Compendium to the WRIA 15 Watershed Restoration and Enhancement Plan

Introduction

The materials in this compendium are not part of the WRIA 15 watershed plan, which was fully approved by the WRIA 15 Committee. This compendium provides background on how the plan was developed or supplemental materials provided by committee members. The inclusion of the compendium provides information on the process and shares the diverse opinions of the WRIA 15 Committee members. The documents in this compendium may provide insights on, or qualifications to, an entity's vote to approve the plan. However, these documents do not change the outcome of a vote by the WRIA 15 Committee to approve the plan.

The Committee did not discuss all the documents included, and Committee members did not attempt to reach consensus on the content of these materials. Any opinions expressed in the documents are solely those of the submitting entity and may not reflect the perspective or position of other members of the Committee.

Contents

The documents in this compendium include:

A. Supplemental Write Up on the Salmon Recovery Portal, provided by the Washington Department of Fish and Wildlife.
B. Assessing Precipitation Variability in Outdoor Domestic Water Use Calculations for WRIAs 14 and 15, provided by Skokomish Tribe (developed by Aspect Consulting).
A. Statements provided by members.
B. Etc

Supplemental Document Provided by Washington Department of Fish and Wildlife: Project Tracking for WRE Plans

A Framework for Tracking Projects and New Permit-Exempt Wells using Salmon Recovery Portal

This document describes the elements required to track projects from a conceptual stage through completion and monitor new permit-exempt domestic well construction. Project and well tracking are an essential component of implementation monitoring and adaptive management procedures. Therefore, it is recommended that projects be tracked through planning and implementation phases to enhance the Committee's ability to conduct implementation monitoring at the sub-basin and WRIA scale, monitor grant funding, identify plan successes and deficiencies, and streamline project development.

The Committee recommends a pilot program using the Salmon Recovery Portal (SRP; https://srp.rco.wa.gov/about) to conduct project tracking for the streamflow restoration effort under 90.94.030 RCW. As a statewide salmon recovery tracking tool, the capacity for the SRP to allow for goal setting, hierarchical project tiers, supplemental information, and printing of automated reports makes it well-suited for tracking projects associated with streamflow restoration and salmon recovery efforts. As a statewide tool administered by the Recreation and Conservation Office (RCO) and in partnership with salmon recovery Lead Entities (LE), the SRP provides a dynamic platform to track project development, funding, and offsets.

Tracking of projects will consist of two primary phases: (1) uploading required project information from all projects included in this plan into the SRP, and (2) uploading and updating all funded projects, project reports, and completed projects into the SRP database on an annual basis. Phase 1 will be coordinated and funded by the Washington Department of Fish and Wildlife (WDFW) and implemented by trained University of Washington (UW) data stewards in collaboration with RCO staff and Washington Department of Ecology (Ecology) staff. Phase 2 project uploads will be implemented by UW data stewards in consultation with Ecology grant management, RCO, and WDFW staff. To improve harmonization of streamflow restoration efforts with ongoing salmon recovery activities, local salmon recovery LE Coordinators shall be consulted prior to initial data uploads. While input and oversight is welcomed, no commitment of additional work is required from LE Coordinators. Streamflow restoration projects not funded through the streamflow restoration grant program, will be updated by data stewards during any grant reporting to Ecology or RCO. Primary quality control measures will be performed by data stewards. Funds to support initial and ongoing costs of data steward data entry (Phases 1 and 2) will be provided by WDFW.

The Committee recommends, at minimum, the following data fields for streamflow tracking: WRIA, sub-basin, project description, funding source, estimated cost, project spatial boundaries or coordinates, project sponsor (if applicable), estimated water offset or habitat benefits (using Pacific Salmon Recovery Fund (PCSRF) metrics or reference to the PCSRF list), and target project start date. Projects with sensitive locations can be made private or those with undetermined locations can be entered as a project boundary or defined at the sub-basin scale. New domestic permit-exempt well location data will be drawn from the Ecology Washington State Well Report database[1]. Well location data will be incorporated into the SRP using point coordinates, or at the section or sub-basin scale to support implementation monitoring and adaptive management goals.

To support the implementation of the above program for tracking projects under 90.94.030 RCW, WDFW has initiated pilot projects in two 90.94.020 RCW basins: the Nisqually River Basin (WRIA 11) and the Chehalis River Basin (WRIAs 22/23). These pilots are coordinated by WDFW in conjunction with RCO, Ecology, local LE Coordinators, and the Planning Units. Intended as a proof of concept, these pilots are examining the capacity and effectiveness of the SRP to track streamflow restoration projects.

[1] https://appswr.ecology.wa.gov/wellconstruction/map/WCLSWebMap/default.aspx

DRAFT MEMORANDUM

Project No. 190315

April 30, 2020

To: Dana Sarff, Project Manager
Skokomish Tribe Department of Natural Resources

cc: Seth Book, EPA Grants Coordinator
Skokomish Tribe Department of Natural Resources

From:

Parker Wittman
Associate Data Scientist
pwittman@aspectconsulting.com

Re: **Assessing Precipitation Variability in Outdoor Domestic Water Use Calculations for WRIAs 14 and 15**

Background

As a key part of the requirements of ESSB 6091 and RCW 90.94, the watershed restoration enhancement committees of Water Resource Inventory Areas (WRIAs) 14 (Kennedy-Goldsborough) and 15 (Kitsap) are in the process of developing estimates of consumptive water use for new permit-exempt well withdrawals over a 20-year planning horizon. There are three key pieces of making such an estimate:

1. Estimating the total number of new residences expected to be supplied by permit-exempt wells over this planning horizon
2. Estimating the consumptive indoor water use of each permit-exempt well[1]
3. Estimating the consumptive outdoor water use of each permit-exempt well.

In essence, the total amount of water needed for ESSB 6091 offset and mitigation projects in each WRIA is the sum of the per-residence indoor and outdoor consumptive use estimates times the number of new residences.

[1] *Consumptive* indoor domestic water use is generally much less than outdoor. An estimated quantity for indoor use (60 gpd total use per person or 6 gpd consumptive use per person) is usually taken directly from *ESSB 6091 - Recommendations for Water Use Estimates*—which itself cites a 2016 study by the Water Research Foundation (DeOreo, et al., 2016).

Aspect Consulting, LLC (Aspect) prepared this memorandum to address one element of the above: the estimate of per-residence **outdoor** consumptive water use. In particular, this memo addresses the calculation of outdoor consumptive water use through what is often called the "Ecology Method" – as described in the Washington State Department of Ecology (Ecology) guidance document *ESSB 6091 - Recommendations for Water Use Estimates*.[2] More specifically, the focus of this memo is on the potential variability of lawn irrigation water requirements across time (dry vs. drought years) and geography (north Kitsap Peninsula vs. south Kitsap Peninsula) and the impact that variability might have on outdoor water use calculations using the Ecology Method.

Calculating Outdoor Water Use and the Washington Irrigation Guide

Per *ESSB 6091 - Recommendations for Water Use Estimates*, the calculation for Household Consumptive Outdoor Water Use (HCOWU) is found by:

1. Using the Washington Irrigation Guide (WAIG)[3] to find the Net Irrigation Water Requirement for pasture/turf (IWR_{net}) for a nearby, representative station (see Figure 1).
2. Multiplying this value for IWR_{net} from the WAIG (converted to units of feet per year) by the estimated average size of a permit-exempt well residence lawn (in acres).
3. Dividing by a 75 percent application efficiency rate to account for water loss during the irrigation process (i.e., assume 25 percent lost due to application inefficiencies).
4. Multiplying by 80 percent to account for water that not consumed (i.e., a 20 percent return flow rate to groundwater or surface water systems).

Or:

$$\frac{IWR_{net} \times Irrigated\ Area}{Application\ Efficiency\ (75\%)} \times \%\ Consumptive\ (80\%) = \ Outdoor\ Consumptive\ Water\ Use$$

Thus, the calculation of outdoor consumptive water use is directly proportional to two factors:

- The estimated lawn size (which is generally established through GIS-based aerial photo review).[4]
- The estimated amount of irrigation water required to maintain it (usually a value or range of values looked up in the WAIG).

The WAIG itself contains tables of irrigation water requirements for various crops and various stations across Washington State. These tables are presented as two appendices: "Appendix A - Climatic Stations for Consumptive Use" and "Appendix B - Crop Irrigation Requirement (CIR) and Crop Consumptive use (CU) West of the Cascades." Appendix A includes data published in 1985 and Appendix B includes data published in a 1992 supplemental update. Each of these publications

[2] https://fortress.wa.gov/ecy/publications/SummaryPages/1811007.html

[3] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/wa/technical/engineering/?cid=nrcs144p2_036314

[4] Estimates for average lawn size have been or are being developed by the WRIA 14 and 15 watershed restoration enhancement committees. This estimate is not the focus of this memo.

give crop water use estimates for what might be considered a normal or average year, with respect to climatological conditions.

There are two WAIG stations in WRIA 14 (Grapeview and Shelton) and one in WRIA 15 (Bremerton). Table 1A (below) shows the annual pasture/turf irrigation water requirements for these (and other regional) stations. Approximate locations for these stations relative to the WRIAs can be seen on Figure 1.

Table 1A. Net Crop Irrigation Water Requirements for Pasture/Turf from WAIG Appendices

Station	WRIA	WAIG Appendix A Crop Irrigation Requirement (net) for Pasture/Turf (inches/year)	WAIG Appendix B Crop Irrigation Requirement (net) for Pasture/Turf (inches/year)
Bremerton	15	16.84	19.49
Grapeview	14	16.62	18.80
Olympia	13	15.75	16.47
Quilcene	17	12.68	17.54
Seattle: Sea-Tac Airport	9	17.25	20.02
Seattle: UW	8	18.10	NA[1]
Shelton	14	16.06	17.84
Tacoma	10	17.64	20.37

Notes:
1) Not Applicable

As an example, applying the pasture/turf net irrigation water requirement value from WAIG Appendix A for Bremerton (16.84 in/yr) to the average estimated outdoor irrigated area being considered for adoption by the WRIA 15 Planning Unit (0.08 acres) gives:

$$\frac{\dfrac{\mathbf{16.84}\,\frac{in}{yr}}{12\,\frac{in}{ft}} \times 0.08\,acres}{75\%} \times 80\% = \mathbf{0.12}\,\frac{\boldsymbol{acre\text{–}feet}}{\boldsymbol{year}}\ \left(or\ 107\,\frac{gal}{day}\right)$$

Table 1B (below) shows this calculation of per-residence outdoor consumptive use using WAIG crop irrigation requirement values in Table 1A.

Table 1B. Calculated Per-residence Outdoor Consumptive Using 0.08 Acre Lawn Size

	Using WAIG Appendix A		*Using WAIG Appendix B*	
Station	**WAIG Appendix A Crop Irrigation Requirement (net) for Pasture/Turf (inches/year)**	**Calculated Annual Outdoor Consumptive Use for 0.08 acre Lawn (gpd)**	**WAIG Appendix B Crop Irrigation Requirement (net) for Pasture/Turf (inches/year)**	**Calculated Annual Outdoor Consumptive Use for 0.08 acre Lawn (gpd)**
Bremerton	16.84	107	19.49	124
Grapeview	16.62	105	18.80	119
Olympia	15.75	100	16.47	104
Quilcene	12.68	80	17.54	111
Seattle: Sea-Tac Airport	17.25	109	20.02	127
Seattle: UW	18.10	115	NA	NA
Shelton	16.06	102	17.84	113
Tacoma	17.64	112	20.37	129

Though WAIG Appendix-based calculations are likely reasonable for estimating consumptive water use impacts in WRIAs 14 and 15,[5] it is still worth considering how and whether modern climate change influences, drought-year water needs, or more-contemporary climatological data might impact (or improve) these estimates for the purposes of planning.

Notably, though *ESSB 6091 - Recommendations for Water Use Estimates* only specifically cites Appendix A (and not B) for looking up pasture/turf irrigation requirements, it does not explicitly say that Appendix A *must* be used—only that crop water use values *such as* those in Appendix A should be used.

Alternate Data Source #1: The Provisional Update to the WAIG

The WAIG is a state-specific supplement to the National Engineering Handbook (NEH), Part 652, Irrigation Guide (National Irrigation Guide). It is intended that state-specific supplements to the National Irrigation Guide are updated as regularly as is necessary to reflect recent climatological data, employ improve calculation methods, and use updated crop coefficient values (based on contemporary research). To date, there have been four versions or supplements for Washington:[6]

- **1969** (Circular 512). *Evapotranspiration (ET) estimated by Blaney-Criddle method.*
- **1982** (Irrigation Requirements for Washington—Estimates and Methodology, or “Bulletin XB0925”). *ET estimated by the Doorenbos and Pruitt Blaney-Criddle method.*

[5] Especially given other notable sources of uncertainty in the calculations, e.g. lawn size and population growth
[6] *See Frequently Asked Questions on Updating the Washington Irrigation Guide* (Ecology Publication #12-11-004) https://fortress.wa.gov/ecy/publications/SummaryPages/1211004.html

- **1985** (the current WAIG, including Appendix A, as referenced above). *ET estimated by the FAO 24 Modified Blaney-Criddle and SCS Modified Blaney-Criddle methods.*
- **1992** (supplemental/updated data for stations west of the Cascades. WAIG Appendix B, as referenced above). *ET estimated by the FAO 24 Modified Blaney-Criddle and SCS Modified Blaney-Criddle methods.*

A fifth update was initiated in 2008 but has yet to be formally adopted and is still considered "provisional." This update (the "Provisional WIG") was intended to incorporate several decades-worth of new climate data and better scientific formulas to estimate crop water needs (with ET calculated by the ASCE Standardized Penman-Monteith method[7]). Data from the Provisional WIG is available online at: http://irrigation.wsu.edu/Content/Calculators/Historic/StationCropDOY.php.

Table 2 (below) lists the values for annual net irrigation water requirements from the Provisional WIG for stations in the general vicinity of WRIAs 14 and 15 as well as the corresponding calculated annual outdoor consumptive use for an example 0.08 acre lawn. Like the values from Appendix A and Appendix B of the WAIG, these values represent a normal or average weather year. They are, however, generally lower than the values from the WAIG.

Table 2. Annual Net Irrigation Water Requirements for Lawn from Provisional WIG for Select Stations

Station	IWR_{net} (in)	Calculated Annual Outdoor Consumptive Use for 0.08 acre Lawn (gpd)
Bremerton	13.2	84
Cushman Powerhouse 2	11.8	75
Grapeview 3 SW	12.2	77
Olympia Priest Pt Park	12.7	81
Port Townsend	15.8	100
Quilcene 2 SW	15.6	99
Seattle-UW	13.4	85
Shelton	12.5	79
Vashon Island	12.2	77
Wauna 3 W	12.7	81

[7] From Ecology Publication #12-11-004: *"Depending on what method is used, the estimate of crop water need can vary by ± 25%. For this reason, the American Society of Civil Engineers did a study of the most appropriate ET method to use when estimating crop water needs and determined that the Penman-Monteith method was preferable.*

Alternate Data Source #2: WSU AWN

Washington State University's (WSU) AgWeatherNet (AWN)[8] provides weather data and weather-related decision-support tools on a public-facing web server. A network of automated weather stations collect data at 15-minute intervals, with parameters including air temperature, relative humidity, soil temperature, rainfall, wind speed, wind direction, and solar radiation. Some stations also measure atmospheric pressure, soil moisture, and/or leaf wetness. The data (and calculated values) provided by AWN can be used to calculate irrigation water requirements for lawn/turf, where:

$$\begin{aligned}&Net\ Irrigation\ Water\ Requirement\ (IWR_{net})\\&\quad = Grass\ (Pasture/Turf)\ Evapotranspiration\ (ET_c) - \boldsymbol{Effective}\ Precipitation\ (P_e)\end{aligned}$$

That is, the amount of irrigation water required to maintain a healthy lawn is the total amount of water required by the crop (crop evapotranspiration or "ET_c")[9] less the amount of precipitation that is actually added to and stored in the soil (effective precipitation or "P_e").

For the purposes of comparing AWN-derived values to those from the WAIG, a selection of AWN stations within the general geographic vicinity of WRIAs 14 and 15 were identified. These stations are listed in Table 3 (below). Among these stations, only "Poulsbo.S" (#355001) falls within either WRIA 14 or 15.

Table 3. AgWeatherNet Stations in the Vicinity of WRIAs 14 and 15

Station	Station Installation Date	Latitude (approx.)	Longitude (approx.)	AWN Link
Chimacum	4/16/2015	48.01	-122.77	https://weather.wsu.edu/?p=90150&UNIT_ID=300220
Langley	12/17/2014	48.00	-122.43	https://weather.wsu.edu/?p=90150&UNIT_ID=300214
Montesano	7/18/2008	46.98	-123.49	https://weather.wsu.edu/?p=90150&UNIT_ID=310022
Olympia.E	2/9/2010	46.95	-122.84	https://weather.wsu.edu/?p=90150&UNIT_ID=330151
Poulsbo.S	**2/26/2013**	**47.66**	**-122.65**	**https://weather.wsu.edu/?p=90150&UNIT_ID=355001**
Puyallup	6/1/1995	47.19	-122.33	https://weather.wsu.edu/?p=90150&UNIT_ID=310102
Seattle	12/16/2011	47.66	-122.29	https://weather.wsu.edu/?p=90150&UNIT_ID=330092
Tumwater	8/11/2011	46.95	-122.96	https://weather.wsu.edu/?p=90150&UNIT_ID=330153

[8] https://weather.wsu.edu/

[9] The AWN glossary entry for evapotranspiration reads: *"The amount of water required to grow a crop consists of transpiration by the plant (T) due to water uptake and the water evaporated from the soil surface (E). Combined these two are called evapotranspiration (ET) and is also referred to as crop water use. ET is measured in inches of water used per day. ETr is the estimated evapotranspiration of a reference surface of fully grown alfalfa crop and is calculated from measured weather parameters. These include solar radiation, air temperatures, relative humidity, and wind speed. The reference ET for alfalfa (ETr) is calculated with the ASCE standardized Penman-Monteith Equation (ASCE - EWRI, 2005)"*

AWN data tables for the selected stations in Table 3 were downloaded and processed for the ten-year period 2010 to 2019.[10] These datasets[11] provide month-over-month (or daily) summary data for selected stations and include values such as (but not limited to) air temperature (minimum, maximum, average), wind direction/speed, total precipitation, and ET values for alfalfa (the "reference" ET or "ET_r") and grass (ET_c). These data were used to compare total annual *growing season* precipitation for each station (to identify representative dry years) and to calculate monthly effective precipitation (P_e) as a function of monthly total precipitation (P_t) and monthly crop ET (ET_c), using the equation:

$$\mathbf{P_e} = 0.921719*(0.70917*\mathbf{P_t}\text{^}0.82416-0.11556)*10\text{^}(0.02426*\mathbf{ET_c})$$

This equation for effective precipitation comes from documentation in the Provisional WIG (citing NRCS), with an assumed 2-inch soil water storage. [12]

These data and the corresponding calculated values are presented in Tables 4A through 4B (below).

Table 4A. April-Sept Total Precipitation (inches) from Ag Weather Net

Station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Chimacum	--	--	--	--	--	--	6.97	4.30	5.62	6.85
Langley	--	--	--	--	--	5.69	6.03	6.81	8.32	9.23
Montesano	20.04	18.42	11.39	24.76	16.28	6.14	9.02	12.54	14.61	8.89
Olympia.E	18.45	12.43	10.80	21.23	12.23	6.40	6.78	13.92	11.00	9.46
Poulsbo.S	--	--	--	13.76	10.49	5.55	5.28	8.87	7.85	8.54
Puyallup	13.45	13.03	8.93	18.34	11.67	5.62	6.11	9.34	8.75	10.00
Seattle	--	--	7.83	11.71	11.86	7.72	6.80	8.93	8.74	11.66
Tumwater	--	--	9.95	19.82	14.36	6.87	6.97	12.46	10.64	9.10

[10] Not all of the selected AWN stations had data for this time interval. Table 2 (above) includes the installation date of each station.

[11] "Monthly Weather Data" (https://weather.wsu.edu/?p=93150) and "Water Use Model" (https://weather.wsu.edu/?p=97750)

[12] http://irrigation.wsu.edu/Content/ET_IWR_For_WA.php

Table 4B. Calculated April-Sept Effective Precipitation (inches)

Station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Chimacum	--	--	--	--	--	--	4.29	2.48	3.22	4.20
Langley	--	--	--	--	--	3.60	3.80	3.96	4.60	5.42
Montesano	11.22	10.21	6.49	13.22	9.61	3.84	5.76	7.07	7.78	5.24
Olympia.E	10.17	7.28	6.23	11.22	7.44	3.95	4.30	7.89	5.86	5.63
Poulsbo.S	--	--	--	7.91	6.51	3.52	3.36	5.07	4.27	5.34
Puyallup	7.96	7.65	5.35	10.17	7.32	3.56	4.09	5.45	4.97	6.10
Seattle	--	--	4.81	6.80	7.52	4.76	4.34	5.27	4.80	7.19
Tumwater	--	--	5.79	10.72	8.62	4.23	4.43	7.10	5.63	5.37

Table 4C. April-Sept Lawn Evapotranspiration (ETc) (inches) from Ag Weather Net

Station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Chimacum	--	--	--	--	--	--	22.66	22.75	19.66	19.58
Langley	--	--	--	--	--	22.99	21.30	21.45	20.29	19.83
Montesano	18.53	20.92	19.87	19.54	23.09	26.05	25.29	24.18	23.23	20.69
Olympia.E	18.52	20.04	20.54	19.09	23.10	23.53	21.43	21.61	22.84	21.35
Poulsbo.S	--	--	--	22.68	22.02	23.29	21.32	21.60	21.40	19.62
Puyallup	20.89	21.83	22.64	22.37	24.18	25.91	23.96	24.00	22.91	21.63
Seattle	--	--	22.20	22.33	23.52	25.02	22.80	23.00	22.45	21.18
Tumwater	--	--	22.87	21.99	24.61	25.80	22.78	23.32	22.31	20.79

Table 4D. Calculated Lawn Net Irrigation Water Requirement (inches)

Station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	% difference between 2015 and 2018
Chimacum	--	--	--	--	--	--	18.37	20.27	16.44	15.38	--
Langley	--	--	--	--	--	19.39	17.50	17.49	15.69	14.41	24%
Montesano	7.31	10.71	13.38	6.32	13.48	22.21	19.53	17.11	15.45	15.45	44%
Olympia.E	8.35	12.76	14.31	7.87	15.66	19.58	17.13	13.72	16.98	15.72	15%
Poulsbo.S	--	--	--	14.77	15.51	19.77	17.96	16.53	17.13	14.28	15%
Puyallup	12.93	14.18	17.29	12.20	16.86	22.35	19.87	18.55	17.94	15.53	25%
Seattle	--	--	17.39	15.53	16.00	20.26	18.46	17.73	17.65	13.99	15%
Tumwater	--	--	17.08	11.27	15.99	21.57	18.35	16.22	16.68	15.42	29%

Table 4D (above) shows that across a 10-year span (2010 to 2019), the crop irrigation water requirement (and, by extension, domestic outdoor consumptive use) could be about 15 to 40 percent more in a relatively dry year/season (such as 2015) compared to a more normal year/season (such as 2018).

Alternate Data Source #3: PRISM Climate Data: 1990 to 2018

Oregon State University's PRISM[13] Climate Group, in partnership with the NRCS National Water and Climate Center (NWCC), provides digital maps of climate data for the United States.[14] Since PRISM data is not provided by station (like Ag Weather Net) and is instead interpolated into a continuous data set, it is particularly useful in the context of this work. Using GIS, PRISM data can be aggregated and summarized *across each WRIA and subbasin*, creating a more geographically specific estimate.

For this analysis, a variety of PRISM grids (.bil format rasters) were downloaded and processed, including:

- 30-year normals[15] for precipitation, mean temperature, and maximum temperature (annual normals and for all months, January through December)
- Monthly total precipitation grids for every individual month between January 1990 and December 2018

[13] PRISM (the Parameter-elevation Regressions on Independent Slopes Model) uses data from instrumented stations, topography data, and other spatial data sets to generate contiguous, gridded estimates of monthly, annual, and 30-year average ("normal") climatic parameters, such as precipitation and temperature.
[14] http://www.prism.oregonstate.edu/
[15] baseline datasets describing average monthly and annual conditions over the most recent three full decades, 1980 to 2010

Using GIS, the average, minimum, and maximum values across each one of the raster datasets was calculated for each WRIA subbasin area. This process resulted in a dataset that gives an individual result for total precipitation (in inches) for each subbasin for every month between January 1990 and December 2018, as well as the 30-year normal for each subbasin for each month of the year.

Since the analysis of irrigation water requirements is specific to the 6 months in which irrigation is required for lawns,[16] precipitation data for April through September was totaled for each year, yielding a total “irrigation season” precipitation for each subbasin and year. Additionally, the 30-year normal values for the months April through September were totaled to get a 30-year normal total precipitation value for the irrigation season, by subbasin.

Figure 2 (attached) shows irrigation season (total of April through September) precipitation contours (isohyets) across WRIAs 14 and 15 (and surrounding areas). As this map shows, normal precipitation between April and September has a range of about 7 inches in WRIA 15—as the northern end of the Kitsap Peninsula (Hansville area) sees about 8 inches of rainfall during these months, where areas in South Hood Canal see about 15 inches (or about double the rainfall). In WRIA 14, the total range of April through September precipitation is about the same (7 inches difference)—varying from about 11 inches in the Harstine Island area to over 18 inches in the upper Kennedy, Skookum, Mill, and Goldsborough subbasins.

Table 5 (attached) shows a year-by-year breakdown of total April through September precipitation in each subbasin and compares those totals to the 30-year normal, thus identifying dry and wet irrigation season years in WRIAs 14 and 15. Among the 29 years (1990 through 2018), 1998 was the driest across WRIAs 14 and 15, with about half the normal precipitation between April through September. The next-driest irrigation seasons in WRIAs 14 and 15 were 2016 (59 percent of normal), 2003 (64 percent), 2006 (70 percent), and 1999 (70 percent).

Approximating Irrigation Water Requirements with PRISM Data

By itself, PRISM data is inadequate to accurately calculate effective precipitation, ET, and crop irrigation water requirements. In an effort to develop a rough approximation of these values, each subbasin was assigned a “proxy station” from the Provisional WIG (for example, the South Sound subbasin of WRIA 15 was associated with the WAUNA 3 W station). ET values from the Provision WIG at these proxy stations for April through September were used to calculate effective precipitation[17] by year and, by extension, irrigation water requirements. These approximations are limited insofar as each is using precipitation values from PRISM that are specific to a 6-month period of a given year, but long-term average ET values from the Provisional WIG. This has the likely effect of pulling all values towards the middle, since crop ET would be higher in a drier, hotter summer and less in a wetter, cooler summer. Regardless, the results are useful to get a sense of the range of lawn irrigation water requirements by subbasin over the 30-year period (1990-2019).

[16] This is consistent with Ag Weather Net and WAIG data, where the crop irrigation water requirement in the area of interest for lawn/grass/pasture/turf is zero for the months January through March and October through December.

[17] Where Pe = 0.921719*(0.70917*Pt^0.82416-0.11556)*10^(0.02426*ETc)

Table 6 (attached) shows the calculations and results for approximate effective precipitation and net crop irrigation water requirements, by subbasin, by year, as described above.

Conclusions

The results presented in Table 4D (AgWeatherNet-based calculations of IWR_{net}) and Table 6 (PRISM-based approximations of IWR_{net}) suggest that lawn irrigation water requirements in a dry/drought year are (or could be) about 15 to 40 percent greater as compared to more average years. However, given that irrigation water requirement values presented in the Provisional WIG are lower than those presented in Appendix A of the WAIG by roughly 20 to 30 percent, it might be assumed that the Appendix A WAIG numbers are sufficiently conservative to account for dry year water use in a 20-year planning horizon.

Additionally, the range of irrigation season precipitation across the areas of WRIAs 14 and 15 (see Table 5 and Figure 2) is sufficiently wide to warrant consideration of variable outdoor consumptive water use calculations (by subbasin or some other geographic unit)—a consideration that may depend on estimated population growth patterns in the areas of higher or lower normal precipitation.

Limitations

Work for this project was performed for the Skokomish Tribe (Client), and this memorandum was 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. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

Attachments: Table 5 – PRISM Total Precipitation Data: 30-year Normal and Annually, 1990-2018 - by WRIA 14 and 15 Subbasin

Table 6 – Approximate Effective Precipitation and Irrigation Water Requirements Based on PRISM Data, 1990-2018 - by WRIA 14 and 15 Subbasin

Figure 1 – WRIAs, Subbasins and Area Irrigation Guide/Weather Data Stations

Figure 2 – Calculated 30-year Normal Irrigation Season Precipitation in WRIAs 14 and 15

V:\190315 Skokomish Tribe WRIA 14-15 Strmflw Restoration\Deliverables\Precip Variability Memo\Memo_PrecipitationVariability_forCUCalcs_Draft.docx

TABLES

Table 5. PRISM Total Precipitation Data: 30-year Normal and Annually, 1990-2018 - by WRIA 14 and 15 Subbasin

Project No. 190315, Shelton, Washington

DRAFT

Wria	Subbasin	PRISM 30-year (1981-2010) Normal Total Precipitation for Irrigation Season (inches)							April through September Precipitation Total by Year (inches) from PRISM																												
		April	*May*	*Jun*	*July*	*Aug*	*Sept*	***Total***	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**	**1994**	**1993**	**1992**	**1991**	**1990**
14	Case	4.4	2.7	2.0	0.9	1.1	1.9	**13.0**	13.2	15.3	7.4	10.2	17.0	21.2	11.1	15.6	18.8	13.7	9.1	11.5	8.4	15.4	12.5	8.1	11.0	14.3	12.5	8.6	5.9	23.7	19.4	12.3	10.4	17.5	11.7	17.1	11.1
	Goldsborough	5.7	3.3	2.2	1.0	1.3	2.5	**16.0**	17.3	17.9	9.4	11.6	20.3	26.0	14.2	20.3	22.4	15.8	11.5	14.2	10.2	19.0	14.8	10.9	13.1	17.5	16.9	10.7	7.0	29.6	23.4	15.8	13.8	21.4	14.3	19.9	13.2
	Harstine	3.8	2.4	1.9	0.8	1.0	1.7	**11.5**	11.4	13.9	6.7	8.6	15.8	20.2	10.7	14.1	18.3	13.2	8.0	10.2	7.8	13.9	11.3	7.3	9.5	12.9	10.7	8.0	5.5	21.1	17.5	10.9	9.1	15.5	10.5	16.1	10.3
	Hood	4.2	2.5	1.9	0.9	1.0	1.9	**12.4**	12.6	14.5	7.0	9.7	16.4	20.2	10.7	15.0	17.8	13.1	8.8	11.0	8.2	14.8	12.3	7.6	10.3	13.8	11.8	8.3	5.8	23.1	18.7	11.9	9.9	16.6	11.3	16.4	10.8
	Kennedy	5.0	3.0	2.2	0.9	1.2	2.3	**14.5**	15.6	16.6	9.2	11.0	19.6	25.4	13.0	18.4	20.5	15.0	10.1	12.6	9.3	17.1	13.7	9.8	11.6	15.5	14.3	9.7	6.8	26.7	21.0	14.1	11.5	19.1	12.5	17.5	12.7
	Mill	4.9	2.9	2.0	0.9	1.1	2.2	**14.0**	14.5	16.0	8.0	10.2	18.5	23.6	12.6	18.2	20.1	14.7	10.0	12.7	9.0	16.6	12.8	9.4	11.3	15.1	14.1	9.5	6.3	26.3	21.1	14.1	11.6	19.0	12.1	17.6	12.4
	Oakland	4.6	2.7	2.0	0.9	1.1	2.1	**13.4**	13.9	15.7	7.5	10.8	17.5	22.4	11.6	16.8	19.2	14.0	9.4	12.2	8.6	15.9	12.8	8.6	11.0	14.5	13.2	8.8	5.9	25.3	20.4	13.2	10.9	18.2	11.8	17.0	11.6
	Skookum	4.8	2.9	2.1	0.9	1.2	2.1	**14.0**	14.5	16.1	8.4	10.3	18.6	23.8	12.7	17.9	20.2	14.8	9.9	12.6	9.0	16.6	12.9	9.4	11.2	15.1	13.9	9.5	6.5	25.8	20.9	13.9	11.4	18.8	12.1	17.6	12.3
15	Bainbridge Island	2.9	2.0	1.7	0.7	0.8	1.4	**9.4**	8.5	9.2	6.0	6.6	11.2	14.1	8.9	10.7	13.0	10.2	8.1	8.6	7.7	12.3	10.5	6.1	7.0	12.0	8.3	7.2	5.5	17.1	14.5	9.9	7.5	12.8	9.5	11.7	8.2
	McNeil Island, Anderson Island, Ketron Island	3.1	2.1	1.7	0.7	0.9	1.4	**10.0**	9.7	12.0	5.9	6.9	14.4	18.3	10.0	12.6	17.3	11.1	7.1	8.8	7.5	12.8	10.3	6.6	8.4	12.1	9.5	7.2	4.8	18.7	15.7	9.5	8.5	13.7	9.4	14.7	9.6
	North Hood Canal	3.1	2.2	1.7	0.8	0.9	1.5	**10.2**	9.6	10.2	6.4	7.6	12.4	15.6	10.1	11.6	14.1	10.6	8.2	8.7	8.1	12.3	10.8	6.2	7.3	11.7	8.6	8.0	6.1	17.6	14.8	10.4	7.8	13.8	9.8	11.9	8.9
	South Hood Canal	4.6	2.8	2.0	1.0	1.1	2.0	**13.6**	14.0	15.7	7.5	10.4	17.4	21.8	11.6	16.0	18.9	13.8	9.4	11.9	8.8	15.9	13.1	8.3	11.1	15.4	12.8	9.1	6.4	24.8	19.8	13.0	10.8	18.4	12.4	17.3	11.1
	South Sound	3.6	2.3	1.8	0.8	1.0	1.6	**11.1**	10.5	13.1	6.7	8.3	15.3	18.9	9.8	13.9	17.5	12.8	8.0	9.5	7.5	13.6	10.8	6.7	9.3	12.7	10.1	7.8	5.2	20.2	16.7	10.1	9.1	14.6	10.0	15.8	10.2
	Vashon - Maury Island	3.0	2.1	1.7	0.8	0.9	1.5	**10.0**	9.2	10.7	6.2	7.6	13.6	17.4	9.3	12.5	15.9	11.6	7.9	8.2	8.1	12.4	10.3	5.9	8.1	12.2	8.9	7.3	5.1	17.3	14.8	9.2	8.4	12.7	9.0	13.4	9.0
	West Sound	3.2	2.2	1.7	0.8	0.9	1.5	**10.4**	9.7	10.9	6.5	7.8	12.7	16.4	9.8	12.0	15.0	11.4	8.4	9.2	8.0	13.2	11.3	6.5	7.7	12.7	9.1	7.9	5.8	18.5	15.3	10.5	8.1	14.1	10.2	12.7	8.8

WRIA	Subbasin								April through September Precipitation Total as Percent of 30-year Normal by Year																												
		April	*May*	*Jun*	*July*	*Aug*	*Sept*	***Total***	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**	**1994**	**1993**	**1992**	**1991**	**1990**
14	Case	4.4	2.7	2.0	0.9	1.1	1.9	**13.0**	101%	117%	57%	78%	131%	163%	85%	120%	144%	105%	70%	89%	64%	118%	96%	62%	84%	110%	96%	66%	46%	182%	149%	95%	80%	135%	90%	132%	85%
	Goldsborough	5.7	3.3	2.2	1.0	1.3	2.5	**16.0**	108%	112%	58%	72%	127%	162%	88%	127%	140%	98%	72%	88%	64%	119%	92%	68%	82%	109%	106%	67%	44%	185%	146%	99%	86%	134%	90%	124%	82%
	Harstine	3.8	2.4	1.9	0.8	1.0	1.7	**11.5**	99%	121%	58%	75%	137%	176%	93%	122%	158%	114%	69%	88%	67%	121%	98%	64%	83%	112%	93%	69%	48%	183%	152%	95%	79%	134%	91%	140%	90%
	Hood	4.2	2.5	1.9	0.9	1.0	1.9	**12.4**	102%	117%	56%	78%	133%	163%	86%	122%	144%	106%	71%	89%	66%	120%	100%	62%	83%	112%	95%	67%	47%	187%	152%	96%	80%	135%	91%	133%	87%
	Kennedy	5.0	3.0	2.2	0.9	1.2	2.3	**14.5**	107%	114%	64%	76%	135%	175%	90%	127%	141%	103%	69%	87%	64%	118%	94%	67%	80%	107%	98%	67%	47%	184%	145%	97%	79%	131%	86%	121%	87%
	Mill	4.9	2.9	2.0	0.9	1.1	2.2	**14.0**	103%	114%	57%	73%	132%	169%	90%	130%	143%	105%	71%	91%	64%	119%	91%	67%	80%	108%	100%	68%	45%	188%	151%	101%	83%	135%	87%	125%	88%
	Oakland	4.6	2.7	2.0	0.9	1.1	2.1	**13.4**	104%	118%	56%	81%	131%	167%	86%	125%	144%	105%	70%	92%	64%	119%	96%	64%	82%	109%	99%	66%	44%	189%	153%	99%	82%	136%	88%	127%	86%
	Skookum	4.8	2.9	2.1	0.9	1.2	2.1	**14.0**	103%	115%	60%	74%	133%	170%	90%	127%	144%	106%	70%	90%	64%	118%	92%	67%	80%	108%	99%	68%	46%	184%	149%	99%	81%	134%	86%	125%	88%
15	Bainbridge Island	2.9	2.0	1.7	0.7	0.8	1.4	**9.4**	90%	98%	64%	70%	119%	150%	94%	113%	137%	108%	85%	91%	82%	131%	112%	64%	74%	127%	88%	77%	58%	181%	154%	105%	79%	136%	100%	124%	87%
	McNeil Island, Anderson Island, Ketron Island	3.1	2.1	1.7	0.7	0.9	1.4	**10.0**	97%	121%	59%	69%	145%	184%	100%	126%	173%	111%	71%	88%	75%	128%	103%	66%	84%	121%	95%	72%	48%	187%	157%	95%	85%	138%	94%	147%	96%
	North Hood Canal	3.1	2.2	1.7	0.8	0.9	1.5	**10.2**	94%	100%	63%	75%	122%	152%	99%	114%	138%	104%	80%	85%	79%	121%	106%	60%	72%	115%	84%	78%	60%	173%	145%	101%	77%	135%	96%	117%	87%
	South Hood Canal	4.6	2.8	2.0	1.0	1.1	2.0	**13.6**	103%	115%	55%	76%	128%	160%	85%	118%	139%	101%	69%	88%	65%	117%	97%	61%	82%	113%	94%	67%	47%	182%	146%	95%	79%	135%	91%	127%	82%
	South Sound	3.6	2.3	1.8	0.8	1.0	1.6	**11.1**	95%	118%	61%	75%	138%	170%	88%	125%	158%	115%	72%	85%	67%	122%	97%	60%	84%	115%	91%	71%	47%	183%	151%	91%	82%	132%	90%	142%	92%
	Vashon - Maury Island	3.0	2.1	1.7	0.8	0.9	1.5	**10.0**	92%	107%	62%	76%	136%	173%	92%	124%	159%	116%	79%	82%	80%	124%	102%	59%	81%	121%	89%	73%	51%	173%	148%	92%	84%	127%	90%	133%	90%
	West Sound	3.2	2.2	1.7	0.8	0.9	1.5	**10.4**	93%	104%	62%	74%	122%	158%	94%	115%	144%	110%	81%	88%	77%	126%	108%	62%	73%	122%	87%	76%	56%	177%	147%	100%	77%	135%	97%	122%	84%
								Average	*99%*	*113%*	*59%*	*75%*	*131%*	*166%*	*91%*	*122%*	*147%*	*107%*	*73%*	*88%*	*70%*	*121%*	*99%*	*64%*	*80%*	*114%*	*94%*	*70%*	*49%*	*183%*	*150%*	*97%*	*81%*	*134%*	*91%*	*129%*	*87%*
								Rank	*17*	*19*	*2*	*7*	*24*	*28*	*12*	*22*	*26*	*18*	*6*	*11*	*4*	*21*	*16*	*3*	*8*	*20*	*14*	*5*	*1*	*29*	*27*	*15*	*9*	*25*	*13*	*23*	*10*

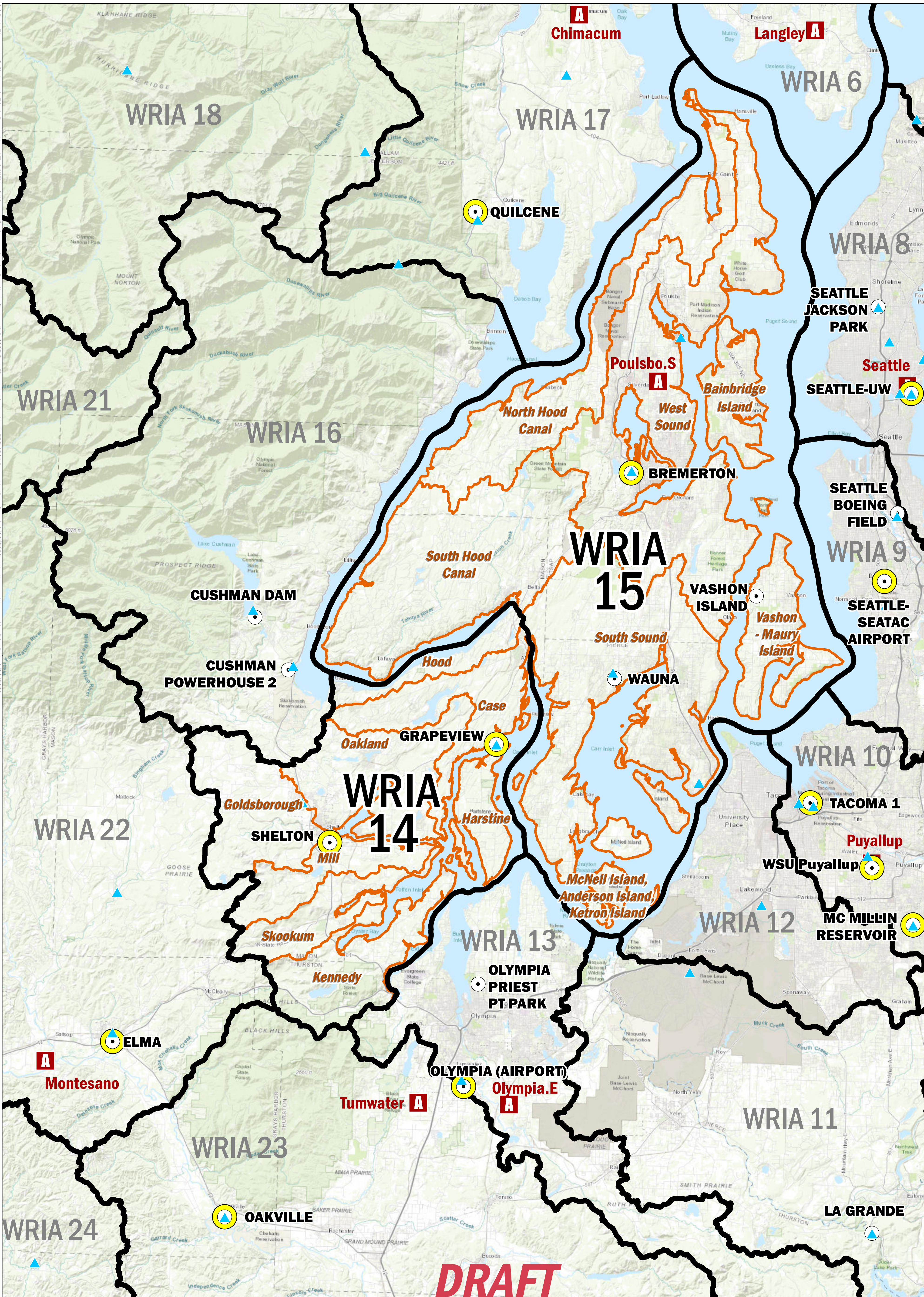
Table 6. Approximate Effective Precipitation and Irrigation Water Requirements Based on PRISM Data, 1990-2018 - by WRIA 14 and 15 Subbasin

Project No. 190315, Shelton, Washington

				Provisional WIG Numbers (Apr-Sept)				April through September Calculated Effective Precipitation (Pe) Total by Year (inches) *Calculated for all months individually, then totalled: Pe(in) = 0.921719*(0.70917*[Pt(in)]^0.82416-0.11556)*(10^(0.02426*[ETc(in)])) - where ETc (in) is the monthly normal for the given proxy station*																												
Wria	Subbasin	PRISM 30-yr Normal Precip. (in)	WIG Station Proxy	Total Precip (in)	Eff. Precip (in)	ET(c)	Net IWR (in)	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
14	Case	13.0	GRAPEVIEW 3 SW	13.7	8.2	20.1	12.2	6.8	8.3	4.6	6.0	9.8	11.5	6.5	8.8	10.6	7.8	5.6	7.2	4.9	8.9	7.5	4.5	6.4	8.7	7.6	5.5	3.7	13.5	10.5	7.6	6.4	9.7	6.7	9.5	6.7
	Goldsborough	16.0	SHELTON	14.8	8.9	21.0	12.5	8.8	9.6	5.8	6.8	11.4	13.9	8.1	11.3	12.4	8.9	7.0	8.8	6.0	10.8	8.7	6.0	7.5	10.3	10.0	6.7	4.4	16.3	12.5	9.5	8.3	11.7	7.9	11.0	7.9
	Harstine	11.5	GRAPEVIEW 3 SW	13.7	8.2	20.1	12.2	6.0	7.7	4.2	5.1	9.2	11.0	6.2	8.1	10.3	7.6	5.0	6.5	4.6	8.1	6.8	4.1	5.6	7.9	6.6	5.1	3.4	12.2	9.6	6.8	5.6	8.7	6.1	9.0	6.3
	Hood	12.4	GRAPEVIEW 3 SW	13.7	8.2	20.1	12.2	6.5	7.9	4.4	5.7	9.4	11.0	6.3	8.6	10.1	7.5	5.4	6.9	4.8	8.6	7.4	4.3	6.1	8.4	7.2	5.3	3.6	13.2	10.2	7.4	6.1	9.3	6.5	9.1	6.5
	Kennedy	14.5	SHELTON	14.8	8.9	21.0	12.5	7.9	9.1	5.7	6.5	11.1	13.5	7.6	10.4	11.5	8.6	6.2	7.9	5.5	9.9	8.1	5.5	6.7	9.3	8.6	6.1	4.2	15.0	11.4	8.6	7.1	10.6	7.1	9.8	7.7
	Mill	14.0	SHELTON	14.8	8.9	21.0	12.5	7.4	8.8	5.0	6.0	10.6	12.7	7.3	10.2	11.2	8.4	6.2	8.0	5.3	9.6	7.6	5.2	6.6	9.1	8.5	6.0	3.9	14.8	11.4	8.6	7.1	10.5	6.8	9.8	7.5
	Oakland	13.4	SHELTON	14.8	8.9	21.0	12.5	7.1	8.6	4.7	6.4	10.0	12.1	6.8	9.5	10.8	8.0	5.8	7.7	5.1	9.2	7.6	4.8	6.4	8.8	8.0	5.6	3.7	14.4	11.1	8.1	6.7	10.2	6.7	9.5	7.0
	Skookum	14.0	SHELTON	14.8	8.9	21.0	12.5	7.4	8.8	5.2	6.1	10.6	12.8	7.3	10.1	11.3	8.4	6.1	7.9	5.3	9.6	7.7	5.3	6.5	9.1	8.3	6.0	4.0	14.6	11.3	8.5	7.0	10.5	6.8	9.8	7.5
15	Bainbridge Island	9.4	BREMERTON	11.4	7.0	20.0	13.2	4.7	5.2	3.8	4.1	6.9	8.0	5.4	6.4	7.6	6.0	5.0	5.6	4.6	7.4	6.5	3.5	4.3	7.5	5.2	4.7	3.5	10.2	8.3	6.2	4.6	7.4	5.8	6.8	5.1
	McNeil Island, Anderson Island, Ketron Island	10.0	WAUNA 3 W	11.8	7.3	20.0	12.7	5.2	6.7	3.6	4.2	8.5	10.1	5.8	7.3	9.8	6.5	4.5	5.7	4.4	7.5	6.2	3.7	5.0	7.4	5.9	4.6	3.0	11.0	8.7	6.1	5.2	7.8	5.5	8.2	5.8
	North Hood Canal	10.2	BREMERTON	11.4	7.0	20.0	13.2	5.3	5.7	4.1	4.7	7.5	8.7	6.1	6.9	8.2	6.2	5.1	5.6	4.8	7.4	6.7	3.5	4.5	7.3	5.4	5.1	3.9	10.5	8.5	6.5	4.8	8.0	5.9	7.0	5.5
	South Hood Canal	13.6	CUSHMAN POWERHOUSE 2	16.2	9.6	20.5	11.8	7.3	8.5	4.8	6.1	10.0	11.8	6.8	9.1	10.7	7.8	5.8	7.5	5.2	9.2	7.9	4.7	6.6	9.3	7.7	5.8	4.0	14.0	10.8	7.9	6.6	10.2	7.1	9.6	6.8
	South Sound	11.1	WAUNA 3 W	11.8	7.3	20.0	12.7	5.6	7.2	4.3	5.0	8.9	10.3	5.7	8.0	10.0	7.4	5.0	6.1	4.4	8.0	6.5	3.8	5.5	7.8	6.2	5.0	3.2	11.8	9.2	6.4	5.6	8.2	5.9	8.8	6.2
	Vashon - Maury Island	10.0	VASHON ISLAND	13.4	8.2	20.1	12.2	4.8	6.0	4.0	4.6	8.1	9.6	5.5	7.3	9.2	6.7	5.0	5.3	4.8	7.4	6.2	3.4	4.9	7.5	5.6	4.7	3.2	10.3	8.3	5.9	5.2	7.3	5.5	7.6	5.5
	West Sound	10.4	BREMERTON	11.4	7.0	20.0	13.2	5.3	6.1	4.1	4.8	7.7	9.1	5.9	7.1	8.7	6.6	5.2	5.9	4.7	7.8	6.9	3.7	4.7	7.9	5.7	5.1	3.7	10.9	8.7	6.5	4.9	8.1	6.1	7.3	5.4

				Provisional WIG Numbers (Apr-Sept)				April through September Calculated Net Irrigation Water Requirement by Year (inches) *ET(c) - Pe*																												
Wria	Subbasin	PRISM 30-yr Normal Precip. (in)	WIG Station Proxy	Total Precip (in)	Eff. Precip (in)	ET(c)	Net IWR (in)	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
14	Case	13.0	GRAPEVIEW 3 SW	13.7	8.2	20.1	12.2	13.3	11.8	15.5	14.1	10.3	8.6	13.6	11.3	9.5	12.3	14.5	12.9	15.2	11.2	12.6	15.6	13.7	11.4	12.5	14.6	16.4	6.6	9.6	12.5	13.7	10.4	13.4	10.6	13.4
	Goldsborough	16.0	SHELTON	14.8	8.9	21.0	12.5	12.2	11.4	15.2	14.2	9.6	7.1	12.9	9.7	8.6	12.1	14.0	12.2	15.0	10.2	12.3	15.0	13.5	10.7	11.0	14.3	16.6	4.7	8.5	11.5	12.7	9.3	13.1	10.0	13.1
	Harstine	11.5	GRAPEVIEW 3 SW	13.7	8.2	20.1	12.2	14.1	12.4	15.9	15.0	10.9	9.1	13.9	12.0	9.8	12.5	15.1	13.6	15.5	12.0	13.3	16.0	14.5	12.2	13.5	15.0	16.7	7.9	10.5	13.3	14.5	11.4	14.0	11.1	13.8
	Hood	12.4	GRAPEVIEW 3 SW	13.7	8.2	20.1	12.2	13.6	12.2	15.7	14.4	10.7	9.1	13.8	11.5	10.0	12.6	14.7	13.2	15.3	11.5	12.7	15.8	14.0	11.7	12.9	14.8	16.5	6.9	9.9	12.7	14.0	10.8	13.6	11.0	13.6
	Kennedy	14.5	SHELTON	14.8	8.9	21.0	12.5	13.1	11.9	15.3	14.5	9.9	7.5	13.4	10.6	9.5	12.4	14.8	13.1	15.5	11.1	12.9	15.5	14.3	11.7	12.4	14.9	16.8	6.0	9.6	12.4	13.9	10.4	13.9	11.2	13.3
	Mill	14.0	SHELTON	14.8	8.9	21.0	12.5	13.6	12.2	16.0	15.0	10.4	8.3	13.7	10.8	9.8	12.6	14.8	13.0	15.7	11.4	13.4	15.8	14.4	11.9	12.5	15.0	17.1	6.2	9.6	12.4	13.9	10.5	14.2	11.2	13.5
	Oakland	13.4	SHELTON	14.8	8.9	21.0	12.5	13.9	12.4	16.3	14.6	11.0	8.9	14.2	11.5	10.2	13.0	15.2	13.3	15.9	11.8	13.4	16.2	14.6	12.2	13.0	15.4	17.3	6.6	9.9	12.9	14.3	10.8	14.3	11.5	14.0
	Skookum	14.0	SHELTON	14.8	8.9	21.0	12.5	13.6	12.2	15.8	14.9	10.4	8.2	13.7	10.9	9.7	12.6	14.9	13.1	15.7	11.4	13.3	15.7	14.5	11.9	12.7	15.0	17.0	6.4	9.7	12.5	14.0	10.5	14.2	11.2	13.5
15	Bainbridge Island	9.4	BREMERTON	11.4	7.0	20.0	13.2	15.3	14.8	16.2	15.9	13.1	12.0	14.6	13.6	12.4	14.0	15.0	14.4	15.4	12.6	13.5	16.5	15.7	12.5	14.8	15.3	16.5	9.8	11.7	13.8	15.4	12.6	14.2	13.2	14.9
	McNeil Island, Anderson Island, Ketron Island	10.0	WAUNA 3 W	11.8	7.3	20.0	12.7	14.8	13.3	16.4	15.8	11.5	9.9	14.2	12.7	10.2	13.5	15.5	14.3	15.6	12.5	13.8	16.3	15.0	12.6	14.1	15.4	17.0	9.0	11.3	13.9	14.8	12.2	14.5	11.8	14.2
	North Hood Canal	10.2	BREMERTON	11.4	7.0	20.0	13.2	14.7	14.3	15.9	15.3	12.5	11.3	13.9	13.1	11.8	13.8	14.9	14.4	15.2	12.6	13.3	16.5	15.5	12.7	14.6	14.9	16.1	9.5	11.5	13.5	15.2	12.0	14.1	13.0	14.5
	South Hood Canal	13.6	CUSHMAN POWERHOUSE 2	16.2	9.6	20.5	11.8	13.2	12.0	15.7	14.4	10.5	8.7	13.7	11.4	9.8	12.7	14.7	13.0	15.3	11.3	12.6	15.8	13.9	11.2	12.8	14.7	16.5	6.5	9.7	12.6	13.9	10.3	13.4	10.9	13.7
	South Sound	11.1	WAUNA 3 W	11.8	7.3	20.0	12.7	14.4	12.8	15.7	15.0	11.1	9.7	14.3	12.0	10.0	12.6	15.0	13.9	15.6	12.0	13.5	16.2	14.5	12.2	13.8	15.0	16.8	8.2	10.8	13.6	14.4	11.8	14.1	11.2	13.8
	Vashon - Maury Island	10.0	VASHON ISLAND	13.4	8.2	20.1	12.2	15.3	14.1	16.1	15.5	12.0	10.5	14.6	12.8	10.9	13.4	15.1	14.8	15.3	12.7	13.9	16.7	15.2	12.6	14.5	15.4	16.9	9.8	11.8	14.2	14.9	12.8	14.6	12.5	14.6
	West Sound	10.4	BREMERTON	11.4	7.0	20.0	13.2	14.7	13.9	15.9	15.2	12.3	10.9	14.1	12.9	11.3	13.4	14.8	14.1	15.3	12.2	13.1	16.3	15.3	12.1	14.3	14.9	16.3	9.1	11.3	13.5	15.1	11.9	13.9	12.7	14.6

FIGURES



GIS Path: T:\projects_8\Skokomish_Tribe_Precip_Memo\Fig1_WRIAs_Subbasins_Stations.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 4/30/2020 || User: pwittman || Print Date: 4/30/2020

- Washington Irrigation Guide (WAIG) Station (approx.)
- WSU (Provisional WIG) Station
- PRISM Station
- AgWeatherNet Station
- Water Resource Inventory Area (WRIA)
- Subbasin

0 3 6
Miles

WRIAs, Subbasins and Area Irrigation Guide/Weather Data Stations

Assessing Precipitation Variability in Outdoor Domestic Water Use Calculations for WRIAs 14 and 15
Skokomish Tribe
Washington

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	PROJECT NO. 190315	REVISED BY: - - -	

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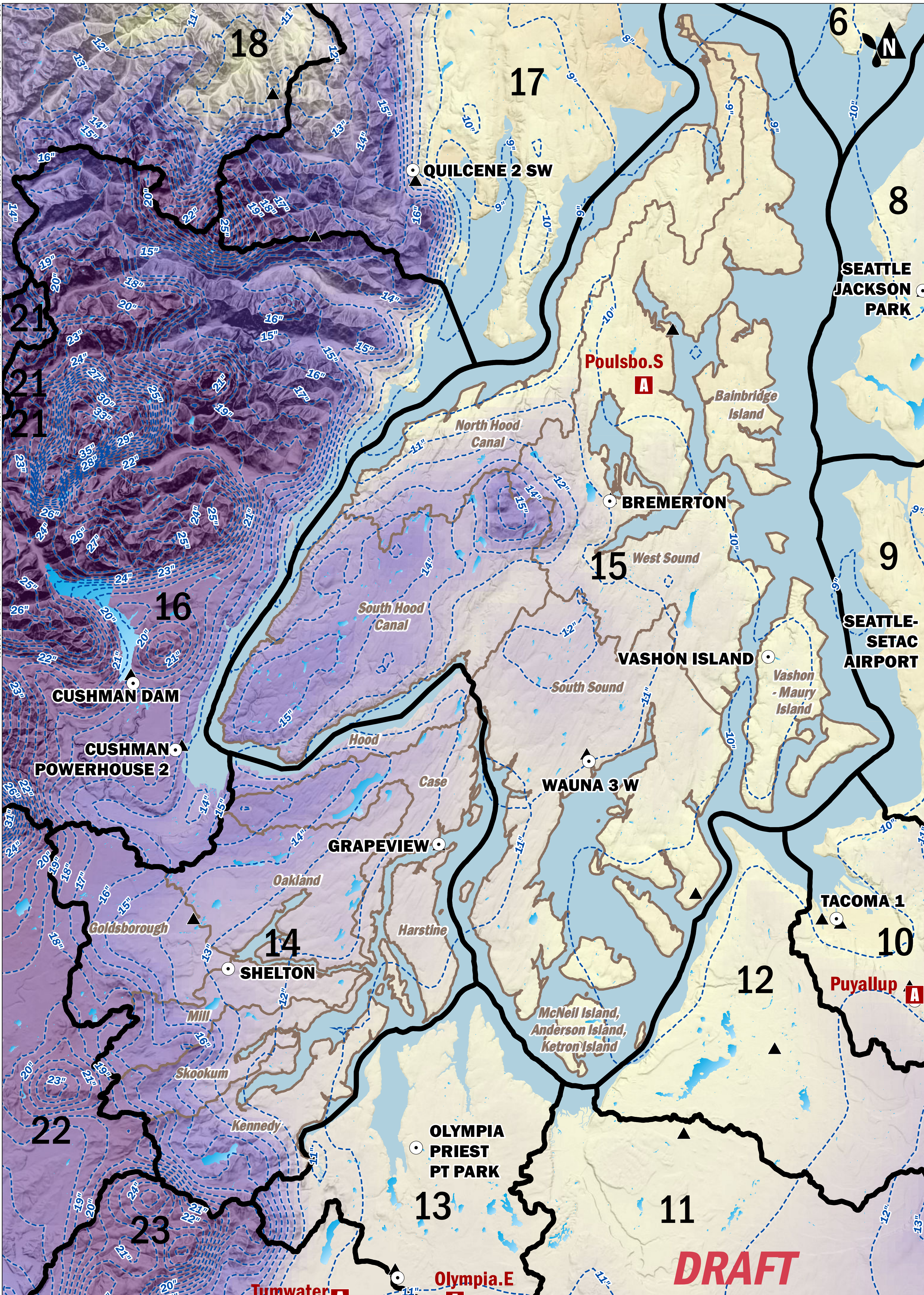

Irrigation Guide Station (WAIG and/or WSU)

PRISM Station

AgWeatherNet Station

WRIA

Subbasin

30-year Normal Apr-Sept Total Precipitation (PRISM)

20" or more

0"

0 3 6

Miles

30-year Normal Total Precipitation between April and September (1-inch isohyets) from PRISM

Calculated 30-year Normal Irrigation Season Precipitation in WRIAs 14 and 15

Assessing Precipitation Variability in Outdoor Domestic Water Use Calculations for WRIAs 14 and 15

Skokomish Tribe

Washington

Aspect CONSULTING

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