Basin Evaluation and Management Strategies For Thurston County

WRIAs 13 and 14
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THURSTON COUNTY
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thurston regional planning council

GUIDING GROWTH – HEALTHY WATERSHEDS

Translating Science into Local Policy

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Report Authors

Veena Tabbutt	Thurston Regional Planning Council
Michael Ambrogi	Thurston Regional Planning Council
Michael Burnham	Thurston Regional Planning Council
Molly Levitt	Thurston County Planning Department
Steven W. Morrison	Thurston Regional Planning Council
Allison Osterberg	Thurston County Planning Department
Cynthia Wilson	Project Manager — Thurston County Planning

Thurston County Staff

Cynthia Wilson	Senior Planner
Molly Levitt	Assistant Planner
Allison Osterberg	Associate Planner
Pat Allen	Senior Civil Engineer for the Drainage and Erosion Control Manual
Rich Doenges	Planning Coordinator
Barb Wood	Utility Planner
Laura McDowell	Public Information Specialist
Josh Brann	GIS Analyst I
Cheryl Armstrong	Accounting Asst IV
Carrie Toebbe	Administrative Asst I
Jim Bachmeier	Water Resources Program Manager
Scott Clark	Planning Director
Cliff Moore	Resource Stewardship Director

Thurston Regional Planning Council Staff

Veena Tabbutt	Senior Planner
Steven Morrison	Senior Planner
Michael Burnham	Associate Planner
Scott Carte	GIS Manager
Jeff Holcomb	GIS Analyst
Michael Ambrogi	GIS Analyst
Rosalie Bostwick	Office Manager
Erin Cahill	Project Assistant
Burlina Montgomery	Office Specialist III
Lon D. Wyrick	Executive Director
Jared Burbidge	Assistant Director

Municipal Stormwater Technical Advisory Committee for Thurston County (2010-2011)

Pat Allen	Thurston County
Eric Christiansen	City of Olympia
Doug Christensen	City of Lacey
Sue Davis	Thurston County
Rich Doenges	Thurston County
Laura Keehan	City of Olympia
Rick McBloom	City of Lacey
Steven W. Morrison	Thurston Regional Planning Council
Joe Rousch	City of Olympia
Larry Schaffner	WSDOT
Tim Wilson	City of Tumwater
Barb Wood	Thurston County

Water Resource Inventory Area 13 & 14 Salmon Habitat Workgroup (2010-2011)

Christina Donehower	People for Puget Sound
Jamie Glasgow	Wild Fish Conservancy
Kim Gridley	South Puget Sound Salmon Enhancement Group
Amy Hatch-Winecka	Thurston Conservation District
Erin Keith	City of Lacey
Jeanne Kinney	Thurston County
Chris Mann	Thurston County
Steven W. Morrison	Thurston Regional Planning Council
Laurence Reeves	Capitol Land Trust
Adam Sant	South Puget Sound Salmon Enhancement Group
Debbie Smith	City of Tumwater
Scott Steltzner	Squaxin Island Tribe
Michelle Stevie	City of Olympia
Lance Winecka	South Puget Sound Salmon Enhancement Group
Barb Wood	Thurston County

Squaxin Island Tribe — Natural Resources (2010-2011)

Jeff Dickison	Squaxin Island Tribe
John Konovsky	Squaxin Island Tribe
Scott Steltzner	Squaxin Island Tribe

Interested Parties

Andy Haub	City of Olympia
Susan Grigsby	Washington State Department of Ecology
Ed O'Brien	Washington State Department of Ecology
Mindy Roberts	Washington State Department of Ecology
Stephen Stanley	Washington State Department of Ecology
Lydia Wagner	Washington State Department of Ecology
Karla Fowler	LOTT Clean Water Alliance
Mike Milne	LOTT Clean Water Alliance Consultant
Sue Davis	Thurston County Environmental Health

Advance Planners for the Thurston Region (2010-2011)

Dennis Bloom	Intercity Transit
Paul Brewster	Thurston Regional Planning Council
Joshua Brann	Thurston County
Jared Burbidge	Thurston Regional Planning Council
Dave Burns	City of Lacey
Scott Clark	Thurston County
Jeremy Davis	Thurston County
Andrew Deffobis	Thurston County
John Druelinger	Thurston County
Holly Gilbert	Thurston Regional Planning Council
David Ginther	City of Tumwater
Nathan Harber	Joint Base Lewis-McChord
Cari Hornbein	City of Olympia
Jennifer Kenny	City of Olympia
Molly Levitt	Thurston County
Kathy McCormick	Thurston Regional Planning Council
Steven W. Morrison	Thurston Regional Planning Council
Bharath Paladugu	Thurston Regional Planning Council
Karen Parkhurst	Thurston Regional Planning Council
Janet Rogerson	WA State Department of Commerce
Tim Smith	City of Tumwater
Todd Stamm	City of Olympia
Pete Swenssen	Thurston Regional Planning Council
Veena Tabbutt	Thurston Regional Planning Council
Olivia Terwilleger	Thurston County
Cynthia Wilson	Thurston County

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EXECUTIVE SUMMARY

Protecting the Puget Sound will require new approaches and new partnerships. This project focuses on identifying where conservation and restoration efforts will have the greatest impact by looking not only at stream and river basin conditions today – but also looking into the future. The focus is on protection; protecting basins that are well-functioning today from future degradation due to urbanization.

Many of Thurston County's well-functioning basins are zoned to remain rural in the future. In some of these basins there are concerns over loss of forest cover to rural residential development. In the partially rural – partially urban basins that are already impacted by urbanization – there are concerns regarding impacts of continued development.

This report represents the first step in a comprehensive process to first identify relatively well-functioning or impacted basins at risk of further degradation due to urbanization, determine effective management strategies, and then implement them. There are no easy answers or quick solutions. By taking a thoughtful, collaborative, and science-based approach with supportive technical tools we will increase our chances of protecting and eventually restoring the health of Thurston County's watersheds and the Puget Sound Basin.

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I. INTRODUCTION

Thurston County has many features that make it an incredible place to live. We have lakes, rivers, streams, and the sparkling Puget Sound. Together with the friendliness and livability of our local communities, it's no wonder that more than 250,000 people call Thurston County home, and that Thurston County is one of the fastest-growing counties in Washington State.

There are downsides to rapid population growth in Thurston County. Growth in the wrong parts of the county can damage the health of our local watersheds. Damaged watersheds harm lakes, rivers, streams, and ultimately Puget Sound, resulting in waterways that are unhealthy or even unusable for people and wildlife.

This project, *Guiding Growth – Healthy Watersheds: Translating Science into Local Policy,* aims to identify ways to accommodate future population growth while conserving our healthy watersheds and Puget Sound.

Thurston County has teamed with Thurston Regional Planning Council (TRPC) to bring watershed science into local policies that protect water quality in Puget Sound. This collaborative effort is funded by a grant from the U.S. Environmental Protection Agency. The project will require working with local cities and tribes and involve people who live, work, and recreate in the county.

This project begins by better understanding the existing characteristics of our watersheds and basins. Since each basin is unique, there is no one-size-fits-all approach to management and protection. Scientific studies are under way to characterize watersheds draining into Puget Sound to determine if they are healthy or degraded. Computerized tools will predict where growth is likely to occur and the effect it may have on our streams, lakes, and marine waters.

This study presents a framework that will be used by Thurston County and Thurston Regional Planning Council to work with the cities of Lacey, Olympia, Tumwater, and Rainier to develop better management policies and programs to maintain water quality and quantity in watershed basins that drain into Puget Sound.

The format, organization, and rationale used in this report draws heavily from the 1999 *Aquatic Habitat Evaluation and Management Report: City Streams and Wetlands Report*. This earlier study was used to develop a management strategy for City of Olympia basins, with follow-up work leading to the re-examination of management strategies in the Green Cove Creek basin – and subsequent changes to both zoning and development regulations.

The science presented in this report draws heavily from sources used in Thurston County's Watershed Characterization, including references provided to the county during the peer-review process. This report marks the first step in understanding the processes that shape our basins and maintain their health.

The watersheds included in this study are part of Water Resource Inventory Areas (WRIAs) 13 and 14 in Thurston County, and include:

- Eld Inlet
- Budd/Deschutes
- Henderson Inlet
- Totten Inlet
- Nisqually Reach (part of the Nisqually Watershed but within WRIA 13)

This report reviews all drainage basins within the study area and integrates scientific information into a management framework.

From the drainage basins reviewed in this report, three will be evaluated with new management options for growth. The most effective strategies to guide growth will be linked to a basin's health. Potential management options may include changes to existing development regulations, transfer or purchase of development rights, low-impact development, wetland mitigation, purchasing sensitive lands, or funding required capital projects.

Local jurisdictions will be able to pick which management strategies would best fit their community. Although this project will recommend a preferred management approach for each basin, jurisdictions will need to approve these through their own public process.

II. PROJECT BACKGROUND

This project is designed as a regional collaboration between the Thurston County, the Thurston Regional Planning Council, cities of Lacey, Olympia, Tumwater, and Rainier, and the Squaxin Island Tribe to implement long-range land use strategies to better protect basins draining into the Puget Sound.

As the project was underway, the region received a grant "Sustainable Thurston" to develop a Regional Plan for Sustainable Development – funded by a partnership between the federal Office of Housing and Urban Development, Department of Transportation, and Environmental Protection Agency.

The *Guiding Growth – Healthy Watersheds: Translating Science into Local Policy* project will build the scientific base for strategies to better protect water resources in Thurston County. Many of the strategies will be implemented at the local level. In addition, policy discussions through the Sustainable Thurston collaborative effort will integrate the strategies into a broader sustainability policy framework for the region.

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III. WATERSHEDS, BASINS, SUB-BASINS, ANALYSIS UNITS

The terms watershed, basin, sub-basin and analysis unit are used throughout this document. In this study, the term watershed is used for those areas shown on Map 1:

- Eld Inlet
- Budd/Deschutes
- Henderson Inlet
- Totten Inlet
- Nisqually Reach

These areas make up part of the much larger Puget Sound Watershed. A watershed consists of all land area that "sheds" water to the outlet during a rainstorm (Figure 1). In the case of this study, the "outlets" for the watersheds are the marine inlets of the Puget Sound.

Within each of these broader watersheds are smaller watersheds, which are described in this study as basins and are shown on Map 2. These might be described as the area draining to Point B in Figure 1. In the text of this document, many of the coastal basins are grouped together in the tables due to lack of information for many of the unnamed coastal basins.

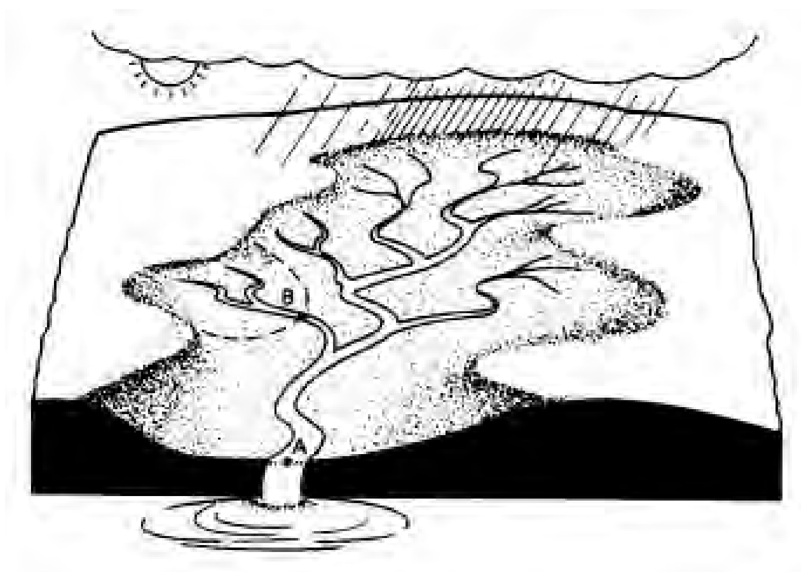

FIGURE 1: DELINEATION OF A WATERSHED BOUNDARY.
SOURCE: MICHIGAN STATE UNIVERSITY ENGINEERING DEPARTMENT.

Thurston County basins were delineated several decades ago based on U.S. Geological Survey topographic maps. Basins were defined for both lake and stream basins. These basins became the basis for a series of basin plans developed in the 1990s as collaborative interjurisdictional efforts between the county and cities.

Over time, basin boundaries were adjusted slightly as better topographic data became available to delineate drainage areas. Drainage area refers to all the land that drains to a common body of water.

The basin boundaries used in this study are aggregations of the Puget Sound Watershed Characterization analysis units (Map 3). These units are in turn aggregations of smaller catchments from the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP). Such units reflect the processes that form and maintain stream segments. They are based primarily on gradient and confinement, and, secondarily, on habitat types. They were developed by the Northwest Indian Fisheries Commission (Stanley, 2010), and they were used in the Budd Inlet Landscape Assessment.

Efforts have been made to ensure that information collected from previous reports and presented in Table 12 and in the appendix are consistent with basin boundaries shown in this report. It should be noted that not all of the basins in this report are headwater basins, as the boundaries were meant to approximately correspond with existing reports. The Deschutes River basin consists of a mainstem and several smaller headwater basins such as Chambers Basin. The mainstem is broken into three sub-basins — lower, middle, and upper — based on natural geomorphic breaks (Raines, 2007). Some information in the appendix table is broken into these levels, while other information is for the basin as a whole. The other exception is Black Lake basin, which – when draining to the north – functions as the upper reach of Percival Basin. The basin also has an outlet to the south.

It should be noted that Thurston County's Watershed Characterization developed a unique set of drainage analysis units for the purposes of its study. These units were based on an original interpretation of a digital elevation model. The unit boundaries were not used in this study because they did not cover the entire study area.

While coastal basins are not unique to Thurston County, the miles of marine shoreline, numerous unnamed streams entering Puget Sound, and recent assessment of the near-shore environment in Budd Inlet (Squaxin Island Tribe and Brakensick, 2010) led to some information being presented on accompanying maps at a finer level of detail.

IV. SUMMARY OF RELATED RESEARCH

A. Water Quality and Urbanization

The water quality in many of the watersheds in the U.S. has been degraded due to the effects of urbanization. Urbanization leads to changes in the hydrological cycle, such as increased urban runoff, mainly as a result of an increase of impervious surfaces (roads, rooftops, driveways) and associated loss of vegetation (Booth, 1991; U.S. EPA, 1997). Nationwide, the EPA reports that urban runoff has resulted in, or contributed to, the impairment of: 3 percent of total assessed estuary miles; 4 percent of total assessed river miles; and 4 percent of total assessed lake acres (U.S. EPA, 2009).

Urban runoff resulting from increased impervious surfaces affects both the quality and quantity of water entering natural water bodies in many ways, and can lead to severe environmental impacts such as flooding, habitat loss, erosion, channel widening, and streambed alteration (Table 1) (Booth, 1991; Grant et al, 2000; U.S. EPA, 1997).

Impervious surfaces, by definition, are materials that prevent the infiltration of water into the soil. The most common impervious surfaces in the built environment are roads, rooftops, sidewalks, and patios. While these structures are almost 100 percent impervious, other features such as gravel roads, compacted soils, and even lawns are impervious to varying degrees, as they allow for less infiltration than natural ground cover such as forests (Arnold, 1996; May, 1997). As urbanization increases, so does the amount of impervious surface, which leads to changes in the way water is transported, or the hydrology of a drainage basin (Figure 2).

One of the most notable changes is the increase in runoff or surface water flow and associated decrease in infiltration. Decreased infiltration reduces groundwater supplies, which may lead to a lowering of the water table. Ground water provides a consistent water supply to streams, wetlands, and lakes, and decreases in ground water supply may cause a stream or wetland to dry out during months when precipitation is low (Arnold, 1996).

Increases in impervious surfaces lead to increases in volume, rate (peak discharges), and duration of surface runoff (Figure 2). Efforts at mitigating stormwater runoff, such as building detention basins, serve to lessen peak flows, but do not lower the total volume of runoff (Harbor, 1994). The increased volume of both water and sediment load, and the increased energy associated with peak flows, tend to make natural drainage channels straighter, deeper, and wider (Arnold, 1996; U.S. EPA, 1997).

TABLE 1: IMPACTS FROM INCREASES IN IMPERVIOUS SURFACES.

Increased Imperviousness leads to:	Resulting Impacts				
	Flooding	Habitat Loss	Erosion	Channel widening	Streambed alteration
Increased volume	X	X	X	X	X
Increased peak flow	X	X	X	X	X
Increased peak flow duration	X	X	X	X	X
Changes in sediment loading	X	X	X	X	X
Decreased base flow		X			
Increased stream temperature		X			
Increased stream acidity		X			
Increased water pollution		X			

SOURCES: (GRANT ET AL, 2000; U.S. EPA, 1997).

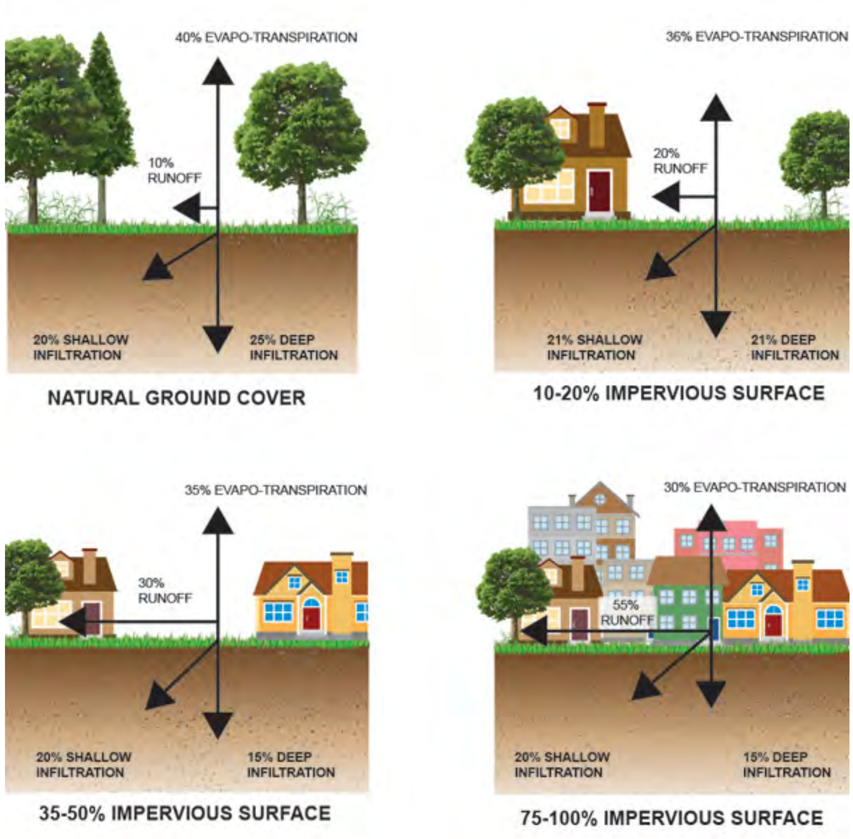

FIGURE 2: WATER CYCLE CHANGES ASSOCIATED WITH URBANIZATION.
SOURCE: (GUIDANCE SPECIFYING MANAGEMENT MEASURES FOR SOURCES OF NONPOINT SOURCE POLLUTION IN COASTAL WATERS, 1993) AS SHOWN IN (ARNOLD, 1996).

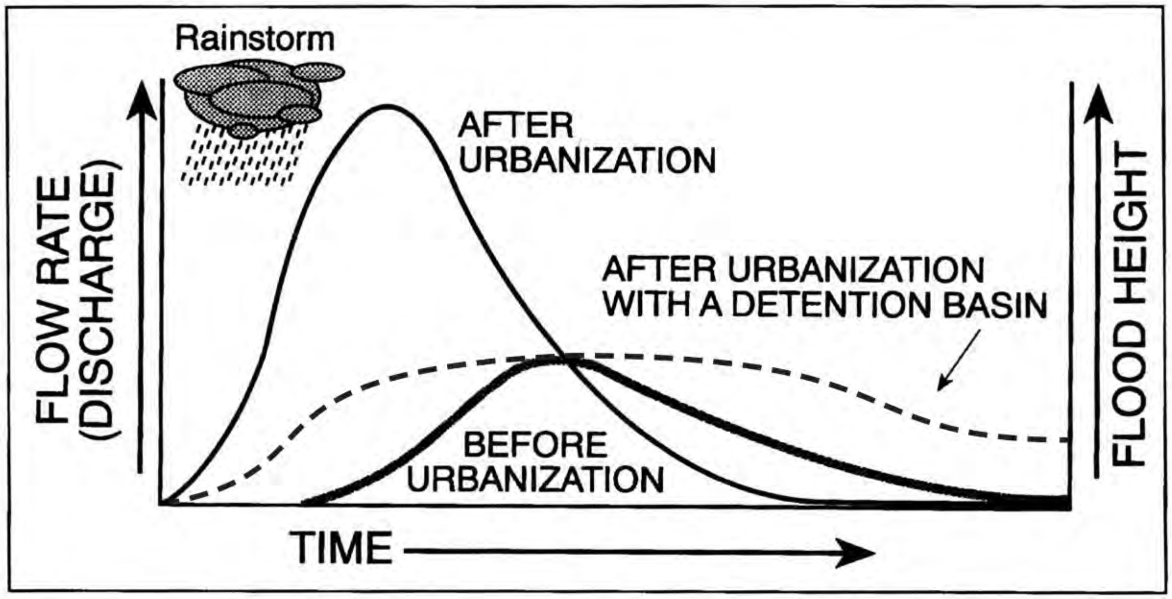

FIGURE 3: THE IMPACT OF URBANIZATION ON STORMWATER RUNOFF.
SOURCE: MODIFIED FROM HARBOR, 1994.

Erosion of the stream bank during peak flows removes vegetation that provides stability and natural cover for wildlife and aquatic species (Booth, 2000). Increased sediment load and scour during peak events change the morphology of steam beds, altering spawning habitat for salmon (*Onchorynchus sp.*). All of the above-mentioned changes combine to increase the risks of downstream flooding (U.S. EPA, 1997).

In addition to causing a disruption in flows, impervious surfaces can also affect water temperature. Water heated on hot pavements and rooftops contributes to stormwater runoff and may cause an elevation in water temperature in streams, lakes, and wetlands (Grant et al, 2000). In addition, lack of forest cover in riparian areas, caused by either stream bank instability or infringement of the urban environment to the stream edge, can cause losses in shade and subsequent rises in water temperature (Arnold, 1996). Heating can also occur in wetponds for treatment and detention ponds. This effect is less serious in the Pacific Northwest due to lower precipitation levels in summer months.

Increased water temperatures can cause favorable environments for algae blooms, changing the nutrient load in a stream or lake. In addition, increases in temperature cause a decrease in dissolved oxygen in water. Many cold water fish and insects are extremely temperature-sensitive in their reproduction and health (Grant et al, 2000).

B. Puget Sound Lowland Streams

A significant amount of research has been completed regarding the impacts of urbanization on streams and wetlands in Puget Sound lowland basins. University of Washington researchers studied 31 sites on 19 lowland streams in the Puget Sound basin, including three in Olympia (Percival Creek, Green Cove Creek, and Schneider Creek), representing a full range of development intensity, from nearly undisturbed to highly urbanized basins. The key objective of the stream study was to identify links between landscape conditions and in-stream environmental factors. An additional objective was to identify any possible thresholds of watershed urbanization related to in-stream habitat characteristics and biological integrity (Horner and May, 2001).

The City of Olympia (1999) (Figure 4) summarized the findings below:

Increased urbanization, measured by percent of total impervious surface area (%TIA):

- Changes basin hydrology, measured by increases in stormwater runoff and decreases in low flows (Figure 5);

- And changes riparian corridor integrity, measured by width of, and disturbance within, the riparian buffer (Figure 6).

Changes in these basin conditions, in turn, affect aquatic habitat, including:

- Physical stream characteristics, measured by amount of large woody debris (LWD), which contributes to habitat diversity, and other factors such as sediment load and streambed stability;

- And chemical water quality, measured by parameters such as conductivity, zinc, phosphorus, and suspended solids (Figure 8).

Changes in aquatic habitat affect the extent and variety of aquatic biota, including:

- Macroinvertebrates, including insects and crustaceans;

- Salmonids and other fish species (Figure 9);

- Shellfish.

Functional Relationships between Development, Basin and Habitat Conditions, and Aquatic Biota					
Level of Urbanization →	**Basin and Riparian Conditions** →		**In-Stream and Wetland Habitat Conditions** →		**Aquatic Biota**
Current and Future Estimates of Impervious Area	Hydrology	Riparian Corridor	Physical Conditions	Chemical (Water Quality)	Macroinvertebrates Fish Shellfish

FIGURE 4: FUNCTIONAL RELATIONSHIPS BETWEEN DEVELOPMENT, BASIN AND HABITAT CONDITIONS, AND AQUATIC BIOTA.
SOURCE: ADAPTED FROM CITY OF OLYMPIA, 1999.

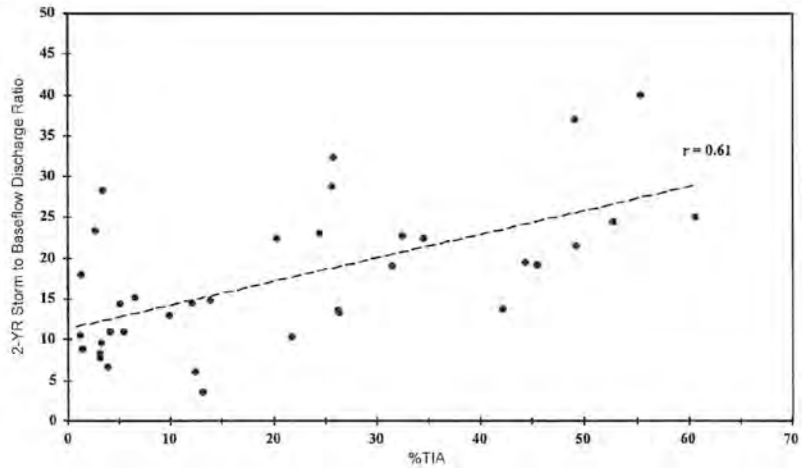

FIGURE 5: RELATIONSHIP OF CHANGE IN BASIN HYDROLOGY TO URBANIZATION IN PUGET SOUND LOWLAND STREAM BASINS, INDICATED BY THE RATIO OF 2-YEAR STORM FLOW TO WINTER BASIN FLOW.
SOURCE: MAY ET AL., 1997.

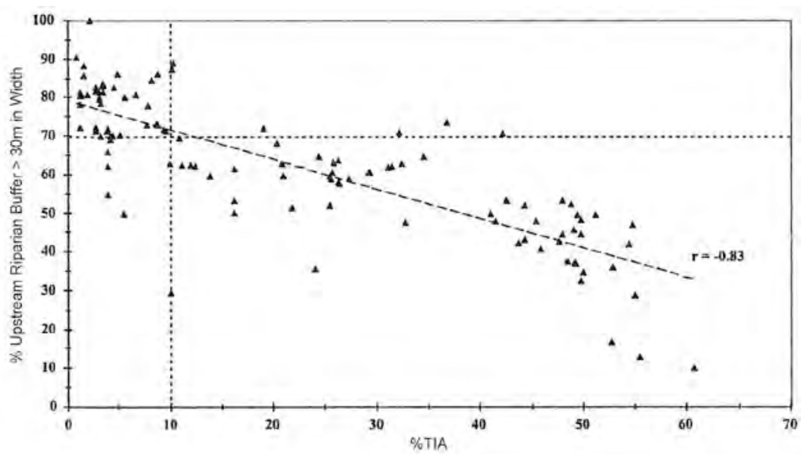

FIGURE 6: RELATIONSHIP BETWEEN RIPARIAN BUFFER WIDTH AND URBANIZATION (%TIA) IN PUGET SOUND LOWLAND STREAM BASINS.
SOURCE: MAY ET AL., 1997.

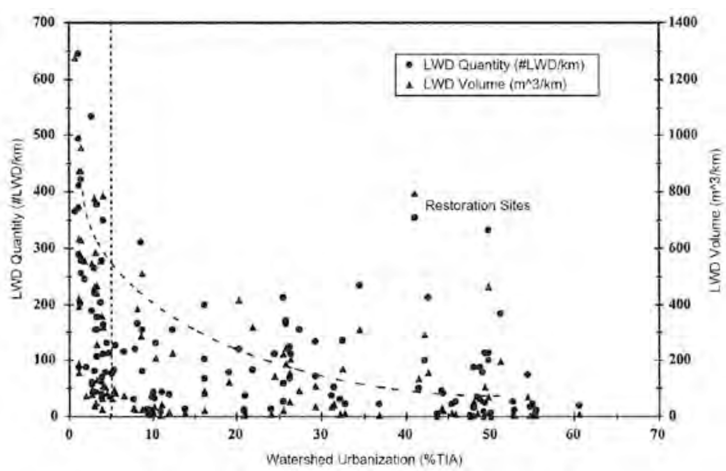

FIGURE 7: RELATIONSHIP OF QUANTITY OF LARGE WOODY DEBRIS (LWD) IN STREAMS TO URBANIZATION IN PUGET SOUND LOWLAND STREAM BASINS.
SOURCE: MAY ET AL., 1997.

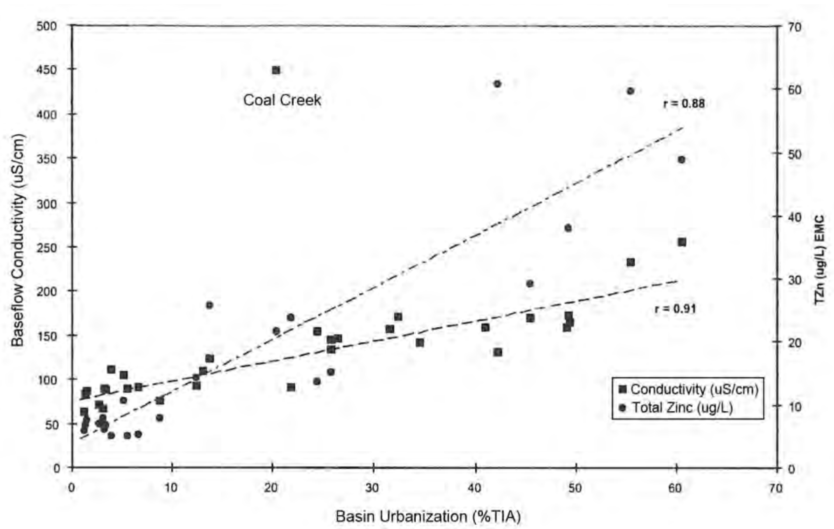

FIGURE 8: RELATIONSHIP BETWEEN WATER QUALITY (CONDUCTIVITY) AND URBANIZATION IN PUGET SOUND LOWLAND STREAM BASINS.
SOURCE: MAY ET AL., 1997.

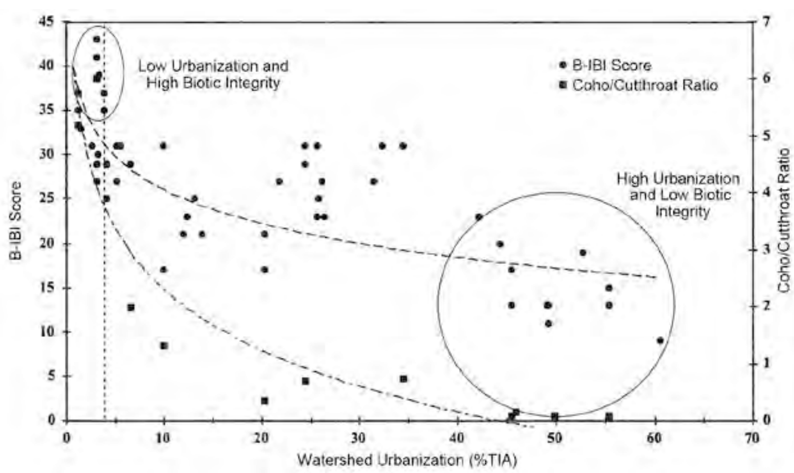

FIGURE 9: RELATIONSHIP BETWEEN INDICES OF SPECIES DIVERSITY AND URBANIZATION IN PUGET SOUND LOWLAND STREAM BASINS.
SOURCE: MAY ET AL., 1997.

C. Relationship between Land Cover and Stream Channel Stability

Figure 10 shows the conceptual relationship between channel stability, impervious surfaces, and forest cover for rural Puget Sound lowland streams. The basis for this generalization is the empirical data showing a direct correlation between forest cover, impervious area, and stream conditions from a large number of studies (Booth, 2000; Booth et al., 2002).

These studies indicate that it is important to maintain a forest cover of more than 60 percent, even where effective impervious area is fairly low (in the 2 to 6 percent range). As impervious area increases, the stabilizing effect of forest cover becomes increasingly important. There is no particular impervious threshold where degradation in stream integrity begins to occur — rather the relationship is a continuum.

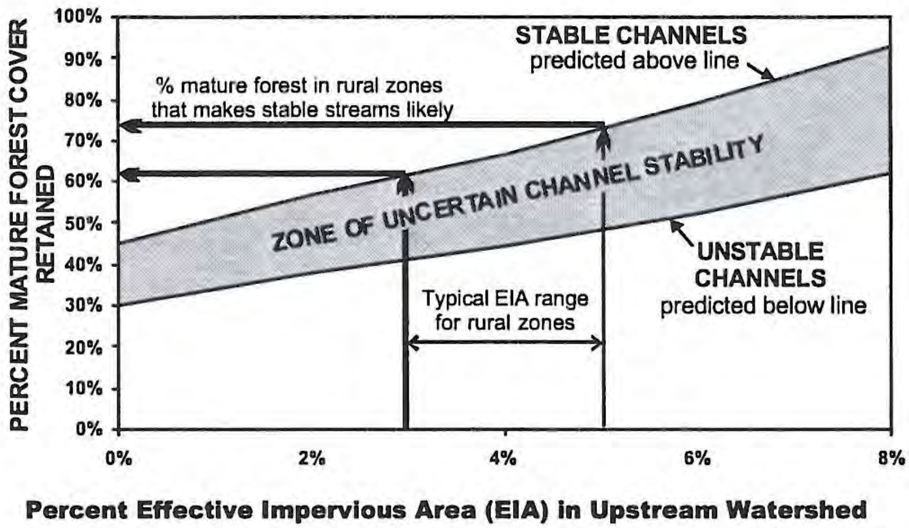

FIGURE 10: CONCEPTUAL RELATIONSHIP BETWEEN CHANNEL STABILITY, IMPERVIOUS SURFACES, AND FOREST COVER FOR RURAL PUGET SOUND LOWLAND STREAMS.
SOURCE: BOOTH ET AL., 2002.

D. Relationship between Land Cover and Biological Integrity

Biologic indicators, such as the monitoring of benthic macroinvertebrates, are increasingly becoming a means of evaluating the health of an ecosystem (Barbour et al., 2007). Biologic indicators measure the response of stream invertebrates to combined effects of water pollution (i.e., toxics, nutrients, and temperature), altered hydrology, channel instability, and other stressors (Storer, 2009). Many stream invertebrates require clear, cool water, adequate oxygen, stable flows, and a steady source of food in order to complete their life cycles (Fore, 1998). Others are more resilient to change. Overall stream invertebrates represent an enormous diversity of body shapes, survival strategies, and adaptations. The common biologic indicator is the Benthic Index of Biotic Integrity (B-IBI).

In 2000, Booth summarized much of the data compiled for Puget Sound Lowland watersheds (Figure 11) and drew the following conclusions:

- Imperviousness is clearly associated with stream-system decline. A range of stream conditions, however, can be associated with a given level of imperviousness;
- Biologic indicators demonstrate a continuum of effects resulting from human disturbance. Earlier attempts to define thresholds where large changes in stream health occur do not represent actual conditions;
- Significant degradation can occur at any level of human disturbance, but the level of imperviousness does appear to represent the upper boundary of stream health; i.e., stream health can be lower than predicted by the imperviousness, but is unlikely to be higher.

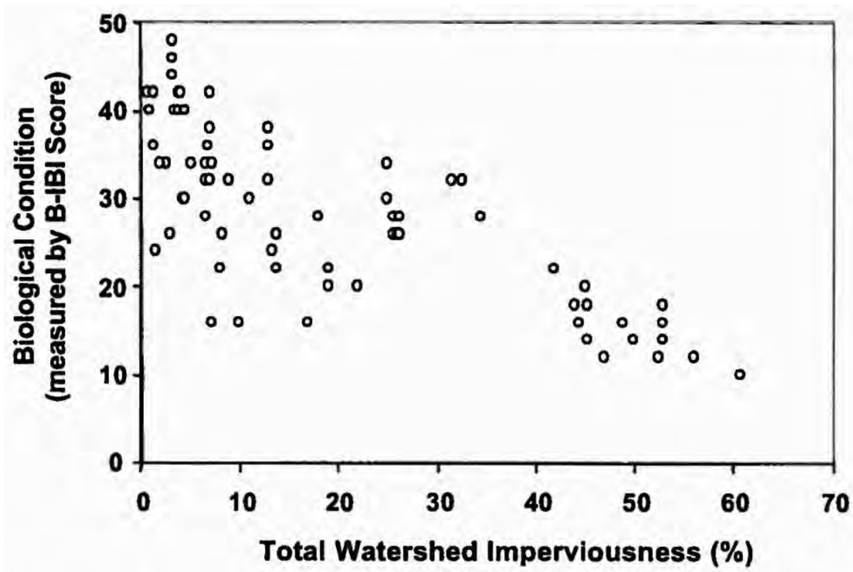

FIGURE 11: COMPILATION OF BIOLOGIC DATA ON PUGET LOWLAND WATERSHEDS.
SOURCE: BOOTH, 2000.

Some of the variation in B-IBI scores can be explained by land cover in the riparian zone. Stream reaches with relatively intact, wide riparian zones in wetland or forest cover typically exhibit higher B-IBI values than reaches with equivalent impervious area, but less intact riparian zones (Livingston et al., 2006). Relationships between B-IBI and various land cover indices have also been developed (Livingston et al., 2006). Various land cover characteristics such as watershed and riparian forest cover, wetlands, and total impervious area have been compared statistically to B-IBI, examples of which are shown in Figure 12 and Figure 13. Alberti et al., (2007) published a study that compared B-IBI scores to a variety of landscape factors. This study compared data from 42 sub-basins across the Puget Sound. This study confirmed that impervious area does explain a great deal of the variance in B-IBI across sub-basins, but that other variables such as configuration and connectivity of the landscape (measured by mean forest patch size and number of road crossings) were also contributing factors.

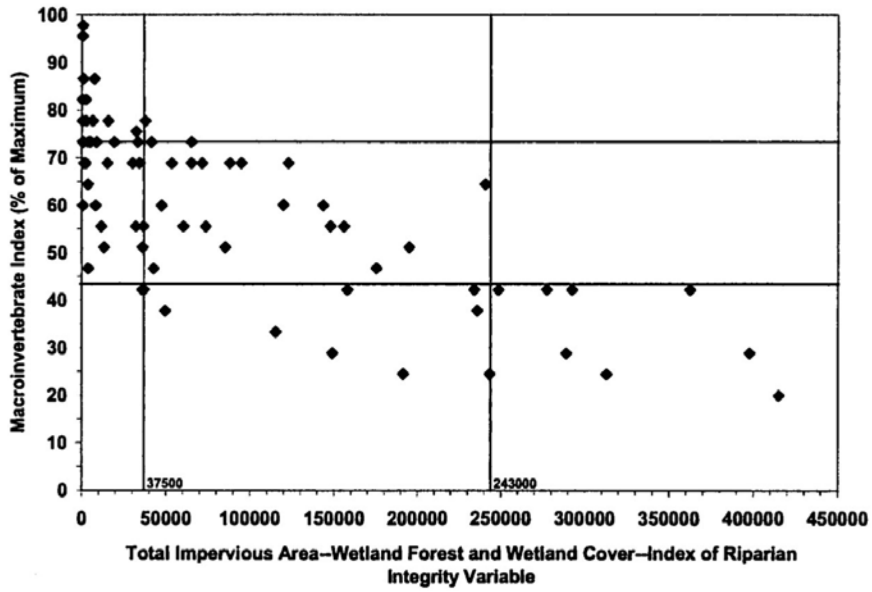

FIGURE 12: PUGET SOUND BIOLOGICAL COMMUNITY INDICES VERSUS (% TOTAL IMPERVIOUS AREA, TIA) * 100-FOREST AND WETLAND COVER) * (100-INDEX OF RIPARIAN INTEGRITY, IRI, VARIABLE).

Note: Upper and lower horizontal lines represent indices considered to define relatively high and low levels of biological integrity, respectively. Left and right vertical lines indicate maximum TIA associated with high biological integrity and minimum TIA associated with low biological integrity, respectively. Numbers near the vertical lines are horizontal axis-intercepts.

SOURCE: LIVINGSTON ET AL., 2006.

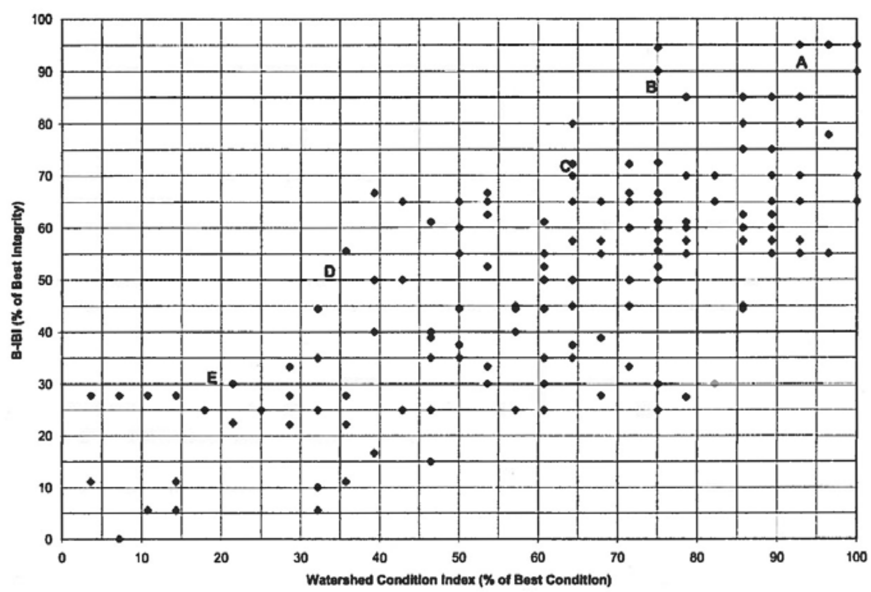

FIGURE 13: BENTHIC INDEX OF BIOTIC INTEGRITY IN RELATION TO PUGET SOUND WATERSHED CONDITION INDEX.

SOURCE: LIVINGSTON ET AL., 2006.

Note: A, B, C, D, and E represent water condition indices generally associated with B-IBI > 90, > 85, > 70, >50, and <30 percent of best integrity, respectively.

Studies relating urban development and aquatic-system conditions have been conducted for decades. Through a large body of research, a conceptual relationship between riparian forest and land use to biotic integrity of a stream has been developed and is shown in Figure 14 (Booth, 2000).

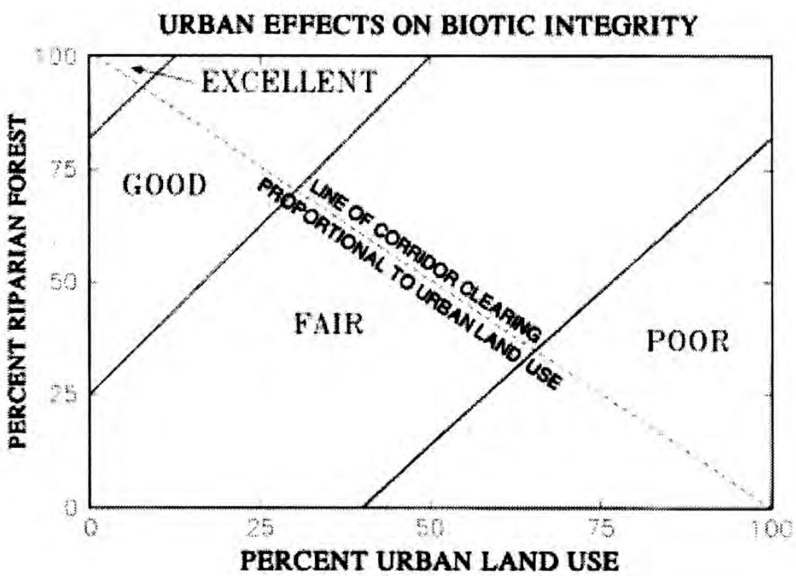

FIGURE 14: CONCEPTUAL RELATIONSHIP BETWEEN URBAN LAND USE (IMPERVIOUS SURFACES), FOREST COVER AND BIOLOGICAL CONDITIONS.
SOURCE: BOOTH, 2000.

Figure 15 shows a stylized relationship between watershed impervious coverage and stream health. In very general terms, stream health is considered protected with watershed impervious coverage less than 10 percent, impacted at between 10 and 20 percent, and degraded more than 30 percent.

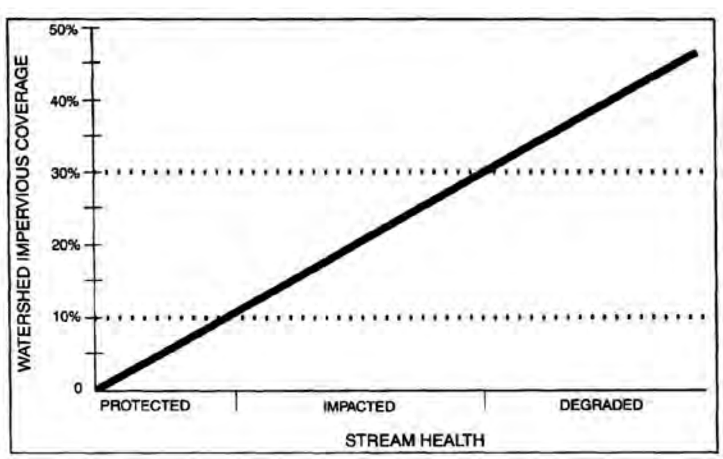

FIGURE 15: STYLIZED RELATIONSHIP OF WATERSHED IMPERVIOUS COVERAGE AND STREAM HEALTH
SOURCE: ARNOLD, 1996. THE RELATIONSHIP IS A CONTINUUM.

V. THURSTON COUNTY LOWLAND AND COASTAL BASINS – RELATIONSHIP OF B-IBI AND LAND COVER

A. Background

This study focuses on the hydrologic basins in Thurston County's WRIAs 13 and 14. This area encompasses the entire Eld, Totten, Budd/Deschutes, and Henderson Inlet Watersheds, and part of the Nisqually Watershed (Map 1).

In Thurston County's Puget Sound lowland basins, monitoring of benthic macroinvertebrates has been conducted since the late 1990s. These samples are collected by South Sound Green and Stream Team volunteers, and Thurston County Environmental Health staff. Monitoring samples are compiled into a Benthic Invertebrate Index of Biologic Integrity (B-IBI) and provide an indicator of overall stream integrity.

Thurston County Public Health and Social Services Department, Environmental Health Division and Thurston County Resource Stewardship Department, Water Resources Division, in cooperation with the cities of Olympia, Lacey, and Tumwater, publish annual B-IBI monitoring data in the bi-annual Water Resources Monitoring Report. For this study the scores are generalized into four categories:

- Low Biologic Integrity - B-IBI scores between 0 and 27
- Low/Moderate Biologic Integrity – B-IBI scores between 27 and 35
- Moderate/High Biologic Integrity – B-IBI scores between 36 and 40
- High Biologic Integrity – B-IBI scores >41

For this study, B-IBI sample locations on major streams were identified. Stream upland drainage areas were approximated based on basin boundaries (Map 4). B-IBI scores varied from year to year depending on the timing of sample collection relative to rainfall or flow events. To smooth out the data, three-year averages were calculated.

Two time periods of data were used — 2001 (average of 2000-2002) and 2006 (average of 2005-2007) — corresponding to available land cover, impervious, and forest canopy data. Sample locations on very small streams were excluded. All streams were selected to be within the study area of Puget Sound Lowland streams in WRIAs 13 and 14. B-IBI collected for the mainstem Deschutes River was not used. Between the two time periods, a total of 34 B-IBI averaged samples were used in this study, representing 21 unique sample points. Twenty-one averaged samples were used for 2005-2007, and 13 averaged samples were used from 2000-2002 to relate to the 2006 and 2001 land cover data layers, respectively (Table 2).

TABLE 2: B-IBI SAMPLE LOCATIONS USED IN THIS STUDY.

Stream	Location	Organization	2001	2006
Adam's Creek	Liengang @ Gull Harbor	South Sound Green	No	Yes
Black Lake Ditch	R.W. Johnson Road	Stream Team	Yes	Yes
Chambers Creek	End of 58th Avenue	Environmental Health	Yes	Yes
Ellis Creek	Priest Point Park	Stream Team	Yes	Yes
Green Cove Creek	36th Avenue NW	Stream Team	Yes	Yes
Green Cove Creek	4311 Cooper Point Road	Environmental Health	Yes	Yes
Indian Creek	Wheeler Avenue SE	Stream Team	No	Yes
Kennedy Creek	Near Highway 101	Environmental Health	Yes	Yes
McLane Creek	Delphi Road Bridge	Environmental Health	Yes	Yes
McLane Creek	DNR Nature Trail	Stream Team	Yes	Yes
Mission Creek	East Bay Drive	South Sound Green	Yes	Yes
Moxlie Creek	Watershed Park	Environmental Health	No	Yes
Percival Creek	footbridge below Evergreen Park Dr.	Environmental Health	No	Yes
Percival Creek	Chapparal Road	South Sound Green	No	Yes
Percival Creek	SPSCC Artist's Bridge	Stream Team	No	Yes
Perry Creek	Perry Creek Road	Environmental Health	Yes	Yes
Schneider Creek (B)	West Bay Drive	Stream Team	No	Yes
Schneider Creek (T)	4100 Pneumonia Gulch Lane NW	Environmental Health	No	Yes
Woodard Creek	4116 Libby Road	Environmental Health	Yes	Yes
Woodland Creek	Pleasant Glade Road	Stream Team	Yes	Yes
Woodland Creek	Draham Road	Stream Team	Yes	Yes

B. Relationship of B-IBI and Land Cover

A variety of land cover conditions were mapped in a geographic information system and compared against B-IBI using bivariate correlations (Pearson Correlation). The R-squared correlation is also shown for comparison (Table 3).

Basin-wide level: The two strongest correlations found between 3-year average B-IBI at the basin-wide level were:

- Total Impervious Area: Basin-wide (Figure 16, Table 3). This relationship showed a negative correlation;
- Unmodified Wetlands: Basin-wide (Figure 17, Table 3) (for basins with TIA of greater than 3 percent).

It should be noted that there was no significant correlation between B-IBI and unmodified wetlands when **all** basins were considered. For those basins with low TIA and high B-IBI scores, percent unmodified wetlands varied from very low to quite high. There are two likely possible reasons for this:

1. There is a natural variation in the amount of wetlands in each basin in Thurston County, and therefore simply having a low percent of wetlands does not indicate the health of basin; or,

2. Many rural basins (low TIA) with a low percent of unmodified wetlands also have a high percent of forest cover. It is possible that unmodified wetlands are present in these basins but not mapped, either because the GIS coverage does not cover all of Thurston County (areas such as Capitol Forest are not mapped), or because forested wetlands are difficult to map with aerial photography.

Figure 18 shows the relationship of B-IBI-generalized categories compared to basin-wide unmodified wetlands and basin-wide total impervious area. Using these relationships, generalized categories of high, moderate/high, and low/moderate health can be drawn (indicted with gray shading). It is important to note that loss of stream biologic integrity can occur at lower levels than the thresholds identified in Figure 18. These thresholds should be considered the maximum at which high or moderately high biologic integrity can be maintained.

Riparian Areas: Land cover characteristics within riparian areas along stream corridors were compared to 3-year average B-IBI. Widths were measured from the edge-point of the stream on both sides.

- The strongest relationships were found between B-IBI and percent impervious in the riparian buffer at distances of 1000 (strongest relationship), 250, and 150 feet. These relationships showed a negative correlation. (Table 3).

Combining Land Cover Classes: Multiple regressions (linear) were performed on the land cover classes cited in literature and also showing significant correlations with B-IBI. Regressions show a slightly better correlation with B-IBI than single land covers alone (Table 4).

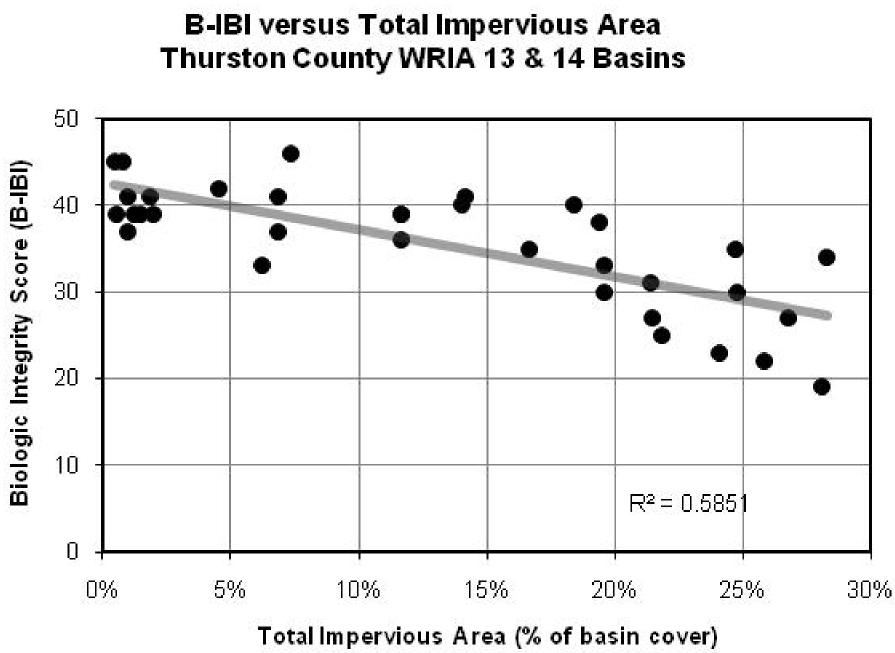

FIGURE 16: RELATIONSHIP OF BENTHIC INVERTEBRATE INDEX TO TOTAL IMPERVIOUS AREA FOR THURSTON COUNTY PUGET SOUND LOWLAND STREAMS.

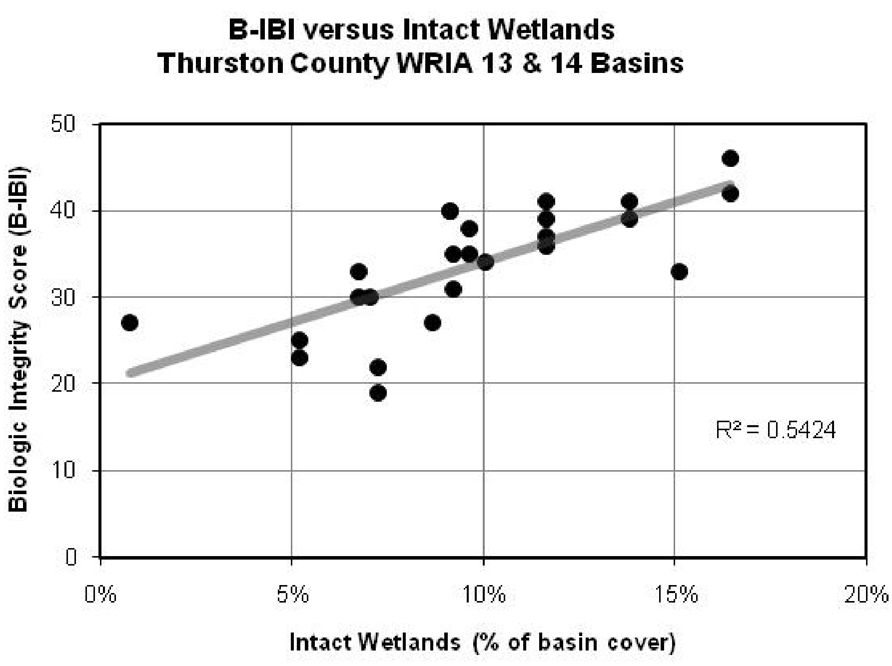

FIGURE 17: RELATIONSHIP OF BENTHIC INVERTEBRATE INDEX TO UNMODIFIED WETLANDS FOR THURSTON COUNTY PUGET SOUND LOWLAND STREAMS BASINS WITH TIA GREATER THAN 3 PERCENT.

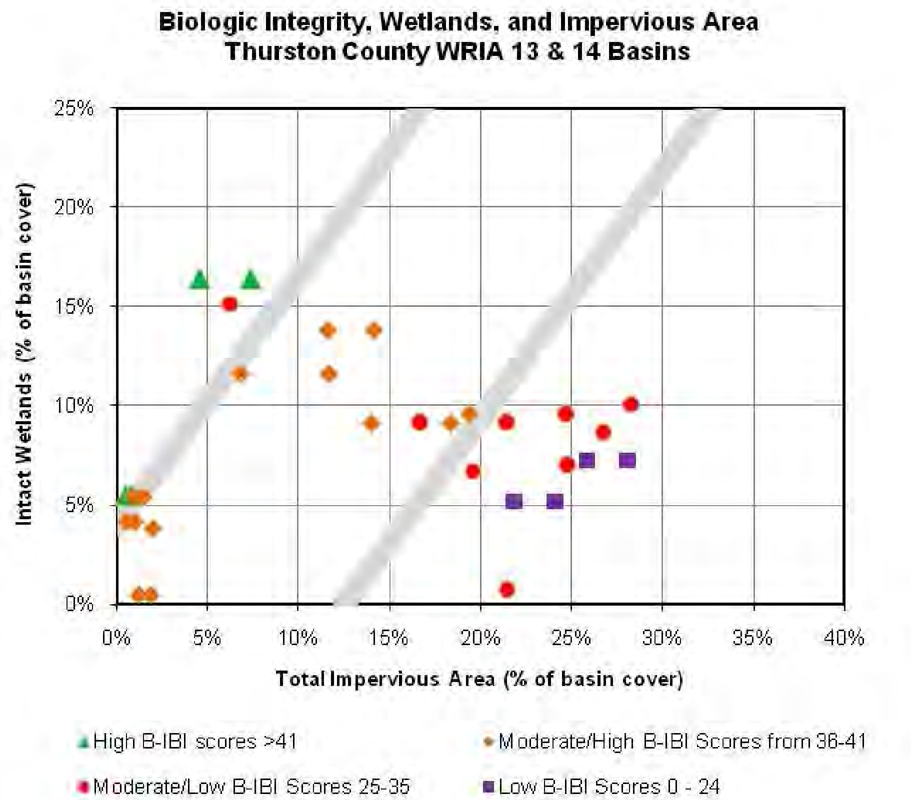

FIGURE 18: RELATIONSHIP OF TOTAL IMPERVIOUS AREA, UNMODIFIED WETLANDS, AND BIOLOGIC INTEGRITY (B-IBI) FOR THURSTON COUNTY BASINS IN WRIAS 13 AND 14.

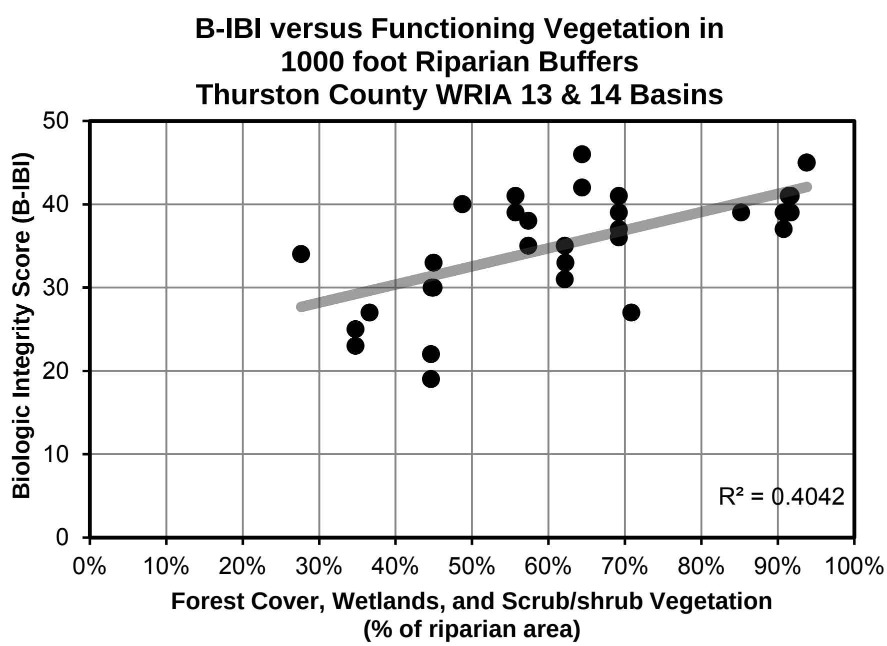

FIGURE 19: RELATIONSHIP OF BENTHIC INVERTEBRATE INDEX TO VEGETATION COVER IN 1000 FOOT RIPARIAN BUFFERS FOR THURSTON COUNTY PUGET SOUND LOWLAND STREAMS.

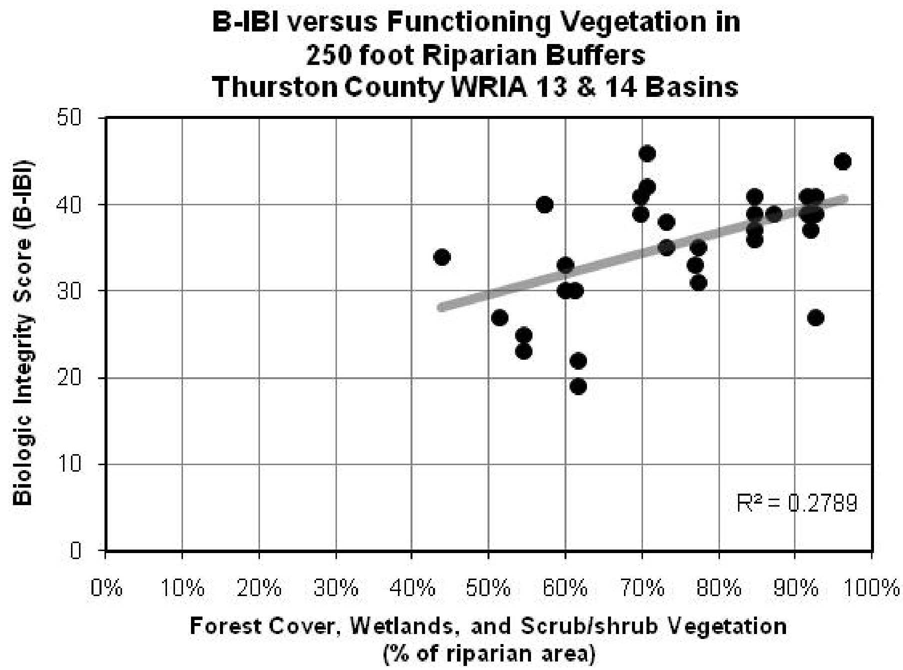

FIGURE 20: RELATIONSHIP OF BENTHIC INVERTEBRATE INDEX TO VEGETATION COVER IN 250 FOOT RIPARIAN BUFFERS FOR THURSTON COUNTY PUGET SOUND LOWLAND STREAMS.

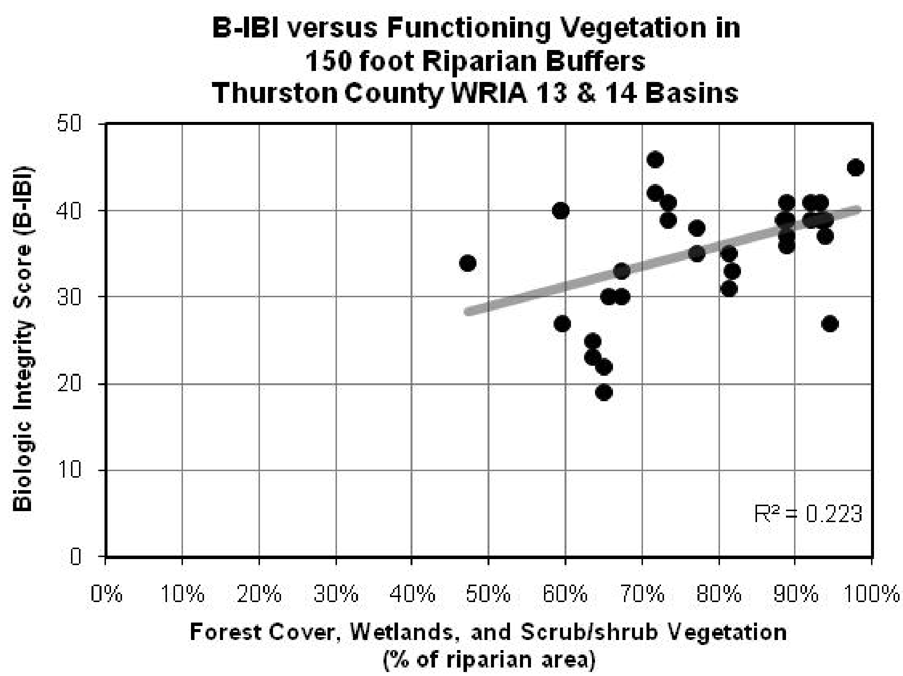

FIGURE 21: RELATIONSHIP OF BENTHIC INVERTEBRATE INDEX TO VEGETATION COVER IN 250 FOOT RIPARIAN BUFFERS FOR THURSTON COUNTY PUGET SOUND LOWLAND STREAMS.

TABLE 3: CORRELATION BETWEEN B-IBI AND VARIOUS LAND COVER CHARACTERISTICS IN THURSTON COUNTY LOWLAND BASINS.

Land Cover Characteristic Correlation With 3-Year Average B-IBI	Pearson Correlation	Significant Correlation	R Squared	Number in Sample
Basin total impervious area (TIA) percent (Figure 16)	-0.765	**	-0.585	34
1000 ft. stream buffer TIA percent	-0.794	**	-0.630	34
250 ft. stream buffer TIA percent	-0.635	**	-0.404	34
150 ft. stream buffer TIA percent	-0.590	**	-0.348	34
Basin forest canopy (over 40% canopy)	0.459	**	0.211	34
1000 ft. stream buffer forest canopy percent	0.425	*	0.181	34
250 ft. stream buffer forest canopy percent	0.145	-	0.021	34
150 ft. stream buffer forest canopy percent	0.034	-	0.001	34
Basin forest and wetland (combined) cover	0.571	**	0.326	34
1000 ft. forest and wetland (combined) cover	0.576	**	0.332	34
250 ft. forest and wetland (combined) cover	0.408	*	0.166	34
150 ft. forest and wetland (combined) cover	0.334	-	0.112	34
Basin forest, wetland, and shrub/scrub combined cover	0.580	**	0.336	34
1000 ft. forest, wetland, and shrub/scrub combined cover (Figure 19)	0.636	**	0.404	34
250 ft. forest, wetland, and shrub/scrub combined cover (Figure 20)	0.528	**	0.279	34
150 ft. forest, wetland, and shrub/scrub combined cover (Figure 21)	0.472	**	0.223	34
Basin unmodified wetlands percent	0.218	-	0.048	34
Basin unmodified wetlands percent with basin TIA more than 3% (Figure 17)	0.736	**	0.542	25
Basin unmodified and modified wetlands percent with basin TIA > 3%	0.689	**	0.474	25
Road crossings per mile of stream	-0.423	*	0.179	34

SOURCES: SEE SOURCES IN APPENDIX

Note: buffers measured from stream edge. ** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed); - No significant correlation found

TABLE 4: LINEAR MULTIPLE REGRESSION RESULTS FOR SELECT LAND COVER COMBINATIONS.

Multiple (Linear Regression Results)	R Squared	Number in Sample
Basin wide total impervious area; Basin wide canopy cover	0.640	34
Basin wide total impervious area; Basin wide canopy cover; 250 ft. forest, wetland, and shrub/scrub combined cover	0.641	34
Basin wide total impervious area; Basin wide canopy cover 250 ft. forest, wetland, and shrub/scrub combined cover Wetlands; Basin unmodified wetlands percent with basin TIA more than 3%	0.672	25

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VI. POLICY IMPLICATIONS OF RESEARCH

The research has significant implications for land use and resource management of Thurston County's lowland and coastal basins. Since the early 1990s, effort has been placed on protecting and restoring critical riparian and wetland habitat. By the late 1990s, research in the greater Puget Sound was showing that retention of a wide, nearly continuous riparian buffer of native vegetation was important to maintaining stream biologic integrity (Horner and May, 1999). The importance of upland forest retention was also shown to offer valuable benefits, especially in undeveloped or lightly developed watersheds, and the cumulative effects of basin urbanization on stream health were better understood (Horner and May, 1999; Booth et al., 2002).

Schueler (1994), in summarizing research on this topic, states: "It is extremely difficult to maintain pre-development stream quality when watershed development exceeds 10-15 percent impervious cover." He suggested developing watershed management categories where different goals and strategies could be applied, and that stream basins be grouped into "sensitive," "impacted," or "non-supporting" (degraded). For each of these groupings, resource objectives and management strategies could be developed. This understanding of basin conditions could help prioritize preservation, enhancement (restoration) and mitigation efforts — which should be focused on basins where ecologic function is impaired but not entirely lost (May et al., 1997). Preservation of well-functioning basins may require directing development elsewhere, and where development is likely to occur, preservation of landscape functions will require mitigation for development, which could include impervious surface limits, forest cover retention, stormwater detention, protection of critical areas, and maintenance of riparian buffers (Booth et al., 2002).

The relationship of unmodified wetlands and stream biologic health in Thurston County lowland basins (this study; Figure 17) points to continued focus on protecting and restoring critical wetland habitat, especially in basins that are showing impacts of development. In addition, the retention of any functioning vegetative cover (forest, wetland, or shrub/scrub) basin-wide and near stream and wetland corridors, should be considered in basins that are impacted by development.

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VII. PUGET SOUND PARTNERSHIP INDICATORS

In 2010, the Puget Sound Partnership identified key ecosystem indicators and pressures that would help the region track whether progress was being made in restoring the Puget Sound. In 2011, the Puget Sound Partnership Leadership Council adopted targets – specific measures that the region could use as “Vital Signs” of Puget Sound’s health.

One of the targets the Partnership adopted for freshwater quality related to B-IBI. The target was to:

- Protect small streams that are currently ranked as “excellent” by B-IBI for biologic condition, and
- Improve and Restore streams ranked “fair” so that their average scores become “good.”

It should be noted that the Puget Sound Partnership relies on B-IBI data from Puget Sound Stream Benthos, while this study contains B-IBI data from a variety of other local sources that have been analyzed with different methodology – leading to slightly different results and rankings.

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VIII. WATERSHED CHARACTERIZATIONS AND LANDSCAPE ASSESSMENTS

Watershed characterizations are one source of information that will be used in implementing watershed-based land use planning in Thurston County. Watershed characterizations, as well as existing studies and reports, land cover data, and monitoring data will be used to inventory and characterize current conditions within the basins in WRIAs 13 and 14. These sources as well as future land cover estimates will be used to identify potential problems. Finally, land use scenarios and results of hydrologic modeling will be used to test and evaluate solutions (to identified problems) using a variety of management options such as changes in land use, development regulations, restoration activities, and implementation of new preservation or restoration programs.

Watershed characterizations are a GIS-based tool[1] for understanding the ecological conditions of landscapes over a variety of spatial scales, and to the extent they have been successfully designed to do so, they can shed a great deal of light on the condition of terrestrial and aquatic resources within a drainage system. These GIS-based characterizations can be potentially useful in ranking drainage areas of different scales within a larger study area with respect to importance of ecological function and level of ecological impairment and thus inform the selection and prioritization of management actions (or categories of actions) among these drainage areas.

There are currently three watershed characterizations available for Thurston County. They are described below in order of generalized to detailed. All provide unique and valuable information to better develop management strategies for Thurston County basins.

A. Puget Sound Watershed Characterization - Water Flow Process Assessment

The Washington State Department of Ecology (Ecology) released a draft water flow assessment as part of its Puget Sound Watershed Characterization Project in the spring of 2010. The data and report were reviewed, and several suggestions including modification of analysis unit boundaries were incorporated into the subsequent release. The most significant changes were:

- Inclusion of the Black Lake basin in WRIA 13. This lake drains from the north into Black Lake ditch, then Percival Creek through Capitol Lake and into Budd Inlet. A southern drainage is generally blocked by beaver dams, although flows have been observed. This basin is now included in both WRIA 13 and 23 analyses;
- Placement of Barnes Lake into the Deschutes River basin, rather than Percival Creek. This lake has some surface flow, and can drain in either direction. For consistency

[1] GIS-based characterizations typically invoke qualitative or semi-quantitative, non-dynamic relationships between spatial data types and ecological outputs. These relationships are typically invoked within a mapped analysis unit with little or no reference to neighboring units. Thus, processes of accumulation, attenuation, or transformation within a drainage network are typically neglected or only weakly represented. GIS-based characterizations require careful interpretation that recognizes the limitations of underlying data and approaches. In some cases augmentation using other analytic tools may be warranted as a means to refine management prescriptions for a mapped analysis unit, specific stream reach, or drain area composed of multiple units.

with other Thurston County basin layers, it was shifted to show drainage into the Deschutes River;

- Combining all analysis units in the project study area into one assessment so that basin data were comparable (rather than relative to each WRIA)

Ecology's Water Flow Assessment evaluates one watershed process, the movement of water, as part of the Puget Sound Watershed Characterization Project. Watershed processes are defined by Ecology as "the dynamic physical and chemical interactions that form and maintain the landscape and ecosystems on a geographic scale of watershed to basins (hundreds to thousands of square miles)." Scientists are developing a consensus that in order to adequately protect and restore aquatic ecosystems, it is essential to understand watershed processes at a broad scale.

Watershed processes such as water flow are often altered by human activities that change features such as land cover, topography, or soils, which in turn, control the structure and function of habitats. Some common human activities that degrade water flow processes include impervious surfaces, forest clearing, filling and draining/diking wetlands and floodplains, roads and associated storm drainage systems, and removal of riparian vegetation.

Ecology's Water Flow Assessment includes an evaluation and results for several components of the water flow process (delivery, surface water storage, and groundwater recharge and discharge) as well as results combining all components of the water flow model.

Ecology's Water Flow Assessment provides an assessment of not only analysis unit conditions (described as impairment in the model), but also the importance of each analysis unit (Map 3) for each of the processes based on pre-development functions. Ecology uses analysis units which are based on groupings of watershed catchment units defined by the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP, Northwest Indian Fisheries Commission). Typically, analysis units are smaller than basins (see Map 2 versus Map 3).

The analysis units in WRIA 13 and 14 were broken into three landscape groups based on similarity of climate, surficial geology, topography, groundwater, and surface flow patterns in relation to aquatic ecosystems. The three landscape groups are mountainous, lowland, and coastal (Map 16). Analysis units are evaluated for their relative importance only within their landscape group. For example, the importance of an analysis unit in the lowland group could only be compared to the importance of other analysis units in the lowland group, and not to units in the mountainous or lowland groups. Areas that are shown to be of high importance in one group are not comparable to areas that are high importance in the other landscape groups. For this report, the analysis units in WRIAs 13 and 14 were compared relative to each other.

Suggested Management Strategy

The Puget Sound Watershed Characterization suggests a management strategy based on a relative comparison of the level of degradation (current conditions) to level of importance (potential conditions) in analysis units.

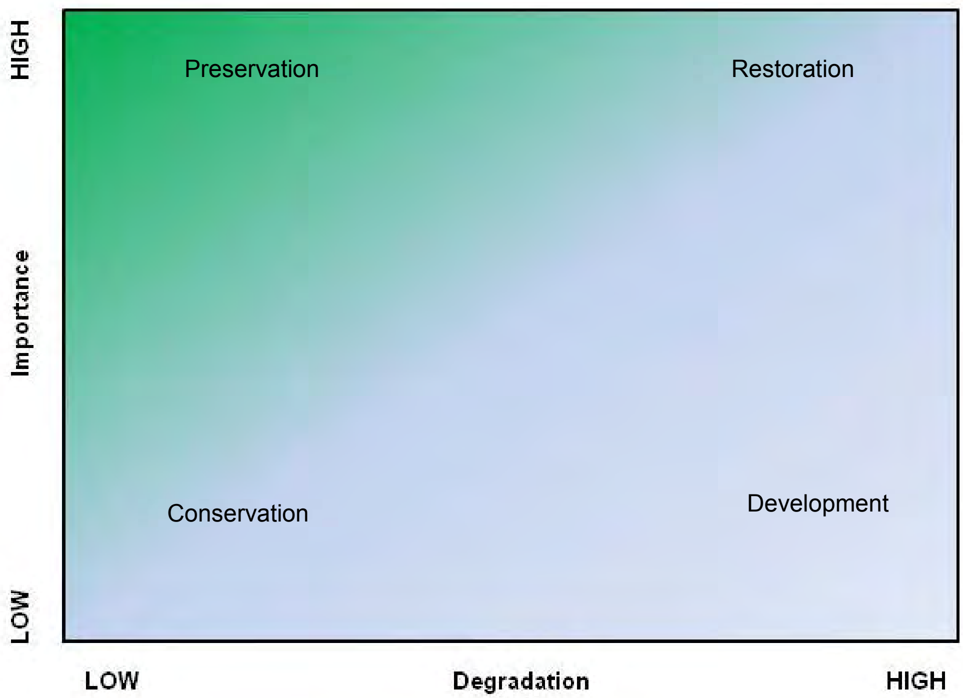

FIGURE 22: CONCEPTUAL WATERSHED MANAGEMENT MATRIX.
SOURCE: BASED ON STANLEY ET AL. 2010.

In this management strategy, the following is suggested:

- Those areas that are important and relatively unimpaired become candidates for protection (upper left corner of the matrix), to ensure the water processes remain intact. Extra care should be taken to establish land use patterns that protect and maintain water flow processes.
- Areas that are important to the process but more impaired become candidates for restoration of water flow processes (upper right corner of the matrix). Focusing restoration in these analysis units will increase the likelihood that associated water flow processes will be restored. Zoning and regulations in these areas should promote development that restores areas important to water flow processes (excluding heavily urbanized areas).
- Areas rated low for process importance and low for impairment (lower left corner of the matrix), are the most suitable for conservation. These areas have a lower level of relative importance; however, they play an important role in sustaining down-gradient aquatic ecosystems. In these analysis units, management can include traditional protection measures, as well as environmentally friendly infrastructure.

- Areas that are both relatively less important for a process and are already severely degraded are the areas where there will be less impact to processes if additional human land use activities occur (lower right corner of the matrix). The aquatic ecosystems in these latter areas are assumed to change less if human disturbances are increased. However, measures should still be taken at the site scale to protect water quality and quantity functions, and significant habitat functions.

NOTE: Additional Results of the Puget Sound Watershed Characterization became available after this report was completed. The results are anticipated to be used by the Project Team in later stages of the Guiding Growth – Healthy Watershed: Translating Science into Local Policy project based on input provided by the Consulting Hydrologist and guidance from the project's Scientific Advisory Team.

B. Thurston County Watershed Characterization

The Thurston County Watershed Characterization is similar in concept to Ecology's Watershed Characterization, but differs in scale and level of detail. The Thurston County Watershed Characterization is complete for Budd/Deschutes Watershed, and Henderson, Eld, and Totten Inlets.

Thurston County's Watershed Characterization measures the condition of five landscape-scale ecological processes and two biological elements. The physical processes include: movement of water, sediment, pollutants, large wood, and heat through stream systems within the study areas. The biologic elements include aquatic integrity and upland habitat connectivity (Thurston County, 2010). The scale at which these are measured is a drainage analysis unit (DAU) of approximately 0.25 square miles. These are smaller in size to Ecology's analysis units (Map 3) but are comparable in that they represent analysis units rather than drainage basins. Each DAU is identified overall as properly functioning, at risk, or not properly functioning for each of the five processes, and two biological elements.

The second component of Thurston County's Watershed Characterization is to identify and rank natural resource sites (wetlands, riparian, and floodplains) for their potential to improve the ecological function of DAUs through restoration activities.

The landscape scale (DAU) and site scale information are combined to give an overall score to each site. This analysis can be used as a first screening tool by Thurston County to choose restoration sites.

NOTE: Results and data layers from the Thurston County Watershed Characterization were under development at the time this report was being developed. The results and data are anticipated to be used (to the maximum extent possible) in later stages of the Guiding Growth – Healthy Watershed: Translating Science into Local Policy project based on input provided by the Consulting Hydrologist and guidance from the project's Scientific Advisory Team.

C. *Budd Inlet Landscape Assessment*

The Budd Inlet Landscape Assessment was developed by the Squaxin Island Tribe Natural Resources Group and Kyle Brakensick as a tool to approach prioritization and conservation of areas within Budd Inlet (Squaxin Island Tribe and Brakensick, 2010). The ecosystem analysis unit used for this project was watershed catchment units defined by the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP, Northwest Indian Fisheries Commission). The ecosystem analysis units were divided into upland catchments and nearshore catchments.

The Budd Inlet Landscape Assessment used NOAA C-CAP land cover data (2006) to allow a coarse determination of the degree of human impact. The NOAA C-CAP land cover data allowed them to quantify the amount of human development (as impervious surface area types) for each catchment unit. The approach assumes that land cover data provides a quantitative method to infer the degree of ecosystem function impairment, with impairments being loss/removal of natural vegetation cover and resulting loss of hydrologic regimes. The Budd Inlet Landscape Assessment quantified the percent total development for each catchment unit. Site versus landscape scale relationships were also evaluated by summing the development scores of all "neighboring catchments" to each catchment and then averaging by the number of neighboring catchments. "Neighboring catchments" were defined as any adjacent polygon catchment sharing a common border regardless of whether they are a nearshore or upland catchment.

Suggested Management Strategy

The Budd Inlet Landscape Assessment suggests management strategies for nearshore and upland catchments along Budd Inlet based on an assessment of the level of disturbance at both the site and landscape scales. The suggested management strategies are shown below at a conceptual level.

TABLE 5: RESTORATION STRATEGIES BASED ON DEGREE OF DISTURBANCE AT THE SITE SCALE.
FROM: DIEFENDERFER ET AL. 2007 TABLE 11; ADAPTED FROM THOM AND OTHERS 2005A.

		Landscape Scale		
	Disturbance	**Low**	**Medium**	**High**
Site Scale	**High**	Restore Enhance	Enhance Restore	Create Enhance
	Medium	Restore Enhance Conserve Preserve	Enhance Restore Conserve	Enhance Create
	Low	Conserve Preserve	Conserve Enhance Restore Preserve	Enhance Conserve

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IX. MANAGEMENT GOALS, OBJECTIVES, AND STRATEGIES

A. Background and Regulatory Framework

Until the 1970s, the importance of maintaining habitat in urban areas was not widely recognized. Wetlands were filled; streams were placed into concrete ditches, or piped under city centers. Northern Thurston County was no exception. Moxlie Creek flows under much of downtown Olympia in a pipe; Chambers Lake drains into Chambers Creek through a ditch, and the outflow of Black Lake was redirected from the south (into Black River and out toward the Chehalis River) to the north and into Budd Inlet through Black Lake Ditch.

The Turning Point

During the 1970s, the value and importance of wetlands became more apparent. The federal government — which up to this point had been encouraging the draining and filling of wetlands — decided to protect them. The passage of the Clean Water Act in 1972 (officially an amendment to the Federal Water Pollution Control Act of 1948) was a big step forward in both protecting wetlands and managing water pollution. This law led to many changes in how local governments treated pollution and is still the primary law protecting water quality in the United States. Wetlands weren't actually included in the act; however, Congress and the federal courts interpreted them to be protected - for the main reason that waterways could not be effectively protected without also protecting the wetlands that fed into them.

Protection of Thurston County's streams, lakes, wetlands, and marine shorelines

Within the Thurston region, the protection of streams, lakes, wetlands, and marine shoreline began in 1972 after voters approved the State Shoreline Management Act through public referendum. This state law required local governments to adopt plans and standards for development along the large bodies of waters. In a state where comprehensive planning and zoning had been optional, shoreline master programs required local planning for the small ribbon of land along designated shorelines.

In the 1980s, other local environmental regulations were added by Thurston County and the City of Olympia. Both adopted "Environmentally Sensitive Areas" regulations for streams and wetlands. Nationally, by 1986, the importance of protecting critical areas such as wetlands was better understood, and the passage of the Emergency Wetlands Resource Act signaled a new concern over protecting wetlands.

By the early 1990s, the state's Growth Management Act directed local governments to adopt Critical Area Ordinance regulations to protect critical areas, including wetlands and stream corridors, in balance with managing growth.

In 1995, the state amended the Growth Management Act to require counties and cities to include the "best available science" in developing policies and development regulations to protect the functions and values of critical areas. These policies were updated between 2005 and 2012 – depending on the jurisdiction.

In 1995, the Washington Legislature directed Ecology to update guidelines for developing shoreline master programs (a requirement of the Shoreline Management Act). The update of the guidance was completed in 2003. Local jurisdictions are in the midst of their updates now.

Water Quality

Paralleling the effort to protect critical areas, in the mid-1980s, local residents were becoming increasingly concerned about the impacts of untreated stormwater runoff on the community's surface water quality. The community was witnessing the degradation of its streams and Puget Sound and was aware of the habitat losses as a result of increased pollution and development. The Puget Sound Water Quality Management Plan, issued in 1987, required local governments to address stormwater quality.

One of the programs created under the Clean Water Act was the National Pollutant Discharge Elimination System (NPDES). This program is responsible for controlling and regulating point sources of discharge of pollutants to waters within each state to maintain, protect, and restore the water quality of streams, lakes, and rivers. Point sources are discrete conveyances such as pipes or man-made ditches. Phase I of the program went into effect in 1990 and applied to large municipalities (greater than 100,000). Phase II went into effect by 1999 and applied to smaller municipalities such as the combined urban area of northern Thurston County.

One of the requirements under this program was the development of a comprehensive stormwater management program, required in Thurston County after a Phase II NPDES permit was issued in 2008. Based on guidance in Ecology's 2005 manual an update of local regulation followed, with Drainage Design and Erosion Control Manuals adopted by affected local governments in 2009 and 2010. Ecology updated their manual in 2012. Phase II jurisdictions must adopt updated regulations by December 31, 2016.

Watershed-based Planning

Despite all of the existing regulations, streams and wetlands remained at risk of further degradation. A growing body of research began to look at the cumulative effects of urbanization, especially impervious area and loss of forest cover, on watershed health.

In the mid-1990s Thurston County and the cities coordinated to develop a series of basin plans. Basin plans are thorough investigations into the water problems and potential solutions within a given drainage basin. (The term "drainage basin" refers to all the land that drains to a common body of water.)

Basin plans address issues such as flooding, poor water quality, erosion, and the degradation of aquatic habitat. The plans involve gathering data about the topography of the land, and the way water moves through the soil. The plans also assess how drainage projects and other activities in one area might affect other areas of the watershed.

Recognizing that resources were limited to address all of the problems identified in basin plans, in the late 1990s, the City of Olympia developed criteria for evaluating the viability of aquatic habitat in Olympia's eight stream basins. Based on a foundation of scientific research pointing to environmental degradation occurring at very low levels of development, the report concluded that *"the goal of both accommodating projected growth and protecting habitat is not realistic in the long term."* The suggested approach was to adopt different goals and policies based on the habitat potential of a given basin. This work culminated in a change in land use and stormwater regulations in the Green Cove Creek basin, in efforts to protect this moderately well-functioning basin from further degradation.

B. Management Goals

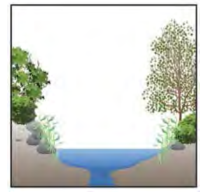
In this decade, our region balances accommodating projected growth, as required under the Growth Management Act, with protecting basin and critical habitat ecological functions, water quality, and water flow conditions, and trying to improve ecological function and water quality conditions. Key to accomplishing this is recognizing where efforts are likely to succeed and where they are likely to not be achievable. As it is becoming recognized that basin-wide restoration of pre-development conditions is unlikely to be achievable, the priorities of this study are to:

1. Prevent any basins from going from "Intact" or "Sensitive" to "Impacted" in the future.

2. Prevent any basins from going from "Impacted" to "Degraded" in the future. Move some basins from "Impacted" to "Sensitive" in the future.

Table 6 summarizes reasonable management goals that are likely to be achievable based on the research shown in Section IV.

TABLE 6: SUMMARY OF MANAGEMENT GOALS BASED ON EXISTING BASIN CONDITIONS.

	Basin and In-Stream Current Conditions		
	Intact or Sensitive	**Impacted**	**Degraded or Highly Degraded**
Management Goals:			
Basin-wide Conditions to support properly functioning Water Flow and Water Quality			
Protect basin-wide conditions[2]	Yes	Functions already impacted	Functions already degraded
Restore basin-wide conditions	Yes	Possibly	Probably not achievable
Maintain existing basin-wide conditions	Yes	Yes	Yes
Critical Habitats Functions (Shorelines, Wetlands, Riparian Corridors)			
Protect critical habitats:	Yes	Yes	Yes
Restore critical habitats:	Yes	Possibly	Less likely although it is dependent on the size / uniformity of basin conditions[3]
Water Quality			
Minimize downstream pollutants from new growth:	Yes	Yes	Yes
Improve water quality – lower existing pollutant levels:	Yes	Yes	Yes
Water Flow (Flooding)			
Minimize increase in peak flows	Yes	Yes	Yes
Improve water flow conditions where degraded	Yes	Yes	Yes

[2] Basin conditions – mainly related to land use and land cover characteristics such as urbanization and impervious area, forest cover, and other land uses that effect in-stream conditions.
[3] Some basins may have large patches of intact or sensitive areas where restoration will be successful. Each basin must be evaluated for local conditions.

C. *Management Strategies and Tools*

A variety of strategies and tools can be used to achieve basin habitat management goals and objectives. In general, many of the strategies are employed locally and were identified in Olympia's 1999 report, including:

- Development review and regulations (including critical area ordinances, zoning, stormwater management requirements, low-impact development ordinances, updates to the shoreline master program, and county-wide planning policies);
- Land acquisition and capital improvements;
- Re-vegetation and land stewardship;
- Regional planning and coordination;
- Public involvement and education;
- Operations and maintenance;
- Monitoring and research.

There are three general management approaches that can provide structure to these strategies and tools. They are:

- Reducing the impacts of growth;
- Guiding growth away from sensitive and impacted basins;
- Encouraging growth in areas where redevelopment is desired and that are least susceptible to stormwater / habitat impacts.

Reducing the Impacts of Growth

Mitigating the impacts of growth can include a wide variety of regulatory and non-regulatory tools.

Regulatory Tools

The regulatory tools most commonly used to reduce the impacts of future growth are:

1. Zoning regulations;
2. Critical areas regulations;
3. Stormwater management regulations.

All three regulatory tools can address some but not all of the impacts of new development. Zoning establishes land use densities and separates high-intensity land uses from low-intensity uses, such as agriculture and forestry. Critical areas regulations focus on the most unstable or vulnerable areas of the landscape, such as steep slopes or wetlands. Zoning and critical areas are generally located within a defined area, whereas stormwater regulations are generally tailored to levels and types of land development regardless of location. Since all three target new development, they are generally not very effective at addressing already impacted environmental and hydrologic systems, which are referred to as "legacy impacts."

Low Impact Development Techniques: Low Impact Development (LID) covers a wide variety of practices intended to mimic natural hydrologic patterns and reduce the negative impacts development has on hydrology and water quality. The key to effective LID implementation is to determine the desired functions to be maintained or restored. The application of LID techniques can offer a number of advantages over traditional, engineered stormwater drainage approaches. LID can be encouraged or mandated through zoning or stormwater development regulations, or in critical area ordinances.

Green Stormwater Infrastructure: Green Stormwater Infrastructure (GSI) includes stormwater best management practices designed to mimic natural hydrology and water quality from development using infiltration, evapotranspiration, and/or stormwater reuse. Examples of green stormwater infrastructure include trees, bioretention facilities, permeable pavement, green roofs, rainwater harvesting and bioretention planters with underdrains.

Mandatory Cluster Development: The clustering of residential subdivisions has locally been a part of the regulatory tool box for several decades. Clustering provides for the development of a part of a parcel with a significant portion being in an "open space tract," "tree tract," or "rural reserve tract," which would have little or no future development potential. Cluster development is noted as an LID technique to reduce hydrologic impact in the Puget Sound Action Team *Low Impact Development Technical Guidance Manual for Puget Sound* (Puget Sound Action Team, 2005).[4]

Tree Retention and Impervious Surface Limits– Integrated Land Use and Stormwater Regulations. Tree retention is often mentioned as a possible Low Impact Development (LID) technique. As noted above, LID techniques are intended to minimize the development impacts of new development. They are most often incorporated into stormwater regulations, but there is also a land use part of the equation, which may fit into a Critical Area Ordinance (CAO).

*Relationship of Zoning Density and Basin Current Condition*s: Zoning densities have a strong relationship to basin current conditions. In general, it will be extremely difficult to maintain a basin rating of "intact" or "sensitive" if zoning allows for significant urban uses.

Non-Regulatory Tools

There is also a suite of non-regulatory tools that may reduce or avoid the effects of development. They include:

- Fee simple acquisitions
- Purchase of conservation easements
- Restoration

[4] It should be noted that there are also some negative impacts from cluster development. Clustering is largely the arrangement of given number of dwelling units. It does nothing to change the underlying density, which may be too intense for the local conditions. Further, cluster ordinances with density bonuses only compound this condition. There is also a design issue when accomplished in a rural setting. Without architectural controls and alternative site-layout designs to create something like a "village" community, a clustered development can end up looking like a traditional subdivision inserted into the countryside and looking very much out of place.

These tools generally provide protection for areas containing high-quality sites or habitats. Protecting intact and functioning areas can serve multiple purposes. Depending on their size, preserve sites can serve as seasonal refuges for local wildlife while protecting the wellhead of a local water supply and allowing limited recreational opportunities. Fee simple acquisitions are the most direct approach, with a public entity purchasing the property. Such a purchase will normally be "at fair market value." As a public asset, these sites will require yearly management and operation costs, even in a natural condition.

A less-costly non-regulatory approach can include the acquisition of "development rights," or conservation easements. These may be donated or purchased at a reduced rate. The land remains in private ownership with the future development potential strictly limited or removed entirely. Management of the land would remain with the property owner, with the holder of the conservation easement or similar being a public entity, a resource stewardship entity (e.g., The Nature Conservancy), or a local land trust (e.g. Capitol Land Trust, Nisqually Basin Land Trust, etc.).

A third non-regulatory approach is the restoration of degraded sites. It is embraced by the Puget Sound Partnership and the Salmon Recovery Funding Board as one of two principal management strategies. The restoration of degraded sites can be tricky. A key step is to identify sites with the highest potential for achieving full or nearly full ecosystem function. This usually requires that the attributes of degradation be neither numerous nor so irreversible as to make restoration infeasible.

Thurston County Water Resources is in the process of developing a watershed characterization tool to help identify potential restoration sites. Such a screening tool should be a help to restoration scientists so that they can focus their attention and limited financial resources on appropriate sites within priority watersheds.

Guiding Growth Away from Basins Rated as "Intact" or "Sensitive"

Thurston County is one of the fastest-growing counties in the Puget Sound basin. This project offers the opportunity to manage future growth in a way that enhances the livability of urban areas, while protecting basins rated as "intact" or "sensitive." Some of the tools that have been implemented locally to guide growth away from "intact" or "sensitive" stream basins are as follows:

- Changes in Zoning;
- Purchase of Development Rights (PDR) and Transfer of Development Rights (TDR);
- Compensatory Mitigation (Thurston County Pilot Program).

Changes in Density Requirements: A reduction of the land use intensity or zoning density (units per acre) is a traditional approach to avoid future growth in a given location. Known as a "rezone," it maintains the same land use (residential) but reduces the density, which in turn minimizes new development impacts. This is only effective in areas that are not already subdivided into small lots (lots smaller than the proposed density) or vested for future development.

Purchase / Transfer of Development Rights: In the mid-1990's Thurston County adopted a Purchase of Development Rights (PDR) and a Transfer of Development Rights Program (TDR) for select agricultural lands within the County. The PDR program purchased the development potential on 940 acres of farm land within the Nisqually Valley. The TDR program was applied to all other long-term agricultural areas. This program could be expanded to additional areas of the County.

The intent of the Transfer of Development Rights program is to provide an opportunity for working-land owners to sell their development rights without having to sell their entire property for development. Under this approach, the rural character and agricultural economy of Thurston County is preserved, and working-land owners have the opportunity to realize some of the true market value of their land without having to sell the land altogether for urban development. The Transfer of Development Rights Program could be extended to cover lands identified to be of ecologic importance. Under such a program, growth would be redirected from these areas into urban areas that are already degraded.

Compensatory Mitigation Program: A compensatory mitigation program could address unavoidable development impacts that cannot be addressed by on-site mitigation. A system of fees and credits would be created for restoration of an off-site parcel (generally located within the same watershed.) At the present, Thurston County does not have off-site compensatory mitigation program, such as wetland banking or fee-in-lieu. Thurston County Resource Stewardship Department, Water Resources Program is exploring a pilot in-lieu fee program within the Deschutes watershed, funded by the Puget Sound Partnership. Included in the pre-capitalization activities are a feasibility study, preliminary design plans, and an appraisal. A preliminary site within the Deschutes River floodplain was withdrawn by the property owner, so site selection and evaluation are continuing.

Encouraging Growth in Areas where Redevelopment is Desired

Attracting growth to existing city centers and transit corridors will help to focus growth in areas that are already impacted by urbanization, and protect undeveloped and rural areas. Our region has been working on this for decades. In 2011 the region embarked on an effort to develop a Regional Plan for Sustainable Development as part of the Sustainable Thurston effort. The effort focused on creating places and preserving spaces, as well as implementing sustainability efforts related to other topic areas such as water quality and energy.

Strategies identified through this effort to attract growth to existing city centers include:

- Make clear the center development wanted and needed to achieve the live, work, shop, play, and economic activity described. Use processes that answer as many questions as possible up front with the goal of creating investment-ready places. Involve residents in broad or specific plan discussion. Resolve issues as much as possible to allow efficient development processes.
- Leverage public money to attract private investment in center development projects. Investments such as streets and sidewalks, utilities, public and private buildings,

parks, plazas and tree-lined streets can help attract the additional housing and jobs that will support the vitality and density envisioned.

- Encourage development dense enough to support envisioned commercial and transportation services — in a form that induces active (walk/bike) transportation.
- Create incentives for the mix and type of development wanted that will also achieve economic development goals.
- Use innovative financing tools to supply credit for center projects.
- Form partnerships to create conditions that attract investments in center projects.
- Hire ombudsman to aggregate properties for priority uses, market center development sites or master-planned areas, and resolve issues during development process.
- Pursue legislative agenda for tools that improve financial feasibility for center development.

A similar set of strategies can be employed to attract growth to major urban transit corridors that link city centers. They include:

- Involve neighborhoods adjacent to corridors in opportunity site planning for their area that will achieve goals for safe, inviting, walkable transit corridors that offer services close by or a short bus ride away.
- Refine regulations to ensure corridor buildings are of the appropriate scale and design and are approved expeditiously.
- Leverage public investments to attract private investments in corridor development projects.
- Refine Impact Fee Strategy to spread the costs of growth fairly.
- Use urban growth boundaries to constrain the supply of outlying lands and make urban infill and redevelopment more attractive.
- Create public-private or public-public land swap strategies to reduce the cost and risk of investments in the corridor and achieve vision and goals for the area.
- Create community lending pool to supply credit for the most viable investment ready corridor areas.
- Form multi-agency partnership to create conditions that attract investments in corridor projects.
- Pursue legislative agenda to reduce the risk and cost of corridor redevelopment.

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X. THURSTON COUNTY BASIN EVALUATION CRITERIA

This section reviews the information used to evaluate and group the basins for current conditions in Watershed Resource Inventory Areas (WRIAs) 13 and 14.

A. Evaluation

Information on individual basins was compiled from a variety of sources, including existing reports, basin plans, GIS data layers and monitoring data. Data were assembled in both a narrative form and in tables arranged by the functional relationships show in Figure 4 and Table 7:

Narrative data and data tables are available in the appendix.

TABLE 7: DATA USED TO EVALUATE THURSTON COUNTY BASINS IN WRIAS 13 AND 14.

Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	Riparian Corridor	Physical Conditions	Water Quality	
• Basin area ___ acres; urban growth area __%; rural __% • Total Impervious Area Estimate 1991: % 2006: % 2035: % Buildout: %	• Effective Impervious Area: 2006: % • Forest Cover: % • Unmodified Wetlands: % • Miles of Stream: __ • Lakes: Lake, Acres • Miles of Marine Shoreline: _ • Modifications piping or ditches • Areas of high ground water flooding: % of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: % • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft.: 250 ft. : 1000 ft. : • # of road crossings per mile of creek:	• Overall habitat condition • Rearing and spawning habitat • Fish barriers & difficulty of removal • Wetland conditions	• Monitoring results: ____ water quality • Problems o 303(d) o TMDL	• B-IBI average from most downstream sampling location 2002-2011 • Fish • Shellfish

The rationale for choosing these data sources shown in Table 7 is:

Level of Urbanization and Basin Hydrology

Total Impervious Area (TIA) and Effective Impervious Area (EIA)[5] was used as a measure of hydrology, as storm flow data were not available for all basins within the study area. Changes in both level and duration of storm flow events have been related to TIA and EIA.

Extent of Forest Cover and presence of unmodified wetlands is used to indicate how much natural infiltration and storage occurs in the basin.

Extent of modifications or how much of the creek hydrology has changed by routing through ditches, pipes and culverts is another way to characterize changes in hydrology.

Riparian Corridor Integrity

Percent riparian coniferous forest cover is used as an indicator of riparian corridor condition and the recruitment potential for large woody debris.

Extent of forest, wetlands, and scrub/shrub vegetation in varying riparian buffer widths (150 ft., 250 ft., and 1000 ft. both sides of the stream) is used to give an overall assessment of stream riparian conditions.

Number of road crossings per mile of stream is used to indicate the extent to which the riparian corridor is fragmented.

Physical Conditions

A number of qualitative assessments of in-stream habitat were used to indicate the diversity of habitat and barriers to fish passage.

Overall condition is a qualitative assessment based on the results of the other categories listed below.

Rearing and spawning habitat includes information on diversity of instream habitat (spacing of pools and riffles), large woody debris, instream flows, off-channel habitat, and stream temperature, among other indicators. Streams become increasingly less diverse and structurally lacking in urbanizing areas.

Wetland conditions such as the condition of headwater wetlands.

[5] Thurston Regional Planning Council: Thurston Regional Planning Council (2013), *Estimates of Current and Future Impervious Area and Forest Lands Vulnerable to Conversion for Watershed Based Land Use Planning*, Thurston County, March 2013 for an explanation of methodology used to estimate total and effective impervious area.

Water Quality

A general assessment of water quality from monitoring results, and violations of state standards, was used in this category.

Aquatic Biota

Benthic Macroinvertebrates. Invertebrate species that live in streams are an essential part of the food chain. These species are also sensitive to stream conditions, and the benthic index of biotic indicators (B-IBI) has become a tool used in many streams to monitor aquatic health.

Priority Fish Species. The presence and diversity of salmonid species as well as other priority fish species.

B. Measures

From the data sources collected, measures to evaluate basin current condition were chosen based on available data, research presented in Section IV, and significant correlations with B-IBI for quantitative measures. The measures present a mixture of qualitative and quantitative information and are shown below:

- Level of urbanization – measured by percent TIA in the basin
- Basin and Riparian Conditions
    - Basin Hydrology — measured by percent canopy in the basin.
    - Percent unmodified wetlands were noted but not used as a measure.
    - Riparian corridor integrity — measured by percent forest, scrub/shrub, or wetlands in 250 ft. riparian corridor.
- Current aquatic habitat condition
    - Habitat value of in-stream water chemistry (water quality) — measured by the general water quality rating from Thurston County Water Quality Monitoring Reports, and for streams not monitored by Thurston County but that had 303d data, the number of parameters on the 303d list.
- Aquatic biota — measured by the B-IBI average between 2002-2011 for those stream basins with B-IBI sampling
- Overall assessment — Puget Sound Watershed Characterization Water Flow Impairment

C. Basin Grouping for Current Conditions

Using an adaptation of the framework proposed by Schueler (1994), and used in the Olympia study (1999), and the review of available research, the criteria in Table 8 were used to group basins based on current conditions.

Scale

Lowland Basins (See Map 16): Most lowland basins in the study area have current basin plans and consist of two or three of the Ecology's Puget Sound Watershed Characterization analysis units. Lowland basins were analyzed as one unit. Lowland basins range in size from around 1,500 acres, or 2.3 square miles (Indian Creek), to more than 16,000 acres, or 25 square miles (Woodland Creek). The average size is around 5,000 acres, or just over 8 square miles.

Coastal Basins (See Map 16): Thurston County shoreline is punctuated by numerous small streams (Carrasasquero-Verde, 2005). Thurston County's traditional basin boundaries do not capture the detail of these smaller catchments. Therefore, Ecology's Puget Sound Watershed Characterization analysis units were used to break down the larger Thurston County traditional basin boundaries into smaller coastal basins. The resulting coastal basins range in size from 300 acres (almost 0.5 square miles) to just over 1,000 acres (1.5 square miles).

Deschutes River Basin (See Map 16): The Deschutes River mainstem basin is the largest in the study area, and the basin ranges from forest lands to highly urbanized areas. It was separated into three sub-basin units for the purposes of assessment. The upper sub-basin is mountainous, and the middle and lower sub-basins are lowlands. The basin was sub-divided based on geomorphic and geologic features outlined by Raines (2007). The upper and middle sub-basins are approximately 23,000 acres (35 square miles) in size. The lower sub-basin is around 11,000 acres (17.5 square miles). There are several other lowland basins that drain into the Deschutes River, such as Spurgeon Creek, Chambers Creek, Offut Lake, Lake Lawrence, McIntosh Lake, and Reichel Lake. Percival Creek drains into Capitol Lake, which is a man-made lake at the mouth of the Deschutes River. All other lowland and coastal basins in the study have direct outlets to the marine inlets.

Preliminary Grouping

Basins were grouped into four categories — intact, sensitive, impacted, and degraded, to reflect the range of conditions in the study area. In addition, although there are five categories shown in Table 9, no basin contained enough highly degraded conditions to be categorized highly degraded. The highest impervious area for basins within the study area did not exceed 40 percent, and the measured B-IBI never reached the lowest category found in other basins in the Puget Sound lowlands. Please see Figure 23 and Figure 24 for comparison with other Puget Sound basins.

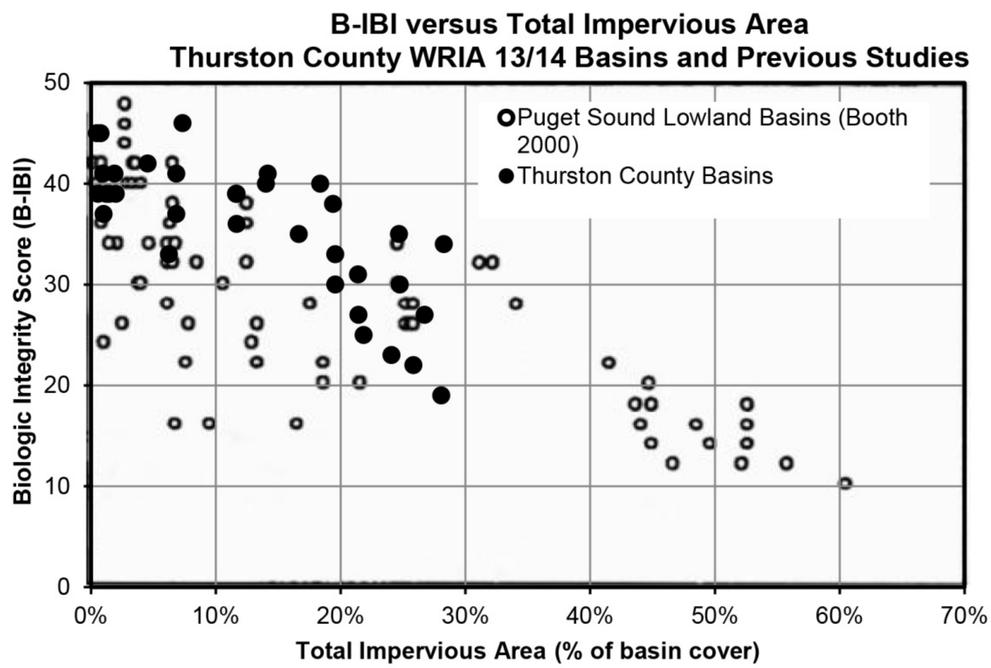


Figure 23: Comparison of B-IBI and Total Impervious Area for Thurston County Basins versus the remainder of the Puget Sound Lowland Basins.
Source: Booth (2000) and this study.

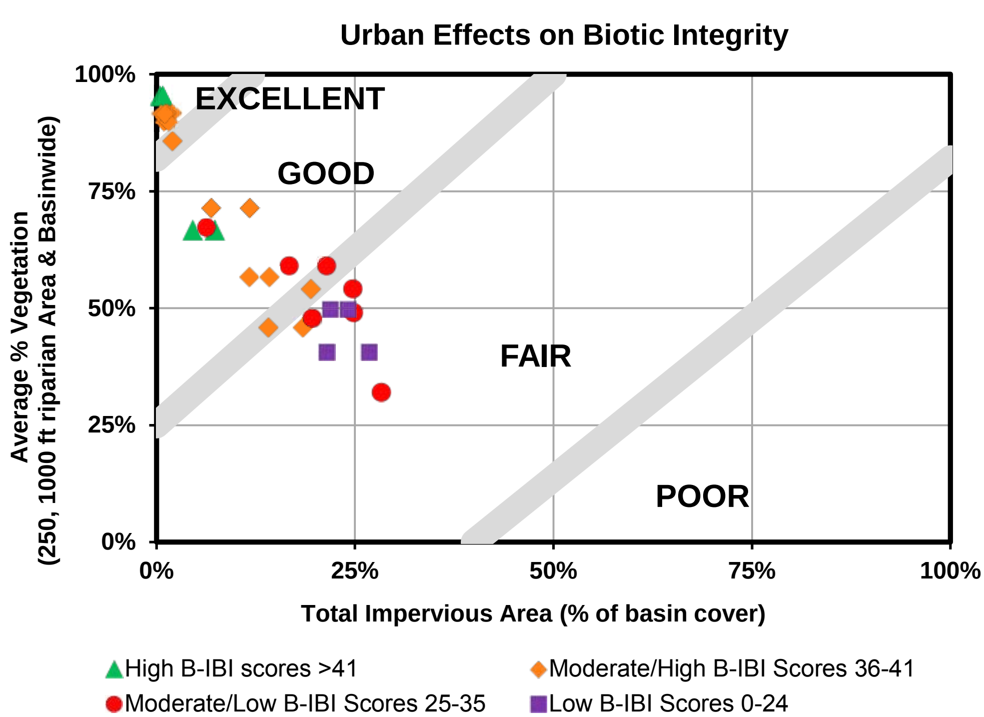
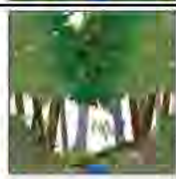


Figure 24: B-IBI, Percent Riparian Vegetation, and Total Impervious Area for Thurston County Lowland Basins compared to Puget Sound Conceptual Relationships.
See Figure 14 for original figure from Booth (2000).

TABLE 8: MEASURES USED TO GROUP CURRENT CONDITIONS OF BASINS IN THIS STUDY.

Overall Current Conditions		Level of Urbanization	Basin and Riparian Conditions: Hydrology		Basin and Riparian Conditions: Riparian Corridor	In-Stream and Wetland Habitat Conditions: Water Quality	Aquatic Biota
Groups		Total Impervious Area	Percent Canopy	Percent Unmodified Wetlands	Forest, scrub/shrub or wetlands in 250 ft. riparian corridor	Overall rating	Average B-IBI 2002-2009 (mouth of basin)
Intact		<2%	>80%	>15% may increase hydrology stabilization	>90%	Excellent (from Thurston County monitoring) Streams: No water quality standard violations; Lakes: Classified as Oligotrophic; Uses not impaired. If no monitoring by Thurston County, then use 303d list. Excellent = no parameters on 303d list.	>41
Sensitive		2-10%	65-80%		75-90%	Good (from Thurston County monitoring) Streams: Usually meets water quality standards; Lakes: Classified as Mesotrophic; Uses not impaired. If no monitoring by Thurston County, then use 303d list. Good = one parameter on 303d list.	36-41
Impacted		10-25%	45-65%	>10% to 15% may stabilize hydrology	60-75%	Fair (from Thurston County monitoring) Streams: Frequently fails one or more water quality standards; Lakes: Classified as Eutrophic; Uses sometimes impaired. If no monitoring by Thurston County, then use 303d list. Fair = two parameters on 303d list.	28-35
Degraded		25-40%	30-45%	Values less than 10% may not be predictive and were not used	30-60%	Poor (from Thurston County monitoring) Streams: Routinely fails water quality standards by a large margin; Lakes: Classified as Eutrophic; Uses impaired during most of the summer season by excess algae and/or aquatic macrophyte (plant) growth. If no monitoring by Thurston County, then use 303d list. Poor = three or more parameters on 303d list.	0-27
Highly Degraded		>40%	0-30%		<30%		

Thresholds

The numeric thresholds for measures shown in Table 8 were determined through calibrating the measures to B-IBI where data were available. These thresholds were cross checked against research presented in Section IV.

Lack of Data for Selected Measures

While sufficient data were available to group the lowland basins, for many of the coastal basins the preliminary groupings relied solely on land cover characteristics rather than monitoring data. Five measures were used to determine the preliminary current conditions category, including:

- Percent total impervious area (% TIA, 2010);
- Percent canopy (2006);
- Percent forest, scrub/shrub or wetlands in 250-foot riparian corridor
- Water quality rating; and,
- Average B-IBI 2002-2011 (monitoring data from the mouth of the basin).

In addition, the percentage of unmodified wetlands was also reviewed but not used in assessing current conditions.

In many basins, not all five measures had data. In those cases, the available measures were used based on the decision tree in Table 9.

TABLE 9: PRELIMINARY BASIN CURRENT CONDITION CATEGORIZATION.

Measures	Preliminary Basin Current Condition
If all categories with data fall in intact	Intact
If have data for 5 categories – and at least 4 of 5 fall in sensitive or better	Sensitive
If have data for 4 categories – and 3 of 4 fall in sensitive or better	
If have data for 3 categories – and 2 of 3 fall in sensitive or better	
If have data for 2 categories – and 2 of 2 fall in sensitive or better	
If have data for 5 categories – and at least 3 of 5 are impacted or worse*	Impacted
If have data for 4 categories – and at least 2 out of 4 fall in impacted or worse	
If have data for 3 categories – and at least 2 out of 3 are impacted or worse	
If have data for 5 categories - and at least 4 of 5 fall in degraded or worse	Degraded
If have data for 4 categories – and at least 3 of 4 fall in degraded or worse	
If have data for 3 categories – and at least 2 of 3 fall in degraded or worse	

*Mission Creek is right on the line between impacted and degraded. It was put in the impacted category to be consistent with this categorization framework, but it should be noted that its TIA value is within 1% of falling in the degraded category which would give it four of five categories needed to be considered degraded.

D. *Summary of Information*

The data used to group the basins is shown in Table 10. Available information for basins is summarized in the appendix, with basin information listed in alphabetical order by watershed. The level of detail varies considerably between basins. More complete data are available for basins which have been extensively studied and/or for which a comprehensive basin plan has been developed. Impervious surface estimates have been adjusted for current conditions and may be somewhat different than the estimates presented in the basin plans. Map 5 through Map 15 provide additional information to support the tables and information in the appendix.

TABLE 10: BASINS GROUPED BY CURRENT CONDITIONS.

		Level of Urbanization	Basin and Riparian Conditions			In-Stream and Wetland Habitat Conditions		Current Conditions Preliminary Category
			Hydrology		Riparian Corridor	Water Quality	Aquatic Biota	
Watershed Basin	Landscape Group	Total Impervious Area	Percent Canopy	Percent Unmodified Wetlands	Forest, scrub/shrub or wetlands in 250-ft riparian corridor	Overall Rating	Average B-IBI 2002-2011 (mouth of basin)	
Budd Inlet/Deschutes River								
Black Lake	Lowland	8.3%	44.1%	20.6%	79.9%	Fair	No data	Impacted
Capitol Lake	Lowland	36.9%	28.6%	22.6%	17.3%	Fair to Poor	No data	Degraded
Chambers	Lowland	19.9%	32.3%	8.9%	54.2%	Good	40.2	Impacted
Deschutes River (Lower)	Lowland	15.1%	41.8%	6.8%	63.3%	Good	No data	Impacted
Deschutes River (Middle)	Lowland	2.0%	52.9%	4.5%	82.2%	Good	No data	Sensitive
Deschutes River (Upper)	Mountain	0.9%	71.2%	1.2%	95.4%	Good	No data	Sensitive
East Bay 1	Coastal	7.1%	70.7%	8.7%	95.6%	No data	No data	Sensitive
East Bay 2	Coastal	3.2%	63.1%	7.6%	80.1%	No data	No data	Sensitive
East Bay 3	Coastal	6.4%	59.2%	15.1%	76.9%	303d: two parameters	31.3	Impacted
East Bay 4	Coastal	8.2%	59.6%	13.2%	58.3%	No data	No data	Impacted
Ellis Creek	Coastal	7.5%	65.3%	17.4%	70.7%	Good	45.6	Sensitive
Indian Creek	Lowland	28.6%	37.4%	10.1%	43.8%	Poor	34	Degraded
Lake Lawrence	Lowland	5.0%	44.6%	15.8%	18.0%	Fair	No data	Impacted
McIntosh Lake	Lowland	2.2%	80.6%	12.9%	No sig riparian	303d: one parameter	No data	Sensitive
Mission Creek	Coastal	24.5%	44.7%	5.1%	54.6%	Fair	27.2	Impacted
Moxlie Creek	Lowland	35.8%	27.2%	5.0%	52.3%	Poor	28.4	Degraded
Offut Lake	Lowland	2.9%	61.2%	22.7%	76.4%	303d: one parameter	No data	Sensitive
Percival Creek	Lowland	25.5%	45.7%	7.1%	61.3%	Fair	31.7	Impacted
Reichel Lake	Mountain	1.5%	62.3%	4.1%	67.1%	303d: three parameters	No data	Impacted
Schneider Creek (West Bay)	Coastal	21.7%	55.6%	0.8%	51.5%	Good	31.2	Impacted
Spurgeon Creek	Lowland	1.6%	69.4%	5.6%	75.2%	Good	No data	Sensitive
West Bay 1	Coastal	7.9%	74.8%	1.3%	70.6%	No data	No data	Sensitive
West Bay 2	Coastal	9.6%	70.0%	5.2%	61.1%	303d: one parameter	No data	Sensitive
West Bay 3	Coastal	40.6%	22.0%	0.0%	41.2%	No data	No data	Degraded

TABLE 10: BASINS GROUPED BY CURRENT CONDITIONS.

		Level of Urbanization	Basin and Riparian Conditions			In-Stream and Wetland Habitat Conditions		Current Conditions Preliminary Category
			Hydrology		Riparian Corridor	Water Quality	Aquatic Biota	
Basin or sub-basin	Landscape Group	Total Impervious Area	Percent Canopy	Percent Unmodified Wetlands	Forest, scrub/shrub or wetlands in 250-ft riparian corridor	Overall Rating	Average B-IBI 2002-2011 (mouth of basin)	
Eld Inlet								
Eld Inlet 1	Coastal	4.2%	72.1%	1.0%	83.0%	No data	No data	Sensitive
Eld Inlet 2	Coastal	4.1%	74.2%	1.1%	83.1%	No data	No data	Sensitive
Eld Inlet 3	Coastal	1.3%	80.3%	16.3%	96.0%	No data	No data	Intact
Eld Inlet 4	Coastal	1.7%	76.3%	13.4%	91.5%	No data	No data	Sensitive
Eld Inlet 5	Coastal	2.4%	71.5%	3.9%	88.1%	No data	No data	Sensitive
Eld Inlet 6	Coastal	7.9%	69.8%	3.4%	92.1%	No data	No data	Sensitive
Eld Inlet 7	Coastal	6.0%	74.5%	0.8%	96.1%	No data	No data	Sensitive
Eld Inlet 8	Coastal	8.0%	31.3%	7.3%	17.8%	No data	No data	Degraded
Eld Inlet 9	Coastal	13.0%	56.4%	5.4%	88.0%	No data	No data	Impacted
Eld Inlet 10	Coastal	5.1%	87.9%	12.5%	88.7%	No data	No data	Sensitive
Eld Inlet 11	Coastal	4.7%	80.1%	5.2%	72.8%	No data	No data	Sensitive
Eld Inlet 12	Coastal	2.8%	92.9%	7.4%	96.8%	No data	No data	Sensitive
Eld Inlet 13	Coastal	5.2%	85.8%	5.5%	92.2%	No data	No data	Sensitive
Eld Inlet 14	Coastal	6.1%	79.1%	1.4%	83.3%	No data	No data	Sensitive
Green Cove Creek	Lowland	12.2%	66.4%	11.6%	84.7%	Good	39.6	Sensitive
McLane Creek	Lowland	1.1%	72.7%	4.1%	92.0%	Fair	39	Sensitive
Perry Creek	Lowland	1.9%	80.3%	0.5%	91.6%	Good	43.6	Sensitive
Squaxin Passage	Coastal	10.5%	68.4%	0.3%	53.7%	No data	No data	Impacted
Nisqually Reach								
Nisqually Reach 1	Coastal	3.1%	72.2%	18.8%	92.2%	No data	No data	Sensitive
Nisqually Reach 2	Coastal	5.0%	71.2%	13.0%	87.5%	No data	No data	Sensitive
Nisqually Reach 3	Coastal	4.0%	84.4%	7.4%	92.3%	No data	No data	Sensitive
Nisqually Reach 4	Coastal	8.2%	57.8%	2.4%	90.5%	No data	No data	Sensitive
Nisqually Reach 5	Coastal	16.0%	67.7%	2.2%	90.9%	No data	No data	Sensitive
Nisqually Reach 6	Coastal	20.7%	46.6%	3.1%	70.9%	No data	No data	Impacted
Nisqually Reach 7	Coastal	12.9%	71.2%	2.8%	81.3%	No data	No data	Sensitive

TABLE 10: BASINS GROUPED BY CURRENT CONDITIONS.

		Level of Urbanization	Basin and Riparian Conditions			In-Stream and Wetland Habitat Conditions		Current Conditions Preliminary Category
			Hydrology		Riparian Corridor	Water Quality	Aquatic Biota	
Basin or sub-basin	Landscape Group	Total Impervious Area	Percent Canopy	Percent Unmodified Wetlands	Forest, scrub/shrub or wetlands in 250-ft riparian corridor	Overall Rating	Average B-IBI 2002-2011 (mouth of basin)	
Henderson Inlet								
Dana Passage 1	Coastal	3.1%	79.0%	5.7%	93.4%	No data	No data	Sensitive
Dana Passage 2	Coastal	6.1%	77.9%	8.1%	90.1%	No data	No data	Sensitive
Henderson 1	Coastal	1.6%	72.1%	14.5%	87.4%	303d: two parameters	No data	Sensitive
Henderson 2	Coastal	1.1%	86.4%	0.3%	97.8%	No data	No data	Intact
Henderson 3	Coastal	3.4%	55.3%	7.4%	68.2%	No data	No data	Impacted
Henderson 4	Coastal	4.8%	52.6%	35.7%	65.5%	No data	No data	Impacted
Henderson 5	Coastal	5.6%	59.9%	10.8%	77.0%	No data	No data	Sensitive
Henderson 6	Coastal	3.0%	72.8%	15.0%	95.2%	303d: two parameters	No data	Sensitive
Henderson 7	Coastal	5.3%	71.9%	17.6%	68.6%	No data	No data	Sensitive
Henderson 8	Coastal	3.8%	73.8%	4.0%	73.5%	No data	No data	Sensitive
Woodard Creek	Lowland	14.6%	45.9%	13.8%	69.8%	Fair	40.8	Impacted
Woodland Creek	Lowland	22.1%	40.1%	9.2%	77.3%	Fair	33.2	Impacted
Totten Inlet								
Burns/Pierre	Coastal	2.5%	69.9%	0.0%	79.9%	No data	No data	Sensitive
Kennedy Creek	Lowland	1.5%	68.0%	4.9%	92.6%	Good	41.4	Sensitive
Schneider Creek (Totten)	Lowland	1.8%	70.5%	3.2%	87.5%	Good	41.4	Sensitive
Totten 1	Coastal	4.8%	81.2%	1.3%	no stream	No data	No data	Sensitive
Totten 2	Coastal	3.8%	82.7%	1.8%	94.0%	No data	No data	Sensitive
Totten 3	Coastal	2.4%	83.9%	2.5%	95.7%	No data	No data	Sensitive
Totten 4	Coastal	1.2%	67.0%	7.7%	92.0%	No data	No data	Sensitive
Totten 5	Coastal	3.1%	89.3%	0.1%	90.3%	No data	No data	Sensitive

Refining the Preliminary Groupings Using Emerging Science

Puget Sound Watershed Characterization Assessment of Impairment to Water Flow conditions (Stanley, 2010): Ecology's water flow assessment results for WRIAs 13 and 14 identifies areas of the landscape that are important for maintaining the water flow processes and the relative degradation of the processes from human activity. Following the preliminary basin grouping, the degradation processes were used to refine the assessment and refine basin current conditions.

Ecology provides the data in a GIS format with normalized data (values from 0 to 1) for each process:

- Delivery
- Surface water
- Groundwater recharge
- Groundwater discharge

Ecology's watershed characterization groups analysis units into four equal groups (high, moderate high, moderate, and low) based on quartiles to show their relative degradation. For this project, Ecology's analysis units were averaged to reflect basin boundaries and then grouped into three unequal-sized groups for each water flow process:

- High
- Moderate
- Low

The proportions in each category reflected the percentages of basins in the preliminary groupings of current conditions. These values were then compared to the preliminary basin groupings. Percentages in each group are shown in Table 11.

TABLE 11: PERCENT OF ANALYSIS UNITS IN STUDY AREA RANKED AS LOW, MODERATE, OR HIGH DEGRADATION.

Relative Degradation Rank	Percent of Analysis units
Low	68%
Moderate	25%
High	7%

The following rationale was used to determine if the results of Ecology's Watershed Characterization (water flow impairment) should override the preliminary current conditions categorization shown in Table 10.

The rationale was based on the recognition that Ecology's watershed characterization used a wider variety of GIS data sources than the simple methodology presented in Table 8 and was also peer reviewed.

However, when there are water quality data or B-IBI monitoring data for a basin, Ecology's results did not influence the final rating because no model results should over-ride actual monitoring data.

In basins where there are ***not*** water quality or B-IBI data, Ecology's results may influence the final basin condition category in the following ways:

- If the preliminary categorization of a basin is sensitive *and* if Ecology's impairment results show medium or high impairment for 3 or 4 of 4 processes, then the basin should be categorized as impacted;

- If a basin was categorized as impacted *and* if Ecology's impairment results show high impairment for 3 or 4 of 4 processes, then the basin should be categorized as degraded;

- If a basin was categorized as impacted *and* if Ecology's impairment results show low impairment for 2 or more of 4 processes, then the basin should be categorized as sensitive.

These criteria resulted in re-categorization of five out of 69 basins – all of them coastal (shown in shading in Table 12.) Two of the basins (West Bay 2 and Nisqually Reach 4) were shifted from sensitive to impacted while for the other three the converse occurred (Squaxin Passage, Henderson 3 and 4). The overall results suggest broad concurrence between Ecology's Puget Sound Characterization and the preliminary evaluation methodology.

Final Categories

Final basin groupings for current conditions are shown in Table 12 and on Map 17.

TABLE 12: BASIN GROUPINGS BASED ON BASIN AND IN-STREAM CONDITIONS AND WATER FLOW PROCESS DEGRADATION.

Budd Inlet/Deschutes River Watershed	Landscape Group	Categories - Current Basin and In-Stream Conditions	Puget Sound Watershed Characterization Water Flow Degradation				Revised Current Condition Categories
			Delivery	Surface Water	Groundwater Recharge	Groundwater Discharge	
Budd Inlet/Deschutes River Watershed							
Black Lake	Lowland	Impacted	Medium	n/a	Medium	Medium	Impacted
Capitol Lake	Lowland	Degraded	High	n/a	High	Low	Degraded
Chambers	Lowland	Impacted	Medium	Medium	Medium	Medium	Impacted
Deschutes River (Lower)	Lowland	Impacted	Medium	Medium	Medium	Medium	Impacted
Deschutes River (Middle)	Lowland	Sensitive	Low	Medium	Low	Low	Sensitive
Deschutes River (Upper)	Mountain	Sensitive	Low	Low	Low	Low	Sensitive
East Bay 1	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
East Bay 2	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
East Bay 3	Coastal	Impacted	Medium	Medium	Medium	Medium	Impacted
East Bay 4	Coastal	Impacted	Medium	Medium	Medium	Medium	Impacted
Ellis Creek	Coastal	Sensitive	Medium	Medium	Low	Low	Sensitive
Indian Creek	Lowland	Degraded	High	High	Medium	High	Degraded
Lake Lawrence	Lowland	Impacted	Low	n/a	Low	Medium	Impacted
McIntosh Lake	Lowland	Sensitive	Low	Low	Low	Low	Sensitive
Mission Creek	Coastal	Impacted	Medium	Medium	Medium	Low	Impacted
Moxlie Creek	Lowland	Degraded	High	Medium	High	Low	Degraded
Offut Lake	Lowland	Sensitive	Low	n/a	Low	Medium	Sensitive
Percival Creek	Lowland	Impacted	Medium	Medium	Medium	Medium	Impacted
Reichel Lake	Mountain	Impacted	Low	n/a	Low	Medium	Impacted
Schneider Creek (WB)	Coastal	Impacted	Medium	Low	Medium	Low	Impacted
Spurgeon Creek	Lowland	Sensitive	Low	Medium	Low	Low	Sensitive
West Bay 1	Coastal	Sensitive	Low	Low	Low	Medium	Sensitive
West Bay 2	Coastal	Sensitive	Medium	Medium	Low	High	Impacted
West Bay 3	Coastal	Degraded	High	Low	High	Low	Degraded

TABLE 12: BASIN GROUPINGS BASED ON BASIN AND IN-STREAM CONDITIONS AND WATER FLOW PROCESS DEGRADATION.

	Landscape Group	Categories - Current Basin and In-Stream Conditions	Puget Sound Watershed Characterization Water Flow Degradation				Revised Current Condition Categories
			Delivery	Surface Water	Groundwater Recharge	Groundwater Discharge	
Eld Inlet							
Eld Inlet 1	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Eld Inlet 2	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Eld Inlet 3	Coastal	Intact	Low	Low	Low	Low	Intact
Eld Inlet 4	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Eld Inlet 5	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Eld Inlet 6	Coastal	Sensitive	Low	Low	Medium	Medium	Sensitive
Eld Inlet 7	Coastal	Sensitive	Low	Low	Medium	Medium	Sensitive
Eld Inlet 8	Coastal	Degraded	Medium	High	Medium	High	Degraded
Eld Inlet 9	Coastal	Impacted	Medium	Low	Medium	High	Impacted
Eld Inlet 10	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Eld Inlet 11	Coastal	Sensitive	Low	Low	Low	Medium	Sensitive
Eld Inlet 12	Coastal	Sensitive	Low	Low	Low	Medium	Sensitive
Eld Inlet 13	Coastal	Sensitive	Low	Low	Low	Medium	Sensitive
Eld Inlet 14	Coastal	Sensitive	Low	Low	Low	Medium	Sensitive
Green Cove Creek	Lowland	Sensitive	Medium	Medium	Medium	Medium	Sensitive
McLane Creek	Lowland	Sensitive	Low	Low	Low	Low	Sensitive
Perry Creek	Lowland	Sensitive	Low	Low	Low	Low	Sensitive
Squaxin Passage	Coastal	Impacted	Medium	Low	Medium	Low	Sensitive
Nisqually Reach							
Nisqually Reach 1	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Nisqually Reach 2	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Nisqually Reach 3	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Nisqually Reach 4	Coastal	Sensitive	Medium	Low	Medium	Medium	Impacted
Nisqually Reach 5	Coastal	Sensitive	Medium	Low	Medium	Low	Sensitive
Nisqually Reach 6	Coastal	Impacted	Medium	Medium	Medium	Low	Impacted
Nisqually Reach 7	Coastal	Sensitive	Medium	Low	Medium	Low	Sensitive

TABLE 12: BASIN GROUPINGS BASED ON BASIN AND IN-STREAM CONDITIONS AND WATER FLOW PROCESS DEGRADATION.

Henderson Inlet	Landscape Group	Categories - Current Basin and In-Stream Conditions	Puget Sound Watershed Characterization Water Flow Degradation				Revised Current Condition Categories
			Delivery	Surface Water	Groundwater Recharge	Groundwater Discharge	
Henderson Inlet							
Dana Passage 1	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Dana Passage 2	Coastal	Sensitive	Low	Low	Low	Medium	Sensitive
Henderson 1	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Henderson 2	Coastal	Intact	Low	Low	Low	Low	Intact
Henderson 3	Coastal	Impacted	Low	Medium	Low	Medium	Sensitive
Henderson 4	Coastal	Impacted	Medium	Low	Low	Low	Sensitive
Henderson 5	Coastal	Sensitive	Low	Medium	Low	Medium	Sensitive
Henderson 6	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Henderson 7	Coastal	Sensitive	Low	Medium	Low	Medium	Sensitive
Henderson 8	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Woodard Creek	Lowland	Impacted	Medium	Medium	Medium	Medium	Impacted
Woodland Creek	Lowland	Impacted	Medium	Low	Medium	Low	Impacted
Totten Inlet							
Burns/Pierre	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Kennedy Creek	Lowland	Sensitive	Low	Low	Low	Low	Sensitive
Schneider Creek (Totten)	Lowland	Sensitive	Low	Medium	Low	Low	Sensitive
Totten 1	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Totten 2	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Totten 3	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Totten 4	Coastal	Sensitive	Low	Low	Low	Low	Sensitive
Totten 5	Coastal	Sensitive	Low	Low	Low	Low	Sensitive

XI. TYPE AND EXTENT OF FUTURE GROWTH OR DEVELOPMENT

A. Future Conditions

Understanding the type and extent of future growth in Thurston County's basins is key to developing management strategies. Such growth in Thurston County is regulated under local comprehensive plans, zoning, and development regulations. This means that urban growth can only occur within designated urban areas (called urban growth areas), and rural growth is allowable in rural zoning districts and other areas are set aside for forestry, agriculture, or open space protection. Growth areas were defined for Thurston County as early as 1983, well before zoning and comprehensive plans were required under the state's Growth Management Act. The availability of detailed plans and regulations gives predictability to future growth patterns that can be used to forecast growth and impervious area conditions.

Under the county-wide planning policies (a group of policies that govern how local governments plan in a coordinated way), the Thurston Regional Planning Council (TRPC) has been designated to provide forecasts of population and employment for Thurston County. TRPC has been providing these forecasts since the 1960s, and updates them approximately every five years. The latest forecasts were completed 2013 with a forecast horizon of 2035-40.

The reliability of TRPC's forecasts is good. Seven TRPC forecasts include the year 2010 in their time horizons: 1985, 1989, 1992, 1996, 1999, 2004, and 2009. They vary in accuracy for the predicted 2010 population from 0.4 percent error (2009) to 3.8 percent error (1989), with an average error of 2.0 percent. The average annual growth rate was 2.4 percent during the period 1985-2010. Looked at another way, the forecasts all correctly predicted that Thurston County would reach a population of 250,000 between 2008 and 2010 (i.e., by 2009, give or take one year) (TRPC, 2012).

The forecasts show the pattern of growth that is likely to occur under current conditions, assuming no major changes in policy at the national, state, or local level, and no major wars or natural disasters. The local forecasts are based on economic projections at the national and state level and calibrated to past growth patterns. At the local level, the county-wide forecast is distributed to planning areas or neighborhoods based on recent trends, available land supply, and zoning. These allocations assume that water and infrastructure will be provided as planned in local capital facilities plans. Information on development projects that are in the development pipeline but not built is included in the forecasts.

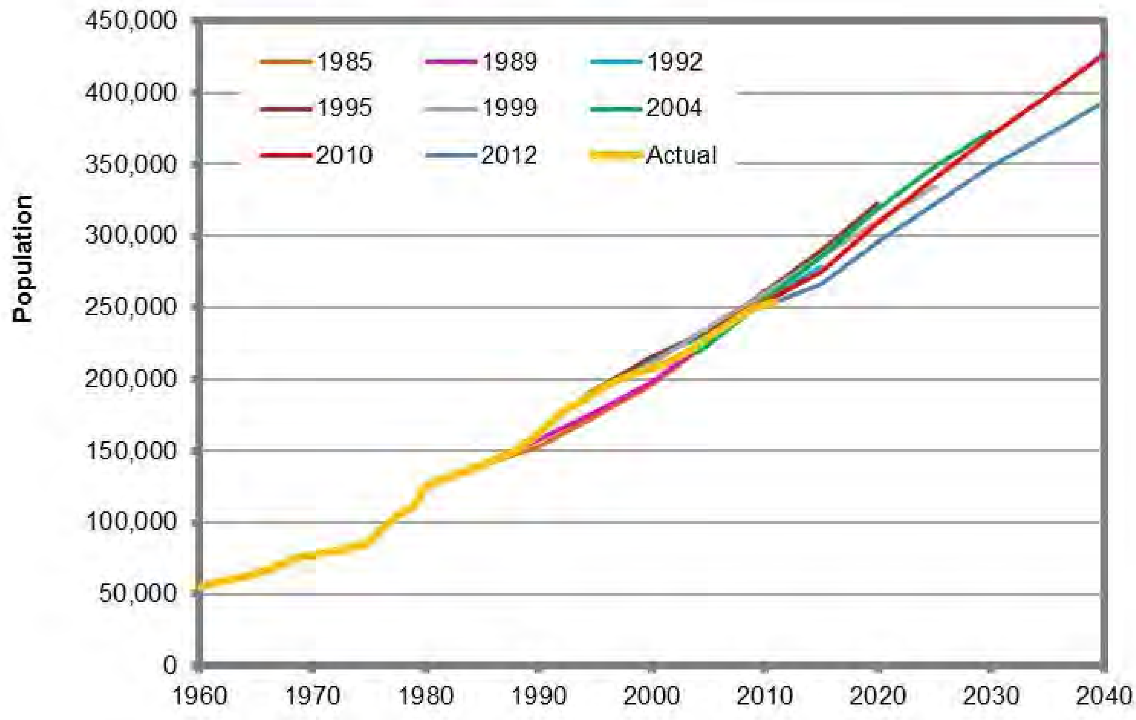


FIGURE 25: COMPARISON OF TRPC COUNTY-WIDE POPULATION FORECASTS.

These forecasts are based on local adopted comprehensive plans and zoning regulations, and are used by local governments to plan for schools, roads, and other facilities. If zoning or other local regulations that govern type and density of growth are changed, then the changes are included in subsequent forecasts. The most recent forecasts were developed in the fall of 2007 after the county rural rezone. The forecasts were updated in 2012-2013.

The Forecast Model has been updated with several modules to provide key data sets for this study:

- The first is the estimate of total impervious area at buildout. This estimate allows for the reporting of both total impervious area at buildout and also expected increase in total impervious area based on anticipated growth. These estimates give an indication of how "at risk" a basin is to degradation due to future development.

- The second key piece of information is the type of residential growth that is anticipated for a specific basin. This information is reported in terms of dwelling unit capacity and is only available for residential buildout conditions — or the culmination of local land use plans. Using a combination of existing lot sizes, and knowledge of the development projects currently under review (and likely vested) by local governments, growth can be categorized into three groups as shown in Table 13.

- Finally, estimates of Forest Lands vulnerable to urban conversion can also be generated from the Forecast Model.

TABLE 13: TYPES OF RESIDENTIAL CAPACITY.

Type of Residential Development Capacity	Description	Regulations	Rezone Potential
Legacy Lots or Plats that are Likely Vested	Legacy Lots – legal lots that may not conform to current zoning densities Subdivision Plats that are under review and likely vested	Building codes apply, however each lot is likely to fall below any stormwater control threshold. Vesting can expire.	Unlikely to have further subdivision potential
Short Plat Potential	Smaller lots with subdivision potential (4 dwelling units or less in county; 9 units or less in some cities)	Building codes apply. Subdivisions may be of a size where they may fall below current stormwater control thresholds;	Yes
Long Plat (Subdivision) Potential or Redevelopment	Larger vacant (or partially vacant) lots with long plat subdivision potential, or lots with redevelopment potential	Will be evaluated under current zoning and development regulations	Yes

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XII. BASIN PRELIMINARY EVALUATION CRITERIA

This project seeks to implement new strategies to protect in-stream habitat and water quality where they have the greatest chance for success. One tool to better understand the effects of possible alternatives is scenario modeling.

Scenario modeling will be conducted using a hydrologic model to better understand hydrologic flow and water quality issues. Due to the level of effort and cost involved, three basins will be selected for hydrologic modeling.

Basin selection will be a multi-step process:

- This report will conduct a preliminary screening for basins,
- Input from the hydrologic modeling team will be requested, and, finally,
- Local policy makers will decide which basins will be studied further.

The initial screening of basins as candidates for further study relies on several factors, including:

- Evaluation of impacts of planned growth;
- Evaluation of vulnerability of forestlands;
- Evaluation of effectiveness of changes in land use regulations as a potential management strategy;
- Stakeholder input;
- Availability of data to support hydrologic modeling.

Other Factors including:

- Overview of basin and limiting factors;
- Presence of priority fish species;
- Presence of shellfish beds;
- Important catchments; and
- Evaluation of importance of analysis units

will also inform basin selection.

A. Evaluation of Impacts of Planned Growth

Basin current conditions were evaluated and categorized in Section X of this report. Current conditions were compared to Total Impervious Area (TIA) at buildout to determine the “risk” of further degradation due to planned growth.

Basins were evaluated for the expected increase in total impervious area compared to current conditions and 2010 TIA. A **percent increase** was used as research shows that there is no particular impervious area threshold where degradation in stream integrity begins to occur; rather, the relationship is a continuum (Figure 15). As degradation can occur at even low levels of total impervious area (Figure 10), increase in impervious area was used as an evaluation criterion to ensure that the risk of even low levels of growth was considered during the basin selection process. Evaluation criteria are shown in Table 14.

TABLE 14: CRITERIA USED TO EVALUATE BASINS FOR THE IMPACTS OF PLANNED GROWTH.

Current Condition	Change Criteria	Evaluation of Impacts of Planned Growth
Sensitive or Intact	Increase in TIA of <1.0%	Likely to remain in current condition
	Increase in TIA of ≥1% but <3%	Possibly at risk for further impacts
	Increase in TIA of ≥3.0%	At risk for further impacts
Impacted	Increase in TIA of <1.0% Existing TIA <15%	Likely to remain in current condition
	Increase in TIA of ≥1% but <3% Existing TIA <15%	Possibly at risk for further impacts
	Increase in TIA of ≥3.0% Existing TIA <15%	At risk for further impacts
	Increase in TIA of ≥3.0% Existing TIA >15%	Possibly at risk for further impacts
Degraded	Any increase in TIA	Likely to remain in current condition

Refer to Table 8 for a description of the terms: “Intact” “Sensitive,” “Impacted,” and “Degraded.”

B. *Evaluation of Effectiveness of Changes in Land Use Regulations as a Potential Management Strategy*

This evaluation tool recognizes that regulatory measures put into place to protect basins from the impacts of planned growth will only be effective where growth is likely to occur. For the purposes of this evaluation, a fairly conservative (low) threshold was used to separate out candidate basins for possible changes in land use regulations, from those basins where little growth is anticipated. To account for the differences in basin area, and the many smaller basins, this threshold was then considered relative to the median basin size, 1.22 square miles. Thus, basins with more than 82 expected additional dwelling units (100 units/1.22 sq mi) are identified as appropriate areas of focus (Table 15).

TABLE 15: CRITERIA USED TO EVALUATE THE EFFECTIVENESS OF ZONING OR DEVELOPMENT REGULATIONS AS AN EFFECTIVE MANAGEMENT TOOL FOR PLANNED GROWTH.

Basin Current Conditions Evaluation of Impacts of Planned Growth	Planned Future Dwelling Units	Are changes in zoning or development regulations an appropriate tool to consider for this basin?
Sensitive		
Likely to remain in current condition	N/A	No
Possibly at risk for further Impacts	< 82 units/sq mi	No
	> 82 units/sq mi	Yes
Impacted		
Likely to remain in current condition	N/A	No
Possibly at risk for further Impacts	< 82 units/sq mi	No
	> 82 units/sq mi	Yes
At risk for further Impacts	< 82 units/sq mi	No
	> 82 units/sq mi	Yes
Degraded		
Likely to remain in current condition	N/A	No

Refer to Table 8 for a description of the terms: “Sensitive,” “Impacted,” and “Degraded.”

C. Summary Tables

Table 16 lists the data used in evaluating the impacts of planned growth. It includes Revised Current Condition (from Table 12) and three variables of Total Impervious Area (TIA).

The various TIA values include an estimate for 2010 (the base year), an estimate of TIA at buildout, and a description of the predicted increase in TIA. The predicted increase in TIA is expressed in percent increase and with a descriptive term (from very low to very high). The final column describes the possible Impacts of Planned Growth based on the criteria in Table 14.

Table 17 lists the data used in evaluating the effectiveness of zoning or development regulations as an effective tool. The criteria are shown in Table 15.

In addition to showing basin current condition and evaluating of impacts of planned growth, it provides a total number of dwelling units at the time of buildout. More detail on this growth can be found in a companion document to this report: *Estimates of Current and Future Impervious Area for Watershed Based Land Use Planning* (Thurston County and TRPC, 2011). The data on TIA, projected increases in TIA to buildout, and dwelling units used in this report have been updated to use more current estimates.

TABLE 16: BASIN EVALUATION OF IMPACTS OF PLANNED GROWTH (UNDER CURRENT PLANS).

Basin or sub-basin	Landscape Group	Revised Current Condition	TIA 2010	TIA Buildout	Increase TIA, 2010-Buildout		Evaluation of Impacts of Planned Growth
Budd/Deschutes							
Black Lake	Lowland	Impacted	8.3%	14.7%	Very High	6.5%	At risk of further impacts
Capitol Lake	Lowland	Degraded	36.9%	38.4%	Moderate	1.4%	Likely to remain in current condition
Chambers	Lowland	Impacted	19.9%	23.4%	High	3.5%	Possibly at risk of further impacts
Deschutes River (Lower)	Lowland	Impacted	15.1%	19.1%	High	4.0%	Possibly at risk of further impacts
Deschutes River (Middle)	Lowland	Sensitive	2.0%	3.0%	Moderate	1.0%	Possibly at risk of further impacts
Deschutes River (Upper)	Mountain	Sensitive	0.9%	0.9%	Very Low	0.0%	Likely to remain in current condition
East Bay 1	Coastal	Sensitive	7.1%	7.9%	Low	0.8%	Likely to remain in current condition
East Bay 2	Coastal	Sensitive	3.2%	3.6%	Very Low	0.4%	Likely to remain in current condition
East Bay 3	Coastal	Impacted	6.4%	6.9%	Very Low	0.5%	Likely to remain in current condition
East Bay 4	Coastal	Impacted	8.2%	8.6%	Very Low	0.4%	Likely to remain in current condition
Ellis Creek	Coastal	Sensitive	7.5%	8.5%	Moderate	1.0%	Possibly at risk of further impacts
Indian Creek	Lowland	Degraded	28.6%	33.7%	High	4.1%	Likely to remain in current condition
Lake Lawrence	Lowland	Impacted	5.0%	5.9%	Low	0.8%	Likely to remain in current condition
McIntosh Lake	Lowland	Sensitive	2.2%	2.7%	Very Low	0.5%	Likely to remain in current condition
Mission Creek	Coastal	Impacted	24.5%	28.6%	High	4.0%	Possibly at risk of further impacts
Moxlie Creek	Lowland	Degraded	35.8%	39.5%	High	3.7%	Likely to remain in current condition
Offut Lake	Lowland	Sensitive	2.9%	3.7%	Low	0.8%	Likely to remain in current condition
Percival Creek	Lowland	Impacted	25.5%	31.7%	Very High	6.2%	Possibly at risk of further impacts
Reichel Lake	Mountain	Impacted	1.5%	1.6%	Very Low	0.1%	Likely to remain in current condition
Schneider Creek (West Bay)	Coastal	Impacted	21.7%	28.7%	Very High	7.0%	Possibly at risk of further impacts
Spurgeon Creek	Lowland	Sensitive	1.6%	2.2%	Very Low	0.5%	Likely to remain in current condition
West Bay 1	Coastal	Sensitive	7.9%	9.4%	Moderate	1.5%	Possibly at risk of further impacts
West Bay 2	Coastal	Impacted	9.6%	16.2%	Very High	6.7%	At risk of further impacts
West Bay 3	Coastal	Degraded	40.6%	45.0%	High	4.4%	Likely to remain in current condition

Table 16: Basin Evaluation of Impacts of Planned Growth (Under current plans), continued.

Basin or sub-basin	Landscape Group	Revised Current Condition	TIA 2010	TIA Buildout	Increase TIA, 2010-Buildout		Evaluation of Planned Impacts of Growth
Eld Inlet							
Eld Inlet 1	Coastal	Sensitive	4.2%	5.5%	Moderate	1.3%	Possibly at risk for further impacts
Eld Inlet 2	Coastal	Sensitive	4.1%	5.0%	Low	0.9%	Likely to remain in current condition
Eld Inlet 3	Coastal	Intact	1.3%	2.2%	Moderate	1.0%	Possibly at risk for further impacts
Eld Inlet 4	Coastal	Sensitive	1.7%	2.8%	Moderate	1.1%	Possibly at risk for further impacts
Eld Inlet 5	Coastal	Sensitive	2.4%	3.2%	Low	0.7%	Likely to remain in current condition
Eld Inlet 6	Coastal	Sensitive	7.9%	9.0%	Moderate	1.1%	Possibly at risk for further impacts
Eld Inlet 7	Coastal	Sensitive	6.0%	7.1%	Moderate	1.1%	Possibly at risk for further impacts
Eld Inlet 8	Coastal	Degraded	8.0%	8.7%	Low	0.6%	Likely to remain in current condition
Eld Inlet 9	Coastal	Impacted	13.0%	19.7%	Very High	6.7%	At risk for further impacts
Eld Inlet 10	Coastal	Sensitive	5.1%	5.4%	Very Low	0.2%	Likely to remain in current condition
Eld Inlet 11	Coastal	Sensitive	4.7%	5.4%	Low	0.6%	Likely to remain in current condition
Eld Inlet 12	Coastal	Sensitive	2.8%	3.5%	Low	0.6%	Likely to remain in current condition
Eld Inlet 13	Coastal	Sensitive	5.2%	6.2%	Moderate	1.0%	Possibly at risk for further impacts
Eld Inlet 14	Coastal	Sensitive	6.1%	7.2%	Moderate	1.2%	Possibly at risk for further impacts
Green Cove Creek	Lowland	Sensitive	12.2%	14.1%	Moderate	1.8%	Possibly at risk for further impacts
McLane Creek	Lowland	Sensitive	1.1%	1.6%	Very Low	0.5%	Likely to remain in current condition
Perry Creek	Lowland	Sensitive	1.9%	2.1%	Very Low	0.2%	Likely to remain in current condition
Squaxin Passage	Coastal	Sensitive	10.5%	11.5%	Moderate	1.0%	Possibly at risk for further impacts
Nisqually Reach							
Nisqually Reach 1	Coastal	Sensitive	3.1%	3.9%	Low	0.8%	Likely to remain in current condition
Nisqually Reach 2	Coastal	Sensitive	5.0%	5.7%	Low	0.7%	Likely to remain in current condition
Nisqually Reach 3	Coastal	Sensitive	4.0%	5.0%	Moderate	1.0%	Possibly at risk for further impacts
Nisqually Reach 4	Coastal	Impacted	8.2%	8.7%	Very Low	0.5%	Likely to remain in current condition
Nisqually Reach 5	Coastal	Sensitive	16.0%	20.2%	High	4.2%	At risk for further impacts
Nisqually Reach 6	Coastal	Impacted	20.7%	26.0%	Very High	5.3%	Possibly at risk for further impacts
Nisqually Reach 7	Coastal	Sensitive	12.9%	16.6%	High	3.7%	At risk for further impacts

TABLE 16: BASIN EVALUATION OF IMPACTS OF PLANNED GROWTH (UNDER CURRENT PLANS), CONTINUED.

Basin or sub-basin	Landscape Group	Revised Current Condition	TIA 2010	TIA Buildout	Increase TIA, 2010-Buildout		Evaluation of Planned Impacts of Growth
Henderson Inlet							
Dana Passage 1	Coastal	Sensitive	3.1%	4.7%	Moderate	1.5%	Possibly at risk for further impacts
Dana Passage 2	Coastal	Sensitive	6.1%	7.0%	Low	0.9%	Likely to remain in current condition
Henderson 1	Coastal	Sensitive	1.6%	2.4%	Low	0.8%	Likely to remain in current condition
Henderson 2	Coastal	Intact	1.1%	1.5%	Very Low	0.5%	Likely to remain in current condition
Henderson 3	Coastal	Sensitive	3.4%	3.7%	Very Low	0.3%	Likely to remain in current condition
Henderson 4	Coastal	Sensitive	4.8%	5.7%	Low	0.9%	Likely to remain in current condition
Henderson 5	Coastal	Sensitive	5.6%	6.3%	Low	0.7%	Likely to remain in current condition
Henderson 6	Coastal	Sensitive	3.0%	3.7%	Low	0.8%	Likely to remain in current condition
Henderson 7	Coastal	Sensitive	5.3%	5.7%	Very Low	0.3%	Likely to remain in current condition
Henderson 8	Coastal	Sensitive	3.8%	5.1%	Moderate	1.2%	Possibly at risk for further impacts
Woodard Creek	Lowland	Impacted	14.6%	17.4%	Moderate	2.8%	Possibly at risk for further impacts
Woodland Creek	Lowland	Impacted	22.1%	29.1%	Very High	7.0%	Possibly at risk for further impacts
Totten Inlet							
Burns/Pierre	Coastal	Sensitive	2.5%	3.9%	Moderate	1.3%	Possibly at risk of further impacts
Kennedy Creek	Lowland	Sensitive	1.5%	1.7%	Very Low	0.2%	Likely to remain in current condition
Schneider Creek (Totten)	Lowland	Sensitive	1.8%	2.5%	Low	0.6%	Likely to remain in current condition
Totten 1	Coastal	Sensitive	4.8%	5.8%	Moderate	1.0%	Possibly at risk of further impacts
Totten 2	Coastal	Sensitive	3.8%	5.1%	Moderate	1.3%	Possibly at risk of further impacts
Totten 3	Coastal	Sensitive	2.4%	3.8%	Moderate	1.3%	Possibly at risk of further impacts
Totten 4	Coastal	Sensitive	1.2%	2.4%	Moderate	1.2%	Possibly at risk of further impacts
Totten 5	Coastal	Sensitive	3.1%	3.7%	Low	0.6%	Likely to remain in current condition

TABLE 17: BASIN EVALUATION FOR EFFECTIVENESS OF MANAGEMENT STRATEGIES.

Basin or sub-basin	Current Conditions (Table 12)	Impacts due to Growth (Table 17)	Potential Dwelling Units (TRPC 2013)	Potential Dwelling Units/Sq Mi	Zoning changes an effective tool? (Criteria in Table 15)	Initial Screening Outcomes
Budd Inlet/Deschutes						
Black Lake	Impacted	At risk of further impacts	3,158	460	Yes	Yes
Capitol Lake	Degraded	Likely to remain in current condition	639	336	Yes	No
Chambers	Impacted	Possibly at risk of further impacts	5,648	426	Yes	Possibly - Yes
Deschutes River (Lower)	Impacted	Possibly at risk of further impacts	3,954	226	Yes	Possibly - Yes
Deschutes River (Middle)	Sensitive	Possibly at risk of further impacts	1,948	54	No	No
Deschutes River (Upper)	Sensitive	Likely to remain in current condition	37	1	No	No
East Bay 1	Sensitive	Likely to remain in current condition	19	33	No	No
East Bay 2	Sensitive	Likely to remain in current condition	15	14	No	No
East Bay 3	Impacted	Likely to remain in current condition	27	20	No	No
East Bay 4	Impacted	Likely to remain in current condition	22	24	No	No
Ellis Creek	Sensitive	Possibly at risk of further impacts	129	88	Yes	Possibly - Yes
Indian Creek	Degraded	Likely to remain in current condition	870	374	Yes	No
Lake Lawrence	Impacted	Likely to remain in current condition	160	44	No	No
McIntosh Lake	Sensitive	Likely to remain in current condition	51	20	No	No
Mission Creek	Impacted	Possibly at risk of further impacts	490	427	Yes	Possibly - Yes
Moxlie Creek	Degraded	Likely to remain in current condition	1,683	430	Yes	No
Offut Lake	Sensitive	Likely to remain in current condition	120	43	No	No
Percival Creek	Impacted	Possibly at risk of further impacts	5,378	609	Yes	Possibly - Yes
Reichel Lake	Impacted	Likely to remain in current condition	41	6	No	No
Schneider Creek (West Bay)	Impacted	Possibly at risk of further impacts	812	782	Yes	Possibly - Yes
Spurgeon Creek	Sensitive	Likely to remain in current condition	353	37	No	No
West Bay 1	Sensitive	Possibly at risk of further impacts	101	76	No	No
West Bay 2	Impacted	At risk of further impacts	441	688	Yes	Yes
West Bay 3	Degraded	Likely to remain in current condition	859	967	Yes	No

Table 17: Basin Evaluation for Effectiveness of Management Strategies, continued.

Basin or sub-basin	Current Conditions (Table 12)	Impacts due to Growth (Table 17)	Potential Dwelling Units (TRPC 2013)	Potential Dwelling Units/Sq Mi	Zoning changes an effective tool? (Criteria in Table 15)	Initial Screening Outcomes
Eld Inlet						
Eld Inlet 1	Sensitive	Possibly at risk for further impacts	65	54	No	No
Eld Inlet 2	Sensitive	Likely to remain in current condition	30	38	No	No
Eld Inlet 3	Intact	Possibly at risk for further impacts	49	36	No	No
Eld Inlet 4	Sensitive	Possibly at risk for further impacts	68	43	No	No
Eld Inlet 5	Sensitive	Likely to remain in current condition	56	46	No	No
Eld Inlet 6	Sensitive	Possibly at risk for further impacts	69	48	No	No
Eld Inlet 7	Sensitive	Possibly at risk for further impacts	39	38	No	No
Eld Inlet 8	Degraded	Likely to remain in current condition	27	29	No	No
Eld Inlet 9	Impacted	At risk for further impacts	1,168	677	Yes	Yes
Eld Inlet 10	Sensitive	Likely to remain in current condition	7	10	No	No
Eld Inlet 11	Sensitive	Likely to remain in current condition	18	38	No	No
Eld Inlet 12	Sensitive	Likely to remain in current condition	31	34	No	No
Eld Inlet 13	Sensitive	Possibly at risk for further impacts	60	57	No	No
Eld Inlet 14	Sensitive	Possibly at risk for further impacts	70	67	No	No
Green Cove Creek	Sensitive	Possibly at risk for further impacts	471	136	Yes	Possibly - Yes
McLane Creek	Sensitive	Likely to remain in current condition	274	25	No	No
Perry Creek	Sensitive	Likely to remain in current condition	49	8	No	No
Squaxin Passage	Sensitive	Possibly at risk for further impacts	43	57	No	No
Nisqually Reach						
Nisqually Reach 1	Sensitive	Likely to remain in current condition	29	29	No	No
Nisqually Reach 2	Sensitive	Likely to remain in current condition	31	33	No	No
Nisqually Reach 3	Sensitive	Possibly at risk for further impacts	48	40	No	No
Nisqually Reach 4	Impacted	Likely to remain in current condition	27	28	No	No
Nisqually Reach 5	Sensitive	At risk for further impacts	384	322	Yes	Yes
Nisqually Reach 6	Impacted	Possibly at risk for further impacts	827	473	Yes	Possibly - Yes
Nisqually Reach 7	Sensitive	At risk for further impacts	362	309	Yes	Yes

TABLE 17: BASIN EVALUATION FOR EFFECTIVENESS OF MANAGEMENT STRATEGIES, CONTINUED.

Basin or sub-basin	Current Conditions (Table 12)	Impacts due to Growth (Table 17)	Potential Dwelling Units (TRPC 2013)	Potential Dwelling Units/Sq Mi	Zoning changes an effective tool? (Criteria in Table 15)	Initial Screening Outcomes
Henderson Inlet						
Dana Passage 1	Sensitive	Possibly at risk for further impacts	116	74	No	No
Dana Passage 2	Sensitive	Likely to remain in current condition	28	37	No	No
Henderson 1	Sensitive	Likely to remain in current condition	74	32	No	No
Henderson 2	Intact	Likely to remain in current condition	13	21	No	No
Henderson 3	Sensitive	Likely to remain in current condition	12	20	No	No
Henderson 4	Sensitive	Likely to remain in current condition	43	34	No	No
Henderson 5	Sensitive	Likely to remain in current condition	75	37	No	No
Henderson 6	Sensitive	Likely to remain in current condition	27	31	No	No
Henderson 7	Sensitive	Likely to remain in current condition	14	17	No	No
Henderson 8	Sensitive	Possibly at risk for further impacts	75	55	No	No
Woodard Creek	Impacted	Possibly at risk for further impacts	2,526	304	Yes	Possibly - Yes
Woodland Creek	Impacted	Possibly at risk for further impacts	10,905	429	Yes	Possibly - Yes
Totten Inlet						
Burns/Pierre	Sensitive	Possibly at risk of further impacts	39	67	No	No
Kennedy Creek	Sensitive	Likely to remain in current condition	162	9	No	No
Schneider Creek (Totten)	Sensitive	Likely to remain in current condition	180	22	No	No
Totten 1	Sensitive	Possibly at risk of further impacts	51	47	No	No
Totten 2	Sensitive	Possibly at risk of further impacts	53	56	No	No
Totten 3	Sensitive	Possibly at risk of further impacts	71	73	No	No
Totten 4	Sensitive	Possibly at risk of further impacts	52	46	No	No
Totten 5	Sensitive	Likely to remain in current condition	16	27	No	No

D. Impacts from Forest Land Conversion

Additionally, basins were considered for their vulnerability to loss of forest cover. Sensitive areas that are expected to experience only limited increases in impervious area may still be impacted by a loss of canopy cover, as land that is currently forested is cleared for residential, agricultural, or other use. Basins were evaluated by identifying forest lands within each basin that are vulnerable to urban conversion based on current zoning, ownership, and land use patterns. Basins with good existing forest cover that are projected to lose a substantial portion (>5%) of their total area to other, non-forested uses may be at risk of degradation, as described in Table 18.

TABLE 18: CRITERIA USED TO EVALUATE BASINS FOR THE IMPACTS OF FOREST CONVERSION.

Current Condition	Percent Canopy (Table 10)	Change Criteria	Potential Impacts of Forest Land Conversion
Sensitive or Intact	> 65%	Forest Lands vulnerable to urbanization >5% of basin area	High
Sensitive or Impacted	45-65%	Forest Lands vulnerable to urbanization >5% of basin area	Moderate
Impacted or Degraded	30-45%	Any vulnerability to urbanization of Forest Lands	Low

Table 19 displays the results of this evaluation. A comparison of these results with the initial screening results (Table 17) is shown in Table 20.

TABLE 19: BASIN EVALUATION OF POTENTIAL IMPACTS OF FOREST CONVERSION.

Basin or sub-basin	Landscape Group	Current Conditions (Table 12)	Percent Canopy 2006	Forest Lands Likely to Convert (2010-2035)	Forest Lands Vulnerable to Urbanization (Buildout)	Potential Impacts of Forest Conversion
Budd/Deschutes						
Black Lake	Lowland	Impacted	44.1%	3.0%	6.3%	Low
Capitol Lake	Lowland	Degraded	28.6%	0.0%	0.0%	Low
Chambers	Lowland	Impacted	32.3%	1.3%	2.0%	Low
Deschutes River (Lower)	Lowland	Impacted	41.8%	8.7%	12.6%	Low
Deschutes River (Middle)	Lowland	Sensitive	52.9%	5.8%	13.7%	Moderate
Deschutes River (Upper)	Mountain	Sensitive	71.2%	0.1%	0.3%	Low
East Bay 1	Coastal	Sensitive	70.7%	1.9%	7.3%	High
East Bay 2	Coastal	Sensitive	63.1%	0.9%	3.3%	Low
East Bay 3	Coastal	Impacted	59.2%	0.0%	0.0%	Low
East Bay 4	Coastal	Impacted	59.6%	0.0%	0.0%	Low
Ellis Creek	Coastal	Sensitive	65.3%	0.0%	0.0%	Low
Indian Creek	Lowland	Degraded	37.4%	0.0%	0.0%	Low
Lake Lawrence	Lowland	Impacted	44.6%	2.8%	5.6%	Low
McIntosh Lake	Lowland	Sensitive	80.6%	2.0%	4.5%	Low
Mission Creek	Coastal	Impacted	44.7%	0.0%	0.0%	Low
Moxlie Creek	Lowland	Degraded	27.2%	0.0%	0.0%	Low
Offut Lake	Lowland	Sensitive	61.2%	23.1%	42.7%	Moderate
Percival Creek	Lowland	Impacted	45.7%	2.8%	6.4%	Moderate
Reichel Lake	Mountain	Impacted	62.3%	1.4%	3.0%	Low
Schneider Creek (West Bay)	Coastal	Impacted	55.6%	0.0%	0.0%	Low
Spurgeon Creek	Lowland	Sensitive	69.4%	1.4%	1.8%	Low
West Bay 1	Coastal	Sensitive	74.8%	1.9%	15.5%	High
West Bay 2	Coastal	Impacted	70.0%	1.4%	1.4%	Low
West Bay 3	Coastal	Degraded	22.0%	0.0%	0.0%	Low

TABLE 19: BASIN EVALUATION OF POTENTIAL IMPACTS OF FOREST CONVERSION, CONTINUED.

Basin or sub-basin	Landscape Group	Current Conditions (Table 12)	Percent Canopy 2006	Forest Lands Likely to Convert (2010-2035)	Forest Lands Vulnerable to Urbanization (Buildout)	Potential Impacts of Forest Conversion
Eld Inlet						
Eld Inlet 1	Coastal	Sensitive	72.1%	3.6%	9.1%	High
Eld Inlet 2	Coastal	Sensitive	74.2%	0.0%	0.0%	Low
Eld Inlet 3	Coastal	Intact	80.3%	10.6%	26.7%	High
Eld Inlet 4	Coastal	Sensitive	76.3%	15.3%	40.9%	High
Eld Inlet 5	Coastal	Sensitive	71.5%	7.5%	17.5%	High
Eld Inlet 6	Coastal	Sensitive	69.8%	2.6%	6.0%	High
Eld Inlet 7	Coastal	Sensitive	74.5%	8.2%	16.2%	High
Eld Inlet 8	Coastal	Degraded	31.3%	6.0%	11.7%	Low
Eld Inlet 9	Coastal	Impacted	56.4%	2.3%	4.6%	Low
Eld Inlet 10	Coastal	Sensitive	87.9%	0.6%	1.0%	Low
Eld Inlet 11	Coastal	Sensitive	80.1%	11.7%	17.4%	High
Eld Inlet 12	Coastal	Sensitive	92.9%	2.2%	3.2%	Low
Eld Inlet 13	Coastal	Sensitive	85.8%	0.7%	1.1%	Low
Eld Inlet 14	Coastal	Sensitive	79.1%	0.1%	0.8%	Low
Green Cove Creek	Lowland	Sensitive	66.4%	0.2%	0.4%	Low
McLane Creek	Lowland	Sensitive	72.7%	6.6%	13.0%	High
Perry Creek	Lowland	Sensitive	80.3%	2.3%	4.7%	Low
Squaxin Passage	Coastal	Sensitive	68.4%	0.8%	2.0%	Low
Nisqually Reach						
Nisqually Reach 1	Coastal	Sensitive	72.2%	0.0%	0.0%	Low
Nisqually Reach 2	Coastal	Sensitive	71.2%	0.0%	0.0%	Low
Nisqually Reach 3	Coastal	Sensitive	84.4%	0.8%	1.5%	Low
Nisqually Reach 4	Coastal	Impacted	57.8%	6.7%	13.1%	Moderate
Nisqually Reach 5	Coastal	Sensitive	67.7%	4.0%	7.8%	High
Nisqually Reach 6	Coastal	Impacted	46.6%	0.0%	0.0%	Low
Nisqually Reach 7	Coastal	Sensitive	71.2%	0.0%	0.0%	Low

TABLE 19: BASIN EVALUATION OF POTENTIAL IMPACTS OF FOREST CONVERSION, CONTINUED.

Basin or sub-basin	Landscape Group	Current Conditions (Table 12)	Percent Canopy 2006	Forest Lands Likely to Convert (2010-2035)	Forest Lands Vulnerable to Urbanization (Buildout)	Potential Impacts of Forest Conversion
Henderson Inlet						
Dana Passage 1	Coastal	Sensitive	79.0%	0.9%	3.3%	Low
Dana Passage 2	Coastal	Sensitive	77.9%	1.5%	5.9%	High
Henderson 1	Coastal	Sensitive	72.1%	10.9%	22.2%	High
Henderson 2	Coastal	Intact	86.4%	0.0%	0.0%	Low
Henderson 3	Coastal	Sensitive	55.3%	0.0%	0.0%	Low
Henderson 4	Coastal	Sensitive	52.6%	2.8%	5.6%	Moderate
Henderson 5	Coastal	Sensitive	59.9%	12.1%	23.6%	Moderate
Henderson 6	Coastal	Sensitive	72.8%	3.6%	7.0%	High
Henderson 7	Coastal	Sensitive	71.9%	0.0%	0.0%	Low
Henderson 8	Coastal	Sensitive	73.8%	0.0%	0.0%	Low
Woodard Creek	Lowland	Impacted	45.9%	0.4%	0.9%	Low
Woodland Creek	Lowland	Impacted	40.1%	1.0%	2.2%	Low
Totten Inlet						
Burns/Pierre	Coastal	Sensitive	69.9%	0.0%	0.0%	Low
Kennedy Creek	Lowland	Sensitive	68.0%	0.2%	0.5%	Low
Schneider Creek (Totten)	Lowland	Sensitive	70.5%	3.9%	11.2%	High
Totten 1	Coastal	Sensitive	81.2%	0.0%	0.0%	Low
Totten 2	Coastal	Sensitive	82.7%	3.0%	10.7%	High
Totten 3	Coastal	Sensitive	83.9%	10.1%	34.5%	High
Totten 4	Coastal	Sensitive	67.0%	5.2%	17.8%	High
Totten 5	Coastal	Sensitive	89.3%	0.0%	0.0%	Low

TABLE 20: BASIN SCREENING COMPARISON.

Basin or sub-basin	Landscape Group	Current Conditions (Table 12)	At Risk from Growth (Table 17)	At Risk from Forest Conversion (Table 19)
		Budd/Deschutes		
Black Lake	Lowland	Impacted	Yes	Low
Capitol Lake	Lowland	Degraded	No	Low
Chambers	Lowland	Impacted	Possibly - Yes	Low
Deschutes River (Lower)	Lowland	Impacted	Possibly - Yes	Low
Deschutes River (Middle)	Lowland	Sensitive	No	Moderate
Deschutes River (Upper)	Mountain	Sensitive	No	Low
East Bay 1	Coastal	Sensitive	No	High
East Bay 2	Coastal	Sensitive	No	Low
East Bay 3	Coastal	Impacted	No	Low
East Bay 4	Coastal	Impacted	No	Low
Ellis Creek	Coastal	Sensitive	Possibly - Yes	Low
Indian Creek	Lowland	Degraded	No	Low
Lake Lawrence	Lowland	Impacted	No	Low
McIntosh Lake	Lowland	Sensitive	No	Low
Mission Creek	Coastal	Impacted	Possibly - Yes	Low
Moxlie Creek	Lowland	Degraded	No	Low
Offut Lake	Lowland	Sensitive	No	Moderate
Percival Creek	Lowland	Impacted	Possibly - Yes	Moderate
Reichel Lake	Mountain	Impacted	No	Low
Schneider Creek (West Bay)	Coastal	Impacted	Possibly - Yes	Low
Spurgeon Creek	Lowland	Sensitive	No	Low
West Bay 1	Coastal	Sensitive	No	High
West Bay 2	Coastal	Impacted	Yes	Low
West Bay 3	Coastal	Degraded	No	Low

TABLE 20: BASIN SCREENING COMPARISON, CONTINUED.

Basin or sub-basin	Landscape Group	Current Conditions (Table 12)	At Risk from Growth (Table 17)	At Risk from Forest Conversion (Table 19)
Eld Inlet				
Eld Inlet 1	Coastal	Sensitive	No	High
Eld Inlet 2	Coastal	Sensitive	No	Low
Eld Inlet 3	Coastal	Intact	No	High
Eld Inlet 4	Coastal	Sensitive	No	High
Eld Inlet 5	Coastal	Sensitive	No	High
Eld Inlet 6	Coastal	Sensitive	No	High
Eld Inlet 7	Coastal	Sensitive	No	High
Eld Inlet 8	Coastal	Degraded	No	Low
Eld Inlet 9	Coastal	Impacted	Yes	Low
Eld Inlet 10	Coastal	Sensitive	No	Low
Eld Inlet 11	Coastal	Sensitive	No	High
Eld Inlet 12	Coastal	Sensitive	No	Low
Eld Inlet 13	Coastal	Sensitive	No	Low
Eld Inlet 14	Coastal	Sensitive	No	Low
Green Cove Creek	Lowland	Sensitive	Possibly - Yes	Low
McLane Creek	Lowland	Sensitive	No	High
Perry Creek	Lowland	Sensitive	No	Low
Squaxin Passage	Coastal	Sensitive	No	Low
Nisqually Reach				
Nisqually Reach 1	Coastal	Sensitive	No	Low
Nisqually Reach 2	Coastal	Sensitive	No	Low
Nisqually Reach 3	Coastal	Sensitive	No	Low
Nisqually Reach 4	Coastal	Impacted	No	Moderate
Nisqually Reach 5	Coastal	Sensitive	Yes	High
Nisqually Reach 6	Coastal	Impacted	Possibly - Yes	Low
Nisqually Reach 7	Coastal	Sensitive	Yes	Low

TABLE 20: BASIN SCREENING COMPARISON, CONTINUED.

Basin or sub-basin	Landscape Group	Current Conditions (Table 12)	At Risk from Growth (Table 17)	At Risk from Forest Conversion (Table 19)
Henderson Inlet				
Dana Passage 1	Coastal	Sensitive	No	Low
Dana Passage 2	Coastal	Sensitive	No	High
Henderson 1	Coastal	Sensitive	No	High
Henderson 2	Coastal	Intact	No	Low
Henderson 3	Coastal	Sensitive	No	Low
Henderson 4	Coastal	Sensitive	No	Moderate
Henderson 5	Coastal	Sensitive	No	Moderate
Henderson 6	Coastal	Sensitive	No	High
Henderson 7	Coastal	Sensitive	No	Low
Henderson 8	Coastal	Sensitive	No	Low
Woodard Creek	Lowland	Impacted	Possibly - Yes	Low
Woodland Creek	Lowland	Impacted	Possibly - Yes	Low
Totten Inlet				
Burns/Pierre	Coastal	Sensitive	No	Low
Kennedy Creek	Lowland	Sensitive	No	Low
Schneider Creek (Totten)	Lowland	Sensitive	No	High
Totten 1	Coastal	Sensitive	No	Low
Totten 2	Coastal	Sensitive	No	High
Totten 3	Coastal	Sensitive	No	High
Totten 4	Coastal	Sensitive	No	High
Totten 5	Coastal	Sensitive	No	Low

E. Stakeholder Input

Stakeholder input was identified as a key evaluation factor in this project. An evaluation of other local and regional ecosystem-based management approaches indicates the following:

> *"Effectively engaging all of the key people early in the process … (is) a key determinant of success in the planning process … ." "This engagement doesn't need to include every individual with an interest, but ensuring that all of those interests were represented seems to make a substantial difference. Including an adequate range of expertise to improve credibility and outcomes." "In short, effective early engagement seems to improve the process, outcome, and durability of the implementation."* (Smith and Snyder, 2011)

Efforts were made to contact a broad cross-section of interested parties, departments, agencies, and Tribal governments. Comments were collected from the following stakeholder groups:

- Squaxin Island Tribe natural resources staff;
- Water quality and health staff from Ecology, LOTT Cleanwater Alliance, and Thurston County;
- Water Resource Inventory Area 13 & 14 Salmon Habitat Restoration Workgroup;
- Stormwater Utilities staff of Lacey, Olympia, Tumwater, and Thurston County;
- Long Range Planning staff of Lacey, Olympia, Rainier, Tumwater, and Thurston County;
- Department of Ecology Water Quality, Stormwater, and Watershed Characterization divisions.

Full stakeholder input can be found in the appendix. Stakeholder input will be fully utilized in final basin selection but was not a component of the initial screening.

F. Other Factors to Consider

Budd Inlet Landscape Assessment Catchments of Interest: The results of the Budd Inlet Landscape Assessment are shown in the appendix and summarized in the narrative section. This assessment covers only part of the marine shorelines in WRIA 13. It identifies marine catchments of interest. Catchments of interest include particular catchments if they fall within the bottom 25 percent bin for development (least development). Additionally, if a particular catchment had development scores binned greater than the 25 percent quartile, it was selected if the neighboring catchment development score (average of all neighboring polygon development scores) was in the top 25 percent (least developed) quartile.

Puget Sound Watershed Characterization
Assessment of analysis units for importance for water flow

The Puget Sound Watershed Characterization assesses analysis units for importance for four water flow processes: delivery, surface water, groundwater recharge and discharge. For the study area Ecology staff advised that delivery, which is based on precipitation, would not vary much throughout the study area.

Importance is based on basin pre-development conditions, and it is therefore an assessment of how the analysis unit process performs the function today or would perform it if restored to pre-development conditions. For this reason, importance must be compared to current conditions. Importance is evaluated at the sub-basin level and shown in Maps 18 to 20 for the following water flow processes:

- Surface water (storage);
- Ground water recharge;
- Ground water discharge.

Note: The project Consulting Hydrologist will identify how any additional results of Ecology's Watershed Characterization and Thurston County's Watershed Characterization can be used in this study. This determination will be made under the guidance of the project's Scientific Advisory Team.

A review of available precipitation, flow, and water quality data in Thurston County (Appendix J) found sufficient data for 17 basins within the study area, and ranked those basins according to the quality of the available data. A total of 10 basins were identified as having data of high enough quality for hydrologic modeling. A summary of these results, compared with the risk and management screening categories discussed in Table 20 is included below in Table 21.

TABLE21: BASINS WITH DATA AVAILABLE FOR MODELING.

Basin or sub-basin	Watershed	Landscape Group	Current Conditions (Table 12)	Data Availability Tier (Highest=1)	At Risk from Growth	At Risk from Forest Conversion
Green Cove Creek	Eld Inlet	Lowland	Sensitive	1	Possibly - Yes	Low
Percival Creek	Budd/Deschutes	Lowland	Impacted	1	Possibly - Yes	Moderate
Woodard Creek	Henderson Inlet	Lowland	Impacted	1	Possibly - Yes	Low
Black Lake	Budd/Deschutes	Lowland	Impacted	1	Yes	Low
McLane Creek	Eld Inlet	Lowland	Sensitive	1	No	High
Chambers	Budd/Deschutes	Lowland	Impacted	1	Possibly - Yes	Low
Woodland Creek	Henderson Inlet	Lowland	Impacted	2	Possibly - Yes	Low
Ellis Creek	Budd/Deschutes	Coastal	Sensitive	2	Possibly - Yes	Low
Deschutes River (Lower)	Budd/Deschutes	Lowland	Impacted	3	Possibly - Yes	Low
Deschutes River (Middle)	Budd/Deschutes	Mountain	Sensitive	3	No	Moderate

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XIV. NEXT STEPS

The information in this report will be reviewed by the Consulting Hydrologist and integrated with results of additional studies, including the Thurston County Watershed Characterization (to the maximum extent possible), to inform basin selection. This work will be completed under the guidance of the project's Scientific Advisory Team. After further stakeholder input, local policy makers will decide which basins will be studied further.

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XV. LIST OF MAPS

Map 1: Thurston County Watersheds

Map 2: Thurston County Basins

Map 3: Thurston County Analysis units

Map 4: Benthic Index of Biotic Integrity (B-IBI) Sample Site locations

Map 5: General Water Quality for Thurston County's Streams – 2007-2009 Water Years

Map 6: 1991 Total Impervious Area by Basin

Map 7: 2010 Total Impervious Area by Basin

Map 8: 2035 Total Impervious Area by Basin

Map 9: Total Impervious Area Estimate at Build out by Basin

Map 10: Estimated Increase in Total Impervious Area – 2010 to Buildout

Map 11: 1991 Forest Canopy by Basin

Map 12: 2006 Forest Canopy by Basin

Map 13: Forest Lands Vulnerable to Conversion.

Map 14: Thurston County Wetlands

Map 15: Stream Riparian buffers

Map 16: Landscape Groups: Puget Sound Watershed Characterization

Map 17: Basin Current Conditions

Map 18: Importance of Waterflow – Surface Water: Puget Sound Watershed Characterization

Map 19: Importance of Waterflow – Groundwater Recharge: Puget Sound Watershed Characterization

Map 20: Importance of Waterflow – Groundwater Discharge: Puget Sound Watershed Characterization

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