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RIVER AND STREAM IMPAIRMENT ANALYSIS

WRIA 16 and 14b, Skokomish-Dosewallips Planning Area

Prepared for: WRIA 16 Planning Unit

Project No. 080261-001-03 • June 30, 2009

Funded through a Dept. of Ecology Watershed Planning Grant, #G0800033

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Acronyms

ADU	accessory dwelling unit
afy	acre-feet/year
AMDT	Average Maximum Daily Temperature
CIR	Crop Irrigation Requirement
DEM	Digital Elevation Model
DM	domestic multiple
DS	domestic single
DO	Dissolved Oxygen
Ecology	Washington State Department of Ecology
ERU	equivalent residential unit
ESA	Endangered Species Act
ESU	evolutionary significant unit
FS	fishery
GIS	Geographic Information System
gpd	gallons per day
gpdpc	gallons per day per capita
HCCC	Hood Canal Coordinating Council
HCDOP	Hood Canal Dissolved Oxygen Program
HCSEG	Hood Canal Salmon Enhancement Group
IMAT	Instantaneous Maximum Annual Temperature
IR	irrigation
LiDAR	Light Detection and Ranging
LLTK	Long Live The Kings
LWD	Large Woody Debris
MRLC	Multi-Resolution Land Characteristics Consortium
MU	municipal

NLCD	Nation Land Cover Dataset
NMFS	National Marine Fisheries Service
PGST	Port Gamble S'Klallam Tribe
PNPTC	Point No Point Treaty Council
PO	power
PSAT	Puget Sound Action Team
PSP	Puget Sound Partnership
PU	Planning Unit
PUDs	public utility districts
PWS	Public water system
Qa	annual quantity
Qi	instantaneous flow
QQ	quarter-quarter
Reservation	Skokomish Reservation
RFEG	Regional Fisheries Enhancement Group
RR	rural residential
RT	rural tourist
SaSI	Salmonid Stock Inventory
SaSSI	Salmon and Steelhead Stock Inventory
SEG	Salmon Enhancement Group
SSHEAR	Salmon Screening, Habitat Enhancement and Restoration
SSHIAP	Salmon and Steelhead Habitat Inventory Assessment Project
SRFB	Salmon Recovery Funding Board
TAGs	technical advisory groups
TRS	township-range-section
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Society

WDFW	Washington State Department of Fish and Wildlife
WDNR Resources	Washington State Department of Natural
WDOH	Washington State Department of Health
WOFM	Washington State Office of Financial Management
WRIA	Water Resource Inventory Area
WRTS	Water Rights Tracking System
WSCC	Washington State Conservation Commission

Executive Summary

This study analyzes existing hydrologic, habitat, and water use data to provide a relative characterization of the potential for stream impairment within Water Resource Inventory (WRIA) 16/14b. WRIA 16 and 14b are located along the west and south shores of Hood Canal (Figure 1). A tandem study examining aggradation potential within WRIA 16/14b streams was also performed under this contract and results are reported in Appendix D of this document.

The objective of this study is to provide a relative ranking of subbasins and stream reaches within the WRIA based on salmonid habitat conditions and the potential for streamflow impacts resulting from future groundwater withdrawals. The system for stream impairment ratings developed in this document provide a relative ranking of basins and a dynamic screening tool to prioritize future actions within the WRIA.

The method used to assess stream impairment included:

- Quantitatively characterize habitat conditions by stream reach;
- Rate potential impact of water use on streamflow; and
- Combine the above ratings of habitat condition and streamflow impact in order to provide an overall assessment of the relative potential for stream impairment.

Basic data was compiled from Washington State Department of Ecology (Ecology), Washington State Department of Health (WDOH), Hood Canal Coordinating Council (HCCC), Hood Canal Dissolved Oxygen Program (HCDOP), Mason and Jefferson Counties, the Skokomish Tribe, Washington State Conservation Commission (WSCC), Washington State Department of Fish and Wildlife (WDFW), consultant reports, and other sources. Geographic Information System (GIS) datasets from these sources were combined into a GIS database. The GIS database and this report are the principal deliverables for this project. No field work was performed as part of this investigation.

Salmonid habitat conditions were evaluated primarily using WSCC Salmon and Steelhead Limiting Factors Analyses (Correa, 2003 and Kuttel, 2003). These studies assessed up to 18 parameters per stream reach using a poor, fair, or good system. Habitat parameters were then weighted and used to develop overall habitat condition ratings by stream reach. Approximately 22% of streams (by length) within the WRIA received a habitat rating of good, 33% received fair ratings, 28% received poor ratings, and 17% had insufficient data for evaluation. All streams in the South Shore basin were ranked as poor habitat condition, while mixed conditions existed in the other subbasins.

Current water use in the WRIA was estimated using both population- and source-based methods. The source-based method is considered to provide the better estimate as it accounts for nonresidential uses. From these analyses, total current water withdrawals in the WRIA 16/14b study area are estimated at 2,300 acre-feet/year (afy) and consumptive use is estimated at 1,000 afy. Irrigation withdrawals were estimated at about 280 afy. The

water use estimates are sensitive to assumptions regarding irrigation of agricultural lands, particularly in the Skokomish River Valley.

Estimates of **future water use** were made based on full buildout as allowed by current zoning. Full buildout water use for WRIA 16 and 14b was estimated at approximately 12,500 afy, of which an estimated 7,000 afy is consumptive. The buildout analysis required assumptions regarding some zoning classifications. Zoning regulations are prescribed for certain zoning categories such as rural residential, but allow for a wide array of land uses and parcel sizes in other zoning categories such as rural commercial. The extent to which irrigation of agriculturally zoned lands occurs in future buildout is also uncertain. Assumptions regarding buildout for the less prescribed zoning classifications and agriculture can have a significant effect on the estimated water use at buildout. In addition, no zoning maps are available for the Skokomish Reservation (Reservation) and future water use estimates were based on current parcel maps and land uses. Water use estimates for the Reservation could vary significantly from those assumed in this document and the Planning Unit may wish to revise these and other assumptions in the future with more area-specific planning information.

Evaluation of **potential streamflow impacts** would typically be done by comparison of streamflows to instream flow regulations; however, no instream flows have been set for the WRIA. In lieu of instream flow regulations, baseflow of the streams was used to place current and future groundwater consumptive use in the context of streamflow for the purpose of evaluating potential streamflow impact from these withdrawals. Baseflow was defined as the 90% exceedance value for September flows and was determined using gaged data where available and was estimated for ungaged streams by correlation to gaged basins using basin area.

Streamflow impact potential was characterized by the peak monthly consumptive use as percentage of baseflow (high >10%, moderate 5-10%, and low <5%). Under current (2008) conditions, Purdy Creek located within the Skokomish Valley had the greatest estimated peak monthly groundwater withdrawal expressed as percent of baseflow (7%), but the stream is ungaged and baseflow estimates could be biased low as the stream may receive recharge from Skokomish River losses. Three streams in the South Shore subbasin had peak monthly groundwater withdrawals between 3.5 and 6% of baseflow. Current estimated peak monthly groundwater withdrawals as a percent of baseflow were less than 3.5% in other streams in the study area.

Under future buildout conditions, the number of streams with peak monthly groundwater withdrawals exceeding 10% of baseflow increased signficantly to 13 (24%) of the subbasins analyzed.

An alogrithm was developed to evaluate the overall **potential for stream impairment**. Because of the many assumptions used for the input parameters, the rating of potential stream impairment is considered a relative ranking of streams within the WRIA, rather than an absolute scoring of the stream condition. In the alogrithm, habitat conditions and potential for streamflow impact are weighted equally. Habitat conditions of poor, fair, and good were scored 1, 2, and 3, respectively. Peak monthly groundwater withdrawals as a percent of baseflow were scored as follows (>10%=1 [high potential], , 5-10%=2 [moderate potential], and <5%=3 [low potential]). The product of the habitat condition score and the streamflow impact score was used for the overall rating. Streams scoring from 1 to 3 were considered high potential for impairment, scores of 4-6 were considered moderate potential for impairment, and scores of 7-9 as low stream impairment potential.

Under full-buildout conditions, each of the subbasins had at least one stream reach that scored as high potential for stream impairment under the future buildout analysis. The greatest concentration of streams rating with high potential for impairment was in the South Shore subbasin. Each of the eleven streams in the South Shore subbasin that were analyzed ranked high for overall potential stream impairment, with most streams scoring as poor habitat condition and high potential for streamflow impact. The least impaired subbasin under buildout conditions is the Duckabush.

The upper portions of the larger watersheds (Dosewallips, Duckabush, Hamma Hamma, Lilliwaup, and South Fork of the Skokomish (above river mile 23.5) were rated as relatively low potential for stream impairment under current and future buildout conditions. However, the lower segments of these rivers that discharge directly to Hood Canal were rated as high potential for stream impairment. Other stream segments that discharged directly to Hood Canal received a moderate or high potential for impairment.

For the 19 **public water systems** with water right and service area data, total withdrawal under buildout conditions was estimated at about 3,800 afy, compared with most recent usage estimates of about 1,300 afy. Net water right availability under buildout conditions for all 19 systems is -1,400 afy (i.e., demand exceeds water rights by 1,400 afy). Most of that shortfall, 83%, is attributable to the Lake Cushman Water System that has applied for a water right of 1,329 afy and if granted would leave a shortfall for the Lake Cushman system of about 80 afy.

At full buildout, 13 systems have net water right deficit. Six systems have an apparent excess of water right capacity at full buildout: Brinnonwold, Alderbrook, Potlatch Beach, Pleasant Tides, Highland Park, and Beacon Point.

Recommendations are provided for improving evaluation of habitat condition, and estimates of current and future water use.

These recommendations are summarized as follows:

- **General –** Develop LiDAR coverage for the entire WRIA. Current LiDAR coverage is limited to shoreline areas and currently about 75% of the WRIA has no LiDAR coverage. LiDAR is very useful for future studies where accurate topographic control is required.
- **Habitat –** About 52% of the salmonid habitat parameters used in this study have been assessed, leaving considerable data gaps, particularly considering the abundant salmonid habitat within the WRIA. In addition, several large storm events have occurred since the habitat parameters were assessed in 2003. Habitat parameters assessment should be completed and updated and the habitat ranking scores reevaluated.
- **Water Use –** The emphasis for water use recommendations is on measurement and reporting. To improve fundamental information related to water use, we recommend metering of self-supplied wells or small Group B systems to obtain

better estimates of water use where there is no fee associated with water use, more comprehensive metering and reporting by PWS, and delineation of irrigated areas and metering of irrigation quantities.

- **Future Water Use –** Water use in the future buildout analysis could be improved with better planning information. Zoning categories such as rural commercial allow a wide array of uses. A more detailed analysis of likely development scenarios on these and other zoning categories would improve the buildout water use estimate. Agricultural zoning accounts for a large portion of future water use. A detailed analysis of future land use on these parcels and the potential for irrigation would also improve water use estimates under buildout conditions.
- **Stream Impairment Assessment –** Detailed investigations of the hydrogeology of specific subbasins within the WRIA will facilitate understanding of groundwater/surface water interactions and allow a better assessment of the impacts of groundwater withdrawals on streamflows. Studies similar to the investigation undertaken on the lower Dosewallips basin (Aspect Consulting, 2005) provide fundamental information on groundwater resources including characterization of aquifers within the individual subbasins, groundwater flow paths and points of discharge, and losing/gaining characteristics of rivers and streams.
- **Interagency Partnership –** Future projects performed by the WRIA 16 PU will likely require some degree of coordination with the Puget Sound Partnership (PSP) for funding, data sharing, and planning. Coordination with other regional entities such as the Hood Canal Coordinating Council, may also be beneficial.

1 Introduction

This report presents the findings of an investigation to evaluate the relationship of groundwater withdrawals and salmonid habitat in Water Resources Inventory Areas (WRIAs) 16 and 14b. The WRIA 16 Planning Unit contracted with Aspect Consulting, LLC, to perform an analysis of river and stream impairment in the WRIA. The project objective is to:

> *Identify and prioritize stream reaches or watersheds in WRIA 16 and 14b where (1) maintenance of adequate quality and quantity of instream flows for salmonids is of concern and where (2) the instream flow may be impacted by present and future groundwater withdrawals.*

The project was intended as a screening tool to make preliminary determinations of areas that are potentially impaired and where further study/action is warranted. The study provides a relative rating of the potential for stream impairment. The product of the investigation is this report and a Geographic Information System (GIS) tool that will assist:

- The PU with prioritizing subbasins for additional hydrologic and hydrogeologic studies based upon habitat rankings and water use.
- Jefferson and Mason Counties in making future land use decisions including long range planning;
- Skokomish Tribe, Hood Canal Coordinating Council (HCCC) and other salmon enhancement groups prioritize future habitat projects; and,
- Ecology in making water rights decisions and developing future water management rules.

In addition to the central project objective, the Planning Unit (PU) also authorized Aspect Consulting to evaluate the potential for stream channel aggradation. Recent high intensity precipitation events have lead to transport and build-up of streambed gravels that result in flow becoming subsurface during low flow periods in some streams. The aggradation study is provided in Appendix D of this report.

The project location is shown on Figure 1 and the study area boundary is presented in Figure 2. WRIA 16 is located in Mason and Jefferson Counties on the western side of the Hood Canal on the Olympic Peninsula in western Washington. WRIA 14b is located in Mason County on the south shore of Hood Canal and borders WRIA 16 on its west boundary. PU responsibilities for WRIA 14b were transferred to the WRIA 16 PU under House Bill 1295. The terms WRIA and study area are used throughout this report to refer to the study area that includes WRIAs 16 and 14b.

The WRIA is divided into the following six principal subbasins:

- Dosewallips
- Duckabush
- Hamma Hamma
- Finch/Lilliwaup
- Skokomish; and
- South Shore.

The principal subbasin locations are presented on Figure 2. Subbasins were further divided into catchments for the analyses performed in this study.

No field work was performed as part of this investigation and the data analyses relied on existing information and ongoing investigations in the WRIA by Jefferson and Mason Counties, Skokomish Tribe, Port Gamble S'Klallam Tribe (PGST), HCCC, Washington State Department of Ecology (Ecology), Washington State Conservation Commission (WSCC), Mason and Jefferson County public utility districts (PUDs), consultant reports, and other sources.

This report is organized as follows:

- **Section 2, Data Sources**, presents an overview of data sources and development of the GIS tool;
- **Section 3, Water Quality and Salmonid Habitat**, reviews and analyzes existing water quality and habitat data and presents a rating of salmonid habitat conditions by stream reach within each subbasin;
- **Section 4, Water Use Estimates,** evaluates water rights, assembles data on public water systems (PWSs), and presents estimates of current water use using population-based and source-based methods. An estimate of water use at future buildout is presented based on current zoning;
- **Section 5, Habitat and Groundwater Withdrawal Assessment**, identifies and prioritizes subbasins where current and/or future groundwater withdrawals could potentially impact salmonid habitat; and,
- **Section 6, Water Systems and Demand at Buildout**, compares total water rights for public water systems within the WRIA with estimated withdrawals at future buildout;
- **Section 7, Conclusions and Recommendations,** presents study conclusions and summarizes recommendations**.**

2 Data Sources

The data used in this study include extensive spreadsheets, databases, and geospatial datasets from tribal, federal, state, and county sources, numerous WRIA 16 specific habitat and water use studies, and professional literature on salmonid habitat and water use. Not all of the compiled datasets were used in the study, but all are included with electronic metadata in electronic form.

2.1 Databases and Geospatial Datasets

Table 1 provides a list of the databases and geospatial datasets, with brief descriptions and sources, assembled for the study. More extensive metadata is included as Appendix A. The geospatial datasets contain information with location data that can be processed by a geographic information system (GIS) program. The datasets include general cartographic and land use data as well as study specific information. The former category includes topographic maps, aerial photography, elevation data (LiDAR and DEM models), hydrography, geology, land cover, roads, and zoning maps. The latter category includes fish presence and habitat information, stream gauging data, public water system and source data, well log data, water rights data.

A number of special datasets created for this study:

- Public water system service areas;
- Known aggradation and erosion sites;
- Catchment areas within the subbasins;
- Overall salmonid habitat ranking by stream reach; and
- Assessment of relative water withdrawal impacts.

These datasets will be discussed in subsequent sections with the associated analyses.

Elevation data was available as both 10 meter (m) digital elevation model (DEM) and from LiDAR (Light Detection and Ranging) model. The LiDAR data only covered areas near the shoreline. As the majority, about 75%, of the WRIA only had DEM coverage, the DEM dataset was used for uniformity of analysis.

In the implementation of this study’s analyses, every effort was made to link calculated data to parameter tables or mapping tables that provide the ability to change critical parameter values, and to update the calculated data in a streamlined and self-contained manner.

A number of databases, spreadsheets, and ArcView Model Builder Models (macros) were developed to process and tabulate data, including spreadsheets for estimation of water use and evaluation of water rights, well logs, and public water systems. These spreadsheets are setup to allow replacement of data and changes in parameters in order to allow recalculation and presentation of results with greatly reduced effort. These updates should be made as better data becomes available.

2.2 Frameworks of Analysis

While every effort was made to effectively integrate, automate, and generally streamline the methodologies developed in this study, it is essential to understand that each type of analysis is structured around, and in some cases limited by, the particulars of the analysis inputs and the framework of the methodology. The “tools” developed are, for the most part, products of the inputs designed to assist and inform a professional with a high degree of technical proficiency in spreadsheets, databases, and GIS. The particulars of each tool/framework are unique, as each type of estimate or analysis requires different inputs and produces different outputs. But most of the analyses rely, in-part, on running queries in tabular or geospatial Access databases.

In the source-based consumptive use estimate, which relies primarily on a tabular Access database, an analyst is required to first populate a table of sources by quarter-quarter section designation, their types, and counts (number or acreage). The inputs for this table can come from any sort of tabulation that is useful or available to the analyst, but in the case of well logs and water rights, Microsoft Excel pivot tables have been pre-built to readily compile the necessary information. Since the public water system data has a few more processing requirements, the Access database, that was compiled to store and view the data provided by WDOH, contains a stored query to provide input for the aforementioned source-based use estimate database table. Additional inputs are entered manually.

The system then checks a “lookup table” inside the access database for multipliers related to estimating consumptive use for each of the given inputs. The values in this table are entered by the analyst based on a provided Excel table. The analysis outputs can be readily adjusted by changing these values and re-running the appropriate queries.

The system’s final step is to automatically spatially locate the points by their quarter-quarter section designation for potential use in GIS software.

The population-based consumptive water use estimate requires running pre-built ESRI ArcView Model Builder Models with various inputs. These models require a particular add-on to ArcView from DataEast called XTools. The self contained model requires only that an analyst have prepared a number of spatial datasets and placed them with particular names into particular locations. The analyst should have a strong working knowledge of the tools contained within the model, as certain variable inputs (such as consumptive use multipliers) are hard-coded into tool properties. Though making changes to these parameters is straightforward and simple in the Model Builder interface, it does require familiarity and comfort with the software.

Buildout estimates are made by running pre-packaged queries inside an Access geodatabase front-end. Changes in the values calculated for particular zones are readily modified through a lookup table and a framework has been established to automatically include calculations for specified “exceptions”, which must be entered into the required tables. In this case, changes to the spatial parcel or zoning data will require that the analyst re-develop, re-join and re-import the new feature class of combined county zoning and parcel into the geodatabase. The database itself primarily exists in the form of the queries and auxiliary tables that streamline the analysis framework.

2.3 System Maintenance

The data that is used as model/analysis inputs in these tools may change in format in the future. Developing tools that relied heavily on automatic import and processing of existing datasets would have been relatively time consuming. Instead, analysts will be required to exercise attention in carefully assembling data, geospatial and tabular to fit within these frameworks using whatever formats are available in the future. However, the more typical scenario will be for the user to change input constants and multipliers, which is an exercise to which these tools are well suited.

As is apparent from the above descriptions, none of the analyses or frameworks are turnkey systems unto themselves. The analyses all require advanced knowledge of the supporting software as well as the data that constitute the inputs and outputs.

Efforts may be made in the future to improve the tools to accept more generic inputs and to perhaps develop user interfaces for Access databases. Additional effort could develop a turnkey framework, but the aforementioned caveats of source data format would still apply.

3 Water Quality and Salmonid Habitat

The purposes of this section are to briefly review the history of salmonid investigations, habitat assessments, and salmon stocks in WRIA 16 and 14b; to define critical parameters for characterizing habitat conditions; to evaluate habitat conditions; and to evaluate available habitat datasets for presentation of habitat conditions using GIS software.

3.1 History of Salmonid Investigations

In the mid 1980s, State and Federal agencies began an intensive assessment of the health and status of salmon in the Pacific Northwest. In 1990, the State of Washington established 14 non-profit salmon enhancement groups under the Regional Fisheries Enhancement Group (RFEG) program. The salmon enhancement groups work together with the Washington Department of Fish and Wildlife (WDFW), Washington State Conservation Commission (WSCC), Treaty Tribes of Washington, and local governments to assess and restore fish habitat within all the watersheds. The Hood Canal Salmon Enhancement Group (HCSEG) covers WRIAs 16 and 14b, along with parts of WRIAs 15 and 17.

In addition to HCSEG, the Skokomish Tribe, Long Live The Kings (LLTK) and the HCCC are active in salmon recovery efforts in Hood Canal. These groups, together with the Port Gamble S'Klallam Tribe (PGST), the Point No Point Treaty Council (PNPTC), WSCC, Ecology, DNR, PSAT, and USFS, have coordinated with WDFW in assessing the condition of the habitat in WRIA 16 as well as in planning and implementing habitat restoration projects. These groups, working with local agencies, formed watershed specific technical advisory groups (TAGs) to implement the restoration and recovery of listed species.

WSCC has produced a series of *habitat limiting factors* studies for all WRIAs throughout the state. The limiting factors study for WRIA 16 was presented by Correa (2003) and that for WRIA 14b was included in Kuttel (2003).

Chinook salmon and Hood Canal summer chum salmon were listed as threatened species in 1999, which intensified restoration and recovery efforts in the Puget Sound and Hood Canal regions. State and Federal agencies began programs to remove manmade barriers to fish migration in all of the watersheds that feed into Puget Sound. These and other recovery projects continue to be supported from both the Salmon Recovery Funding Board (SRFB), managed through the Washington State RFEG program by the Washington State Recreation and Conservation Office, and other federal, state, and local funds.

Western Washington, including Hood Canal, steelhead was listed in 2008 as Threatened under the Endangered Species Act. At the time of the most recently published habitat assessments, the WDFW SASI documents indicated steelhead status as "unknown".

3.1.1 Habitat Assessments

The presence or absence of salmonids is documented by WDFW (2002) in the Salmon and Steelhead Stock Inventory (SaSI) program, which includes the SalmonScape database. The SaSI program developed from the Salmon and Steelhead Stock Inventory (SASSI) program and include the Screening, Habitat Enhancement and Restoration (SSHEAR) and Salmon and Steelhead Habitat Inventory Assessment Project (SSHIAP). Stock status is updated on a continual basis and is maintained by WDFW.

Together with the material presented in the WSCC WRIA documents for WRIA 14b (Kuttel, 2003) and WRIA 16 (Correa, 2003), the references in this document originate in the published data described above and the referenced Tribal data or personal communications. The primary geospatial data source, i.e. data with geographical location, is the *SalmonScape* database prepared by WDFW and available through links in SaSI.

The most recent detailed evaluation of salmonid and bull trout presence and habitat conditions within specific watersheds are the Salmon and Steelhead Habitat Limiting Factors studies conducted by the Washington State Conservation Commission. Habitat conditions on the west side of Hood Canal (WRIA 16) are documented by Correa (2003) and along the south shore (WRIA 14b) by Kuttel (2003). These studies characterize habitat conditions by stream reach and provide good-fair-poor ranking of critical habitat parameters, but do not generate an overall habitat condition rating by reach. Labbe et al. (2005) performed a study on the lower Dosewallips River that combined field reconnaissance with simultaneous LiDAR and aerial photography over flights. The study (Labbe et al., 2005) provided overall ratings for individual reaches on the Dosewallips, but evaluated stream reaches using a different process than the parameter rankings in the Limiting Factors studies.

3.1.2 Salmonid Stocks

Within WRIA 16 there are seven native anadromous salmonid stocks of the genus *Oncorhynchus*: Chinook *(Oncorhynchus tshawytscha)*, chum *(O keta)*, coho *(O kisutch)*, pinks *(O gorbushca)*, steelhead *(O mykiss)*, sockeye salmon *(O nerka)*, and searun (coastal) cutthroat trout *(O clarki clarki)* (WDFW, 1998). In addition, there is an ESU (evolutionary significant unit) population of bull trout (*Salvelinus confluentus*) present in the Skokomish watershed, and presumed in the Hamma Hamma, Duckabush and Dosewallips Watersheds (Correa, 2003). Also present within the watersheds of WRIA 16 are populations of resident rainbow trout *(O mykiss)* and non-native populations of Eastern brook trout *(Salvelinus fontinalis)*.

Under the federal Endangered Species Act (ESA), listing of a population as either endangered or threatened requires actions by all the governmental agencies to protect and restore the species. These designations also put regulatory requirements in place that must be followed where any activity disrupts the normal function of the species. Within the State of Washington, the species of concern status *critical* is similar to the federal status of endangered; the state *threatened* status similar to candidate; and state *sensitive* category similar to monitored.

In 1999, Chinook salmon and Hood Canal summer chum salmon were listed as threatened under the ESA by National Marine Fisheries Service (NMFS). In 2008, steelhead populations of all of Western Washington were listed as threatened.

Within the Hood Canal populations of chum salmon, there are two distinct and separate populations. The summer chum salmon have been listed as a threatened species while the SaSI documents indicate that the fall chum are healthy in the majority of the watersheds within WRIA 16. Summer chum are present in Dosewallips, Duckabush, Hamma Hamma, and Lilliwaup subbasins. Summer chum are considered extinct in the Skokomish watershed due to a population size too small to sustain a healthy population. Fall chum are present in these watersheds as well as the Skokomish subbasin. Chinook salmon, pink salmon, coho salmon and steelhead are present in all the subbasins of WRIA 16, while sockeye salmon are found only in the Skokomish subbasin. WDFW SaSI reports indicate that Chinook salmon stocks are considered critical in the Dosewallips, Duckabush and Hamma Hamma watersheds, while within the Skokomish they are considered depressed. Coho stocks are considered healthy in the Duckabush, Skokomish and west side of Hood Canal, but their status is unknown in the Dosewallips and Hamma Hamma Rivers. Pink salmon are considered healthy in the Hamma Hamma River but depressed in the Dosewallips and Duckabush Rivers. Winter steelhead are depressed throughout WRIA 16, while summer steelhead status is unknown (Correa, 2003).

Bull trout (Dolly Varden) are a unique species of salmonid that require very cold water temperatures of less than 10 degrees C for spawning and juvenile rearing. There is a healthy population of bull trout in the Skokomish watershed and historic information indicated the presence of bull trout in the Duckabush River (WDFW, 1998). Potential habitat exists in the upper reaches of the major snow-melt dominated watersheds on the west side of Hood Canal.

Coastal cutthroat, resident cutthroat, and rainbow trout are present in WRIA 16. Coastal cutthroat trout are present or presumed present in all the streams in the study area that have no barriers to saltwater, either anthropogenic or natural. Upland streams have populations of resident cutthroat and also rainbow trout. Coastal cutthroat of West Hood Canal are considered as a unique and independent population but the status of the stock is unknown (WDFW, 2002).

3.2 Parameters Characterizing Habitat Conditions

This study characterizes salmonid habitat conditions following the Salmon and Steelhead Habitat Limiting Factors reports prepared by WSCC (Correa, 2003 and Kuttel, 2003). A set of 8 habitat conditions were defined by 18 parameters as follows:

- Fish Passage
    - Access
- Floodplain
    - Floodplain Connectivity
    - Floodplain Habitat

- Channel Conditions
  - Fine Sediment
  - Large Woody Debris (LWD)
  - Percent Pools
  - Pool Frequency
  - Pool Quality
  - Bank Stability
- Sediment Input
  - Sediment Supply
  - Mass Wasting
  - Road Density
- Riparian Zones
  - Riparian Condition
- Water Quality
  - Water Temperature
  - Dissolved Oxygen
- Flow
  - Hydrologic Maturity
  - Percent Impervious Surfaces
- Biological Processes
  - Nutrients

The protocols for habitat assessment have been established by the Technical Advisory Group for each watershed and is defined in both Correa (2003) and Kuttel (2003). It is a format addressing Best Available Science that is used by all the state and federal agencies when conducting watershed assessments.

The parameters are evaluated for each watershed, including tributary streams, and summarized on Correa (2003) and Kuttel (2003). The field surveys were conducted by the TAG members, teams from the PGST, PNPTC biologists, and HCSEG and LLTK volunteers and biologists. Reaches were evaluated as G (good), F (fair), P (poor), or DG (data gap). This score is directly related to a specific characteristic observed in the field by the individuals that documented watershed habitat as part of the watershed reach surveys. Of the 63 stream reaches evaluated in WRIA 16 and 14b, 24 reaches had less than 50% of the categories ranked.

3.3 Datasets for Geospatial Analysis:

This section lists the datasets or databases with geospatial, i.e. locational, information that can be used in GIS-based analysis. Existing geospatial datasets (Section 2) relevant to habitat conditions are as follows:

- Salmonid and bull trout presence (WDFW SalmonScape);
- Water quality (Ecology Category 5, formerly 303d, list);
- Percent impervious surface (HCCC and NLCD);
- Anthropogenic passage barriers (WDFW SalmonScape);
- Natural passage barriers (WDFW SalmonScape);
- Roads (Jefferson and Mason Counties);
- Population centers; and
- Known and potential aggradation sites.

No geospatial dataset was available that provided an overall habitat condition rating by stream reach.

3.3.1 Development of a Habitat Condition Rating for Geospatial Analysis

The available habitat data most amenable for rating stream reaches was the good-fair-poor ranking of habitat condition parameters in the limiting factors studies (Correa, 2003 and Kuttel, 2003). These rankings were weighted and summed to provide overall ratings by stream reach (Table 2), thus creating a new geospatial dataset of habitat conditions.

The data matrix for developing the reach ratings is presented in Table 2. Parameters were evaluated for all the watersheds using a scale of good (G), fair (F), and poor (P). The letter evaluations were converted to numerical values and each parameter assigned a weighting factor. Poor was assigned a value of 1 and good a value of 5. The weighting factors were adjusted to sum to 100%.

Reaches typically had 60% of parameters assessed, with a standard deviation of 15%. Relatively well evaluated watersheds (>75%) included the upper watersheds of Dosewallips and Duckabush Rivers, McDonald Creek, John Creek, South Fork of the Skokomish River, and Brown and Le Bar Creeks that are tributaries to the South Fork Skokomish River. Streams were scored by first obtaining the “perfect” score for the parameters assessed. Stream scores were expressed as a percent of the perfect score.

Scores above 90% were judged to be good habitat and above 60 % were judged to be fair habitat. These levels are chosen to provide a simplified tool for comparing scores of reaches as well as looking at impact of specific categories on the total score. For the initial assessment in this study, the major categories were given equal weights of 16.67%. The parameters within each category were equally weighted within the category (Table 2).

The resultants *raw score, habitat condition rank*, and *percentage of the assessed parameters* are shown in columns on the right side of Table 2. The spreadsheet allows simple manipulation of weighting factors to assess relative impacts of parameters. Any rating for habitat condition required evaluation of a minimum of 25% of the 18 parameters; otherwise the reach was rated "insufficient data"(id). The scores for rating habitat as good, fair, and poor were determined by comparing raw scores with known good and problematic habitat conditions.

The habitat conditions for fish passage and biological processes were given zero weight as they are indirect indicators of the functional quality of specific reaches. Passage is obviously critical for species presence or absence, but is not a direct measure of the functional quality of a stream reach. Recent research has indicated that nutrients from salmon carcasses are integrated into the woody structure of riparian vegetation and trophic levels of other organisms (Gende et al., 2007). However, nutrients (i.e. fish carcasses) relate more directly to the level of salmonid use and only indirectly to habitat quality.

Overall, 6 watersheds (10%) were rated as good, 20 (32%) as fair, and 28 (45%) as poor. Eight reaches (13%) were rated as having insufficient data (i.e. <25% of 18 parameters assessed).

3.3.2 Evaluation of Rating Scale

Raw scores were reduced to good/fair/poor habitat quality ratings by qualitative comparison of known stream conditions with the quantitative data.

The upper watersheds, above areas of logging and development, are known to have good habitat conditions. The relatively well assessed upper watersheds of the mainstem rivers received scores of "good" for the Dosewallips above the falls, for the Duckabush above the falls, the Hamma Hamma above RM 2.3, the upper Lilliwaup above RM 0.7 and for the Skokomish above the natural barrier at river mile 23.5.

Fulton Creek with 61% of parameters assessed scored 81%. This creek is considered to be an example of fair habitat condition given low level of development and impervious surfaces, but concerns with high water temperature and lack of LWD. Therefore, the boundary for fair/good was taken as a midpoint (90%) between scores for Fulton Creek and for the upper Duckabush River (81% and 100%, respectively). The criteria for distinguishing fair and poor habitats used Dosewallips upstream and downstream of RM 3.6 was used. For WRIA 14b, the South Shore of Hood Canal, streams are small, there are a number of water quality exceedances, and development is relatively extensive. Therefore, low scores and poor ratings were expected. The top score in the South Shore subbasin was 59% for Devereaux Creek. Twanoh Creek, although relatively well assessed (72%) also has a low weighted score (43%), well below many of the smaller streams in WRIA 16.

The reach of Little Lilliwaup Creek is similar in size to WRIA 14b streams, but with much less development. The weighted score for Lilliwaup is 86%, with 39% of parameters assessed, which rates the creek on the upper end of a fair rating.

The lack of ratings for North Fork Skokomish River and McTaggert Creek reflect a lack of evaluations made by the data sources used in this study during the period of negotiations concerning the Cushman Dams.

3.4 Summary of Water Quality and Habitat Conditions

Geospatial information from the habitat condition ratings (discussed above), salmonid and bull trout presence (SalmonScape), passage barriers, aggradation sites, and impervious surfaces are combined in Figures 10 to 16 for the WRIA 16 and 14b subbasins.

Habitat conditions of good, fair, or poor are indicated by broad bands of color along the water courses. The SalmonScape attribute for fish presence is shown by narrower lines. Presence as shown on the figures includes the attribute values of *documented*, *presumed*, and *potential*. The value *undetected* reflects negative findings of an investigation and is considered indication of non-presence. Other habitat attributes shown are Category 5 water quality exceedances, culverts, natural barriers (both falls and steep gradients), impervious surfaces, and known or likely aggradation areas.

The following summaries discuss, first, the data for selected habitat categories and, second, results for each subbasin.

3.4.1 Evaluation by Habitat Category

The Habitat Condition Rating (Table 17 in Correa, 2003) indicates good quality habitat for all parameters above the natural barriers on the Dosewallips River, Duckabush River, and Skokomish River. This is due primarily to the boundaries for the Olympic National Park and the Olympic National Forest boundaries. These are areas where there has been little recent disturbance to the habitat from development or logging. Within the Forest Service boundaries there has been recent logging. On the Hamma Hamma River above the natural barrier there are 11 data gaps (DG) and 3 poor to fair (P/F) and 5 good (G) ratings in the Correa summary of habitat conditions. The area downstream of the natural barriers (lower watersheds) of all the sub-basins have degraded riparian habitat, with the resultant poor or fair rating for a significant number of the parameters identified. The GIS map and data indicate the road presence, probably for logging, at a much higher level than the adjacent watersheds to the North.

Fish Passage

Fish barriers are shown on the watershed habitat maps, Figures 10 to 16. This is the GIS and GPS data that has been accessed through SalmonScape (WDFW). Natural barriers are present at RM 12.5 on the Dosewallips, RM 8.0 on the Duckabush, RM 2.3 on the Hamma Hamma, RM 0.7 on the Lilliwaup and RM 23.5 on the South Fork of the Skokomish. The GIS data includes barriers on tributaries to the mainstem rivers. Barriers to fish passage due to low flow conditions are not presented on the habitat condition figures. Minimum streamflows for fish passage were previously investigated for Fulton, Jorsted and Johns Creek (Aspect Consulting, 2005)

Channel Conditions

Large Woody Debris

Large woody material (LWD) is perhaps one of the most important habitat items in the entire watershed. This material is an indicator of the health of the riparian habitat as well as the general health of fish rearing and spawning habitat. In the study done by Port Gamble S'Klallam Tribe (Labbe et al., 2005.) on the Dosewallips River the importance of LWD and a methodology for assessing its impact are clearly defined. This level of assessment should be completed on all the major watersheds in WRIA 16. Most of the mainstem watersheds below the natural barriers have mostly a poor rating while above the barriers the ratings are good. Only five of the primary tributaries have a rating of good and the balance are rated poor to fair.

Pool Quality

The pool quality parameter is directly tied to the previous LWD condition as good quality LWD and distribution in the watershed usually results in a much higher percentage of quality pool habitat. Labbe (2005) concludes that "though degraded habitat conditions currently prevail along the Dosewallips River, natural recovery of in-channel LWD is occurring as mediated by flood disturbances". This assessment confirms the findings of Correa (2003) indicating that above the natural barriers and the areas of human impact, quality pool conditions prevail. Quality pool habitat can also be linked to the condition of the riparian habitat and where development, including logging, has significantly altered the vegetation and bank stability there is poorer quality pool habitat. The balance of the watersheds in WRIA 16 (Duckabush, Hamma Hamma, and Lilliwaup) have limited data available (data gaps). The one exception is the South Fork of the Skokomish for which Correa (2003) indicates good pool quality above river mile 3.0.

Riparian Habitat

Within the Dosewallips watershed the rating for riparian condition is good to poor in the area downstream of the falls (RM 12.5) a natural barrier to fish passage, and good above the falls. In the Duckabush, the riparian habitat upstream of the natural fish passage barrier at river mile 8.0 is rated as good and good from RM 8.0 to RM 5.0. However, downstream of RM5.0 it is rated as poor to fair. The Hamma Hamma River is rated as poor from the mouth at Hood Canal to RM 1.5. Above RM 1.5, the river riparian habitat is rated as good. Johns Creek, a tributary that supports both summer chum salmon and Chinook salmon is rated fair. The lower 3 miles of the Skokomish are rated as poor. The left bank is fairly well vegetated and not as proximal to the road as the right bank. The rest of the watershed is rated as fair to good with the exception of Vance Creek which is shown as a data gap (Correa, 2003).

Water Quality

Temperature

Water temperature problems at discrete points on the rivers are based on Instantaneous Maximum Annual Temperature (IMAT), 7-day Average Maximum Daily Temperature (7-DAMDT) and 21-day Average Maximum Daily Temperature (21-DAMDT). The 7-day and 21-day temperatures are of the most concern as they can represent a chronic condition of elevated temperatures. Chronic elevated temperatures cause stresses that can lead to disease and mortality of juvenile salmonids.

Only 19 of 63 reaches were ranked for temperature (Correa, 2003 and Kuttel, 2003), although additional data is available as reviewed below. Water temperature was evaluated for data that included monitoring for extended periods and that provided the highest annual temperature recorded, an average temperature over a 7-day period and an average temperature over a 21-day period.

The amount of data available to assess water temperature issues is very limited in terms of extended time periods. There is also a limited amount of data for complete reaches of a given watershed. Although a preliminary assessment of the potential for a temperature problem can be made from using data at a single location on a stream, this procedure is not appropriate for a complete assessment that shows the potential for impacts downstream or concerning a specific aspect of fish utilization. To assess temperature data that is available, a temperature threshold of greater than 12 degrees C was used and a search of all the files available online was conducted. The result is shown in Table 3.

There were 3 measurements identified on the Skokomish River, 1 at the Highway 101 Bridge and 2 at the Highway 106 Bridge and none of the readings were above 12.5 degrees C. On the Lilliwaup River at Highway 101 was 1 reading of 17.8 degrees C and 1 reading of 12.4 degrees C. The reading of 17.8 degrees C is well above an acceptable level. However, these readings were taken in the late afternoon on an August day when the diurnal conditions were probably the worst. Data from the Hamma Hamma River at the Highway 101 bridge resulted in 1 reading of 17.3 degrees C on the same day that the extreme high readings were taken on the Lilliwaup River. With the exception of the 2 high readings, all of the temperature data is within the category of good water quality. Elevated temperatures at the lower reach bridges highlight the need for collecting data in the reaches above these sites to determine if the fish can find sanctuaries of lower water temperature upstream of the problem areas.

Dissolved Oxygen (DO)

There is very limited DO data on any of the watersheds. Within the reaches where there is sufficient gradient and bottom structure to create turbulence there is probably little or no concern about DO. In the shallow gradients with slow moving water and little riparian cover there could be isolated pool habitat with reduced DO levels during the hot summer months. Correa (2003) indicates only 3 reaches ranked for DO in WRIA 16 and Kuttel (2003) shows a data gap for all of WRIA 14b.

Flow

Although stream gage data can be of importance in large river system for monitoring stormwater flows and flood warnings; the most important aspect for salmonid impact is in-depth monitoring of presence or absence of both adults (spawners) and juvenile rearing. The latter is particularly critical for juveniles that spend an addition 12 to 15 months in a stream prior to migrating to saltwater. These fish need pool habitat that will support the growth and development to provide healthy smolts (downstream migrants). The recent instream flow study completed for the WRIA 16 Planning Unit (Aspect Consulting, 2005) clearly highlighted the problem with attempting to use a specific flow criteria (the Thompson Flow Criteria). The variability of flow during storm events is the parameter that most often results in adults moving into the rivers and streams to spawn as was evidenced in the study completed by Aspect Consulting (2005). The recent study completed by the PGST (Labbe, 2005) on the Dosewallips River presents a much more complete assessment that highlights habitat quality that is a function of flow. This level of assessment is critical for evaluating the potential impact of groundwater flow reduction that may be associated with development on small tributaries to the mainstem rivers in addition to groundwater flow directly into the mainstem. When aggregation occurs and there are reduced flows both in the mainstem and side channels, the result may be subsurface flow and stranded juveniles in the side channel pools.

3.4.2 Evaluation by Subbasin

Figures 10 to 16 are the watershed maps showing the critical habitat features that are summarized in the SalmonScape file for use with GIS formatting. The habitat features are non-natural fish barriers (dams and culverts) impervious surfaces, population centers, and roads. The critical parameters have been discussed in the Analysis Parameters section. Specific areas of habitat assessment taken from the most current documents are included in the following summaries.

Dosewallips Subbasin

Habitat conditions are shown in Figure 10. Two detailed studies (Correa, 2003 and Labbe, 2005) are the primary sources of habitat evaluation within the Dosewallips watershed. Correa (2003) assessed the mainstem from the mouth to an area upstream of the falls at RM 12.5, Turner Creek, Rocky Brook Creek, and Walker Creek. Labbe et al. (2003) focused on the Dosewallips mainstem. The two studies taken together provide a level of detail and information is a model for salmon and steelhead habitat assessments in all watersheds.

The primary population center is Brinnon, with development extending along the shoreline and up the mainstem channel. Upstream of Brinnon, there have been major river bank modifications for flood protection of the Lazy C residential area. Labbe (2005) identified the area from the estuary to just above Walcott Flat (approximately RM 6.0) as the reach with the largest loss of aquatic habitat associated with logging and development. One short reach downstream of Lazy C, Power Line, has retained much natural habitat function due to the undisturbed river channel under the power lines.

There are 4 total barriers and 2 partial barriers shown on the subbasin map summarizing the habitat data from SalmonScape. Fish passage and barriers are included in the documentation by Correa but do not compare the impact of natural barriers on resident salmonids as compared to anadromous species.

Fish barriers are not present on the mainstem to RM 12.5, a natural falls. However, the US Highway 101 Bridge at the estuary has created partial barriers to side channels and restricts the natural function of the estuary. Rocky Brook Creek, the largest tributary to the Dosewallips, has a natural barrier at RM 0.3. Turner Creek has a culvert blockage at US 101. Walker Creek has a natural barrier at RM 0.75.

In-stream channel conditions are rated good above the falls, fair in Walker Creek and poor for the tributaries and mainstem below the falls . The extensive study done by Labbe (2005) concentrated on the interaction between LWD and the quality of the stream channel. Labbe, 2005 points out that it is important to compare undisturbed habitat in the watershed with the condition of the disturbed areas and use this as a guide for habitat restoration efforts. In the Labbe study, they found that using general guidelines for assessing habitat condition resulted in fair to good ratings in the lower reaches that are compromised and marginally functional due to development and logging activities within the watershed.

Pool frequency has been presented as good above the falls and in Rocky Brook Creek. The mainstem downstream of the falls and in Turner Creek are presented as a data gap or good indicating the influence in some reaches of LWD providing the hydraulic action to maintain a combination of good pool habitat together with spawning habitat.

Riparian habitat adjacent to the mainstem and the tributaries has been intensively assessed Correa (2003) and Labbe (2005). Data in the Correa document indicates a data gap on Turner Creek and Rocky Brook Creek, poor to fair in Walker Creek, poor in the lower 3.6 river miles, good to poor from RM3.6 to RM 12.5 and good above RM 12.5.

Water quality is evaluated by DO and temperature. DO is presented as a data gap for all of the Dosewallips, including the assessed tributaries, downstream of the falls at RM 12.5. Most of this mainstem watershed has a gradient and streambed roughness that creates good quality DO. Temperature is good above the falls, fair to good from RM 3.6 to RM 12.5 and fair from the estuary to RM 3.6. Rocky Brook Creek is shown to have fair to good DO and Rocky Creek and Turner Creek have data gaps. The middle Dosewallips temperature data presented in the Correa (2003) document indicates average 7 day (7-DADMT) in excess of 13 degrees C in 2001 and 2002.

Duckabush Subbasin

The lower portion of the river supports salmonid utilization for all the anadromous salmonids except sockeye. Overall habitat ratings are presented in Figure11. Correa (2003) states that 46% of the riparian area downstream of RM 3.0 is developed as commercial, urban or rural residential with the subsequent degraded habitat due to impaired riparian habitat. There is a natural fish barrier at RM 8.0. The river above RM 5.0 is confined to steep rock walls through much of the reach. Upstream of the falls this same type of terrain limits the development and logging activities to the Olympic National Park boundary at RM 11.5.

Anthropogenic barriers include 16 culverts identified on Figure 11 are considered total barriers shown on the lower reach tributaries, RM 3.0 downstream to the estuary.

Instream channel conditions for the river are compromised in the lower reach to RM 5.0. The river enters a steep walled canyon habitat at this point limiting the function of the river to a series of natural cascades and limited spawning or rearing habitat. LWD is present in the lower 1.5 miles but has been impacted by removal of log jams and LWD for flood protection. The river becomes confined above this point with limited deposition of LWD.

Pool quality is listed as a data gap below the falls and good above the falls. The reduced logging and development above the falls and the National Park Boundary has allowed this section of the river to remain in a natural state.

Riparian conditions are considered poor to fair in the lower reach (RM 0.0 to 5.0) and good above this point. There is extensive private and USFS timber harvest in this lower section in addition to rural residential and commercial development in the lower 1.5 miles.

Water quality: DO is documented as a data gap below the falls at RM 8.0 and good above the falls. Temperature data indicates fair to good temperatures from the mouth of the river to RM 5.0, a data gap exists to the falls and above the falls temperature is rated as good. The 7-DADMT monitored in the lower reaches in 2002 was 14.0 degrees C. This is above the 12.0 degrees considered ideal but within water quality requirements for fish health.

Hamma Hamma Subbasin

Habitat conditions for the Hamma Hamma are shown on Figure 12. There is a natural total barrier at RM 2.5. In spite of the short distance of river that is accessible to salmonids this watershed supports all of six of seven salmonids in WRIA 16. Approximately 95% of the watershed is in public ownership with 60% in managed forest.

Barriers within the Hamma Hamma watershed include 8 culverts along the shoreline for streams discharging to salt water. Of these 8 culverts, 5 are total barriers and the remaining 3 are partial barriers. There are no culvert barriers on the river itself, although there is the natural barrier at RM 2.5 mentioned above.

John Creek is a right bank tributary to the Hamma Hamma that supports all six of the salmonids. Correa (2003) indicated a potential natural barrier at the mouth of the creek due to logging operations in the John Creek watershed, but Aspect Consulting (2005) reported presence of chum, possibly Chinook, and redds.

Riparian conditions are considered good upstream of RM 1.5 on the Hamma Hamma River and also on Fulton Creek. Poor riparian ratings are shown for the lower reach of the Hamma Hamma and McDonald Creek. Waketickeh Creek is listed as fair and Johns Creek is listed as poor to fair. The balance of creeks in the watershed are listed as data gaps.

Water quality: DO is documented as a data gap for the entire watershed.

Temperature data indicates good temperature quality in the Hamma Hamma from the estuary to RM 1.5, fair in John Creek, poor/fair in McDonald Creek, poor in Fulton Creek, and a data gap for the balance of the watershed. There is no published data in the lower Hamma Hamma watershed for temperature, but Long Live The Kings (LLTK) recorded temperatures between 4.05 and 13.96 degrees C in 2003. LLTK also recorded temperature data in John Creek and found a variation of 3.36 to 15.02 degrees near the confluence with the Hamma Hamma River and temperatures above 14 degrees C were observed in the months of July and August (Correa, 2003).

Finch/Lilliwaup Subbasin

The Finch/Lilliwaup watershed contains 9 creeks with salmonids that empty directly into Hood Canal. Habitat conditions for 8 of the creeks are shown on Figure 13.

Of the streams that support salmonid populations, the most significant system is Lilliwaup Creek, which supports both summer chum and Chinook salmon. Lilliwaup Creek has a very limited reach for anadromous salmonid use due to the falls at RM 0.7.

In spite of this short reach of habitat, the only species that does not use this system is sockeye salmon. All of the returning adults use the short reach downstream of the falls and often spawning adults will use the exact space used by another adult within minutes or hours. The spawning reach is limited due to the low elevation of the site and saltwater intrusion at high tides. In addition to the natural spawning, LLTK operates a small captive broodstock hatchery for summer chum salmon and research for coho and Chinook salmon.

Along the Hood Canal shoreline in this watershed, there are 11 culvert barriers identified in the SalmonScape database. Ten of the culverts are shown as partial or total barriers.

Water quality and channel condition data are mostly lacking for the small streams, which all discharge directly to salt water, of this subbasin.

Skokomish Subbasin

Habitat and water quality conditions are shown on Figures 14 and 15 for the Skokomish watershed, which includes the North Fork, South Fork and 11 major tributaries to the mainstem and the South Fork. There is a natural barrier on the South Fork at RM 23.5. In 1926, Cushman Dam was constructed on the North Fork resulting in the total dewatering of the North Fork in the lower 17 miles. There is a native wild population of bull trout in the North Fork above the dam. This population is considered healthy although bull trout are listed as threatened. There are also land-locked Chinook in Cushman Reservoir.

There are 12 major tributaries to the mainstem Skokomish, 4 downstream of the mouth of the North Fork (RM 9.0), 1 tributary below the dam at RM 13.5 and 7 major tributaries on the South Fork from RM 9.0 to RM 23.5.

Consumptive use of North Fork water for power generation, at Powerhouse #2, dwarfs all other consumptive uses in the study area. Flows were modified in March 2008 and will fluctuate in the future.

Within the entire sub-basin, the SalmonScape database indicates 15 Hood Canal shoreline culvert barriers, 9 North Fork culvert barriers and 2 mainstem culvert barriers.

Fish barriers are not hindering fish movement on the main stem Skokomish and the South Fork to RM 23.5, the natural falls on the South Fork. With the exception of Cedar Creek, access is rated as good for the entire watershed. As indicated above, there are two dams on the North Fork that restrict anadromous fish passage to the reach downstream of the lower dam at RM 17.3.

In-stream channel conditions for LWD are rated good above the falls, fair to good from RM 10.0 to the falls and poor to the mouth of the South Fork. The mainstem river from RM 9.0 to the saltwater is rated as poor as well as the tributaries Weaver Creek and Hunter Creek. The tributaries Purdy Creek and Richert Springs are rated as good. There are data gaps for the tributaries that feed directly to the saltwater.

Pool frequency is shown as a data gap or poor for all the tributaries of the Skokomish with the exception of Richert Springs which is rated as good.

Riparian habitat in the lower 3 miles and the mainstem to the saltwater are considered poor. The habitat from RM 3.0 to 23.5 is considered fair while above the falls at RM 23.5

riparian habitat is considered good. The tributaries to the South Fork downstream of the falls are rated as good with the exception of Church Creek which is rated fair.

Water quality: DO is presented as a data gap for all of the Skokomish sub-basin, including the assessed tributaries. Most of this mainstem watershed has a gradient and streambed roughness that likely creates good quality DO. Areas that may be subject to reduced DO levels would most likely be in the flat lower watershed during the hot summer months.

Temperature (T) is shown as a data gap for the mainstem including the tributaries from RM 23.5 to Hood Canal. There are also data gaps for Vance Creek and Rock Creek. Temperature is rated as good for Brown Creek, Fair for LeBar Creek, and good for Cedar, Pine and Church Creeks. Above the falls at RM 23.5 the South Fork is rated good.

South Shore Subbasin

Habitat and water quality conditions are presented in Figure 16. Habitat conditions were reported by Kuttel (2003) as part of the Salmonid Habitat Limiting Factors for WRIA's 15 (West) and 14 (North, i.e. 14b). There are significant data gaps in the detailed categories of habitat assessment, with only 1 of 11 streams having greater than 50% of parameters assessed. Eight streams are identified as fish bearing.

The south shore watershed contains small, short streams with limited forested habitat. All enter the saltwater along a highly developed waterfront along SR 106 with significant alterations of the shoreline habitat and the stream habitat at the interface with Hood Canal.

At least 16 culvert barriers are indicated along the shoreline with additional upstream culverts on some streams.

With respect to water quality, there are a relatively large number of exceedances (8 streams) for fecal coli form. There are no temperature or dissolved oxygen data.

Small Streams with Discharge to Saltwater

Within the study area, there are a significant number of small streams that outfall to Hood Canal or to main stems of the major river systems (Figures 10 to 16). The majority of these streams flowing directly into Hood Canal have either total or partial barriers located close to outfalls to the Canal. These barriers are shown on the watershed maps. The streams that do not have barriers close to the saltwater support coastal cutthroat trout populations as well as juvenile salmonids that have immigrated out of larger system on their way to the open ocean. These juveniles will move in and out of the streams feeding on the aquatic insects and seeking refuge from predators. All of the 32 small streams identified by Correa (2003) and the 11 reviewed by Kuttel (2003) have significant data gaps for the characterization parameters.

For these small stream systems, the factors that may have the greatest impact on the health of the streams are road density (Correa, 2003) and percent impervious surface. Road density is an indicator of potential impacts to water quality or flow due to impervious surfaces, access for timber harvest, and/or commercial and residential development. Road density is typically assessed as poor for the small streams. Ratings for impervious surfaces are mixed, with about half lacking data.

3.5 Conclusions and Recommendations

3.5.1 Conclusions

The assessments completed within WRIAs 16 and 14b (Correa, 2003 and Kuttel, 2003) are the end result of a process of identifying critical parameters and developing consistent measurement protocols for quantifying habitat conditions and planning habitat improvement projects. Habitat assessment has been linked to habitat restoration for over 25 years by the scientific communities and fisheries managers. A significant American Fisheries Society symposium in 1981 catalyzed work towards a coordinated methodology for watershed assessments.

Habitat restoration, enhancement, and protection are dependent on a detailed knowledge of the existing conditions. Efforts to fill the data gaps in the current WRIA 16 and 14b assessments will provide more meaningful analysis and minimize restoration costs. Additional temperature and flow data will be beneficial in limiting impact of development and logging on salmonid populations.

Datasets

With respect to datasets that evaluate habitat conditions by reach, two models of analysis were reviewed. The WSCC Limiting Habitat Factors studies used a format that ranked individual habitat condition parameters. This format was adapted by the current study to generate overall habitat ratings by stream reach. The overall ratings and WSCC defined reaches were used to create a new geospatial dataset.

The Port Gamble S'Klallam study of the lower Dosewallips combined field evaluations with LiDAR and aerial photography to rate stream reaches. That work shows the value of detailed, field-based assessments, but the work was performed for only the single river and results were not presented in a format suitable for GIS-based analysis.

Habitat Characterization Parameters

The assessment parameters that have been summarized and reviewed for this document represent the best available science for habitat assessment as developed by the technical advisory groups representing the Tribes and federal, state, and county agencies. Representative parameters have been carefully selected over a period of years to identify the critical factors that determine the health of the watersheds and the health of the aquatic life in the watersheds. Measurement protocols have been refined to provide consistent results across watersheds.

Reduction of data gaps by performance of complete assessments is recommended. An average of 52% of parameters have been assessed for WRIA 16 and 14b streams.

Temperature

The temperature data that has been collected is of good quality, but the areal extent needs to be expanded to assess more of the critical spawning and rearing habitat throughout the WRIA 16 area. In addition, there is a need to review the data in terms of interaction of tributary data with the data collected on the main stems of the river systems. Areas where extensive logging has occurred on tributaries need to be flagged for review of potential impact of elevated temperature downstream of the confluence with the mainstem system.

Collection of water temperature data is recommended for extended reaches of streams in the areas of current or planned development or watershed alterations.

Large Woody Debris (LWD)

LWD plays a key role in the development of pool habitat and is a major element of habitat used by both adults returning to spawn and juveniles migrating downstream or rearing for more than a year in the watershed. There has been a significant amount of effort to categorize the distribution of LWD. However, there is a need to update existing data, since two major storm events in 2007 and 2008 that have likely altered LWD distributions in all the watersheds.

3.5.2 Recommendations

Habitat Condition Datasets

This study's adaptation of the WSCC habitat characterization parameters and application of weighting factors should be critiqued and evaluated for future use by the biological community.

Incorporation of the WSCC parameter characterizations into the SalmonScape database is recommended.

Successful long-term use and periodic updating of the base datasets is dependent on stable formatting of the source datasets. The PU should inform important partner agencies (PSP, Mason County, Jefferson County, Skokomish Tribe, HCCC, WSCC, WDFW, and Ecology) of the WRIA 16 use of and dependence on the agency datasets and encourage stability in dataset formats.

Stream Temperature

Stream temperature is relatively easily measured, but the number of current monitoring locations (19 of 63 reaches) is limited. The majority of the data points are at a single location on the entire stream. The knowledge of stream temperature may be improved by: (1) increasing the number of monitoring locations instrumented with low cost temperature loggers, collecting continuous data, and (2) creating a geospatial dataset of stream temperature that includes biologically significant averages and minimums. Priority should be given to streams downstream of logging and development activities, to smaller streams and tributaries, and to spawning reaches as described below.

Temperature measurements in spawning reaches should provide data to evaluate potential impacts on areas of observed spawning activity as well as typical spawning reaches. Each species will have slightly different areas of preference with fish size playing a major factor. Chinook salmon will look for areas of larger alluvial material with water flowing through the gravel as well as upwelling flows. The critical issue is adequate flow through the gravel to keep the eggs well aerated and providing cold water that reduces the potential for fungus to form on the eggs.

Large Woody Debris

The process of evaluating the Dosewallips by the PGST (Labbe et al., 2005) should be utilized on all the major watersheds. The leveraging of expensive field time with LiDAR and aerial photographic flyovers is considered to be an efficient method of habitat assessment.

In-Depth Studies

In-depth studies to prioritize stream reaches suitable for habitat conservation and/or habitat improvement are recommended for mainstems, tributaries, and saltwater streams where major changes have occurred, such as due to storm events, logging, or development.

Instream Flow and Fish Passage Studies

Identification of critical instream flows requires additional, small scale, site-specific data collection. There is relatively little instream flow data. The study completed by Aspect Consulting (2005) is a good model for assessing streamflow and fish passage.

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4 Water Use Estimates

Estimates of current and future water use were made in the study area to evaluate the influence of groundwater withdrawals on stream baseflow conditions. This section presents water use estimate methodologies and results and Section 5 analyzes water use in the context of streamflow. Water use estimates were derived using generally accepted professional practices and relied upon existing data of varying quality. The water use estimates were developed for use by the WRIA 16 PU for application to this project.

This section first describes the methods and assumptions for estimating domestic/municipal water use on a per capita and per ERU basis and irrigation use on a per acre basis. These fundamental components of water use are then used to estimate current use with population and source based methods and future water use based on full buildout.

Population-based water use estimate method relies on census population data to arrive at a water use value for domestic use and applies the use to a census block. Source-based water use estimate method is based on the location of the point of withdrawal, which are totaled to the nearest ¼, ¼, section. Future buildout analysis is based on zoning overlays and estimates water at place of use.

Estimated consumptive water use assuming full utilization of water rights is also described in this section.

4.1 Water Use Data

In this study, the focus is on estimating *consumptive use*. For clarification, we will use the term *withdrawals* when referring to the quantity of water removed from a source or provided to a customer. Consumptive water use was estimated using three techniques: population, sources, and zoning. The population technique combined projected census data, PWS residential connection numbers, and estimated irrigation. Resolution was by census block and PWS service area. The source-based technique has primarily quarter-quarter resolution and used PWS usage estimates applied to source wells, well logs, domestic single (DS) surface water rights, and estimated irrigation. The zoning based technique estimated future water use based on full buildout of current zoning with selected adjustments for irrigation.

4.1.1 Water Use Parameters

Table 4 presents the fundamental water use parameters used in this study to estimate withdrawals and consumptive use. Previous estimates by the Level I Assessment (Golder, 2003) and the USGS Washington water study (Lane, 2004) are provided along with different indoor/outdoor use scenarios in Table 4.

For estimating water use, the following residential parameter values were assumed:

- Population per residence or equivalent residential unit (ERU) is 2.5 (Mason County 2000 census);
- Indoor use is 65 gallons per day per capita (gpdpc);
- Outdoor use varies depending on assumed irrigated acreage;
- Indoor consumptive rate is 10%;
- Outdoor consumptive rate is 85%; and
- Crop irrigation requirements of 1.47 ft/yr.

The row in Table 4 for public water systems (shown as "water systems") is calculated from an estimated withdrawal of 0.29 afy per ERU or connection. The irrigated acreage and consumptive use were then calculated using the above parameters. Other results in the table were calculated directly from the parameters, but used the indicated values for irrigated acreage.

Public water system withdrawal of 0.29 afy per ERU in the study area was estimated as the median withdrawal for 10 systems for which measurement based estimates were provided in water system management plans. Table 8 indicates systems used in this calculation. Consumptive use was then calculated at 0.096 afy per ERU assuming a non-consumptive 10% conveyance loss. The average per capita withdrawal of 104 gpdpc is slightly lower than the value of 120 gpdpc in the Level 1 Assessment, but compares closely with Mason County average of 110 gpd by Lane (2004).

The population per residence, ERU, or connection was taken as 2.5 based on the 2000 census average for Mason County. Per capita indoor usage of 65 gpdpc is based on discussion with Ecology.

Indoor consumptive rate estimates are not well researched. Sapik et al. (1988) assumed a rate of 10% for a modeling study and discussions with Ecology supported the 10% value that is used here. The outdoor consumptive rate, or irrigation efficiency, was estimated from Ecology Guidance Document 1210 (Ecology, 2005) at 85%.

For the crop irrigation requirement (CIR), an average of 1.47 ft/yr was calculated from values for pasture/turf at Shelton and Quilcene (USDA, 1992). These stations are located to the south and north of the study area, respectively. The application rate was calculated as 1.73 ft/yr using the assumed outdoor consumptive rate of 85%.

Irrigated acreage was backcalculated for the PWS scenario as 0.05 acres per connection. We assume that irrigation for permit exempt wells and other similar self-supplied sources would typically be higher due to larger parcel sizes and lack of incentive for conservation with unmetered supplies. An estimated average of 0.1 acres was assumed, which gave a withdrawal of 0.35 afy per residence (127 gpdpc), higher than the 120 gpdpc value in the Level 1 Assessment, and a consumptive use of 0.165 afy per ERU. The withdrawal value of 0.35 afy for self-supplied compares favorably with using a multiplier of 1.3 times PWS use (1.3 * 0.29 = 0.38 afy) based on USGS data for all of Washington (Hutson et al., 2004). For the assumed PWS and self-supplied scenarios, annual average net consumptive rates were 33% and 47% respectively. By comparison, Solley et al. (1995)

estimated a nationwide average consumptive rate of 26% for municipal and self-supplied sources, with a range of 10% to 50%. The estimated consumptive use of 33% for PWS is slightly higher than the reported national average. The self-supplied consumptive use of 47%, where outdoor irrigation may be expected to be greater than for a dwelling supplied by a PWS, is near the upper end of this range.

4.1.2 Water Systems

Data for all Group A and Group B public water systems and sources were received as a download from WDOH. The source data included x,y locations, which meant that data was directly usable as a geospatial dataset.

Data for 28 public water systems identified by the Inchoate Water Rights Analysis (WRIA 16, 2008) were assembled from the WDOH data, 18 water system management plans, and Mason and Jefferson County PUDs. Services areas for 8 systems in Jefferson County were provided as a GIS layer by Jefferson County. Service areas for the remaining 13 systems were drawn and snapped to parcel boundaries, thus creating a new geospatial dataset. Data for the selected water systems is discussed further in Section 6, with inclusion of results from the buildout analysis, and presented as Table 8.

Usage data available for ten Group A water systems provided a median withdrawal of 0.29 afy per connection. There was a large variance in the reported data (0.10 to 0.68 afy) and for the most recent year reported (1996 to 2008), which depended on the year of preparation of the water management plans. Current withdrawal data is not available through the WDOH Sentry database, but will become publicly available through the Water Use Efficiency Rule starting July 2009.

Using the parameters previously noted (Table 4) and assuming 10% non-consumptive conveyance loss, consumptive use was estimated at 0.096 afy for PWS. This estimate of 0.096 afy was taken as consumptive use per ERU and applied to the other public water systems, both Group A and Group B.

The study area contains 239 water systems for primarily residential use. The PWSs include 93 Group A and 146 Group B systems with 5,135 residential and 6,960 total connections, of which about 90% are in the Group A systems. Sources were 95% groundwater and 5% spring or surface water.

4.1.3 Self-Supplied (Well logs)

Well logs were downloaded directly from the Ecology online well database for all quarter-quarter sections that straddled the WRIA 16 boundary to provide information on the number of self-supplied residences. Wells types A and R (abandoned and resource protection wells) were removed. Of the 1,833 remaining logs, 1,557 (85%) had quarter-quarter designations. All well logs were used in the source-based analysis, and applied to quarter-quarter section, quarter section, or section as appropriate.

Each well log was assumed to represent one permit exempt well serving one residence. Using the stated parameters and assuming 0.1 irrigated acre, withdrawal per exempt well was estimated at 0.35 afy per well and consumptive use estimated at 0.165 afy. The larger consumptive use for an exempt well compared to a PWS connection is justified by presumed larger lot sizes, possibly with livestock, and absence of costs sensitive to usage.

4.1.4 Water Rights

Water rights in WRIA 16 and 14b are shown on Figures 17 through 23. Water rights are shown only for state granted water rights. Tribal rights are summarized in the WRIA 16 Watershed Management Plan and summarized as follows. The Skokomish Tribe has a claim for “Winters Doctrine” rights and for aboriginal water rights. Under the “Winters Doctrine”, a federal water right is impliedly reserved to fulfill the primary purpose of the Reservation. The Skokomish Tribe has made a claim for these rights, but they have not been confirmed or quantified by the courts. The Skokomish Tribe’s aboriginal water rights reserves the right to fish in the “usual and accustomed” fishing area and were reaffirmed under the Boldt decision. Previous court rulings held that when a Tribe retains fishing rights it also retains the right to maintain in-streamflows of sufficient quantity and quality to maintain that fishery. These flows have not been quantified. The reader is referred to the Watershed Management Plan (May 11, 2006) for additional information. Only state granted water rights are included in this analysis.

Figures 17 through 23 show only active consumptive water rights. Symbols distinguish groundwater and surface water sources and colors indicate purposes of use. Note that for best interpretation, the figures should be viewed at a magnified scale as many water rights are hidden under others.

The water rights data is summarized in Appendix B and sorted by the identification number used on the figures. Appendix B also includes the estimated actual consumptive use discussed below in this section based on water rights. The full data set with additional data is included electronically in the spreadsheet <WRIA 16 Water Use for GIS.xls>.

Active water rights information was extracted from the Ecology WRTS database. The records were first selected with standard GIS techniques by using position (latitude-longitude), but it appeared that the position field contained extensive errors, primarily for the WRIA 14 data. The records were then selected using the lower accuracy township-range-section (TRS) and quarter-quarter (QQ) designations. This location data is used to show the water rights in the figures. The TRSQQ search provided 540 records of which about half (47%) had QQ designations. The 540 records included certificates, changes, and permits, but not applications and claims. By comparison, the Level 1 Assessment (Golder, 2003) evaluated 427 certificates, changes, and permits, 752 claims, and 44 applications. Claims and applications are not included in the current analysis.

Water rights were not identified as additive or non-additive in the WRTS data. The non-additive rights were necessarily treated as additive and represent an overestimate of consumptive use. The quantity of this overestimate is unknown.

Groundwater and surface water rights accounted for, respectively, 189 (35%) and 348 (64%) of the records. The remaining 3 water rights were for reservoirs. Both groundwater and surface water records had similar percentages with QQ designations. Annual quantity (Qa) values were provided for nearly all (99%) of groundwater rights, but only 35% of surface water rights.

For all water rights, a set of criteria were applied within an Excel spreadsheet in order to provide estimates of the consumptive use that would occur if all rights were in use. This analysis is presented in Appendix C.

4.1.5 Irrigation

There are no specific estimates for irrigated acreage for WRIA 16. Assessors' data indicates agricultural zoning of 1,866 acres in Mason County [zoning code *Ag(CU)*] and 44 acres in Jefferson County (zoning code *Open Space-Agricultural*). Water rights data indicate about 2,200 acres with IR purpose in WRIA 16, most in the Skokomish floodplain. Agriculturally zoned parcels were overlain onto aerial photograph to eliminate those parcels with forested ground cover or in river deltas. The majority of the likely active agricultural parcels were in the Skokomish floodplain, except for one property north of Miller Creek, one in the Hamma Hamma basin, and three in the Dosewallips valley. Consumptive irrigation was taken as the crop irrigation requirement from the Washington Irrigation Guide. Stations north and south of the WRIA (Quilcence and Shelton) were averaged to obtain a crop irrigation requirement of 1.47 afy/acre. At an estimated irrigation efficiency of 85% total irrigation withdrawal per acre was estimated at 1.73 afy (Table 4) .

4.2 Current and Future Water Use Estimates

This section presents a summary of current and future water use estimates. Current water use was estimated using two methodologies: population-based estimate and a source-based estimate. The source-based estimate, which is considered the better estimate, indicates total consumptive water use of approximately 1,000 afy within the study area. Figure 24 presents the results of the population-based estimate and Figure 25 presents results of the source-based estimate. Each of these figures are shown for the study area using units of afy per acre to facilitate comparison. Individual maps showing source-based consumptive water use by subbasin are presented on Figures 26 through 32.

Future water use was estimated based on zoning overlays for Mason and Jefferson Counties and parcel data for the Skokomish Reservation (where no zoning is available at this time). Figure 33 presents the future build-out consumptive water use for the entire WRIA using the units of afy per acre to facilitate comparison with current use shown on Figures 25 and 26. Summary by subbasin are presented in Table 6.

4.2.1 Population-based Consumptive Water Use Estimate

The population-based method uses population data, number of connections for public water systems and irrigation water rights to estimate current consumptive water use.

The 2000 census (US Census, 2008) is included as a dataset with this study. The census is the basis for population estimates provided by the Washington State Office of Financial Management (WOFM). WOFM provides three estimates for population projections. Jefferson County uses the medium projections and Mason County's comprehensive plan (Mason County, 2005), projects population slightly above the medium curve.

The estimated population increase from 2000 to 2008 in the study area is 13%, which was determined using straight line interpolation between 2005 and 2010 WOFM medium range estimates for Mason County. Geographical resolution for population data is the census blocks, which vary greatly in size from tens of acres to large portions of a subbasin (Dosewallips and Duckabush areas).

U.S. Census block data (TIGER) was combined for Mason and Jefferson Counties. A population density for each block was calculated by dividing the population for that block by the total area. The census blocks were then clipped to the WRIA boundary.

Total 2008 population for the WRIA 16/14b study area was estimated at 8,338 in this manner. Population data is organized spatially by census blocks and these census blocks are reflected in the results presented in Figure 24. Estimated 2000 and 2008 population by subbasin are presented below.

WATERSHED	2000 Population	2008 Population Est.
Dosewallips	593	670
Duckabush	364	411
Finch/Lilliwaup	1,119	1,264
Hamma Hamma	295	333
Skokomish	2,553	2,885
South Shore	2,455	2,774
TOTAL	**7,379**	**8,338**

Available PWS area boundaries were created by digitizing paper figures from WDOH and combining with information from both counties. Each boundary was associated (joined) with the Sentry database to get the number of connections for each system (residential and other).

PWS boundaries overlap the census blocks and this overlap was accounted for in the water use estimate. Where a PWS had a service area boundary available to Aspect, the water use within the service area was determined based on the number of connections by PWS listed in the Sentry database. A PWS consumptive water use of 34 gpd/capita (0.096 afy/ERU) was applied to each connection (Table 4).

The population of census blocks outside the PWS areas was obtained by proportioning the population to this area, thereby removing overlap with the PWS area. Consumptive water use was estimated by multiplying the population by 59 gpd/capita (0.165 afy/ERU) and assigning it to the census block.

There is considerable uncertainty in the total water use for agricultural irrigation. The amount of water right appropriations listed in Ecology's WRTS database (often referred to as paper rights) exceeds, in many cases significantly, actual annual water use and therefore, other indirect methods of analysis were used to estimate agricultural irrigation demand for the study area. Assessors' data indicates agricultural zoning of 1,866 acres in Mason County [zoning code *Ag(CU)*] and 44 acres in Jefferson County (zoning code *Open Space-Agricultural*). To confirm the agricultural parcels identified in the assessors data, these parcels were overlaid on the aerial photo coverage in GIS and a good correspondence was found between the agricultural parcels in the assessor's database and fields identified on the aerial photographs.

Water rights were spatially correlated with these parcels to estimate which lands could potentially be irrigated. Given the locational accuracy of the irrigation water rights in the WRATs database (about ½ to quarter section and remainder to Section centroids), all agricultural lands appeared to have a water source and none were eliminated based on the water rights. Water rights without associated irrigated land were assumed to be unused and were not included in the estimate of irrigation water use.

Estimation of irrigation from acreage is not appropriate for the Skokomish floodplain, which is known to have a high water table that limits or eliminates the need for irrigation (Book, 2009). Therefore, irrigation is estimated for 1% of the 1,242 acres in the Skokomish valley and 100% of the 150 acres elsewhere within WRIA 16. The actual irrigated acreage may be closer to 0.2% of the 1242 acres (Rich Geiger, personal communication, June 18, 2009). At the crop irrigation rate of 1.47 ft/yr, consumptive irrigation usage is estimated at 18 afy in the Skokomish, and 260 afy elsewhere.

Agricultural lands outside the Skokomish Valley were used at the full crop irrigation requirement (1.47 ft).

Total consumptive water use in the WRIA using the population-based method was estimated at 900 afy for the 2008 population. Total withdrawals were estimated at 1900 afy. The Level 1 Technical Assessment (Golder, 2003) used a population-based methodology to estimate water use in 2000 at 1,500 to 2,000 acre-feet/year (afy), of which residential use accounted for 1,000 to 1,500 afy and irrigation 500 afy. These use estimates were for withdrawals and did not address consumptive use. In addition, Golder (2003) estimated hydroelectric consumptive use of the North Fork Skokomish River for Cushman Powerhouse #2 at 333,000 afy.

4.2.2 Source-based Consumptive Water Use Estimate

Withdrawals and consumptive water use was also estimated using a source base method to evaluate water use based on point of withdrawal information. The method relies on the following basic data categories:

- Group A and B public water system connections;
- Well logs;
- Agricultural and golf course irrigation; and
- Domestic single (DS) surface water rights

Water rights other than irrigation water rights such as domestic multiple and municipal were considered to be redundant with water use estimated from Group A and B connection data and were not used in the source-based computation. Nonconsumptive uses including power generation and fish hatcheries were also excluded from the analysis.

For source-based analysis, consumptive use was aggregated by quarter-quarter and summed with water system use. To limit double counting, total use in each quarter-quarter section was reduced by the number of PWS sources within each quarter-quarter times the self-supplied use of 0.165 afy per ERU.

Residential water use for PWSs (Group A and B systems) was assigned to each source for the PWS. This analysis includes all Group A and B water systems listed in the Sentry database for the study area including those discussed in the population method. PWS sources were clipped to the study area based on location in the Sentry database.

Consumptive water use for each PWS was estimated from the total number of connections and the estimated PWS consumptive water use per ERU described in Section 4.1.2 (0.096 afy/ERU). The total water use for the PWS was then assigned equally to each of the sources (emergency sources were excluded from the source analysis).

Nonresidential uses were assumed to be camp and seasonal occupancy cabins and were estimated at 50% of the residential water use. This assumption may result in local under estimation of water use for some non-residential uses such as hotels.

Water use for self-supplied residences was estimated from well logs. Well log data downloaded from Ecology's well log database was clipped to the WRIA boundary based on northings and eastings provided in the database. The remaining wells were counted by their QQ section designation (or best available designation). We assumed each well log was equivalent to a permit exempt well and had one ERU associated with it. Wells with more than one ERU were assumed to be captured in the PWS analysis (i.e. if a well has more than one connection it is assumed to be a Group A or B well). Connections of assessor dwelling units to exempt wells could result in an underestimate of water use. Conversely, many exempt wells, particularly older wells, may be in use and not have a well log on file with Ecology, and therefore are not included in the water use estimate. Water use for each well was estimated using the same assumptions as for the PWS, except that irrigation of 0.1 acres was assumed. Consumptive use was calculated as the number of wells times 0.165 afy.

Water rights were analyzed and consumptive use estimates calculated for all active water rights (Section 4.1.4 and Appendix C). For the source based analysis, all domestic single (DS) surface water rights were included. Non-consumptive purposes, e.g. fishery (FS) and power (PO), were not included. Domestic multiple purpose water rights were assumed to be represented by either the Group A and B water systems or by a well log. Irrigation water rights were used only to verify that a parcel indicated as agricultural could be potentially irrigated, as discussed in Section 4.2.1.

Each domestic single surface water right was assigned a self-supplied consumptive water use. Similar to groundwater self-supplied ERUs, the DS water rights were assumed to be equivalent to one ERU. Irrigation water rights were included only if associated with an active agricultural parcel (Section 4.2.1). Irrigation water rights use in the Skokomish Valley were reduced to 1% of the calculated estimate due to the known high water table that limits the need for irrigation.

Surface water rights were clipped to the WRIA boundary by their section designation (as it was judged that the Lat/Long provided was inaccurate). That is, if a water right was inside a section that overlapped the study area, it was considered to be within the study area.

The consumptive use estimates from PWS, exempt wells, domestic single surface water rights, and irrigation were totaled by best location designation (again, QQ, Q or section) to get a total consumptive use estimate per location. Most use sums are on a quarter-quarter section basis, but some water use could only be located to the nearest ¼ section or section.

Total consumptive water use estimated using the source-based method is summarized in the table below by water use category and Table 6 by subbasin.

Measurement	afy
Irrigated Parcel (In Skokomish Valley)	18.3
Irrigated Parcel (Outside Skokomish Valley)	220.6
Residential Connections	436.5
Nonresidential Connections	73.9
Water Rights (Surface, DS)	7.4
Self-Supplied (Well Logs)	223.1
	979.7

Residential is the predominant current consumptive use and is estimated at about 436 afy or about 45% of total consumptive water use. Irrigation is also a significant portion of the total consumptive use and assumptions regarding irrigation could significantly affect the total consumptive use estimate. Irrigation within the Skokomish Valley, while estimated at 183 afy could vary significantly from this estimate if more or less than the 1% of lands are irrigated. In addition, assumptions regarding nonresidential water use could also have a significant effect on the estimate.

The source-based estimate of 980 afy consumptive use is larger than the population-based estimate of about 908 afy as a result of inclusion of non-residential connections. Although both estimates show reasonable agreement, the source-based estimate is considered the best estimate of current water use within the WRIA.

In contrast, total consumptive water use based on water rights is estimated at 3,900 afy (excluding consumptive power use). The nearly 4-fold greater estimate of consumptive water use from water rights than by the population based or source based estimates suggests many water rights are not being fully utilized.

4.2.3 Zoning Based Water Use Estimate at Buildout

Future buildout water use (Figure 33) was estimated from zoning overlays and parcel maps provided by Jefferson and Mason Counties and from parcel data provided by the Skokomish Tribe. The buildout analysis assumes that each zoning classification will be developed to the reasonable maximum extent allowed by Jefferson or Mason County Zoning Regulations. Mason County Development Regulations (March 10, 2009), Jefferson County Code (Chapter 18.15) and communications with the Planning Unit were used to develop estimates for full buildout scenarios. The assumption that each zoning classification will be developed to the reasonable maximum extent may lead to an overestimation of eventual growth.

Each zoning classification present within the WRIA is listed in Table 5 with the corresponding development regulation, a summary of the allowed density, the minimum lot size, information related to ERUs per zoning class parcel, and an estimate of the consumptive use for the minimum allowable parcel size within the zoning classification.

Buildout for several zoning classifications are narrowly defined in the zoning regulations. For example, the rural residential-5 category allows for a minimum lot size of 5 acres, one primary dwelling unit and one accessory dwelling unit (ADU). In this case, two ERUs are assumed for the RR-5 zoning.

Several zoning classifications were not fully prescribed in the regulations and required assumptions regarding future buildout. For example, the minimum lot size for the Mason County Rural Center 1 (RC-1) zoning classification depends on the subject property location. A wide range of uses are allowed in this zoning classification. In this case, it was assumed that the minimum parcel size would be 1 acre with 3 ERUs of water use. Site-specific knowledge beyond the scope of this study would be required to refine these assumed buildout scenarios. In a few places (e.g., Alderbrook), site-specific buildout data was available and used. Lands designated as agricultural in the zoning codes were assumed be irrigated at 80% of their total acreage.

In the full buildout analysis, lands within the Skokomish River floodway were assumed to be unbuildable and were excluded from the analysis.

Total water use under the full buildout scenario is estimated at 12,500 afy and total consumptive water use at future buildout is estimated at 7,000 afy. The breakdown by zoning classification is listed below.

County	Zone_Code	Total CU (afy)
Jefferson		0
Jefferson	AL-20	334
Jefferson	CF-80	28
Jefferson	IF-20	34
Jefferson	MPR-BRN	121
Jefferson	PPR	0
Jefferson	RF-40	3
Jefferson	RR-10	0
Jefferson	RR-20	54
Jefferson	RR-5	448
Jefferson	RVC	22
Mason	AGR	2225
Mason	IH	46
Mason	IR	76
Mason	LTCF	228
Mason	ONF	0
Mason	ONP	0
Mason	RC1	4
Mason	RC2	14
Mason	RC3	27
Mason	RI	8
Mason	RMF	7
Mason	RNR	18
Mason	RR10	163
Mason	RR2.5	191
Mason	RR20	324
Mason	RR5	1967
Mason	RT	727
Mason	UGA	9
Mason	W	0
		7081

Note: Total varies slightly from Table 6 due to clipping assumptions.

Irrigation of agricultural lands presents the greatest category of consumptive water use in the WRIA at future buildout. At over 2,500 afy consumptive water use, this category is nearly half of the total consumptive water use at buildout. The rural residential categories (RR) present the next largest group of consumptive water use at about 3,200 afy. The rural tourist (RT) category that includes Alderbrook Inn and golf course has an estimated consumptive use of 672 afy. Other zoning categories have a relatively small contribution to consumptive water use at full buildout given the assumptions used.

4.2.4 Recommendations

The following items are recommended for consideration by the Planning Unit:

- Develop a database or work with state agencies to provide accurate well and water right locations. The importance of having complete and accurate records for location cannot be underestimated for use of the data for geospatial analysis.
- Investigate actual water use for agricultural irrigation in WRIA 16 in order to improve estimates. This could be done through detailed mapping of irrigated lands.
- Encourage public water systems to determine actual usage for golf course irrigation.
- More carefully evaluate future buildout scenarios to improve the buildout analysis, particularly potential uses on agricultural lands and commercial centers.
- Consider monitoring a sampling of exempt wells to better evaluate self-supplied water use (see also Recommendations in Section 6).
- Continue encouragement of metering and reporting of public water systems (see also Recommendations in Section 6).

5 Habitat and Consumptive Water Use Assessment

The project objective is to provide a relative ranking of subbasins within the WRIA based on habitat conditions and the potential for streamflow impacts resulting from future groundwater withdrawals.

A key component of this objective is to understand instream flow needs for salmonids and relate the instream flow to water use for a given stream reach. No instream flow rules have been adopted to date for the WRIA. An instream flow is defined by Ecology as follows:

> *The term "**instream flow**" is used to identify a specific stream flow (typically measured in cubic feet per second, or cfs) at a specific location for a defined time, and typically following seasonal variations. Instream flows are usually defined as the stream flows needed to protect and preserve instream resources and values, such as fish, wildlife and recreation. Instream flows are most often described and established in a formal legal document, typically an adopted state rule.*

In lieu of instream flows, water use was evaluated in terms of stream baseflow to develop a relative ranking of potential impact of current and future groundwater withdrawals on fish habitat. Habitat rankings were combined with an assessment of groundwater withdrawals relative to baseflow to rank the potential for streams overall impairment.

Ranking scores developed herein provide a relative ranking of each of the subbasins with respect to other subbasins in the WRIA and allows them to be prioritized for future study. Impacts from groundwater withdrawals depend on many site-specific features which are beyond the scope of this WRIA-wide study. These include but are not limited to timing of groundwater withdrawal impacts on surface water bodies, timing of salmonids within a stream, minimum instream flow required for fish passage and habitat, and groundwater/surface water interaction among others.

5.1 Algorithm Definition and Implementation

An algorithm was developed to rank the relative **potential for stream impairment**. The evaluation of potential impacts of groundwater withdrawals on salmonid habitat used two critical attributes:

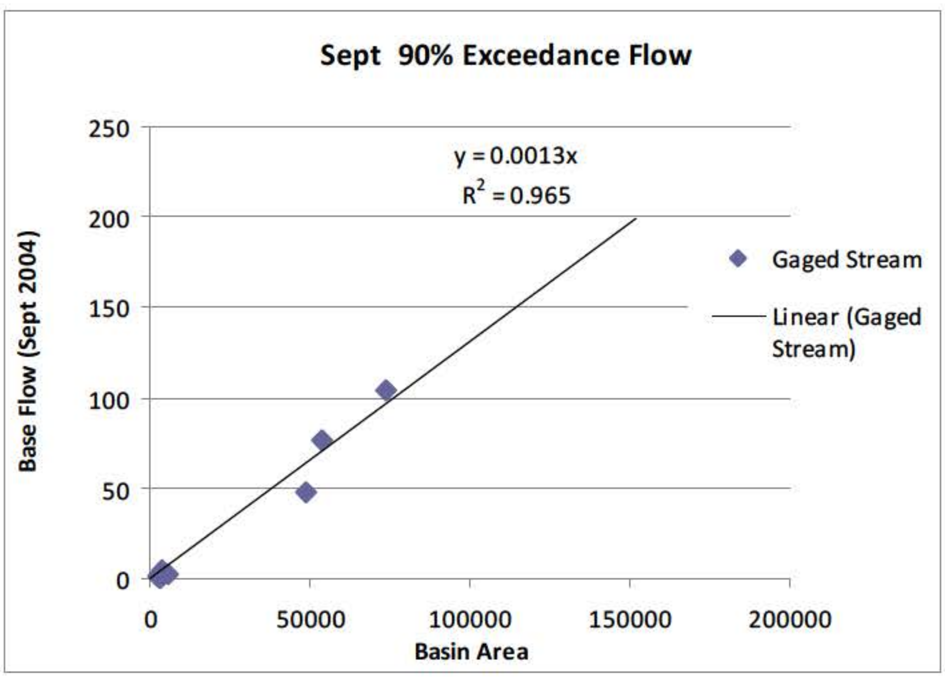
- **habitat conditions** as discussed in Section 3; and,
- **potential streamflow impact -**groundwater withdrawals as percent of baseflow (in lieu of instream flows).

Potential for stream impairment refers to the overall rating of potential impact from groundwater withdrawals on salmonid habitat based on combining the habitat condition rating and the potential streamflow impact rating. **Habitat condition** refers to the rating developed using the eight habitat conditions and associated parameters discussed in Section 3. The habitat condition parameters do not directly consider streamflow. As such, the **potential for streamflow impact** was rated based on consumptive water use under current and future buildout conditions and stream baseflows.

Stream Baseflow Estimates

For each subbasin listed by Correa (2004) and Kuttel (2003) and evaluated in Section 3.0, the stream baseflow was estimated. Most streams in the basin do not have sufficient gaging data to evaluate baseflow conditions and estimates of baseflow were made using data from gaged streams within the WRIA. Seven streams were gaged for one year period in 2004-2005 (Aspect, 2005) and USGS has gaged the North and South Forks of the Skokomish River. For the nine stations with available gaging data, baseflow was based on a statistical analysis of the gaging data. For the purposes of algorithm, baseflow is taken as the 90% exceedance value for September, that is, that flow in September of which 90% of the flows are greater. September was selected as the critical month, because Chinook and Summer Run Chum use several of the streams for spawning during this low flow period. Table 7 lists the streams and the 90% exceedance flow for the month of September for the nine stations with gaging data.

Baseflow for the ungaged streams was estimated by taking the nine streams with gaging data, correlating the flow to the basin area, and using this correlation to estimate baseflow for the ungaged stations from the basin area. The estimated baseflows are presented in Table 7. There is a high degree of uncertainty related to these baseflow estimates and we recommend gaging of these streams be performed to reduce this uncertainty.



Of particular interest in the evaluation of streamflow impacts from groundwater withdrawals is the timing of water use. Greater withdrawals occur during the summer months. As such, the annual water use estimates were partitioned to a monthly basis. Total consumptive water use within each subbasin was totaled from the current source-based estimate and the future buildout estimates. These annual quantities were then proportioned on a monthly basis by assuming 5% of the annual consumptive total occurs each month indoors (Vaccaro and Olsen, 2007) and the remainder is outdoor use proportioned based on the monthly irrigation distribution in the WIG (USDA, 1992). The results indicate that consumptive water use in July is about twice that of the annual average. Table 7 presents the estimated annual average water use and July water use for each subbasin.

5.1.1 Potential Streamflow Impact (Consumptive Use as Function of Baseflow)

To evaluate the effect of groundwater withdrawals on baseflows, the total peak groundwater withdrawal rate for the month of July was expressed as a percent of baseflow. Implicit in the method is that all wells within the basin are in hydraulic continutity with the surface water body and that the July groundwater withdrawal impacts the river in September. This later assumption can be placed in context by examining August and September consumptive withdrawals. August consumptive use is about 1.7 times the annual average. September is about equal to the annual average consumptive use, and as discussed previously July is about two times the annual average. Thus, to the extent that the time delay is less than 2 months, the impact on the stream will be less than that presented.

Table 7 presents water use for each stream segment as a percent of stream baseflow. For current water use, the subbasin with greatest impact to streamflows identified by this method was in the South Shore subbasins where Holyoke, Big Bend, and Springbrook Creek had groundwater consumptive use ranging from 3.5 to 5 % of estimated baseflow. No agricultural lands are present in the south shore area and these estimates would not be affected by assumptions regarding irrigation. On the other hand, peak monthly groundwater withdrawals in Purdy Creek were estimated at 7% of baseflow and would be affected by assumptions regarding irrigation. In addition, as discussed further in Section 5.2, Purdy Creek baseflow appears to be supported, in part, by losses from the South Fork of the Skokomish River, which could lead to an underestimate of baseflow using the method in this study.

At full buildout, about 24% of the streams show peak monthly consumptive groundwater withdrawals greater than 10% of estimated stream base flow (Table 7).

Streamflow impact potential was divided into three categories and assigned numerical ratings as follows:

Subbasin Consumptive Water Use as Percent of Baseflow	Relative Streamflow impact Potential Rating
<5%	3 (low)
5-10%	2 (moderate)
>10%	1 (high)

The streamflow impact ranking scheme is arbitrary, but provides a means to rank potential impairment in each of the study area subbasins relative to one another. The rankings do not provide an absolute quantiative assessment of stream impairment. Basin specific data and analysis would be necessary for an absolute quanitification.

5.1.2 Stream Impairment Potential Algorithm

To assess overall stream impairment, habitat conditions and the potential for streamflow impact were combined to develop a single scoring for each subbasin. Habitat conditions of poor, fair, and good were scored 1, 2, and 3, respectively. The habitat condition rating was multiplied by the streamflow impact rating to arrive at a relative rating of the potential for impairment of the habitat condition inclusive of groundwater withdrawal impacts (referred to as stream impairment potential). Final scores ranged from 1 through 9. Scores from 1-3 were considered to indicate high potential for stream impairment relative to other streams in the study area, while scores of 4 to 6 indicate moderate potential and scores from 7 to 9 indicate low potential.

By way of example, the middle reach of the Dosewallips River had a fair habitat score (Table 7). This habitat score is expressed numerically as “2”. Peak monthly groundwater withdrawals under full buildout conditions were computed to be 0.6% of estimated baseflow. This streamflow impact assessment is less than 5% of baseflow and is expressed numerically as a “3”. The alogrithm uses the product of the habitat rating and streamflow impact , 6 (2 times 3). Values ranging from 4 to 6 are considered to have a moderate potential for streamflow impact relative to other streams in the WRIA.

5.2 Results and Discussion

The algorithm was applied to each of the subbasins with a habitat condition score. Table 7 contains results for the full buildout condition and 2008 condition. Results for the full buildout condition are presented on Figures 34 through 40 for each of the subbasins. Color coding of the subbasins on these figures corresponds to the relative ranking. Posted on the figures for each subbasin are the estimated baseflow, the estimated peak monthly groundwater withdrawal, and the peak monthly consumptive groundwater use as a percent of the baseflow.

Dosewallips Subbasin

Within the Dosewallips Subbasin, the lower portion of the Dosewallips River and Walkers Creek each show high potential for stream impairment, predominantly as a function of habitat condition (Figure 34). Habitat conditions were ranked as poor for each of these streams. The upper Dosewallips has both good habitat and low expected water use at full buildout and ranks as “low” potential for stream impairment. The middle section of Dosewallips River, Turner Creek, and Rocky Brook Creek have low groundwater withdrawals as a percent of base flow, fair habitat ratings and a moderate potential for streamflow impact.

Under current conditions, peak monthly water use is a small percent of base flows for all Dosewallips subbasins. Under full buildout, steamflow impact potential rating increases from low to moderate for Walker Creek, while the upper Dosewallips stream segments remain at low streamflow impact potential under full buildout.

Total withdrawals in the Dosewallips subbasin are estimated at 300 afy under 2008 conditions and increase to 1000 afy under full buildout.

Duckabush Subbasin

The lower portion of the Duckabush was ranked as high potential for overall stream impairment based on the habitat condition (Figure 35). With groundwater withdrawals at buildout of 0.8% of flow, the potential for streamflow impact was considered low.

The upper and middle reaches of the Duckabush have good habitat condition ratings, very little water use, and are ranked as “low” potential for habitat impairment. Total withdrawals in the Duckabush subbasin are estimated at 83 afy under 2008 conditions and increase to 579 afy under full buildout conditions. The Duckabush had the lowest total withdrawals of any subbasin in the WRIA under 2008 conditions.

The apparent decline in baseflow between the middle (53 cfs) and the lower section of the river (48 cfs) (Figure 35) results from use of gaged flow data for the lower section and estimated data for the middle river segment.

Hamma Hamma Subbasin

The lower reaches of the Hamma Hamma, John Creek and three smaller streams that drain directly to Hood Canal were ranked with a high potential for overall stream impairment (Figure 36). The smaller streams, MacDonald Creek, , Unnamed Tributary (Mikes Beach), and Waketickeh Creek, and the lower Hamma Hamma each had poor habitat condition rankings. John Creek, although showing a low potential for streamflow impact, scored as poor in the habitat ranking and high in the overall stream impairment potential ranking. Sediment supply, pool quality and mass wasting were all scored as poor (Correa, 2003) in the habitat condition ranking for this stream.

McDonald and an Unnamed Tributary (Mikes Beach) had moderate potential for streamflow impact with peak month groundwater withdrawals at buildout of 6 and 5% of baseflow, respectively.

Fulton and Schaerer Creeks each had fair habitat ratings, low potential for streamflow impact, and a moderate stream impairment potential.

The upper portion of the Hamma Hamma has good habitat rating, low buildout groundwater withdrawals, and a low potential for stream impairment.

Total withdrawals in the Hamma Hamma subbasin are estimated at 184 afy for 2008 and increase to 1400 afy at full buildout. At greater than a seven fold increase, this is the largest increase in water use from 2008 to full buildout on a percentage basis for the study area subbasins.

Finch Creek/Lilliwaup Subbasin

Jorsted Creek, Lower Lilliwaup, Sund Creek, Miller Creek, and Clark Creek each had poor habitat conditions and ranked as high for potential stream impairment. Of these, groundwater withdrawals at buildout were most significant in Jorsted Creek subbasin (32%).

Eagle Creek, Little Lilliwaup, Finch Creek, and Hill Creek had fair habitat potential, low to moderate water withdrawals (as percent of baseflow) and moderate potential for stream impairment.

The upper Lilliwaup watershed has good habitat condition, small groundwater withdrawals and a low potential for stream impairment.

Total groundwater withdrawals for 2008 are estimated at 334 afy and increase to 1,465 afy at full buildout.

Skokomish Subbasin

The lower portion of the Skokomish River including the tributaries of Vance, Weaver, Hunter and Purdy Creeks, are rated with a high stream impairment potential (Figures 38 and 39). With the exception of Purdy Creek, each of these streams had a poor habitat condition rating. Purdy Creek has the greatest estimated withdrawals under current conditions (7%) and is estimated to increase to 21% of baseflow at full buildout. Hunter Creek, Weaver Creek, and Richert Springs in the lower Skokomish also show significant peak monthly groundwater withdrawals as a percent of baseflow under full buildout conditions (ranging from 27 to 112%). Assumptions regarding irrigation of agricultural lands are critical in the rating of streamflow impact for these streams.

Rich Geiger with Mason Conservation District reported the following information regarding aggradation and hydrology of the lower Skokomish River. The US Army Corps of Engineers is currently investigating the Skokomish River under a General Investigation to restore this watershed’s ecological functions. Ongoing aggradation in the South Fork and Main Stem have led to high groundwater levels in the lower Skokomish basin. Groundwater elevations in the Skokomish Valley have been rising for several years and are currently very close to the ground surface throughout the central Skokomish Valley.

The aggradation deposits have a high permeability and streams losses through these deposits is high. The Skokomish River has gone completely dry since the summer of 2003 with river bed losses along some sections of up to 100 cfs, without water emerging from the surface. The bottom of the Skokomish River bed along the north side of the Skokomish Valley is higher than the ground elevation along the South valley wall. Purdy, Weaver, and Hunter Creeks appear to be recharged by surface water losses from the Skokomish River, flowing underground from north to south (Rich Gieger, personal communication, June 10, 2009).

To the extent baseflow in Purdy, Weaver and Hunter Creeks is supported by South Fork, losses, baseflow used in this study would be an underestimate. As such, the streamflow impact potential may be overestimated for these creeks. Gaging of these streams would provide better information on the potential for streamflow impact. Furthermore, the Skokomish Valley has large tracts zoned agricultural in the buildout analysis. If the water table remains high in the area, then it is unlikely that these parcels would be irrigated in the foreseeable future. In that case, peak monthly withdrawals would be significantly reduced from those computed in this report, and the potential for streamflow impact correspondingly reduced.

Several creeks in the Skokomish subbasin had fair habitat conditions, relatively low water use, and a moderate potential for stream impairment, driven by the habitat conditions assessment. The uppermost portion of the Skokomish River valley had good habitat rating, low water use, and low potential for stream impairment.

Total withdrawals in the Skokomish subbasin for 2008 are estimated at 835 afy and 5400 afy at full buildout. The increase of over 4500 afy is the greatest projected water use increase for any of the subbasins and results from the large amount of agriculturally zoned land.

South Shore

Each of the streams in the South Shore Subbasin was ranked with a high potential for stream impairment (Figure 40). Each of these creeks had a poor habitat condition rating and all but three creeks (two unnamed and Twanoh Creek) had a peak monthly groundwater withdrawals at buildout exceed 10% of estimated baseflow. Of these Alderbrook Creek shows the greatest potential impact related to groundwater withdrawals, with withdrawals at full buildout estimated to be 127% of creek baseflow. Under current conditions, the analysis indicates Alderbrook Creek subbasin has no water use. The current condition estimate is based on the source based analysis which assigns the withdrawal to a point (which are typically located to a ¼, ¼ section). The buildout analysis assigns the water use to the place of use.

The small basin areas could lead to considerable uncertainty in baseflow estimates for the South Shore streams given that baseflow was estimated based on streams with considerably larger catchments. Total 2008 withdrawals for the South Shore subbasin is estimated at 574 afy and increased to 2,673 afy at full buildout. The increase of 2,100 afy is the second greatest projected water use increase of the study area subbasins.

5.2.1 Discussion and Limitations of the Study

Values for a number of parameters in the study were assumed or had limited accuracies. The uncertainties presented throughout the report are compiled and discussed in this section.

5.2.1.1 Habitat

Habitat condition by reach was rated for streams where a minimum of 25% of the 18 habitat parameters were assessed. Several of the parameters used to characterize habitat condition have not been evaluated for many of the streams. Assessment of missing parameters and inclusion in the rating system will improve the reliability of the habitat ranking scores. In addition, parameters have not been assessed since the significant storms in 2007 and 2008.

The rating matrix was based on professional judgment and used streams with relatively more complete assessments to define good, fair, and poor demarcation points. Other rating systems may be explored in the future and ratings may change as a result.

5.2.1.2 Water Use

Uncertainties regarding water use are subdivided into assumptions used for:

- Establishing fundamental consumptive water use values (i.e., usage, per capita, population per ERU, and irrigation per acre);
- Estimating the number and location of water users for current water use estimates; and
- Estimating future buildout scenarios.

Fundamental Water Use Values

Assumptions regarding total residential withdrawals for PWS are based on data as metered and reported by 10 water systems. These values could be improved as additional metering data becomes available. Consumptive water use estimates for PWS ERUs utilized assumptions regarding inside (65 gpdpc) and outside withdrawals (balance of metered data and inside withdrawals) and number of people per household. Per ERU population estimate of 2.5 is considered to be a good estimate. Values for inside and outside water use and estimates of consumptive use (10% for indoors and 85% for outdoors) for these categories are based on studies from various regions of the U.S. and judgment of Ecology personnel. Overall the consumptive use estimate for PWS ERUs is considered to have a reasonable level of certainty.

Estimate of self-supplied water withdrawal (0.35 afy/ERU) is based on an assumed irrigated acreage of 0.1 acres. This value compared favorably with a multiplier of 1.3 times PWS use (0.38 afy/ERU) indicated by USGS data. Metering of exempt wells could improve these estimates. Overall self-supplied water use has less certainty than for PWS use.

Crop irrigation requirements are considered to have a reasonable level of certainty. Consumptive crop use was based on stations north and south of the study area. The consumptive crop estimates are based on the WIG which used the SCS Blaney Criddle method to estimate evapotranspiration. More rigorous methods for estimating ET are available (for example Penman Montieth) however, the data to support these methods is likely unavailable in the study area. Improvements would likely lead to changes on the order of 1 to 2 inches, which is not considered significant to the WRIA-wide estimates given the relatively small amount of irrigated land in the WRIA. The assumed irrigation efficiency of 85% is considered a moderate to good estimate. The estimate could be improved with more information regarding specific irrigation practices.

Current Water Use Estimates

The population based water use estimate assumes no non-residential water use. This estimate could be improved by incorporating non-residential water use. In addition, the projection of population from 2000 census data to 2008 also has a slight uncertainty that could be removed by updating the estimate with 2010 census data when it becomes available.

Source-based water use estimates rely on a well logs for determining the locations and number of self-supplied households. Some wells will be in use that don't have an associated well log. On the other hand, this error may be offset by wells that have logs and are no longer utilized. Well logs often have poor locational accuracy and some are likely mislocated within the WRIA. The location of domestic single surface water rights may not be accurate for all water rights. In addition, some rights are located only to the nearest section. Ground truthing of self-supplied well locations and water right locations would improve the estimate.

Water use from non-residential connections is considered to have a high degree of uncertainty in the source-based water use estimate. We assumed 50% of the residential connections, however, depending on the actual use of the nonresidential connection, these estimates could vary significantly from the assumed 50% of residential use.

In both the population- and source-based methods, the area of irrigated lands is uncertain, particularly in the Skokomish Basin. While estimated at 1% of the mapped agricultural land in the area, the actual irrigated acreage may be closer to 0.2% (Rich Gieger, personal communication, June 18, 2009) . Mapping of irrigated lands could improve this estimate.

Future Water Use Estimates

Future water use required a great number of assumptions regarding future land use activities. These assumptions are summarized in Table 5 and may be updated as additional information becomes available. The breakdown by zoning classification in the Zoning Based Water Use Estimate Section presents the area assigned to each of the zoning classifications and which are more prevalent, and therefore, may have a greater impact on the water use estimate.

Streamflow Impact Analysis

Estimates of stream base flow were used in the absence of instream flow rules to place groundwater withdrawals in the context of streamflow impact. These estimates are based on correlation by basin area to gaged streams. This could lead to considerable error, particularly in smaller streams. Estimated stream base flow is very small for many of the smaller creeks, and small changes in the base flow estimate (in terms of absolute magnitude) presents considerable uncertainty into the estimate of groundwater withdrawals as a percent of base flow. Defining instream flows and/or gaging of ungaged streams would eliminate the uncertainty associated with this parameter.

Peak monthly water use estimates were based on USGS studies. WRIA specific information could improve this estimate.

The assignment of 0-5%, 5-10%, and >10% of peak monthly groundwater consumptive use to low, moderate and high potential for streamflow impact provides a relative ranking, but could be quantified using biologic studies that relate streamflow to salmonid habitat as these studies are made.

5.2.1.3 Stream Impairment

Because the assumptions and uncertainties for habitat conditions, water use, and streamflow were applied throughout the study area, the results provide a relative ranking of the potential for stream impairment within the WRIA. These rankings can be utilized to screen and prioritize subbasins for future actions.

The algorithm, which rates stream impairment, can be readily modified as additional data becomes available. The relative contribution of habitat conditions and streamflow impact to the overall stream impairment potential can be easily changed to evaluate alternative rankings.

5.3 Recommendations

Areas for additional data refinements related to evaluating streamflow impact include:

- Establishment of instream flows;
- Evaluation of surface water/groundwater continuity and the assumption that 100% of the groundwater withdrawals within a subbasin impact streamflow within that subbasin;
- Analysis of the timing of groundwater flow impacts on streamflow;
- Stream gaging measurements to obtain baseflow data of ungaged streams; and
- Evaluation of groundwater withdrawals relative to instream flows rather than estimated baseflow.

6 Public Water Systems and Demand at Buildout

This section compares total water rights for public water systems within the WRIA with estimated withdrawals at full buildout.

6.1 Methodology

The methodology for estimating consumptive use under buildout conditions is discussed above in Section 4.2.3. Briefly, zoning classifications were assigned consumptive use values per parcel and adjustments made to include agricultural irrigation, and also golf course irrigation for Rural Tourist zoning in the Alderbrook and Lake Cushman water systems.

The consumptive use under full buildout conditions was summed for each PWS service area and converted to withdrawals using the appropriate net consumptive rate from Table 4. Service areas for systems within Jefferson County utilized county GIS data. For Mason County, service areas were digitized from PWS maps. Future service areas were available and used in the buildout analysis for five systems: Belfair Water District No. 1, Canal Beach Tracts Mutual Water System, Hoodsport Water System, Lazy C Water System, and Triton Cove Water System.

Water right surplus/deficit by water system was calculated as total water rights less withdrawal at buildout. This calculation was performed for those systems for which services areas and water rights were available.

The public water systems considered for evaluation were 28 systems listed in the inchoate water rights paper (WRIA 16, 2008). To those were added three systems whose service areas were provided as GIS data by Jefferson County. Six systems were removed and two added due to mergers resulting in 27 systems. Of 27 systems, 25 PWS had water right data provided by WRIA 16 (2008) or reported in a water management plan. Service areas were available for 22 PWS (Figure 41). The intersection of systems with both water right and service area data resulted in a set of 19 PWS suitable for analysis.

6.2 Results

Table 8 presents a summary of PWS data, usage, and water rights. Water rights were taken as self-reported data from water system plans, where available, and then from the inchoate analysis (WRIA 16, 2008). Estimates of inchoate water rights were made by subtracting the *most recent water use* from the water right. These data were estimates only as some irregularities in water rights data were noted, protocols for measurement of usage vary, and about half of recent usage values were estimated from the number of connections.

There were 13 self-reported estimates for 2025 withdrawals and 7 self-reported estimates at buildout. For the buildout analysis in this study, both consumptive use and total withdrawal are reported for 22 systems. Water right surplus/deficit is calculated for 19 systems.

For the 19 systems, total withdrawal estimated under buildout conditions was about 3,800 afy, compared with most recent usage estimates of about 1,300 afy. Consumptive use at buildout was estimated to be about 1,700 afy with a net consumptive rate of 45%. Net water right availability for all 19 systems is -1,400 afy. Most of that shortfall, 83%, is attributable to the Lake Cushman Water System. Estimated current use, with golf course irrigation added, is about 600 afy, while zoning based buildout use is estimated at 1,400 afy. The 2003 water system plan notes that water rights of 1,329 afy have been applied for, which if granted would leave a much smaller shortfall of about 80 afy.

Three other water systems, Lazy C, Belfair, and Union have significant negative net water right availabilities of about -320, -270, and -180 afy, respectively. Hoodsport and Hood Canal systems also have substantial negative availabilities of -86 and -82 afy, respectively (Table 8). A total of 13 water systems have negative water right availability at buildout.

For Lazy C, the negative water rights availability and, also, the large difference between self-reported buildout withdrawal and zoning based buildout withdrawals, 28 and 380 afy respectively, are due to the difference between current and future service areas. For water system planning, Jefferson County PUD has defined a future Lazy C service area to include much of Brinnon, based on discussion of a petition for a water system outside the current retail service area. Jefferson PUD elected to get approval from the County Water Utility Coordinating Council to move ahead in the planning process regardless of the fact that the PUD currently lacks sufficient water rights to serve the expanded future service area (Graham, 2009). The computed 380 afy withdrawal uses this larger service area and the 28 afy withdrawal uses the smaller, current retail area.

The Alderbrook Water Company has an apparent, considerable excess water right availability of about 590 afy. Five other systems, Potlatch Beach, Pleasant Tides, Highland Park, Beacon Point, and Brinnonwold have estimated net availabilities of 58, 34, 33, 25, and 5 afy, respectively.

Outside of the large consumptive use for power in the North Fork of the Skokomish River, Group A public water systems represent a significant amount of the total consumptive use in WRIA 16 and 14b. The buildout analysis suggests that Group A systems may use about one-third of total water withdrawn in the WRIA and current use estimates indicate PWS withdrawals are slightly more than half of total withdrawals.

6.3 Recommendations

Review of the data in Table 8 suggests that the greatest area for improvement and understanding of water use patterns is to improve data collection protocols. The following items are presented for consideration:

1. Update and complete the determination of existing water rights for Group A systems. Identify which water rights are non-additive. During preparation of the data summary, some inconsistencies were noted between system plans, the WRIA 16 inchoate analysis, and Ecology water rights data.

2. Investigate more carefully the current and future usages for public water systems with large projected withdrawals, internal discrepancies in the data, and large net water rights availabilities, either negative or positive.
3. Continue encouraging implementation of water metering and use reporting for Group A systems, which represent more than half of total withdrawals in the WRIA. Source and connection metering can provide accurate use information and help identify system leaks. It should be expected that reporting and data sharing may be adversely affected until the current legal uncertainties about municipal water rights are resolved.
4. Identify an agency or agencies to collect and analyze water system use data and source water level data. The Kitsap PUD web site provides an example of how this data may be processed and made available to the public.
5. Develop and implement a pilot voluntary program for metering usage at Group B and exempt well sources where user cost is not related to usage. The program should select a variety of sites and include an inventory of parameters that can be correlated with usage patterns and will improve withdrawal estimates for non-metered sources. Possible parameters may include zoning code, parcel size, building development, land cover, land use, and building types and sizes.
6. Continue pursuing implementation of water conservation and water supply and use recommendations previously made (WRIA 16, 2006).
7. Periodically reevaluate current and future water supply needs using the tools provide by this study.

7 Conclusions and Recommendations

7.1 Conclusions

1. Habitat conditions were rated within the WRIA based on previously scored parameters. Ratings indicate that approximately 22% of the assessed stream length rate as “good” habitat condition, 33% rate as fair, and 28% rate as poor. Seventeen percent (17%) had insufficient data to allow assessment.

2. Water use for public water systems was estimated at 104 gpdpc with consumptive use totaling 34 gpdpc (33%). Self-supplied water use was estimated at 127 gpdpc with 59 gpdpc consumptive use (47%).

3. Consumptive agricultural water use was estimated as 1.47 ft per year based on the crop irrigation rate (WIG) for pasture/turf at Shelton and Quilcene. Irrigation water withdrawals were estimated 1.7 ft/acre, assuming an irrigation efficiency of 85%.

4. Total water withdrawals in 2008 were estimated at 2,300 afy for the study area with 980 afy (43%) estimated as consumptive. Approximately 280 afy of the total withdrawals are for agricultural irrigation. Assumptions regarding irrigated lands within the WRIA may have a significant impact on the estimated water use. Consumptive use obtained using the population method (910 afy) compares favorably with the source-based method, but likely underestimates nonresidential use.

5. Water use under future buildout conditions was estimated based on current zoning codes. Total groundwater withdrawal at full build-out was estimated at 12,500 afy and consumptive water use was estimated at 6,900 afy indicating an approximately 5 fold increase in total withdrawals at full buildout compared to 2008 conditions.

6. Consumptive use estimated from water rights totaled 3,900 afy, not including consumptive use of power generation. The total consumptive use estimated from water rights is about 4-fold greater than estimated current water use, indicating much of the existing water rights are unused. The proportions of groundwater and surface water use based on water rights were 55% and 45%, respectively, excluding consumptive use power generation.

7. Peak monthly groundwater withdrawals were expressed as percent of stream baseflow in order to rate potential streamflow impacts resulting from groundwater development. No instream flows have been set for the WRIA and estimated baseflows were used to evaluate groundwater withdrawals with respect to streamflow. Baseflow was estimated from gaging data and correlation with gaged streams.

8. Under current conditions, peak monthly consumptive groundwater use was found to be a maximum of 7% of baseflow at Purdy Creek, a tributary stream of the Skokomish River. Assumptions regarding irrigation withdrawals in the Skokomish basin and baseflow estimates could effect this estimate. Three South Shore streams

had peak monthly groundwater withdrawals ranging between 3.5 and 6%. Assumptions regarding irrigation have little effect on these estimates, but baseflow estimates in these small streams can have a significant effect on the estimated percentages.

9. Under full buildout conditions, peak monthly consumptive groundwater use increases significantly with 13 streams exceeding 10% of baseflow. Assumptions regarding buildout conditions could have a significant influence on this estimate.

10. The relative potential for groundwater withdrawals to impair salmonid habitat was evaluated through consideration of habitat condition and groundwater withdrawals as a percent of baseflow. Under current conditions, 28 of 61 subbasins were rated with a relative high overall potential for stream impairment. The habitat conditions in those subbasins were generally rated as poor. Under full buildout, 30 of the 61 subbasins were rated with a relative high overall potential for stream impairment. The rankings of Purdy Creek and Richert Springs change from moderate to high potential under buildout conditions as a result of increased groundwater withdrawals.

11. For the 19 public water systems with water right and service area data, total withdrawal under buildout conditions was estimated at about 3,800 afy, compared with most recent withdrawal estimates of about 1,300 afy. Thirteen systems had a negative net water right availability at buildout. Six systems had a positive net water right availability. Net water right capacity for all 19 systems is -1,400 afy (i.e., demand exceeds water rights by 1,400 afy). Most of that shortfall, 83%, is attributable to the Lake Cushman Water System that has applied for a water right of 1,329 afy and if granted would leave a shortfall of about 80 afy.

7.2 Summary of Recommendations

A. General

1. Develop LiDAR coverage for the entire WRIA 16 and 14b study area. The improved topographic accuracy will significantly improve topographic control for future studies and analyses.

2. As new data becomes available, utilize the ArcView Model Builder Model to update the analysis.

3. Successful updating and long-term use of the base datasets is dependent on stable formatting. The PU should inform important partner agencies (Mason County, Jefferson County, Skokomish Tribe, WSCC, WDFW, and Ecology) of the WRIA 16 use of and dependence on the agency datasets and develop formal interagency relationships to encourage stability in dataset formats.

B. Habitat

4. Reduction of data gaps by complete assessment of habitat condition parameters is recommended. An average of 52% of habitat evaluation parameters has been assessed for WRIA 16 and 14b stream reaches.

5. This study's development of overall habitat ratings by stream reach, which weighted multiple WSCC habitat characterization parameters, should be critiqued and evaluated by the professional biological community.

6. Incorporate this study's overall habitat ratings, by stream reach into the SalmonScape database.

7. Expand monitoring of stream temperature. Temperature is relatively easily measured, but the number of current monitoring locations (19 of 63 reaches) is limited. In addition, the majority of the data points are at a single location on the entire stream. The knowledge of stream temperature may be improved by: (1) increasing the number of monitoring locations instrumented with low cost temperature loggers and collecting continuous data, and (2) creating a geospatial dataset of stream temperature that includes biologically significant averages and minimums. Priority for site selection should be given to streams downstream of logging and development activities and to smaller streams and tributaries.

8. The process of evaluating the Dosewallips by the PGST (Labbe et al., 2005) should be utilized on all the major watersheds. The leveraging of expensive field time with LiDAR and aerial photographic flyovers is considered to be an efficient method of habitat assessment.

9. Update existing habitat condition data where required by storm events, logging, or development. For example, two major storm events in 2007 and 2008 have likely altered LWD distributions in all the watersheds.

10. Identification of critical instream flows requires additional site-specific data collection. There is relatively little instream flow data. The study completed by Aspect (2005) is an example for collection of instream flow and fish passage data.

C. Water Use

11. Develop a database or work with state agencies (WDOH for Group A/B sources; Ecology for permit exempt wells and water rights) to provide accurate withdrawal and diversion locations. The importance of having complete and accurate x,y location records cannot be underestimated for using the data in geospatial analysis.

12. Investigate actual water use for agricultural irrigation in WRIA 16 in order to improve estimates. This could be done through detailed mapping of irrigated lands.

13. Continue encouragement of metering and reporting of water use by public water systems.

14. Encourage public water systems to measure actual usage for golf course irrigation.

15. Develop a program for monitoring a sampling of exempt wells to better evaluate self-supplied water use in western Washington.

16. More carefully evaluate future buildout scenarios to improve the buildout analysis, particularly potential uses on agricultural lands and commercial centers.

D. Habitat and Consumptive Water Use Assessment

17. Establish instream flow rules and evaluate groundwater withdrawals relative to instream flows rather than to estimated baseflows.

18. Evaluate surface water/groundwater continuity and the assumption that 100% of the groundwater withdrawals impact streamflow within catchment or subbasin.

19. Analyze timing of groundwater flow impacts on streamflow.

20. Measure streamflows throughout WRIA 16 and 14b to obtain baseflow data on ungaged streams and to determine correlations with gaged streams.

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Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of WRIA 16 Planning Unit for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

Table 1 - Dataset Summary
WRIA 16 Impaired River Analysis

Dataset Name/Desc.	Type	Use/Purpose	Source
FEMA Q3 Flood Data	Vector (coverage)	100 year floodplains	FEMA
Habitat Conditions Database	Tables (Access Database)	data on in-stream ecological indicators in the Hood Canal watershed	HCCC via PetersonGIS
2006 Impervious Surfaces from HCCC	Vector (shapefile)	impervious surfaces such as rooftops, driveways, paved and dirt roads, and quarry sites	HCCC via PetersonGIS
Jefferson County Potential Soil Erosion Areas	Vector (shapefile)	potential erosion hazards in eastern Jefferson County	Jefferson County GIS
Jefferson County Roads	Vector (shapefile)	roads in Jefferson County	Jefferson County GIS
Jefferson County Parcel Data	Vector (shapefile)	parcels, assessor's land use data	Jefferson County GIS
Jefferson County Water Service Areas	Vector (shapefile)	current and future water service areas in Jefferson County	Jefferson County GIS
Jefferson County Zoning	Vector (shapefile)	zoning in Jefferson County	Jefferson County GIS
Mason County Hazone -landform areas of landslide hazard	Vector (shapefile)	identifies the known landslide hazards in Mason County	Mason County GIS
Mason County Road Damage Incidents	Vector (shapefile)	locations of road damage during the December 3rd, 2007 storm	Mason County GIS
Mason County Roads	Vector (shapefile)	roads in Mason County	Mason County GIS
Mason County Development Areas	Vector (shapefile)	development areas for Mason County as described in the Mason County Development Regulations, Title 17 (adopted as Ord. No. 82-96, as revised).	Mason County GIS
Mason County Parcel Data	Vector (shapefile)	parcels, assessor's land use data	Mason County GIS
Mason County Water Districts	Vector (shapefile)	represents the 4 water districts in Mason County	Mason County GIS
NLCD Land Cover	Raster (TIFF)	landsat-based landcover classifications	MRLC via WA Ecology
Watershed Hydrologic Unit Boundaries	Vector (shapefile)	hydrologic units, watershed boundaries, subwatershed boundaries	Pacific Northwest Hydrography Framework
2005 DNR Aerial Photos	Raster (TIFF)	aerial photo	Skokomish Tribe
2007 WSDOT Aerial Photos	Raster (TIFF)	aerial photo	Skokomish Tribe
Skokomish Tribe: Average Daily Temperature	Table (Excel)	temp monitoring on the South Fork for the steelhead project	Skokomish Tribe
Land Use Skokomish Reservation as of 2007-08	Vector (shapefile)	land use and planning on reservation	Skokomish Tribe
US Census TIGER 2008: blocks	Vector (shapefile)	2000 Census population data	US Census Bureau via WOFM
NAIP Aerial Photos	Raster (MrSID)	aerial photo	USDA
USGS 1:24K Topo Quads	Raster (ESRI GRID)	Topo Maps	USGS
USGS Digital Elevation Models	Raster (ESRI GRID)	ground surface elevations, stream slopes, watershed delineation	USGS
Shoreline Slope Stability	Vector (shapefile)	shoreline slope stability coverage	WA Ecology
2001 Impervious Surfaces from 2001 NLCD	Raster (TIFF)	impervious surfaces based on MRLC/NLCD (percent imperviousness)	WA Ecology
WRIA Boundaries	Vector (shapefile)	WRIA boundary and subbasins	WA Ecology
2008 Water Quality Assessment: 303(d)	Vector (shapefile)	Category 5 water quality assessment	WA Ecology

Table 1 - Dataset Summary

WRIA 16 Impaired River Analysis

Dataset Name/Desc.	Type	Use/Purpose	Source
Well Log Database	Table (Excel)	well locations and information	WA Ecology
WRTS Database	Table (Excel)	water right locations and information	WA Ecology
SalmonScape: Culverts	Vector (shapefile)	location of culverts (fish passage barriers)	WDFW
SalmonScape: Dams	Vector (shapefile)	location of dams (fish passage barriers)	WDFW
SalmonScape: Fish Distribution	Vector (shapefile)	spatial representation of anadromous and resident salmonid fish distribution maintained by the Washington Department of Fish and Wildlife (WDFW).	WDFW
SalmonScape: Fish Passage	Vector (shapefile)	fish passage barriers	WDFW
SalmonScape: Natural Barriers	Vector (shapefile)	natural barriers - waterfalls and gradients (fish passage barriers)	WDFW
SalmonScape: Salmonid Stock Inventory (SaSI)	Vector (shapefile)	compilation of data on all wild stocks and a scientific determination of each stock's status as: healthy, depressed, critical, unknown, or extinct	WDFW
Geology: Faults	Vector (shapefile)	information describing both the contacts between geologic units and fault types - only those contacts with fault info have been extracted	WDNR
Geology: Folds	Vector (shapefile)	fold axes and descriptive data - shows the location and types of folds in rocks in the State of Washington	WDNR
Surficial Geologic Units	Vector (shapefile)	defining the extent, and label of each geologic unit	WDNR
WDNR 1:24K Waterbodies	Vector (coverage)	features such as Puget Sound, lakes, wet areas, reservoirs, impoundments, glaciers, islands, and dams	WDNR
WDNR 1:24K Watercourses	Vector (coverage)	watercourses representing streams, ditches, or pipelines, or as centerlines through water body polygons such as double-banked streams, lakes, impoundments, reservoirs, wet areas, or glaciers	WDNR
Mason County Aerial Photo	Raster (MrSID)	aerial photo	WDNR via Mason County
PWS Sentry Database	Database and Tables	public Water System data such as number of connections, locations, population	WDOH

Table 2 - Habitat Condition Rating by Stream Reach

WRIA 16 Impaired River Analysis

		Passage	Floodplain		Channel Condition						Sediment Input			Riparian Zones	Water Quality		Flow		Biological Processes				
Weighting Factors		0.00	8.33	8.33	2.78	2.78	2.78	2.78	2.78	2.78	5.56	5.56	5.56	16.67	8.33	8.33	8.33	8.33	0.00				
Stream Name/Segment	WRIA	Access	Floodplain Connectivity	Floodplain Habitat	Fine Sediment	Large Woody Debris (LWD)	% Pools	Pool Frequency	Pool Quality	Bank Stability	Sediment Supply	Mass Wasting	Road Density	Riparian Condition	Water Temperature	Dissolved Oxygen	Hydrologic Maturity	% Impervious Surface	Nutrients	Score for Assessed Parameters (using weighting factors)	Perfect Score for Parameters Assessed	Score as Percent of Perfect Score	Habitat Condition Rank
WRIA 16																							
Dosewallips																							
Turner Creek	16.0559	1	3	3		1	1		2		1		3				5	5	1	167	264	63%	F
Dose RM 0.0-3.6	16.0442	5	1	5		1			1	1	1	5	3	1	3			5	1	192	375	51%	P
Dose RM 3.6-12.5	16.0442	5	1	1		1			1	1	5	5	5	3	4			5		233	375	62%	F
Dose above RM 12.5	16.0442	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		500	500	100%	G
Dose - Rocky Brook	16.0449	5				1	1	5	1			1	1		4		5	5		150	236	64%	F
Walkers Creek	16.0441	5				3	3		1		5		1	2			1	5	1	136	264	52%	P
Duckabush																							
Duck RM 0.0-5.0	16.0351	5	2	1		2	3					1	3	2	4		3	5	1	194	375	52%	P
Duck RM 5.0 - 8.0	16.0351	5								5		1	5	5			5	5		214	236	91%	G
Duck above RM 8.0	16.0351	5			5	5	5	5	5	5	5	5	5	5	5	5	5	5		417	417	100%	G
Hamma Hamma																							
McDonald Creek	16.0349	5	5	3	5	3	3	3		3	1	5	1	1	2		1	5		236	445	53%	P
Fulton Creek	16.0332	5	3	5		1	1				5		5	5	1		5	5		303	375	81%	F
Schaerer Creek	16.0326	5	5	5								1	3				5	5		189	222	85%	F
Unnamed Trib (Mikes Bch)	16.0325	1	1	1							1		1				3			53	181	29%	P
Waketickeh Creek	16.0318	5	1	1									1	3			5	5	2	156	278	56%	P
Hamma RM 0.0-1.5	16.0251	5	1	3		1	3			5	5		1	1	5			5	2	192	347	55%	P
Hamma RM 1.5-2.3	16.0251	5				1	3			5			1	5				5		156	195	80%	F
Hamma above RM 2.3	16.0251		5	5			1						5	5			3	5	2	264	292	90%	G
John Creek	16.0253	5	3	3	3	3	3		1		1	1	3	2	3		5	5		247	431	57%	P
Finch/Lilliwaup																							
Jorsted Creek	16.0248	5	1	1		1				3		3	1				5	3		117	250	47%	P
Eagle Creek	16.0243	5	3	5		3				5			1				5	5	5	178	222	80%	F
Lilliwaup RM 0.0-0.7	16.0230	5	1	1		1				3	5	5	1	1			5	5		189	361	52%	P
Lilliwaup above RM 0.7	16.0230	5	5	5						5		5	1	5			5	5		297	319	93%	G
Little Lilliwaup	16.0228	5	3	3						5	5	5		5						203	236	86%	F
Sund Creek	16.0226	5	1	1		1					1	5	3	1			5			128	306	42%	P
Miller Creek	16.0225	5	1	1		1				1	1	5	1	1			5			119	320	37%	P
Clark Creek	16.0224	5	1	1		1				5				3					1	83	194	43%	P
Finch Creek	16.0222	1	1	1		1				1	5	5	1	3			5	5	1	217	361	60%	F
Hill Creek	16.0221	5				1				5			1	5						106	139	76%	F
Skokomish																							
Unnamed Creek (Canal Side)	16.0220	1	1	1																17	83	20%	id
Minerva Creek	16.0218	1	1	1																17	83	20%	id
Potlatch Creek	16.0217	1	1	1		1														19	97	20%	id
Entai Creek	16.0216	1	1	1															1	17	83	20%	id
Skokomish, RM 0.0-9.0	16.0001	5	1	1		1				5	1		1	1			1			69	292	24%	P
Purdy Creek	16.0005	5	5	5		5					5		1	3	5		1	5		272	361	75%	F

Table 2 - Habitat Condition Rating by Stream Reach

WRIA 16 Impaired River Analysis

		Passage	Floodplain		Channel Condition						Sediment Input			Riparian Zones	Water Quality		Flow		Biological Processes				
Weighting Factors		0.00	8.33	8.33	2.78	2.78	2.78	2.78	2.78	2.78	5.56	5.56	5.56	16.67	8.33	8.33	8.33	8.33	0.00				
Stream Name/Segment	WRIA	Access	Floodplain Connectivity	Floodplain Habitat	Fine Sediment	Large Woody Debris (LWD)	% Pools	Pool Frequency	Pool Quality	Bank Stability	Sediment Supply	Mass Wasting	Road Density	Riparian Condition	Water Temperature	Dissolved Oxygen	Hydrologic Maturity	% Impervious Surface	Nutrients	Score for Assessed Parameters (using weighting factors)	Perfect Score for Parameters Assessed	Score as Percent of Perfect Score	Habitat Condition Rank
Weaver Creek	16.0006	5	1	1		1	1	1	1				1	1	5		1	5		142	375	38%	P
Hunter Creek	16.0007	5	1	2		1	1	1	1			5	1	1	5		1	5		178	403	44%	P
Richert Springs	16.0009	5	5	5		5	5	5	5	5				4			3	5		286	319	90%	F
NF Skok, mouth to RM 17.3	16.0001																			0	0	NA	id
NF Skok, above RM 17.3	16.0001																			0	0	NA	id
McTaggert Creek	16.0105																			0	0	NA	id
SF Skok, mouth to RM 3.0	16.0011	5	1	3	3	1	1	1	1	1	1	1	1	1			1		1	97	417	23%	P
SF Skok, RM 3.0-10.0	16.0011	5			5	1	5	5	5	5	1	5	3	5			3		5	231	292	79%	F
SF Skok, RM 10.0-23.5	16.0011	5	5	5	5	4	1	1	5	4	1	1	0	3			5	5	5	283	417	68%	F
SF Skok, above RM 23.5	16.0011	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		500	500	100%	G
Vance Creek	16.0013	5	1	1	3	1	1	1	1	1	1	1					1		1	58	264	22%	P
Rock Creek	16.0038	5		3		5			1	3	5		1	5			2	5	1	225	306	74%	F
Brown Creek	16.0047	5	5	3		5			5	1	2	1	1	5	5		1	5	5	294	417	71%	F
Le Bar Creek	16.0053	5	5	3		1	1			1	5	1	3	5	3		1	5	5	283	417	68%	F
Cedar Creek	16.0066	1				5	5		5	4	5	3	1	5	5		1	5	1	278	347	80%	F
Pine Creek	16.0071	5				1	1		1	1	2	1	3	5	5		2	5		228	347	66%	F
Church Creek	16.0077	5	5	5		3				1		1	1	3	5		1	5		247	375	66%	F
WRIA 14b																							
South Shore																							
Devereaux Creek		1	5	5		1	2						1	3				1	1	156	264	59%	P
Springbrook Creek		1	1	1		2	1						1	5						114	222	51%	P
Holyoke Creek		5	1	1		5	3						1	5						128	222	58%	P
14.0129		5	1	1		4	3						5							64	139	46%	P
14.013		5	1	1									3							33	111	30%	id
Twanoh Falls Creek		1	1	1		2	3			1			1	2						72	236	31%	P
Twanoh Creek		5	1	1	2	1	1	1	1	2			1	3				5	5	136	320	43%	P
Nordstrom Creek		1	1	1		3	3						1					1	1	47	181	26%	P
Alderbrook Creek		1	1	1		4	1						1	2				1	1	78	264	29%	P
Dalby Creek		1	1	1		4	1						1	5						119	222	54%	P
Big Bend Creek		3	1	1									1	3						72	194	37%	P

Notes and Abbreviations:
Data from Correa, 2003 and Kuttel, 2003.
Zero value cells are shown as empty for readability.
Hunter Creek is incorrectly identified as Weaver Creek on Skokomish topographic map.
G = good (green shading)
F = fair (blue shading)
P = poor (no shading)
id = insufficient data (no shading)

Scoring	
G, GG	5
F/G	4
F, FF, P/G	3
P/F	2
P	1
G/DG	0
DG = data gap	0
NA	0

Control Points

greater than	0%	P
greater than	60%	F
greater than	90%	G
fewer than 5 parameters assessed:		id

Table 3 – Water Temperature Exceedances

WRIA 16 Impaired River Analysis

Temp (deg C)	Date Time	Site Description	Lat	Long
12.1	08/22/06 2:56:26 PM	Skokomish R mainstem at Hwy 101 bridge, park/access from SE. Under bridge, RR. WAND	47.30988	-123.17687
12.1	07/17/07 3:36:53 PM	Skokomish R mainstem at Hwy 101 bridge, park/access from SE. Under bridge, RR. WAND	47.30988	-123.17687
12.5	07/17/07 3:59:52 PM	Skokomish River @ 106 bridge	47.32369	-123.15169
12.1	08/20/07 3:00:01 PM	Skokomish River @ 106 bridge	47.32369	-123.15169
17.8	08/22/06 5:09:38 PM	Lilliwaup River at Hwy 101, park N of bridge. DS, RL. STEEP. WAND	47.46762	-123.12216
12.4	09/18/06 12:51:01 PM	Lilliwaup River at Hwy 101, park N of bridge. DS, RL. STEEP. WAND	47.46762	-123.12216
17.3	08/22/06 5:42:20 PM	Hamma Hamma River at Hwy 101 south-most bridge. US, RR. WAND	47.54492	-123.04175
12.3	09/18/06 12:18:11 PM	Hamma Hamma River at Hwy 101 south-most bridge. US, RR. WAND	47.54492	-123.04175

Table 4 - Parameters and Estimates for Water Use

WRIA 16 Impaired River Analysis

Parameter Values			
Per Capita Inside Withdrawal =	65	gpdpc	Ecology discussions.
Population Per Residence =	2.5		Mason County (US Census, 2000).
Crop Irrigation Requirement =	1.47	ft/yr	Average of pasture/turf CIR for Shelton and Quilcene (USDA, 1992).
Irrigation Withdrawal =	1.73	ft/yr	Total irrigation including evapotranspiration losses (CIR / outside consumptive rate).
Inside Consumptive Rate =	10%		Assumed by Sapik (1988); Ecology discussions.
Outside Consumptive Rate =	85%		Shaffer, et. al, 2007, Ecology Guidance 1210 (2005)
Conveyance Loss =	10%		Professional judgment.

Water Use Estimates (based on annual average)

	Irrigated Acreage	Withdrawal			Consumptive Use			Net Consumptive Rate	Notes
	acres	gpdpc	gpd/ERU	afy/ERU	gpdpc	gpd/ERU	afy/ERU		
Estimates for this Study									
Water Systems	0.05	104	259	**0.29**	34	85	**0.096**	**33%**	Median of 10 WRIA 16 public water systems. Assume 10% conveyance loss is non-consumptive. Acreage is backcalculated assuming 65 gpdpc inside withdrawal.
Permit Exempt Well or Well Log	0.1	127	317	0.35	59	147	**0.165**	**47%**	Assume residence plus 1/10 irrigated acre.
Domestic Single (DS) Water Right	0.1	127	317	0.35	59	147	**0.165**	**47%**	Assume residence plus 1/10 irrigated acre.
Domestic Multiple (DM) Water Right - Minimum	0.2			0.71			**0.330**		Assume minimum of two residences and use double DS value.
Previous Estimates									
WRIA 16 Level 1 Assessment		**120**	300	0.34					(Golder, 2003).
USGS Washington Water Use Study		**110**	275	0.31					Mason County (Lane, 2000).
Comparative Scenarios									
Residence without irrigation	0	65	163	0.18	7	16	**0.018**	**10%**	
Residence with 1/4 acre irrigation	0.25	219	549	0.61	138	344	**0.39**	**63%**	
Residence with 1/2 acre irrigation	0.5	374	935	1.05	269	672	**0.75**	**72%**	
Residence with 1 acre irrigation	1	683	1707	1.91	531	1329	**1.49**	**78%**	

Table 5 - Estimated Consumptive Use at Buildout by Zoning Code
WRIA 16 Impaired River Analysis

County	Zoning Code	Description	Development Regulation[1]	Density Summary	Minimum Parcel Size (acres)	Assumed Consumptive Water Use per ERU	ERUs per Minimum Parcel Size	Estimated Consumptive Water Use per Minimum Parcel Size	Assumptions/Comments
					(acres)	(afy)	-	(afy)	
Mason	AGR	Agricultural Resource Lands	17.03.037	One DU/10 acres; Additional density of one DU/5acres.	10	-	2	12.09	Assume 10 acre parcel 80% irrigated at WIG (USDW, 1992) Shelton/Quilcene rate with primary dwelling and ADU.
Mason	IH	Inholding Lands	17.02.049	5 acre minimum parcel size per Resource Ordinance 17.01.062.	5	0.165	2	0.33	Assume ADU is allowed.
Mason	IR	Indian Reservation	na	Tribal and non-tribal commercial, commercial/residential.	na	0.165	4	0.66	Assume these zoning categories are equivalent to 4 ERU per parcel.
			na	All other on-reservation categories.	na	0.165	1	0.17	Assume 1 ERU per parcel.
Mason	LTCF	Long Term Commercial Forest	17.01.06.0.d.1	80 acres.	80	0.165	2	0.33	Assume ADU is allowed.
Mason	ONF	Olympic National Forest	17.02.034	Assume no development.	-	-	-	0	Assume no development.
Mason	ONP	Olympic National Park	17.02.032	Assume no development.	-	-	-	0	Assume no development.
Mason	RC1	Rural Commercial 1	17.04.320	Minimum lot size depends on subject property location; allows for convenience general store, gas, restaurant, B and B, laundry.	1	0.165	3	0.50	1 acre minimum lot size is assumed. Number of ERUs assumes general store, residence and laundry.
Mason	RC2	Rural Commercial 2	17.04.330	Same as RR1 but also allows for restaurant, vehicle repair, small office, public meeting space, nursery, post office, day care.	1	0.165	3	0.50	1 acre minimum lot size is assumed. Number of ERUs assumes general store, residence and laundry.
Mason	RC3	Rural Commercial 3	17.04.340	Same as RR2 but with wider permitted uses including medical dental clinic, winery, ADU.	1	0.165	4	0.66	1 acre minimum lot size is assumed. Add one additional ERU over RR2.
Mason	RI	Rural Industrial	17.04.400	Lot size dependent on subject property location. Uses manufacturing, warehousing, contractor yards.	1	0.165	3	0.50	1 acre minimum lot size is assumed. Assume warehouse equivalent to 3 times ERUs.
Mason	RMF	Rural Multi Family	17.04.250	Minimum lot size of 5 acres; allows for multifamily residences, duplexes, mobile home park.	5	0.096	20	1.91	Usage similar to water system; density based on condo density near Union with this zoning that appears built out.
Mason	RNR	Rural Natural Resource	17.04.500	Minimum lot size 5 acres; allows for processing of native natural material such as forest products, mining, aquaculture, agriculture.	5	0.165	10	1.65	Intensive water use equal to 10 ERUs.
Mason	RR10	Rural Residential 10 Acres	17.04.230	1 principal residence per 10 acres.	10	0.165	2	0.33	Regulations indicate maximum density of 1 dwelling per 5 acres.
Mason	RR2.5	Rural Residential 2.5 Acres	17.04.210	1 dwelling unit per 2.5 acres; one ADU.	2.5	0.165	2	0.33	Assume one dwelling and one ADU on 2.5 acres.
Mason	RR20	Rural Residential 20 Acres	17.04.240	1 principal residence per 20 acres.	20	0.165	2	0.33	Assume one dwelling unit and one ADU on 20 acres.
Mason	RR5	Rural Residential 5 Acres	17.04.223	1 principal residence per 5 acres; 1 ADU/parcel.	5	0.165	2	0.33	Assume on dwelling unit and one ADU on 5 acres.
Mason	RT	Rural Tourist	17.04.600	Lot size dependent on subject property location. Allows for lodging, motel, golf course, restaurant, water park.	1	0.096	5	0.48	1 acre minimum lot size assumed. Usage similar to water system. Assume restaurant, health club with water usage equal to 5 ERU. For Alderbrook Inn, based on full build out total consumptive use of 143 af for Inn, golf course and WWTP based on Robischan (1998). For Lake Cushman golf course, assume 140 afy consumptive use.
Mason	UGA	Urban Growth Area	17.02.026	Small portion of Allyn UGA. Regulations intended to accommodate existing land use patterns and densities while planning for future growth.	0.75	0.096	1	0.05	Existing development appears to be ~3/4 acre lots with about 1/2 of surrounding area as open space. Water use divided in half to account for open space. Assume future development is consistent with this.
Mason	W	Water	na	Assume unbuildable.	-	-	-	0	Assume unbuildable water covered parcels.
Jefferson	AL-20	AL-20 Local Agriculture	18.15.020(1b)	Assume one dwelling and 1 ADU per 20 acres.	20	-	2	23.85	Assume 80% of land is irrigated at WIG (USDA, 1992) Shelton/Quilcene irrigation rate and one dwelling and one ADU.
Jefferson	CF-80	CF-80 Commercial Forest	18.15.020(2a)	Assume one dwelling and 1 ADU per 80 acres.	80	0.165	2	0.33	Assume 1 DU and 1 ADU allowed per 80 acres.
Jefferson	IF-20	IF-20 Inholding Forest	18.15.020(2c)	Assume one dwelling and 1 ADU per 20 acres.	20	0.165	2	0.33	Assume 1 DU and 1 ADU allowed per 20 acres.

Table 5 - Estimated Consumptive Use at Buildout by Zoning Code

WRIA 16 Impaired River Analysis

County	Zoning Code	Description	Development Regulation[1]	Density Summary	Minimum Parcel Size (acres)	Assumed Consumptive Water Use per ERU	ERUs per Minimum Parcel Size	Estimated Consumptive Water Use per Minimum Parcel Size	Assumptions/Comments
					(acres)	(afy)	-	(afy)	
Jefferson	MPR-BRN	MPR-BRN Master Planned Resort - Brinnon	18.15.025	Assume 890 Units, 10% year round occupied, 2 persons/unit.	-	-	-	84.70	Assume 121 acft potable water demand, 121 acft nonpotable demand that is 70% consumptive supplied by water reuse (Subsurface Group, 2008).
Jefferson	PPR	PPR Parks, Preserves, and Recreation	18.15.030	Assume no dwelling allowed.	-	-	-	0	Assume building not allowed.
Jefferson	RF-40	RF-40 Rural Forest	18.15.020(2b)	assume 1 residential unit/40 acres and one ADU.	40	0.165	1	0.17	Regulation not explicit on dwelling. Assume one dwelling.
Jefferson	RR-10	RR-10 Rural Residential	18.15.015(1b)	1 residential unit/10 acres.	10	0.165	2	0.33	Assume 1 dwelling unit and 1 ADU
Jefferson	RR-20	RR-20 Rural Residential	18.15.015(1c)	1 residential unit/20 acres.	20	0.165	2	0.33	Assume 1 dwelling unit and 1 ADU
Jefferson	RR-5	RR-5 Rural Residential	18.15.015(1a)	1 residential unit/5 acres.	5	0.165	2	0.33	Assume 1 dwelling unit and 1 ADU
Jefferson	RVC	RVC Rural Village Center	18.15.015(2a)	Commercial and residential community center that provides rural levels of service; includes Brinnon in study area.	0.3	0.096	1	0.10	Assume 1/3 acre parcel are typical of future commercial and residential development in Brinnon..

Abbreviations:
ADU = Accessory Dwelling Unit
DU = Dwelling Unit
ERU = Equivalent Residential Unit
na = not applicable

Notes:
1. Mason County Development Regulations March 10, 2009 or Jefferson County Code Chapter 18.15 Land Use Districts.

Table 6 - Water Use Summary by Subbasin

WRIA 16 Impaired River Analysis

Basin	Water Rights Consumptive Use afy	Population Based Consumptive Use afy	Population Based Total Withdrawal afy	Source Based Consumptive Use afy	Source Based Withdrawal afy	Buildout Consumptive Use afy	Buildout Withdrawal afy
Dosewallip	248	110	199	146	302	606	1,005
Duckabush	48	30	66	36	83	295	579
Hamma Hamma	323	72	146	83	184	620	1,391
Finch/Lilliwaup	825	114	279	123	334	683	1,465
Skokomish	1,651	391	804	382	835	3,509	5,414
Skokomish with consumptive power use	*334,961*						
South Shore	791	191	391	208	574	1,223	2,673
WRIA 16 & 14b	3,887	908	1,885	980	2,312	6,937	12,528
WRIA 16 & 14b with consumptive power use	*338,629*						

Table 7 - Relative Stream Impairment Rankings - Current and Full Buildout Conditions

WRIA 15 Impaired River Analysis

Stream/River Segment	Basin Name	Catchment Area above lowest indicated RM (total area contributing flow to low area of segment) (Acres)	Base Flow--September 90% Exceedance flow (cfs)		Gaged Area	Habitat Condition	Hab Condition Value	2008 Consumptive Water Use (Source Based Method)			2008 Peak Monthly Consumptive Use as a Percent of Baseflow	2008 Peak Monthly Consumptive Use/Base Flow Rating (per catchment)	2008 Consumptive Use & Habitat Condition Potential Impact Relative Rating		Full Buildout Consumptive Use			Buildout Peak Monthly Consumptive Use as a Percent of Baseflow	Buildout Peak Monthly Consumptive Use/Base Flow Rating (per catchment)	Full Buildout Consumptive Use & Habitat Condition Potential Impact Relative Rating	
		(acres)	Measured (cfs)	Estimated (cfs)	(acres)			(afy)	average annual (cfs)	peak month (cfs)			Score	Potential Impact Relative Rating	(afy)	average annual (cfs)	peak month (cfs)			Score	Potential Impact Relative Rating
Dose RM 0.0-3.6	Dosewallips	73801	104	96	73801	P	1	83.2	0.11	0.23	0.2%	3	3	H	276.7	0.38	0.77	0.7%	3	3	H
Dose RM 3.6-12.5	Dosewallips	64008		83		F	2	58.3	0.08	0.16	0.2%	3	6	M	190.4	0.26	0.53	0.6%	3	6	M
Dose - Rocky Brook	Dosewallips	5681		7		F	2	0.5	0.00	0.00	0.0%	3	6	M	1.9	0.00	0.01	0.1%	3	6	M
Dose above RM 12.5	Dosewallips	49991		65		G	3	0.5	0.00	0.00	0.0%	3	9	L	0.0	0.00	0.00	0.0%	3	9	L
Turner Creek	Dosewallips	499		1		F	2	0.0	0.00	0.00	0.0%	3	6	M	0.9	0.00	0.00	0.4%	3	6	M
Walkers Creek	Dosewallips	511		1		P	1	3.5	0.00	0.01	1.5%	3	3	H	15.0	0.02	0.04	6.3%	2	2	H
Duck RM 0.0-5.0	Duckabush	48915	48	64	48915	P	1	18.5	0.03	0.05	0.1%	3	3	H	129.3	0.18	0.36	0.8%	3	3	H
Duck RM 5.0 - 8.0	Duckabush	41020		53		G	3	0.2	0.00	0.00	0.0%	3	9	L	0.0	0.00	0.00	0.0%	3	9	L
Duck above RM 8.0	Duckabush	35269		46		G	3	0.0	0.00	0.00	0.0%	3	9	L	0.0	0.00	0.00	0.0%	3	9	L
Clark Creek	Finch/Lilliwaup	830		1		P	1	0.3	0.00	0.00	0.1%	3	3	H	13.0	0.02	0.04	3.4%	3	3	H
Eagle Creek	Finch/Lilliwaup	3608	4.5	5	3608	F	2	0.5	0.00	0.00	0.0%	3	6	M	25.9	0.04	0.07	1.6%	3	6	M
Finch Creek	Finch/Lilliwaup	2333		3		F	2	20.7	0.03	0.06	1.9%	3	6	M	89.3	0.12	0.25	8.2%	2	4	M
Hill Creek	Finch/Lilliwaup	759		1		F	2	2.5	0.00	0.01	0.7%	3	6	M	18.7	0.03	0.05	5.3%	2	4	M
Jorsted Creek	Finch/Lilliwaup	3095	0.39	4	3095	P	1	3.1	0.00	0.01	2.2%	3	3	H	45.2	0.06	0.13	32.4%	1	1	H
Lilliwaup above RM 0.7	Finch/Lilliwaup	10448		14		G	3	12.0	0.02	0.03	0.2%	3	9	L	54.9	0.08	0.15	1.1%	3	9	L
Lilliwaup RM 0.0-0.7	Finch/Lilliwaup	11035		14		P	1	12.0	0.02	0.03	0.2%	3	3	H	66.7	0.09	0.19	1.3%	3	3	H
Little Lilliwaup	Finch/Lilliwaup	905		1		F	2	1.8	0.00	0.00	0.4%	3	6	M	10.1	0.01	0.03	2.4%	2	6	M
Miller Creek	Finch/Lilliwaup	1084		1		P	1	6.4	0.01	0.02	1.3%	3	3	H	18.2	0.03	0.05	3.6%	3	3	H
Minerva Creek	Finch/Lilliwaup	381		0		id	0	0.0	0.00	0.00	0.0%	3	id	id	2.5	0.00	0.01	1.4%	3	id	id
Sund Creek	Finch/Lilliwaup	1237		2		P	1	6.3	0.01	0.02	1.1%	3	3	H	7.3	0.01	0.02	1.3%	3	3	H
Unnamed Creek (Canal Side)	Finch/Lilliwaup	189		0		id	0	0.2	0.00	0.00	0.2%	3	id	id	2.1	0.00	0.01	2.4%	3	id	id
Fulton Creek	Hamma Hamma	5349	2.5	7	5349	F	2	12.6	0.02	0.04	1.4%	3	6	M	14.8	0.02	0.04	1.7%	3	6	M
Hamma RM 0.0-1.5	Hamma Hamma	53746	76	70	53746	P	1	41.4	0.06	0.12	0.2%	3	3	H	116.6	0.16	0.33	0.4%	3	3	H
Hamma RM 1.5-2.3	Hamma Hamma	50465		66		F	2	10.0	0.01	0.03	0.0%	3	6	M	18.2	0.03	0.05	0.1%	3	6	M
Hamma above RM 2.3	Hamma Hamma	50129		65		G	3	10.0	0.01	0.03	0.0%	3	9	L	16.2	0.02	0.05	0.1%	3	9	L
John Creek	Hamma Hamma	2765	1.3	4	2765	P	1	1.0	0.00	0.00	0.2%	3	3	H	10.7	0.01	0.03	2.3%	3	3	H
McDonald Creek	Hamma Hamma	1174		2		P	1	1.2	0.00	0.00	0.2%	3	3	H	30.3	0.04	0.08	5.6%	2	2	H
Schaerer Creek	Hamma Hamma	1060		1		F	2	0.3	0.00	0.00	0.1%	3	6	M	23.7	0.03	0.07	4.8%	3	6	M
Unnamed Trib (Mikes Bch)	Hamma Hamma	220		0		P	1	0.0	0.00	0.00	0.0%	3	3	H	5.5	0.01	0.02	5.4%	2	2	H
Waketickeh Creek	Hamma Hamma	4930		6		P	1	0.2	0.00	0.00	0.0%	3	3	H	27.8	0.04	0.08	1.2%	3	3	H
Brown Creek	Skokomish	5098		7		F	2	0.0	0.00	0.00	0.0%	3	6	M	8.2	0.01	0.02	0.3%	3	6	M
Cedar Creek	Skokomish	3605		5		F	2	0.0	0.00	0.00	0.0%	3	6	M	0.0	0.00	0.00	0.0%	3	6	M
Church Creek	Skokomish	2502		3		F	2	0.0	0.00	0.00	0.0%	3	6	M	0.0	0.00	0.00	0.0%	3	6	M
Entai Creek	Skokomish	470		1		id	0	0.0	0.00	0.00	0.0%	3	id	id	1.3	0.00	0.00	0.6%	3	id	id
Hunter Creek	Skokomish	1776		2		P	1	6.1	0.01	0.02	0.7%	3	3	H	562.3	0.78	1.57	68.2%	1	1	H
Le Bar Creek	Skokomish	6269		8		F	2	0.2	0.00	0.00	0.0%	3	6	M	0.0	0.00	0.00	0.0%	3	6	M
McTaggert Creek	Skokomish	5857		8		id	0	0.5	0.00	0.00	0.0%	3	id	id	15.9	0.02	0.04	0.6%	3	id	id
NF Skok, above RM 17.3	Skokomish	62401		81	36305	id	0	171.2	0.24	0.48	0.6%	3	id	id	723.8	1.00	2.03	2.5%	3	id	id
NF Skok, mouth to RM 17.3	Skokomish	75121		98		id	0	172.8	0.24	0.48	0.5%	3	id	id	1019.0	1.41	2.85	2.9%	3	id	id
Pine Creek	Skokomish	2425		3		F	2	0.0	0.00	0.00	0.0%	3	6	M	0.0	0.00	0.00	0.0%	3	6	M
Potlatch Creek	Skokomish	624		1		id	0	0.3	0.00	0.00	0.1%	3	id	id	10.4	0.01	0.03	3.6%	3	id	id
Purdy Creek	Skokomish	4732		6		F	2	154.3	0.21	0.43	7.0%	2	4	M	452.2	0.62	1.27	20.6%	1	2	H
Richert Springs	Skokomish	613		1		F	2	1.4	0.00	0.00	0.5%	3	6	M	76.1	0.11	0.21	26.7%	1	2	H
Rock Creek	Skokomish	4379		6		F	2	0.0	0.00	0.00	0.0%	3	6	M	0.5	0.00	0.00	0.0%	3	6	M
SF Skok, mouth to RM 3.0	Skokomish	66240		86		P	1	9.8	0.01	0.03	0.0%	3	3	H	245.8	0.34	0.69	0.8%	3	3	H
SF Skok, RM 3.0-10.0	Skokomish	49377		64	49377	F	2	1.0	0.00	0.00	0.0%	3	6	M	20.3	0.03	0.06	0.1%	3	6	M
SF Skok, RM 10.0-23.5	Skokomish	40647		53		F	2	1.0	0.00	0.00	0.0%	3	6	M	11.6	0.02	0.03	0.1%	3	6	M
SF Skok, above RM 23.5	Skokomish	6368		8		G	3	0.0	0.00	0.00	0.0%	3	9	L	0.0	0.00	0.00	0.0%	3	9	L
Skokomish, RM 0.0-9.0	Skokomish	152155		198		P	1	355.2	0.49	0.99	0.5%	3	3	H	2714.8	3.75	7.60	3.8%	3	3	H
Vance Creek	Skokomish	15327		20		P	1	4.3	0.01	0.01	0.1%	3	3	H	57.9	0.08	0.16	0.8%	3	3	H
Weaver Creek	Skokomish	527		1		P	1	3.2	0.00	0.01	1.3%	3	3	H	273.8	0.38	0.77	111.8%	1	1	H
14.0129	South Shore	530		1		P	1	2.2	0.00	0.01	0.9%	3	3	H	8.8	0.01	0.02	3.6%	3	3	H
14.013	South Shore	361		0		id	0	1.2	0.00	0.00	0.7%	3	id	id	13.2	0.02	0.04	7.9%	2	id	id
Alderbrook Creek	South Shore	101		0		P	1	0.0	0.00	0.00	0.0%	3	3	H	59.6	0.08	0.17	127.3%	1	1	H
Big Bend Creek	South Shore	686		1		P	1	13.3	0.02	0.04	4.2%	3	3	H	86.3	0.12	0.24	27.1%	1	1	H
Dalby Creek	South Shore	295		0		P	1	2.1	0.00	0.01	1.5%	3	3	H	48.6	0.07	0.14	35.5%	1	1	H
Devereaux Creek	South Shore	1761		2		P	1	14.4	0.02	0.04	1.8%	3	3	H	255.9	0.35	0.72	31.3%	1	1	H
Holyoke Creek	South Shore	766		1		P	1	19.9	0.03	0.06	5.6%	2	2	H	53.7	0.07	0.15	15.1%	1	1	H
Nordstrom Creek	South Shore	268		0		P	1	1.2	0.00	0.00	0.9%	3	3	H	39.4	0.05	0.11	31.6%	1	1	H
Springbrook Creek	South Shore	904		1		P	1	16.1	0.02	0.05	3.8%	3	3	H	81.9	0.11	0.23	19.5%	1	1	H
Twanoh Creek	South Shore	413		1		P	1	0.5	0.00	0.00	0.3%	3	3	H	7.4	0.01	0.02	3.9%	3	3	H
Twanoh Falls Creek	South Shore	574		1		P	1	1.2	0.00	0.00	0.4%	3	3	H	29.5	0.04	0.08	11.1%	1	1	H

Table 8 - Public Water Systems: Use, Buildout Demand, and Water Rights

WRIA 16 Impaired River Analysis

Water System						Total Water Rights	Current Annual Withdrawals									Inchoate Water Right		2025 Usage		Buildout Conditions (per PWS reports)		Buildout Conditions (per analysis)		
DOH PWSID	Name	Group	Type	County	Plan	Qa	Highest		Most Recent		Data Source	Active Residential Connections	Total Connections	Connections per Mason PUD	Most Recent Usage per Connection	(calculated from most recent usage)		Water System Forecast	Water Right Surplus/ Deficit	Withdrawal at Buildout	Water Right Surplus/ Deficit	Consumptive Use at Buildout	Withdrawal at Buildout	Water Right Surplus/ Deficit
						afy	afy	period	afy	year		ResConn	Total Conn		afy	afy	year	afy	afy	afy	afy	afy	afy	afy
07066	BRINNONWOLD ASSOC	A	Comm	JEFFERSON	2003	18			4.6	2003	2	16	16	-	0.29	13.4	2003	na	-	15.4	2.6	5.4	13.0	5
02676	LAZY C	A	Comm	JEFFERSON	2005	60			13.3	2008	1	112	112	-	0.12	46.7	2008	20	40	28.2	32	198.4	379.9	**-320**
03313	PLEASANT TIDES WATER CO OP	A	Comm	JEFFERSON	2007	85			27.1	2003	2	63	102	-	0.43	57.9	2003	38.4	46.6	71.8	13	21.6	51.4	34
06373	PLEASANT HARBOR BEACH TRACTS	B	-	JEFFERSON			Supplied by and buildout added to Pleasant Tides #03313.					0	13	-	-	-	-	-	-	-	-	4.1	9.8	-
11196	BEACH CLUB HOUSE CANAL LANE	A	TNC	JEFFERSON			No plan identified					25	35	-	-	-	-	-	-	-	-	6.9	16.5	-
-	BLACK POINT PROPERTIES, LLC	-	-	JEFFERSON			Presumed inactive.					0	1	-	-	-	-	-	-	-	-	16.0	22.9	-
05025	BEACON POINT COMMUNITY CLUB	A	Comm	MASON	2008	72			12.8	2006	2	59	114	-	0.22	59.2	2006	na	-	34.9	37	19.6	46.6	25
76986	SEAMOUNT ESTATES COMMUNITY	A	Comm	JEFFERSON		51	No plan		*30.1*	*ERU est*		**104**	114	-	-	20.9	-	-	-	-	-	25.4	60.5	**-9**
89447	TRITON COVE	A	Comm	JEFFERSON	2005	29	6.8		5.3	2008	1,2	52	53	-	0.10	23.7	2008	8	21	-	-	20.5	48.7	**-20**
89450	TRITON HEAD ASSN	A	Comm	MASON		50	No plan		*20.0*	*ERU est*		**69**	69	-	-	30.0	-	-	-	-	-	-	-	-
03450	AYOCK BEACH IMPROVEMENT	A	Comm	MASON		47	No plan		*16.2*	*ERU est*		**56**	56	-	-	30.8	-	-	-	-	-	-	-	-
14080	COLONY SURF WATER SUPPLY	A	Comm	MASON	2005	196			57	2004	2	84	242	-	0.68	139.0	2004	114	82	213	**-17**	88.9	211.7	**-16**
06689	CANAL BEACH TRACTS MUTUAL WATER	A	Comm	MASON	2007	11			*11.7*	*2007 est*		49	53	87	-	**-0.7**	-	12.8	**-1.8**	-	-	6.1	17.6	**-7**
10999	CANAL MUTUAL WATER	A	Comm	MASON		40	See Canal Beach Tracts Mutual.					49	53	53	-	-	-	-	-	-	-	-	-	-
13776	GLEN AYR CANAL RESORT	A	TNC	MASON		exempt well	Merged with Canal Beach Tracts Mutual.					18	40	34	-	-	-	-	-	-	-	-	-	-
34013	HILL VALLEY	A	TNC	MASON		7	No plan		*1.7*	*ERU est*		**6**	8	-	-	5.3	-	-	-	-	-	-	-	-
34100	HOODSPORT	A	Comm	MASON	2008	228	48.1		31.9	2007	2	162	201	196	0.16	196.1	2007	130.8	97.2	172	56	131.4	314.2	**-86**
69050	POTLATCH BEACH MUTUAL	A	Comm	MASON	2006	99	71.8		37.3	2005	2	69	75	-	0.54	61.7	2005	51.8	47.2	70	29	17.4	41.4	58
84100	STETSONS COVE INC	A	TNC	MASON		7	No plan		*12.1*	*ERU est*		**42**	42	-	-	**-5.1**	-	-	-	-	-	-	-	-
43794	LAKE CUSHMAN MAINT COMPANY	A	Comm	MASON	2003	220	nd		*411.0*	*ERU est*	2	800	801	**1,421**	-	**-190.9**	-	-	-	-	-	641.7	1406.6	**-1187**
03528	LAKE CUSHMAN SYSTEM 3	A	Comm	MASON		29	See Lake Cushman Maintenance Co.					347	347	-	-	-	-	-	-	-	-	-	-	-
03529	LAKE CUSHMAN SYSTEM 5	A	Comm	MASON		250	See Lake Cushman Maintenance Co.					1257	1,257	-	-	-	-	-	-	-	-	-	-	-
11656	MOUNTAIN VIEW	B		MASON	2006	8			3.2	2003-2005	2	10	11	11	0.29	4.8	-	7.4	0.6	7.4	0.6	5.6	13.4	**-5**
55070	MINERVA TERRACE	A	Comm	MASON	2001	18	nd		*8.7*	*ERU est*	2	29	34	**30**	-	9.3	-	-	-	-	-	12.4	29.6	**-12**
51920	UNION	A	Comm	MASON	1998	13.6			58	1996 est		234	245	219	-	**-44.4**	-	114	**-100.4**	-	-	81.9	195.1	**-181**
06553	UNION RIDGE	A	Comm	MASON		26	No plan		*7.5*	*ERU est*		24	28	**26**	-	18.5	-	na	-	-	-	12.2	29.1	**-3**
32820	HIGHLAND PARK	A	Comm	MASON	1998	72	nd		*17.6*	*ERU est*		68	71	**61**	-	54.4	-	46	26	-	-	16.5	39.3	33
34050	HOOD CANAL WATER COMPANY A	A	Comm	MASON	1998	27			53	1997 est	2	12	21	120	-	**-26.0**	-	103	**-76**	-	-	40.4	98.9	**-72**
AA418	HOOD CANAL WATER COMPANY B	A	Comm	MASON		70	Reported with Hood Canal Water #34050.					82	118	Inc. above.	-	-	-	-	-	-	-	-	-	-
01050	ALDERBROOK WATER CO	A	Comm	MASON	1998	843	145 with 20% loss	1990	328	1997 est	2	393	974	937	-	515.0	-	616	227	616	227	145.7	248.8	594
49950	MADRONA BEACH SUPPLY	A	Comm	MASON		27	No plan		*5.8*	*ERU est*		20	20	**20**	-	21.2	-	na	-	-	-	-	-	-
86040	SUNSET BEACH	A	Comm	MASON		22	No plan		*20.2*	*ERU est*		**70**	71	-	-	1.8	-	na	-	-	-	-	-	-
05350	BELFAIR WATER DISTRICT 1	A	Comm	MASON	2008	225	146	2001-2005	146	2005	2	455	571	-	0.32	79.0	2005	233	**-8**	-	-	204.7	491.8	**-267**
						Median = 38			Median = 17						Median = 0.29									

Notes:

Data Source 1 = reported by water system.

Data Source 2 = reported in water management plan.

Shading indicates system has merged with or is supplied by another PWS.

afy estimate per ERU ---> **0.29**

Bold font in connections column indicates data used for calculating ERU based use estimates.

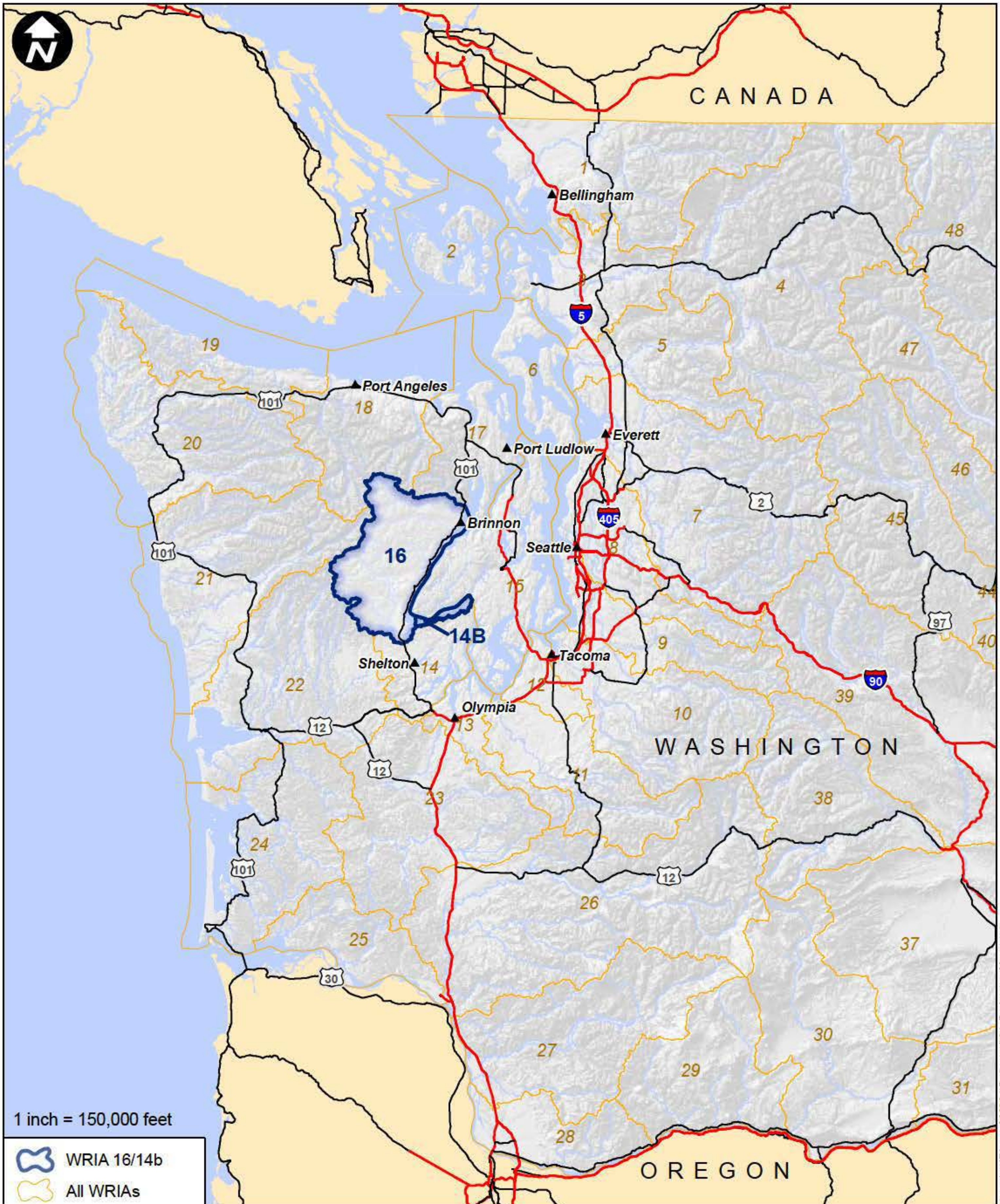
Buildout use and withdrawal for Pleasant Tides Water Coop includes values for Pleasant Harbor Beach Tracts.

Abbreviations:

ERU = equivalent residential unit.

est = usage estimated in plan, but not measured.

ERU est = usage estimate per active residential connection.



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Project Location Map
WRIA 16 Impaired Rivers Analysis
Washington

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 1
REVISED BY: -	

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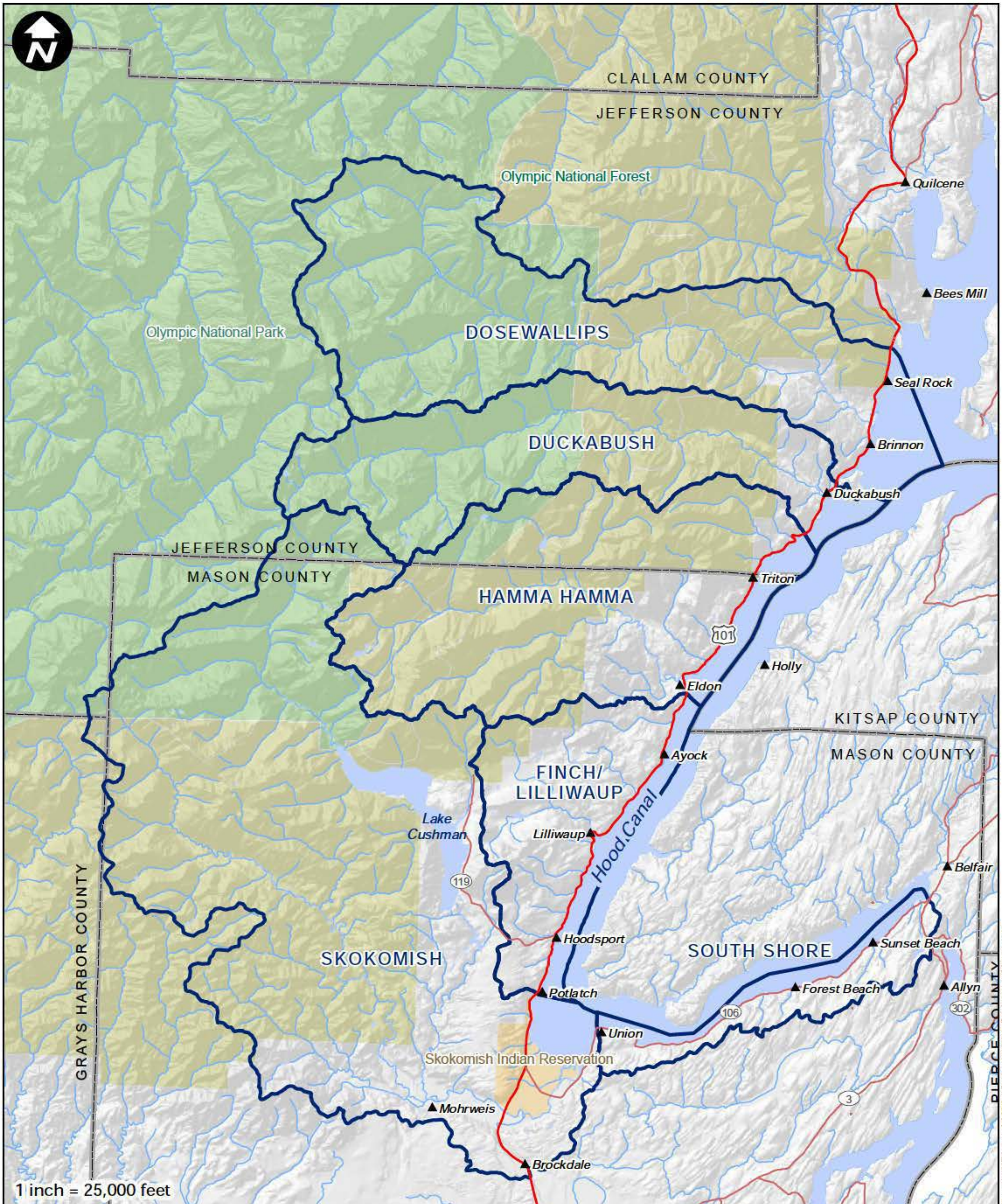
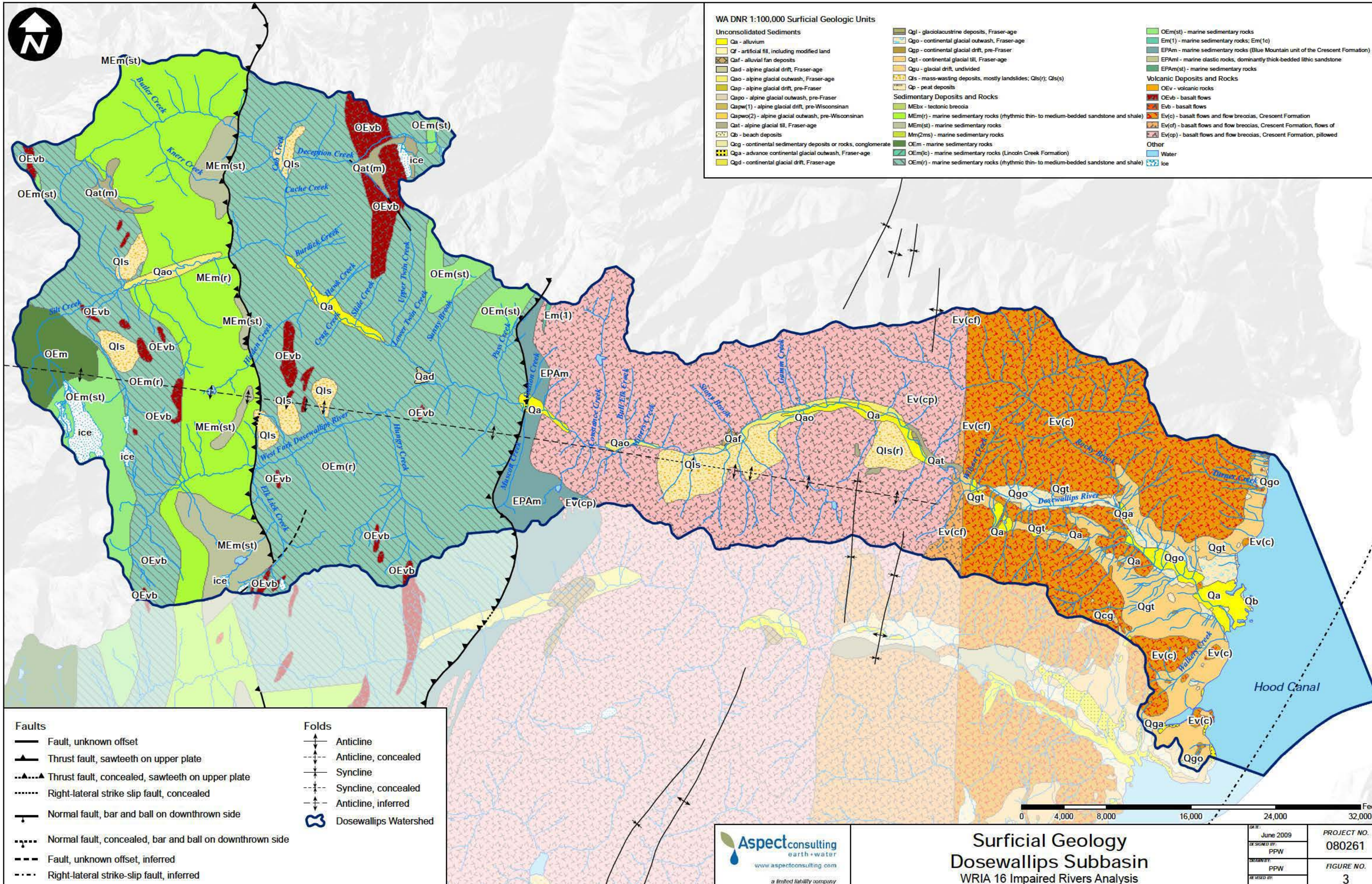
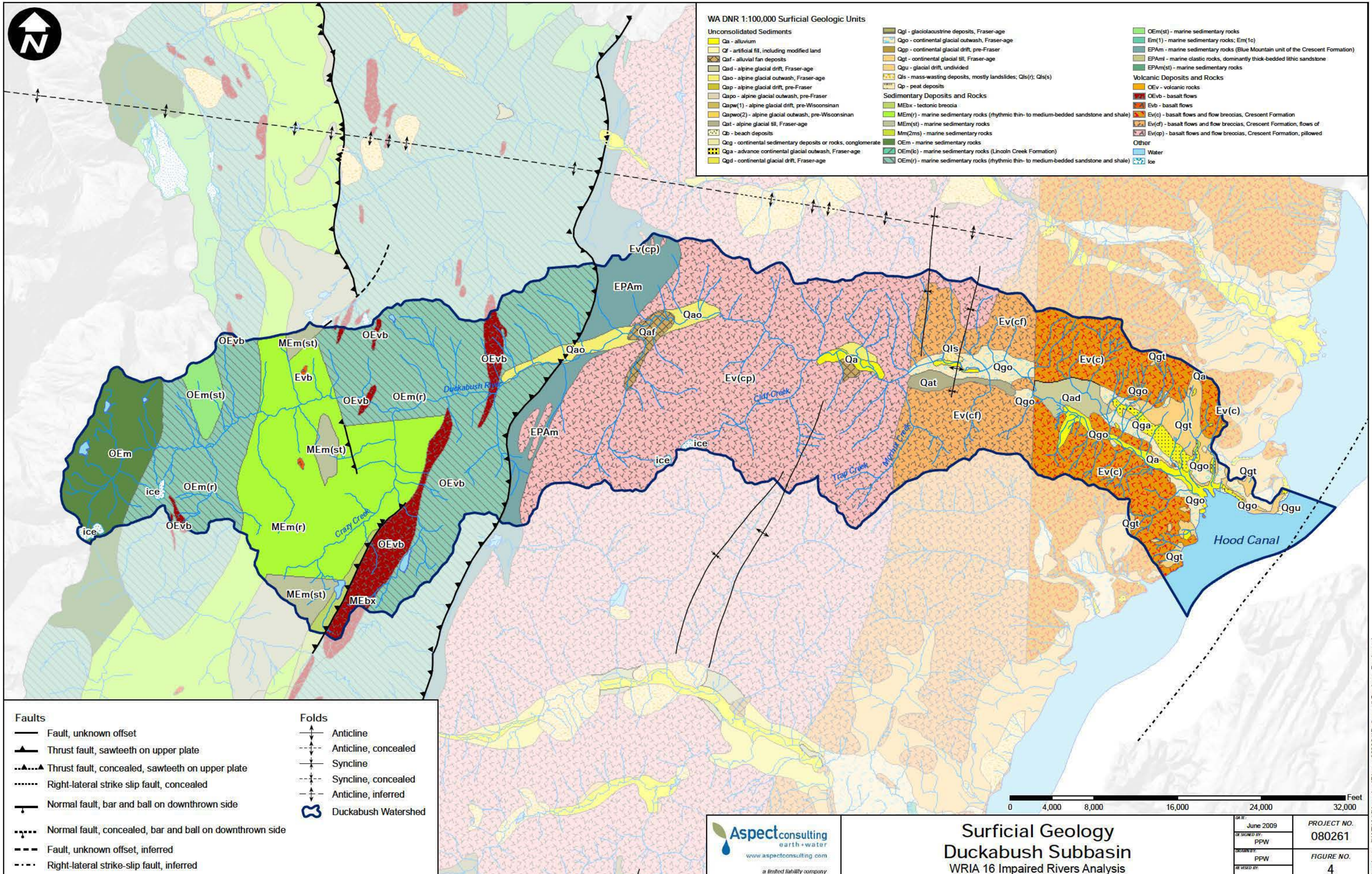


Aspect consulting earth+water www.aspectconsulting.com *a limited liability company*	**Study Area Map** WRIA 16 Impaired Rivers Analysis Washington	DATE: June 2009	PROJECT NO. 080261
		DESIGNED BY: PPW	
		DRAWN BY: PPW	FIGURE NO. 2
		REVISED BY: -	

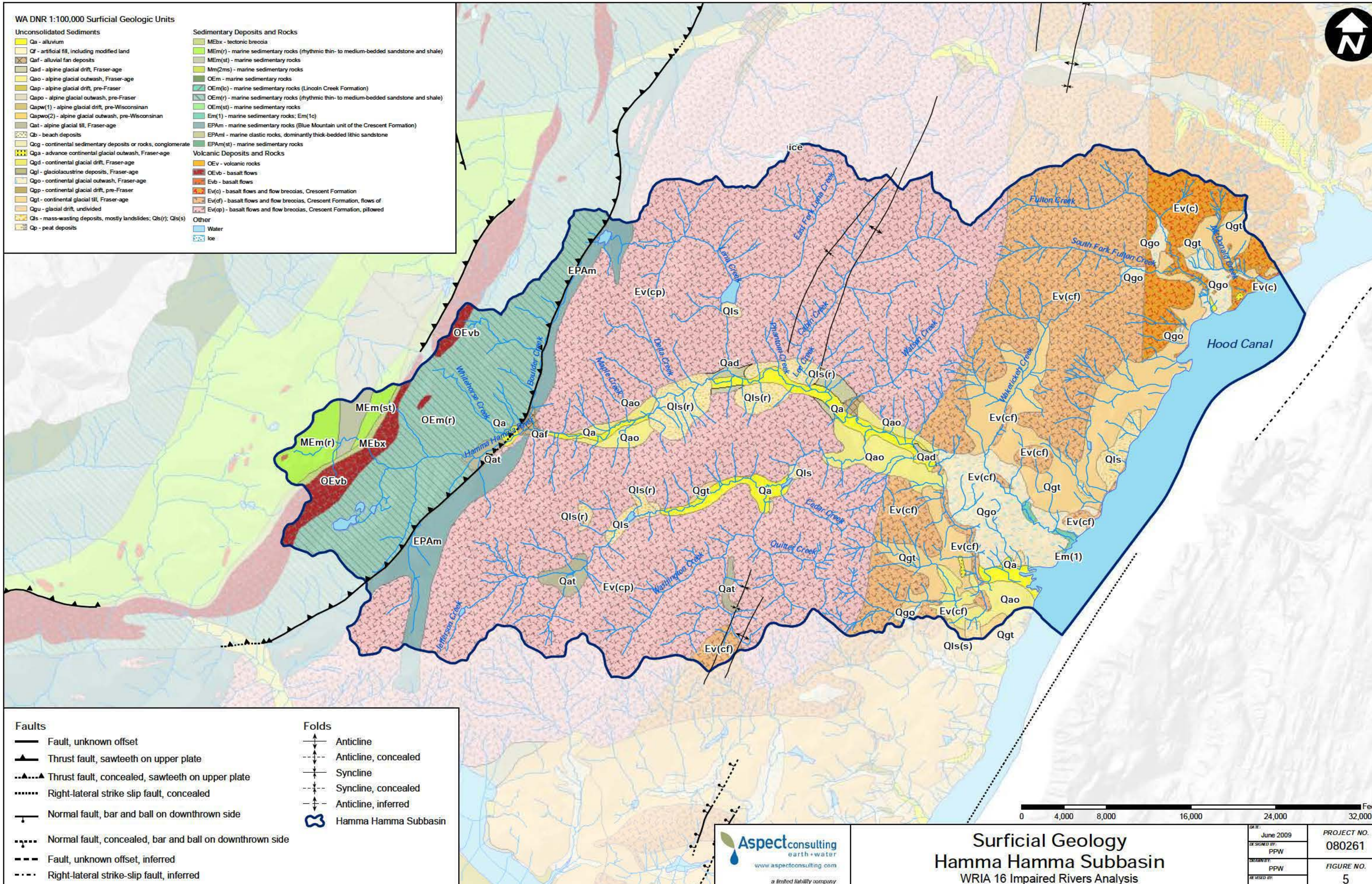
T:\projects_8\WRIA16ImpairedRivers-080261\Delivered\01_ProjectLocMap.mxd



Surficial Geology
Dosewallips Subbasin
WRIA 16 Impaired Rivers Analysis



Surficial Geology
Duckabush Subbasin
WRIA 16 Impaired Rivers Analysis


WA DNR 1:100,000 Surficial Geologic Units
Unconsolidated Sediments
Qa - alluvium
Qf - artificial fill, including modified land
Qaf - alluvial fan deposits
Qad - alpine glacial drift, Fraser-age
Qao - alpine glacial outwash, Fraser-age
Qap - alpine glacial drift, pre-Fraser
Qapo - alpine glacial outwash, pre-Fraser
Qapw(1) - alpine glacial drift, pre-Wisconsinan
Qapwo(2) - alpine glacial outwash, pre-Wisconsinan
Qat - alpine glacial till, Fraser-age
Qb - beach deposits
Qcg - continental sedimentary deposits or rocks, conglomerate
Qga - advance continental glacial outwash, Fraser-age
Qgd - continental glacial drift, Fraser-age
Qgl - glaciolacustrine deposits, Fraser-age
Qgo - continental glacial outwash, Fraser-age
Qgp - continental glacial drift, pre-Fraser
Qgt - continental glacial till, Fraser-age
Qgu - glacial drift, undivided
Qls - mass-wasting deposits, mostly landslides; Qls(r); Qls(s)
Qp - peat deposits
Sedimentary Deposits and Rocks
MEbx - tectonic breccia
MEm(r) - marine sedimentary rocks (rhythmic thin- to medium-bedded sandstone and shale)
MEm(st) - marine sedimentary rocks
Mm(2ms) - marine sedimentary rocks
OEm - marine sedimentary rocks
OEm(lc) - marine sedimentary rocks (Lincoln Creek Formation)
OEm(r) - marine sedimentary rocks (rhythmic thin- to medium-bedded sandstone and shale)
OEm(st) - marine sedimentary rocks
Em(1) - marine sedimentary rocks; Em(1c)
EPAm - marine sedimentary rocks (Blue Mountain unit of the Crescent Formation)
EPAml - marine clastic rocks, dominantly thick-bedded lithic sandstone
EPAm(st) - marine sedimentary rocks
Volcanic Deposits and Rocks
OEv - volcanic rocks
OEvb - basalt flows
Evb - basalt flows
Ev(c) - basalt flows and flow breccias, Crescent Formation
Ev(cf) - basalt flows and flow breccias, Crescent Formation, flows of
Ev(cp) - basalt flows and flow breccias, Crescent Formation, pillowed
Other
Water
Ice
Faults
Fault, unknown offset
Thrust fault, sawteeth on upper plate
Thrust fault, concealed, sawteeth on upper plate
Right-lateral strike slip fault, concealed
Normal fault, bar and ball on downthrown side
Normal fault, concealed, bar and ball on downthrown side
Fault, unknown offset, inferred
Right-lateral strike-slip fault, inferred
Folds
Anticline
Anticline, concealed
Syncline
Syncline, concealed
Anticline, inferred
Hamma Hamma Subbasin
Hood Canal
Fulton Creek
South Fork Fulton Creek
East Fork Lena Creek
Lena Creek
Cabin Creek
Watson Creek
Phantom Creek
Lee Creek
Delta Creek
Maple Creek
Boulder Creek
Whitehorse Creek
Hamma Hamma River
Cedar Creek
Waketickeh Creek
Washington Creek
Jefferson Creek
Quitter Creek
ice
EPAm
Ev(cp)
Qls
Ev(c)
Qgt
Qgo
Ev(cf)
OEvb
MEm(st)
OEm(r)
MEm(r)
MEbx
Qa
Qaf
Qat
Qad
Qls(r)
Qao
Em(1)
Qls(s)
Feet
0 4,000 8,000 16,000 24,000 32,000
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Surficial Geology
Hamma Hamma Subbasin
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
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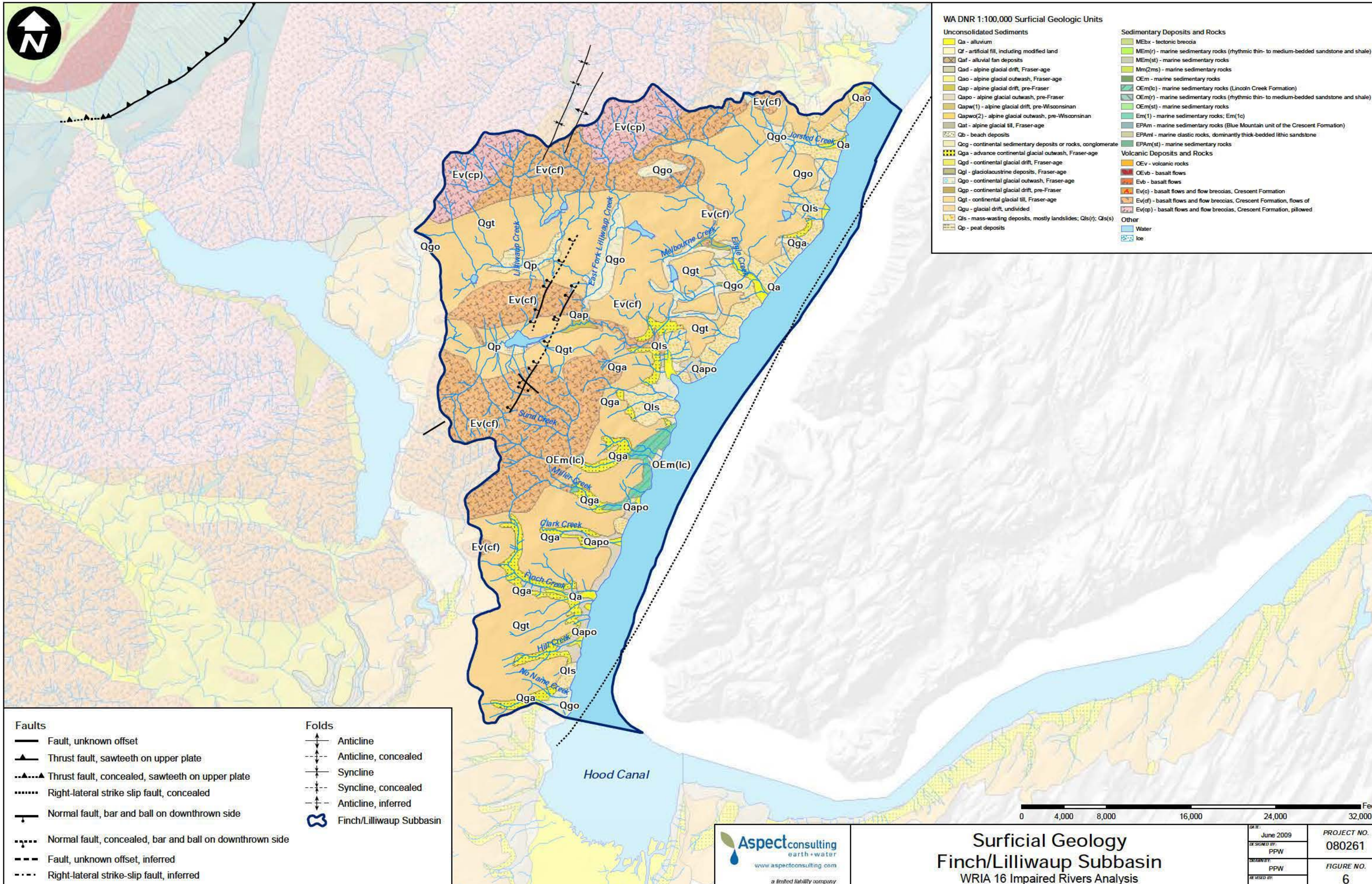
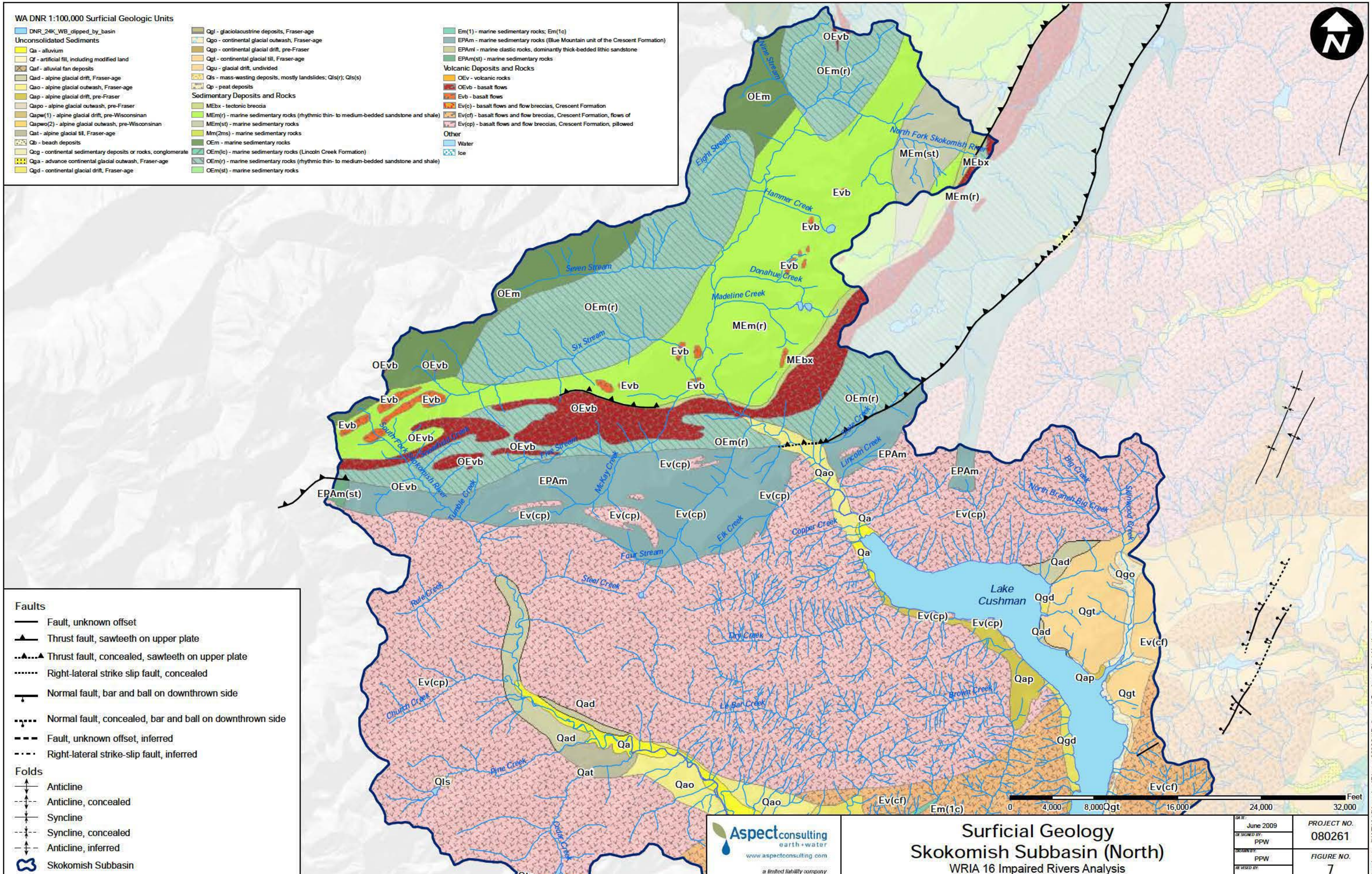
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 5
T:\projects_8\WRIA16ImpairedRivers-080261\Delivered\Geology_Hamma.mxd



Surficial Geology
Finch/Lilliwaup Subbasin
WRIA 16 Impaired Rivers Analysis


WA DNR 1:100,000 Surficial Geologic Units
DNR_24K_WB_clipped_by_basin
Unconsolidated Sediments
Qa - alluvium
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Ice
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Normal fault, bar and ball on downthrown side
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Fault, unknown offset, inferred
Right-lateral strike-slip fault, inferred
Folds
Anticline
Anticline, concealed
Syncline
Syncline, concealed
Anticline, inferred
Skokomish Subbasin
N
OEvb
OEm(r)
OEm
North Fork Skokomish River
MEm(st)
MEbx
MEm(r)
Eight Stream
Hammer Creek
Evb
Seven Stream
Donahue Creek
Madeline Creek
MEm(r)
Six Stream
MEbx
OEvb
OEvb
Evb
OEm(r)
OEm(r)
South Fork Skokomish River
Five Stream
McKay Creek
Lincoln Creek
EPAm
Ev(cp)
Qao
EPAm(st)
Tumble Creek
Big Creek
North Branch Big Creek
Skinwood Creek
Copper Creek
Elk Creek
Four Stream
Steel Creek
Rule Creek
Qa
Qad
Qgo
Lake Cushman
Qgd
Qgt
Dry Creek
Ev(cf)
Qap
Church Creek
Brown Creek
LeBar Creek
Qat
Pine Creek
Qls
Cedar Creek
Em(1c)
Feet
0
4,000
8,000
16,000
24,000
32,000
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Surficial Geology
Skokomish Subbasin (North)
WRIA 16 Impaired Rivers Analysis
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REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 7
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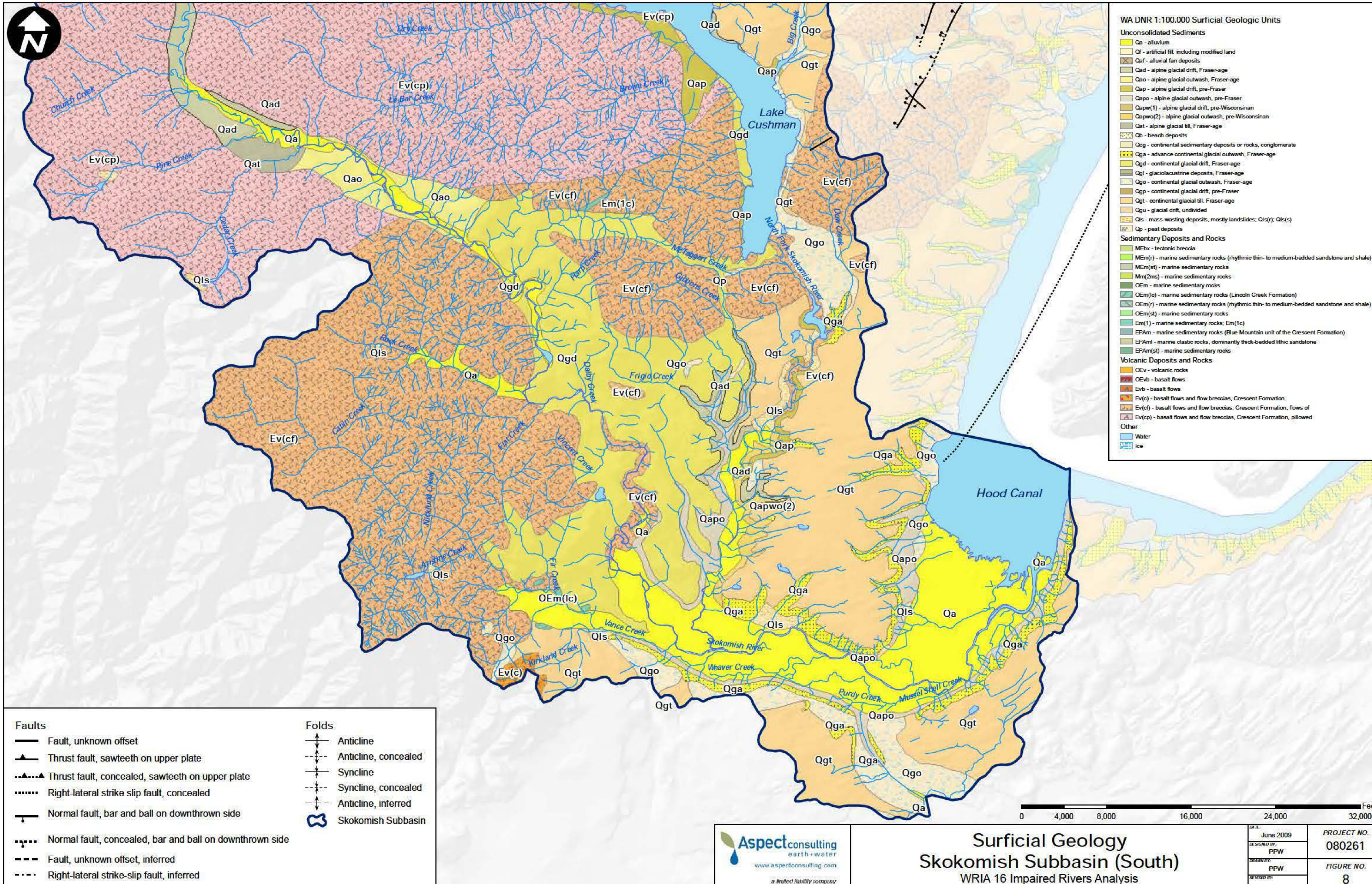
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Qb - beach deposits
Qcg - continental sedimentary deposits or rocks, conglomerate
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Qgd - continental glacial drift, Fraser-age
Qgl - glaciolacustrine deposits, Fraser-age
Qgo - continental glacial outwash, Fraser-age
Qgp - continental glacial drift, pre-Fraser
Qgt - continental glacial till, Fraser-age
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OEv - volcanic rocks
OEvb - basalt flows
Evb - basalt flows
Ev(c) - basalt flows and flow breccias, Crescent Formation
Ev(cf) - basalt flows and flow breccias, Crescent Formation, flows of
Ev(cp) - basalt flows and flow breccias, Crescent Formation, pillowed
Other
Water
Ice
Faults
Fault, unknown offset
Thrust fault, sawteeth on upper plate
Thrust fault, concealed, sawteeth on upper plate
Right-lateral strike slip fault, concealed
Normal fault, bar and ball on downthrown side
Normal fault, concealed, bar and ball on downthrown side
Fault, unknown offset, inferred
Right-lateral strike-slip fault, inferred
Folds
Anticline
Anticline, concealed
Syncline
Syncline, concealed
Anticline, inferred
Skokomish Subbasin
Lake Cushman
Hood Canal
North Fork Skokomish River
Skokomish River
Church Creek
Pine Creek
Dry Creek
Le Bar Creek
Brown Creek
Big Creek
Dow Creek
McTaggert Creek
Gibbons Creek
Harp Creek
Rock Creek
Dalby Creek
Frigid Creek
Cabin Creek
Flat Creek
Vincent Creek
Nicklund Creek
Fir Creek
Vance Creek
Kirkland Creek
Weaver Creek
Purdy Creek
Mussel Shell Creek
Feet
0
4,000
8,000
16,000
24,000
32,000
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Skokomish Subbasin (South)
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PROJECT NO. 080261
FIGURE NO. 8
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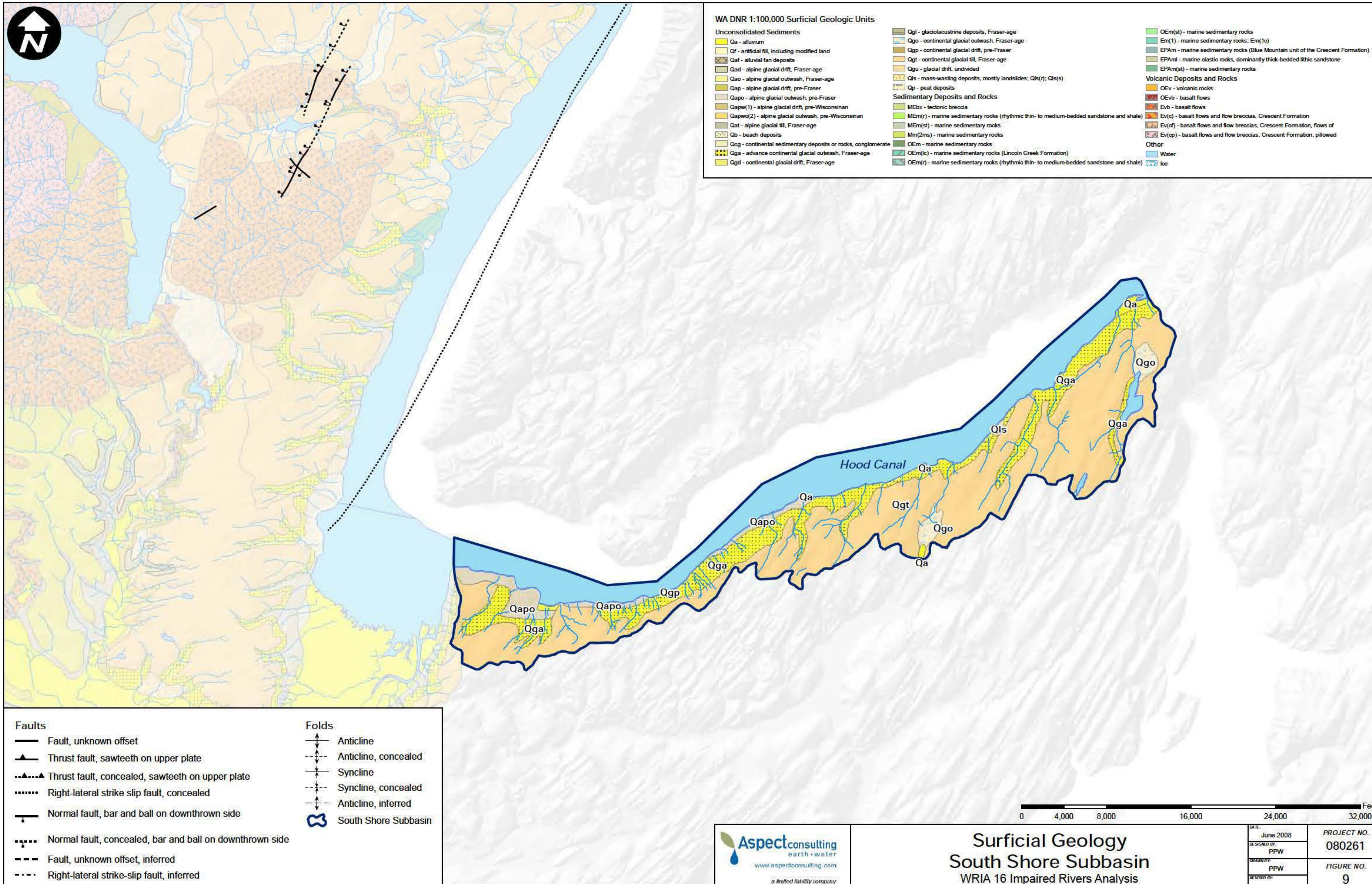
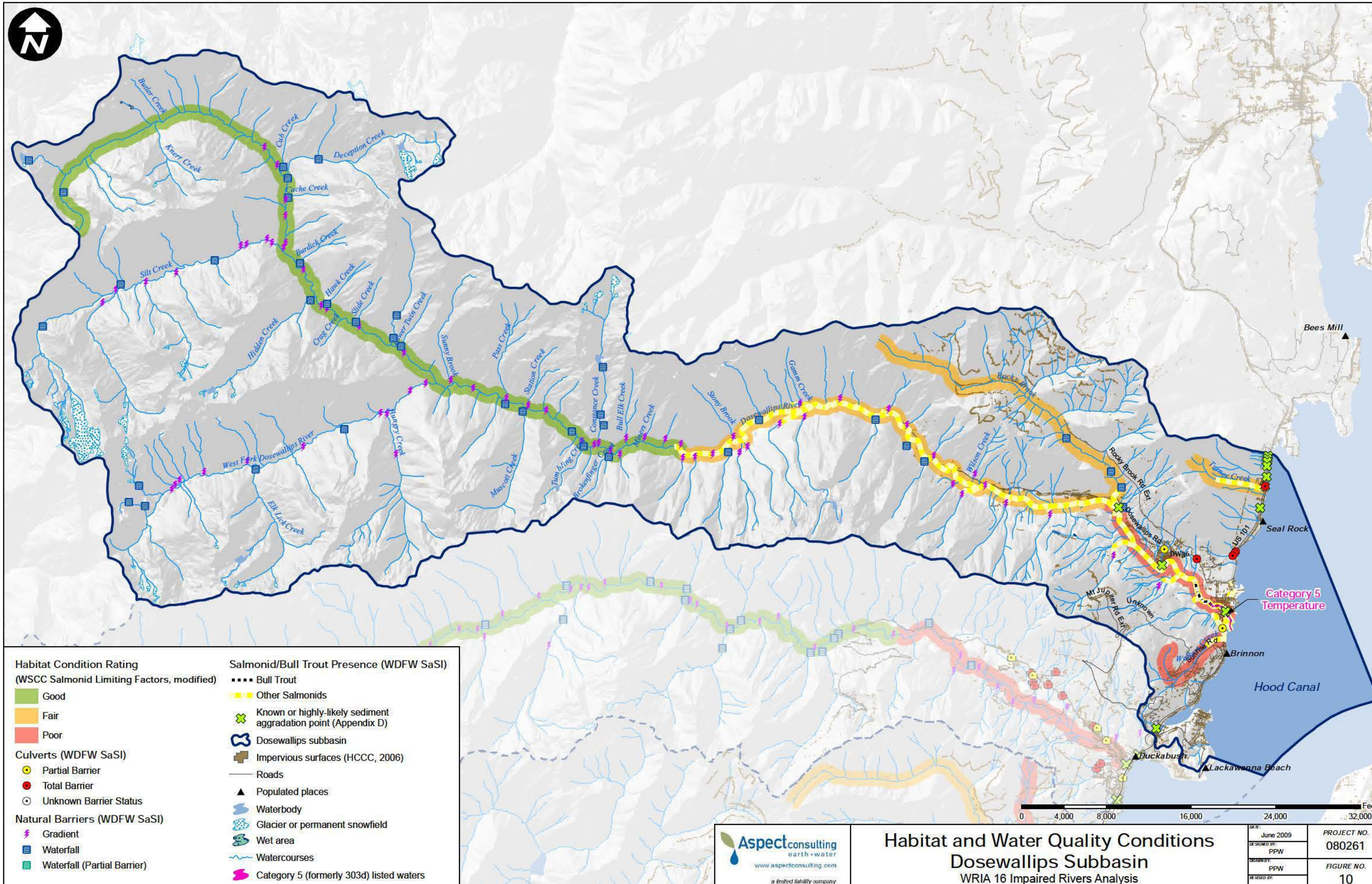


Surficial Geology
South Shore Subbasin
WRIA 16 Impaired Rivers Analysis



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Habitat and Water Quality Conditions
Dosewallips Subbasin
WRIA 16 Impaired Rivers Analysis

DATE: June 2009	PROJECT NO. 080261
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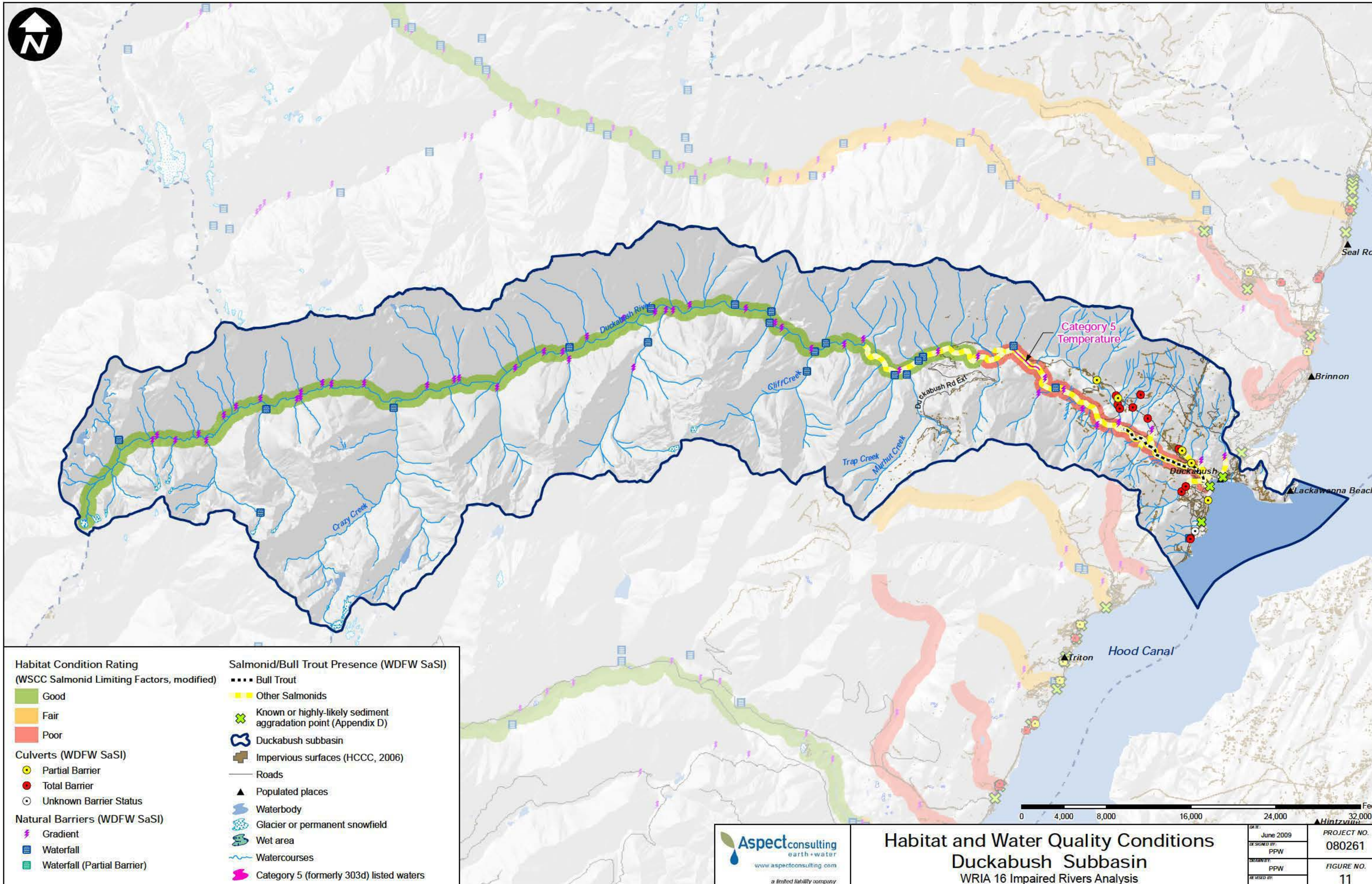
DRAWN BY: PPW	FIGURE NO. 10
REVISED BY: -	


N
Seal Rock
Brinnon
Category 5
Temperature
Duckabush River
Cliff Creek
Duckabush Rd Ext
Trap Creek
Murhut Creek
Crazy Creek
Duckabush
Lackawanna Beach
Triton
Hood Canal
Hintzville
Feet
0
4,000
8,000
16,000
24,000
32,000
Habitat Condition Rating
(WSCC Salmonid Limiting Factors, modified)
Good
Fair
Poor
Culverts (WDFW SaSI)
Partial Barrier
Total Barrier
Unknown Barrier Status
Natural Barriers (WDFW SaSI)
Gradient
Waterfall
Waterfall (Partial Barrier)
Salmonid/Bull Trout Presence (WDFW SaSI)
Bull Trout
Other Salmonids
Known or highly-likely sediment aggradation point (Appendix D)
Duckabush subbasin
Impervious surfaces (HCCC, 2006)
Roads
Populated places
Waterbody
Glacier or permanent snowfield
Wet area
Watercourses
Category 5 (formerly 303d) listed waters
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Habitat and Water Quality Conditions
Duckabush Subbasin
WRIA 16 Impaired Rivers Analysis
DATE:
June 2009
DESIGNED BY:
PPW
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PPW
REVISED BY:
-
PROJECT NO.
080261
FIGURE NO.
11
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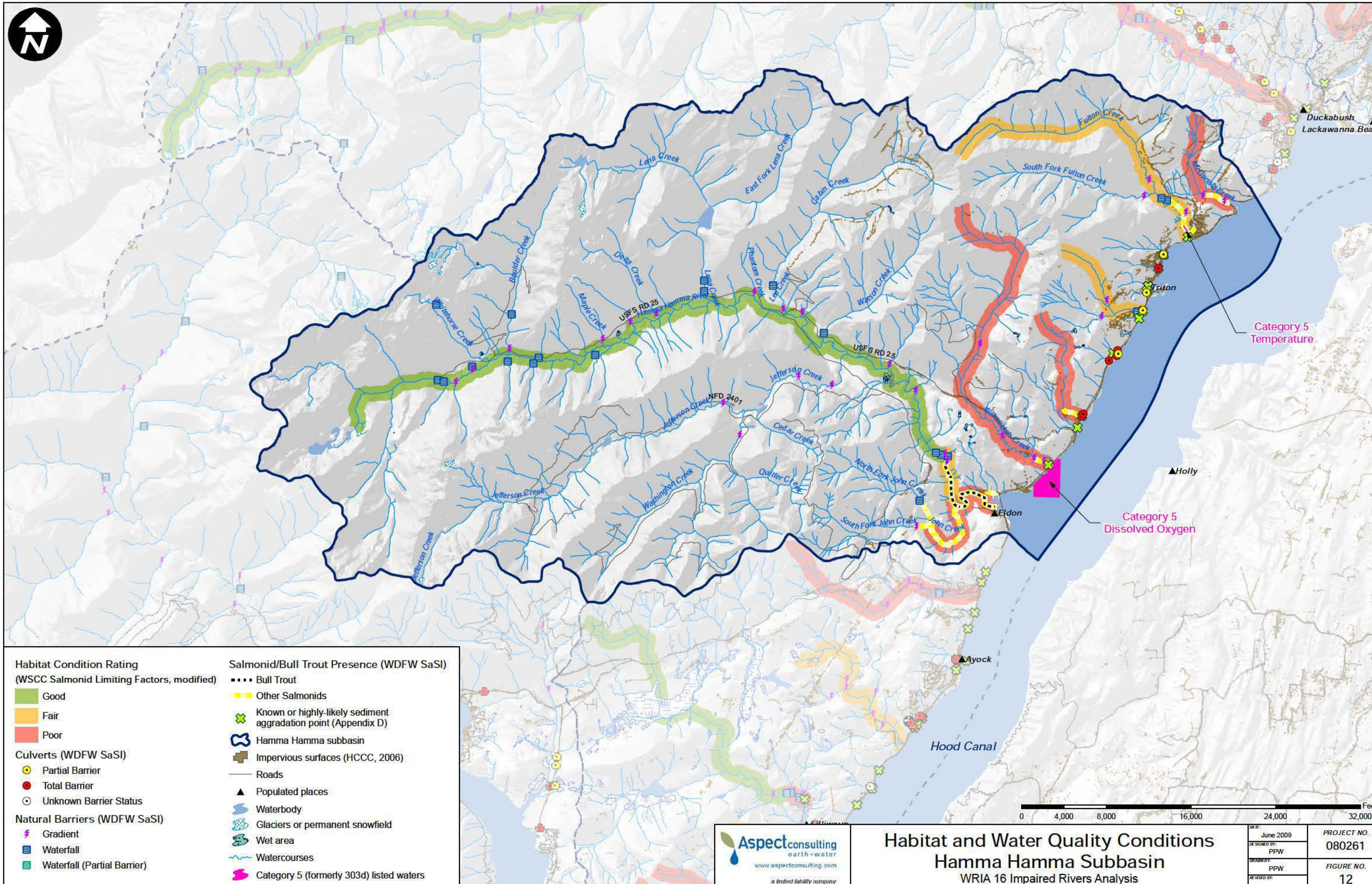

Duckabush
Lackawanna Beach
Fulton Creek
South Fork Fulton Creek
Category 5
Temperature
Triton
Lena Creek
East Fork Lena Creek
Cabin Creek
Delta Creek
Boulder Creek
Whitehorse Creek
Maple Creek
USFS RD 25
Hamma Hamma River
Phantom Creek
Watson Creek
Jefferson Creek
NFD 2401
Cedar Creek
Washington Creek
Quinter Creek
North Fork John Creek
South Fork John Creek
John Creek
Eldon
Holly
Category 5
Dissolved Oxygen
Ayock
Hood Canal
Habitat Condition Rating
(WSCC Salmonid Limiting Factors, modified)
Good
Fair
Poor
Culverts (WDFW SaSI)
Partial Barrier
Total Barrier
Unknown Barrier Status
Natural Barriers (WDFW SaSI)
Gradient
Waterfall
Waterfall (Partial Barrier)
Salmonid/Bull Trout Presence (WDFW SaSI)
Bull Trout
Other Salmonids
Known or highly-likely sediment aggradation point (Appendix D)
Hamma Hamma subbasin
Impervious surfaces (HCCC, 2006)
Roads
Populated places
Waterbody
Glaciers or permanent snowfield
Wet area
Watercourses
Category 5 (formerly 303d) listed waters
Feet
0 4,000 8,000 16,000 24,000 32,000
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earth + water
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a limited liability company
Habitat and Water Quality Conditions
Hamma Hamma Subbasin
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 12
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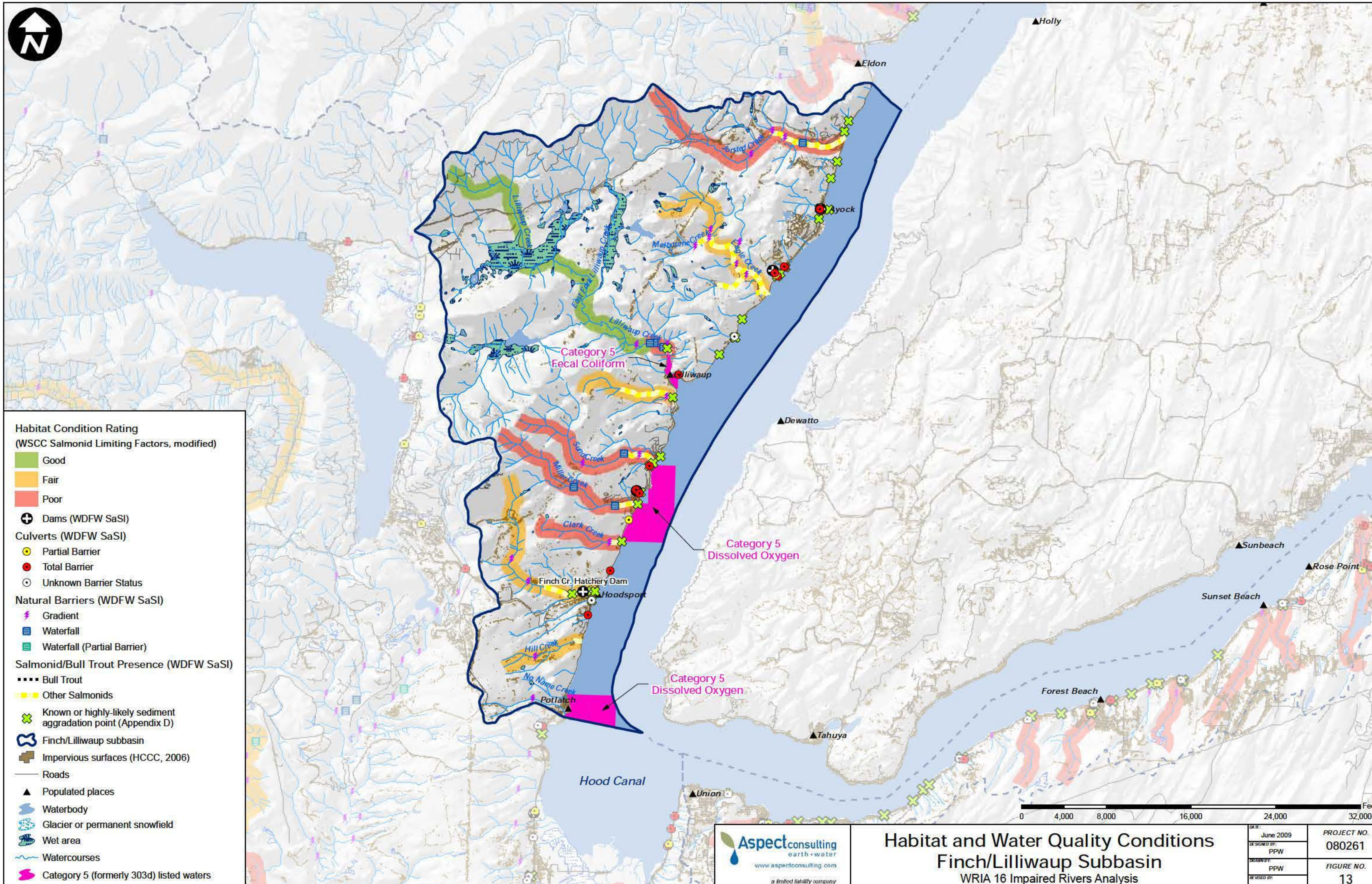

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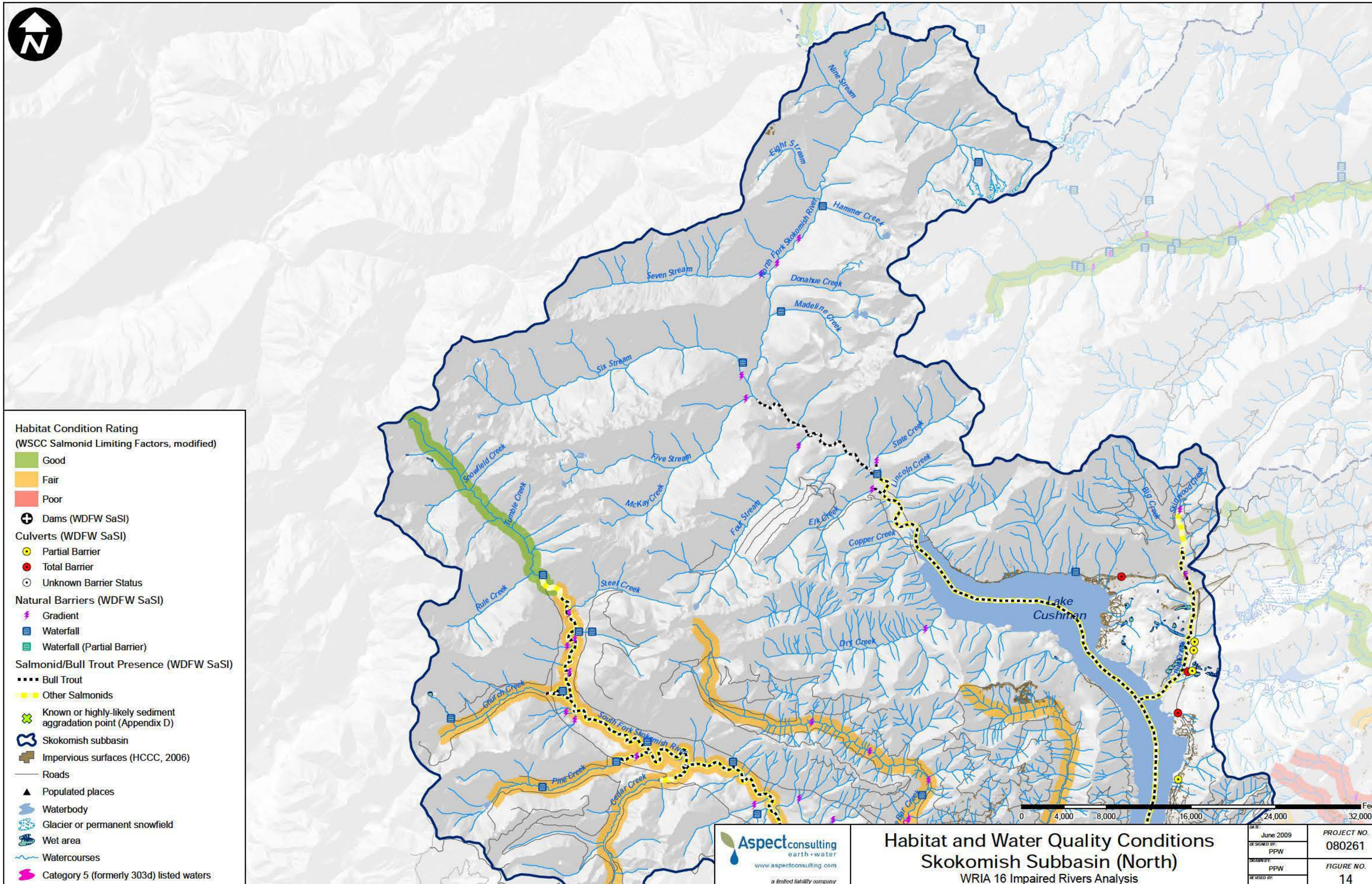
N
Nine Stream
Eight Stream
Hammer Creek
North Fork Skokomish River
Seven Stream
Donahue Creek
Madeline Creek
Six Stream
Five Stream
Slate Creek
Lincoln Creek
Snowfield Creek
Tumble Creek
McKay Creek
Four Stream
Elk Creek
Copper Creek
Big Creek
Steel Creek
Rule Creek
Lake Cushman
Dry Creek
Church Creek
South Fork Skokomish River
Pine Creek
Cedar Creek
Bar Creek
Feet
0 4,000 8,000 16,000 24,000 32,000
Habitat Condition Rating
(WSCC Salmonid Limiting Factors, modified)
Good
Fair
Poor
Dams (WDFW SaSI)
Culverts (WDFW SaSI)
Partial Barrier
Total Barrier
Unknown Barrier Status
Natural Barriers (WDFW SaSI)
Gradient
Waterfall
Waterfall (Partial Barrier)
Salmonid/Bull Trout Presence (WDFW SaSI)
Bull Trout
Other Salmonids
Known or highly-likely sediment aggradation point (Appendix D)
Skokomish subbasin
Impervious surfaces (HCCC, 2006)
Roads
Populated places
Waterbody
Glacier or permanent snowfield
Wet area
Watercourses
Category 5 (formerly 303d) listed waters
Aspect consulting
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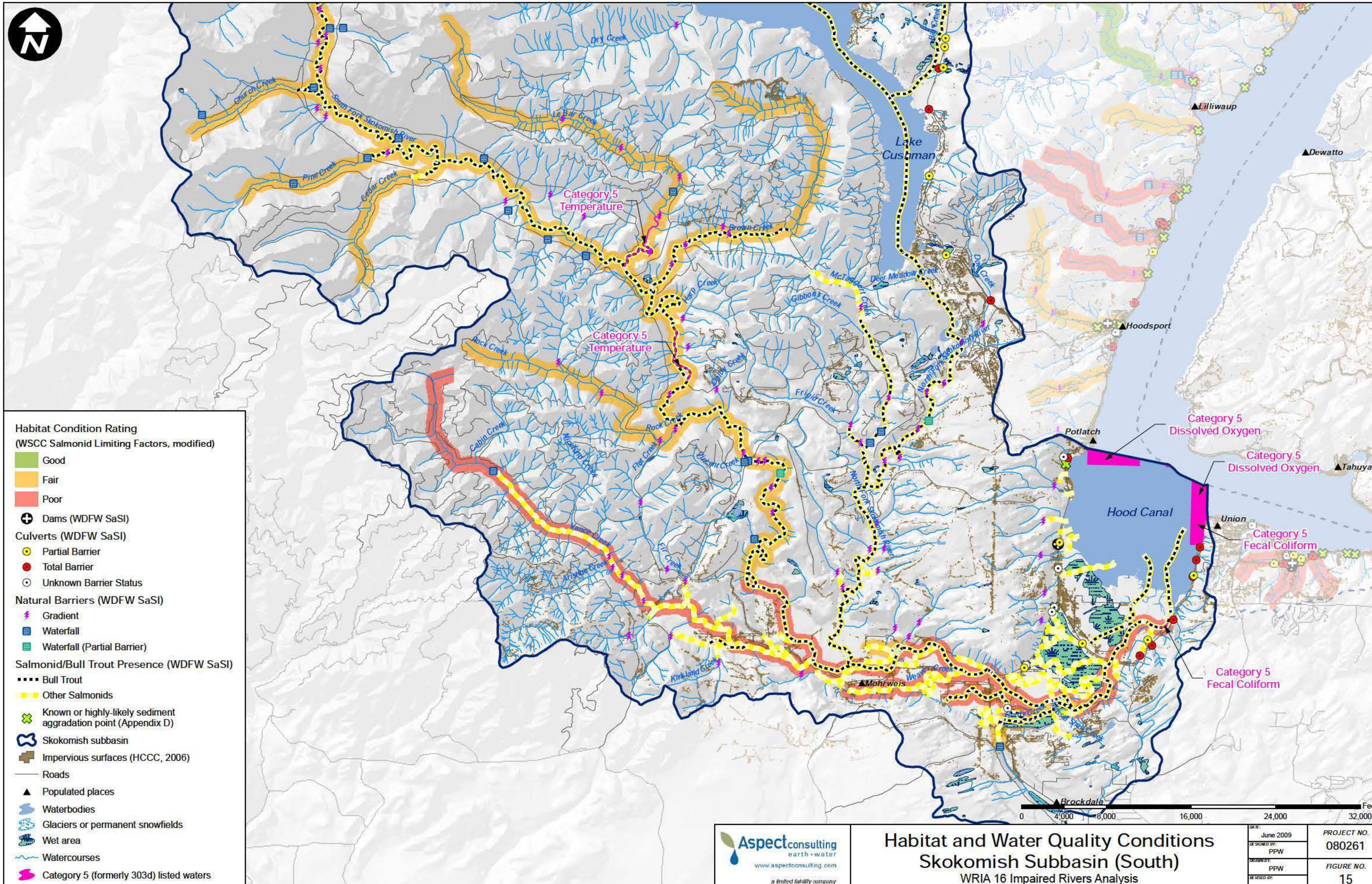
Habitat and Water Quality Conditions
Skokomish Subbasin (North)
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 14
T:\projects_8\WRIA16ImpairedRivers-080261\Delivered\Habitat_SkokNorth.mxd


N
Dry Creek
Church Creek
South Fork Skokomish River
Le Bar Creek
Pine Creek
Cedar Creek
Category 5 Temperature
Brown Creek
Lake Cushman
Lilliwaup
Dewatto
McTaggert Creek
Deer Meadow Creek
Gibbons Creek
Harp Creek
Category 5 Temperature
Rock Creek
Hoodsport
North Fork Skokomish River
Frigid Creek
Cabin Creek
Rock Creek
Flat Creek
Vincent Creek
Potlatch
Category 5 Dissolved Oxygen
Category 5 Dissolved Oxygen
Tahuya
Hood Canal
Union
Category 5 Fecal Coliform
Fir Creek
Kirkland Creek
Mohrweis
Weaver Creek
Category 5 Fecal Coliform
Brockdale
Feet
0 4,000 8,000 16,000 24,000 32,000
Habitat Condition Rating
(WSCC Salmonid Limiting Factors, modified)
Good
Fair
Poor
Dams (WDFW SaSI)
Culverts (WDFW SaSI)
Partial Barrier
Total Barrier
Unknown Barrier Status
Natural Barriers (WDFW SaSI)
Gradient
Waterfall
Waterfall (Partial Barrier)
Salmonid/Bull Trout Presence (WDFW SaSI)
Bull Trout
Other Salmonids
Known or highly-likely sediment aggradation point (Appendix D)
Skokomish subbasin
Impervious surfaces (HCCC, 2006)
Roads
Populated places
Waterbodies
Glaciers or permanent snowfields
Wet area
Watercourses
Category 5 (formerly 303d) listed waters
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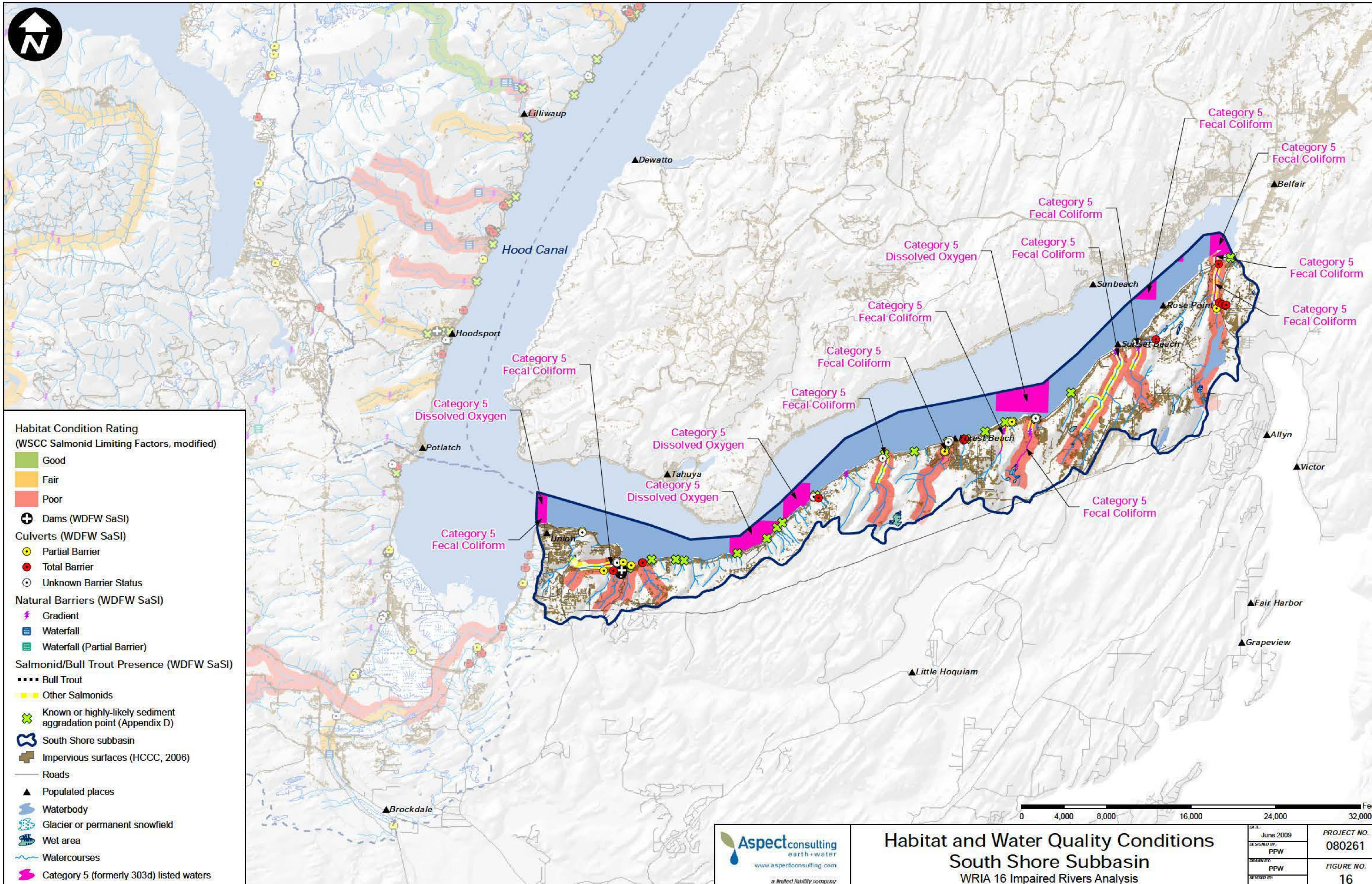
Habitat and Water Quality Conditions
Skokomish Subbasin (South)
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 15
T:\projects_8\WRIA16ImpairedRivers-080261\Delivered\Habitat_SkokSouth.mxd



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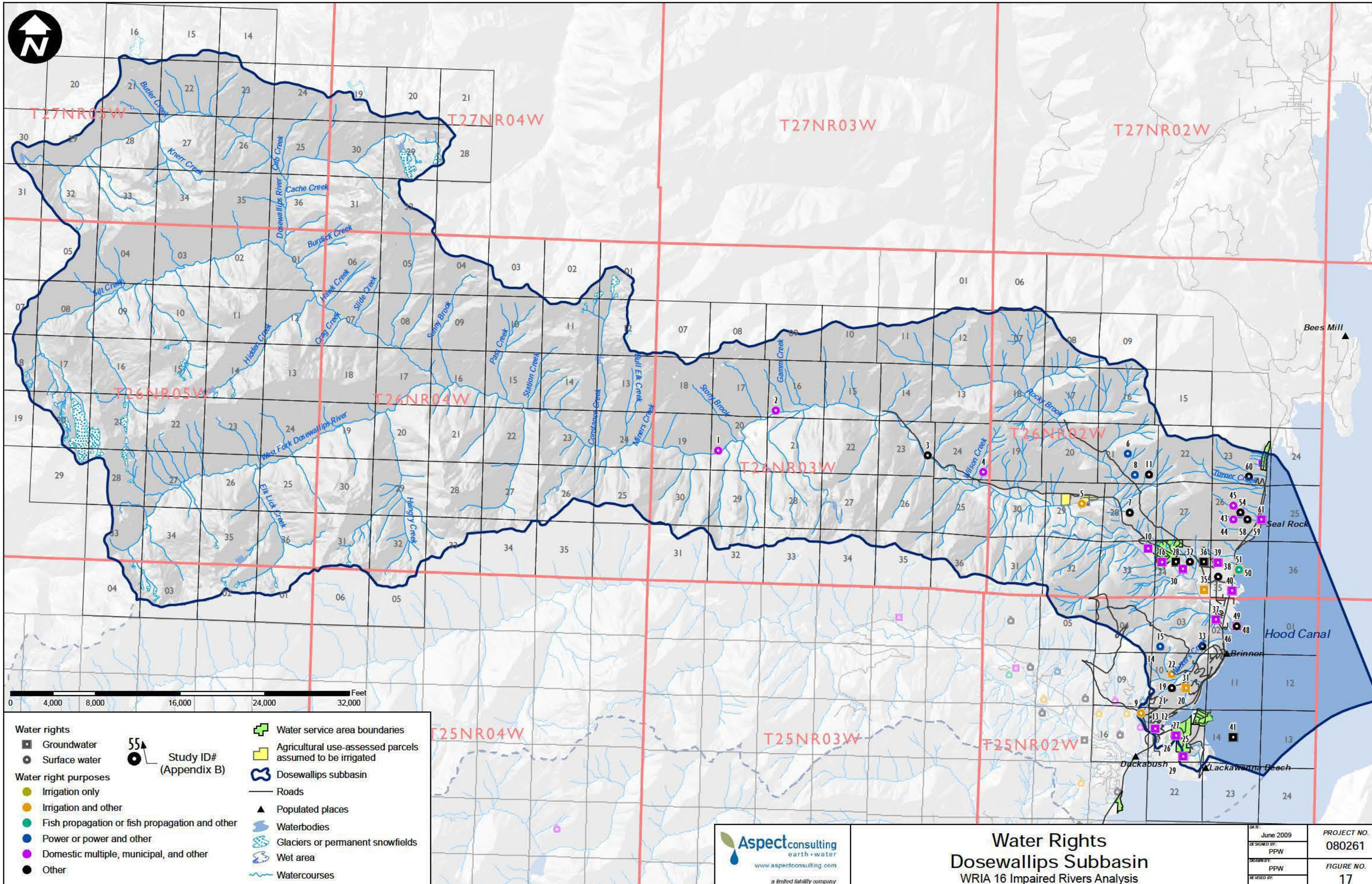

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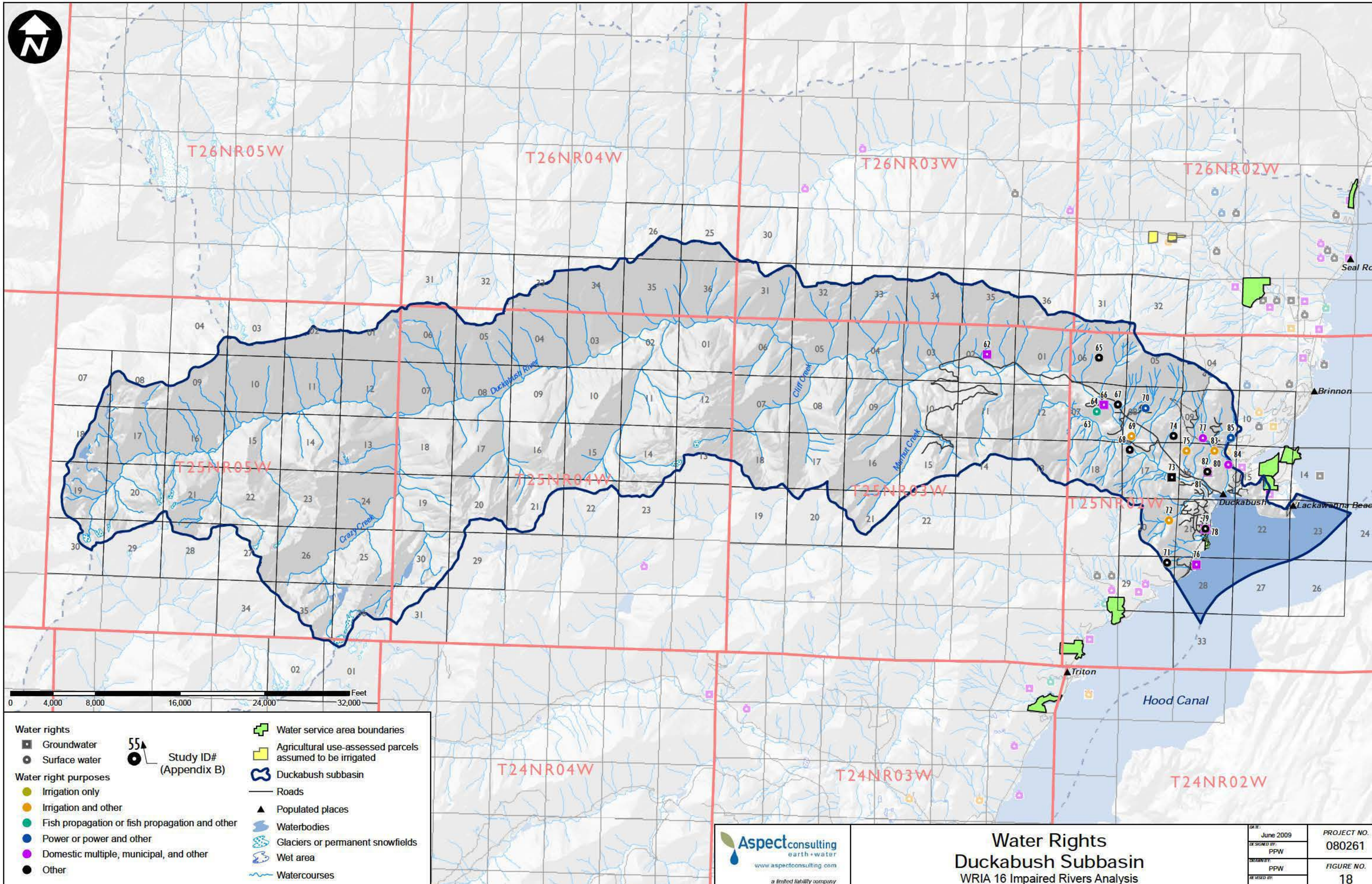
Water Rights
Dosewallips Subbasin
WRIA 16 Impaired Rivers Analysis

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 17
REVISED BY: -	



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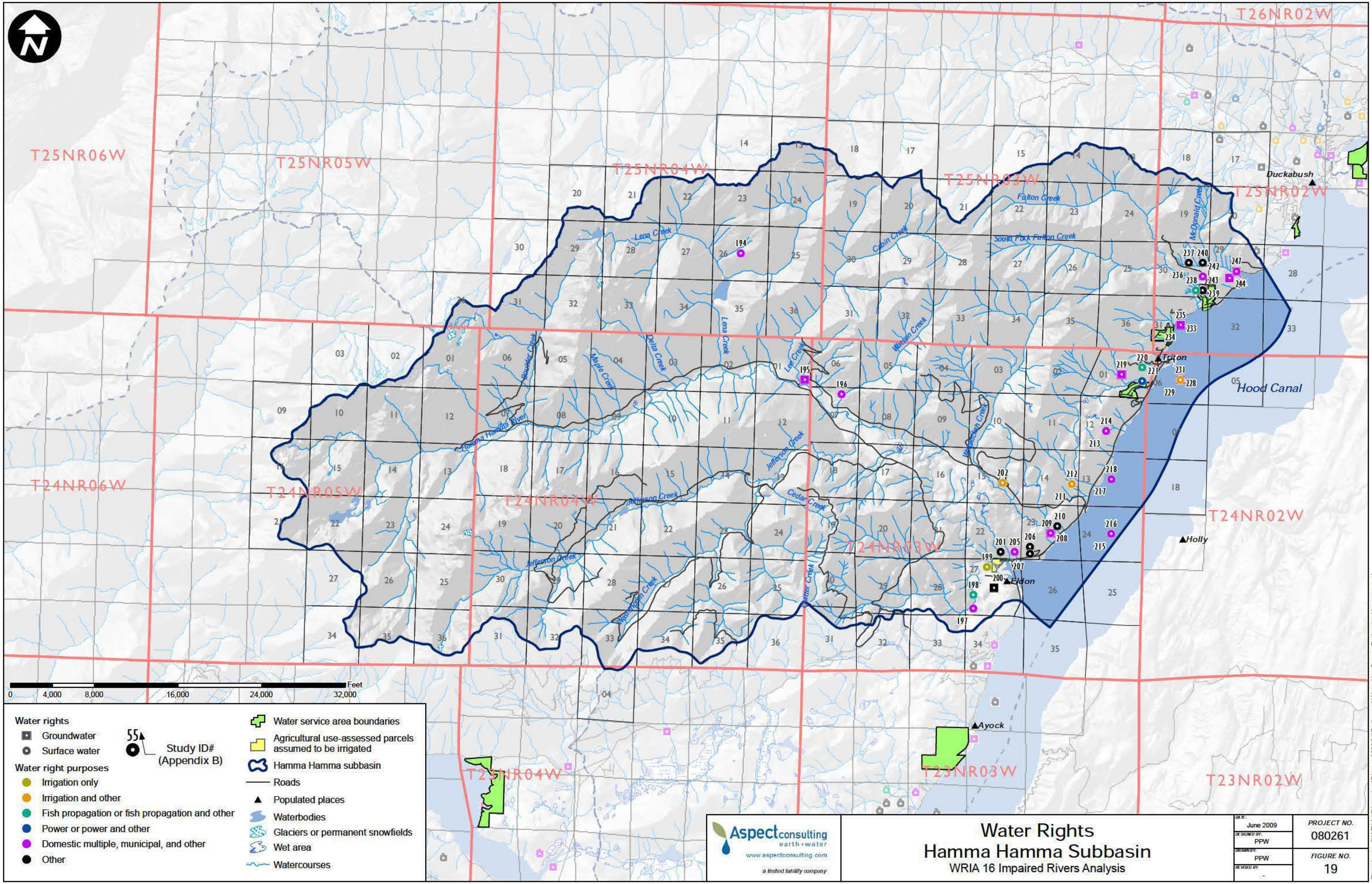
Water Rights
Duckabush Subbasin
WRIA 16 Impaired Rivers Analysis

DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 18


T26NR02W
T25NR06W
T25NR05W
T25NR04W
T25NR03W
T25NR02W
T24NR06W
T24NR05W
T24NR04W
T24NR03W
T24NR02W
T23NR04W
T23NR03W
T23NR02W
Duckabush
Triton
Eldon
Holly
Ayock
Hood Canal
Lena Creek
Fulton Creek
South Fork Fulton Creek
Cabin Creek
McDonald Creek
Boulder Creek
Maple Creek
Delta Creek
Lee Creek
Watson Creek
Hamma Hamma River
Jefferson Creek
Cedar Creek
Waketickeh Creek
Washington Creek
Cabin Creek
Gatter Creek
Feet
0
4,000
8,000
16,000
24,000
32,000
Water rights
Groundwater
Surface water
Water right purposes
Irrigation only
Irrigation and other
Fish propagation or fish propagation and other
Power or power and other
Domestic multiple, municipal, and other
Other
Study ID#
(Appendix B)
Water service area boundaries
Agricultural use-assessed parcels assumed to be irrigated
Hamma Hamma subbasin
Roads
Populated places
Waterbodies
Glaciers or permanent snowfields
Wet area
Watercourses
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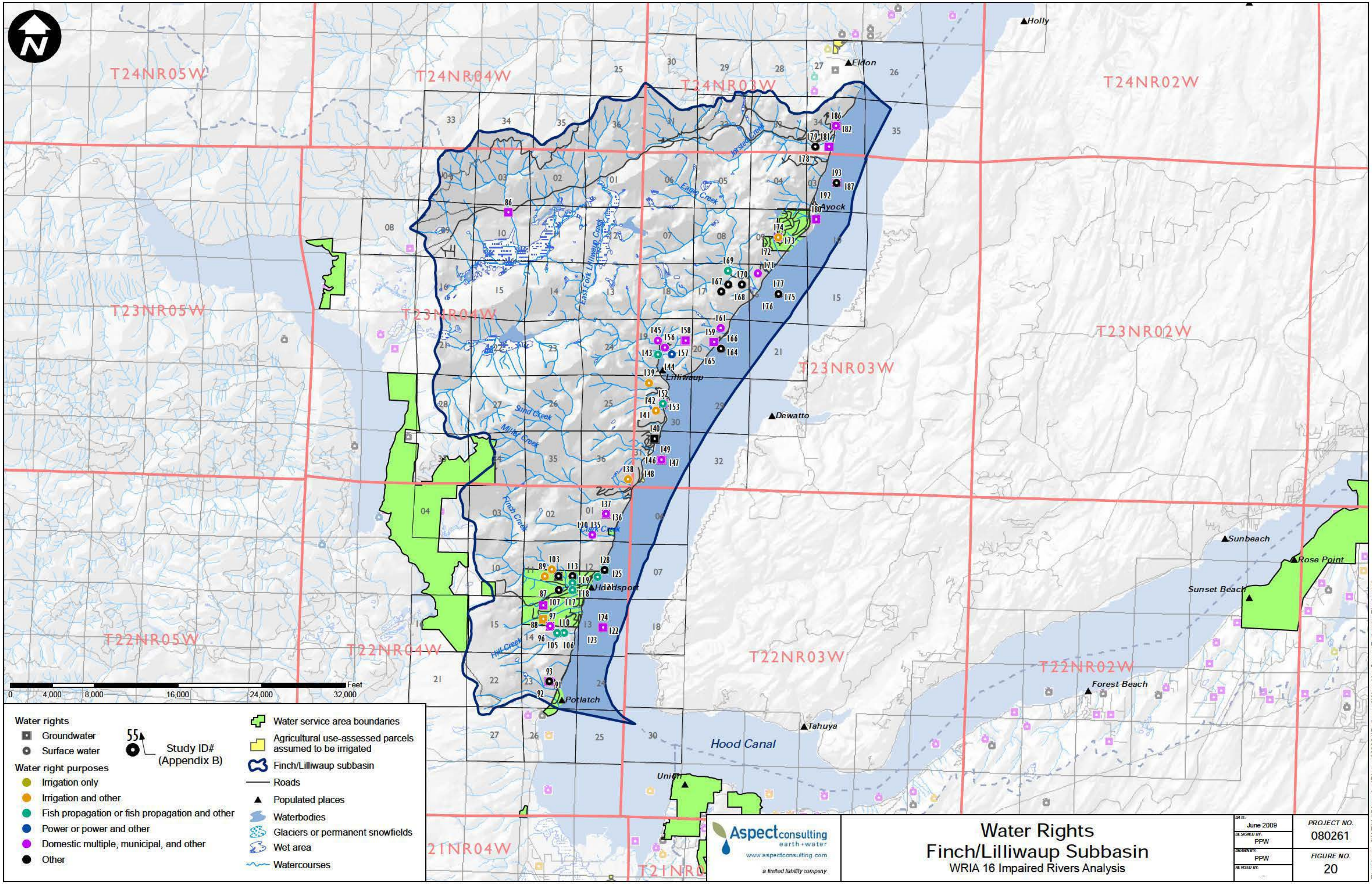
Water Rights
Hamma Hamma Subbasin
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 19
T:\projects_8\WRIA16ImpairedRivers-080261\Delivered\WaterUseSourceEstimate_Hamma.mxd


T24NR05W
T24NR04W
T24NR03W
T24NR02W
T23NR05W
T23NR04W
T23NR03W
T23NR02W
T22NR05W
T22NR04W
T22NR03W
T22NR02W
Holly
Eldon
Ayock
Lilliwaup
Dewatto
Hoodsport
Potlatch
Tahuya
Union
Sunbeach
Rose Point
Sunset Beach
Forest Beach
Hood Canal
Jorsted Creek
Eagle Creek
East Fork Lilliwaup Creek
Sund Creek
Miller Creek
Finch Creek
Clark Creek
Hill Creek
0 4,000 8,000 16,000 24,000 32,000 Feet
Water rights
Groundwater
Surface water
Water right purposes
Irrigation only
Irrigation and other
Fish propagation or fish propagation and other
Power or power and other
Domestic multiple, municipal, and other
Other
Study ID# (Appendix B)
Water service area boundaries
Agricultural use-assessed parcels assumed to be irrigated
Finch/Lilliwaup subbasin
Roads
Populated places
Waterbodies
Glaciers or permanent snowfields
Wet area
Watercourses
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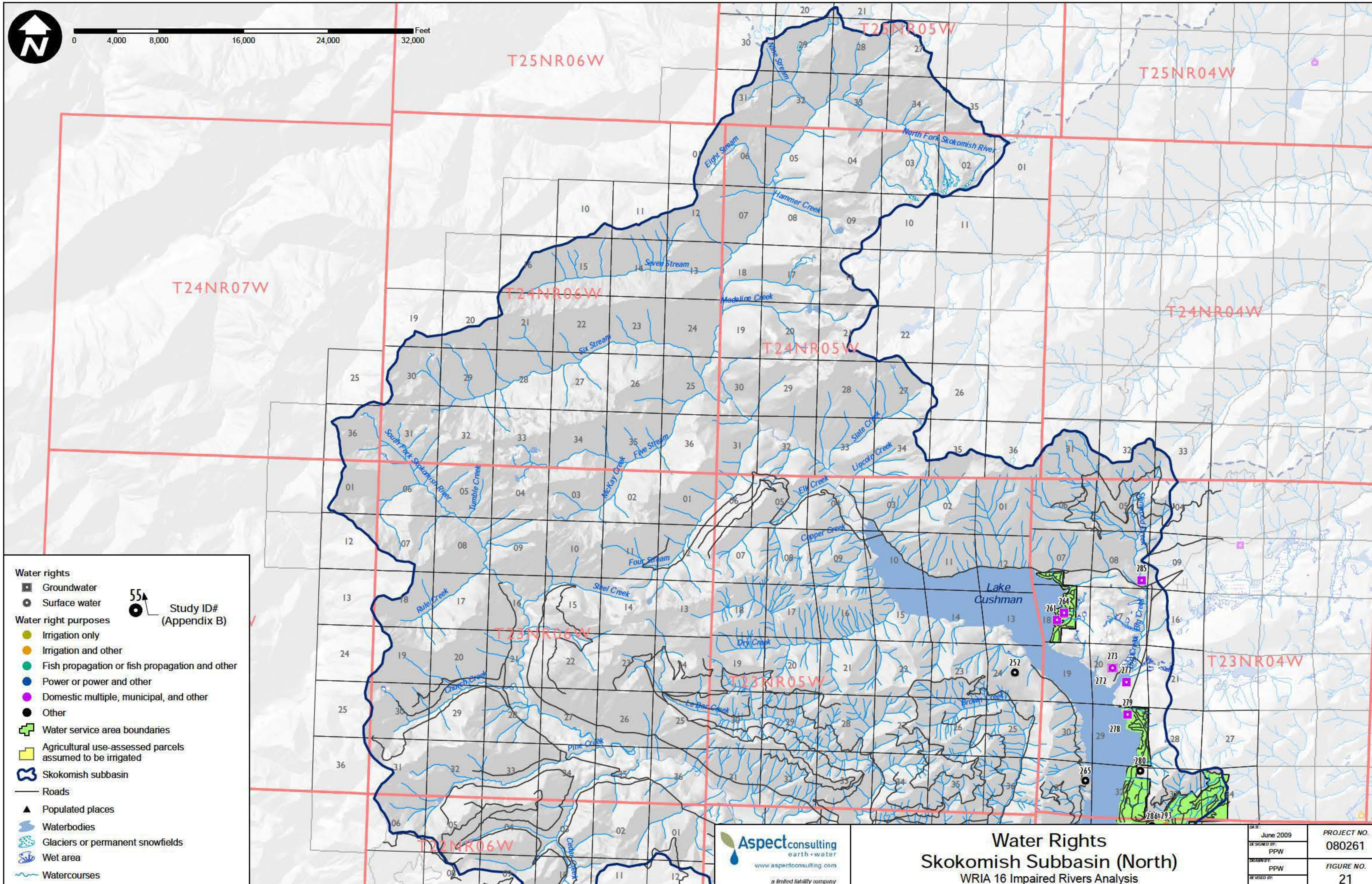
Water Rights
Finch/Lilliwaup Subbasin
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 20
T:\projects_8\WRIA16ImpairedRivers-080261\Delivered\WaterUseSourceEstimate_Finch.mxd



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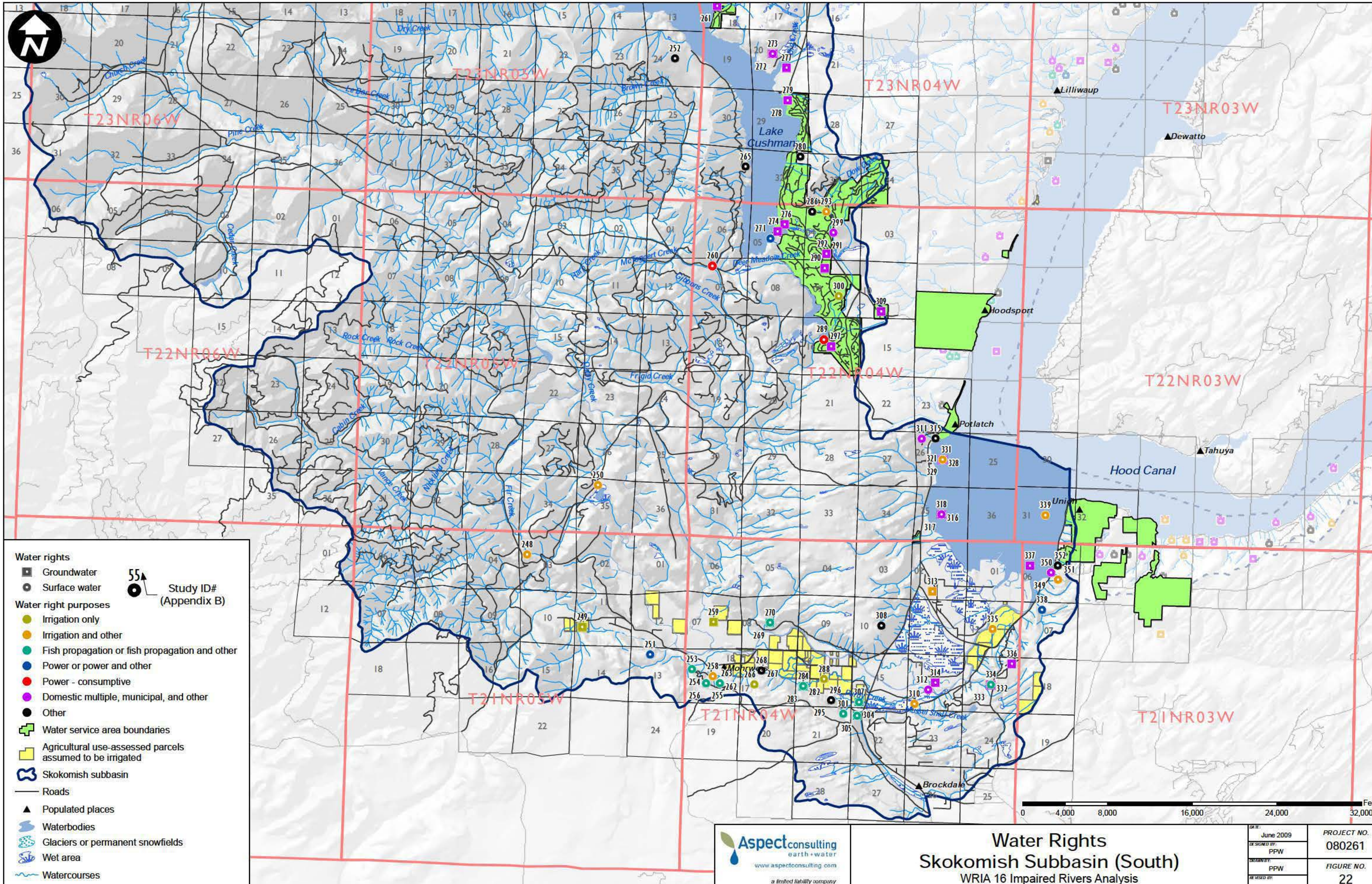
Water Rights
Skokomish Subbasin (North)
WRIA 16 Impaired Rivers Analysis

DATE: June 2009 | DESIGNED BY: PPW | DRAWN BY: PPW | REVISED BY: - | PROJECT NO. 080261 | FIGURE NO. 21



T23NR06W
T23NR05W
T23NR04W
T23NR03W
T22NR06W
T22NR05W
T22NR04W
T22NR03W
T21NR05W
T21NR04W
T21NR03W
Lake Cushman
Hood Canal
Lilliwaup
Dewatto
Hoodsport
Potlatch
Tahuya
Union
Monroe
Brockdale
Church Creek
Le Bar Creek
Pine Creek
Brown Creek
Dry Creek
Cabin Creek
McTaggart Creek
Deer Meadow Creek
Gibbons Creek
Rock Creek
Frigid Creek
Vance Creek
Nicklund Creek
Fir Creek
Dow Creek
Water rights
Groundwater
Surface water
Water right purposes
Irrigation only
Irrigation and other
Fish propagation or fish propagation and other
Power or power and other
Power - consumptive
Domestic multiple, municipal, and other
Other
Study ID# (Appendix B)
Water service area boundaries
Agricultural use-assessed parcels assumed to be irrigated
Skokomish subbasin
Roads
Populated places
Waterbodies
Glaciers or permanent snowfields
Wet area
Watercourses
Feet
0 4,000 8,000 16,000 24,000 32,000
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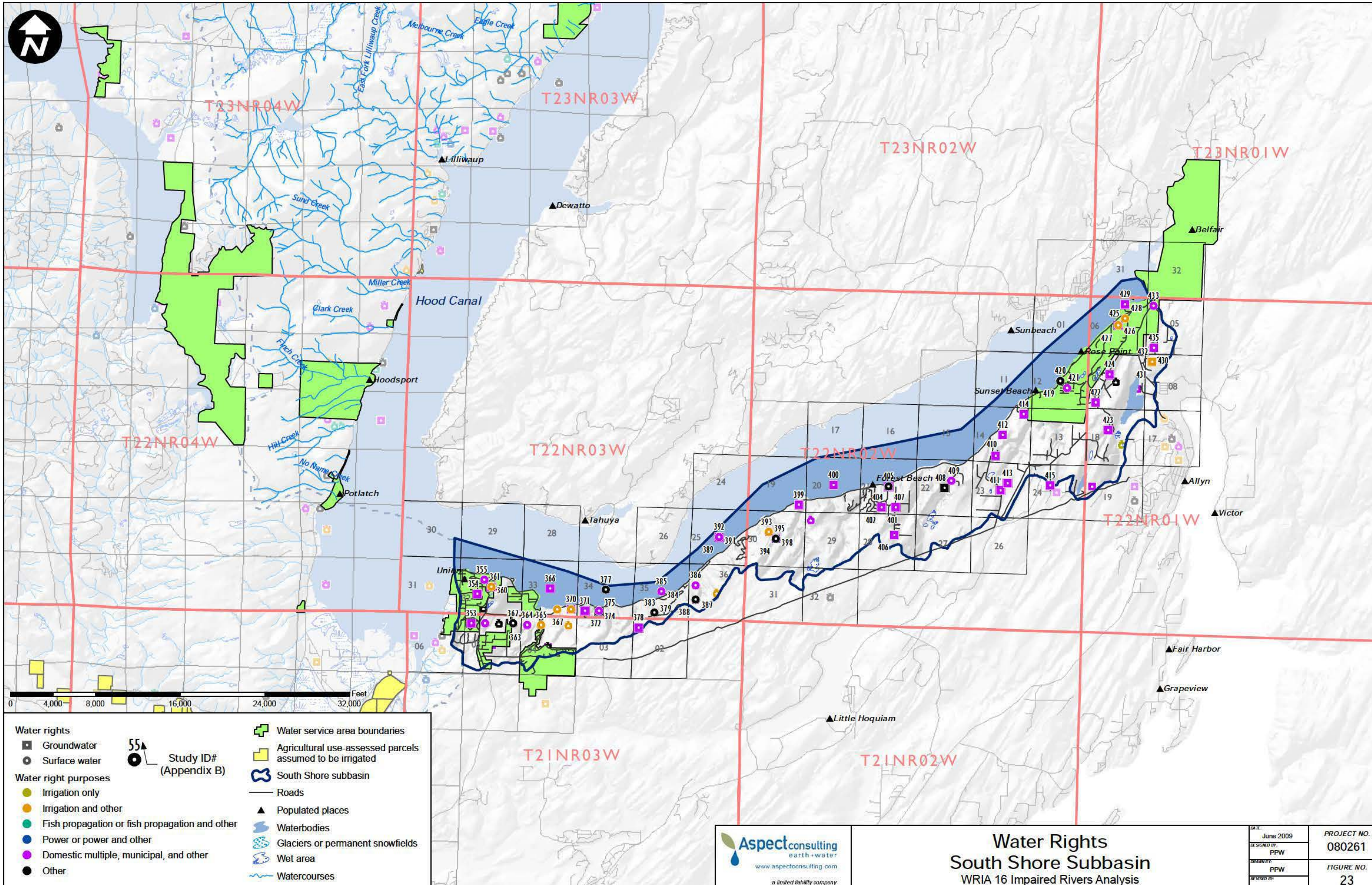
Water Rights
Skokomish Subbasin (South)
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 22
T:\projects_8\WRIA16ImpairedRivers-080261\Delivered\WaterUseSourceEstimate_SkokSouth.mxd



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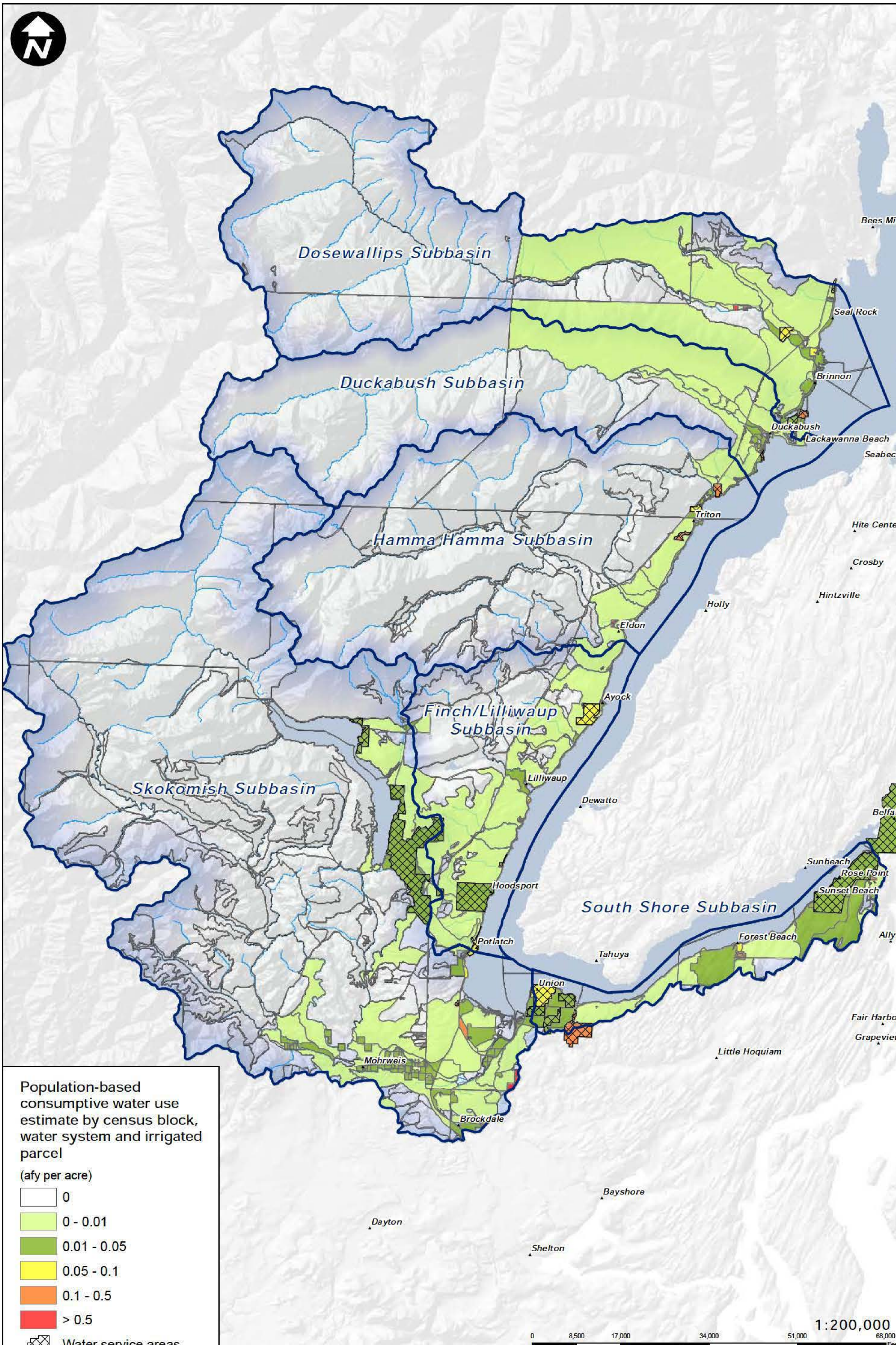
Water Rights
South Shore Subbasin
WRIA 16 Impaired Rivers Analysis

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 23
REVISED BY: -	



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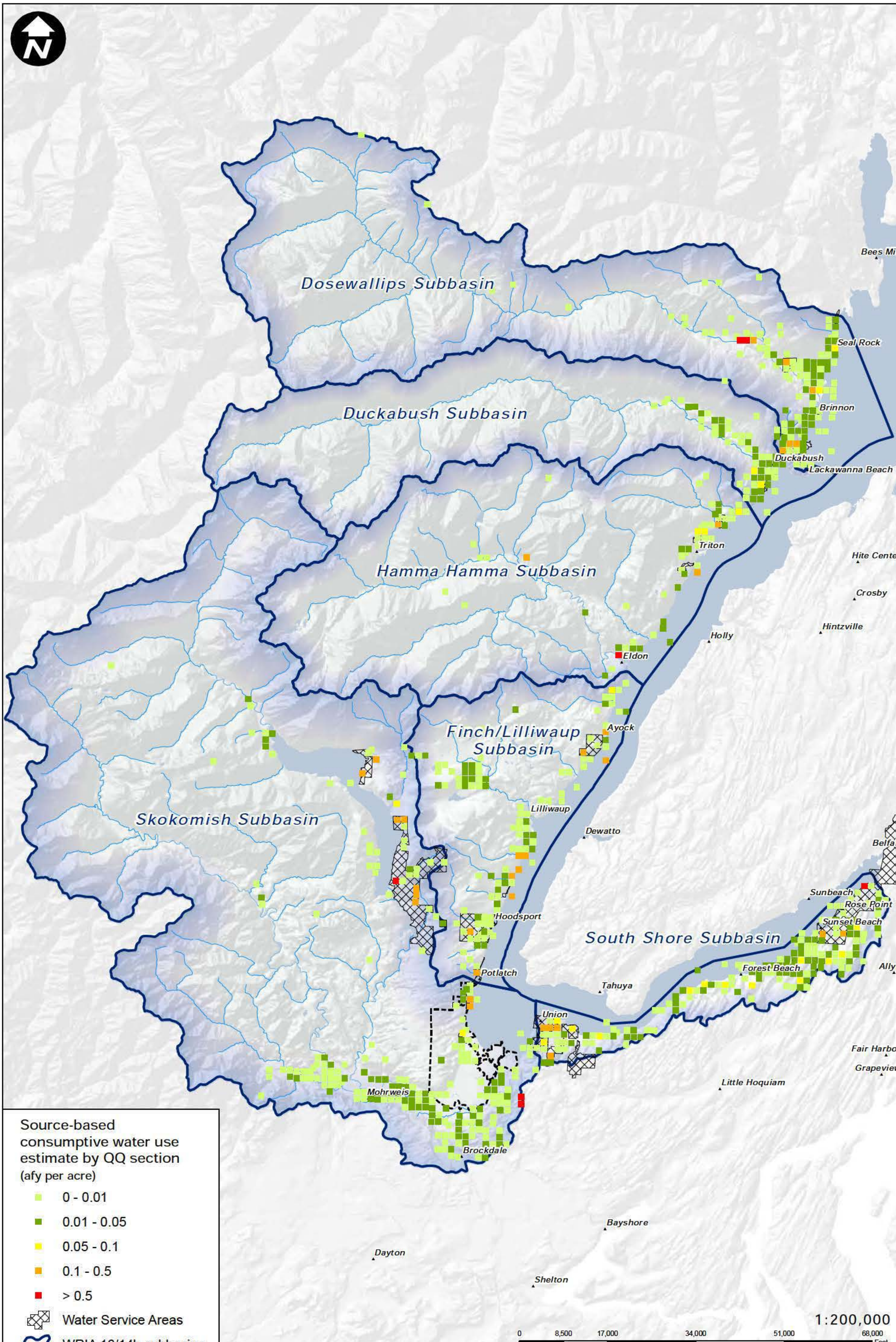
Population-Based Water Use Estimate
WRIA 16/14b
WRIA 16 Impaired Rivers Analysis

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 24
REVISED BY: -	



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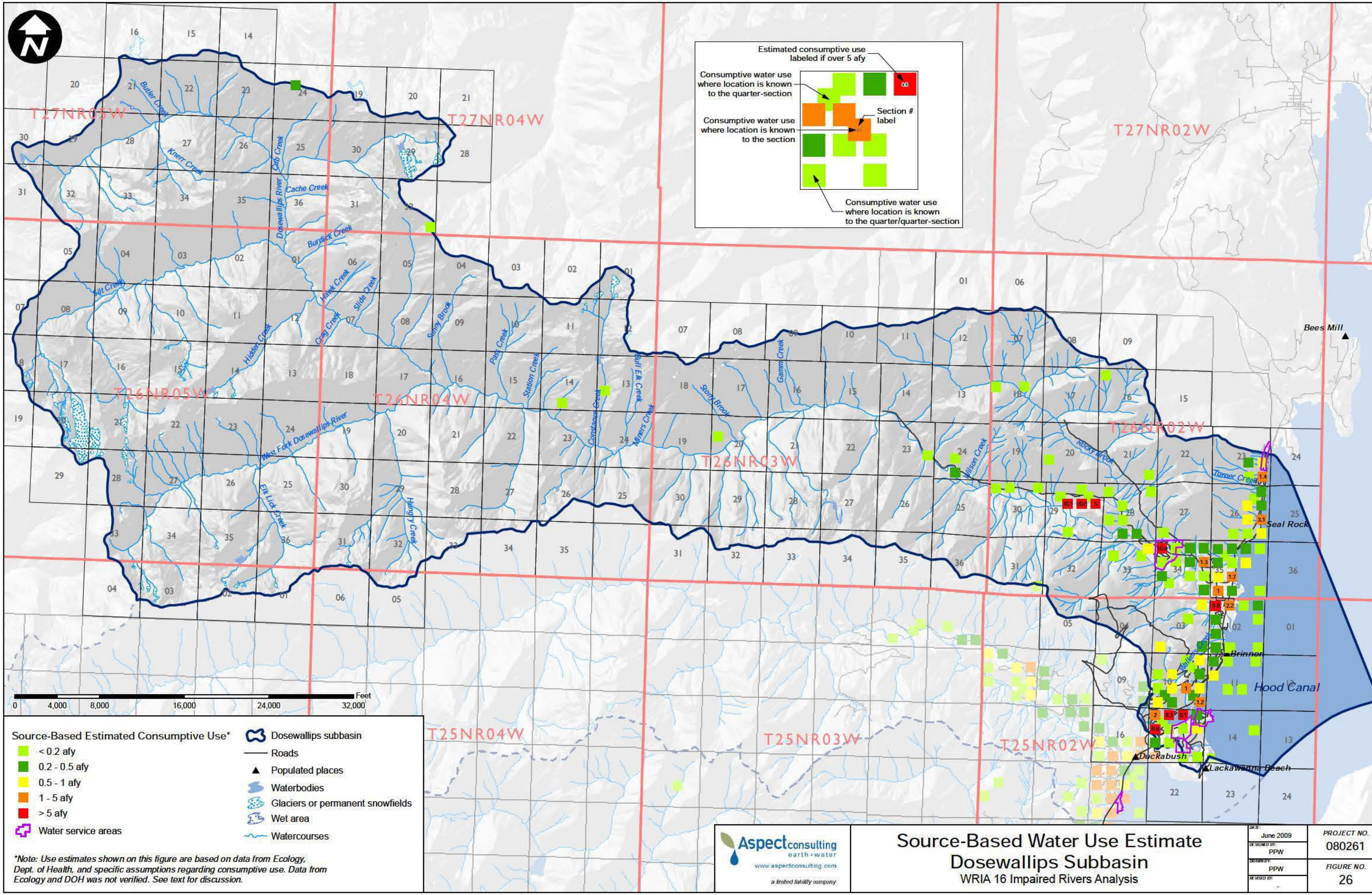
Source-Based Water Use Estimate WRIA 16/14b

WRIA 16 Impaired Rivers Analysis

DATE: June 2009		PROJECT NO.	080261
DESIGNED BY: PPW			
DRAWN BY: PPW		FIGURE NO.	25
REVISED BY: -			

T:\projects_8\WRIA16ImpairedRivers-080261\Working\DeliveredWaterUse_SourceEstimate.mxd



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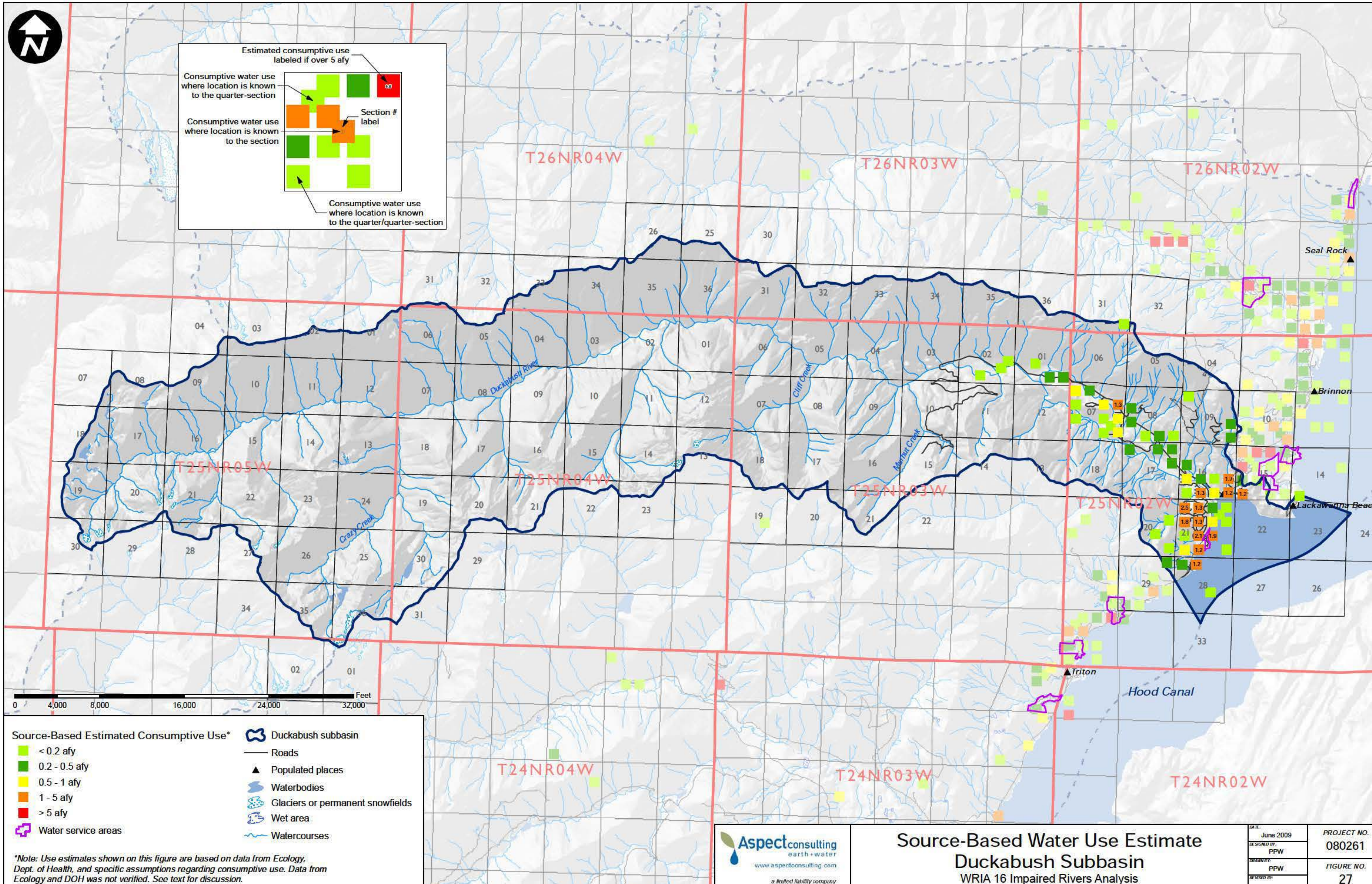
Source-Based Water Use Estimate
Dosewallips Subbasin
WRIA 16 Impaired Rivers Analysis

DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 26



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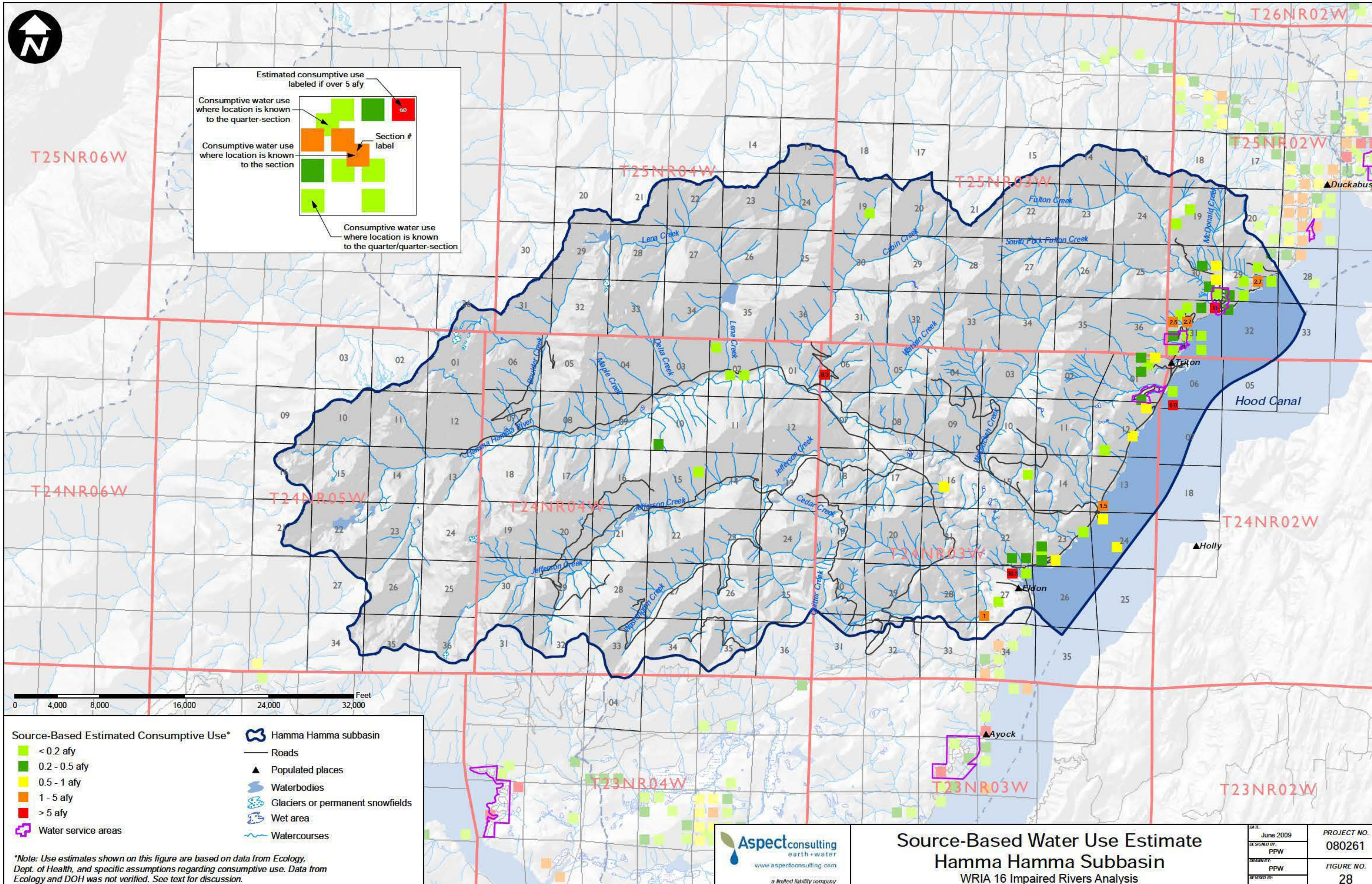
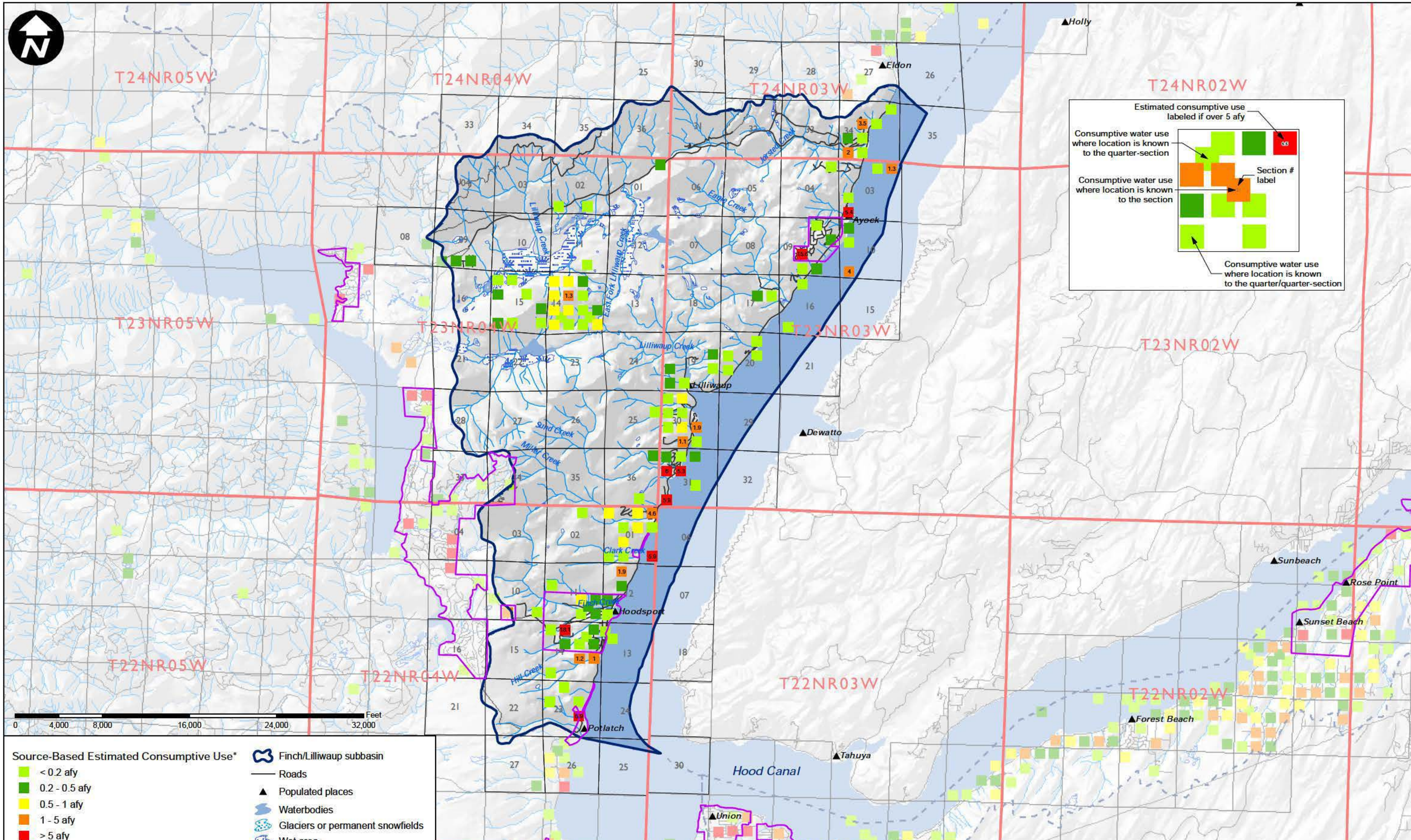
Source-Based Water Use Estimate
Duckabush Subbasin
WRIA 16 Impaired Rivers Analysis

DATE: June 2009		PROJECT NO.	080261
DESIGNED BY: PPW			
DRAWN BY: PPW		FIGURE NO.	27
REVISED BY: -			



Source-Based Water Use Estimate
Hamma Hamma Subbasin
WRIA 16 Impaired Rivers Analysis



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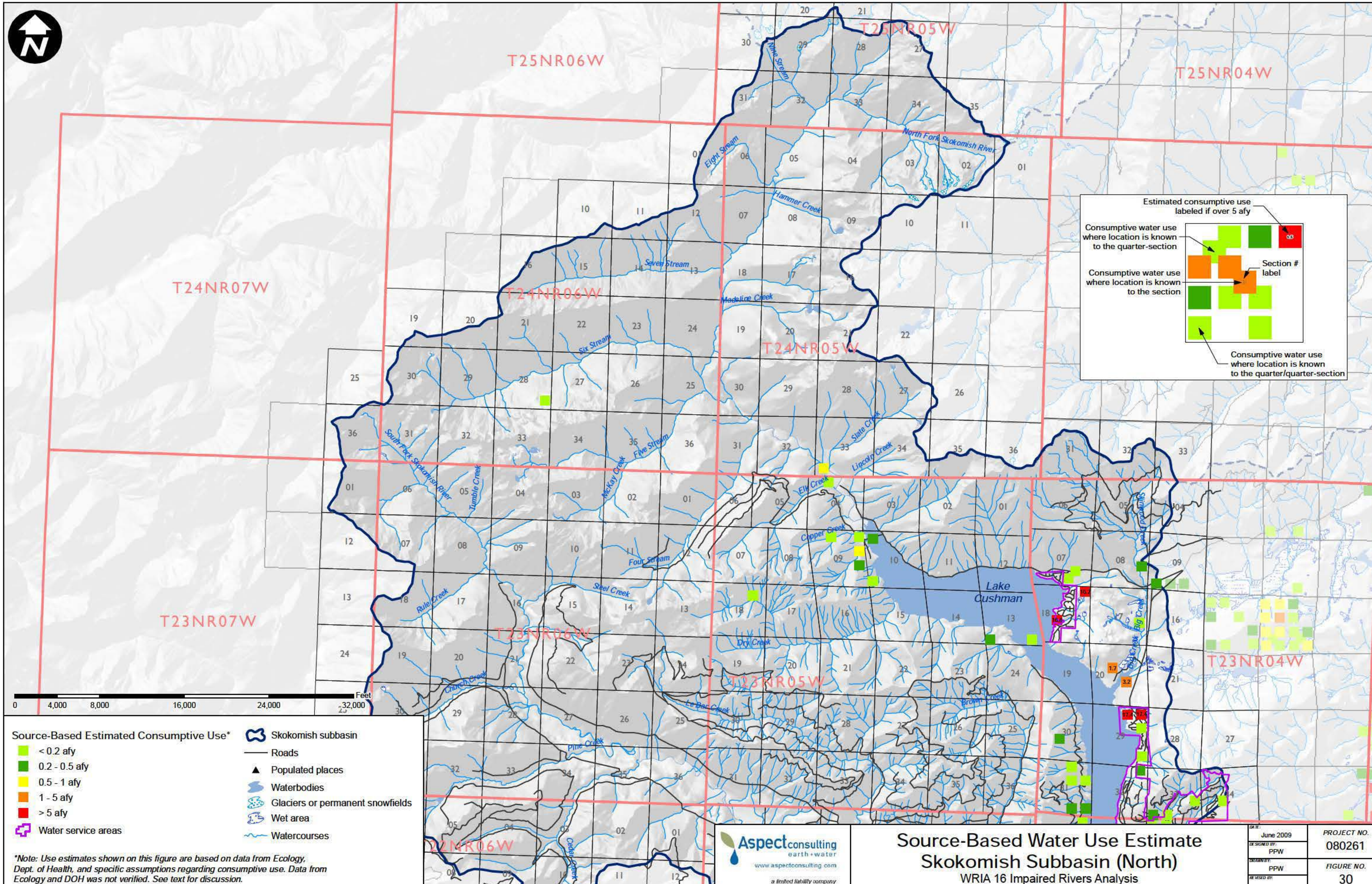
Source-Based Water Use Estimate
Finch/Lilliwaup Subbasin
WRIA 16 Impaired Rivers Analysis

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 29
REVISED BY: -	



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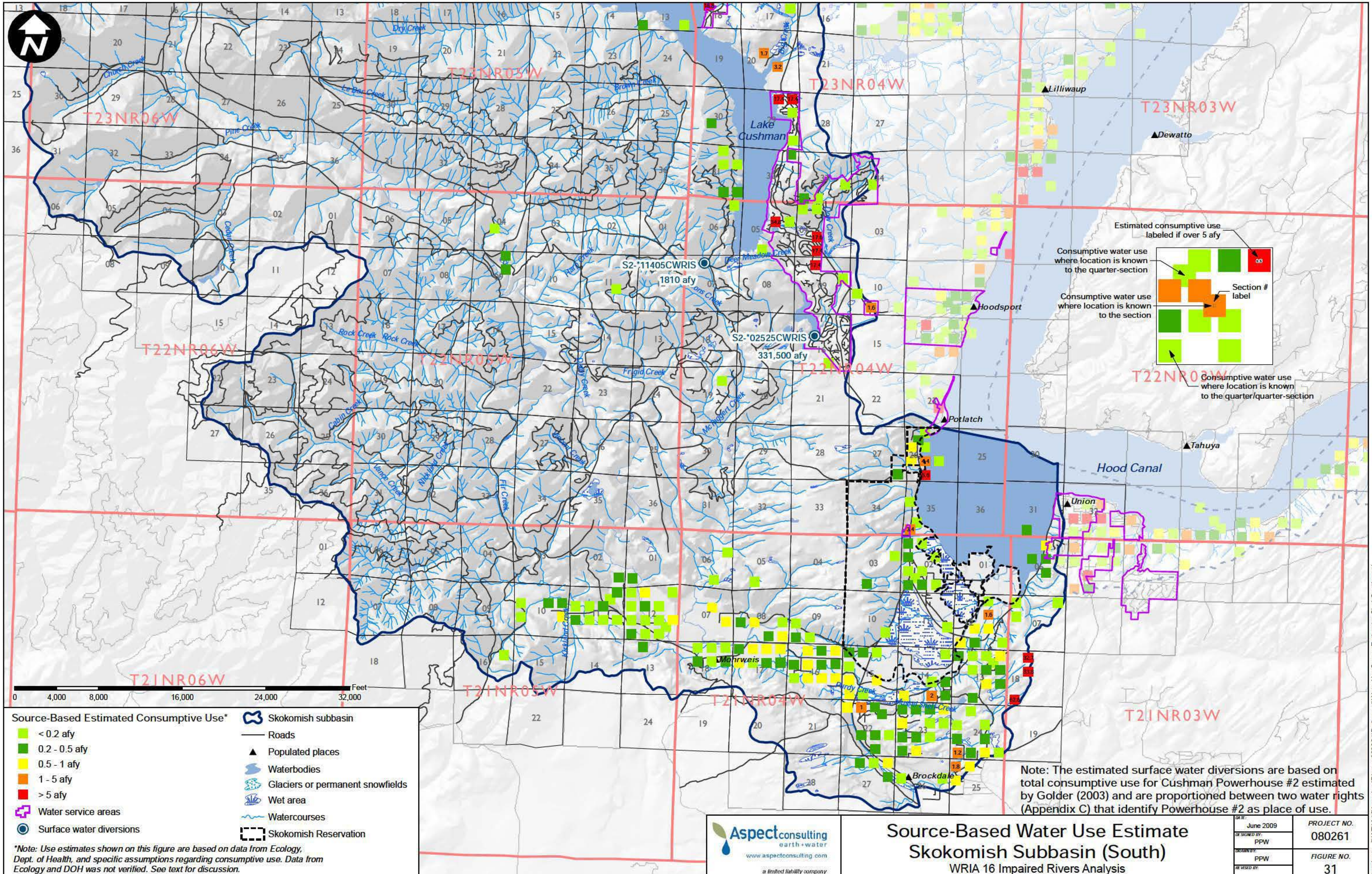
Source-Based Water Use Estimate Skokomish Subbasin (North)

WRIA 16 Impaired Rivers Analysis

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 30
REVISED BY: -	



T23NR06W
T23NR05W
T23NR04W
T23NR03W
T22NR06W
T22NR05W
T22NR04W
T22NR03W
T21NR06W
T21NR05W
T21NR04W
T21NR03W
Lake Cushman
Hood Canal
Lilliwaup
Dewatto
Hoodsport
Potlatch
Tahuya
Union
Mohrweis
Brockdale
Dry Creek
Church Creek
Le Bar Creek
Brown Creek
Pine Creek
Rock Creek
Frigid Creek
Deer Meadow Creek
Purdy Creek
S2-*11405CWRIS
1810 afy
S2-*02525CWRIS
331,500 afy
Estimated consumptive use labeled if over 5 afy
Consumptive water use where location is known to the quarter-section
Consumptive water use where location is known to the section
Section # label
Consumptive water use where location is known to the quarter/quarter-section
Feet
0 4,000 8,000 16,000 24,000 32,000
Source-Based Estimated Consumptive Use*
< 0.2 afy
0.2 - 0.5 afy
0.5 - 1 afy
1 - 5 afy
> 5 afy
Water service areas
Surface water diversions
Skokomish subbasin
Roads
Populated places
Waterbodies
Glaciers or permanent snowfields
Wet area
Watercourses
Skokomish Reservation
*Note: Use estimates shown on this figure are based on data from Ecology, Dept. of Health, and specific assumptions regarding consumptive use. Data from Ecology and DOH was not verified. See text for discussion.
Note: The estimated surface water diversions are based on total consumptive use for Cushman Powerhouse #2 estimated by Golder (2003) and are proportioned between two water rights (Appendix C) that identify Powerhouse #2 as place of use.
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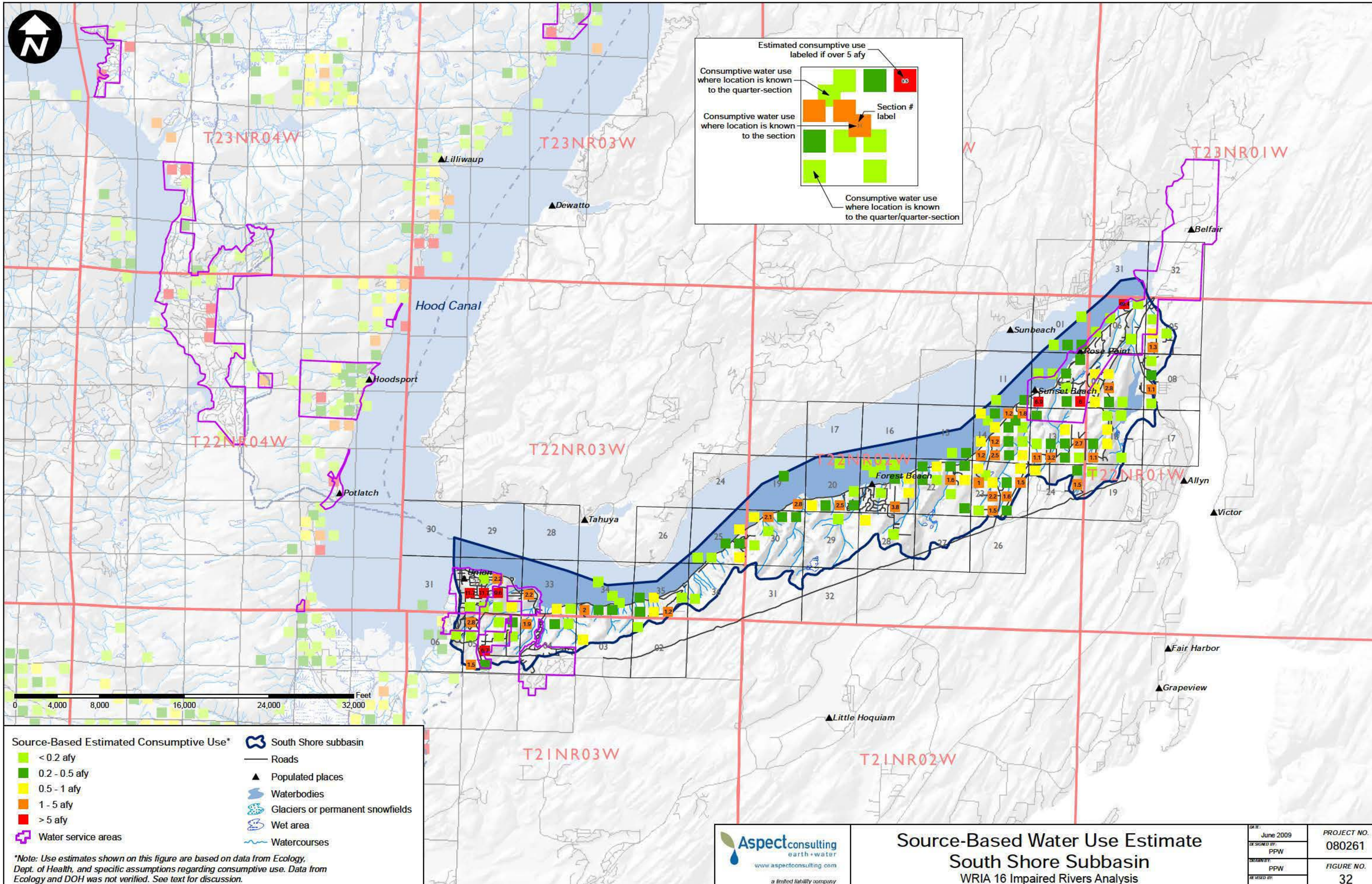
Source-Based Water Use Estimate
Skokomish Subbasin (South)
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 31
T:\projects_8\WRIA16ImpairedRivers-080261\Delivered\WaterUseSourceEstimate_SkokSouth.mxd



N
Estimated consumptive use labeled if over 5 afy
Consumptive water use where location is known to the quarter-section
Consumptive water use where location is known to the section
Section # label
Consumptive water use where location is known to the quarter/quarter-section
T23NR04W
T23NR03W
T23NR01W
T22NR04W
T22NR03W
T22NR02W
T22NR01W
T21NR03W
T21NR02W
Lilliwaup
Dewatto
Hood Canal
Hoodsport
Potlatch
Tahuya
Union
Belfair
Sunbeach
Rose Point
Sunset Beach
Forest Beach
Allyn
Victor
Fair Harbor
Grapeview
Little Hoquiam
Feet
0
4,000
8,000
16,000
24,000
32,000
Source-Based Estimated Consumptive Use*
< 0.2 afy
0.2 - 0.5 afy
0.5 - 1 afy
1 - 5 afy
> 5 afy
Water service areas
South Shore subbasin
Roads
Populated places
Waterbodies
Glaciers or permanent snowfields
Wet area
Watercourses
*Note: Use estimates shown on this figure are based on data from Ecology, Dept. of Health, and specific assumptions regarding consumptive use. Data from Ecology and DOH was not verified. See text for discussion.
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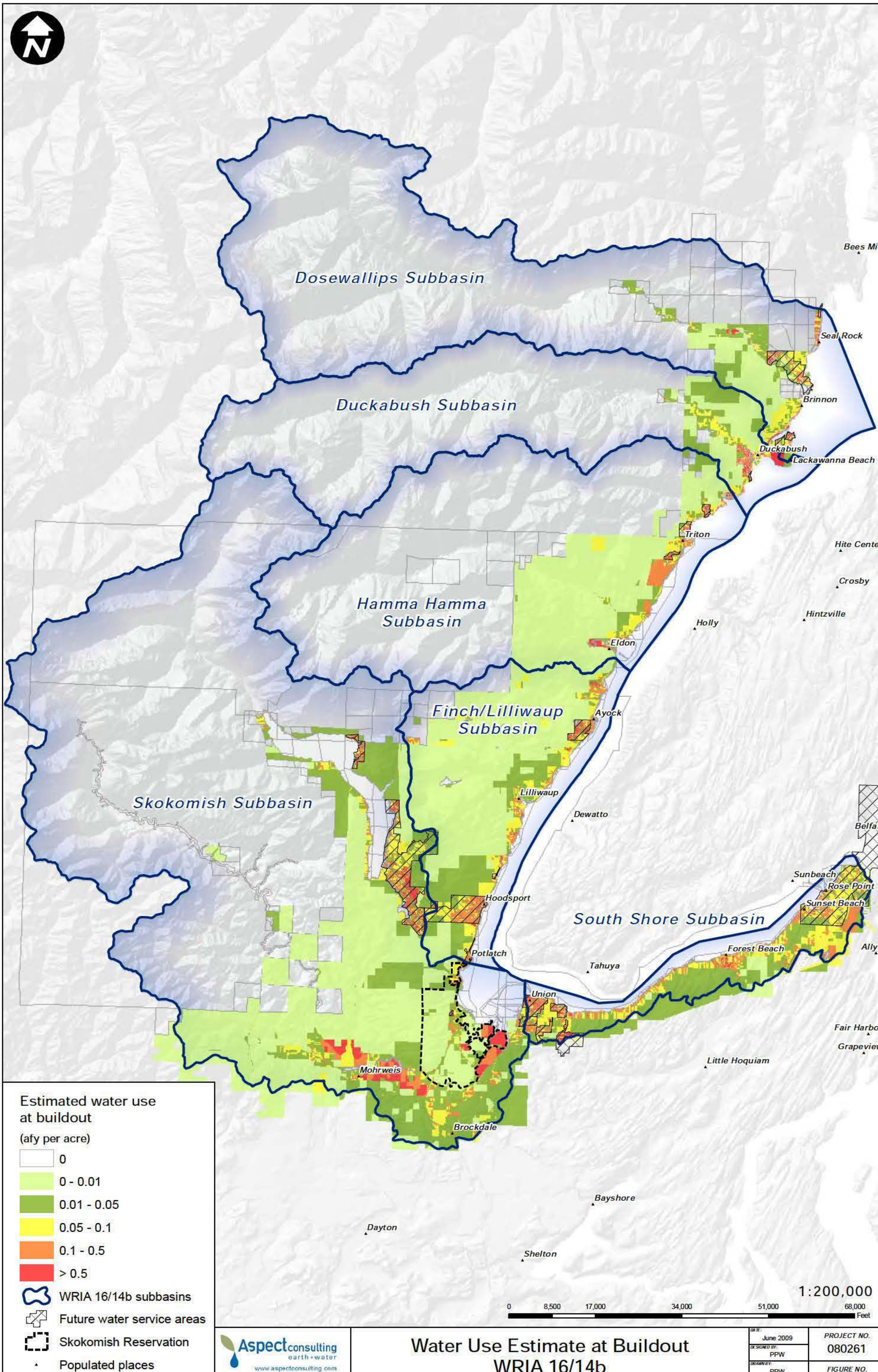
Source-Based Water Use Estimate
South Shore Subbasin
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 32
T:\projects_8\WRIA16ImpairedRivers-080261\Delivered\WaterUseSourceEstimate_SouthShore.mxd



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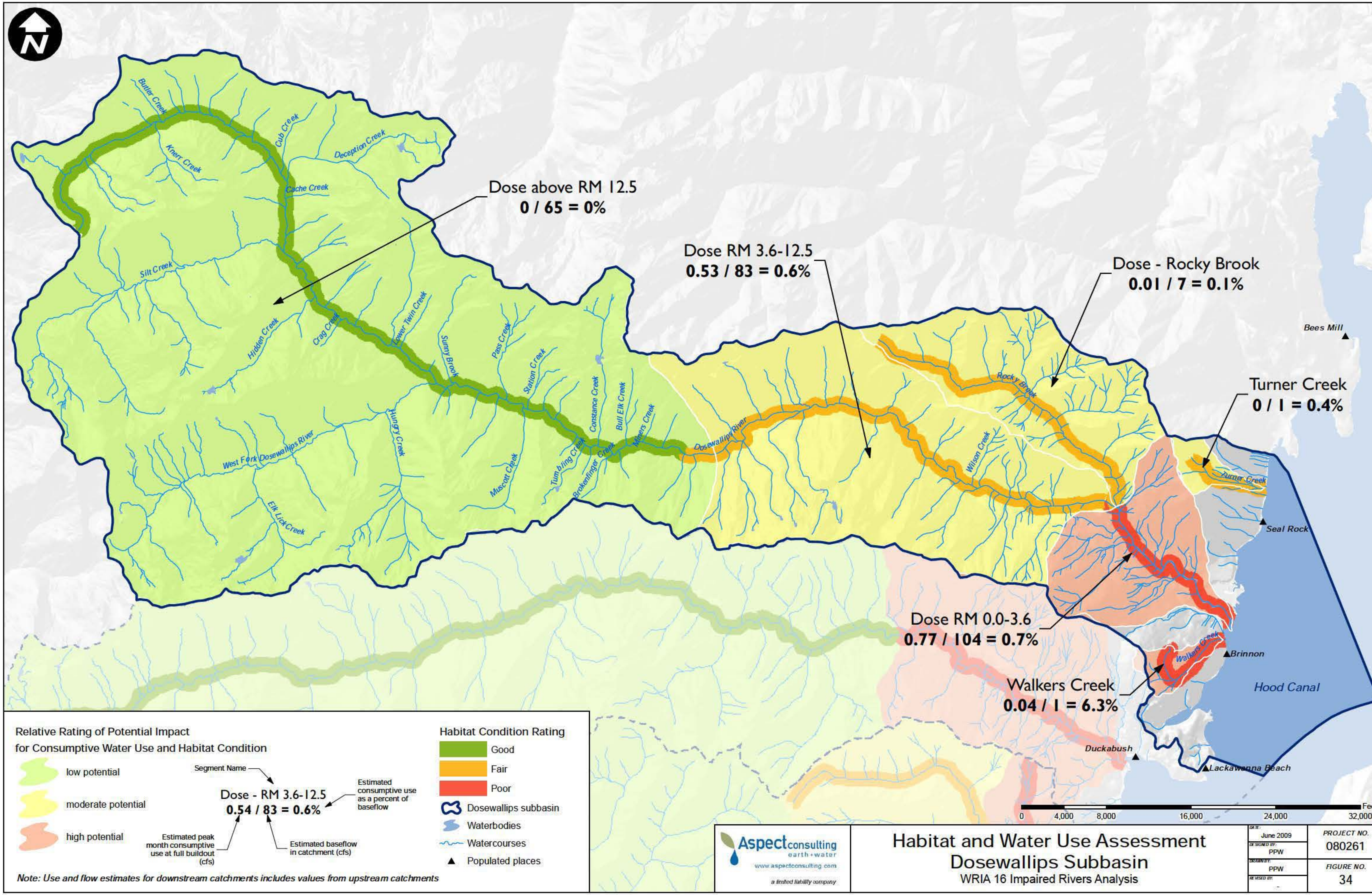
Water Use Estimate at Buildout
WRIA 16/14b
WRIA 16 Impaired Rivers Analysis

DATE:	June 2009	PROJECT NO.	080261
DESIGNED BY:	PPW		
DRAWN BY:	PPW	FIGURE NO.	33
REVISED BY:	-		



Dose above RM 12.5
0 / 65 = 0%
Dose RM 3.6-12.5
0.53 / 83 = 0.6%
Dose - Rocky Brook
0.01 / 7 = 0.1%
Turner Creek
0 / 1 = 0.4%
Dose RM 0.0-3.6
0.77 / 104 = 0.7%
Walkers Creek
0.04 / 1 = 6.3%
Butler Creek
Cub Creek
Deception Creek
Knerr Creek
Cache Creek
Silt Creek
Hidden Creek
Crag Creek
Lower Twin Creek
Sunny Brook
Pass Creek
Station Creek
Constance Creek
Bull Elk Creek
Miners Creek
Hungry Creek
West Fork Dosewallips River
Muscott Creek
Tumbling Creek
Brokenfinger Creek
Elk Lick Creek
Dosewallips River
Rocky Brook
Wilson Creek
Turner Creek
Walkers Creek
Bees Mill
Seal Rock
Brinnon
Hood Canal
Duckabush
Lackawanna Beach
Relative Rating of Potential Impact for Consumptive Water Use and Habitat Condition
low potential
moderate potential
high potential
Segment Name
Dose - RM 3.6-12.5
0.54 / 83 = 0.6%
Estimated consumptive use as a percent of baseflow
Estimated peak month consumptive use at full buildout (cfs)
Estimated baseflow in catchment (cfs)
Note: Use and flow estimates for downstream catchments includes values from upstream catchments
Habitat Condition Rating
Good
Fair
Poor
Dosewallips subbasin
Waterbodies
Watercourses
Populated places
0 4,000 8,000 16,000 24,000 32,000 Feet
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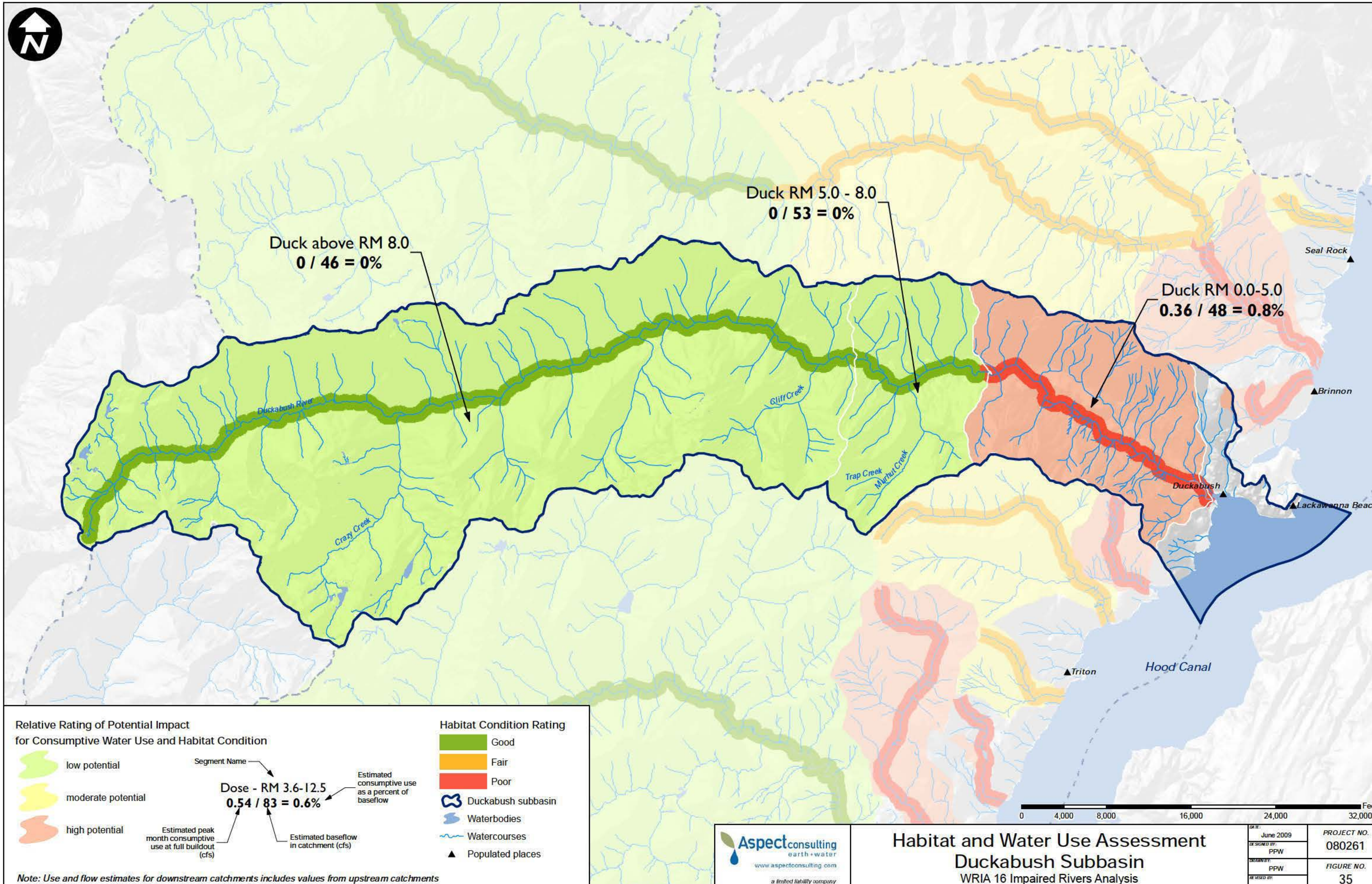
Habitat and Water Use Assessment
Dosewallips Subbasin
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 34



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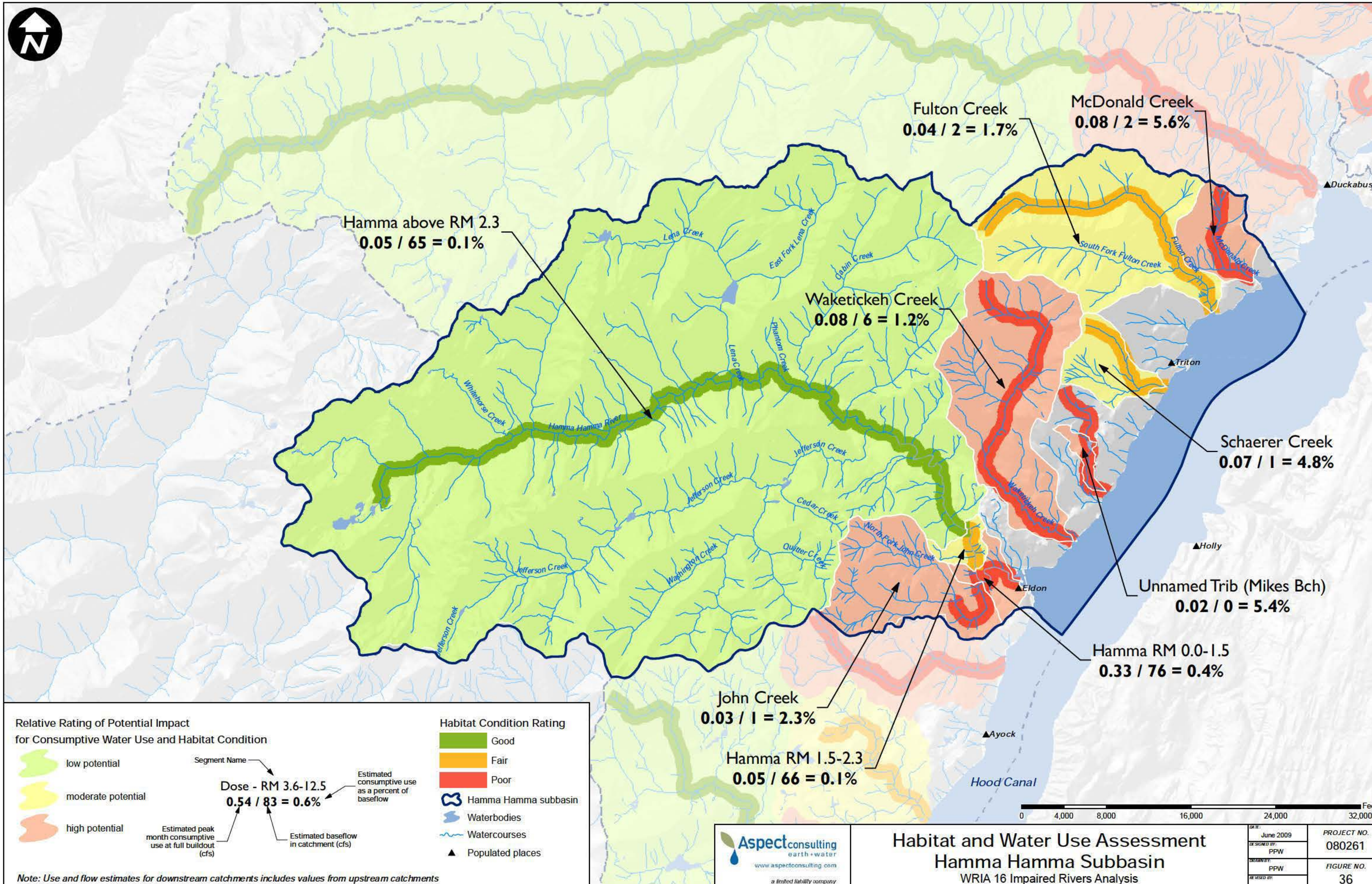

Hamma above RM 2.3
0.05 / 65 = 0.1%
Fulton Creek
0.04 / 2 = 1.7%
McDonald Creek
0.08 / 2 = 5.6%
Waketickeh Creek
0.08 / 6 = 1.2%
Schaerer Creek
0.07 / 1 = 4.8%
Unnamed Trib (Mikes Bch)
0.02 / 0 = 5.4%
Hamma RM 0.0-1.5
0.33 / 76 = 0.4%
John Creek
0.03 / 1 = 2.3%
Hamma RM 1.5-2.3
0.05 / 66 = 0.1%
Duckabush
Triton
Holly
Eldon
Ayock
Hood Canal
Lena Creek
East Fork Lena Creek
Cabin Creek
Phantom Creek
South Fork Fulton Creek
Fulton Creek
McDonald Creek
Whitehorse Creek
Hamma Hamma River
Jefferson Creek
Cedar Creek
Quilter Creek
North Fork John Creek
Washington Creek
Waketickeh Creek
Feet
0 4,000 8,000 16,000 24,000 32,000
Relative Rating of Potential Impact
for Consumptive Water Use and Habitat Condition
low potential
moderate potential
high potential
Segment Name
Dose - RM 3.6-12.5
0.54 / 83 = 0.6%
Estimated consumptive use as a percent of baseflow
Estimated peak month consumptive use at full buildout (cfs)
Estimated baseflow in catchment (cfs)
Habitat Condition Rating
Good
Fair
Poor
Hamma Hamma subbasin
Waterbodies
Watercourses
Populated places
Note: Use and flow estimates for downstream catchments includes values from upstream catchments
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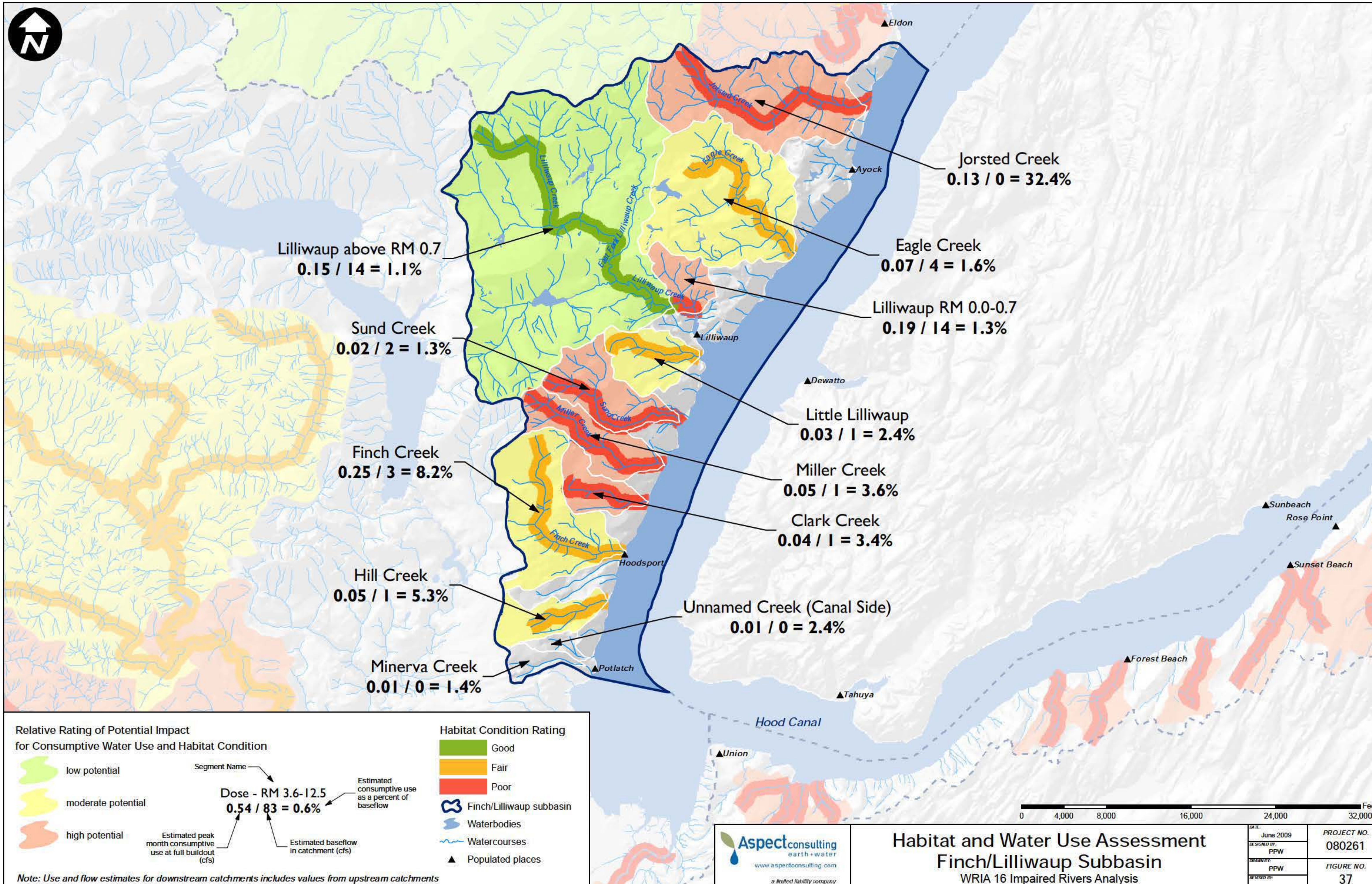
Habitat and Water Use Assessment
Hamma Hamma Subbasin
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 36


N
Eldon
Jorsted Creek
0.13 / 0 = 32.4%
Ayock
Eagle Creek
0.07 / 4 = 1.6%
Lilliwaup above RM 0.7
0.15 / 14 = 1.1%
Lilliwaup Creek
East Fork Lilliwaup Creek
Lilliwaup RM 0.0-0.7
0.19 / 14 = 1.3%
Lilliwaup
Sund Creek
0.02 / 2 = 1.3%
Dewatto
Little Lilliwaup
0.03 / 1 = 2.4%
Miller Creek
0.05 / 1 = 3.6%
Finch Creek
0.25 / 3 = 8.2%
Clark Creek
0.04 / 1 = 3.4%
Hoodsport
Hill Creek
0.05 / 1 = 5.3%
Unnamed Creek (Canal Side)
0.01 / 0 = 2.4%
Minerva Creek
0.01 / 0 = 1.4%
Potlatch
Tahuya
Hood Canal
Union
Sunbeach
Rose Point
Sunset Beach
Forest Beach
Relative Rating of Potential Impact
for Consumptive Water Use and Habitat Condition
low potential
moderate potential
high potential
Segment Name
Dose - RM 3.6-12.5
0.54 / 83 = 0.6%
Estimated consumptive use as a percent of baseflow
Estimated peak month consumptive use at full buildout (cfs)
Estimated baseflow in catchment (cfs)
Habitat Condition Rating
Good
Fair
Poor
Finch/Lilliwaup subbasin
Waterbodies
Watercourses
Populated places
Note: Use and flow estimates for downstream catchments includes values from upstream catchments
0 4,000 8,000 16,000 24,000 32,000 Feet
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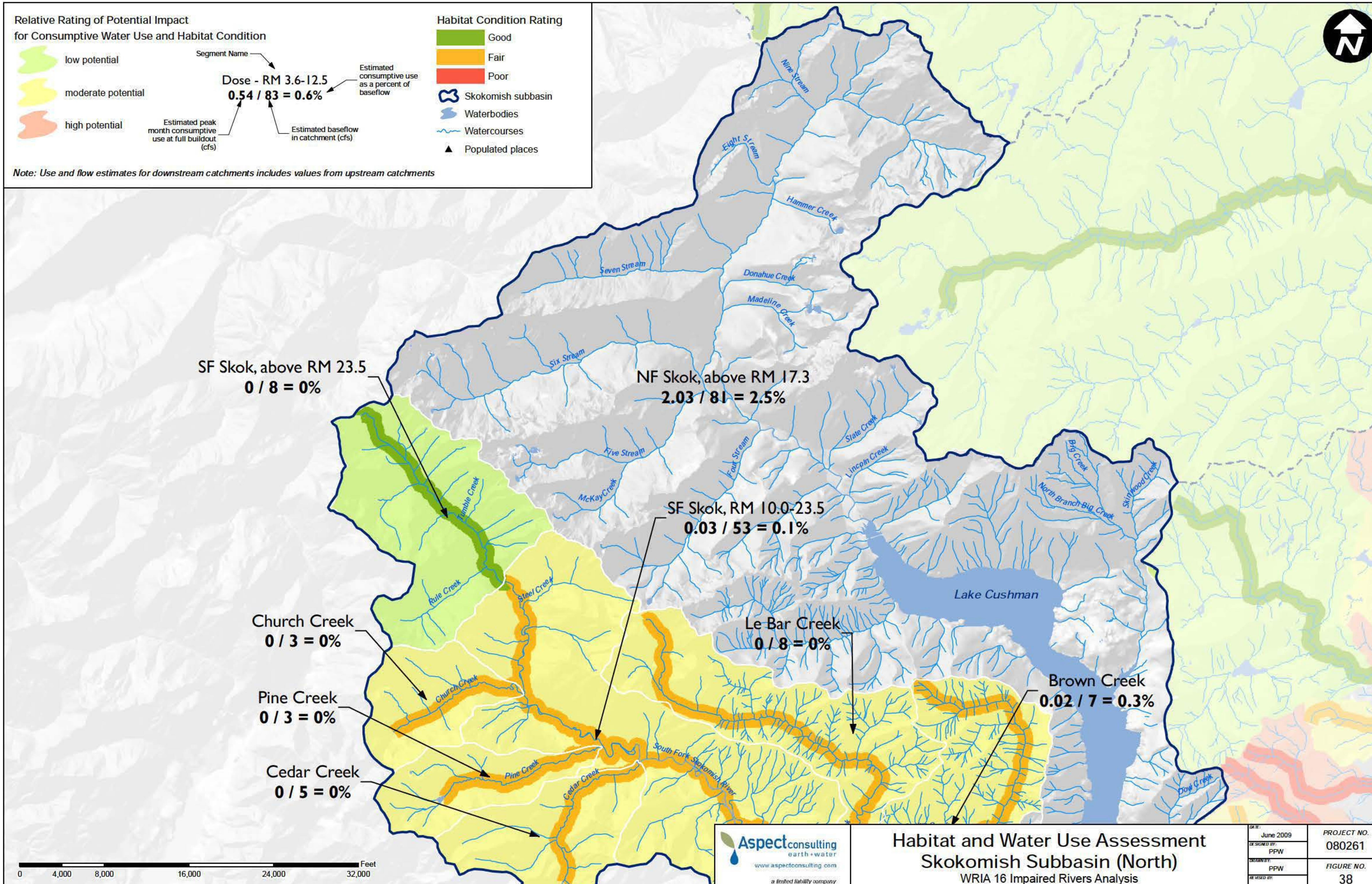
Habitat and Water Use Assessment
Finch/Lilliwaup Subbasin
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 37



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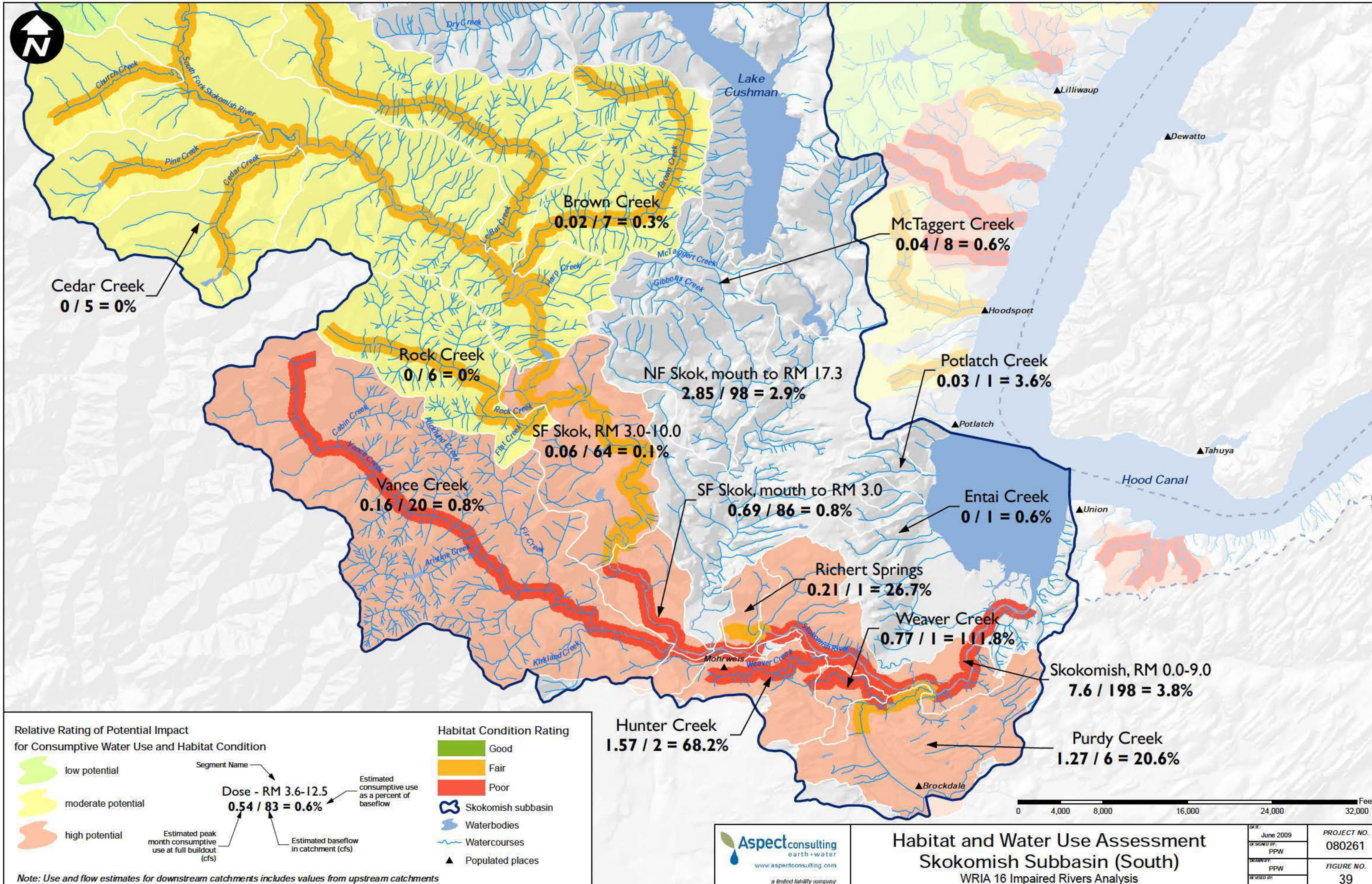
Habitat and Water Use Assessment
Skokomish Subbasin (North)

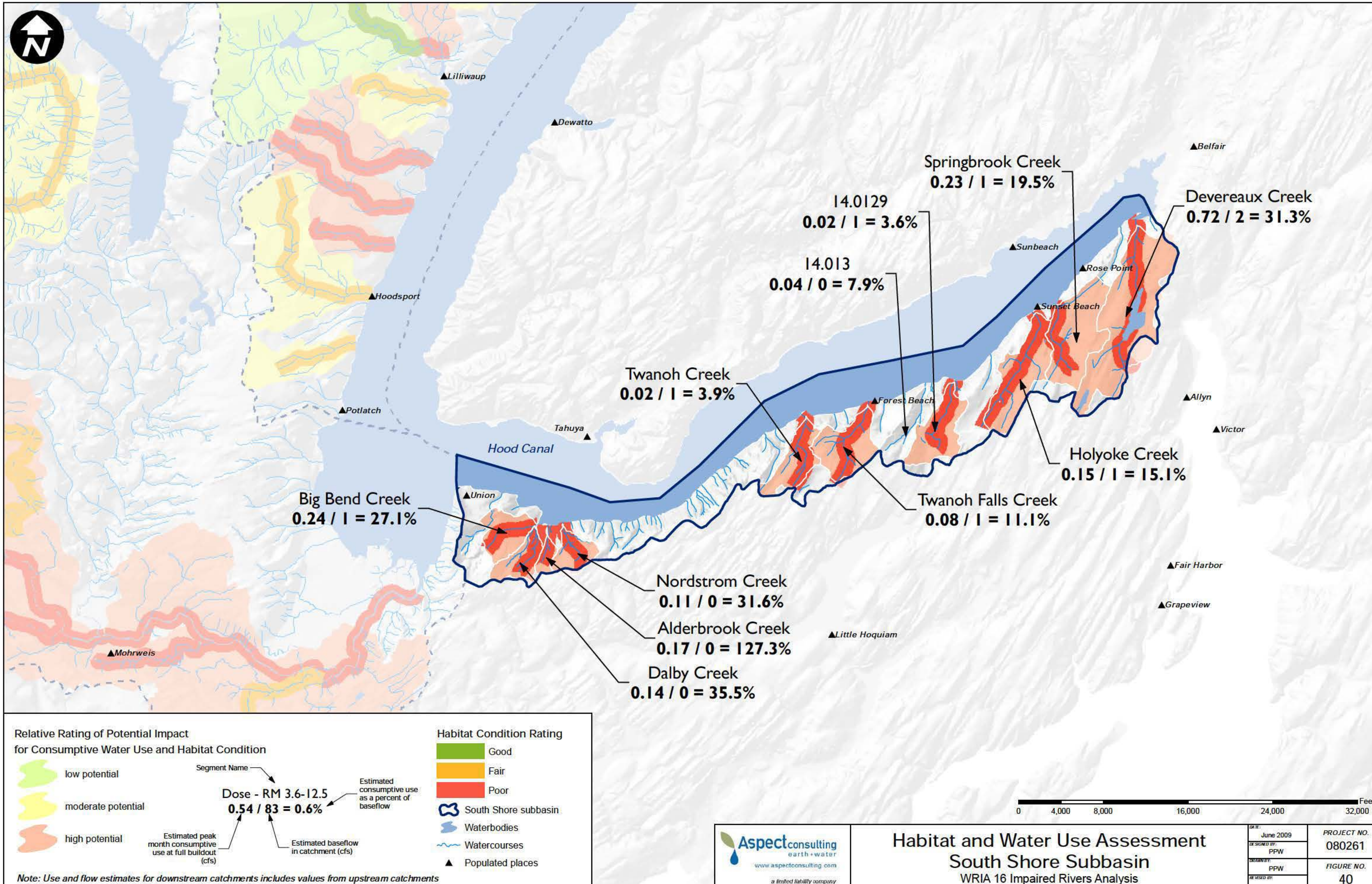
WRIA 16 Impaired Rivers Analysis

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 38
REVISED BY: -	

T:\projects_8\WRIA16ImpairedRivers-080261\Delivered\HabitatAndWaterUseAssessment_SkokNorth.mxd



Habitat and Water Use Assessment
Skokomish Subbasin (South)
WRIA 16 Impaired Rivers Analysis


Lilliwaup
Dewatto
Belfair
Springbrook Creek
0.23 / 1 = 19.5%
Devereaux Creek
0.72 / 2 = 31.3%
14.0129
0.02 / 1 = 3.6%
Sunbeach
Rose Point
14.013
0.04 / 0 = 7.9%
Hoodsport
Sunset Beach
Twanoh Creek
0.02 / 1 = 3.9%
Forest Beach
Allyn
Potlatch
Tahuya
Victor
Hood Canal
Holyoke Creek
0.15 / 1 = 15.1%
Union
Big Bend Creek
0.24 / 1 = 27.1%
Twanoh Falls Creek
0.08 / 1 = 11.1%
Fair Harbor
Nordstrom Creek
0.11 / 0 = 31.6%
Grapeview
Alderbrook Creek
0.17 / 0 = 127.3%
Little Hoquiam
Mohrweis
Dalby Creek
0.14 / 0 = 35.5%
Relative Rating of Potential Impact
for Consumptive Water Use and Habitat Condition
low potential
moderate potential
high potential
Segment Name
Dose - RM 3.6-12.5
0.54 / 83 = 0.6%
Estimated consumptive use as a percent of baseflow
Estimated peak month consumptive use at full buildout (cfs)
Estimated baseflow in catchment (cfs)
Habitat Condition Rating
Good
Fair
Poor
South Shore subbasin
Waterbodies
Watercourses
Populated places
Note: Use and flow estimates for downstream catchments includes values from upstream catchments
Feet
0 4,000 8,000 16,000 24,000 32,000
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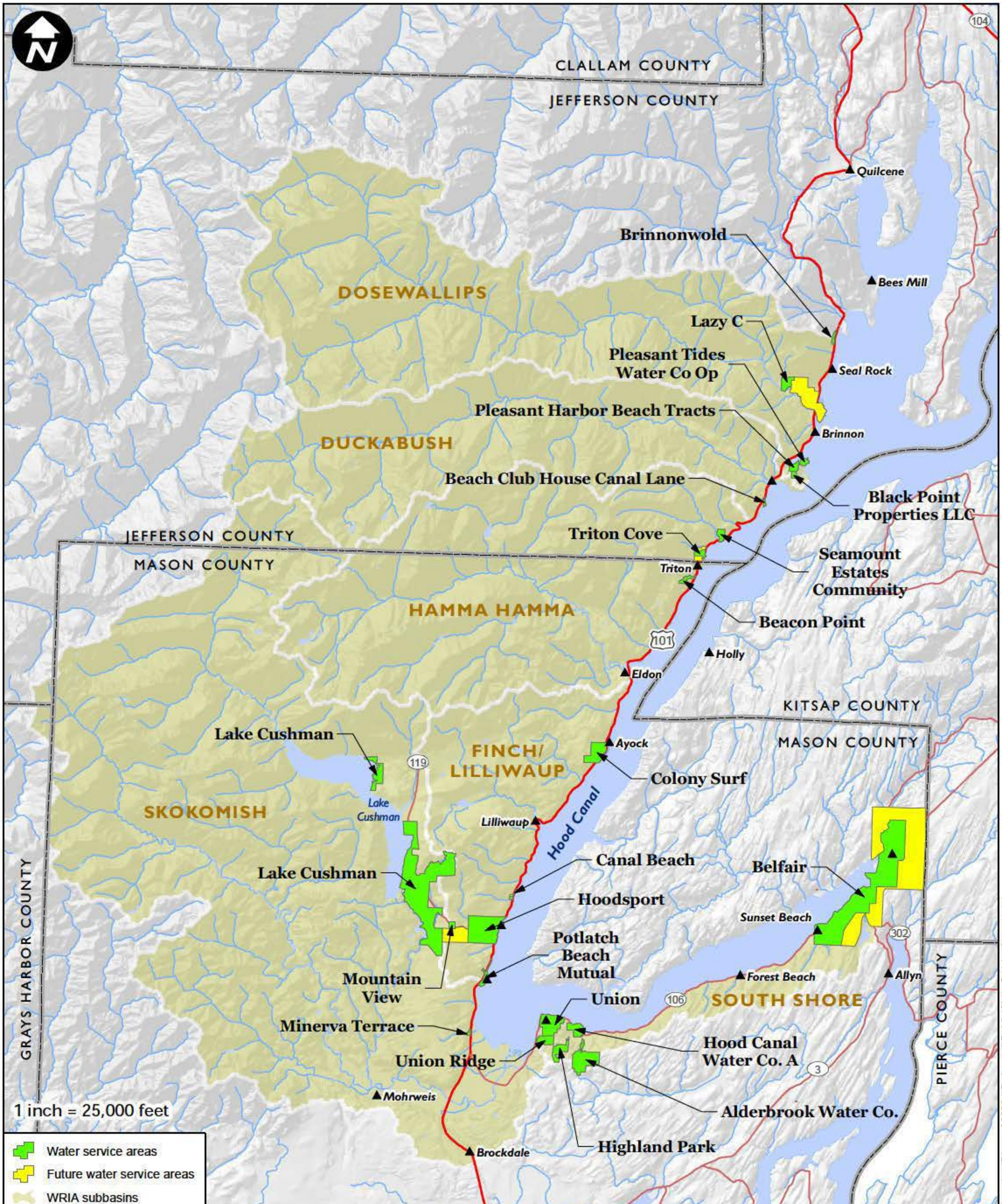
Habitat and Water Use Assessment
South Shore Subbasin
WRIA 16 Impaired Rivers Analysis
DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. 40



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Public Water Service Areas

WRIA 16 Impaired Rivers Analysis
Washington

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 41
REVISED BY: -	

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APPENDIX A

List of Datasets

Data Set Name/Desc.	Data Group	Data Type	Geometry Type	Use or Attributes of Interest or Notes	Date	Source	Source (URL(if available)	Spatial Scale or Accuracy	Extent	Projected Horiz. Coordinate System	Geographic Horiz. Coordinate System	Vert. Coord System	Has Metadata
CTC "Mason30m" Landcover/Landuse	Land Use	Raster (ESRI GRID)		Land Use/Land Cover Classification	7/21/1999	CTC via HCCC via PetersonGIS		30 meter pixels	WRIA 16 and 14 + lower Kitsap County	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		Yes
FEMA Q3 Flood Data	Aggradation	Vector (coverage)	Polygon	100 year floodplains	1996	FEMA	http://www.ecy.wa.gov/services/gis/data/flood/q3flood.htm	1:24K	Mason and Jefferson Counties	None	GCS_North_American_1927		Yes
HCCC "Areas Analysis": Estuaries	Fish Habitat	Vector (shapefile)	Polygons	Estuary polygons for select streams in the Hood Canal/Strait of Juan de Fuca Summer Chum ESU Geographic Area used in the Buildout Report	6/1/2005	HCCC		?	Hood Canal/Summer chum ESU	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		Yes (limited)
HCCC "Areas Analysis": Riparian Corridors	Fish Habitat	Vector (shapefile)	Polygons	Riparian Corridor polygons for select streams in the Hood Canal/Strait of Juan de Fuca Summer Chum ESU Geographic Area used in the Buildout Report	6/1/2005	HCCC		?	Hood Canal/Summer chum ESU	CUSTOM	GCS_North_American_1983		Yes (limited)
HCCC 2008 Buildout Data	Water Use and Population	Vector (GeoDB Featureclass)	Polygons	These data comprise the master buildout file for 2008 parcel data. Included are the current landcodes, buildout landcodes, and associated impervious surface estimates - all on an individual parcel basis. Mason, Jefferson, and Kitsap Counties, Washington State. Uses landuse codes assigned by the tax assessor departments, current zoning, and size of parcel as the basis for the landcode assignments. Previous buildouts were conducted for 2006 and 2003 parcel data.	2008	HCCC		?	Hood Canal/Summer chum ESU	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		Yes (limited)
Habitat Conditions Database	Fish Habitat	Tables (Access Database)	Can Join to Lines	This habitat conditions database contains data on in-stream ecological indicators in the Hood Canal watershed. In-stream habitat data such as channel width, gradient, and several large woody debris metrics are represented here for a total of 103 measured parameters.	2003	HCCC via PetersonGIS		1:24 when joined to WDFW LLID Streams	Hood Canal/Summer chum ESU	NAD_1927_StatePlane_Washington_South_FIPS_4602	GCS_North_American_1927		Limited
Protected Lands: HCCC_ProtectedLandParcels2	Fish Habitat	Vector (shapefile)	Polygons	To identify protected lands in East Jefferson County	11/7/2007	HCCC via PetersonGIS			East Jefferson County	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		Very Limited
Protected Lands: HCCC_ProtectedLandParcels3	Fish Habitat	Vector (shapefile)	Polygons	An inventory of protected lands throughout the Mason County, Kitsap County, and Jefferson County portions of the summer chum ESU in Washington State to provide an overview of where the protected lands are and to what level they are protected.	4/6/2008	HCCC via PetersonGIS			Hood Canal/Summer chum ESU	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		Yes

Data Set Name/Desc.	Data Group	Data Type	Geometry Type	Use or Attributes of Interest or Notes	Date	Source	Source (URL(if available)	Spatial Scale or Accuracy	Extent	Projected Horiz. Coordinate System	Geographic Horiz. Coordinate System	Vert. Coord System	Has Metadata
Protected Lands: Olympic National Forest Ownership	Fish Habitat	Vector (shapefile)	Polygons	Presumed to be parcel based date for Olympic National Forest Land Ownership	?	HCCC via PetersonGIS			Hood Canal/Summer chum ESU	NAD_1927_UTM_Zone_10N	GCS_North_American_1927		No
2006 Impervious Surfaces from HCCC	Hydrology	Vector (shapefile)	Polygons	impervious surfaces such as rooftops, driveways, paved and dirt roads, and quarry sites. They do not include recent clearcuts or other bare ground surfaces. This is a Boolean based impervious surface dataset. That is, a surface was either regarded to be impervious or not - there was no attempt to gauge percent impervious surface within polygons.	2006	HCCC via PetersonGIS		based on 1 meter pixel data	Within the summer chum ESU, Washington State (parts of Kitsap, Mason, Jefferson, and Clallam Counties are included)	NAD_1983_UTM_Zone_10N	GCS_North_American_1983		Yes
Jefferson County Potential Landslide Areas based on Soil Types	Aggradation	Vector (shapefile)	polygon	Depict potential landslide hazards in eastern Jefferson County	3/19/1997	Jefferson County GIS			Jefferson County	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		Yes
Jefferson County Potential Seismic Hazard Areas based on Soil Type	Aggradation	Vector (shapefile)	Polygon	Depict potential seismic hazards in eastern Jefferson County	3/19/1997	Jefferson County GIS			Jefferson County	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		Yes
Jefferson County Potential Soil Erosion Areas	Aggradation	Vector (shapefile)	Polygon	Depict potential erosion hazards in eastern Jefferson County	3/19/1997	Jefferson County GIS			Jefferson County	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		Yes
Jefferson County Roads	General	Vector (shapefile)	Lines	Roads in Jefferson County	?	Jefferson County GIS			Jefferson County outside of National Forest and Park	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		No
Jefferson County Parcel Data	Water Use and Population	Vector (shapefile)	Polygon	Parcels, Land Use	?	Jefferson County GIS			Jefferson County	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		No
Jefferson County Water Service Areas	Water Use and Population	Vector (shapefile)	Polygon	Current and future water service areas in Jefferson County	?	Jefferson County GIS			Jefferson County	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		No
Jefferson County Zoning	Water Use and Population	Vector (shapefile)	Polygon	Zoning	?	Jefferson County GIS		Not necessarily based on parcel data	Jefferson County	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		No

Data Set Name/Desc.	Data Group	Data Type	Geometry Type	Use or Attributes of Interest or Notes	Date	Source	Source (URL(if available)	Spatial Scale or Accuracy	Extent	Projected Horiz. Coordinate System	Geographic Horiz. Coordinate System	Vert. Coord System	Has Metadata
Mason County Hazone -landform areas of landslide hazard	Aggradation	Vector (shapefile)	Polygon	To provide a screening tool that identifies the known landslide hazards for the state of Washington, to eliminate the error of omission in the identification of unstable slopes. To support the needs of the Landslide Hazard Zonation project, as well as to provide and ongoing, supported platform to place landslide hazard area information that is regularly collected by a variety of agencies, both public and private.	1/15/2007	Mason County GIS			Mason County (limited)	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		Yes
Mason County Isi-Landslide Inventory	Aggradation	Vector (shapefile)	Polygon	The LSI coverage is an Inventory of Landslides (Also Known As Mass Wasting Events).	2004	Mason County GIS			Mason County (limited)	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		Yes
Mason County Road Damage Incidents	Aggradation	Vector (shapefile)	Points	To show the location of Road Damage during the December 3rd, 2007 storm	2007	Mason County GIS			Mason County	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		Yes (limited)
Mason County Slope Stability	Aggradation	Vector (shapefile)	Polygon	Extract of Statewide shoreline slope stability coverage	1975	Mason County GIS			Mason County Shorelines	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		Yes
Mason County Roads	General	Vector (shapefile)	Lines	Roads in Mason County	3/23/2009	Mason County GIS		Based on 2005 aerials	Mason County	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		Yes
Mason County Development Areas	Water Use and Population	Vector (shapefile)	Polygon	Zoning for buildout analysis. This data set shows the development areas for Mason County as described in the Mason County Development Regulations, Title 17 (adopted as Ord. No. 82-96, as revised).	8/1/2008	Mason County GIS			Mason County	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		Yes
Mason County Parcel Data	Water Use and Population	Vector (shapefile)	Polygon	Parcels, Land Use (Assessor)	3/23/2009	Mason County GIS			Mason County	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		Yes
Mason County Water Districts	Water Use and Population	Vector (shapefile)	Polygon	The "WATER_DISTRICTS" shapefile represents the 4 water districts in Mason County. These data are maintained by the county Assessor's Office and the Washington State Department of Revenue.	6/5/2006	Mason County GIS			Mason County	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		Yes

Data Set Name/Desc.	Data Group	Data Type	Geometry Type	Use or Attributes of Interest or Notes	Date	Source	Source (URL(if available)	Spatial Scale or Accuracy	Extent	Projected Horiz. Coordinate System	Geographic Horiz. Coordinate System	Vert. Coord System	Has Metadata
NLCD Land Cover	Land Use	Raster (TIFF)		Landsat Land Cover	2001	NLCD via WA Ecology	http://www.ecy.wa.gov/services/gis/data/impervious/basins.htm	30 meter pixels	Western Washington	NAD_1983_HARN_Lambert_Conformal_Conic	GCS_North_American_1983_HARN		Yes
Watershed Hydrologic Unit Boundaries	Hydrology	Vector (shapefile)	Polygons	Hydrologic units, Watershed Boundaries, Subwatershed Boundaries	9/3/2008	Pacific Northwest Hydrography Framework	http://hydro.reo.gov/layers.html		Washington State (clipped to study area)	None	GCS_North_American_1983		Yes
CTC Refugia: Nodal Corridors	Fish Habitat	Vector (shapefile)	Polygons	Nodal Corridors from CTC completed phase II of a refugia study for Mason County	2003?	PetersonGIS		?	Hood Canal/Summer chum ESU	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983		No
LiDAR Digital Elevation Models	General	Raster (ESRI GRID)		Ground surface elevations and earth geometry	2002	Puget Sound Lidar Consortium	http://pugetsoundlidar.ess.washington.edu/lidardata/index.html	approx 6 ft pixels	Limited to eastern edge of WRIA. (see http://pugetsoundlidar.ess.washington.edu/PSIC_status_map.pdf)	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	GCS_North_American_1983	NAVD88	Yes
2005 DNR Aerial Photos	General	Raster (TIFF)		Aerial Photo	2005	Skokomish Tribe		18 inch pixels	Lower Skokomish Up to Lake Cushman	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		No
2007 WSDOT Aerial Photos	General	Raster (TIFF)		Aerial Photo	2007	Skokomish Tribe		1 foot pixels	8 townships in lower Skokomish	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		No
Skokomish Tribe: Average Daily Temperature	Water Quality	Table (Excel)		temp monitoring on the South Fork for the steelhead project	Summer 2008	Skokomish Tribe		Presumed GPS	South Fork Skokomish	NAD_1983_UTM_Zone_10N	GCS_North_American_1983		No
Land Use Skokomish Reservation as of 2007-08	Water Use and Population	Vector (shapefile)	polygons	Land Use Planning	2007-08	Skokomish Tribe		Base Parcel information from BIA and Mason County.	Skokomish Reservation	NAD_1927_UTM_Zone_10N	GCS_North_American_1927		Yes
US Census Tiger 2008: blocks	Water Use and Population	Vector (shapefile)	Polygons	2000 Census population data	2008	US Census Bureau via WOFM	http://www.ofm.wa.gov/geographic/08tiger.asp		Jefferson County and Mason County	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes

Data Set Name/Desc.	Data Group	Data Type	Geometry Type	Use or Attributes of Interest or Notes	Date	Source	Source (URL(if available)	Spatial Scale or Accuracy	Extent	Projected Horiz. Coordinate System	Geographic Horiz. Coordinate System	Vert. Coord System	Has Metadata
NAIP Aerial Photos	General	Raster (MrSID)		Imagery	2006	USDA	http://rocky2.ess.washington.edu/data/raster/naip2006/index.html	1 meter pixels	Mason County and Jefferson County	NAD_1983_UTM_Zone_10N	GCS_North_American_1983		Yes
USGS 1:24K Topo Quads	General	Raster (ESRI GRID)		Topo Maps	?	USGS	http://duff.geology.washington.edu/data/raster/drgclip/index.html			NAD_1927_UTM_Zone_10N	GCS_North_American_1927		No
USGS Digital Elevation Models	General	Raster (ESRI GRID)		Ground surface elevations	?	USGS	http://rocky.ess.washington.edu/data/raster/tenmeter/byquad/index.html	10 meter pixels	Individuals are by 1:24K Quads, all relevant DEMs have been mosaicked into a single file	NAD_1927_UTM_Zone_10N	GCS_North_American_1927	NGVD27	No
Shoreline Slope Stability	Aggradation	Vector (shapefile)	Polygon	The digital maps presented here were originally published as hard copy maps in the Coastal Zone Atlas of Washington between 1978 and 1980. Although the Atlas has been out of print for many years, the maps contain information that remain the basis for local planning decisions.	1975	WA Ecology	http://www.ecy.wa.gov/services/gis/data/data.htm		Puget Sound	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
Seasonal Supplemental Temperature Standards for Salmonids	Fish Habitat	Vector (shapefile)	Lines	must be used in conjunction with other temperature data in the Water Quality Standards for Surface Waters for Washington Chapter 173-201A WAC. The temperatures represented in these data represent the regulatory maximum threshold for the time period specified.	May-06	WA Ecology	http://www.ecy.wa.gov/services/gis/data/data.htm	1:24K	Washington State	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
Seasonal Supplemental Temperature Standards for Salmonids	Fish Habitat	Vector (shapefile)	Lines	This Layer is the spatial representation of the Ecology Publication No. 06-10-038: Waters Requiring Supplemental Spawning and Incubation Protection for Salmonid Species and is part of the Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC). These data indicated where and when additional temperature criteria are required to ensure protection for the incubation of salmon, trout, and char.	2006	WA Ecology	http://www.ecy.wa.gov/services/gis/data/data.htm		Washington State	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes

Data Set Name/Desc.	Data Group	Data Type	Geometry Type	Use or Attributes of Interest or Notes	Date	Source	Source (URL(if available)	Spatial Scale or Accuracy	Extent	Projected Horiz. Coordinate System	Geographic Horiz. Coordinate System	Vert. Coord System	Has Metadata
Native American Ceded Tribal lands in Washington State	General	Vector (shapefile)	Polygon	Tribal boundaries	2/24/2009	WA Ecology	http://www.ecy.wa.gov/services/gis/data/data.htm		Washington State	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
2001 Impervious Surfaces from 2001 NLCD	Hydrology	Raster (TIFF)		Impervious surfaces based on MRLC/NLCD	2001	WA Ecology	http://www.ecy.wa.gov/services/gis/data/impervious/basins.htm	30 meter pixels	Western Washington	NAD_1983_HARN_Lambert_Conformal_Conic	GCS_North_American_1983_HARN		Yes
WRIA Boundaries	Hydrology	Vector (shapefile)	Polygon	WRIA boundary and subbasins	2006	WA Ecology			WRIA 16 and 14b	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Limited
2008 Water Quality Assessment: 303(d)	Water Quality	Vector (shapefile)	Polygons	303(d) information	2008	WA Ecology	http://www.ecy.wa.gov/services/gis/data/data.htm	1:24K LLID	Washington State	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
2008 Water Quality Assessment: 305(b)	Water Quality	Vector (shapefile)	Polygons	The WQA consists of both the 303(d) List and the 305(b) Report. The 303(d) List is comprised of only Category 5 listings. The 305(b) Report lists all waters and all categories.	2008	WA Ecology	http://www.ecy.wa.gov/services/gis/data/data.htm	1:24K LLID	Washington State	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
Well Log Database	Water Use and Population	Table (Excel)		Wells	2009	WA Ecology	http://apps.ecy.wa.gov/welllog/textsearch.asp	Quarter-Quarter Section	WRIA 16 and WRIA 14	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		No
WRTS Database	Water Use and Population	Table (Excel)		Water rights	2009	WA Ecology		?	WRIA 16 and WRIA 14	None	GCS_WGS_1984		No
WSDOT State Roads	General	Vector (shapefile)	Lines	State Road Locations	12/31/2007	WADOT	http://www.wsdot.wa.gov/mapsdata/geodatacatalog/default.htm	1:24K	Washington State	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
SalmonScape: Barrier Repairs	Fish Habitat	Vector (shapefile)	Points	The purpose of Barrier Repairs is to identify where fish passage barriers have been corrected. Data can be used with GIS to estimate habitat gain.	4/30/2004	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	GPS (5 meters or better)	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes

Data Set Name/Desc.	Data Group	Data Type	Geometry Type	Use or Attributes of Interest or Notes	Date	Source	Source (URL(if available)	Spatial Scale or Accuracy	Extent	Projected Horiz. Coordinate System	Geographic Horiz. Coordinate System	Vert. Coord System	Has Metadata
SalmonScape: Culverts	Fish Habitat	Vector (shapefile)	Points	The data are used to identify, locate, and prioritize correction of human-made fish passage barriers. Identifying and correcting fish passage barriers is a key component of salmon recovery. The data may be used by any group interested in salmon and habitat recovery. The data are also used to track where inventory efforts have occurred and include culverts in non-fish bearing streams.	4/30/2004	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	GPS (5 meters or better)	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
SalmonScape: Dams	Fish Habitat	Vector (shapefile)	Points	The data are used to identify, locate, and prioritize correction of man-made fish passage barriers. Identifying and correcting fish passage barriers is a key component of salmon recovery. The data may be used by any group interested in salmon and habitat recovery. The data are also used to track where inventory efforts have occurred.	4/30/2004	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	GPS (5 meters or better)	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
SalmonScape: Ecosystem Diagnosis and Treatment Preservation	Fish Habitat	Vector (shapefile)	Lines	The 1:24,000 scale Ecosystem Diagnosis and Treatment (EDT) preservation layer contains stream reaches that are ranked for preservation priorities based on current habitat conditions. High priority preservation reaches will contribute more to population performance than will reaches with a lower preservation rank if not further degraded.	2002	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	1:24K	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
SalmonScape: Ecosystem Diagnosis and Treatment Restoration	Fish Habitat	Vector (shapefile)	Lines	The 1:24,000 scale Ecosystem Diagnosis and Treament (EDT) restoration layer contains stream reaches that are ranked for restoration priorities based on comparisons between current and historic habitat conditions. If restored to historic conditions, high priority restoration reaches will contribute more to a population's performance than reaches ranked lower in restoration.	2002	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	1:24K	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
SalmonScape: Fish Distribution	Fish Habitat	Vector (shapefile)	Lines	This dataset is a 1:24,000 scale spatial representation of anadromous and resident salmonid fish distribution maintained by the Washington Department of Fish and Wildlife (WDFW).	2006	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	1:24K	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
SalmonScape: Fish Passage	Fish Habitat	Vector (shapefile)	Points	The fish passage layer identifies point locations for stream crossing structures, dams and natural barriers. Information is provided on the type and degree of blockage, location, and data source. Fish passage data are compiled from a variety of sources including WDFW Fish Passage and Diversion Screening Inventory database (FPDSI), Limiting Factors Analysis reports, WDFW biologists, counties, conservation districts, Washington Department of Ecology, U.S. Forest Service, U.S. Geological Survey, Tribes, and others.	4/30/2004	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	GPS (5 meters or better)	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes

Data Set Name/Desc.	Data Group	Data Type	Geometry Type	Use or Attributes of Interest or Notes	Date	Source	Source (URL(if available)	Spatial Scale or Accuracy	Extent	Projected Horiz. Coordinate System	Geographic Horiz. Coordinate System	Vert. Coord System	Has Metadata
SalmonScape: Fishways	Fish Habitat	Vector (shapefile)	Points	The data are used to identify, locate, and prioritize correction of man-made fish passage barriers. Identifying and correcting fish passage barriers is a key component of salmon recovery. The data may be used by any group interested in salmon and habitat recovery. The data are also used to track where inventory efforts have occurred.	4/30/2004	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	GPS (5 meters or better)	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
SalmonScape: Natural Barriers	Fish Habitat	Vector (shapefile)	Points	The purpose of this dataset is to integrate existing fish passage structure databases into one layer, related to the Washington Department of Fish Wildlife's 1:24,000 scale hydrography layer. Multiple sources of fish passage structures exist for each Water Resource Inventory Area basin. This dataset merges the primary attributes of the various datasets into one format and integrates fish passage structure information with the 1:24,000 scale cleaned and routed hydrography layer.	2005	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	Horizontal accuracy of the data is to within 1,500 feet and can be assumed to be no better than 3 feet depending on data source and data collection method. Many source point locational attributes were collected using the Global Positioning System (GPS).	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
SalmonScape: Non-Culvert Crossing	Fish Habitat	Vector (shapefile)	Points	The Washington State Fish Passage Barrier Non_Culvert_Crossing Inventory data set contains information on the location, physical characteristics, and fish passage barrier status of non-culvert stream crossings.	4/30/2004	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	GPS (5 meters or better)	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
SalmonScape: Salmonid Stock Inventory (SASI)	Fish Habitat	Vector (shapefile)	Lines	Salmonid Stock Inventory (SASI) is a standardized, uniform approach to identifying and monitoring the status of Washington's salmonid fish stocks. The inventory is a compilation of data on all wild stocks and a scientific determination of each stock's status as: healthy, depressed, critical, unknown, or extinct. SaSI thus is a basis for prioritizing recovery efforts and for measuring the results of future recovery actions.	1/1/2002	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	1:24K	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes

Data Set Name/Desc.	Data Group	Data Type	Geometry Type	Use or Attributes of Interest or Notes	Date	Source	Source (URL(if available)	Spatial Scale or Accuracy	Extent	Projected Horiz. Coordinate System	Geographic Horiz. Coordinate System	Vert. Coord System	Has Metadata
SalmonScape: Stream Segments	Fish Habitat	Vector (shapefile)	Lines	The 1:24,000 scale stream segment layer contains gradient categories, water body type, naturally occurring confinement, and Rosgen channel type delineation.	2002	WDFW	http://wdfw.wa.gov/mapping/salmonscape/	1:24K	WRIA 16 and WRIA 14	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
Geology: Faults	Geology	Vector (shapefile)	Lines	Contains arc information describing both the contacts between geologic units and fault types - only those contacts with fault info have been extracted	2005	WDNR	http://fortress.wa.gov/dnr/app1/dataweb/dmmatrix.html	1:100K	Washington State clipped to generous buffer around study area	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
Geology: Folds	Geology	Vector (shapefile)	Lines	fold axes and descriptive data - shows the location and types of folds in rocks in the State of Washington	2005	WDNR	http://fortress.wa.gov/dnr/app1/dataweb/dmmatrix.html	1:100K	Washington State clipped to generous buffer around study area	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
Surficial Geologic Units	Geology	Vector (shapefile)	Polygons	defining the extent, and label of each geologic unit	2005	WDNR	http://fortress.wa.gov/dnr/app1/dataweb/dmmatrix.html	1:100K	Washington State clipped to generous buffer around study area	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
Stream Temperature Class	Hydrology	Vector (coverage)	Polygons or lines	Stream Temperature Class for Washington State Forest Practices Rules compliance	2/28/1995	WDNR	http://fortress.wa.gov/dnr/app1/dataweb/dmmatrix.html	1:250K	Washington State	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
WDNR 1:24K Waterbodies	Hydrology	Vector (coverage)	Polygons or lines	features such as Puget Sound, lakes, wet areas, reservoirs, impoundments, glaciers, islands, and dams	3/1/2009	WDNR	http://fortress.wa.gov/dnr/app1/dataweb/hydrod.html	1:24K	Mason and Jefferson Counties	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
WDNR 1:24K Watercourses	Hydrology	Vector (coverage)	Lines	watercourses representing streams, ditches, or pipelines, or as centerlines through water body polygons such as double-banked streams, lakes, impoundments, reservoirs, wet areas, or glaciers + DNR Forest Practices Fish Habitat Water Type Codes (WC_HYDR_FTR_CD)	3/1/2009	WDNR	http://fortress.wa.gov/dnr/app1/dataweb/hydrod.html	1:24K	Mason and Jefferson Counties	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
Mason County Aerial Photo	General	Raster (MrSID)		Imagery	2005	WDNR via Mason County		18 inch pixels	approx 70% of Mason County (missing portion in NW corner) + small parts of Kitsap, Pierce and Thurston	NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983		Limited

Data Set Name/Desc.	Data Group	Data Type	Geometry Type	Use or Attributes of Interest or Notes	Date	Source	Source (URL(if available)	Spatial Scale or Accuracy	Extent	Projected Horiz. Coordinate System	Geographic Horiz. Coordinate System	Vert. Coord System	Has Metadata
Large Onsite Septics	Water Systems	Vector (shapefile)	Points	Locations of large onsite septic systems with a design flow of 3,500 - 14,500 gallons per day. Department of Ecology regulates larger systems within their Facility Site database.	2006	WDOH	http://ww4.doh.wa.gov/gis/gisdata.htm	Geocoded locations range from within a few feet to a few miles depending on the reference data used.	Washington State	NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet	GCS_North_American_1983_HARN		Yes
PWS Sentry Database	Water Use and Population	Database and Tables		Public Water System data such as number of connections, locations, population	?	WDOH		GPS, QQ Sections, Sections	WRIAs 16 and 14		WGS84		No

APPENDIX B

Water Rights Data Summary

Aspect Map ID	Number	TRS	QQ	Purpose	Qi	Units	Qa (afy)	Irrigated Acres	WRIA Subbasin	Estimated Actual Consumptive Use (afy)
1	S2-*17606CWRIS	26.0N 03.0W 20	NW/SW	DM	0.003	CFS			Dosewallips	0.2
2	S2-*04381CWRIS	26.0N 03.0W 16	SW/SW	DM	0.05	CFS			Dosewallips	3.2
3	S2-*08843CWRIS	26.0N 03.0W 23	NE/SE	DS	0.01	CFS			Dosewallips	0.2
4	S2-*04391CWRIS	26.0N 03.0W 24	SE/SE	DM	0.05	CFS			Dosewallips	3.2
5	S2-*19880CWRIS	26.0N 02.0W 29	SW/NE	ST,IR	0.06	CFS	11	5	Dosewallips	5.2
6	S2-25751CWRIS	26.0N 02.0W 21		PO	40	CFS			Dosewallips	0
7	S2-28417	26.0N 02.0W 28		DS	0.02	CFS	0.5		Dosewallips	0.2
8	S2-26808	26.0N 02.0W 21	SW/SE	PO	28	CFS			Dosewallips	0
9	S2-*02991CWRIS	25.0N 02.0W 16	NE/NE	IR,DM	0.07	CFS			Dosewallips	23.8
10	G2-27795CWRIS	26.0N 02.0W 33	NE/NE	DM	10	GPM	1		Dosewallips	0.5
11	S2-28415	26.0N 02.0W 21	SE/SE	DS	0.02	CFS	0.5		Dosewallips	0.2
12	G2-23623CWRIS	25.0N 02.0W 15	SW/NW	DM	45	GPM	60		Dosewallips	28.2
13	G2-21134CWRIS	25.0N 02.0W 15	SW/NW	DM	40	GPM	60		Dosewallips	28.2
14	S2-*04587CWRIS	25.0N 02.0W 03	SW/SW	PO,DM	0.5	CFS			Dosewallips	0
15	S2-27640CWRIS	25.0N 02.0W 03	SW/SW	PO,DS	0.04	CFS	28.55		Dosewallips	0.2
16	G2-24136CWRIS	26.0N 02.0W 34	SW/NW	DM	30	GPM	60		Dosewallips	28.2
17	S2-26242CWRIS	25.0N 02.0W 10	SE/NW	DS	0.02	CFS	1		Dosewallips	0.2
18	S2-*07903CWRIS	25.0N 02.0W 10	NE/SW	DM	0.02	CFS			Dosewallips	1.3
19	S2-*08114CWRIS	25.0N 02.0W 10	NE/SW	DS	0.01	CFS			Dosewallips	0.2
20	S2-25194CWRIS	25.0N 02.0W 10	NE/SW	DS	0.01	CFS	1		Dosewallips	0.2
21	S2-*12539CWRIS	25.0N 02.0W 10	NE/SW	DS	0.01	CFS			Dosewallips	0.2
22	S2-CV1P153	25.0N 02.0W 10	SE/NW	IR,DS	0.3	CFS			Dosewallips	0.2
23	G2-27059CWRIS	25.0N 02.0W 15		DS	21	GPM	1		Dosewallips	0.2
24	G2-00465CWRIS	25.0N 02.0W 15		DS	20	GPM	1		Dosewallips	0.2
25	G2-24359CWRIS	25.0N 02.0W 15		DM	60	GPM	3		Dosewallips	1.4
26	G2-*11071CWRIS	25.0N 02.0W 15		DS	20	GPM	1		Dosewallips	0.2
27	G2-27964	25.0N 02.0W 15		DM	215	GPM	25		Dosewallips	11.8
28	G2-*08418CWRIS	26.0N 02.0W 34	SE/NW	DS	4.5	GPM	1		Dosewallips	0.2
29	G2-20465CWRIS	25.0N 02.0W 15	SW/SE	DM	55	GPM	25		Dosewallips	11.8
30	G2-*08095C	26.0N 02.0W 34		MU	40	GPM	38		Dosewallips	12.6
31	G2-26783CWRIS	25.0N 02.0W 10	NW/SE	ST,IR	25	GPM	1	1	Dosewallips	0.5
32	S2-20131CWRIS	26.0N 02.0W 34	SW/NE	ST,DS	0.02	CFS	1.25		Dosewallips	0.6
33	S2-21623ALCWRIS	25.0N 02.0W 03	SE/SE	DS	0.05	CFS	3.5		Dosewallips	1.6
34	G2-25821CWRIS	26.0N 02.0W 34	SE/NE	DS	500	GPM	0.5		Dosewallips	0.2
35	G2-25564GWRIS	26.0N 02.0W 34	SE/SE	IR,DS	85	GPM	37	18	Dosewallips	26.6
36	G2-25054CWRIS	26.0N 02.0W 34	SE/NE	DS	12	GPM	1		Dosewallips	0.2
37	G2-*07099CWRIS	25.0N 02.0W 02	SW/NW	DM	60	GPM	36		Dosewallips	16.9
38	S2-*08194CWRIS	26.0N 02.0W 35	NW/SW	ST,DS	0.01	CFS			Dosewallips	3.4
39	G2-24586CWRIS	26.0N 02.0W 35	SW/NW	DM	50	GPM	8.4		Dosewallips	3.9
40	G2-26451CWRIS	26.0N 02.0W 35	SE/SW	DM,CI	62	GPM	6.7		Dosewallips	3.1
41	G2-*10991CWRIS	25.0N 02.0W 14		DS	10	GPM	1		Dosewallips	0.2
42	S2-*09749CWRIS	26.0N 02.0W 26	SE/NW	DM	0.005	CFS			Dosewallips	0.3
43	S2-*08817CWRIS	26.0N 02.0W 26	NE/SW	DM	0.01	CFS			Dosewallips	0.6
44	S2-CV2P555	26.0N 02.0W 26	NE/SW	DM	0.01	CFS			Dosewallips	0.6
45	S2-CV2P556	26.0N 02.0W 26	SE/NW	DM	0.005	CFS			Dosewallips	0.3
46	G2-00592CWRIS	25.0N 02.0W 02		DM	24	GPM	4		Dosewallips	1.9
47	S2-*18019CWRIS	25.0N 02.0W 02		DS,CI	0.02	CFS			Dosewallips	6.8
48	S2-*11141CWRIS	25.0N 02.0W 02		DS	0.005	CFS			Dosewallips	0.2
49	G2-28861	25.0N 02.0W 02		DM	13	GPM	4.7		Dosewallips	2.2
50	G2-23685CWRIS	26.0N 02.0W 35		DM,CI	73	GPM	5.5		Dosewallips	2.6
51	G2-22684CWRIS	26.0N 02.0W 35		IR,DS	80	GPM	11.5	5	Dosewallips	7.5
52	S2-*13929CWRIS	26.0N 02.0W 35		FS	5	CFS			Dosewallips	0
53	S2-00519CWRIS	26.0N 02.0W 26		DS	0.0005	CFS	0.5		Dosewallips	0.2
54	G2-*06544CWRIS	26.0N 02.0W 26		DM	8	GPM	6.4		Dosewallips	3
55	S2-*17545CWRIS	26.0N 02.0W 26		DS	0.01	CFS			Dosewallips	0.2
56	S2-*04593CWRIS	26.0N 02.0W 26	NW/SE	DS	0.01	CFS			Dosewallips	0.2
57	S2-*05263CWRIS	26.0N 02.0W 26	NW/SE	DM	0.02	CFS			Dosewallips	1.3
58	S2-*02116CWRIS	26.0N 02.0W 26	NW/SE	DS	0.02	CFS			Dosewallips	0.2
59	S2-CV2P564	26.0N 02.0W 26	NW/SE	DS	0.02	CFS			Dosewallips	0.2
60	S2-00002CWRIS	26.0N 02.0W 23	SW/SE	DS	0.005	CFS	0.5		Dosewallips	0.2
61	G2-26968CWRIS	26.0N 02.0W 26	NE/SE	DM	26.3	GPM	2		Dosewallips	0.9

Aspect Map ID	Number	TRS	QQ	Purpose	Qi	Units	Qa (afy)	Irrigated Acres	WRIA Subbasin	Estimated Actual Consumptive Use (afy)
62	G2-*07030CWRIS	25.0N 03.0W 02		DM	45	GPM	2		Duckabush	0.9
63	S2-22116CWRIS	25.0N 02.0W 07		IR	0.04	CFS	4	2	Duckabush	2.9
64	S2-24634	25.0N 02.0W 07		FS	0.33	CFS	0		Duckabush	0
65	S2-20594CWRIS	25.0N 02.0W 06		DS	0.01	CFS	1		Duckabush	0.2
66	G2-26982CWRIS	25.0N 02.0W 07	SW/NE	DM	4	GPM	1		Duckabush	0.5
67	S2-00666CWRIS	25.0N 02.0W 07	SE/NE	DS	0.02	CFS	1		Duckabush	0.2
68	S2-25139CWRIS	25.0N 02.0W 17	NW/NW	DS	0.01	CFS	1		Duckabush	0.2
69	S2-*02656CWRIS	25.0N 02.0W 08	SW/SW	IR,DS	0.01	CFS		1	Duckabush	1.6
70	S2-23789CWRIS	25.0N 02.0W 08	SE/NW	PO,DS	0.12	CFS	1		Duckabush	0.2
71	S2-25455CWRIS	25.0N 02.0W 29	NE/NE	DS	0.005	CFS	1		Duckabush	0.2
72	S2-*01317CWRIS	25.0N 02.0W 20	SE/NE	IR,DM	0.05	CFS		2.5	Duckabush	4
73	G2-22801CWRIS	25.0N 02.0W 17	NE/SE	DS	6	GPM	1		Duckabush	0.2
74	S2-*17844CWRIS	25.0N 02.0W 08	SE/SE	DS	0.01	CFS			Duckabush	0.2
75	S2-*17946CWRIS	25.0N 02.0W 16	NW/NW	ST,IR	0.04	CFS	8	4	Duckabush	3.8
76	G2-28199	25.0N 02.0W 28	NE/NW	DM	8	GPM	2.5		Duckabush	1.2
77	S2-*14930CWRIS	25.0N 02.0W 09	SE/SW	DM	0.22	CFS			Duckabush	14
78	S2-23878CWRIS	25.0N 02.0W 21		DS	0.02	CFS	0.5		Duckabush	0.2
79	G2-29605	25.0N 02.0W 21		DM	32	GPM	11		Duckabush	5.2
80	S2-*21479CWRIS	25.0N 02.0W 16		DS	0.01	CFS	1		Duckabush	0.2
81	G2-24339CWRIS	25.0N 02.0W 16		IR,DS	26	GPM	7	3	Duckabush	4.6
82	G2-29988	25.0N 02.0W 16		DM	10	GPM	10		Duckabush	4.7
83	S2-*21690CWRIS	25.0N 02.0W 16	NW/NE	IR,DS	0.04	CFS	4	1	Duckabush	1.6
84	S2-00753CWRIS	25.0N 02.0W 16	SE/NE	DM	0.05	CFS	2		Duckabush	0.9
85	S2-27978	25.0N 02.0W 09	SE/SE	PO,DS	0.06	CFS			Duckabush	0.2
86	G2-00490CWRIS	23.0N 04.0W 10	NW/NE	DM	3	GPM	0.5		Finch/Lilliwaup	0.3
87	G2-24030CWRIS	22.0N 04.0W 14	NE/NW	DM	50	GPM	40		Finch/Lilliwaup	18.8
88	G2-29203	22.0N 04.0W 14	SE/NW	IR,DM	34.8	GPM	2	2	Finch/Lilliwaup	3.3
89	S2-*16368CWRIS	22.0N 04.0W 11	NE/SW	IR,DS	0.05	CFS	8	4	Finch/Lilliwaup	6
90	S2-*16257CWRIS	22.0N 04.0W 23		DS	0.01	CFS			Finch/Lilliwaup	0.2
91	G2-23773CWRIS	22.0N 04.0W 23		DM	199	GPM	85.5		Finch/Lilliwaup	40.2
92	G2-*00435SWRIS	22.0N 04.0W 23		DM	51	GPM	13.5		Finch/Lilliwaup	6.3
93	G2-CV2P733	22.0N 04.0W 23		DM	51	GPM	13.5		Finch/Lilliwaup	6.3
94	S2-*19886CWRIS	22.0N 04.0W 14		DS	0.01	CFS	1		Finch/Lilliwaup	0.2
95	S2-*08323CWRIS	22.0N 04.0W 14		DM	0.02	CFS			Finch/Lilliwaup	1.3
96	G2-29932	22.0N 04.0W 14		DM,CI	125	GPM	6.8		Finch/Lilliwaup	3.2
97	G2-24628CWRIS	22.0N 04.0W 14		DM	19	GPM	15.4		Finch/Lilliwaup	7.2
98	S2-*14389CWRIS	22.0N 04.0W 14		DS	0.01	CFS			Finch/Lilliwaup	0.2
99	G2-24068	22.0N 04.0W 14		FS,DM	1000	GPM	410		Finch/Lilliwaup	0
100	S2-*07014CWRIS	22.0N 04.0W 14		FR,DM	0.03	CFS			Finch/Lilliwaup	10.2
101	G2-29963	22.0N 04.0W 14		MU	250	GPM	228		Finch/Lilliwaup	75.7
102	S2-23444CWRIS	22.0N 04.0W 11		DS	0.03	CFS	1		Finch/Lilliwaup	0.2
103	S2-*19250CWRIS	22.0N 04.0W 11		RE,IR	0.1	CFS	0.5	0.25	Finch/Lilliwaup	0.2
104	S2-23476CWRIS	22.0N 04.0W 14	NW/SE	DM,CI	0.03	CFS	3		Finch/Lilliwaup	1.4
105	S2-*05276AGCWRIS	22.0N 04.0W 14	NW/SE	FS	0.4	CFS			Finch/Lilliwaup	0
106	S2-CV1P425	22.0N 04.0W 14	NW/SE	FS,DS	0.2	CFS			Finch/Lilliwaup	0.2
107	S2-*09670AWCWRIS	22.0N 04.0W 11	SW/SE	DS	0.005	CFS			Finch/Lilliwaup	0.2
108	S2-*03616CWRIS	22.0N 04.0W 11	NW/SE	DS	0.1	CFS			Finch/Lilliwaup	0.2
109	G2-*10708CWRIS	22.0N 04.0W 11	NW/SE	DS	15	GPM	1		Finch/Lilliwaup	0.2
110	S2-21882CWRIS	22.0N 04.0W 14	N2/SE	FS	4	CFS			Finch/Lilliwaup	0
111	S2-26838CWRIS	22.0N 04.0W 11	NE/SE	DS	0.02	CFS	1		Finch/Lilliwaup	0.2
112	S2-*00927CWRIS	22.0N 04.0W 11	NE/SE	DM,CI	0.5	CFS			Finch/Lilliwaup	170.1
113	S2-23701CWRIS	22.0N 04.0W 11	NE/SE	DS	0.02	CFS	1		Finch/Lilliwaup	0.2
114	S2-*02176CWRIS	22.0N 04.0W 11	SE/SE	DS	0.01	CFS			Finch/Lilliwaup	0.2
115	S2-*20588CWRIS	22.0N 04.0W 11	E2/SE	FS	7.9	CFS			Finch/Lilliwaup	0
116	S2-*16438CWRIS	22.0N 04.0W 11	SE/SE	FS	4.5	CFS			Finch/Lilliwaup	0
117	S2-*10052CWRIS	22.0N 04.0W 11	SE/SE	FS	5	CFS			Finch/Lilliwaup	0
118	S2-CV2P978	22.0N 04.0W 11	SE/SE	FS	4.5	CFS			Finch/Lilliwaup	0
119	S2-CV2P979	22.0N 04.0W 11	SE/SE	FS	5	CFS			Finch/Lilliwaup	0
120	S2-*03263CWRIS	22.0N 04.0W 01	S2/SW	FR,DM	0.2	CFS			Finch/Lilliwaup	68.1
121	S2-28855	22.0N 04.0W 12	NE/SW	FS	8.8	CFS			Finch/Lilliwaup	0
122	G2-21884CWRIS	22.0N 04.0W 13		DM	50	GPM	8		Finch/Lilliwaup	3.8

Aspect Map ID	Number	TRS	QQ	Purpose	Qi	Units	Qa (afy)	Irrigated Acres	WRIA Subbasin	Estimated Actual Consumptive Use (afy)
123	G2-*08289CWRIS	22.0N 04.0W 13		DS	10	GPM	1		Finch/Lilliwaup	0.2
124	G2-*08285CWRIS	22.0N 04.0W 13		RE,DM	18	GPM	8		Finch/Lilliwaup	3.8
125	G2-20533CWRIS	22.0N 04.0W 12		DM,CI	30	GPM	2.5		Finch/Lilliwaup	1.2
126	S2-*17113CWRIS	22.0N 04.0W 12		DM	0.02	CFS			Finch/Lilliwaup	1.3
127	S2-*02031CWRIS	22.0N 04.0W 12		DS	0.01	CFS			Finch/Lilliwaup	0.2
128	G2-24099CWRIS	22.0N 04.0W 12		FS	14	GPM	21.5		Finch/Lilliwaup	0
129	G2-*10309CWRIS	22.0N 04.0W 01		DM	50	GPM	8		Finch/Lilliwaup	3.8
130	S2-*04157CWRIS	22.0N 04.0W 01		DM	0.01	CFS			Finch/Lilliwaup	0.6
131	G2-00466CWRIS	22.0N 04.0W 01		DM	140	GPM	51.5		Finch/Lilliwaup	24.2
132	G2-23289CWRIS	22.0N 04.0W 01		DM	30	GPM	1.5		Finch/Lilliwaup	0.7
133	G2-*11018CWRIS	22.0N 04.0W 01		DS	15	GPM	1		Finch/Lilliwaup	0.2
134	S2-*15002CWRIS	22.0N 04.0W 01		DM	0.02	CFS			Finch/Lilliwaup	1.3
135	G2-00166CWRIS	22.0N 04.0W 01		DM	20	GPM	4		Finch/Lilliwaup	1.9
136	G2-*10763CWRIS	22.0N 04.0W 01		DM	40	GPM	7		Finch/Lilliwaup	3.3
137	G2-CV1-2P64	22.0N 04.0W 01		DM	20	GPM	4		Finch/Lilliwaup	1.9
138	S2-*01965CWRIS	23.0N 04.0W 36	SE/SE	IR,DS	0.04	CFS			Finch/Lilliwaup	0.2
139	S2-*00068CWRIS	23.0N 03.0W 30	N2/NW	IR,DM	0.1	CFS		1	Finch/Lilliwaup	1.8
140	G2-28230	23.0N 03.0W 31	NE/NW	DS	30	GPM	0.5		Finch/Lilliwaup	0.2
141	S2-21951CWRIS	23.0N 03.0W 30	NE/SW	DM	0.02	CFS	4		Finch/Lilliwaup	1.9
142	S2-22307CWRIS	23.0N 03.0W 30	NE/SW	IR,FR	0.02	CFS	2.5	1	Finch/Lilliwaup	1.2
143	S2-*06320CWRIS	23.0N 03.0W 19	SE/NW	RE,IR	0.05	CFS		4	Finch/Lilliwaup	17
144	S2-28127	23.0N 03.0W 19	NE/SW	FS	0.2	CFS	145		Finch/Lilliwaup	0
145	S2-27987	23.0N 03.0W 19	SE/NW	DM	2.5	CFS			Finch/Lilliwaup	0
146	S2-*21931CWRIS	23.0N 03.0W 31		DM	0.33	CFS	40		Finch/Lilliwaup	18.8
147	G2-27230CWRIS	23.0N 03.0W 31		DM	50	GPM	40		Finch/Lilliwaup	18.8
148	G2-*10546CWRIS	23.0N 03.0W 31		DM	150	GPM	40		Finch/Lilliwaup	18.8
149	G2-23934CWRIS	23.0N 03.0W 31		DM	45	GPM	25		Finch/Lilliwaup	11.8
150	S2-10040	23.0N 03.0W 30		DM	0.1	CFS	9		Finch/Lilliwaup	4.2
151	S2-*17026AWC	23.0N 03.0W 30		DM	0.1	CFS	9		Finch/Lilliwaup	4.2
152	G2-*10826CWRIS	23.0N 03.0W 30		DM	64	GPM	22		Finch/Lilliwaup	10.3
153	S2-24983CWRIS	23.0N 03.0W 30		FS	0.27	CFS			Finch/Lilliwaup	0
154	S2-*05819CWRIS	23.0N 03.0W 19		PO,DS	5	CFS			Finch/Lilliwaup	0.2
155	S2-25687CWRIS	23.0N 03.0W 19		PO	70	CFS			Finch/Lilliwaup	0
156	S2-00954CWRIS	23.0N 03.0W 19		DM	0.25	CFS	6.7		Finch/Lilliwaup	3.1
157	S2-*02024CWRIS	23.0N 03.0W 19	NW/SE	PO,DM	0.1	CFS			Finch/Lilliwaup	0
158	G2-26201CWRIS	23.0N 03.0W 19	SE/NE	DM	100	GPM	38		Finch/Lilliwaup	17.9
159	G2-27029CWRIS	23.0N 03.0W 20	SE/NW	DM	29	GPM	2.9		Finch/Lilliwaup	1.4
160	S2-*19346CWRIS	23.0N 03.0W 20		DM	0.05	CFS	4		Finch/Lilliwaup	1.9
161	S2-*14055CWRIS	23.0N 03.0W 20	N2/N2	DM	0.06	CFS			Finch/Lilliwaup	3.8
162	S2-20026CWRIS	23.0N 03.0W 20		DM	0.05	CFS	2.5		Finch/Lilliwaup	1.2
163	S2-*17286CWRIS	23.0N 03.0W 20		DM	0.02	CFS			Finch/Lilliwaup	1.3
164	S2-*22556CWRIS	23.0N 03.0W 20		DS	0.01	CFS	1		Finch/Lilliwaup	0.2
165	S2-*18842CWRIS	23.0N 03.0W 20		RE	0.02	CFS			Finch/Lilliwaup	6.8
166	S2-21295CWRIS	23.0N 03.0W 20		DS	0.01	CFS	0.5		Finch/Lilliwaup	0.2
167	S2-*08543CWRIS	23.0N 03.0W 17		RE,DS	0.02	CFS			Finch/Lilliwaup	6.8
168	S2-*06003CWRIS	23.0N 03.0W 17	SW/NE	DS	0.01	CFS			Finch/Lilliwaup	0.2
169	S2-24703CWRIS	23.0N 03.0W 17	NW/NE	FS	0.66	CFS			Finch/Lilliwaup	0
170	S2-*09894CWRIS	23.0N 03.0W 17	SE/NE	DS	0.01	CFS			Finch/Lilliwaup	0.2
171	S2-*05280CWRIS	23.0N 03.0W 16	NW/NW	DM	0.02	CFS			Finch/Lilliwaup	1.3
172	G2-00651CWRIS	23.0N 03.0W 09		DM	100	GPM	33.6		Finch/Lilliwaup	15.8
173	S2-*02881CWRIS	23.0N 03.0W 09		IR,DS	0.02	CFS		1	Finch/Lilliwaup	1.6
174	G2-29997	23.0N 03.0W 09		DM	450	GPM	162.4		Finch/Lilliwaup	76.3
175	S2-*04379CWRIS	23.0N 03.0W 16		DS	0.02	CFS			Finch/Lilliwaup	0.2
176	S2-*22586CWRIS	23.0N 03.0W 16		DS	0.01	CFS	1		Finch/Lilliwaup	0.2
177	S2-24693CWRIS	23.0N 03.0W 16		DS	0.02	CFS	1		Finch/Lilliwaup	0.2
178	S2-*07528CWRIS	24.0N 03.0W 34	SW/SW	DS	0.05	CFS			Finch/Lilliwaup	0.2
179	S2-CV3P1179	24.0N 03.0W 34	SW/SW	DS	0.05	CFS			Finch/Lilliwaup	0.2
180	G2-26601CWRIS	23.0N 03.0W 10	NW/NW	DM	34	GPM	6.7		Finch/Lilliwaup	3.1
181	G2-20672CWRIS	24.0N 03.0W 34	SE/SW	DM	150	GPM	56		Finch/Lilliwaup	26.3
182	G2-20581CWRIS	24.0N 03.0W 34		DS	10	GPM	1		Finch/Lilliwaup	0.2
183	S2-*14577CWRIS	24.0N 03.0W 34		DM	0.02	CFS			Finch/Lilliwaup	1.3

Aspect Map ID	Number	TRS	QQ	Purpose	Qi	Units	Qa (afy)	Irrigated Acres	WRIA Subbasin	Estimated Actual Consumptive Use (afy)
184	S2-*14552CWRIS	24.0N 03.0W 34		DS	0.01	CFS			Finch/Lilliwaup	0.2
185	S2-*18474CWRIS	24.0N 03.0W 34		DM	0.01	CFS			Finch/Lilliwaup	0.6
186	G2-28297	24.0N 03.0W 34		DM	150	GPM	42.2		Finch/Lilliwaup	19.8
187	G2-*08182CWRIS	23.0N 03.0W 03		DM	58	GPM	47		Finch/Lilliwaup	22.1
188	S2-*06829CWRIS	23.0N 03.0W 03		DS	0.02	CFS			Finch/Lilliwaup	0.2
189	S2-*07771CWRIS	23.0N 03.0W 03		DS	0.005	CFS			Finch/Lilliwaup	0.2
190	S2-*00684CWRIS	23.0N 03.0W 03		PO,IR	1.5	CFS		15	Finch/Lilliwaup	22.1
191	S2-*07770CWRIS	23.0N 03.0W 03		DS	0.01	CFS			Finch/Lilliwaup	0.2
192	S2-*07774CWRIS	23.0N 03.0W 03		DS	0.01	CFS			Finch/Lilliwaup	0.2
193	G2-27878	23.0N 03.0W 03		DM	45	GPM	22		Finch/Lilliwaup	10.3
194	S2-*18339CWRIS	25.0N 04.0W 26		DM	0.05	CFS			Hamma Hamma	3.2
195	G2-*06542CWRIS	24.0N 04.0W 01	E2/SE	DM	3	GPM	2.4		Hamma Hamma	1.1
196	S2-*05056CWRIS	24.0N 03.0W 07	NW/NE	DM	0.05	CFS			Hamma Hamma	3.2
197	S2-*09169C	24.0N 03.0W 27	SW/SW	ST,DM	0.1	CFS			Hamma Hamma	34
198	S2-25002CWRIS	24.0N 03.0W 27	NW/SW	FS	0.13	CFS			Hamma Hamma	0
199	S2-*11530CWRIS	24.0N 03.0W 27	NE/NW	IR	0.2	CFS		20	Hamma Hamma	29.4
200	G2-24188CWRIS	24.0N 03.0W 27		CI	50	GPM	9.5		Hamma Hamma	4.5
201	S2-*01540CWRIS	24.0N 03.0W 22	SW/SE	DS	0.01	CFS			Hamma Hamma	0.2
202	S2-22147CWRIS	24.0N 03.0W 15	NW/SE	PO,IR	0.05	CFS	1	0.5	Hamma Hamma	0.7
203	S2-*07494CWRIS	24.0N 03.0W 22	SE/SE	DS	0.0008	CFS			Hamma Hamma	0.2
204	S2-*04533CWRIS	24.0N 03.0W 22	SE/SE	DS	0.01	CFS			Hamma Hamma	0.2
205	S2-*10165CWRIS	24.0N 03.0W 22	SE/SE	DM	0.0008	CFS			Hamma Hamma	0.3
206	S2-*16180CWRIS	24.0N 03.0W 23	W2/SW	DS	0.01	CFS			Hamma Hamma	0.2
207	S2-*17262CWRIS	24.0N 03.0W 23	SW/SW	DS	0.01	CFS			Hamma Hamma	0.2
208	S2-*19255CWRIS	24.0N 03.0W 23		DM,CI	0.13	CFS	8.7		Hamma Hamma	4.1
209	G2-25680CWRIS	24.0N 03.0W 23		DM	7.5	GPM	4.5		Hamma Hamma	2.1
210	S2-*15349CWRIS	24.0N 03.0W 23	SW/NE	DS,CI	0.06	CFS			Hamma Hamma	20.4
211	S2-*16289CWRIS	24.0N 03.0W 14	NE/SE	IR,DM	0.06	CFS	8	4	Hamma Hamma	6.2
212	S2-*05613CWRIS	24.0N 03.0W 14	NE/SE	IR,FS	0.05	CFS		2	Hamma Hamma	2.9
213	S2-*04914CWRIS	24.0N 03.0W 12	NE/SW	IR,DM	0.4	CFS		5	Hamma Hamma	7.7
214	S2-*04915CWRIS	24.0N 03.0W 12	NE/SW	DM	0.03	CFS			Hamma Hamma	1.9
215	S2-*13864CWRIS	24.0N 03.0W 24		DM	0.2	CFS			Hamma Hamma	12.7
216	S2-*15732CWRIS	24.0N 03.0W 24		DM	0.07	CFS			Hamma Hamma	4.4
217	S2-*08615CWRIS	24.0N 03.0W 13		DM	0.02	CFS			Hamma Hamma	1.3
218	S2-*12604CWRIS	24.0N 03.0W 13		FR,DM	0.05	CFS	22.4		Hamma Hamma	10.5
219	G2-26110CWRIS	24.0N 03.0W 01		DM	50	GPM	2.8		Hamma Hamma	1.3
220	S2-26056	24.0N 03.0W 01	SE/NE	FS,DS	0.1	CFS	1		Hamma Hamma	0.2
221	S2-*01368CWRIS	24.0N 03.0W 01	NE/SE	PO,DM	0.85	CFS			Hamma Hamma	0
222	G2-*08919CWRIS	24.0N 02.0W 06		DS	10	GPM	1		Hamma Hamma	0.2
223	G2-21392CWRIS	24.0N 02.0W 06		DM	60	GPM	72		Hamma Hamma	33.8
224	G2-*09047CWRIS	24.0N 02.0W 06		DS	2	GPM	1		Hamma Hamma	0.2
225	G2-*08918CWRIS	24.0N 02.0W 06		DS	5	GPM	1		Hamma Hamma	0.2
226	S2-22809CWRIS	24.0N 02.0W 06		IR	0.02	CFS	2	1	Hamma Hamma	1.5
227	S2-*20421CWRIS	24.0N 02.0W 06		DM	0.01	CFS	1		Hamma Hamma	0.5
228	G2-*09416CWRIS	24.0N 02.0W 06		IR,DS	15	GPM	3	1	Hamma Hamma	1.6
229	G2-*09244CWRIS	24.0N 02.0W 06		DM	20	GPM	2		Hamma Hamma	0.9
230	S2-*01289CWRIS	24.0N 02.0W 06		IR,DM	0.1	CFS			Hamma Hamma	34
231	G2-23983CWRIS	24.0N 02.0W 06		DM	55	GPM	50		Hamma Hamma	23.5
232	G2-24354CWRIS	25.0N 02.0W 31		DM	60	GPM	29		Hamma Hamma	13.6
233	G2-25854CWRIS	25.0N 02.0W 31		DM	60	GPM	8		Hamma Hamma	3.8
234	G2-26553CWRIS	25.0N 02.0W 31		DM	10	GPM	5.6		Hamma Hamma	2.6
235	G2-00345CWRIS	25.0N 02.0W 31		DM	60	GPM	29		Hamma Hamma	13.6
236	S2-*09903CWRIS	25.0N 02.0W 30	SW/NE	DS	0.01	CFS			Hamma Hamma	0.2
237	S2-*09826CWRIS	25.0N 02.0W 30	SW/NE	DS	0.01	CFS			Hamma Hamma	0.2
238	S2-25063CWRIS	25.0N 02.0W 30	S2/SE	FS	0.11	CFS			Hamma Hamma	0
239	S2-27109CWRIS	25.0N 02.0W 30	SE/SE	DS	0.02	CFS	1		Hamma Hamma	0.2
240	S2-22887CWRIS	25.0N 02.0W 30	SE/NE	DS	0.01	CFS	1		Hamma Hamma	0.2
241	S2-20960CWRIS	25.0N 02.0W 30	NE/SE	DS	0.01	CFS	1		Hamma Hamma	0.2
242	S2-22643CWRIS	25.0N 02.0W 30	NE/SE	DM	0.01	CFS	1.5		Hamma Hamma	0.7
243	G2-24230CWRIS	25.0N 02.0W 30	SE/SE	DM	300	GPM	50.7		Hamma Hamma	23.8
244	G2-21036CWRIS	25.0N 02.0W 29	NE/SW	DM	60	GPM	8.75		Hamma Hamma	4.1

Aspect Map ID	Number	TRS	QQ	Purpose	Qi	Units	Qa (afy)	Irrigated Acres	WRIA Subbasin	Estimated Actual Consumptive Use (afy)
245	S2-*18270CWRIS	25.0N 02.0W 29		DM,CI	0.025	CFS	1.8		Hamma Hamma	0.8
246	S2-*11585CWRIS	25.0N 02.0W 29		DM	0.01	CFS			Hamma Hamma	0.6
247	G2-*08472CWRIS	25.0N 02.0W 29		DM	50	GPM	20		Hamma Hamma	9.4
248	S2-22806CWRIS	21.0N 05.0W 03	SW/NW	IR,EN	0.05	CFS	130	0.25	Skokomish	61.1
249	G2-20319CWRIS	21.0N 05.0W 11	NW/SW	IR	135	GPM	32	16	Skokomish	23.5
250	S2-26420CWRIS	22.0N 05.0W 35	NE/NW	IR,FR	0.12	CFS	1	30	Skokomish	0.5
251	S2-*00127CWRIS	21.0N 05.0W 13	NE/NW	PO,DM	3.94	CFS			Skokomish	0
252	S2-*01267CWRIS	23.0N 05.0W 24		DS,DG	1	CFS		5	Skokomish	340.3
253	S2-*13403CWRIS	21.0N 04.0W 18	SW/NW	FS	30	CFS			Skokomish	0
254	S2-*05430CWRIS	21.0N 04.0W 18	NE/SW	IR,DM	0.15	CFS		12	Skokomish	18
255	S2-24325CWRIS	21.0N 04.0W 18	NE/SW	FS	4	CFS			Skokomish	0
256	S2-*05447CWRIS	21.0N 04.0W 18	NE/SW	FS,DS	3	CFS			Skokomish	0.2
257	S2-*01563CWRIS	21.0N 04.0W 18		IR,DS	0.5	CFS			Skokomish	0.2
258	S2-CV1-2P133	21.0N 04.0W 18		IR,DS	0.5	CFS			Skokomish	0.2
259	G2-27550	21.0N 04.0W 07		IR	500	GPM	180	90	Skokomish	132.3
260	S2-*11405CWRIS	22.0N 04.0W 07	NE/NW	PO	5	CFS			Skokomish	1,810.00
261	G2-27597CWRIS	23.0N 04.0W 18	NE/SW	DM	100	GPM	28.7		Skokomish	13.5
262	S2-*05046CWRIS	21.0N 04.0W 18	NW/SE	IR,DS	0.02	CFS		2	Skokomish	3.1
263	S2-*05446CWRIS	21.0N 04.0W 18	NW/SE	FS,DS	5	CFS			Skokomish	0.2
264	G2-01036CWRIS	23.0N 04.0W 18		DM	300	GPM	29.1		Skokomish	13.7
265	S2-23846CWRIS	23.0N 04.0W 31	SE/NE	DS	0.005	CFS	1		Skokomish	0.2
266	S2-26119	21.0N 04.0W 17	N2/SW	IR	1	CFS	150	75	Skokomish	110.3
267	S2-26118CWRIS	21.0N 04.0W 17	SE/NW	ST,DS	0.1	CFS	2		Skokomish	0.9
268	S2-*03922CWRIS	21.0N 04.0W 17	SE/NW	DS	0.01	CFS			Skokomish	0.2
269	S2-27070	21.0N 04.0W 08		FS	5	CFS			Skokomish	0
270	G2-27071	21.0N 04.0W 08		FS	3600	GPM	5500		Skokomish	0
271	S2-*00353BSCWRIS	22.0N 04.0W 05	NE/SW	PO	1000	CFS			Skokomish	0
272	S2-*21349CWRIS	23.0N 04.0W 20	SE/NW	DM	0.1	CFS	5		Skokomish	2.4
273	G2-25111CWRIS	23.0N 04.0W 20	SE/NW	RE,DM	60	GPM	1.5		Skokomish	0.7
274	G2-23350CWRIS	22.0N 04.0W 05		DM	300	GPM	14.3		Skokomish	6.7
275	R2-*00354CWRIS	22.0N 04.0W 05		PO		CFS	190000		Skokomish	0
276	G2-27388CWRIS	22.0N 04.0W 05	SW/NE	DM	145	GPM	88.28		Skokomish	41.5
277	G2-00919CWRIS	23.0N 04.0W 20	NW/SE	DM	45	GPM	17		Skokomish	8
278	G2-00895CWRIS	23.0N 04.0W 29	NW/NE	DM	180	GPM	14.4		Skokomish	6.8
279	G2-27596CWRIS	23.0N 04.0W 29	NW/NE	DM	100	GPM	14.4		Skokomish	6.8
280	S2-00687CWRIS	23.0N 04.0W 32	NE/NE	DS	0.02	CFS	0.5		Skokomish	0.2
281	S2-26758CWRIS	21.0N 04.0W 16	NW/SW	ST,IR	0.45	CFS	8.5		Skokomish	4
282	S2-24595CWRIS	21.0N 04.0W 16	NW/SW	FS	12	CFS			Skokomish	0
283	G2-24909CWRIS	21.0N 04.0W 16	NW/SW	DS	35	GPM	1.5		Skokomish	0.2
284	G2-24943CWRIS	21.0N 04.0W 16	NW/SW	FS	3120	GPM	3775		Skokomish	0
285	G2-27366ALCWRIS	23.0N 04.0W 08	SE/SE	DM	40	GPM	1.4		Skokomish	0.7
286	S2-24965CWRIS	22.0N 04.0W 04	NW/NW	DS	0.02	CFS	1		Skokomish	0.2
287	S2-*00777BMCWRIS	21.0N 04.0W 16		ST,IR	0.053	CFS		1	Skokomish	18
288	S2-*20069CWRIS	21.0N 04.0W 16		IR	1.34	CFS	180	90	Skokomish	132.3
289	S2-*02525CWRIS	22.0N 04.0W 16	SE/NW	PO	1000	CFS			Skokomish	331,500.10
290	G2-27598CWRIS	22.0N 04.0W 09	NE/NW	DM	60	GPM	76.9		Skokomish	36.1
291	G2-00896CWRIS	22.0N 04.0W 04	SE/SW	DM	400	GPM	55.78		Skokomish	26.2
292	G2-27389CWRIS	22.0N 04.0W 04	SE/SW	DM	55	GPM	88.28		Skokomish	41.5
293	S2-*04176CWRIS	22.0N 04.0W 04	NE/NW	IR,HE	2	CFS			Skokomish	0
294	S2-*00777AMCWRIS	21.0N 04.0W 16	SW/SE	ST,IR	0.027	CFS		1	Skokomish	9.2
295	S2-26631CWRIS	21.0N 04.0W 16	SW/SE	PO,DS	0.45	CFS	1		Skokomish	0.2
296	S2-*19119CWRIS	21.0N 04.0W 16	SW/SE	ST,DS	0.02	CFS	3		Skokomish	1.4
297	G2-00897C	22.0N 04.0W 16		DM	160	GPM	18.2		Skokomish	8.6
298	R2-*03766CWRIS	22.0N 04.0W 16		PO		CFS	7300		Skokomish	0
299	S2-*04787CWRIS	22.0N 04.0W 04		MU,HE	0.5	CFS			Skokomish	120.2
300	S2-00883CWRIS	22.0N 04.0W 09	NW/SE	IR	0.67	CFS	53	50	Skokomish	73.5
301	S2-25769	21.0N 04.0W 21	NE/NE	FS	2.5	CFS	1814		Skokomish	0
302	S2-23232CWRIS	21.0N 04.0W 22	NW/NW	FS	1.5	CFS			Skokomish	0
303	S2-*20811CWRIS	21.0N 04.0W 22	NW/NW	FS	10	CFS			Skokomish	0
304	S2-*05575CWRIS	21.0N 04.0W 22	NW/NW	FS	9.75	CFS			Skokomish	0
305	G2-24645CWRIS	21.0N 04.0W 22	NW/NW	FS	1400	GPM	2258		Skokomish	0

Aspect Map ID	Number	TRS	QQ	Purpose	Qi	Units	Qa (afy)	Irrigated Acres	WRIA Subbasin	Estimated Actual Consumptive Use (afy)
306	S2-24688CWRIS	21.0N 04.0W 15	SW/SW	FS	6	CFS			Skokomish	0
307	G2-26481CWRIS	21.0N 04.0W 15	SW/SW	FS	1500	GPM	2036		Skokomish	0
308	S2-*12691CWRIS	21.0N 04.0W 10		DS	0.01	CFS			Skokomish	0.2
309	G2-25605	22.0N 04.0W 10	SE/SW	DM	51.5	GPM	8		Skokomish	3.8
310	S2-*06746CWRIS	21.0N 04.0W 14	SW/SW	IR,DS	0.15	CFS		15	Skokomish	22.2
311	S2-*21282CWRIS	22.0N 04.0W 26	NW/NW	DM	0.08	CFS	8		Skokomish	3.8
312	S2-28473	21.0N 04.0W 14	NE/SW	DM	0.08	CFS	4		Skokomish	1.9
313	G2-27819CWRIS	21.0N 04.0W 02	SE/SW	IR,FP	300	GPM	14.6	2	Skokomish	6.9
314	G2-28285	21.0N 04.0W 14		DM	50	GPM	7		Skokomish	3.3
315	S2-*02197CWRIS	22.0N 04.0W 26	NE/NW	DS	0.05	CFS			Skokomish	0.2
316	S2-*02730CWRIS	22.0N 04.0W 35		DS	0.01	CFS			Skokomish	0.2
317	S2-*03826CWRIS	22.0N 04.0W 35		RE,DM	0.25	CFS			Skokomish	85.1
318	G2-21939	22.0N 04.0W 35		DM	75	GPM	18		Skokomish	8.5
319	G2-*00983CWRIS	22.0N 04.0W 26		IR,DM	50	GPM	15	4	Skokomish	6.2
320	S2-*00820CPCWRIS	22.0N 04.0W 26		IR,DS	0.1	CFS		4	Skokomish	6
321	G2-*09962CWRIS	22.0N 04.0W 26		DM,CI	60	GPM	22		Skokomish	10.3
322	S2-*13555CWRIS	22.0N 04.0W 26		DS	0.01	CFS			Skokomish	0.2
323	S2-*00820BPCWRIS	22.0N 04.0W 26		IR,DS	0.33	CFS		2.5	Skokomish	3.8
324	S2-*04548CWRIS	22.0N 04.0W 26		IR,DS	0.05	CFS		5	Skokomish	7.5
325	S2-*03478CWRIS	22.0N 04.0W 26		IR,DS	0.02	CFS			Skokomish	0.2
326	S2-*00820APCWRIS	22.0N 04.0W 26		IR,DS	0.33	CFS		2	Skokomish	3.1
327	S2-*21283CWRIS	22.0N 04.0W 26		DM	0.08	CFS	8		Skokomish	3.8
328	G2-*10921CWRIS	22.0N 04.0W 26		DM	30	GPM	5		Skokomish	2.4
329	G2-25477NWRIS	22.0N 04.0W 26		IR,DM	30	GPM	23	10	Skokomish	15
330	S2-*15892CWRIS	22.0N 04.0W 26		RE,IR	0.25	CFS	2	1	Skokomish	0.9
331	G2-21635	22.0N 04.0W 26		DM	47	GPM	8		Skokomish	3.8
332	S2-29267	21.0N 04.0W 13		DS	0.03	CFS	0.3		Skokomish	0.2
333	S2-25504CWRIS	21.0N 04.0W 13		FS,DS	0.55	CFS	1		Skokomish	0.2
334	G2-28583	21.0N 04.0W 13		DM	50	GPM			Skokomish	7.1
335	S2-26759	21.0N 04.0W 12		ST,IR	1.33	CFS	306	150	Skokomish	143.8
336	G2-28483	21.0N 04.0W 13	NE/NE	DM	6.8	GPM			Skokomish	1
337	G2-25935CWRIS	21.0N 03.0W 06	SW/NW	DM	100	GPM	53.3		Skokomish	25.1
338	S2-*01111CWRIS	21.0N 03.0W 07	NE/NW	PO,DS	2	CFS			Skokomish	0.2
339	S2-*02139CWRIS	22.0N 03.0W 31		IR,DM	0.05	CFS		2	Skokomish	3.3
340	S2-*10143CWRIS	21.0N 03.0W 06		FS	0.1	CFS			Skokomish	0
341	S2-*08306CWRIS	21.0N 03.0W 06		FS	0.3	CFS			Skokomish	0
342	S2-*06562CWRIS	21.0N 03.0W 06		DS	0.01	CFS			Skokomish	0.2
343	S2-*06324CWRIS	21.0N 03.0W 06		DS	0.01	CFS			Skokomish	0.2
344	S2-*02369CWRIS	21.0N 03.0W 06		DS	0.05	CFS			Skokomish	0.2
345	S2-*06153CWRIS	21.0N 03.0W 06		IR,DS	0.01	CFS		1	Skokomish	1.6
346	S2-*06542CWRIS	21.0N 03.0W 06		DS	0.01	CFS			Skokomish	0.2
347	S2-*06729CWRIS	21.0N 03.0W 06		DS	0.01	CFS			Skokomish	0.2
348	S2-*15680AWCWRIS	21.0N 03.0W 06		DM	0.03	CFS			Skokomish	1.9
349	S2-*06183CWRIS	21.0N 03.0W 06		IR,DS	0.01	CFS			Skokomish	0.2
350	S2-*06849CWRIS	21.0N 03.0W 06		DM	0.03	CFS			Skokomish	1.9
351	S2-*01656CWRIS	21.0N 03.0W 06	NW/SE	IR,DS	0.04	CFS		1.25	Skokomish	2
352	S2-27963	21.0N 03.0W 06	SW/NE	DS	0.02	CFS	0.5		Skokomish	0.2
353	G2-25611CWRIS	21.0N 03.0W 05	NW/NW	MU	52	GPM	26		South Shore	8.6
354	G2-20745CWRIS	22.0N 03.0W 32	N2/SW	MU	200	GPM	32.5		South Shore	10.8
355	S2-*05363CWRIS	22.0N 03.0W 32	SE/NW	DM	0.05	CFS			South Shore	3.2
356	S2-25660CWRIS	21.0N 03.0W 05	NE/NW	DM	0.02	CFS	2		South Shore	0.9
357	S2-*05737CWRIS	22.0N 03.0W 32		IR,DS	0.02	CFS		3	South Shore	4.6
358	G2-*04689CWRIS	22.0N 03.0W 32		DS	8	GPM	5.6		South Shore	0.2
359	S2-*01697CWRIS	22.0N 03.0W 32		IR,DS	0.011	CFS		5	South Shore	7.5
360	G2-29491	22.0N 03.0W 32		MU	240	GPM	70		South Shore	23.2
361	G2-29315	22.0N 03.0W 32		MU	300	GPM	176		South Shore	58.4
362	S2-24651CWRIS	21.0N 03.0W 05	NE/NE	DS	0.02	CFS	1		South Shore	0.2
363	S2-*01644CWRIS	21.0N 03.0W 04	NW/NW	IR,FS	0.55	CFS		3	South Shore	4.4
364	S2-*04139CWRIS	21.0N 03.0W 04	NW/NW	DM	0.02	CFS	0		South Shore	0.3
365	S2-CV1P143	21.0N 03.0W 04	NE/NW	IR,FR	0.2	CFS			South Shore	68.1
366	G2-29550	22.0N 03.0W 33		DM	25	GPM	3.4		South Shore	1.6

Aspect Map ID	Number	TRS	QQ	Purpose	Qi	Units	Qa (afy)	Irrigated Acres	WRIA Subbasin	Estimated Actual Consumptive Use (afy)
367	S2-*01745C	22.0N 03.0W 33	SW/SE	IR,FS	0.1	CFS	72.34	5.02	South Shore	7.4
368	G2-27827CWRIS	22.0N 03.0W 33	SE/SE	DM	25	GPM	1.16		South Shore	0.5
369	S2-27920CWRIS	22.0N 03.0W 33	SE/SE	IR,FR	0.07	CFS	14	7.5	South Shore	6.6
370	G2-27919CWRIS	22.0N 03.0W 33	SE/SE	DM	60	GPM	2		South Shore	0.9
371	G2-27835CWRIS	22.0N 03.0W 34	SW/SW	DM	24.6	GPM	1		South Shore	0.5
372	G2-27909CWRIS	22.0N 03.0W 34	SE/SW	DS	10	GPM	0.5		South Shore	0.2
373	S2-28564	22.0N 03.0W 34	SE/SW	FS	0.05	CFS	0		South Shore	0
374	G2-28563	22.0N 03.0W 34	SE/SW	DS	15	GPM	0.5		South Shore	0.2
375	G2-27884CWRIS	22.0N 03.0W 34	SE/SW	DS	10	GPM	0.5		South Shore	0.2
376	S2-27874CWRIS	22.0N 03.0W 34	SE/SW	DM	0.04	CFS	1		South Shore	0.5
377	S2-29518	22.0N 03.0W 34		DS	0.01	CFS	0.3		South Shore	0.2
378	G2-27836CWRIS	21.0N 03.0W 02	NW/NW	DM	45	GPM	4.5		South Shore	2.1
379	S2-*04717CWRIS	22.0N 03.0W 35	SE/SW	DS	0.005	CFS			South Shore	0.2
380	S2-*01643CWRIS	22.0N 03.0W 35		DM	0.02	CFS			South Shore	1.3
381	S2-*18069CWRIS	22.0N 03.0W 35		IR,FS	0.03	CFS	0.5	0.25	South Shore	0.4
382	S2-*08474CWRIS	22.0N 03.0W 35		DM	0.15	CFS	25		South Shore	11.8
383	S2-*04621CWRIS	22.0N 03.0W 35		DS	0.01	CFS			South Shore	0.2
384	S2-*04716CWRIS	22.0N 03.0W 35		DS	0.01	CFS			South Shore	0.2
385	S2-28642	22.0N 03.0W 35		DM	0.03	CFS	0.25		South Shore	0.3
386	S2-26054CWRIS	22.0N 03.0W 36	SW/NW	DM	0.15	CFS	26.5		South Shore	12.5
387	S2-25855CWRIS	22.0N 03.0W 36	NW/SW	DM	0.35	CFS	25		South Shore	11.8
388	S2-*04039CWRIS	22.0N 03.0W 36	NW/SW	DS	0.01	CFS			South Shore	0.2
389	G2-27126CWRIS	22.0N 03.0W 25		DM	40	GPM	4.5		South Shore	2.1
390	S2-*04355CWRIS	22.0N 03.0W 25		DM	0.05	CFS			South Shore	3.2
391	S2-*21916CWRIS	22.0N 03.0W 25		FR,DM	0.01	CFS	2		South Shore	0.9
392	G2-28449	22.0N 03.0W 25		DM	38	GPM	6		South Shore	2.8
393	S2-*02588CWRIS	22.0N 02.0W 30	SE/NW	IR,DS	0.05	CFS		15	South Shore	22.2
394	G2-25800CWRIS	22.0N 02.0W 30		DM	21	GPM	7		South Shore	3.3
395	G2-25801CWRIS	22.0N 02.0W 30		DM	24	GPM	7		South Shore	3.3
396	S2-*05739CWRIS	22.0N 02.0W 30		DS	0.0025	CFS			South Shore	0.2
397	S2-*02992APCWRIS	22.0N 02.0W 30		DS	0.01	CFS			South Shore	0.2
398	S2-*02992BPCWRIS	22.0N 02.0W 30		DS	0.01	CFS			South Shore	0.2
399	G2-*07400CWRIS	22.0N 02.0W 19	SE/SE	DM	75	GPM	15		South Shore	7.1
400	G2-26107CWRIS	22.0N 02.0W 20		DM	10	GPM	0.5		South Shore	0.3
401	G2-27273CWRIS	22.0N 02.0W 21	SE/SW	DM	128	GPM	104		South Shore	48.9
402	G2-25026CWRIS	22.0N 02.0W 21	SE/SW	DM	95	GPM	100		South Shore	47
403	S2-*15035CWRIS	22.0N 02.0W 21		DS	0.01	CFS			South Shore	0.2
404	G2-00697CWRIS	22.0N 02.0W 21		DM	100	GPM	157.2		South Shore	73.9
405	G2-28717	22.0N 02.0W 21		MU	100	GPM	19		South Shore	6.3
406	G2-27500CWRIS	22.0N 02.0W 28	SW/NE	DM	90	GPM	20		South Shore	9.4
407	G2-25320CWRIS	22.0N 02.0W 21	SW/SE	DM	105	GPM	16		South Shore	7.5
408	G2-26900CWRIS	22.0N 02.0W 22		DS	10	GPM	1		South Shore	0.2
409	S2-*01956CWRIS	22.0N 02.0W 22	SW/NE	DM	0.02	CFS			South Shore	1.3
410	G2-27129CWRIS	22.0N 02.0W 14	SE/SW	DM	40	GPM	4.5		South Shore	2.1
411	G2-*07380	22.0N 02.0W 23		DM	66	GPM	106		South Shore	49.8
412	G2-29131	22.0N 02.0W 14		DM	40	GPM	3.2		South Shore	1.5
413	G2-28040CWRIS	22.0N 02.0W 23	SW/NE	DM	36.8	GPM	4.5		South Shore	2.1
414	G2-25040CWRIS	22.0N 02.0W 14	NE/NE	DM	30	GPM	5		South Shore	2.4
415	G2-28243	22.0N 02.0W 24	SE/NW	DM	225	GPM	139.5		South Shore	65.6
416	S2-*10009CWRIS	22.0N 02.0W 12		DS	0.01	CFS			South Shore	0.2
417	S2-*09976CWRIS	22.0N 02.0W 12		DS	0.01	CFS			South Shore	0.2
418	S2-*03213CWRIS	22.0N 02.0W 12		DS	0.5	CFS			South Shore	0.2
419	S2-*07831CWRIS	22.0N 02.0W 12		IR	0.01	CFS		1	South Shore	1.5
420	S2-CV1P433	22.0N 02.0W 12		DS	0.5	CFS			South Shore	0.2
421	S2-*07396CWRIS	22.0N 02.0W 12	NW/SE	DM	0.03	CFS			South Shore	1.9
422	G2-25975CWRIS	22.0N 01.0W 07	SW/SW	DM	30	GPM	6		South Shore	2.8
423	G2-26731CWRIS	22.0N 01.0W 18	SE/NW	DM	40	GPM	4		South Shore	1.9
424	G2-26827CWRIS	22.0N 01.0W 07	SE/NW	DM	15	GPM	3		South Shore	1.4
425	G2-26962	22.0N 01.0W 06		DM	275	GPM	225		South Shore	105.8
426	S2-*05357CWRIS	22.0N 01.0W 06		DS	0.005	CFS			South Shore	0.2
427	S2-*04879CWRIS	22.0N 01.0W 06		IR,DS	0.04	CFS		1	South Shore	1.6

Aspect Map ID	Number	TRS	QQ	Purpose	Qi	Units	Qa (afy)	Irrigated Acres	WRIA Subbasin	Estimated Actual Consumptive Use (afy)
428	S2-*04881CWRIS	22.0N 01.0W 06	SW/NE	IR,DS	0.01	CFS		3	South Shore	4.6
429	G2-27157CWRIS	22.0N 01.0W 06	NW/NE	DM	20	GPM	2		South Shore	0.9
430	G2-26265CWRIS	22.0N 01.0W 08	NW/NW	IR,DM	27	GPM	43.5	11	South Shore	16.5
431	G2-26266CWRIS	22.0N 01.0W 08	NW/NW	IR,DM	50	GPM	44.4	11	South Shore	16.5
432	G2-26267CWRIS	22.0N 01.0W 08	NW/NW	IR,DM	100	GPM	44.4	11	South Shore	16.5
433	S2-*05400CWRIS	22.0N 01.0W 05	NW/NW	DM	0.01	CFS			South Shore	0.6
434	G2-27792CWRIS	22.0N 01.0W 05	SW/SW	DM	45	GPM	4.5		South Shore	2.1
435	G2-27378CWRIS	22.0N 01.0W 05	SW/SW	DM	37	GPM	4.5		South Shore	2.1
436	S2-*05242CWRIS	22.0N 03.0W 32	SE/SW	PO,DS	0.05	CFS				0.2
437	S2-*08415CWRIS	22.0N 03.0W 32	SE/SW	DS	0.01	CFS				0.2
438	S2-*08069CWRIS	22.0N 03.0W 32		DM	0.02	CFS				1.3
439	S2-*01857CWRIS	22.0N 03.0W 32		DS	0.001	CFS				0.2
440	G2-*11190CWRIS	22.0N 03.0W 32		DM	60	GPM	7			3.3
441	G2-21955C	21.0N 03.0W 05		DM	100	GPM	72			33.8
442	S2-21093CWRIS	21.0N 03.0W 05	NW/NE	DS	0.005	CFS	0.5			0.2
443	G2-*07783CWRIS	21.0N 03.0W 04	SW/SW	IR,DM	156	GPM	249	120		176.7
444	S2-*05174CWRIS	21.0N 03.0W 04	NW/NW	DM	0.3	CFS				19
445	G2-21544CWRIS	22.0N 03.0W 33	NW/SW	DM	40	GPM	10.25			4.8
446	S2-*05499CWRIS	21.0N 03.0W 04	NE/NW	IR,DS	0.01	CFS		0.5		0.9
447	S2-CV1P174	21.0N 03.0W 04	NE/NW	PO,IR	0.3	CFS				0
448	G2-26232	21.0N 03.0W 09		IR,DM	600	GPM	370	120		176.7
449	S2-*02104CWRIS	21.0N 03.0W 04		IR,FS	0.8	CFS				0
450	S2-*18897CWRIS	21.0N 03.0W 04		DS	0.01	CFS	1			0.2
451	G2-*10291CWRIS	21.0N 03.0W 04		IR,DM	140	GPM	224	120		176.7
452	G2-*08400C	21.0N 03.0W 04		DM	60	GPM	26.67			12.5
453	S2-*09967CWRIS	22.0N 03.0W 33		DS	0.01	CFS				0.2
454	S2-*01623CWRIS	22.0N 03.0W 33		DS	0.05	CFS				0.2
455	S2-*14756CWRIS	22.0N 03.0W 33		IR,DS	0.01	CFS		0.5		0.9
456	S2-*01940CWRIS	21.0N 03.0W 04	NE/NE	IR,DM	0.1	CFS		2		3.3
457	S2-00305CWRIS	22.0N 03.0W 34		DS	0.01	CFS	1			0.2
458	S2-23051CWRIS	22.0N 03.0W 34		DS	0.01	CFS	1			0.2
459	S2-21383CWRIS	22.0N 03.0W 34		DS	0.01	CFS	0.5			0.2
460	G2-*05758CWRIS	22.0N 03.0W 34		DM	33	GPM	27			12.7
461	S2-*06454CWRIS	22.0N 03.0W 34		DM	0.1	CFS				6.3
462	S2-*04480CWRIS	22.0N 03.0W 35		IR,DM	0.1	CFS				34
463	S2-*05458CWRIS	22.0N 03.0W 35		DM	0.015	CFS				1
464	S2-*08304CWRIS	22.0N 03.0W 35		DM	0.05	CFS				3.2
465	S2-*05335CWRIS	22.0N 03.0W 35		IR,DM	0.04	CFS		0.5		1.1
466	S2-*04866CWRIS	22.0N 03.0W 35		IR,DS	0.01	CFS		0.5		0.9
467	S2-*18044CWRIS	22.0N 03.0W 36	NW/SW	DM	1.2	CFS	108			50.8
468	S2-*17477CWRIS	22.0N 03.0W 36	NW/SW	DM	0.35	CFS				22.2
469	S2-*05663CWRIS	22.0N 03.0W 36		IR,DM	0.02	CFS				6.8
470	S2-*04248CWRIS	22.0N 03.0W 25		IR,DS	0.01	CFS		1		1.6
471	S2-*04411CWRIS	22.0N 03.0W 25		DS	0.01	CFS				0.2
472	S2-23230CWRIS	22.0N 03.0W 25		DS	0.01	CFS	1			0.2
473	S2-*09374CWRIS	22.0N 03.0W 25		DS	0.01	CFS				0.2
474	S2-*13358CWRIS	22.0N 03.0W 25		DS	0.01	CFS	5.6			0.2
475	S2-*16997CWRIS	22.0N 03.0W 25		DM	0.01	CFS				0.6
476	S2-20278CWRIS	22.0N 03.0W 25		DM	0.044	CFS	3.4			1.6
477	S2-*21875CWRIS	22.0N 03.0W 25		DM	0.03	CFS	3			1.4
478	S2-*22316CWRIS	22.0N 03.0W 25		DS	0.008	CFS	1			0.2
479	S2-*18603CWRIS	22.0N 03.0W 25		FR,DS	0.01	CFS				3.4
480	S2-00838CWRIS	22.0N 03.0W 25		DS	0.05	CFS				0.2
481	S2-*04496CWRIS	22.0N 03.0W 25		DM	0.3	CFS				19
482	S2-00741CWRIS	22.0N 02.0W 30	SE/NW	DM	0.07	CFS	8			3.8
483	S2-21443CWRIS	22.0N 02.0W 30		DM	0.02	CFS	1.4			0.7
484	S2-*18780CWRIS	22.0N 02.0W 29	NW/NW	DM	0.15	CFS	15			7.1
485	G2-*06029CWRIS	22.0N 02.0W 32		DM	30	GPM	16.8			7.9
486	S2-21248CWRIS	22.0N 02.0W 32		DS	0.01	CFS	0.25			0.2
487	S2-00561CWRIS	22.0N 02.0W 32		DS	0.01	CFS	0.5			0.2
488	S2-*22489CWRIS	22.0N 02.0W 32		DS	0.01	CFS	1			0.2

Aspect Map ID	Number	TRS	QQ	Purpose	Qi	Units	Qa (afy)	Irrigated Acres	WRIA Subbasin	Estimated Actual Consumptive Use (afy)
489	G2-*07189CWRIS	22.0N 02.0W 32		DS	10	GPM	5.6			0.2
490	S2-21349CWRIS	22.0N 02.0W 32		DS	0.01	CFS	0.25			0.2
491	S2-00623CWRIS	22.0N 02.0W 32		DS	0.01	CFS	0.5			0.2
492	S2-22115CWRIS	22.0N 02.0W 32		DS	0.02	CFS	0.5			0.2
493	S2-22114CWRIS	22.0N 02.0W 32		DS	0.02	CFS	0.25			0.2
494	S2-*14264CWRIS	22.0N 02.0W 20		DM	0.12	CFS				7.6
495	S2-00352CWRIS	22.0N 02.0W 20		DS	0.005	CFS	0.5			0.2
496	S2-*02397CWRIS	22.0N 02.0W 20		IR,DS	0.05	CFS		2		3.1
497	S2-20464CWRIS	22.0N 02.0W 20		DS	0.01	CFS	1			0.2
498	S2-*12957CWRIS	22.0N 02.0W 21		DS	0.01	CFS				0.2
499	S2-*22406CWRIS	22.0N 02.0W 22		DM	0.04	CFS	4			1.9
500	S2-*03110CWRIS	22.0N 02.0W 22		DS	0.01	CFS				0.2
501	G2-00941CWRIS	22.0N 02.0W 14		DS	12	GPM	2			0.2
502	G2-*04975CWRIS	22.0N 02.0W 14		DM	10	GPM	16			7.5
503	S2-*04662CWRIS	22.0N 02.0W 14		DS	0.02	CFS				0.2
504	S2-*05935CWRIS	22.0N 02.0W 14		DS	0.01	CFS				0.2
505	G2-*10913CWRIS	22.0N 02.0W 14		DS	35	GPM	1			0.2
506	S2-20529CWRIS	22.0N 02.0W 14		DM	0.005	CFS	1			0.5
507	G2-00420	22.0N 02.0W 24		DM	42	GPM	33.5			15.7
508	S2-*09227CWRIS	22.0N 02.0W 12		IR,DS	0.02	CFS		1		1.6
509	S2-*02949CWRIS	22.0N 02.0W 12		IR,DM	0.05	CFS				17
510	S2-*13518CWRIS	22.0N 02.0W 12		IR,DS	0.02	CFS	7.6	1		1.6
511	G2-01059CWRIS	22.0N 02.0W 12		DM	150	GPM	67			31.5
512	S2-*11795CWRIS	22.0N 02.0W 12		DS	0.01	CFS				0.2
513	S2-*19503CWRIS	22.0N 02.0W 12		DS	0.01	CFS	1			0.2
514	G2-00892CWRIS	22.0N 02.0W 12		DM	120	GPM	22.4			10.5
515	S2-*06338CWRIS	22.0N 02.0W 12	NW/SE	DM	0.02	CFS				1.3
516	G2-26185CWRIS	26.0N 02.0W 23	NE/SE	DM	25	GPM	18			8.5
517	G2-24192CWRIS	26.0N 02.0W 23	NE/SE	DM	15	GPM	18			8.5
518	G2-23025CWRIS	22.0N 01.0W 19	SW/NW	DM	100	GPM	1.62			0.8
519	S2-*17888CWRIS	22.0N 01.0W 07		IR	0.11	CFS	22	11		16.2
520	S2-23388CWRIS	22.0N 01.0W 07		DS	0.01	CFS	0.5			0.2
521	G2-*00335CWRIS	22.0N 01.0W 06		IR,DM	17	GPM	4.3	1		1.8
522	S2-*09999CWRIS	22.0N 01.0W 06		DS	0.01	CFS				0.2
523	S2-*07734CWRIS	22.0N 01.0W 06		DS	0.01	CFS				0.2
524	S2-*06862CWRIS	22.0N 01.0W 06		DM	0.03	CFS				1.9
525	S2-*08701CWRIS	22.0N 01.0W 06		DS	0.01	CFS				0.2
526	S2-*03914CWRIS	22.0N 01.0W 06		DS	0.01	CFS				0.2
527	G2-*01878CWRIS	22.0N 01.0W 06		DS	6	GPM	9.7			0.2
528	S2-*14482CWRIS	22.0N 01.0W 06		DM	0.02	CFS				1.3
529	S2-01045CWRIS	22.0N 01.0W 18	NW/SE	IR	0.45	CFS	90	45		66.2
530	G2-*08417CWRIS	22.0N 01.0W 19	SE/NE	DM	40	GPM	64			30.1
531	R2-*18256CWRIS	22.0N 01.0W 19	NE/SE	RE		CFS	335			0
532	S2-*18255CWRIS	22.0N 01.0W 19	NE/SE	RE	0.6	CFS				204.2
533	G2-20378CWRIS	22.0N 01.0W 07	NE/SE	DM	60	GPM	35			16.5
534	G2-26658CWRIS	22.0N 01.0W 17	NE/SW	IR,DM	130	GPM	208	52		76.8
535	S2-*19204CWRIS	22.0N 01.0W 17	NE/NW	IR,DS	0.04	CFS	7	3		4.6
536	G2-23579CWRIS	22.0N 01.0W 17		DM,CI	30	GPM	46			21.6
537	S2-25011CWRIS	22.0N 01.0W 17		DS	0.02	CFS	1			0.2
538	G2-21045CWRIS	22.0N 01.0W 17	SW/SE	IR,DM	150	GPM	180	45		66.5
539	S2-*15091CWRIS	22.0N 01.0W 17	NW/SE	DM	0.02	CFS				1.3
540	S2-*05169CWRIS	22.0N 01.0W 17	NW/SE	DM	0.05	CFS				3.2

APPENDIX C

Estimation of Consumptive Use from Water Rights

C.1 Estimation of Consumptive Use from Water Rights

This appendix describes the methodology used to estimate consumptive water use based on water rights. The starting point in the analysis was the water right information of stated *purpose*, *annual quantity* (Qa), and *instantaneous flow rate* (Qi). Purposes appear both singly and in combination and may be treated separately in the analysis. Primary purposes are municipal (MU), fishery (FS), power (PO), irrigation (IR), domestic single (DS), and domestic multiple (DM)

Fishery (FS) and power (PO) purposes were considered non-consumptive uses, except for City of Tacoma use at Lake Cushman Powerhouse #2 or where combined with a consumptive category.

Municipal (MU) purpose use was assumed to be equal to the annual quantity times the estimated consumptive rate of 33% for water systems (Table 4).

For irrigation (IR), the crop irrigation requirement of 1.47 ft/yr (Section 4.3.1) was used and applied to all irrigation water rights for which irrigated acreage is reported. Irrigation usage was taken to be zero where no acreage was reported.

For domestic single (DS) purpose, usage was assumed to be similar to that for a self-supplied permit exempt well. A plot of Qa versus Qi data for DS purpose water rights showed very poor correlation. Therefore, a uniform usage was applied to all DS-only water rights and to multiple purposes including a non-consumptive purpose (e.g. FS, DS; PO, DS, etc.). The domestic single usage was estimated assuming 0.1 acre irrigation for a withdrawal of 0.35 afy and consumptive use of 0.165 afy (Table 4).

For domestic multiple (DM) purpose, the Qa versus Qi data indicated a modest correlation (R^2 = 0.35) for a straight line curve fit (Qa = 135 * Qi). Review of several water rights documents showed that the DM category included small water systems and recreational developments, which are uses where the paper water right might be claimed. Therefore, consumptive uses are estimated from the stated or estimated Qa values except that a minimum consumptive use was assumed. For determining the minimum value, two domestic single equivalent residences were assumed and minimum use defined as 0.71 afy withdrawal and 0.33 afy consumptive use (Table 4). Water rights with DM purpose were thus characterized by using: (1) a minimum consumptive use of 0.33 afy for stated or estimated Qa < 0.71 afy, or else (2) the stated Qa times the consumptive rate for the self-supplied scenario (Qa * 47%), or else (3) an estimated Qa calculated from Qi and multiplied by the consumptive rate (135 * Qi * 47%)

In summary, PO and FS purposes are assumed to be non-consumptive except for rights associated with Cushman Powerhouse #2. All municipal rights are taken at full Qa value times the consumptive rate for public water systems. All domestic single purposes are assumed the same as for a self-supplied well. All domestic multiple purposes are set to a minimum, the actual Qa, or a regressed Qa value (and all adjusted to consumptive use) as described above. Irrigation is calculated for rights where acreage is stated. Reservoir evaporative losses are assumed to be included in the consumptive power use for Powerhouse #2.

Results of the analysis are presented by subbasin in the second column of Table 6.

C.1.1 Spreadsheet Analysis

This section presents an overview of the water rights spreadsheet use in the computation of consumptive water rights.

The spreadsheet <WRIA 16 water Use for GIS.xls> contains two tabs that estimate consumptive use (C) via successive criteria applied as follows. The tab <Instr_for_WRs> is used to insert parameters and provides instructions. The tab <WRs_andDrainages> contains the Ecology data and formulae for calculating consumptive use estimates. The symbol C is used to indicate consumptive use. CIR is the crop irrigation requirement (1.47 afy). Estimates are made as follows, where numbering corresponds to steps in the spreadsheet:

1. Convert all Qi to units of cfs;
2. Use Qa, if reported, or calculate from Qi (assume continuous duty);
3. Populate a new consumptive use (C) column from Step 2 with C = Qa * CR, where CR is the consumptive rate of 47% used for DS and DM purposes;
4. For rights with assumed non-consumptive FS-only and PO-only purposes, set C =0;

5a. For IR-only purpose with acreage, set C = acreage * CIR;

5b. For DS-only purpose, set C = estimated usage with 0.1 acre irrigation (0.165 afy);

5c. For DM-only purpose, set C = minimum DM use (0.33 afy); except set C = Qa * CR for Qa > minimum use; or if no Qa, set C = 135 * Qi * CR.

6a. For FS/DS and PO/DS purposes, assume FS and PO portions are non-consumptive and set C = DS use (0.165 afy);

6b. For IR/DS purpose, set C = DS use + acreage * CIR;

7. For irrigation with power or fishery (IR/FS and IR/PO) purposes, set C = acreage * CIR;
8. For municipal purposes, set C = Qa * consumptive rate for water systems (33%);

9. Assume reservoir evaporative losses are included in consumptive estimate for Powerhouse #2 and set C = 0 for reservoir water rights; and

10. Make adjustments for special issues or known database errors (see spreadsheet).

Consumptive uses for remaining purposes and combination of purposes are estimated at stated Qa, or Qa calculated from Qi, and multiplied by the consumptive rate.

APPENDIX D

River and Stream Impairment Analysis: Stream Aggradation Potential Analysis

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Acronyms

DEM	Digital Elevation Model
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HCCC	Hood Canal Coordinating Council
LWD	Large Woody Debris
NFD	National Forest Development
NLCD	National Land Cover Dataset
PU	Planning Unit
USFS	United States Forest Service
USGS	United States Geological Survey
WA DNR	Washington Department of natural Resources
WRIA	Water Resource Inventory Area
WDFW	Washington State Department of Fish and Wildlife

Executive Summary

This investigation characterized sediment aggradation potential in watersheds within Water Resource Inventory Areas (WRIA) 16 and 14b located in Mason and Jefferson Counties, Washington (Figure D-1). WRIA 16 includes drainages into the west side of Hood Canal, from the Dosewallips River on the north to the Skokomish River on the south. WRIA 14b covers the small drainages on the south shore of Hood Canal between Union and Belfair (Figure D-2). The analysis was performed by Aspect Consulting, LLC, under contract to Mason County as Task 4, *WRIA 16 Analysis of Impaired Rivers and Streams*.

Purpose of Study

The purpose of this study was to categorize stream reaches in the WRIA 16 and 14b Planning Unit according to their relative potential risk for flood-related stream aggradation. The study is intended as a tool to be used by the WRIA 16 Planning Unit (PU) to evaluate the potential risk for stream aggradation The study may be used by the PU to evaluation the potential of adverse stream channel impacts from future development projects and, also, to evaluate some stream reaches that aggraded during recent, high precipitation events.

Summary of Work Performed

This study used GIS-based data as well as maps, aerial photographs and published data to assess the potential for sediment aggradation on watercourses identified by the Washington Department of Natural Resources (WA DNR) in WRIA 16 and WRIA 14b. After review of available GIS datasets and published data, metrics were established to evaluate sites based on stream transport capacity, upstream, in-channel and local sediment supply, and barriers to sediment transport. GIS analysis was used to delineate catchments and compute channel gradients on the watercourses.

The criteria for selecting analysis locations were established to preferentially choose areas at risk for sedimentation. These included stream sites at road crossings, flow junctions, gradient changes and in zones of active stream migration. Eighteen problem areas identified for the WRIA 16 Planning Unit (PU) and 12 sites from 2007 Mason County storm damage were also included resulting in a total of four hundred eight (408) analysis sites.

The analysis established weighting values for the sites in each of the assessed metrics to calculate transport, supply and barrier ratings. The three rating values were combined to form a cumulative rating for sediment aggradation at each site according to low, moderate, high and very high potential for aggradation. Results were then reviewed and interpreted for all the sites to understand the capabilities and limitations of the analysis.

Conclusions

1. From the candidate set of 408 potential sediment aggradation problem areas: 67 were rated with a low potential for sediment aggradation, 130 were rated with moderate potential, 138 were identified at high potential and 73 were identified at very high potential for aggradation of sediment. Most of the sites with high and very high potential for aggradation were located along the Hood Canal at State Routes 101 and 106.
2. The investigation was successful in rating 17 out 18 problem areas identified by the WRIA 16 PU as high or very high potential sediment aggradation sites.
3. The findings for the 12 stream-related road damage locations were consistent with storm damage reports which included erosion, sedimentation and slope failures.
4. The GIS based assessment performed well as a tool for relative comparison of the possibility of sediment aggradation at a group of sites. The analysis ranked sites according to their relative potential for aggradation, but did not assess the absolute probability for occurrence of a problem.
5. The relative magnitudes of transport capacity, sediment supply and barriers to sediment transport allowed identification of probable causes of aggradation problems at high risk sites.
6. The GIS-based assessment tool can be improved by expanding the types, extent and resolution of available data.

Recommendations

1. Improve the GIS-based assessment tool – The predictive accuracy of the GIS-based assessment can be improved by the following activities.
    - Improving LiDAR coverage to refine catchment delineation and watercourse accuracy.
    - Comparing the improvements to accuracy using LiDAR vs DEM for a portion of study area where both datasets are present.
    - Validating the assessment tool by comparing results of GIS and field assessments at selected critical sites
    - Expanding, updating and gathering additional datasets such as system-wide inventories of culvert hydraulics, large wood debris, bank stability or historic channel locations. This can be facilitated by actively coordinating Planning Unit partners to increase datasharing, GIS capabilities and the elimination of data gaps.
2. Perform site specific evaluations for a subset of the high to very high potential aggradation sites. Tasks that can be accomplished as part of the evaluation are:
    - Confirming the severity of sediment aggradation at selected sites,
    - Characterizing the hydraulic condition of instream structures such as culverts,
    - Distinguishing natural and man-made sediment issues, and

- Making site specific recommendations for remedies.

3. Expand the GIS-based assessment to include general sedimentation issues: aggradation, erosion, and channel stability.

D.1 Introduction

This report presents the findings of an investigation of stream aggradation potential in stream drainages within Water Resource Inventory Areas (WRIA) 16 and 14b. This work has been performed by Aspect Consulting, LLC, under contract to Mason County as Task 4, *WRIA 16 Analysis of Impaired Rivers and Streams*.

The study area encompasses WRIAs 16 and 14b located in Mason and Jefferson Counties, Washington. WRIA 16 includes drainages into the west side of Hood Canal, from the Dosewallips River on the north to the Skokomish River on the south. WRIA 14b covers the small drainages on the south shore of Hood Canal between Union and Belfair.

The scope of this investigation was to categorize stream reaches in the study area by the potential for flood-related gravel buildup. The study is intended as a tool to be used by the WRIA 16 Planning Unit (PU) to evaluate the potential risk for stream aggradation. The study may be used by the PU to evaluate the potential of adverse stream channel impacts from future development projects and, also, to evaluate some stream reaches that aggraded during recent, high precipitation events.

It was recognized that the availability and specificity of data might limit the accuracy and/or extent of the categorization of stream reaches. Therefore, the purposes of this task were to:

1. Characterize streams with the available data;
2. Determine the extent to which the available data can identify or predict problem areas; and
3. Identify and make recommendations for more rigorous data collection or analysis in order to provide a better tool.

Generally, investigation of channel dynamics is a site-specific process. However, this project combined use of large scale datasets with Geographic Information System (GIS) analysis, visual inspection of topographic and aerial photography data, and review of available published data to provide useful information to the PU.

The analysis combined three primary elements:

1. An inventory of gravel sources and depositional areas as obtained from aerial views, topography, land use and geologic hazard maps as well as contributions by land cover from GIS analysis. The inventory also includes known deposition and erosion problem areas identified by WRIA 16 member agencies;
2. Estimates of channel stability and gravel transport capacity determined from channel and catchment geometry, including channel constrictions defined by topographic data and anthropogenic features (i.e., road crossings, culverts, dams, or weirs), as well as channel gradients, bank topography and upgradient catchment area calculated from Digital Elevation Model (DEM) data; and

3. Review of available flow data and other published data and analyses for the watersheds.

Section D.2 of this report details the study methodology, evaluates the available data, discusses technical limitations, and makes recommendations for future study.

Section D.3 presents the findings for sediment deposition potential and addresses specific stream reaches with past aggradation problems identified by the PU and provided to Aspect (Table D-1). These reaches were evaluated within the context of the larger analysis and recommendations made for future work or investigation.

Section D.4 presents general guidelines for mitigation measures that prevent or reduce gravel deposition, such as low impact design features and storm water best management practices.

Conclusions and recommendations are summarized in Section D.5.

D.2 Aggradation Analysis

D.2.1 Study Methodology

While erosion, sedimentation and channel migration are features of most natural river systems, these processes can pose a problem near roads and structures. In addition changes in sediment availability, supply and grain size can adversely affect riparian and stream ecosystems and the life cycles of fish. The principle focus of this study was to screen for some of these problems by categorizing stream reaches in the study area according to their potential for flood-related gravel accretion. The intent was to provide a diagnostic level assessment using existing, available, area-wide data from GIS and map-based resources.

Commonly, diagnostic level stream channel assessment is a site-specific process that requires collection of both reach and site-specific data. Diagnostic methods developed by Rosgen (2001), Montgomery and MacDonald (2002) and others have built on the early work of Pfankuch (1975) by gathering stream reach and site data on topography, channel form, sediments as well as other local conditions. As an example, typical characteristics evaluated in a site-specific stream channel assessment (Johnson, 2005) include:

1. Flow regime and flow hydrographs
2. Channel patterns and sinuosity
3. Channel entrenchment and confinement
4. Valley and channel slopes
5. Watershed land use and floodplain alterations
6. Bed and bank material composition and bank slope
7. Mass wasting, cutting and bank failure
8. Bed forms, bars and Large Woody Debris (LWD)
9. Bank and riparian vegetation
10. Natural and manmade channel obstructions.

Categories 1 to 4 pertain generally to flow and flow patterns in stream channels. Categories 5-9 characterize how sediment is produced, passed through, or redistributed in a watershed, while the last category encompasses flow modifications or obstructions that directly affect erosion and sedimentation.

The study presented here combined GIS and map and aerial review to assess as many of the features above as possible using available study area-wide datasets. Where sufficient data was not available to make an assessment, related datasets were used as surrogates for site-specific measurements. The methodology for the analysis is presented below.

D.2.1.1 Selection of Analysis Locations

Because of the large spatial extent of the study area and the resources required to carry out both the GIS and the manual analyses in each of the six subbasins, it was not practical to evaluate all locations along a given watercourse. Specific points along watercourses were selected for analysis based on satisfying one of the following criteria:

- WRIA 16 and 14b PU identified problem areas. These 18 problem areas and descriptions were submitted for review by the PU on April 14, 2009. These areas are summarized in Table D-1.
- Twelve stream-related damage locations from the storm of December 3, 2007 as reported by Mason County. These locations are summarized in Table D-1.
- All streams at crossings with state and county roads as determined by GIS. Road crossing locations were deemed important for two main reasons: firstly, because stream modifications such as culverts and slope stabilization at crossings can create changes in flow conditions. Additionally, roads often follow topographic features such as floodplain margins and slope breaks that are natural locations for changes in stream flow. Changes in flow can lead to local erosion or sedimentation, making these desirable locations for analysis.
- Points on main watercourses downstream of junctions with WA DNR named tributaries. Local flow and sediment inflows from tributaries can cause changes in flow conditions downstream of the flow junction. As mentioned above, changes in flow can alter the potential in a watercourse for erosion or sedimentation, making junction points good candidates for sedimentation analysis. Only named tributaries were used since these streams carried the implication of significant additional inflow. Inclusion of all flow junctions in the analysis was not practical because each point needed to be manually identified, set and adjusted to coincide with the low flow channel. Both DEM calculated watercourses and topographic maps were used to select the points.
- Points on main watercourses with significant reduction in local gradient as compared with upstream gradient. Areas with large reduction in channel gradient often coincide with increased deposition of sediments and so were considered important possible areas for analysis. As with the channel junctions, these point were selected manually, based on DEM calculated watercourse gradients.
- Points on main watercourses in areas of active stream migration or braiding. Local sedimentation problems often result from lateral migration of a stream channel between valley walls or reoccupation of abandoned channels. The locations were selected manually after review of aerial photographs.

The point selection procedure resulted in a set of 408 locations that were possible candidates for sediment aggradation. It is important to recognize that the criteria were established to preferentially choose areas at risk for sedimentation and the subsequent analysis was designed to either confirm or disprove this assumption.

D.2.1.2 Transport Capacity

This study used sediment transport capacity to evaluate flow related characteristics at each of the selected sites. Sediment transport capacity is the ability of the flow in a channel to carry sediment downstream either as suspended particles in the flow (suspended load) or as moving bed material (bedload). Metrics like flow regime, channel type and entrenchment or confinement all depend on transport capacity, or on the balance between transport capacity and sediment supply in a channel. Evaluation of these metrics requires generating input data on channel cross section and channel planform throughout the large study area either using the DEM or by manual calculation. Because the flow related metrics were neither readily available as data nor practical to evaluate accurately throughout study area with GIS, transport capacity was used as a substitute for these metrics.

The most direct measure of transport capacity in mountain drainages is the shear stress or traction force of the flowing water on the channel bed material. Measuring the shear stress in a channel requires precise knowledge of channel cross section, water surface elevation (stage) and discharge for a particular flow. As mentioned above, the determination of cross channel geometry and bankfull flow elevations are small scale features difficult to evaluate using DEM data resolution. Instead, a common measure of transport capacity used in GIS analysis is total stream power: the energy available to transport sediment. Total stream power per unit length of channel, with units of Work per unit length, is defined as follows:

$$\Omega = \gamma Q S \tag{1}$$

Where γ is the specific weight of water (= 9810 N/m^3, 62.4 lbs/ft^3), Q is the water discharge (m^3/s, ft^3/s) and S is the energy slope (m/m, ft/ft) which is usually approximated by the channel slope.

Several studies have been successful in using specific stream power, (Ω/channel width) to estimate channel stability directly (Petit et al., 2005; Stacey and Rutherfurd, 2007); however, those analyses required calculation of flow width in the channel as well as data about sediment sizes. The analysis used for the present study relied instead, on the total stream power, Ω, a quantity that has been calculated successfully at high resolution using DEMs (Worthy, 2005).

Stream power values were calculated for estimates of a peak discharge, Q, with a 5-year return interval at each of the selected points. This return interval was based on observations that for steep gravel-bedded rivers, a sediment-moving flow occurs approximately every three to four years at a given location (Emmet and Wolman, 2001). Since actual sediment load predictions were not part of the analysis, the 5-year return was chosen as an upper limit value to ensure that different catchments were represented correctly with respect to each other during events with large scale sediment motion. Calculation of the 5-year peak flow values from available gauge data is detailed in Section D.2.3.2. Channel slopes were based on calculations at 50-foot intervals from watercourses in the DEM. The measures of transport capacity calculated using this data evaluated the ability of the watercourse to move sediment at each of the selected analysis points.

D.2.1.3 Sediment Supply

Factors that contribute to the sediment available for transport in a watershed include upslope erosion, mass wasting, bank stability, and bed composition. Channel stability is also an issue: changes in channel storage of sediment in bedforms as well as lateral formation of bars and channel migration affect how sediment moves through a stream system. Ideally, analysis would include specifics on sediment size, bank geometry and vegetation as well as the presence of LWD. Some of this data were available for certain portions of the study area; however, in order to make a uniform comparison, only area-wide or county-wide datasets were employed in the analysis. Sediment supply was evaluated using the following GIS datasets:

- NLCD Land Cover (2001) 30 meter resolution. Land Cover provides information on the capacity of a watershed to contribute to or retain both fine and coarse sediments in stream channels. For example, cultivated land that lies fallow in the floodplain during high flow winter months has a much greater likely hood for sediment contribution than an equivalent area of palustrine forested wetland.
- State and County erosion and landslide data including:
    - Mason County Landslide Hazards (2007).
    - Jefferson County Soil Erosion Hazards (1997).
    - Washington Coastal Atlas Unstable Slopes (1979).

  Although these datasets used somewhat different criteria for erosion and/or slope stability, when they were used together, they provided a study-wide measure of the amount of area near an analysis point or in a catchment that was capable of contributing sediments to the channel.
- Adverse change in channel gradients calculated from the DEM. As a watercourse becomes less steep, it becomes less capable of carrying larger sediment grain sizes. Decreases in channel gradient compared to upstream reaches were used to indicate areas where in-channel sediment deposition and storage was possible.
- Gradients and waterfalls identified from Washington State Department of Fish and Wildlife (WDFW) SalmonScape data. Sediment often accumulates downstream of a high gradient area, such as a cascade, because of the deceleration of the rapid flow. In addition, high gradient reaches can cause bank cutting and recruitment of bank material into the stream channel.
- Federal Emergency Management Agency (FEMA) 100-year Floodplain Width. In areas of significant floodplain width, the channel typically migrates between valley walls if flow controls are not present. Floodplain width was used as a measure of channel stability and potential for lateral migration of the stream bed and the consequent change in sediment supply at a particular lateral location on the floodplain.

Although these datasets do not contain specific measures of channel geometry, sediment size or riparian vegetation, they do characterize the significant processes that contribute to sediment supply in a watershed. The datasets were used to quantify the magnitude of possible contributions to sediment aggradation at each of the selected analysis locations.

D.2.1.4 Sediment Barriers

The final component of this diagnostic analysis of sediment aggradation was to assess the role of barriers impeding sediment passage. These obstructions can be bedrock outcrops, beaver dams and log or ice jams that occur naturally in a river system or manmade revetments, dikes, vanes, grade control or other engineered modifications at roads and structures. It is impossible to asses the actual impact of barriers to transport without site-specific analysis. However, the likelihood that sedimentation or erosion problems will occur increases with the density of flow modification and development in a given location. For example, a particular culvert may be appropriately designed and maintained to convey sediments and water during a flood, but if a location has a high number of revetments and road crossings, then the number of maintenance and design issues increases greatly. The degree of possible obstruction of sediment transport for the study locations was assessed using the following data:

- Impervious surfaces. Both HCCC (2006), 1-meter resolution impervious surface data and NLCD (2001) 30-meter resolution % impervious surface data were used to quantify the amount of development in the vicinity of analysis locations.
- Roads. Calculation of lineal feet of county and state roads near an analysis location serves to assess both the amount of development and the possibility of road stabilization measures such as revetments and dikes near a watercourse.
- Culverts identified from WDFW SalmonScape data. Since the assessment of a particular culvert is a site-specific task, the culverts identified in this dataset represent possible, but not definitive areas, where a sediment problem may occur.

It is important to note that the effect on a particular site of these possible barriers to sediment transport can be either sediment aggradation or erosion or possibly both processes. It is common to find both erosion and sedimentation associated with development and manmade flow control measures as well as with natural flow obstructions. This part of the analysis addressed the potential for sediment problems but did not specifically examine whether aggradation or erosion would occur. It should also be noted that no natural barriers to flow were included in the analysis.

D.2.1.5 Sediment Aggradation Rating

Several conditions must occur in order for a location to aggrade sediments. One possibility is that sediment transport capacity is significantly lower than in upstream reaches. Then, if sufficient sediment is present, the channel area will aggrade. Another possibility is that the channel actively migrates in the floodplain, then sediments will aggrade locally, even if there is no drop in transport capacity. The addition of manmade flow alterations further increase the possibility of local aggradation. The worst case is reduced transport capacity accompanied by high sediment load and flow restrictions.

The datasets used in this study were used to develop three rating values:

- Transport Capacity,
- Sediment Supply and
- Sediment Barriers.

The rating process evaluated each of the selected points relative to all the other points in the study area. Finally, all three ratings were combined to form a cumulative rating for sediment aggradation. The analysis did not assess the absolute probability for occurrence of sedimentation. Instead it evaluated the 408 sites according to their relative potential for aggradation. Each site received a rating based on low, moderate, high or very high potential to aggrade sediment. The specific calculations used to develop the ratings are detailed in Section D.2.3.

D.2.2 Data Sources

Data used in the analysis was taken from a combination of GIS based information, reports on the study area, aerial maps, and publicly available federal gauge and topographic information. Because each selected location was analyzed relative to all other points in the study area, the study relied on datasets that covered the entire study area. The analysis excluded data that was only available for certain catchments. For example, LiDAR data was available for about 25% of the study area – concentrated in the near-shore area around Hood Canal but absent for the bulk of the inland area. Since use of this data would have affected the accuracy of rating values for some locations preferentially over others, the LiDAR information was not incorporated into the analysis. The GIS data sources used for this study are summarized in Table D-2.

D.2.3 Analysis

This section describes the analysis performed at each of the 408 locations selected for evaluation of sediment aggradation. Watershed characteristics were calculated at each location and each point was subsequently given a rating in each of three areas:

1. Capacity to transport sediment during high flows.
2. Availability of sediment for transport either in the channel bed, in the floodplain or from upstream.
3. Impediments to transport from flow constrictions.

The three ratings were then combined into a composite sediment aggradation rating. This rating value represents the potential for sediment aggradation of a particular point on the watershed as compared to the entire population of evaluated points. It is a relative rating within a set of locations that were already screened as candidates for sediment aggradation.

Figure D-3 presents a flowchart of the steps used in the selection and in the rating process. In Figure D-3, tasks shaded in gray were carried out using GIS. The criteria for selection of analysis locations are detailed in Section D.2.1.

D.2.3.1 Watershed Characteristics

Catchment Delineation and Catchment Areas

A critical component for this study was the delineation of upstream catchment area at each analysis location. This area was required for calculation of discharge and for area calculations of land cover, 100-year floodplain, erosion hazards, impervious areas and road coverage. The analysis location was used as a "pour point" into which flowpaths from upslope areas would be expected to convey water as well as sediment inflows.

Catchment delineation was accomplished by first "filling" the DEM to eliminate small sinks. The filled DEM was then processed to create a flow direction grid which was, in turn, used to derive a flow accumulation grid. Since the vector watercourse information and the flow accumulation model are not always collinear, the "pour points" that represented each analysis location were manually adjusted to fall directly in the DEM-derived paths of high flow. It is worth noting that this method of basin delineation produces discrete catchments for each pour point, that is, the delineated catchment extends upgradient until it reaches another in-basin pour point, at which location the subsequent upstream area is defined as the catchment for that second, upstream pour point. Thus, each discrete catchment had to be manually recombined with all of the associated upstream catchments to effectively define the contributing area to each analysis point.

Watercourse Slopes

Another important task in assessing potential sediment aggradation areas was to calculate channel gradients along all named watercourses in the study area. For this task, the named watercourses (as defined in the WA DNR hydrography dataset) were divided into individual 50-foot segments. Elevations for the upstream and downstream ends of each segment were then derived for the underlying DEM data. The slope was calculated as:

$$\frac{Elevation_{upstream} - Elevation_{downstream}}{Segment\ Length} \qquad (2)$$

The calculated segment slopes were also compared to a running average of 4 upstream slope values to highlight places where significant changes in slope occurred. The DEM calculated slopes were used together with topographic maps as a tool to examine channel gradient. Since a large number of the analysis locations were on unnamed streams, slope calculations were also extended to cover all watercourses within the study area. In areas where the channel was constrained between steep slopes or where large bedforms and multiple channel topography were present, small displacements from the actual low flow channel resulted in large variations in calculated slope. This was a consequence of using the digitized vector data that defined the watercourse and is further discussed in Section D.2.4.

Map, Aerial, Document and Data Review

In addition to the data gathered about the watershed by GIS, topographic maps and aerial photographs of the study area were reviewed to verify GIS based calculations and to assist with manual point selection and data analysis. Reports on specific sites (Lautz, 2007; Jackson, 2007; Park, 2008) and instream flows in WRIA 16 (Aspect, 2005) were reviewed to obtain a general knowledge of hydrology and sediment issues in the study area. Additional gauge data from daily flow monitoring by the Washington Department of Ecology and HCDOP were also reviewed. Daily flow data were not used in the analysis since mean flows are not major contributors to bedload sediment motion.

D.2.3.2 Peak Flow Regression Analysis

To calculate the transport capacity at a site using stream power, the analysis required estimation of a discharge capable of moving sediments during a flood event. Ordinarily stream power would be used together with sediment grain size to calculate actual sediment loads, but for this analysis it was applied as a metric to measure the relative power of flows at different sites. For this study, a peak 5-year return flow was calculated with the reasonable expectation that this would generate an effective discharge capable of moving large amounts of bed material.

This study calculated 5-year peak flows using an area surrogate method. This method uses historical data to correlate peak flow with contributing area using a power law:

$$Q = K\ A^{n} \qquad (3)$$

Where Q is discharge in ft^3/s or m^3/s, K is a regression coefficient and n is a regression exponent obtained from a least squares fit to observed data. This approach has been demonstrated as valid for regional scale river systems (Finlayson and Montgomery, 2003). It has been used successfully for the estimation of annual mean streamflows in the Hood Canal area (Paulson et al., 2007).

Calculation of 5-year Peak Flows

Table D-3 shows the 18 United States Geological Survey (USGS) gauging stations used to determine 5-year peak flows for the study area. Each of these stations had multiple years of peak flow data with the smallest dataset of 8 years for Mission Creek near Belfair and the largest dataset of 83 years for the North Fork Skokomish River below Staircase Rapids. Catchments of different sizes in the Hood Canal area were selected to characterize the flows in local watersheds. Because of the need for several data points to address flows in lowland streams, several of the gauging stations used for small catchments near Hood Canal were located near but outside of the study area. Each dataset was analyzed for peak flood flow frequency using a Log-Pearson Type III distribution. The Log-Pearson Type III distribution is a skewed distribution common used to forecast floods which can have infrequently observed large values. Peak flows with a return interval of 5 years were selected for each of the gauge stations and a regression analysis was performed to determine a best fit power relation.

Figure D-4 shows the results of the regression analysis for 5-year peak flows. Four different area surrogate relations are distinguishable. Northern catchments such as the Dosewallips, Duckabush, and Hamma Hamma Rivers and tributaries differ in peak flow behavior from the Skokomish River and from lowland coastal catchments. In addition, the presence of flow control at the Cushman Dam also results in a different regression result for the North Fork Skokomish River below Cushman Dam.

The differences in peak flow behavior for watersheds with different sizes and locations are consistent with the findings of Paulson et al. (2007) for mean annual streamflow in the Hood Canal. In the case of 5-year flows, storm events in the higher mountain watersheds involve snowmelt as well as rainfall, whereas lowland storm response is primarily rain driven. Watershed size, rain shadow effects and land use also affect response to storm events. The regression coefficients, exponents and the coefficients of determination (correlation coefficients) for 5-year peak flow in different catchment types are summarized in Table D-4.

The appropriate regression equation was used together with the contributing catchment area calculation at each analysis location to estimate a 5-year peak discharge value at each of the 408 sites.

D.2.3.3 Transport Capacity

For the rating of transport capacity, stream power was evaluated as the total stream power per unit length of channel per unit weight of water or "specific stream power".

The transport capacity rating was comprised of three components. Specific weighting values used in the calculations are summarized in Attachment B:

- QS = Local Stream Power = (Discharge×Local Slope of a 50 foot channel segment). This measured the capacity of the channel to transport material at the analysis location.
- ∆QS = Change in Stream Power = (Local Stream Power – Upstream Stream Power (1500 foot segment)). This evaluated whether the incoming flow was gaining or losing transport capacity.
- W = Logical test for proximity of Hood Canal or Lake Cushman. This test assessed the tendency of lake and canal inflows to lose transport capacity in response to backwater from large downstream waterbodies. This effect is much more important for small streams than for large rivers.

To build the final transport rating, QS and ∆QS values were each divided into a set of approximately 25 ranges. QS = 0 was assigned a rating of 0, QS = 0.5 was rated at 1, QS=1 was rated 2 and so forth, raising the rating by 1 point for every doubling of the stream power value. The calculated values were assigned a rating number according to the range in which they fell. This ensured that large flows with wide channels were not weighted too heavily in the analysis. For example, the maximum calculated QS value in the dataset was 1142 ft^3/s and the minimum was -314 ft^3/s, resulting in ratings of 12 and -11, respectively.

The final transport capacity rating was calculated by using a weighted sum of all three components. Each dataset was scaled so that the spans of the data (maximum value-minimum value) were equal and then the span of the component W was divided by a factor of four. In this way, the calculation assigned equal weights to local stream power, QS, and changing stream power, ∆QS, and approximately one-quarter of that weight to the lake proximity metric, W. This had the effect of making W an important factor for small streams with low transport capacities and less important for the larger flows.

D.2.3.4 Sediment Supply

The sediment supply rating was comprised of five components. Specific weighting values used in the calculations are summarized in Attachment B:

- LC = Land cover contributions. This assessed the possibility of sediment entering the watercourse from upslope land areas. Each land cover type was assigned a weight, LC_i according to its tendency to erode or retain sediment. The weighted total of all areas contributing flow to the selected site was then divided by the total catchment area upstream of the site using the formula below:

$$LC = \frac{\sum \left(LC_i \times Contributing\ Area_i \right)}{Upstream\ Catchment\ Area} \qquad (4)$$

  The LC_i weighting values are listed in Attachment B.

- 100YR = 100-year floodplain contributions. This assessed the ability of the channel to meander laterally by measuring the area of 100-year floodplain area in several buffer zones around the selected site. This metric was a weighted sum of the percentage of the 100-year floodplain in three concentric buffer zones of 100 ft, 500 ft and 100 ft around the selected location according to the following equation:

$$100YR = 0.5\left(100\ ft\ \%\right) + 0.3\left(500\ ft\ \%\right) + 0.2\left(1000\ ft\ \%\right) \qquad (5)$$

  where the expression in parenthesis refers to the area percentage of 100-year floodplain within the particular radius. Hood Canal and Lake Cushman were excluded from the floodplain areas in the buffer calculations. Because of the area exclusion calculation, the composite floodplain contribution required the use of overlapping buffer zones.

- ER = Logical test for proximity of erosion or landslide hazards. This metric checked whether identified landslide or erosion hazards existed in the vicinity of the site and in the upstream catchment area. Three different datasets were used in the calculation: erosion hazards from Jefferson County, landslide hazards from Mason County and unstable slopes from the Washington State Coastal Atlas. As a result, areas for these different data types were not evaluated directly, but instead the existence of a hazard from any one of the three sources was tested in the upstream catchment and in three non-intersecting concentric bands of outer diameters 100 feet, 500 feet and 1000 feet around each analysis point. The presence of a hazard area was weighted according to:

$$ER_k = 4\left(0-100\,ft\,?\right) + 3\left(100-500\,ft\,?\right) + 2\left(500-1000\,ft\,?\right) + 1\left(Catchment\,?\right) \qquad (6)$$

  where ER_k is the contribution for one of the three datasets and the question in parenthesis resulted in a value of 1 if there was a hazard in each radial range and a value of 0 if there was not. The contributions from the three datasets were added with equal weights to obtain a total value:

$$ER = \sum \left(ER_k \right) \qquad (7)$$

- ΔS = Logical test for adverse channel gradient change = ([Local slope of 50 foot segment – Upstream slope of 1500 ft segment] < 0?). This metric evaluated whether in-channel sedimentation was occurring by testing for local slope values that were less than the average gradient of the 1500 ft upstream reach.
- GR = Logical test for presence of upstream gradient, cascade or waterfall. The number of high gradient locations, including waterfalls or cascades from the WDFW SalmonScape dataset were counted in three non-intersecting radial bands with outer diameters of 100 feet, 500 feet and 1000 feet, respectively. The identified high gradient locations were screened manually to include only those upstream of the analysis point and then summed according to the following weighting:

$$GR = 5(\# < 100\,ft) + 3(100 < \# < 500\,ft) + 2(500 < \# < 1000\,ft) \tag{8}$$

  where the expression in parentheses sums the number of high gradient locations within a particular radius range.

The final sediment supply rating was calculated by using a weighted sum of all five components. The calculation assigned equal weights to land cover, LC, 100-year floodplain area, 100YR, and erosion and landslide hazards, ER by scaling each dataset so that the spans of the data (maximum value-minimum value) were equal. Adverse channel gradient, ΔS, and gradients, GR were assigned a half weighting each since they were the two components of in-channel sediment sources. The scaling factors used in the analysis are listed in Attachment B.

D.2.3.5 Sediment Barriers

The barrier to transport rating was composed of three components:

- IP = Impervious surface coverage in vicinity. This metric evaluated the percentage of impervious surface located in three non-intersecting concentric bands of outer diameters 100 feet, 500 feet and 1000 feet around each analysis point. Two datasets were combined to evaluate each point: NLDS % impervious surface data and the high resolution impervious surface inventory from HCCC. Data was weighted using the formula:

$$IP_k = 5(\% < 100\,ft) + 3(100 < \% < 500\,ft) + 1(500 < \% < 1000\,ft) \tag{9}$$

  where IP_k is the contribution from one of the two datasets and the expression in parentheses returns the area percentage of impervious surface within a particular radius range. The contributions from the two datasets were scaled to yield the same maximum value in each dataset and added to obtain a total value.

- RD = Road coverage in vicinity. This metric evaluated the lineal distance in feet of state and county roads located in three non-intersecting concentric bands of outer diameters 100 feet, 500 feet and 1000 feet around each analysis point. The weighted value was calculated using the following formula:

$$RD = 0.5(road\ \ ft < 100) + 0.3(100 < road\ \ ft < 500) + 0.2(500 < road\ \ ft < 1000) \tag{10}$$

where the expression in parentheses sums the number of lineal feet of road within a particular radius range.

- CU = Number of nearby culverts. The number of culverts from the WDFW SalmonScape dataset were counted in three non-intersecting radial bands with outer diameters of 100 feet, 500 feet and 1000 feet, respectively. The resulting values were weighted and summed using the equation:

$$CU = 5\left(\# < 100\,ft\right) + 3\left(100 < \# < 500\,ft\right) + 2\left(500 < \# < 1000\,ft\right) \qquad (11)$$

where the expression in parentheses returns the number of culverts within a particular radius range.

The final sediment barrier rating was calculated by using a weighted sum of all three components. The calculation assigned equal weights to impervious surface, IP, road coverage, RD, and culverts, CU, by scaling each dataset so that the spans of the data (maximum value-minimum value) were equal. The values for each component were then added. The scaling factors used in the analysis are listed in Attachment B.

D.2.3.6 Cumulative Sediment Aggradation Rating

The cumulative sediment aggradation rating at each analysis site was the sum of the three transport ratings. Each rating was given equal weight in the analysis.

As a first step, each rating was scaled relative to the values calculated at all the analysis points so that its possible values ranged from 0 to 100. The value of 0 represented the condition least likely to cause aggradation and 100 was the condition most likely to cause aggradation. This scaling was performed relative to the range of values actually calculated for the entire set of 408 selected locations. For example, the location with the worst scores for local stream power, QS, change in stream power, ΔQS and water body proximity, W, was scaled to a transport capacity rating score of 100, while the point with the best transport capacity received a rating of 0.

The three scaled rating for transport, sediment supply and barriers were added and then scaled once more to span the range from 0 to 100. This final value was called the scaled cumulative aggradation rating. Using this method, a high value meant that a point had high potential for sediment aggradation. The final distribution of values had a mean of 47 and a standard deviation of 21. Table D-5 shows the statistics of the cumulative aggradation rating and the three component ratings.

The validity of the analysis was evaluated by observing how well sedimentation issues were predicted in known problem areas. Identified problem areas were not used to adjust the weights of the ratings or the rating components; however, the conditions in these areas were used to verify the overall accuracy of calculations.

D.2.4 Technical Limitations

The technical limitations for this study arise from two main issues:

- GIS datasets, map and aerial analyses were used as surrogates for site-specific data. The types of available geographic data as well as uniformity of coverage and data resolution were principal limiting factors.
- The analysis required a significant amount of manual data manipulation over a very large geographic area. The large number of catchments, flow conditions and analysis locations require as much automated data processing as possible. The use of manual calculations and attention to specific sites greatly reduce the efficiency of resources allocated to analysis.

The following is a summary of some of the main limitations that result from these issues.

Catchment Delineation – ArcView's Spatial Analyst "Watershed" tool was used to automatically delineate the catchments expressed by each pour point. For the case of small catchments and for catchment areas with very flat terrain, the DEM filling and flow accumulation mapping, described in Section D.2.3.1, resulted in some uncertainty in the catchment delineation. In the representation of flow accumulation across the entire watershed, the pixels of high-flow form something of an elevation-derived stream network. Not surprisingly, the vector watercourse information and the flow accumulation model are not always collinear. As such, the "pour points" that represent each analysis location need to be manually adjusted to fall directly in these DEM-derived paths of high-flow so as to effectively capture the drainage area. It is worth noting that this method of basin delineation produces discrete catchments for each pour point, that is, the catchment as delineated in ArcView extents upgradient until it reaches another in-basin pour point, at which location the subsequent upstream area is defined as the catchment for that second, upstream pour point. Thus, each discrete catchment also had to be manually recombined with all of the associated upstream catchments to effectively define the contributing area to each analysis point.

In summary, the disparity of vector water course information and DEM-based flow accumulation necessitated a large amount manual manipulation of analysis locations. The use of the DEM to delineate catchment boundaries was also subject to uncertainty in some areas.

Watercourse Gradients **–** Stream slope calculations were screened manually to exclude areas where erroneous gradient values resulted from the mismatch between the watercourse location in WA DNR vector data and the DEM low-flow channel. This occurred predominantly in areas where the flow was highly constricted between steep valley walls or where the channel had significant bars or bedforms. In these places, a small displacement of the channel resulted in the watercourse "climbing" the valley walls or gravel bars in one spot and "falling back" into the channel in others. The resulting excursions were occasionally greater than 100 feet. Higher accuracy segment slope calculations would be possible if the vector watercourse data matched directly with the channels as expressed in the DEM (whether LiDAR or USGS DEM). A possible approach for calculation of slopes and catchment areas would be to define each watercourse not from the digitized vector data (such as that from WA DNR) but to derive the watercourse paths from the elevation model itself. This is an application where more accurate study-wide information such as LiDAR would also improve the quality of the data.

Transport Capacity – The relative ability of different watercourses to carry sediment was calculated using specific stream power per unit length of flow, QS. While this is a good order-of-magnitude measure, it is more accurate to evaluate the tractive force per area of channel bed by dividing QS by the channel width. As mentioned previously, channel cross section information was not readily available from GIS analysis: channel geometry calculation is a relatively small-scale analysis that is ill-suited to DEM data resolutions.

The stream power calculation relied on both watercourse gradients and prediction of peak flows. The former are discussed above. Peak flow prediction using historical gauge data and the area surrogate method does not take into account a number of factors. These include small scale geographic variations in catchment response to storm events, historical changes in land use and climate change. Additionally using the same peak flow return interval may not be appropriate for all sizes and locations of catchments.

Additional information that would contribute to understanding transport capacity includes study-wide channel type classification, sinuosity measurements and entrenchment or confinement of channels.

Sediment Supply – In rating the amount of sediment available for transport in a location, the evaluation of upslope erosion was very important. Land use data and erosion hazard inventories provide qualitative measures of erosion potential but are not quantitative. Additionally, a single erosion hazard dataset for the entire study area was not available, so the analysis relied on piecing together different types of data from County and State datasets. Erosion, landslides and other landform changes that have occurred as a result of 2007 to 2009 flooding were not available as datasets or as study-wide aerials and so are not included in this analysis.

The analysis used floodplain width as a surrogate for channel stability. While this gives an idea of the historic limits of flooding and channel movement, it is not as accurate as historical data on channel location and evaluation of active bank cutting areas. Study-wide evaluations of riparian and stream vegetation and habitat features, including LWD, could also be used to enhance a channel stability assessment.

The gradient of a watercourse can reflect the potential for in-channel storage of sediment but it also includes the effects of underlying topography. The limitations on channel gradient calculations are discussed above. Bed and bank material composition as well as channel and bank topography are other data that could be used to support estimates of in-channel sediments that mobilize during flood flows.

Sediment Barriers – This rating was the most difficult to evaluate using the GIS datasets. Barriers to transport of sediments were not analyzed directly in this study. Instead the analysis relied on assessing the amount of development around a particular location by evaluating road lengths, impervious surfaces and culverts.

- The road length measurement did not differentiate between road types: a county gravel road and a state highway were weighted equally. This task could have been done using GIS but would have required additional time and resources.
- Since the study wide coverage and data type of NLCD and HCCC impervious surface data was different, both datasets were combined to evaluate impervious surfaces. Areas of omission and areas of overlap were inherent in the process of combining the data.
- Culverts were used as a proxy to assess the amount of stream channel modifications near a given location. This process did not actually evaluate whether the culvert was a sediment barrier. Although the WDFW SalmonScape data includes identification of culverts that are barriers to fish passage, this identification does not distinguish the nature of the passage issue. For example, a perched culvert is an erosion issue but not a problem for sediment aggradation. In addition, some river training measures such as rip-rap and gradient control structures do not necessarily occur near road crossings and would not be represented in the culvert inventory.
- Naturally occurring barriers such as wood debris or rock outcrops were not available as a study-wide dataset and were not included in the analysis.

Additional information that would contribute to understanding sediment barriers would address specific details on river works such as revetments and dikes as well as culverts and stream crossing structures.

D.2.5 Recommendations for Additional Work

The following activities would expand the capability for GIS-based sedimentation assessments in the WRIA 16 and 14b study areas:

- Expanding and improving LiDAR coverage of the study area. This will allow the development of high resolution watercourse locations and verified area-wide catchment delineations. Since watercourse gradients and catchment area calculations are an essential part of any GIS-based sediment assessment, establishing this dataset would improve the accuracy and efficiency of future investigations that use GIS.
- Extending selected existing datasets to cover the entire study area. Local area-specific datasets such as LiDAR-based elevations, erosion hazard areas and habitat assessments have been developed by state, tribal and county agencies. Extension of these datasets would increase the accuracy and validity of analyses that cover all of WRIA 16 or 14b. For example, data on large wood jams, pools and secondary channels compiled for the Dosewallips River (Labbe, et al., 2005) would have been useful for assessing channel stability but were not included in

this study because the analysis would have evaluated Dosewallips River sites differently from sites outside that watershed.

- Evaluating specific locations in critical areas using site-specific criteria as well as GIS data. This task would both address sedimentation issues in the critical area and be available for use as calibration data for broader GIS analyses. For this study, two site assessments at stream crossings by WA-DOT (Lautz, 2007, Park, 2008) were compared to the sediment aggradation analysis. These comparisons appear in Sections D.3.1 and D.3.6.
- Updating existing datasets to current conditions when possible. To incorporate storm events in recent years into a GIS-based analysis, aerial photographs and datasets such as landslide and erosion hazard inventories should be refreshed on a regular basis.
- Expanding inventory of river works, culverts, river crossings including details and maintenance issues. Apart from habitat remediation, much of the expense related to sediment issues occurs near roads and structures. The more specific the data is on alterations to the floodplain, the better the tools that will be developed to assess sedimentation issues.
- Addressing the need for GIS-based channel form and floodplain cross section geometry, bank composition, sediment and vegetation information for specific area investigations. Although, this task would be difficult to accomplish for the entire study area, the methodology to extract this information from high resolution data as well as historical maps and aerials has been developing since the early 1990s (Downward et al., 1994).

D.3 Sediment Aggradation Potential

Results of the sediment aggradation analysis are presented by subbasin in Figures D-5 through D-11. The analysis ranked sites according to their relative potential for aggradation, but did not assess the absolute probability for occurrence of a problem. It is also important to recall that sites were chosen because they were in locations that were particularly prone to sediment issues and the analysis was designed to evaluate the validity of that assumption. The aggradation rating as well as component rating for low-transport, sediment supply and sediment barriers are all discussed in terms of how they compare with the rest of the sites in the analysis, not how they would compared to a site chosen at random.

In the figures, the analysis points are shown on watercourses as colored circles with low, moderate, high, and very high potential for sediment aggradation represented in green, yellow, orange and red, respectively. Station labels for sites with “very high” potential are shown in large, bold font. Stations with low through high potential are labeled in smaller font. The limits of these classifications were based on fitting a normal distribution to the aggradation rating results. Sites with ratings below one standard deviation away from the mean value (≤ 25) are labeled as low risk. Values above one standard deviation yet below the mean (25 < rating value < 47) were classified at moderate risk and so on with very high risk assigned to sites with ratings above one standard deviation from the mean (≥ 68).

The problem areas identified by the WRIA 16 PU are shown with an added purple ring around the site location, while stream-related damage areas from the December 3, 2007 storm have a pink square surround. Additional features denoted on the figures include zones of relatively high or low channel gradient, the FEMA 100-year floodplain, HCCC impervious surfaces, roads and instream structures from the WDFW SalmonScape database.

Sediment aggradation potential for each subbasin is discussed below. For more extended descriptions of the subbasins along with watershed issues, refer to the *Watershed Management Plan for the Skokomish-Dosewallips Water Resource Inventory Area (WRIA 16) including the WRIA 14 South Shore Sub-basin* (WRIA 16 Planning Unit, 2006).

D.3.1 Dosewallips Subbasin

The Dosewallips subbasin drains an area of approximately130 square miles eastward into the Hood Canal. The Dosewallips River with major tributaries of Silt Creek, the West Fork Dosewallips and Rocky Brook Creek forms the primary river system in the subbasin. Additional watercourses in the subbasin include Walker Creek, and Turner Creek. The Olympic National Park and Olympic National Forest comprise most of the subbasin area. The lower elevations contain some private forest and rural land with residential and commercial development near the mouth of the Dosewallips at Brinnon.

Figure D-5 summarizes the sediment aggradation analysis results for the Dosewallips subbasin. A total of 58 locations were evaluated with the following results:

- ***Low potential for sediment aggradation*** – 16 sites. All of these sites occur in the Dosewallips River at and upstream of Wilson Creek. Each of the low potential sites is away from barriers to sediment passage on the main part of the river. Transport capacity is high because of favorable channel gradients and sediment supply is in the lowest quartile of the sites analyzed.
- ***Moderate potential for sediment aggradation*** – 17 sites. Twelve of these sites are on the Dosewallips above Wilson Creek. These sites fall in low channel gradient areas or near locations with many locally steep tributaries. Transport ratings tend to be average with few barriers and moderate sediment supply (below the mean of all sites analyzed). Lower on the Dosewallips, site DW31 occurs in a split channel area where transport is low and sediment supply is high due to the potential for channel meander. The remaining four sites are at road crossings. Though sediment supply is not a problem, the presence of culverts and impervious surfaces raise the barrier rating at these locations.
- ***High potential for sediment aggradation*** – 15 sites. Site DW03 on the West Fork Dosewallips at the confluence with Elk Lick Creek is located in an area where the river decelerates because of an adverse change in slope. Additionally upstream waterfalls and high gradients contribute to the high potential for aggradation. Two additional sites along on the Dosewallips at or above Rocky Brook Creek are on tributaries at road crossings with average transport capacity, moderate sediment supply and moderate barrier ratings.
- The remainder of the high aggradation potential locations occurs in the lower Dosewallips and in smaller streams that drain into Hood Canal. In most of these cases, the three ratings, transport, supply and barriers, are all equal contributors to the high potential for aggradation. Point DW39 is an exception in that there are few nearby floodplain modifications. It occurs at a local pinch point in the channel where transport is reduced and the upstream floodplain area indicates a high sediment supply. For points DW49, DW50 and DW52, the large number of nearby culverts yields an especially high barrier rating in the upper quartile of all sites. Point DW36 is a WRIA 16 PU identified problem area and is discussed below.
- ***Very high potential for sediment aggradation*** – 10 sites. Site DW33 received the highest potential sediment aggradation rating for the Dosewallips subbasin. At this location, transport is limited by a flattening of the river channel prior to passing through a local constriction. The wide upstream floodplain and inflows from Rocky Brook Creek indicate a high sediment supply potential. In addition, culverts along Dosewallips Road yield a moderately high barrier rating. Point DW44 is a WRIA 16 PU identified problem area and is discussed.

below. The remaining eight sites are all on small coastal streams along State Route 101. These sites had average to low transport capacity (average to high rating) and high ratings in supply and barriers to transport for a variety of reasons:

- Adverse changes in channel gradient depositing sediments as the steep streams reach the shore area and cross the highway.
- Large areas of scrub or grassland relative to catchment size with implied high sediment yields.
- Nearby erosion hazards on the steep slopes adjacent to the highway.
- Large areas of impervious surface relative to catchment size indicating stream confinement.
- Large number of nearby culverts with possible barriers to transport.

Throughout the study area these were common features for steep coastal streams.

WRIA 16 Planning Unit Identified Problem Areas in Dosewallips Subbasin

DW 36 – Dosewallips River at Appaloosa Dr. – This site received a cumulative sediment aggradation rating of 63, giving it a relatively high potential for sediment aggradation. It lies in a decelerating low channel gradient area so the transport capacity is poor (above average low-transport rating of 54). The wide floodplain and nearby roads and development lead to supply and barrier ratings of 53 and 46, respectively. The analysis indicates the possibility that channel sediment accumulation and lateral migration of the river channel may cause a problem in areas where the flow is constricted. Further evaluation would require more site-specific data.

DW 44 – Dosewallips River at SR101 Bridge – This site received a cumulative sediment aggradation rating of 81, giving it a very high potential for sediment aggradation. Transport capacity analysis shows a rapid drop in the ability to move sediment at this site compared to upstream reaches (low-transport rating of 70). The sediment supply rating is significant at 64 because of in-channel storage, floodplain width and contributions from upstream land use and erosion hazards. Road length and impervious area contribute to an above average possibility of barriers to transport (58). Although this is not an uncommon condition at river mouths, it is probable that this area will continue to aggrade unless sediment supply to the site is reduced. Development which restricts the floodplain can contribute to problems in this area. Further evaluation would require more site-specific data.

D.3.2 Duckabush Subbasin

The Duckabush subbasin, located south of the Dosewallips subbasin, drains an area of approximately 82 square miles eastward into Hood Canal. The Duckabush River with major tributaries of Crazy Creek, Cliff Creek and Murhut Creek is the primary river system in this subbasin. As with the Dosewallips, the major part of the watershed is covered by the Olympic National Park and the Olympic National Forest with lower elevations consisting of private forest and rural land. Most of the residential and commercial property in the watershed is located near the Duckabush estuary.

Figure D-6 summarizes the sediment aggradation analysis results for the Duckabush subbasin. A total of 20 locations were evaluated with the following results:

- ***Low potential for sediment aggradation*** – 6 sites. Each of the low potential sites is away from barriers to sediment passage on the main part of the Duckabush River. Five of these sites occur at or upstream of Murhut Creek. Transport capacity is high to moderate because of favorable channel gradients and sediment supply is in the lowest quartile of the sites analyzed. The sixth site, DK14, lies in the broad floodplain in the lower Duckabush, but since the channel gradient is sufficiently steep in this location, transport capacity is high and the overall site rating indicates low potential for aggradation.

- ***Moderate potential for sediment aggradation*** – 6 sites. These sites are on the Duckabush at or upstream of the Duckabush Road Extension. They fall in low channel gradient areas or near locations with many locally steep tributaries. Transport ratings tend to be average with few barriers and moderate sediment supply (below the mean of all sites analyzed).

- ***High potential for sediment aggradation*** – 5 sites. Site DK12 is located in an area where the Duckabush River decelerates because of an adverse change in slope. Because of the large drop in sediment transport capacity at this site, it has the highest low-transport rating (lowest transport capacity) of all the sites evaluated for this study. Additionally an upstream high gradient and wide floodplain contribute to the high potential for aggradation. Site DK13 has moderate transport capacity but relative to other analyzed sites, the wide floodplain and erosion hazards result in a high sediment supply.

  Three high aggradation potential locations, DK15, 16 and 17 occur in smaller streams that drain directly into Hood Canal. In these cases, the three ratings of transport, supply and barriers are all equal contributors to the high potential for aggradation.

- ***Very high potential for sediment aggradation*** – 3 sites. Site DK19 is a WRIA 16 PU identified problem area and is discussed below. Sites DK18 and DK 20 are similar to DK15 through 17 above but with locations closer to the mouth of the Duckabush River and uniformly higher rating values. DK18 has a higher barrier rating than DK20 because of the larger amount of development (road length and impervious area) near the site.

WRIA 16 Planning Unit Identified Problem Areas in Duckabush Subbasin

DK19 – Duckabush River at SR101 – The cumulative sediment aggradation rating at this site was 69: very high potential for sediment aggradation. The low-transport, supply and barrier ratings were 52, 73, and 41, respectively. The channel gradient calculated at this site was -0.0004 and the 1500 ft upstream gradient was -0.016, which indicate that under non-flood conditions the flow is practically still. Given the upstream adverse gradient, sediment will be deposited upstream of the analysis site according to this analysis. It is possible that the slope values at DK19 result from a mismatch between the watercourse location in WA DNR vector data and the DEM low-flow channel as discussed in Section D.2.4. Regardless of the transport capacity, in-channel storage, floodplain width and contributions from upstream land use and erosion hazards predict a high sediment supply to this site. Road length, culverts and impervious area contribute to an average possibility of barriers to transport. As with DW44 in the Dosewallips subbasin, aggradation problems will continue without a reduction in sediment supply and can be aggravated by improperly planned development. Further evaluation would require more site-specific data.

D.3.3 Hamma Hamma Subbasin

The Hamma Hamma subbasin drains approximately 120 square miles eastward to the Hood Canal. The Hamma Hamma River along with major tributaries of Boulder Creek, Lena Creek, Cabin Creek, Jefferson Creek and Waketickeh Creek forms the main river system in this subbasin. Like the Dosewallips and Duckabush, this subbasin is primarily Olympic National Forest and Olympic National Park land. Unlike the northern subbasins, the Hamma Hamma River has several alpine lakes. Smaller drainages include Johns Creek which feeds the Hamma Hamma Estuary and Fulton Creek which drains directly to the Hood Canal. Agricultural and residential areas border the river mouth near Eldon and line the Hood Canal.

Figure D-7 summarizes the sediment aggradation analysis results for the Hamma Hamma subbasin. A total of 68 locations were evaluated with the following results:

- ***Low potential for sediment aggradation*** – 10 sites. These lie in the upper reaches of the Hamma Hamma River, Jefferson Creek and tributaries and on John Creek. Transport capacity is high to moderate because of favorable channel gradients and sediment supply is in the lowest quartile of the sites analyzed. Although there are local roads in the vicinity of some of the analysis points, the barrier ratings are relatively low as well.

- ***Moderate potential for sediment aggradation*** – 25 sites. Most of these sites are distributed throughout the subbasin away from the Hood Canal. They fall in low channel gradient areas or near locations with many locally steep tributaries. Transport ratings tend to be average with none or few barriers and moderate sediment supply (below the mean of all sites analyzed). For sites HH42 and HH44, sediment transport capacity is favorable; however, the sediment supply rating is high because of the presence of erosion hazards. For site HH40 at the junction of John Creek with the Hamma Hamma estuary, both transport and supply ratings are high but the absence of any nearby development or culverts keep the overall rating in the moderate range.

- ***High potential for sediment aggradation*** – 19 sites. Ten sites on the Hamma Hamma River, Jefferson Creek and Fulton Creek are located in areas where there are flow junctions or where the watercourses decelerate because of an adverse change in slope. Nearby upstream waterfalls and high gradients contribute to the high potential for aggradation. Most of these sites have nearby roads or road crossings. The remainder of the high aggradation potential locations occurs along smaller streams that drain into Hood Canal. In most of these cases, the three ratings transport, supply and barriers all contribute substantially to the high potential for aggradation.

- ***Very high potential for sediment aggradation*** – 14 sites. These sites all lie along the Hood Canal in small coastal watercourses. As with the coastal catchments in the Dosewallips subbasin (Section D.3.1), these sites have average to low transport capacity and high supply and sediment barrier ratings. An exception to this is site HH66 at the mouth of Fulton Creek. In this area, although there only moderate barriers to transport, the channel gradient is quite low resulting in an unfavorable transport rating that yields a very high aggregation potential. Site HH56 has the highest sediment supply rating out of all the sites analyzed for this study primarily because of floodplain width and nearby erosion hazards.

D.3.4 Finch/Lilliwaup Subbasin

The Finch/Lilliwaup subbasin is an assemblage of several drainages encompassing about 55 square miles. Lilliwaup Creek contains a number of lakes and wetlands and constitutes the largest drainage area of approximately 18 square miles. Other significant watercourses are Jorsted Creek, Eagle Creek, and Finch Creek. The Finch/Lilliwaup subbasin has an appreciably long shoreline where many small creeks drain directly into the Hood Canal. These include Little Lilliwaup Creek, Sund Creek, Miller Creek, Clark Creek and Hill Creek. The eastern portions of this subbasin lie primarily in lowlands and higher elevations are used for recreation, lumber and tree-farming. Commercial and residential development occurs along the shore of Hood Canal and near the Towns of Lilliwaup and Hoodsport.

Figure D-8 summarizes the sediment aggradation analysis results for the Finch/Lilliwaup subbasin. A total of 53 locations were evaluated with the following results:

- ***Low potential for sediment aggradation*** – 3 sites. These points are located along United States Forest Service (USFS) Road 24 in upper parts of the Lilliwaup Creek and Jorsted creek drainages. They have relatively high transport capacity, low sediment supply and minimal barriers to transport of sediments. It should be noted that high transport capacity with low sediment supply implies that channels in this area may erode material and become entrenched.
- ***Moderate potential for sediment aggradation*** – 6 sites. Site FL17 is a WRIA 16 PU identified problem area and is discussed below. The remaining five sites fall in low channel gradient areas (FL07, FL34) or in areas of adverse change in channel slope (FL01, FL03 and FL27). Most of these sites are near or at tributary points. Transport ratings are average with few barriers and moderate sediment supply (below the mean of all sites analyzed).
- ***High potential for sediment aggradation*** – 21 sites. Sites FL22 and FL43 are WRIA 16 PU identified problem areas and are discussed below. Road damage occurred at site FL36 during the storm of December of 2007. This site is also discussed below. The sites with high potential for sediment aggradation in the Finch Lilliwaup subbasin all occur on the shoreline of the Hood Canal. With the exception of FL49 at Jorsted Creek, all of the these sites have transport values in

the range of 47 to 62, indicating either flat channel slopes or an adverse change in channel slope with respect to upstream. Sediment supply and barrier ratings are also near or above the mean of all the sites analyzed in the study area.

At Jorsted Creek site FL49, the overall topography implies that the flow should be decelerating, however the calculated transport rating is high. The computed slope at this site is quite flat (0.009); however, the 1500 upstream channel gradient has a small negative value (-0.001). This returns a condition of accelerating flow, which coupled with the high discharge at the mouth of the creek, yields a favorable transport capacity. It is probable that this computation is in error and results from a mismatch between the watercourse location in WA DNR vector data and the DEM low-flow channel as discussed in Section D.2.4. If the site at FL49 were to have a transport capacity similar to other estuarine sites then its aggradation potential would be in the very high range.

- ***Very high potential for sediment aggradation*** – 23 sites. Sites FL15, FL16, FL20, FL25, FL33 and FL46 are WRIA 16 PU identified problem areas and are discussed below. Road damage occurred at sites FL06 and FL10 during the storm of December of 2007. These sites are also discussed below. The remaining 15 sites all lie along the Hood Canal in small coastal watercourses. As with the coastal catchments in the Dosewallips subbasin (Section D.3.1), these sites have average to low transport capacities (average to high ratings) and high supply and sediment barrier ratings.

WRIA 16 Planning Unit Identified Problem Areas in Finch/Lilliwaup Subbasin

FL17 – Miller Creek – The analysis site at the Miller Creek crossing of State Route 101 was rated to have a moderate sediment aggradation potential value of 43 with low-transport, supply and barrier ratings of 27, 27 and 56, respectively. The local channel slope calculated for Miller Creek at the analysis location was relatively steep for a stream on the Hood Canal shoreline at 0.11. This was appreciably higher than the 1,500-foot upstream value of 0.03. As was detailed above for site FL49, there is a definite possibility that this is a result of a mismatch between the watercourse location in WA DNR vector data and the DEM low-flow channel. This analysis limitation is discussed in detail in Section D.2.4. For Miller Creek it appears that the WA DNR watercourse cuts into a high coastal hill just upstream of the analysis site, resulting in an artificially high slope value.

The sediment supply rating is relatively low with some contributions from land use and a coastal erosion hazard. It is possible that upstream landsliding occurred as a result of storm activity in recent years (Jackson, 2009), but since this is not in the current GIS dataset, it can not be included in the analysis. Additionally, since there are no culverts designated near the crossing, the restriction of the creek mouth at State Route 101 by a low bridge is not taken into account in the barrier rating.

The site at Miller Creek is a good illustration of the data needs for improving accuracy of the GIS-based analysis of possible sedimentation areas. It is likely that with more accurate and up-to-date data, the rating for this site would yield a high or very high potential for sediment aggradation.

FL22 – Lilliwaup Creek at Lilliwaup Street, FL43 – Stetson Beach Creek – These sites were rated with a high potential for sediment aggradation with values of 60 and 63, respectively. Of the two sites Lilliwaup Creek has the lowest rating for barriers to transport with a value of 15. A large adverse change in channel gradient along with local erosion hazards gives it high ratings for low-transport (63) and sediment supply (69). The Stetson Beach Area has uniformly average or above average ratings in all areas. Channel slope decreases near the site (low-transport = 48), while erosion hazards and nearby development results in above average values for sediment supply (59) and sediment barriers (51). Further evaluation would require more site-specific data.

FL15 – Finch Creek, FL16 – Clark Creek, FL20 – Sund Creek, FL25 – Little Lilliwaup Creek, FL33 – Carroll Point, FL46 – Ayock Beach. These sites have potential sediment aggregation ratings of between 68 and 76. The component rating values appear on Figure D-8. As a group these sites have similar characteristics including adverse gradient change, land use, in-channel and floodplain sediment contributions, nearby erosion hazards and a high concentration of development, roads and culverts. Sedimentation issues are likely to persist in these streams if remedial actions are not undertaken. FL15 at Finch Creek is somewhat different in that transport capacity is higher (lower low-transport rating) but the site has more impervious surfaces and roads than the rest of the problem areas in this subbasin. It is possible that this could lead to local areas of scour at constrictions with sedimentation occurring downstream. Further evaluation would require more site-specific data.

Areas of Winter 2007 Stream-Related Road Damage in Finch/Lilliwaup Subbasin

FL36 – Eagle Creek at SR101 – This site was rated with a high potential for sediment aggradation with an aggradation rating of 54 and low-transport, supply and barrier ratings of 52, 51 and 32, respectively. Although the channel gradient at Eagle Creek is fair with a value of 0.014, flow is decelerating from a steeper region upstream. A moderately high sediment supply results from land use, in-channel and floodplain contributions as well as erosion hazards upstream of the site. Development is relatively low, yielding a high rating rather than a very high rating. Allowing increased development in this area would likely result in larger problems with sediment aggradation. Further evaluation would require more site-specific data.

FL06 and FL10 – Finch Creek Bridges 1 and 2 – These sites have very high sediment aggradation potential ratings of 77 and 84, respectively. Component ratings are listed on Figure D-8. Both sites have adverse gradient change, land use, in-channel and floodplain sediment contributions, nearby erosion hazards and a high concentration of development, roads and culverts. FL10 has slightly better transport capacity and a more highly constrained floodplain with more impervious area, road length and culverts. As with FL15 above, this may lead to local scour and downstream sedimentation but this can not be determined without a site-specific investigation.

D.3.5 Skokomish Subbasin

The Skokomish subbasin covers approximately 240 square miles, draining the eastern slopes of the Olympic Mountains and part of the southern shore of Hood Canal. The Skokomish River is the primary river system in this subbasin with two main branches: the South Fork Skokomish with drainage area of over 100 square miles and North Fork Skokomish which covers almost 120 square miles.

Land use in the subbasin is managed primarily for forestry, hydropower and agriculture with residential areas along the shores of the Cushman Reservoir and Hood Canal. The Skokomish Tribal Reservation lies in the estuary of the mainstem Skokomish River near its junction with the Hood Canal. The South Fork Skokomish is mostly comprised of USFS land with logging in the upper reaches and agriculture in the lower floodplain. Main tributaries are Pine Creek, Cedar Creek, Rock Creek and Vance Creek. The North Fork Skokomish contains the Cushman and Kokanee Reservoirs and bypasses water below the dams to power generating facilities for the City of Tacoma. Areas above the Cushman Dam are primarily Olympic National Park land with tributaries including Six Stream Creek and Big Creek. Large tributaries below the reservoirs are Dow Creek and McTaggert Creek. The confluence of the two forks forms a broad estuary at the southeast end of Hood Canal with rural, agricultural and residential land uses.

Figures D-9 and D-10 summarize the sediment aggradation analysis results for the Skokomish subbasin. A total of 159 locations were evaluated with the following results:

- ***Low potential for sediment aggradation*** – 32 sites. These sites lie on the South Fork Skokomish River, on the North Fork Skokomish River above Cushman Reservoir and in the higher elevations of tributaries. They fall mostly in areas where either transport capacity is high or sediment supply is low and there are few roads or development. The only point with a computed low potential for aggradation in the upper Skokomish delta is SK145 which falls near the confluence of Mussel Shell Creek with the Skokomish River. At this site, the sediment supply rating is moderate and the barrier rating is low while channel slopes indicate that the transport capacity is high.

- ***Moderate potential for sediment aggradation*** –73 sites. Road damage occurred at sites SK113, SK138, SK144 and SK146 during the storm of December of 2007. These sites are discussed below. Most of the sites with moderate potential for aggradation are located upstream of the junction of the North and South Forks of the Skokomish River either in the main river channels or on tributaries. As in other subbasins, they fall in low channel gradient areas or in areas of adverse change in channel slope. Many sites are near or at tributary points. Transport ratings are average with few barriers and moderate sediment supply (below the mean of all sites analyzed). There are a few exceptions: SK044 on the South Fork Skokomish has a high transport capacity since it falls in an accelerating reach but, due to nearby roads, the barrier rating is moderately high. Sites SK 008 (Cedar Creek), 103 (Skinwood Creek) and 118 (Dow Creek) have low sediment supply ratings but relatively high barrier ratings.

Six sites have moderate potential for aggradation in the Skokomish estuary area. They all have average transport capacity values and moderate sediment supply and barrier ratings.

- ***High potential for sediment aggradation*** – 51 sites. Road damage occurred at sites SK101, SK121 and SK135 during the storm of December of 2007. These sites are discussed below. Most of the sites with high aggradation potential are located on the mainstem Skokomish River and estuary, in broad floodplains on the North and South Fork Skokomish Rivers and at the inlet to the Cushman Reservoir. Two additional sites are located in the upper reaches of Vance and Cabin Creeks where there are rapid adverse changes in channel gradient. The lowest transport capacity values occur in the lowest reaches of the North and South Fork Skokomish Rivers: although these areas have few barriers to transport the very low transport capacity along with significant sediment supply lead to the high potential for aggradation. The other sites have moderate to low transport capacities and significant sediment supply as well as nearby roads and culverts.
- ***Very high potential for sediment aggradation*** – 3 sites. Sites SK125, SK132 and SK139 are all locations at SR101 where steep catchments descend to the floodplain or to the Hood Canal. They have uniformly above average ratings for low transport, sediment supply and sediment barriers when compared with all the sites evaluated in this study. As discussed for other subbasins, this is primarily due to:
    - Adverse changes in channel gradient depositing sediments as the steep streams reach the floodplain and cross the highway.
    - Large areas of scrub or grassland relative to catchment size with implied high sediment yields.
    - Large areas of impervious surface relative to catchment size indicating stream confinement.
    - Large number of nearby culverts with possible barriers to transport.

Areas of winter 2007 stream-related road damage in Skokomish Subbasin

SK113 – North Sunnyside Road, SK138 – Mussel Shell Creek, SK144 – East Purdy Cutoff Road, SK146 – Skokomish River at State Route 106 – Sites SK113, SK138 and SK144 have aggradation ratings of between 37 and 41. All these sites on roads bordering the floodplain have similar ratings values: below average transport capacity (50-58) due to adverse channel gradient change, moderate sediment supply and relatively few barriers to transport. No culverts are noted on the WDFW SalmonScape database. Since the hillside slopes are steep in these areas and the road damage notations refer to slides, the issue may be bank and hillslope stability which is not addressable in this analysis. A site-specific investigation would resolve the further potential for road damage. The site on the Skokomish River, SK146, has a high transport capacity (low low-transport rating of 5) with moderate values for sediment supply and possible barriers to transport. Since the site is located in the floodplain, erosion from channel migration would seem to be a more likely issue at this site than aggradation. Further evaluation would require more site-specific data.

SK101 – Skokomish Valley Road, SK121 – State Route 101 at Bourgault Road, SK135 – State Route 101 at Potlatch – These sites had high potential for sediment aggradation with values of 54, 62 and57, respectively. Site SK101 has average transport capacity with a low-transport rating of 49 due to adverse change in channel gradient, sediment supply is high (62) and barriers to transport are relatively low(23). Sediment aggradation is likely here because of deposition and reworking of floodplain sediments by channel migration. Further evaluation would require more site-specific data.

SK121 has a slightly low transport capacity (low-transport rating of 54), average sediment supply (43) and a relatively high amount of possible barriers to transport from roads, development and road crossings such as culverts (54). The analysis implies that without flow improvements this area may continue to aggrade. Further evaluation would require more site-specific data.

SK135 has a low transport capacity (low-transport rating of 63), moderate sediment supply (28) and a significant number of possible barriers to transport (barrier rating of 49) primarily from roads and impervious surface. Because the low transport rating is from large adverse change in channel gradient, sediment deposition at the road junction may cause an aggradation problem. Further evaluation would require more site-specific data.

D.3.6 South Shore Subbasin

The South Shore subbasin is comprised of small streams draining the coastal bluffs located on the southern shore of Hood Canal east of Belfair. These are part of WRIA 14. These small streams include Twanoh Falls Creek, Twanoh Creek, Holyoke Creek, and Big Bend Creek. With the exception of Devereaux Creek, all the drainages are less than 2 square miles in area. Much of the coastal area is residential with large residential areas in Union and near Belfair.

Figure D-11 summarizes the sediment aggradation analysis results for the South Shore subbasin. A total of 50 locations were evaluated with the following results:

- ***Low potential for sediment aggradation*** – 0 sites.
- ***Moderate potential for sediment aggradation*** – 3 sites. At two of these sites, SS01 and SS45, road damage occurred during the storm of December of 2007. These sites are discussed below. The site SS49 has an average sediment transport capacity along with moderate ratings for sediment supply and barriers.
- ***High potential for sediment aggradation*** – 27 sites. Sites SS04, SS33 and SS36 are WRIA 16 PU identified problem areas and are discussed below. The 24 other sites that were rated as high potential for sediment aggradation all lie along State Route 106. They have average to low transport capacities (average to high low-transport rating), average to high supply ratings, and a significant number of possible barriers to transport from nearby roads, culverts and impervious areas.

- ***Very high potential for sediment aggradation*** – 20 sites. Sites SS05, SS37 and SS47 are WRIA 16 PU identified problem areas and are discussed below. All of the sites with very high potential for sediment aggradation are along State Route 106. As in other subbasins, they are small coastal catchments with average to low transport capacity (average to high low-transport rating), and either high sediment supply or a large number of possible barriers to sediment transport or both. Site SS30 has the highest barrier rating out of all the sites analyzed because of road density and the large area of impervious surface compared to its catchment size.

WRIA 16 Planning Unit Identified Problem Areas in South Shore Subbasin

SS04 – Big Bend Creek at State Route 106, SS33 – Twanoh Creek at State Route 106, SS36 – Twanoh Falls Creek at Creekside Drive – These three sites were rated with high potential for sediment aggradation with values of 59, 60 and 63, respectively.

The analysis indicated that SS04 has an average transport capacity (49), low sediment supply (7) and a very high sediment barrier rating from impervious surfaces, culverts and roads. This carries the possibility of local areas of sediment aggradation at constrictions in the flow. The low sediment supply can result in locally eroded areas as well. The actual condition of barriers to transport determine whether sedimentation is an issue.

SS33 at Twanoh State Park has an average value for low-transport capacity (56) due an adverse change in channel gradient and above average sediment supply (56) and barrier ratings (34) due to erosion hazards and a large number of culverts This area can be expected to aggrade if nothing is done to stabilize upstream slopes and ensure minimal flow restrictions.

SS36 is located in an area of accelerating flow with a low low-transport rating of 36, an average sediment supply rating of 48, primarily from erosion hazards, and a high barrier rating of 69. The high transport capacity combined with nearby culverts and roads has the potential to cause either sedimentation if transport is not adequately conveyed or local areas of scour and downstream sedimentation if transport is unconstrained. Erosion has been confirmed to be a problem (Park, 2008) in that the main culvert at this site has been replaced to adequately to pass flows resulting in downstream sediment problems.

Specific recommendations would require data collection at these sites.

SS05 – Dalby Creek, SS37 – Twanoh Falls Creek at State Route 106, SS47 – Unnamed Creek West of 17601 State Route 106 – These three sites have very potential for sediment aggradation with ratings of 72, 90 and 86.

For SS05, Dalby Creek, transport capacity is average when compared with all the analyzed sites with a value of 48 and a slightly decelerating flow. The sediment supply rating is also average at 44, mostly due to upstream erosion hazards. This site has potentially large barriers to transport because of culverts, roads and impervious area and a very high barrier rating of 82. Ensuring adequate flow through the site would allow sediments to move gradually through the Creek and not accumulate during flood flows.

SS47, Twanoh Falls Creek at State Route 106, has low transport capacity (a low-transport rating of 59), high sediment loads from upstream (see SS36 above) and a barrier rating of 99. The analysis implies that this is a critical area for sediment aggradation and that without modifications, sediment problems will persist at this location.

SS47 on State Route 106 lies in an area of adverse change in channel gradient, with a low-transport rating of 61. Land use, in-channel and floodplain contributions as well as upstream erosion hazards and a high gradient reach result in a high sediment supply (76). In addition, the barrier rating is well above average at 64. This is a very likely area for continued sedimentation if no remedial action is undertaken.

Specific recommendations would require data collection at the sites.

Areas of winter 2007 stream-related road damage in South Shore Subbasin

SS01 – East McReavy Road, SS45 – East Trails End Road – The analysis at both these locations resulted in a moderate potential for sediment aggradation. The aggradation rating for SS01 is 38 with transport , supply and barrier ratings of 40, 14 and 46, respectively. Though the high barrier rating results in moderate potential for sedimentation, transport capacity is above average (below average low-transport rating) and sediment supply is low, so sedimentation may not actually be a problem for this site. The sediment aggradation potential rating for SS45 is 31. Transport, supply and barrier ratings are 52, 1 and 32, respectively. Since sediment supply is so low, sedimentation may not actually be a problem for this site either. As is the case for SS36, the actual condition of barriers to transport dictates whether sedimentation is an issue. Since road damage at both these sites resulted in slope failures, it is likely that a site-specific study would indicate erosion or bank instability. This task is not within the scope of this analysis and would require site-specific investigation.

D.4 Guidelines for Addressing Stream Aggradation Issues

The GIS-based diagnostic level assessment carried out for this investigation represents one step in an overall strategy for addressing stream aggradation in WRIA 16 and WRIA 14b. An area wide strategy for addressing this issue is a proactive ongoing process that recognizes the certainty of future flooding events and balances the allocation of resources between planning, maintenance and emergency management accordingly. The following is a brief outline of actions that address stream aggradation in the study area. They can be broken into five main tasks:

1. Assessment of identified and potential aggradation areas.
2. Evaluation of actual conditions and trends.
3. Prioritization and remediation in critical action areas.
4. Prevention of new problems.
5. Maintenance and follow-up.

Assessment of identified and potential aggradation areas – Diagnostic tools such as the GIS-based assessment developed for this investigation can assist greatly with the preliminary screening of problem areas. To ensure the accuracy of the assessments the tools need to be evaluated, refined and updated on an ongoing basis. Some of these improvements for the GIS-based analysis are discussed in detail in Section D.2.5. They include:

- Developing high resolution watercourse locations and verified area-wide catchment delineations,
- Extending selected existing datasets to cover the entire study area,
- Updating existing datasets to reflect current conditions,
- Expanding inventories of river works, culverts and river crossings including construction details and maintenance issues,
- Adding datasets that improve the predictive capabilities of the assessment tool,
- Refining the data analyses and validating the accuracy of the assessment tool, and
- Addressing the need for GIS-based channel form and floodplain cross section geometry, bank composition, as well as sediment and vegetation information.

Prioritization and evaluation of actual conditions and trends **–** Once possible sediment aggradation sites have been identified, selected high priority sites should be evaluated to confirm if they are actual problem areas. The severity of sediment aggradation problems should be evaluated using site specific assessments. Some of the activities that may be needed in this step are:

- Confirming the actual condition of culverts and floodplain structures and assessing their impact on the stream channel,
- Assessing the level of impact from floodplain modifying activities at, and upstream of selected sites,
- Performing a geomorphic analysis of selected sites and stream reaches. This includes assessment of historic watershed and channel changes as well as assessment of current conditions, and
- Evaluating hydraulic conditions at selected sites. If required, this includes modeling flows and sediment motion in the floodplain and at structures.

Remedial activities in prioritized critical action areas **–** Remediation of sites that have been confirmed as sediment aggradation problem areas requires a balance of short term, mid-range and long-term planning. While an immediate solution may be required to maintain use of infrastructure or habitat at a site, a solution that addresses the sources of the sedimentation problem usually involves long term changes. Many of the activities undertaken to address sediment aggradation issues are consistent with activities that also restore stream habitat. A useful summary can be found in WDFW's "Stream Habitat Restoration Guidelines," (Saldi-Caromile, 2004).

Short-term and emergency measures usually involve sediment removal, replacement and repair of infrastructure and construction of bank protection.

In the mid-range, re-engineering and modification of floodplain structures can enhance the capacity of a river or stream to both store and pass sediment. When planning these modifications, it is crucial to understand the impacts upstream, downstream and cross-stream of the structure so that the sedimentation problem does not simply migrate to a different portion of the channel. Some common approaches used in mountain drainages are:

- Culvert replacement,
- Bridge pier modification or re-alignment,
- Dike and levee modification or removal,
- Use of drop structures and porous weirs near development, and
- Bank protection modification or removal.

Long-term approaches reduce sediment influx, increase the ability of the watershed to store water during storm events and slow movement of sediments through a stream system. The following is a list of some of these techniques.

- Land use changes to reduce flood flows and sediment influx.
- Stabilization of upstream erosion and landslide hazards.

- Riparian restoration and management.
- Side channel and off-channel habitat restoration.
- Fish passage restoration.
- Use of Large wood, engineered log jams and boulder clusters.
- Beaver re-introduction.

Prevention of new problems – Watersheds constantly experience pressure from a population's need for natural resources, transportation, residential and commercial development, and recreation. As sedimentation issues are addressed, it is important to minimize the creation of new problems areas by review of current policies in place for land use, floodplain development as well as for design and selection of instream structures. Review of these policies is an ongoing task for preventing sediment aggradation problems.

Follow-up and maintenance – Any activities undertaken to reduce sedimentation problems will require monitoring and possible maintenance to ensure that the measures are working as planned. In addition, assessment tools also require follow-up to make certain that they reflect the current understanding of floodplain mechanics and make use of up-to-date data.

D.5 Conclusions and Recommendations

D.5.1 Conclusions

1. The GIS-based assessment successfully used available data to characterize selected sites in WRIA 16 and 14b. Since criteria were established to preferentially choose areas at risk for sedimentation, the analysis was designed to either confirm or disprove this assumption. Of 408 possible sediment aggradation problem areas: 67 were rated with a low potential for sediment aggradation, 130 were rated with moderate potential, 138 were identified at high potential and 73 were identified at very high potential for aggradation of sediment.

2. The investigation was successful in correctly rating 17 out 18 sites identified by the WRIA 16 PU as sediment aggradation problem areas. Of these areas, six were identified by the tool as high potential for aggradation and 11 as very high potential for aggradation. Findings for remaining site, rated as at moderate potential for aggradation were not consistent with reported sedimentation and highlighted additional resolution and data needs for the analysis.

3. The analysis evaluated 12 road damage incidents from the flood event of December 3, 2007. Six had moderate ratings, four were at high potential for aggradation and two were at very high potential. The findings were consistent with reported stream related road damage which included erosion, sedimentation and slope failures.

4. The GIS-based assessment is a tool for relative comparison of the possibility of sedimentation at a group of sites. Since the available data is not sufficient to positively identify an actual sediment aggradation problem, the tool is not definitive and needs site-specific confirmations of high aggradation locations.

5. The assessment used three components in the analysis: transport capacity, sediment supply and barriers to sediment transport. The relative magnitudes of these components allowed identification of probable causes of aggradation problems at high risk sites.

6. The GIS-based assessment tool can be improved expanding the types, extent and resolution of available data. Additional data and analysis needs are discussed in detail in Section D.2.5. They include:

    - Developing high resolution watercourse locations and verified area-wide catchment delineations,
    - Extending selected existing datasets to cover the entire study area,
    - Updating existing datasets to current conditions when possible,
    - Expanding inventory of river works, culverts, river crossings including details and maintenance issues, and

- Using high resolution data and field observations as well as historical maps and aerials to define channel form and floodplain cross section geometry, bank composition, sediment and vegetation information in GIS layers.

D.5.2 Recommended Future Tasks

1. Improvements to the GIS-based assessment tool – The predictive accuracy of the GIS-based assessment can be improved by the following activities.
   - Improving LiDAR coverage to refine catchment delineation and watercourse accuracy.
   - Comparing the improvements to accuracy using LiDAR vs DEM for a portion of study area where both datasets are present.
   - Validating the assessment tool by comparing results of GIS and field assessments at selected critical sites.
   - Expanding, updating and gathering additional datasets such as system-wide inventories of culvert hydraulics, large wood debris, bank stability or historic channel locations. This can be facilitated by actively coordinating Planning Unit partners to increase datasharing, GIS capabilities and the elimination of data gaps.
2. Site specific evaluation – For a subset of the high to very high potential sites:
   - Perform a site specific confirmation of aggradation,
   - Characterize the hydraulic condition of instream structures such as culverts,
   - Distinguish natural and man-made sediment issues, and
   - Make site specific recommendations for remedies.
3. Expansion of the GIS-based assessment to include general sedimentation issues: aggradation, erosion, and channel stability.

D.6 References

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Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of WRIA 16 Planning Unit for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Table D-1 – Problem Areas as Identified by WRIA 16 Impaired Rivers and Streams Technical Committee

WRIA 16 Impaired River Analysis – Aggradation Study

CREEK NAME	Point ID #	Identified Area	2007 damage	Approximate Location (WGS 84)		Roadway / Location	Erosion	Flooding	Sedimen-tation	Comments
				Latitude	Longitude					
WEST SHORE OF HOOD CANAL										
Finch Creek	FL15	X		47°24'24.29"N	123° 8'26.00"W	SR 101 Hoodsport	X	X		
Miller Creek	FL17	X		47°25'46.70"N	123° 7'31.74"W	SR 101		X	X	
Clark Creek	FL16	X		47°25'9.04"N	123° 7'53.22"W	SR 101		X	X	
Sund Creek	FL20	X		47°26'25.04"N	123° 7'12.66"W	SR 101		X	X	Study in process
Little Lilliwaup Creek	FL25	X		47°27'27.07"N	123° 6'48.34"W	SR 101		X	X	
Lilliwaup Creek	FL22	X		47°28'10.70"N	123° 6'58.99"W	Lilliwaup St. below falls	X		X	
Unnamed Creek	FL33	X	X	47°28'24.49"N	123° 5'23.41"W	N. Carroll Point Rd.		X	X	
Unnamed Creek	FL43	X	X	47°30'16.83"N	123° 3'29.27"W	Stetson Beach		X	X	Flows from Fosen Lake
Unnamed Creek	FL46	X	X	47°30'25.86"N	123° 3'29.67"W	Ayock Beach		X	X	
Duckabush River	DK19	X		47°39'4.15"N	122°56'1.53"W	SR 101	X	X	X	Includes Pierce Creek
Dosewallips River	DW44	X		47°41'25.64"N	122°53'58.37"W	SR 101 bridge				
Dosewallips River	DW36	X		47°42'5.06"N	122°55'27.68"W	410, 420 Appaloosa Dr.	X	X	X	Issues span C meander
"Every stream along SR101"		X				SR 101	X		X	
SOUTH SHORE OF HOOD CANAL										
Dalby Creek	SS05	X		47°20'47.51"N	123° 4'10.33"W	SR 106	X		X	
Big Bend Creek	SS04	X		47°20'52.77"N	123° 4'26.12"W	SR 106	X		X	Constrained by fill at mouth
Twanoh Creek	SS33	X		47°22'40.35"N	122°58'23.03"W	SR 106	X		X	Constrained by park
Twanoh Falls Creek	SS36	X		47°22'44.72"N	122°57'1.04"W	Creekside Dr.	X			DOT study
Twanoh Falls Creek	SS37	X		47°22'53.52"N	122°56'56.55"W	SR 106		X	X	DOT study
Small Unnamed Creek	SS47	X		47°24'30.78"N	122°52'41.47"W	SR 106	X		X	
2007 STREAM-RELATED ROAD DAMAGE										
Unnamed Creek	SK144		X	47°18'22.30"N	123° 9'1.61"W	E. Purdy Cutoff Rd.		X		Slide and water
Unnamed Creek	SK121		X	47°18'22.64"N	123°10'43.49"W	SR 101 (Bourgault Rd.)	X			Hwy closed
Skokomish River	SK101		X	47°18'55.68"N	123°13'23.26"W	Skokomish Valley Rd		X		Dike broke
Mussel Shell Creek	SK138		X	47°18'8.56"N	123° 9'41.22"W	E. Purdy Cutoff Rd.		X		Slide and water
Skokomish River	SK146		X	47°19'10.83"N	123° 8'23.44"W	SR 106				Hwy closed
Unnamed Creek	SK113		X	47°19'11.59"N	123°11'59.46"W	N. Sunnyside Rd				
Unnamed Creek	SK135		X	47°20'16.22"N	123° 9'38.93"W	SR 101 (Potlatch)				Hwy closed
Unnamed Creek	SS01		X	47°20'47.20"N	123° 5'34.58"W	E. McReavy Rd. MP 1				Road blocked
Unnamed Creek	SS45		X	47°22'56.82"N	122°53'56.16"W	E. Trails End Rd.	X			Slide
Finch Creek	FL10		X	47°24'22.24"N	123° 8'37.56"W	Finch Creek Bridge #2		X		Washout
Finch Creek	FL06		X	47°24'22.60"N	123° 8'58.06"W	Finch Creek Bridge #1		X		Washout
Eagle Creek	FL36		X	47°29'5.96"N	123° 4'42.48"W	SR 101				

Table D-2 – Sources of Information Used in GIS Analysis

WRIA 16 Impaired River Analysis – Aggradation Study

Data Set	Data Group	Data Type	Geometry Type	Date	Source	Spatial Scale	Extent	Projected Horizontal Coordinate System	Geographic Horizontal Coordinate System	Vertical Datum
USGS Digital Elevation Models	General	Raster (ESRI GRID)			USGS	10 m pixels	1:24K Quads, DEMs mosaiced to a single file	NAD 1927 UTM Zone 10N	GCS North American 1927	NGVD27
USGS Topographic maps	General	Image			USGS	NA	1:24K quads in WRIA	NAD 1927 UTM Zone 10N	GCS North American 1927	
NAIP Aerial Photos	General	Raster (MrSID)		2006	USDA	1 m pixels	Mason Co. and Jefferson Co.	NAD 1983 UTM Zone 10N	GCS North American 1983	
Mason Co. Aerial Photo	General	Raster (MrSID)		2005	WDNR via Mason Co.	18 inch pixels	Parts of Mason, Kitsap, Pierce and Thurston Cos.	NAD 1983 StatePlane WA South FIPS 4602 Feet	GCS North American 1983	
WSDOT State Roads	General	Vector (shapefile)	Lines	12/31/07	WADOT	1:24K	WA State	NAD 1983 HARN StatePlane WA South FIPS 4602 Feet	GCS North American 1983 HARN	
Mason Co. Roads	General	Vector (shapefile)	Lines	3/23/09	Mason Co. GIS	Based on 2005 aerials	Mason Co.	NAD 1983 StatePlane WA South FIPS 4602 Feet	GCS North American 1983	
Jefferson Co. Roads	General	Vector (shapefile)	Lines		Jefferson Co. GIS		Jefferson Co. outside of National Forest and Park	NAD 1983 StatePlane WA North FIPS 4601 Feet	GCS North American 1983	
WRIA Boundaries	Hydrology	Vector (shapefile)	Polygon	2006	WA Ecology		WRIA 16 and 14b	NAD 1983 HARN StatePlane WA South FIPS 4602 Feet	GCS North American 1983 HARN	
WDNR 1:24K Watercourses	Hydrology	Vector (coverage)	Lines	3/1/09	WDNR	1:24K	Mason and Jefferson Cos.	NAD 1983 HARN StatePlane WA South FIPS 4602 Feet	GCS North American 1983 HARN	
WDNR 1:24K Waterbodies	Hydrology	Vector (coverage)	Polygons or lines	3/1/09	WDNR	1:24K	Mason and Jefferson Cos.	NAD 1983 HARN StatePlane WA South FIPS 4602 Feet	GCS North American 1983 HARN	
Watershed Hydrologic Unit Boundaries	Hydrology	Vector (shapefile)	Polygons	9/3/08	PNHF		WA State (clipped to study area)	None	GCS North American 1983	
FEMA 100 year Floodplain	Hydrology	Vector (coverage)	Polygons	1996	FEMA Q3 via WA Ecology	1:24K	Mason and Jefferson Cos.	None	GCS North American 1927	
2006 Impervious Surfaces from HCCC	Hydrology	Vector (shapefile)	Polygons	2006	HCCC	based on 1 m pixel	Parts of Kitsap, Mason, Jefferson, & Clallam Cos.	NAD 1983 UTM Zone 10N	GCS North American 1983	
2001 Impervious Surfaces from 2001 NLCD	Hydrology	Raster (TIFF)		2001	WA Ecology	30 m pixels	Western WA	NAD 1983 HARN Lambert Conformal Conic	GCS North American 1983 HARN	
NLCD Land Cover	Land Use	Raster (TIFF)		2001	NLCD via WA Ecology	30 m pixels	Western WA	NAD 1983 HARN Lambert Conformal Conic	GCS North American 1983 HARN	
SalmonScape: Fish Passage	Fish Habitat	Vector (shapefile)	Points	4/30/04	WDFW	GPS <=5 m	WRIA 16 and WRIA 14	NAD 1983 HARN StatePlane WA South FIPS 4602 Feet	GCS North American 1983 HARN	
WA Coastal Atlas Unstable Slopes	Hazards	Vector (shapefile)	Polygons	1979	WA Ecology	1:24K	WA State Coastlines	NAD 1983 HARN StatePlane WA South FIPS 4602 Feet	GCS North American 1983 HARN	
Mason Co. Landslide Hazards	Hazards	Vector (shapefile)	Polygons	1/25/07	Mason Co. GIS	1:12K	Mason Co. (partial)	NAD 1983 StatePlane WA South FIPS 4602 Feet	GCS North American 1983	
Jefferson Co. Soil Erosion Hazards	Hazards	Vector (shapefile)	Polygons	3/19/97	Jefferson Co. GIS		Jefferson Co.	NAD 1983 StatePlane WA North FIPS 4601 Feet	GCS North American 1983	

Table D-3 – USGS Gauge Data Used for 5-Year Peak Flow Analysis

WRIA 16 Impaired River Analysis – Aggradation Study

Station No.	USGS Gauge Site Description	Period of Record for Peak Flows			Drainage Area.	
		Begin Date	End Date	No. of Peaks	Km^2	Mi^2
12059800	South Fork Skokomish near Hoodsport	10/21/1963	3/4/1979	15	67.3	26.0
12056500	NF Skok. River below Staircase Rapids	2/2/1925	11/15/2006	83	148	57.2
12060000	South Fork Skokomish River near Potlatch	1/31/1924	10/21/1963	27	170	65.6
12060500	South Fork Skokomish River near Union	2/26/1932	11/15/2006	65	198	76.3
12061500	Skokomish River near Potlatch	12/1/1933	12/25/2005	64	332	128
12058800	NF Skok, R. below Lower Cushman Dam	8/28/1989	12/15/2006	19	264	102
12059500	NF Skokomish River near Potlatch	2/7/1945	11/6/2006	63	303	117
12054600	Jefferson Creek near Eldon	2/18/1958	3/4/1979	22	55.9	21.6
12054500	Hamma Hamma River near Eldon	11/30/1951	3/4/1979	28	133	51.3
12054000	Duckabush River near Brinnon	1/1/1939	11/6/2006	69	172	66.5
12053000	Dosewallips River near Brinnon	1/23/1931	1/14/1968	38	242	93.5
12053400	Dosewallips River Tributary near Brinnon	2/10/1951	12/13/1969	20	1.61	0.62
12056300	Annas Bay Tributary near Potlatch	12/28/1949	4/9/1970	21	2.12	0.82
12058000	Deer Meadow Creek near Hoodsport	1/2/1953	3/4/1979	27	4.74	1.83
12065000	*Mission Creek near Belfair**	1/4/1946	1/9/1953	8	11.5	4.43
12052400	*Penny Creek near Quilcene**	2/22/1949	1/14/1968	20	17.6	6.78
12067500	*Tahuya River near Belfair**	4/11/1946	11/3/1955	11	38.8	15.0
12063500	*Union River near Belfair**	10/19/1947	4/30/1959	12	51.3	19.8
	** Outside WRIA 16 and 14b*					

Table D-4 – Regression Coefficients for 5-Year Peak Discharge Prediction

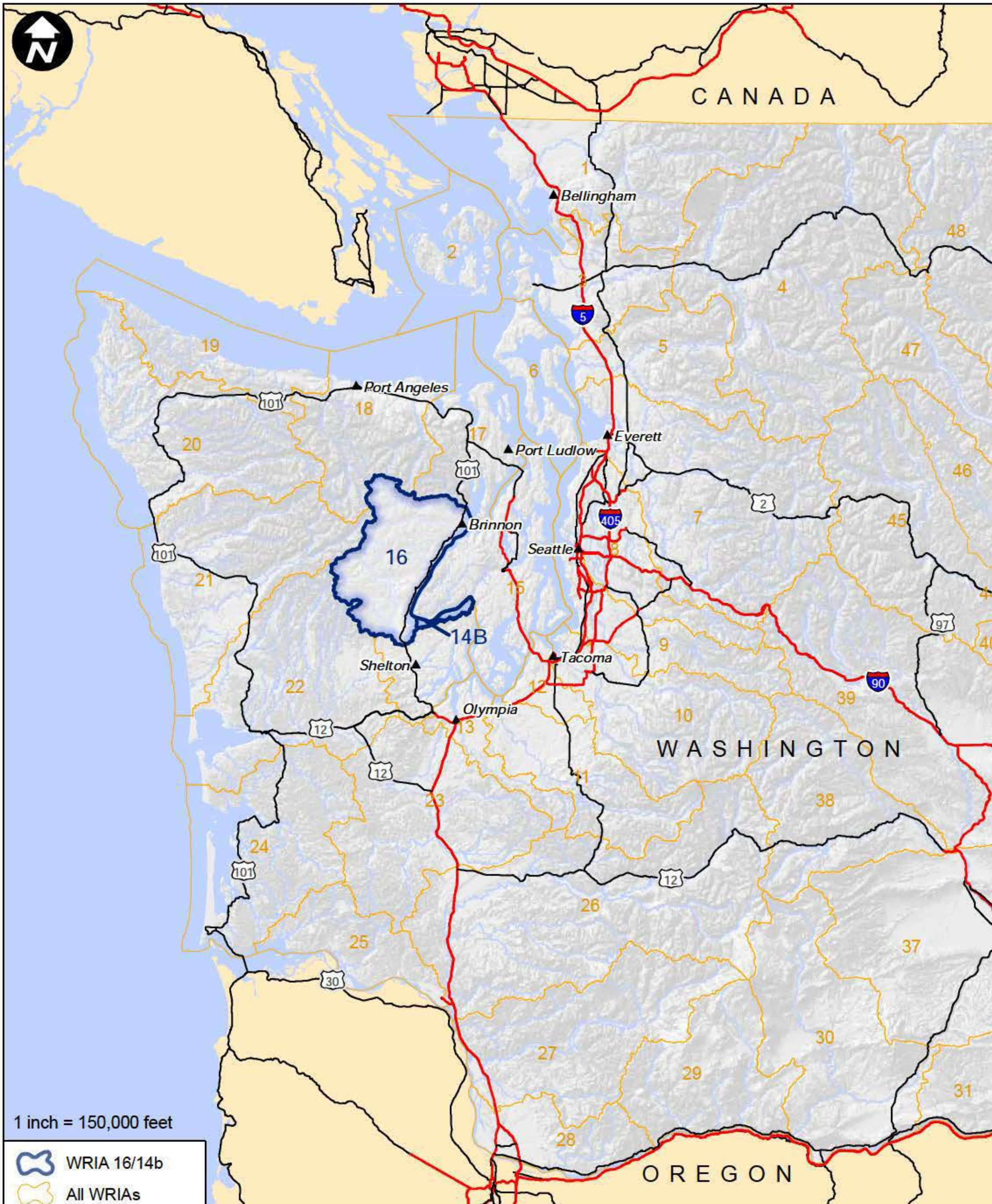
WRIA 16 Impaired River Analysis – Aggradation Study

	K (metric)	K (English)	n	R^2
Coastal Catchments	**1.29**	**97.12**	**0.798**	**0.956**
Northern Catchments	**7.61**	**473.54**	**0.596**	**0.999**
Skokomish River	**0.834**	**89.5**	**1.17**	**0.969**
North Fork Skokomish below Cushman Dam	**0.0004**	**0.120**	**2.15**	**1**
5-year Peak Discharge = (K)*Area^n		**K = Regression Coefficient n = Regression Exponent R^2 = Coefficient of Determination (Correlation Coefficient)**		

Table D-5 – Sediment Agggradation Rating Statistics

WRIA 16 Impaired River Analysis – Aggradation Study

	Scaled (0-100) Cumulative Aggradation Rating	Scaled Low Transport Rating	Scaled Supply Rating	Scaled Barrier Rating
Maximum Value	**100**	**100**	**100**	**100**
Minimum Value	**0**	**0**	**0**	**0**
Mean Value	**47**	**51**	**40**	**28**
Median	**48**	**54**	**38**	**25**
Standard Deviation	**21**	**17**	**21**	**23**



Project Location Map

WRIA 16 Impaired Rivers Analysis - Aggradation Study
Washington

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. D-1
REVISED BY: -	

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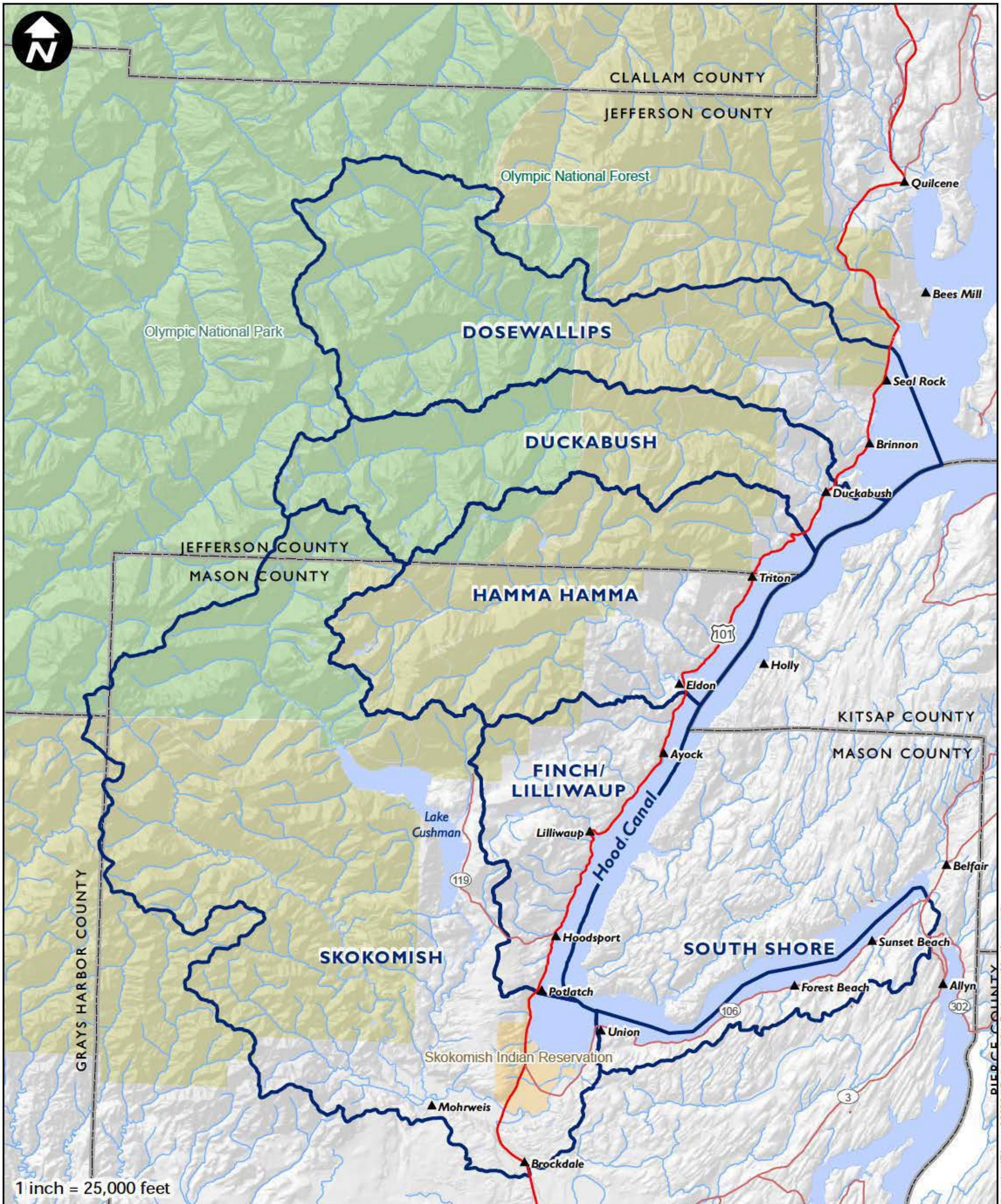

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Study Area Map

WRIA 16 Impaired Rivers Analysis - Aggradation Study
Washington

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. D-2
REVISED BY: -	

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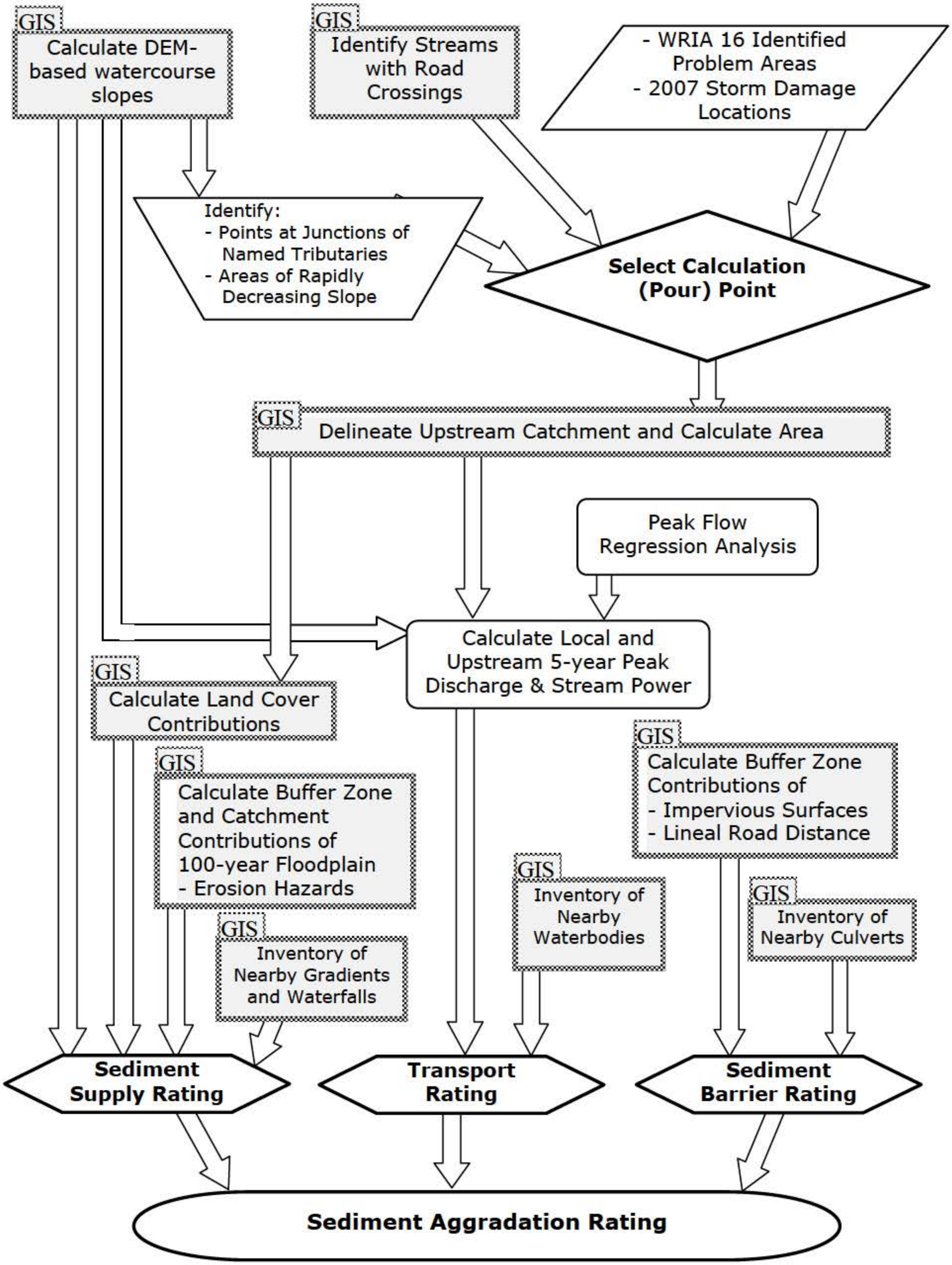


Figure D-3
GIS Analysis Flow Chart
WRIA 16 Impaired River Analysis – Aggradation Study

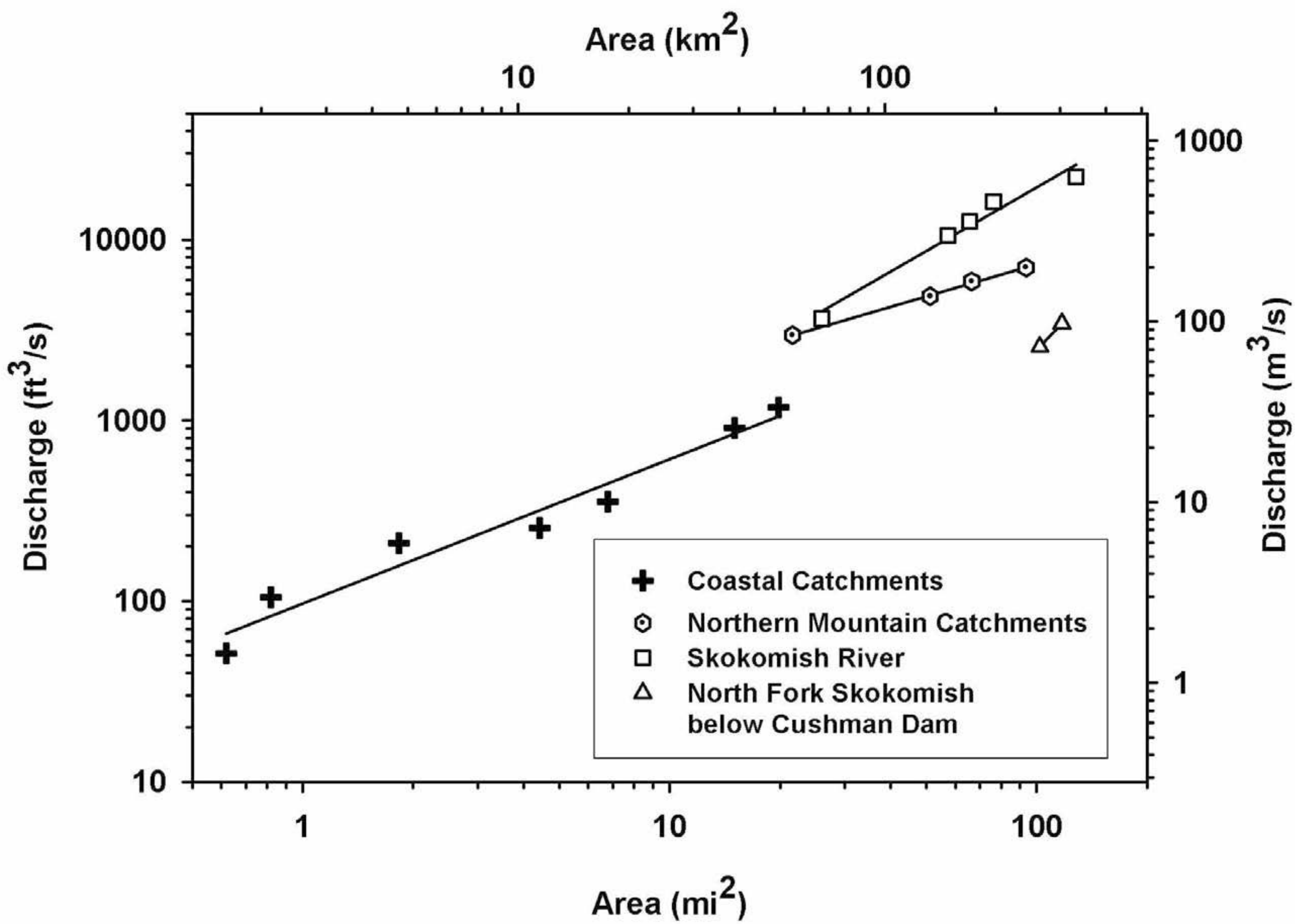
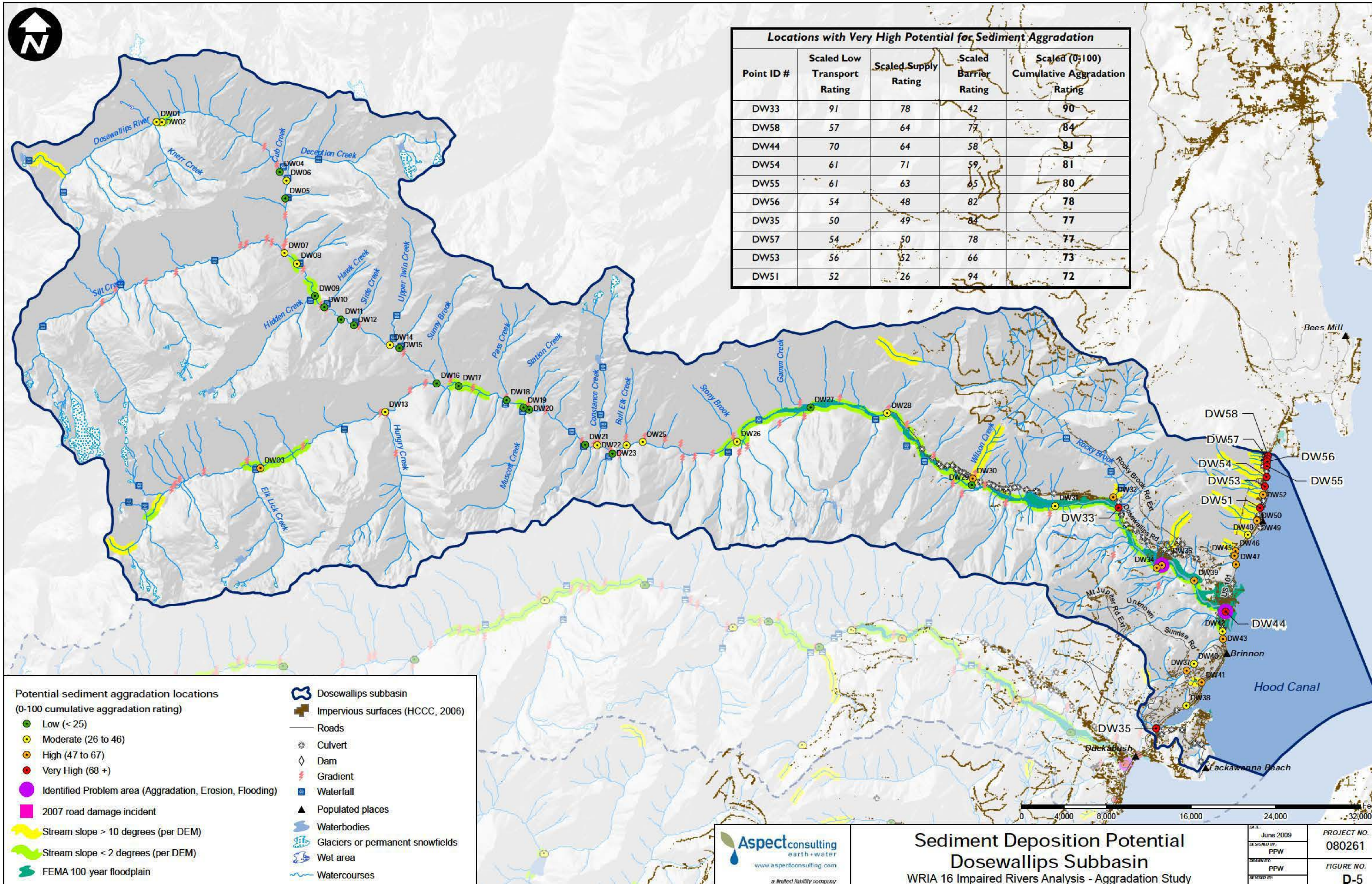


Figure D-4
5-Year Peak Flow Regression Analysis
WRIA 16 Impaired River Analysis – Aggradation Study



Locations with Very High Potential for Sediment Aggradation

Point ID #	Scaled Low Transport Rating	Scaled Supply Rating	Scaled Barrier Rating	Scaled (0-100) Cumulative Aggradation Rating
DW33	91	78	42	90
DW58	57	64	77	84
DW44	70	64	58	81
DW54	61	71	59	81
DW55	61	63	65	80
DW56	54	48	82	78
DW35	50	49	84	77
DW57	54	50	78	77
DW53	56	52	66	73
DW51	52	26	94	72

Potential sediment aggradation locations
(0-100 cumulative aggradation rating)
- Low (< 25)
- Moderate (26 to 46)
- High (47 to 67)
- Very High (68 +)
- Identified Problem area (Aggradation, Erosion, Flooding)
- 2007 road damage incident
- Stream slope > 10 degrees (per DEM)
- Stream slope < 2 degrees (per DEM)
- FEMA 100-year floodplain

- Dosewallips subbasin
- Impervious surfaces (HCCC, 2006)
- Roads
- Culvert
- Dam
- Gradient
- Waterfall
- Populated places
- Waterbodies
- Glaciers or permanent snowfields
- Wet area
- Watercourses

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Sediment Deposition Potential Dosewallips Subbasin

WRIA 16 Impaired Rivers Analysis - Aggradation Study

DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -

PROJECT NO. 080261
FIGURE NO. D-5

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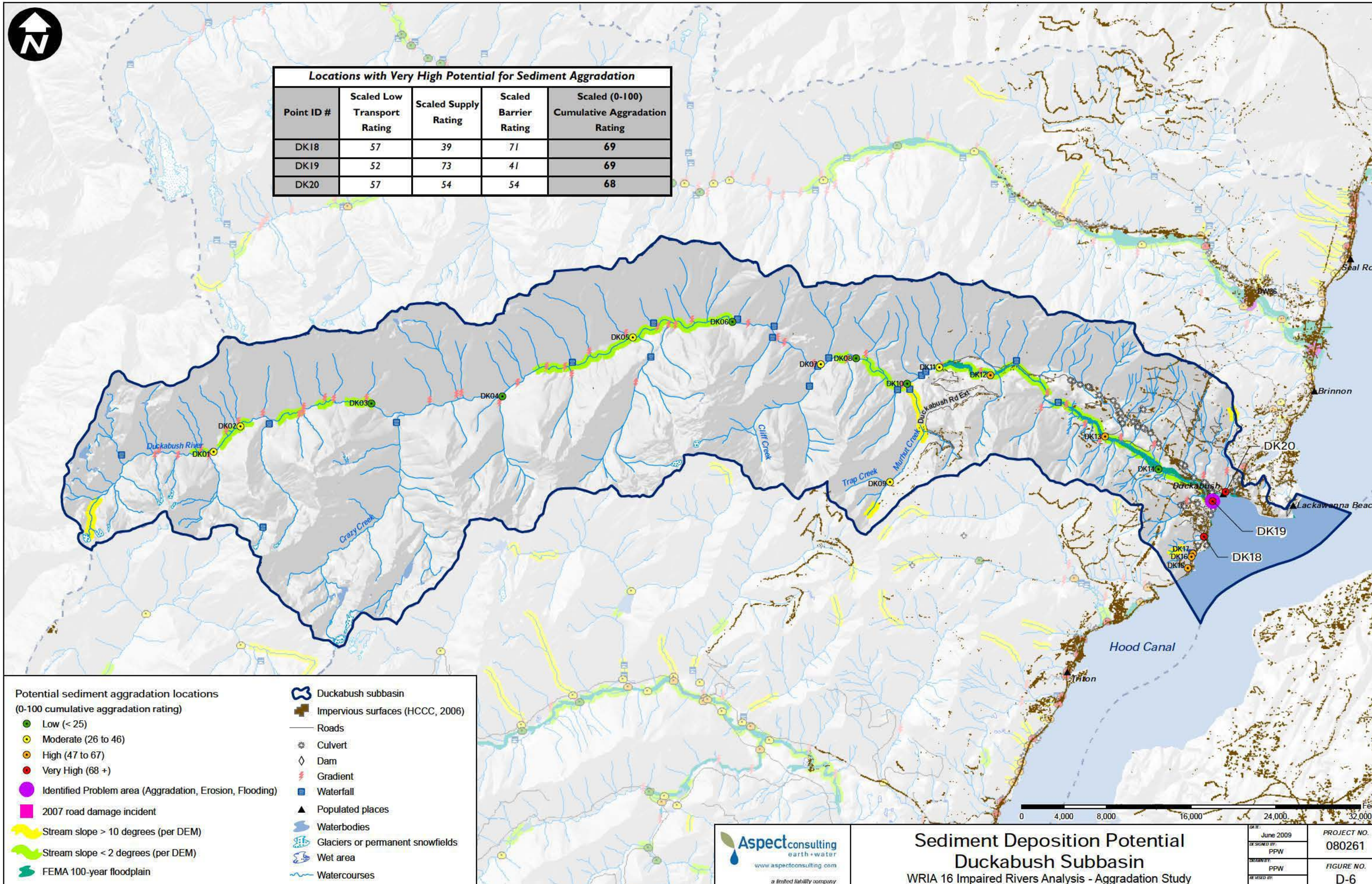

Locations with Very High Potential for Sediment Aggradation

Point ID #	Scaled Low Transport Rating	Scaled Supply Rating	Scaled Barrier Rating	Scaled (0-100) Cumulative Aggradation Rating
DK18	57	39	71	**69**
DK19	52	73	41	**69**
DK20	57	54	54	**68**

Potential sediment aggradation locations
(0-100 cumulative aggradation rating)
- Low (< 25)
- Moderate (26 to 46)
- High (47 to 67)
- Very High (68 +)
- Identified Problem area (Aggradation, Erosion, Flooding)
- 2007 road damage incident
- Stream slope > 10 degrees (per DEM)
- Stream slope < 2 degrees (per DEM)
- FEMA 100-year floodplain
- Duckabush subbasin
- Impervious surfaces (HCCC, 2006)
- Roads
- Culvert
- Dam
- Gradient
- Waterfall
- Populated places
- Waterbodies
- Glaciers or permanent snowfields
- Wet area
- Watercourses

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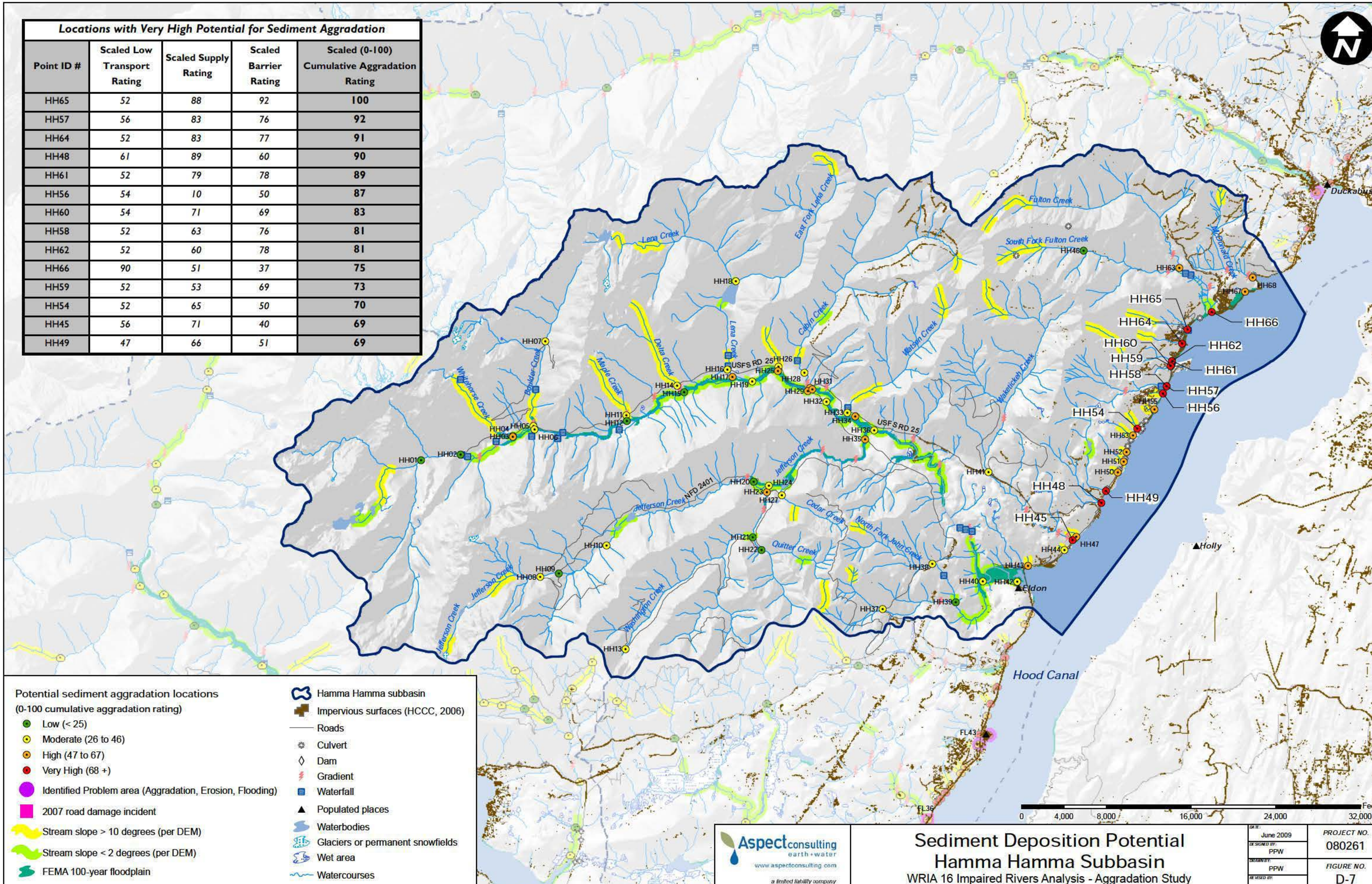
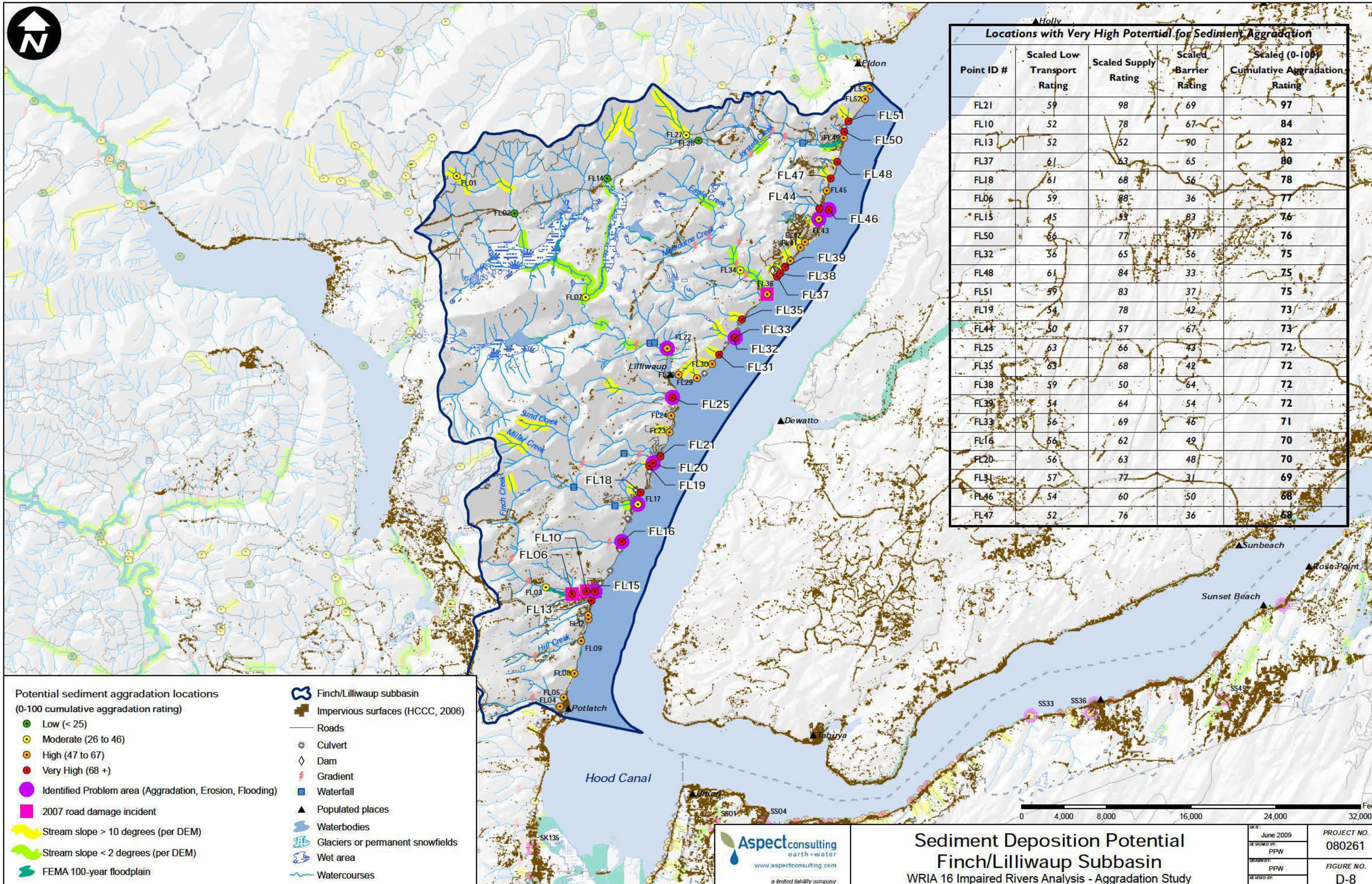
Sediment Deposition Potential
Duckabush Subbasin
WRIA 16 Impaired Rivers Analysis - Aggradation Study

DATE: June 2009
DESIGNED BY: PPW
DRAWN BY: PPW
REVISED BY: -
PROJECT NO. 080261
FIGURE NO. D-6

Locations with Very High Potential for Sediment Aggradation

Point ID #	Scaled Low Transport Rating	Scaled Supply Rating	Scaled Barrier Rating	Scaled (0-100) Cumulative Aggradation Rating
HH65	52	88	92	**100**
HH57	56	83	76	**92**
HH64	52	83	77	**91**
HH48	61	89	60	**90**
HH61	52	79	78	**89**
HH56	54	10	50	**87**
HH60	54	71	69	**83**
HH58	52	63	76	**81**
HH62	52	60	78	**81**
HH66	90	51	37	**75**
HH59	52	53	69	**73**
HH54	52	65	50	**70**
HH45	56	71	40	**69**
HH49	47	66	51	**69**





Locations with Very High Potential for Sediment Aggradation

Point ID #	Scaled Low Transport Rating	Scaled Supply Rating	Scaled Barrier Rating	Scaled (0-100) Cumulative Aggradation Rating
FL21	59	98	69	**97**
FL10	52	78	67	**84**
FL13	52	52	90	**82**
FL37	61	63	65	**80**
FL18	61	68	56	**78**
FL06	59	88	36	**77**
FL15	45	53	83	**76**
FL50	56	77	47	**76**
FL32	56	65	56	**75**
FL48	61	84	33	**75**
FL51	59	83	37	**75**
FL19	54	78	42	**73**
FL44	50	57	67	**73**
FL25	63	66	43	**72**
FL35	63	68	42	**72**
FL38	59	50	64	**72**
FL39	54	64	54	**72**
FL33	56	69	46	**71**
FL16	56	62	49	**70**
FL20	56	63	48	**70**
FL31	57	77	31	**69**
FL46	54	60	50	**68**
FL47	52	76	36	**68**

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Sediment Deposition Potential
Finch/Lilliwaup Subbasin

WRIA 16 Impaired Rivers Analysis - Aggradation Study

DATE:	June 2009	PROJECT NO.	080261
DESIGNED BY:	PPW		
DRAWN BY:	PPW	FIGURE NO.	D-8
REVISED BY:	-		

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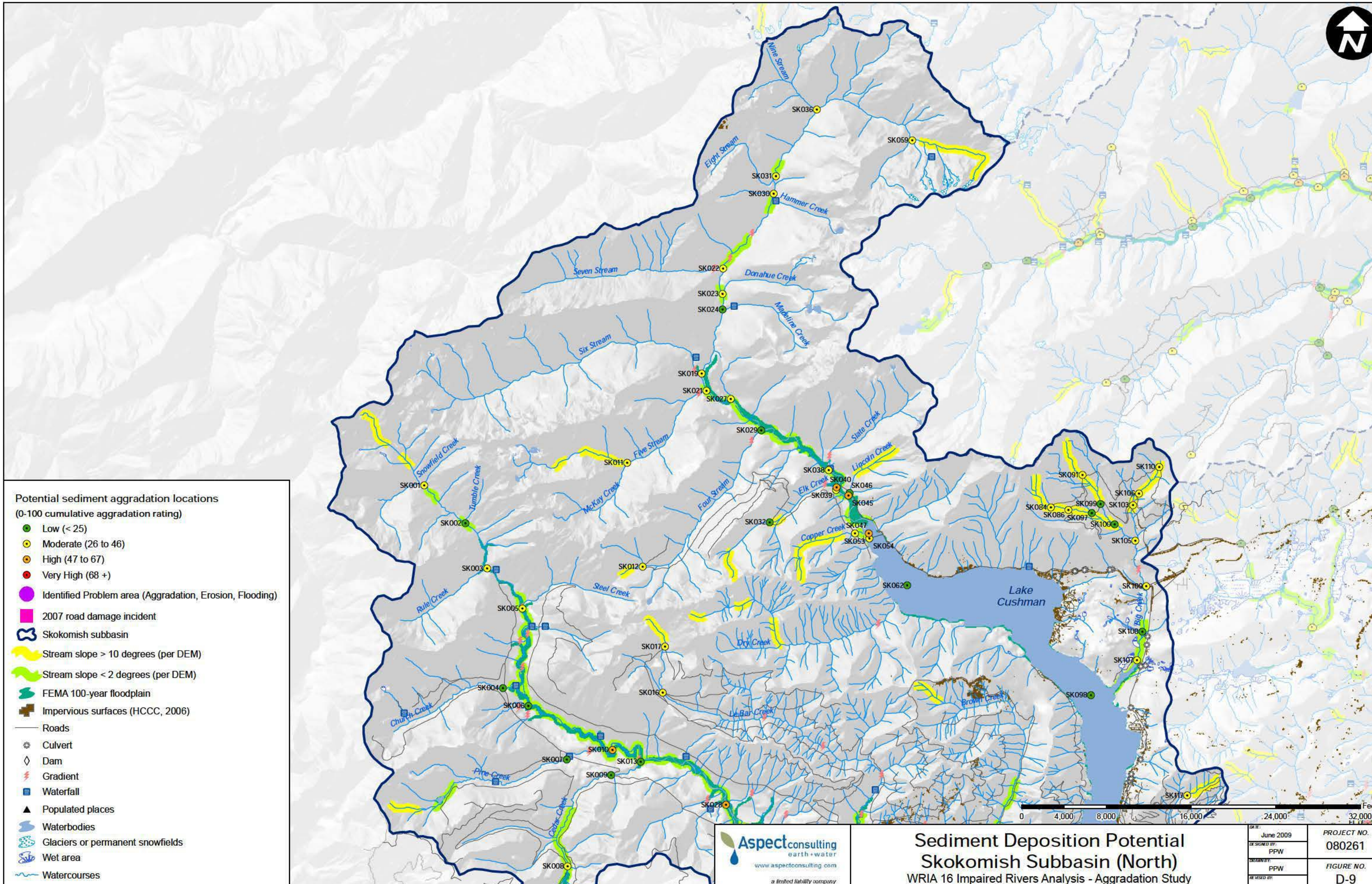

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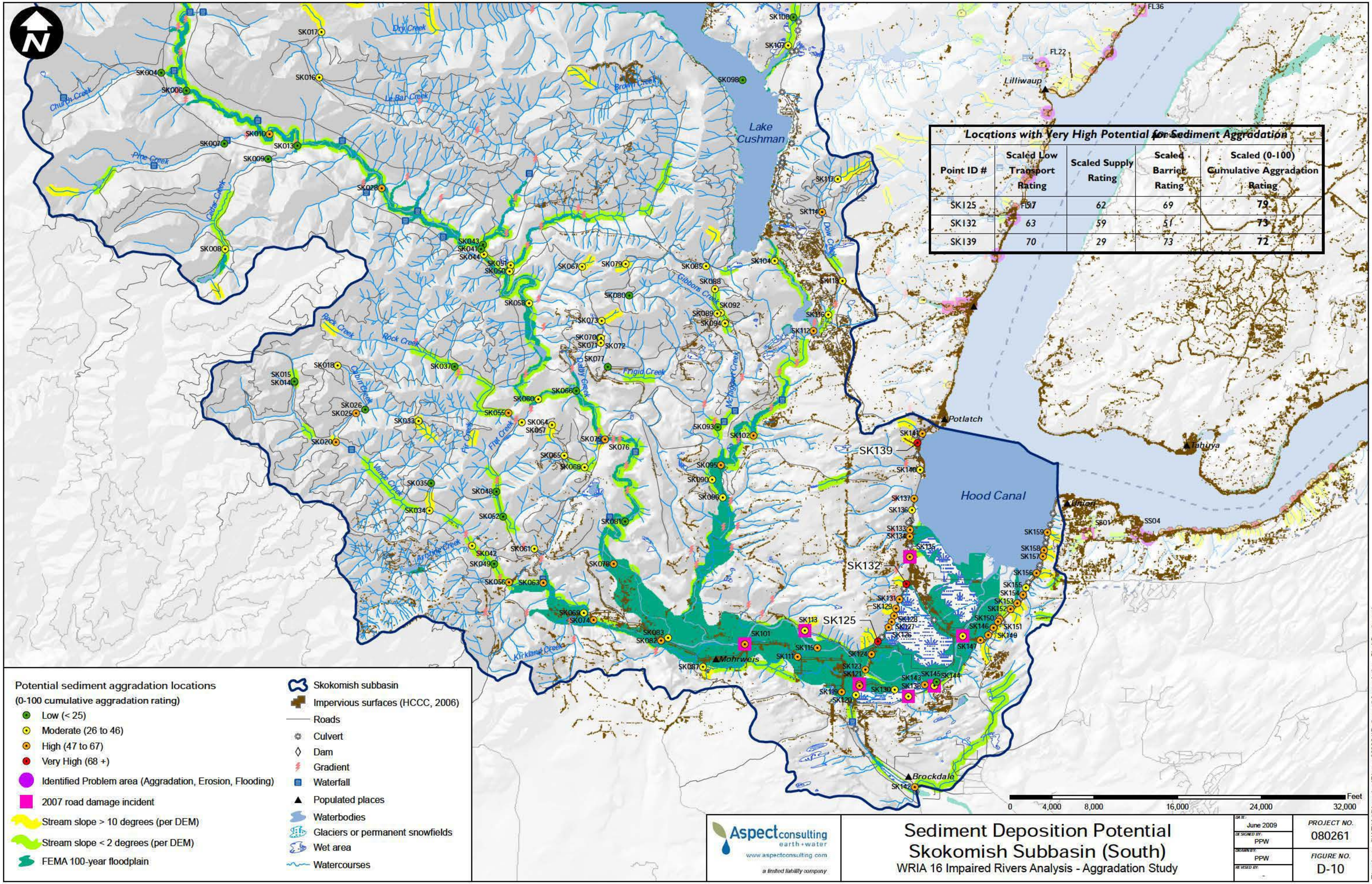
Sediment Deposition Potential
Skokomish Subbasin (North)

WRIA 16 Impaired Rivers Analysis - Aggradation Study

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. D-9
REVISED BY: -	



Locations with Very High Potential for Sediment Aggradation

Point ID #	Scaled Low Transport Rating	Scaled Supply Rating	Scaled Barrier Rating	Scaled (0-100) Cumulative Aggradation Rating
SK125	57	62	69	**79**
SK132	63	59	51	**73**
SK139	70	29	73	**72**

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Sediment Deposition Potential
Skokomish Subbasin (South)

WRIA 16 Impaired Rivers Analysis - Aggradation Study

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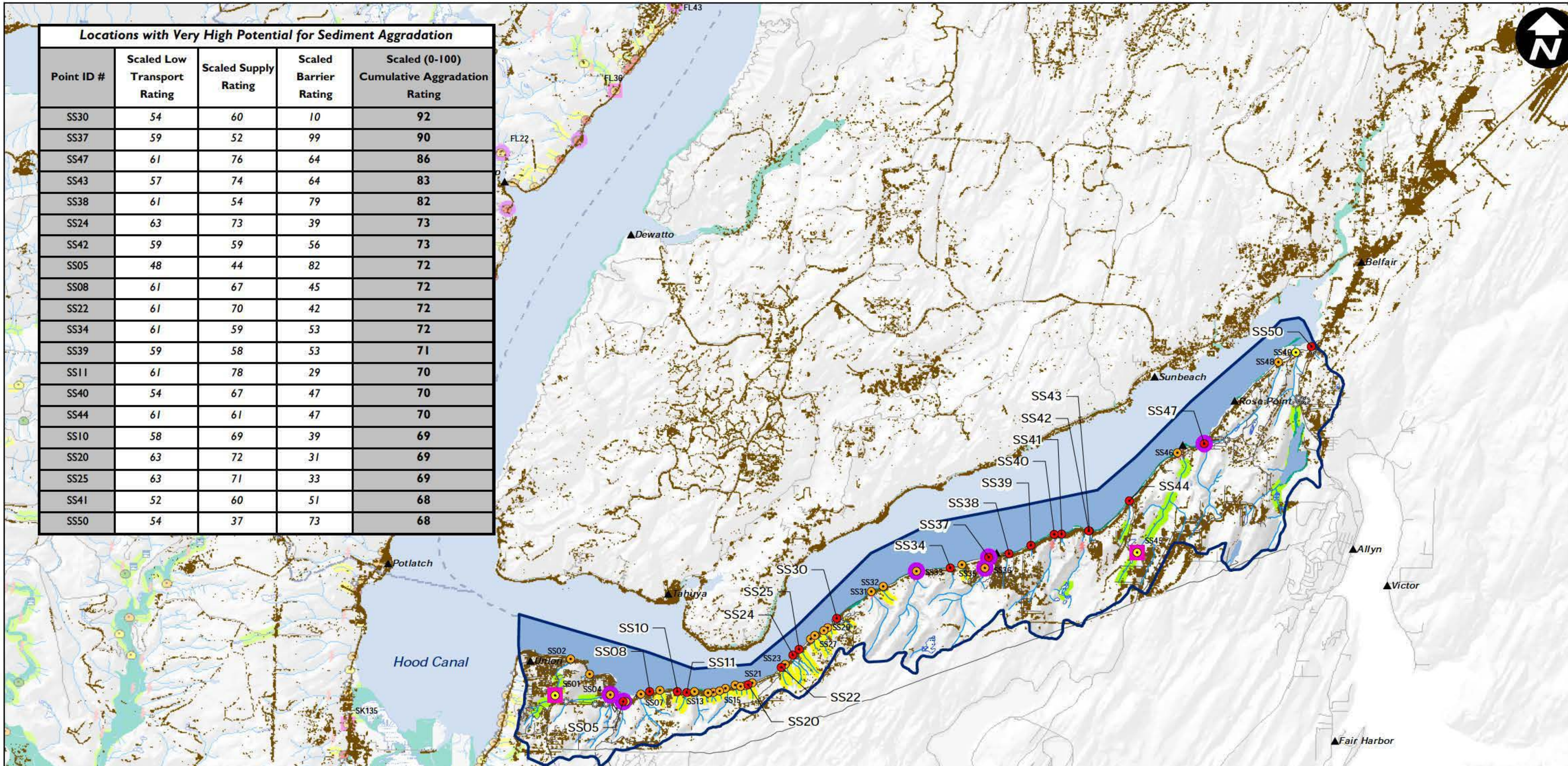
REVISED BY:	-
PROJECT NO.	080261
FIGURE NO.	D-10

Locations with Very High Potential for Sediment Aggradation

Point ID #	Scaled Low Transport Rating	Scaled Supply Rating	Scaled Barrier Rating	Scaled (0-100) Cumulative Aggradation Rating
SS30	54	60	10	92
SS37	59	52	99	90
SS47	61	76	64	86
SS43	57	74	64	83
SS38	61	54	79	82
SS24	63	73	39	73
SS42	59	59	56	73
SS05	48	44	82	72
SS08	61	67	45	72
SS22	61	70	42	72
SS34	61	59	53	72
SS39	59	58	53	71
SS11	61	78	29	70
SS40	54	67	47	70
SS44	61	61	47	70
SS10	58	69	39	69
SS20	63	72	31	69
SS25	63	71	33	69
SS41	52	60	51	68
SS50	54	37	73	68



Potential sediment aggradation locations
(0-100 cumulative aggradation rating)

- Low (< 25)
- Moderate (26 to 46)
- High (47 to 67)
- Very High (68 +)
- Identified Problem Area (Aggradation, Erosion, Flooding)
- 2007 road damage incident
- Stream slope > 10 degrees (per DEM)
- Stream slope < 2 degrees (per DEM)
- FEMA 100-year floodplain
- South Shore subbasin
- Impervious surfaces (HCCC, 2006)
- Roads
- Culvert
- Dam
- Gradient
- Waterfall
- Populated places
- Waterbodies
- Glaciers or permanent snowfields
- Wet area
- Watercourses

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Sediment Deposition Potential South Shore Subbasin

WRIA 16 Impaired Rivers Analysis - Aggradation Study

DATE: June 2009	PROJECT NO. 080261
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. D-11
REVISED BY: -	

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ATTACHMENT A

Analysis Locations

Attachment A – Analysis Location

WRIA 16 Impaired River Analysis – Aggradation Study

Point #	GIS Watercourse name	Identified Problem Area	2007 Storm Damage	Road Crossing?	Stream junction	Catchment Area (sq. mi.)	Catchment Area Uncertain	Cumulative Aggradation Rating	Low Transport Rating	Supply Rating	Barrier Rating
DK01	Duckabush River				Unnamed Crk.	7.28		36	66	31	0
DK02	Duckabush River				Unnamed Crk.	8.28		34	59	33	0
DK03	Duckabush River				Crazy Crk.	15.40		10	30	11	0
DK04	Duckabush River				One Too Many Crk.	31.69		2	14	10	0
DK05	Duckabush River				Unnamed Crk.	37.97		30	54	29	0
DK06	Duckabush River				Unnamed Crk.	46.61		18	52	6	0
DK07	Duckabush River				Cliff Crk.	53.55		35	58	36	0
DK08	Duckabush River				Unnamed Crk.	55.11		3	16	10	0
DK09	Murhut Creek				Trap Crk.	1.14		29	56	22	2
DK10	Duckabush River				Murhut Crk.	60.63		3	11	14	0
DK11	Duckabush River			Duckabush Rd		61.49		43	58	37	14
DK12	Duckabush River				Unnamed Crk.	64.09		62	100	42	9
DK13	Duckabush River				Unnamed Crk.	69.92		57	49	87	4
DK14	Duckabush River				Unnamed Crk.	73.79		24	14	56	0
DK15	Unnamed Creek			US 101		0.05	X	51	52	33	43
DK16	Unnamed Creek			US 101		0.10		66	54	55	50
DK17	Unnamed Creek			US 101		0.11		65	54	44	58
DK18	Unnamed Creek			US 101		0.21		69	57	39	71
DK19	Duckabush River	X		US 101		77.29		69	52	73	41
DK20	Unnamed Creek			US 101		0.38		68	57	54	54
DW01	Dosewallips River				Knerr Crk.	5.34		31	54	31	0
DW02	Dosewallips River				Butler Crk.	5.82		32	56	32	0
DW03	West Fork Dosewallips River				Elk Lick Crk.	10.32		49	91	34	0
DW04	Dosewallips River				Cub Crk.	9.84		6	11	21	0
DW05	Dosewallips River				Cache Crk.	14.87		10	14	26	0
DW06	Dosewallips River				Deception Crk.	14.26		35	56	39	0
DW07	Dosewallips River				Silt Crk.	29.67		35	56	38	0
DW08	Dosewallips River				Burdick Crk.	30.91		35	56	38	0
DW09	Dosewallips River				Hidden Crk.	33.96		7	18	15	0
DW10	Dosewallips River				Hawk Crk.	34.60		7	5	29	0
DW11	Dosewallips River				Crag Crk.	35.44		1	11	11	0
DW12	Dosewallips River				Slide Crk.	35.64		8	14	23	0
DW13	West Fork Dosewallips River				Hungry Crk.	19.31		37	61	38	0
DW14	Dosewallips River				Upper Twin Crk.	37.01		30	54	29	0
DW15	Dosewallips River				Lower Twin Crk.	39.20		5	9	21	0
DW16	Dosewallips River				W. Fork Dosewallips River	59.97		25	45	27	0
DW17	Dosewallips River				Sunny Brook	62.13		2	11	13	0
DW18	Dosewallips River				Pass Crk.	65.44		5	9	21	0
DW19	Dosewallips River				Muscott Crk.	68.01		6	11	21	0
DW20	Dosewallips River				Station Crk.	68.98		8	18	19	0
DW21	Dosewallips River				Tumbling Crk.	70.94		4	5	23	0
DW22	Dosewallips River				Slide Crk.	73.20		39	58	39	4
DW23	Dosewallips River				Brokenfinger Crk.	73.82		7	11	24	0

Point #	GIS Watercourse name	Identified Problem Area	2007 Storm Damage	Road Crossing?	Stream junction	Catchment Area (sq. mi.)	Catchment Area Uncertain	Cumulative Aggradation Rating	Low Transport Rating	Supply Rating	Barrier Rating
DW24	Dosewallips River				Bull Elk Crk.	74.86		31	54	31	0
DW25	Dosewallips River				Miners Crk.	75.56		30	49	33	0
DW26	Dosewallips River				Stony Brook	79.97		31	54	31	0
DW27	Dosewallips River				Gamm Crk.	85.93		14	18	32	0
DW28	Dosewallips River				Unnamed Crk.	89.82		46	56	51	11
DW29	Dosewallips River				Wilson Crk.	94.67		11	0	24	19
DW30	Wilson Creek			Dosewallips Rd		0.34		51	56	29	42
DW31	Dosewallips River				split channel reconnect	99.08		46	56	61	0
DW32	Rocky Brook			Dosewallips Rd		8.80		57	61	47	33
DW33	Dosewallips River				Rocky Brook	109.18		90	91	78	42
DW34	Dosewallips River				Unnamed Crk.	113.10	X	50	54	54	18
DW35	Unnamed Creek			US 101		0.11		77	50	49	84
DW36	Unnamed Creek	X		Appaloosa Dr		0.07		63	54	53	46
DW37	Walkers Creek			Sunrise Rd		0.55		54	54	41	38
DW38	Unnamed Creek			US 101		0.07		36	36	15	44
DW39	Dosewallips River				Unnamed Crk.	114.62		64	91	59	5
DW40	Walkers Creek			Moose Mountain Rd		0.63		37	45	17	34
DW41	Unnamed Creek			US 101		0.01	X	67	54	52	56
DW42	Unnamed Creek			US 101		0.25	X	45	50	20	46
DW43	Walkers Creek			US 101		0.80		51	52	43	33
DW44	Dosewallips River	X		US 101		115.93		81	70	64	58
DW45	Unnamed Creek			US 101		0.12	X	48	34	45	43
DW46	Unnamed Creek			US 101		0.10	X	63	56	44	54
DW47	Unnamed Creek			US 101		0.11		53	39	59	35
DW48	Unnamed Creek			US 101		0.04	X	45	52	21	42
DW49	Unnamed Creek			US 101		0.10	X	61	52	23	75
DW50	Unnamed Creek			US 101		0.03	X	64	57	22	77
DW51	Unnamed Creek			US 101		0.05	X	72	52	26	94
DW52	Unnamed Creek			US 101		0.08	X	64	50	33	73
DW53	Turner Creek			US 101		0.78		73	56	52	66
DW54	Unnamed Creek			US 101		0.16	X	81	61	71	59
DW55	Unnamed Creek			US 101		0.00		80	61	63	65
DW56	Unnamed Creek			US 101		0.05	X	78	54	48	82
DW57	Unnamed Creek			US 101		0.01	X	77	54	50	78
DW58	Unnamed Creek			US 101		0.03	X	84	57	64	77
FL01	Lilliwaup Creek			NFD 2464		0.07		35	49	24	20
FL02	Lilliwaup Creek			USFS Rd. 24		1.84		10	25	3	12
FL03	Finch Creek				Near road bend	2.14		34	56	29	6
FL04	Unnamed Creek			US 101		0.60		52	54	31	45
FL05	No Name Creek			US 101		0.30		59	54	31	59
FL06	Finch Creek		X	N Finch Crk. Rd		2.75		77	59	88	36
FL07	Lilliwaup Creek				East Fork Lilliwaup Crk.	10.72		28	58	19	0

Attachment A – Analysis Location

WRIA 16 Impaired River Analysis – Aggradation Study

Point #	GIS Watercourse name	Identified Problem Area	2007 Storm Damage	Road Crossing?	Stream junction	Catchment Area (sq. mi.)	Catchment Area Uncertain	Cumulative Aggradation Rating	Low Transport Rating	Supply Rating	Barrier Rating
FL08	Unnamed Creek			US 101		0.02	X	47	54	35	31
FL09	Hill Creek			US 101		1.19		60	54	47	47
FL10	Finch Creek		X	N Finch Crk. Rd		3.31		84	52	78	67
FL11	Unnamed Creek			US 101		0.10	X	67	54	40	68
FL12	Unnamed Creek			US 101		0.02	X	62	52	46	53
FL13	Unnamed Creek			US 101		0.71		82	52	52	90
FL14	East Fork Lilliwaup Creek			USFS Rd. 24		0.72		7	18	3	13
FL15	Finch Creek	X		US 101		3.35		76	45	53	83
FL16	Clark Creek	X		US 101		1.30		70	56	62	49
FL17	Miller Creek	X		US 101		1.69		43	27	27	56
FL18	Unnamed Creek			US 101		0.07	X	78	61	68	56
FL19	Unnamed Creek			US 101		0.10	X	73	54	78	42
FL20	Sund Creek	X		US 101		1.93		70	56	63	48
FL21	Unnamed Creek			US 101		0.08	X	97	59	98	69
FL22	Lilliwaup Creek	X		N Lilliwaup St		17.77		60	63	69	15
FL23	Unnamed Creek			US 101		0.03	X	66	54	69	37
FL24	Unnamed Creek			US 101		0.02	X	52	50	43	38
FL25	Little Lilliwaup Creek.	X		US 101		1.41		72	63	66	43
FL26	Unnamed Creek			US 101		0.01	X	67	61	66	35
FL27	Jorsted Creek			NFD 2480		0.35		38	56	20	23
FL28	Jorsted Creek			USFS Rd. 24		1.16		18	36	1	20
FL29	Unnamed Creek			US 101		0.02	X	56	49	55	34
FL30	Unnamed Creek			US 101		0.03	X	64	56	72	28
FL31	Unnamed Creek			US 101		0.02	X	69	57	77	31
FL32	Unnamed Creek			US 101		0.43		75	56	65	56
FL33	Unnamed Creek	X		N Carroll Pt Rd		0.43		71	56	69	46
FL34	Eagle Creek				Unnamed Crk.	3.46		35	59	28	7
FL35	Unnamed Creek			US 101		0.07	X	72	63	68	42
FL36	Eagle Creek		X	US 101		5.65		54	52	51	32
FL37	Unnamed Creek			US 101		0.02	X	80	61	63	65
FL38	Unnamed Creek			US 101		0.005	X	72	59	50	64
FL39	Unnamed Creek			US 101		0.02	X	72	54	64	54
FL40	Unnamed Creek			US 101		0.07	X	64	48	58	50
FL41	Unnamed Creek			US 101		0.01	X	64	54	58	43
FL42	Unnamed Creek			US 101		0.01	X	64	54	56	45
FL43	Unnamed Creek	X		US 101	Stetson Beach Area	0.05	X	65	48	58	51
FL44	Unnamed Creek			US 101		0.74		73	50	57	67
FL45	Unnamed Creek			US 101		0.10	X	63	48	75	30
FL46	Unnamed Creek	X		N Ayock Beach Dr.	Ayock beach Area	0.74		68	54	60	50
FL47	Unnamed Creek			US 101		0.03	X	68	52	76	36
FL48	Unnamed Creek			US 101		0.00	X	75	61	84	33
FL49	Jorsted Creek			US 101		4.36		64	30	77	48
FL50	Unnamed Creek			US 101		0.04	X	76	56	77	47
FL51	Unnamed Creek			US 101		0.03	X	75	59	83	37

Point #	GIS Watercourse name	Identified Problem Area	2007 Storm Damage	Road Crossing?	Stream junction	Catchment Area (sq. mi.)	Catchment Area Uncertain	Cumulative Aggradation Rating	Low Transport Rating	Supply Rating	Barrier Rating
FL52	Unnamed Creek			US 101		0.08		49	47	48	29
FL53	Unnamed Creek			US 101		0.002	X	56	59	57	22
HH01	Hamma Hamma River				Unnamed Crk.	8.93		3	18	8	0
HH02	Hamma Hamma River			USFS Rd. 25		10.29		5	7	15	9
HH03	Hamma Hamma River				Whitehorde Crk.	13.06		47	54	53	12
HH04	Whitehorse Creek			USFS Rd. 25		1.66		46	54	49	14
HH05	Boulder Creek			USFS Rd. 25		4.44		45	49	50	16
HH06	Hamma Hamma River				Boulder Crk.	20.16		31	27	43	15
HH07	Boulder Creek			NFD 2466		1.96		37	49	26	23
HH08	Jefferson Creek			NFD 2401		2.50		40	52	31	22
HH09	Jefferson Creek			NFD 2401		2.61		10	7	13	21
HH10	Jefferson Creek				Unnamed Crk.	6.15		29	54	27	0
HH11	Maple Creek			USFS Rd. 25		0.45		39	54	37	12
HH12	Hamma Hamma River				Maple Crk.	22.81		17	16	32	8
HH13	Washington Creek			NFD 2441		0.26		40	56	22	25
HH14	Delta Creek			USFS Rd. 25		1.11		37	54	32	12
HH15	Hamma Hamma River				Delta Crk.	27.16		14	18	28	4
HH16	Lena Creek			USFS Rd. 25		10.33	X	41	60	31	16
HH17	Hamma Hamma River				Lena Crk.	28.52		56	91	37	10
HH18	E Fork Lena Creek				Lena Lake	3.53		36	68	28	0
HH19	Hamma Hamma River				Unnamed Crk.	39.24		39	56	46	0
HH20	Jefferson Creek			NFD 2401		10.25		17	18	19	19
HH21	Washington Creek				Quitter Crk.	8.13		15	23	4	24
HH22	Quitter Creek			NFD 2441		2.17		13	23	1	24
HH23	Washington Creek			NFD 2401		8.59		48	54	44	23
HH24	Jefferson Creek				Washington Crk.	8.85		44	54	46	13
HH25	Hamma Hamma River				Phantom Crk.	40.16		50	54	58	14
HH26	Phantom Creek			USFS Rd. 25		0.15		41	56	38	12
HH27	Cedar Creek			NFD 2401		0.73		34	54	22	16
HH28	Cabin Creek				Lee Crk.	6.65		26	54	22	0
HH29	Hamma Hamma River			USFS Rd. 2480		40.97		54	68	47	20
HH30	Cabin Creek			USFS Rd. 25		7.08		62	72	53	26
HH31	Hamma Hamma River				Cabin Crk.	48.15		63	74	50	27
HH32	Hamma Hamma River				Unnamed Crk.	0.00000	X	35	52	27	14
HH33	Watson Creek			USFS Rd. 25		2.31		41	58	30	17
HH34	Hamma Hamma River				Watson Crk.	51.76		50	66	48	13
HH35	Jefferson Creek			USFS Rd. 2480		21.33		51	68	48	12
HH36	Hamma Hamma River				Jefferson Crk.	73.56		34	52	29	11
HH37	SF John Creek			USFS Rd. 2480		0.95		35	56	19	19

Point #	GIS Watercourse name	Identified Problem Area	2007 Storm Damage	Road Crossing?	Stream junction	Catchment Area (sq. mi.)	Catchment Area Uncertain	Cumulative Aggradation Rating	Low Transport Rating	Supply Rating	Barrier Rating
HH38	NF John Creek			USFS Rd. 2480		1.42		29	47	21	12
HH39	John Creek				SF and NF John Crk.	3.61		2	20	3	0
HH40	Hamma Hamma River				John Crk.	83.05		46	63	55	0
HH41	Waketickeh Creek			USFS Rd. 25		5.86		41	49	22	35
HH42	Hamma Hamma River				Hamma mouth	84.32		42	32	61	17
HH43	Unnamed Creek			US 101		0.06	X	63	52	66	35
HH44	Unnamed Creek			US 101		0.01	X	46	45	51	22
HH45	Waketickeh Creek			US 101		7.70		69	56	71	40
HH46	SF Fulton Creek				Unnamed road	1.74		9	36	3	0
HH47	Unnamed Creek			US 101		0.02		55	48	52	37
HH48	Unnamed Creek			US 101		0.97		90	61	89	60
HH49	Unnamed Creek			US 101		0.34	X	69	47	66	51
HH50	Unnamed Creek			US 101		0.01	X	59	54	65	25
HH51	Unnamed Creek			US 101		0.35	X	59	52	64	30
HH52	Unnamed Creek			US 101		0.04	X	60	50	67	30
HH53	Unnamed Creek			US 101		0.66	X	64	50	60	45
HH54	Unnamed Creek			US 101		0.05	X	70	52	65	50
HH55	Unnamed Creek			US 101		0.05	X	64	41	74	40
HH56	Unnamed Creek			US 101		0.002	X	87	54	100	50
HH57	Unnamed Creek			US 101		1.66		92	56	83	76
HH58	Unnamed Creek			US 101		1.66		81	52	63	76
HH59	Unnamed Creek			US 101		0.06	X	73	52	53	69
HH60	Unnamed Creek			US 101		0.06	X	83	54	71	69
HH61	Unnamed Creek			US 101		0.25		89	52	79	78
HH62	Unnamed Creek			US 101		0.25		81	52	60	78
HH63	Fulton Creek				SF Fulton Crk.	7.88		47	58	59	2
HH64	Unnamed Creek			US 101		0.26	X	91	52	83	77
HH65	Unnamed Creek			US 101		0.89		100	52	88	92
HH66	Fulton Creek			US 101		8.35		75	90	51	37
HH67	Unnamed Creek			US 101		0.01	X	59	50	60	35
HH68	McDonald Creek			US 101		1.65		50	43	52	31
SK001	SF Skokomish River				Snowfield Crk.	4.10		30	61	21	0
SK002	SF Skokomish River				Tumble Crk.	5.92		25	52	21	0
SK003	SF Skokomish River				Rule Crk.	9.69		44	58	45	8
SK004	Church Creek			USFS Rd. 2361		3.74		14	25	5	20
SK005	SF Skokomish River				Steel Crk.	12.38		26	27	41	6
SK006	SF Skokomish River				Church Crk.	20.35		21	25	38	0
SK007	Pine Creek			USFS Rd. 2361		3.51		18	23	8	27
SK008	Cedar Creek			USFS Rd. 23		1.05		28	43	2	33
SK009	Cedar Creek			USFS Rd. 2361		4.85		21	27	2	34
SK010	SF Skokomish River				Pine Crk.	26.40		52	82	49	0
SK011	Five Stream				McKay Crk.	2.20		30	61	23	0
SK012	Four Stream			N Fourstream Rd.		0.34		33	56	20	13
SK013	SF Skokomish River				Cedar Crk.	32.64		13	11	35	0

Point #	GIS Watercourse name	Identified Problem Area	2007 Storm Damage	Road Crossing?	Stream junction	Catchment Area (sq. mi.)	Catchment Area Uncertain	Cumulative Aggradation Rating	Low Transport Rating	Supply Rating	Barrier Rating
SK014	Vance Creek			USFS Rd. 2342		1.05		36	54	23	19
SK015	Vance Creek			NFD 2330		1.05		22	43	4	20
SK016	Le Bar Creek			NFD 2354		1.96		42	52	23	34
SK017	Le Bar Creek			NFD 2379		0.64		38	54	24	22
SK018	Cabin Creek			160		0.07		34	54	21	16
SK019	NF Skokomish River				Six Stream Crk.	26.08		43	56	54	0
SK020	Vance Creek				Cabin Crk.	6.37		47	86	22	11
SK021	NF Skokomish River				Five Stream Crk.	42.55		44	60	53	0
SK022	NF Skokomish River				Seven Stream Crk.	20.95		33	61	29	0
SK023	NF Skokomish River				Donahue Crk.	23.10		29	56	24	0
SK024	NF Skokomish River				Madeline Crk.	23.40		0	14	6	0
SK025	Cabin Creek			NFD 2350		1.42		49	79	22	23
SK026	Cabin Creek			160		0.79		13	29	3	15
SK027	NF Skokomish River				Unnamed Crk.	43.73		40	54	50	0
SK028	SF Skokomish River				Braided Channel	37.18		59	93	51	0
SK029	NF Skokomish River				Four Stream Crk.	49.75		9	9	30	0
SK030	NF Skokomish River				Hammer Crk.	12.86		30	58	25	0
SK031	NF Skokomish River				Eight Stream Crk.	10.75		30	58	25	0
SK032	Elk Creek			N Fourstream Rd.		0.82		13	32	2	12
SK033	Nicklund Creek			NFD 2351		0.01		45	54	28	34
SK034	Vance Creek				Nicklund Crk.	10.77		31	60	21	4
SK035	Nicklund Creek			NFD 2350		0.93		19	36	2	20
SK036	NF Skokomish River				Nine Stream Crk.	8.89		27	52	26	0
SK037	Rock Creek				Unnamed Crk.	4.56		9	23	7	7
SK038	NF Skokomish River				Slate Crk.	54.41		44	58	55	0
SK039	NF Skokomish River				Elk Crk.	56.73		40	52	37	15
SK040	NF Skokomish River				Staircase Ranger Station	54.65		62	86	52	12
SK041	SF Skokomish River				LeBar Crk.	51.55		20	12	29	21
SK042	Vance Creek				Aristine Crk.	14.59		38	68	32	0
SK043	Le Bar Creek			NFD 2340		9.82		21	18	27	19
SK044	SF Skokomish River			USFS Rd. 2353		51.58		26	14	20	41
SK045	NF Skokomish River				Lincoln Crk.	57.71		64	93	51	13
SK046	Lincoln Creek			N Staircase Rd.		0.87		24	41	16	14
SK047	Copper Creek			N Fourstream Rd.		0.72		32	54	20	14
SK048	Fir Creek			NFD 2350		0.98		21	36	6	22
SK049	Vance Creek			Trestle Rd.		14.89		8	11	3	22
SK050	SF Skokomish River				Brown Crk.	60.17		45	58	38	19
SK051	Brown Creek			USFS Rd. 2340		7.94		41	40	47	18
SK052	Fir Creek			USFS Rd. 23		1.38		19	39	2	20
SK053	Copper Creek				Crk. Mouth	0.81		49	70	38	16
SK054	NF Skokomish River			N Fourstream Rd.		60.93		44	52	41	19
SK055	Rock Creek			USFS Rd. 23		6.26		51	84	22	22
SK056	Vance Creek			Simpson 800 Mainline		15.57		55	84	35	17
SK057	Rock Creek				Flat Crk.	6.68		32	52	26	10

Attachment A – Analysis Location

WRIA 16 Impaired River Analysis – Aggradation Study

Point #	GIS Watercourse name	Identified Problem Area	2007 Storm Damage	Road Crossing?	Stream junction	Catchment Area (sq. mi.)	Catchment Area Uncertain	Cumulative Aggradation Rating	Low Transport Rating	Supply Rating	Barrier Rating
SK058	SF Skokomish River				Harp Crk.	62.12		32	45	43	0
SK059	NF Skokomish River				Unnamed Crk.	1.74		28	52	28	0
SK060	SF Skokomish River				Rock Crk.	71.04		40	63	42	0
SK061	Fir Creek			USFS Rd. 23		1.98		40	52	21	32
SK062	Dry Creek				Crk. mouth	5.74		20	59	4	0
SK063	Vance Creek				Fir Crk.	2.77		55	77	58	0
SK064	Vincent Creek			Simpson Rd 8200		0.02		45	54	30	31
SK065	Vincent Creek			8210		0.33		44	54	26	33
SK066	SF Skokomish River				Dalby Crk.	71.95		12	14	32	0
SK067	Harp Creek			NFD 14		0.06		31	52	19	14
SK068	Vincent Creek			Simpson Rd 8200		0.73		38	50	26	25
SK069	Vance Creek			W Skokomish Valley Rd.		21.41		31	25	39	21
SK070	Dalby Creek			8500		0.02		24	52	0	19
SK071	Dalby Creek			8500		0.04		35	54	19	19
SK072	Dalby Creek			8500		0.02		35	57	19	19
SK073	Frigid Creek			NFD 2301		0.08		33	52	19	19
SK074	Vance Creek				Kirkland Crk.	21.77		57	84	49	6
SK075	SF Skokomish River				Vincent Crk.	74.05		48	52	39	31
SK076	SF Skokomish River			USFS Rd. 2340		74.05		56	53	53	31
SK077	Frigid Creek			USFS Rd. 2340		0.48		22	43	1	23
SK078	SF Skokomish River				Unnamed Crk.	77.14		63	95	58	0
SK079	McTaggert Creek			NFD 2301		0.06		32	52	18	16
SK080	Gibbons Creek			NFD 2301		0.22		22	48	0	19
SK081	SF Skokomish River				Unnamed Crk.	75.65		14	16	34	0
SK082	Vance Creek			W Skokomish Valley Rd.		23.73		63	74	62	16
SK083	SF Skokomish River				Vance Crk.	103.19		41	52	44	10
SK084	North Branch Big Creek			NFD 14		0.25		40	49	35	20
SK085	McTaggert Creek				Unnamed Crk.	1.14		38	52	19	28
SK086	North Branch Big Creek			NFD 2419		0.41		29	32	14	34
SK087	Weaver Creek			W Eells Hill Rd.		0.03		36	50	4	42
SK088	McTaggert Creek			USFS Rd. 2340		1.56		39	54	30	18
SK089	Gibbons Creek			USFS Rd. 2340		1.04		36	52	20	24
SK090	NF Skokomish River				Unnamed Crk.	111.46		38	49	45	5
SK091	Big Creek			NFD 2419		0.18		46	45	40	31
SK092	McTaggert Creek			8700		1.72		36	54	20	22
SK093	McTaggert Creek				Frigid Crk.	8.38		11	29	13	0
SK094	McTaggert Creek				Gibbons Crk.	2.87		31	45	20	21
SK095	NF Skokomish River				McTaggert Crk.	102.16		65	91	55	11
SK096	NF Skokomish River			Stephens Rd.		111.72		29	25	34	22
SK097	North Branch Big Creek			NFD 2419		0.52		23	34	12	23
SK098	Big Creek				Crk. mouth	12.40		21	59	4	0

Attachment A – Analysis Location

WRIA 16 Impaired River Analysis – Aggradation Study

Point #	GIS Watercourse name	Identified Problem Area	2007 Storm Damage	Road Crossing?	Stream junction	Catchment Area (sq. mi.)	Catchment Area Uncertain	Cumulative Aggradation Rating	Low Transport Rating	Supply Rating	Barrier Rating
SK099	Big Creek			NFD 2419		1.17		20	32	12	18
SK100	Big Creek				N Branch Big Crk.	2.39		12	27	9	9
SK101	Skokomish River		X	W Skokomish Valley Rd.		221.22		54	49	62	23
SK102	NF Skokomish River				Unnamed Crk.	101.74		51	91	36	0
SK103	Skinwood Creek			NFD 2419		0.95		30	27	12	44
SK104	Deer Meadow Creek				Crk. mouth	93.28		34	56	31	5
SK105	Big Creek				Skinwood Crk.	4.05		27	47	25	4
SK106	Skinwood Creek			NFD 2464		0.59		37	52	21	25
SK107	Big Creek			1500		5.76		43	56	26	29
SK108	Big Creek				Unnamed Crk.	5.04		17	36	6	13
SK109	Big Creek			N Staircase Rd.		4.34		41	52	24	30
SK110	Skinwood Creek			NFD 2419		0.07		39	52	20	30
SK111	Weaver Creek			W Skokomish Valley Rd.		2.69		47	45	41	33
SK112	Dow Creek				Crk. mouth at Kokanee Lake	95.07		58	79	48	17
SK113	Unnamed Creek		X	N Sunnyside Rd.		224.73		37	58	29	12
SK114	Dow Creek			N Bright Star Dr.		0.68		49	54	19	49
SK115	Weaver Creek				Crk. mouth	2.77		53	68	59	6
SK116	Dow Creek			N Dow Crk. Dr.		2.14		41	56	19	30
SK117	Dow Creek			N Dow Mountain Rd.		0.22		34	52	19	21
SK118	Dow Creek			N Lake Cushman Rd.		1.74		29	39	1	42
SK119	Purdy Creek			W Skokomish Valley Rd		0.20		56	57	59	23
SK120	Purdy Creek			US 101		6.03	X	43	39	40	32
SK121	Unnamed Creek		X	W Bourgault Rd.		0.43	X	62	54	43	54
SK122	Unnamed Creek			US 101		0.43		62	54	50	46
SK123	Skokomish River			US 101		228.77		55	49	58	29
SK124	Unnamed Creek			US 101		0.06	X	55	59	46	31
SK125	Unnamed Creek			US 101		0.06		79	57	62	69
SK126	Unnamed Creek			US 101		0.02	X	58	54	62	26
SK127	Unnamed Creek			US 101		0.16	X	61	59	62	28
SK128	Unnamed Creek			US 101		0.01	X	59	54	62	29
SK129	Unnamed Creek			US 101		0.03	X	48	48	45	28
SK130	Purdy Creek			E Bourgault Rd.		6.47		46	52	45	20
SK131	Unnamed Creek			US 101		0.07	X	48	45	46	31
SK132	Unnamed Creek			US 101		0.17	X	73	63	59	51
SK133	Unnamed Creek			US 101		0.91		57	50	33	58
SK134	Unnamed Creek			US 101		0.27	X	60	61	33	52
SK135	Unnamed Creek		X	US 101		0.49		57	63	28	49
SK136	Unnamed Creek			US 101		0.05	X	36	52	20	25
SK137	Unnamed Creek			US 101		0.73	X	60	57	50	39
SK138	Mussel Shell Creek		X	E Purdy Cutoff Rd.		0.30		41	54	34	19

Point #	GIS Watercourse name	Identified Problem Area	2007 Storm Damage	Road Crossing?	Stream junction	Catchment Area (sq. mi.)	Catchment Area Uncertain	Cumulative Aggradation Rating	Low Transport Rating	Supply Rating	Barrier Rating
SK139	Unnamed Creek			US 101		0.08	X	72	70	29	73
SK140	Unnamed Creek			US 101		0.98		30	39	6	39
SK141	Unnamed Creek			US 101		0.12	X	58	57	25	61
SK142	Unnamed Creek			US 101		3.32		48	48	35	39
SK143	Purdy Creek				Crk. mouth	235.88		58	70	60	13
SK144	Unnamed Creek		X	E Purdy Cutoff Rd.		0.05		41	50	33	23
SK145	Mussel Shell Creek				Crk. mouth	236.42		24	16	35	19
SK146	Skokomish River		X	SR 106		237.36		32	5	43	40
SK147	Unnamed Creek			SR 106		0.12		49	47	35	40
SK148	Unnamed Creek			SR 106		0.03		56	59	31	49
SK149	Unnamed Creek			SR 106		0.01	X	54	57	29	48
SK150	Unnamed Creek			SR 106		0.002	X	55	54	20	62
SK151	Unnamed Creek			SR 106		0.13		63	63	25	65
SK152	Unnamed Creek			SR 106		0.05		48	57	20	45
SK153	Unnamed Creek			SR 106		0.01		48	57	27	37
SK154	Unnamed Creek			SR 106		0.42		47	58	29	33
SK155	Unnamed Creek			SR 106		0.13	X	44	52	26	35
SK156	Unnamed Creek			SR 106		0.04	X	59	59	42	43
SK157	Unnamed Creek			SR 106		0.01	X	61	57	44	48
SK158	Unnamed Creek			SR 106		0.01	X	60	61	34	51
SK159	Unnamed Creek			SR 106		0.04		52	58	28	43
SS01	Unnamed Creek		X	E McReavy Rd.		0.58	X	38	41	14	46
SS02	Unnamed Creek			SR 106		0.68	X	56	43	34	62
SS03	Unnamed Creek			SR 106		0.03	X	63	59	47	47
SS04	Unnamed Creek	X		SR 106	Big Bend Crk.	1.07		59	49	7	87
SS05	Unnamed Creek	X		SR 106	Dalby Crk.	0.16		72	48	44	82
SS06	Unnamed Creek			SR 106		0.001	X	60	52	19	76
SS07	Unnamed Creek			SR 106		0.42		66	52	66	43
SS08	Unnamed Creek			SR 106		0.03	X	72	61	67	45
SS09	Unnamed Creek			SR 106		0.03	X	66	61	54	44
SS10	Unnamed Creek			SR 106		0.04		69	58	69	39
SS11	Unnamed Creek			SR 106		0.08		70	61	78	29
SS12	Unnamed Creek			SR 106		0.20		61	61	68	22
SS13	Unnamed Creek			SR 106		0.02	X	66	61	62	37
SS14	Unnamed Creek			SR 106		0.004	X	59	61	62	21
SS15	Unnamed Creek			SR 106		0.002	X	59	61	64	19
SS16	Unnamed Creek			SR 106		0.15		60	61	67	20
SS17	Unnamed Creek			SR 106		0.001	X	57	54	56	29
SS18	Unnamed Creek			SR 106		0.04	X	59	63	52	29
SS19	Unnamed Creek			SR 106		0.003	X	60	61	65	21
SS20	Unnamed Creek			SR 106		0.09		69	63	72	31
SS21	Unnamed Creek			SR 106		0.02	X	56	54	35	48
SS22	Unnamed Creek			SR 106		0.04	X	72	61	70	42
SS23	Unnamed Creek			SR 106		0.04	X	65	63	67	27

Attachment A – Analysis Location
WRIA 16 Impaired River Analysis – Aggradation Study

Point #	GIS Watercourse name	Identified Problem Area	2007 Storm Damage	Road Crossing?	Stream junction	Catchment Area (sq. mi.)	Catchment Area Uncertain	Cumulative Aggradation Rating	Low Transport Rating	Supply Rating	Barrier Rating
SS24	Unnamed Creek			SR 106		0.05	X	73	63	73	39
SS25	Unnamed Creek			SR 106		0.05	X	69	63	71	33
SS26	Unnamed Creek			SR 106		0.06	X	57	56	54	31
SS27	Unnamed Creek			SR 106		0.06		56	61	54	23
SS28	Unnamed Creek			SR 106		0.01		60	61	59	26
SS29	Unnamed Creek			SR 106		0.00	X	64	61	67	28
SS30	Unnamed Creek			SR 106		0.19		92	54	60	100
SS31	Unnamed Creek			SR 106		0.18		64	57	82	17
SS32	Unnamed Creek			SR 106		0.05		62	54	70	27
SS33	Unnamed Creek	X		SR 106	Twanoh Crk.	0.64		60	56	56	34
SS34	Unnamed Creek			SR 106		0.05		72	61	59	53
SS35	Unnamed Creek			SR 106		0.03		60	50	70	28
SS36	Unnamed Creek	X		E Creekside Dr.	Twanoh Falls Crk.	0.87		63	36	48	69
SS37	Unnamed Creek	X		SR 106	Twanoh Falls Crk.	0.90		90	59	52	99
SS38	Unnamed Creek			SR 106		0.22		82	61	54	79
SS39	Unnamed Creek			SR 106		0.03	X	71	59	58	53
SS40	Unnamed Creek			SR 106		0.56		70	54	67	47
SS41	Unnamed Creek			SR 106		0.07		68	52	60	51
SS42	Unnamed Creek			SR 106		0.83		73	59	59	56
SS43	Unnamed Creek			SR 106		0.04		83	57	74	64
SS44	Unnamed Creek			SR 106		0.66		70	61	61	47
SS45	Unnamed Creek		X	E Trails Rd.		0.08		31	52	1	32
SS46	Unnamed Creek			SR 106		1.20		54	38	55	41
SS47	Unnamed Creek	X		SR 106	Crk. W of 17601 SR106	1.41		86	61	76	64
SS48	Unnamed Creek			SR 106		0.13		51	57	43	28
SS49	Unnamed Creek			SR 106		2.75		46	54	31	32
SS50	Unnamed Creek			SR 106		0.02	X	68	54	37	73

ATTACHMENT B

Analysis Inputs and Weights

Attachment B – Analysis Inputs and Weights

WRIA 16 Impaired River Analysis – Aggradation Study

Symbol	Metric	Inputs	Value based on	Maximum Value	Minimum Value	Weight	Scaled Maximum	Scaled Minimum
QS	Stream power	5-year Discharge, Slope	ranged values -13 to 13	12	-11	4.4	52.2	-47.9
∆QS	Change in stream power	5-year Discharge, Slopes	ranged values -13 to 14	11	-13	4.2	45.9	-54.2
W	Downstream waterbody	Waterbody within 100 ft	present/not present	1	0	12	12.0	0.0
	Transport Capacity Rating	**QS, ∆QS, W**	**weighted contributions**	**98**	**-89**	**-0.53**	**100.0**	**0.0**
LC1	Land cover contribution	Cultivated Land	Area (sq. ft.) upstream of pour point	1.23E+05	0	3		
LC2	Land cover contribution	Grassland	Area (sq. ft.) upstream of pour point	2.90E+08	0	2		
LC3	Land cover contribution	Deciduous Forest	Area (sq. ft.) upstream of pour point	2.29E+07	0	1		
LC4	Land cover contribution	Evergreen Forest	Area (sq. ft.) upstream of pour point	4.66E+09	0	0		
LC5	Land cover contribution	Mixed Forest	Area (sq. ft.) upstream of pour point	9.17E+07	0	0.5		
LC6	Land cover contribution	Scrub/Shrub	Area (sq. ft.) upstream of pour point	9.67E+08	0	1.5		
LC7	Land cover contribution	Palustrine Forested Wetland	Area (sq. ft.) upstream of pour point	5.57E+07	0	-2		
LC8	Land cover contribution	Palustrine Scrub/Shrub Wetland	Area (sq. ft.) upstream of pour point	6.41E+07	0	-1.5		
LC9	Land cover contribution	Palustrine Emergent Wetland	Area (sq. ft.) upstream of pour point	4.93E+07	0	-1		
LC10	Land cover contribution	Estuarine Emergent	Area (sq. ft.) upstream of pour point	2.46E+05	0	-1.5		
LC11	Land cover contribution	Unconsolidated Shore	Area (sq. ft.) upstream of pour point	2.62E+07	0	2.5		
LC12	Land cover contribution	Bare Land	Area (sq. ft.) upstream of pour point	2.96E+08	0	4		
LC13	Land cover contribution	Water	Area (sq. ft.) upstream of pour point	1.72E+08	0	-3		
LC14	Land cover contribution	Estuarine Aquatic Bed	Area (sq. ft.) upstream of pour point	9688	0	-3		

Symbol	Metric	Inputs	Value based on	Maximum Value	Minimum Value	Weight	Scaled Maximum	Scaled Minimum
LC	Land cover	LCi	weighted contributions	273	-114	0.26	71.0	-29.6
100YR1	100-year floodplain contribution	100-year floodplain area	% area within 100 foot radius	100	0	0.5		
100YR2	100-year floodplain contribution	100-year floodplain area	% area within 500 foot radius	100	0	0.3		
100YR3	100-year floodplain contribution	100-year floodplain area	% area within 1000 foot radius	100	0	0.1		
100YR	100-year floodplain	100YRi	weighted contributions	100	0	1	100.0	0.0
ER1	Erosion hazard contribution	Identified hazard area	hazard present in 100 foot radius	1	0	4		
ER2	Erosion hazard contribution	Identified hazard area	hazard present between 100 & 500 foot radii	1	0	3		
ER3	Erosion hazard contribution	Identified hazard area	hazard present between 500 & 1000 foot radii	1	0	2		
ERi	Erosion hazard contribution	Identified hazard area	hazard present upstream of pour point	1	0	1		
ERk	Erosion hazard data set	ERi	weighted contributions	10	0	1		
ER	Erosion hazard	ERk	actual contribution	10	0	10	100.0	0.0
ΔS	Watercourse gradients	Local and 1500 ft slopes	increasing (0) or decreasing (1)	1	0	50	50.0	0.0
GR1	High Gradient contribution	Gradient locations	# of gradients upstream in 100 foot radius	1	0	5		
GR2	High Gradient contribution	Gradient locations	# of gradients upstream 100 to 500 foot radii	3	0	3		
GR3	High Gradient contribution	Gradient locations	# of gradients upstream 500 to 1000 foot radii	3	0	2		
GR	Number of upstream high gradients	GRi	weighted contributions	9	0	5.6	50.0	0.0
	Sediment Supply Rating	**LC, 100YR, ER, ΔS, GR**	**weighted contributions**	**270**	**0.1**	**0.4**	**100.0**	**0.0**
IP1	Impervious surface contribution	% impervious surface area	% area within 100 foot radius	98, 89	0	0.5		
IP2	Impervious surface contribution	% impervious surface area	% area between 100 & 500 foot radii	42, 67	0	0.3		
IP3	Impervious surface contribution	% impervious surface area	% area between 500 & 1000 foot radii	18, 67	0	0.2		

Attachment B – Analysis Inputs and Weights

WRIA 16 Impaired River Analysis – Aggradation Study

Symbol	Metric	Inputs	Value based on	Maximum Value	Minimum Value	Weight	Scaled Maximum	Scaled Minimum
IPk	Impervious data set	IPi	weighted contributions	54, 69	0	0.53, 0.47		
IP	Impervious area	IPk	weighted contributions	59	0	1.7	100.0	0.0
RD1	Road coverage contribution	Lineal feet of road	road distance (ft) within 100 foot radius	427	0	0.5		
RD2	Road coverage contribution	Lineal feet of road	road distance (ft) between 500 & 1000 foot radii	3430	0	0.3		
RD3	Road coverage contribution	Lineal feet of road	road distance (ft) between 100 & 500 foot radii	7576	0	0.2		
RD	Road coverage	RDi	weighted contributions	2266	0	0.044	100.0	0.0
CU1	Proximity of culverts contribution	Culvert locations	# of culverts in 100 foot radius	2	0	5		
CU2	Proximity of culverts contribution	Culvert locations	# of culverts between 100 & 500 foot radii	5	0	3		
CU3	Proximity of culverts contribution	Culvert locations	# of culverts between 500 & 1000 foot radii	6	0	2		
CU	Proximity of culverts	CUi	weighted contributions	24	0	4.2	100.0	0.0
	Sediment Barrier Rating	**IP, RD, CU**	**weighted contributions**	**202**	**0**	**0.5**	**100.0**	**0.0**