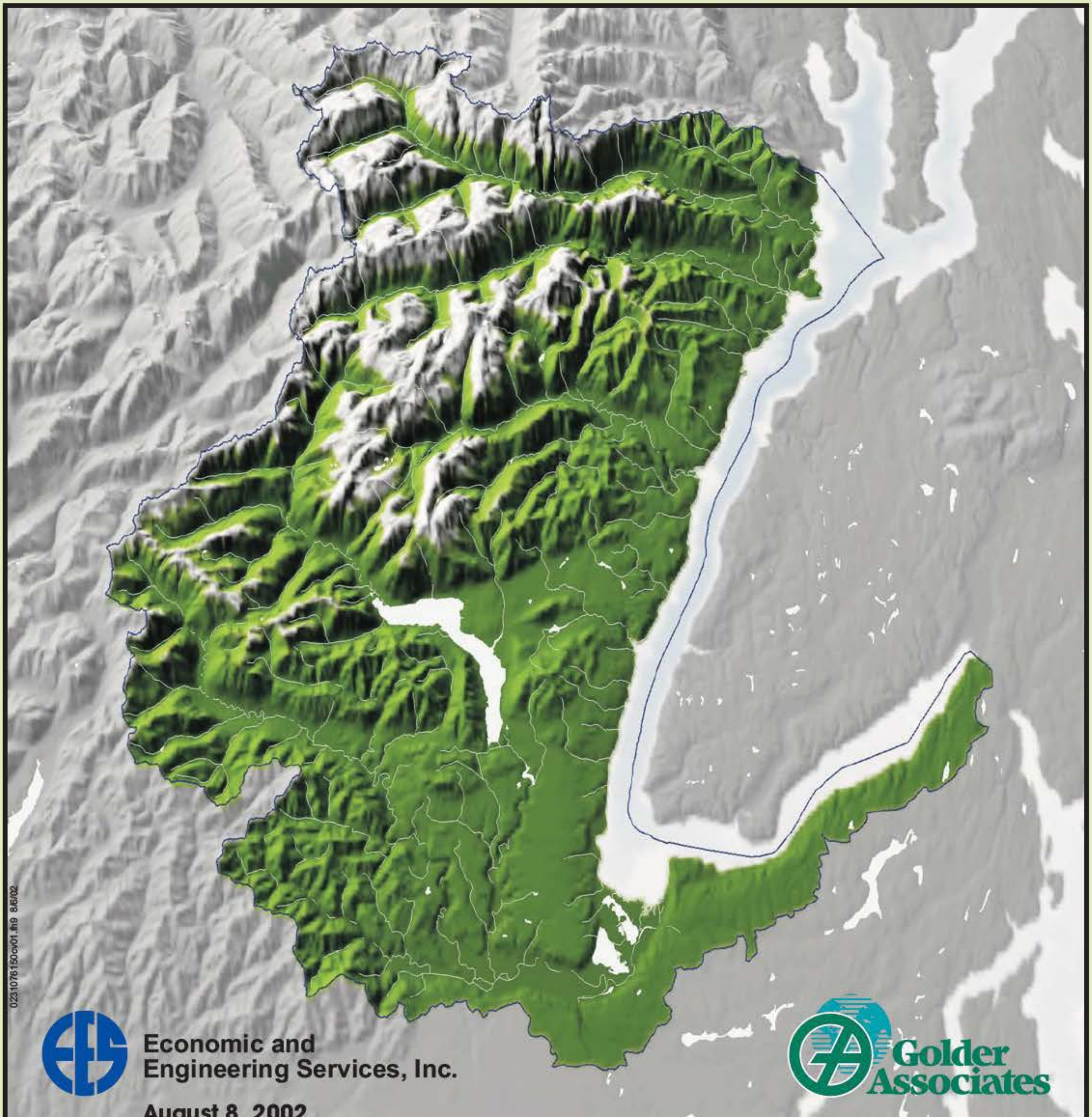
Skokomish-Dosewallips Basin Watershed Planning (WRIA 16)

Level 1 Assessment - DRAFT



Economic and Engineering Services, Inc.

August 8, 2002

Golder Associates

DRAFT REPORT
ON

SKOKOMISH-DOSEWALLIPS WATERSHED (WRIA 16)
PHASE II – LEVEL 1 ASSESMENT
DATA COMPILATION AND PRELIMINARY ASSESSMENT

Prepared for:

WRIA 16 Planning Unit Steering Committee
Shelton, WA

Submitted by:

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In association with:

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EXECUTIVE SUMMARY

Stakeholders in the Skokomish-Dosewallips Watershed have taken the initiative provided by the State of Washington under Chapter 90.82 of the Revised Code of Washington to undertake watershed planning for the watershed. The watershed comprises Water Resources Inventory Area (WRIA) 16 and is located on the eastern side of the Olympic Peninsula on the western shore of Hood Canal.

Watershed planning of the portion of the Kennedy-Goldsborough Basin (WRIA 14) that drains into the south shore of Hood Canal has been transferred to WRIA 16 by an interlocal agreement. This was done to consolidate water quality efforts affecting Hood Canal.

This Level 1 Assessment provides a compilation of existing information to provide an overview of the water resources of the Skokomish-Dosewallips Basin. Based on the current understanding of the watershed and available information, the Planning Unit will decide how to proceed and allocate effort in the Level 2 Assessment.

Before embarking on Level 2 work, goals and objectives must be defined for watershed planning. With these defined, the direction of Level 2 will be more productively focused to support development of the watershed plan.

SETTING

The Olympic Peninsula and the Skokomish Watershed ranges from steep rocky terrains ranging up to over 7,000 feet high in the northern interior of the basin, to flat floodplains in the southern coastal areas. Annual precipitation ranges from 60 inches to over 250 inches that supports a temperate rainforest.

Most of the land (~60%) in the basin is under federal ownership in the form of national forest and national park. Major commercial activities include forest industry, shellfish harvest, and hydroelectric power generation.

The geology of the mountainous terrain is rocky with sedimentary and basalt rocks. Runoff from the rocky terrain is quick with minor groundwater storage capacity. Minor alluvial sediments are present in the river valleys.

Alluvial and glacial sediments along the coast and in floodplains and estuaries host a significant groundwater flow system that the primary source of groundwater supply in the basin.

SUMMARY OF FINDINGS

Streamflows

Two patterns of annual streamflow hydrographs are recognized. In catchments where there is significant snowpack influences, peak flow periods occur in the late fall and late spring. Although significant precipitation occurs during the winter, winter streamflows are suppressed by the accumulation of precipitation as snowpack. In stream catchments of lower elevations, peak flows are coincident with peak precipitation in the middle of the winter.

Streamflows are flashy with sharp spikes of increased streamflow that dissipate quickly. This reflects the small storage capacity of the basins as groundwater, and rain on snow events that cause quick releases of water from snowpack storage.

An instream flow study (Instream Flow Incremental Methodology [IFIM]) was conducted in the early 1980s by Ecology under the Instream Resource Protection Program (IRPP). A draft rule for minimum instream flows was prepared but not adopted. Current streamflows do not meet the proposed regulations in most years.

Average annual streamflow volume of the basin is on the order of three million acre-feet per year (AF/yr).

Water Rights

The total amount of water estimated to be allocated in the basin is approximately 16,000 AF/yr, excluding water rights and claims for purposes of use of power, fish propagation and fire suppression. This represents approximately 0.5% of the total streamflow in the watershed. This estimated allocation is distributed approximately equally between groundwater and surface water, and between irrigation and residential use. No evaluation of the validity of these rights was attempted. Experiences in other watersheds have been that approximately 75% of the allocated water rights and claims are not valid.

Pending applications for new water rights include approximately 34 for groundwater (total of 4,742 gpm) and 11 for surface water (8,640.1 cfs). The most significant of these appear associated with the North Fork Skokomish River for power generation (total of 3,200 cfs), and municipal use (5,440 cfs). All other applications are for domestic or municipal purposes of use except for one commercial industrial application (26 gpm) near the community of Duckabush.

There are eight pending applications for changes to existing water rights, split evenly between surface and groundwater.

No assessment was conducted of tribally and federally reserved water rights.

Actual and Future Water Use

Actual residential use was estimated to be between 1,000 and 1,500 AF/yr (including exempt wells), or approximately ¼ to 1/3 of the estimated allocation for this purpose of use (excluding exempt wells). This represents approximately 0.03% of the total estimated streamflow in the basin.

Irrigation use was estimated to be approximately 500 AF/yr, assuming even distribution of irrigated lands across Mason and Jefferson Counties. Actual distributions may be concentrated within these counties outside of WRIA 16, particularly in Jefferson County, thereby reducing the estimate of actual use for irrigation. Commercial/industrial use was not estimated.

Population growth in the watershed from 1990-2000 was 24% and was concentrated in the North Mason and Lower Skokomish Subbasins. Anticipated increased demand for water supply is expected to be concentrated primarily in the Brinnon, Lower Skokomish, and North Mason areas.

Water Quality

Water quality in the basin in general is excellent. One marine waterbody (Hood Canal South) and nine freshwater waterbodies are listed as having water quality impairments in WRIA 16 and the portion of WRIA 14 on the south shore of Hood Canal that is designated as the Upper Mason sub-basin and is being considered with WRIA 16. Seven waterbodies are listed as impaired for fecal coliform, and two for pH, all of which will require TMDL development. The North Fork of the Skokomish River, which is listed for instream flow, will not require TMDL development, since instream flow is not considered a pollutant under the Clean Water Act.

Water Balance Summary

Precipitation:	3,400,000 AF/yr	
Streamflow:	3,000,000 AF/yr	
Evapotranspiration:	400,000 AF/yr	
Allocation:	**16,000 AF/yr (0.5% of streamflow)**	
		8,000 AF/yr domestic/municipal use
		8,000 AF/yr irrigation use
Actual Use:	**2,000 AF/yr (0.07% of streamflow)**	
		1,500 AF/yr domestic/municipal use
		500 AF/yr irrigation

Data Gaps

Data gaps exist in all technical areas. Those that will need to be addressed to support watershed planning decisions will depend on the goals and objectives of the Planning Unit for the watershed plan. The chapter on data gaps will be prepared for the final version of this report based on comments received from the Planning Unit on this draft Level 1 Assessment report.

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1. INTRODUCTION

This section presents the objective and purpose of this study, the location of the study area, a summary of the watershed issues and the technical approach for this project. A list of acronyms is presented in Table 1-1.

1.1 Background

This Phase II Level 1 Technical Assessment summarizes information for Skokomish-Dosewallips Water Resources Inventory Area (WRIA) 16 and provides a data compilation and preliminary assessment of water quantity, water allocation, water use, and water quality for the WRIA. This Level 1 Data Compilation and Preliminary Assessment represents the first step in the technical review and analysis of water resources in WRIA 16. This assessment will be followed by subsequent stages of data collection and/or analysis and eventual preparation of a watershed plan.

The Initiating Governments started the Skokomish-Dosewallips Watershed Planning effort in 1999. These include all counties with land within the WRIA (Mason, Jefferson and Grays Harbor Counties), the largest purveyor (Mason County Public Utility District #1), and tribes with reservation lands within the WRIA (Skokomish Tribe). Ecology is participating as a stakeholder in this basin and consensus approval with the Initiating Governments is needed on all decisions. The Planning Unit established the scope of this assessment consistent with the requirements of the Watershed Management Act (RCW 90.82). The assessment has been funded in part by the Washington Department of Ecology.

An agreement has been entered into between the Planning Units of WRIAs 14 and 16 in which the portion of WRIA 14 that drains into the Hood Canal will be included in the watershed planning process of WRIA 16. Therefore, this Level 1 Assessment covers WRIA 16 plus that portion of WRIA 14.

1.2 Skokomish-Dosewallips WRIA 16 Overview

The Skokomish-Dosewallips Basin, WRIA 16, is located on the Olympic Peninsula on the west side of the Hood Canal (Figure 1.1). It lies in the northwestern half of Mason County and the southeastern portion of Jefferson County, and encompasses an area of about 660 square miles. The physiography of the WRIA ranges from craggy snow-capped peaks of the Olympic Mountains in the western portion of the basin to the flatlands of the Skokomish River Valley and northern portion of WRIA 14 (Figure 1.2).

Principal drainages in the basin are the Dosewallips, Duckabush, Hamma Hamma, and the Skokomish Rivers, with many smaller streams along the Hood Canal (Figure 1.3). There are 557 identified streams providing over 825 near miles of rivers, tributaries, and independent streams in the basin (Ecology, 1985). High elevation snowfields in the Olympic Mountains, direct runoff of precipitation, and groundwater baseflow maintain stream flows. Natural storage of water occurs in snow pack, lakes, wetlands and groundwater, which functions to moderate extreme high and low flow stream conditions (Ecology, 1985).

Peak runoff in WRIA 16 streams occurs during the winter and early spring months during snowmelt and when precipitation is the highest. As the precipitation subsides in late spring and early summer, stream flow levels begin to fall off. By August or September streams have usually reached their lowest levels. Stream flows then increases again in the fall.

Sixty percent of the land area in WRIA 16 is located within the Olympic National Park and Olympic Forest. The remaining 40 percent is state and privately owned (Figure 1.4). Forestry is one of the largest activities in the basin. Hydroelectric dams have significantly changed the stream flow regime of the North Fork of the Skokomish River (Cushman Dams No. 1 & 2; Figure 1.2). There is on-going litigation related to operation of these dams, and assessment of these dams and their effect on the watershed are excluded from this report.

Development in the basin is concentrated in a narrow strip along the coast. Agricultural activity is concentrated in the Lower Skokomish River Valley. Water supply is needed for future development in the Brinnon area. Shellfish in Hood Canal is important to both tribal interests and the private sector.

An Instream Resource Protection Program (IRPP) study has been conducted in WRIA 16 and an instream flow regulation (Ch. 173-516 WAC) has been drafted (Ecology, 1985). Ecology conducted Instream Flow Incremental Methodology (IFIM) studies on the Dosewallips, Duckabush, and Hamma Hamma Rivers; and on Finch, Eagle, Johns, Jorsted, and Fulton Creeks. The US Fish and Wildlife Service did IFIM studies on the North Fork, South Fork, and mainstem Skokomish River. Tacoma did an IFIM study on the lower North Fork Skokomish River.

The US Geological Survey has monitored nutrients, ions, dissolved carbon, and sediment at the Highway 101. Ecology recently had an ambient water quality monitoring station at Finch Creek in Hoodsport. The Skokomish Tribe (1997) measured various parameters in the Skokomish watershed.

The Skokomish Tribe is developing a restoration plan for the Skokomish watershed. A Comprehensive Flood Hazard Management Plan has also been developed for the Skokomish River. The Hood Canal Coordinating Council is active in the Hood Canal portions of WRIAs 14-17 and has received funding to assess impacts of Highway 101 causeway on historic estuary/tidal channels. The Simpson Timber Company and the Washington Department of Natural Resources completed a Watershed Analysis for the South Fork of the Skokomish River.

1.3 Purpose and Scope of Phase II Level 1 Assessment

The ultimate goal of watershed planning is to manage water resources. Watershed planning in Washington State is sponsored by the Washington Department of Ecology, which provides guidance to local stakeholders on the development of watershed management plans for water resources within a WRIA.

The purpose of Phase II of the watershed planning process is to provide the technical support to prepare a watershed plan in Phase III. Phase II is divided into two levels. In Level 1 (data compilation and preliminary assessment), existing data is compiled and data gaps that may impair preparation of the watershed plan in Phase III are identified. In Level 2 (data collection and/or analysis), data collection may be conducted and analysis of the data made to support development of the watershed plan. The work conducted in Level 2 should be conducted to directly support development of the plan in Phase III. Therefore, Phase III should be sufficiently developed (e.g., goals and objectives) before the Level 2 Data Collection and/or Analysis is conducted.

Thoughts on the possible final form of the watershed plan should be developed at the earliest stages of watershed planning and continue to evolve through all stages of the process. Topics of the final watershed plan and the structure of implementation will require time to develop into a form that will be: accepted by members of the Planning Unit; approved by the counties; and, be ready to be implemented. An understanding at an early stage of what form the watershed plan may assume will allow the most focused and productive allocation of effort throughout Phase II of the process.

1.4 Approach

The approach to Level 1 Data Compilation and Preliminary Assessment is to fulfill selected requirements of the watershed planning grant (e.g., assessment of allocation, preparation of a water balance and estimates of actual use). Fulfillment of additional requirements will be conducted in Level 2. Upon review of the Level 1 Assessment, and development of the objectives and goals for watershed planning, the Planning Unit will decide the direction and approach to conducting Level 2 work to support development of a plan. Level 2 work may be focused in several ways:

- Particular technical areas (e.g., refined water balance, collection of additional water quality data, etc.);
- Particular geographical areas (e.g., assessment of global warming on snowpack dependent streams, groundwater stratigraphy in the Brinnon and/or Lower Skokomish Valleys, etc.); or,
- To support complimentary programs (e.g., salmon recovery, instream flows, etc.).

In order to provide a useful water resource assessment of the basin, the data compilation and analyses is descretized on the sub-basin level. There are nine sub-basins in WRIA 16 that have been delineated by Washington Department of Natural Resources (Watershed Administrative Units; WAUs), plus a portion of WRIA 14. These subbasin delineations are used in this report with the exception that the two sub-basins comprising the drainage of the Dosewallips River (Mount Anderson and Lower Dosewallips Sub-basin WAUs) are consolidated. As a result, the following nine sub-basins were considered in this assessment (Figure 1.3):

- Dosewallips
- Duckabush
- Hamma Hamma

- Cushman
- Lilliwaup
- North Fork Skokomish
- South Fork Skokomish
- Skokomish, Lower
- Upper Mason

Most components of the assessment provided in this report are provided at the resolution of these subbasins.

1.5 Objective

The objective of this report is to present an overview of the watershed as it is known and top conduct a preliminary assessment of several parameters including: development of a water balance; estimating the level of allocation, number of applications for new water rights and changes; assessing actual water use and future demand; and, synopsizing the status of water quality. This report is designed to address the following:

- Fulfill selected requirements of the Phase II, Level I Assessment of the 1998 Watershed Planning Act (Ch. 90.82 RCW);
- Provide an inventory of core documents used in this assessment;
- Develop a conceptual hydrologic model and characterization of the watershed;
- Estimate the degree of allocation;
- Estimate the degree of actual water use;
- Create a water balance for the hydrologic cycle by sub-basin for WRIA 16;
- Characterize and summarize the status of water quality of the surface water bodies in WRIA 16;
- Identify and summarize data gaps that could impair later stages of watershed planning efforts; and,
- Provide a level of understanding of the watershed to develop the work plan for Level 2 Assessment of Phase II of watershed planning will be developed.

1.6 Authorization and Acknowledgements

This report was authorized by Mason County on April 5, 2002. The WRIA 16 Steering Committee contributed significantly to the preparation of this report including development of the scope and providing important reference documents. Jason Manassee, Mason County Department of Community Development, is the WRIA 16 Administrative Lead, on behalf of Mason County.

Chris Pitre, Senior Project Manager, Water Resources, is the project manager on behalf of Golder Associates Inc. David Banton of Golder is the Principle in Charge. Donna DeFancesco, Philip Beetlestone, and Michael Klisch of Golder conducted much of the analysis. Marc Horton and Jerry Louthain of Economic and Engineering Services, Inc. (EES) consulted on this project and participated in scope development, project review, data collection, analysis and report preparation and prepared sections of this report on actual and future use, and water quality.

2. WATERSHED PLANNING

The 1998 Washington State legislature passed House Bill 2514, codified into Ch. 90.82 RCW, to set a framework for addressing the State's water resources issues:

> *"The legislature finds that the local development of watershed plans for managing water resources and for protecting existing water rights is vital to both state and local interests. The local development of these plans serves vital local interests by placing it in the hands of people: Who have the greatest knowledge of both the resources and the aspirations of those who live and work in the watershed; and who have the greatest stake in the proper, long-term management resources. The development of such plans serves the state's vital interests by ensuring that the state's water resources are used wisely, by protecting existing water rights, by protecting instream flows for fish and by providing for the economic well-being of the state's citizenry and communities. Therefore the legislature believes it necessary for units of local government throughout the state to engage in orderly development of these watershed plans."*

Twelve State agencies signed a Memorandum of Understanding identifying roles and responsibilities for coordination under the Watershed Planning Act. This memorandum commits these agencies to work through issues in order to speak with one governmental voice when sitting at local planning unit tables. The following agencies signed this document:

- The Department of Agriculture;
- The Conservation Commission;
- The Department of Community, Trade and Economic Development;
- The Department of Ecology;
- The Department of Fish and Wildlife;
- The Department of Health;
- The Department of Natural Resources;
- The Department of Transportation;
- The Interagency Committee for Outdoor Recreation;
- The Puget Sound Water Quality Action Team;
- The Salmon Recovery Office, within the Governor's Office; and,
- The State Parks and Recreation Commission.

The purpose of the 1998 Watershed Management Act (WMA) is to provide a framework for local government, interest groups and citizens to collaboratively identify and solve water related issues in each of the 62 Water Resource Inventory Areas (WRIAs) of Washington State.
The WMA does not require watershed planning but instead enables a group of initiating agencies to:

- Select a lead agency;
- Apply for grant funding;
- Define the scope of the planning; and,
- Convene a local group called a planning unit for the purpose of conducting watershed planning.

The initiating agencies include all the counties within the WRIA, the largest city and water purveyor within the WRIA. Indian tribes with reservation lands within the watershed must be invited to participate as an initiating government. Although their participation is optimal, participation is not required for watershed planning to proceed.

Upon successful completion of Phase I, Ecology may grant up to $450,000 per WRIA to fund watershed planning: $200,000 for Phase II (Assessment), and $250,000 for Phase III (Watershed plan development). Under the law, the Planning Unit has considerable flexibility to determine the planning process, focus on areas or elements of particular importance to local citizens, assess water resources and needs, and recommend management strategies. Ecology may also make available supplemental funding of up to $100,000 for expanded studies on each of instream flow, water quality and storage.

The WMA identifies four topics that can be addressed within the watershed assessment plan. Table 2-1 provides a description of the technical assessment requirements of the WMA. Water quantity must be addressed if grant funds are accepted. Water quality, habitat and instream flows may be addressed but are optional. The Skokomish-Dosewallips Planning Unit has adopted to address all optional components, water quality, habitat and instream flow; but has chosen to focus the efforts of this assessment on water quality and water quantity. The law specifies certain types of information that must be gathered and a range of water resource management strategies that need to be addressed.

The law also includes constraints on the activities of planning units. For example, the Planning Unit does not have the authority to change existing laws, alter water rights or treaty rights, or require any party to take an action unless that party agrees.

Three phases of watershed planning are identified in the WMA:

- Phase I - Organization
- Phase II - Assessment

⇒ <u>Level 1 Assessment</u>: A compilation and review of existing data (within time and budget limitations) relevant to defined objectives. If the Planning Unit decides that the existing data is sufficient to support the management requirements of all or some of the issues, the Planning Unit may choose to skip Level 2 and move on to Level 3 for these issues.

⇒ <u>Level 2 Assessment</u>: Collection of new data within the time frame of the planning process to fill data gaps and to support decision needs.

⇒ Level 3 Assessment: Long term monitoring of selected parameters following completion of the initial watershed plan to improve management strategies.

- Phase III – Planning

  The WMA calls for a consensus approval of the watershed plan by all members of the Planning Unit, or a consensus of the initiating governments and a majority vote by the remaining members of the Planning Unit. Following approval by the Planning Unit, the WMA calls for a joint session of the legislative session bodies of all counties in the watershed to consider the plan. The counties can recommend changes to the plan but the Planning Unit must agree to make the changes for them to be effective. County and state agencies are required to implement the plan once the county legislative bodies and the Planning Unit approve the plan.

2.1 The Watershed Planning Concept

Watershed planning within Watershed Resource Inventory Areas (WRIAs) recognizes the large scale and complexity of water resources and the wide variety of factors that influence the amount of water available for use. Although the geographic area contained in a WRIA rarely corresponds with political/jurisdictional boundaries, water resource issues such as water supply, water quality, and habitat for fish and wildlife are closely linked together within watersheds.

From an assessment perspective, the watershed (or basin) scale is appropriate because the hydrologic processes that occur within WRIA boundaries can be approximated by a basin scale hydrologic cycle or equation. This equation can be expressed generally as "water inflow to the basin is equal to water outflow from the basin plus/minus changes in water storage within the basin". With a conceptual understanding of the hydrologic cycle within a basin, planners can gain an intuition on how future actions within the watershed may impact water resources and decide how to allocate "available water" among competing needs and uses, including instream flows.

2.2 The WRIA 16 Planning Unit

The Initiating Governments started the Skokomish-Dosewallips Watershed Planning effort in 1999. These include all counties with land within the WRIA (Mason, Jefferson and Grays Harbor Counties), the largest purveyor (Mason County Public Utility District #1), and tribes with reservation lands within the WRIA (Skokomish Tribe). Ecology is participating as a stakeholder in this basin and consensus approval with the Initiating Governments is needed on all decisions. The following is a list of the agencies and individuals in the WRIA 16 Planning Unit.

WRIA 16

Planning Unit Membership

Name (alternate)	**Affiliation**
INITIATING GOVERNMENTS – CONSENSUS APPROVAL	
Dave Christensen	Jefferson County
Keith Dublanica (Richard Guest)	Skokomish Tribe
Bob Fink	Mason County
Lee Hansmann	Grays Harbor County
Jason Manassee	Mason County
Phil Wiatrak (Cynthia Nelson)	WA Dept. of Ecology
Dick Wilson (Debbie Knipschield)	Mason County PUD #1
ORGANIZATIONS – MAJORITY VOTE APPROVAL	
Al Adams (Neil Warner)	Hood Canal Salmon Enhancement Group
Mark Biser	Trout Unlimited
Warren Dawes	Growth Management
Chuck Finnila	Jefferson County citizen
George Fisher (Norma Cameron)	Save the Lakes
Kerry Holm	Port of Hoodsport
William Matchett (Donna Simmons)	Hood Canal Environmental Council
Vicki Pavel (Michael Pavel)	Seowin Society
Tom Schreiber	Mason County – citizen
Keith Simmons (Patti Case)	Simpson Timber
EX-OFFICIO, NON-VOTING MEMBERS	
Shannon Bonnett (Mike Madsen)	Mason County Conservation District
Don Haring	WA State Conservation Commission
Harriet Beale (Stuart Glascoe)	PSWQ Action Team
Bill Lewis	WA DNR
Mark McHenry	US Forest Service
Lori Morris	US Army Corps of Engineers
Dave Morris	US Olympic National Park
Sue Patnude (Ginna Correa)	WDFW
Ken Stone	WA DOT
Jay Watson	Hood Canal Coordinating Council

The Port Gamble S'Klallam Indian Tribe has Usual and Accustomed lands in the northeast portion of the basin and has conducted natural resource studies in that area.

The following individuals and firms have provided consulting services to the Watershed WRIA 16 Planning Unit.

Name (Alternate)	**Affiliation**

Susan Gulick	Sound Resolutions
Marc Horton (Jerry Louthain)	Economic & Engineering Services Inc.
Chris Pitre (Donna DeFrancesco)	Golder Associates Inc.

2.3 WRIA 16 Watershed Planning Background Issues

Because water resources are limited and the requirements of the natural environment and needs of the people are not always commensurate, the resource will require management if the needs of both are to be met. The watershed planning process under RCW 90.82 requires that water quantity be addressed. The WRIA 16 Planning Unit has chosen to also address in watershed planning the optional components of water quality, habitat and instream flows. Some of the important issues to the Planning Unit and the watershed planning process in each of these areas are described below.

2.3.1 Water Quantity

Water quantity analysis and characterization is a required component of the watershed planning process. Surface water in Skokomish Basin is used for a variety of purposes. WRIA 16 is an attractive area for hydropower development due to the relatively large number of potential sites, high runoff, rapid fall of streams from the mountains to the Hood Canal, and the proximity to urban power markets. Hydroelectricity is generated on the North Fork of the Skokomish River and on Lilliwaup Creek, and has been proposed on other streams within the basin. Small water diversions for commercial and domestic supply exist in the lowlands of the Hood Canal. Other rivers and streams are used for municipal water supplies (Ecology, 1985). Water is also used at fish hatcheries in the basin. As population increases in the Hood Canal area and the Puget Sound region in general, the demand for water supply and energy production is likely to increase. Current growth pressures and associated increased demand for water supply is occurring in the Brinnon area of Jefferson County.

Forest road building has had major impacts on flood conditions in the Skokomish system. Road systems route surface runoff to stream channels and are directly related to peak flows and sediment delivery. Increased aggradation throughout the South Fork Skokomish drainage system has resulted in higher groundwater tables and frequent flooding. Land use activities such as forestry, clearing and grading have increased the sediment load and siltation in the lower reaches of rivers. Combined with filling of overflow channels and wetland complexes, this has have compounded naturally occurring flooding cycles. Dikes and levees confine several miles of the Lower Skokomish River. Flooding is typically addressed under the Federal Emergency Management Agency's (FEMA) Flood Insurance Studies program.

2.3.2 Water Quality

A number of surface water bodies in the watershed have been listed under Section 303(d) of the Clean Water Act. Forest road construction has resulted in increased sediment loading of surface waters. Agricultural activities and riparian vegetation removal have contributed to higher stream temperatures, lower dissolved oxygen, increased fecal coliform contamination and overall water quality degradation (Ecology 1998).

Establishment of a Total Maximum Daily Load (TMDL) and Clean Up Action Plan is underway for the Skokomish River for fecal coliform impairments. Maintaining a high level of water quality is important to the watershed for recreational and commercial use, the maintenance of salmonid habitat, and for long-term protection of groundwater quality

2.3.3 Marine Water Quality

Shellfish harvesting in the Hood Canal is important for both tribal and commercial interests. Dosewallips and Potlatch State Parks are Washington's most used public beaches for recreational shellfish harvest. The Department of Health has listed Annas Bay and Lilliwaup shellfish areas as threatened with downgrades due to periodic high fecal coliform counts. The state and county are working on identifying fecal coliform sources in the Lilliwaup area, and Mason County has received a grant from Ecology to conduct studies failing on-site septic systems in these areas. There are also known problems with septic systems on Finch Creek and suspected problems in other areas (Ecology, 1998).

2.3.4 Habitat

Water quantity and quality are important to fish habitat. Streams of WRIA 16 are important production grounds for coho, chum, pink and chinook salmon. Steelhead and cutthroat trout also inhabit waters of this WRIA and are important to the recreational fishery (Ecology, 1985). The decline in salmon abundance and recent listing of Puget Sound chinook and Hood Canal summer chum under the Endangered Species Act reflect a coast-wide decline in salmon habitat quality.

The Washington Department of Fish and Wildlife is concerned about the effects of instream flow alterations, sediment loading, and temperature of fish populations and habitat in the Skokomish River, particularly as it relates to Skokomish winter steelhead, a depressed stock. WDFW is also concerned about low oxygen events, which cause late summer fish mortalities in Lower Hood Canal.

In the Eastern Olympic Region, one of the limiting factors for migratory fish is impassable culverts. Hood Canal alone has over one hundred impassable culverts under state and county highways in tributary streams. An assessment of impassable culverts in tributaries of the Hood Canal on the Olympic Peninsula has not been completed (Ecology, 1998). The Hood Canal Salmon Enhancement Group received Salmon Recovery Funding Board (SRFB) and National Fish and Wildlife Foundation funds to assess Highway 101 causeway impacts on the historic estuary/tidal channels. Timberland conversion, riparian vegetation removal, forest roads, agricultural activities, and other land use activities such as clearing and grading, filling of overflow channels, and wetland complexes have also resulted in degradation of habitat (Ecology, 1998).

3. SKOKOMISH-DOSEWALLIPS WATERSHED DESCRIPTION

The Water Resources Act of 1971 defined 62 Watershed Resource Inventory Areas (WRIAs) in Washington State for the purposes of managing water resources including the administration of water rights. The Skokomish-Dosewallips Water Resource Inventory Area (WRIA 16) is located on the Eastern Olympic Peninsula in northwestern Washington State and is bounded by the Hood Canal to the east and the Olympic Mountains to the west. It encompasses an area of about 660 square miles in the northwestern half of Mason county and the southeastern portion of Jefferson County. To the north is the Quilcene River basin of WRIA 17 and to the south the drainages of the Kennedy Goldsborough WRIA 14.

The land area is evenly split between Jefferson and Mason Counties; however, the majority of the population is located in Mason County. Most of the population is located in unincorporated areas. The population centers are all located along the coast of the Hood Canal and include Brinnon in the northern portion of the basin and Lilliwaup and Hoodsport in the southern portion of the basin. The Skokomish Indian Tribe is located at the mouth of the Skokomish River on the north shore. Sixty percent of land ownership is federal as the Olympic National Park and Olympic National Forest. The remaining is state and privately owned.

3.1 Physiography

Physiography of the WRIA ranges from the mountainous regions of the Olympic Mountains to the northern and southern lowlands along the Hood Canal (Figure 1.2). The highest peak is 7,788-foot MSL Mount Deception. Mount Anderson is 7,319 feet MSL in elevation. Geologic formation of the Olympic Mountains occurred from uplifting during the Pleistocene Epoch, three million years ago. The bedrock of the Olympic Mountains consists of older (Miocene and Tertiary) consolidated sedimentary rock and volcanics. The northern lowlands are comprised of Quaternary deposits of fluvial or glacial origin. The southern lowlands are comprised of thick layers of recessional outwash, composed of sand, gravel, silt and clay. Recent alluvium occurs primarily in the Skokomish floodplain. This consists primarily of fine sand and silt with minor amounts of clay and peat. With thickness of up to 100 feet, the alluvium is saturated to about river level.

3.2 Sub-basins

The Skokomish-Dosewallips watershed is divided into sub-basins based primarily on surface water divides. The Skokomish watershed is divided into nine sub-basins (Figure 1.3; Table 3-1):

- Dosewallips
- Duckabush
- Hamma Hamma
- Cushman

- Lilliwaup
- North Fork Skokomish
- South Fork Skokomish
- Lower Skokomish
- Upper Mason (from WRIA 14)

The analysis in this Level 1 Assessment is conducted at the resolution of these sub-basin levels. However, conditions may vary internally within a sub-basin and general findings arrived at in this Level 1 Assessment about each sub-basin may not be applicable to the complete sub-basin. Potential inconsistencies may be addressed in more detailed planning that will result from the overall watershed planning process.

The three northern subbasins (Dosewallips, Duckabush and Hamma Hamma) are very similar, have the highest elevation headwaters, and flow directly into Hood Canal. These three subbasins are dominated by rocky geology and have unconsolidated sediments only along valley floors and along the Hood Canal coast. The Lilliwaup, North Fork Skokomish, Lower Skokomish and North Mason Subbasins are predominantly flat and underlain by unconsolidated sediments. The Cushman and South Fork Skokomish Subbasins have a mix of both rocky mountainous, and flat sedimentary terrains.

3.2.1 Dosewallips River Sub-basin

The Dosewallips River is the northernmost river in the WRIA 16 and one of the largest rivers in East Jefferson County. Draining a watershed area of approximately 74,142 acres (approximately 116 square miles) from the Olympics eastward into the northern portion of the Hood Canal, the Dosewallips is the largest drainage entering the northern area of the Hood Canal. It contains 28.3 mainstem stream miles and 104.5 miles of tributaries. The average annual discharge at River Mile (RM) 7.1 is 446 cubic feet per second (cfs).

The largest landowners in the Dosewallips watershed are the Olympic National Park (47,231 acres) and the Olympic National Forest (22,028 acres), which together comprise 93% of the watershed. A significant portion of the National Forest land is protected as wilderness area. The remaining 7% is divided among privately held forest lands, rural residential, park land, and commercial uses. There are 34 acres of commercial zoning within the watershed, in the lower reaches. The predominant residential zoning within the watershed is one residence per 20 acres. The rural center of Brinnon is located at the mouth of the river (Hood Canal Coordinating Council, 2001).

3.2.2 Duckabush River Sub-basin

The Duckabush River is located in southeastern Jefferson County. The watershed comprises approximately 49,970 acres (about 78 square miles). The average annual discharge is 411 cfs at RM 4.9. The Duckabush mainstem is 24.1 miles long with 34.2 miles of tributaries.

The Duckabush River watershed is similar to that of the Dosewallips River. Approximately 28,875 acres are within the Olympic National Park and 15,681 acres are within the Olympic National Forest, together comprising 89% of the watershed area. The remaining watershed is zoned for privately held forests (3,725 acres), rural residential land use (1,414 acres) and parks (134 acres). There is no commercial or industrial-zoned land in the Duckabush Subbasin. The predominant residential zoning is one residence per five acres (Hood Canal Coordinating Council, 2001).

3.2.3 Hamma Hamma River Sub-Basin

The Hamma Hamma River basin has only 17.8 miles of mainstem, but extensive tributary drainage of over 74.1 miles. The Hamma Hamma watershed is about 85 square miles. Several alpine lakes are found in the highest reaches of the Hamma Hamma drainage. The average annual gaged flow at is 366 cfs. Jefferson Creek flows into the Hamma Hamma immediately downstream of the mainstem USGS gage and contributes an additional average annual gaged flow of 154 cfs for a total average annual gaged flow on the Hamma Hamma system of 520 cfs.

Ninety-five percent of the watershed is in public ownership. Sixty percent of the watershed lies within the Olympic National Forest and 34% lies within the Olympic National Park or wilderness areas. Five percent of the watershed is privately owned with some agriculture and residences in the lower 1.5 miles of the subbasin (Hood Canal Coordinating Council, 2001).

3.2.4 Lilliwaup Creek Sub-basin

The Lilliwaup Creek watershed is about 17.9 square miles with 6.9 miles of mainstem and 10.8 miles of tributary habitat. It originates in extensive wetlands associated with Price Lake in the Upper Lilliwaup Valley. From there it flows through high gradient habitat, down an impassable falls at RM 0.7, through a well-developed floodplain to the estuary and Hood Canal at the locality of Lilliwaup. Eighty-nine percent of the watershed is in public forest, seven percent is in private forest and two percent is residential (Hood Canal Coordinating Council, 2001). There are no USGS stream gaging data for this basin.

3.2.5 Skokomish River Basin

The Skokomish River drains approximately 240 square miles of the eastern slopes of the Olympic Mountains to Annas Bay in southern Hood Canal and has the largest flow in the map area. With 80 miles of mainstem and over 260 miles of tributaries, it discharges more freshwater into Hood Canal than the combined flow of all the other streams in this part of Mason County. The mainstem flows range from 200 cfs upwards to 20,000 cfs. The Skokomish estuary and intertidal delta are the largest in the Hood Canal Basin.

The Skokomish River basin is comprised of 4 subbasins: South Fork Skokomish, Cushman, North Fork Skokomish, and the Lower Skokomish Subbasins.

3.2.5.1 South Fork Skokomish Sub-basin

The South Fork Skokomish Subbasin has an area of 104 square miles and contributes the majority of flow in the main stem of the Skokomish River. The average annual gaged flow at is 757 cfs. The South Fork originates in the Olympic National Park, flows through public and private commercial forest. Logging is the primary land use in the subbasin. The US Forest Service manages about 80% of the subbasin. Simpson Timber Company owns approximately 13% of the watershed area. Other landowners include the National Park Service and individuals. Approximately 60% of the watershed has been logged since the late 1920's. Currently, about 40 % of the watershed is either virgin timber or alpine vegetation.

Public works include the state operated Eells Springs Hatchery, the County maintained Skokomish Valley and Eells Hill Roads, three bridges, and PUD power lines. Landslides on Eels Hill have interrupted water supplies for the hatchery and segments of the Skokomish Valley road are periodically flooded.

3.2.5.2 Cushman and North Fork Skokomish Sub-basins

Cushman Dam No. 1 divides the watershed of the North Fork of the Skokomish River into the upper Cushman and lower North Fork Subbasins. The North Fork originates in the Olympic National Park and has an average annual gaged flow Staircase Rapids of 515 cfs.

Streamflow in the 33.3-mile long North Fork Skokomish River has been regulated at Cushman Dam since 1925. Cushman Dam forms the 4,000-acre Lake Cushman Reservoir, with an active storage capacity of 453,000 acre-feet. Lower Cushman Dam impounds 70 acres to from Lake Kokanee, with a capacity of 8,000 acre-feet. The shores of Lake Cushman have some residential development. Most of the water flowing out of the reservoirs is directed through a spillway to the City of Tacoma power generating facility which then discharges directly to Hood Canal; with 30 cfs continuing down the stream channel (historic natural peak streamflow were 700 cfs). Other than the 30 cfs, and except on rare occasions when flow is spilled or released from the dam, the only water in the lower North Fork Skokomish River channel is from drainage of adjacent slopes.

Immediately before the confluence with the mainstem of the Skokomish River, the North Fork has an average annual gaged flow of 115 cfs including the relatively constant 30 cfs release from Cushman Dam No. 2.

3.2.5.3 Lower Skokomish Sub-basin

The North and South Fork join to form the mainstem at RM 8, which flows through a wide alluvial valley and along the south side of the Skokomish Indian Reservation to the estuary/delta. The Skokomish Indian Reservation is located at the mouth of the basin and contains low-density residential areas. The wide valley of the Lower Skokomish sub-basin is the primary area of agricultural and residential land in the basin. The streams and springs in the lower valley contribute to several large wetland areas which then drain to the mainstem of the Skokomish River mostly downstream of Highway 101 at river mile 5.3. The annual average gaged flow near the mouth of the river is 1,224 cfs.

Commercial and noncommercial agricultural activities occur in the lower river valley and include cattle and other livestock, hay and Christmas tree production, and some vegetable production. The Annas Bay estuary contains rich shellfish resources. Recreational shellfish beds are located within and to the south of Potlatch State Park.

3.2.6 North Mason Sub-basin

The North Mason Subbasin is located on the south shore of Hood Canal. Drainage occurs by numerous small creeks and there are no major surface water drainages. Residential development is occurring along the length of the coast with a concentration around the Town of Union at the west end of the subbasin.

3.3 Climate

Cool, wet winters and dry summers characterize the watershed. Ranging from in latitude from approximately 47° 15′ north to 47° 50′ north, temperature is moderated by the marine influence of the Pacific Ocean and primarily determined by elevation. The Olympic Mountains that range up to 7,000 feet above sea level have a strong influence on precipitation patterns.

The spatial distribution of average precipitation and temperature is characterized using the PRISM model. The PRISM model uses point data and a digital elevation model (DEM) to generate gridded estimates of climate parameters (Daly and others, 1994). PRISM was written by meteorologists specifically to address climate and is well suited to reflect the effects of terrain on climate, which is significant in the Skokomish Basin. This study uses PRISM to estimate mean annual, mean monthly and event-based precipitation, temperature, and other variables. The model grid resolution is 4-km square. The outputs used in this study are re-sampled to 2-km resolution using mathematical filtering procedures (Daly and others, 1994).

The PRISM precipitation data are considered to be of high quality due to the vast amount of data used in the analysis and the high degree of peer review, which the product has received since it was published.

There are several National Oceanic and Atmospheric Administration (NOAA) Cooperative meteorological stations in and around WRIA 16 that can aid in understanding precipitation variations across the region (Figure 3.1 and Table 3-3). In analyzing, climatic data and its relation to streamflow data, the NOAA meteorological station based in Shelton, Washington was used. This station was selected because it had a length of record greater than 50 years and because its location provided data analysis overlap with the WRIA 14 Level 1 Assessment. To augment the data from the NOAA stations outputs from the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) were used to represent precipitation data for the basin.

In assessing watersheds, quantifying the amount and variability of precipitation is of utmost importance because it supplies inputs for groundwater recharge and stream flows. Precipitation varies both temporally and spatially. This variability is complicated by multiple factors such as seasonal variation, dry versus wet years, and cool versus warm periods. El Nino/La Nina occur in one- to three-year cycles with cool dryer and warm wetter years respectively. The Pacific Decadal Oscillations are typically expressed on a 20-30 year cycle. Recognized PDO periods in the recent record of the Pacific Northwest are approximately as follows:

Recent Pacific Decadal Oscillation Periods

Drier than average	Wetter than average
	Post-1995
1974-1995	
	1947-1974
1920-1947	
	Pre-1920

Global warming is broadly accepted in the scientific community as an on-going phenomenon. Regardless of whether the cause of global warming is natural or induced by human activities, statistically significant increases in global temperatures have been recorded in the past century and all indications are that this trend will continue. The result of increased global temperatures will be reduced storage in snow packs. For streams that are currently affected by snow pack melt, some runoff will be shifted from early summer spring runoff toward the rainy season and, lower flows will result during the late summer.

3.3.1 Precipitation

Precipitation variability across WRIA 16 is primarily a function of topographic influences from the Olympic Mountains (Figures 3.1 and 3.2; Table 3-2). The typical climatic cycle is recognized by a dry season May through August, followed by a rainy season that reaches its peak in November, December, and January. Average annual precipitation ranges 70 inches in the northeast corner of the basin to over 300 inches at the headwaters of the Skokomish River (Figure 3.1). Almost 90% of the precipitation falls between mid-September and May 1, while July is typically the driest month. Frequent long duration storms (12-72 hours) of low to moderate intensity (0.2 –0.5 inches per hour) occur form mid-September to April. Maximum 24-hour precipitation totaling 7 inches has the probability of occurring every 5 years in the Skokomish Basin (Stoddard and Park, 1995).

Snow generally accumulates above the 2,500-foot elevation and snow pack persists above this elevation through late spring (Harr, 1981). Snow and rain are common between 1,000 and 2,500 feet. At this intermediate elevation shallow snowpack (less than 15 inches deep) accumulate and melt quickly several times each winter (Harr et. al 1981). Snow is uncommon in most years below the 1,000-foot elevation.

3.3.2 Temperature

Temperatures range from an average low of 35 degrees Fahrenheit in January to an average high of 61 °F) in August (PRISM; Table 3-4). From east to west across the WRIA, temperatures vary by 4 to 5 degrees each month between lower temperatures in the more mountainous upper catchments to the warmer temperatures of the coastal catchments. Temperatures vary widely among sub-basins, varying as much as 7 to 9°F between the Duckabush River sub-basin in the north portion of the WRIA and the North Mason sub-basin in the southeastern portion of this assessment. The Skokomish-Dosewallips watershed has an annual average of 46 °F.

3.4 Geology

In the upper most headwaters, bedrock consists of bedded marine slates, argillites and sandstones. Continental glaciation extending from the mountains in British Columbia overran the lower basin and deposited unstable sediments on hill slopes. Where glacial sediments are deposited in valley bottoms, soils are deep. On steep hill slopes, however, soils are typically less than 3 feet in depth.

3.5 Population

The distribution of population is characterized in this report for the purposes of estimating current and future water use (Figure 3.3). Population data were obtained from the US Census Bureau for the 1990 and 2000 census and was distributed by census block. Census blocks are defined by the Census Bureau and are usually bounded on all sides by visible features such as streets, roads, streams, and railroad tracks, and by invisible boundaries such as city, town, township, and county limits, and short imaginary extensions of streets and roads.

The population data was descretized by subbasin. Where census blocks straddle subbasin boundaries, the population of the census block was distributed between the subbasins proportional to the area of the census block in each subbasin. This assumes the population to be evenly distributed within the block. In actuality, this may not be the case. However, the error is considered acceptable for the purposes of this study given the size of the population being examined.

The overall population of the WRIA including the North Mason sub-basin was 7,746 in 2000. The majority of the population resides in rural, unincorporated areas. Hoodsport, Lilliwaup, and Brinnon are the major population centers on the coast. The southern end of the basin contains 68% of the population (Lilliwaup, Lower Skokomish River, and North Mason Sub-basins).

Current population was evaluated from 2000 US census bureau data and compared to 1990 census data (Table 3-5). The basin's population, including the North Mason Sub-basin, increased by 1,505 people from 1990 to 2000. The largest population growth rates occurred in the North Mason, Lower Skokomish, and Lower North Fork Skokomish Sub-basins (Figure 3.4). Population decreases occurred in the Hamma Hamma River Subbasin and the South Fork Skokomish sub-basin. The greatest change in population density occurred in sub-areas on the shore of the Hood Canal.

Projected growth in the watershed was assumed to continue at the current growth rates observed from 1990 to 2000. Projected yearly growth rates are presented in Table 3-6. If growth from the period 1990-2000 continues at the same rate until 2010, the 2010 population of the basin will be 9,612 people.

4. THE HYDROLOGIC CYCLE

The hydrologic cycle forms the technical basis for watershed planning. At the watershed scale, the hydrologic cycle focuses in on the land-based hydrologic system that is bounded by surface water divides.

A watershed must be viewed as a combination of both the surface drainage area and the subsurface soils and rocks that underlie the watershed (Figure 4.1). A good understanding of the hydrologic cycle at the watershed scale involves an inventory of the water inputs, outputs and storage within the watershed. Knowledge of the dynamic processes of a watershed hydrologic cycle provides an understanding of what effects various resource management approaches will have on the natural system.

In order to inventory and ultimately model a watershed, it is useful to also represent the hydrologic cycle as a systems diagram. Figure 4.2 illustrates the systems approach to the basin scale hydrologic cycle and differentiates between those terms that involve rates of movement (hexagonal boxes) and those that involve storage (rectangular boxes).

The hydrologic cycle, illustrated in Figures 4.1 and 4.2, is a network of inflows and outflows that may be expressed as a water balance or water budget by equating the primary variables (input, output and change in storage):

$$\text{Input} = \text{Output} +/- \text{Change In Storage}$$

This equation is a conservative statement that assures that all the water within the watershed is accounted for and that water cannot be lost or gained.

The main input to the hydrologic system is precipitation, in the form of rainfall and snowmelt. The amount of precipitation is the primary control on the amount of water that may be available within the watershed. Secondary inflows to the hydrologic system include groundwater recharge and surface water recharge into the watershed.

Outflow from a watershed occurs naturally as streamflow or runoff, groundwater discharge and as evapotranspiration. Evapotranspiration is the combination of evaporation from open bodies of water, evaporation from soil surfaces and transpiration from the soil by plants. Outflow from a watershed also occurs as a result of human consumption and redirection of flows

Movement of water within a watershed occurs naturally through a number of processes. Overland flow delivers precipitation to stream channels. Infiltration results in movement of water at the land surface downward into the subsurface. Groundwater flow results in movement of water within the subsurface. Baseflow delivers groundwater to stream channels. Streamflow or surface water flow results in movement of water within stream channels. The nature of the land surface and subsurface determines infiltration and groundwater flow rates. Infiltration rates and groundwater flow rates, in turn, influence the timing and spatial distribution of surface water flows. Groundwater flows and surface water flows are linked by the relationships between infiltration, groundwater recharge, baseflow and streamflow generation.

Movement and outflow/inflow of water within a watershed is also impacted by a number of human factors including groundwater pumping, extraction of surface water, stormwater generation and discharge, wastewater generation and discharge, and agricultural and land use practices.

The hydrologic cycle at a watershed scale is most commonly analyzed on an annual basis over the water year, defined as October 1 through September 30 (i.e., the beginning of autumn through to the end of summer). Successive years are compared so that changes in the water budget (and its components) can be assessed. The primary variables are affected by seasonal, interannual, interdecadal and decadal variability (e.g.: dry versus wet years; El Nino / El Nina; and, Pacific Decadal Oscillations, respectively).

4.1 Principal Drivers of the Hydrologic Cycle in Skokomish Dosewallips

The hydrologic cycle in the Skokomish Dosewallips watershed is primarily driven by the natural variability of precipitation and local geology. Anthropogenic impacts such as dams and human water use have more localized impacts.

4.1.1 Precipitation

Moisture laden clouds coming off the Pacific Ocean precipitate as they are lifted over the Olympic Mountains producing a rain shadow on the lee (east) side of the mountains. The climate becomes drier as one moves north along Hood Canal. Local precipitation quantities are greatly influenced by local topographic features. Precipitation ranges from 60 inches per year to 250 inches per year at the headwaters of the Skokomish River.

The majority of precipitation falls during the winter months. Much of this precipitation falls as rain in the southern and eastern lowlands of the basin, whereas winter precipitation collects in snow pack and supports spring streamflows in the central higher elevation portion of the basin.

4.1.2 Geology

Approximately 35 million years ago, marine clastic rocks and sediments that would form the future Olympic Mountains were submerged beneath the Pacific Ocean that lapped up against the Cascade foothills. Basalt lavas erupted over the surface of these sediments. This assemblage of sediment and rocks were then scrunched up into the Olympic Mountains. These sedimentary and marine rocks now form the heart of the Olympic Mountains, ringed by the basalt (Figure 4.3). The dominance of these rock types in the Skokomish Basin cause runoff to occur quickly and restricts the active groundwater regime to shallow depths.

Alluvial sediments were deposited by weathering along the river valleys and on the low lands by glaciation. These loose unconsolidated sediments are the primary aquifer used in the basin.

4.1.3 Groundwater

Although groundwater is a significant source of water available to sustain summer river flows, groundwater storage in bedrock-dominated catchments is limited. Lake Cushman and Lower Lake Cushman do provide steady flow to the Skokomish River; but the volume of stored water in natural lakes in the watershed changes little during the summer providing little in the way of summer flows (Richardson, 1974).

Ground water contributions differ considerably in response to local geologic and hydrologic conditions but tend to be greatest in the lower reaches of most streams. Because low flows are largely sustained by ground-water discharge, the summertime ground-water levels are of critical importance in maintaining those flows. Many of the other streams in the area do not receive enough ground water to sustain their flow, especially in their upper reaches, and usually go dry in the summer.

5. STREAMFLOW CHARACTERIZATION

High elevation snow fields in the Olympic Mountains, direct precipitation, and groundwater inflow all contribute to stream flows in the Skokomish-Dosewallips watershed. In addition to directly contributing to stream flow, those sources also contribute to storage in lakes and groundwater aquifers, which serve as natural reservoirs helping to moderate extreme high and extreme low flows. There are extreme variations in elevation, precipitation and geology that differentiate river responses in each sub-basin. This section describes available streamflow data in the Skokomish-Dosewallips watershed, river basin characteristics, exceedance probabilities of flows and minimum instream flows.

5.1 Available Data

A review of available flow data from USGS gauging stations within the WRIA was conducted. A total of 22 flow gauging stations within the WRIA were documented as having historical flow data. There is abundant streamflow gaging in the Skokomish River basin while the amount of gaging in other river basins is variable (Tables 5-1 and 5-2; Figure 5.1). As land use in the area intensifies, more data on all aspects of the water resources will be needed for assessing the influences of changing land use on the area's lakes and streams.

5.2 River Basin Characteristics

The principal drainages in the basin are the Dosewallips, Duckabush, Hamma Hamma and Skokomish, with many smaller streams draining areas along Hood Canal. The Skokomish River carries larger flows than other rivers in the watershed primarily due to heavy winter precipitation in the basin, in addition to it being a larger basin. The South Fork Skokomish River contributes most of the flow of the Skokomish River due to regulation on the North Fork Skokomish River. The Cushman Dams, which diverts water to a powerhouse on Hood Canal, have regulated streamflow in the North Skokomish River since 1925.

Peak runoff occurs during the winter and/or during spring months depending on the elevation of the basin, climatic conditions, and degree of snowpack influence. Generally rivers originating from higher elevation areas in the northern and western portions of the basin are more visibly affected by snowpack while rivers originating in lower elevations are less affected by snow melt. The Dosewallips, Duckabush, Hamma Hamma, and North Fork Skokomish Rivers generally reach a peak flow during December or January depending on rainfall levels, and then reach a second peak flow period during the May or June spring melt freshet that can equal or exceed peak winter flows.

The South Fork Skokomish River and smaller rivers, such as Jefferson Creek show a similar winter peak period, with flows peaking in December or February corresponding to the peak in precipitation patterns, but do not exhibit a distinct spring freshet peak flow. As precipitation and snowmelt subside in late spring and early summer, stream flow levels begin to fall for the entire basin so that by August or September streams have usually reached their lowest levels. Stream flows increase as precipitation increases in the fall, usually by October.

Sustained spring runoff does not occur in many of the smaller, low elevation stream basins close to Hood Canal due to a lack of significant seasonal snowpack. Monthly variations in discharge are representative of short-term precipitation (Richardson, 1974).

Annual flows for USGS gages with more than 10 years of record are displayed in Figure 5.2 to 5.4. A total yearly flow volume plot can be useful in visualizing or calculating if there has been a change in streamflow levels over the long term. No significant trends in annual streamflow levels are apparent in these figures.

5.3 Frequency Analysis

Exceedance probability plots are used to present how often, or how probable, it is that that a certain flow will be equaled or exceeded in a specified time frame. Frequency analysis techniques were primarily developed by civil engineers needing to determine design criteria for hydrologic structures, particularly during hydrologic extremes (e.g. floods and droughts). The analysis is dependant on the length of the period of record and the range of flows seen within that period. Therefore, the validity of results generally increases with the length of the record and the range of possible flows that are collected.

Frequency analysis was performed on USGS gauging stations with a period of record of a minimum of 10 years. Twelve USGS flow gauges located in WRIA 16 had at least 10 years of flow data and are include:

- USGS no. 12053000 Dosewallips R. near Brinnon
- USGS no. 12054000 Duckabush R. near Brinnon, WA
- USGS no. 12054500 Hamma Hamma R. near Eldon
- USGS no. 12054600 Jefferson Creek near Eldon, WA
- USGS no. 12056500 N. Fork Skokomish below Staircase
- USGS no. 12057500 N. Fork Skokomish R. near Hoodsport
- USGS no. 12058000 Deer Meadow Cr. Near Hoodsport
- USGS no. 12058800N. Fork Skokomish R. below Cushman Dam
- USGS no. 12060000 S. Fork Skokomish R. near Potlatch
- USGS no. 12060500 S. Fork Skokomish R. near Union, WA
- USGS no. 12061500 Skokomish R. near Potlatch, WA

Exceedance curves for 10%, 50%, and 90% probabilities were computed for 7-day average flows using the entire period of record available at each gage (Figures 5.5 to 5.15). A frequency probability plot is not a hydrograph. For example, the occurrence of a 90% exceedance flow of 200 cfs from January 1-7 does not imply that the following 7-day period will be at the 90% exceedance flow. Therefore, frequency analysis is useful in setting design criteria and understanding the range of flows, but less useful for deciding how to respond to specific hydrologic conditions.

Flows in catchments with significant snowpack influence display a "double hump" in the exceedance data (Figures 5.5 through 5.8). Such a response reflects a river system responding to early winter rainfall, mid-winter snow accumulation, and spring snowmelt.

Flows in catchments at lower elevations without a dominant snowpack effect display a single hump in the exceedance curves (Figure 5.9 to 5.15). Although snow does accumulate in the mountains to the west and supports late season flow, the combined effect of portions of the subbasin dominated by snow pack and no snowpack results in a single flow peak in the winter rather than the fall and spring.

The North Fork Skokomish River below Cushman Dam, displays regulated flow leaving the dam (Figure 5.16). Variations in flow are due to occasional spills or releases of water from the dam.

Proposed minimum instream flow levels are plotted on Figures 5.5 through 5.15 for streams for which they have been developed, and are discussed in Section 7.5.

6. WATER BALANCE

The hydrologic cycle forms the technical basis for watershed planning. The traditional method for expressing the hydrologic cycle is through a water balance of the primary elements of the hydrologic cycle. The conventional physical water balance for watershed assessments considers the proportioning of water among the components of precipitation, evapotranspiration, runoff and storage (often represented by groundwater). It is this approach that is presented in this chapter.

Other types of water balances may be considered. Within a quantified limit of water availability, water may be apportioned among various uses including consumptive and non-consumptive out of stream uses, and environmental and instream flow uses. A water balance of out of stream uses can also be prepared in which the timing of diversions/withdrawals and returns, consumptive uses, and wastewater streams are analyzed.

6.1 Physical Water Balance

A good understanding of the hydrologic cycle at the watershed scale involves an inventory of the water inputs, outputs and storage within the watershed - a water balance (Figure 4.1). The physical water balance expresses the primary variables (input, output and change in storage) of the hydrologic cycle through a simple relationship:

$$\text{Input} = \text{Output} +/- \text{Change In Storage}$$

This equation is a conservation of mass statement that assures that all the water within the watershed is accounted for and that water cannot be lost or gained.

The hydrologic cycle's distribution of components and timing of water movement can be altered by human impacts. Water storage and transport affect the timing of surface water movement through the system in both the stream flow, evaporative and groundwater phases. Changes in land use and land cover alter infiltration, evaporation, transpiration and run-off rates.

The Skokomish-Dosewallips watershed is a not one single hydraulically closed system, but the composite of nine subbasins. This study analyzes the nine sub-basins, separated into both mountainous and coastal catchments. All water in the system originates from precipitation that falls in the watershed as rain or snow.

Surface water flow/stream flow in the watershed has historically been monitored by the USGS. However, gauging data are not available at all the discharge points of the sub-basins and then only for limited or discrete periods of time. The available data indicate that two distinct flow regimes are evident in the WRIA and can be divided between the upper (snowpack dominated) and lower (rainfall dominated) basins. The flows in streams with their headwaters in the mountains, the upper basins, have a flow regime with two high points; one peak results from snowmelt while the other results from direct precipitation. The lower basin flow regimes have only a single peak. To model the watershed effectively two basins representative of the upper and lower basins were selected from the historically gauged basins to be applied to all the basins of the WRIA.

As a result of the watershed's geology, climate and the inadequacy of surface water data, the water balance of WRIA 16 presents some unique challenges and the traditional method of calculating a water balance will require modification.

A water balance's units are, by convention, inches and acre-feet. Values expressed in inches are typically used to compare the relative magnitude of the components of the water balance within a sub-area. Values expressed in acre-feet are typically used to compare the relative magnitude of the components of the water balance between sub-areas. This is an important distinction. An inch of water in a large sub-area represents more water than an inch of water in a small sub-area.

6.2 Water Balance Methodology

Given the diversity of terrain in the Skokomish Basin, an empirical approach was taken to developing a water balance using average precipitation and gaged streamflow data. Annual evapotranspiration is calculated by subtracting streamflow from precipitation (Table 6-1). Precipitation data is obtained from PRISM (Figures 3.1 and 3.2). Stream gaging data is obtained from the USGS and is only available for less than the complete watershed (Figure 6.1). Data for only seven catchments were considered valid for evaluation (i.e., at least 10 years of stream gaging data; Table 6-1). These were further divided into catchments that are dominated by snowpack (upper basins) and rainfall (lower catchments).

The resulting estimates of evapotranspiration (ET) indicated a range of reliability in the data. Typical ET for this part of Washington State is on the order of 10-12 inches per year (US Weather Bureau, 1962). The stream gaging period of record for the Hamma Hamma catchment is dominated by a wet climate period (Table 5-2) and therefore results in an anomalously low ET estimate when average PRISM precipitation data is used. Values on the Skokomish River system are all considered to be affected by the Cushman dams.

Therefore only the estimated ET of the Duckabush catchment is considered representative. Annual ET to other basins was extrapolated to all other basins proportional the ET calculated using the Thornthwaite method. The annual distribution of ET within each basin was distributed proportional to monthly Thornthwaite values (Table 6-2).

Annual streamflow for each area was calculated by subtracting annual ET from precipitation. Annual streamflow was distributed across the months using the average monthly distribution in the Jefferson catchment for rainfall-dominated areas, and the Duckabush catchment for snowpack dominated areas (Table 6-3). The resulting water balance for each subbasin is tabulated in Table 6-4 and presented in Figures 6.2 through 6.9. The water balance for the North Mason Subbasin is taken from the Level 1 Assessment for WRIA 14.

6.3 Groundwater

This water balance approach assumes that groundwater discharge from the basin is negligible relative to the other water balance components. Groundwater discharge out of the basin to marine waters along the shore of Hood Canal is estimated using Darcy's Law and representative values for: hydraulic conductivity; seepage front thickness; and hydraulic gradient:

$$Q = KiA$$

Where:

- Q is the groundwater discharge (ft^3/d);
- K is the hydraulic conductivity (ft/d);
- i is the hydraulic gradient (ft/ft); and
- A is the cross-sectional area (ft^2).

Reasonable values for the conditions on the west side of Hood Canal were used as inputs to Darcy's Law. The values used were based on literature review, area conditions, and professional judgment. The sensitivity of the seepage estimate was evaluated by varying the input parameters. The input parameters used for the seepage estimate are summarized as follows:

- A value of 5 ft/d (2×10^{-3} cm/s) was used. This value is typical for a sand or silty sand (Freeze and Cherry 1979);
- The hydraulic gradient was assumed to be equal to the topographic gradient. A value of 0.25 ft/ft was used to approximate the average topographic gradient; and,
- The area through which seepage occurs, or seepage face, was estimated to be 20 feet high. A unit width was used to make the initial calculation. The length of WRIA 14 along the west side of Hood Canal, from the southern boundary of the Lower Skokomish subbasin to the northern boundary of the Dosewallips subbasin, was measured using USGS 7.5-minute topographic maps. This length was multiplied by the seepage face to determine the cross sectional area.

Using these input parameters, the average annual groundwater seepage to Hood Canal was estimated to be 42 cfs. The seepage from the individual subbasins to Hood Canal is summarized as follows:

Subbasin	Percent of Shoreline along Hood Canal	Seepage to Hood Canal (cfs)
Lower Dosewallips	11	4.6
Lower Duckabush	7	3.1
Hamma Hamma	32	13.7
Lilliwaup	35	14.7
Lower Skokomish	15	6.2
Total	**100**	**42**

This compares to a total average annual streamflow in the basin of approximately 4,100 cfs, or approximately 1% of the total annual streamflow. Groundwater discharge to streams as baseflow is implicitly accounted for by stream gaging data. Typically, the acceptable accuracy of stream gaging is within 5%. Therefore not addressing groundwater discharge to Hood Canal in the water balance is acceptable because it is within the level of accuracy of the data.

The sensitivity of the estimated seepage rate to the input parameters was evaluated by varying one of the input parameters, while holding the others constant. The results are summarized as follows:

Parameter	Change	Result	Total Seepage to Hood Canal (cfs)
Hydraulic Conductivity	Increase 1 order of magnitude to 50 ft/d	Increase seepage by 1 order of magnitude	422
	Decrease 1 order of magnitude to 0.5 ft/d	Decrease seepage by 1 order of magnitude	4.2
Hydraulic Gradient or Seepage Face	Double Parameter	Double seepage	84
	Half Parameter	Half seepage	21

The Lower Skokomish subbasin is dominated by the Skokomish River delta. Therefore, the hydraulic gradient may be lower than estimated and the seepage face may be smaller than estimated. However, the hydraulic conductivity may be higher than estimated, balancing the lower gradient and smaller seepage face.

The applied water balance methodology provides a limited characterization of groundwater flows. Because groundwater is anticipated to be the primary source of future water supply, a more detailed evaluation in specific geographic areas may be appropriate in the Level 2 Assessment.

7. WATER RIGHTS

This chapter provides an assessment of the degree of allocation of water in the Skokomish Basin estimated from claims and administratively issued water rights. Ecology maintains a database to track and store water rights information, called the Water Rights Application Tracking System (WRATS) database. An abbreviated version of the WRATS database, called "WRATS On a Bun," or WOB, that is current as of August 2001 was used for the assessment of allocation in the Skokomish Basin. Although the WOB database was used in the analysis presented in this report, the term WRATS database is used because it is more commonly recognized and understood reference. The actual WRATS database was not used in this report. Finally, instream flow regulations are reviewed.

7.1 Water Rights in Washington

Administrative water rights issued by Ecology have existed in Washington State since 1917 for surface water and 1945 for groundwater. These take the form of permits and certificates and are collectively referred to as administratively issued water rights. Legal water use since these dates requires application to, and approval from, Ecology. Water rights are valid only as long as they are used, and except under specific conditions, cease to exist if they are not used for a continuous period of five years (i.e., they are relinquished). A description of claims is presented below because of the uncertainty associated with the status of claims in the assessment of allocation.

Water use before 1917 (for surface water) or 1945 (for groundwater) is "grandfathered" in and establishes a water right, subject to conditions (e.g., the water must be applied to beneficial use, must not have been relinquished, etc.). Such rights are referred to as claims, and must have been registered with Ecology. Since the establishment of the surface and groundwater codes, there have been four claim registration periods. Claims for water use may have been registered multiple times resulting in duplicate, triplicate, or possibly quadruplicate records in Ecology's database for what is intended to be a single water right claim. Claims do not necessarily represent a valid water right, and Ecology does not have the authority to determine their validity.

Approximately 177,000 claims were filed statewide in the initial opening to the water right claims registry (July 1, 1969 through June 30, 1974) in response to Ch. 90.14.041 RCW. A list of the information that the claimant had to provide was specified in Ch. 90.14.041 RCW. In 1973, Ch. 90.14.041 RCW was amended to allow a less extensive list of information – a "short form" filing. The short form only requires inclusion of sufficient data to identify the claimant, source of water, purpose of use and legal description of the land upon which the water is used and is of limited evidentiary value in adjudications. With the amendment to RCW 90.14.051 in 1973, there are long forms (exclusively used prior to 1973, and selectively used after 1973) and short forms.

The intent was that short forms were supposed to be used only by those who were diverting water pursuant to Ch. 90.44.050 RCW (exempt wells), but that is not what happens in practice. The language of the statute is as follows: "Except, however, that any claim for diversion or withdrawal of surface or ground water for those uses described in the exemption from the permit requirements of Ch. 90.44.050 RCW may be filed on a short form to be provided by the department." This language is confusing because there is no exemption for the diversion of surface water under Ch. 90.44.050 RCW.

The second opening was from July 1, 1979 through December 31, 1979, and was created by Ch. 90.14.043 RCW. That section of the code was amended in 1985.

The third opening was July 1, 1985 through September 1, 1985. In those cases the claimant first had to petition the Pollution Control Hearings Board (PCHB) for a certificate and make a showing to the PCHB regarding their water use. A certification was issued by the Pollution Control Hearings Board if, upon petition to the board, it was shown to the satisfaction of the board that:

(a) Waters of the state have been applied to beneficial use continuously (with no period of nonuse exceeding five consecutive years) in the case of surface water beginning not later than June 7, 1917, and in the case of ground water beginning not later than June 7, 1945; or,

(b) Waters of the state have been applied to beneficial use continuously (with no period of nonuse exceeding five consecutive years) from the date of entry of a court decree confirming a water right and any failure to register a claim resulted from a reasonable misinterpretation of the requirements as they related to such court decreed rights.

If the claimant received a certificate from the Board, then Ecology accepted the filing of the claim and entered it into the claims registry.

The fourth opening was September 1, 1997 through June 30, 1998. These claims are commonly entered into the WRATS database without designation as to whether they are long or short form claims.

Each of the openings came with limitations and differences from the other claim openings and most of that information can only be gleamed by reading the various laws that created/limited the openings. For example, filings in the September 1, 1997 through June 30, 1998, opening have a water right priority date of as of the date the statement of claim is filed with Ecology – even though to be a valid claim the water use needed to start prior to 1917 for surface water and 1945 for ground water.

An adjudication must be conducted to determine the validity of claims, and to resolve conflicts between water rights holders. Adjudication is a court process that may be initiated by petition by a person claiming a right to water, by Ecology, or by planning units. There have been no adjudications in the Skokomish Basin.

Water rights may be established for instream flow values under the Water Resources Act of 1971 (Ch. 173-500 WAC). Regulated instream flow quantity is a water right with a corresponding priority date and period of use. The purpose of establishing such flows is typically for the maintenance and/or protection of aquatic biota/fish, although other values may also be considered, such as water quality and recreational uses. Water may also be reserved or set aside for future use. Ecology must initiate a review of such regulations whenever new information, changing conditions, or statutory modifications make it necessary. An Instream Resource Protection Program (IRPP) study was prepared for the Skokomish Basin. A draft instream flow rule was prepared (WAC 173-516) based on the IRPP study, however it was not formally adopted by the legislature.

No other forms of water rights are addressed in this chapter including, but not limited to, tribal and federally reserved rights. A groundwater right for the withdrawal of up to 5,000 gallons per day of groundwater for prescribed uses may be established without application to Ecology, and are referred to as "exempt wells." Exempt well use is addressed in the chapter assessing actual use.

7.2 Assessment of Allocation

This section describes water rights allocated by the Washington Department of Ecology (Ecology) in the Skokomish Basin and by sub-basins. The characterization of water rights was based on:

- Source type (groundwater or surface water);
- Document type (certificate, permit, claim, etc.);
- Purpose of use (irrigation, domestic, municipal, etc.); and,
- Subbasin.

The WRATS database was initially queried to exclude those documents listed in the database as relinquished, rejected, cancelled, or otherwise indicated in the database to not be valid. The extracted data were placed in a new database for further analysis. Certificates and permits make up about 37% of the total number of documents while claims (long form, short form, and claims without a designation) make up about 60% of the total documents (Table 7.1). The remaining documents are applications for new water rights (3%) or changes to existing rights (<1%).

7.2.1 Characterization by Purpose of Use

For each subbasin, the database was queried to extract the distribution of documents by purpose of use for both groundwater and surface water. The order of extraction was as follows:

- All documents including the "MU" (municipal) purpose of use;
- Remaining including the "IR" (irrigation) purpose of use;
- Remaining documents including the "D*" (domestic) purpose of use;
- Remaining documents with non-consumptive or rarely applied purposes of use (power, fish propagation, and fire).
- All other documents including all other purposes of use (commercial/industrial, recreation, stock, etc, including those not assigned a purpose of use); and

After each query, the records were removed from the database before applying the next query. In this way, water rights with multiple purposes of use will be accounted for only one purpose of use. Water rights for domestic purpose of use make up about 73% of the total number of records. The remaining consumptive uses consist of irrigation (22%), other uses (~2%) and municipal (~1%). This characterization is based solely on the number of records.

Non-consumptive or rarely used water rights comprise approximately 3 percent of all documents, and were not characterized following initial extraction from the database. Fire suppression, while a consumptive use of water, is considered to be non-consumptive in this analysis as water is rarely used for this purpose. The surface water diversions for non-consumptive use are summarized as follows:

- Six certificates for a total of 2,143 cfs, and two applications for a total of 3,200 cfs for power generation; and,
- 23 certificates for a total of 113 cfs, and two permits totaling 5 cfs, for fire suppression.

Groundwater withdrawals for non-consumptive use are summarized as follows:

- Four certificates and one permit for fire suppression, with a total Qi of 9,634 gpm.

Although called non-consumptive, these water rights have a varying effect on the hydrology of the watershed. Diversion of water for power generation can cause dewatering of bypassed reaches of the river. Withdrawals of water for fish hatchery facilities may locally augment streamflows, particularly during low flow periods.

7.2.2 Assignment of Annual Withdrawals and Diversions

Water rights are assigned with a variety of properties among which are an instantaneous withdrawal/diversion rate (Qi; in gallons per minute [gpm] for groundwater, and cubic feet per second [cfs] for surface water), and an annual withdrawal/diversion rate (Qa; acre feet per year for both surface and groundwater, respectively). (Groundwater is typically described with the term "withdrawal" while surface water is generally described with the term "diversion." The terms withdrawal and diversion may be used interchangeably in this report.) Assessment of allocation on a watershed scale is appropriately considered by examination of the annual permitted quantities, which may then be seasonally distributed.

The WRATS database includes instantaneous withdrawal rates (Qi) for almost all administratively issued rights (permits and certificates). Annual withdrawal rates (Qa) are defined for almost all administratively issued groundwater rights, but only a third of surface water rights (Table 7.2). For records that do not include Qa, the Qa is assigned to allow an assessment of allocation. The method of estimating assigned Qa is described below.

7.2.2.1 Assignment of Qa to Certificates and Permits

Certificates and permits for irrigation use typically contain information on irrigated acreage. For those certificates and permits without Qa but with irrigated acres, the Qa was estimated by multiplying the irrigated acres by a duty of 2 feet. The median duty for surface water irrigation certificates and permits is 2 feet, and the median duty for groundwater certificates and permits is 1.9 feet (Table 7.2). Therefore, a duty of 2 feet is considered representative.

For certificates and permits for all purposes of use that did not have a defined Qa or irrigated acres, a value was assigned based on the ratio of Qa/Qi within each purpose of use category listed above. Both median and mean values of Qa/Qi were evaluated (Table 7.2). Median values were considered more statistically representative because of the skewed distribution of data created by a few large water rights. The median Qa/Qi ratios calculated for groundwater and surface water are generally similar, but the median groundwater Qa/Qi ratio is considered most statistically representative due to the following reasons:

- Qa has been assigned to almost all (i.e., >98%) groundwater certificates and permits; and,
- About 60 to 70 percent of the surface water certificates and permits for the most common purposes of use (domestic and irrigation) do not have Qa assigned.

Therefore, the median groundwater Qa/Qi values for irrigation and domestic use were used in assigning Qa values to surface water certificates and permits and the small amount of groundwater certificates and permits for which Qa is not defined in the WRATS database.

7.2.2.2 Assignment of Qa to Claims

Long and short form claims generally do not contain complete information on Qa, Qi, or irrigated acres. Therefore, the Qa needs to be estimated to evaluate the claimed water allocation. New claims filed during the last claim registration period (September 1, 1997 through June 30, 1998) have Qa and Qi information.

Short form claims are generally equivalent to exempt well as defined in Ch. 90.44.050 RCW, such as for domestic water use and limited irrigation (i.e., less than 0.5 acre). Short form claims were assigned a Qa of 0.5 AF/yr, regardless of purpose of use, consistent with domestic, stock, and limited irrigation use.

Approximately 87% of long form claims included irrigated acreage information. For these claims, the Qa was estimated by multiplying the number of irrigated acres by a duty of 2 AF/acre.
Long form claims for irrigation use without a defined number of irrigated acres were assigned a Qa based on the median number of irrigated acres for groundwater or surface water certificates and a duty of 2 AF/acre. The median irrigated acres for groundwater certificates and permits is 4.5 acres. The median irrigated acres for surface water certificates and permits is 2 acres. Therefore, the Qa assigned to irrigation long form

claims without Qa or irrigated acres is 9 AF/yr for groundwater and 4 AF/yr for surface water.

There were no long form claims for municipal use. For domestic use, all of the long form claims have a purpose of use of general domestic. Several are for general domestic and stock use. For the remaining long form claims, the purpose of use includes stock, or no purpose of use is listed. A Qa of 2 AF/yr was assigned to all of these remaining long form claims.

7.3 Allocation by Subbasin

The WRATS database lists the location of water rights and claims by Township, Range, and Section (TRS). Sections and associated water rights and claims were assigned to subbasins based on the subbasin in which the centroid of the section was located. If the centroid of a particular section fell within the defined subbasin boundary, all water rights in that section were included in that subbasin regardless of whether portions of that section were located in other subbasins (Figure 7.1). It is therefore possible that some water rights that were located within a particular subbasin were assigned into a different subbasin as the centroid of that section was in the different subbasin.

A number of water rights and claims have a place of use that covers multiple sections. For these documents, the Qa was allocated between sections by dividing the total Qa by the number of sections.

7.4 Evaluation of Results

The following limitations must be considered when estimating the amount of water allocated:

- The WRATS database may not be complete or may contain erroneous entries;
- Some claims may have been repeatedly filed for the same water over several claim registration periods; and,
- Not all of the rights and claims used in the analysis may be valid to the estimated Qa.

Many claims are for water that was not put to use prior to the required 1917 and 1945 dates and are therefore invalid. No estimation of validity was made other than an initial screening of the documents listed in the WRATS database (see Section 7.2).

A total of approximately 16,000 AF/yr is estimated to be allocated in WRIA 16, with certificates and permits comprising about 60 percent of the allocation, and claims about 40 percent (Table 7-3). The subbasins with the highest proportion of annual estimated volumes in claims is the Lower Skokomish and Duckabush with approximately 70% of the estimated allocated volume in claims. The North Fork Skokomish has the next highest proportion of claims (47%) and all other subbasins have less than 30% of the estimated volume of allocation in the form of claims.

Surface water allocations comprise approximately 44% of the allocated water in WRIA 16 of which approximately 70% are in certificates and permits, and the remainder is claims (Table 7-3). Allocated water is distributed primarily along the coast of Hood Canal, along Cushman Lake (Figure 7.2). The highest concentrations occur in the Lower Skokomish and Lilliwaup Subbasins.

Groundwater comprises a slight majority of the total allocation in the Skokomish Basin (56%) and is approximately equally split between administratively issued water rights (certificates and permits) and claims. The distribution of groundwater rights is similar to that for surface water (Figure 7.3).

Irrigation use accounts for about half of the allocated water (Table 7-4). Combined domestic and municipal use accounts for slightly less than half (46%) of the total allocation. Water allocations for domestic and municipal use are highest in the most developed sub-areas such as the Lilliwaup and North Mason Subbasins.

Figure 7.4 shows applications for new water rights and change applications summarized by sub-area in Tables 7-3 and 7-4. Note that there are two applications for surface water for municipal and commercial-industrial use for 2,720 cfs (5,440 cfs total). It is uncertain if there is a duplication error in the listed Qi in the WRATS database. The applications are located in T22N/R4W-26, in the Mason Subbasin.

In summary:

- Groundwater accounts for about 56% of the allocated water in WRIA 16;
- Combined domestic and municipal purpose of use accounts for about 46% of the allocated water;
- Irrigation use accounts for about 51% of the allocated water;
- Commercial-industrial and other uses account for about two percent of the allocated water; and,
- Water allocations are highest in the most heavily populated sub-areas, particularly along Hood Canal.

7.5 Water Right Applications

A listing of pending water right applications for new water rights as well as changes to existing water rights in April 2002 is provided in Table 7-5. Most of the water rights are for residential use (Purpose of Use= DS, DM, or MU). A few water rights are for irrigation (Purpose of Use = IR). There are two applications for power applications (Purpose of Use = PO), and a single application is for commercial industrial use (Purpose of Use = CI). There are eight applications for changes to existing water rights.

7.6 Administrative Status of Instream Flows

The administrative status of instream flows can be found in Skokomish-Dosewallips Instream Resources Protection Program (IRPP) report (Ecology, 1985) and is summarized here.

7.6.1 Current Status

Stream closures and low flow conditions have been established through water right actions of Ecology under the authority of RCW 75.20.050 (Fisheries Code) and in consultation with the Departments of Game and Fisheries. Of the streams inventories in WRIA 16, two have instream flow limitations:

- Waketickeh Creek, a tributary to the Hood Canal has a source limitation of low flow (0.60 cfs at a point 1150 feet east of center of Sec.23 T. 24 N. R 3 W. W. M)
- McTaggart Creek, a tributary to the North Fork of the Skokomish River has a source limitation at low flow (2.0 cfs at a point 500 feet west and 1,000 feet south of the N1/4 corner of Sec. 4, T. 7N., R 4 W.W.M.)

No streams are currently closed to additional consumptive appropriation.

7.6.2 Proposed Status

Proposed instream flow levels were developed using the results, recommendations and information contained in two Instream Flow Incremental Methodology (IFIM) studies. The first was completed by the Department of Fisheries (now Washington Department of Fish and Wildlife, WDFW). This study was completed in cooperation with Ecology, the Department of Game and the Point-No-Point Treaty Council, and included the Dosewallips, Duckabush, Hamma Hamma, Eagle, Finch, Fulton, John and Jorsted Rivers and Creeks. The U.S. Fish and Wildlife Service (USFWS) completed the second IFIM study for the North Fork, South Fork and mainstem Skokomish rivers.

The Cooperative Instream Flow Service Group of USFWS developed the IFIM technique used. It involved "the collection of discharge, stage, velocity, and depth measurements over a range of flows to develop a hydraulic model of the behavior of these parameters with changes in flow through typical channel sections." (Ecology, 1985.) The exact methodology and data used for this study are not explicitly stated, so it is not clear if they match techniques that are currently considered for IFIM evaluations.

Instream flows and partial closures were proposed on all 11 studied streams. The location of proposed control points designated to provide control of surface water appropriations are shown in Figure 7.5. Proposed status for streams and river is shown in the following table.

Name	Minimum Flows Proposed	Proposed Closure Period
Dosewallips	Yes	
Duckabush	Yes	
Hamma Hamma	Yes	
Eagle Creek	Yes	June 1 – December 31
Finch Creek	Yes	All Year
Fulton Creek	Yes	June 1 – December 31
John Creek	Yes	April 1 – December 31
Jorsted Creek	Yes	June 1 – December 31
North Fork Skokomish River	Yes	All Year
Purdy Creek	No	All Year
South Fork Skokomish River	Yes	
Skokomish River	Yes	

In addition many small stream closures were recommended due to their habitation by anadromous fish populations, and recreational and aesthetic values. The following streams were proposed to be closed for consumptive purposes from June 1 through December 31:

Clark Creek	Unnamed Creek 0010
Hill Creek	Unnamed Creek 0215
Hunter Creek	Unnamed Creek 0216
Lilliwaup Creek	Unnamed Creek 0217
Little Lilliwaup Creek	Unnamed Creek 0218
McDonald Creek	Unnamed Creek 0439
Miller Creek	Schaerer Creek
Pierce Creek	Sund Creek
Vance Creek	Waketickeh Creek

Proposed instream flow levels for 6 of the 11 streams are depicted Figures 5.5 through 5.15. Dosewallips, Duckabush and Hamma Hamma Rivers proposed instream flow levels are at approximately the 50% exceedance curve. On the North Fork Skokomish River water appears to be released from the Cushman Dam at or above the proposed instream flow levels. Proposed instream flow levels for the South Fork Skokomish and Skokomish Rivers are close to the 90% exceedance level for most of the year except in the late summer months when the proposed regulatory flows approach the 50% (Skokomish River) and 10% (South Fork Skokomish) exceedance levels.

Instream flows have been established in WRIA 14. There are no control points and minimum instream flows established in the North Mason Subbasin however, Alderbrook and Twanoh Creeks are closed to further consumptive appropriation for the period May 1-October 31.

8. ACTUAL WATER USE

Water use estimates for current and future conditions are a required element of watershed planning under Chapter 90.82 RCW. The types of water use that will be evaluated by category for WRIA 16 are as follows:

- Public water supplies (purveyor water use)
- Individual households (primarily exempt wells)
- Agricultural irrigation
- Hydropower
- Other uses

Some synthesis of the components of water use is necessary to understand water use. Watershed planning typically focuses on the water balance and the way that humans affect it through water use.

8.1 Background Issues

Background water use issues are a combination of regulatory and technical issues. Issues related to water use include:

- Water use can be consumptive or non-consumptive;
- The primary water use in the watershed is from individual households on public water supply systems or individual households on self-supplied systems;
- Many individual households are not on public water supply systems and use "exempt wells" as a water source. To better understand the effects of "exempt wells" on groundwater resources an estimation of their number, their spatial distribution, and the amount of water consumptively used needs to be understood;
- Another significant category of water use is irrigation; and,
- A major water use for power, which is typically considered as a non-consumptive use, occurs in this watershed, with the water diverted from the river basin, and discharged directly to Hood Canal

8.2 Objective and Level of Detail

The objective of this section is to estimate actual water use based on available data and provide the planning unit with a tool to determine the relative amount of water use in the watershed. The actual use estimate may help determine the level of water availability for future allocation. Current estimated water use in the watershed based on available data is aggregated according to the nine subbasins.

8.2.1 Purveyor Water Use

Purveyors are entities that provide water to the public and private sector and may include municipalities, water districts and private water systems. This report the term purveyor will include all drinking water systems recorded in Washington's Department of Health database and generally include all public water systems, which include municipalities, water districts and privately owned public water systems that provide domestic water to two or more services.

In general, purveyor water use is comprised of two components; a low consumptive use, "base use", component characterized by water that is returned to the hydrologic system through wastewater treatment plants and septic systems, and a high consumptive use, "peak use", component in the form of irrigation of landscaping and home gardens. Purveyor water use is typically expressed on a per capita basis and a peaking factor is commonly used to represent the increase in outdoor watering during the summer.

8.2.1.1 Base Use

The low-consumptive component is considered base use for the purpose of this discussion. Year-round base use is generally for interior use and therefore almost all the water is returned to the hydrologic system via a wastewater treatment plant or septic system. Base water use is usually fairly consistent throughout the year. Generally, water use during the non-growing season, October through March, can be a good indicator of base water use. However, in WRIA 16, discharge from wastewater treatment plants is to marine waters, therefore indoor use in sewered areas is effectively more consumptive than in non-sewered areas where at least a portion of the water soaks back into the ground through septic systems.

8.2.1.2 Peak Use

During the months of April through September, water use increases substantially. The increased water use is commonly discussed in terms of peaking factor. A typical peaking factor in the Puget Sound area is approximately two times the base, indoor per capita usage. These peak summer water uses above base water use are mostly assumed to be outdoor use, including lawn watering, car washing and other outdoor uses. Outdoor water use comprises a significant consumptive use of water in the form of being lost to evaporation, soil wetting and evapotranspiration.

8.2.1.3 Wastewater Return

Interior use is usually discharged to septic systems or wastewater treatment plants. Wastewater effluent is not considered in this Level 1 Assessment although an understanding of the relative contributions of wastewater facilities may be important in sub-areas selected for further assessment. Residences without public water service, and therefore on exempt wells, typically do not have sewer service and use septic systems. The return of wastewater from exempt wells to septic systems may offset a significant portion of potential impacts to shallow aquifers.

8.2.2 Exempt Well Water Use for Individual Households

Exempt wells are an important factor in watershed planning because the total number of wells and quantity of water they withdraw is not well known. Wells described as exempt wells are exempt from the requirement to obtain a water right from the Department of Ecology under Chapter 90.44 RCW.

Individual household water supplies from surface water sources are not exempt from the requirement to obtain a water right, and as such individual household surface water uses should be included in Department of Ecology water right/claims records.

Although exempt wells are allowed to use up to 5,000 gallons a day, which is equivalent to a maximum annual use of 5.6 AF/yr, individual household use usually is a much smaller annual amount.

Items affecting water use from exempt wells include:

- Population;
- Base water use;
- Peak water use;
- Net consumptive use; and,
- Return flows (commonly through septic systems).

The methods used to estimate the number of exempt wells and their quantity of water used typically assume that the population outside of the service areas of purveyors is served by exempt wells. Exempt well water use patterns typically are similar to public water supply systems. However, higher or lower use patterns are possible from exempt wells.

Variables contributing to higher water use from exempt wells include:

- Since exempt wells are not metered and therefore have no meter charges for water used, as there is for most water supplied from public water systems, there is less incentive to conserve water;
- Exempt wells occur in rural areas with some larger lot sizes. Therefore landscaping and garden use can be higher for the larger lots than in more developed areas; and,
- Exempt wells occur in rural areas that commonly have livestock that use water from these wells.

Variables contributing to lower water use from exempt wells include:

- Exempt wells may be installed in less productive aquifers which limit the volumes of water that can be withdrawn;
- Exempt wells may support homes in rural areas that do not have any landscape water needs; and,

- Some exempt wells provide water to vacation homes, with smaller lot sizes and/or less than continuous year-round usage.

8.2.3 Agricultural Irrigation Water Use

Agricultural Census and land zoning information from 1997 USDA data indicate that there is very little irrigated agriculture in the watershed. This data source reports the total number of irrigated acres by county.

Irrigated Acres in WRIA 16

County	Total Acres in County	Total Acres in WRIA 16	Total Irrig Acres in County	% Of County in WRIA 16	Irrig Acres in County in WRIA 16[a]
Jefferson	1,155,200	165,611	847	14	119
Mason	592,640	242,040	382	41	157
Total	1,747,840	407,651	1,229		276

[a] Assuming equal distribution of irrigated acres across the county.

Agricultural irrigated acreage in Jefferson County represents approximately only 0.07 % of the land area in the county. Irrigated acreage in Mason County is also minimal and also represents only approximately 0.06 % of the land area in the county.

The distribution of irrigated agricultural land within the two counties or within the WRIA cannot be determined with currently available data. The above estimation of irrigated acres in WRIA 16 assumes an equal distribution of irrigated acres across the counties. Due to the relatively small amount and the assumed diffuse distribution of acreage in irrigated agriculture, water use for agricultural irrigation will not be further characterized into individual sub-basins, nor will projected water use be estimated.

8.2.4 Hydropower Water Use

The City of Tacoma, Tacoma Public Utilities, operates the Cushman Hydro Project, which consists of Cushman Dams No. 1 and No. 2, on the North Fork of the Skokomish River. Cushman Powerhouse No. 1 is located downstream of Dam No. 1. Water is then diverted out of the North Fork basin downstream of Cushman Dam No. 2, into penstocks to power generating facilities at Cushman Powerhouse No. 2 located adjacent to Hood Canal. Dam No. 1 was completed in 1925 and Dam No. 2 was completed in 1930.

There are also some much smaller hydropower projects within this watershed, however due to the magnitude of these projects compared to the Cushman Hydro Project, they are not evaluated for water use during this phase of watershed planning.

8.3 Residential Use Methodology of Analysis

Residential water use is typically estimated using population data and per capita water use. The typical approach used is to start with total population represented by the most recent population data, which is the year 2000 census data. The portion of the population on public water systems (PWS) is estimated based on data provided by the Department of Health (DOH) for public water systems. A public water system is one DOH defines as any domestic water supply serving more than a single-family residence. The remaining population is then assumed to be on exempt wells. The following data sources were used:

- PWS GIS coverage from DOH;
- Number of connections per water system from DOH;
- 2000 US Census total population data; and,
- 2000 census number of residents per household by county.

8.3.1 GIS Treatment of Population

The number of people within each sub-basin served by public water systems was based on the Washington Department of Health's (DOH) Group A and B Public Water Systems and 2000 US Census data.

PWS point coordinates, representing sources for the systems, are the only spatial data contained in the DOH database. The locations of PWSs were represented by their sources. For water systems with multiple sources, all connections were attributed to the first source listed in the database. This methodology places the use of water at the same location as where it is diverted.

The total number of people on PWSs was determined from the DOH PWS data by summing the number of people being served by public water systems by sub-basin.

The typical method of determining an approximate number of people on exempt wells is to subtract each sub-basin's population served by purveyor systems from the population of the sub-basin. This is based on the general assumption that all persons not supplied by a purveyor are supplied by an exempt well.

8.3.2 Purveyor Residential Water Use

An average residential water use rate of 120 gallons per capita per day (gpdpc) was used in the June 1997 Jefferson County Coordinated Water System Plan for all public water supply systems in the County except for the City of Port Townsend. In the July 1996 PUD No. 1 of Jefferson County Water System Plan, 200 gallons per day per connection was used for the two developments that are in WRIA 16, Lazy C and Triton Cove. Each of these developments can be considered as at least partially seasonal use in nature, which would result in a lesser average daily water use. Using the average size household of 2.24 in Jefferson County (US 2000 census), this would equate to approximately 89 gallons per day per capita.

There are no similar plans or reports available for Mason County. Water use patterns for residential populations within WRIA 16 in Mason County can however be assumed for purposes of this assessment to be similar to those in Jefferson County.

In the Phase II Level 1 Watershed Planning Assessment Report for the Kitsap WRIA 15, values used were 115 gallons per day per capita for sub-basins in Kitsap County and 142 gallons per day per capita for sub-basins in Mason and Pierce Counties.

Based on the limited data available, the amount of 120 gallons per day per capita as used in the June 1997 Jefferson County Coordinated Water System Plan, appears to be a reasonable number for estimating purveyor water use for all of WRIA 16.

Total purveyor water use by sub-basin was calculated by multiplying the per capita water use rate by the number of people on purveyor systems within a respective sub-basin.

8.3.3 Exempt Well Residential Water Use

The normal method for estimating the number of exempt well water users in a watershed is described above in 8.4.1. This involves subtracting the number of people on purveyor systems from the population of the sub-basin with the number of people remaining to be supplied by exempt wells.

Using the same methodology used to calculate water use by the population on purveyor systems, the amount of water used by persons on exempt wells can be calculated. For estimation purposes in this assessment, it is assumed that the per capita residential water use for exempt wells is the same as the per capita water use of 120 gallons per day used for PWSs.

8.3.4 Hydropower Water Use

Although hydropower water use in most instances is considered as a non-consumptive water use, the large hydropower water use in the North Fork of the Skokomish River Basin has a significant effect on streamflows because the water is diverted out of the Skokomish basin, and discharged directly into Hood Canal.

Records from the U.S. Geological Survey and the City of Tacoma will be used to determine an approximate annual amount of water diverted out of the Skokomish basin.

8.4 Current Water Use Estimates

This section discusses water use estimates for the WRIA. Consumptive use versus non-consumptive use of water is not quantified in this assessment. Water returned to the hydrologic system via septic systems or other means may need to be estimated in Phase II Level 2 to gain a better understanding of the consumptive water use in the watershed.

Transfers of water between sub-basins were also not accounted for in this assessment but should be addressed in Level 2 due to the effect on the water budget in sub-basins where this occurs.

8.4.1 Public Water Supply

According to DOH records, there are a total of 82 Group A and 121 Group B public water systems within WRIA 16, which for purposes of this report, includes the south shore of Hood Canal, identified as the Upper Mason Subbasin.

The highest number of Group A and Group B public water systems is in the Upper Mason Sub-basin, with a total of 23 and 48 respectively. The lowest number of Group A and Group B public water systems is in the Skokomish Lower North Fork Sub-basin, with only one Group A and one Group B public water system.

The largest residential population served by Group A public water systems is in the Cushman Subbasin with a total of 3,211. The Upper Mason Subbasin closely follows with 3,129. The largest residential population served by Group B public water systems is in the Upper Mason Sub-basin with a total of 482. The smallest residential population served by Group A and Group B public water systems is in the Lower North Fork Sub-basin, with no residential population for the one Group A and one Group B public water system in the sub-basin.

Table 8-1 shows the number of Group A and Group B public water systems and the residential population for each of the nine subbasins considered. Population data by sub-basin is shown in Table 8-2 for the 1990 and 2000 census. The largest population for the year 2000 is in the Upper Mason Sub-basin, with a total of 2,772. This is more than two times the next largest population of 1,351 in the Lower Skokomish Sub-basin. The smallest population for the year 2000 is in the South Fork Skokomish Sub-basin, with a total of 208.

By comparing the public water systems data shown in Table 8-1 and the census data shown in Table 8-2, it is noted that in some of the sub-basins, particularly the Cushman and Upper Mason Sub-basins, the residential population being served by public water systems exceeds the census data. In fact, because of the large differences for these two sub-basins, these data show that the subbasin total population served by public water systems exceeds the sub-basin total population from the 2000 census data. It is expected that the primary reason this apparent error exists is because many of those included as being served by the public water systems are only occupants during part of the year and are not included in the census data, because this is not their primary residence. Because of this anomaly for this watershed where many of the water users are part-time occupants of properties, it is not realistic in this watershed to follow the normal approach described earlier for determining the breakdown between water users on public water systems and water users on exempt wells.

Therefore, until this anomaly and data gap can be investigated more thoroughly and additional data collected, a modified conservative approach will be followed in Level 1 to determine residential water use from public water supplies and from exempt wells.

In six of the nine sub-basins, the number of residents from the 2000 census data exceeds the public water supply residential water users by what appears to be reasonable amounts (Table 8-3). Therefore it can be assumed that using the differences between these two numbers is a reasonable method to estimate the residential population on exempt wells. This is the standard approach as described above and will be used for these six sub-basins.

In the remaining three sub-basins, where the data show that the residential population served by public water supplies exceeds the census data population, the total residential population served by public water supplies will be used as the population for the sub-basin. This method is expected to result in a higher, more conservative estimate of residential water use for these sub-basins, because many of these residents only spend less than half the year in these sub-basins. For Level 1, there will be no estimate made for the residential population being served by exempt wells in these three sub-basins because the currently available data to make this evaluation at this time, even though there are exempt wells in these three sub-basins.

Using 120 gallons per day per capita as the average water use for residents on a public water supply, a total water use of 1,181 acre-feet per year (AF/yr) for PWS use within WRIA 16 (Table 8-4). The highest PWS water use is in the Upper Mason and Cushman Subbasins with 469 AF/yr and 417 AF/yr, respectively (Figure 8.1). The Skokomish, Lower N. F. Subbasin is the lowest PWS water use with no residential population shown to be on a public water supply.

Based on the amount of water use per square mile, the highest water use density is in the Upper Mason Sub-basin with 16.1 AF/yr per square mile, with the next largest being the Cushman Sub-basin, with 4.5 AF/yr/square miles.

8.4.2 Exempt wells

The number of people served by exempt wells was estimated using population data, and the number of people on public water systems. As a result of the accuracy of the data provided and a number of simplifying assumptions used in the analysis of population on public water systems, in some of the sub-basins the population on public water systems is greater than the total population calculated for the sub-basin. In fact, exempt wells are known to exist in all of the sub-basins.

Based on the method of analysis used, the sub-basins of Cushman, Hamma Hamma, and Upper Mason were determined to have no population serviced by exempt wells. It is known that exempt wells are being used in these sub-basins, so the DOH data for the number of people on purveyor system may be too high for these sub-basins, resulting in the estimated population on exempt wells to be les than actual.

Exempt well water use in the watershed was estimated at 323 AF/year and provided water to 2,460 people as shown in Table 8-4. The estimated per capita water use for exempt wells used was the same as for the population on public water systems (i.e., 120 gpdpc). The greatest exempt well water use is shown to be in the Lower Skokomish and Lower N.F. Skokomish Sub-basins of 132 and 102 AF/yr, respectively (Figure 8.2).

Normalizing water use by people using exempt well water use density, water use per square mile, the greatest use occurs in the Lower N.F. Skokomish and Lower Skokomish Sub-basins at 4.1 and 3.8 AF/year/mi^2 respectively.

8.4.3 Total Residential Water Use

Using the combination of data from DOH records for public water systems and the census data, results in a disparity between these numbers for some sub-basins by showing the total population on public water systems as being higher than the entire sub-basin population, as described above. The following approach is shown as another method of determining total residential water use.

Table 8-4 also shows what the total residential water use would be using only the population data as the basis for calculation. This results in a much lower amount of water use, 1,010 AF/yr, as compared with 1,504 AF/yr, by using the combination of DOH records and census data. The actual amount of residential water use is likely to be somewhere between these two numbers when permanent residents and visitors are accounted for. The distribution of total residential water use is shown in Figure 8.3.

In order to have a common method of projecting estimates of future water use, the residential water use based on the population data will be used as the basis for estimating projected water use, because population data is the only projected data available.

8.4.4 Agriculture

Based on the determination of the number of irrigated acres in WRIA 16 as discussed in Section 8.3.3, and using a factor for Western Washington of 2 acre-feet per year per acre, the total estimated amount of water use for irrigation of 276 acres in WRIA, is 552 acre-feet per year.

The actual applied duty is a function of local precipitation. Because of the high rates of precipitation in the Skokomish Basin, probably less than the 2 feet per year typical of Western Washington is applied in the Skokomish Basin. An even distribution of irrigated acres across the counties is assumed. The above estimation of irrigated acres in WRIA 16 assumes an equal distribution of irrigated acres across the counties. Most of the irrigated acreage in Jefferson County is concentrated in WRIA 17 to the north. Similarly, irrigated lands in Mason County are more likely to be concentrated in the flat lands of WRIA 14, although there are some irrigated lands in the lower Skokomish River Valley. For these reasons, the estimate of irrigation water use is considered to represent an upper range of actual use.

8.4.5 Hydropower

The following is based on the stream gaging records from the U. S. Geological Survey for the North Fork Skokomish River basin. The average annual amount of water entering Lake Cushman, upstream of Cushman Dam No. 1, has been 368,000 AF/yr, and the average annual amount of water in the North Fork Skokomish River downstream of Cushman Dam No. 2 has been 34,690 AF/yr.

By subtracting the numbers for the average annual flow into Lake Cushman and the average annual flow downstream of Cushman Dam No. 2, the average annual amount of water diverted from the North Fork Skokomish River basin for power purposes is 333,310 AF/yr, which is approximately 90 percent of the total flow in the North Fork basin.

8.5 Projected Water Use

Because there are only minimal amounts of estimated actual water use in WRIA 16 for uses other than residential use, the projected water use will only be determined for this assessment for residential use.

Projected water use is not divided between purveyor and exempt wells, because of the questionable existing data on the breakdown between the population served by purveyor and exempt wells. Growth in water use is not broken out between municipal/ purveyor (i.e., PWSs) and exempt wells because it is difficult to determine where growth will occur within a sub-basin, if the growth will occur on purveyor systems or exempt wells and how the water supply system would chose to accommodate growth demands.

Projected water use was calculated by determining the projected 2010 population determined in Section 4. Applying the projected 2010 population to current water use rates, an estimate of future water use can be calculated. The projected water use estimate only addresses water use based on population. Also, as discussed in 8.5.3, because the PWS data from DOH is not consistent with the census data population for the year 2000, only the existing and projected population data can be compared, so the population data is used for projected water use.

In addition, water use savings as the result of conservation was not investigated or incorporated into the projected water use estimate.

Population was anticipated to continue to grow at the same rate as between 1990 and 2000, which was approximately 24% for the 10-year period. Projected water use was calculated using the projected 2010 watershed population of 9,802 people. A summary of the estimated projected population for 2010 by sub-area is presented in Table 8-5. Water use by purveyor residences and exempt wells is projected to be 1,275 AF/yr for 2010 as shown in Table 8-5. This represents an increase of 265 AF/yr as compared to 2000 water use estimates using 2000 population data (Table 8-4).

8.6 Data Gaps

The following are some identified data gaps related to water use:

- Verification of the DOH data on PWS related to number of residences on each of the PWS;

- Information on the number of connections on PWS that are only used on a part-time or vacation basis;
- Information on the number of exempt wells that are only used on a part-time or vacation basis;
- Information on the total number of exempt wells in the watershed, and within specific sub-basins;
- Further evaluation to determine the exact location of PWS and exempt well usage within specific sub-basins;
- Information on the actual number of irrigated acres; and,
- Information on the actual amount of water diverted out of the North Fork Skokomish Sub-basin for hydropower use by the Cushman Project.

9. SURFACE WATER QUALITY

This section provides a general summary of existing information pertaining to the condition of surface water quality in WRIA16. According to RCW 90.82.090, the following are items for inclusion in the optional water quality component of watershed planning.

- An examination based on existing studies conducted by federal, state, and local agencies of the degree to which legally established water quality standards are being met in the management area;
- An examination based on existing studies conducted by federal, state, and local agencies of the causes of water quality violations in the management area, including an examination of information regarding pollutants, point and non-point sources of pollution, and pollution-carrying capacities of water bodies in the management area. The analysis shall take into account seasonal stream flow or level variations, natural events, and pollution from natural sources that occurs independent of human activities;
- An examination of the legally established characteristic uses of each of the non-marine bodies of water in the management area;
- An examination of any total maximum daily load established for non-marine bodies of water in the management area, unless a total maximum daily load process has begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060;
- An examination of existing data related to the impact of fresh water on marine water quality;
- A recommended approach for implementing the total maximum daily load established for achieving compliance with water quality standards for the non-marine bodies of water in the management area, unless a total maximum daily load process has begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060; and,
- Recommended means of monitoring by appropriate government agencies whether actions taken to implement the approach to bring about improvements in water quality are sufficient to achieve compliance with water quality standards.

9.1 Objective and Level of Detail

This Level 1 Assessment focuses on summarizing existing surface water quality information within WRIA 16. This assessment does not address the quality of groundwater resources, which may be a consideration for Level 2 work. As a result, the information in this assessment includes:

- A summary of Washington State designated waterbody classifications, uses, and state water quality standards;

- A description of waterbodies within the WRIA in which legally established water quality standards are not being met (as identified in Washington State's 1998 list of impaired and threatened waterbodies);
- A description of the pollutants affecting the waterbodies in the WRIA;
- A summary of ongoing TMDL (Total Maximum Daily Load) studies and approved TMDL water quality clean up plans within the WRIA; and,
- An identification of data quality and quantity and potential data gaps.

9.2 Waterbody Classification

Surface waters in the state of Washington are classified into one of four classes with respect to water quality criteria: AA (extraordinary), A (excellent), B (good), and C (fair) according to the intended use of the waterbody (WAC 173-201A-030). Each classification contains water quality criteria needed to support the variety of stream or stream segment designated uses (Parametrix 2001).

All the major rivers in WRIA 16(Dosewallips, Duckabush, Hamma Hamma, and Skokomish) and their tributaries are classified as Class AA waters. Hood Canal is also classified as Class AA. All lakes are classified as Lake Class, and tributaries to lakes are classified as Class AA. All other unclassified surface waters are considered to be Class A.

A general requirement of Class AA waters is that "the water quality shall markedly and uniformly exceed the requirements for all or substantially all uses". A general requirement of Class A and Lake Class waters is that the water quality shall meet or exceed the requirements for all or substantially all uses" (WAC 173-201A-030).

9.3 Beneficial Uses

Beneficial uses are defined broadly as "uses of water for domestic, stock watering, industrial, commercial, agricultural, irrigation, hydroelectric power production, mining, fish and wildlife maintenance and enhancement, recreational, and thermal power production purposes, and preservation of environmental and aesthetic values, and all other uses compatible with the enjoyment of the public waters of the state" (WAC 173-500-050).

Characteristic uses of Class AA, Class A, and Lake Class waters include:

- Water supply (domestic, industrial, agricultural);
- Stock watering;
- Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting, other fish migration, rearing, spawning, and harvesting, clam, oyster, and mussel rearing, spawning, and harvesting, crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing, spawning, and harvesting;
- Wildlife habitat;

- Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment); and,
- Commerce and navigation.

9.4 State of Washington Water Quality Standards

Water quality standards for surface water are assigned based on the classification of the waterbody as described above. Standards for water quality vary between the assigned classes and among fresh and marine waters. Water quality standards for parameters in Class AA and Class A freshwater streams are listed in Table 9-1. Marine water quality standards for Class AA and A waters are listed in Table 9-2

In determining water quality standards for areas in which waters of two different classes meet, the water quality criteria for the higher classification shall prevail at the boundary between waters of different classifications. In addition, in brackish waters of estuaries, where the fresh and marine water quality criteria differ within the same classification, the criteria shall be applied on the basis of vertically averaged salinity. The freshwater criteria shall be applied at any point where ninety-five percent of the vertically averaged daily maximum salinity values are less than or equal to one part per thousand. Marine criteria shall apply at all other locations; except that the marine water quality criteria shall apply for dissolved oxygen when the salinity is one part per thousand or greater and for fecal coliform organisms when the salinity is ten parts per thousand or greater.

9.5 Shellfish Harvesting Standards

The National Shellfish Sanitation Program (NSSP) requires a shoreline survey and a growing area standard to classify a shellfish growing area. The shoreline survey locates and evaluates all significant point and non-point pollution sources along the shorelines and in upland drainage areas. The growing area standard is based on the following water quality criteria:

- The geometric mean of fecal coliform (FC) data shall not exceed 14 per 100 mL, and
- The 90th percentile of the FC data shall not exceed 43 per 100 mL

A minimum of 30 samples is required from each sampling station to determine the required statistics. Samples are taken six times a year from “Approved” areas and once a month from “Conditionally Approved” areas. Both criteria must be met in order to be compliant with the Growing Area Standard (DOH 1999a, Parametrix 2001).

9.6 List of Impaired or Threatened Waterbodies (303 (d) List)

Under Section 303(d) of the Clean Water Act, the Washington Department of Ecology (Ecology) identifies waterbodies that do not meet water quality standards. This list is known as the List of Impaired or Threatened Waterbodies (303(d) list). Table 9-3 and Figure 9.1 depict waterbodies listed on the 1998 Section 303(d) list, most recently updated in 1998 by the Department of Ecology. An update to the 303(d) list is scheduled to be released in 2002.

One marine waterbody (Hood Canal South) and nine freshwater waterbodies are listed as having water quality impairments in WRIA 16 and the portion of WRIA 14 on the south shore of Hood Canal that is designated as the Upper Mason sub-basin and is being considered with WRIA 16. Seven waterbodies are listed as impaired for fecal coliform, and two for pH, all of which will require TMDL development. The North Fork of the Skokomish River, which is listed for instream flow, will not require TMDL development, because instream flow is not considered a pollutant under the Clean Water Act.

9.7 Pollutants

A predominant parameter exceeding state water quality standards in the freshwater impaired waterbodies of WRIA 16 is fecal coliform. As stated above there are also two listed for pH, and also one other listing for instream flow. Although there are many additional pollutants that can cause impairment to water quality standards, including temperature, dissolved oxygen, total phosphorous, and turbidity, none of these parameters are shown as the basis for listing on the 303(d) list in WRIA 16. Because none of these other common parameters are the basis for 303(d) listing in WRIA 16, they will not be addressed further in this report.

9.7.1 Fecal Coliform

Fecal coliform is the most widespread pollutant affecting waterbodies in WRIA 16. Waterbodies that have documented exceedances of state water quality standards for fecal coliform and require the development of a TMDL are:

- Hood Canal (South);
- Hunter Creek;
- Purdy Creek;
- Skokomish River;
- Ten Acre Creek;
- Weaver Creek; and,
- Happy Hollow Creek.

Fecal coliform (FC) bacteria are a type of coliform bacteria. Coliform bacteria are a group of microorganisms found in the feces of all warm-blooded animals, although these bacteria are not unique to feces. In water, coliform organisms are typically used as an indicator of the potential presence of disease-causing organisms. The presence of FC in water indicates the potential microbial degradation of water, and although FC do not affect fish or shellfish themselves, shellfish do retain these microorganisms through the process of filter feeding. Human consumption of shellfish from areas contaminated with FC can create a possible health risk (Parametrix, 2001).

9.7.2 pH

Exceedances of pH are the second largest reason for water quality impairments in WRIA 16, and two waterbodies on the south shore of Hood Canal, Twanoh Falls Creek and an unnamed creek in Section 22, Township 22N, Range 2W, will require the development of a TMDL:

The acidic or basic nature of a solution is measured as pH on a scale of 0 to 14. The pH of neutral solutions, such as pure water, is equal to 7. Alkaline solutions will have high pH (8-14), and acidic solutions will have low pH (1-6). The most common cause of exceedance of pH water quality criteria is the influence of photosynthetic processes. Invasion by exotic plants such as milfoil or algal blossoms caused by high nutrient concentrations will cause wide daily fluctuations of pH. During the day when photosynthesis is occurring, the plants produce oxygen that raises the pH above 8. During the night, the plants undergo respiration producing carbon dioxide and lowering the pH below 6.

One of the most significant environmental impacts that pH can have is its effect on the solubility and thus the bioavailability of other substances. Runoff from agricultural, domestic, and industrial areas may contain iron, lead, chromium, ammonia, mercury, or other elements. The pH of the water affects the solubility of these substances. A decrease in pH can increase metal availability in the system, lending itself to greater metal uptake by organisms. Metal uptake can cause extreme physiological damage to aquatic life (Connell and others, 1984). Acidic inputs from non-point sources such as acid mine drainage and wet/dry acid deposition, can substantially lower the pH of a system to an acidic level. Table 9-4 lists the effects of various pH levels on aquatic life.

9.7.3 Instream Flow

The North Fork Skokomish River is designated on the 303 (d) list with instream flow shown as the parameter or reason for listing. The reach of the river below the Cushman Hydro project has a substantially reduced flow on a year-round basis because of the diversion of water from this basin via a penstock to a powerhouse located on Hood Canal.

Although instream flow is not considered as a pollutant under the Clean Water Act, and as such a TMDL will not be required for the North Fork Skokomish River, it is included as a parameter for a listing on the 303(d) list.

9.8 Ongoing or Completed TMDL Studies and Plans

As of the time of this report, no TMDLS have been completed and approved by the EPA for WRIA 16 water bodies. Currently, there is one TMDL plan in progress in WRIA 16 for fecal coliform impairments in the Skokomish River basin; the "Skokomish River Basin Fecal Coliform Total Maximum Daily Load (Water Cleanup Plan) Submittal Report," (Ecology, 2001). The next step in the Skokomish River plan development is to develop a Detailed Implementation Plan that includes the stakeholders. The plan will then have to be approved by the EPA. The plan is currently under development and there is no scheduled completion date at this time.

10. SUBBASIN SUMMARIES

The physiography of the Skokomish-Dosewallips Basin is a mix of extremely rugged mountains, and flat lowlands. The mountains dominate the northwestern and interior part of the basin, while the flatlands dominate the North Mason Subbasin, portions of the Skokomish River Basin and a narrow strip along the Hood Canal coast. The average annual precipitation of the basin is 96 inches, much of which falls as snow in the mountains.

The total population of the watershed in 2000 was around 7,700 people, concentrated in the North Mason, Lower Skokomish, and Lilliwaup Subbasins, each with more than 1,000 people. The average annual population growth rate during 1990-2000 occurred in as a whole (2.2%).

Total annual precipitation averages approximately 3.4 million AF/yr. Approximately 3 million AF/yr, or 90%, is estimated to run off in streams. The remainder is returned to the atmosphere through evapotranspiration. Groundwater discharge to Hood Canal is estimated to be less than 1% of the total basin streamflow. There are two styles of stream hydrographs in the basin. Rainfall dominated basins show a peak runoff coincidental with peak precipitation in December-January. In snowpack dominated subbasins, this peak is suppressed as a result of snowpack accumulation and peak runoff occurs immediately before (November-December) development of snowpack, and during snowpack melt (May-June).

Total allocation of water (including permits, certificates and claims) in the watershed is approximately 16,000 AF/yr, or approximately 5% of the total streamflow of the basin. This total excludes water rights for the purposes of use of power (including the Cushman Dams), fish propagation, and fire suppression. The distribution of estimated allocated water is approximately equally split between groundwater (~56%) and surface water (~44%), and between residential (i.e., domestic and municipal) and irrigation purposes of use. Commercial/industrial purposes of use account for less than 2% of the total allocated water.

Actual water use estimates in the basin for the residential population is 1,000 AF/yr. There is a significant seasonal visitor population that may use up to an additional 500 AF/yr. Therefore less than 20% of the water allocated for residential use (i.e., domestic and municipal) is estimated to be used. An estimate of 500 AF/yr for irrigation use is considered to represent the upper end of the range of actual use. Therefore approximately 6% of the water allocated for irrigation use is being used. Total actual water use for residential and irrigation purposes of use (~2,000 AF/yr) represents less than 0.07% of the total basin streamflow.

Instream flows exist for Waketickeh and McTaggert Creeks under the authority of Ch. 75.20.050 RCW (Fisheries Code). An Instream Resource Protection Program (IRPP) study was completed in 1985 in which a draft rule (Ch. 173-516 WAC) for minimum instream flow regulations were prepared, but were never adopted. If adopted, the proposed minimum instream flows would not be met in approximately half of the years (based on historical flows in streams for which there is at least 10 years of gaging data).

Freshwater waterbodies are listed as impaired for fecal coliform (7), and pH (2), all of which will require TMDL development. Hood Canal South is listed for dissolved oxygen, fecal coliform and pH. No TMDLS have been completed and approved by the EPA for water bodies in the Skokomish Basin. There is one TMDL plan in progress in WRIA 16 for fecal coliform impairments in the Skokomish River basin: the "Skokomish River Basin Fecal Coliform Total Maximum Daily Load (Water Cleanup Plan) Submittal Report" (Ecology, 2001). The next step in the Skokomish River plan development is to develop a Detailed Implementation Plan that includes the stakeholders. The plan will then have to be approved by the EPA. The plan is currently under development and there is no scheduled completion date at this time.

Findings for each subbasin are summarized below.

10.1 Dosewallips Subbasin

The Dosewallips Subbasin covers the northern end of the watershed. It is the largest of the subbasins and is totally contained within Jefferson County. It is the driest subbasin with mountainous terrain in WRIA 16 (average annual precipitation of 80 inches). Only the Lower Skokomish (69 inches) and North Mason (60 inches) Subbasins are drier. It is the coldest subbasin, primarily as a function of the high elevation of its mountainous terrain, and much of the precipitation falls as snow.

The subbasin is predominantly bedrock (>90%) with sand and gravel deposits along the lower reaches of the Dosewallips River valley. Greater than 90% of the subbasin is within national parks and forests. The portion within the national park is entirely undisturbed and pristine. Significant logging on private lands in the lower part of the basin is apparent from satellite images, which may influence runoff patterns.

Fish productivity is limited by natural conditions of the river including floods, steep gradients, and natural fish passage barriers. Proposed minimum instream flow regulations for the Dosewallips River approximate the 50% exceedance curve. This means that if the proposed instream flows were implemented, the regulations would not be met in approximately every second year. Summertime stream low flows are supported primarily by snowpack melt. Groundwater supported baseflow is minimal as a result of the dominance of bedrock geology.

A total of 919 AF/yr has been allocated in this subbasin of which approximately a quarter are estimated to be in the form of claims. Approximately 70% of the total allocated water is from groundwater. Approximately 70% of the total allocated water is for domestic/municipal purposes of use, and 25% for irrigation. Less than 600 people live in the basin (2000), and the major community in the subbasin is Brinnon. Total estimated residential demand is 76 AF/yr.

There are no freshwater listings for impaired water quality under the Clean Water Act for the Dosewallips Subbasin. However, fecal coliform is listed in the nearshore marine environment. Potential sources of fecal coliform are wastewater from communities or soil coliform associated with sediment runoff.

10.2 Duckabush Subbasin

The Duckabush Subbasin is located immediately south of the Dosewallips Subbasin and is almost totally contained within Jefferson County. Average annual precipitation is 87 inches. The high elevation of its mountainous terrain results in relatively cold temperatures, and much of the precipitation falls as snow.

The subbasin is predominantly bedrock (>90%) with sand and gravel deposits along the lower reaches of the Duckabush River valley. Approximately 90% of the subbasin is within national parks and forests. The portion within the national park is entirely undisturbed and pristine. Some logging on private lands occurs in the lower part of the basin is apparent from satellite images which may influence runoff patterns. Fish productivity is limited by natural conditions of the river including floods, steep gradients, and natural fish passage barriers. Proposed minimum instream flow regulations for the Duckabush River are slightly less than the 50% exceedance curve. Summertime stream low flows are supported primarily by snowpack melt. Groundwater supported baseflow is minimal as a result of the dominance of bedrock geology.

A total of 254 AF/yr has been allocated in this subbasin of which approximately a 70% are estimated to be in the form of claims. Approximately 73% of the total allocated water is from groundwater. Approximately 67% of the total allocated water is for domestic/municipal purposes of use, and 32% for irrigation. Less than 400 people live in the basin (2000) with a total estimated residential demand of 48 AF/yr. This subbasin has not yet felt the impact of civilization.

There are no freshwater listings for impaired water quality under the Clean Water Act for the Duckabush Subbasin. However, fecal coliform is listed in nearshore marine environment. Potential sources of fecal coliform are septic systems or coliform associated with sediment runoff.

10.3 Hamma Hamma Subbasin

The Hamma Hamma Subbasin is centrally located in WRIA 16. It spans the Jefferson-Mason County line with approximately two thirds in Mason County. Average annual precipitation is 84 inches. The high elevation of its mountainous terrain results in relatively cold temperatures, and much of the precipitation falls as snow. The subbasin is predominantly bedrock (>85%) with sand and gravel deposits along the lower reaches of the Hamma Hamma River valley. Approximately 75% of the subbasin is within national parks and forests.

Fish productivity is limited by natural conditions of the river including floods, steep gradients, and natural fish passage barriers. Waketickeh Creek, a tributary to the Hood Canal that only has 0.1 river miles of accessible fish habitat, has a source limitation of low flow under the authority of RCW 75.20.050 (Fisheries Code). Proposed minimum instream flow regulations approximate the 50% exceedance curve. This means that if the proposed instream flows were implemented, the regulations would not be met in approximately every second year. Instream flow regulations have also been proposed for Fulton and John Creeks at the north and south ends of the subbasin, respectively. Summertime stream low flows are supported primarily by snowpack melt. Groundwater supported baseflow is minimal as a result of the dominance of bedrock geology.

A total of 688 AF/yr has been allocated in this subbasin of which approximately a 12% are estimated to be in the form of claims. Approximately 55% of the total allocated water is from groundwater. Approximately 75% of the total allocated water is for domestic/municipal purposes of use, and 23% for irrigation. Less than 300 people live in the basin (2000), primarily in the community of Eldon at the mouth of the Hamma Hamma River. Total estimated residential demand is 39 AF/yr.

There are no listings for impaired water quality under the Clean Water Act for the Hamma Hamma Subbasin.

10.4 Lilliwaup Subbasin

The Lilliwaup Subbasin is centrally located in WRIA 16 and is totally contained within Mason County. Average annual precipitation is 82 inches which falls primarily as rainfall. There is little snowpack influence due to the relatively low elevation of its terrain. About a third of the subbasin is underlain by volcanic rock, with the rest underlain by sand and gravel. Less than 10% of the subbasin is in national forest lands.

Unlike the other subbasins of this watershed, the Lilliwaup Subbasin does not have a dominant river and is drained by a number of small creeks. A major salmon hatchery is located at Hoodsport. Proposed minimum instream flow regulations have been proposed for Jorsted, Eagle and Finch Creeks. Insufficient data exists to make a statement as to the attainability of the proposed minimum instream flows based on historical stream gaging records.

A total of 2,449AF/yr has been allocated in this subbasin of which approximately less than 10% are estimated to be in the form of claims. Approximately 60% of the total allocated water is from groundwater. Approximately 92% of the total allocation is for domestic/municipal purposes of use, and 7% for irrigation. Approximately 1,100 people live in the basin (2000), primarily in the community of Lilliwaup at the mouth of Finch Creek. Total estimated residential demand is 143 AF/yr.

There are no listings for impaired water quality under the Clean Water Act for the Lilliwaup Subbasin.

10.5 Cushman Subbasin

The Cushman Subbasin includes Lake Cushman and its drainage area upstream, all within Mason County. Average annual precipitation is the highest in the watershed at 134 inches. The high elevation of its mountainous terrain results in relatively cold temperatures, and much of the precipitation falls as snow. The subbasin is predominantly bedrock (>90%) with an area of sand and gravel deposits along the middle east banks of Lake Cushman. Approximately 10% of the subbasin is within national parks and forests.

Summertime stream low flows are supported primarily by snowpack melt. Groundwater supported baseflow is minimal as a result of the dominance of bedrock geology. There are no proposed minimum instream flow regulations for the Cushman Subbasin.

The basin is inaccessible to migratory salmonids as a result of the Cushman Dams. Landlocked salmon are restricted to Lake Cushman and short distances up associated tributaries.

A total of 587 /yr has been allocated in this subbasin of which approximately less than 3% are estimated to be in the form of claims. Approximately 36% of the total allocated water is from groundwater. Almost all of the allocated water is for residential consumption (>98%).

The Cushman Subbasin had the second highest annual population growth rate during the 1990s at 3.7%. Approximately 272 people live in the basin (2000), primarily in a residential development on Lake Cushman. Total estimated residential demand is 35 AF/yr.

There are no listings for impaired water quality under the Clean Water Act for the Cushman Subbasin.

10.6 North Fork Skokomish Subbasin

The North Fork Skokomish Subbasin extends from Cushman Dam No. 1 at the foot of Lake Cushman, downstream to the confluence with the mainstem Skokomish River. It is the smallest basin and the most modified from its natural condition as a result of the Cushman Dams No. 1 and 2.

Average annual precipitation is 89 inches and falls mostly as rain. The subbasin is underlain primarily by unconsolidated sand and gravel deposits, which supports the development of baseflows in streams.

Chum and coho runs spawn heavily in the Lower North Fork system including McTaggert Creek. Migration of chinook is limited as a result of low flows. And resulting difficult passage. McTaggart Creek, a tributary to the North Fork of the Skokomish River has a source limitation at low flow under the authority of RCW 75.20.050 (Fisheries Code). A minimum instream flow is proposed for the Lower North Fork Skokomish River. It appears that the proposed minimum instream flow will be met by releases from the Cushman Dam.

Allocated water is estimated at 1,226 AF/yr, excluding the purposes of use of power, fish propagation and fire suppression. A quarter of the estimated allocation is in the form of claims. Groundwater allocation accounts for two thirds of the total estimated allocation.

Approximately 30% of the total allocation is for domestic/municipal purposes of use, and 70% for irrigation.

The highest annual population growth rate during 1990-2000 occurred in the Lower North Fork Skokomish Subbasin (4.7%) at more than double that of the basin as a whole (2.2%). Approximately 800 people live in the basin (2000) for a total estimated residential demand of 100 AF/yr.

There are two applications by the City of Tacoma for large surface water rights (i.e., 1,500 cfs and 1,700 cfs) for the purpose of use of power generation. These appear to be related to Cushman Dams No. 1 and 2. Other applications in the basin are for groundwater for domestic use.

There is one listing under Section 303(d) of the Clean Water Act for instream flows. However, instream flow is not considered a pollutant, and a TMDL is not required.

10.7 South Fork Skokomish Subbasin

The South Fork Skokomish Subbasin extends upstream from the confluence with the North Fork Skokomish River. Average annual precipitation of 131 inches is the second highest in the watershed, after the North Fork Skokomish. The subbasin has a mix of high elevation where significant snowpack develops during the winter, and lowlands where rain is the dominant form of precipitation. The subbasin is predominantly bedrock (~90%) with sand and gravel deposits along the lower reaches of the South Fork Skokomish River. Approximately 90% of the subbasin is within national parks and forests. Significant logging occurs in the Olympic National Forest within this subbasin.

Minimum instream flow regulations have been proposed. Historical stream gaging data indicate that the proposed flow regulations will only be met in one year out of ten during the summer low flow period. Chinook and coho spawn in the mainstem and lower reaches of tributaries.

A total of 587 AF/yr has been allocated in this subbasin of which less than 3% are estimated to be in the form of claims. Approximately 36% of the total allocated water is from groundwater. Almost all of the allocated water is for residential consumption (>98%). Approximately 272 people live in the basin (2000), primarily in a residential development on Lake Cushman. Total estimated residential demand is 35 AF/yr.

There are no listings for impaired water quality under the Clean Water Act in the South Fork Skokomish Subbasin.

10.8 Lower Skokomish Subbasin

The Lower Skokomish Subbasin extends from the mouth of the river in Hood Canal to the confluence of the North and South Forks. It is the driest subbasin in WRIA 16 with an annual average precipitation of 69 inches, although the North Mason Subbasin in WRIA 14 is drier (60 inches). Precipitation falls mostly as rain. The subbasin is totally underlain by unconsolidated sand and gravel deposits, which supports the development of baseflows in streams.

The Lower Skokomish has prolific production of chinook, coho and chum. Unnaturally low flows from regulation by the Cushman Dams reduce salmon productivity. Proposed minimum instream flows for the Lower Skokomish River during the low flow summer months are not met 50% of the time.

Approximately 40% of the estimated allocated water in the watershed is in the Lower Skokomish Subbasin with 6,457 AF/yr. This basin also has the highest proportion of claims representing the total subbasin allocation at 70%. Groundwater allocation accounts for ~47% of the total estimated allocation. Approximately 18% of the total allocation is for domestic/municipal purposes of use, and 79% for irrigation. Approximately 1,350 people live in the basin (2000) with a total estimated residential demand of 176 AF/yr.

Two large surface water applications are pending for a total amount of 5,440 cfs. Although the application lists a location in the Lower Skokomish Subbasin, the North Fork Skokomish is listed as the source. The purpose of use is municipal.

There are several listing s for fecal coliform under the Clean Water Act in the Lower Skokomish Subbasin including the mainstem, Hunter Creek, Purdy, Ten Acre and Weaver Creeks. A TMDL plan is in progress for the Lower Skokomish River. The next step in the Skokomish River plan development is to develop a Detailed Implementation Plan that includes the stakeholders. The plan will then have to be approved by the EPA. The plan is currently under development and there is no scheduled completion date at this time.

10.9 North Mason Subbasin

The North Mason Subbasin, which is part of WRIA 14, is being addressed under the watershed planning effort of WRIA 16 in order to consolidate assessment of water quality impacts to Hood Canal from contributing drainages from the west and south. The North Mason Subbasin is the driest subbasin assessed in this report with an annual average precipitation of 60 inches that falls mostly as rain.

There is no primary drainage in this subbasin and numerous small creeks drain the area. The subbasin is totally underlain by unconsolidated sand and gravel deposits, which supports the development of baseflows in streams. Instream flows have been established in WRIA 14. There are no control points and minimum instream flows established in the North Mason Subbasin however, Alderbrook and Twanoh Creeks are closed to further consumptive appropriation for the period May 1-October 31.

Approximately 1,700 AF/yr has been allocated in this subbasin of which approximately 19% are estimated to be in the form of claims. Approximately 59% of the total allocated water is from groundwater. Of the allocated water, 84% is for residential use. The North Mason Subbasin has the highest water use of all subbasins assessed in this report.

Approximately 2,772 people live in the basin (2000) with a total estimated residential demand of 360 AF/yr.

Mason County PUD has submitted applications for two groundwater rights totaling 580 gpm for domestic purpose of use. Several other smaller applications are pending in the subbasin, also for domestic or undefined purpose of use, all of which are from groundwater except for one.

There are several freshwater listing s under the Clean Water Act in the North Mason Subbasin including: Happy Hollow for fecal coliform; and, Twanoh Falls Creek and an unnamed creek for pH. The nearshore marine environment has listings for dissolved oxygen, fecal coliform and pH. Potential sources of fecal coliform are septic systems. The Union River in WRIA 15, which is known to have fecal coliform problems and drains into Hood Canal, may be a significant source of water quality degradation in Hood Canal.

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TABLES

TABLE 1-1

Acronym List

°F	Degrees Fahrenheit
abv	above
af/yr, AF/yr	acre-feet per year
amsl	above mean sea level
blw	below
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Oxygen Demand
CD	Cumulative Departure
CE-QUAL-W2	Surface water quality model developed by the US Army Corps of Engineers
cfs	cubic feet per second
cfs/af/yr	cubic feet per second per acre-feet per year
CIR	Crop Irrigation Requirement
CORPS	United States Army Corps of Engineers
CU	Consumptive Use
degrees C	Degrees Celsius
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality
DNR	Department of Natural Resources
DO	Dissolved Oxygen
Ecology	Washington Department of Ecology
e.g.	for example
EES	Economic and Engineering Services
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
ESA	Federal Endangered Species Act
ET	Evapotranspiration
ft	feet
ft/gpm	feet per gallons per minute
ftp	File Transfer Protocol
gpcpd	gallons per capita per day
GIS	Geographic Information System
GMA	Growth Management Act
Gpd/ft	gallons per day per foot
Gpm/af/yr	gallons per minute per acre-feet per year
Gpm/ft	gallons per minute per foot
HUC	Hydrologic Units Codes
IFIM	Instream Flow Incremental Methodology
ISFs	Instream Flows
LULC	Land Use and Land Cover
m/s	meters per second

TABLE 1-1

Acronym List

max	maximum
mg/L	milligrams per liter
mi^2	square miles
min	minimum
mL	milliliters
mm/h	millimeters per hour
MSL	Mean Sea Level
NASA	National Aeronautics & Space Administration
NAWQA	National Water-Quality Assessment Program
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NID	National Inventory of Dams
NOAA	National Oceanic and Atmospheric Administration
nr	near
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Units
NW	North West
P_{ET}	Potential Evapotranspiration
POD	Point of Diversion
POR	Period of Record
ppb	parts per billion
ppt	Precipitation
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PU	Planning Unit
Qa	Annual Water Use
Qa/Qi	ratio for non-irrigation groundwater and surface water rights
Qi	Instantaneous Water Use
R	Runoff
RCW	Revised Code of Washington
RM	River Mile
SDWA	Safe Drinking Water Act
SEPA	State Environmental Policy Act
stn	Station
TMDL	Total Maximum Daily Load
TRS	Township, Range, Section
U of W	University of Washington
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
w/o	without
WA, Wa, Wash.	Washington

TABLE 1-1

Acronym List

WAC	Washington Administrative Code
WMA	Watershed Management Act
WQMP	Water Quality Management Program
WRATS	Water Rights Application Tracking System
WRIA	Water Resource Inventory Area
WRIA 16	Skokomish/Dosewallips WRIA
WRIS	Water Resources Information System

TABLE 2-1

Technical Assessment Requirements of the Watershed Management Act (WMA) Status (from EES,1999)

Component	Technical Assessment Requirements of the Watershed Management Act (WMA)
Water Quantity	An estimate of the surface water and groundwater present in the management area.
	An estimate of the surface water and groundwater available in the management area (taking into account seasonal and other variations).
	An estimate of the water in the management area represented by claims in the claims registry, water use permits, certificated rights, existing minimum instream flow rules, federally reserved rights, and any other rights to water.
	An estimate of the surface water and groundwater actually being used in the management area.
	An estimate of the water needed in the future for use in the management area.
	Identification of the location of areas where aquifers are known to recharge surface water bodies and areas known to provide for the recharge of aquifers from the surface.
	An estimate of the surface water and groundwater available for further appropriation, taking into account the minimum instream flows adopted by rule or to be adopted by rule under this chapter for streams in the management area including the data necessary to evaluate necessary flows for fish.
Water Quality	An examination based on existing studies conducted by federal, state and local agencies of the degree to which legally established water quality standards are being met in the management area.
	An examination based on existing studies conducted by federal, state and local agencies of the causes of water quality violations in the management area, including an examination of information regarding pollutants, point and non-point sources of pollution, and pollution-carrying capacities of water bodies in the management area. the analysis shall take into account seasonal stream flow or level variations, natural events and pollution from natural sources that occurs independent of human activities.
	An examination of the legally established characteristic uses of each of the nonmarine water bodies in the management area.
	An examination of any Total Maximum Daily Load (TMDL) established for nonmarine water bodies in the management area, unless a TMDL process has begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060.
	An examination of existing data related to the impact of fresh water on marine water quality.
	A recommended approach for implementing the TMDL established for achieving compliance with water quality standards for the nonmarine water bodies in the management area, unless a TMDL process has begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060.
	Recommended means of monitoring by appropriate government agencies whether actions taken to implement the approach to bring about improvements in water quality are sufficient to achieve compliance with water quality standards.

Table 3-1

Skokomish-Dosewallips WRIA 16 Area Summary

	Acres	Sq Miles	Percent of Basin
By WRIA			
WRIA 16	427,584	667.9	100%
By Sub-Area			
Cushman	59,378	92.7	14%
Dosewallips	83,825	130.9	20%
Duckabush	52,256	81.6	12%
Hamma Hamma	75,205	117.5	18%
Lilliwaup	35,048	54.7	8%
Lower NF Skokomish	15,738	24.6	4%
Lower Skokomish	20,747	32.4	5%
South Fork Skokomish	66,766	104.3	16%
Upper Mason	18,622	29	4%

TABLE 3-2

Average PRISM Precipitation by Sub-Area

Sub-Area	***January***	***February***	***March***	***April***	***May***	***June***	***July***	***August***	***September***	***October***	***November***	***December***	***Annual***
Cushman	23.4	14.9	14.5	8.0	4.6	3.6	2.1	2.1	5.5	12.9	18.3	24.3	134.1
Dosewallips	11.1	9.3	9.3	5.2	4.0	2.9	1.6	1.8	2.8	6.6	12.2	13.4	80.1
Duckabush	12.3	10.4	10.1	5.6	4.1	3.1	1.7	1.7	3.1	7.4	13.1	14.7	87.3
Hamma Hamma	12.8	10.5	9.5	5.2	3.6	2.7	1.4	1.5	3.1	6.9	13.2	13.7	84.1
Lilliwaup	13.2	9.8	9.0	5.0	2.9	2.1	1.2	1.4	3.3	7.6	12.4	14.5	82.4
Lower NF Skokomish	14.4	10.6	9.6	5.4	3.0	2.2	1.2	1.4	3.5	8.4	13.4	16.0	89.1
Lower Skokomish	11.0	8.5	7.3	4.4	2.5	1.9	1.0	1.3	2.9	6.0	10.8	11.7	69.4
SF Skokomish	22.2	14.7	13.9	7.8	4.3	3.4	2.0	2.2	5.2	13.3	17.9	24.4	131.2
Upper Mason	9.3	7.4	6.5	3.7	2.4	1.8	1.0	1.3	2.5	5.2	9.5	9.9	60.4
Watershed Average	15.2	11.2	10.6	5.9	3.8	2.9	1.6	1.7	3.7	8.7	14.1	16.8	96.3

TABLE 3-3

Comparison of PRISM and NOAA Station Precipitation Data

Station Name	Avg. Annual Station Precipitation (inches)	Avg. Annual PRISM Precipitation (inches)	Percent Difference
Grapeview 3 SW, WA	52.7	53.9	2.3%
Shelton, WA	66.2	64.9	2.0%
Quilcene 2 SW, WA	55.7	57.1	2.4%

TABLE 3-4

Average PRISM Temperature by Sub-Area

Sub-Area	January	February	March	April	May	June	July	August	September	October	November	December	Average Annual
Cushman	33.3	35.1	37.8	41.5	47.8	51.9	57.1	58.1	54.2	45.7	36.9	34.1	44.4
Dosewallips	31.5	32.1	35.0	39.2	45.6	50.5	55.6	56.4	53.0	44.1	35.0	31.8	42.5
Duckabush	32.2	33.0	36.1	40.3	46.4	51.4	56.1	57.0	53.2	44.8	35.9	32.7	43.3
Hamma Hamma	34.4	35.7	39.0	43.4	49.3	54.4	58.7	59.4	54.8	46.8	38.4	34.8	45.8
Lilliwaup	38.4	40.8	44.3	48.5	54.0	59.2	63.1	63.6	58.7	50.9	42.9	38.6	50.2
Lower NF Skokomish	38.8	41.1	44.7	48.9	54.2	59.4	63.2	63.6	58.9	51.2	42.9	38.8	50.5
Lower Skokomish	39.6	41.7	45.2	49.4	54.8	60.1	63.9	64.3	59.7	51.7	43.7	39.6	51.2
SF Skokomish	35.9	38.4	41.1	45.1	51.0	55.4	60.0	60.8	56.5	48.4	40.0	36.6	47.4
Upper Mason	39.5	42.0	45.1	49.3	54.8	60.0	63.9	64.3	59.6	51.7	44.1	39.7	51.2

TABLE 3-5

Population Growth 1990-2000

Sub-Area	Sub-Area Area ($mile^2$)	1990 Population	2000 Population	Population Increase	1990-2000 Growth	1990-2000 Annual Growth Rate	1990 Pop. Density ($people/mile^2$)	2000 Pop. Density ($people/mile^2$)	Change in Pop. Density ($people/mile^2$)
Cushman	229.1	190	272	82	43%	3.7%	0.8	1.2	0.4
Dosewallips	92.7	514	589	75	15%	1.4%	5.5	6.4	0.8
Duckabush	130.9	309	365	56	18%	1.7%	2.4	2.8	0.4
Hamma Hamma	117.5	319	299	-20	-6%	-0.6%	2.7	2.5	-0.2
Lilliwaup	54.7	1,075	1,106	31	3%	0.3%	19.6	20.2	0.6
Lower NF Skokomish	32.4	495	786	291	59%	4.7%	15.3	24.3	9.0
Lower Skokomish	81.6	989	1,351	362	37%	3.2%	12.1	16.6	4.4
SF Skokomish	24.6	212	208	-4	-2%	-0.2%	8.6	8.5	-0.2
Upper Mason	104.3	2,139	2,772	633	30%	2.6%	20.5	26.6	6.1
TOTAL	**570.3**	**6,242**	**7,748**	**1,506**	**24%**	**2.2%**	**10.9**	**13.6**	**2.6**

TABLE 3-6

Projected Population 2000 -2010

Sub-Area	Sub-Area Area ($mile^2$)	2000 Population	2000 Population Density ($people/mile^2$)	2000-2010 Projected Annual Growth Rate	Projected 2010 Population	Increase in Population	Projected 2010 Population Density ($people/mile^2$)	Change in Pop. Density 2000-2010 ($people/mile^2$)
Cushman	229.1	272	1.2	3.7%	389	117	1.7	0.5
Dosewallips	92.7	589	6.4	1.4%	675	86	7.3	0.9
Duckabush	130.9	365	2.8	1.7%	431	66	3.3	0.5
Hamma Hamma	117.5	299	2.5	-0.6%	280	-19	2.4	-0.2
Liliwaup	54.7	1,106	20.2	0.3%	1,138	32	20.8	0.6
Lower NF Skokomish	32.4	786	24.3	4.7%	1,248	462	38.5	14.3
Lower Skokomish	81.6	1,351	16.6	3.2%	1,846	495	22.6	6.1
SF Skokomish	24.6	208	8.5	-0.2%	204	-4	8.3	-0.2
Upper Mason	104.3	2,772	26.6	2.6%	3,592	820	34.4	7.9
TOTAL	**867.9**	**7,748**	**13.6**	**2.2%**	**9,617**	**2,055**	**11.1**	**-2.5**

TABLE 5-1

Station Summary for USGS Gaging Stations in WRIA 16

Site Number	Site Name	First Gauging	Last Gauging	Elevation (NGVD29)	Drainage Area (mi2)	Station Status	Continous Years of Record	Mean Annual Flow (cfs)
12053000	DOSEWALLIPS RIVER NR BRINNON, WASH.	10/1/30	9/30/51	392.00	93.50	Inactive	18	448
12053500	DOSEWALLIPS R. AT BRINNON	11/1/10	9/30/30		116.00	Inactive	2	297
12054000	DUCKABUSH RIVER NEAR BRINNON, WASH.	7/1/38	9/30/00	241.49	66.50	Active	62	420
12054500	HAMMA HAMMA RIVER NEAR ELDON, WASH.	7/1/51	6/30/71	510.00	51.30	Inactive	20	364
12054600	JEFFERSON CREEK NEAR ELDON, WASH.	10/1/57	7/7/71	500.00	21.60	Inactive	13	153
12055000	HAMMA HAMMA R N HOODSPORT WASH	3/1/26	9/30/30	N/A	83.50	Inactive	5	N/A
12055500	EAGLE CREEK NEAR LILLIWAUP, WA	1951	1951	N/A	N/A	Inactive	1	436
12056000	FINCH CREEK AT HOODSPORT, WA	1951	1951	N/A	N/A	Inactive	1	N/A
12056500	NF SKOKOMISH R BLW STRCSE RPDS NR HDSPRT, WASH.	8/1/24	9/30/00	762.26	N/A	Active	76	512
12057000	LAKE CUSHMAN NR HOODSPORT	1925	1982	N/A	N/A	Inactive	57	N/A
12057500	NORTH FORK SKOKOMISH RIVER NR HOODSPORT, WASH.	2/1/13	9/30/78	430.00	93.70	Inactive	66	756
12058000	DEER MEADOW CREEK NEAR HOODSPORT, WASH.	9/1/50	9/24/73	688.28	1.83	Inactive	23	8
12058500	DOW CREEK NEAR HOODSPORT, WASH.	9/1/50	9/30/54	N/A	1.67	Inactive	4	8
12058800	NF SKOKOMISH R. BL LWR CUSHMAN DAM NR POTLATCH, WA	6/7/88	9/30/00	N/A	N/A	Active	12	50
12059000	MCTAGGERT CREEK NEAR HOODSPORT, WASH.	10/1/50	8/31/53	N/A	1.30	Inactive	3	4
12059500	N.F. SKOKOMISH RIVER NR POTLATCH, WA	4/1/44	9/30/00	63.49	117.00	Active	50	113
12059800	S.F. SKOKOMISH RIVER NR HOODSPORT, WASH.	10/1/63	9/30/70	750.00	26.00	Inactive	7	305
12060000	S.F. SKOKOMISH RIVER NR POTLATCH, WASH.	10/1/23	9/30/64	456.00	65.60	Inactive	18	605
12060500	SOUTH FORK SKOKOMISH RIVER NEAR UNION, WASH.	8/1/31	9/30/00	103.35	76.30	Active	53	753
12061500	SKOKOMISH RIVER NEAR POTLATCH, WASH.	7/1/43	9/30/00	10.67	227.00	Active	57	1223
12061000	VANCE CREEK NEAR POTLATCH, WASH.	1955	1956	N/A	N/A	Inactive	2	N/A
12062500	PURDY CREEK NEAR UNION, WASH.	9/1/54	7/31/60	28.76	3.73	Inactive	6	24

TABLE 5-2

Period of Records for USGS Gaging Stations in WRIA 16

Station Name	Station	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Dosewallips River near Brinnon	12053000																			
Dosewallips River at Brinnon	12053500																			
Duckabush River	12054000																			
Hamma Hamma River nr Eldon	12054500																			
Jefferson Creek	12054600																			
Hamma Hamma nr Hoodsport	12055000																			
Eagle Creek	12055500																			
Finch Creek	12056000																			
NF Skokomish blw Staircase Rapids nr Hoodsport, Wa.	12056500																			
Lake Cushman	12057000																			
N.F. Skokomish near Hoodsport	12057500																			
Deer Meadow Creek	12058000																			
Dow Creek	12058500																			
NF Skokomish River blw lower Cushman Dam nr Potlatch	12058800																			
McTaggert Creek	12059000																			
N.F. Skokomish River Nr Potlatch	12059500																			
S.F. Skokomish River near Hoodsport	12059800																			
S.F. Skokomish River near Potlatch	12060000																			
S.F. Skokomish River near Union.	12060500																			
Skokomish River near Potlatch	12061500																			
Vance Creek	12061000																			
Purdy Creek	12062500																			
Pacific Decadal Oscillation Influence	**WET** / **DRY**																			

TABLE 6-1

Empirical Annual Water Balances

	Area	Precipitation		Streamflow		Evapotranspiration[1]	
	Acres	Inches	Acre-feet	cfs	Acre-feet	Inches	Acre-feet
Upper Catchments							
Upper Duckabush (12054000)	42,358	93.6	330,532	418	296,688	9.6	33,844
Upper Hamma Hamma (12054500)	33,035	98	268,659	364	258,024	3.9	10,635
Upper NF Skokomish (12056500)	36,014	149	448,279	511	362,395	28.6	85,884
Lower Catchments							
Jefferson Creek (12054600)	13,791	101	116,270	153	108,651	6.6	7,619
Lower Skokomish Near Potlatch	21,998	102.60	188,074	350	248,356	-32.9	-60,283
NF Skokomish Near Potlatch (12059500)[2]	75,040	126	785,729	114	80,954		
Upper SF Skokomish (12060500)	48,798	139	563,988	751	532,747		31,241

Note: 1) Evapotranspiration is the residual of precipitation minus streamflow

2) Streamflow has been influenced by the Cushman Dam

3) Lower Skokomish excludes flows from the south or north forks of the Skokomish

TABLE 6-2

Unit Evapotranspiration by Catchment

Sub-basin/Catchment	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cushman	0.01	0.02	0.04	0.07	0.12	0.15	0.18	0.17	0.13	0.07	0.03	0.01
Jefferson (12054600)	0.01	0.02	0.04	0.07	0.12	0.16	0.18	0.17	0.13	0.07	0.03	0.01
Lilliwaup	0.02	0.03	0.05	0.07	0.11	0.15	0.17	0.16	0.12	0.07	0.03	0.02
Skokomish Lower	0.02	0.03	0.05	0.07	0.11	0.15	0.17	0.16	0.12	0.07	0.03	0.02
Skokomish, Lower NF	0.02	0.03	0.05	0.08	0.11	0.15	0.17	0.16	0.12	0.07	0.03	0.02
Skokomish, SF	0.01	0.03	0.04	0.07	0.12	0.15	0.17	0.16	0.12	0.07	0.03	0.02
Upper Cushman (12056500)	0.00	0.02	0.03	0.06	0.12	0.15	0.19	0.18	0.14	0.08	0.02	0.01
Upper Dosewallips (12053000)	0.00	0.00	0.00	0.07	0.12	0.17	0.20	0.19	0.15	0.08	0.02	0.00
Upper Duckabush (12054000)	0.00	0.00	0.03	0.06	0.12	0.16	0.20	0.19	0.14	0.08	0.02	0.00
Upper Hamma Hamma (12054500)	0.00	0.01	0.03	0.07	0.12	0.16	0.19	0.18	0.14	0.08	0.02	0.00
Upper SF Skokomish (12060500)	0.01	0.03	0.04	0.07	0.12	0.15	0.18	0.17	0.12	0.07	0.03	0.02

TABLE 6-3

Average Monthly Streamflow and Unit Monthly Streamflow

USGS Gaging Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Monthly Streamflow (acre-feet)													
Duckabush Near Brinnon (12054000)	17,038	29,148	36,244	29,890	30,404	22,665	23,902	33,655	33,560	21,795	10,138	8,248	296,688
Jefferson Creek Near Eldon (12054600)	17,701	13,758	10,958	9,089	7,947	5,751	2,884	1,547	1,998	6,924	12,935	17,159	108,651
Unit Streamflow (fraction of annual streamflow)													
Duckabush Near Brinnon (12054000)	0.06	0.10	0.12	0.10	0.10	0.08	0.08	0.11	0.11	0.07	0.03	0.03	1.00
Jefferson Creek Near Eldon (12054600)	0.16	0.13	0.10	0.08	0.07	0.05	0.03	0.01	0.02	0.06	0.12	0.16	1.00

Source: USGS

TABLE 6-4

Monthly Water Balance Summary By Sub-basin

Sub-basin	Balance Component	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Cushman														
	Precipitation	63,633	90,551	120,438	115,886	73,678	71,649	39,635	22,663	17,665	10,490	10,144	27,066	663,498
	ET	3,967	1,382	590	408	1,010	2,014	3,581	6,210	8,053	9,661	9,148	7,007	53,030
	Streamflow	44,845	20,860	16,972	35,058	59,975	74,577	61,501	62,560	46,635	49,181	69,250	69,054	610,468
Dosewallips														
	Precipitation	42,787	79,742	87,642	66,704	60,711	61,250	33,767	28,067	20,641	10,878	11,689	17,166	521,046
	ET	5,234	1,447	221	199	352	808	4,468	8,025	11,081	12,978	12,230	9,392	66,434
	Streamflow	32,644	22,093	22,693	34,258	46,856	53,890	44,479	44,322	32,916	32,451	43,905	44,105	454,612
Duckabush														
	Precipitation	31,877	56,823	63,142	52,762	44,743	43,383	23,983	17,673	13,178	7,140	7,215	13,399	375,319
	ET	3,217	961	165	166	275	1,271	2,782	4,962	6,743	7,930	7,493	5,712	41,677
	Streamflow	24,168	14,380	13,843	22,863	33,774	40,011	33,013	33,162	24,664	24,983	34,366	34,416	333,642
Hamma Hamma														
	Precipitation	43,885	83,924	86,912	81,740	67,045	60,751	33,044	23,035	16,890	8,927	9,360	20,012	535,525
	ET	4,767	1,820	652	590	1,119	2,555	4,660	7,658	10,310	11,894	11,146	8,286	65,457
	Streamflow	32,319	35,351	42,639	50,967	52,631	52,582	43,473	41,506	30,578	25,594	30,781	31,647	470,069
Lilliwaup														
	Precipitation	22,109	36,333	42,408	38,611	28,681	26,286	14,516	8,499	6,221	3,359	4,030	9,638	240,690
	ET	2,379	1,111	585	590	972	1,602	2,547	3,896	5,206	5,896	5,490	4,026	34,301
	Streamflow	13,152	24,570	32,594	33,624	26,135	20,815	17,266	15,096	10,924	5,478	2,939	3,796	206,389
Skokomish Lower														
	Precipitation	10,443	18,724	20,263	19,070	14,713	12,639	7,538	4,392	3,268	1,746	2,265	4,997	120,058
	ET	1,143	541	303	315	483	785	1,233	1,869	2,500	2,829	2,630	1,948	16,577
	Streamflow	6,594	12,319	16,342	16,858	13,103	10,436	8,657	7,569	5,477	2,747	1,474	1,903	103,481
Skokomish, Lower NF														
	Precipitation	10,990	17,534	20,984	18,925	13,902	12,551	7,056	3,961	2,885	1,561	1,849	4,616	116,813
	ET	1,077	492	266	278	443	740	1,166	1,754	2,345	2,649	2,460	1,819	15,489
	Streamflow	6,457	12,062	16,002	16,507	12,830	10,219	8,476	7,411	5,363	2,689	1,443	1,864	101,324
Skokomish, SF														
	Precipitation	73,721	99,648	135,813	123,684	81,510	77,226	43,454	23,925	18,861	10,961	12,296	29,043	730,143
	ET	4,784	2,020	1,070	946	1,783	2,916	4,765	7,672	9,943	11,624	10,949	8,232	66,705
	Streamflow	42,278	78,981	104,775	108,083	84,010	66,909	55,500	48,527	35,115	17,610	9,448	12,203	663,438
Upper Mason														
	Precipitation	6,382	11,633	12,224	11,461	9,051	7,981	4,538	2,927	2,214	1,217	1,549	3,111	74,289
	ET	3,364	1,824	1,329	1,331	1,631	2,524	3,565	4,710	3,348	1,472	619	325	26,043
	Streamflow	1,583	2,763	4,337	4,616	3,469	3,168	3,105	1,513	964	711	546	778	27,553
WRIA 16														
	Precipitation	305,828	494,914	589,826	528,842	394,034	373,716	207,530	135,139	101,824	56,279	60,399	129,049	3,377,380
	ET	29,931	11,597	5,181	4,823	8,067	15,214	28,767	46,757	59,528	66,934	62,164	46,747	385,712
	Streamflow	204,040	223,380	270,198	322,835	332,783	332,606	275,471	261,667	192,635	161,444	194,152	199,765	2,970,975

Note: The 20,693 AF discrepancy in the WRIA 16 total water balance is the result of using a different approach on the Upper Mason water balance. The 20,693 AF represents the underflow groundwater component, which was incorporated into the streamflow component of the other WRIA 16 sub-basins.

TABLE 7-1

WRIA 16 Summary of Water Rights Documents

Purpose of Use	Total	Administratively Issued Rights		Claims			Applications		Percent
		Certificate	Permit	Claim/L	Claim/S	Claim/[a]	New Water	Change	
Domestic	963	349	11	328	239	1	35		72%
Irrigation	291	83	1	71	122	10	4		22%
Other Uses[b]	29	2		10	6	4	2	5	2%
Municipal	9	6					3		1%
Non-Consumptive[c]	38	33	3				2		3%
Total	1,330	473	15	791			46	5	100%
Percent	100%	36%	1%	59%			3%	0.4%	

Notes:

a. Claims filed during last claim registration period (September 1, 1997 through June 30, 1998).

b. Other uses include commercial-industrial, recreation, and stock. Changes and some claims do not have a purpose of use listed and are included as other.

c. Non-consumptive or rarely applied use includes power, fish, and fire.

d. Data source: Washington State Department of Ecology, WRATS (Water Rights Application Tracking System), August 2001.

TABLE 7-2

WRIA 16 Water Right Annual and Instantaneous Permitted Quantities

Purpose of Use	Groundwater Certificates and Permits				Surface Water Certificates and Permits			
	MU	**IR**	**D***	**Other**	**MU**	**IR**	**D***	**Other**
Number of Documents	5	12	141	1	1	72	219	1
Percent without Qa	0%	0%	2%	0%	100%	68%	63%	100%
Mean Qa (AF/yr)	51	52	25	10	-	44	6	-
Median Qa (AF/yr)	38	15	8	-	-	8	1	-
Mean Qi/Qa (cfs/AF/yr)	0.0091	0.0144	0.0338	0.012	-	0.0334	0.0305	-
Median Qi/Qa (cfs/AF/yr)	0.0040	0.0085	0.0116	-	-	0.0075	0.0100	-
Mean Irrigated Acres	-	25.1	-	-	-	10.6	-	-
Median Irrigated Acres	-	4.5	-	-	-	2.0	-	-
Mean Water Duty (AF/yr)	-	2.3	-	-	-	2.4	-	-
Median Water Duty (AF/yr)	-	1.9	-	-	-	2.0	-	-

Note:

Purpose of use: MU - municipal
IR - irrigation
D* - domestic
Other - includes commercial industrial, stock, recreation.

TABLE 7-3

Subbasin Water Allocation by Document Type

Document Type	Cushman	Dosewallips	Duckabush	Hamma Hamma	Lilliwap	Lower Skokomish	Mason	North Fork Skokomish	South Fork Skokomish	Subtotal
Number of Documents										
Groundwater										
Applications	3	8	4	2	6	2	9	1		35
Changes						1		1		2
Certificates	9	26	5	18	35	8	33	4	2	140
Claim/						2		3		5
Claim/L	3	55	62	14	33	49	89	5	15	325
Claim/S		49	32	13	39	46	98	1	9	287
Permit		1			3	3	1			8
Subtotal Groundwater	15	139	103	47	116	111	230	15	26	802
Surface Water										
Applications	2	2		1	1	2	1			9
Changes		1	1	1	1	1	1			6
Certificates	6	27	16	34	56	41	80	4	3	267
Claim/					1	6				7
Claim/L	4	6		6	9	12	23		1	61
Claim/S	2	15	11	5	11	6	17			67
Permit		1				2	1			4
Subtotal Surface Water	14	52	28	47	79	70	123	4	4	421
TOTAL	**29**	**191**	**131**	**94**	**195**	**181**	**353**	**19**	**30**	**1,223**
Acre-Feet per Year										
Groundwater										
Applications										0
Changes										0
Certificates	208	410	14	310	1,229	189	767	239	38	3,404
Claim/						43		255		298
Claim/L	6	181	156	58	98	2,725	204	318	1,105	4,851
Claim/S		29	16	8	20	24	49	1	5	151
Permit		25			76	25	10			135
Subtotal Groundwater	214	645	186	376	1,423	3,005	1,030	813	1,147	8,839
Surface Water										
Applications										0
Changes					18	150				168
Certificates	364	237	63	294	934	1,443	613	414	471	4,831
Claim/					10	523				533
Claim/L	8	28		16	76	1,168	54		44	1,394
Claim/S	1	9	6	3	6	4	9			36
Permit		1				314	0			315
Subtotal Surface Water	373	274	68	313	1,026	3,452	675	414	515	7,109
TOTAL	**587**	**919**	**254**	**688**	**2,449**	**6,457**	**1,705**	**1,226**	**1,662**	**15,947**

TABLE 7-4

Subbasin Water Allocation by Purpose of Use

Groundwater (Acre-Feet per Year)										
Purpose of Use	Cushman	Dosewallips	Duckabush	Hamma Hamma	Lilliwap	Lower Skokomish	Mason	North Fork Skokomish	South Fork Skokomish	Subtotal
Municipal		38			176		14			228
Domestic	214	503	135	322	1,194	238	963	246	24	3,839
Irrigation		104	49	35	47	2,767	53	565	1,122	4,740
Other		0	3	19	6	0	0	2	2	32
Subtotal Groundwater	214	645	186	376	1,423	3,005	1,030	813	1,147	8,839
Surface Water (Acre-Feet per Year)										
Purpose of Use	Cushman	Dosewallips	Duckabush	Hamma Hamma	Lilliwap	Lower Skokomish	Mason	North Fork Skokomish	South Fork Skokomish	Subtotal
Municipal						0		125		125
Domestic	363	121	35	191	888	959	454	1	340	3,352
Irrigation	10	150	33	122	131	2,306	219	288	175	3,434
Other		3	1	0	24	337	3			367
Subtotal Surface Water	373	274	68	313	1,044	3,602	675	414	515	7,277
TOTAL	**587**	**919**	**254**	**688**	**2,467**	**6,607**	**1,705**	**1,226**	**1,662**	**16,115**

Groundwater (Number of Documents)										
Purpose of Use	Cushman	Dosewallips	Duckabush	Hamma Hamma	Lilliwap	Lower Skokomish	Mason	North Fork Skokomish	South Fork Skokomish	Subtotal
Municipal		1			3		1			5
Domestic	15	110	93	40	92	68	192	9	13	632
Irrigation		27	8	6	19	42	36	4	12	154
Other		1	2	1	2	1	1	2	1	11
Subtotal Groundwater	15	139	103	47	116	111	230	15	26	802
Surface Water (Number of Documents)										
Purpose of Use	Cushman	Dosewallips	Duckabush	Hamma Hamma	Lilliwap	Lower Skokomish	Mason	North Fork Skokomish	South Fork Skokomish	Subtotal
Municipal						2		1		3
Domestic	13	42	14	36	54	31	90	1	1	282
Irrigation	1	7	12	10	20	30	30	2	3	115
Other		3	2	1	5	7	3			21
Subtotal Surface Water	14	52	28	47	79	70	123	4	4	421
TOTAL	**29**	**191**	**131**	**94**	**195**	**181**	**353**	**19**	**30**	**1,223**

Water Right Applications (sorted by TRS)

Water Right Number	Name	Purpose of Use	Instantaneous Quantity	TRS
Applications for New Rights				
Groundwater			**(gpm)**	
G2-30060	NORDSTROM, JOHN		400	T21N/R03W-03
G2-29131	BUSH, RONALD	DM	40	T22N/R02W-14
G2-28717	TWANOH HEIGHTS COMMU	DM	100	T22N/R02W-21
G2-28718	TWANOH HEIGHTS COMMU	DM	100	T22N/R02W-21
G2-28969	JOHNSON, JACK		100	T22N/R02W-22
G2-29376	OLYMPIC WATER CO,	DM	60	T22N/R02W-23
G2-29315	MASON CNTY PUD 1,	DM	340	T22N/R03W-32
G2-29491	MASON CNTY PUD 1,	DM	240	T22N/R03W-32
G2-29639	SCHIRMER, WILLIAM	DS	20	T22N/R03W-34
G2-29837	GLEN AYR CANAL RESOR	DM	50	T22N/R4W- 1
G2-29384	LAKE CUSHMAN MAINTEN	DM	445	T22N/R4W- 4
G2-29381	LAKE CUSHMAN MAINTEN	DM	445	T22N/R4W- 5
G2-29203	FAITH GARDENS,	IR	34.8	T22N/R4W-14
G2-29963	MASON CNTY PUD 1,	MU	250	T22N/R4W-14
G2-29168	ROBERTS-JACKSON & AS	DM	150	T22N/R4W-26
G2-21939	MASON CNTY PUD 1,	DM	75	T22N/R4W-35
G2-28394	HENRY D. NELSON, SQU	DM	150	T23N/R3W- 3
G2-29997	COLONY SURF CLUB,	DM	300	T23N/R3W- 9
G2-29382	LAKE CUSHMAN MAINTEN	DM	400	T23N/R4W-18
G2-29385	LAKE CUSHMAN MAINTEN	DM	280	T23N/R4W-29
G2-28730	BEACON POINT CO, REI	DM	65	T24N/R3W- 1
G2-28861	MOJI, YOKIMURI	DM	13	T25N/R2W- 2
G2-29233	JOHNSTON, STAN	DM	20	T25N/R2W- 2
G2-29063	HAMILTON, JOHN	DM	60	T25N/R2W- 7
G2-29472	HYDE, MIKE	IR	15	T25N/R2W-10
G2-29065	TUDOR, LINDA	DM	46	T25N/R2W-15
G2-29237	SILSBEE, DONALD	CI	26	T25N/R2W-15
G2-29839	JEFFERSON CNTY PUD 1	DM	300	T25N/R2W-16
G2-29988	DUCKABUSH WATER GROU	DM	10	T25N/R2W-16
G2-29605	OLYMPIC CANAL MAINTE	DM	18	T25N/R2W-21
G2-28464	JEFFERSON CNTY PUD 1	DM	100	T25N/R2W-31
G2-29143	BAISCH, JOSEPH	IR	20	T26N/R2W-29
G2-29994	SCHWEIGER, RICHARD	IR	40	T26N/R2W-33
G2-29265	JEFFERSON CNTY PUD 1	DM	70	T26N/R2W-34
		TOTAL:	**4782.8**	
Surface Water			**(cfs)**	
S2-29518	LAAKSO, ROBERTA	DS	0.03	T22N/R03W-34
S2-27419	TACOMA CITY, BROOKSH	PO	1500	T22N/R4W- 5
S2-28280	HOODSPORT WINERY INC	DM	0.02	T22N/R4W-14
S2-27420	TACOMA CITY, BROOKSH	PO	1700	T22N/R4W-16
S2-28890	SPRAGG, TERRY	MU	2720	T22N/R4W-26
S2-28891	SPRAGG, TERRY	MU	2720	T22N/R4W-26
S2-29274	HAYNIE, RICHARD	DS	0.02	T23N/R4W-19
S2-29832	ANDERSON, DENNIS	DS	0.02	T23N/R4W-32
S2-29817	WILLIAMS, GERALD	DS	0.01	T25N/R2W-29
S2-29153	GOODWIN, CAROL	DS	0.01	T26N/R3W-23
S2-29367	JAHNS, THOMAS	DS	0.02	T26N/R3W-25
		TOTAL:	**8640.13**	
Change Applications				
Groundwater				
CG2-28583	WILEY, RICHARD			T21N/R4W-13
CG2-*07380	TRAILS END WATER DIS			T22N/R02W-23
CG2-00420	TRAILS END WATER DIS			T22N/R02W-23
CG2-00897	LAKE CUSHMAN CO,			T22N/R4W-16
Surface Water				
CS2-*01745	SUNNY BEACH WATER,			T22N/R03W-33
CS2-*09169	HAMA HAMA CO,			T24N/R3W-27
CS2-23789C	CLARKSON JOE,			T25N/R2W- 8
CS2-00753	DUCKABUSH PARK ASSOC			T25N/R2W-16

TABLE 8-1

Public Water Systems (PWS)

Sub-Basin	Group A		Group B		Total	
	Residential Population	No. of PWS	Residential Population	No. of PWS	Residential Population	No. of PWS
Cushman	3,211	5	0	0	3,211	5
Dosewallips	367	10	151	22	518	32
Duckabush	17	4	42	6	59	10
Hamma Hamma	279	10	46	0	325	10
Lilliwaup	858	17	145	21	1,003	38
Skokomish, Lower	197	9	140	20	337	29
Skokomish, Lower N.F.	0	1	0	1	0	2
Skokomish, S.F.	5	3	23	3	28	6
Upper Mason	3,129	23	482	48	3,611	71
Totals	**8,063**	**82**	**1,029**	**121**	**9,092**	**203**

TABLE 8-2

1990 and 2000 Census Data

Sub-Basin	1990 Census	2000 Census
Cushman	190	272
Dosewallips	514	589
Duckabush	309	365
Hamma Hamma	319	299
Lilliwaup	1,075	1,106
Skokomish, Lower	989	1,351
Skokomish, Lower N.F.	495	786
Skokomish, S.F.	212	208
Upper Mason	2,139	2,772
Totals	**6,242**	**7,748**

TABLE 8-3

PWS and Exempt Well Population

Sub-Basin	2000 Census Data Population	Residential Population Served by PWS	Higher Number Census or PWS Data	Residential Population on Exempt Wells
Cushman	272	3,211	3,211 *	NA
Dosewallips	589	518	589	71
Duckabush	365	59	365	306
Hamma Hamma	299	325	299 *	NA
Lilliwaup	1,106	1,003	1,106	103
Skokomish, Lower	1,351	337	1,351	1,014
Skokomish, Lower N.F.	786	0	786	786
Skokomish, S.F.	208	28	208	180
Upper Mason	2,772	3,611	3,611 *	NA
Totals	**7,748**	**9,092**	**11,526**	**2,460**

*Residential population served by PWS, greater than 2000 Census data.

TABLE 8-4

Current 2000 Public Water Systems (PWS) and Exempt Well Water Use

Sub-Basin	Sub-Basin Area (mile^2)	2000 Population	Per Capita Water Use (gallons/yr)*	Per Capita per Year Water Use (AF/yr)	Population on PWS	PWS Water Use (AF/yr)	Exempt Well Population**	Exempt Well Water Use (AF/yr)	Total Water Use (AF/yr)	Total Water Use Population Based (AF/yr)
Cushman	92.8	272	43,800	0.13	3,211	417	NA	0	417	35
Dosewallips	131.0	589	43,800	0.13	518	67	71	9	76	76
Duckabush	81.6	365	43,800	0.13	59	8	306	40	48	48
Hamma Hamma	117.5	299	43,800	0.13	325	42	NA	0	42	39
Lilliwaup	54.8	1,106	43,800	0.13	1,003	130	103	13	143	143
Skokomish, Lower	32.4	1,351	43,800	0.13	337	44	1,014	132	176	176
Skokomish, Lower N.F.	24.6	786	43,800	0.13	0	0	786	102	102	102
Skokomish, S.F.	104.3	208	43,800	0.13	28	4	180	27	31	31
Upper Mason	29.1	2,772	43,800	0.13	3,611	469	NA	0	469	360
Totals	**668.1**	**7,748**			**9,092**	**1,181**	**2,460**	**323**	**1,504**	**1,010**

*Assumes no conservation. Per capita water use was assumed at 120 gpdpc.

**Refer to Chapter 8 of the text for discussion related to entry for population on exempt wells is NA, it was assumed that the total population is on purveyor systems, for these sub basins.

TABLE 8-5

Projected 2010 Water Use

Sub-Basin	1990 Census	2000 Census	Increase/ Decrease	10-year Percent Increase	Projected 2010 Population	Projected per Capital Water Use (gal/yr)	Per Capita Water Use (AF/yr)	Total Water Use (AF/yr)
Cushman	190	272	82	43.2%	390	43,800	0.13	51
Dosewallips	514	589	75	14.6%	674	43,800	0.13	88
Duckabush	309	365	56	18.1%	431	43,800	0.13	56
Hamma Hamma	319	299	-20	-6.3%	280	43,800	0.13	36
Lilliwaup	1,075	1,106	31	2.9%	1,138	43,800	0.13	148
Skokomish, Lower	989	1,351	362	36.6%	1,844	43,800	0.13	240
Skokomish, NF	495	786	291	58.8%	1,248	43,800	0.13	162
Skokomish, SF	212	208	-4	-1.9%	204	43,800	0.13	27
Upper Mason	2,139	2,772	633	29.6%	3,593	43,800	0.13	467
Total	**6,242**	**7,748**	**1,506**	**24.1%**	**9,802**			**1,275**

TABLE 9-1

Water Quality Standards for Freshwater (WAC 173-201A)

Parameter	**Class AA**	**Class A**	**Lake Class**
Fecal Coliform	Geometric mean <50 colonies /100 mL and <10% of samples >100 colonies/100 mL	Geometric mean <100 colonies /100 mL and <10% samples >200 colonies/100 mL	Geometric mean <50 colonies /100 mL and <10% of samples >100 colonies/100 mL
Dissolved Oxygen	>9.5 mg/L	>8.0 mg/L	No measurable change from natural condition
Total Dissolved Gas	<110% of saturation	<110% of saturation	<110% of saturation
Temperature	<16.0 C or if > 16 C due to natural conditions, no human-caused increases of 0.3 C. Point source activities shall not exceed t=23/(T+5), Non-point source activities shall not exceed 2.8 C	<18.0 C or, if >18 C due to natural conditions, no human-caused increases of 0.3 C. Point source activities shall not exceed t=28/(T+7), Non-point source activities shall not exceed 2.8 C	No measurable change from natural condition
pH	6.5 - 8.5 with a human-caused variation of <0.2 within the range	6.5 - 8.5 with human-caused variation of <0.5 within the range	No measurable change from natural condition
Turbidity	<5 NTU over background (50 NTU or less) or <10% increase when background is >50 NTU	<5 NTU over background (50 NTU or less) or <10% increase when background is >50 NTU	<5 NTU over background
Toxic, radioactive, or deleterious material	Below levels which adversely affect characteristic water uses, biota, or public health	Below levels which adversely affect characteristic water uses, biota, or public health	Below levels which adversely affect characteristic water uses, biota or public health
Aesthetic values	No impairment that offends sight, smell, touch, or taste	No impairment that offends sight, smell, touch, or taste	No impairment that offends sight, smell, touch, or taste

t = maximum permissible temperature increase measured at a mixing zone boundary.

T = background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

* Detailed criteria for toxic and radioactive material is presented in WAC 173-201A-040.

TABLE 9-2

Water Quality Standards for Marine Water (WAC 173-201A)

Parameter	Class AA	Class A
Fecal Coliform	Geo. Mean <14 colonies/100 mL and <10% of samples >43 colonies/100 mL	Geo. Mean <14 colonies/100 mL and <10% of samples >43 colonies/100mL
Dissolved Oxygen	>7.0 mg/L or, if <7 mg/L due to natural conditions, then human-caused degradation must be <0.2 mg/L	>6.0 mg/L or, if <6 mg/L due to natural conditions, then human-caused degradation must be <0.2 mg/L
Temperature	<13.0 C or, if >13 C due to natural conditions, no human-caused increases of 0.3 C. Point source activities shall not exceed t=8/(T-4), Non-point source activities shall not exceed 2.8 C	<16.0 C or, if >16 C due to natural conditions, no human-caused increases of 0.3 C. Point source activities shall not exceed t=12/(T-2), Non-point source activities shall not exceed 2.8 C
pH	7.0 - 8.5 with a human-caused variation of <0.2 within the range	7.0 - 8.5 with human-caused variation of <0.5 within the range
Turbidity	<5 NTU over background (50 NTU or less) or <10% increase when background is >50 NTU	<5 NTU over background (50 NTU or less) or <10% increase when background is >50 NTU
Toxic, radioactive, or deleterious material*	Below levels which adversely affect characteristic water uses, biota, or public health	Below levels which adversely affect characteristic water uses, biota, or public health
Aesthetic values	No impairment that offends sight, smell, touch, or taste	No impairment that offends sight, smell, touch or taste

t = maximum permissible temperature increase measured at a mixing zone boundary.

T = background temperature as measured at a point or points unaffected by the discharge an of the highest ambient water temperature in the vicinity of the discharge.

* Detailed criteria for toxic and radioactive material is presented in WAC 173-201A-040.

TABLE 9-3

1998 Section 303(d) List

WRIA	Waterbody Name	Parameter	Lat., Long.	New ID #	Old ID #
16	**Great Bend/Lynch Cove**	**Dissolved Oxygen**	**47.355N, 123.025W**	390KRD	WA-PS-0260
16	**Great Bend/Lynch Cove**	Fecal Coliform	**47.425N, 122.855W**	390KRD	WA-PS-0261
16	**Great Bend/Lynch Cove**	pH	**47.355N, 123.025W**	**390KRD**	WA-PS-0262
16	Hood Canal (South)	Fecal Coliform	47.645N, 122.925W	390KRD	WA-PS-0250
16	Hood Canal (South)	Fecal Coliform	47.645N, 122.935W	390KRD	WA-PS-0250
16	Hood Canal (South)	Fecal Coliform	47.685N, 122.895W	390KRD	WA-PS-0250
			TRS		
16	Hunter Creek	Fecal Coliform	T21N R04W S17	No-ID	WA-16-1016
16	Purdy Creek	Fecal Coliform	T21N R04W S14	MJ89JI	WA-16-1013
16	Purdy Creek	Fecal Coliform	T21N R04W S15	MJ89JI	WA-16-1013
16	Skokomish River	Fecal Coliform	T21N R03W S7	WW06HB	WA-16-1010
16	Skokomish River	Fecal Coliform	T21N R04W S12	WW06HB	WA-16-1010
16	Skokomish River	Fecal Coliform	T21N R04W S15	WW06HB	WA-16-1010
16	Skokomish River, N.F.	Instream Flow	T22N R04W S16	BH48GW	WA-16-1020
16	Ten Acre Creek	Fecal Coliform	T21N R04W S16	No-ID	WA-16-1015
16	Weaver Creek	Fecal Coliform	T21N R04W S16	No-ID	WA-16-1014
14	Happy Hollow Creek	Fecal Coliform	T22N R02W S22	No-ID	WA-14-2030
14	Twanoh Falls Creek	pH	T22N R02W S21	HL04LK	WA-14-2010
14	Unnamed Creek	pH	T22N R02W S22	No-ID	WA-14-2020

TABLE 9-4

Effects of pH Range on Aquatic Species

pH	Effects on Aquatic Species
3.0 - 3.5	Unlikely that fish can survive for more than a few hours
3.5 - 4.0	Known to be lethal to all salmonid
4.0 - 4.5	All fish, most frogs and insects not present
4.5 - 5.0	Most fish eggs won't hatch; mayfly and other insect species not found
5.0 - 5.5	Bottom dwelling decomposing bacteria begin to die off; plankton begin to disappear
6.0 - 6.5	Freshwater shrimp not present
6.5 - 8.5	Optimal for most organisms
8.5 - 9.0	Unlikely to be harmful to fish, but indirect effects from chemical changes to water may occur
9.0 - 10.5	Harmful to perch and salmonids if prolonged exposure
10.5 - 11.0	Prolonged exposure lethal to carp and perch
11.0 - 11.5	Lethal to all fish species

North Carolina State University 1998