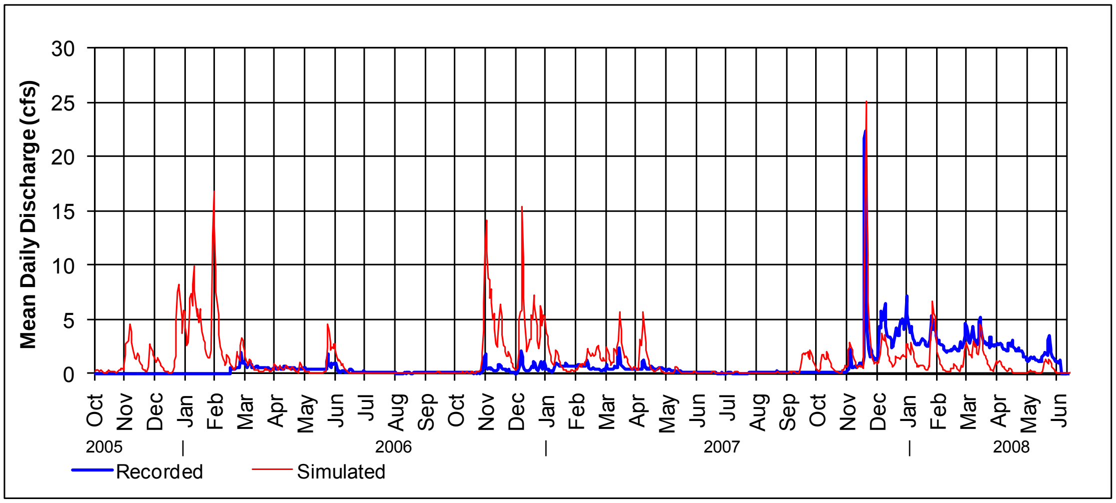


Figure 8 – Comparison of Simulated and Recorded Flow at Mouth of Ebright Creek
(Note: Gage not used for Calibration due to data Quality Concerns)

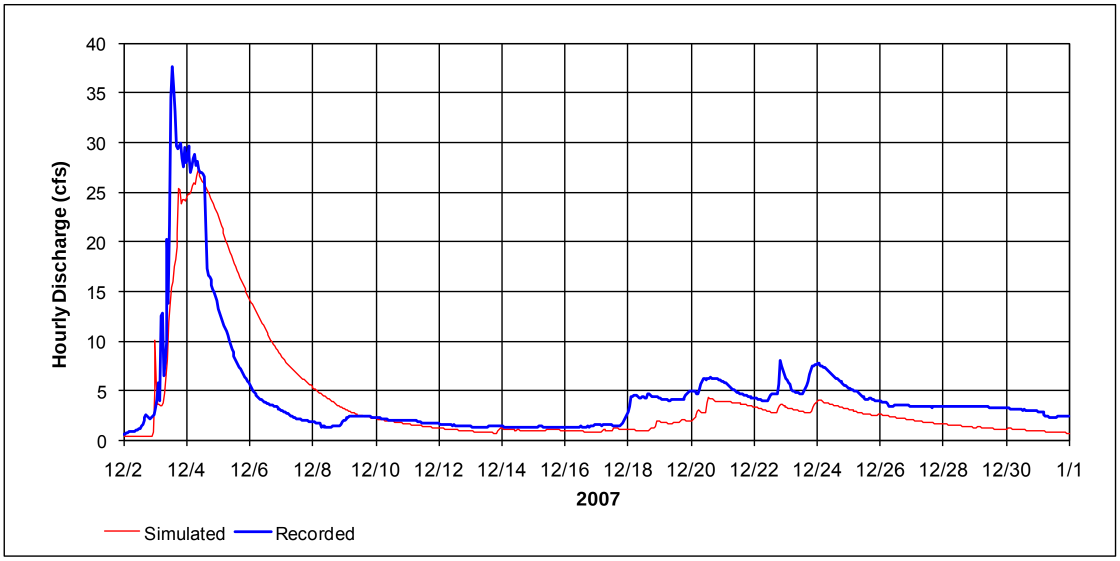


Figure 9 – Comparison of Simulated and Recorded Flow at Mouth of Ebright Creek
December 2007 Storm
(Note: Gage not used for Calibration due to data Quality Concerns)

TOWN CENTER ANALYSIS USING THE MGSFLOOD MODEL

MGSFlood[2] is a continuous rainfall runoff model used for stormwater facility analysis and design. The model uses the same rainfall-runoff algorithms as HSPF but includes routines for sizing stormwater detention facilities and simulating LID measures. MGSFlood model input was developed for both the Inglewood and Thompson Basins using the same land use, soil type, hydraulic routing, and runoff parameters used in the HSPF model. This approach allowed for numerous stormwater mitigation measures to be analyzed, especially in the Town Center basins. Simulation results for the Town Center alternatives are presented in the Town Center Comprehensive Stormwater Plan.

An additional benefit of the MGSFlood model is that it is much easier to use compared with HSPF. The MGSFlood model can be used in the future by City staff or their consultants to analyze changes to the Town Center plan or other developments in the watersheds and analyze the effects of the changes in a basin-wide context.

HSPF WATERSHED MODEL – ANALYSIS/PREDICTION APPROACH

SIMULATION PERIOD

Following the calibration phase, the model may be used for analysis and prediction of streamflows for various land use conditions. For this application, long-term, high-quality, precipitation timeseries are needed that are representative of the hourly, daily, weekly and monthly precipitation characteristics that have occurred in the past, and can be expected to occur in the future.

The Washington State Department of Transportation, Extended Precipitation Timeseries for Continuous Hydrologic Modeling[12,13] was used as input for the analysis of the Inglewood and Thompson Basins. This timeseries has a 1-hour timestep, is 158-years in length, and represents the rainfall characteristics of the basins (48 inches mean annual precipitation).

PEAK FLOW MAGNITUDE-FREQUENCY STATISTICS

Peak discharge magnitude-frequency estimates were computed at locations of interest in the watersheds using the HSPF model. The annual maxima discharge rates were saved at each location from the 158-years simulated. Peak flow and elevation magnitude-frequency relationships were computed using the Gringorten[14,15] plotting position formula (Equation 1).

$$Tr = \frac{N + 0.12}{i - 0.44} \qquad (1)$$

Where: Tr is the recurrence interval of the peak flow,
i is the rank of the annual maxima peak flow ordered from highest to lowest,
N is the total number of years simulated (158 in this case).

Flow Duration Statistics

Modifications to the land surface during urbanization increase both the runoff peak rate and volume. The increase in runoff volume is the result of the loss of water storage in the soil column because of the compaction of the soil and the introduction of impervious surfaces. Figure 10 compares the allocation of precipitation falling on a forested and an urban watershed. In the forested watershed, the precipitation ends up nearly all evaporation and infiltration with very little surface runoff. With an urban watershed, the evaporation and infiltration are reduced significantly, and a much higher percentage of the rainfall ending up as surface overland flow.

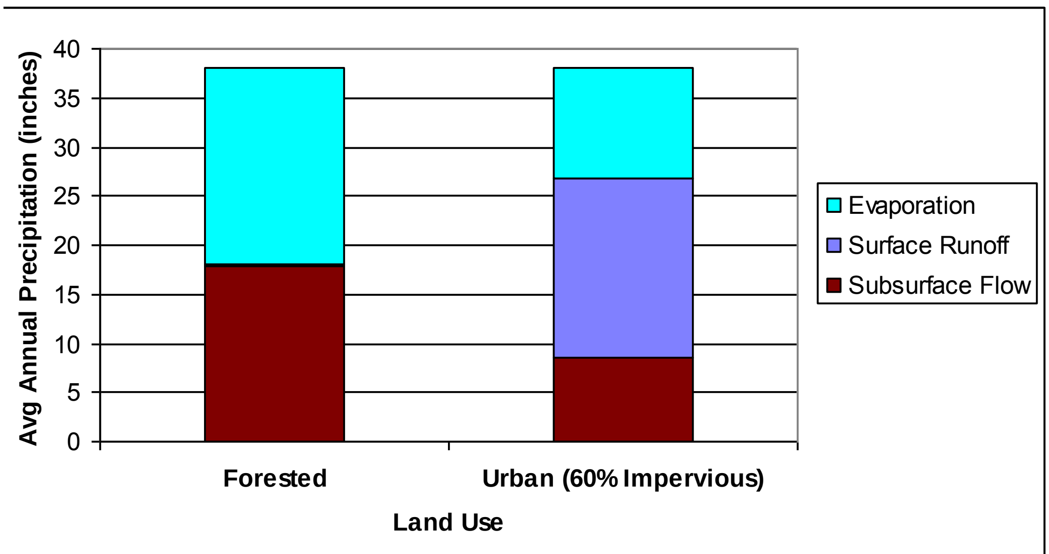


Figure 10 – Mean Annual Precipitation Water Budget for a Forested and Urban Site

The increase in runoff volume combined with the increase in runoff rate results in higher stream discharges occurring for a <u>longer duration</u>. The increase in duration of a given flow rate results in more erosive work on the stream channel over time, particularly when the discharge rate exceeds the threshold for streambed movement in the receiving channel.

Flow duration statistics provide a convenient tool for characterizing streamflow computed with a continuous hydrologic model. Duration statistics are computed by tracking the fraction of time that a specified flow rate is equaled or exceeded. HSPF does this by dividing the range of flows simulated into discrete increments and then tracks the fraction of time that each flow is equaled or exceeded. The fraction of time that a particular flow is equaled or exceeded is called *exceedance probability*. It should be noted that exceedance probability for duration statistics is different from the *annual exceedance probability* associated with flood frequency statistics and there is no practical way of converting/relating annual exceedance probability statistics to flow duration statistics.

FLOOD FREQUENCY AND FLOW DURATION RESULTS

INTRODUCTION

Precipitation timeseries 158-years in length at a 1-hour timestep and daily evaporation derived from the Puyallup 2 West Experimental Station (station number 45-6803) were used as input to the model, which resulted in a 158-year, 1-hour timeseries of flow at the outlet of each subbasin simulated. Flood magnitude-frequency and duration analyses were subsequently performed on the flow timeseries at locations of interest in the watershed.

The future land use scenarios were simulated with stormwater mitigation designed according to the City's proposed stormwater detention ordinance[10]. The simulation results presented in this section provide an assessment of the performance of stormwater mitigation in a basin-wide context. Details on mitigation options for the Town Center that includes Low Impact Development as well as traditional stormwater detention, is presented in the Town Center Comprehensive Stormwater Plan.

FLOOD PEAK DISCHARGE RESULTS

Increases in peak discharge rates under future conditions in the Inglewood Basin are negligible in most areas and actually decrease other areas relative to the existing land use scenario (Figures 11a, 11b, and Tables 3a, 3b, and 3c). The reason for the small change in discharge rate is the presence of the glacial outwash deposit, which infiltrates the majority of surface runoff produced in the till capped uplands. As discussed in the model calibration section, the outwash deposit is equivalent to approximately 7,000 acre-feet of stormwater detention storage in the Inglewood Basin.

While natural infiltration of the outwash in the central portion of the watershed provides substantial natural buffering of the runoff under the future land use, on-site detention and LID controls are still necessary to ensure that runoff rates associated with future development do not overwhelm the infiltration capacity in the channels underlain by outwash.

Peak runoff rates in the Thompson Basin show a greater reduction in the future flows relative to existing conditions (Figures 12a, 12b and Tables 4a and 4b). This is because there are many developments in the basin with little or no stormwater controls and the Thompson Basin does not contain the infiltrative outwash present in the Inglewood Basin to mitigate runoff from existing development.

Peak runoff rates in the Town Center subbasins show a dramatic reduction in peak flows under future conditions relative to existing conditions in the majority of subbasins (Figures 13a, 13b, and Tables 5a, and 5b). In most areas, the peak discharge under future land use conditions is reduced to rates comparable to the forested land use condition.

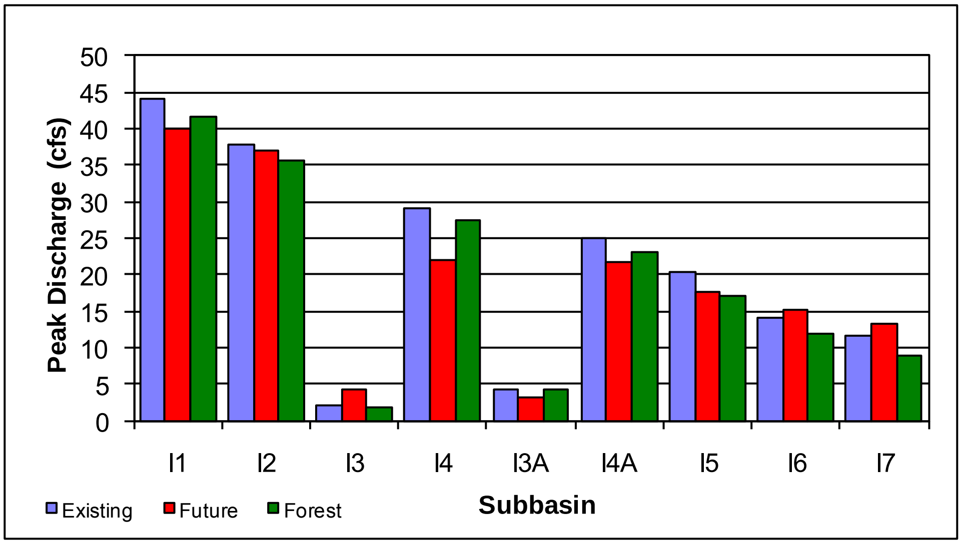


Figure 11a – George Davis Creek, Comparison of 100-Year Flood Peak Discharge Existing, Future, and Forested Land Use

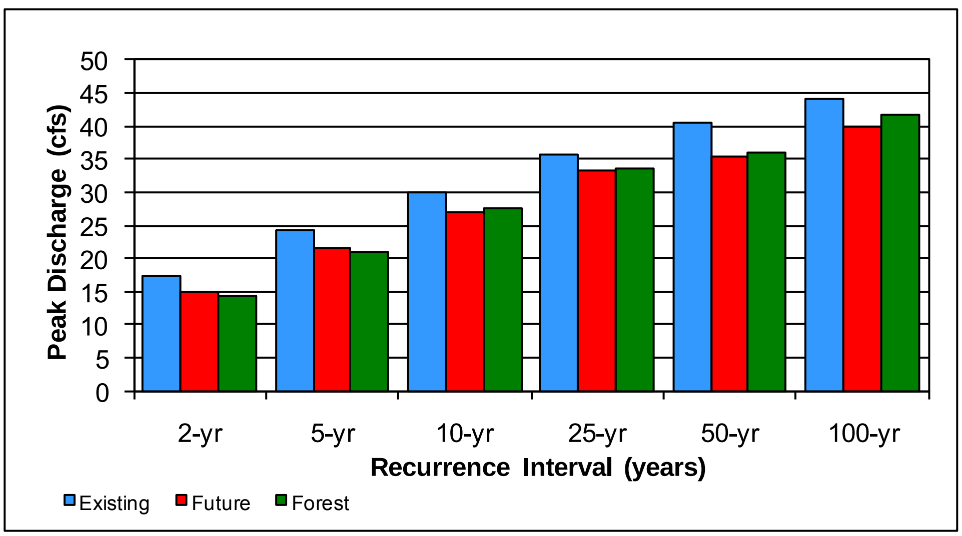


Figure 11b – Comparison of Flood Peak Discharge at Mouth of George Davis Creek (Inglewood Basin) Existing, Future, and Forested Land Use

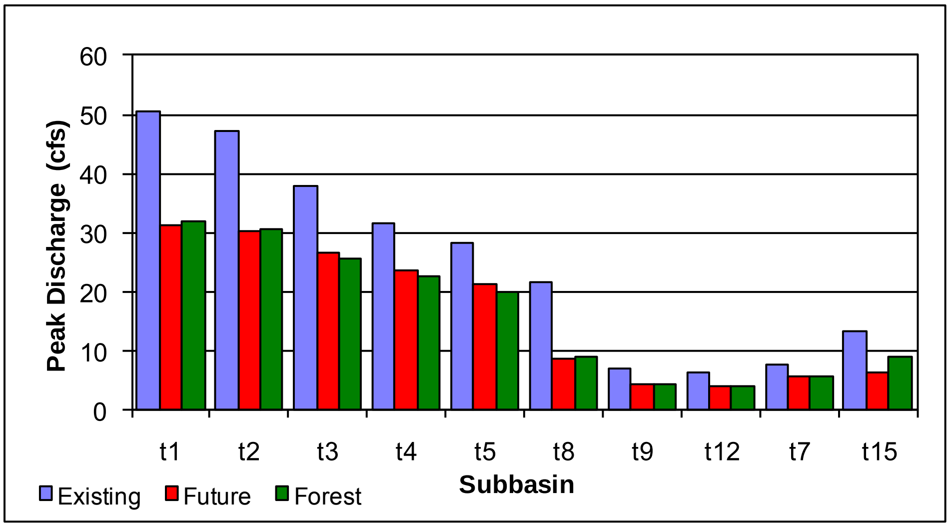


Figure 12a – Ebright Creek, Comparison of 100-Year Flood Peak Discharge Existing, Future, and Forested Land Use

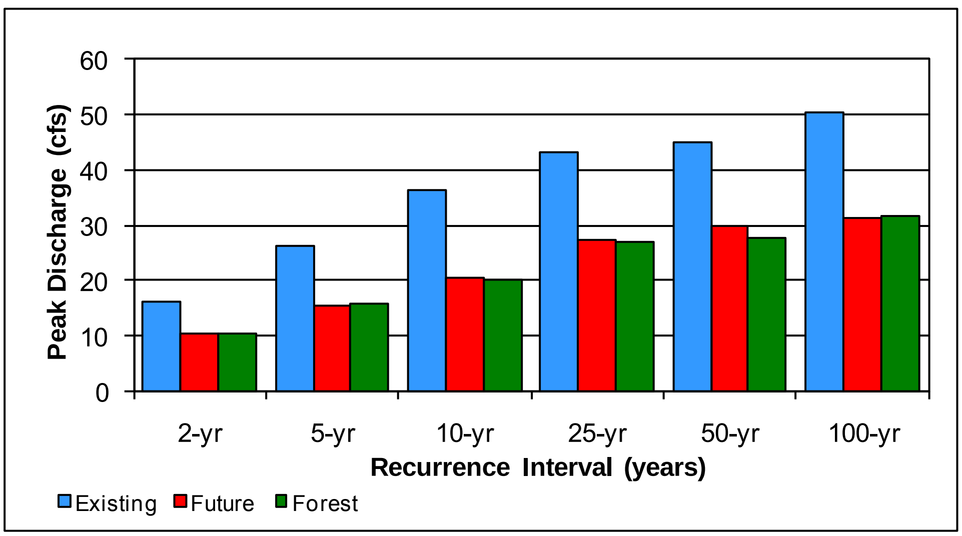


Figure 12b – Comparison of Flood Peak Discharge at Mouth of Ebright Creek (Thompson Basin) Existing, Future, and Forested Land Use

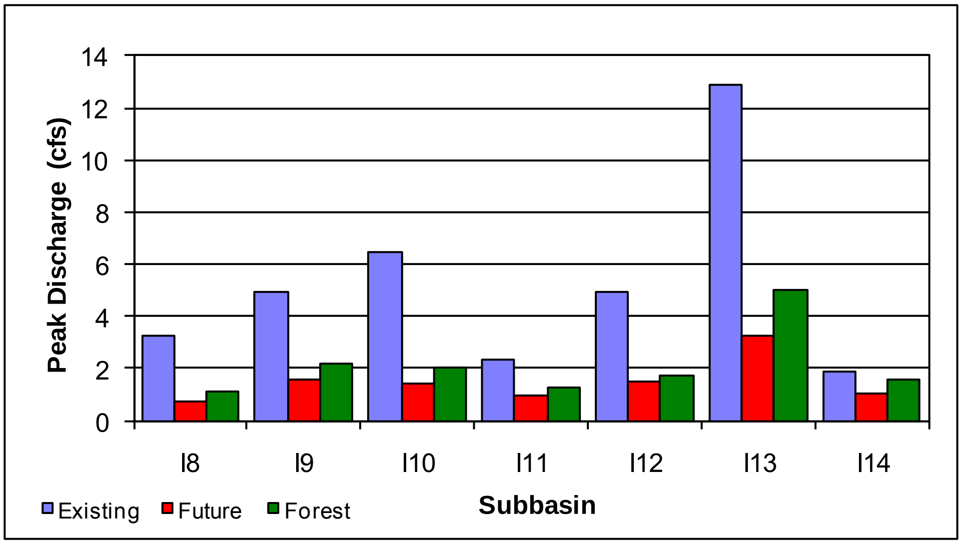


Figure 13a – Town Center Subbasins in the Inglewood Basin, Comparison of 100-Year Flood Peak Discharge
Existing, Future, and Forested Land Use

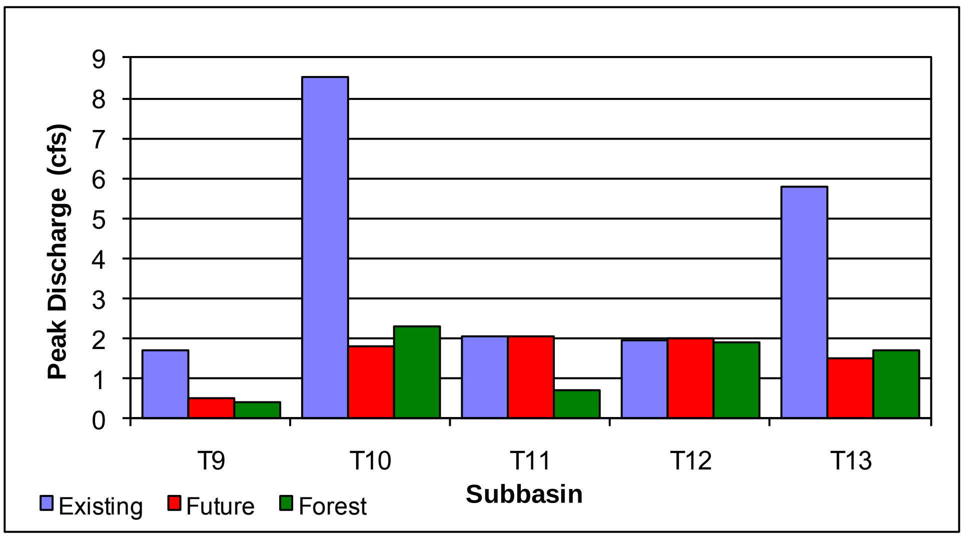


Figure 13b – Town Center Subbasins in the Thompson Basin, Comparison of 100-Year Flood Peak Discharge
Existing, Future, and Forested Land Use

Table 3a – Inglewood Basin Flood Magnitude-Frequency Estimates (cfs) Existing Land Use (2006) (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SUBBASIN I1	17	24	30	36	40	44
SUBBASIN I2	15	20	26	31	35	38
SUBBASIN I3	0.9	1.1	1.4	1.7	1.8	1.9
SUBBASIN I4	12	16	20	24	27	29
SUBBASIN I3A	1.9	2.5	3.1	3.7	4.0	4.2
SUBBASIN I4A	10	14	17	21	23	25
SUBBASIN I5	8.3	11	14	17	18	20
SUBBASIN I6	6.1	7.8	10	12	13	14
SUBBASIN I7	4.9	6.4	8.3	10	11	12

Table 3b – Inglewood Basin Flood Magnitude-Frequency Estimates (cfs) Future Land Use with Mitigation (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SUBBASIN I1	15	21	27	33	35	40
SUBBASIN I2	12	18	22	28	29	37
SUBBASIN I3	0.5	0.7	1.1	2.4	2.6	4.3
SUBBASIN I4	10	13	16	19	20	22
SUBBASIN I3A	0.2	0.3	0.4	2.1	2.6	3.2
SUBBASIN I4A	10	13	16	18	20	22
SUBBASIN I5	7.7	10	12	15	16	18
SUBBASIN I6	6.6	8.7	11	14	14	15
SUBBASIN I7	5.8	7.7	10	12	12	13

Table 3c – Inglewood Basin Flood Magnitude-Frequency Estimates (cfs) Forested Land Use (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SUBBASIN I1	14	21	28	34	36	42
SUBBASIN I2	12	17	23	29	31	36
SUBBASIN I3	0.7	0.9	1.3	1.6	1.7	1.9
SUBBASIN I4	11	14	19	23	24	27
SUBBASIN I3A	1.6	2.1	2.8	3.5	3.8	4.1
SUBBASIN I4A	8.9	12	16	19	21	23
SUBBASIN I5	6.6	8.8	12	14	15	17
SUBBASIN I6	4.4	5.8	7.9	10	11	12
SUBBASIN I7	3.3	4.3	5.9	7.4	8.0	8.9

Table 4a – Thompson Basin Flood Magnitude-Frequency Estimates (cfs) Existing Land Use (2006) (Discharge is Referenced to Subbasin Outlet)						
Subbasin	Flood Magnitude-Frequency Estimates (cfs)					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SUBBASIN t1	16	26	36	43	45	51
SUBBASIN t2	15	25	34	39	42	47
SUBBASIN t3	13	19	24	30	35	38
SUBBASIN t4	11	15	21	27	30	31
SUBBASIN t5 WL17	10	13	19	24	26	28
SUBBASIN t8	6.4	10	15	20	21	22
SUBBASIN t9	2.2	3.1	4.2	6.0	6.4	6.8
SUBBASIN t12 WL61	2.1	2.9	3.9	5.6	6.0	6.3
SUBBASIN t7	3.0	4.2	5.4	7.1	7.4	7.7
SUBBASIN t15	3.5	5.4	7.1	10	11	13

Table 4b – Thompson Basin Flood Magnitude-Frequency Estimates (cfs) Future Land Use with Mitigation (Discharge is Referenced to Subbasin Outlet)						
Subbasin	Flood Magnitude-Frequency Estimates (cfs)					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SUBBASIN t1	10	15	21	27	30	31
SUBBASIN t2	10	15	20	27	29	30
SUBBASIN t3	8.6	13	17	23	25	26
SUBBASIN t4	7.7	11	15	20	22	24
SUBBASIN t5 WL17	6.8	10	13	18	20	21
SUBBASIN t8	2.7	4.2	5.4	7.3	8.3	8.5
SUBBASIN t9	1.2	1.9	2.6	3.5	3.8	4.2
SUBBASIN t12 WL61	1.1	1.8	2.4	3.3	3.6	4.0
SUBBASIN t7	1.8	2.7	3.8	4.9	5.4	5.6
SUBBASIN t15	2.3	3.2	4.4	5.6	5.9	6.3

Table 4c – Thompson Basin Flood Magnitude-Frequency Estimates (cfs) Forested Land Use (Discharge is Referenced to Subbasin Outlet)						
Subbasin	Flood Magnitude-Frequency Estimates (cfs)					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SUBBASIN t1	10	16	20	27	28	32
SUBBASIN t2	10	15	19	26	26	31
SUBBASIN t3	7.9	12	16	21	22	26
SUBBASIN t4	6.9	10	14	18	20	22
SUBBASIN t5 WL17	6.1	8.7	12	16	17	20
SUBBASIN t8	2.8	4.5	5.8	7.9	8.1	9.0
SUBBASIN t9	1.2	1.6	2.5	3.3	3.6	4.2
SUBBASIN t12 WL61	1.1	1.6	2.3	3.1	3.4	3.9
SUBBASIN t7	2.0	2.7	3.7	4.7	5.0	5.6
SUBBASIN t15	2.1	3.7	4.6	6.2	7.3	8.8

Table 5a – Town Center Flood Magnitude-Frequency Estimates (cfs) Existing Land Use (2006) (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN I8	0.72	1.19	1.63	2.52	2.61	3.22
SUBBASIN I9	1.37	2.12	2.88	3.84	4.03	4.91
SUBBASIN I10	1.52	2.40	3.25	5.10	5.47	6.43
SUBBASIN I11	0.61	1.02	1.47	1.87	2.03	2.32
SUBBASIN I12	1.20	1.89	2.52	3.86	4.08	4.96
SUBBASIN I13	3.41	5.16	6.84	9.78	10.37	12.93
SUBBASIN I14	0.52	0.84	1.02	1.35	1.51	1.87
SUBBASIN t9	0.46	0.69	0.91	1.35	1.56	1.70
SUBBASIN t10	2.14	3.24	4.27	6.78	7.53	8.51
SUBBASIN t11	0.47	0.76	1.05	1.60	1.70	2.04
SUBBASIN t12	0.64	0.92	1.11	1.37	1.52	1.93
SUBBASIN t13	1.28	2.08	2.85	4.60	5.02	5.77

Table 5b – Town Center Flood Magnitude-Frequency Estimates (cfs) Future Land Use with Mitigation (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN I8	0.20	0.35	0.50	0.66	0.73	0.74
SUBBASIN I9	0.47	0.75	1.09	1.41	1.54	1.56
SUBBASIN I10	0.38	0.61	0.87	1.22	1.36	1.43
SUBBASIN I11	0.28	0.44	0.64	0.82	0.91	0.98
SUBBASIN I12	0.73	0.89	1.04	1.31	1.37	1.51
SUBBASIN I13	0.87	1.42	1.88	2.61	2.89	3.25
SUBBASIN I14	0.32	0.46	0.60	0.78	0.87	1.00
SUBBASIN t9	0.27	0.33	0.39	0.46	0.49	0.50
SUBBASIN t10	0.61	0.88	1.20	1.61	1.66	1.78
SUBBASIN t11	0.46	0.76	1.05	1.61	1.71	2.05
SUBBASIN t12	0.66	0.94	1.14	1.39	1.55	1.98
SUBBASIN t13	0.64	0.81	1.09	1.37	1.44	1.47

Table 5c – Town Center Flood Magnitude-Frequency Estimates (cfs) Forested Land Use (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN I8	0.34	0.54	0.67	0.91	0.99	1.14
SUBBASIN I9	0.62	1.01	1.25	1.71	1.85	2.15
SUBBASIN I10	0.61	0.96	1.19	1.63	1.76	2.04
SUBBASIN I11	0.37	0.59	0.73	1.00	1.08	1.25
SUBBASIN I12	0.49	0.82	0.97	1.32	1.45	1.70
SUBBASIN I13	1.45	2.42	2.84	3.91	4.31	5.03
SUBBASIN I14	0.45	0.73	0.85	1.19	1.29	1.55
SUBBASIN t9	0.12	0.19	0.23	0.32	0.34	0.40
SUBBASIN t10	0.69	1.08	1.34	1.84	1.99	2.31
SUBBASIN t11	0.19	0.32	0.38	0.52	0.57	0.67
SUBBASIN t12	0.63	0.90	1.09	1.34	1.49	1.87
SUBBASIN t13	0.50	0.79	0.98	1.34	1.45	1.68

FLOW DURATION RESULTS

Flow duration statistics provide an indication of the relative amount of erosive work performed on the stream channel. The increase in duration at a given flow rate results in more erosive work being performed on the stream channel over time. As urbanization occurs in the watershed, the frequency of discharge that exceeds the historic bedload movement threshold increases. This results in greater erosive work on the stream channel leading to an expansion in the channel cross section and leads to larger sized stream gravel as the smaller gravel fraction is carried downstream.

Figures 14a and 14b compare flow duration statistics in the ravine area of George Davis and Ebright creeks, respectively and show a relatively small change in the flow duration statistics for future relative to existing land use. This suggests that under build-out conditions, the potential for increased stream channel erosion is relatively small. Again, this is due to the presence of highly infiltrative outwash in the central part of the watershed, which greatly reduces the surface runoff response from the watershed. Flow duration statistics for each subbasin are summarized in Tables 6a -6c for the Inglewood Basin and Tables 7a -7c for the Thompson Basin.

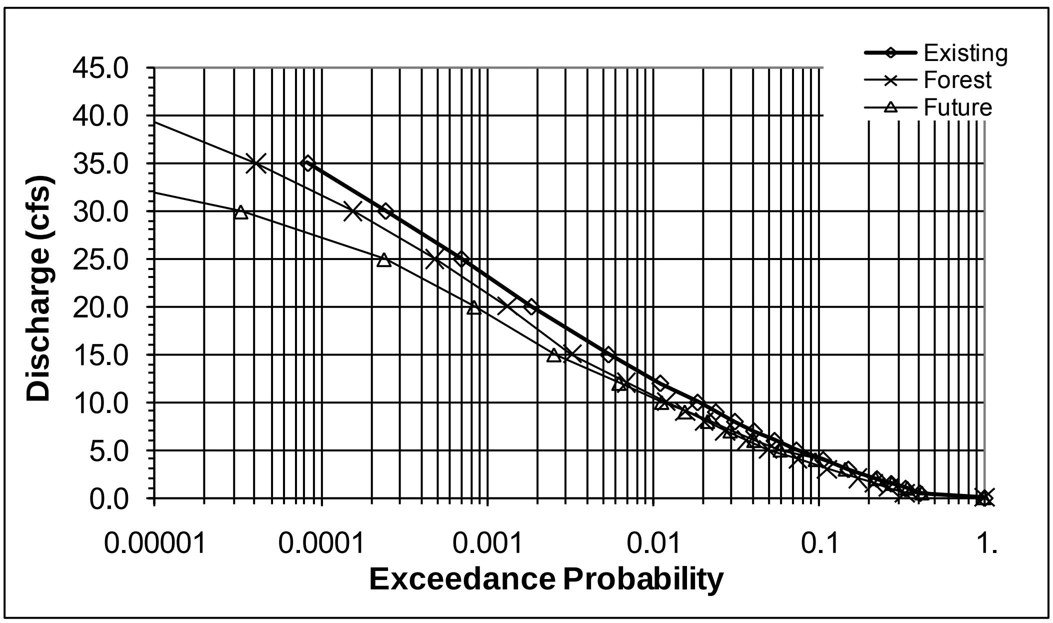


Figure 14a – Comparison of Simulated Flow Duration, Existing, Future, and Forest Land Use George Davis Creek, Inglewood Basin, Subbasin I2, Ravine

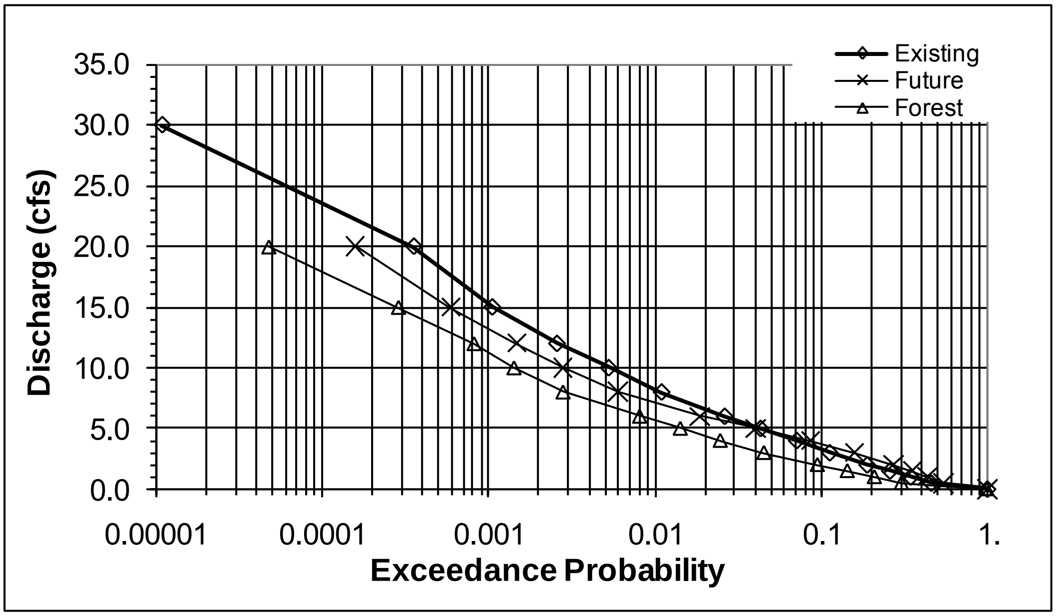


Figure 14b – Comparison of Simulated Flow Duration, Existing, Future, and Forest Land Use Ebright Creek, Thompson Basin, Subbasin t4, Ravine

Table 6a – Inglewood Basin Flow Duration Analysis Results, Existing Land Use

	Existing Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
I1	0.10	0.78	3.47	5.78
I2	0.06	0.39	2.29	4.16
I3	0.02	0.11	0.25	0.35
I4	0.07	0.47	2.52	4.36
I5	0.06	0.41	1.64	2.83
I6	0.05	0.34	1.26	2.13
I7	0.05	0.32	1.03	1.74
I3A	0.03	0.19	0.45	0.70
I4A	0.07	0.45	2.14	3.64

Table 6b – Inglewood Basin Flow Duration Analysis Results, Future Mitigated Land Use

	Future Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
I1	0.10	0.84	3.54	5.64
I2	0.06	0.40	2.25	3.91
I3	0.01	0.07	0.17	0.24
I4	0.08	0.50	2.42	3.94
I5	0.07	0.46	1.86	3.11
I6	0.06	0.39	1.61	2.56
I7	0.06	0.37	1.38	2.19
I3A	0.01	0.04	0.08	0.12
I4A	0.07	0.49	2.36	3.83

Table 6c – Inglewood Basin Flow Duration Analysis Results, Forested Land Use

	Future Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
I1	0.08	0.58	2.79	4.81
I2	0.05	0.31	1.65	3.28
I3	0.01	0.09	0.21	0.30
I4	0.06	0.37	1.90	3.46
I5	0.05	0.32	1.23	2.09
I6	0.04	0.24	0.68	1.40
I7	0.03	0.22	0.51	1.04
I3A	0.02	0.16	0.37	0.55
I4A	0.05	0.35	1.62	2.89

Table 7a – Thompson Basin Flow Duration Analysis Results, Existing Land Use

	Existing Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
t1	0.08	0.53	2.48	4.24
t2	0.08	0.50	2.39	4.09
t3	0.07	0.45	2.05	3.52
t4	0.07	0.45	1.91	3.26
t5 Wetland 17	0.07	0.44	1.77	3.01
t8	0.04	0.24	0.60	1.09
t9	0.03	0.17	0.40	0.61
t12 Wetland 61	0.03	0.16	0.38	0.58
t7	0.03	0.21	0.49	0.90
t15	0.03	0.19	0.43	0.77

Table 7b – Thompson Basin Flow Duration Analysis Results, Future Mitigated Land Use

	Future Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
t1	0.09	0.80	3.29	4.89
t2	0.09	0.79	3.20	4.75
t3	0.09	0.72	2.82	4.17
t4	0.09	0.68	2.58	3.77
t5 Wetland 17	0.08	0.64	2.32	3.38
t8	0.05	0.31	0.80	1.15
t9	0.03	0.18	0.42	0.58
t12 Wetland 61	0.03	0.17	0.40	0.56
t7	0.04	0.27	0.63	0.90
t15	0.03	0.22	0.50	0.66

Table 7c – Thompson Basin Flow Duration Analysis Results, Forested Land Use

	Future Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
t1	0.05	0.35	1.54	2.75
t2	0.05	0.34	1.47	2.64
t3	0.05	0.30	1.17	2.17
t4	0.04	0.29	1.07	1.95
t5 Wetland 17	0.04	0.29	0.98	1.75
t8	0.02	0.16	0.38	0.59
t9	0.02	0.11	0.25	0.36
t12 Wetland 61	0.02	0.11	0.24	0.35
t7	0.02	0.14	0.33	0.47
t15	0.02	0.12	0.28	0.40

SUMMARY AND RECOMMENDATIONS

A hydrologic analysis of the Inglewood and Thompson Basins was performed using the HSPF and MGSFlood models in support of the Inglewood Basin Plan Update, the Thompson Basin Plan, and the Sammamish Town Center Comprehensive Stormwater Plan. HSPF models developed for earlier analyses were updated to reflect changes in land use and to include additional subbasins in the proposed Town Center development area. The HSPF model was calibrated to streamflow data collected over a 20 month period from October 2001 through May 2003 at the outlet of George Davis Creek (Inglewood Basin). Flow data collected at the mouth of Ebright Creek was not of sufficient quality to use for model calibration; however, comparisons of simulated flows showed a fairly close match with the recorded data for Ebright Creek.

The MGSFlood model uses similar computational algorithms as HSPF, but also includes routines for analyzing stormwater detention and LID mitigation techniques. Watershed input data and runoff parameters used in the HSPF model development and calibration were used to create MGSFlood model input. The MGSFlood model was used to analyze treatment alternatives at Town Center that included detention and LID measures.

The presence of glacial outwash in the central part of the Inglewood Basin infiltrates the majority of surface flow produced in the upper parts of the watershed and results in little or no flow in the stream immediately upstream of the ravine (Subbasin I2). Downstream, the stream intersects the groundwater table (Subbasin I1) and receives the majority of flow via groundwater discharge. The groundwater discharge also produces year around base flow in the lower reaches of the stream. The outwash deposit infiltrates and stores runoff from the upper watershed and is equivalent to approximately 7,000 acre-feet of stormwater detention storage. Flows in the lower stream reach are relatively low (attenuated) during floods because of the storage that occurs in the outwash deposit.

The Thompson Basin does not have the same infiltrative outwash deposit as the Inglewood Basin, but does have a large wetland (Wetland 17) situated at the top of the ravine. This 30 acre wetland provides substantial flood attenuation and buffering of flows entering from the uplands before discharging to the ravine.

Existing and future build-out conditions were simulated with the HSPF model and flood peak and flow duration statistics computed. Little or no increases in runoff rates relative to existing conditions were predicted under future land for the Inglewood Basin. In the Thompson Basin, future peak flow rates were predicted to decrease relative to existing conditions. These results show that stormwater mitigation designed according to the City's stormwater detention standard, which seeks to control runoff rates to forested conditions, is effective at mitigating increased runoff due to development. Because of this, the rates of erosion and flooding should not increase in the future and in areas of the Thompson Basin, may actually decrease provided that the facilities are properly maintained in the future.

RECOMMENDATIONS

1. Maintenance of Outwash Infiltration Areas –The glacial outwash deposit in the central part of the Inglewood Basin is currently infiltrating the majority of surface runoff from the upper watershed. Maintaining the infiltration function of this area is critical to ensuring a stable flow regime and the health of George Davis Creek in the future.

   Infiltration of stormwater with pretreatment should be encouraged for new developments located in areas with outwash deposits. A general map of the geology of the Inglewood Basin showing the extent of the outwash deposit is shown in Figure 4. Local site conditions will dictate whether infiltration is feasible on an individual development site and must be evaluated by the site development engineer. Stormwater conveyance should also be maintained in open channels to the greatest extent possible to promote infiltration into the outwash deposit.

2. On-Site Detention and Low Impact Development Methods – The City's detention standard, which is consistent with the 2005 Ecology Stormwater Management Manual[16], is effective at mitigating the increased potential for flooding and erosion associated with development. Stormwater detention facilities designed according to this standard are large and often expensive to construct. Low Impact Development (LID) methods provide a means to reduce the rate and volume of runoff associated with development, and increases the amount of potential groundwater recharge. LID methods should be encouraged to the greatest extent practical for new construction in the Inglewood and Thompson watersheds.

3. Streamflow Monitoring – Streamflow gages have been operated and maintained by a third party contractor in the past at the mouth of George Davis and Ebright creeks. These gages should be reestablished and data collected from them quality checked and validated on an on-going basis.

REFERENCES

1. US Environmental Protection Agency, Hydrological Simulation Program-Fortran, Release 11, EPA/600/R-97/030, August 1997.

2. MGS Software, LLC, MGSFlood, Continuous Hydrologic Model for Stormwater Facility Analysis, Version 4, August 2009.

3. Dinicola, R. S., Validation of a numerical modeling method for simulating rainfall-runoff relations for headwater basins in western King and Snohomish counties, Washington, Water Supply Paper 2495, 2001.

4. King County Surface Water Management, East Lake Sammamish Basin Watershed Management Committee Basin and Nonpoint Action Plan, December 1994.

5. City of Sammamish, Sammamish Town Center Plan, June 2008.

6. Sutherland, Roger, C., Methodology for Estimating the Effective Impervious Area of Urban Watersheds, Technical Note 58, Watershed Protection Techniques, Vol 2, No 1, Fall 1995.

7. Dinicola, R. S., Characterization and Simulation of Rainfall Runoff Relations in Western King and Snohomish Counties, Washington, U.S. Geological Survey, Water-Resources Investigations Report 89-4052.

8. Sacket, Jill, Booth, Derek, Surface Geology of King County, GIS Coverage, King County GIS Center, April 2002.

9. King County, Washington Surface Water Design Manual, King County Department of Natural Resources, September 1998.

10. King County, Washington Surface Water Design Manual, King County Department of Natural Resources, January 2005.

11. MGS Engineering Consultants, Inc, Hydrologic and Hydraulic Analysis of Inglewood Creek using the HSPF Model, March, 2004.

12. Schaefer MG, Barker BL, Wallis JR and Nelson RN, Creation of Extended Precipitation Time-Series for Continuous Hydrological Modeling in Pierce County Washington, prepared for Pierce County Public Works by MGS Engineering Consultants Inc, Entranco, and JR Wallis, February 2001.

13. Schaefer MG and Barker BL, Extended Precipitation Time-Series for Continuous Hydrological Modeling in Western Washington, prepared for Washington State Department of Transportation by MGS Engineering Consultants Inc, April 2002.

14. Gringorten, I. I., A Plotting Rule for Extreme Probability Paper, Journal of Geophysical Research, vol. 68, pp. 813-814, 1963.

15. Stedinger JR, Vogel RM, and Foufoula-Georgiou E, Frequency Analysis of Extreme Events, Chapter 18, *Handbook of Hydrology*, McGraw Hill, 1992.

16. Ecology, Stormwater Management Manual for Western Washington, Washington State Department of Ecology Water Quality Program, Publication Numbers 05-10-029 through 05-10-033 99-13, February 2005.

APPENDIX A – LAND USE DATA

Table A-1 – Inglewood Basin Forested Land Use (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
I1	0.0	81.8	0.0	121.8	0.0	0.0	203.7
I10	0.0	20.5	0.0	3.2	0.0	0.0	23.7
I11	0.0	12.6	0.0	0.2	0.0	0.0	12.8
I12	0.0	13.7	0.0	5.5	0.0	0.0	19.2
I13	0.0	39.2	0.0	1.2	0.0	3.5	43.9
I14	0.0	9.9	0.0	0.0	0.0	1.7	11.7
I2	0.0	188.5	0.0	62.9	0.0	0.0	251.4
I3	0.0	39.4	0.0	12.4	0.0	5.1	56.9
I3A	0.0	4.3	0.0	24.0	0.0	27.0	55.4
I4	0.0	3.1	0.0	10.1	0.0	0.0	13.2
I4A	0.0	164.9	0.0	187.7	0.0	21.9	374.6
I5	0.0	8.3	0.0	48.3	0.0	19.3	76.0
I5A	0.0	49.9	0.0	6.3	0.0	14.6	70.8
I5B	0.0	54.4	0.0	0.0	0.0	0.0	54.4
I6	0.0	42.1	0.0	13.9	0.0	0.0	56.0
I6A	0.0	21.2	0.0	0.1	0.0	0.0	21.3
I7	0.0	216.5	0.0	5.4	0.0	17.5	239.4
I7A	0.0	17.7	0.0	0.3	0.0	0.0	18.0
I8	0.0	11.4	0.0	0.0	0.0	0.0	11.4
I9	0.0	20.8	0.0	3.1	0.0	0.2	24.1
Total	0.0	1020	0.0	506	0.0	111	1637.7

Table A-2 – Inglewood Basin Existing (year 2006) Land Use (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
I1	20.0	32.5	41.3	43.1	66.8	0.0	203.7
I10	1.3	4.2	15.2	0.0	3.0	0.0	23.7
I11	0.5	7.9	4.2	0.0	0.2	0.0	12.8
I12	0.9	1.7	11.3	3.4	1.8	0.0	19.2
I13	4.5	11.9	22.9	0.0	1.0	3.5	43.9
I14	0.1	8.4	1.4	0.0	0.0	1.7	11.7
I2	27.7	63.0	104.7	12.0	44.0	0.0	251.4
I3	5.7	2.1	33.0	1.4	9.6	5.1	56.9
I3A	3.5	1.0	2.9	0.0	21.0	27.0	55.4
I4	0.8	2.9	0.0	0.6	8.9	0.0	13.2
I4A	102.9	28.7	88.1	36.9	96.1	21.9	374.6
I5	25.5	2.1	2.5	7.0	19.6	19.3	76.0
I5A	1.0	27.5	21.5	3.2	3.0	14.6	70.8
I5B	10.7	5.1	38.6	0.0	0.0	0.0	54.4
I6	2.3	13.7	26.7	2.9	10.4	0.0	56.0
I6A	4.9	0.0	16.3	0.0	0.1	0.0	21.3
I7	31.5	77.9	107.9	4.6	0.0	17.5	239.4
I7A	4.0	0.4	13.3	0.0	0.2	0.0	18.0
I8	0.5	3.5	7.4	0.0	0.0	0.0	11.4
I9	2.1	11.5	7.5	0.0	2.8	0.2	24.1
Total	251	306	567	115	289	111	1637.7

Table A-3 – Inglewood Basin Future Build-Out Land Use, According to City of Sammamish Zoning and Sammamish Town Center Plan (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
I1	58.3	0.0	59.5	0.0	85.9	0.0	203.7
I10	4.5	0.0	16.8	0.0	2.4	0.0	23.7
I11	6.7	0.0	6.1	0.0	0.1	0.0	12.8
I12	8.7	0.0	6.0	0.0	3.4	1.0	19.2
I13	15.4	0.0	24.9	0.0	0.2	3.5	43.9
I14	2.7	0.0	7.0	0.0	0.0	1.9	11.7
I2	74.5	0.0	130.3	0.0	46.6	0.0	251.4
I3	12.6	0.0	26.2	0.0	9.0	9.0	56.9
I3A	4.5	0.0	0.3	0.0	11.1	39.5	55.4
I4	3.5	0.0	2.2	0.0	7.5	0.0	13.2
I4A	168.2	0.0	92.7	0.0	98.2	15.5	374.6
I5	30.0	0.0	5.5	0.0	10.8	29.6	76.0
I5A	11.6	0.0	41.0	0.0	5.3	12.9	70.8
I5B	17.3	0.0	35.7	0.0	0.0	1.4	54.4
I6	12.0	0.0	32.8	0.0	10.9	0.2	56.0
I6A	7.9	0.0	13.3	0.0	0.0	0.0	21.3
I7	63.9	0.0	153.8	0.0	3.8	17.8	239.4
I7A	5.4	0.0	11.8	0.0	0.2	0.7	18.0
I8	5.2	0.0	6.2	0.0	0.0	0.0	11.4
I9	10.8	0.0	11.8	0.0	1.5	0.0	24.1
Total	524	0	684	0	297	133	1637.7

Table A-4 – Thompson Basin Forested Land Use (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
t01	0.0	15.2	0.0	1.0	0.0	0.0	16.2
t02	0.0	66.4	0.0	1.6	0.0	0.0	68.0
t03	0.0	45.8	0.0	3.3	0.0	3.3	52.4
t04	0.0	44.5	0.0	1.5	0.0	0.0	46.0
t05	0.0	85.9	0.0	48.1	0.0	28.3	162.3
t06	0.0	26.0	0.0	51.9	0.0	3.8	81.7
t07	0.0	23.5	0.0	33.6	0.0	7.7	64.7
t08	0.0	65.2	0.0	43.8	0.0	0.0	109.0
t09	0.0	4.0	0.0	7.3	0.0	0.0	11.3
t10	0.0	23.2	0.0	0.1	0.0	0.0	23.3
t11	0.0	5.4	0.0	4.2	0.0	0.4	10.0
t12	0.0	0.4	0.0	0.3	0.0	5.7	6.4
t13	0.0	16.8	0.0	4.4	0.0	0.0	21.2
t14	0.0	18.5	0.0	12.0	0.0	0.0	30.5
t15	0.0	5.9	0.0	24.6	0.0	0.0	30.5
t16	0.0	27.5	0.0	0.0	0.0	0.0	27.5
t17	0.0	36.9	0.0	0.2	0.0	0.0	37.1
Total	0.0	511.1	0.0	237.7	0.0	49.2	798.0

Table A-5 – Thompson Basin Existing Land Use (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
t01	1.0	2.8	11.5	0.0	0.9	0.0	16.2
t02	2.5	32.6	31.5	1.2	0.3	0.0	68.0
t03	1.0	30.8	14.1	3.2	0.0	3.3	52.4
t04	1.6	24.0	19.0	0.0	1.5	0.0	46.0
t05	7.7	19.8	61.1	16.5	28.8	28.3	162.3
t06	5.7	5.6	18.5	25.0	23.1	3.8	81.7
t07	2.5	14.8	7.7	15.3	16.8	7.7	64.7
t08	5.6	26.0	35.9	11.1	30.4	0.0	109.0
t09	0.7	0.0	3.7	3.5	3.3	0.0	11.3
t10	2.3	0.0	20.9	0.0	0.1	0.0	23.3
t11	0.2	0.2	5.0	0.1	4.0	0.4	10.0
t12	0.0	0.1	0.3	0.2	0.1	5.7	6.4
t13	0.3	0.5	16.1	0.6	3.7	0.0	21.2
t14	11.4	3.6	8.0	1.2	6.3	0.0	30.5
t15	1.4	2.7	3.0	14.3	9.1	0.0	30.5
t16	9.3	0.5	17.6	0.0	0.0	0.0	27.5
t17	10.4	1.3	25.3	0.0	0.1	0.0	37.1
Total	63.5	165.2	299.2	92.3	128.7	49.2	798.0

Table A-6 – Thompson Basin Future Build-Out Land Use, According to City of Sammamish Zoning and Sammamish Town Center Plan (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
t01	2.4	0.0	12.9	0.0	0.9	0.0	16.2
t02	11.0	0.0	55.6	0.0	1.4	0.0	68.0
t03	5.2	0.0	41.0	0.0	2.9	3.3	52.4
t04	7.6	0.0	37.5	0.0	1.0	0.0	46.0
t05	30.6	0.0	63.5	0.0	39.8	28.3	162.3
t06	18.2	0.0	21.2	0.0	38.6	3.8	81.7
t07	11.2	0.0	19.6	0.0	26.3	7.7	64.7
t08	24.2	0.0	49.5	0.0	35.2	0.0	109.0
t09	1.8	0.0	3.2	0.0	6.3	0.0	11.3
t10	7.8	0.0	15.4	0.0	0.1	0.0	23.3
t11	0.1	0.0	5.4	0.0	4.1	0.4	10.0
t12	0.1	0.0	0.4	0.0	0.3	5.6	6.4
t13	7.0	0.0	10.0	0.0	4.2	0.0	21.2
t14	15.5	0.0	8.5	0.0	6.4	0.0	30.5
t15	7.2	0.0	4.5	0.0	18.8	0.0	30.5
t16	13.3	0.0	14.2	0.0	0.0	0.0	27.5
t17	14.4	0.0	22.6	0.0	0.1	0.0	37.1
Total	177.4	0.0	384.9	0.0	186.6	49.2	798.0

APPENDIX B

Wetland Data Forms

Sammamish Basin Plans
Wetland Field Data Form

W of Inglewood Hill Rd.

Wetland No: 14. **Location:** behind Presbyterian Church. **Date:** Dec 4/08

Sub-basin: Inglewood **Cowardin Class:** PEM **HGM Class:** depressional.

Estimated Wetland Size (ac): <0.1 ____ 0.1-1 ✓ 1-5 ____ 5-10 ____ >10 ____

Identified by: CH, EC. **Photo No.** ____

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes ☐ No ☑

- ☐ a. dredging
- ☐ b. filling
- ☐ c. draining
- ☐ d. clearing
- ☐ e. drainage ditches/diversions
- ☐ f. crop production
- ☐ g. other ____

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes ☑ No ☐

- ☐ a. clearing
- ☐ b. grazing/agriculture
- ☐ c. litter
- ☐ d. recreational overuse
- ☑ e. residential development
- ☐ f. other ____

Hydrology

Water sources and hydroperiod:

- ☐ Ground water (perched water table, through flow…)
- ☐ Surface water
- ☑ Seep
- ☐ Seasonally flooded/saturated
- ☐ Permanently flooded/saturated
- ☐ Other ____

Inlet/outlet:

- ☑ a. constrained, size____
- ☐ b. unconstrained
- ☐ c. natural channel
- ☑ d. none runoff
- ☑ e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes ☐ No ☑

Indicators of wetland hydrology:

- ☐ a. inundation
- ☑ b. saturated in upper 12"
- ☐ c. water marks
- ☐ d. drift lines
- ☐ e. sediment deposits
- ☐ f. drainage patterns in wetlands
- ☐ h. water-stained leaves
- ☐ i. other ____

Soil

Is the wetland mapped on hydric soil? Yes ☐ No ☐

Soil profile: –

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: PHAR, RUSP

Invasive Species? Yes (%) 90 No

Approximate age of dominant woody vegetation (years)?	<50	✓	50-80		>80	
# of habitat types:	1	✓	2		≥ 3	
Degree of interspersion:	Low	✓	Mod		High	

Vegetation connectivity to other habitats? no

Food sources or habitat features for wildlife? no

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [✓] No [ ]

- [ ] a. grass-lawn
- [ ] b. herbaceous-native
- [ ] c. scrub-shrub
- [✓] d. forested
- [ ] f. other ______

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [50] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [✓] No [ ]

- [✓] a. restoration
- [ ] b. creation
- [✓] c. enhancement
- [ ] d. preservation

Notes:

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 18 Observer(s): CH, EC. Date: Dec 4/08

FUNCTION	CRITERIA: LOW RATING	MODERATE RATING	HIGH RATING
Water Quality Improvement	rapid flow through wetland	moderate flow through wetland	✓ little or no flow present
	<50% vegetation density	50-80% vegetation density	✓ >80% vegetation density
	no proximity to pollutants	✓ downstream from non-point pollutants	downstream from point discharges
Evaluation:	✓ detains <25% overland runoff	detains 25-50% overland runoff	detains >50% overland runoff
Flood/Storm Water Control	✓ size <5 acres	size 5-10 acres	size >10 acres
Evaluation:	✓ riverine, shallow depression	mid-sloped wetland	lake, depressions, headwaters, bogs
Groundwater Recharge	✓ size <5 acres	size 5-10 acres	size >10 acres
	temporarily saturated/inundated	✓ seasonally saturated/inundated	permanently inundated
Evaluation:	springs present outflow>inflow	✓ outflow=inflow	outflow<inflow
Natural Biological Support	✓ size <5 acres	size 5-10 acres	size >10 acres
	✓ isolated systems associated with ephemeral surface water	associated with permanent surface water	associated with permanent open water
	✓ one habitat type	two habitat types	three or more habitat types
	✓ little or no interspersion of habitats	some habitat interspersion	habitats highly interspersed
	✓ low plant diversity	moderate plant diversity	high plant diversity
	✓ few, if any habitat features present	some habitat features present	several habitat features present
	adjacent buffers primarily disturbed and/or developed	✓ buffers somewhat disturbed and/or developed	buffers generally undisturbed native vegetation and undeveloped
	✓ few connections to other habitat types	some connection to other habitat types	significant connections to high quality habitat types
Evaluation:	✓ Agricultural land or low vegetation structure	moderate vegetation structure	high vegetation structure
Erosion/Shoreline Protection	✓ sparse grass/forbs or not vegetation	sparse woody vegetation or dense herb vegetation	dense woody vegetation
Evaluation:			

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 18 **Location:** E of 228th 3 bisected by SE 8th **Date:** Dec 4/08

Sub-basin: Inglewood **Cowardin Class:** PSS, PFO, PEM **HGM Class:** Riverine

Estimated Wetland Size (ac): <0.1 ___ 0.1-1 ___ 1-5 ___ 5-10 ✗ >10 X

Identified by: CH, EC **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [X]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ___

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [ ] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [X] e. residential development
- [ ] f. other ___

Hydrology

Water sources and hydroperiod:

- [ ] Ground water (perched water table, through flow…)
- [✓] Surface water
- [ ] Seep
- [ ] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet:

- [ ] a. constrained, size___
- [✓] b. unconstrained
- [✓] c. natural channel
- [ ] d. none
- [ ] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [✓] No [ ]

Indicators of wetland hydrology:

- [ ] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: —

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Salix, ALRU, QUAR, ~~THAA~~ RUSP, SPDO, COSE

Invasive Species? Yes (%) ✓ No

Approximate age of dominant woody vegetation (years)?	<50	✓	50-80		>80	
# of habitat types:	1		2		≥ 3	✓
Degree of interspersion:	Low		Mod		High	✓

Vegetation connectivity to other habitats? yes

Food sources or habitat features for wildlife? yes, - snags

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes ☐ No ☐

- ☐ a. grass-lawn
- ☐ b. herbaceous-native
- ☐ c. scrub-shrub
- ☐ d. forested
- ☐ f. other

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- ☐ a. % no buffer
- ☐ b. % <25 ft
- 70 c. % 25-50 ft
- ☐ d. % 50-100 ft
- ☐ e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes ✓ No ☐

- ✓ a. restoration
- ☐ b. creation
- ✓ c. enhancement
- ☐ d. preservation

Notes: remove lawn grass that abuts wetland. artificial ponds created could remove (N of 8th off of 234th Ave SE

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 18 **Observer(s):** CH, EC **Date:** Dec. 4/08

FUNCTION	CRITERIA: LOW RATING	MODERATE RATING	HIGH RATING
Water Quality Improvement	___ rapid flow through wetland	✓ moderate flow through wetland	___ little or no flow present
	___ <50% vegetation density	___ 50-80% vegetation density	✓ >80% vegetation density
	___ no proximity to pollutants	✓ downstream from non-point pollutants	___ downstream from point discharges
Evaluation: ___	___ detains <25% overland runoff	___ detains 25-50% overland runoff	✓ detains >50% overland runoff
Flood/Storm Water Control	___ size <5 acres	___ size 5-10 acres	✓ size >10 acres
Evaluation: ___	✓ riverine, shallow depression	___ mid-sloped wetland	✓ lake, depressions, ~~headwaters~~, bogs
Groundwater Recharge	___ size <5 acres	___ size 5-10 acres	✓ size >10 acres
	___ temporarily saturated/inundated	✓ seasonally saturated/inundated	✓ permanently inundated
Evaluation: ___	___ springs present outflow>inflow	✓ outflow=inflow	___ outflow<inflow
Natural Biological Support	___ size <5 acres	___ size 5-10 acres	✓ size >10 acres
	___ isolated systems associated with ephemeral surface water	✓ associated with permanent surface water	___ associated with permanent open water
	___ one habitat type	___ two habitat types	✓ three or more habitat types
	___ little or no interspersion of habitats	___ some habitat interspersion	✓ habitats highly interspersed
	___ low plant diversity	___ moderate plant diversity	✓ high plant diversity
	___ few, if any habitat features present	___ some habitat features present	✓ several habitat features present
	___ adjacent buffers primarily disturbed and/or developed	✓ buffers somewhat disturbed and/or developed	___ buffers generally undisturbed native vegetation and undeveloped
	___ few connections to other habitat types	✓ some connection to other habitat types	___ significant connections to high quality habitat types
Evaluation: ___	___ Agricultural land or low vegetation structure	___ moderate vegetation structure	✓ high vegetation structure
Erosion/Shoreline Protection	___ sparse grass/forbs or not vegetation	___ sparse woody vegetation or dense herb vegetation	✓ dense woody vegetation
Evaluation: ___			

Sammamish Basin Plans
Wetland Field Data Form

1832

Wetland No:	WK8	**Location:**	235th Ave. NE. N of NE8th	**Date:**	Dec 4/08
Sub-basin:	Inglewood.	**Cowardin Class:**	PEm, open water	**HGM Class:**	Dep.

Estimated Wetland Size (ac): <0.1 ___ 0.1-1 ___ 1-5 ✓ 5-10 ___ >10 ___

Identified by: CH, EC. **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [ ]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ___

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [x] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [x] e. residential development
- [ ] f. other ___

Hydrology

Water sources and hydroperiod:

- [x] Ground water (perched water table, through flow…)
- [ ] Surface water
- [ ] Seep
- [x] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ponding

Inlet/outlet:

- [ ] a. constrained, size___
- [ ] b. unconstrained
- [ ] c. natural channel
- [x] d. none
- [x] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [ ] No [x]

Indicators of wetland hydrology:

- [x] a. inundation
- [x] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: —

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Invasive Species? Yes (%) 20 No

Poa, Salix sp. PHAR, SPDO

Approximate age of dominant woody vegetation (years)?	<50	✓	50-80		>80	
# of habitat types:	1	✓	2		≥ 3	
Degree of interspersion:	Low	✓	Mod		High	

Vegetation connectivity to other habitats? no

Food sources or habitat features for wildlife? no

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes ☑ No ☐

- ☑ a. grass-lawn
- ☐ b. herbaceous-native
- ☐ c. scrub-shrub
- ☑ d. forested
- ☐ f. other ________

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [65] b. % <25 ft
- [ ] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes ☐ No ☐

- ☑ a. restoration
- ☐ b. creation
- ☐ c. enhancement
- ☐ d. preservation

Notes:

shelly 425-894-7704
Mike 425-444-0903

1832

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. W15. **Observer(s):** CH, EC. **Date:** Dec 4/08

FUNCTION	CRITERIA: LOW RATING	CRITERIA: MODERATE RATING	CRITERIA: HIGH RATING
Water Quality Improvement	___ rapid flow through wetland	___ moderate flow through wetland	✓ little or no flow present
	___ <50% vegetation density	___ 50-80% vegetation density	✓ >80% vegetation density
	___ no proximity to pollutants	✓ downstream from non-point pollutants	___ downstream from point discharges
Evaluation: ________	✓ detains <25% overland runoff	___ detains 25-50% overland runoff	___ detains >50% overland runoff
Flood/Storm Water Control	___ size <5 acres	✓ size 5-10 acres	___ size >10 acres
Evaluation: ________	___ riverine, shallow depression	___ mid-sloped wetland	___ lake, depressions, headwaters, bogs
Groundwater Recharge	✓ size <5 acres	___ size 5-10 acres	___ size >10 acres
	___ temporarily saturated/inundated	✓ seasonally saturated/inundated	___ permanently inundated
Evaluation: ________	___ springs present outflow>inflow	✓ outflow=inflow	___ outflow<inflow
Natural Biological Support	✓ size <5 acres	___ size 5-10 acres	___ size >10 acres
	✓ isolated systems associated with ephemeral surface water	___ associated with permanent surface water	___ associated with permanent open water
	✓ one habitat type	___ two habitat types	___ three or more habitat types
	✓ little or no interspersion of habitats	___ some habitat interspersion	___ habitats highly interspersed
	✓ low plant diversity	___ moderate plant diversity	___ high plant diversity
	✓ few, if any habitat features present	___ some habitat features present	___ several habitat features present
	___ adjacent buffers primarily disturbed and/or developed	✓ buffers somewhat disturbed and/or developed	___ buffers generally undisturbed native vegetation and undeveloped
	✓ few connections to other habitat types	___ some connection to other habitat types	___ significant connections to high quality habitat types
Evaluation: ________	___ Agricultural land or low vegetation structure	✓ moderate vegetation structure	___ high vegetation structure
Erosion/Shoreline Protection	___ sparse grass/forbs or not vegetation	✓ sparse woody vegetation or dense herb vegetation	___ dense woody vegetation
Evaluation: ________			

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: ~~Pb~~ 1502 Location: N of NE 8th Date: Dec 4/08

Sub-basin: Inglewood Cowardin Class: PSS, PEM HGM Class: Dep

Estimated Wetland Size (ac): <0.1 ____ 0.1-1 ✓ 1-5 ____ 5-10 ____ >10 ____

Identified by: CH, EC Photo No. ____

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [✓]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ____

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [✓] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [X] e. residential development
- [ ] f. other ____

Hydrology

Water sources and hydroperiod:

- [X] Ground water (perched water table, through flow…)
- [ ] Surface water
- [ ] Seep
- [ ] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ____

Inlet/outlet:

- [ ] a. constrained, size____
- [ ] b. unconstrained
- [ ] c. natural channel
- [ ] d. none
- [✓] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [ ] No [✓]

Indicators of wetland hydrology:

- [ ] a. inundation
- [✓] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ____

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: —

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: RUSP, SPDO, ALRU, Salix, RURA, THPL, PHAR

Invasive Species? Yes (%) 20 No ___

Approximate age of dominant woody vegetation (years)?	<50	✓	50-80		>80	
# of habitat types:	1		2	✓	≥3	
Degree of interspersion:	Low	✓	Mod		High	

Vegetation connectivity to other habitats?

Food sources or habitat features for wildlife?

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [✓] No [ ]

- [✓] a. grass-lawn
- [ ] b. herbaceous-native
- [ ] c. scrub-shrub
- [✓] d. forested
- [ ] f. other ______

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [80] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [✓] No [ ]

- [✓] a. restoration
- [ ] b. creation
- [ ] c. enhancement
- [ ] d. preservation

Notes:

WQ	H	Biosupport L
	H	L
	M	M
	L	L
Flood/Slo	L	L
	$ (shallow dep)	M
GW recharge	L	M
	M	M
	M	M
		H

Data transferred to data sheet. Dec 8/08

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 1502 **Observer(s):** Ncf NE 8th **Date:** Dec 4/08

FUNCTION		CRITERIA: LOW RATING		MODERATE RATING		HIGH RATING
Water Quality ~~Improvement~~		rapid flow through wetland		moderate flow through wetland	✓	little or no flow present
		<50% vegetation density		50-80% vegetation density	✓	>80% vegetation density
		no proximity to pollutants	✓	downstream from non-point pollutants		downstream from point discharges
Evaluation:	✓	detains <25% overland runoff		detains 25-50% overland runoff		detains >50% overland runoff
Flood/Storm Water Control	✓	size <5 acres		size 5-10 acres		size >10 acres
Evaluation:	✓	riverine, shallow depression		mid-sloped wetland		lake, depressions, headwaters, bogs
Groundwater Recharge	✓	size <5 acres		size 5-10 acres		size >10 acres
		temporarily saturated/inundated	✓	seasonally saturated/inundated		permanently inundated
Evaluation:		springs present outflow>inflow	✓	outflow=inflow		outflow<inflow
Natural Biological Support	✓	size <5 acres		size 5-10 acres		size >10 acres
	✓	isolated systems associated with ephemeral surface water		associated with permanent surface water		associated with permanent open water
		one habitat type	✓	two habitat types		three or more habitat types
	✓	little or no interspersion of habitats		some habitat interspersion		habitats highly interspersed
	✓	low plant diversity		moderate plant diversity		high plant diversity
		few, if any habitat features present	✓	some habitat features present		several habitat features present
		adjacent buffers primarily disturbed and/or developed	✓	buffers somewhat disturbed and/or developed		buffers generally undisturbed native vegetation and undeveloped
		few connections to other habitat types	✓	some connection to other habitat types		significant connections to high quality habitat types
Evaluation:		Agricultural land or low vegetation structure	✓	moderate vegetation structure		high vegetation structure
Erosion/Shoreline Protection		sparse grass/forbs or not vegetation		sparse woody vegetation or dense herb vegetation	✓	dense woody vegetation
Evaluation:						

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 1509 **Location:** Starts E of 228th Ave over to 244th **Date:** Dec 4/08

Sub-basin: Inglewood **Cowardin Class:** PSS, PEM, **HGM Class:** Riverine

Estimated Wetland Size (ac): <0.1 ____ 0.1-1 ____ 1-5 ____ 5-10 ____ >10 ✓

Identified by: CH, EC **Photo No.** ____

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [✓]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other development, pipeline

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [✓] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [X] e. residential development
- [ ] f. other ____

Hydrology

Water sources and hydroperiod:

- [ ] Ground water (perched water table, through flow…)
- [✓] Surface water
- [ ] Seep
- [✓] Seasonally flooded/saturated
- [✓] Permanently flooded/saturated
- [ ] Other ____

Inlet/outlet:

- [ ] a. constrained, size____
- [ ] b. unconstrained
- [ ] c. natural channel
- [ ] d. none
- [✓] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [✓] No [ ]

Indicators of wetland hydrology:

- [✓] a. inundation
- [✓] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ____

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: —

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: RUSP, ~~tree~~ PHCA, POBA, red osier, TYLA, CUAR

Invasive Species? Yes (%) 20+ No ___

Approximate age of dominant woody vegetation (years)?	<50	✓	50-80		>80	
# of habitat types:	1		2		≥3	✓
Degree of interspersion:	Low		Mod		High	✓

Vegetation connectivity to other habitats? yes.

Food sources or habitat features for wildlife? ~~tbop~~, snags.

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes ✓ No ☐

- ☒ a. grass-lawn
- ☐ b. herbaceous-native
- ☐ c. scrub-shrub
- ☒ d. forested
- ☒ f. other large wetland, buffer developed

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- ☐ a. % no buffer
- 100 b. % <25 ft
- ☐ c. % 25-50 ft
- ☐ d. % 50-100 ft
- ☐ e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes ✓ No ☐

- ☐ a. restoration
- ☐ b. creation
- ✓ c. enhancement
- ☐ d. preservation

Notes:

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 1509 Observer(s): CH, EC Date: Dec 4/00

FUNCTION	CRITERIA: LOW RATING	MODERATE RATING	HIGH RATING
Water Quality Improvement	rapid flow through wetland	✓ moderate flow through wetland	little or no flow present
	<50% vegetation density	50-80% vegetation density	✓ >80% vegetation density
	no proximity to pollutants	✓ downstream from non-point pollutants	downstream from point discharges
Evaluation:	detains <25% overland runoff	detains 25-50% overland runoff	✓ detains >50% overland runoff
Flood/Storm Water Control	size <5 acres	size 5-10 acres	✓ size >10 acres
Evaluation:	riverine, shallow depression	mid-sloped wetland	lake, depressions, headwaters, bogs
Groundwater Recharge	size <5 acres	size 5-10 acres	✓ size >10 acres
	temporarily saturated/inundated	seasonally saturated/inundated	✓ permanently inundated
Evaluation:	springs present outflow>inflow	outflow=inflow	outflow<inflow
Natural Biological Support	size <5 acres	size 5-10 acres	✓ size >10 acres
	isolated systems associated with ephemeral surface water	✓ associated with permanent surface water	associated with permanent open water
	one habitat type	two habitat types	✓ three or more habitat types
	little or no interspersion of habitats	some habitat interspersion	✓ habitats highly interspersed
	low plant diversity	moderate plant diversity	✓ high plant diversity
	few, if any habitat features present	some habitat features present	✓ several habitat features present
	adjacent buffers primarily disturbed and/or developed	✓ buffers somewhat disturbed and/or developed	buffers generally undisturbed native vegetation and undeveloped
	few connections to other habitat types	✓ some connection to other habitat types	significant connections to high quality habitat types
Evaluation:	Agricultural land or low vegetation structure	✓ moderate vegetation structure	high vegetation structure
Erosion/Shoreline Protection	sparse grass/forbs or not vegetation	sparse woody vegetation or dense herb vegetation	✓ dense woody vegetation
Evaluation:			

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 1S11 **Location:** E of 228th, N of SE 8th **Date:** Dec 4/08

Sub-basin: Inglewood. **Cowardin Class:** PSS, PEM **HGM Class:** Riverine

Estimated Wetland Size (ac): <0.1 ___ 0.1-1 ___ 1-5 ___ 5-10 ✓ >10 ___

Identified by: CH, CE **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [✓]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ___

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [✓] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [✓] e. residential development
- [ ] f. other ___

Hydrology

Water sources and hydroperiod:

- [ ] Ground water (perched water table, through flow…)
- [✓] Surface water
- [ ] Seep
- [ ] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet:

- [ ] a. constrained, size ___
- [ ] b. unconstrained
- [✓] c. natural channel
- [ ] d. none
- [ ] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [✓] No [ ]

Indicators of wetland hydrology:

- [✓] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: —

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Invasive Species? Yes (%) ✓ No ___

Juncus, sp. TYLA, grass spp, RUSP, RUAR

Approximate age of dominant woody vegetation (years)?	<50	✓	50-80		>80	
# of habitat types:	1		2		≥ 3	✓
Degree of interspersion:	Low		Mod		High	✓

Vegetation connectivity to other habitats? yes.

Food sources or habitat features for wildlife? yes

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes ☑ No ☐

- ☑ a. grass-lawn
- ☑ b. herbaceous-native
- ☐ c. scrub-shrub
- ☑ d. forested
- ☐ f. other ___

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [ ] c. % 25-50 ft
- [50] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes ☑ No ☐

- ☑ a. restoration
- ☐ b. creation
- ☐ c. enhancement
- ☐ d. preservation

Notes:

Attachment B

Thompson Sub-basin Plan

Prepared for

City of Sammamish
801 228th Avenue SE
Sammamish, WA 98075

Prepared by

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September 2011 | 558-3847-002 (01/07)

CITATION

City of Sammamish. 2011. Thompson Sub-basin Plan.
Prepared by Parametrix, Bellevue, Washington,
in association with WindWard Environmental,
Seattle, Washington. September 2011.

CERTIFICATION

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

Prepared by Erin Nelson

Checked by Jan Rosholt

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ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
CAO	Critical Areas Ordinance
CIP	Capital Improvement Project
City	City of Sammamish
DEIS	Draft Environmental Impact Statement
Ecology	Washington State Department of Ecology
GMA	Growth Management Act
gpm	gallons per minute
KCC	King County Code
LID	Low Impact Development
msl	mean sea level
NPDES	National Pollutant Discharge Elimination System
RCW	Revised Code of Washington
RM	river mile
SEPA	State Environmental Policy Act
SMC	Sammamish Municipal Code
UGA	urban growth area
WDFW	Washington Department of Fish and Wildlife

EXECUTIVE SUMMARY

The Thompson Sub-basin is one of two basins located at the headwaters of the proposed Sammamish Town Center development, which is entirely within the urban growth area (UGA) for the City of Sammamish (City) and designated for future development (Figure ES-1). The Thompson Sub-basin also consists of high quality natural areas, including kokanee spawning habitat in Ebright Creek, that are worthy of protection. The juxtaposition of increased development and natural area protection can result in conflicting goals and require thoughtful land use policies and consideration of potential environmental consequences. The proposed Town Center will be a model of sustainability, incorporating green architecture and infrastructure (City of Sammamish. 2007), with a goal of minimizing impacts to natural resources. This basin plan augments the Town Center planning efforts through documentation of downstream resources in the Thompson Sub-basin and provides strategies to effectively manage existing and potential future stormwater and surface water runoff issues.

In general, the Thompson Sub-basin is in fairly good condition with respect to aquatic habitat because it is still relatively undeveloped compared to many suburbs east of Lake Washington. The Ebright Creek corridor has remained forested because only minor development has occurred in the basin and large wetlands at the headwaters of the creek attenuated flows to the downstream reaches.

Specific features that define the Thompson Sub-basin and are important considerations in the development of projects and strategies are as follows:

Basin Topography—Basin topography is characterized by a relatively flat plateau bisected by a steep ravine that funnels water directly into a well-defined stream channel of Ebright Creek and outlets into Lake Sammamish. The wetland complexes on the top of the plateau attenuate flow to Ebright Creek and should be protected.

Development—Current level of development in Thompson Sub-basin is less than many other suburbs east of Lake Washington, with less impervious surfaces and a more rural character. There is more to preserve here than restore.

Geology—The underlying geological features on the plateau of Thompson Sub-basin consist mostly of compacted till, representing a challenge for infiltrative stormwater best management practices. However, the steep ravines are located in erosive advanced outwash and are prone to landslides. It is important to manage stormwater runoff close to the top of the basin to minimize impacts downstream, particularly in large high quality wetlands.

Kokanee Salmon—Ebright Creek supports what is perhaps one of the last viable, native Lake Sammamish late-run kokanee populations in the greater Lake Sammamish Watershed.

The projects and strategies recommended are designed to preserve ecological function in areas that are currently functioning well, solve existing problems, and prevent future degradation as the Thompson Sub-basin is further developed (Table ES-1).

The cost of these projects is about $500,000, not including property acquisition. The projects represent a variety of issues and strategies to protect the Thompson Sub-basin. Because the basin is relatively undeveloped compared to its zoning potential, there are not a lot of capital projects to fix existing problems. The most pressing need in the basin is to preserve the existing natural resources and prevent future harm. Many of the recommended projects would be eligible for grant funding. Other projects could be largely accomplished with volunteers or community and environmental groups. Funding strategies will likely need to be multi-faceted, taking advantage of opportunities as they arise.

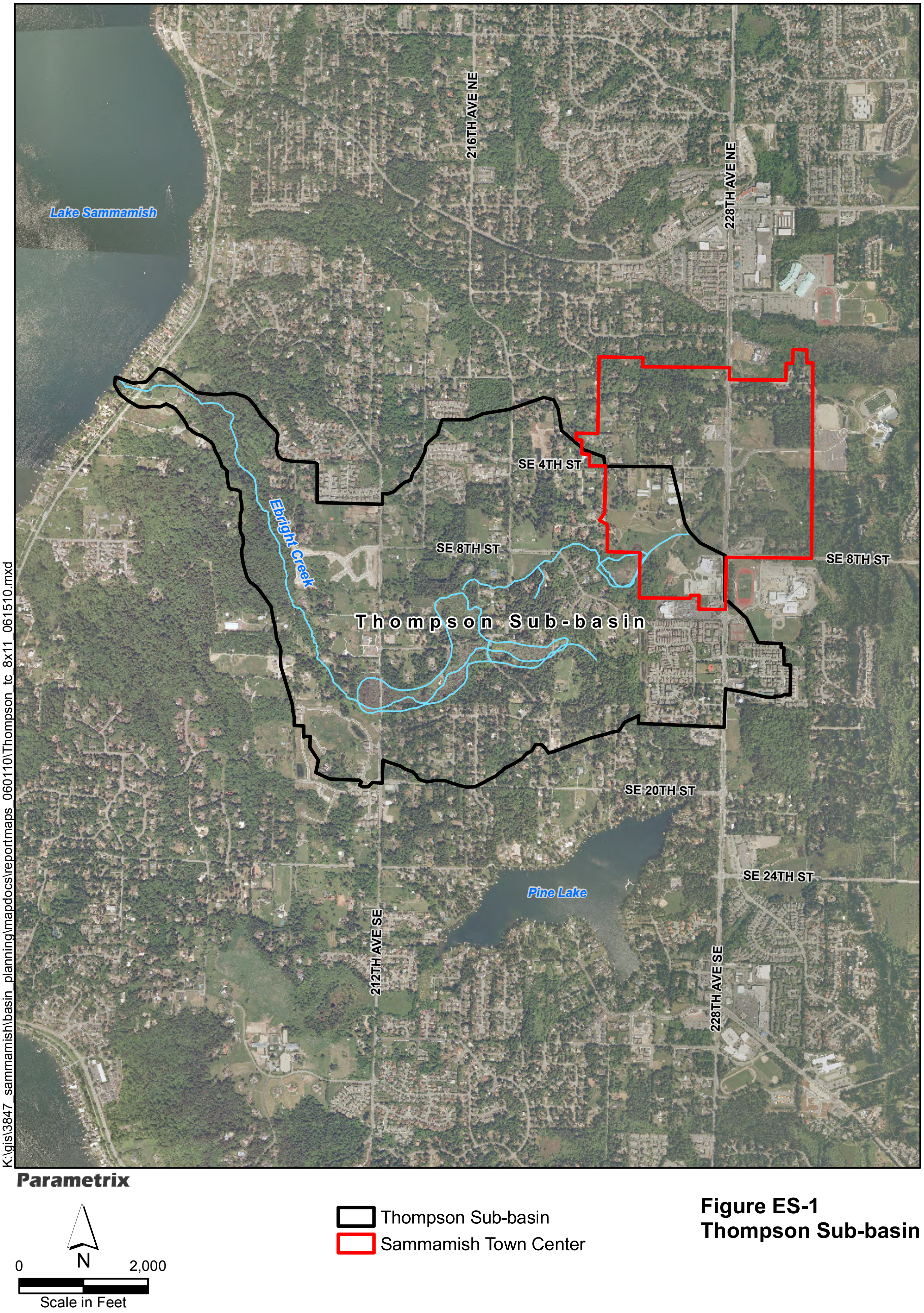


Figure ES-1
Thompson Sub-basin

Table ES-1. Matrix of Recommended Projects

Strategy	Project Identification	Type of Strategy: Planning	Education	Capital	Description	Potential Partners	Cost	Priority
Acquire high quality property for conservation	Cons-1			X	Partner with land conservancy organizations to acquire undeveloped, forested tracts of land near the headwaters of Ebright Creek to preserve wetland functions and wildlife corridors		$87,000 per acre	High
Replace private culvert on Ebright Creek	Culv-1			X	Upgrade private culvert on Ebright Creek to provide/improve fish passage to upstream spawning habitat for kokanee salmon	Private property owner, King County, grant organizations	$118,000	High
Encourage manure management strategies	Ed-3		X		Increase awareness of bacterial effects from manure in streams and utilize resources available from King County to aid in manure management	City of Sammamish, King County, private citizens, King County Conservation District	$800	High
Implement Beaver Management Program	Plan-1	X			Implement beaver management strategies where necessary, including Wetland 17	Private citizens, Washington Department of Fish and Wildlife (WDFW)	$10,000 plan, ~ $12,000 beaver deceiver	High
Conduct kokanee salmon awareness and mascot campaign	Ed-4		X		Campaign to increase awareness of kokanee salmon and the importance of Ebright Creek to the continued existence of this population of fish	School groups, environmental organizations	$13,000	Medium
Evaluate injection of treated stormwater	Study-1	X			Evaluate if injection of treated stormwater in deep wells is feasible		To be determined	Medium
Enhance Wetland 17	Enh-1 and Enh-2			X	Restore/enhance pasture area in Wetland 17	Private property owners, developers in need of potential mitigation, conservancy groups	$152,000 for both	Low

Table ES-1. Matrix of Recommended Projects (continued)

Strategy	Project Identification	Type of Strategy: Planning	Type of Strategy: Education	Type of Strategy: Capital	Description	Potential Partners	Cost	Priority
Enhance Wetlands 1 and 2	Enh-3 and Enh-4			X	Enhance Wetlands 1 and 2 in Ebright Creek Park	Sammamish Parks Department, private citizens, conservancy groups	$152,000 for both	Low
Conduct wetland tours	Ed-1		X		Sponsor wetland tours to foster appreciation and stewardship of Sammamish wetlands	Audubon Society, non-profit environmental groups	$6,000	Low
Encourage low impact development (LID) educational strategies	Ed-2		X		Encourage LID techniques for developers and homeowners in the Thompson sub-basin	Sammamish Water and Sewer District, conservancy groups, private citizens	$6,000	Low
Evaluate LID effectiveness	Study-2	X			Evaluate effectiveness of LID ordinance		To be determined	Low
Install and monitor Ebright Creek flow gauge	Mon-1	X			Use Ebright Creek flow data to calibrate existing model and monitor effects of development within the watershed	City of Sammamish	$15,000 first year, $5,000 annually	Not rated
Conduct Wetland 17 elevation monitoring	Mon-2	X			Continue collecting Wetland 17 elevations to monitor changes over time	City of Sammamish	$7,000 annually	Not rated
Conduct Wetland 61 elevation monitoring	Mon-3	X			Monitor Wetland 61 elevation to correlate any effects of development with wetland elevations	City of Sammamish	$7,000 annually	Not rated
Conduct Ebright Creek cross section monitoring	Mon-4	X			Conduct annual measurements of two cross sections to determine changing channel conditions	City of Sammamish	$3,000 annually, one-time report cost of $4,000	Not rated
Conduct water quality monitoring	Mon-5	X			Continue King County's monitoring of Ebright Creek to record levels of nutrients, dissolved oxygen, and bacteria	King County, City of Sammamish	To be determined	Not rated

1. INTRODUCTION

The Thompson Sub-basin is one of two basins located at the headwaters of the proposed Sammamish Town Center development, which is entirely within the urban growth area (UGA) for the City of Sammamish (City) and designated for future development (Figure 1). The Thompson Sub-basin also consists of high quality natural areas, including kokanee spawning habitat in Ebright Creek, that are worthy of protection. The juxtaposition of increased development and natural area protection can result in conflicting goals and require thoughtful land use policies and consideration of potential environmental consequences. The proposed Town Center will be a model of sustainability, incorporating green architecture and infrastructure (City of Sammamish 2007), with a goal of minimizing impacts to natural resources. This basin plan augments the Town Center planning efforts through documentation of downstream resources in the Thompson Sub-basin and provides strategies to effectively manage existing and potential future stormwater and surface water runoff issues.

Previous studies have been completed that included the Thompson Sub-basin, beginning in 1995 with King County's East Lake Sammamish Basin and Nonpoint Action Plan that evaluated the entire East Lake Sammamish Watershed. This King County plan was completed at a scale that addressed impacts occurring in the mid-1990s when highly forested rural areas on the Sammamish Plateau were being converted to moderate density residential areas with commercial centers. Current plans for a high density and sustainable Sammamish Town Center require the development of a more focused strategy for assessing the Thompson Sub-basin to facilitate responsible planning so that potential watershed issues associated with the Town Center and other planned urban development can be averted.

1.1 BASIN PLANNING CONTEXT

The goals of this basin plan are to identify stormwater and surface water-related projects and strategies that (1) protect existing natural resources, (2) restore or enhance ecological or surface water functions where they are impaired, and (3) prevent future degradation of natural resources from future development. The City's Comprehensive Plan (City of Sammamish 2003) provides the impetus for completing basin plans:

> "The City shall provide Basin Plans for all areas of the City by either adopting existing plans or creating new ones, to assure that permitted development will not degrade the surface or ground water resources." (Goal ECP-1.27)

Additionally, the City has many environmental goals in the Comprehensive Plan (City of Sammamish 2003) that relate directly to basin planning efforts, including:

> **"**Preserve and enhance the natural features and historic, cultural and archeological resources of the community." (Goal LUG-9)
>
> **"**Preserve trees and other natural resources as integral components of the community's overall design." (Goal LUG-10)
>
> **"**Practice environmental stewardship by protecting, enhancing, and promoting the natural environment in and around the City." (Goal EC-1)
>
> **"**Maintain a surface water and groundwater system that serves the community, enhances the quality of life, and protects the environment." (Goal EC-3)

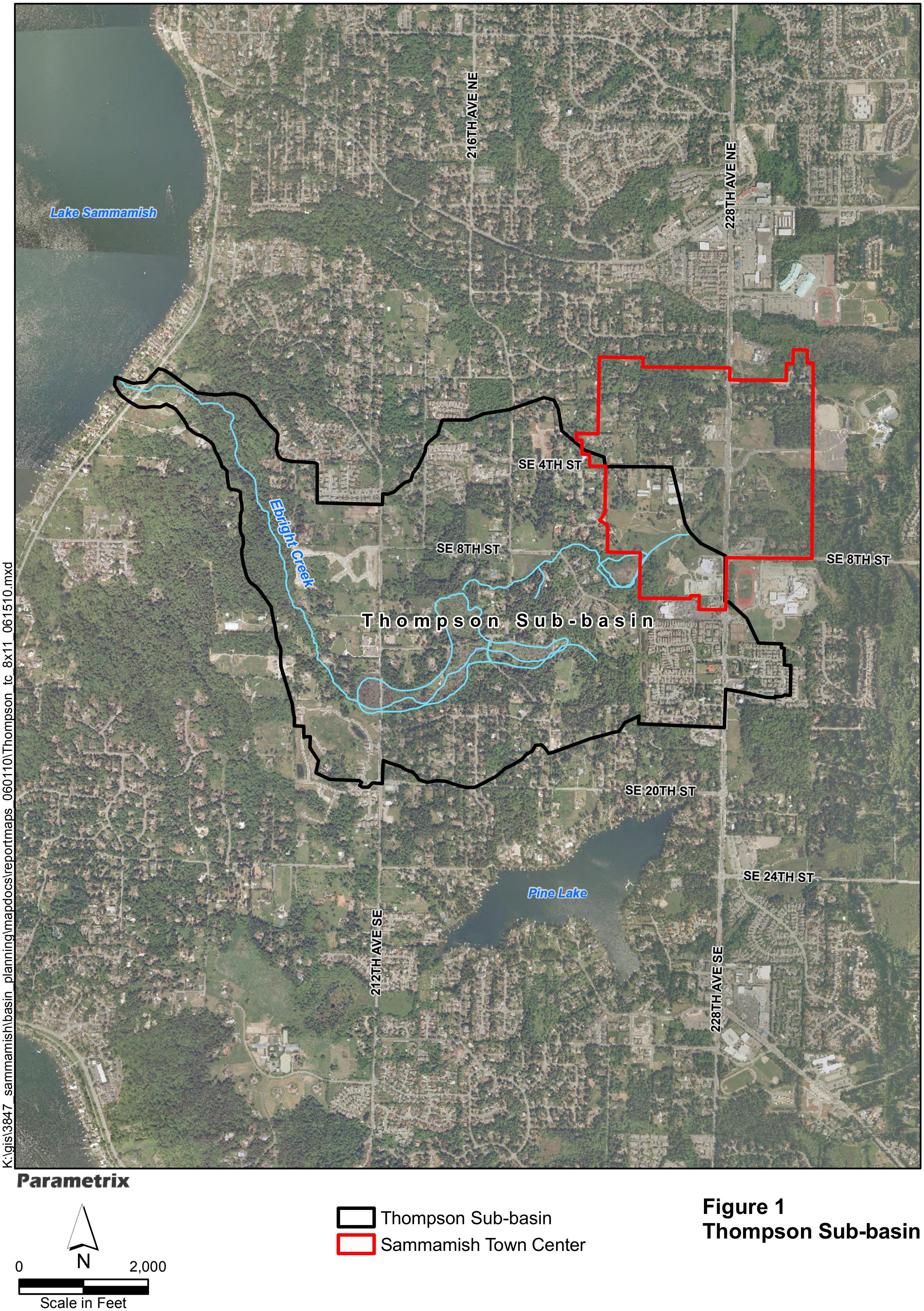


Figure 1
Thompson Sub-basin

These City goals, as well as regulatory directives, such as the City's National Pollutant Discharge Elimination System (NPDES) Phase II permit, and public safety issues such as flooding and access to clean water, provide the framework for development of the Thompson Sub-basin plan (Figure 2).

Figure 2. Basin Plan Framework

In general, this basin plan is organized into sections based on the community and regulatory framework and what is known (review of previous documentation, results of the Parametrix field investigation and hydrologic modeling), followed by recommendations that are consistent with the City's goals and policies to address existing and potential future watershed concerns. Specific projects and strategies to address watershed concerns were developed into stand-alone projects that can be implemented through the City's Capital Improvement Project (CIP) program.

2. COMMUNITY AND REGULATORY FRAMEWORK

The City of Sammamish governs land use, stormwater, and the use of natural resources through codes and ordinances that are specific to the City or dictated by overarching state and federal regulations. These regulations, along with the City's vision to "blend small town atmosphere with suburban character" and maintain "quality neighborhoods, vibrant natural features, and outstanding recreational opportunities," result in several overlapping policies and goals regarding the management of stormwater and natural resources in the Thompson Sub-basin. Table 1 summarizes existing federal, state, and local regulations related to stormwater runoff and natural resources and the relevance of these regulations to the Thompson Sub-basin.

Table 1. Regulatory Framework of Surface Water Management in the Thompson Sub-basin

Law	Implementing Entity	Regulatory Programs	Intent and Specifics	Relevance to Thompson Sub-basin
Clean Water Act	Washington State Department of Ecology	NPDES Phase II Municipal Separate Storm Sewer System Permit	Eliminate discharge of pollutants into the nation's water, and achieve water quality levels that are protective of beneficial uses	The City of Sammamish is a NPDES Phase II permittee and must comply with conditions of the permit.
	Washington State Department of Ecology	Surface Water Quality Standards	Protect and regulate the quality of surface water in Washington State through (1) sustaining designated uses, (2) meeting numeric water quality criteria, and (3) implementing anti-degradation policies	Ebright Creek is listed on the state's 303(d) Category 5 list for water quality impairment by fecal coliform bacteria because of non-compliance with numeric water quality standards. Ebright Creek is also on the Category 2 water of concern list for dissolved oxygen.
	Washington State Department of Ecology and U.S. Army Corps of Engineers	Sections 401 and 404	Requires a permit for activities classified by the U.S. Army Corps of Engineers for dredge or discharge of fill material to Waters of the United States	Ebright Creek and associated wetlands and tributaries, including Lake Sammamish, are considered Waters of the United States. In-water activities that meet minimum dredge and fill limits require a permit.
Tribal Agreements and Related Case Law	Muckleshoot Tribe or Snoqualmie Tribe		Protect fish populations in traditional fishing grounds of Native American tribes	Snoqualmie and Muckleshoot Tribes are party to State Environmental Policy Act (SEPA) review of development proposals and programs within the Thompson Watershed.
Endangered Species Act	United States Fish and Wildlife Service and NOAA Fisheries in consultation with lead federal agencies		Prevent further decline of listed terrestrial and aquatic species, including Puget Sound Chinook salmon, steelhead trout, marbled murrelet, and other species	Kokanee salmon may receive endangered species status and kokanee are known to spawn in Ebright Creek. The potential listing of kokanee salmon would require project proponents to consider potential impacts to listed species during project reviews if a federal nexus was present (i.e., federal permit such as Section 404 permit or federal funding).

Table 1. Regulatory Framework of Surface Water Management in the Thompson Basin (continued)

Law	Implementing Entity	Regulatory Programs	Intent and Specifics	Relevance to Thompson Sub-basin
State Environmental Policy Act	The City of Sammamish conducts reviews and issues SEPA determinations on proposed projects within its jurisdiction		Identify and require mitigation of the environmental impacts of proposals and programs	SEPA is used to address impacts on projects in the Thompson Sub-basin that are not covered in other City code requirements.
Shoreline Management Act	City of Sammamish Shoreline Master Plan		Protect use and functions (economic, ecological, aesthetic) of shoreline areas	Only the part of the Thompson Sub-basin that borders Lake Sammamish is included in the City's Shoreline Master Plan.
Washington State Hydraulic Code	Washington State Department of Fish and Wildlife (WDFW)		Sets requirements for placement of culverts and other hydraulic devices that may affect fish use	Projects within ordinary high water mark of streams must obtain a Hydraulic Project Approval permit from WDFW. Culverts must be fish passable where fish are present.
Growth Management Act (GMA)	City of Sammamish implements GMA	City of Sammamish Comprehensive Plan, Sammamish Town Center Plan	Regulate land use to meet growth targets while providing necessary services and protecting sensitive environmental resources	The Thompson Sub-basin is located in a designated UGA within the City of Sammamish.

2.1 CITY OF SAMMAMISH SURFACE WATER CODE AND REQUIREMENTS

The City's surface water code (Sammamish Municipal Code [SMC] §15.05.010), through adoption of King County's 1998 Surface Water Design Manual and code (King County Code [KCC] §9.12.035), outlines stormwater management requirements for new development and redevelopment projects that meet certain size thresholds within the City's jurisdiction. This is the primary regulatory mechanism for managing stormwater. The City is in the process of updating its code to include adoption of the latest King County Surface Water Design Manual (2009) or the Washington State Department of Ecology (Ecology) 2005 Stormwater Management Manual for Western Washington (2005 Ecology Manual), as required by the City's Phase II NPDES permit.

The City of Sammamish adopted a Low Impact Development (LID) Ordinance (02008-236) in 2008. This ordinance is based on incentives and encourages development proposals to incorporate LID techniques in exchange for increased density, signage, publicity, and other incentives.

In addition to adoption of a stormwater management manual that is consistent with the 2005 Ecology Manual, the City's NPDES Phase II permit outlines several stormwater management requirements related to water quality, including:

- Public education;
- Illicit discharge detection and elimination programs;
- Public involvement and participation;
- Construction and development runoff control; and
- Municipal operation and maintenance.

The City already has many of these stormwater management components in place and is currently updating its stormwater management approach to comply with NPDES Phase II permit requirements. The NPDES program requirements will affect the Thompson Sub-basin in the following ways: updated stormwater management requirements for new development; opportunities for developers to obtain special allowances in exchange for utilizing LID techniques; increased maintenance frequency for City stormwater infrastructure; and continued public involvement and education regarding stormwater issues.

2.2 CITY OF SAMMAMISH COMPREHENSIVE PLAN

The Comprehensive Plan was adopted in 2003 and updated in 2006. It was developed in accordance with the state GMA's planning goals (Revised Code of Washington [RCW] 36.70A.020), which includes encouraging growth in urban areas where City services will be provided, limiting sprawl, protecting the environment and natural areas, and encouraging the involvement of citizens in the planning process. The Thompson Sub-basin is located entirely within the city's UGA. The Comprehensive Plan outlines several goals associated with each planning element. The goals related to surface water management and basin planning are summarized in Table 2 showing how these goals relate to existing City regulations.

Table 2. Relationship of Comprehensive Plan Goals to Existing City Regulations and Programs

	Elements of Comprehensive Plan Goals Related to Stormwater Management									
City Codes and Regulations	**Preservation of Natural Environment/Open Space**	**Encourage Non-traditional Alternatives to Stormwater Management**	**Environmental Education**	**Protect Surface and Ground Water Resources**	**Minimize Impervious Surfaces**	**Integrated Water Resources Management**	**Use Incentives, Regulations and Programs to Manage Water Resources**	**Enhance Water Quality**	**Protect Ground Water Recharge Quantity and Quality**	**Maintain Ecologic and Hydrologic Functioning of Natural Systems**
Critical Areas Ordinance	√			√					√	√
Growth Management Act	√									
LID Ordinance		√			√		√			
City/Town Center Stormwater Code		√		√	√	√				√
Shoreline Management Act	√									
NPDES Phase II Permit			√					√		

2.2.1 Town Center Plan

The Sammamish Town Center Plan was adopted in June 2008, outlining elements related to the development of 240 acres of property along 228th Avenue SE at the headwaters of the Thompson and Inglewood basins. The elements in the Town Center Plan that relate to this basin plan include land use, open space, natural systems, and capital facilities and utilities. The Town Center Plan cites opportunities to "employ an integrated strategy to managing storm water and enhance the ecology" through "LID techniques to more closely emulate the natural hydrology" and "coordinate storm water management through an integrated regional system." A separate Comprehensive Stormwater Master Plan was prepared for the Town Center (Parametrix 2009a); design strategies for the Town Center will also be briefly discussed in this plan.

2.2.2 Critical Areas Ordinance

Several designated critical areas are located within the Thompson Sub-basin, including landslide and erosion hazard areas on the flanks of Ebright Creek, wetlands, streams, wildlife corridors, and critical aquifer recharge areas (Figure 3). Approximately two-thirds of the entire basin is designated as a critical area. The City's Critical Areas Ordinance (No. 02005-193) and Environmentally Critical Areas Code (SMC Chapter 21A.50) specify activities allowed and prohibited in these areas, as well as requirements for mitigating impacts to critical areas. In addition to the Critical Areas Code that applies to the entire city, two special overlay areas (wetlands overlay and erosion hazards overlay) have additional requirements and include portions of the Thompson Sub-basin. The Critical Areas Code is important to basin planning because it outlines requirements related to surface water runoff and management through development restrictions adjacent to erosion hazard areas, limitations on impervious surface construction in critical aquifer recharge areas, and wetland and stream buffers to keep riparian areas and wildlife corridors intact.

2.3 CITY OF SAMMAMISH SHORELINE MASTER PROGRAM

The city's waterbodies that are considered shorelines of the state include Lake Sammamish, Pine Lake, and Beaver Lake. None of the streams located within the basin limits, including Ebright Creek, is large enough to be included in the Shoreline Master Program. The Thompson Sub-basin does include a very small portion of the Lake Sammamish shoreline. Parametrix did not evaluate shoreline conditions and implications of the Shoreline Master Program for the Thompson Sub-basin.

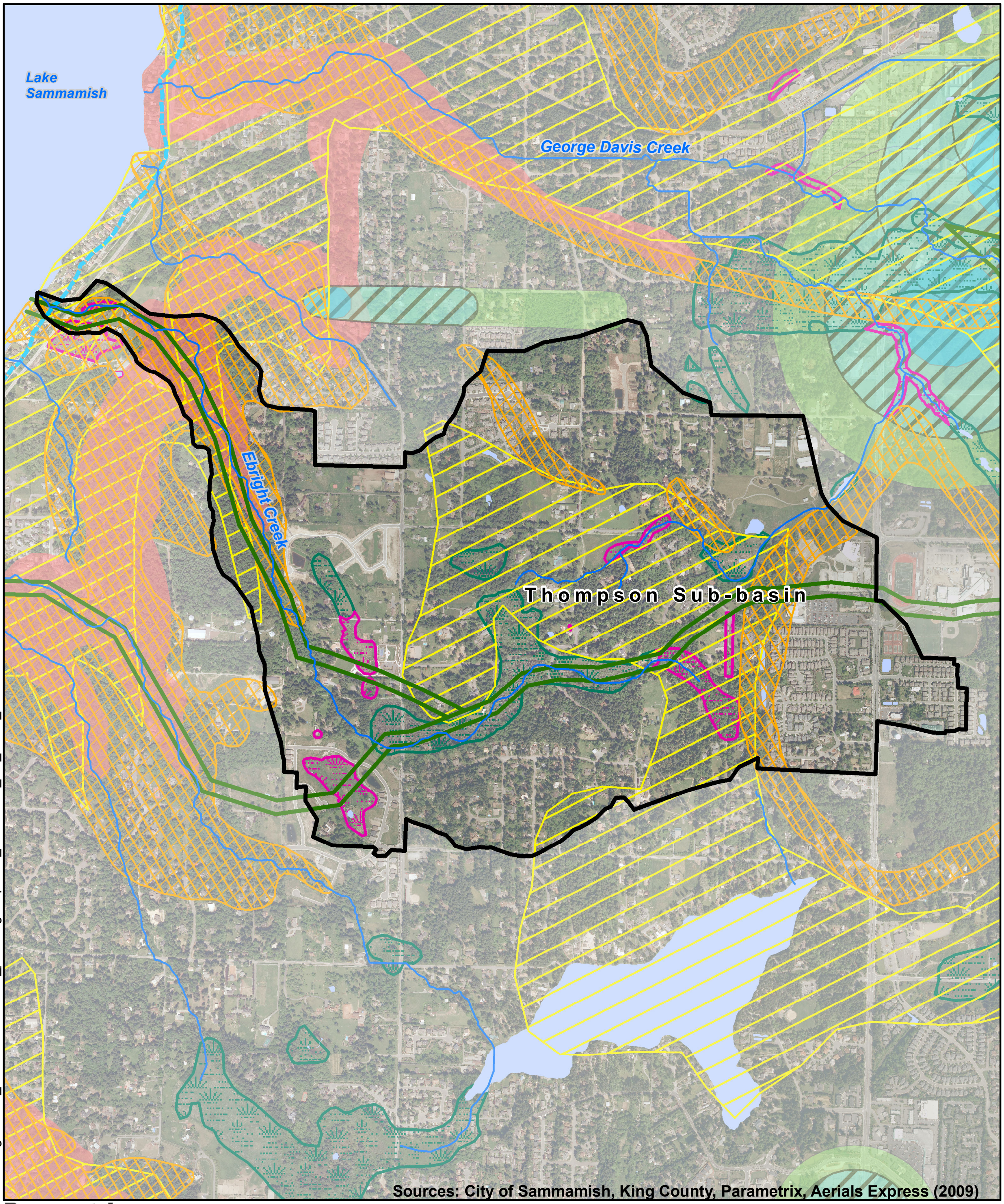
2.4 SEATTLE AND KING COUNTY PUBLIC HEALTH DEPARTMENT

The Seattle and King County Public Health Department regulate drinking water sources, including surface water developed for water supply, and drilled wells using groundwater as a source of potable water. Additionally, the health department helps to ensure that septic systems are installed and operating properly. The areas that have been recently developed (within the last 10 years) in the Thompson Sub-basin receive sanitary sewer service through the Sammamish Water and Sewer District; however, the single-family residences on large lot sizes typically have private sewer (septic) systems. Additionally, at least 13 private water wells are located in the basin ranging in depth from 46 feet below ground surface (bgs) to 240 feet bgs depending on the location in the basin and depth to groundwater. Parametrix did not investigate whether there have been any water quality or quantity concerns from private well owners, or whether private sewer systems are properly functioning.

2.5 SAMMAMISH PLATEAU WATER AND SEWER DISTRICT

The entire Thompson Sub-basin is within the Sammamish Plateau Water and Sewer District service area. As mentioned above, large areas of the basin are still on private sewer systems, but the District's plan is to construct future mains and lift stations to service the basin (Sammamish Plateau Water and Sewer District 2003). As the area is redeveloped, new water lines will also likely service those residents that are currently on private well systems.

The District operates 13 municipal water wells in the vicinity of the city limits. These wells range in depth from 134 feet bgs to 955 feet bgs for a total capacity of approximately 7,000 gallons per minute (gpm) (WSDOH 2011).



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Parametrix

- Thompson Sub-basin
- Stream
- 200' Shoreline Buffer
- Waterbody
- NWI/ City of Sammamish Mapped Wetlands
- Field Modified/Additional Wetlands
- Class 1- 1 year TOT
- Class 1- 5 year TOT
- Class 2- 10 year TOT
- Erosion Hazard Area
- Critical Aquifer Recharge Area
- Landslide Hazard
- Wildlife Corridor (King County)

N

0 1,600

Scale in Feet

Note: Wetland and stream buffers are not shown.

Figure 3
Thompson Sub-basin Critical Areas

3. WATERSHED CHARACTERISTICS

Existing watershed characteristics were evaluated by reviewing previous studies and documentation, aerial photographs, maps, and field reconnaissance that included walking the stream channels and visiting wetlands in the basin. Additionally, supplemental information was obtained from residents at public meetings held in December 2008 and March 2009. Physical stream channel attributes collected in the field along with existing land use, future zoning, and geologic data were used to develop a hydrologic model of the basin to evaluate existing and future surface water flow conditions.

In general, the Thompson Sub-basin is in fairly good condition with respect to aquatic habitat because it is still relatively undeveloped compared to many suburbs east of Lake Washington. The Ebright Creek corridor has remained forested because development occurred in the basin and large wetlands at the headwaters of the creek attenuated flows to the downstream reaches. Table 3 summarizes existing conditions, potential future impacts, and existing regulatory measures in place to ensure protection of natural resources.

Table 3. Summary of Existing Conditions and Future Impacts

	Watershed Characteristic	Existing Conditions	Potential Future Impacts	Existing Regulatory Measures to Ensure Protection
Biological Characteristics	**Fisheries**	Kokanee, coho, sockeye, chum and cutthroat habitat.	Indirect habitat impacts from upstream development (sediment, channel erosion).	Critical Areas Ordinance (CAO)—150-foot stream buffer on Ebright Creek.
		Partial fish passage barrier at Pereyra culvert.		CAO—Subdivisions must place wildlife corridors (such as Ebright Creek) in a contiguous permanent open-space tract.
		Benthic invertebrate index scores indicate generally poor conditions.		
		Good habitat between East Lake Sammamish Parkway and Ebright Creek Park (culvert fish passage barrier at SE 12th Street).		
	Wetlands	Several large depressional wetlands, with groundwater hydrology and seasonal flooding. Some wetlands and buffers are degraded from residential development; others are in fairly good shape.	Vegetation and hydroperiod changes from increased stormwater runoff or infiltration; encroachment from urbanization.	CAO—Wetland buffers vary from 50 to 215 feet depending on wetland category.
		Wetlands attenuate peak flows downstream in Ebright Creek.		CAO—Wetland special district overlay (180) requires a maximum impervious surface area of 8% in areas zoned R-1 within special overlay. Some portions of Thompson sub-basin are within this overlay.
		Wetlands receive more flow now with increased development (anecdotal information, may be backwater from beaver dams). Trees have been dying due to longer periods of saturation.		CAO—Surface water discharges are allowed in wetlands and their buffers only if the discharge does not increase rate of flow, decrease water quality, or change plant composition.
	Riparian Corridor	Fairly good condition in vicinity of Ebright Creek ravine and Wetland 17.	Encroachment from development, change in size and type of vegetation (smaller trees, less dense).	CAO—Wetland and stream buffers (see above) and vegetation management plan for clearing done in critical areas
				50% of sites must retain trees or re-vegetate with trees in areas zoned R-1 within wetland special overlay area.

Table 3. Summary of Existing Conditions and Future Impacts (continued)

	Watershed Characteristic	Existing Conditions	Potential Future Impacts	Existing Regulatory Measures to Ensure Protection
Chemical Characteristics	**Water Quality**	Ebright Creek is on 303(d) list as a Category 5 impaired water body for fecal coliform bacteria.	Unknown; could improve due to less hobby farms and better manure management.	
Physical Characteristics	**Groundwater Hydrology**	Several domestic groundwater wells in the Thompson sub-basin ranging in depth from 100 feet bgs to 700 feet bgs.	Reduction in groundwater elevations in shallower aquifers due to more impervious surfaces and less groundwater recharge.	CAO—Much of Thompson sub-basin is located within critical aquifer recharge areas. 75% of on-site stormwater generated from new development must be infiltrated in these areas, unless not feasible.
		Groundwater recharge occurs in undeveloped portions of the basin at varying rates depending on surface geologic conditions.		CAO—Some activities are prohibited in critical aquifer recharge areas to protect groundwater quality.
	Surface Hydrology	Surface water hydrological conditions relatively intact	Increased flows and durations from new development. Estimated flow increases are from 58% to 66% for flows ranging from 2-year to 200-year rates.	CAO—All runoff from new impervious surfaces must be retained on-site in erosion hazard special overlay areas.
				King County Title 9—Surface water management code adopted by City of Sammamish, Level 3 flow control match 100-year peak for pre-developed forest conditions.
	Hillslope Geomorphology	Lower reaches of Ebright Creek are within an erosion hazard area. A few landslides were observed adjacent to Ebright Creek; none was the result of obvious human disturbance.	Removal of vegetation or discharge of stormwater near the slopes of Ebright Creek could compromise slope conditions and cause additional landslides.	CAO—Special overlay 190. No disturbance areas on the sloped portions of erosion hazards near Ebright Creek. New development proposals.
Built Environment	**Impervious Surface Coverage**	Currently, approximately 8% total impervious surface in basin.	Impervious surface estimates for future land use is 22% of basin.	CAO—Wetland overlay limits impervious surface to 8% in areas zoned R-1.

The watershed threats in the Thompson Sub-basin are primarily related to the conversion of land from rural and suburban uses to more intense urban development that could result in water quality and habitat degradation in streams, wetlands, and Lake Sammamish. If the basin is built out to its full zoning potential, this could represent an increase in impervious surfaces from 8 percent to 22 percent.

3.1 PHYSICAL SETTING

The Thompson Sub-basin is located on the east side of Lake Sammamish in east King County, Washington. The basin is approximately 1.3 square miles, with an elevation range of 570 feet above mean sea level (msl) at the top of the Sammamish Plateau to an elevation of 40 feet above msl at the mouth of Ebright Creek (Ebright Creek is the primary drainage feature in the Thompson Sub-basin) in Lake Sammamish (see Figure 1). Approximately 32 percent of the basin is forested, with much of the forested area located in the riparian corridor adjacent to Ebright Creek. Impervious surface is approximately 8 percent of the total area based on average assumed impervious surface coverage for the different land types in the basin. Road density in the basin is about 4.3 miles per square mile, which is typical of less developed suburban areas in Puget Sound.

3.2 LAND USE AND POPULATION

Over 40 percent of the Thompson Sub-basin consists of residential development. Higher density residential development is clustered in a few areas off 228th Avenue SE, 212th Avenue SE, and 214th Avenue SE. Additionally, the corridor along 228th Avenue SE also consists of City Hall, a new King County library, churches, and school facilities. The remaining residential development is primarily low density in character and includes some small farms.

Population on the Sammamish Plateau grew by nearly 600 percent between 1970 and 2001 (City of Sammamish 2003). Parametrix reviewed historical aerial photographs from 1944, 1970, 1979, 1996, 2002, and 2009. The 1979, 1996, 2002, and 2009 photographs are shown in Figures 4 through 7. Based on aerial photographs between 1979 and 2009, forest and rural land uses have been converted to suburban and commercial land uses at a consistent pace, with significant urbanization occurring post-1996.

The Thompson Sub-basin is not built out based on existing zoning (Figure 8). The proposed Town Center includes more than 50 acres in the Thompson Sub-basin, some of which will be converted to dense development. Additionally, large areas zoned R-4 and R-6 (four and six dwelling units per acre, respectively) are currently forested or developed at a rural density. These areas are likely to be built out and could result in stormwater and surface water impacts.

3.3 GEOLOGY AND GROUNDWATER

3.3.1 Geology

The geological features of the East Lake Sammamish Plateau have been mapped by Derek B. Booth and others at the U.S. Geological Survey (USGS 2006). A map of the basin surface geology is presented in Figure 9. Cross sections showing approximate subsurface geologic conditions were developed based on water well logs obtained from Ecology and geotechnical studies available in unpublished reports (Hong West and Associates 1996; Nelson and Associates 1987; Terra Associates 1995, 1998, 1999). These cross sections are shown in Figures 10 and 11. The geological features are characterized by the following general sequence of unconsolidated glacial deposits from the surface downward:

- Vashon recessional outwash (Qvr);
- Vashon till (Qvt);
- Vashon advance outwash (Qva); and
- Pre-Vashon undifferentiated unconsolidated deposits—glacial and non-glacial (Qpf).

Most of the upland areas of the Sammamish Plateau and the Thompson Sub-basin are mantled by Vashon Till (Qvt)—a densely compacted poorly sorted mixture of boulders, cobbles, gravel, and sand in a matrix of silt and clay, often identified in driller's logs as "hardpan." The till is up to about 150 to 200 feet thick in some upland areas of the Sammamish Plateau based on a review of well records in the vicinity. The presence of till is an important consideration for stormwater management techniques because it is more difficult to infiltrate stormwater in these areas due to the compact nature and low permeability of the till.

The Vashon Till is locally overlain by Vashon Recessional Outwash deposits (Qvr)—a poorly sorted to well sorted, light gray, stratified gravel and sand with minor amounts of silt and clay deposited behind the receding glacier. The recessional outwash deposits are relatively thin in the upper reaches of the Thompson Sub-basin (less than 20 feet).

The Vashon Till is underlain by Vashon Advance Outwash (Qva) that consist of variably compacted sand and gravel deposited by streams and rivers ahead of the advancing glacier. Vashon Advance Outwash is typically variable in grain size, varying from silt to gravel and in sorting from well sorted to unsorted. The advance outwash is generally more compacted than the recessional outwash due to the pressure of the overriding glaciers. The Vashon Advance Outwash is exposed along the Ebright Creek channel at approximate elevations of 300 to 340 feet msl. A contact was observed between the advance outwash and overlying till unit in the Ebright Creek channel downstream of the 212th Avenue SE culvert crossing at an approximate elevation of 300 feet. Advance outwash deposits are typically highly erodible and it is within these deposits that many landslides originate.

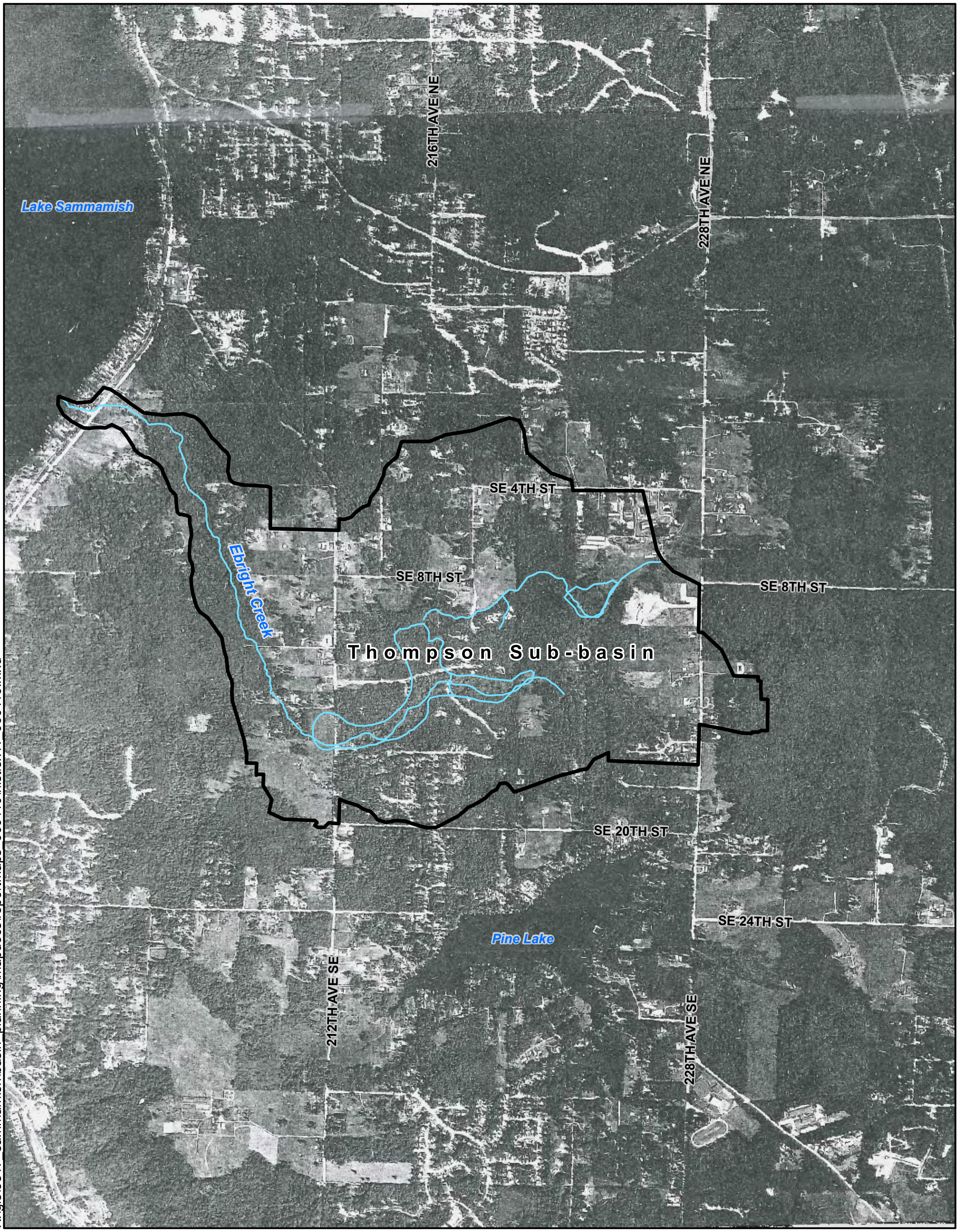
Pre-Vashon glacial deposits underlying the Vashon Advance Outwash include both glacial and non-glacial units. Two finer-grained and three coarser-grained units have been defined within these undifferentiated deposits.

Most of the surficial soils in the upland areas of the Thompson Sub-basin are mapped as Alderwood Series (Soil Conservation Service 1973) developed in the weathered Vashon Till. These soils are very gravelly sandy loam to very gravelly fine sandy loam and are typically moderately well drained, moderately deep, and are formed in glacial tills in upland areas. There is a seasonal high water table due to the presence of the underlying low permeability till.

More recent surficial units mapped within the Thompson Sub-basin include:

- Alluvium (Qal);
- Wetland deposits (Qw); and
- Mass-wastage deposits (Qmw).

Wetland deposits (Qw) are mapped along the upper reaches of Ebright Creek, and are described as peat and alluvium, poorly drained and intermittently wet. In the lower reaches of Ebright Creek and on the west-facing slopes above Lake Sammamish, the surficial geologic deposits are mapped as mass-wastage deposits (Qmw) formed by erosion on the steep slopes, described as colluvium; this soil and landslide debris is typically up to 10 feet thick. Alluvium (Qal) occurring along Lake Sammamish is described as moderately sorted cobble gravel, pebbly sand, and sandy silt along low-lying areas adjacent to Lake Sammamish, possibly beach and lacustrine deposits.



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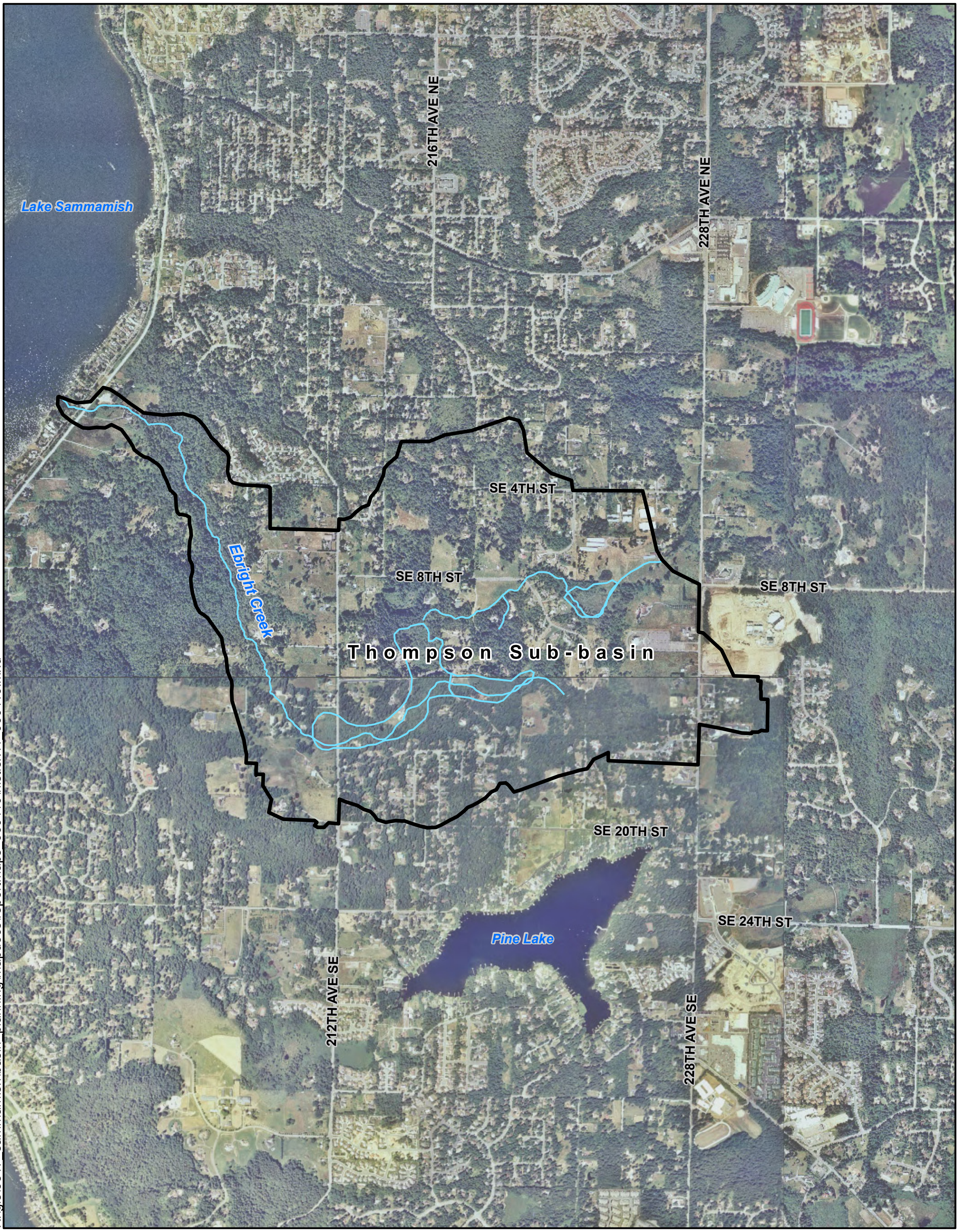
Scale in Feet

Thompson Sub-basin

Figure 4
Thompson Sub-basin
1979 Aerial Photography



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Thompson Sub-basin

Figure 5
Thompson Sub-basin
1996 Aerial Photography

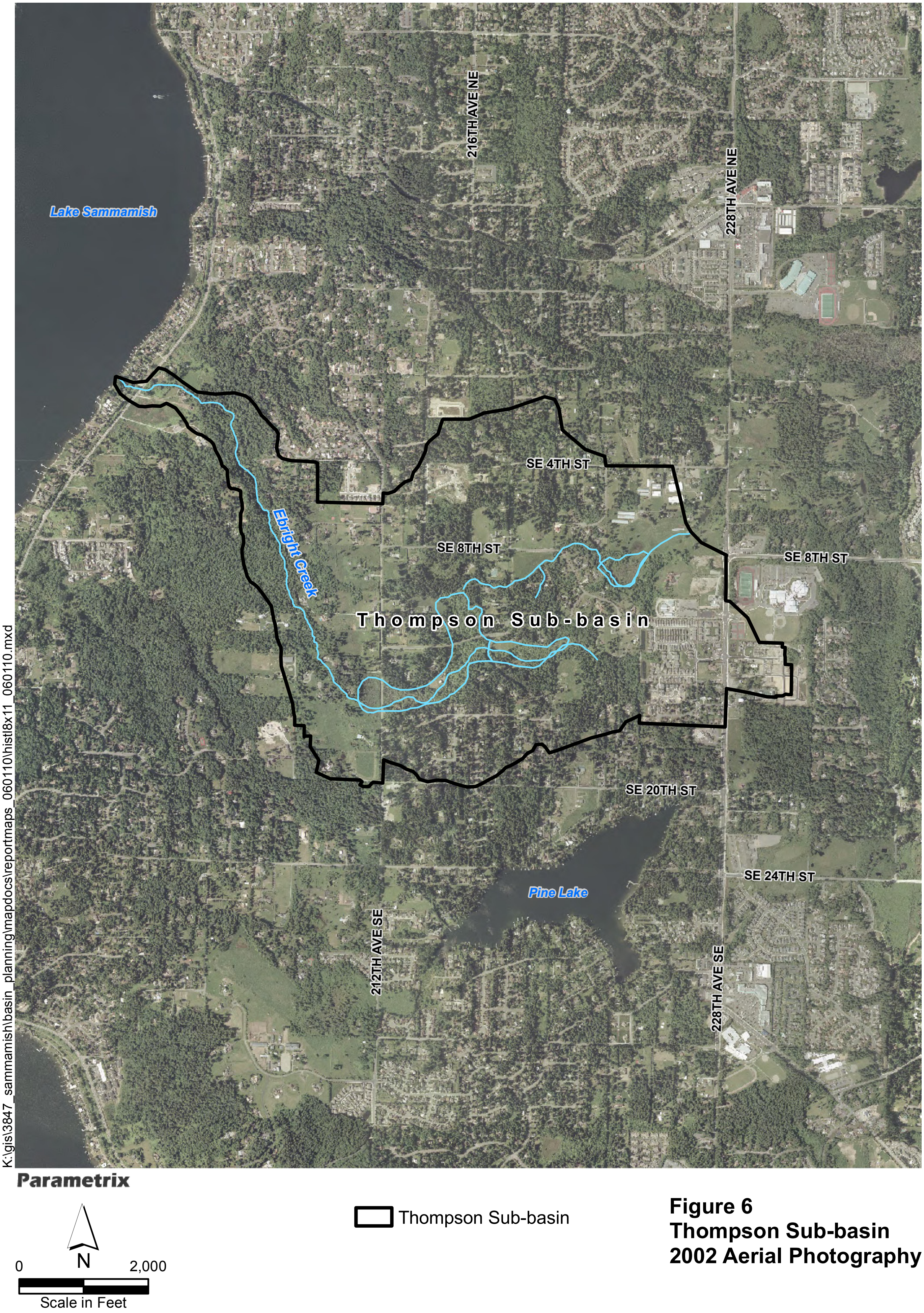


Figure 6
Thompson Sub-basin
2002 Aerial Photography

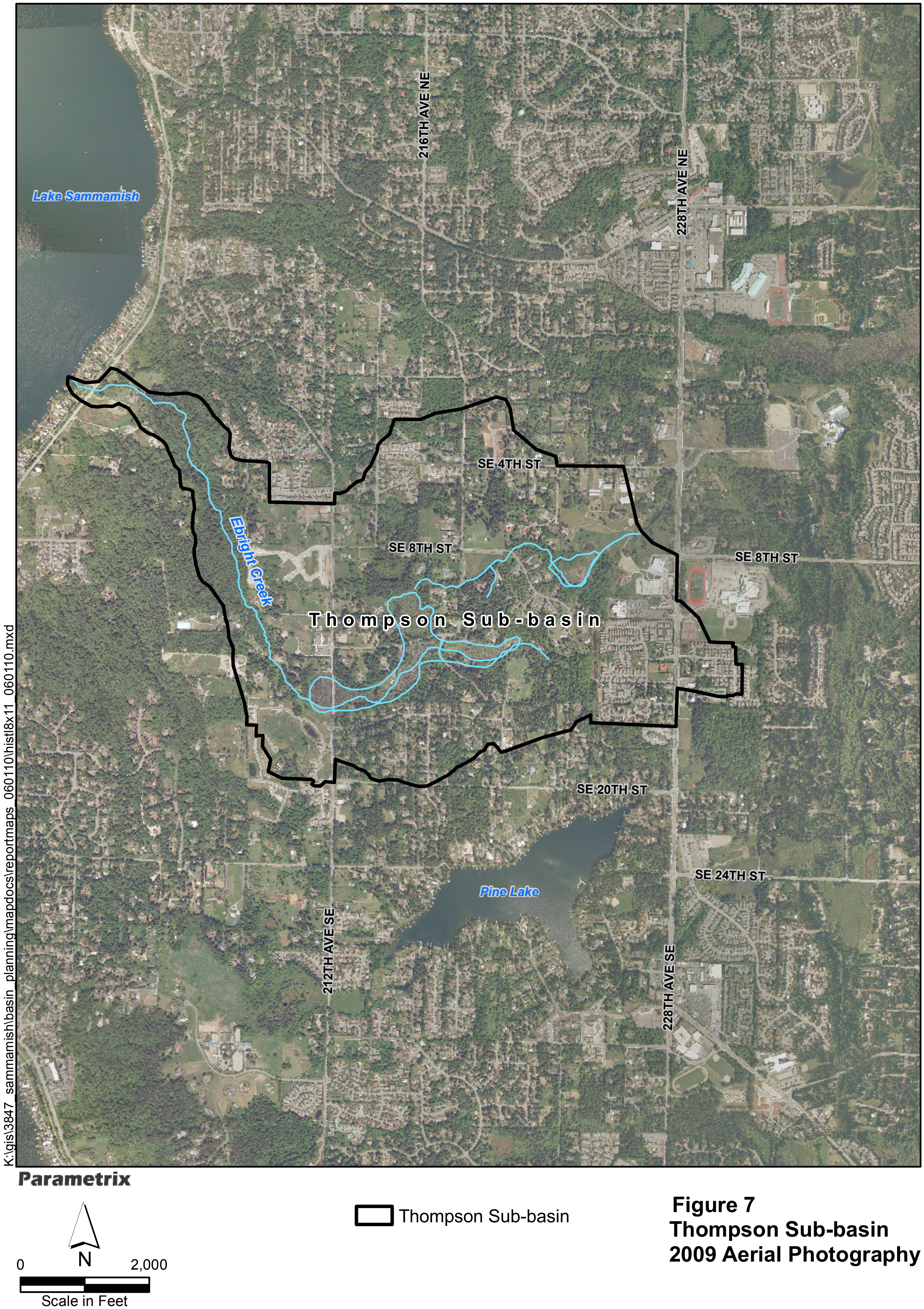


Figure 7
Thompson Sub-basin
2009 Aerial Photography

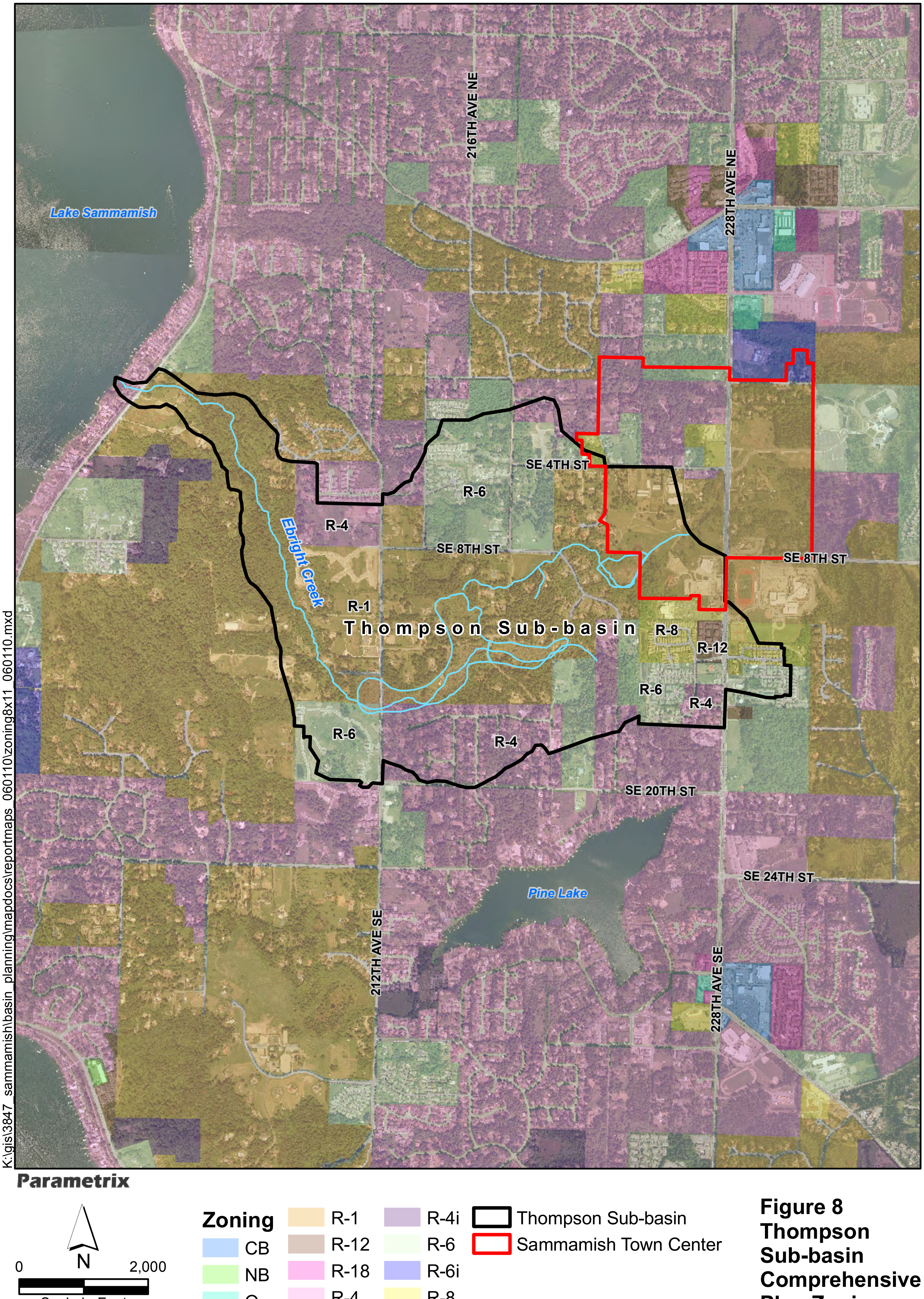


Figure 8
Thompson Sub-basin Comprehensive Plan Zoning

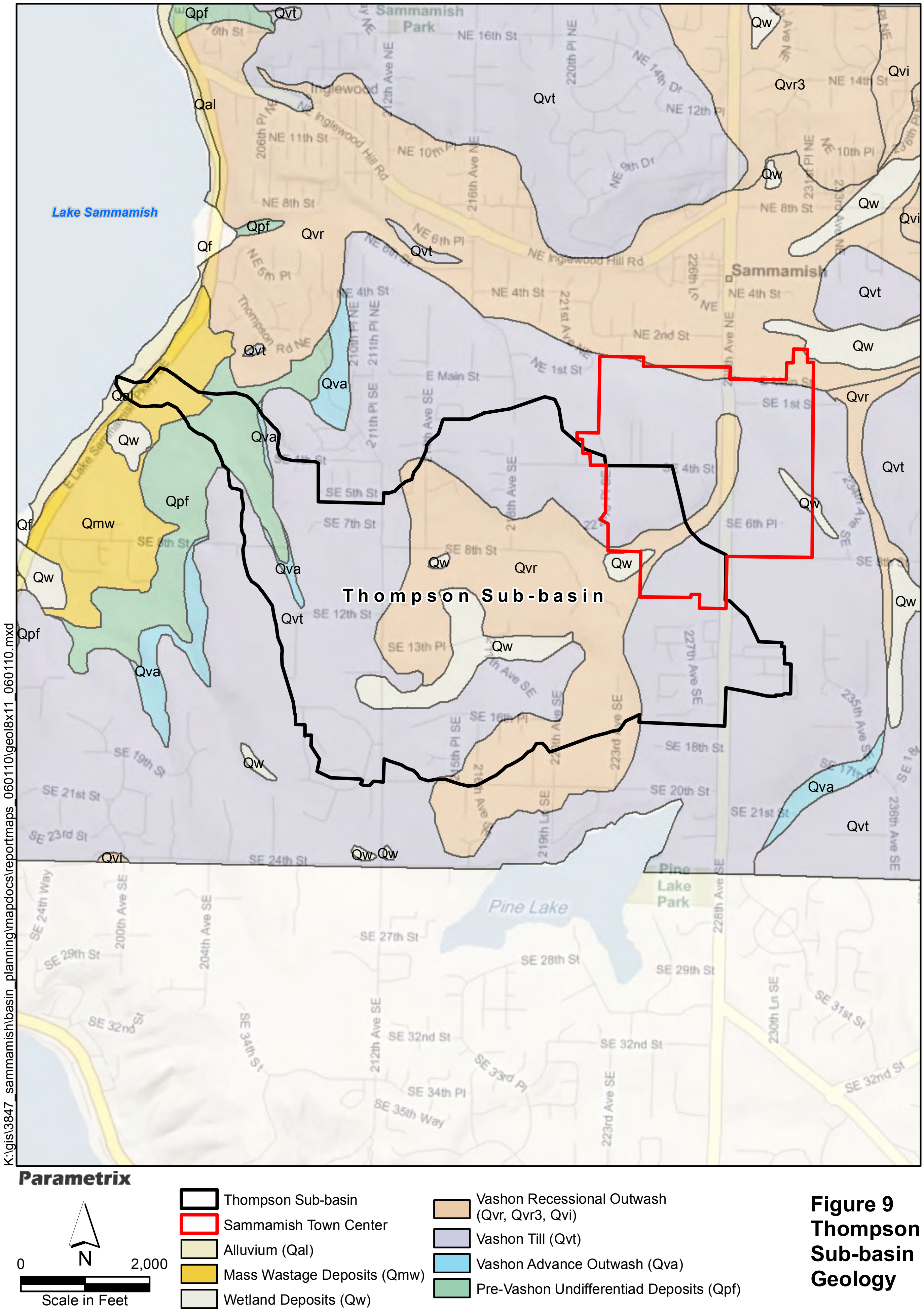
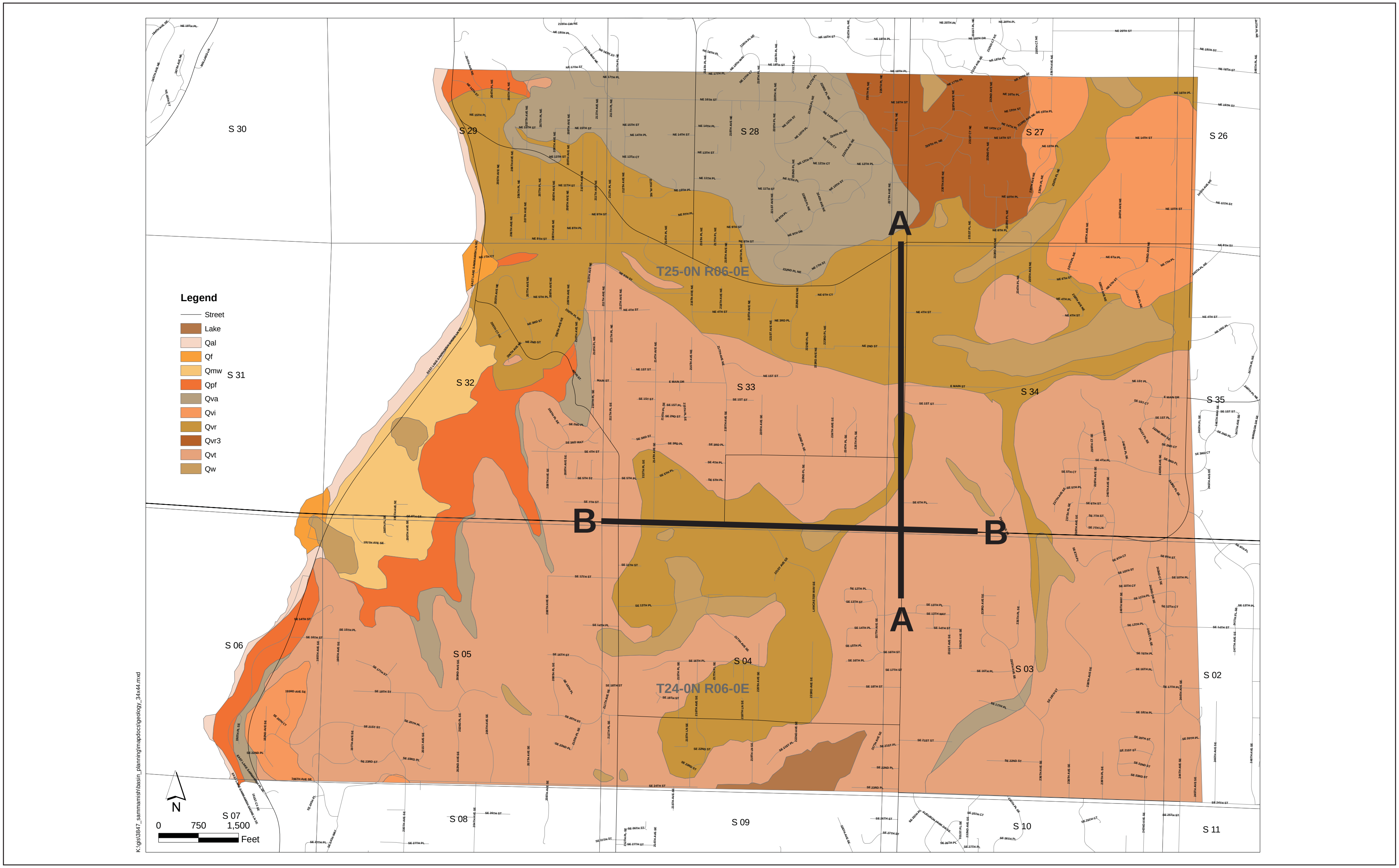


Figure 9 Thompson Sub-basin Geology



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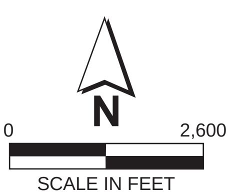
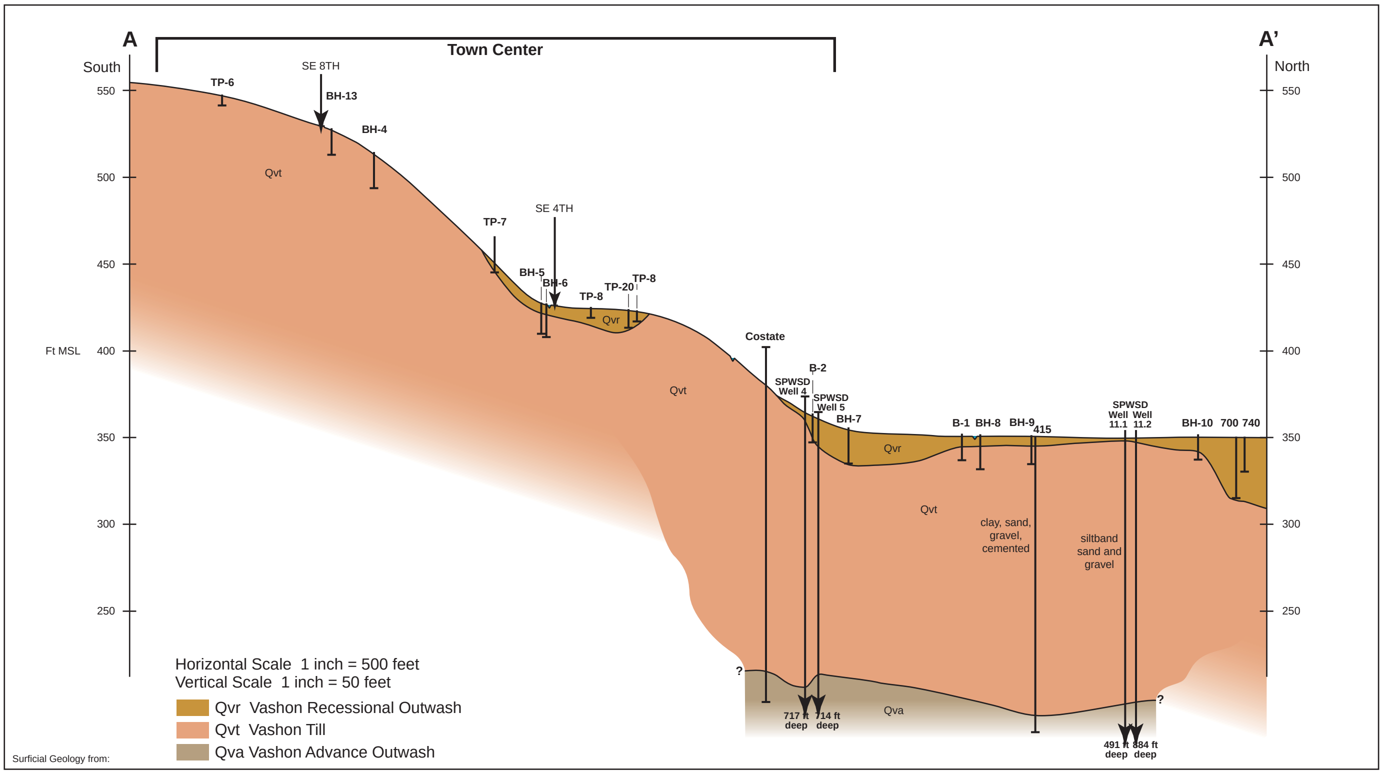
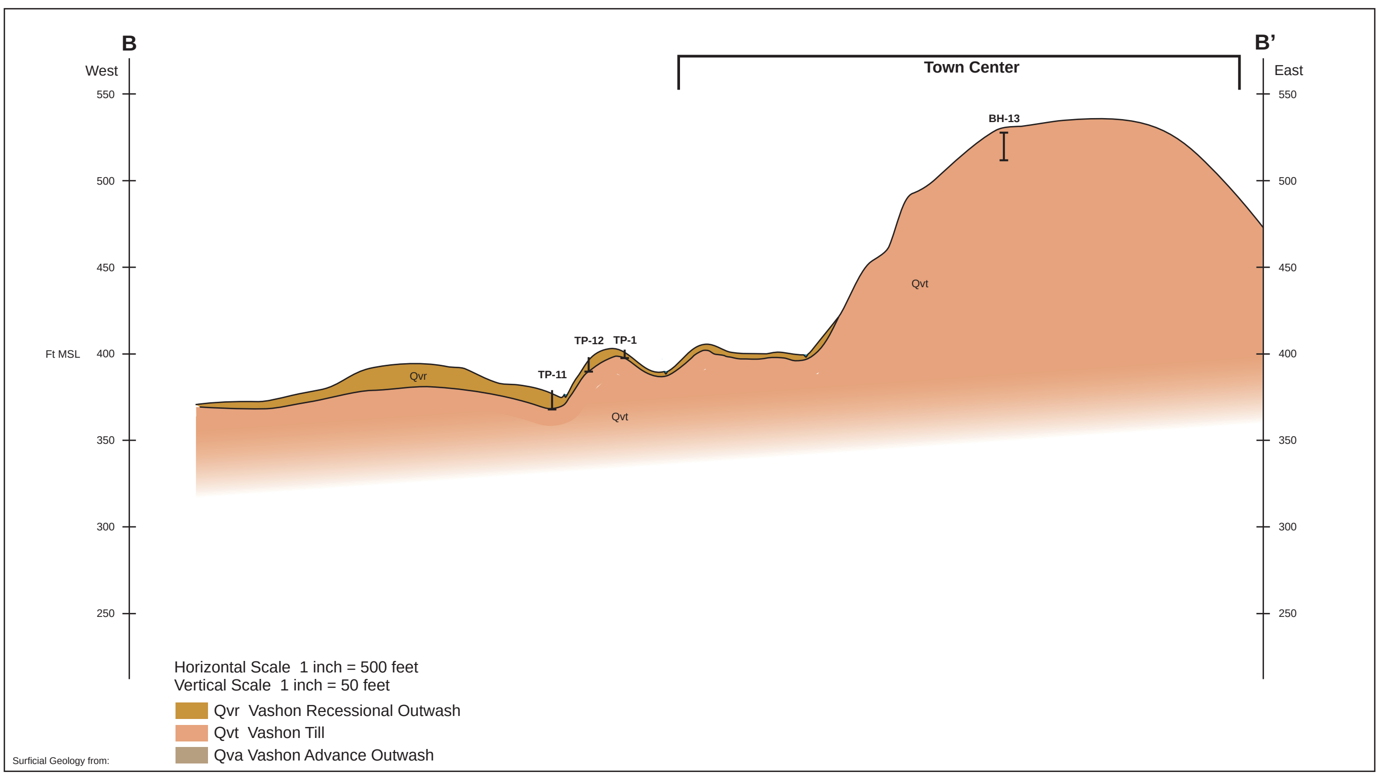


Figure 10
General Geology and Location of Geologic Cross Sections



Geologic Cross Section Along 228th Ave
City of Sammamish Town Center



Geologic Cross Section Along NE 8th Street
City of Sammamish Town Center

Figure 11
Geologic Cross Sections A-A' and B-B'

3.3.2 Groundwater Occurrence

Groundwater resources of the Sammamish Plateau are described in Turney et al. (1995) and Leisch et al. (1963). Precipitation provides the source of recharge to shallow aquifers in the upland areas of the Sammamish Plateau. Recharge in the project vicinity is estimated to be 10 to 20 inches per year in the till, and 21 to 30 inches per year in the recessional outwash (Turney et al. 1995). Groundwater flow in the upper units is locally influenced by variations in lithology. Deeper aquifers are recharged by downward movement from shallow aquifers and by lateral flow from regional recharge areas to the east. In the upper aquifers of the project vicinity, overall groundwater flow is westward toward Lake Sammamish.

Areas of the Thompson Sub-basin with recessional outwash mapped at the surface are designated as critical aquifer recharge areas in the Critical Areas Ordinance due to the permeable nature of these deposits. Although permeable, the relatively limited depths of the recessional outwash are not adequate to yield significant quantities of groundwater to wells. However, infiltration of precipitation through the recessional outwash provides an important source of recharge to underlying aquifers.

The upper part of the Vashon Till is typically more permeable than the lower part, and perched or semi-perched groundwater occurs locally within sand and gravel lenses. Wells completed in the till may yield small quantities of water that are adequate for domestic supply. The Vashon Advance Outwash yields a more reliable source of groundwater to some domestic wells in upland areas of the Sammamish Plateau completed at depths of approximately 100 to 300 feet.

Unconsolidated Pre-Vashon deposits underlying the Vashon Advance Outwash in the project vicinity provide the source of water supply to the City of Sammamish wells, completed at depths ranging from about 350 to 700 feet bgs, and elevations from 100 to less than -350 feet msl. One of the wells is located in the Thompson Sub-basin along Louis Thompson Road (Well 6, completed at a depth of 340 feet bgs), and four wells are located east of the Thompson Sub-basin along 228th Avenue (Wells 4, 5, 11.1, and 11.2), completed at approximate depths from 500 to over 700 feet bgs. Wellhead protection areas are designated in accordance with the Critical Areas Ordinance for each of the City wells. Water wells along East Lake Sammamish Parkway are typically less than 100 feet deep and many have artesian flow.

3.4 SURFACE WATER HYDROLOGY

The surface water hydrology of the Thompson Sub-basin is governed by rainfall rates, vegetative conditions (forest vs. grass), surface geology (permeable vs. impermeable geologic units), topography, groundwater occurrence, and land development. Many large depressional wetlands in the upper part of the basin on the plateau tend to attenuate surface water flows into the steep ravines that lead to Lake Sammamish and provide summer baseflow to Ebright Creek through groundwater connections. Currently, the basin has some fairly large forested areas and less impervious surfaces (8 percent) compared to other basins in urban areas. These factors result in few observable issues related to stormwater runoff with the exception of potential wetland impacts discussed below. There is only one stormwater outfall piped directly to the Ebright Creek channel downstream of the wetland complexes. This outfall is designed to discharge stormwater runoff from a stormwater detention facility for the new Chestnut Lane development that is yet to be built. The pipe has been stabilized and “tightlined” to the stream channel.

3.4.1 Hydrologic Modeling

The surface hydrology of the Thompson Sub-basin was modeled using MGSFlood, an HSPF-based (Hydrologic Simulation Program Fortran) continuous hydrologic model. The basin was divided into 17 sub-basins for the purposes of modeling (Figure 12). Existing and future hydrologic conditions were modeled to evaluate existing and potential future impacts related to increased flow rates. Additionally, the existing and future flows were compared to conditions that would have existed in a pre-developed (forested) condition. Current City of Sammamish stormwater regulations require new development to match pre-developed conditions for the 2-year and 100-year peak flow rates. The modeling results indicate that with future stormwater mitigation, pre-developed peak flow conditions can be met with application of these stormwater management techniques. Figure 13 shows existing, forested, and future mitigated flows for the 2-year, 10-year, and 100-year peak flow rates. The complete modeling results are provided in Appendix A.

Current stormwater requirements require management of flow rates and durations to minimize erosive forces in sensitive stream channels; however, they do not address increased stormwater volumes, which could affect wetland hydrology. Potential impacts to wetland hydrology from stormwater runoff are discussed below.

3.4.2 Culvert Capacities

Stormwater infrastructure in the Thompson Sub-basin largely consists of open channel ditches, wetlands, stream channels, and piped infrastructure and treatment facilities in the newer developments. There are several stream crossings utilizing culverts to convey flow under the roadways. Parametrix evaluated the hydraulic capacity of 13 culverts (Figure 14) based on culvert dimensions and slopes compared to modeled flows. Two of the culverts (culverts 6 and 13) are currently undersized for surface flows according to the analysis (Appendix B); however, Parametrix does not recommend modifications to these culverts because the modeled flows are very close to the estimated capacities and there is no evidence of a current problem.

3.5 WETLANDS

Wetlands in the Thompson Sub-basin were evaluated by a limited field investigation from publicly accessible sites using a quick assessment method. Figure 15 shows the locations and identification numbers of wetlands in the Thompson Sub-basin. A proper delineation would be necessary to confirm wetland classifications and ratings. Wetland data forms are provided in Appendix C. Prior to the field visit the following documents were reviewed:

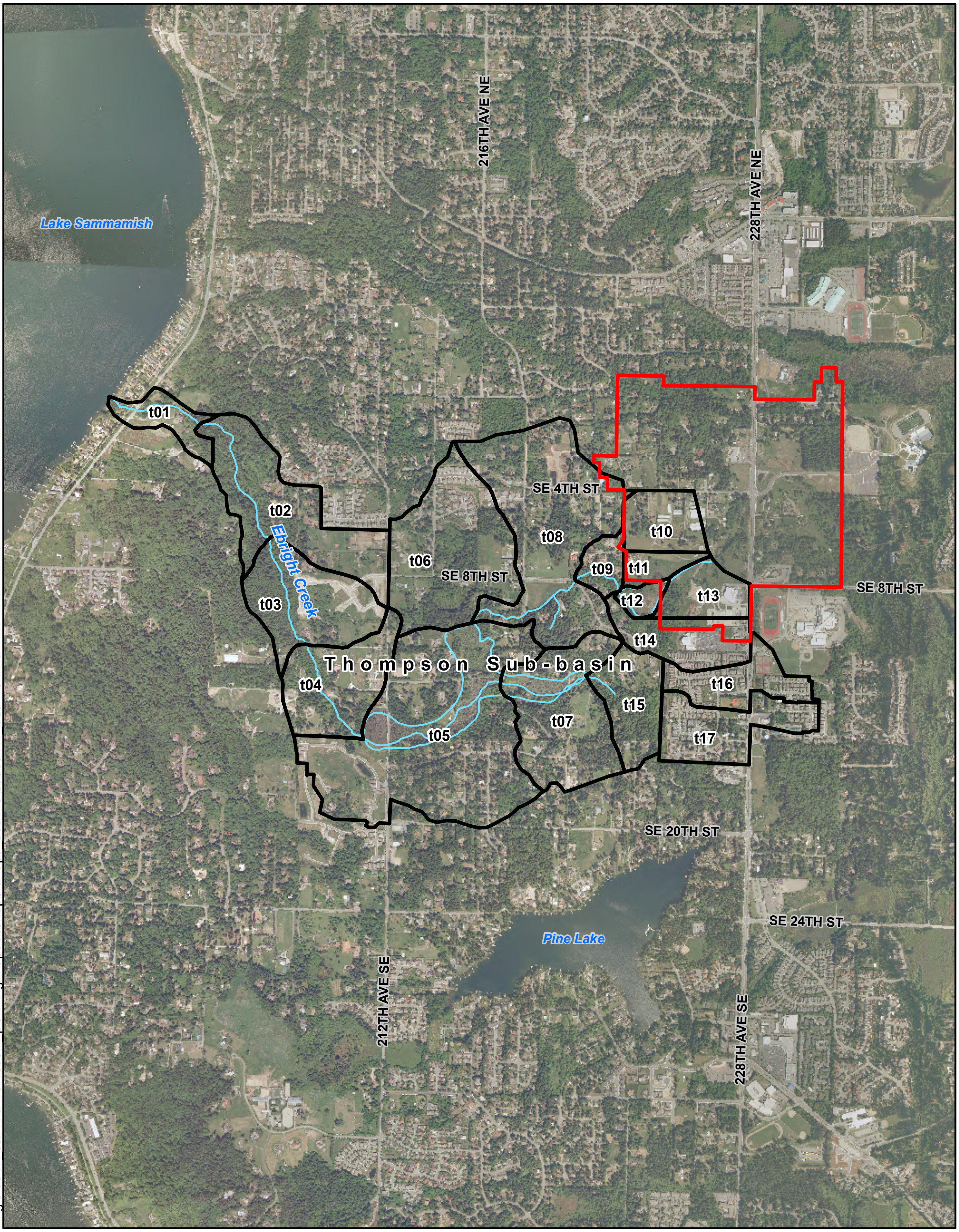
- City of Sammamish Town Center Sub-Area Plan Draft Environmental Impact Statement (DEIS) (City of Sammamish 2007);
- Sammamish Stormwater Comprehensive Plan (City of Sammamish 2003);
- Wetland data on the City of Sammamish Web site; and
- National Wetlands Inventory Maps.

Only Wetland 61 (labeled Wetland 11 in Parametrix field data and Table 4) was delineated as part of the Town Center Comprehensive Stormwater Plan. Wetlands in the Thompson Sub-basin are primarily depressional wetlands with a few riverine wetlands associated with Ebright Creek (Table 4).

Wetland 17 (labeled Wetland 6 in Parametrix field data and Table 4) is the largest wetland in the basin and includes the headwaters of Ebright Creek. Wetland 17 is relatively undisturbed and it has a buffer of greater than 100 feet in many areas. However, the upper portion of the basin is heavily developed leaving little pervious surface. This fact likely has contributed to changes observed by residents that the wetland is storing more water and changing (personal communication, Claire Hoffman, Biologist, Parametrix, 2008).

3.5.1 Wetland 17 Hydrology

Parametrix reviewed 8 years of water elevation data collected for Wetland 17 to evaluate concerns from residents that wetland elevations have increased and that the increase may be due to increased stormwater runoff. A staff gauge located on 212th Avenue SE has been used to record the water elevation of Wetland 17. The data cover the period between October 2000 and March 2009, with readings taken 4 to 13 times per year. In the given period of record, the flux of wetland elevation has decreased (Figure 16). Multiple factors could be responsible for the storage and water levels in a wetland. In the analysis conducted by Parametrix, the factors evaluated are discussed below.



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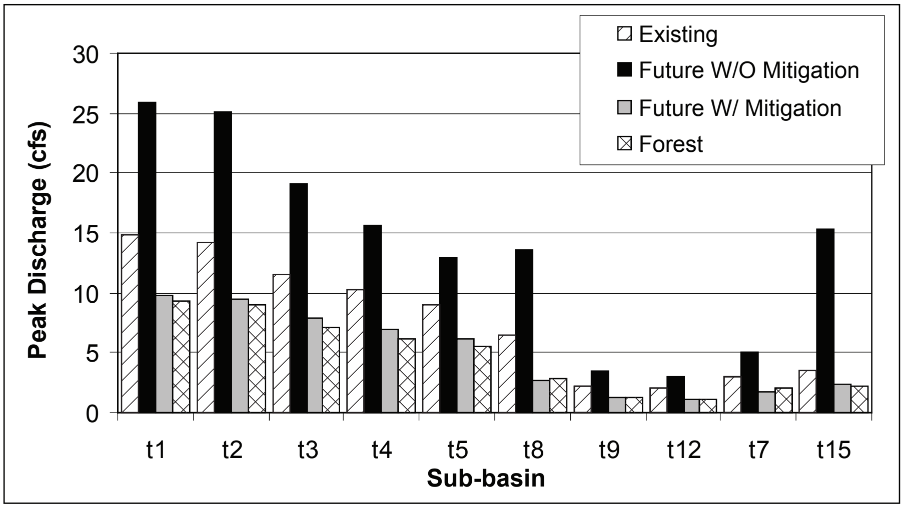
Thompson Sub-basins

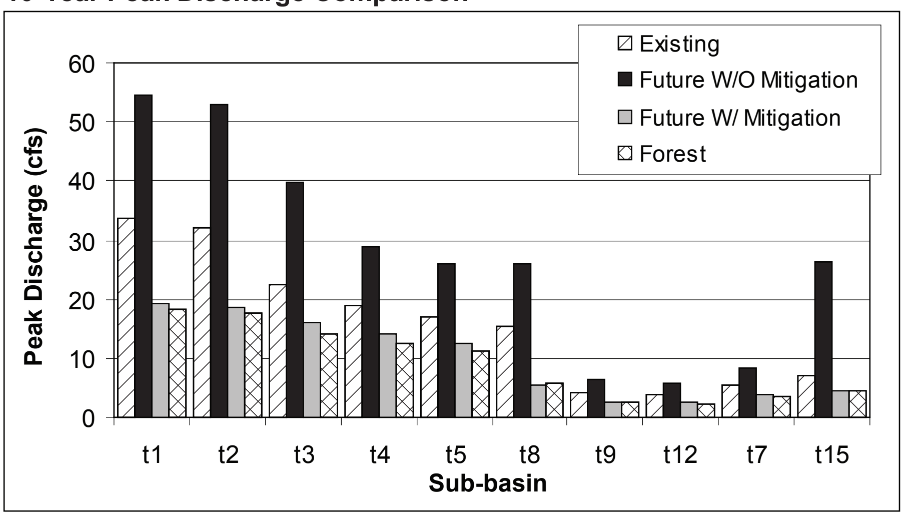
Sammamish Town Center

Figure 12
Thompson Sub-basins

2-Year Peak Discharge Comparison



10-Year Peak Discharge Comparison



100-Year Peak Discharge Comparison

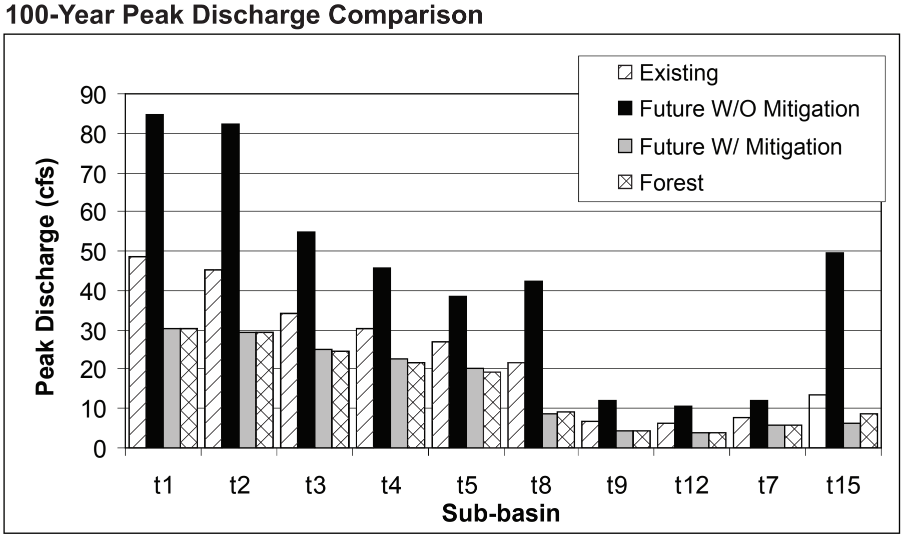


Figure 13
Thompson Sub-basin Hydrological Modeling Results

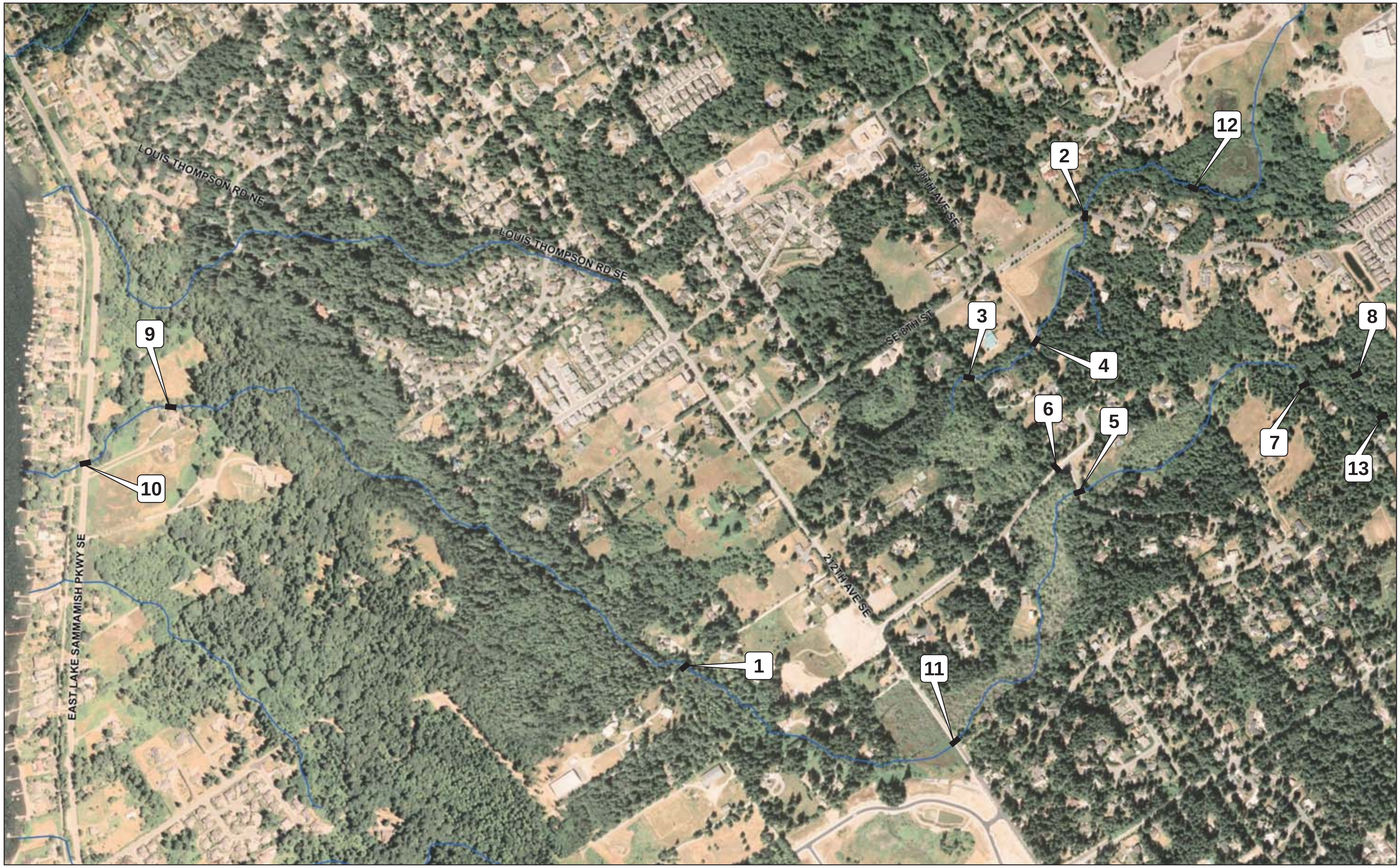


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Figure 14
Thompson Sub-basin
Culvert Locations

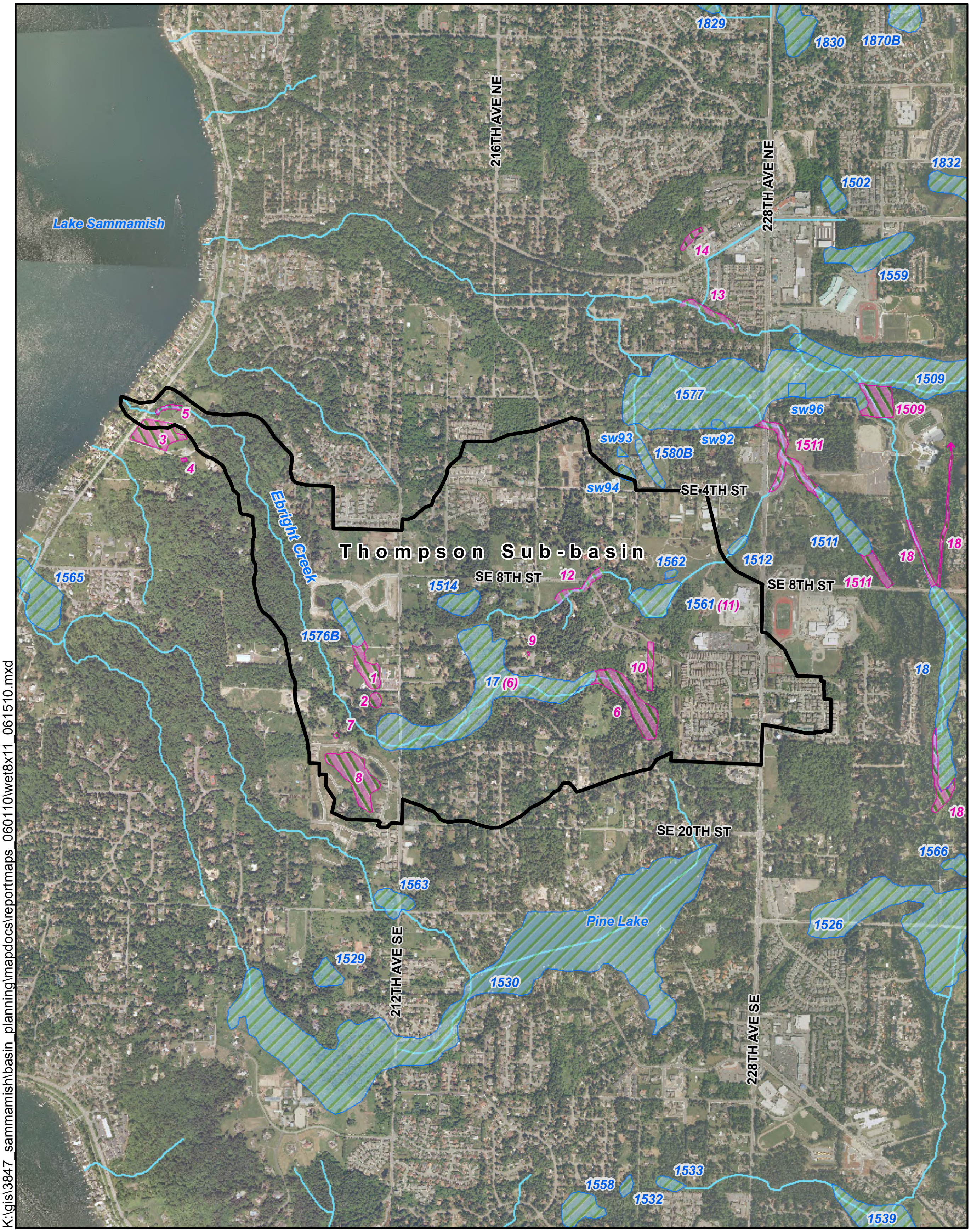
Table 4. Thompson Sub-basin Wetlands

Wetland Name[a]	Approximate Size (acres)	Characteristics	Cowardin Classification	Hydrogeomorphic Classification	Hydrology	Impacts	Mitigation Opportunities	Current Buffers	Quick Rating
1	8	Little habitat interspersion, some connectivity to other habitat types, detains overland runoff, detention pond	Forested, scrub-shrub, emergent	Depressional	Groundwater, seasonally flooded/saturated, stormwater	New residential development fragments habitat	Limited on-site due to park use; may have opportunities on adjacent parcels	Lawn and minimal forested, somewhat disturbed	Moderate
2	< 0.1	Isolated, no interspersion of habitats, low plant diversity	Emergent	Depressional	Surface water, seasonally flooded/saturated	Grazing, historically connected to Wetland 1	Reconnect with Wetland 1	Lawn and minimal forested, somewhat disturbed	Low
3		At the base of the slope near Lake Sammamish, detains some overland runoff, no habitat dispersion, few connections to other habitat types	Emergent	Depressional	Groundwater, seasonally flooded	Agriculture and some residential development	Improve connection with wetland to the south by removing driveway	Herbaceous—native vegetation, somewhat disturbed	Low
4	< 0.1	Likely artificial pond, drains via a ditch to wetland south of Wetland 3, few habitat features present, some connection to other habitat types, detains overland runoff	Emergent, palustrine unconsolidated bottom	Depressional	Groundwater, permanently flooded			Lawn and forested, somewhat disturbed	Low
5	0.1–1	Likely a number of wetlands along Ebright Creek, detains minimal overland runoff, little interspersion of habitats, moderate plant diversity	Forested	Riverine	Surface water (Ebright Creek), seasonally flooded/saturated	Agriculture and some residential development	Enhance wetland and buffer	Lawn and forested, somewhat disturbed	Low
6 (17)	>10	Headwater wetland, habitats highly interspersed, high plant diversity, high vegetation structure	Forested, scrub-shrub, emergent	Riverine, Depressional, Flow-through	Surface water (Ebright Creek), seasonally and permanently flooded/saturated	Residential development, roads through the wetlands	Restore/enhance pasture area	Herbaceous—native, generally undisturbed	High
7	<0.1	Low plant diversity, no interspersion of habitats, few connections to other habitats	Scrub-shrub	Depressional	Groundwater, seasonally saturated	Residential development	Minimal	Lawn and forested, somewhat disturbed	Low

Table 4. Thompson Sub-basin Wetlands (continued)

Wetland Name[a]	Approximate Size (acres)	Characteristics	Cowardin Classification	Hydrogeomorphic Classification	Hydrology	Impacts	Mitigation Opportunities	Current Buffers	Quick Rating
8		Ditches in wetland likely historical agricultural drainage ditches. Surrounded by new residential development. Detains minimal overland runoff, isolated system associated with ephemeral surface water, few habitat features present, few connections to other habitats	Scrub-shrub, emergent	Depressional	Groundwater, seasonally flooded/saturated, surface water	Residential development	Existing plantings around ditches in wetland appear dead	Lawn, herbaceous—native and forested, somewhat disturbed	Moderate
9	<0.1	Detains overland flow, isolated system, no interspersion of habitats, low plant diversity, few connections to other habitats	Emergent	Depressional	Groundwater, seasonally flooded	Residential development	Minimal	Lawn and forested, primarily disturbed	Low
10	<0.1	In road right-of- way, isolated system associated with ephemeral surface water, no interspersion of habitats, low plant diversity, few connections to other habitat types	Scrub-shrub, emergent	Depressional	Surface water, seasonally flooded/saturated	Residential development	Minimal	Lawn, primarily disturbed	Low
11 (61)		Detains some overland runoff, some habitat interspersion, moderate plant diversity, some connections to other habitats, moderate vegetation structure	Forested, scrub-shrub, emergent	Depressional	Groundwater, surface water, seasonally and permanently flooded/saturated	Residential development	Enhancement, creation, preservation	Herbaceous—native, scrub-shrub	Moderate
12	1–5	Little or no interspersion of habitats, low plant diversity, some connections to other habitats, moderate vegetation structure	Scrub-shrub, emergent	Riverine	Surface water, seasonally and permanently flooded/saturated	Residential development		Herbaceous—native	Moderate

a. If the wetland was previously named, this name was used. If the wetland was not named, wetlands were numbered beginning with 1 and ending with 18. Previous wetland names (e.g., Wetland 17) were not used to avoid two wetlands having the same name.



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Scale in Feet

Thompson Sub-basin

Field Modified/Additional Wetlands

NWI/ City of Sammamish Mapped Wetlands

Figure 15
Thompson Sub-basin Wetlands

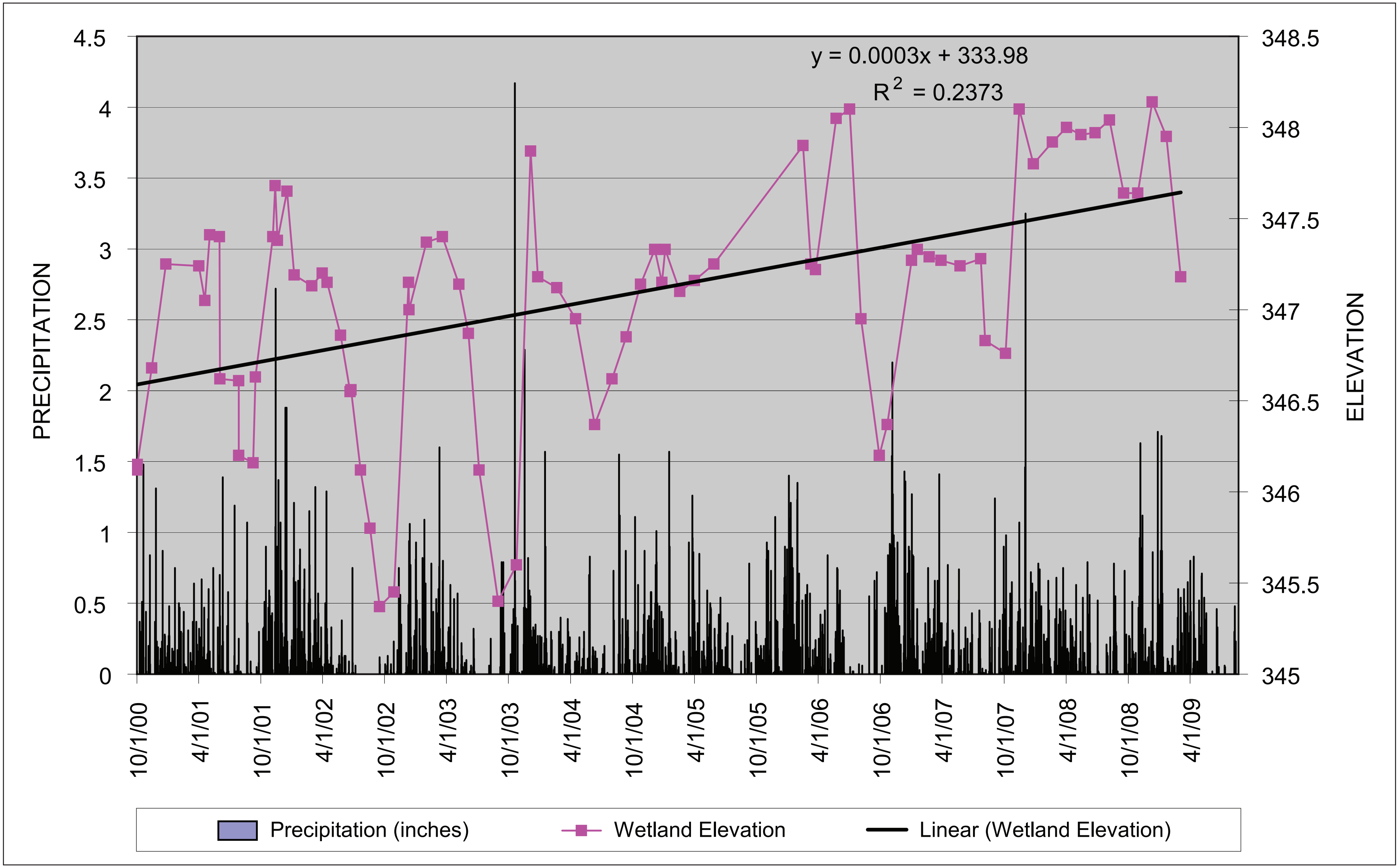

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Figure 16
Wetland 17 Precipitation and Wetland Elevations

3.5.1.1 Record of Data

The 8-year data record has an 8-month gap in 2005 during the construction of The Crossings at Pine Lake. Recordings of Wetland 17 also do not occur on a consistent time interval. This factor may result in missing variations in the wetland level that would affect the overall observed trend.

3.5.1.2 Precipitation Data

An automated King County rain gauge located on the Sammamish Plateau has a data record of daily precipitation totals from October 1, 2000 to present and was used to compare the Wetland 17 elevation with precipitation. Table 5 shows annual minimum wetland levels compared to rainfall data from 1 and 2 months prior to the recorded date. The upward trend in wetland elevation could be due in part to increased precipitation.

Table 5. Minimum Wetland Levels Compared to Precipitation

Date	Previous 1-Month Rain Total (inches)	Previous 2-Month Rain Total (inches)	Wetland Elevation
10/29/2008	2.29	3.6	347.64
3/4/2009	2.3	7.53	347.18
10/5/2007	3.75	6.03	346.76
6/11/2004	3.06	4.69	346.37
9/28/2006	2.95	3.08	346.2
9/8/2001	2.06	3.8	346.16
8/31/2003	0.31	0.31	345.4
9/16/2002	0.12	0.12	345.37

3.5.1.3 Beavers

Beavers have been observed in Wetland 17, particularly on the downstream end of the wetland, and may play a large role in the changed hydrology within the wetland. Beavers are persistent rodents that build dams to control water levels. This may affect the residence time within the wetland, slowing the natural output and increasing the water level.

3.5.1.4 Increased Organic Accumulation

Another factor in the increased water levels observed in Wetland 17 may be due to increasing levels of organic debris. The wetland is highly vegetated and the accumulation of organic debris may be higher than the degradation of the debris. This accumulation may reduce the storage volume available in the wetland.

3.5.1.5 Development

Two developments drain into Wetland 17. The Meadow at Redford Ranch was constructed in 2000 and The Crossings at Pine Lake was constructed in 2005. New developments do not increase peak discharges into the wetland because of stormwater detention facilities that control peak flows, but do increase the volume of stormwater. An increased volume of stormwater may be contributing to an increased elevation in the wetland.

3.5.1.6 Output vs. Input

Multiple factors contribute to the input and output of water in a wetland. It could be that an increased input from stormwater and a decreased output may be contributing to the higher wetland elevation. Outputs from Wetland 17 include culverts conveying water downstream, infiltration, evaporation, and plant uptake. Any of these outputs, along with decreased storage from organic accumulation and longer residence time from beaver dams, could affect the wetland elevation.

3.6 STREAM AND HILLSLOPE GEOMORPHOLOGY

In the early 1990s King County conducted field studies of Ebright Creek and the Thompson Sub-basin. Results of these efforts are documented in the King County Basin and Nonpoint Action Plan for the East Lake Sammamish Basin (King County 1995) as well as the East Lake Sammamish Basin Conditions Report—Preliminary Analysis (King County 1990). Based on a comparison of Parametrix field efforts in 2008 and the field work conducted by King County in the early 1990s, Ebright Creek has experienced very minor stream degradation in the intervening years and has improved in a few areas. The primary direct changes in the stream channel include a new stormwater outfall and dissipation structure that extends to Ebright Creek downstream of 212th Street, and improved channel conditions in Ebright Creek Park due to restoration efforts. The observed hillslope seeps and frequency of slope failures appear to be fairly consistent between observations in 1990 and in 2008. Appendix D summarizes conditions observed in 1990 and 2008, which are documented downstream to upstream.

3.7 FISH HABITAT AND USE

Ebright Creek is a Type F, Class 2S, salmon-bearing creek fed by two tributaries originating in wetlands on the Sammamish Plateau. Stream flow in Ebright Creek is fed primarily by cool groundwater springs, which likely provide year-round temperature conditions suitable to support salmonids.

3.7.1 Kokanee Salmon

The Lake Sammamish kokanee salmon (*Oncorhynchus nerka*) consist of three distinct runs (stocks) differentiated by their spawning timing (early, middle, and late runs). Ebright Creek supports what is perhaps one of the last viable wild, native Lake Sammamish late-run kokanee population in the Lake Sammamish Basin.. Late-run kokanee are currently known to spawn in only six Lake Sammamish tributary streams. In addition to Ebright Creek, they spawn primarily in Lewis and Laughing Jacobs creeks, with limited spawning in Vasa, Pine Lake, and East Fork Issaquah creeks (Berge and Higgins 2003; Young et al. 2004; Jackson 2006). The Ebright, Laughing Jacobs, and Lewis creek populations are genetically unique to Lake Sammamish (Warheit and Bowman 2008) and warrant consideration for protection under the Endangered Species Act (USFWS 2008). Because of the limited distribution of this species and the extensive land development occurring throughout its current distribution, protecting or expanding the spawning habitat in these three drainages should be a priority.

Kokanee salmon are landlocked sockeye salmon that spend their entire lives in freshwater lakes and tributaries. Lake Sammamish kokanee spawn from August into January, although the late run spawns from late October into January (Berge and Higgins 2003; Jackson 2006). In contrast, anadromous sockeye salmon are born in freshwater, but migrate to salt water as young fish to grow and mature before returning to freshwater to spawn from October and November (Newell and Quinn 2005). Adult kokanee are 10 to 20 inches in length, which is smaller than other salmon. Sockeye salmon are also known to spawn in Ebright Creek, as do coho salmon (*O. kisutch*), cutthroat trout (*O. clarki*), and rainbow trout (*O. mykiss*) (King County 1990).

3.7.2 Aquatic Habitat Conditions

Aquatic habitat conditions were assessed by fish biologists during field reconnaissance surveys conducted on December 3 and 4, 2008. In general, habitat conditions were considered to be generally good throughout much of the stream. Three recent kokanee salmon redds (nests), and two spawning adult kokanee, were observed in the lower 0.22 mile of the creek during the survey. In addition, survey flagging from the King County Department of Natural Resources and Parks identified the location of seven other kokanee redds in this same reach. Based on available information, salmon spawning appears to be limited to the lower 0.22 mile of stream, where the stream gradient is low, and appropriate spawning habitat occurs (Photograph 1) (King County 1990). Between river mile (RM) 0.25 and RM 1.3, the stream gradient sometimes approaches 5 percent through a deep ravine, forming tiered or staircase features that result in patchy gravel areas and small volume pools that are favored by trout (King County 1990).

Photograph 1. Typical stream reach in the lower Ebright Creek, just upstream of East Lake Sammamish Parkway, consisting of an extended riffle habitat within a defined channel with few pools, flowing through a moderately functioning riparian corridor.

3.7.3 Culverts

Despite the generally good quality habitat occurring through much of the surveyed portion of the stream, there are some potential problem areas. The culverts under the East Lake Sammamish Trail and East Lake Sammamish Parkway appear to provide adequate fish passage conditions (partially submerged at relatively low flows), although the fish passage conditions would likely deteriorate at both high and low flows. The two 36-inch-diameter culverts under the trail have enough capacity to convey the 100-year flood event, although King County previously identified a CIP to replace these culverts with a bridge to improve fish passage (King County 1994). A detailed fish passage assessment was not included as part of the reconnaissance survey. The two 36-inch-diameter culverts under the parkway are in similar condition. An additional 24-inch-diameter culvert at about RM 0.25 is likely a complete barrier to fish (Ecology 1994), as is the 30-inch-diameter culvert located at SE 12th Street (about RM 1.1).

The reach just downstream of the steeper gradient stream reaches (about RM 0.3) showed some accumulations of sediment and stream channel braiding (Photograph 2). Although the Parametrix biologists reviewed historical aerial photographs, they were unable to determine the degree to which the stream channel braiding is a recent development or if this particular reach has been historically braided due to the low gradient in this area. However, the braided area was relatively short (about 300 feet), with the remainder of the stream typically occurring in a well-defined channel. Although this channel braiding has resulted in a wider and shallower stream channel and floodplain (as compared to the majority of the lower stream reach), this area contained about half of the observed or previously identified spawning redds. Therefore, it is uncertain how much the erosion and sedimentation is affecting salmonid production in the stream.

Photograph 2. Area of braided channel in the lower Ebright Creek, located about 0.2 mile upstream from East Lake Sammamish Parkway. The pink ribbon in the background indicates the location of a kokanee spawning redd.

Appendix E provides a sequence of photographs of Ebright Creek, starting at the mouth and proceeding upstream. The photographs are representative of the general habitat conditions in the various portions of the stream. Overall, the riparian buffers appear to be functioning properly and the stream channel is generally stable. Aside from the issues discussed above, the one aquatic habitat feature that appeared to be lacking in Ebright Creek is good quality pool habitat. Photograph 3 shows typical habitat in the upper reaches of Ebright Creek where riparian condition is good and pool habitat is lacking. King County (1990) also reported that the pool quality in the stream was more representative of trout habitat than salmon habitat. Limited pool sizes also reduce the quantity and quality of salmon spawning habitat, which typically consists of substrate at the downstream end of pools. Limited pool habitat would also restrict the capacity of the stream for supporting juvenile fish (both salmon and trout).

Photograph 3. Typical habitat in the steeper reaches of Ebright Creek, upstream of about RM 0.3.

3.8 WATER QUALITY

King County has been monitoring the ecological health of Ebright Creek in several ways including the collection and analysis of water, sediment, and benthic invertebrate samples. Beginning in 1996, monthly water quality samples have been collected from Station A685, located downstream at East Lake Sammamish Parkway SE. From 1987 through 2002, surface sediment samples were collected from Ebright Creek as part of the Streams Sediment Monitoring Program. Benthic invertebrates were also sampled from the creek in 2002 and 2003.

3.8.1 Ebright Creek

Water quality samples from Ebright Creek are analyzed monthly for temperature, dissolved oxygen, pH, conductivity, turbidity, total suspended solids, ortho-phosphorus, total phosphorus, ammonia, nitrate-nitrogen, total nitrogen, and fecal coliform bacteria. Results are compared to state water quality standards, which are designed to protect public health and aquatic life. Under the 2006 rules, Ebright Creek is categorized as "Core Summer Salmonid Habitat" for aquatic life use and "Primary Contact" for recreational use. According to the 2008 Ecology 303(d) list, Ebright Creek is listed as a Category 1 waterbody (meets tested standard for clean waters) for pH and ammonia-nitrogen, Category 2 (water of concern) for dissolved oxygen, and Category 5 (polluted waters that require a water quality cleanup plan) for fecal coliform bacteria.

3.8.2 Stream Sediments

Sediment data were collected from Ebright Creek as part of the King County Stream Monitoring Program starting in 1987. Data were compiled and analyzed for 1987 through 2002. Data were analyzed for trends and correlations, and were compared to freshwater sediment quality guidelines. No significant trends were identified during data analysis for any of the parameters tested. The results indicated that Ebright Creek sediments did not exceed any sediment quality guidelines. Of the 27 streams monitored in King County, Ebright Creek had the lowest metals concentrations.

3.8.3 Benthic Invertebrates

King County also monitors stream health by collecting samples of benthic invertebrates from selected streams as part of its Benthic Invertebrate Program. Benthic invertebrates are an important link in the food chain for fish in the creek and are an excellent indicator of stream health. In both 2002 and 2003, benthic invertebrate samples were collected and analyzed, and benthic invertebrate index scores were calculated for Ebright Creek.

Benthic invertebrate index scores from Ebright Creek indicated poor conditions for benthic invertebrates. For both years, between 40 and 78 percent of the species present were tolerant of degraded conditions. It is unclear why this difference in percentage makeup is so great between the two years. Future monitoring will be necessary to determine if this indicates an improving trend, or if it can be explained by other phenomena such as sampling variability. During both years when monitoring was conducted, very few individuals of species that are long-lived or sensitive to degraded conditions were found to be present. Longer-lived species typically take longer to reproduce and, along with sensitive species, are among the first to disappear when a stream ecosystem is altered by human activity such as urbanization.

4. RECOMMENDED STRATEGIES

Specific features that define the Thompson Sub-basin and are important considerations in the development of projects and strategies are as follows:

Basin Topography—Basin topography is characterized by a relatively flat plateau bisected by a steep ravine that funnels water directly into the well-defined stream channel of Ebright Creek and outlets into Lake Sammamish. The wetland complexes on the top of the plateau attenuate flow to Ebright Creek and should be protected.

Development—The current level of development in Thompson Sub-basin is less than many other suburbs east of Lake Washington, with less impervious surfaces and a more rural character. There is more to preserve here than restore.

Geology—The underlying geological features on the plateau of Thompson Sub-basin consist mostly of compacted till, representing a challenge for infiltrative stormwater best management practices. However, the steep ravines are located in erosive advanced outwash and are prone to landslides. It is important to manage stormwater runoff close to the top of the basin to minimize impacts downstream, particularly in large high quality wetlands.

Kokanee Salmon—Ebright Creek supports one of perhaps the last viable, native Lake Sammamish late-run kokanee populations in the greater Lake Sammamish Watershed.

The projects and strategies recommended below are designed to preserve ecological function in areas that are currently functioning well, solve existing problems, and prevent future degradation as the Thompson Sub-basin is further developed. Specific projects identified are presented in more detail in Appendix F.

4.1 PRESERVATION AND ENHANCEMENT OF ECOLOGICAL FUNCTION

The natural areas (Ebright Creek and associated wetlands) in the Thompson Sub-basin are largely protected through existing ordinances and, as such, the aquatic resources in the basin are in fairly good condition. Through the City's Critical Areas Ordinance, areas adjacent to stream corridors and wetlands are protected with buffers up to 150 feet. Additionally, a large percentage of Ebright Creek is located in an erosion hazard area that consists of a special district overlay requiring a no disturbance zone on the slope and specific stormwater management requirements to reduce the risk of landslides. Zoning surrounding Ebright Creek and Wetland 17 is R-1 (one dwelling unit per acre), which is fairly low density and will help in the maintenance of the natural resources in this area. It is important to maintain these zoning patterns and ordinances related to the protection of streams, wetlands, and erosion hazard areas for the long-term preservation of these natural resources in the Thompson Sub-basin.

Table 6 lists additional strategies to preserve and enhance existing ecological function in the Thompson Sub-basin. Full descriptions and planning level cost estimates are provided in Appendix F.

Table 6. Strategies to Preserve or Enhance Ecological Function in the Thompson Sub-basin

Strategy	Project Identification	Type of Strategy			Description	Potential Partners
		Planning	Education	Capital		
Acquire high quality property for conservation	Cons-1			X	Partner with land conservancy organizations to acquire undeveloped, forested tracts of land near the headwaters of Ebright Creek to preserve wetland functions and wildlife corridors	
Replace private culvert on Ebright Creek	Culv-1			X	Upgrade private culvert on Ebright Creek to provide/improve fish passage to upstream spawning habitat for kokanee salmon	Private property owner, King County, grant organizations
Enhance Wetland 17	Enh-1 and Enh-2			X	Restore/enhance pasture area in Wetland 17	Private property owners, developers in need of potential mitigation, conservancy groups
Enhance Wetlands 1 and 2	Enh-3 and Enh-4			X	Enhance Wetlands 1 and 2 in and adjacent to Ebright Creek Park	Sammamish Parks Department, private citizens, conservancy groups
Conduct wetland tours	Ed-1		X		Sponsor wetland tours to foster appreciation and stewardship of Sammamish wetlands	Audubon Society, non-profit environmental groups
Promote kokanee salmon awareness	Ed-2		X		Encourage campaign to increase awareness of kokanee salmon and the importance of Ebright Creek to the continued existence of this population of fish	School groups, environmental organizations
Implement beaver management program	Plan-1	X		X	Implement beaver management strategies where necessary, including Wetland 17	Private citizens, WDFW

4.1.1 Capital Projects

4.1.1.1 Acquire High Quality Property for Natural Resource Conservation (Cons-1)

Extensive development has occurred at the headwaters of Ebright Creek on 228th Avenue SE. Stormwater runoff from most of the development is being treated prior to discharge into Ebright Creek and its associated wetlands; future development would be treated as well. However, current stormwater regulations are geared toward preventing erosion from increased flow rates, and do not address increased volumes of stormwater. In addition to the planned Town Center development, many of the under-developed properties at the top of the basin could significantly increase the volume of stormwater runoff to the wetlands and Ebright Creek if developed to their full capacity of R-6 (six dwelling units per acre). Acquisition of one or more large, undeveloped parcels located south of Wetland 17 could continue to provide a greater buffer to the upstream development that has already occurred, and prevent future stormwater volume-related impacts (altered wetland hydroperiod) that may occur with future development. Figure 17 shows potential parcels for acquisition for preservation.

4.1.1.2 Replace Private Culvert on Ebright Creek (Culv-1)

A culvert located approximately 0.25 mile upstream of the mouth of Ebright Creek is either a partial or full barrier to fish passage. Replacing this culvert with a box culvert with natural streambed gravel would facilitate fish passage and provide upstream spawning opportunities for kokanee salmon.

4.1.1.3 Implement Wetland Enhancements

Washington State and federal regulatory agencies require that mitigation efforts follow the prescribed sequence below:

- Avoiding the impacts altogether by not taking a certain action or parts of an action.
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts.
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- Compensating for the impact by replacing, enhancing, or providing substitute resources or environments.
- Monitoring the impact and taking appropriate corrective measures.

In light of these requirements, preservation of existing wetlands is recommended, specifically Wetland 17. This can be done through enforcement of existing critical areas regulations (SMC 21A.50), outright purchase of properties, or establishment of conservation easements. Outright purchase of these properties is likely cost prohibitive; however, the City of Sammamish could consider using funds from their critical areas mitigation fee program (SMC 21A.50.360) to secure properties consistent with a watershed-based mitigation strategy. Alternatively, these projects could act as stand-alone watershed management projects.

In situations where mitigation is required to compensate for impacts, four potential mitigation projects are suggested. The proposed projects are based on limited field observations from publicly accessible sites and photograph interpretation. Other mitigation opportunities likely exist but are not visible from the road. The proposed mitigation options listed below would require a wetland delineation and further evaluation of the wetland for mitigation potential. Mitigation would require either purchase of the property, or establishment of a conservation easement, and cooperation of the landowner.

4.1.1.4 Enhance Wetland 17 (Enh-1 and Enh-2)

Wetland 17 is a high quality riverine wetland associated with Ebright Creek. It is very large, has several habitat types, and attenuates high flows to Ebright Creek. There are opportunities to enhance and enlarge this wetland through incorporation of native vegetation in areas that currently consist of pasture. This action would involve a partnership with the property owner or purchase by the City or other interested party.

A portion of two properties—one at the corner of SE 13th Place and 217th Avenue SE (parcel 9188) and the other at 21341 SE 13th Place (parcel 9196)—has been cleared for pasture and lawn. Some of this area, approximately 20,000 to 40,000 square feet, could be re-established or rehabilitated to wetland habitat on these properties. The area would require excavation of fill materials (where present) and grading as well as the removal of artificial structures and non-native species. The area would be planted with species similar to those in the adjacent forested wetland (black cottonwood, red alder, and willows). Permanent signs would be installed to identify the wetland as a protected area. There are likely other similar re-establishment and/or enhancement opportunities along Wetland 17 where pastures and lawns abut Wetland 17.

4.1.1.5 Enhance Wetlands 1 and 2 (Enh-3 and Enh-4)

Wetlands 1 and 2 are located north and south of Ebright Creek Park, respectively, and could be incorporated into the park.

The pasture could be planted with species similar to those in the adjacent scrub-shrub and emergent wetland (red alder, salmonberry, Nootka rose, red osier dogwood, panicled bulrush, and slough sedge). The site may require excavation of fill materials and removal of artificial structures and non-native species. Permanent signs would be installed to identify the wetland as a protected area.

4.1.2 Educational Strategies

4.1.2.1 Conduct Wetland Tours (Ed-1)

The Thompson Sub-basin has some high quality wetlands that provide important ecological functions, including attenuation of stormwater runoff and habitat for terrestrial and aquatic species. One of the best ways to educate citizens about stewardship of their natural environment is to show them. Wetland tours that feature Wetland 17 in the Thompson Sub-basin, as well as other unique wetland environments on the Sammamish Plateau, would be one way to promote environmental stewardship and increase understanding as to the importance of wetlands.

4.1.2.2 Kokanee Awareness Campaign (Ed-2)

The City of Sammamish is fortunate to have Ebright Creek, one of the last viable late-run kokanee salmon spawning streams in Lake Sammamish, within its jurisdictions. Most citizens are aware of other types of salmon and the effects of ordinary activities on their habitat. However, many people are not aware of kokanee salmon, or their status in the greater Sammamish Watershed and Ebright Creek. A campaign to increase awareness of kokanee salmon would give citizens a tangible reason for protecting Ebright Creek and the Thompson Sub-basin. One way to do this would be to create a city mascot that is a kokanee salmon to help people become aware of this species and give them something to rally around. The mascot would be a fun way to educate children and adults and increase awareness.

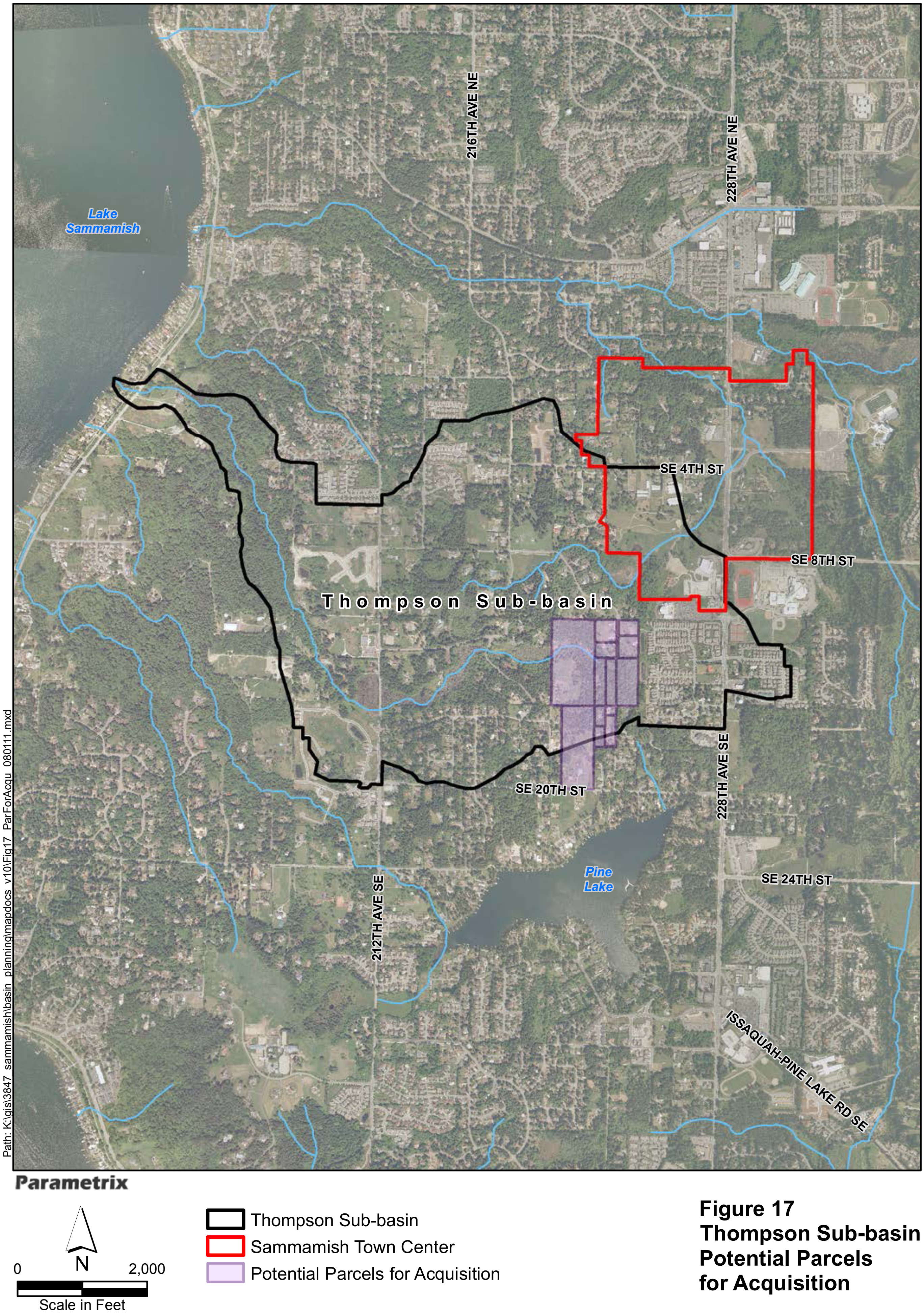


Figure 17
Thompson Sub-basin Potential Parcels for Acquisition

4.1.3 Planning Strategies

4.1.3.1 Implement Beaver Management Plan (Plan-1)

Beavers play an important role in the ecology of aquatic systems; however, this role can conflict with urban development and cause flooding, changes to wetland hydrology, and deforestation. There is evidence of beaver activity in Wetland 17 and beavers may be responsible for increased water elevations. A beaver management plan would help the City respond to citizens' complaints and incorporate non-lethal actions to minimize beaver-related impacts. Specific actions, such as installation of a beaver deceiver on Wetland 17, may be appropriate.

4.2 STRATEGIES TO REDUCE ONGOING STORMWATER DISCHARGE EFFECTS FROM EXISTING DEVELOPMENT

The area of inundation and wetland elevations in Wetland 17 has been increasing over the past decade and may be partially due to increased stormwater volumes from upstream development that mitigate peak flows and durations, but not the volumes of stormwater. Additionally, many single-family residences and roadways in the city of Sammamish do not mitigate stormwater runoff because they were developed prior to current stormwater regulations. Parametrix recommends focusing on educational strategies that citizens could employ on a volunteer basis to mitigate stormwater runoff from their residences, rather than a basin-wide stormwater retrofit program. The basin is still relatively undeveloped and conditions have not been significantly affected by stormwater runoff; therefore, the primary focus for strategies should be to preserve the good ecosystem functions that currently exist and prevent future problems.

Water quality monitoring indicates that fecal coliform bacteria is a pollutant of concern in Ebright Creek and is responsible for impairing water quality. Recent water quality data are not available to determine whether water quality conditions have improved or declined; however, local residents expressed interest in knowing more about manure management for their small farms at public meetings (personal communication, Erin Nelson, Engineer, Parametrix, 2010).

Table 7 lists educational strategies to reduce the effects of ongoing stormwater discharges in Thompson Sub-basin. Full descriptions and planning level cost estimates are provided in Appendix F.

Table 7. Strategies to Reduce Ongoing Stormwater Impacts

Strategy	Project Identification	Type of Strategy			Description	Potential Partners
		Planning	Education	Capital		
Low Impact Development (LID) Educational Strategies	Ed-3		X		Provide informational brochures and technical assistance to residents interested in implementing LID techniques such as rainwater harvesting or rain gardens	Washington State University Extension, private residents
Manure Management Strategies	Ed-4		X		Provide informational brochures and technical assistance to residents interested in improving manure management on their properties	King County, King County Conservation District, private residents

4.2.1 Educational Strategies

4.2.1.1 Low Impact Development Educational Opportunities (Ed-3)

Educational opportunities include encouraging LID retrofits for local homeowners through demonstration projects with informational kiosks, and development of "How to" brochures for rainwater harvesting, rain gardens, and other LID techniques. Additionally, the development of the Town Center provides opportunities for demonstration LID projects.

4.2.1.2 Manure Management Educational Opportunities (Ed-4)

As requested by the citizens, opportunities include providing educational information and local farm tours to demonstrate effective manure management techniques for homeowners that keep farm animals.

4.3 PLAN FOR FUTURE IMPACTS AND MINIMIZING EFFECTS

The Thompson Sub-basin would likely undergo significant changes in the next several decades, including development of the proposed Town Center and conversion of forested parcels to denser development in accordance with current zoning. Impacts related to stormwater runoff would be partially mitigated through flow control and water quality treatment as required by state and local regulations. However, mitigation is not a guarantee that the natural resources such as Ebright Creek and its associated wetlands would not be affected. Stormwater management techniques and strategies are constantly evolving; currently, the regional emphasis is on LID techniques to minimize the effects of stormwater runoff. This is the recommended approach for the Town Center (Parametrix 2009a), and is one of the only ways to mitigate stormwater volume resulting from land conversion.

The Town Center Comprehensive Stormwater Plan recommended using the LID techniques listed in Table 8 to mitigate stormwater runoff.

Table 8. Summary of Stormwater Treatment Requirements and Preferred Choices

Type of Impervious Surface	Treatment Required		First Choice	Second Choice	Third Choice
	Water Quality	Flow Control			
Rooftops		√	Rainwater Harvesting and Reuse	Green Roofs	Bioretention
Roads and Parking Lots	√	√	Minimize Surfaces	Bioretention	Pervious Pavement
Sidewalks and Patios		√	Pervious Pavement	Full Dispersion	Bioretention

The City of Sammamish has adopted an LID ordinance in which LID is provided incentives for new development. There has been little opportunity to test the effectiveness of this ordinance for encouraging use of LID because the economic slowdown of 2009 to 2010 has resulted in little to no development in the city. Although the LID ordinance is voluntary, LID would likely be mandatory (to the extent feasible) in the Town Center (City of Sammamish, 2009). As development activity begins again in the city, it will be important for the City to monitor the success of both approaches to stormwater management using LID and make adjustments as necessary to achieve its goals.

In addition to the use of technical methods to accomplish stormwater management goals, such as LID, there are other implementation mechanisms that could be explored in the future. Some of these implementation strategies are described in the Draft Non-Traditional Stormwater Approaches Memorandum (Parametrix 2009b) and the sub-sections below as recommended future planning strategies.

Table 9 lists planning, educational, and monitoring strategies to plan for future impacts and minimize the effects of stormwater runoff in the Thompson Sub-basin. Full descriptions and planning level cost estimates are provided in Appendix F.

Table 9. Strategies to Plan for and Reduce Effects of Future Stormwater Runoff

Strategy	Project Identification	Type of Strategy			Description	Potential Partners
		Planning	Education	Capital		
Investigate use of injection wells	Study-1	X			Conduct a hydrogeological analysis to determine whether deep underground injection of treated stormwater is feasible within the Thompson Sub-basin	Sammamish Water and Sewer District
Evaluate potential modifications to LID ordinance	Study-2	X			Evaluate success of existing ordinance and make modifications as necessary	
Install new flow gauge on Ebright Creek	Mon-1			X	Replace flow gauge located on private property upstream from Lake Sammamish. The gauge would help in hydrologic model calibration and effects of stormwater management measures implemented in Town Center.	
Collect wetland elevation data on Wetland 17	Mon-2			X	Continue to collect wetland elevation data for Wetland 17, which will also be important for evaluating potential changes resulting from upstream development.	
Collect wetland elevation data on Wetland 61	Mon-3			X	Install a new wetland gauge in Wetland 61 to monitor the wetland hydroperiod and evaluate potential changes resulting from development of the Town Center.	
Conduct channel cross-section monitoring on Ebright Creek	Mon-4			X	Evaluate physical channel conditions on an annual basis to monitor potential effects from upstream land use changes.	
Conduct water quality monitoring on Ebright Creek	Mon-5			X	Consider monitoring water quality on Ebright Creek to continue program that started with King County.	

4.3.1 Planning Strategies

4.3.1.1 Investigate Use of Injection Wells to Reduce Stormwater Runoff (Study-1)

There are many emerging approaches to managing stormwater as a resource rather than a waste stream. In the city of Sammamish, in particular, municipal water sources are partially developed from groundwater sources, which must be replenished through surface infiltration of rainwater. When development prevents infiltration through the construction of impervious surfaces, groundwater aquifers can be affected as well. Many Pacific Northwest communities, including the City of Portland, use underground injection control wells to “dispose” of stormwater. This could be a viable option for the City of Sammamish, but would require thoughtful planning and consideration of potential consequences.

4.3.1.2 Evaluate Options for Potential Modification of LID Ordinance (Study-2)

The existing City of Sammamish LID ordinance has not been tested to determine if this voluntary program would be effective in changing stormwater management strategies in the stormwater community. Once development resumes, the success of the ordinance should be evaluated to determine if modifications should be made.

4.3.2 Monitoring and Performance Strategies

In order to recognize watershed degradation and understand the consequences of future development, it is important to have adequate monitoring data. In the development of this plan, Parametrix relied on previous water quality monitoring data from King County, wetland elevation data collected as mitigation for The Crossings at Pine Lake development, and field information documented in previous basin planning efforts. Flow gauge data were not available for calibration of the hydrologic model. Prior to development of the Town Center, Parametrix recommends monitoring several baseline parameters so that the effectiveness of stormwater management techniques employed at the Town Center can be adequately evaluated and/or adjusted as development occurs.

4.3.2.1 Install New Flow Gauge near the Mouth of Ebright Creek (Mon-1)

A flow gauge was previously installed on Ebright Creek, upstream of East Lake Sammamish Parkway. The company that recorded the data went out of business and the gauge data were not available for this study. Parametrix recommends installing a new gauge or reactivating the existing gauge to collect flow data so that the hydrologic model can be better calibrated and future flows can be monitored.

4.3.2.2 Continue Collecting Wetland Elevation Data in Wetland 17 (Mon-2)

Barghausen Engineers has been collecting wetland elevation data from Wetland 17 at the SE 212th Street road crossing since 2000. Parametrix recommends that the collection of water level data continue through development of the Town Center to evaluate trends.

4.3.2.3 Collect Wetland Elevation Data in Wetland 61 (Mon-3)

Parametrix recommends installing a water level gauge in Wetland 61 so that wetland elevations can be monitored through development of the Town Center.

4.3.2.4 Conduct Channel Cross-Section Monitoring in Ebright Creek (Mon-4)

One of the primary goals of the flow control standards promulgated by King County and Ecology is to minimize erosion from high flows and durations in stream channels. Parametrix recommends installing two permanent cross-section flow gauges on Ebright Creek (one downstream of 212th Street and one upstream of East Lake Sammamish Parkway) to monitor physical changes in channel conditions that could be a result of stormwater runoff.

4.3.2.5 Monitor Ebright Creek Water Quality Downstream of Wetland 17 (Mon-5)

Parametrix recommends implementing a monitoring strategy to continue the work of King County in their stream monitoring program, which collected data on fecal coliform bacteria, temperature, and dissolved oxygen.

5. PROJECT PRIORITIZATION

The projects recommended above represent a variety of issues and strategies to protect the Thompson Sub-basin. Because the basin is relatively undeveloped compared to its zoning potential, there are few capital projects to fix existing problems. The most pressing need in the basin is to preserve the existing natural resources and prevent future harm. Many of the recommended projects would be eligible for grant funding, which is discussed below. Other projects could be largely accomplished with volunteers or community and environmental groups. Funding strategies would likely need to be multi-faceted, taking advantage of opportunities as they arise. None of the projects recommended is critical to the short-term health and safety of the community, but these projects are more important to the long-term sustainability of natural resources in the Thompson Sub-basin. Parametrix prioritized the projects using several criteria, including (1) likelihood of success at achieving the desired outcome, (2) degree to which project meets multiple objectives, (3) degree to which project alleviates threats to wildlife and habitat or property, and (4) cost.

5.1 CRITERIA

Table 10 lists the criteria and ranks the scores associated with a high, medium, or low ranking for each criterion.

Table 10. Criteria and Scoring for Project Prioritization

	Rank scores		
Criteria	**High (5 points)**	**Medium (3 points)**	**Low (1 point)**
Likelihood of Success	Proven in other cases	Mixed results in other cases	Unproven
Number of Issues Addressed	More than three	Two to three	One
Habitat Protection	Protects both habitat and property	Protects habitat OR property	Protects neither
Cost Category (first 5 years)	< $20,000	($20,000 – $50,000)	(> $50,000)

The combined scores of individual criteria were ranked according to the following total points:

Low priority (6 to 8 total points);

Medium priority (10 to 12 total points); and

High priority (over 12 total points).

5.2 MATRIX OF PROJECTS

Table 11 lists the recommended projects according to strategy, cost, and project criteria from highest to lowest priority. The monitoring projects were not prioritized, as they do not address specific goals, but involve collection of data that is important for making decisions

Table 11. Matrix of Recommended Projects

		Type of Strategy						Project Criteria				
Strategy	**Project Identification**	**Planning**	**Education**	**Capital**	**Description**	**Potential Partners**	**Cost**	**Likelihood of Success**	**Number of Issues Addressed**	**Protects Habitat**	**Cost**	**Priority**
Acquire high quality property for conservation	Cons-1			X	Partner with land conservancy organizations to acquire undeveloped, forested tracts of land near the headwaters of Ebright Creek to preserve wetland functions and wildlife corridors		$87,000 per acre	High	High	High	Low	High
Replace private culvert on Ebright Creek	Culv-1			X	Upgrade private culvert on Ebright Creek to provide/improve fish passage to upstream spawning habitat for kokanee salmon	Private property owner, King County, grant organizations	$118,000	High	Medium	High	Low	High
Encourage manure management strategies	Ed-3		X		Increase awareness of effect of bacteria from manure in streams and utilize resources available from King County to aid in manure management	City of Sammamish, King County, private citizens, King Conservation District	$800	High	Low	High	High	High
Implement Beaver Management Program	Plan-1	X			Implement beaver management strategies where necessary, including Wetland 17	Private citizens, WDFW	$10,000 plan, ~ $12,000 Beaver Deceiver	H	L	M	H	High
Injection of treated stormwater	Study-1	X			Evaluate if injection of treated stormwater in deep wells is feasible.		To be determined	L	M	L	H	Medium
Conduct kokanee salmon awareness and mascot campaign	Ed-4		X		Conduct campaign to increase awareness of kokanee salmon and the importance of Ebright Creek to the continued existence of this population of fish	School groups, environmental organizations	$13,000	Medium	Low	Low	High	Medium

Table 11. Matrix of Recommended Projects (continued)

Strategy	Project Identification	Type of Strategy: Planning	Type of Strategy: Education	Type of Strategy: Capital	Description	Potential Partners	Cost	Project Criteria: Likelihood of Success	Project Criteria: Number of Issues Addressed	Project Criteria: Protects Habitat	Project Criteria: Cost	Priority
Enhance Wetland 17	Enh-1 and Enh-2			X	Restore/enhance pasture area in Wetland 17	Private property owners, developers in need of potential mitigation, conservancy groups	$152,000 for both	Medium	Low	Medium	Low	Low
Enhance Wetlands 1 and 2	Enh-3 and Enh-4			X	Enhance Wetlands 1 and 2 in Ebright Creek Park	Sammamish Parks Department, private citizens, conservancy groups	$152,000 for both	Medium	Low	Medium	Low	Low
Conduct wetland tours	Ed-1		X		Sponsor wetland tours to foster appreciation and stewardship of Sammamish wetlands	Audubon Society, non-profit environmental groups	$6,000	Low	Low	Low	High	Low
Encourage LID educational strategies	Ed-2		X		Encourage LID techniques for developers and homeowners in the Thompson sub-basin	Sammamish Water and Sewer District, conservancy groups, private citizens	$6,000	Low	Low	Low	High	Low
LID effectiveness	Study-2	X			Evaluate effectiveness of LID ordinance		To be determined	L	L	L	H	Low
Install and monitor Ebright Creek flow gauge	Mon-1	X			Use Ebright Creek flow data to calibrate existing model and monitor effects of development within the watershed	City of Sammamish	$15,000 first year, $5,000 annually					Not rated
Conduct Wetland 17 elevation monitoring	Mon-2	X			Continue collecting Wetland 17 elevations to monitor changes over time	City of Sammamish	$7,000 annually					Not rated
Conduct Wetland 61 elevation monitoring	Mon-3	X			Monitor Wetland 61 elevation to correlate any effects of development with wetland elevations	City of Sammamish	$7,000 annually					Not rated
Conduct Ebright Creek cross section monitoring	Mon-4	X			Conduct annual measurements of two cross sections to determine changing channel conditions	City of Sammamish	$3,000 annually, one time report cost of $4,000					Not rated

Table 11. Matrix of Recommended Projects (continued)

		Type of Strategy						Project Criteria				
Strategy	Project Identification	Planning	Education	Capital	Description	Potential Partners	Cost	Likelihood of Success	Number of Issues Addressed	Protects Habitat	Cost	Priority
Conduct water quality monitoring	Mon-5	X			Continue King County's monitoring of Ebright Creek to record levels of nutrients, dissolved oxygen, and bacteria	King County, City of Sammamish	To be determined					Not rated

6. POTENTIAL GRANT OPPORTUNITIES

There are many types of grant opportunities available for projects within the city of Sammamish, including several that are listed in Table 12. In many cases, granting agencies require matching funds, which can be volunteer labor or supplies in lieu of money. Additionally, some grants require multiple partners.

Table 12. Potential Grant Opportunities for City of Sammamish Projects

Title of Grant	Granting Agency	Timeframe	Requirements (Matching Funds, Non-profit, etc.)	Types of Projects Covered	Potential Project
Stormwater Management Implementation Grant	Ecology			Stormwater Management	
Clean Water State Revolving Fund	U.S. Environmental Protection Agency (EPA)			Water Quality	
Drinking Water State Revolving Fund	EPA			Water Quality	
Remedial Action Grants and Loans	Ecology				
Area-wide Groundwater Remediation Grants	Ecology		0 to 50% local	Water Quality	
Chapter 173-322 Washington Administrative Code, Remedial Action Grants	Ecology			Water Quality	
U.S. Fish and Wildlife Service Endangered Species Conservation Fund	U.S. Fish and Wildlife Service	Summer, Annually	25%	Wildlife and/or Endangered Species	
U.S. Fish and Wildlife Service Habitat Conservation Plan Land Acquisition	U.S. Fish and Wildlife Service		25%	Endangered Species	
U.S. Fish and Wildlife Service Recovery Land Acquisition	U.S. Fish and Wildlife Service		25%	Endangered Species	
U.S. Fish and Wildlife Service Habitat Conservation Planning Assistance	U.S. Fish and Wildlife Service		25%	Endangered Species	
Community Salmon Fund Program	National Fish and Wildlife Foundation (NFWF)	Fall, Annually	Varied; matching, special	Wildlife Habitat Conservation	Culv-1
Salmon Recovery Funding	Recreation and Conservation Office (RCO)	August 2010, Annually	15% no limit, except for design-only projects, which are limited to $200,000	Replacing barriers to fish migration, replanting stream banks, removing dikes and levees, installing large woody material to slow rivers and create habitat, acquiring pristine habitat	Culv-1
Pioneers in Conservation	NFWF	Spring, Annually	Matching up to $75,000	Wildlife Habitat Conservation	Cons-1
Bring Back the Natives: A public-private partnership for restoring populations of native aquatic species	NFWF	Winter, Annually	2 to 1 matching	Restoring, protecting, enhancing native aquatic species	Culv-1

Table 12. Potential Grant Opportunities for City of Sammamish Projects (continued)

Title of Grant	Granting Agency	Timeframe	Requirements (Matching Funds, Non-profit, etc.)	Types of Projects Covered	Potential Project
grants.gov	All	Varies	Varies	All	
Conservation Innovation Grants	Natural Resources Conservation Service (NRCS)	Spring, Annually	Up to 50%	All innovative conservation approaches and technologies	Cons-1 Enh-1 Enh-2 Enh-3 Plan-1
Environmental Sustainability	The Russell Family Foundation	Annually	Varies	Non-profits such as public schools and school districts; all projects committed to improving the protection of Puget Sound	
North American Wetlands Conservation Act Grants Program U.S. Small Grants	North American Wetlands Conservation Act (NAWCA)	October 28, 2010	Up to $75,000	Wetland preservation for upland bird habitat	Enh-1 Enh-2 Enh-3
Neotropical Migratory Bird Conservation Act Grants Program	Neotropical Migratory Bird Conservation Act (NMBCA)	November 1, 2010	Up to $250,000	Conservation of neotropical migratory birds	Enh-1 Enh-2 Enh-3
Clean Water Grants	BoatUS Foundation	Fall, Annually	Up to $4,000; non-profit, no government	Community Education and Involvement (focus on boaters); Water Quality	
Pulling Together Initiative	NFWF	Varies	Varies	Control of Invasive Plant Species	
Aquatic Weeds Management Fund	Ecology	Annually	Varies	Management plans, education, implementation of vegetation plans, mapping, project evaluation, pilot projects	
Funding Infrastructure DataBase, Access Washington	Washington State Public Works	Varies	Varies	All	All
Centennial Clean Water Fund	Ecology	September to October, Annually	Grant, loan, technical assistance	Education, Land Acquisition, Restoration, Riparian Areas, Waste Water, Water Quality, Wetlands	All
Environmental Education Grants	EPA	Fall, Annually	Match, typical. $25,000 maximum	Education	Ed-1 – Ed-4
Federal Clean Water Act - Section 319	Ecology	Spring, Annually	Match	Education, Fish and Wildlife, Restoration, Riparian Areas, Water Quality, Wetlands	All

Table 12. Potential Grant Opportunities for City of Sammamish Projects (continued)

Title of Grant	Granting Agency	Timeframe	Requirements (Matching Funds, Non-profit, etc.)	Types of Projects Covered	Potential Project
National Recreational Trails Program (NRTP)	Federal Highway Administration (FHWA)	Annually	Varies	Education, Outdoor Recreation, Restoration	Ed-1
Community Development Block Grants	U.S. Department of Housing and Urban Development (HUD)	Varies, Annually	Varies	Neighborhood Revitalization	
Wetlands Reserve Program	NRCS and Farm Service Agency	Year-round	Match required	Education, Fish and Wildlife, Flood Management, Land Acquisition, Land Management, Restoration, Riparian Areas, Water Quality, Wetlands	All
Forest Legacy Program	USDA Forest Service and Washington Department of Natural Resources	Ongoing	Match required	Fish and Wildlife, Forestry, Land Acquisition, Land Management, Riparian Areas, Water Quality, Wetlands	Cons-1 Enh-1 Enh-2 Enh3
Land and Water Conservation Fund (LWCF)	National Park Service	Ongoing	Match required	Fish and Wildlife, Outdoor Recreation, Restoration, Riparian Areas, Wetlands	Culv-1 Enh-1 Enh-2 Enh-3
Puget Sound Program	U.S. Fish and Wildlife Service	Annually Late Spring	Match required	Coastal enhancement and restoration, Fish and Wildlife, Flood Management, Land Management, Restoration, Riparian Areas, Water Quality, Wetlands	
Washington Wildlife and Recreation Program (WWRP)	Washington State Recreation and Conservation Office	May 1, 2008	Match required	Coastal, Fish and Wildlife, Land Acquisition, Outdoor Recreation, Restoration, Riparian Areas, Wetlands	
Environmental Quality Incentive Program	NRCS and Farm Service Agency	Annually	Match required	Agricultural, Fish and Wildlife, Land Management, Riparian Areas, Water Quality, Wetlands	Culv-1 Enh-1 Enh-2 Enh-3 Ed-3

Table 12. Potential Grant Opportunities for City of Sammamish Projects (continued)

Title of Grant	Granting Agency	Timeframe	Requirements (Matching Funds, Non-profit, etc.)	Types of Projects Covered	Potential Project
Clean Water State Revolving Fund	EPA	Annually		Water Quality, Fish and Wildlife	Culv-1 Enh-1 Enh-2 Enh-3 Ed-3 Mon-1 – Mon-5

7. REFERENCES

Berge, H.B., and K. Higgins. 2003. The Current Status of Kokanee in the Greater Lake Washington Watershed. King County Department of Natural Resources and Parks, Water and Land Resources Division. Seattle, Washington. 50 pp.

City of Sammamish. 2003. City of Sammamish Comprehensive Plan. Adopted September 16, 2003. Updated August 2006 per Ordinance No. 02003-130.

City of Sammamish. 2007. City of Sammamish Town Center Sub-Area Plan DEIS.

City of Sammamish. 2009. City of Sammamish Town Center Draft Comprehensive Stormwater Plan. Prepared by Parametrix. October 2009.

David Nelson and Associates, Inc. 1987. Geotechnical Evaluation, Lancaster Ridge, King County, Washington. Prepared for Lakeridge Development Corporation. Bellevue, Washington. Available from Geomap NW.

Ecology (Washington State Department of Ecology). 1994. East Lake Sammamish Basin—Watershed Management Committee Basin and Nonpoint Action Plan. Washington State Department of Ecology. Olympia, Washington.

Hong West and Associates, Inc. 1996. Geotechnical Study: Proposed 228th Avenue Issaquah-Pine Lake Road, King County, Washington. Prepared for Tams Consultants Inc. Available from Geomap NW.

Jackson, C. 2006. Lake Sammamish Watershed Native Late-Run Kokanee Stock Assessment and Management Plan. Washington Department of Fish and Wildlife. Region 4 Fish Program. September 2006. 9 pp.

King County. 1990. East Lake Sammamish Basin Conditions Report—Preliminary Analysis. King County Department of Public Works, Surface Water Management Division. Seattle, Washington. September 1990.

King County. 1994. East Lake Sammamish Basin and Nonpoint Action Plan Annual Report, 1994 Water Year. King County Department of Public Works, Surface Water Management Division. Seattle, Washington.

King County. 1994. Final East Lake Sammamish Basin and Nonpoint Action Plan. Report prepared by the Issaquah/East Lake Sammamish Watershed Management Committee. King County Lead Agency.

Leisch, B.A., C.E. Price, and K.L. Walters. 1963. Geology and Groundwater Resources of Northwestern King County, Washington. Washington Division of Water Resources Water Supply Bulletin No. 20. Prepared in cooperation with U.S. Geological Survey.

Newell, J.C., and T.P. Quinn. 2005. Behavioral Thermoregulation by Maturing Adult Sockeye Salmon (*Oncorhynchus nerka*) in a Stratified Lake prior to Spawning. Canadian Journal of Zoology 83:1232–1239.

Parametrix. 2009a. Comprehensive Stormwater Master Plan. Prepared for the City of Sammamish. Bellevue, WA.

Parametrix. 2009b. Draft Non-Traditional Stormwater Approaches Memorandum. Bellevue, WA.

Sammamish Plateau Water and Sewer District. 2003. Wastewater Comprehensive Plan. Volume 1 Report. Draft Approved for Distribution. October 2003.

Soil Conservation Service. 1973. Soil Survey of King County Area, Washington.

Terra Associates, Inc. 1995. Geotechnical Report—Site No. 61, Elementary School, Lake Washington School District #414, King County, Washington. Prepared for Lake Washington School District. Available from Geomap NW.

Terra Associates, Inc. 1998. Preliminary Geotechnical Report—Lein Plat, 228th Avenue SE and SE 3rd Street Right-of-Way, King County, Washington. Prepared for Doneshvar & Associates. Kirkland, Washington. Available from Geomap NW.

Terra Associates, Inc. 1999. Subsurface Exploration, Skinner North Gravity Interceptor, Sammamish, Washington. Prepared for Pacific Properties, Inc. Bellevue, Washington. Available from Geomap NW.

Turney, G.L., S.C. Kahle, and N.P. Dion. 1995. Geohydrology and Ground-Water Quality of East King County, Washington. Water Resources Investigations Report 94-4082. Prepared in cooperation with Seattle-King County Department of Public Health, Tacoma.

USGS (U.S. Geologic Survey). 2006. Geologic Map of the Issaquah 7.5' Quadrangle, King County, Washington by Derek B. Booth, Timothy J. Walsh, Kathy Goetz Troost, and Scott A. Shimel.

USFWS (U.S. Fish and Wildlife Service). 2008. Endangered and Threatened Wildlife and Plants; 90-Day Finding on a Petition to List Kokanee (*Oncorhynchus nerka*) in Lake Sammamish, Washington, as Threatened or Endangered. 73 FR: No. 88: 24915–24922.

Warheit, K.I., and C. Bowman. 2008. Genetic Structure of Kokanee (*Oncorhynchus nerka*) Spawning in Tributaries of Lake Sammamish, Washington. Report Synthesis Report 37, January 21, 2009. Submitted to King County Department of Natural Resources and Parks, Water and Land Resources Division, and Trout Unlimited – Bellevue/Issaquah as partial fulfillment for Contracts 07-2047 (King County) and 07-2098 (Trout Unlimited). 49 pp.

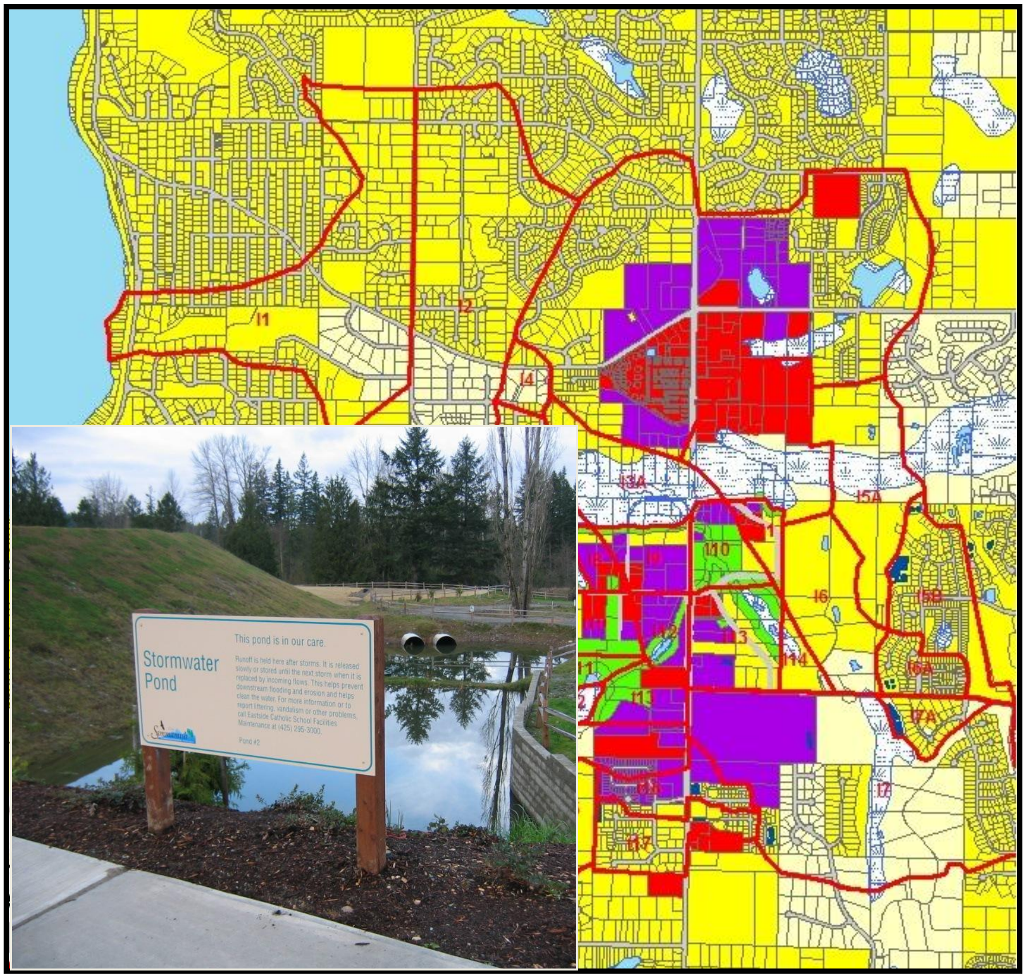
WSDOH (Washington State Department of Health). 2011. Water Facilities Inventory (WFI) Form. System ID No. 409009, System Name: Sammamish Plateau Water & Sewer.

Young, S.F., M.R. Downen, and J.B. Shaklee. 2004. Microsatellite DNA Data Indicate Distinct Native Populations of Kokanee, *Oncorhynchus nerka*, Persist in the Lake Sammamish Basin, Washington. Environmental Biology of Fishes 69:63–79.

APPENDIX A

Hydrologic Modeling Report

Hydrologic Analysis of the Inglewood Basin, Thompson Basin and Sammamish Town Center Using the HSPF Model



Prepared for

The City of Sammamish

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December 8, 2009

Hydrologic and Hydraulic Analysis of Inglewood Basin, Thompson Basin, and Sammamish Town Center Using the HSPF Model

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The engineering analyses and technical material presented in this report were prepared under the supervision and direction of the undersigned professional engineer.

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REGISTERED
PROFESSIONAL ENGINEER
EXPIRES 07/21/11

Bruce Barker, P.E.

EXECUTIVE SUMMARY

This report documents the development of hydrologic models used in the analysis of the Inglewood Basin, Thompson Basin, and Sammamish Town Center. The models were developed to quantify the runoff conditions in the two principal streams; George Davis and Ebright creeks under historic, current, and future land use. In addition, the models were used to analyze the effectiveness of stormwater controls at mitigating the increased runoff associated with future development in the basins.

Two hydrologic models were used in the analysis; the Hydrological Simulation Program-Fortran (HSPF) model and MGSFlood. HSPF has been used extensively in the Puget Sound region over the past 20 years for stormwater analysis. The HSPF model input was originally developed by King County as part of East Lake Sammamish Basin Plan in the mid 1980's and subsequently updated by the City of Sammamish for the Inglewood Basin Plan in 2004. The model input was updated and refined for the current study and recalibrated to streamflow data collected over a 20 month period from October 2001 through May 2003. HSPF model input and calibrated parameters were used in MGSFlood to analyze mitigation alternatives that included stormwater detention and Low Impact Development (LID).

The Inglewood Basin encompasses approximately 1640 acres (2.6 square miles) of suburban land in the City of Sammamish tributary to George Davis Creek. The geology in the central portion of the watershed is composed of highly infiltrative glacial outwash deposits. The outwash infiltrates the majority of surface flow produced in the upper parts of the watershed and results in little or no flow in the stream immediately upstream of the ravine. The stream intersects the groundwater table in the ravine and receives the majority of flow via groundwater discharge in this area. The groundwater discharge also produces year around base flow in the lower reaches of the stream. The outwash deposit infiltrates and stores runoff from the upper watershed and is equivalent to approximately 7,000 acre-feet of stormwater detention storage. Flows in the lower stream reaches are relatively low (attenuated) during floods because of the storage that occurs in the outwash deposit.

The Thompson Basin is located adjacent to the Inglewood basin and drains 800 acres (1.3 square miles) of suburban land via Ebright Creek. The Thompson Basin does not have the same infiltrative outwash deposit as the Inglewood basin, but does have a large wetland (Wetland 17) situated at the top of the ravine. This 30 acre wetland provides substantial flood attenuation and buffering of flows entering from the uplands before discharging to the ravine.

Historic (forested), existing, and future build-out conditions were simulated with the hydrologic models, and flood peak and flow duration statistics were computed. Little or no increases in runoff rates relative to existing conditions were predicted under the mitigated future land use scenario for the Inglewood Basin. In the Thompson Basin, future peak flow rates were predicted to decrease relative to existing conditions. These results show that stormwater mitigation designed according to the City's stormwater detention standard, which seeks to control runoff rates and durations to forested conditions, is effective at mitigating increased runoff associated with development. Because of this, the rates of erosion and flooding should not increase in the future and in most areas of the Thompson Basin, may actually decrease provided that the facilities are properly designed, constructed, and maintained.

The report includes the following recommendations to maintain a stable flow regime to ensure the health of the stream system in the future:

- Maintenance of Outwash Infiltration Areas – The glacial outwash deposit in the central part of the Inglewood Basin is currently infiltrating the majority of surface runoff from the upper watershed. Maintaining the infiltration function of this area is critical to ensuring a stable flow regime and the health of the stream. In addition, infiltration of urban runoff should be encouraged wherever feasible in the Thompson watershed.

- On-Site Detention Standard – The City's proposed detention standard, which is consistent with the 2005 Ecology Stormwater Management Manual, is effective at mitigating the increased potential for flooding and erosion associated with development. Stormwater detention facilities designed according to this standard are large and often expensive to construct. Low Impact Development (LID) methods provide a means to reduce the rate and volume of runoff associated with development, and increases the amount of potential groundwater recharge. LID methods can reduce the size of detention facilities, or replace them altogether. LID methods should be encouraged to the greatest extent practical for new construction in the Inglewood and Thompson Basins.

- Streamflow Monitoring – Streamflow gages have been operated and maintained by a private contractor in the past at the mouth of George Davis and Ebright creeks. These gages should be reestablished and the data collected from them quality checked and validated on an on-going basis.

TABLE OF CONTENTS

Hydrologic Analysis of the
Inglewood Basin, Thompson Basin, and Sammamish Town Center

INTRODUCTION

This report presents findings of a hydrologic analysis of the Inglewood and Thompson Basins in the City of Sammamish. The analysis was performed using the Hydrological Simulation Program Fortran[1] (HSPF) and MGSFlood[2] hydrologic models. The purpose of the analysis was to determine streamflow magnitude-frequency and flow duration statistics at locations of interest in the watersheds under existing and future land use, and determine the effectiveness of mitigation alternatives.

The proposed Sammamish Town Center project, which consists of approximately 208 acres of residential and commercial development, straddles the Thompson/Inglewood basin divide. MGSFlood model and input was developed for historic, existing and future land use. MGSFlood includes routines for quickly analyzing mitigation alternatives including detention and Low Impact Development (LID) techniques.

HSPF MODEL ANALYSIS APPROACH

SUBBASIN DELINEATION INGLEWOOD BASIN/GEORGE DAVIS CREEK

The Inglewood Basin encompasses approximately 1640 acres (2.6 square miles) of suburban land in the City of Sammamish. The principal stream in the Inglewood Basin is named George Davis Creek. The creek originates at a wetland area on the Sammamish plateau and drops approximately 400 feet in three miles to Lake Sammamish (Figure 1).

HSPF model input for the watershed was developed by the USGS[3] and utilized by King County as part of the 1991 East Lake Sammamish Basin Plan[4]. The model was updated in 2004 for the Inglewood Basin Plan Update[5]. The model input was modified in the current analysis to reflect changes in land use that have occurred since 2004, and additional subbasins were added for the analysis of the Sammamish Town Center.

SUBBASIN DELINEATION THOMPSON BASIN/EBRIGHT CREEK

The Thompson Basin is located south of Inglewood and receives runoff from approximately 800 acres (1.25 square miles) of suburban land. The principal stream is Ebright Creek, which originates on the Sammamish plateau and discharges to Lake Sammamish (Figure 1).

HSPF model input for the watershed was developed by the USGS[3] and utilized by King County as part of the 1991 East Lake Sammamish Basin Plan[4]. The model was updated as part of the current analysis to reflect changes in land use, include additional subbasins, and update routing hydraulics.

Subbasin Delineation Town Center

The proposed Sammamish Town Center is a commercial and residential development that encompasses approximately 208 acres in the headwaters of both the Thompson and Inglewood basins (Figure 1). Decisions on flow control standards and mitigation alternatives will affect the streams and wetlands in both the Thompson and Inglewood Basins. The subbasin delineation for the Town Center was based on local topography and the 2008 Town Center Plan[5], which defined land use throughout the Town Center Complex. Subbasins delineated for the Town Center are shaded in Figure 1.

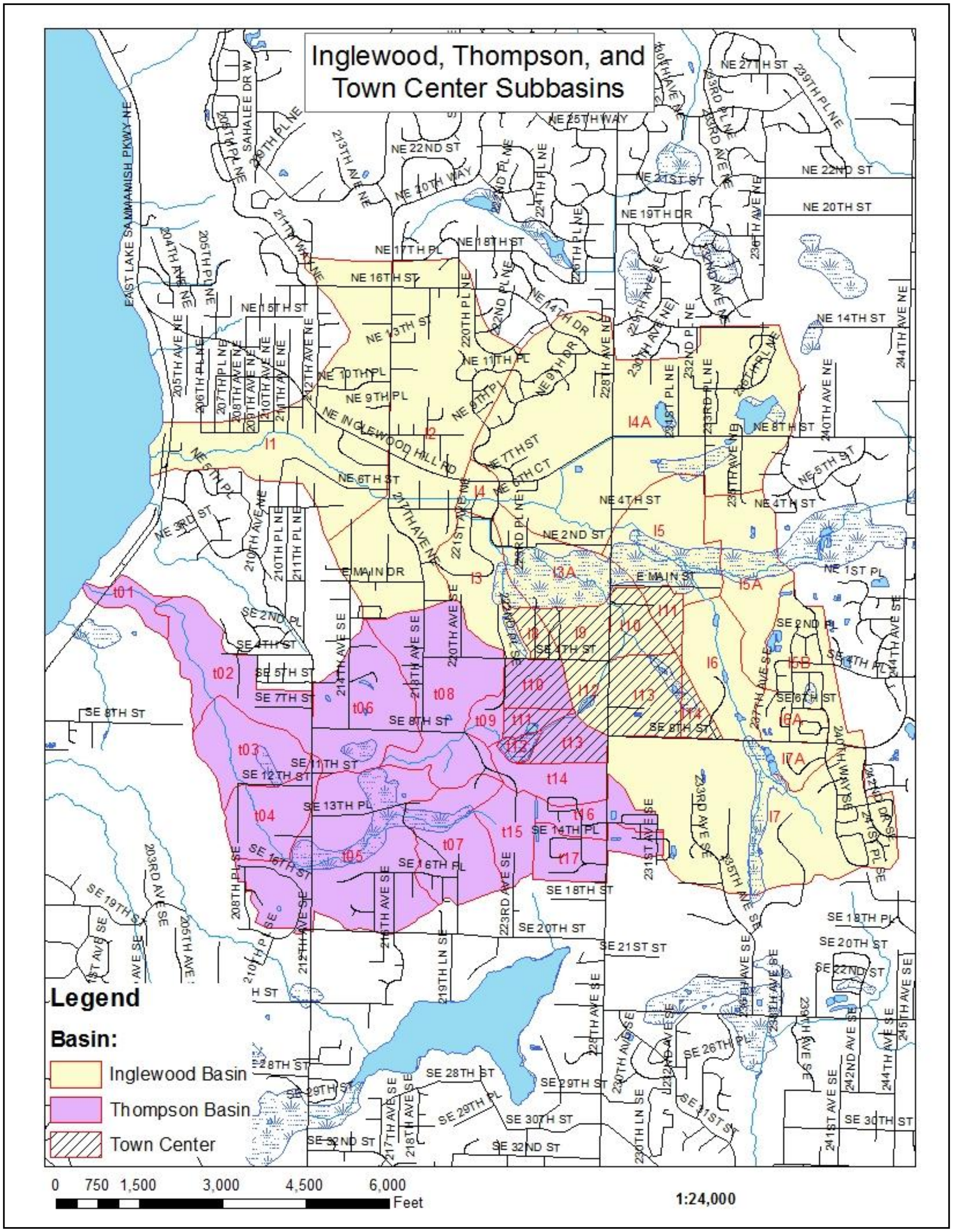


Figure 1 – Inglewood Basin, Thompson Basin and Town Center Subbasins

Land Use Scenarios Analyzed

Three land use scenarios were analyzed; historic conditions, existing land use, and future build-out. Each scenario is summarized in the sections below.

Historic Land Use

Historic land use was analyzed to provide an assessment of conditions in the watershed prior to any development or land use alterations by humans. The scenario was developed by replacing all land covers except for wetlands in the existing land use scenario with forest. All constructed stormwater control facilities are also assumed to be removed. This scenario is useful for estimating what the hydrologic conditions were that led to the formation of the streams.

Existing Land Use

Existing land use was developed based on aerial photos taken in 2006. Land use was defined based on the categories shown in Table 1. The existing land use coverage is shown in Figure 2. Significant existing stormwater detention facilities were included in this scenario. In addition, this scenario was used in hydrologic model calibration to ensure that simulated runoff matched recorded data.

Future Land Use

The future land use scenario was developed based on current zoning and the Town Center Plan[5]. Each land use zone was assigned to one of the hydrologic land uses defined in Table 1 resulting in the Future Land Use Coverage shown in Figure 3. This scenario represents future build-out conditions in the watershed and is the most severe hydrologic condition. Stormwater flow control measures were included for areas that increased in development density relative to existing conditions.

Land Cover Categories

Four land cover categories were considered in analyzing the watershed hydrology: forest, grass, wetland, and impervious. The percentage of each cover allocated to the mapped land uses are shown in Table 1. The effective impervious surface areas were determined based on relationships with mapped impervious surface developed by Sutherland[6] and Dinicola[7].

Table 1 – Land use and Percentage of HSPF Cover Categories

Land Use Code	Land Use	Effective Impervious	Grass	Forest	Wetland
C	Commercial/Industrial	85%	15%	0%	0%
MF	Multi-Family	48%	52%	0%	0%
H	High Density Residential	23%	75%	0%	0%
L	Low Density Residential	10%	90%	0%	0%
RF	Rural Residential Forest	4%	0%	96%	0%
RG	Rural Residential Grass	4%	0%	0%	0%
G	Grass	0%	100%	0%	0%
F	Forest	0%	0%	100%	0%
W	Wetlands/Open Water	0%	0%	0%	100%

The area within each subbasin was classified into areas of common land cover and geologic/soil type, called *PERLNDS*. The HSPF and MGSFlood models compute the hydrologic response of each PERLND within a subbasin on a per-unit-area basis and proportions the amount of surface runoff, interflow and groundwater entering the stream within each subbasin consistent with the PERLND area total for the subbasin.

The area of each category under forested, existing, and future build-out conditions for each basin is summarized in Appendix A.

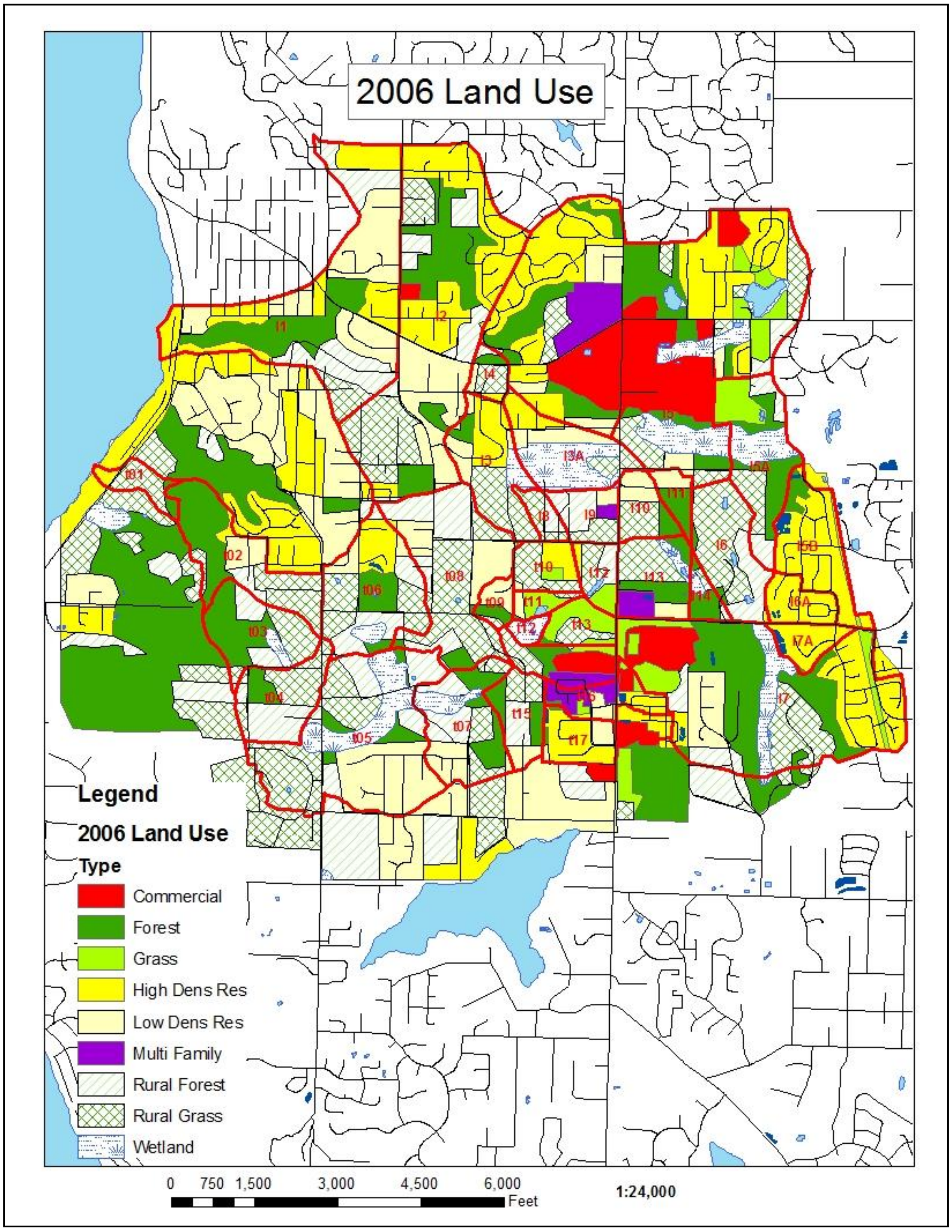


Figure 2 – Inglewood and Thompson Basins, Existing Land Use (2006)

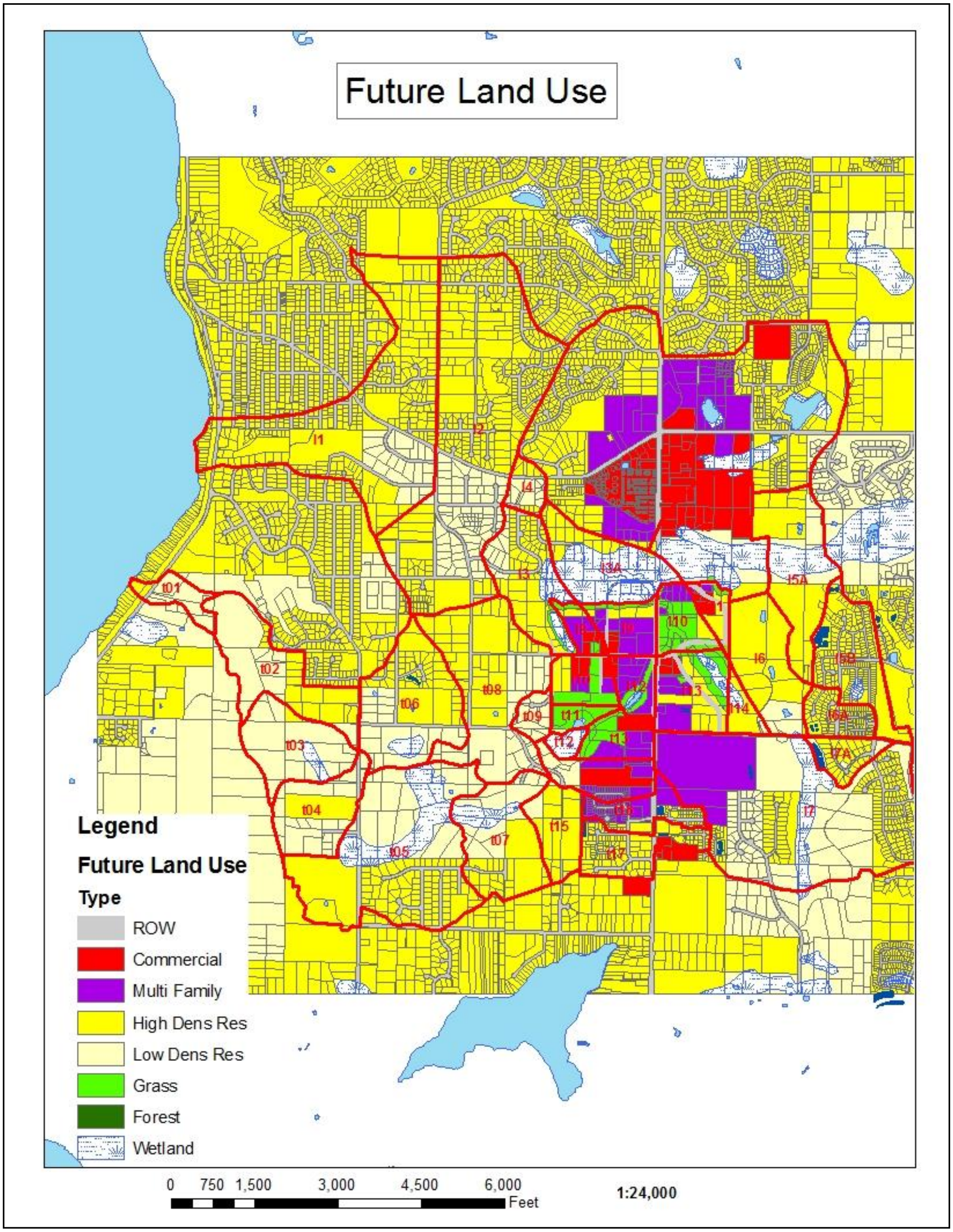


Figure 3 – Inglewood and Thompson Basins, Future Land Use, Developed from City of Sammamish Zoning and Town Center Plan

GEOLOGY

The Inglewood Basin consists of a broad till-capped plateau drained by gently sloping channels. The watershed geology was obtained from King County Department of Natural Resources[8] (Figure 4). The main stream channel flows across recessional outwash deposits incised into the till. Runoff generated on the adjacent till areas must migrate through the outwash before reaching the stream channel. In locations where the perched water table remains near the surface, several wetlands have formed. In the central portion of the watershed (Subbasins I2, I3, and I4), the groundwater is relatively deep, and the stream channel remains dry the majority of the time. Downstream of this point, the stream flows through an incised ravine and drops approximately 300 feet in less than a mile to Lake Sammamish. The lower stream reaches in Subbasin I1 receive discharge from the regional groundwater, which provides a reliable source of base flow to the stream throughout the year.

The Thompson basin is similar to Inglewood in that it originates in uplands of the Sammamish Plateau and drains through a ravine to Lake Sammamish. The lower reaches of the stream also intersect the regional groundwater table, which supports a nearly constant base flow. The Thompson Basin differs geologically from Inglewood in that it does not have a deep outwash deposit that infiltrates runoff upstream of the ravine. The runoff response in Ebright Creek is dominated by a surface and interflow response, similar to many other watersheds in the Puget Lowland that are underlain by glacial till .

For hydrologic modeling purposes, each geologic association in the watershed was assigned to one of three categories; till, outwash, or wetland according to the HSPF modeling methodology developed by the USGS[3,7]. These were combined with surface cover categories consisting of urban grass, forest, wetland/saturated soils, and impervious to form the PERLND groups shown in Table 2.

Table 2 – HSPF Land Cover/Geology (PERLND) Combinations

HSPF PERLND	Land Characteristics
Till Forest	Glacial till soils mature cover, all slopes
Till Urban Grass	Glacial till soils urban grass, all slopes Includes impervious surfaces not directly connected to the drainage network.
Outwash Forest	Glacial outwash soils mature cover, all slopes
Outwash Urban Grass	Glacial outwash soils urban grass, all slopes. Includes impervious surfaces not directly connected to the drainage network.
Wetland/Saturated Soils	Wetlands or areas with saturated soils
Impervious (HSPF IMPLND)	Impervious surfaces that are directly connected to the drainage network.

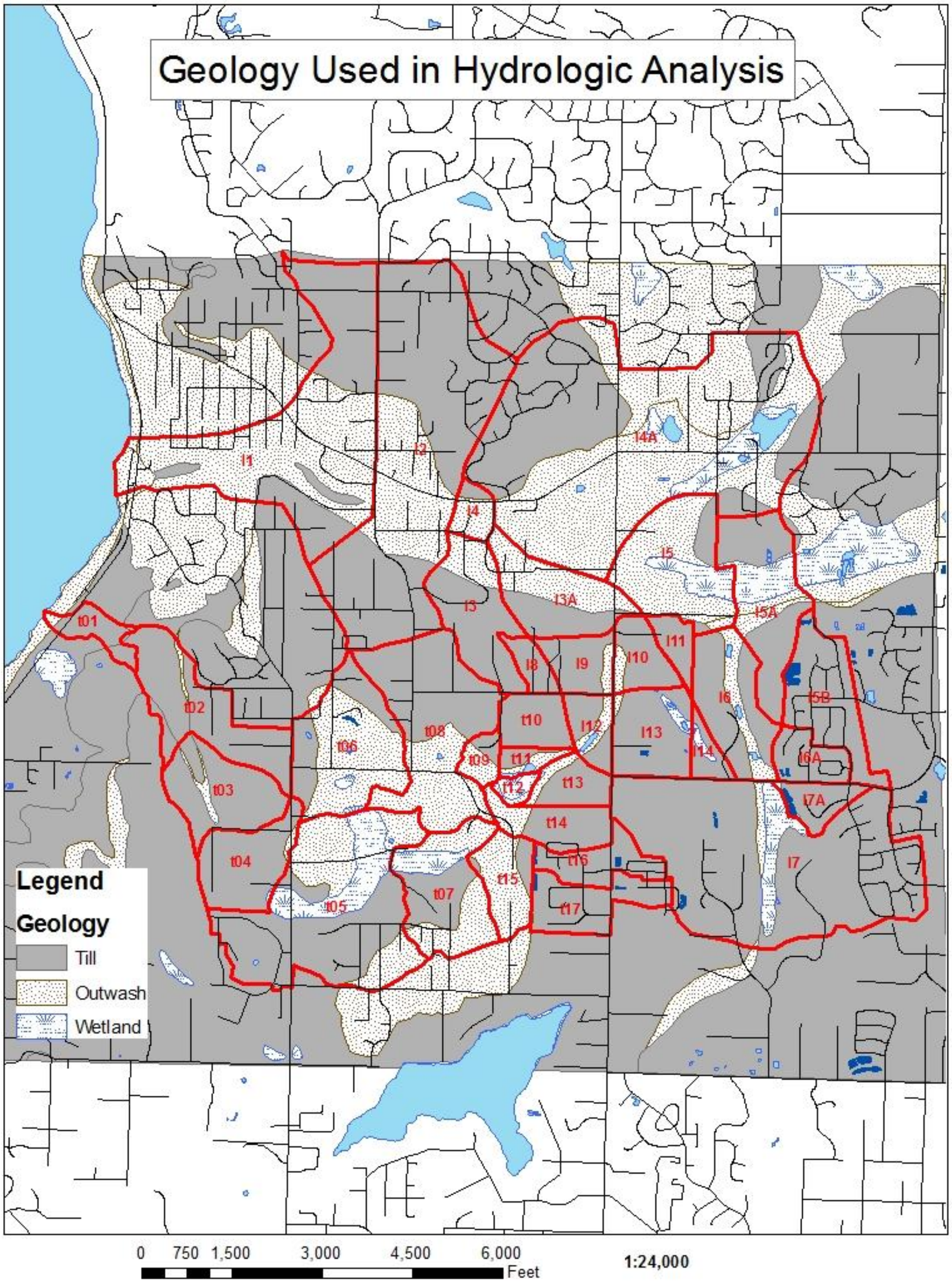


Figure 4 – Inglewood and Thompson Basins Geology as Defined for HSPF and MGSFlood Models

HSPF MODEL CONFIGURATION

INGLEWOOD BASIN

The geology of the Inglewood Basin consists of till in the uplands with glacial outwash in the ravine that carries the stream channel. Surface runoff and interflow produced in the upland till areas is infiltrated as it flows across the outwash deposit and results in a markedly attenuated runoff response from the watershed.

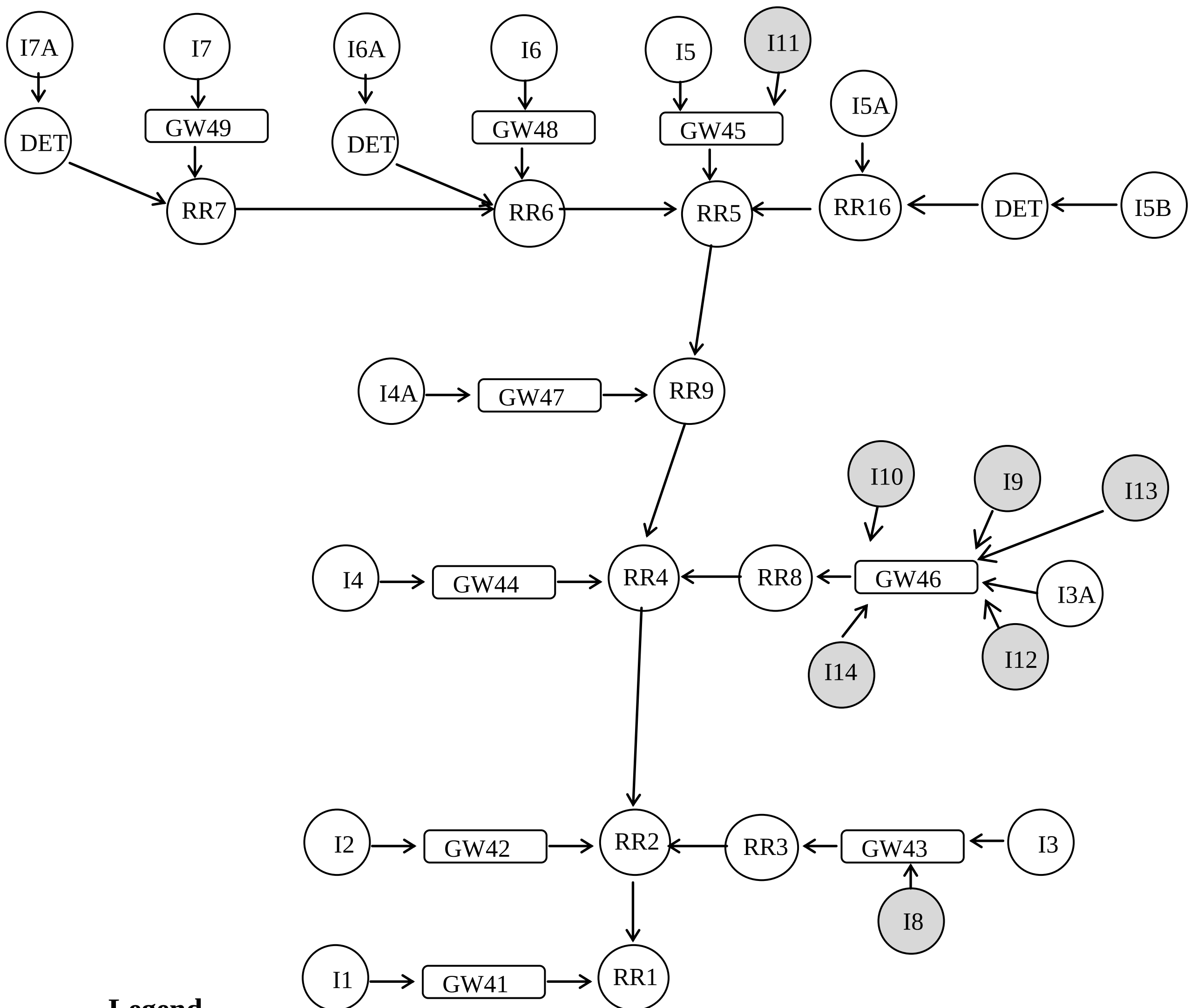
To mimic the infiltration of runoff from the uplands into the outwash deposit as they flow through George Davis Creek, a separate outwash Pervious Land Segment (PERLND) was defined for each subbasin that represents moisture inputs from both precipitation falling on the surface of the outwash and from lateral inflow from the till uplands. The area of these groundwater PERLNDS is equal to the area of outwash within the subbasin. The surface runoff and interflow from the adjacent upland till areas were then connected to each groundwater PERLND which were then connected to the stream channel.

Several large residential developments were constructed in the upper watershed in the time since the King County East Lake Sammamish Basin Plan was completed. The stormwater detention facilities associated with these developments were included in the HSPF model developed for the present analysis. Subbasin I5B, I6A, and I7A were added and define the tributary area to each stormwater pond associated with the new residential development. The ponds were designed according to the King County[9] Level 2 standard and HSPF routing tables (FTABLES) were developed for each subbasin such that they represented the detention pond discharge characteristics in the subbasin. A schematic of the Inglewood Basin HSPF model configuration is shown in Figure 5.

The USGS calibrated the HSPF model to the Inglewood Basin as part of a study to develop and validate regionalized parameters for the HSPF model for use in western Washington[3,7]. The USGS simulated the flow attenuation caused by the outwash using the HSPF channel routing (RCHRES) routine. They added flood storage volume to the stream reaches in each subbasin until the simulated and gaged streamflows matched. This approach produced a reasonable calibration but was not used in the present analysis because it was thought to be less physically representative of the watershed than the approach used (described above). The flood storage volume in the USGS model totaled approximately 7,000 acre-feet, which indicates that 7,000 acre-feet of stormwater detention storage would be required to replicate the flood storage and attenuation provided naturally by the outwash deposit.

Because of the high level of flood attenuation provided by the outwash deposit, the flow attenuation resulting from on-site detention in the future land use scenario would be indistinguishable after routing through the outwash deposit. In addition, connecting upstream stormwater ponds to the downstream groundwater PERLNDS can produce erroneous results in HSPF. Therefore, on-site detention mitigation was only included for the Town Center subbasins in the HSPF model. This does not mean that on-site detention should not be required in future developments in the Inglewood Basin; on the contrary, on-site detention should be required for future developments to ensure that discharge rates reaching the outwash do not increase to the point where they overwhelm the infiltration rate of the outwash deposit. This would result in a dramatic increase in the discharge rate in George Davis Creek as surface runoff in excess of the outwash infiltration rate discharged downstream.

The MGSFlood model was developed with routing reaches to account for the infiltration into the groundwater. The hydraulic characteristics of the routing reaches were defined to produce a response similar to the groundwater PERLNDS developed for the HSPF model. This approach allowed for detention to be included in all subbasins in the MGSFlood Inglewood model. For this reason, peak flow and duration results in the future land use scenario are slightly lower in the MGSFlood model than the HSPF model.



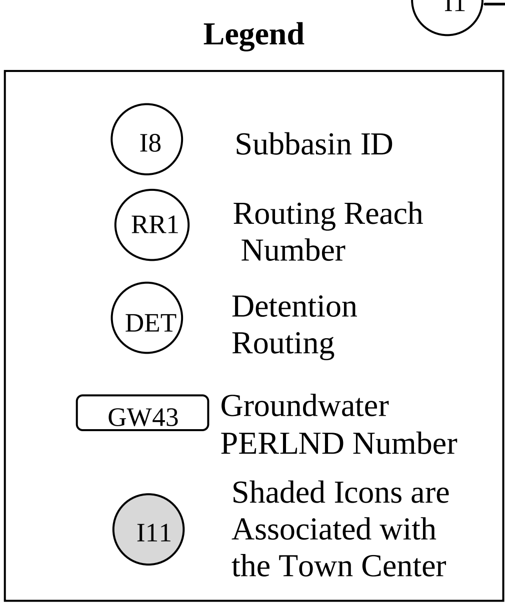
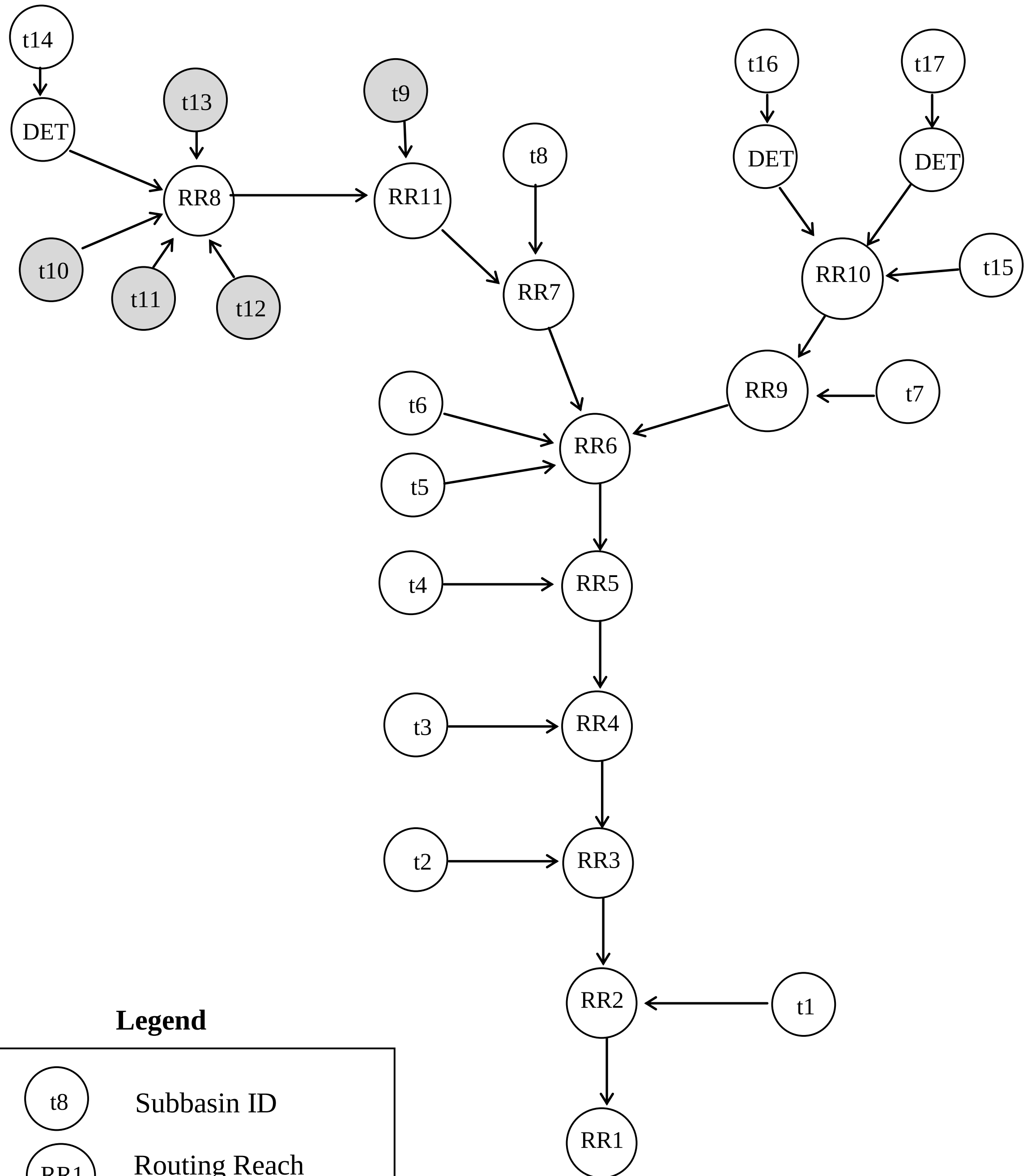


Figure 5 – Inglewood Basin HSPF Model Schematic

THOMPSON BASIN

The Thompson Basin is similar to Inglewood in that it originates in uplands of the Sammamish Plateau and drains through a ravine to Lake Sammamish. The Thompson Basin differs geologically from Inglewood in that it does not have a deep outwash deposit that infiltrates runoff upstream of the ravine. The runoff response in Ebright Creek is similar to many other watersheds in the Puget Lowland that are underlain by glacial till. Thus, routing through the outwash deposit was not included for this basin. While Ebright Creek does not possess the natural infiltration and storage of the outwash, it does have a large wetland (Wetland 17) situated at the top of the ravine. This 30-acre wetland provides substantial flood attenuation and buffering of flows entering from the uplands before discharging to the ravine.

Several existing developments in the upper washed were broken out as separate subbasins (Subbasins t16 and t17) and detention was included using the King County[9] Level 2 standard. A schematic of the Thompson Basin HSPF model configuration is shown in Figure 6.



Legend

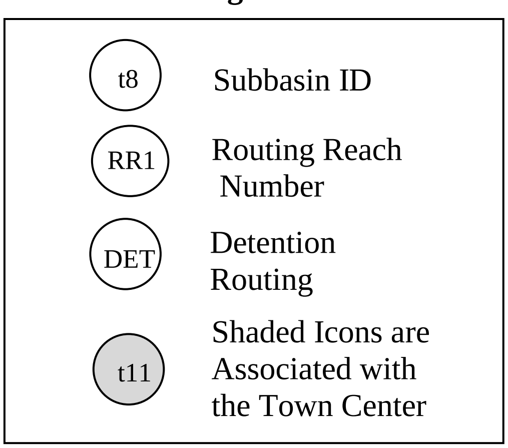


Figure 6 – Thompson Basin HSPF Model Schematic

STORMWATER DETENTION SIMULATION

Future land use was simulated with detention according to the City's proposed on-site detention standard. This standard is based on the current King County design manual[10], which requires that the post development runoff duration is controlled to the predeveloped forest duration from ½ of the predeveloped 2-year to the 50-year. Two detention ponds were included for each subbasin; one for areas on glacial till and one for areas on outwash. The outwash areas were sized as infiltration basins and only the overflow was connected to the receiving stream.

To account for uncertainty due to design, construction, and maintenance, detention mitigation simulated with the future land use scenario was assumed to be 90-percent effective. This was accomplished by sizing detention for only 90-percent of the developed area and routing 90-percent of the area to the pond. The remaining 10-percent of the developed area bypassed the pond. The exception was in the Town Center area where the bypass was not applied because this is a master planned development, and the design, construction, and maintenance will likely be more reliable than a typical development.

HSPF MODEL CALIBRATION

INTRODUCTION

Calibration of the HSPF model was performed to ensure that the hydrologic processes simulated by the model were representative of the conditions in the watershed. Calibration is the process whereby the model input parameters are adjusted until simulated and recorded discharge data match to the greatest extent possible.

CALIBRATION DATA

The model parameters were refined through calibration using streamflow data collected near the mouth of George Davis Creek and concurrent precipitation collected near the headwaters (City of Sammamish Gage 18Y) for the period October 2001-May 2003. Daily evaporation data were developed from data collected at the Puyallup 2 West Experimental Station (station number 45-6803). Flow data at the mouth of Ebright Creek were not of sufficient quality to use in model calibration.

Streamflow data for Ebright Creek was collected at a gage operated by commercial firm, Geotivity under contract to the City of Sammamish. Geotivity went bankrupt several years ago, and maintenance of the gage and quality checking of the data ceased at that time. The flow gage consisted of a sensor that tracked, among other things, the flow depth and velocity. Flow rate was computed using a functional relationship that included the recorded depth and velocity. This metering approach is commonly used in storm and sanitary sewers where the velocity varies across the flow area in a predictable manner. In stream channels, the cross section is irregular in shape and the velocity varies in a much less predictable manner.

The relationship used by Geotivity to derive streamflow from the depth and velocity measurements was not known. The data were analyzed and several relationships were tried to convert the depth and velocity measurements to discharge. The resulting flow data did not appear reasonable when compared with precipitation data recorded in the watershed.

An apparent shift in the depth recordings was also noted following a large storm that occurred in December 2007. Following the storm, the base flow depth recorded by the meter was higher, and resulted in a 1-2 cfs increase in the flow data than prior to the storm.

Because of the issues cited above, the recorded streamflow at the mouth of Ebright Creek were not used to calibrate the models. Parameters derived from the Inglewood Basin calibration were used for the Thompson Basin. Plots comparing simulated and recorded streamflow at the Ebright Creek gage are presented in the next section. The flow rate at the Ebright gage was derived by multiplying the recorded velocity times the cross sectional area corresponding to the recorded depth.

HSPF Model Calibration Results

Existing land use (year 2006) was used for model calibration. Model parameters for the pervious land segments (PERLNDS) were adopted from the 2004 Inglewood Basin Plan update[11]. Hourly streamflow data recorded by the City of Sammamish from October 2001-May 2003 near the outlet of George Davis Creek was used to verify that the current model with updated land use and subbasins produced results similar to the original calibration.

A comparison of simulated and recorded discharge at the outlet of George Davis Creek during water years 2002 and 2003 is shown in Figure 7. In general, the simulated and recorded magnitude and timing of discharge compared well. The general shape of simulated winter storm flows and the magnitude of summer base flows matched well with the recorded streamflow for this period. Several large runoff spikes in the streamflow record (December 2001, October 2002, and March 2003) were attributed to gage malfunction or poor quality data and were discounted in the model calibration. The streamflow record was not of sufficient quality to compute runoff volume or other statistics. The calibration was therefore judged qualitatively by the goodness of fit between simulated and recorded streamflow shown in Figure 7.

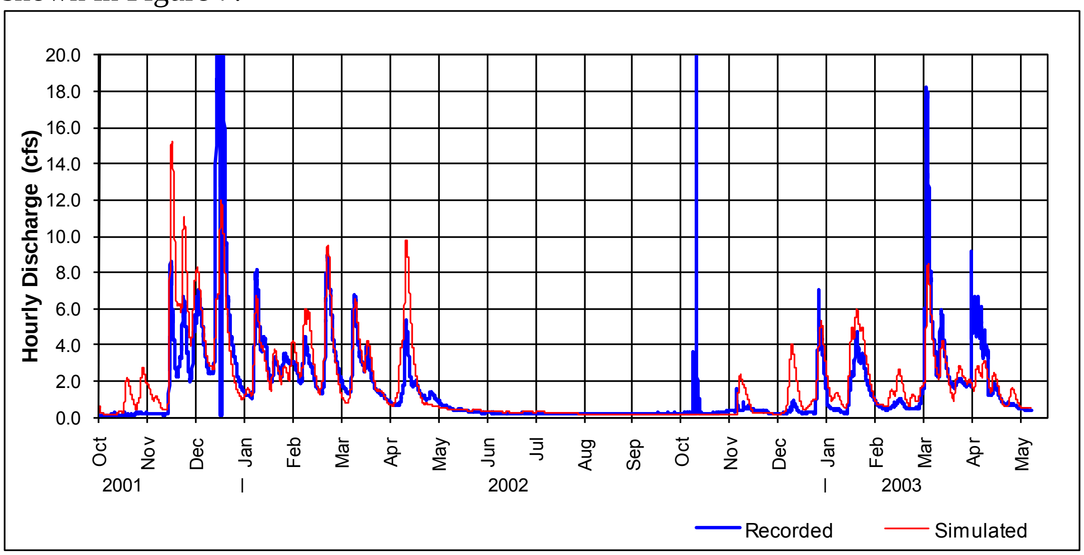


Figure 7 – HSPF Model Calibration, George Davis Creek

As discussed in the previous section, flow data at the mouth of Ebright Creek were deemed of insufficient quality to warrant use in the model calibration. Despite the uncertainty with the recorded streamflow data, there is a fairly close correspondence between the simulated and recorded flows (Figure 8), especially the storm that occurred in December 2007 (Figure 9).

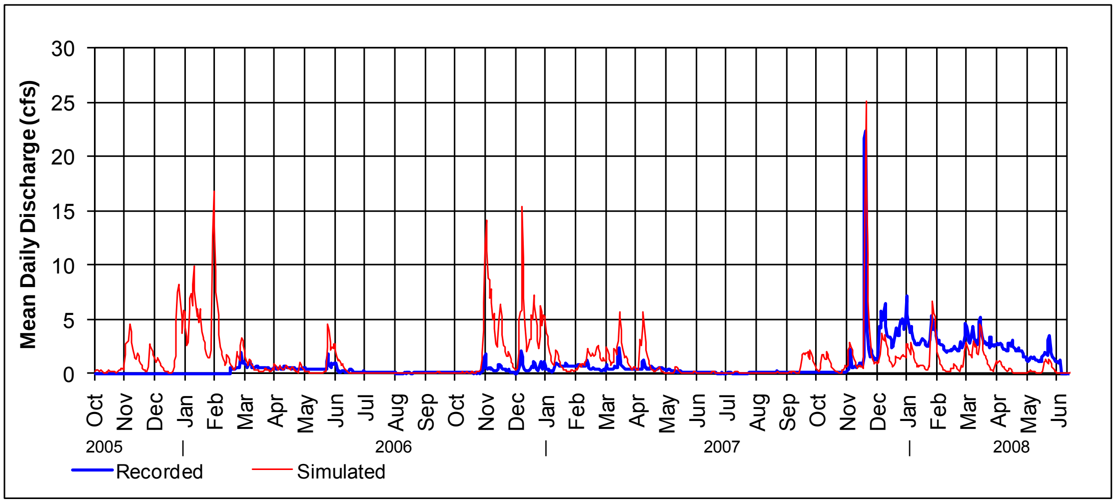


Figure 8 – Comparison of Simulated and Recorded Flow at Mouth of Ebright Creek
(Note: Gage not used for Calibration due to data Quality Concerns)

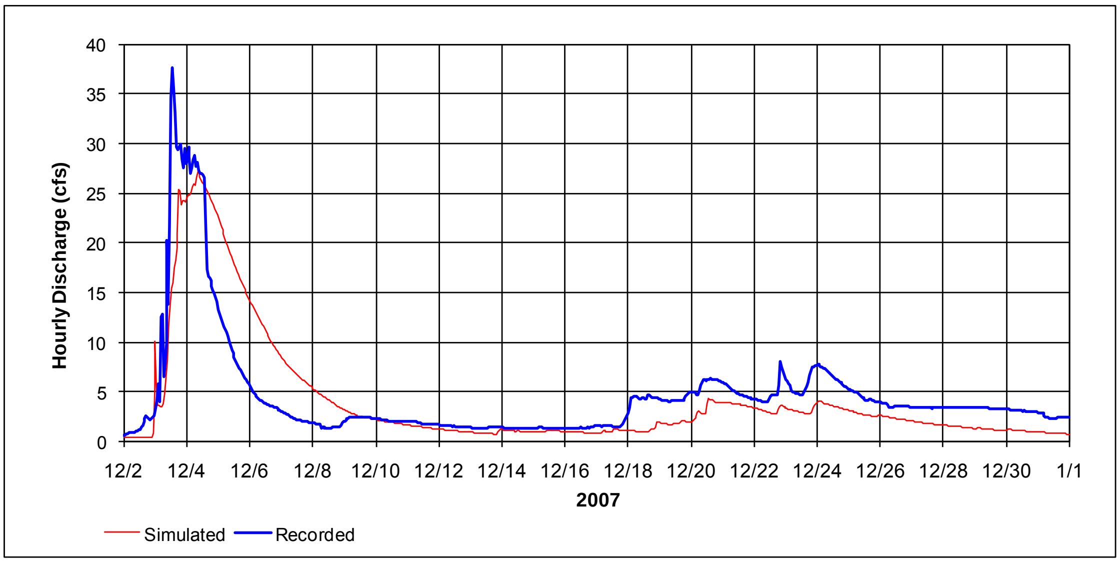


Figure 9 – Comparison of Simulated and Recorded Flow at Mouth of Ebright Creek
December 2007 Storm
(Note: Gage not used for Calibration due to data Quality Concerns)

TOWN CENTER ANALYSIS USING THE MGSFLOOD MODEL

MGSFlood[2] is a continuous rainfall runoff model used for stormwater facility analysis and design. The model uses the same rainfall-runoff algorithms as HSPF but includes routines for sizing stormwater detention facilities and simulating LID measures. MGSFlood model input was developed for both the Inglewood and Thompson Basins using the same land use, soil type, hydraulic routing, and runoff parameters used in the HSPF model. This approach allowed for numerous stormwater mitigation measures to be analyzed, especially in the Town Center basins. Simulation results for the Town Center alternatives are presented in the Town Center Comprehensive Stormwater Plan.

An additional benefit of the MGSFlood model is that it is much easier to use compared with HSPF. The MGSFlood model can be used in the future by City staff or their consultants to analyze changes to the Town Center plan or other developments in the watersheds and analyze the effects of the changes in a basin-wide context.

HSPF WATERSHED MODEL – ANALYSIS/PREDICTION APPROACH

SIMULATION PERIOD

Following the calibration phase, the model may be used for analysis and prediction of streamflows for various land use conditions. For this application, long-term, high-quality, precipitation timeseries are needed that are representative of the hourly, daily, weekly and monthly precipitation characteristics that have occurred in the past, and can be expected to occur in the future.

The Washington State Department of Transportation, Extended Precipitation Timeseries for Continuous Hydrologic Modeling[12,13] was used as input for the analysis of the Inglewood and Thompson Basins. This timeseries has a 1-hour timestep, is 158-years in length, and represents the rainfall characteristics of the basins (48 inches mean annual precipitation).

PEAK FLOW MAGNITUDE-FREQUENCY STATISTICS

Peak discharge magnitude-frequency estimates were computed at locations of interest in the watersheds using the HSPF model. The annual maxima discharge rates were saved at each location from the 158-years simulated. Peak flow and elevation magnitude-frequency relationships were computed using the Gringorten[14,15] plotting position formula (Equation 1).

$$Tr = \frac{N + 0.12}{i - 0.44} \qquad (1)$$

Where: Tr is the recurrence interval of the peak flow,
i is the rank of the annual maxima peak flow ordered from highest to lowest,
N is the total number of years simulated (158 in this case).

FLOW DURATION STATISTICS

Modifications to the land surface during urbanization increase both the runoff peak rate and volume. The increase in runoff volume is the result of the loss of water storage in the soil column because of the compaction of the soil and the introduction of impervious surfaces. Figure 10 compares the allocation of precipitation falling on a forested and an urban watershed. In the forested watershed, the precipitation ends up nearly all evaporation and infiltration with very little surface runoff. With an urban watershed, the evaporation and infiltration are reduced significantly, and a much higher percentage of the rainfall ending up as surface overland flow.

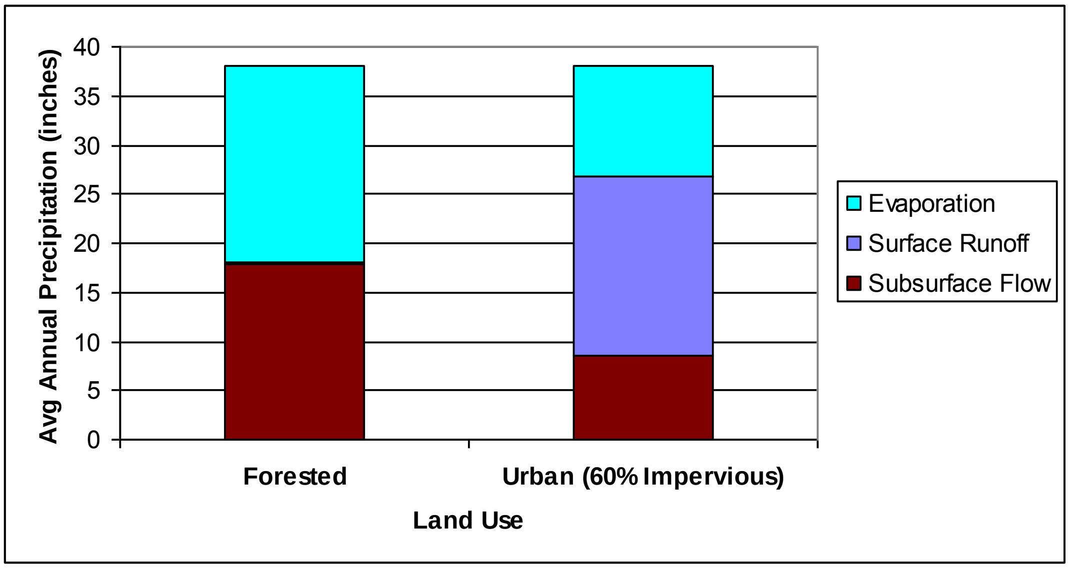


Figure 10 – Mean Annual Precipitation Water Budget for a Forested and Urban Site

The increase in runoff volume combined with the increase in runoff rate results in higher stream discharges occurring for a <u>longer duration</u>. The increase in duration of a given flow rate results in more erosive work on the stream channel over time, particularly when the discharge rate exceeds the threshold for streambed movement in the receiving channel.

Flow duration statistics provide a convenient tool for characterizing streamflow computed with a continuous hydrologic model. Duration statistics are computed by tracking the fraction of time that a specified flow rate is equaled or exceeded. HSPF does this by dividing the range of flows simulated into discrete increments and then tracks the fraction of time that each flow is equaled or exceeded. The fraction of time that a particular flow is equaled or exceeded is called *exceedance probability*. It should be noted that exceedance probability for duration statistics is different from the *annual exceedance probability* associated with flood frequency statistics and there is no practical way of converting/relating annual exceedance probability statistics to flow duration statistics.

FLOOD FREQUENCY AND FLOW DURATION RESULTS

INTRODUCTION

Precipitation timeseries 158-years in length at a 1-hour timestep and daily evaporation derived from the Puyallup 2 West Experimental Station (station number 45-6803) were used as input to the model, which resulted in a 158-year, 1-hour timeseries of flow at the outlet of each subbasin simulated. Flood magnitude-frequency and duration analyses were subsequently performed on the flow timeseries at locations of interest in the watershed.

The future land use scenarios were simulated with stormwater mitigation designed according to the City's proposed stormwater detention ordinance[10]. The simulation results presented in this section provide an assessment of the performance of stormwater mitigation in a basin-wide context. Details on mitigation options for the Town Center that includes Low Impact Development as well as traditional stormwater detention, is presented in the Town Center Comprehensive Stormwater Plan.

FLOOD PEAK DISCHARGE RESULTS

Increases in peak discharge rates under future conditions in the Inglewood Basin are negligible in most areas and actually decrease other areas relative to the existing land use scenario (Figures 11a, 11b, and Tables 3a, 3b, and 3c). The reason for the small change in discharge rate is the presence of the glacial outwash deposit, which infiltrates the majority of surface runoff produced in the till capped uplands. As discussed in the model calibration section, the outwash deposit is equivalent to approximately 7,000 acre-feet of stormwater detention storage in the Inglewood Basin.

While natural infiltration of the outwash in the central portion of the watershed provides substantial natural buffering of the runoff under the future land use, on-site detention and LID controls are still necessary to ensure that runoff rates associated with future development do not overwhelm the infiltration capacity in the channels underlain by outwash.

Peak runoff rates in the Thompson Basin show a greater reduction in the future flows relative to existing conditions (Figures 12a, 12b and Tables 4a and 4b). This is because there are many developments in the basin with little or no stormwater controls and the Thompson Basin does not contain the infiltrative outwash present in the Inglewood Basin to mitigate runoff from existing development.

Peak runoff rates in the Town Center subbasins show a dramatic reduction in peak flows under future conditions relative to existing conditions in the majority of subbasins (Figures 13a, 13b, and Tables 5a, and 5b). In most areas, the peak discharge under future land use conditions is reduced to rates comparable to the forested land use condition.

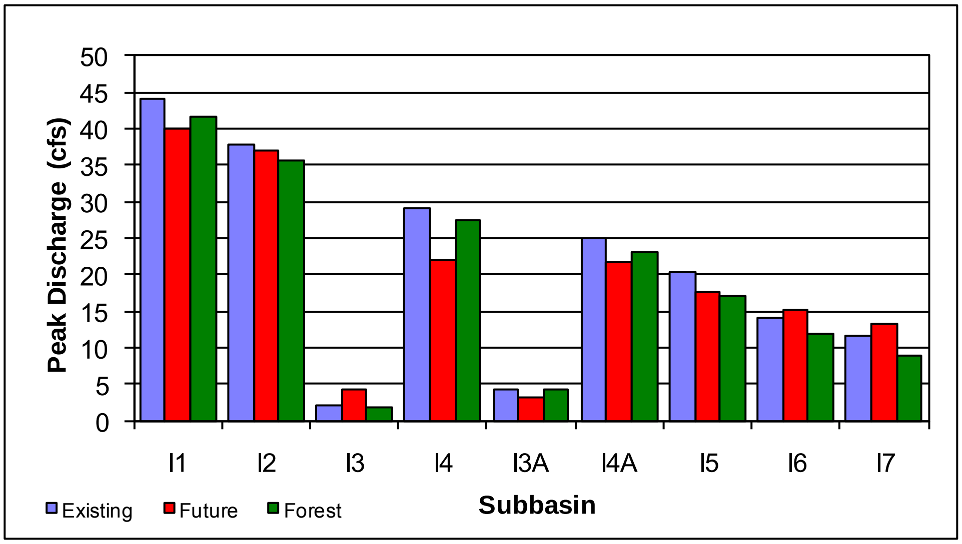


Figure 11a – George Davis Creek, Comparison of 100-Year Flood Peak Discharge Existing, Future, and Forested Land Use

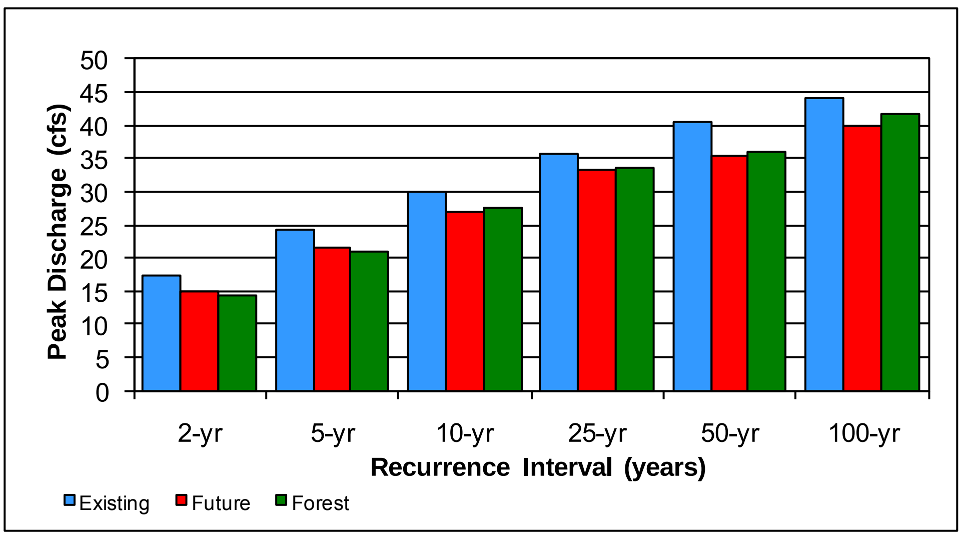


Figure 11b – Comparison of Flood Peak Discharge at Mouth of George Davis Creek (Inglewood Basin) Existing, Future, and Forested Land Use

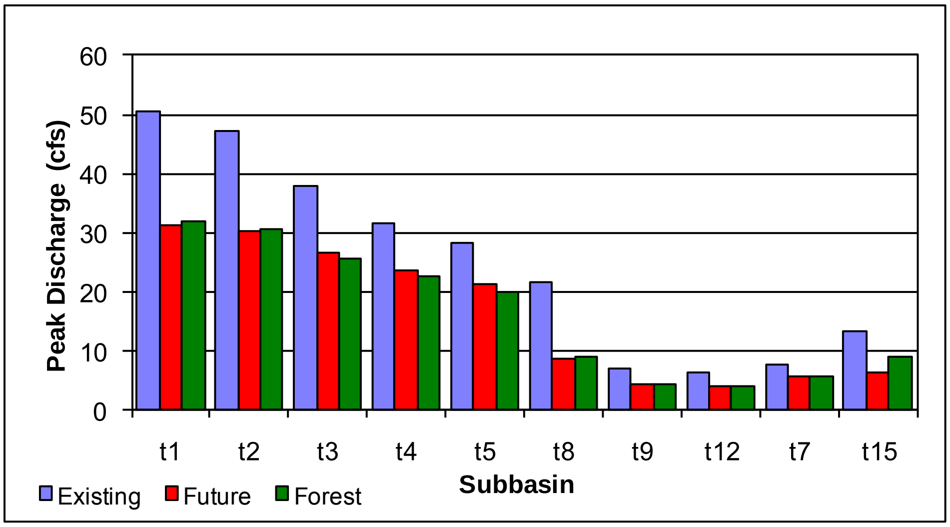


Figure 12a – Ebright Creek, Comparison of 100-Year Flood Peak Discharge Existing, Future, and Forested Land Use

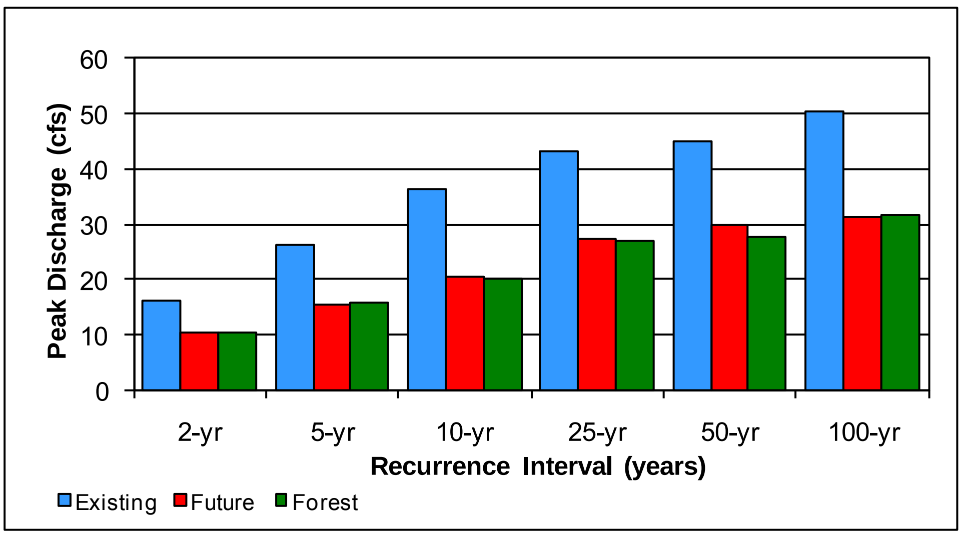


Figure 12b – Comparison of Flood Peak Discharge at Mouth of Ebright Creek (Thompson Basin) Existing, Future, and Forested Land Use

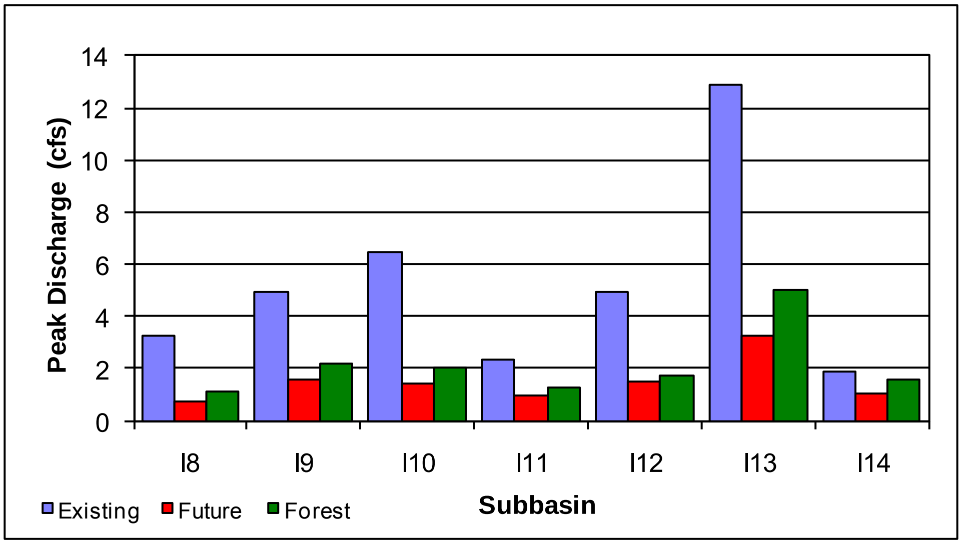


Figure 13a – Town Center Subbasins in the Inglewood Basin, Comparison of 100-Year Flood Peak Discharge
Existing, Future, and Forested Land Use

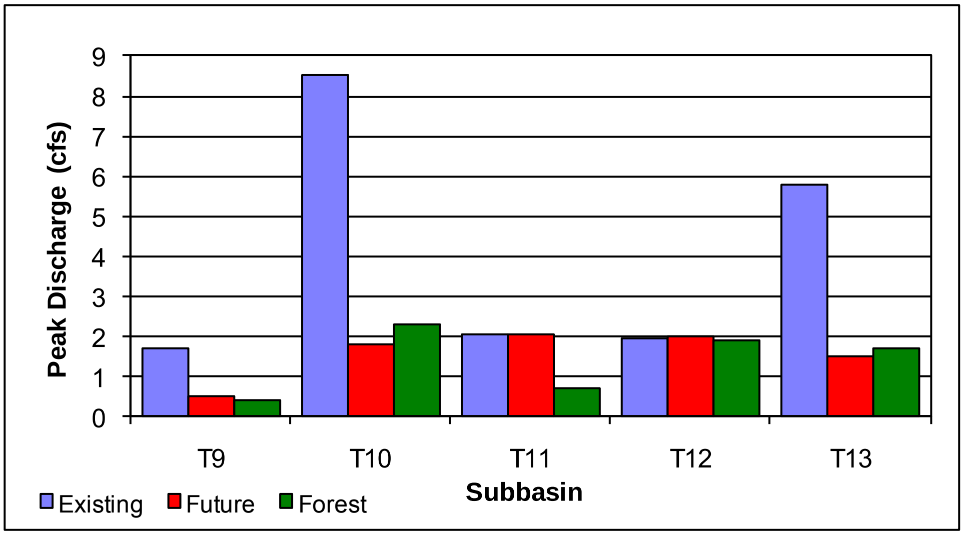


Figure 13b – Town Center Subbasins in the Thompson Basin, Comparison of 100-Year Flood Peak Discharge
Existing, Future, and Forested Land Use

Table 3a – Inglewood Basin Flood Magnitude-Frequency Estimates (cfs) Existing Land Use (2006) (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN I1	17	24	30	36	40	44
SUBBASIN I2	15	20	26	31	35	38
SUBBASIN I3	0.9	1.1	1.4	1.7	1.8	1.9
SUBBASIN I4	12	16	20	24	27	29
SUBBASIN I3A	1.9	2.5	3.1	3.7	4.0	4.2
SUBBASIN I4A	10	14	17	21	23	25
SUBBASIN I5	8.3	11	14	17	18	20
SUBBASIN I6	6.1	7.8	10	12	13	14
SUBBASIN I7	4.9	6.4	8.3	10	11	12

Table 3b – Inglewood Basin Flood Magnitude-Frequency Estimates (cfs) Future Land Use with Mitigation (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN I1	15	21	27	33	35	40
SUBBASIN I2	12	18	22	28	29	37
SUBBASIN I3	0.5	0.7	1.1	2.4	2.6	4.3
SUBBASIN I4	10	13	16	19	20	22
SUBBASIN I3A	0.2	0.3	0.4	2.1	2.6	3.2
SUBBASIN I4A	10	13	16	18	20	22
SUBBASIN I5	7.7	10	12	15	16	18
SUBBASIN I6	6.6	8.7	11	14	14	15
SUBBASIN I7	5.8	7.7	10	12	12	13

Table 3c – Inglewood Basin Flood Magnitude-Frequency Estimates (cfs) Forested Land Use (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN I1	14	21	28	34	36	42
SUBBASIN I2	12	17	23	29	31	36
SUBBASIN I3	0.7	0.9	1.3	1.6	1.7	1.9
SUBBASIN I4	11	14	19	23	24	27
SUBBASIN I3A	1.6	2.1	2.8	3.5	3.8	4.1
SUBBASIN I4A	8.9	12	16	19	21	23
SUBBASIN I5	6.6	8.8	12	14	15	17
SUBBASIN I6	4.4	5.8	7.9	10	11	12
SUBBASIN I7	3.3	4.3	5.9	7.4	8.0	8.9

Table 4a – Thompson Basin Flood Magnitude-Frequency Estimates (cfs) Existing Land Use (2006) (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN t1	16	26	36	43	45	51
SUBBASIN t2	15	25	34	39	42	47
SUBBASIN t3	13	19	24	30	35	38
SUBBASIN t4	11	15	21	27	30	31
SUBBASIN t5 WL17	10	13	19	24	26	28
SUBBASIN t8	6.4	10	15	20	21	22
SUBBASIN t9	2.2	3.1	4.2	6.0	6.4	6.8
SUBBASIN t12 WL61	2.1	2.9	3.9	5.6	6.0	6.3
SUBBASIN t7	3.0	4.2	5.4	7.1	7.4	7.7
SUBBASIN t15	3.5	5.4	7.1	10	11	13

Table 4b – Thompson Basin Flood Magnitude-Frequency Estimates (cfs) Future Land Use with Mitigation (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN t1	10	15	21	27	30	31
SUBBASIN t2	10	15	20	27	29	30
SUBBASIN t3	8.6	13	17	23	25	26
SUBBASIN t4	7.7	11	15	20	22	24
SUBBASIN t5 WL17	6.8	10	13	18	20	21
SUBBASIN t8	2.7	4.2	5.4	7.3	8.3	8.5
SUBBASIN t9	1.2	1.9	2.6	3.5	3.8	4.2
SUBBASIN t12 WL61	1.1	1.8	2.4	3.3	3.6	4.0
SUBBASIN t7	1.8	2.7	3.8	4.9	5.4	5.6
SUBBASIN t15	2.3	3.2	4.4	5.6	5.9	6.3

Table 4c – Thompson Basin Flood Magnitude-Frequency Estimates (cfs) Forested Land Use (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN t1	10	16	20	27	28	32
SUBBASIN t2	10	15	19	26	26	31
SUBBASIN t3	7.9	12	16	21	22	26
SUBBASIN t4	6.9	10	14	18	20	22
SUBBASIN t5 WL17	6.1	8.7	12	16	17	20
SUBBASIN t8	2.8	4.5	5.8	7.9	8.1	9.0
SUBBASIN t9	1.2	1.6	2.5	3.3	3.6	4.2
SUBBASIN t12 WL61	1.1	1.6	2.3	3.1	3.4	3.9
SUBBASIN t7	2.0	2.7	3.7	4.7	5.0	5.6
SUBBASIN t15	2.1	3.7	4.6	6.2	7.3	8.8

Table 5a – Town Center Flood Magnitude-Frequency Estimates (cfs) Existing Land Use (2006) (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN I8	0.72	1.19	1.63	2.52	2.61	3.22
SUBBASIN I9	1.37	2.12	2.88	3.84	4.03	4.91
SUBBASIN I10	1.52	2.40	3.25	5.10	5.47	6.43
SUBBASIN I11	0.61	1.02	1.47	1.87	2.03	2.32
SUBBASIN I12	1.20	1.89	2.52	3.86	4.08	4.96
SUBBASIN I13	3.41	5.16	6.84	9.78	10.37	12.93
SUBBASIN I14	0.52	0.84	1.02	1.35	1.51	1.87
SUBBASIN t9	0.46	0.69	0.91	1.35	1.56	1.70
SUBBASIN t10	2.14	3.24	4.27	6.78	7.53	8.51
SUBBASIN t11	0.47	0.76	1.05	1.60	1.70	2.04
SUBBASIN t12	0.64	0.92	1.11	1.37	1.52	1.93
SUBBASIN t13	1.28	2.08	2.85	4.60	5.02	5.77

Table 5b – Town Center Flood Magnitude-Frequency Estimates (cfs) Future Land Use with Mitigation (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN I8	0.20	0.35	0.50	0.66	0.73	0.74
SUBBASIN I9	0.47	0.75	1.09	1.41	1.54	1.56
SUBBASIN I10	0.38	0.61	0.87	1.22	1.36	1.43
SUBBASIN I11	0.28	0.44	0.64	0.82	0.91	0.98
SUBBASIN I12	0.73	0.89	1.04	1.31	1.37	1.51
SUBBASIN I13	0.87	1.42	1.88	2.61	2.89	3.25
SUBBASIN I14	0.32	0.46	0.60	0.78	0.87	1.00
SUBBASIN t9	0.27	0.33	0.39	0.46	0.49	0.50
SUBBASIN t10	0.61	0.88	1.20	1.61	1.66	1.78
SUBBASIN t11	0.46	0.76	1.05	1.61	1.71	2.05
SUBBASIN t12	0.66	0.94	1.14	1.39	1.55	1.98
SUBBASIN t13	0.64	0.81	1.09	1.37	1.44	1.47

Table 5c – Town Center Flood Magnitude-Frequency Estimates (cfs) Forested Land Use (Discharge is Referenced to Subbasin Outlet)						
	Flood Magnitude-Frequency Estimates (cfs)					
Subbasin	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
SUBBASIN I8	0.34	0.54	0.67	0.91	0.99	1.14
SUBBASIN I9	0.62	1.01	1.25	1.71	1.85	2.15
SUBBASIN I10	0.61	0.96	1.19	1.63	1.76	2.04
SUBBASIN I11	0.37	0.59	0.73	1.00	1.08	1.25
SUBBASIN I12	0.49	0.82	0.97	1.32	1.45	1.70
SUBBASIN I13	1.45	2.42	2.84	3.91	4.31	5.03
SUBBASIN I14	0.45	0.73	0.85	1.19	1.29	1.55
SUBBASIN t9	0.12	0.19	0.23	0.32	0.34	0.40
SUBBASIN t10	0.69	1.08	1.34	1.84	1.99	2.31
SUBBASIN t11	0.19	0.32	0.38	0.52	0.57	0.67
SUBBASIN t12	0.63	0.90	1.09	1.34	1.49	1.87
SUBBASIN t13	0.50	0.79	0.98	1.34	1.45	1.68

FLOW DURATION RESULTS

Flow duration statistics provide an indication of the relative amount of erosive work performed on the stream channel. The increase in duration at a given flow rate results in more erosive work being performed on the stream channel over time. As urbanization occurs in the watershed, the frequency of discharge that exceeds the historic bedload movement threshold increases. This results in greater erosive work on the stream channel leading to an expansion in the channel cross section and leads to larger sized stream gravel as the smaller gravel fraction is carried downstream.

Figures 14a and 14b compare flow duration statistics in the ravine area of George Davis and Ebright creeks, respectively and show a relatively small change in the flow duration statistics for future relative to existing land use. This suggests that under build-out conditions, the potential for increased stream channel erosion is relatively small. Again, this is due to the presence of highly infiltrative outwash in the central part of the watershed, which greatly reduces the surface runoff response from the watershed. Flow duration statistics for each subbasin are summarized in Tables 6a -6c for the Inglewood Basin and Tables 7a -7c for the Thompson Basin.

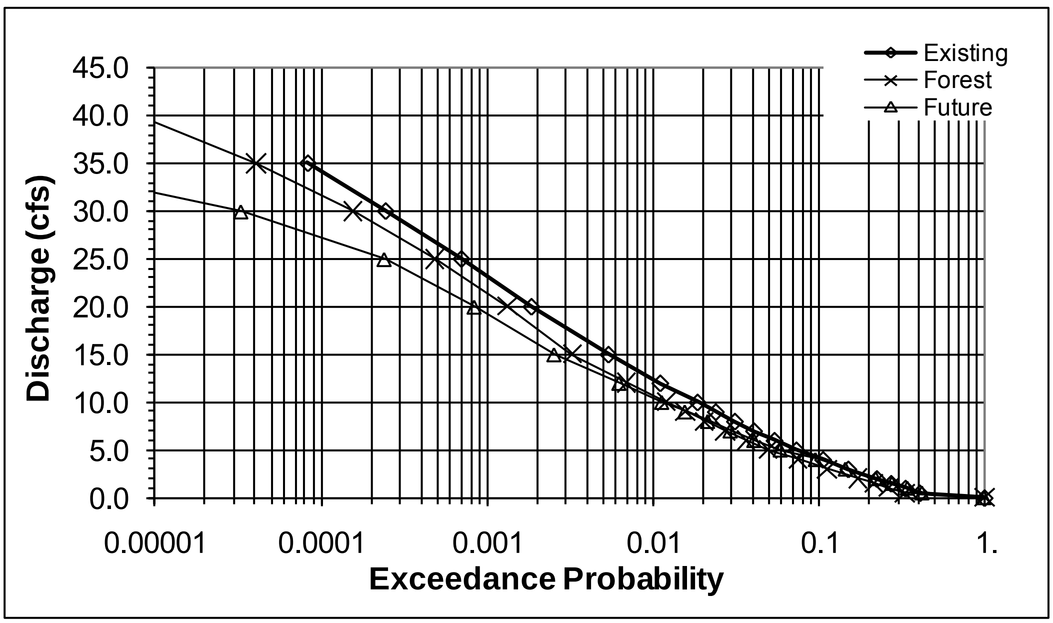


Figure 14a – Comparison of Simulated Flow Duration, Existing, Future, and Forest Land Use George Davis Creek, Inglewood Basin, Subbasin I2, Ravine

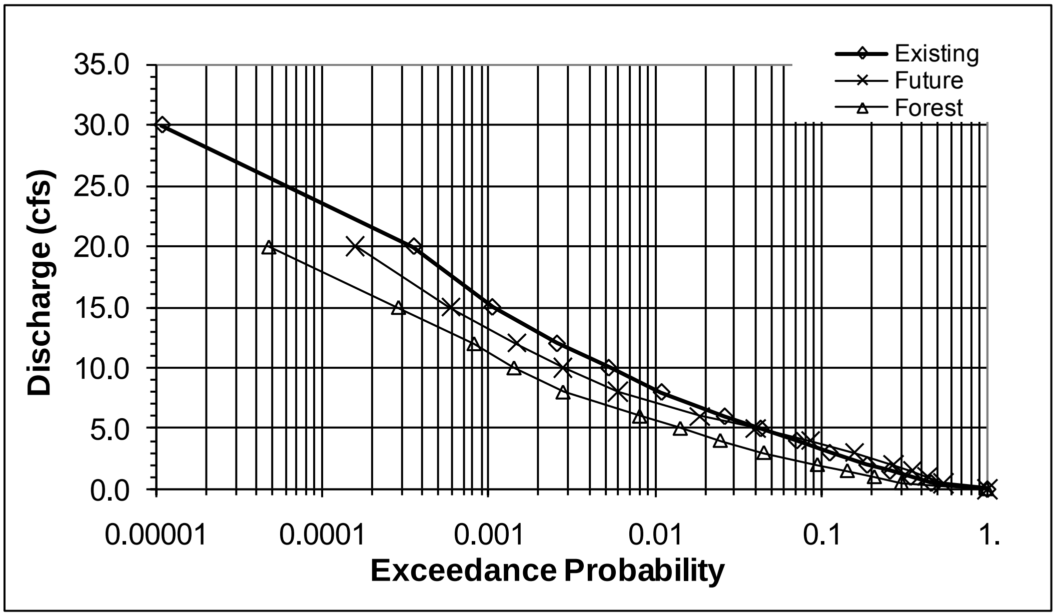


Figure 14b – Comparison of Simulated Flow Duration, Existing, Future, and Forest Land Use Ebright Creek, Thompson Basin, Subbasin t4, Ravine

Table 6a – Inglewood Basin Flow Duration Analysis Results, Existing Land Use

	Existing Land Use			
	Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
I1	0.10	0.78	3.47	5.78
I2	0.06	0.39	2.29	4.16
I3	0.02	0.11	0.25	0.35
I4	0.07	0.47	2.52	4.36
I5	0.06	0.41	1.64	2.83
I6	0.05	0.34	1.26	2.13
I7	0.05	0.32	1.03	1.74
I3A	0.03	0.19	0.45	0.70
I4A	0.07	0.45	2.14	3.64

Table 6b – Inglewood Basin Flow Duration Analysis Results, Future Mitigated Land Use

	Future Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
I1	0.10	0.84	3.54	5.64
I2	0.06	0.40	2.25	3.91
I3	0.01	0.07	0.17	0.24
I4	0.08	0.50	2.42	3.94
I5	0.07	0.46	1.86	3.11
I6	0.06	0.39	1.61	2.56
I7	0.06	0.37	1.38	2.19
I3A	0.01	0.04	0.08	0.12
I4A	0.07	0.49	2.36	3.83

Table 6c – Inglewood Basin Flow Duration Analysis Results, Forested Land Use

	Future Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
I1	0.08	0.58	2.79	4.81
I2	0.05	0.31	1.65	3.28
I3	0.01	0.09	0.21	0.30
I4	0.06	0.37	1.90	3.46
I5	0.05	0.32	1.23	2.09
I6	0.04	0.24	0.68	1.40
I7	0.03	0.22	0.51	1.04
I3A	0.02	0.16	0.37	0.55
I4A	0.05	0.35	1.62	2.89

Table 7a – Thompson Basin Flow Duration Analysis Results, Existing Land Use

	Existing Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
t1	0.08	0.53	2.48	4.24
t2	0.08	0.50	2.39	4.09
t3	0.07	0.45	2.05	3.52
t4	0.07	0.45	1.91	3.26
t5 Wetland 17	0.07	0.44	1.77	3.01
t8	0.04	0.24	0.60	1.09
t9	0.03	0.17	0.40	0.61
t12 Wetland 61	0.03	0.16	0.38	0.58
t7	0.03	0.21	0.49	0.90
t15	0.03	0.19	0.43	0.77

Table 7b – Thompson Basin Flow Duration Analysis Results, Future Mitigated Land Use

	Future Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
t1	0.09	0.80	3.29	4.89
t2	0.09	0.79	3.20	4.75
t3	0.09	0.72	2.82	4.17
t4	0.09	0.68	2.58	3.77
t5 Wetland 17	0.08	0.64	2.32	3.38
t8	0.05	0.31	0.80	1.15
t9	0.03	0.18	0.42	0.58
t12 Wetland 61	0.03	0.17	0.40	0.56
t7	0.04	0.27	0.63	0.90
t15	0.03	0.22	0.50	0.66

Table 7c – Thompson Basin Flow Duration Analysis Results, Forested Land Use

	Future Land Use Discharge Corresponding to Exceedance Probability (cfs)			
Subbasin	**90%**	**50%**	**20%**	**10%**
t1	0.05	0.35	1.54	2.75
t2	0.05	0.34	1.47	2.64
t3	0.05	0.30	1.17	2.17
t4	0.04	0.29	1.07	1.95
t5 Wetland 17	0.04	0.29	0.98	1.75
t8	0.02	0.16	0.38	0.59
t9	0.02	0.11	0.25	0.36
t12 Wetland 61	0.02	0.11	0.24	0.35
t7	0.02	0.14	0.33	0.47
t15	0.02	0.12	0.28	0.40

SUMMARY AND RECOMMENDATIONS

A hydrologic analysis of the Inglewood and Thompson Basins was performed using the HSPF and MGSFlood models in support of the Inglewood Basin Plan Update, the Thompson Basin Plan, and the Sammamish Town Center Comprehensive Stormwater Plan. HSPF models developed for earlier analyses were updated to reflect changes in land use and to include additional subbasins in the proposed Town Center development area. The HSPF model was calibrated to streamflow data collected over a 20 month period from October 2001 through May 2003 at the outlet of George Davis Creek (Inglewood Basin). Flow data collected at the mouth of Ebright Creek was not of sufficient quality to use for model calibration; however, comparisons of simulated flows showed a fairly close match with the recorded data for Ebright Creek.

The MGSFlood model uses similar computational algorithms as HSPF, but also includes routines for analyzing stormwater detention and LID mitigation techniques. Watershed input data and runoff parameters used in the HSPF model development and calibration were used to create MGSFlood model input. The MGSFlood model was used to analyze treatment alternatives at Town Center that included detention and LID measures.

The presence of glacial outwash in the central part of the Inglewood Basin infiltrates the majority of surface flow produced in the upper parts of the watershed and results in little or no flow in the stream immediately upstream of the ravine (Subbasin I2). Downstream, the stream intersects the groundwater table (Subbasin I1) and receives the majority of flow via groundwater discharge. The groundwater discharge also produces year around base flow in the lower reaches of the stream. The outwash deposit infiltrates and stores runoff from the upper watershed and is equivalent to approximately 7,000 acre-feet of stormwater detention storage. Flows in the lower stream reach are relatively low (attenuated) during floods because of the storage that occurs in the outwash deposit.

The Thompson Basin does not have the same infiltrative outwash deposit as the Inglewood Basin, but does have a large wetland (Wetland 17) situated at the top of the ravine. This 30 acre wetland provides substantial flood attenuation and buffering of flows entering from the uplands before discharging to the ravine.

Existing and future build-out conditions were simulated with the HSPF model and flood peak and flow duration statistics computed. Little or no increases in runoff rates relative to existing conditions were predicted under future land for the Inglewood Basin. In the Thompson Basin, future peak flow rates were predicted to decrease relative to existing conditions. These results show that stormwater mitigation designed according to the City’s stormwater detention standard, which seeks to control runoff rates to forested conditions, is effective at mitigating increased runoff due to development. Because of this, the rates of erosion and flooding should not increase in the future and in areas of the Thompson Basin, may actually decrease provided that the facilities are properly maintained in the future.

RECOMMENDATIONS

1. <u>Maintenance of Outwash Infiltration Areas</u> –The glacial outwash deposit in the central part of the Inglewood Basin is currently infiltrating the majority of surface runoff from the upper watershed. Maintaining the infiltration function of this area is critical to ensuring a stable flow regime and the health of George Davis Creek in the future.

   Infiltration of stormwater with pretreatment should be encouraged for new developments located in areas with outwash deposits. A general map of the geology of the Inglewood Basin showing the extent of the outwash deposit is shown in Figure 4. Local site conditions will dictate whether infiltration is feasible on an individual development site and must be evaluated by the site development engineer. Stormwater conveyance should also be maintained in open channels to the greatest extent possible to promote infiltration into the outwash deposit.

2. <u>On-Site Detention and Low Impact Development Methods</u> – The City's detention standard, which is consistent with the 2005 Ecology Stormwater Management Manual[16], is effective at mitigating the increased potential for flooding and erosion associated with development. Stormwater detention facilities designed according to this standard are large and often expensive to construct. Low Impact Development (LID) methods provide a means to reduce the rate and volume of runoff associated with development, and increases the amount of potential groundwater recharge. LID methods should be encouraged to the greatest extent practical for new construction in the Inglewood and Thompson watersheds.

3. <u>Streamflow Monitoring</u> – Streamflow gages have been operated and maintained by a third party contractor in the past at the mouth of George Davis and Ebright creeks. These gages should be reestablished and data collected from them quality checked and validated on an on-going basis.

REFERENCES

1. US Environmental Protection Agency, Hydrological Simulation Program-Fortran, Release 11, EPA/600/R-97/030, August 1997.

2. MGS Software, LLC, MGSFlood, Continuous Hydrologic Model for Stormwater Facility Analysis, Version 4, August 2009.

3. Dinicola, R. S., Validation of a numerical modeling method for simulating rainfall-runoff relations for headwater basins in western King and Snohomish counties, Washington, Water Supply Paper 2495, 2001.

4. King County Surface Water Management, East Lake Sammamish Basin Watershed Management Committee Basin and Nonpoint Action Plan, December 1994.

5. City of Sammamish, Sammamish Town Center Plan, June 2008.

6. Sutherland, Roger, C., Methodology for Estimating the Effective Impervious Area of Urban Watersheds, Technical Note 58, Watershed Protection Techniques, Vol 2, No 1, Fall 1995.

7. Dinicola, R. S., Characterization and Simulation of Rainfall Runoff Relations in Western King and Snohomish Counties, Washington, U.S. Geological Survey, Water-Resources Investigations Report 89-4052.

8. Sacket, Jill, Booth, Derek, Surface Geology of King County, GIS Coverage, King County GIS Center, April 2002.

9. King County, Washington Surface Water Design Manual, King County Department of Natural Resources, September 1998.

10. King County, Washington Surface Water Design Manual, King County Department of Natural Resources, January 2005.

11. MGS Engineering Consultants, Inc, Hydrologic and Hydraulic Analysis of Inglewood Creek using the HSPF Model, March, 2004.

12. Schaefer MG, Barker BL, Wallis JR and Nelson RN, Creation of Extended Precipitation Time-Series for Continuous Hydrological Modeling in Pierce County Washington, prepared for Pierce County Public Works by MGS Engineering Consultants Inc, Entranco, and JR Wallis, February 2001.

13. Schaefer MG and Barker BL, Extended Precipitation Time-Series for Continuous Hydrological Modeling in Western Washington, prepared for Washington State Department of Transportation by MGS Engineering Consultants Inc, April 2002.

14. Gringorten, I. I., A Plotting Rule for Extreme Probability Paper, Journal of Geophysical Research, vol. 68, pp. 813-814, 1963.

15. Stedinger JR, Vogel RM, and Foufoula-Georgiou E, Frequency Analysis of Extreme Events, Chapter 18, *Handbook of Hydrology*, McGraw Hill, 1992.

16. Ecology, Stormwater Management Manual for Western Washington, Washington State Department of Ecology Water Quality Program, Publication Numbers 05-10-029 through 05-10-033 99-13, February 2005.

APPENDIX A – LAND USE DATA

Table A-1 – Inglewood Basin Forested Land Use (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
I1	0.0	81.8	0.0	121.8	0.0	0.0	203.7
I10	0.0	20.5	0.0	3.2	0.0	0.0	23.7
I11	0.0	12.6	0.0	0.2	0.0	0.0	12.8
I12	0.0	13.7	0.0	5.5	0.0	0.0	19.2
I13	0.0	39.2	0.0	1.2	0.0	3.5	43.9
I14	0.0	9.9	0.0	0.0	0.0	1.7	11.7
I2	0.0	188.5	0.0	62.9	0.0	0.0	251.4
I3	0.0	39.4	0.0	12.4	0.0	5.1	56.9
I3A	0.0	4.3	0.0	24.0	0.0	27.0	55.4
I4	0.0	3.1	0.0	10.1	0.0	0.0	13.2
I4A	0.0	164.9	0.0	187.7	0.0	21.9	374.6
I5	0.0	8.3	0.0	48.3	0.0	19.3	76.0
I5A	0.0	49.9	0.0	6.3	0.0	14.6	70.8
I5B	0.0	54.4	0.0	0.0	0.0	0.0	54.4
I6	0.0	42.1	0.0	13.9	0.0	0.0	56.0
I6A	0.0	21.2	0.0	0.1	0.0	0.0	21.3
I7	0.0	216.5	0.0	5.4	0.0	17.5	239.4
I7A	0.0	17.7	0.0	0.3	0.0	0.0	18.0
I8	0.0	11.4	0.0	0.0	0.0	0.0	11.4
I9	0.0	20.8	0.0	3.1	0.0	0.2	24.1
Total	0.0	1020	0.0	506	0.0	111	1637.7

Table A-2 – Inglewood Basin Existing (year 2006) Land Use (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
I1	20.0	32.5	41.3	43.1	66.8	0.0	203.7
I10	1.3	4.2	15.2	0.0	3.0	0.0	23.7
I11	0.5	7.9	4.2	0.0	0.2	0.0	12.8
I12	0.9	1.7	11.3	3.4	1.8	0.0	19.2
I13	4.5	11.9	22.9	0.0	1.0	3.5	43.9
I14	0.1	8.4	1.4	0.0	0.0	1.7	11.7
I2	27.7	63.0	104.7	12.0	44.0	0.0	251.4
I3	5.7	2.1	33.0	1.4	9.6	5.1	56.9
I3A	3.5	1.0	2.9	0.0	21.0	27.0	55.4
I4	0.8	2.9	0.0	0.6	8.9	0.0	13.2
I4A	102.9	28.7	88.1	36.9	96.1	21.9	374.6
I5	25.5	2.1	2.5	7.0	19.6	19.3	76.0
I5A	1.0	27.5	21.5	3.2	3.0	14.6	70.8
I5B	10.7	5.1	38.6	0.0	0.0	0.0	54.4
I6	2.3	13.7	26.7	2.9	10.4	0.0	56.0
I6A	4.9	0.0	16.3	0.0	0.1	0.0	21.3
I7	31.5	77.9	107.9	4.6	0.0	17.5	239.4
I7A	4.0	0.4	13.3	0.0	0.2	0.0	18.0
I8	0.5	3.5	7.4	0.0	0.0	0.0	11.4
I9	2.1	11.5	7.5	0.0	2.8	0.2	24.1
Total	251	306	567	115	289	111	1637.7

Table A-3 – Inglewood Basin Future Build-Out Land Use, According to City of Sammamish Zoning and Sammamish Town Center Plan (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
I1	58.3	0.0	59.5	0.0	85.9	0.0	203.7
I10	4.5	0.0	16.8	0.0	2.4	0.0	23.7
I11	6.7	0.0	6.1	0.0	0.1	0.0	12.8
I12	8.7	0.0	6.0	0.0	3.4	1.0	19.2
I13	15.4	0.0	24.9	0.0	0.2	3.5	43.9
I14	2.7	0.0	7.0	0.0	0.0	1.9	11.7
I2	74.5	0.0	130.3	0.0	46.6	0.0	251.4
I3	12.6	0.0	26.2	0.0	9.0	9.0	56.9
I3A	4.5	0.0	0.3	0.0	11.1	39.5	55.4
I4	3.5	0.0	2.2	0.0	7.5	0.0	13.2
I4A	168.2	0.0	92.7	0.0	98.2	15.5	374.6
I5	30.0	0.0	5.5	0.0	10.8	29.6	76.0
I5A	11.6	0.0	41.0	0.0	5.3	12.9	70.8
I5B	17.3	0.0	35.7	0.0	0.0	1.4	54.4
I6	12.0	0.0	32.8	0.0	10.9	0.2	56.0
I6A	7.9	0.0	13.3	0.0	0.0	0.0	21.3
I7	63.9	0.0	153.8	0.0	3.8	17.8	239.4
I7A	5.4	0.0	11.8	0.0	0.2	0.7	18.0
I8	5.2	0.0	6.2	0.0	0.0	0.0	11.4
I9	10.8	0.0	11.8	0.0	1.5	0.0	24.1
Total	524	0	684	0	297	133	1637.7

Table A-4 – Thompson Basin Forested Land Use (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
t01	0.0	15.2	0.0	1.0	0.0	0.0	16.2
t02	0.0	66.4	0.0	1.6	0.0	0.0	68.0
t03	0.0	45.8	0.0	3.3	0.0	3.3	52.4
t04	0.0	44.5	0.0	1.5	0.0	0.0	46.0
t05	0.0	85.9	0.0	48.1	0.0	28.3	162.3
t06	0.0	26.0	0.0	51.9	0.0	3.8	81.7
t07	0.0	23.5	0.0	33.6	0.0	7.7	64.7
t08	0.0	65.2	0.0	43.8	0.0	0.0	109.0
t09	0.0	4.0	0.0	7.3	0.0	0.0	11.3
t10	0.0	23.2	0.0	0.1	0.0	0.0	23.3
t11	0.0	5.4	0.0	4.2	0.0	0.4	10.0
t12	0.0	0.4	0.0	0.3	0.0	5.7	6.4
t13	0.0	16.8	0.0	4.4	0.0	0.0	21.2
t14	0.0	18.5	0.0	12.0	0.0	0.0	30.5
t15	0.0	5.9	0.0	24.6	0.0	0.0	30.5
t16	0.0	27.5	0.0	0.0	0.0	0.0	27.5
t17	0.0	36.9	0.0	0.2	0.0	0.0	37.1
Total	0.0	511.1	0.0	237.7	0.0	49.2	798.0

Table A-5 – Thompson Basin Existing Land Use (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
t01	1.0	2.8	11.5	0.0	0.9	0.0	16.2
t02	2.5	32.6	31.5	1.2	0.3	0.0	68.0
t03	1.0	30.8	14.1	3.2	0.0	3.3	52.4
t04	1.6	24.0	19.0	0.0	1.5	0.0	46.0
t05	7.7	19.8	61.1	16.5	28.8	28.3	162.3
t06	5.7	5.6	18.5	25.0	23.1	3.8	81.7
t07	2.5	14.8	7.7	15.3	16.8	7.7	64.7
t08	5.6	26.0	35.9	11.1	30.4	0.0	109.0
t09	0.7	0.0	3.7	3.5	3.3	0.0	11.3
t10	2.3	0.0	20.9	0.0	0.1	0.0	23.3
t11	0.2	0.2	5.0	0.1	4.0	0.4	10.0
t12	0.0	0.1	0.3	0.2	0.1	5.7	6.4
t13	0.3	0.5	16.1	0.6	3.7	0.0	21.2
t14	11.4	3.6	8.0	1.2	6.3	0.0	30.5
t15	1.4	2.7	3.0	14.3	9.1	0.0	30.5
t16	9.3	0.5	17.6	0.0	0.0	0.0	27.5
t17	10.4	1.3	25.3	0.0	0.1	0.0	37.1
Total	63.5	165.2	299.2	92.3	128.7	49.2	798.0

Table A-6 – Thompson Basin Future Build-Out Land Use, According to City of Sammamish Zoning and Sammamish Town Center Plan (acres)

Subbasin	Impervious	Till Forest	Till Grass	Outwash Forest	Outwash Grass	Wetland	Total
t01	2.4	0.0	12.9	0.0	0.9	0.0	16.2
t02	11.0	0.0	55.6	0.0	1.4	0.0	68.0
t03	5.2	0.0	41.0	0.0	2.9	3.3	52.4
t04	7.6	0.0	37.5	0.0	1.0	0.0	46.0
t05	30.6	0.0	63.5	0.0	39.8	28.3	162.3
t06	18.2	0.0	21.2	0.0	38.6	3.8	81.7
t07	11.2	0.0	19.6	0.0	26.3	7.7	64.7
t08	24.2	0.0	49.5	0.0	35.2	0.0	109.0
t09	1.8	0.0	3.2	0.0	6.3	0.0	11.3
t10	7.8	0.0	15.4	0.0	0.1	0.0	23.3
t11	0.1	0.0	5.4	0.0	4.1	0.4	10.0
t12	0.1	0.0	0.4	0.0	0.3	5.6	6.4
t13	7.0	0.0	10.0	0.0	4.2	0.0	21.2
t14	15.5	0.0	8.5	0.0	6.4	0.0	30.5
t15	7.2	0.0	4.5	0.0	18.8	0.0	30.5
t16	13.3	0.0	14.2	0.0	0.0	0.0	27.5
t17	14.4	0.0	22.6	0.0	0.1	0.0	37.1
Total	177.4	0.0	384.9	0.0	186.6	49.2	798.0

APPENDIX B

Culvert Capacities

APPENDIX B
CULVERT CAPACITIES

Parametrix evaluated the hydraulic capacity of 13 culverts (Figure 14 of main report) in the Thompson Basin. This appendix describes the culvert capacity evaluation process; provides results of the existing culvert capacities; and provides recommendations for culvert modifications.

METHODS

Three elements were evaluated to determine existing culvert capacities: (1) minimum conveyance requirements for existing culverts, (2) existing culvert capacities, and (3) existing flows at a culvert location. This section discusses each evaluation element.

Minimum Requirements

City of Sammamish uses the 2009 King County Surface Water Design Manual (KCSWDM) for all design requirements. Section 1.2.4.2 of the manual states that an existing conveyance system is required to have sufficient capacity to convey and contain at least the 10-year peak flow. In addition, the 100-year peak flow rate cannot cause sever flooding or severe erosion problems.

Existing Culverts

To determine the existing culvert capacities, Parametrix surveyed the culvert invert elevations at 13 road crossings during a field visit on December 3, 2008. The field team gathered the following data at each road crossing: number of culverts, culvert diameter, length, material, and slope. The field data was entered into Manning's Formula to calculate the maximum flow capacity at each of the 13 culvert locations. Table B-1 summarizes culvert characteristics and flow capacity at each of the 13 locations.

Existing Flow Rates

Hydrologic modeling results for the Thompson Basin are presented in Appendix A (Thompson Basin in Hydrologic Analysis of the Inglewood Basin, Thompson Basin and Sammamish Town Center Using the HSPF presented by MGS Engineering Consultants, Inc.). Parametrix used the existing land use peak flow rates from Table 4a in Appendix A to determine whether the existing culverts are adequately sized for the contributing flow. The 10-year and 100-year peak flow rates for each culvert location are included in the Table B-1.

Table B-1. Thompson Basin Culvert Capacities

Road Name	Culvert Location	Culvert No.	Number of Pipes	Diameter(s) (feet)	Material	Slope, Percent (%)	Length, (feet)	Capacity		
								Q_{full} (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
SE 12th Street	Border of Reaches 4 and 5	1	1	2.8	CMP	9.6%	58.5	100.2	21.0	31.0
SE 8th Street and Lancaster Way	Border of Reaches 7 and 11	2	2	3.0	CMP	1.2%	60.0	84.7	4.2	6.8
Driveway S of 218th Ave SE	Along Reach 7	3	1	3.0	CMP	3.0%	40.5	67.0	15.0	22.0
218th Avenue SE, private road	Along Reach 7	4	1	3.0	HDPE	0.9%	30.0	98.5	15.0	22.0
212th Avenue SE	Wetland 17, Reach 6	11	4	1.0	HDPE	0.1%	38.0	28.1	19.0	28.0
217 Avenue SE	Wetland 17, Border of Reaches 6 and 9	5	1	2.0	CMP	0.9%	59.0	12.5	5.4	5.6
SE 13 Place	Wetland 17, Reach 6 north fork	6	1	2.5	CMP	0.2%	60.0	10.3	15.0	22.0
Driveway NW of 223rd Avenue SE	Reach 10	7	1	2.0	CMP	1.7%	30.0	17.1	7.1	13.0
223 Avenue SE	Reach 10	8	2	2.0	CMP	1.5%	24.0	34.6	7.1	13.0
Driveway E of E Lake Sammamish Pkwy	Beneath Wally's hot tub	9	1	2.0	Concrete	8.1%	21.0	69.6	34.0	47.0
E Lake Sammamish Pkwy	At Wally's driveway entrance	10	2	2.5	Concrete	1.7%	60.0	243.8	36.0	51.0
222nd Place SE (?)	Reach 11 near border with Reach 8	12	2	3.0	CMP	1.0%	40.0	155.8	3.9	6.3
223 Avenue SE	North of twin culverts on 223rd	13	1	1.0	CMP	2.5%	33.0	3.3	3.9	6.3

Note: The Capacity is the velocity that the number of pipes at a road crossing can handle when flowing full.
cfs = cubic feet per second

RESULTS AND RECOMMENDATIONS

The culvert capacity evaluation summary in Table B-1 shows that 11 of the 13 culvert locations have enough capacity to contain the 100-year peak flow rate. These culverts do not need modification to increase flow capacity. There are two culvert locations (culverts 6 and 13, shown on Figure 14 of the report); however, that have a maximum flow capacity that is less than the 10-year peak flow rate. Although the calculated flow capacity of these culverts is less than the modeled 10-year peak flow rate, we do not recommend culvert modifications at this time. More detail is provided below.

Culvert 6

The 24-inch CMP at Culvert 6 drains Wetland 17 beneath SE 13th Place (Figure 14 of main report). During the site visit, the culvert was submerged in 12-inches of water; however, the roadway surface was approximately 3 feet higher than the water surface. This elevation difference acts like a reservoir, preventing the water from over-topping the road, while the culvert drains the wetland. It is our understanding that there is no history of flood problems in this location. Based on this information, Parametrix does not recommend culvert replacement of Culvert 6.

Culvert 13

The 12-inch CMP at Culvert 13 is located near the head waters of Ebright Creek. Table B-1 shows that the 10-year peak flow rate is 0.6 cfs greater than the culvert capacity. During the site visit, the culvert was conveying less than six inches of flow, and the roadway surface was approximately 3 feet higher than the water surface. This elevation difference acts like a reservoir, preventing the water from over-topping the road while the culvert conveys stream flow. It is our understanding that there is no history of flood problems in this location. Based on this information, Parametrix does not recommend culvert replacement at Culvert 13.

APPENDIX C

Wetland Data Forms

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 1 **Location:** PARK OFF OF SE 14th **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PSS /PEM /PFO **HGM Class:** Depressional Closed

Estimated Wetland Size (ac): <0.1 ____ 0.1-1 ____ 1-5 ? 5-10 ____ >10 X ?

Identified by: CH, CW **Photo No.** ____

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [X]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ____

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [ ] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [X] d. recreational overuse buffers
- [X] e. residential development
- [ ] f. other ____

Hydrology

Water sources and hydroperiod:

- [X] Ground water (perched water table, through flow…)
- [ ] Surface water
- [ ] Seep
- [X] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [X] Other Stormwater from upgradient impervious areas (e.g. parking lot)

Inlet/outlet: pipes = inlet

- [X] a. constrained, size____
- [ ] b. unconstrained
- [ ] c. natural channel
- [X] d. none no outlet observed
- [ ] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [X] No [ ]
connected to Thompson Cr.?

Indicators of wetland hydrology:

- [X] a. inundation small pockets
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ____

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ____

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Invasive Species? Yes (%) X No

JUEF, Agrostis, other grasses, PHAR, SPDO, CAOB, CIVU, ALRU, RUSP
Planted veg including COSE, RONU, THPL, FRLA, CRDO

Approximate age of dominant woody vegetation (years)?	<50	X	50-80		>80	
# of habitat types:	1		2	X	≥ 3	X
Degree of interspersion:	Low	X	Mod		High	

Vegetation connectivity to other habitats? Yes, W forest, somewhat disturbed with driveways + park facilities.
No connections near new residential development

Food sources or habitat features for wildlife? Berries.

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [X] No [ ]

- [X] a. grass-lawn
- [ ] b. herbaceous-native
- [ ] c. scrub-shrub
- [X] d. forested (v. narrow)
- [ ] f. other

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [ ] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [X] No [ ]

- [ ] a. restoration
- [ ] b. creation
- [ ] c. enhancement
- [ ] d. preservation

Limited on-site due to park use. May have opportunities on adjacent parcels.

Notes: Portions of WL have been enhanced/planted on park property w/ trees + shrubs. New residential development to north fragmented W habitat buffer.

Note - Standing water + saturated soil in lawn, W of WL. Water is drained to catch basin.

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 1 **Observer(s):** CH, CW **Date:** 12-03-08

FUNCTION	CRITERIA: LOW RATING	CRITERIA: MODERATE RATING	CRITERIA: HIGH RATING
Water Quality Improvement	___ rapid flow through wetland	___ moderate flow through wetland	X little or no flow present
	___ <50% vegetation density	___ 50-80% vegetation density	X >80% vegetation density
	___ no proximity to pollutants	X downstream from non-point pollutants	___ downstream from point discharges
Evaluation: ___	___ detains <25% overland runoff	___ detains 25-50% overland runoff	X detains >50% overland runoff
Flood/Storm Water Control	___ size <5 acres	___ size 5-10 acres	X size >10 acres
Evaluation: ___	___ riverine, shallow depression	___ mid-sloped wetland	X lake, depressions, headwaters, bogs
Groundwater Recharge	___ size <5 acres	___ size 5-10 acres	X size >10 acres
	___ temporarily saturated/inundated	X seasonally saturated/inundated	___ permanently inundated
Evaluation: ___	___ springs present outflow>inflow	___ outflow=inflow	X outflow<inflow
Natural Biological Support	___ size <5 acres	___ size 5-10 acres	X size >10 acres
	X not isolated isolated systems associated with ephemeral surface water	___ associated with permanent surface water	___ associated with permanent open water
	___ one habitat type	X two habitat types	___ three or more habitat types
	X little or no interspersion of habitats	___ some habitat interspersion	___ habitats highly interspersed
	___ low plant diversity	X moderate plant diversity	___ high plant diversity
	X few, if any habitat features present	___ some habitat features present	___ several habitat features present
	X adjacent buffers primarily disturbed and/or developed grass/lawn	___ buffers somewhat disturbed and/or developed	___ buffers generally undisturbed native vegetation and undeveloped
	___ few connections to other habitat types	X some connection to other habitat types	___ significant connections to high quality habitat types
Evaluation: ___	___ Agricultural land or low vegetation structure	X moderate vegetation structure	___ high vegetation structure
Erosion/Shoreline Protection	___ sparse grass/forbs or not vegetation	X sparse woody vegetation or dense herb vegetation	___ dense woody vegetation
Evaluation: ___			

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 2 **Location:** S. of park off of SE 14th **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PEM **HGM Class:** Depressional Closed

Estimated Wetland Size (ac): <0.1 X 0.1-1 ___ 1-5 ___ 5-10 ___ >10 ___

Identified by: CH, CW **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [X]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ___

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [X] No [ ]

- [ ] a. clearing
- [X] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [ ] e. residential development
- [ ] f. other ___

Hydrology

Water sources and hydroperiod:

- [ ] Ground water (perched water table, through flow…)
- [X] Surface water
- [ ] Seep
- [X] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet:

- [ ] a. constrained, size___
- [ ] b. unconstrained
- [ ] c. natural channel
- [X] d. none
- [ ] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [ ] No [X]

Indicators of wetland hydrology:

- [X] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ___

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Invasive Species? Yes (%) X No

Grazed grass, PHAR, SPDO[F], ALRO[F]

Approximate age of dominant woody vegetation (years)? NA	<50		50-80		>80	
# of habitat types:	1	X	2		≥ 3	
Degree of interspersion: NA	Low		Mod		High	

Vegetation connectivity to other habitats? Some, V forest

Food sources or habitat features for wildlife? No

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [X] No [ ]

- [X] a. grass-lawn
- [ ] b. herbaceous-native
- [ ] c. scrub-shrub
- [X] d. forested
- [ ] f. other ______

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [ ] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [X] No [ ]

- [X] a. restoration
- [ ] b. creation
- [ ] c. enhancement
- [ ] d. preservation

Yes, however this is private property

Notes:

Located on parcels to S. of park. Fence crossing through WL (N to S.). Historically was likely connected to W1, prior to development of driveways. Grazed by Shetland ponies. Potentially reconnect system for mitigation. WL may connect to another WL S. of property line.

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 2 Observer(s): CH, cw Date: 12-03-08

FUNCTION		LOW RATING		MODERATE RATING		HIGH RATING
				CRITERIA		
Water Quality Improvement		rapid flow through wetland		moderate flow through wetland	X	little or no flow present
grazed		<50% vegetation density		50-80% vegetation density	X	>80% vegetation density
	X	no proximity to pollutants		downstream from non-point pollutants		downstream from point discharges
Evaluation:		detains <25% overland runoff		detains 25-50% overland runoff	X	detains >50% overland runoff
Flood/Storm Water Control	X	size <5 acres		size 5-10 acres		size >10 acres
Evaluation:		riverine, shallow depression		mid-sloped wetland	X	lake, depressions, headwaters, bogs
Groundwater Recharge	X	size <5 acres		size 5-10 acres		size >10 acres
		temporarily saturated/inundated	X	seasonally saturated/inundated		permanently inundated
Evaluation:		springs present outflow>inflow		outflow=inflow	X	outflow<inflow
Natural Biological Support	X	size <5 acres		size 5-10 acres		size >10 acres
	X	No association isolated systems associated with ephemeral surface water		associated with permanent surface water		associated with permanent open water
	X	one habitat type		two habitat types		three or more habitat types
	X	little or no interspersion of habitats		some habitat interspersion		habitats highly interspersed
	X	low plant diversity		moderate plant diversity		high plant diversity
	X	few, if any habitat features present		some habitat features present		several habitat features present
		adjacent buffers primarily disturbed and/or developed	X	buffers somewhat disturbed and/or developed		buffers generally undisturbed native vegetation and undeveloped
	X	few connections to other habitat types		some connection to other habitat types		significant connections to high quality habitat types
Evaluation:	X	Agricultural land or low vegetation structure		moderate vegetation structure		high vegetation structure
Erosion/Shoreline Protection NA		sparse grass/forbs or not vegetation		sparse woody vegetation or dense herb vegetation		dense woody vegetation
Evaluation:						

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 3 **Location:** E. of E. Lk. Samm. Pkwy **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PEM **HGM Class:** Depressional Outflow ?

Estimated Wetland Size (ac): <0.1 ___ 0.1-1 ___ 1-5 X 5-10 ___ >10 ___

Identified by: CH, CW **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [X]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ___

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [ ] No [X]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [ ] e. residential development
- [ ] f. other ___

Hydrology

Water sources and hydroperiod:

- [X] Ground water (perched water table, through flow…)
- [ ] Surface water
- [ ] Seep
- [X] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet:

- [ ] a. constrained, size___
- [ ] b. unconstrained
- [ ] c. natural channel
- [ ] d. none
- [X] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [X] (likely) No [ ]

Indicators of wetland hydrology:

- [X] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ___

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Invasive Species? Yes (%) X No ___

JUEF, grasses (likely Agrostis), TYLA [LD], PHAR [F]

Approximate age of dominant woody vegetation (years)? NA	<50		50-80		>80	
# of habitat types:	1	X	2		≥3	
Degree of interspersion: NA	Low		Mod		High	

Vegetation connectivity to other habitats? V herbaceous to E, patches of RUAR

Food sources or habitat features for wildlife?

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes ☐ No ☐

- ☐ a. grass-lawn
- ☒ b. herbaceous-native
- ☐ c. scrub-shrub
- ☐ d. forested
- ☐ f. other ___

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- ☐ a. % no buffer
- ☐ b. % <25 ft
- ☐ c. % 25-50 ft
- ☐ d. % 50-100 ft
- ☐ e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes ☒ No ☐

- ☒ a. restoration
- ☒ b. creation
- ☒ c. enhancement
- ☐ d. preservation

Notes:

N, S, W sides bordered by driveways + E. Lk. Samm. Pkwy.

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 3 **Observer(s):** CH, CLO **Date:** 12-03-08

FUNCTION		LOW RATING		MODERATE RATING		HIGH RATING
Water Quality Improvement		rapid flow through wetland		moderate flow through wetland	X	little or no flow present
		<50% vegetation density		50-80% vegetation density	X	>80% vegetation density
		no proximity to pollutants		downstream from non-point pollutants	X	downstream from point discharges road runoff
Evaluation:		detains <25% overland runoff	X	detains 25-50% overland runoff		detains >50% overland runoff
Flood/Storm Water Control	X	size <5 acres		size 5-10 acres		size >10 acres
Evaluation:		riverine, shallow depression		mid-sloped wetland	X	lake, depressions, headwaters, bogs
Groundwater Recharge	X	size <5 acres		size 5-10 acres		size >10 acres
		temporarily saturated/inundated	X	seasonally saturated/inundated		permanently inundated
Evaluation:	X	springs present outflow>inflow		outflow=inflow		outflow<inflow
Natural Biological Support	X	size <5 acres		size 5-10 acres		size >10 acres
	X	Not associated isolated systems associated with ephemeral surface water		associated with permanent surface water		associated with permanent open water
	X	one habitat type		two habitat types		three or more habitat types
	X	little or no interspersion of habitats		some habitat interspersion		habitats highly interspersed
	X	low plant diversity		moderate plant diversity		high plant diversity
	X	few, if any habitat features present		some habitat features present		several habitat features present
	X	adjacent buffers primarily disturbed and/or developed		buffers somewhat disturbed and/or developed		buffers generally undisturbed native vegetation and undeveloped
	X	few connections to other habitat types		some connection to other habitat types		significant connections to high quality habitat types
Evaluation:	X	Agricultural land or low vegetation structure		moderate vegetation structure		high vegetation structure
Erosion/Shoreline Protection NA	X	sparse grass/forbs or not vegetation		sparse woody vegetation or dense herb vegetation		dense woody vegetation
Evaluation:						

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 4 **Location:** 208 E Lk. Samm. Pkwy (East of) **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PEM, PUB **HGM Class:** Depressional Outflow

Estimated Wetland Size (ac): <0.1 X 0.1-1 ___ 1-5 ___ 5-10 ___ >10 ___

Identified by: CH, CW **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [X] No [ ]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [X] g. other pond possibly created/manmade, at least it has been modified.

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [X] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [ ] e. residential development
- [X] f. other see above

Hydrology

Water sources and hydroperiod:

- [X] Ground water (perched water table, through flow…)
- [ ] Surface water
- [ ] Seep
- [ ] Seasonally flooded/saturated
- [X] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet:

- [ ] a. constrained, size___
- [ ] b. unconstrained
- [ ] c. natural channel
- [ ] d. none
- [X] e. could not locate – outlet is likely constrained to ditch

Hydrologic connectivity to other wetlands and streams? Yes [X] No [ ]

Indicators of wetland hydrology:

- [X] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ___

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Invasive Species? Yes (%) ______ No X

TYLA, LEMN

Approximate age of dominant woody vegetation (years)?	NA <50		50-80		>80	
# of habitat types:	1	X	2		≥ 3	
Degree of interspersion:	NA Low		Mod		High	

Vegetation connectivity to other habitats? Yes, w/ forest

Food sources or habitat features for wildlife? Pond

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes ☐ No ☐

- [x] a. grass-lawn
- [ ] b. herbaceous-native
- [ ] c. scrub-shrub
- [x] d. forested
- [ ] f. other ______

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- ☐ a. % no buffer
- ☐ b. % <25 ft
- ☐ c. % 25-50 ft
- ☐ d. % 50-100 ft
- ☐ e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes ☐ No ☐

- ☐ a. restoration
- ☐ b. creation
- ☐ c. enhancement
- ☐ d. preservation

? -

Notes:

Drains via ditch to WL S. of W3 + driveway

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 4 **Observer(s):** CH, CW **Date:** 12-03-08

FUNCTION		LOW RATING		MODERATE RATING		HIGH RATING
				CRITERIA		
Water Quality ~~Improvement~~		rapid flow through wetland	X	moderate flow through wetland		little or no flow present
	X	<50% vegetation density		50-80% vegetation density		>80% vegetation density
		no proximity to pollutants	X	downstream from non-point pollutants – fertilizer runoff ?		downstream from point discharges
Evaluation:		details <25% overland runoff		detains 25-50% overland runoff	X	detains >50% overland runoff
Flood/Storm Water Control	X	size <5 acres		size 5-10 acres		size >10 acres
Evaluation:		riverine, shallow depression		mid-sloped wetland	X	lake, depressions, headwaters, bogs
Groundwater Recharge	X	size <5 acres		size 5-10 acres		size >10 acres
		temporarily saturated/inundated		seasonally saturated/inundated	X	permanently inundated
Evaluation:	X	springs present outflow>inflow		outflow=inflow		outflow<inflow
Natural Biological Support	X	size <5 acres		size 5-10 acres		size >10 acres
	X	isolated systems associated with ephemeral surface water ditch		associated with permanent surface water		associated with permanent open water
	X	one habitat type		two habitat types		three or more habitat types
	X	little or no interspersion of habitats		some habitat interspersion		habitats highly interspersed
	X	low plant diversity		moderate plant diversity		high plant diversity
	X	few, if any habitat features present		some habitat features present		several habitat features present
		adjacent buffers primarily disturbed and/or developed	X	buffers somewhat disturbed and/or developed		buffers generally undisturbed native vegetation and undeveloped
		few connections to other habitat types	X	some connection to other habitat types		significant connections to high quality habitat types
Evaluation:	X	Agricultural land or low vegetation structure		moderate vegetation structure		high vegetation structure
Erosion/Shoreline Protection	X	sparse grass/forbs or not vegetation		sparse woody vegetation or dense herb vegetation		dense woody vegetation
Evaluation:						

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 5 **Location:** Pereyra prop / E. of E. Lk. Samm. Pkwy **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PFO **HGM Class:** Riverine Flow Through

Estimated Wetland Size (ac): <0.1 ___ 0.1-1 X 1-5 ___ 5-10 ___ >10 ___

Identified by: CH, CW **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [X]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ___

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [ ] No [X]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [ ] e. residential development
- [ ] f. other ___

Hydrology

Water sources and hydroperiod:

- [ ] Ground water (perched water table, through flow…)
- [X] Surface water (Ebright Cr.)
- [ ] Seep
- [X] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet:

- [ ] a. constrained, size___
- [ ] b. unconstrained
- [X] c. natural channel Ebright Cr.
- [ ] d. none
- [ ] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [X] No [ ]

Indicators of wetland hydrology:

- [ ] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ___

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: ALRU, POBA, SALU, RUAR, COSE

Invasive Species? Yes (%) X No

Approximate age of dominant woody vegetation (years)?	<50	X	50-80		>80	
# of habitat types:	1	X	2		≥3	
Degree of interspersion:	NA Low		Mod		High	

Vegetation connectivity to other habitats? Stream, small W least, W habs - disturbed from development

Food sources or habitat features for wildlife? Stream, berries

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [X] No [ ]

- [X] a. grass-lawn - mowed + unmowed
- [ ] b. herbaceous-native
- [ ] c. scrub-shrub
- [X] d. forested
- [ ] f. other

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [ ] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [X] No [ ]

- [ ] a. restoration
- [ ] b. creation
- [X] c. enhancement
- [ ] d. preservation

WL + Buffer

Notes:

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 5 Observer(s): CH, CW Date: 12-03-08

FUNCTION		LOW RATING		MODERATE RATING		HIGH RATING
		CRITERIA				
Water Quality Improvement	X	rapid flow through wetland		moderate flow through wetland		little or no flow present
		<50% vegetation density		50-80% vegetation density	X	>80% vegetation density
		no proximity to pollutants	X	downstream from non-point pollutants		downstream from point discharges
Evaluation:	X	detains <25% overland runoff		detains 25-50% overland runoff		detains >50% overland runoff
Flood/Storm Water Control	X	size <5 acres		size 5-10 acres		size >10 acres
Evaluation:	X	riverine shallow depression		mid-sloped wetland		lake, depressions, headwaters, bogs
Groundwater Recharge	X	size <5 acres		size 5-10 acres		size >10 acres
		temporarily saturated/inundated	X	seasonally saturated/inundated		permanently inundated
Evaluation:		springs present outflow>inflow	X	outflow=inflow		outflow<inflow
Natural Biological Support	X	size <5 acres		size 5-10 acres		size >10 acres
		isolated systems associated with ephemeral surface water	X	associated with permanent surface water		associated with permanent open water
	X	one habitat type		two habitat types		three or more habitat types
	X	little or no interspersion of habitats		some habitat interspersion		habitats highly interspersed
		low plant diversity	X	moderate plant diversity		high plant diversity
	X	few, if any habitat features present		some habitat features present		several habitat features present
		adjacent buffers primarily disturbed and/or developed	X	buffers somewhat disturbed and/or developed		buffers generally undisturbed native vegetation and undeveloped
	X	few connections to other habitat types		some connection to other habitat types		significant connections to high quality habitat types
Evaluation:		Agricultural land or low vegetation structure	X	moderate vegetation structure		high vegetation structure
Erosion/Shoreline Protection		sparse grass/forbs or not vegetation		sparse woody vegetation or dense herb vegetation	X	dense woody vegetation
Evaluation:						

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 6 **Location:** 212th (both E+W) along Ebright Cr. **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PSS/PEM/PFO **HGM Class:** Riverine Impounding/Flow-through (Depressional outflow)

Estimated Wetland Size (ac): <0.1 ___ 0.1-1 ___ 1-5 ___ 5-10 ___ >10 X

Identified by: CH, CLS **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [X] No [ ]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [X] g. other roadways bisecting WL.

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [X] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [ ] e. residential development
- [X] f. other roadways through WL/bisecting

Hydrology

Water sources and hydroperiod:

- [ ] Ground water (perched water table, through flow…)
- [X] Surface water Ebright Cr.
- [ ] Seep
- [X] Seasonally flooded/saturated
- [X] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet:

- [ ] a. constrained, size___
- [ ] b. unconstrained
- [X] c. natural channel Ebright Cr. (inlet + outlet) likely also receives SW runoff from various sources possibly other trib.
- [ ] d. none
- [ ] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [X] No [ ]

Indicators of wetland hydrology:

- [X] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [X] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ___

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Invasive Species? Yes (%) X No ___

PFO = ALRU, SPDO, FRLA, LOIN, SODU, THPL, RUSP
PSS = Salix spp., SPDO
PEM = JUEF, PHAR,

Approximate age of dominant woody vegetation (years)?	<50	X	50-80		>80	
# of habitat types:	1		2		≥ 3	X
Degree of interspersion:	Low		Mod		High	X

Vegetation connectivity to other habitats? U forest,

Food sources or habitat features for wildlife? Snags, many LWD

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [ ] No [ ]

- [ ] a. grass-lawn
- [X] b. herbaceous-native
- [ ] c. scrub-shrub
- [X] d. forested
- [ ] f. other ___

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [ ] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [X] No [X]
(see below)

- [X] a. restoration
- [X] b. creation
- [X] c. enhancement
- [X] d. preservation

Notes: Possibly mitigation opportunities ~~at~~ private residential parcels that abut LW (e.g. restore pasture areas).

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 6 Observer(s): CH, CW Date: 12-03-08

FUNCTION		LOW RATING		MODERATE RATING		HIGH RATING
Water Quality Improvement		rapid flow through wetland	X	moderate flow through wetland	X	little or no flow present
		<50% vegetation density	X	50-80% vegetation density	X	>80% vegetation density
		no proximity to pollutants	X	downstream from non-point pollutants	X	downstream from point discharges (at road crossing)
Evaluation:		detains <25% overland runoff	X	details 25-50% overland runoff		detains >50% overland runoff
Flood/Storm Water Control		size <5 acres		size 5-10 acres	X	size >10 acres
Evaluation:	X	riverine, shallow depression		mid-sloped wetland	X	lake, depressions, headwaters, bogs
Groundwater Recharge		size <5 acres		size 5-10 acres	X	size >10 acres
		temporarily saturated/inundated	X	seasonally saturated/inundated	X	permanently inundated
Evaluation:		springs present outflow>inflow	X	outflow=inflow		outflow<inflow
Natural Biological Support		size <5 acres		size 5-10 acres	X	size >10 acres
		isolated systems associated with ephemeral surface water	X	associated with permanent surface water		associated with permanent open water
		one habitat type		two habitat types	X	three or more habitat types
		little or no interspersion of habitats		some habitat interspersion	X	habitats highly interspersed
		low plant diversity		moderate plant diversity	X	high plant diversity
		few, if any habitat features present		some habitat features present	X	several habitat features present
		adjacent buffers primarily disturbed and/or developed	X	buffers somewhat disturbed and/or developed	X	buffers generally undisturbed native vegetation and undeveloped
		few connections to other habitat types	X	some connection to other habitat types		significant connections to high quality habitat types
Evaluation:		Agricultural land or low vegetation structure		moderate vegetation structure	X	high vegetation structure
Erosion/Shoreline Protection		sparse grass/forbs or not vegetation	X	sparse woody vegetation or dense herb vegetation	X	dense woody vegetation
Evaluation:						

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 7 **Location:** Development off of SE 16th ST **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PSS **HGM Class:** Depressional Closed ?

Estimated Wetland Size (ac): <0.1 X 0.1-1 ___ 1-5 ___ 5-10 ___ >10 ___

Identified by: CH, CW **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [X] No [ ]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [X] g. other Residential development

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [X] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [X] e. residential development
- [ ] f. other Surrounding areas is being developed

Hydrology

Water sources and hydroperiod:

- [X] Ground water (perched water table, through flow…)
- [ ] Surface water
- [ ] Seep
- [X] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet:

- [X] a. constrained, size 12" pipe inlet
- [ ] b. unconstrained
- [ ] c. natural channel
- [X] d. none does not appear to have outlet
- [ ] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [ ] No [X]

Indicators of wetland hydrology: None observed

- [ ] a. inundation
- [X] b. saturated in upper 12" (surface)
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ___

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: SPDO, RULA, THPL, RUUR, Alopecurus spp., Agrostis, RUAR, other grasses

Invasive Species? Yes (%) X No

Approximate age of dominant woody vegetation (years)?	<50	X	50-80		>80	
# of habitat types:	1	X	2		≥ 3	
Degree of interspersion:	NA Low		Mod		High	

Vegetation connectivity to other habitats? Residential yards / development, few trees / forest

Food sources or habitat features for wildlife? Berries

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [X] No [ ]

- [X] a. grass-lawn
- [ ] b. herbaceous-native
- [ ] c. scrub-shrub
- [X] d. forested
- [ ] f. other ____

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [ ] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [X] No [ ]

- [ ] a. restoration
- [ ] b. creation
- [X] c. enhancement
- [ ] d. preservation

WL could be enhanced, but would likely not benefit much in regard to functions.

Notes:

Signage around WL demarcating WL / sensitive area.
Houses + roadway isolate WL from surrounding areas.
Receives surface water (during large storm events) from SCW pond across road to the S.

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 7 **Observer(s):** CH, CW **Date:** 12-03-08

FUNCTION		LOW RATING		MODERATE RATING		HIGH RATING
			CRITERIA			
Water Quality Improvement		rapid flow through wetland		moderate flow through wetland	X	little or no flow present
		<50% vegetation density		50-80% vegetation density	X	>80% vegetation density
		no proximity to pollutants	X	downstream from non-point pollutants		downstream from point discharges
Evaluation:		detains <25% overland runoff		detains 25-50% overland runoff	X	detains >50% overland runoff
Flood/Storm Water Control	X	size <5 acres		size 5-10 acres		size >10 acres
Evaluation:		riverine, shallow depression		mid-sloped wetland	X	lake, depressions, headwaters, bogs
Groundwater Recharge	X	size <5 acres		size 5-10 acres		size >10 acres
		temporarily saturated/inundated	X	seasonally saturated/inundated		permanently inundated
Evaluation:		springs present outflow>inflow		outflow=inflow	X	outflow<inflow
Natural Biological Support	X	size <5 acres		size 5-10 acres		size >10 acres
	X	isolated systems associated with ephemeral surface water		associated with permanent surface water		associated with permanent open water
	X	one habitat type		two habitat types		three or more habitat types
	X	little or no interspersion of habitats		some habitat interspersion		habitats highly interspersed
	X	low plant diversity		moderate plant diversity		high plant diversity
	X	few, if any habitat features present		some habitat features present		several habitat features present
		adjacent buffers primarily disturbed and/or developed	X	buffers somewhat disturbed and/or developed		buffers generally undisturbed native vegetation and undeveloped
	X	few connections to other habitat types		some connection to other habitat types		significant connections to high quality habitat types
Evaluation:	X	Agricultural land or low vegetation structure		moderate vegetation structure		high vegetation structure
Erosion/Shoreline Protection NA		sparse grass/forbs or not vegetation	X	sparse woody vegetation or dense herb vegetation		dense woody vegetation
Evaluation:						

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 8 **Location:** Development off of SE 16th ST **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PSS/PEM **HGM Class:** Depressional / Outflow

Estimated Wetland Size (ac): <0.1 ____ 0.1-1 ____ 1-5 ____ 5-10 ____ >10 X

Identified by: CH, CW **Photo No.** ____

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [X] No [ ]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [X] e. drainage ditches/diversions — ditches/channels likely created historically for pasture
- [ ] f. crop production
- [ ] g. other ____

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [X] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [X] e. residential development
- [ ] f. other ____

Hydrology

Water sources and hydroperiod:

- [X] Ground water (perched water table, through flow…)
- [X] Surface water — rec's overflow from SW pond to the NW
- [ ] Seep
- [X] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ____

Inlet/outlet:

- [X] a. constrained, size inlet 12" pipe from SW pond
- [ ] b. unconstrained
- [X] c. natural channel outlet
- [ ] d. none
- [ ] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [X] No [ ]

Indicators of wetland hydrology:

- [X] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [X] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ____

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ____

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Invasive Species? Yes (%) X No

PSS = SPDO, Salix spp. ALRU, PONI, PHAR, Agrostis, CRMO, Prunus spp. (ornamental)
PEM = JUEF, PHAR, grasses
Planted trees & shrubs along ditches / channels.

Approximate age of dominant woody vegetation (years)?	<50	X	50-80		>80	
# of habitat types:	1		2	X	≥ 3	
Degree of interspersion:	Low		Mod	X	High	

Vegetation connectivity to other habitats? ✓ meadow / herb., some ✓ forest

Food sources or habitat features for wildlife? Berries, ponded area

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [X] No [ ]

- [X] a. grass-lawn
- [X] b. herbaceous-native
- [ ] c. scrub-shrub
- [X] d. forested
- [ ] f. other ____

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [ ] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [X] No [ ]

- [ ] a. restoration
- [X] b. creation
- [X] c. enhancement
- [ ] d. preservation

Notes: Mitigation already completed along ditches / channels. Appears to be doing poorly - many dead plants. Still plenty of opportunity. WL continues outside development to the S., did not observe due to private property

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 8 **Observer(s):** CH, CW **Date:** 12-03-08

FUNCTION		LOW RATING		MODERATE RATING		HIGH RATING
Water Quality Improvement		rapid flow through wetland		moderate flow through wetland	X	little or no flow present
		<50% vegetation density		50-80% vegetation density	X	>80% vegetation density
		no proximity to pollutants	X	downstream from non-point pollutants SW pond overflow		downstream from point discharges
Evaluation:	X	detains <25% overland runoff		detains 25-50% overland runoff		detains >50% overland runoff
Flood/Storm Water Control		size <5 acres		size 5-10 acres	X	size >10 acres
Evaluation:		riverine, shallow depression		mid-sloped wetland	X	lake, depressions, headwaters, bogs
Groundwater Recharge		size <5 acres		size 5-10 acres	X	size >10 acres
		temporarily saturated/inundated	X	seasonally saturated/inundated		permanently inundated
Evaluation:		springs present outflow>inflow		outflow=inflow	X	outflow<inflow
Natural Biological Support		size <5 acres		size 5-10 acres	X	size >10 acres
	X	isolated systems associated with ephemeral surface water		associated with permanent surface water		associated with permanent open water
		one habitat type	X	two habitat types		three or more habitat types
		little or no interspersion of habitats	X	some habitat interspersion		habitats highly interspersed
		low plant diversity	X	moderate plant diversity		high plant diversity
	X	few, if any habitat features present		some habitat features present		several habitat features present
		adjacent buffers primarily disturbed and/or developed	X	buffers somewhat disturbed and/or developed		buffers generally undisturbed native vegetation and undeveloped
	X	few connections to other habitat types		some connection to other habitat types		significant connections to high quality habitat types
Evaluation:		Agricultural land or low vegetation structure	X	moderate vegetation structure		high vegetation structure
Erosion/Shoreline Protection NA		sparse grass/forbs or not vegetation	X	sparse woody vegetation or dense herb vegetation		dense woody vegetation
Evaluation:						

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 9 **Location:** SE 13th Place **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PEM **HGM Class:** Depressional Closed

Estimated Wetland Size (ac): <0.1 X 0.1-1 ___ 1-5 ___ 5-10 ___ >10 ___

Identified by: CH, CW **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [X]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ___

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [X] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [ ] e. residential development
- [X] f. other located in residential lawn area / maintained

Hydrology

Water sources and hydroperiod:

- [X] Ground water (perched water table, through flow…)
- [ ] Surface water
- [ ] Seep
- [X] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet:

- [ ] a. constrained, size___
- [ ] b. unconstrained
- [ ] c. natural channel
- [X] d. none no inlet/outlet observed
- [ ] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [ ] No [X]

Indicators of wetland hydrology:

- [X] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ___

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Invasive Species? Yes (%) X No ___

TYLA, SPDO, PHAR

Approximate age of dominant woody vegetation (years)? N	<50	X	50-80		>80	
# of habitat types:	1	X	2		≥ 3	
Degree of interspersion:	Low	X	Mod		High	

Vegetation connectivity to other habitats? Some connection to ~ forest

Food sources or habitat features for wildlife? Standing water

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [X] No [ ]

- [X] a. grass-lawn
- [ ] b. herbaceous-native
- [ ] c. scrub-shrub
- [X] d. forested
- [ ] f. other ___

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [ ] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [X] No [ ]

- [X] a. restoration
- [X] b. creation
- [X] c. enhancement
- [ ] d. preservation

Opportunity limited due to location on private residential parcel

Notes:

Small linear depression in lawn of residential parcel.

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 9 **Observer(s):** CH, CA **Date:** 12-03-08

FUNCTION		CRITERIA: LOW RATING		MODERATE RATING		HIGH RATING
Water Quality Improvement		rapid flow through wetland		moderate flow through wetland	X	little or no flow present
		<50% vegetation density	X	50-80% vegetation density		>80% vegetation density
		no proximity to pollutants	X	downstream from non-point pollutants fertilizer/lawn		downstream from point discharges
Evaluation:		detains <25% overland runoff		detains 25-50% overland runoff	X	detains >50% overland runoff
Flood/Storm Water Control	X	size <5 acres		size 5-10 acres		size >10 acres
Evaluation:		riverine, shallow depression		mid-sloped wetland	X	lake, depressions, headwaters, bogs
Groundwater Recharge	X	size <5 acres		size 5-10 acres		size >10 acres
		temporarily saturated/inundated		seasonally saturated/inundated	X	permanently inundated
Evaluation:		springs present outflow>inflow		outflow=inflow	X	outflow<inflow no flow
Natural Biological Support	X	size <5 acres		size 5-10 acres		size >10 acres
	X	no association isolated systems associated with ephemeral surface water		associated with permanent surface water		associated with permanent open water
	X	one habitat type		two habitat types		three or more habitat types
	X	little or no interspersion of habitats		some habitat interspersion		habitats highly interspersed
	X	low plant diversity		moderate plant diversity		high plant diversity
	X	few, if any habitat features present		some habitat features present		several habitat features present
	X	adjacent buffers primarily disturbed and/or developed		buffers somewhat disturbed and/or developed		buffers generally undisturbed native vegetation and undeveloped
	X	few connections to other habitat types		some connection to other habitat types		significant connections to high quality habitat types
Evaluation:	X	Agricultural land or low vegetation structure		moderate vegetation structure		high vegetation structure
Erosion/Shoreline Protection NA		sparse grass/forbs or not vegetation	X	sparse woody vegetation or dense herb vegetation		dense woody vegetation
Evaluation:						

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 10 **Location:** 223rd Ave SE + Lancaster Way ROW **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PEM / PSS **HGM Class:** Depressional Outflow

Estimated Wetland Size (ac): <0.1 ___ 0.1-1 X ? 1-5 ___ 5-10 ___ >10 ___

Identified by: CH, CW **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [X] No [ ]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [X] e. drainage ditches/diversions linear ditch /channel
- [ ] f. crop production
- [ ] g. other ___

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [X] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [ ] e. residential development
- [X] f. other in road ROW

Hydrology

Water sources and hydroperiod:

- [ ] Ground water (perched water table, through flow…)
- [X] Surface water
- [ ] Seep
- [X] Seasonally flooded/saturated
- [ ] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet: outlet pipe to ditch along 223rd

- [X] a. constrained, size___
- [ ] b. unconstrained
- [ ] c. natural channel
- [ ] d. none
- [ ] e. could not locate

Inlet - likely SW from ponds uphill + possibly groundwater

Hydrologic connectivity to other wetlands and streams? Yes [X] No [ ]

Indicators of wetland hydrology:

- [X] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ___

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: ______ Invasive Species? Yes (%) X No ___

PEM = PHAR

PSS = ALRU, PHAR

Approximate age of dominant woody vegetation (years)?	<50	X	50-80		>80	
# of habitat types:	1		2	X	≥ 3	
Degree of interspersion:	Low	X	Mod		High	

Vegetation connectivity to other habitats? No

Food sources or habitat features for wildlife? No

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes ☐ No ☐

- ☒ a. grass-lawn
- ☐ b. herbaceous-native
- ☐ c. scrub-shrub
- ☐ d. forested
- ☐ f. other ______

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- ☐ a. % no buffer
- ☐ b. % <25 ft
- ☐ c. % 25-50 ft
- ☐ d. % 50-100 ft
- ☐ e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes ☐ No ☒

- ☐ a. restoration
- ☐ b. creation
- ☐ c. enhancement
- ☐ d. preservation

In road ROW

Notes:

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 10 **Observer(s):** CH, CW **Date:** 12-03-08

FUNCTION	LOW RATING	MODERATE RATING	HIGH RATING
Water Quality Improvement	___ rapid flow through wetland	X moderate flow through wetland	___ little or no flow present
	___ <50% vegetation density	___ 50-80% vegetation density	X >80% vegetation density
	___ no proximity to pollutants	X downstream from non-point pollutants	___ downstream from point discharges
Evaluation:	X detains <25% overland runoff	___ detains 25-50% overland runoff	___ detains >50% overland runoff
Flood/Storm Water Control	X size <5 acres	___ size 5-10 acres	___ size >10 acres
Evaluation:	X riverine, shallow depression linear, outflow	___ mid-sloped wetland	___ lake, depressions, headwaters, bogs
Groundwater Recharge	X size <5 acres	___ size 5-10 acres	___ size >10 acres
	___ temporarily saturated/inundated	X seasonally saturated/inundated	___ permanently inundated
Evaluation:	___ springs present outflow>inflow	X outflow=inflow	___ outflow<inflow
Natural Biological Support	X size <5 acres	___ size 5-10 acres	___ size >10 acres
	X isolated systems associated with ephemeral surface water	___ associated with permanent surface water	___ associated with permanent open water
	___ one habitat type	X two habitat types	___ three or more habitat types
	X little or no interspersion of habitats	___ some habitat interspersion	___ habitats highly interspersed
	X low plant diversity	___ moderate plant diversity	___ high plant diversity
	X few, if any habitat features present	___ some habitat features present	___ several habitat features present
	X adjacent buffers primarily disturbed and/or developed	___ buffers somewhat disturbed and/or developed	___ buffers generally undisturbed native vegetation and undeveloped
	X few connections to other habitat types	___ some connection to other habitat types	___ significant connections to high quality habitat types
Evaluation:	X Agricultural land or low vegetation structure	___ moderate vegetation structure	___ high vegetation structure
Erosion/Shoreline Protection NA	___ sparse grass/forbs or not vegetation	X sparse woody vegetation or dense herb vegetation	___ dense woody vegetation
Evaluation:			

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 11 **Location:** N. of Lancaster. **Date:** 12-03-08

Sub-basin: Thompson **Cowardin Class:** PFO/PSS/PEM **HGM Class:** Depressional/ Outflow

Estimated Wetland Size (ac): <0.1 ____ 0.1-1 ____ 1-5 ____ 5-10 X >10 ____

Identified by: CH, CW **Photo No.** ____

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [X]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ____

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [X] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [X] e. residential development (some)
- [ ] f. other ____

Hydrology

Water sources and hydroperiod:

- [X] Ground water (perched water table, through flow…)
- [X] Surface water (tributary)
- [ ] Seep
- [X] Seasonally flooded/saturated
- [X] Permanently flooded/saturated
- [ ] Other ____

Inlet/outlet:

- [ ] a. constrained, size____
- [ ] b. unconstrained
- [X] c. natural channel (trib) also receives SW from SWpond.
- [ ] d. none
- [ ] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [X] No [ ]

Indicators of wetland hydrology:

- [X] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [X] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ____

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: ____

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: Invasive Species? Yes (%) X No

PFO = SPDO, TYLA

PSS = ALRU, RUAR, TYLA, Salix spp.

PEM = PHAR, TYLA, other grasses

Approximate age of dominant woody vegetation (years)?	<50	X	50-80		>80	
# of habitat types:	1		2		≥3	X
Degree of interspersion:	Low		Mod	X	High	

Vegetation connectivity to other habitats? ✓ herbaceous, ✓ forest

Food sources or habitat features for wildlife? standing water

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [ ] No [ ]

- [ ] a. grass-lawn
- [X] b. herbaceous-native
- [X] c. scrub-shrub
- [X] d. forested
- [ ] f. other ____

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [ ] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [X] No [ ]

- [ ] a. restoration
- [X] b. creation
- [X] c. enhancement
- [X] d. preservation

Notes:

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 11 **Observer(s):** CH, CW **Date:** 12-03-08

FUNCTION		LOW RATING		MODERATE RATING		HIGH RATING
Water Quality Improvement	___	rapid flow through wetland	X	moderate flow through wetland	___	little or no flow present
	___	<50% vegetation density	___	50-80% vegetation density	X	>80% vegetation density
	___	no proximity to pollutants	X	downstream from non-point pollutants	___	downstream from point discharges
Evaluation:	___	detains <25% overland runoff	X	detains 25-50% overland runoff	___	detains >50% overland runoff
Flood/Storm Water Control	___	size <5 acres	X	size 5-10 acres	___	size >10 acres
Evaluation:	___	riverine, shallow depression	___	mid-sloped wetland	X	lake, depressions, headwaters, bogs
Groundwater Recharge	___	size <5 acres	X	size 5-10 acres	___	size >10 acres
	___	temporarily saturated/inundated	X	seasonally saturated/inundated	X	permanently inundated
Evaluation:	___	springs present outflow>inflow	___	outflow=inflow	___	outflow<inflow
Natural Biological Support	___	size <5 acres	X	size 5-10 acres	___	size >10 acres
	___	isolated systems associated with ephemeral surface water	X	associated with permanent surface water (may be seasonal trib)	___	associated with permanent open water
	___	one habitat type	___	two habitat types	X	three or more habitat types
	___	little or no interspersion of habitats	X	some habitat interspersion	___	habitats highly interspersed
	___	low plant diversity	X	moderate plant diversity	___	high plant diversity
	___	few, if any habitat features present	X	some habitat features present	___	several habitat features present
	___	adjacent buffers primarily disturbed and/or developed	X	buffers somewhat disturbed and/or developed	___	buffers generally undisturbed native vegetation and undeveloped
	___	few connections to other habitat types	X	some connection to other habitat types	___	significant connections to high quality habitat types
Evaluation:	___	Agricultural land or low vegetation structure	X	moderate vegetation structure	___	high vegetation structure
Erosion/Shoreline Protection	___	sparse grass/forbs or not vegetation	X	sparse woody vegetation or dense herb vegetation	X	dense woody vegetation
Evaluation:						

Sammamish Basin Plans
Wetland Field Data Form

Wetland No: 12 **Location:** E of 216, SE 8th crosses wl. **Date:** Dec. 4/08

Sub-basin: Thompson **Cowardin Class:** PSS **HGM Class:** Riverine

Estimated Wetland Size (ac): <0.1 ___ 0.1-1 ___ 1-5 ✓ 5-10 ___ >10 ___

Identified by: ___ **Photo No.** ___

Wetland Condition

Evidence of hydrologic alterations? If yes, indicate type. Yes [ ] No [✓]

- [ ] a. dredging
- [ ] b. filling
- [ ] c. draining
- [ ] d. clearing
- [ ] e. drainage ditches/diversions
- [ ] f. crop production
- [ ] g. other ___

Apparent impacts/threats to wetland from human use? If yes, indicate type. Yes [✓] No [ ]

- [ ] a. clearing
- [ ] b. grazing/agriculture
- [ ] c. litter
- [ ] d. recreational overuse
- [✓] e. residential development
- [ ] f. other ___

Hydrology

Water sources and hydroperiod:

- [ ] Ground water (perched water table, through flow…)
- [✓] Surface water
- [ ] Seep
- [✓] Seasonally flooded/saturated
- [✓] Permanently flooded/saturated
- [ ] Other ___

Inlet/outlet:

- [ ] a. constrained, size___
- [ ] b. unconstrained
- [ ] c. natural channel
- [ ] d. none
- [✓] e. could not locate

Hydrologic connectivity to other wetlands and streams? Yes [✓] No [ ]

Indicators of wetland hydrology:

- [✓] a. inundation
- [ ] b. saturated in upper 12"
- [ ] c. water marks
- [ ] d. drift lines
- [ ] e. sediment deposits
- [ ] f. drainage patterns in wetlands
- [ ] h. water-stained leaves
- [ ] i. other ___

Soil

Is the wetland mapped on hydric soil? Yes [ ] No [ ]

Soil profile: —

Sammamish Basin Plans
Wetland Field Data Form

Vegetation

Dominant Species: RUSP, ALRU, POBA, RUAR, [illegible]

Invasive Species? Yes (%) 50-80 No ___

Approximate age of dominant woody vegetation (years)?	<50	✓	50-80		>80	
# of habitat types:	1	✓	2		≥ 3	
Degree of interspersion:	Low	✓	Mod		High	

Vegetation connectivity to other habitats?

Food sources or habitat features for wildlife?

Buffer

Does the wetland have a buffer anywhere along its perimeter? Yes [✓] No [ ]

- [ ] a. grass-lawn
- [✓] b. herbaceous-native
- [ ] c. scrub-shrub
- [ ] d. forested
- [ ] f. other ___

If yes, what percentage of the wetland edge is protected by buffers of the width categories listed below? (Note: total should add to 100%)

- [ ] a. % no buffer
- [ ] b. % <25 ft
- [80] c. % 25-50 ft
- [ ] d. % 50-100 ft
- [ ] e. %>100 ft

Mitigation Opportunities

Are any mitigation opportunities present nearby? Yes [✓] No [ ]

- [✓] a. restoration
- [ ] b. creation
- [ ] c. enhancement
- [ ] d. preservation

Notes:

Sammamish Basin Plans
Rapid Qualitative Function Assessment Form

Wetland No. 12. **Observer(s):** CH, EC. **Date:** Dec 4/08.

FUNCTION	LOW RATING	MODERATE RATING	HIGH RATING
Water Quality Improvement	rapid flow through wetland	✓ moderate flow through wetland	little or no flow present
	<50% vegetation density	50-80% vegetation density	✓ >80% vegetation density
	no proximity to pollutants	✓ downstream from non-point pollutants	downstream from point discharges
Evaluation:	detains <25% overland runoff	✓ detains 25-50% overland runoff	detains >50% overland runoff
Flood/Storm Water Control	✓ size <5 acres	size 5-10 acres	size >10 acres
Evaluation:	riverine/shallow depression	mid-sloped wetland	lake, depressions, headwaters, bogs
Groundwater Recharge	✓ size <5 acres	size 5-10 acres	size >10 acres
	temporarily saturated/inundated	✓ seasonally saturated/inundated	permanently inundated
Evaluation:	springs present outflow>inflow	✓ outflow=inflow	outflow<inflow
Natural Biological Support	✓ size <5 acres	size 5-10 acres	size >10 acres
	isolated systems associated with ephemeral surface water	✓ associated with permanent surface water	associated with permanent open water
	✓ one habitat type	two habitat types	three or more habitat types
	✓ little or no interspersion of habitats	some habitat interspersion	habitats highly interspersed
	✓ low plant diversity	moderate plant diversity	high plant diversity
	few, if any habitat features present	✓ some habitat features present	several habitat features present
	adjacent buffers primarily disturbed and/or developed	✓ buffers somewhat disturbed and/or developed	buffers generally undisturbed native vegetation and undeveloped
	few connections to other habitat types	✓ some connection to other habitat types	significant connections to high quality habitat types
Evaluation:	Agricultural land or low vegetation structure	✓ moderate vegetation structure	high vegetation structure
Erosion/Shoreline Protection	sparse grass/forbs or not vegetation	sparse woody vegetation or dense herb vegetation	✓ dense woody vegetation
Evaluation:			

APPENDIX D

Field Data Comparison – 1990 and 2008

Table D-1. Comparison of Conditions in Ebright Creek (1990 and 2008)

KC Subcatchment	PMX Subcatchment	Approx. RM	1990 Description of Conditions (King County)	2008 Description of Conditions (Parametrix)
T-1	T-01	0 - 0.04	Railroad berm crossing, 36 " concrete pipe and 36" CMP. Open channel at outlet to Lake Sammamish	Narrow channel at lake, (3' BFW, 2' BFD) Gravel substrate is 2-3" dia at mouth, very sandy about 50' upstream, then gravel again
T-1	T-01	0.01		Placed logs in channel, ELST crossing 2 (36"dia) culverts
T-1	T-01	0.08	E. lake Sammamish Parkway Crossing (2) 36" concrete pipe, HW/D approx 2.5. 50% filled with sediment	36" concrete culvert under ELSP, skewed to SW under road. BFW~8', BFD`2' just upstream of culvert Lots of sand deposits over gravel.
T-1	T-01	0.1		Several redds upstream of ELSP, observed a pair of Kokanee salmon (12/3/08). Wetland area, stream is somewhat braided in this area, lots of sediment, overbank flow.
T-1	T-01	0.1	Sampling site ELSWQB. TSS, turbidity, TP, fecal coliform, copper, and zinc concentrations were elevated in the 4/23/90 storm. TP was 0.12 mg/L. The lack of extremely high fecal coliform numbers suggests residential and not agricultural activities are the likely source of this high storm TP concentration.	Culvert at private propoerty 24" under hot tub on creek. Flow gage at footbridge over creek.
T-1	T-02	0.3- 0.60	Very good fish habitat. Stream corridor is in excellent conditions	Stream in good condition- forested, gravel and cobble substrate. BFW~ 21', BFD`1.8'
T-1	T-02	0.3 - 0.95	No major problems identified in this reach. Wetland #1517 at middle of subbasin buffer current flow levels.	
T-1	T-03	0.35 - 0.55	Wetlands adjacent to the stream channel. Seeps and springs increase baseflow. Wetland area provides buffer to flood flows via channel and floodplain storage and energy dissipation.	
T-1	T-03	0.4, left bank trib RM 0 - 0.2	Channel formed in swale is shallow (<12" depth) in wetland corridor. No signs of channel incision. Very dense vegetation canopy dominated by blackberry. Upland devleopmentn is forest with pasture clearings.	
T-1	T-03	0.4	Sewer trunk line clearning to edge of stream. Cut timber and slash dumped in tributary ravine at confulence with tributary 0149	
T-1	T-03	0.5		Right bank landslide in clay/silt unit (20'x20'x12') directly into stream channel. Lots of seeps upslope of slide
T-1	T-03	0.4 - 0.6	Left bank landslide (at 0.6, 15' X 36' x 3') and bank erosion.	
T-1	T-03	0.55 - 0.95	Channel bank erosion and downcutting pronounced. Slope failures extend up slope to spring areas. Steep-sloped ravine prone to slope failure and slides. Slope failures on the left bank have formed two large debris jams.	Lots of seeps both sides of channel in laminated clay and silt units, and above.
T-1	T-03	0.65		Contact between clay and outwash above. Channel width is about 40', less flow, smaller cobbles.

Table D-1. Comparison of Conditions in Ebright Creek (1990 and 2008)

KC Subcatchment	PMX Subcatchment	Approx. RM	1990 Description of Conditions (King County)	2008 Description of Conditions (Parametrix)
T-1	T-03	0.65	Residential garbage dumping occurring off top of ravine on left bank.	
T-1	T-03	0.85		Slide areas on right bank
T-1	T-03	0.9		Leftbank slide area (30'x40'x5'), Trash rack on right bank, energy dissipation/pipe and outlet structure from construction site.
T-1	T-03	1		Flagging in stream channel
T-1	T-04	1.15		30" CMP culvert at SE 12th road crossing, 12" HDPE stormpipe above coming off roadway
T-1	T-04	1.25		Stream channel through park, flat, in glacial till, very minor gravel
T-2	T-04	0.95 - 1.25	Lack of vegetative bank cover and canopy. Livestock are eroding streambank. Channelization of stream channel appears cleaved of vegetation to increase conveyance capacity.	
T-2	T-04	0.95- 1.15	Channel altered in portions. Gradient relatively lflat. Erosion is minimal.	
T-3	T-05	1.7	On 217th Ave NE near the end of the cul-de-sac (1441 217th SE, Lamson), there are three horses in an over-used, muddy pasture.	
T-2 and T-3	T-05	1.25 - 1.85	Wetland #17 is controlled by outlet channel invert elevation, local depression. 212th Ave SE crossing at midpoint of wetland. Roadway culverts silt in frequently. Backwater on culverts and sediment deposition limit conveayance capacity. Road flooding potential annually.	
T-3	T-05	1.33	Wetland #1517 acts as buffer to minimize impacts from current flow levels.	
T-3	T-05	1.33 - 1.7	Forested wetland attenuates increases in flows from development in headwater areas. Encroachment has occurred from recent development.	
T-3	T-05	1.33+	Four existing wetlands and buffer areas need preservation.	
T-3	T-08	2.25	Tributary inflow to Wetland #17. Culvert crossing twin CMP at SE 8th Street. Buffer to stream channel reduced. Wetland area preserved at headwater.	Much of flow is coming from ditch along SE 8th street into stream channel (1/4 of total)
T-3	T-08	2.3		Very slow flow, wide channel (15- 20' by 1/2' deep), lots of vegetation, mucky wetland-like
T-3	T-09	2.5		Two 3'dia culverts under old road leading from Wetland 61
T-3	T-09	Wetland 17	Building occurred up to the wetland edge.	

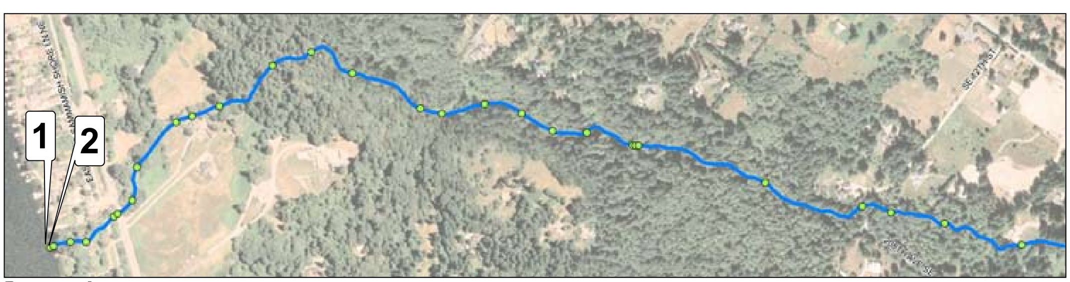
Ebright Creek Existing Conditions (2008) compared to 1990 King County Documented Conditions
Ebright Creek is referred to as Tributary 0149 in King County Existing Conditions Report

APPENDIX E

Photo Logs

Station 1. Mouth of Ebright Creek at Lake Sammamish.

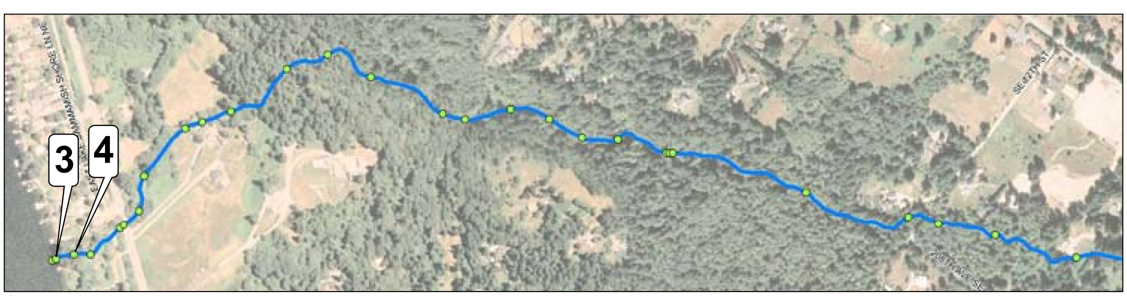
Station 2. Ebright Creek 10 feet upstream from Lake Sammamish.



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 3. Ebright Creek 100 feet upstream from Lake Sammamish.

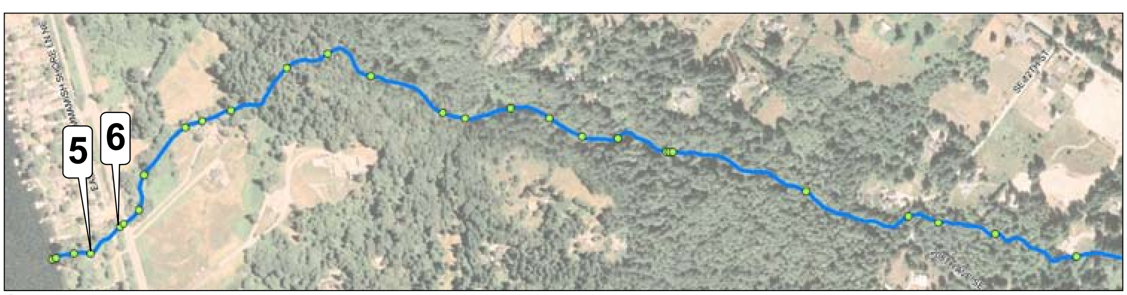
Station 4. Ebright Creek 189 feet upstream from Lake Sammamish.



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 5. Ebright Creek 413 feet upstream from Lake Sammamish at the trail crossing.

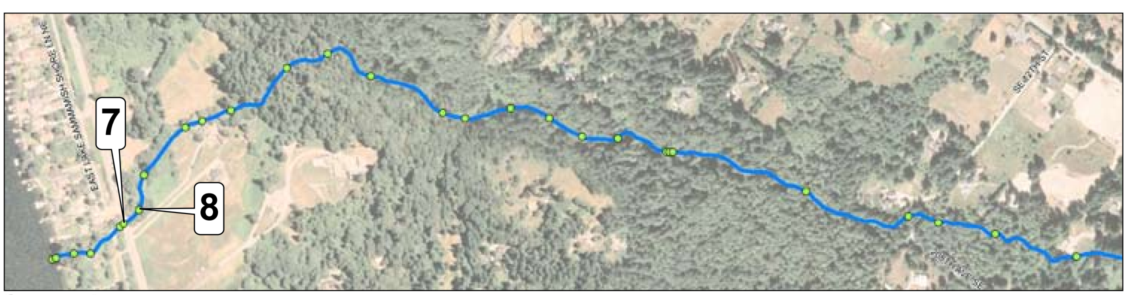
Station 6. Ebright Creek 435 feet upstream from Lake Sammamish at the Parkway.



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 7. Ebright Creek 550 feet upstream from Lake Sammamish.

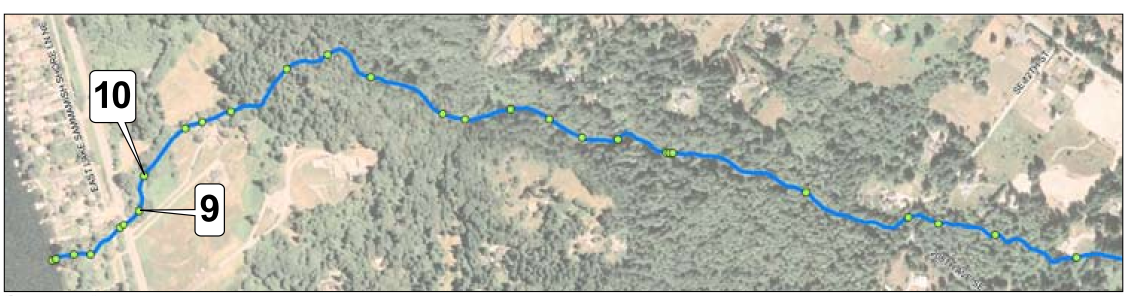
Station 8. Ebright Creek 745 feet upstream from Lake Sammamish.



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 9. Ebright Creek kokanee spawning 745 feet upstream from Lake Sammamish.

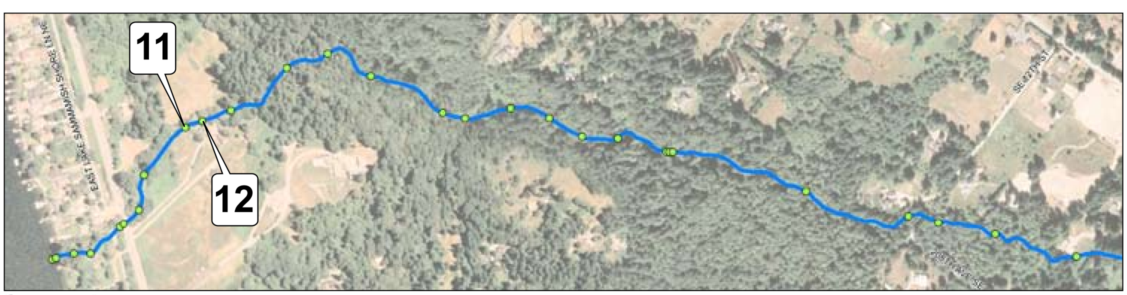
Station 10. Ebright Creek 1100 feet upstream from Lake Sammamish (looking downstream).



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 11. Ebright Creek 1200 feet upstream from Lake Sammamish.

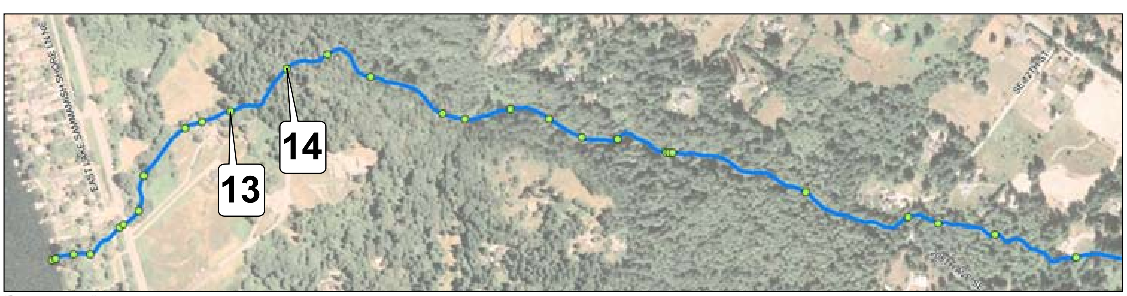
Station 12. Ebright Creek 1365 feet upstream from Lake Sammamish.



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 13. Ebright Creek 1775 feet upstream from Lake Sammamish.

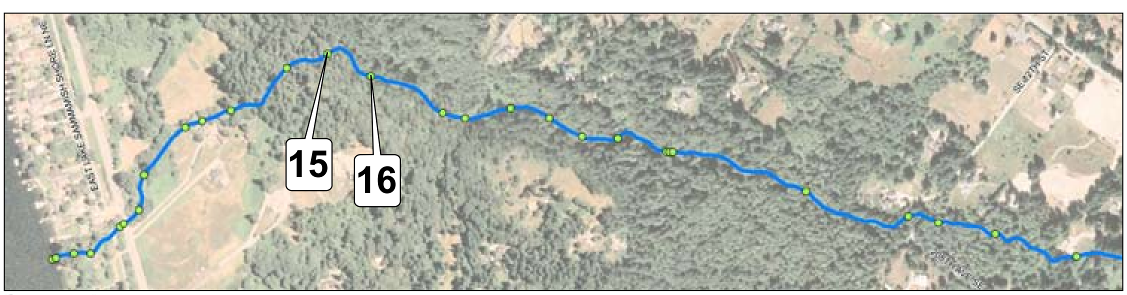
Station 14. Ebright Creek 2015 feet upstream from Lake Sammamish.



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 15. Ebright Creek 2325 feet upstream from Lake Sammamish.

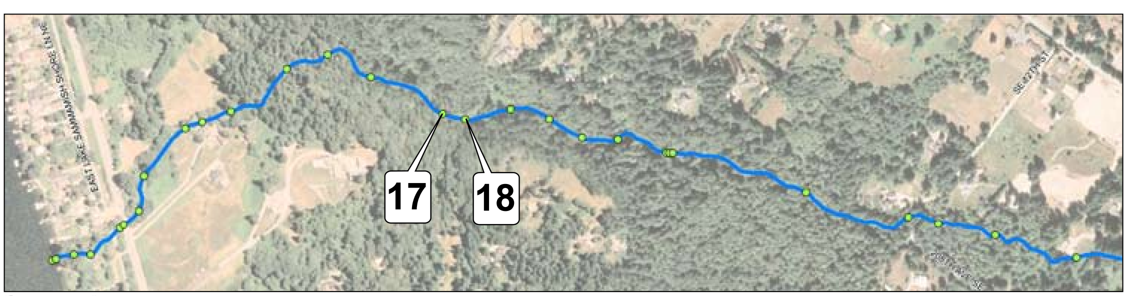
Station 16. Ebright Creek 2775 feet upstream from Lake Sammamish.



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 17. Small slide in clay layer on right bank 2900 feet upstream from Lake Sammamish.

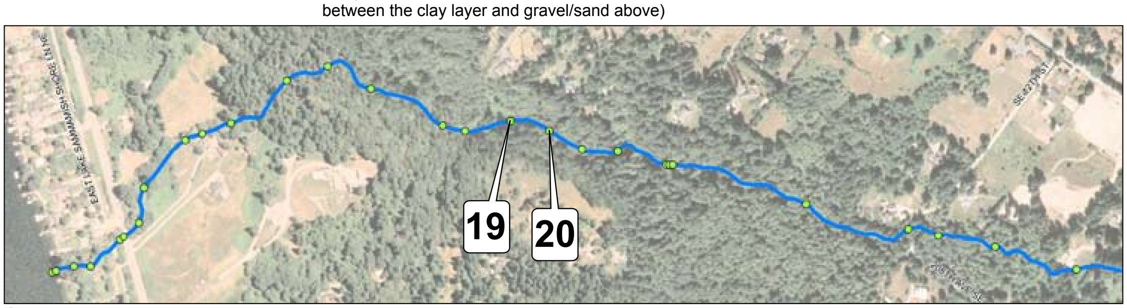
Station 18. Ebright Creek 3150 feet upstream from Lake Sammamish.



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 19. Ebright Creek 3375 feet upstream from Lake Sammamish.

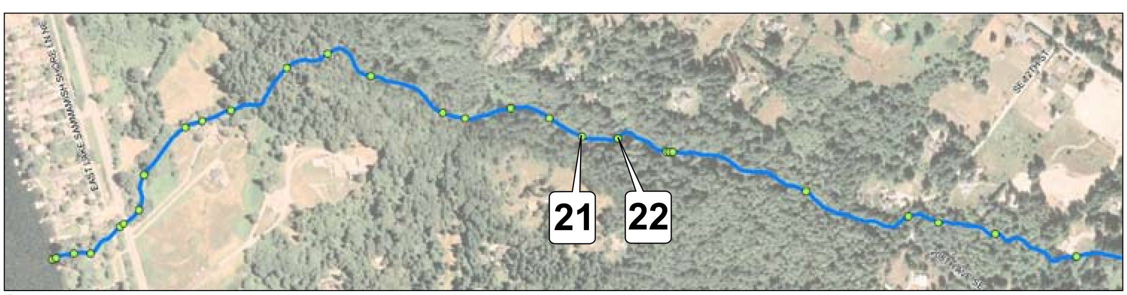
Station 20. Ebright Creek 3575 feet upstream from Lake Sammamish. (note the contact between the clay layer and gravel/sand above)



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 21. Ebright Creek 3775 feet upstream from Lake Sammamish.

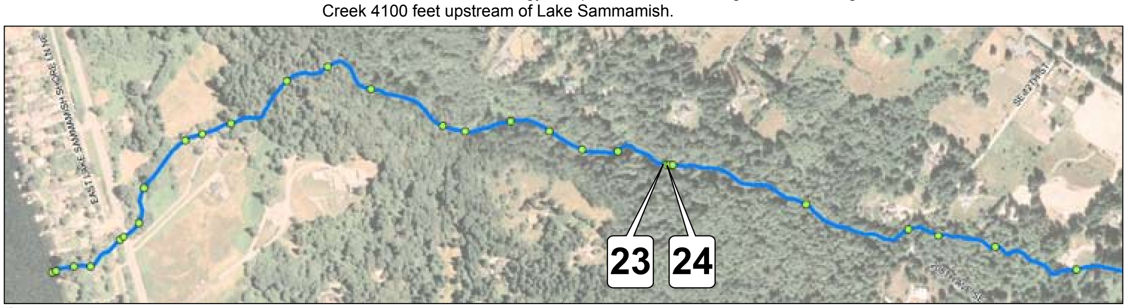
Station 22. Ebright Creek 4075 feet upstream from Lake Sammamish.



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 23. Seepage in glacial outwash (sand/gravel) 4080 feet upstream of Lake Sammamish.

Station 24. Stormwater outfall and energy dissipation structure on right bank of Ebright Creek 4100 feet upstream of Lake Sammamish.



Parametrix 558-3847-002/01(07) 5/09 (B)

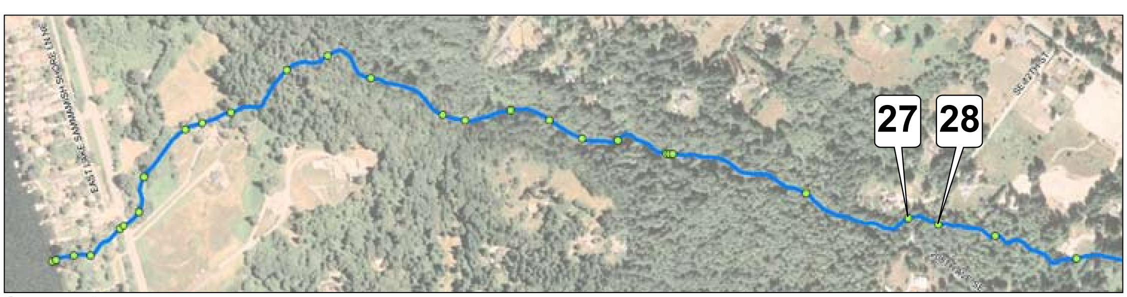
Station 25. Ebright Creek 4875 feet upstream from Lake Sammamish.

Station 26. Ebright Creek culvert at SE 12th Street 5500 feet upstream from Lake Sammamish.

Parametrix 558-3847-002/01(07) 5/09 (B)

Station 27. Ebright Creek 5675 feet upstream from Lake Sammamish.

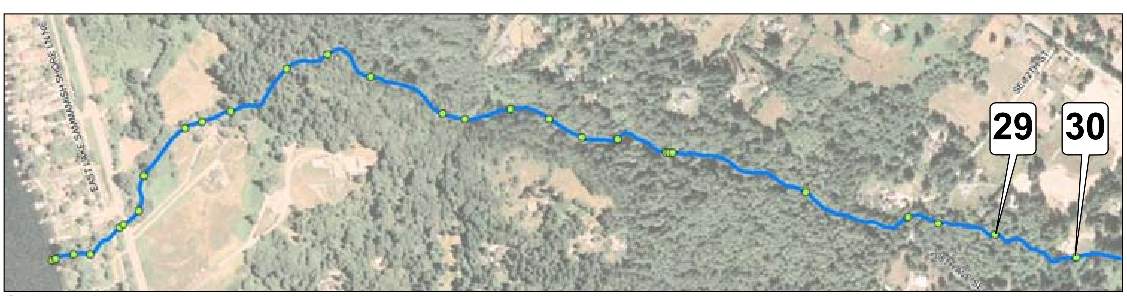
Station 28. Ebright Creek 6000 feet upstream from Lake Sammamish.



Parametrix 558-3847-002/01(07) 5/09 (B)

Station 29. Ebright Creek 6500 feet upstream from Lake Sammamish.

Station 30. Ebright Creek 6720 feet upstream from Lake Sammamish (Ebright Creek Park).



Parametrix 558-3847-002/01(07) 5/09 (B)

APPENDIX F

Specific Conceptual Project Alternatives

Thompson Basin Plan
Project Description

Project Number: Cons-1

Project Name: Acquire Property with High Natural Resources Value

Description: Acquire through conservation easements or direct purchase, large undeveloped mostly forested parcels located in areas of recessional outwash for conservation, restoration and mitigation of wetland and stream impacts, and future parks and open space.

Purpose: Protect shallow aquifers that are easily recharged through surface water infiltration, provide buffer to high quality wetland from adjacent development.

Project Benefits: Continued deep aquifer recharge from shallower zones.

Assumptions: This is a long-term strategy that would need to be coordinated with other city departments, conservancy groups, and citizens. It would also need to be evaluated relative to other high value natural resources within the City of Sammamish.

Estimated Cost: $87,000 per acre

Project Partners: Sammamish Parks Department, Sammamish Water and Sewer District, Conservancy Groups, Private Citizens

Priority: High

Thompson Sub-basin Plan
Project Description

Project Number: Culv-1

Project Name: Replace Ebright Creek Culvert

Description: Replace existing culvert on the Pereyra property with a 12’ x 4’ box culvert

Purpose: Improve fish passage for kokanee salmon

Project Benefits: Access to upstream spawning areas

Assumptions: Private property owner is a willing participant in the culvert replacement. Existing patio will be reconstructed following culvert replacement. Stream restoration will also be conducted as part of this project.

Estimated Cost: $118,000

Project Partners: Private property owner, granting agencies

Priority: High

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Thompson Basin Plan
Preliminary Opinion of Probable Cost

Draft

Project Name: Replacement of Pereyra Property Culvert
Prepared By: Kelli Yamamoto **Checked By:** Rebecca Cushman

Item No.	Estimated Quantity	Unit	Description	Unit Cost	Amount	Percent of Construction Cost
1	1	LS	Mobilization	$3,700.00	$3,700	6.57%
2	1	LS	Restoration	$800.00	$800	1.42%
3	1	LS	12 x 4 Box Culvert	$20,000.00	$20,000	35.52%
4	130	LF	Stream Restoration	$200.00	$26,000	46.18%
5	1	LS	Rebuild Patio	$4,000.00	$4,000	7.10%
6	80	CY	Structure Excavation Class B Incl Haul	$10.00	$800	1.42%
7	1	LS	Removal of Structures and Obstructions	$1,000.00	$1,000.00	1.78%
				Subtotal =	**$56,300**	100.00%
			Contingency	30.0%	$16,890	
			Sales Tax	8.8%	$4,954	
			Planning Level Construction Cost =		**$78,100**	
		AC	Property Acquisition		$0.00	
			Environmental Permitting and Documentation	10.0%	$7,810	
			Surveying	5.9%	$4,574	
			Administration	5.0%	$3,905	
	Preliminary Engineering, PS&E Engineering and Construction Management			30.0%	$23,430	
				TOTAL =	**$118,000**	

ASSUMPTIONS:
Mobilization equals approximately 7-percent of Subtotal
Restoration equals approximately 1-percent of Subtotal
Erosion/Sedimentation Control equals approximately 1-percent of Subtotal ($500 minimum)
Culvert size and length is estimated only
Stream Restoration includes streambed mix and grading of stream

Parametrix 558-3847-002/01(07) 6/10 (B)

NO SCALE

Figure Culv-1(a)
Aerial Photo Pereyra Property with Ebright Creek

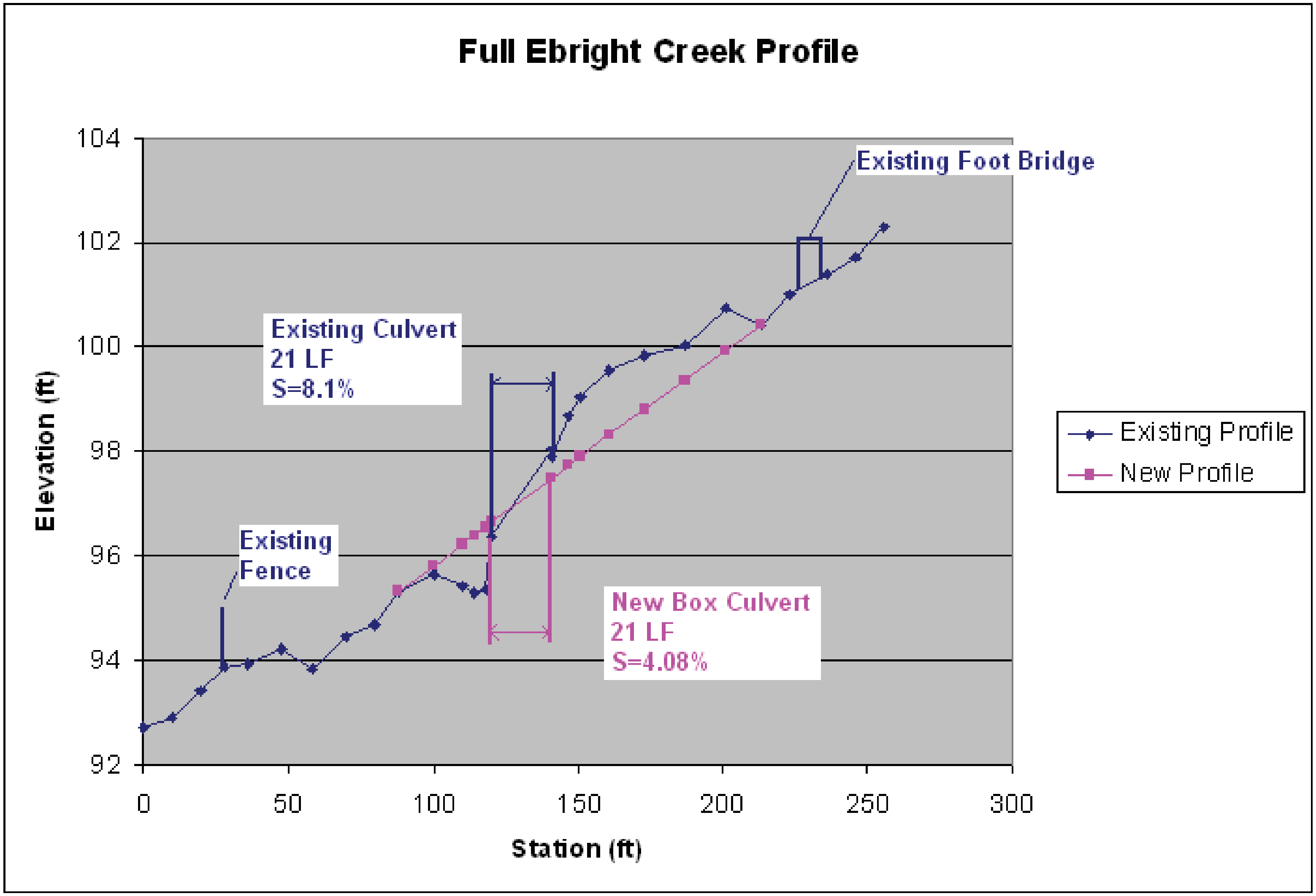


Figure Culv-1(b)
Proposed Box Culvert/Stream Profile Pereyra Property

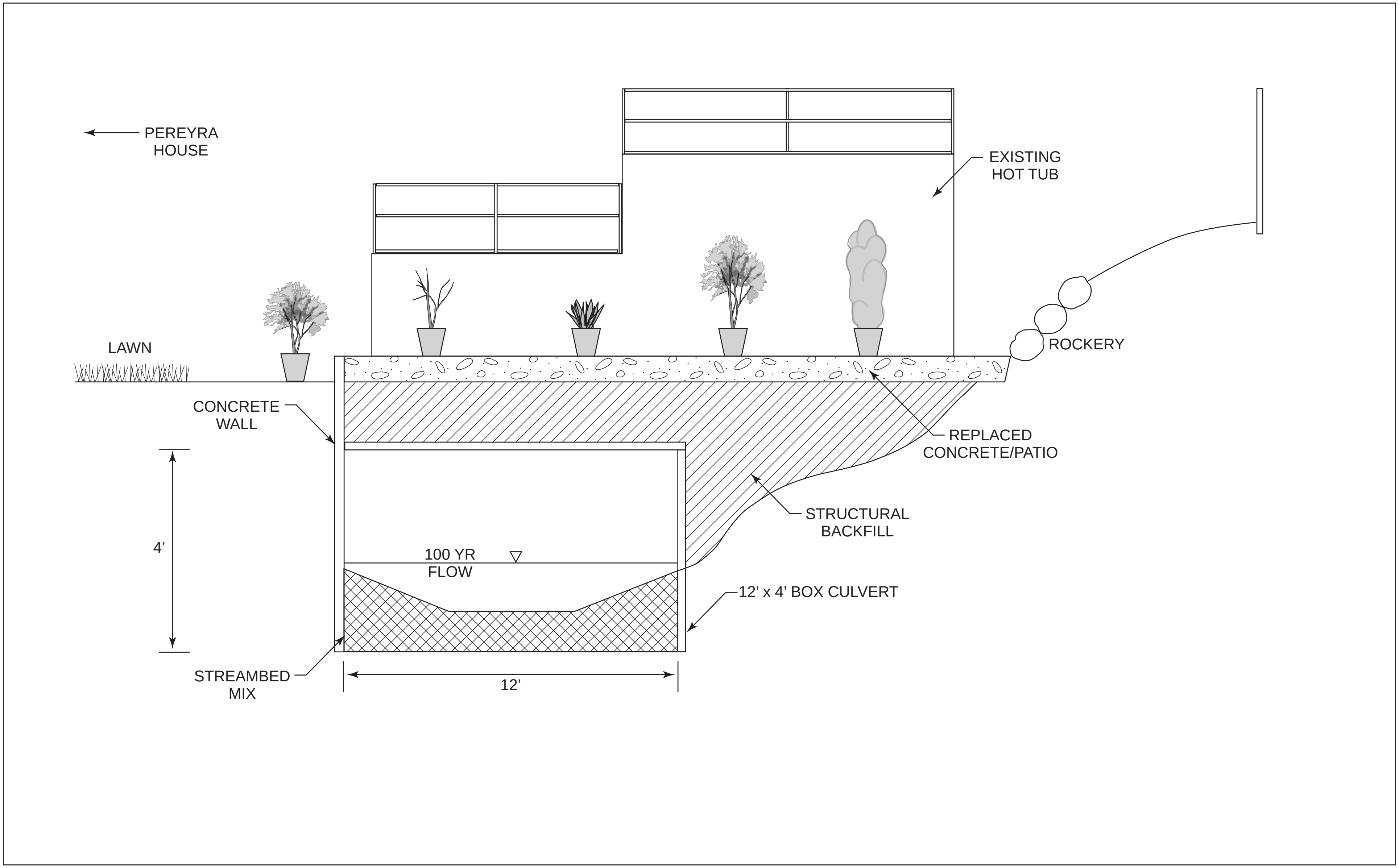
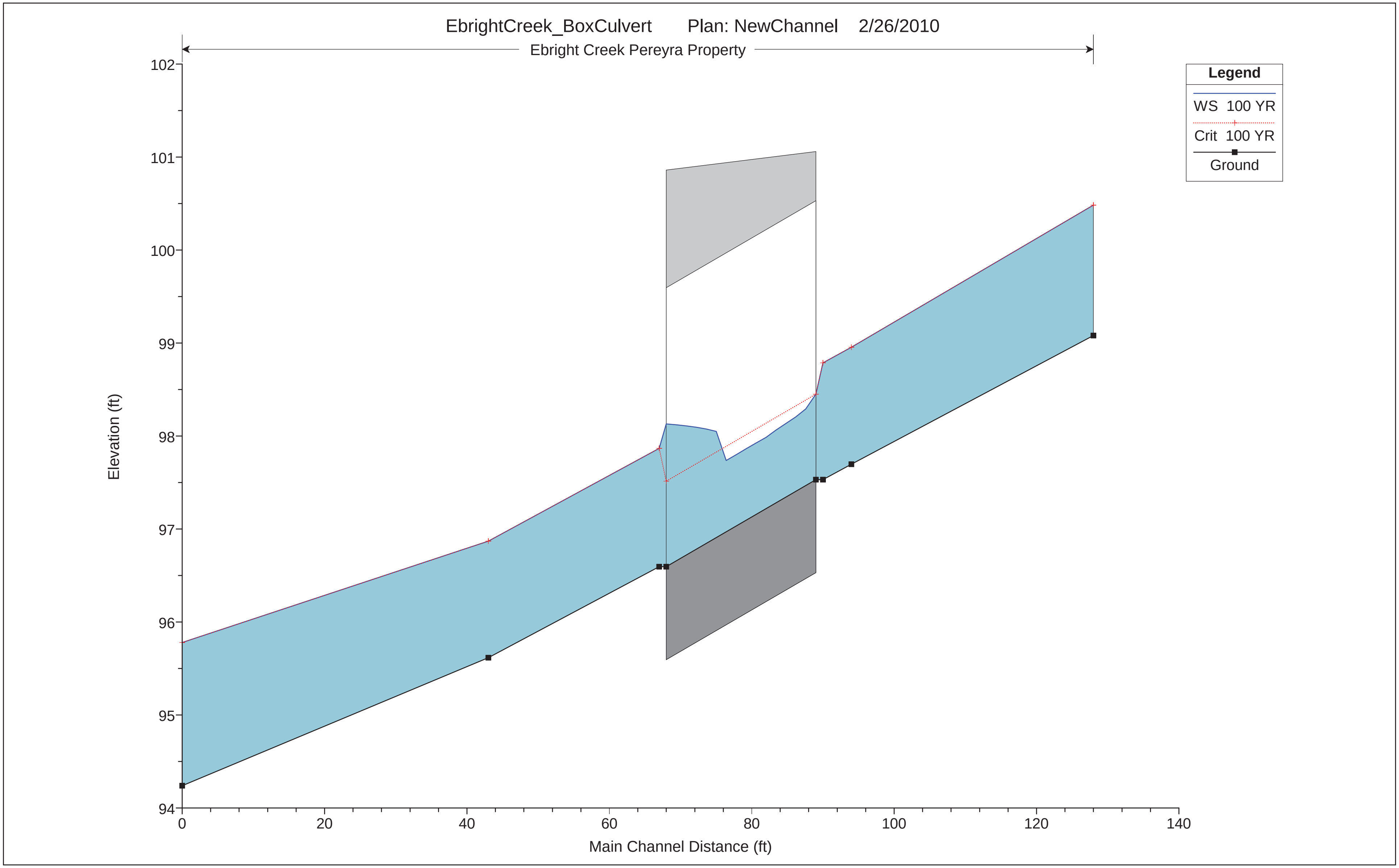


Figure Culv-1(c)
Cross Section View
Upstream of Culvert NTS



Parametrix 558-3847-002/01(07) 6/10 (B)

Figure Culv-1(d)
Proposed Box Culvert at 4.08%
with 100-year Peak Flow

Thompson Basin Plan
Project Description

Project Number: Ed-1

Project Name: Conduct Wetland Tours

Description: Organize and invite residents to participate in 1/2 day walking tours of Sammamish wetlands to learn more about wetland functions, and aquatic and terrestrial life in the wetlands.

Purpose: Better stewardship through better understanding.

Project Benefits: Support for wetland preservation.

Assumptions: City or volunteer wetland scientists/ecologists would lead the tours.

Estimated Cost: $10,000

Project Partners: Audubon Society, Community Groups, Sammamish Parks Department, Private Citizens

Priority: Low

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Thompson Basin Blan
Preliminary Opinion of Probable Cost

Draft

CIP #s: Ed-1
Project Name: Wetland Tours
Prepared By: Chad Wiggins

Item No.	Description		Amount
1	Planning and development of tour brochures		$4,000
2	Advertise tours		$3,000
3	Thank you gifts for volunteers		$200
		Subtotal =	**$7,200**
	Contingency	30.0%	$2,160
		Planning Level Cost =	**$9,400**
	Administration	5.0%	$470
		TOTAL =	**$10,000**

ASSUMPTIONS:
Wetland tours would be conducted by volunteer wetland scientists or City staff

Thompson Basin Plan
Project Description

Project Number: Ed-2

Project Name: LID educational strategies

Description: Encourage Low impact development techniques including rain-gardens and rainwater harvesting for developers and homeowners in the Thompson sub-basin through educational campaign.

Purpose: Ensure that development practices consider techniques that mimic natural hydrology, including infiltration and site development that minimizes impacts to surface water features.

Project Benefits: Infiltrate stormwater through rain gardens and utilize harvested rainwater for irrigation to minimize volume of stormwater produced and minimize use of potable water.

Assumptions: LID manuals will be placed on website. LID information will be printed and available at public works and library.

Estimated Cost: $2,500

Project Partners: Sammamish Water and Sewer District, Conservancy Groups, Private Citizens

Priority: Low

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Thompson Basin Blan
Preliminary Opinion of Probable Cost

CIP #s: Ed-2
Project Name: LID Educational Strategies
Prepared By: Chad Wiggins

Item No.	Description		Amount
1	Upload LID documents to City website		$1,400
2	Print and distribute LID information		$3,000
	Subtotal =		**$4,400**
	Contingency	30.0%	$1,320
	Planning Level Cost =		**$5,700**
	Administration	5.0%	$285
	TOTAL =		**$6,000**

ASSUMPTIONS:
Publically available LID information would be used, such as Raingarden Handbook for Western Washington Homeowners

Thompson Basin Plan
Project Description

Project Number: Ed-3

Project Name: Manure management strategies

Description: Aid citizens with proper strategies to manage manure waste to prevent bacteria from entering surface waters. Manure can be properly used on site, given away, composted off site or disposed.

Purpose: Encourage citizens to manage manure waste properly to protect surface water futures from contamination.

Project Benefits: Prevent bacteria from entering surface water features, share resources with neighboring gardeners (manure as fertilizer).

Assumptions: Citizens can use King County provided information and resources at http://your.kingcounty.gov/solidwaste/naturalyardcare/manure/index.asp . Cost-sharing guidelines for livestock BMP's are available though King County. Information will be posted on City website.

Estimated Cost: $800

Project Partners: City of Sammamish, King County, Private Citizens, King Conservation District

Priority: Medium

Thompson Basin Plan
Project Description

Project Number:	Ed-4
Project Name:	Kokanee Awareness Campaign
Description:	Ebright Creek is one of few creeks that have a natural kokanee run. In order to develop awareness of this important species, the City could adopt the Kokanee as their city mascot.
Purpose:	Educate the public about the need to protect the kokanee by protecting the watershed in which they spawn.
Project Benefits:	Increased public awareness of the Lake Sammamish Kokanee.
Assumptions:	Mascot may be used on posters, billboards, bumper stickers and fun classroom activities. Artist competition needed to render mascot image. Costume development.
Estimated Cost:	$13,000
Project Partners:	City of Sammamish, Public and Private Schools in Sammamish, Local artists
Priority:	Medium

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Thompson Basin Blan
Preliminary Opinion of Probable Cost

Draft

CIP #s: Ed-4
Project Name: Kokanee Awareness Campaign, City Mascot
Prepared By: Chad Wiggins

Item No.	Description			Amount
1	Contest for City Kokanee Logo			$2,000
2	Develop brochures about kokanee			$3,600
3	Create Kokanee Mascot Costume			$1,500
2	Mascot visits local schools and fairs			$2,400
			Subtotal =	**$9,500**
		Contingency	30.0%	$2,850
			Planning Level Cost =	**$12,400**
		Administration	5.0%	$620
			TOTAL =	**$13,000**

ASSUMPTIONS:
City hires part-time worker to be the City mascot at fairs and schools (estimate 120 hours annually)

Thompson Basin Plan
Project Description

Project Number: Mon-1

Project Name: Install and monitor flow gauge on Ebright Creek

Description: Install a flow gauge on Ebright Creek to monitor stream flow as development in the watershed occurs. This gauge would replace a previously operational gauge on Ebright Creek.

Purpose: Flow data of Ebright Creek will be used to calibrate the model used to predict flows through the creek with future development.

Project Benefits: Better understanding of flow characteristics within the Creek will allow for preemptive stormwater solutions prior to damage of the Creek.

Assumptions: City staff or consultants would be required to periodically download gauge data and ensure that it is functioning properly. There would be a one-time installation cost, followed by annual data collection and reporting costs.

Estimated Cost: $15,000 First year. $5,000 per year thereafter

Project Partners:

Priority: Not rated. Important to evaluate trends and relate projects and strategies to physical conditions.

CITY OF SAMMAMISH
Thompson Basin Blan
Preliminary Opinion of Probable Cost

Draft

CIP #s: Mon-1
Project Name: Install Flow Gauge on Ebright Creek
Prepared By: Chad Wiggins

Item No.	Description		Amount
1	Flow gauge equipment		$2,000
2	Installation		$3,840
3	Calibration and data collection (4 times/year)		$2,880
2	Annual reporting and analysis		$2,400
	Subtotal =		**$11,120**
	Contingency	30.0%	$3,336
	Planning Level Cost =		**$14,500**
	Administration	5.0%	$725
	TOTAL =		**$15,000**

ASSUMPTIONS:
City staff or consultant would install, calibrate and monitor gauge.

Parametrix 558-3847-002/01(07) 6/10 (B)

Source: King County, 2010

N

0 900

SCALE IN FEET

Figure Mon-1
Ebright Creek Flow Guage

Thompson Basin Plan
Project Description

Project Number: Mon-2

Project Name: Continue collecting wetland elevation data on Wetland 17

Description: Elevation data on Wetland 17 has been recorded since October, 2000. The Crossings at Pine Lake was instructed to record wetland information until July, 2009. Data collection should continue on a quarterly basis.

Purpose: Determine the hydrology of the wetland and evaluate trends and potential causes of changes to the wetland hydroperiod.

Project Benefits: Continuing monitoring the wetland elevation will determine if action is needed to limit volume inputs or take other actions to ensure the health of the wetland.

Assumptions: Elevation readings four times per year and annual reporting and analysis.

Estimated Cost: $6000 per year

Project Partners: City of Sammamish

Priority: Not rated. Important to evaluate trends and relate projects and strategies to physical and biological conditions.

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Thompson Basin Blan
Preliminary Opinion of Probable Cost

Draft

CIP #s: Mon-2
Project Name: Monitor wetland elevation in Wetland 17
Prepared By: Chad Wiggins

Item No.	Description		Amount
1	Calibration and data collection (4 times/year)		$2,880
2	Annual reporting and analysis		$2,400
	Subtotal =		**$5,280**
	Contingency	30.0%	$1,584
	Planning Level Cost =		**$6,900**
	Administration	5.0%	$345
	TOTAL =		**$7,000**

ASSUMPTIONS:
Wetland elevation gauge has already been installed in the wetland.
Cost only assumes annual monitoring and reporting.

Thompson Basin Plan
Project Description

Project Number:	Mon-3
Project Name:	Collect wetland elevation data on Wetland 61
Description:	Wetland 61 is immediately downstream of the Town Center. Install elevation gauge and collect wetland elevation data to determine trends in wetland elevation related to increased development.
Purpose:	Determine the hydrology of the wetland and evaluate trends and potential causes of changes to the wetland hydroperiod.
Project Benefits:	Monitoring elevation data will determine if wetland elevation changes with future development and if action is needed to address changes to wetland character.
Assumptions:	Monitor and download data four times per year. Annual reporting and analysis.
Estimated Cost:	$6,000 per year
Project Partners:	City of Sammamish
Priority:	Not rated. Important to evaluate trends and relate projects and strategies to physical conditions.

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Thompson Basin Blan
Preliminary Opinion of Probable Cost

Draft

CIP #s: Mon-3
Project Name: Monitor wetland elevation in Wetland 61
Prepared By: Chad Wiggins

Item No.	Description		Amount
1	Calibration and data collection (4 times/year)		$2,880
2	Annual reporting and analysis		$2,400
	Subtotal =		**$5,280**
	Contingency	30.0%	$1,584
	Planning Level Cost =		**$6,900**
	Administration	5.0%	$345
	TOTAL =		**$7,000**

ASSUMPTIONS:
Wetland elevation gauge has already been installed in the wetland.
Cost only assumes annual monitoring and reporting.

Thompson Basin Plan
Project Description

Project Number:	Mon-4
Project Name:	Annual Channel Cross Sections on Ebright Creek
Description:	Survey annual measurements of channel cross sections at two different locations within Ebright Creek. Cross sections should be located upstream and downstream of culvert in private property just east of E. Lake Sammamish Pkwy SE.
Purpose:	To monitor channel conditions over time and evaluate erosion and sedimentation trends within the channel.
Project Benefits:	Determine general trends of channel conditions following development. Monitoring cross sections will help determine if flow control BMP's for development are effective.
Assumptions:	Cross sections will be permanently staked for continuity and annual measurements will be taken.
Estimated Cost:	About $3,000 per year, with a one time reporting cost of $4,000
Project Partners:	City of Sammamish
Priority:	Not rated. Important to evaluate trends and relate projects and strategies to physical conditions.

CITY OF SAMMAMISH
Thompson Basin Blan
Preliminary Opinion of Probable Cost

Draft

CIP #s: Mon-4
Project Name: Channel Cross Sections
Prepared By: Chad Wiggins

Item No.	Description		Amount
1	Annual Cross Section Measurements (assume 2 people/1 day)		$1,920
2	Reporting and analysis (one time)		$2,880
	Subtotal =		**$4,800**
	Contingency	30.0%	$1,440
	Planning Level Cost =		**$6,200**
	Administration	5.0%	$310
	TOTAL =		**$7,000**

ASSUMPTIONS:
Permanent benchmark will be established well outside the floodplain so that cross sections can be located.

Parametrix 558-3847-002/01(07) 6/10 (B)

Source: King County, 2010

N

0 560

SCALE IN FEET

Figure Mon-4
Ebright Creek Cross Section Locations

Thompson Basin Plan
Project Description

Project Number: Mon-5

Project Name: Water Quality monitoring

Description: King County has been recording water quality data for Ebright Creek since 1996, but discontinued monitoring in 2008. Fecal coliform levels for 2008 reached as high as 700 cfu/100ml, well above the secondary contact threshold.

Purpose: Monitor to ensure nutrients and bacteria are not problematic within the creek.

Project Benefits: Recorded data of water quality trends will help determine solutions to increase the health of the channel.

Assumptions: Monthly samples of nutrients, dissolved oxygen and bacteria.

Estimated Cost: Cost will be estimated in future submittal.

Project Partners: King County, City of Sammamish

Priority: Not rated. Important to evaluate trends and relate projects and strategies to stream conditions.

Thompson Basin Plan
Project Description

Project Number: Plan-1

Project Name: Beaver Management Plan and Beaver Deceiver

Description: Develop plan for managing beaver activity in the Thompson Basin, including options for non-lethal removal or prevention of negative consequences due to beaver activity.

Purpose: Provide clarity on options for dealing with beavers.

Project Benefits: Beaver management will help prevent flooding in areas where it cannot be tolerated.

Assumptions: Install beaver deceiver on Wetland 17 culvert crossing where beaver activity has caused raised water levels, and develop plan for longer-term management of beaver population.

Estimated Cost: $10,000 for plan, and $12,000 for beaver deceiver installation

Project Partners: Audubon Society, Community Groups, Sammamish Parks Department, Private Citizens

Priority: High

Alternative Techniques for Beaver Management

Parametrix reviewed potential alternatives that could be incorporated into a Sammamish-specific beaver management plan that includes non-lethal alternatives for preventing surface water challenges associated with beavers.

The techniques described below were reviewed from the following documents:

> Working with Beavers. an article by Nick Gerich, Biological Services Technician with the USDA Forest Service, Leadville Ranger District, San Isabel National Forest, Colorado (http://www.fs.fed.us/r2/psicc/leadville/Beaver-Document.pdf)
>
> Introduction to Non-lethal Beaver Management for Culverts and other Surface Water Facilities (http://www.kingcounty.gov/environment/animalsAndPlants/beavers/solutions/control.aspx)

Assumptions

1. Regular maintenance is required, whether beavers are trapped and relocated (they can multiply quickly and re-inhabit areas where previously removed) or structural devices are used to prevent beaver dams (debris removal around structures needs to be done periodically)
2. All necessary permits must be obtained before construction of "beaver deceivers". In Washington, an hydraulic project approval (HPA) is required from the Washington Department of Fish and Wildlife (WDFW) as well as local county or city permits. Federal permits may also be required if in larger streams systems where Chinook may be present.
3. Modifications to culverts to eliminate the "fall" at the downstream end of the culvert will reduce the noise of running water through the culvert and will reduce conflicts with beavers.
4. It is recommended that fencing is installed around trees that are desirable for protection in areas inhabited by beavers.

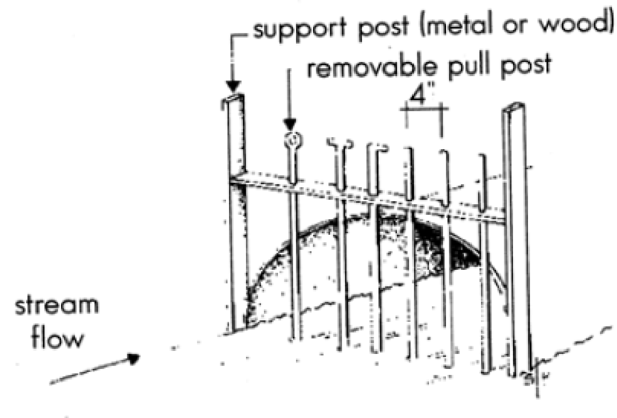
Alternatives

1. ***Live Trapping and Relocation of Beavers*:** For this alternative, traps are placed and checked every morning and evening to ensure the beavers do not drown. A male and female must be relocated together in order to establish a new colony in a new location. In order for this alternative to be successful, the beaver population density must be low. This alternative will not work in high densities because new beavers or new litters will take their place. This alternative is expensive, labor intensive, and a short term solution.

2. ***Removable Pull Rod Grill***: This alternative places grills or wire mesh across the face of the culvert to prevent debris from floating through the culvert.

Success Data: It seems that it only assists the beavers in damming the culvert. It provides them with a foundation to build their damn. Author has personally seen beavers clog up two 5 ft diameter pipes with wire mesh placed in front of them within 18 hours. This alternative should be used to prevent large debris and animals from entering the culvert. Debris caught in the grill will need to be manually removed.

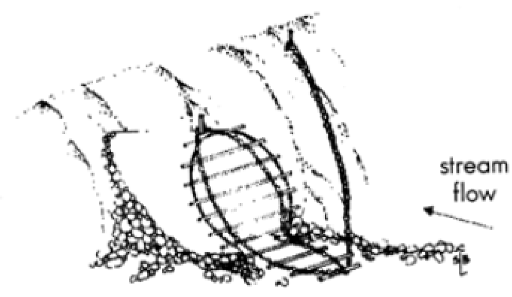
Removable Pull Rod Grill



3. ***Culvert Protector/Cleaner***: This alternative is similar to the Removable Pull Rod Grill, with the exception that the logging chain located at the top of the culvert is hooked to the bumper of a truck in order to lift the culvert cleaner out of the water to maintain and clean.

Success Data: The only difference between this alternative and the removable pull rod grill is that it's quicker and keeps people out of the water.

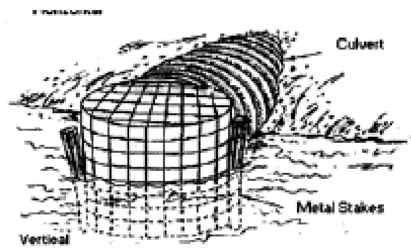
Culvert Protector/Cleaner



4. ***Vertical Cylindrical Wire Mesh Beaver Guard***: This alternative protects the culvert inlet with a larger surface area than the previous two alternatives. The larger the wire mesh, the less maintenance needed to clear the debris.

Success Data: This design has been extremely effective for smaller diameter pipes and culverts. There are minimal amount of materials and time needed to construct this alternative.

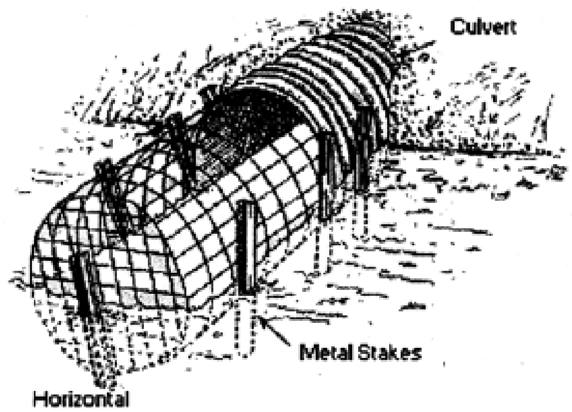
Vertical Cylindrical Wire Mesh Beaver Guard



5. ***Horizontal Cylindrical Wire Mesh Beaver Guard***: This alternative is used for various sized culverts. There is a large amount of surface area with allows more time between cleanings. It is the simplest design, easily constructible, and low cost.

Success Data: Author has found this successful for multiple sized culverts. He was able to construct one by himself in one hour.

Horizontal Cylindrical Wire Mesh Beaver Guard



6. ***Fencing*:** This is a permanent solution for protecting trees from beavers. This alternative consists of loosely wrapping (need room to grow) the important trees with chicken wire or hardware cloth within a riparian zone. The height of the fence only needs to be 3 – 4 feet. To protect large areas, use the 3 – 4 foot tall chicken wire or

similar materials. Stake the fence into the ground to prevent the beavers from crawling

beneath the fence.
(From Beaver Management Plan)

7. ***The Beaver Deceiver*** *(Peterson Pond Example)*: For Peterson Pond, a receiver fence, a pipe, and a round fence were installed to complete the beaver deceiver (if able to build large enough, sometimes a receiver fence is all that is necessary).

The receiver fence in installed at the mouth of the culvert. A footing is required along the outside (at the bottom) of the receiver fence to prevent beavers from digging under. This fence protects the outlet of the pond from beavers. (Introduction to Non-Lethal Beaver Management) It pushes the beavers far enough away from the culvert that the beaver no longer thinks it's worth it to dam the stream. (US Beaver Management Tool Crosses the Pond)

The pipe is prepared by cutting holes to allow trapped air to escape and for the pipe to sink. The pipe is inserted into the round fence, then attached to the receiver fence. (Introduction to Non-Lethal Beaver Management) This pipe / round fence configuration is used to level out the beaver made pond with the other side. (US Beaver Management Tool Crosses the Pond)

Success Data: A wildlife biologist (Skip Lisle) has installed this device at 18 culvert sites over 130,000 acres. Prior to installation, beaver related road maintenance cost was expensive. After installation, road maintenance costs for the past 6 years have been practically non-existent. (Introduction to Non-Lethal Beaver Management) Hundreds of this low maintenance solution are now in place in North America. It's become evident that this alternative maximizes the benefits of the beavers while minimizing the conflicts. (US Beaver Management Tool Crosses the Pond)

Photo of Beaver Deceiver From Solving Problems with Beavers

8. ***Beaver "Bafflers***": Beavers try to repair their dams when they hear, feel, or see running water. They do this to prevent the pond from draining and leaving them exposed to predators. The beaver baffler would disperse the flow without alarming the beavers that water is leaving. There are many different designs, some constructed from plastic or metal pipes, wooden troughs, or metal mesh fencing formed into a culvert.

Thompson Basin Plan
Project Description

Project Number: Std-1

Project Name: Consider implementing a volume-based stormwater management performance standard in the Thompson Basin.

Description: Adopt a volume-based performance standard for the Thompson Basin

Purpose: There are several high quality wetlands in this basin that appear to have been impacted by increased stormwater runoff volumes. A volume-based stormwater management standard would minimize impacts from additional stormwater volumes that accompany new development.

Project Benefits: Maintain quality wetland features.

Assumptions: A standard could be adopted through this basin plan, Town Center stormwater management development code, or revisions to the Sammamish Municipal Code.

Estimated Cost: To be determined.

Project Partners:

Priority:

Thompson Basin Plan
Project Description

Project Number: Study-1

Project Name: Investigate injection of treated stormwater

Description: Conduct hydrogeological and geotechnical analysis to determine the feasibility of using deep injection wells to dispose of treated stormwater.

Purpose: Stormwater volumes are difficult to manage with standard stormwater flow control BMPs, and this technique would minimize discharge of excessive volumes to surface water and recharge ground water aquifers.

Project Benefits: Minimize effects from stormwater runoff flow rates and volumes, and increase aquifer recharge.

Assumptions: Stormwater treatment would have to occur prior to infiltration to ensure that groundwater supplies are not contaminated with pollutants present in the surface water.

Estimated Cost: To be determined.

Project Partners:

Priority:

Thompson Sub-basin Plan
Project Description

Project Number: Study-2

Project Name: Evaluate modifications to LID ordinance

Description: Due to current economic conditions, development has not been occurring in the City of Sammamish and therefore the effect of the LID ordinance and use by developers has not been tested. Once developers have the opportunity to voluntarily use this ordinance, evaluate whether the incentives are strong enough to encourage its use.

Purpose: Evaluation of existing ordinance to determine if incentives encourage voluntary use of LID techniques.

Project Benefits: Modifications to ordinance, if necessary.

Assumptions: This project will be done by City staff.

Estimated Cost: To be determined.

Project Partners:

Priority: Low

Thompson Basin Plan
Project Description

Project Number: Enh-1

Project Name: Enhance Wetland 17

Description: Enhance portion of Wetland 17

Purpose: Re-establish, rehabilitate, and/or enhance portion of Wetland 17 from pasture to functional wetland habitat.

Project Benefits: Improve the wetland functions including attenuation of surface flows and provision of wildlife habitat.

Assumptions: This project would require cooperation of the private property owners, establishment of conservation easements, or outright purchase of property. The wetland enhancement could be incorporated into park property.

Estimated Cost: $76,000, does not include acquisition of property

Project Partners: Sammamish Parks Department, Conservancy Groups, Private Citizens

Priority: High

Thompson Basin Plan
Project Description

Project Number: Enh-2

Project Name: Enhance Wetland 17

Description: Enhance portion of Wetland 17

Purpose: Re-establish, rehabilitate, and/or enhance portion of Wetland 17 from pasture to functional wetland habitat.

Project Benefits: Improve the wetland functions including attenuation of surface flows and provision of wildlife habitat.

Assumptions: This project would require cooperation of the private property owners, establishment of conservation easements, or outright purchase of property. The wetland enhancement could be incorporated into park property.

Estimated Cost: $76,000, does not include acquisition of property

Project Partners: Sammamish Parks Department, Conservancy Groups, Private Citizens

Priority: High

Thompson Basin Plan
Project Description

Project Number: Enh-3

Project Name: Enhance Wetland 1

Description: Enhance portion of Wetland 1 north of Ebright Creek Park.

Purpose: Re-establish, rehabilitate, and/or enhance pasture to functional wetland habitat.

Project Benefits: Preservation of wetland functions including attenuation of surface flows, and provision of wildlife habitat.

Assumptions: The wetland enhancement could be incorporated into Ebright Creek Park. Enhancement would require cooperation with private property owners, purchase of conservation easements, or outright purchase of private property.

Estimated Cost: $76,000, does not include acquisition of property

Project Partners: Sammamish Parks Department, Conservancy Groups, Private Citizens

Priority: Medium

Thompson Basin Plan
Project Description

Project Number:	Enh-4
Project Name:	Enhance Wetland 2
Description:	Enhance portion of Wetland 1 north of Ebright Creek Park.
Purpose:	Re-establish, rehabilitate, and/or enhance Wetland 2 that is south of Ebright Creek Park.
Project Benefits:	Restoration of wetland functions including attenuation of surface flows, and provision of wildlife habitat.
Assumptions:	The wetland enhancement could be incorporated into Ebright Creek Park. Enhancement would require cooperation with private property owners, purchase of conservation easements, or outright purchase of private property.
Estimated Cost:	$76,000, does not include acquisition of property
Project Partners:	Sammamish Parks Department, Conservancy Groups, Private Citizens
Priority:	Low

CITY OF SAMMAMISH
Thompson Basin Plan
Preliminary Opinion of Probable Cost per Wetland Enhancement (all are similar sizes)

Draft

CIP #s: Enh-1, Enh-2, Enh-3, and Enh-4
Project Name: Wetland 17 Enhancement, Wetland 1 Enhancement, Wetland 2 Enhancement
Prepared By: Claire Hoffman

Item No.	Description		Amount	Percent of Construction Cost
1	Wetland Delineation		$2,000	4.21%
2	Surveying		$3,000	6.32%
3	Critical Areas Report		$5,000	10.53%
4	Mitigation Plan		$3,500	7.37%
5	Plant Materials		$25,000	52.63%
6	Fence and signs		$3,000	6.32%
7	Site preparation and grading		$6,000	12.63%
	Subtotal =		**$47,500**	100.00%
	Contingency	30.0%	$14,250	
	Sales Tax	9.5%	$4,513	
	Planning Level Construction Cost =		**$66,300**	
	Environmental Permitting and Documentation	10.0%	$6,630	
	Administration	5.0%	$3,315	
	TOTAL =		**$76,000**	**Per Wetland Enhancement**

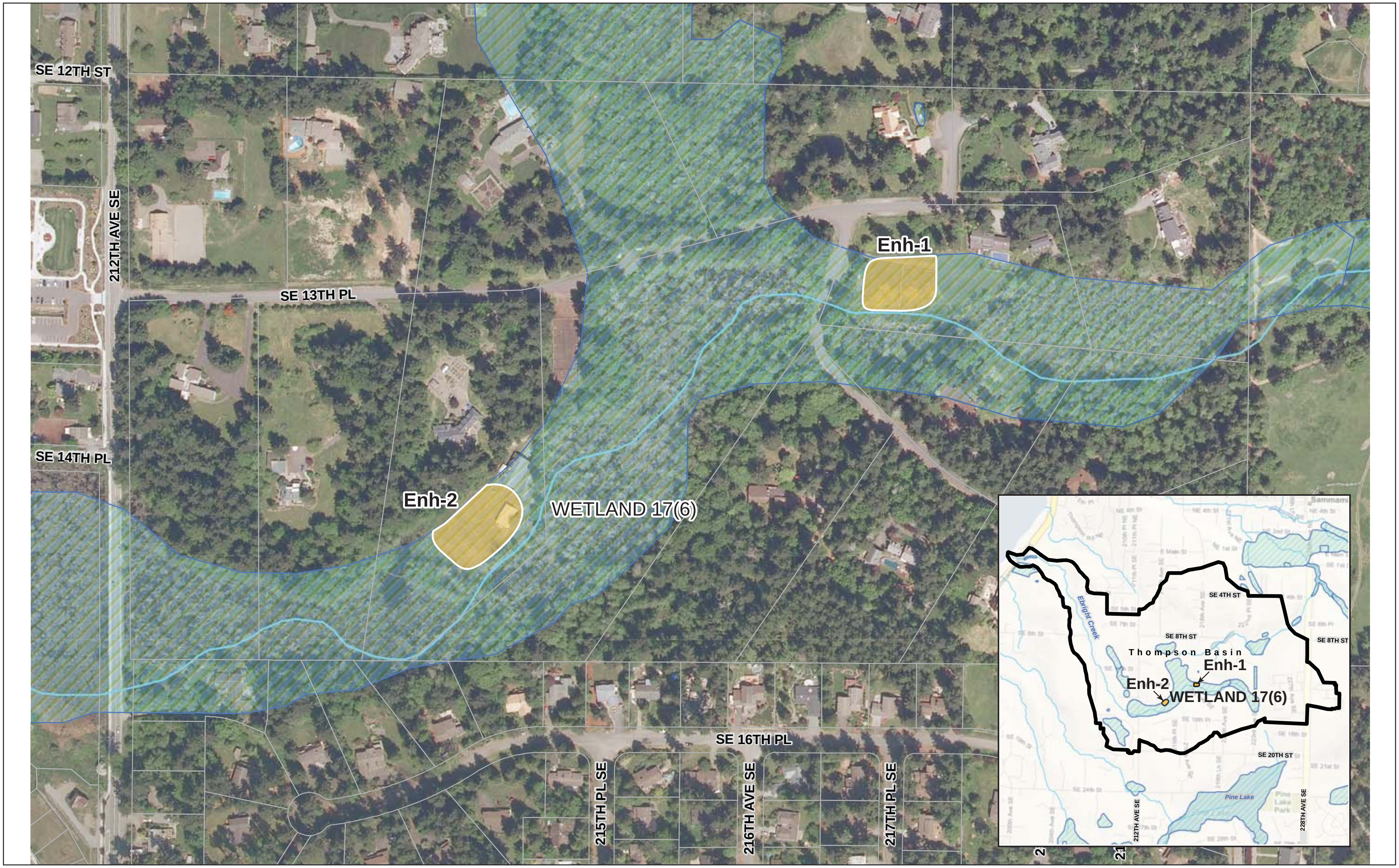
ASSUMPTIONS:
Wetland delineation is one 10 hour field day for two biologists
Fencing is for 300 linear feet
Plant materials includes 1500 plants as well as materials needed for planting
Estimate does not include habitat structures
Estimate does not include obtaining land or easements
Estimate does not include construction and post construction monitoring
Estimate includes 30 percent for contingency

Enh-1 PROJECT DESCRIPTION: Re-establish, rehabilitate, and/or enhance portion of Wetland 17 from pasture to functional wetland habitat.

Enh-2 PROJECT DESCRIPTION: Re-establish, rehabilitate, and/or enhance portion of Wetland 17 from pasture to functional wetland habitat.

Enh-3 PROJECT DESCRIPTION: Enhance portion of Wetland 1 north of Ebright Creek Park.

Enh-4 PROJECT DESCRIPTION: Re-establish, rehabilitate, and/or enhance Wetland 2 that is south of Ebright Creek Park.



Parametrix 558-3847-002/01(07) 6/10 (B)

N

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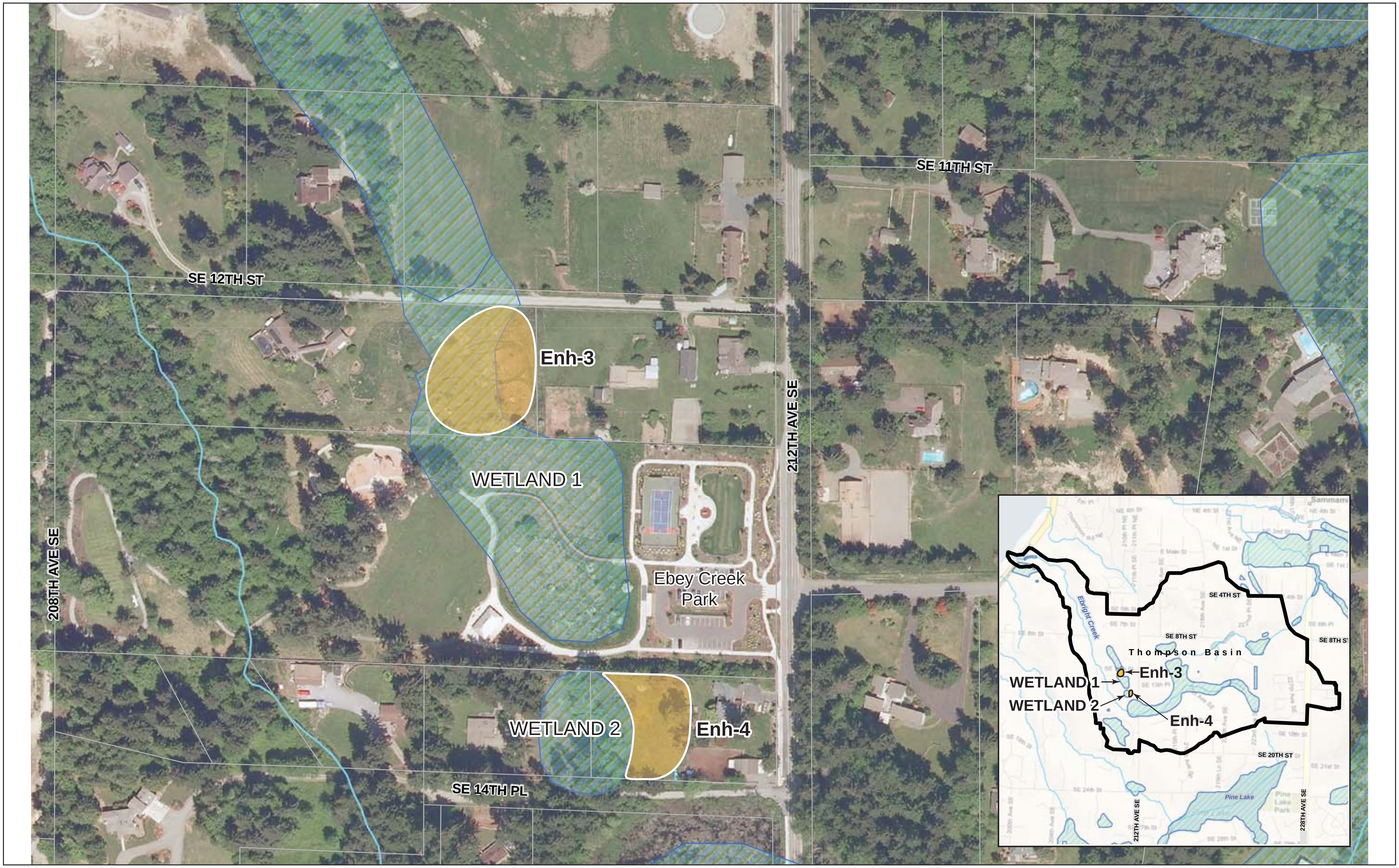
SCALE IN FEET

Mitigation Opportunities

Wetland

Figure Enh(a)
Thompson Sub-Basin
Mitigation Opportunities



Parametrix 558-3847-002/01(07) 6/10 (B)

N

0 250

SCALE IN FEET

Mitigation Opportunities

Wetland

Figure Enh(b)
Thompson Sub-Basin
Mitigation Opportunities