nhc
GEOENGINEERS

17245 NE Union Hill Road, Suite 250, Redmond, Washington, 98052 Telephone: 425.861.6000, Fax: 425.861.6050 www.geoengineers.com

Memorandum

To: Ingria Jones, Washington State Department of Ecology

From: Patty Dillon, Cynthia Carlstad, NHC;
Bridget August, John Monahan, GeoEngineers

Date: January 7, 2021

File: 0504-161-00

Subject: WRIA 7 Consumptive Use Estimates

PATRICIA H. DILLON
STATE OF WASHINGTON
38786
REGISTERED
PROFESSIONAL ENGINEER
1/7/2021

INTRODUCTION

GeoEngineers, Inc. (GeoEngineers) is providing technical support to the Washington State Department of Ecology (Ecology) and the Watershed Restoration and Enhancement (WRE) Committees for Water Resource Inventory Areas (WRIAs) 7, 8 and 9. This memorandum provides a summary of the deliverable for Work Assignment GEO102, Task 4, WRIA 7 Consumptive Use Estimates.

BACKGROUND AND CONTEXT

The Streamflow Restoration law (Revised Code of Washington [RCW 90.94]) specifies that by June 30, 2021, Ecology must establish a WRE Committee and adopt a WRE Plan in the Snohomish Watershed (WRIA 7). The Snohomish (WRIA 7) Watershed Restoration and Enhancement Plan (watershed plan) must include projects and actions that offset the new consumptive water use (consumptive use) from future domestic permit-exempt wells (PE wellsP0F1P). Consumptive water use is considered water that is evaporated, transpired, consumed by humans, or otherwise removed from an immediate water environment due to the use of new permit-exempt domestic wells (Ecology 2019). For watershed planning purposes, consumptive use is water that is drawn from groundwater via a domestic PE well and not replaced through the septic system, irrigation return flow, or other means.

Projections for number and location of new PE wells within WRIA 7 were developed by King County, Snohomish County, and GeoEngineers (GeoEngineers 2021a) for purposes of the watershed plan. This memorandum summarizes the methods used to estimate consumptive use associated with the new PE well connections and provides results for three water use scenarios. Methodology is based on Appendix A of Ecology's Final Guidance for Determining Net Ecological Benefit (Final NEB Guidance) (Ecology 2019) and documented in further detail in the Consumptive Use Estimates Workplan prepared by the GeoEngineers team (GeoEngineers 2019).

[1] "PE wells" is used to refer to new homes associated with new permit-exempt wells and also new homes added to existing wells, including homes on group systems relying on permit-exempt wells.

CONSUMPTIVE WATER USE METHODOLOGY

Measurement of consumptive water use in any setting is difficult, and it is virtually impossible for residential groundwater use, which must account for both indoor and outdoor use. PE wells are generally unmetered, so supply to each home is usually unknown, let alone the amount that is lost to the groundwater system. Therefore, we are limited to estimating consumptive use based on projections of future growth, local patterns and trends in water use, and generally accepted and reasonable assumptions. Water use data from local water purveyors may be useful as a check on calculated estimates but must be used with caution. Homes that pay for municipal water tend to exhibit different water use behaviors, including water saving appliances and reduced landscape watering, that reduce usage compared to homes on wells.

The two categories of household consumptive use are indoor water use and outdoor water use. The methodology used to estimate these quantities for WRIA 7 are described in the following sections.

Indoor Consumptive Use

Indoor consumptive use was estimated using methods and assumptions from the Final NEB Guidance (Ecology 2019), which was based on groundwater monitoring and modeling studies conducted by the U.S. Geological Survey in several areas of Washington. There are two basic elements to estimating indoor consumptive use:

- Amount of total water used. The Final NEB Guidance recommends an assumption of 60 gallons per person per day as a reasonable estimate of indoor water use. To estimate indoor usage per well, the per capita usage was multiplied by the average rural household size, estimated by King County and Snohomish County as 2.73 and 2.75 people per household, respectively. For analysis areas spanning both counties, a weighted value was estimated based on the number of projected PE well connections in each county. Table 1 summarizes the household sizes for each WRIA 7 delineated subbasin with projected PE wells (GeoEngineers 2021b) and for all of WRIA 7.
- Percentage of total water used that is consumptive. The Final NEB Guidance recommends that 10 percent of the total indoor water use is considered consumptive when a home is on a septic system. (All indoor water use is considered consumptive for homes with sewer connections.) Areas projected to be served by PE wells are outside of sewer service areas, so the 10 percent assumption was applied for all projected indoor water use.

TABLE 1. AVERAGE RESIDENTS PER HOUSEHOLD

Subbasin	% Projected Wells by County		Avg. People per Rural Household
	King	Snohomish	
Tulalip	--	100%	2.75
Quilceda-Allen	--	100%	2.75
Estuary/Snohomish Mainstem	--	100%	2.75
Little Pilchuck	--	100%	2.75
Pilchuck	--	100%	2.75
Woods	--	100%	2.75
Sultan	--	100%	2.75
Lower Mid-Skykomish	--	100%	2.75

Subbasin	% Projected Wells by County		Avg. People per Rural Household
	King	Snohomish	
Skykomish Mainstem	--	100%	2.75
Upper Skykomish	49%	51%	2.74
Cherry-Harris	95%	5%	2.73
Snoqualmie North	71%	29%	2.74
Snoqualmie South	100%	--	2.73
Patterson	100%	--	2.73
Raging	100%	--	2.73
Upper Snoqualmie	100%	--	2.73
WRIA Total	**29%**	**71%**	**2.74**

Outdoor Consumptive Use

Outdoor water use is typically the larger portion of domestic single-family residential water use, with irrigation of lawn and garden being the dominant outdoor water use component. The GeoEngineers team conducted a subbasin-specific assessment to determine typical outdoor water use patterns, namely the typical size of irrigated lawn, garden, and landscaping areas associated with newer residential development and irrigation water needs, which vary by crop and climate. The consumptive use estimate assumes that current rural residential landscaping practices and outdoor water use will continue over the 20-year planning horizon.

Irrigated Footprint Analysis

The GeoEngineers team conducted an aerial photo-based analysis of irrigated lawn and garden area for 393 parcels in the 16 WRIA 7 subbasins. Parcels used for the irrigated footprint analysis were selected based on recent (2006-2017) building permits for new single-family residential homes not served by public water. Permits for accessory dwelling units (ADUs) or reconstruction/remodel were excluded. There were nearly 1,600 permits in WRIA 7 meeting these criteria—more than could be reasonably evaluated for this project. A minimum 20-parcel sample per subbasin was targeted as a statistically representative sample size based on statistics from similar analyses in WRIAs 1, 8, and 9. The target sample size is sufficient to ensure that the sample mean is representative over the WRIA within a 95 percent confidence limit. Sample parcels were selected by assigning a random number to each building permit, and then evaluating sites in rank order up to the target sample size. Using a random selection from the permit list avoids the bias that could be introduced if selecting from the imagery.

Each parcel was evaluated visually in Google Earth for irrigated lawn areas. Google Earth's historical imagery collection allowed for clearer identification of irrigated areas by comparing aerial photos spanning multiple seasons and years. Late summer imagery was particularly helpful in determining boundaries of irrigated (green) vs. non-irrigated (brown) grass areas. More often than not, the parcels did not demonstrate such a clear-cut distinction between green and brown spaces. It appears that many homeowners irrigate enough to keep lawns alive but not lush (or comparable to commercial turf grass/golf course green). Delineating these irrigated spaces is subjective, and the GeoEngineers team tried to ensure consistency in the interpretation and results by having one geographic information system (GIS) analyst evaluate all of the selected parcels in the WRIA. The irrigated area was delineated for each parcel based on several key assumptions:

- Landscaped shrub/flower bed areas were included in the irrigated footprint (not just lawn areas).
- Homes that did not show visible signs of irrigation were tracked as zero irrigated footprint.
- Homes or landscaping still under construction in the most recent Google Earth imagery were excluded.
- Native forest or unmaintained grass/pasture were not included in the irrigated footprint.
- Pre-existing agricultural land use was not considered part of the residential irrigation footprint.

Figure 1 shows examples of irrigated area delineation for two representative parcels in the Patterson (left) and Upper Skykomish (right) subbasins. On each photo, the parcel boundary is shown in yellow and the area identified as irrigated in white. Large homes and extensive irrigated lawn and garden areas were much more common in the Patterson, Pilchuck, and Raging subbasins compared to the rest of the WRIA.

Figure 1. Example Irrigated Area Delineations, Patterson subbasin (left) and Upper Skykomish subbasin (right)

Results of the irrigated footprint analysis for all subbasins are summarized in Table 2. Note that more parcels than the target minimum sample were analyzed in each of the subbasins. When identifying the random list for analysis, the GeoEngineers team identified 10 additional sites beyond the target minimum of 20 to allow for dropping parcels that did not meet the analysis criteria (e.g., construction not completed). The full list was analyzed, resulting in a few parcels above the target minimum in each subbasin.

TABLE 2. WRIA 7 IRRIGATED FOOTPRINT SUMMARY

Subbasin	Applicable Permit Parcels	Parcels Analyzed	Total Irrigated Area (ac)	Average Irrigated Area (ac)
Tulalip	116	21	2.0	0.09
Quilceda-Allen	160	26	3.8	0.15
Estuary/Snohomish Mainstem	207	26	7.6	0.29
Little Pilchuck	161	24	4.8	0.20
Pilchuck	153	25	9.1	0.37
Woods	123	28	3.5	0.12
Sultan	29	21	2.4	0.11
Lower Mid-Skykomish	33	22	3.1	0.14

Subbasin	Applicable Permit Parcels	Parcels Analyzed	Total Irrigated Area (ac)	Average Irrigated Area (ac)
Skykomish Mainstem	101	25	3.9	0.16
Upper Skykomish	52	27	1.3	0.05
Cherry-Harris	96	26	4.2	0.16
Snoqualmie North	146	22	4.6	0.21
Snoqualmie South	64	23	4.9	0.21
Patterson	49	23	9.3	0.41
Raging	29	27	11.7	0.43
Upper Snoqualmie	75	27	6.3	0.23
Full Analysis	**1,594**	**393**	**82.5**	**0.21**

Note: The WRIA-aggregated irrigated area in Table 4 is based on subbasin-average lawn sizes weighted by projected PE well connections per subbasin and thus differs slightly from the average irrigated area in Table 2, which is the direct average of irrigated areas from all parcels analyzed.

Crop Irrigation Requirements

The amount of irrigation water required to grow and maintain vegetation depends on the crop, season, and local climate (temperature and precipitation) and thus varies by location throughout the WRIA. The Washington Irrigation Guide (WAIG) (NRCS 1997) includes an appendix listing net irrigation requirements for various common crops for 89 locations throughout Washington, derived from water use and meteorological data from the 1970s and 1980s. Since lawn is a fairly water-intensive crop and the most common target of residential irrigation, irrigation requirements for turf were used to estimate outdoor water needs.

Using the three WAIG stations within WRIA 7 (Everett, Monroe, and Snoqualmie Falls) and surrounding stations to the north and south, the GeoEngineers team spatially interpolated crop irrigation requirements (CIRs) across WRIA 7 by creating a triangulated irregular network (TIN) surface between the WAIG station points. Since there are no stations east of Snoqualmie Falls in the higher-elevation, higher-precipitation eastern subbasins, a lower value was imposed along the Cascade crest to enforce continued reduction in CIR with increasing precipitation. A value of 8 inches per year was used for the boundary value; this is believed to be a conservative value on nearby Cascade foothill station estimates from an unpublished irrigation data set being developed by Washington State University (Peters et al. 2019). Values from the resulting TIN surface were averaged over each subbasin to estimate the irrigation requirement for each subbasin. This analysis was performed for both annual and summer (June-July-August) irrigation requirements to provide information to compare peak summer water use to annual use estimates. Figure 2 shows the locations of WAIG irrigation data stations and the interpolated distribution of annual turf irrigation requirements across WRIA 7. Table 3. WRIA 7 Crop Irrigation Requirements summarizes the average values for both annual and summer CIRs for subbasins with projected PE well connections. Annual values were used for the consumptive use calculations described in this memo.

The CIR is the net amount of external water required by the crop, accounting for precipitation inputs. Since irrigation systems are not 100 percent efficient, additional water must be supplied to ensure that crop needs are met. The application efficiency varies by the type of system (drip irrigation, microsprinklers, pivot sprinklers, etc.). For WRIA 7, the Ecology-recommended value of 75 percent was used to determine the water applied for irrigation (Ecology 2019).

Outdoor water use for each home was then estimated as the applied water for irrigation (computed as a depth) times the average irrigation area. The consumptive use fraction is substantially higher for outdoor use than indoor use (to a septic system) because most of the applied water is taken up by plants or evaporated. Based on the Final NEB Guidance, a consumptive use fraction of 80 percent was applied to the total outdoor water use, meaning that 80 percent of water used for outdoor watering does not return to the local groundwater system (Ecology 2019).

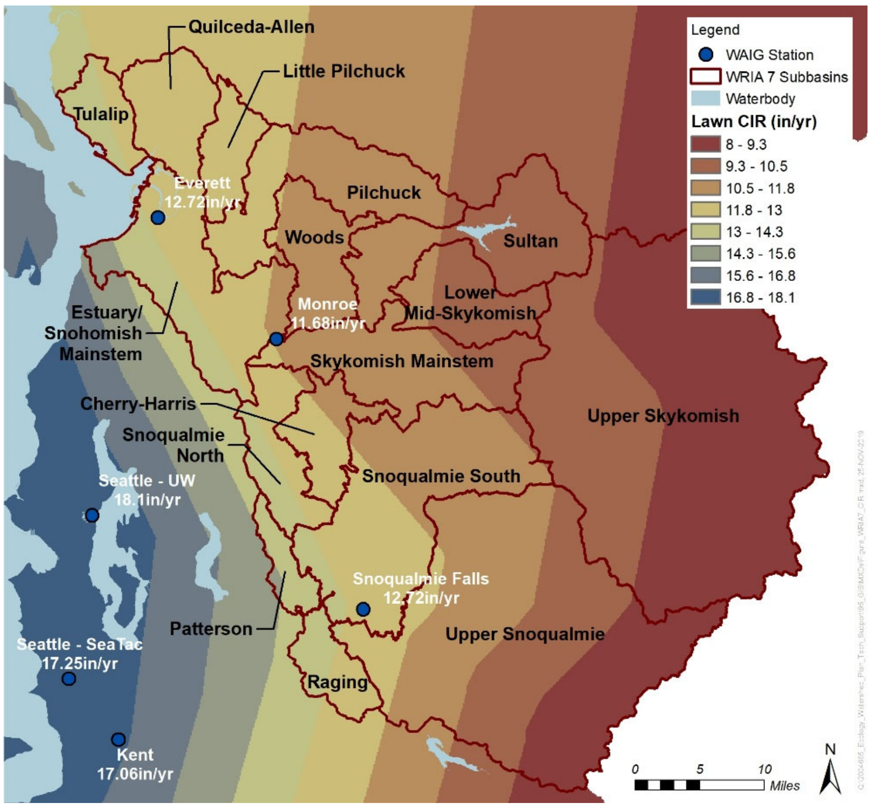


Figure 2. Spatial Distribution of Annual Turf Irrigation Requirement

TABLE 3. WRIA 7 CROP IRRIGATION REQUIREMENTS

Subbasin	Annual Turf CIR (in)	Summer (JJA) Turf CIR (in)
Tulalip	13.22	10.74
Quilceda-Allen	12.40	10.27
Estuary/Snohomish Mainstem	12.85	10.68
Little Pilchuck	12.25	10.16
Pilchuck	11.49	9.93
Woods	11.46	9.93
Sultan	10.22	9.26
Lower Mid-Skykomish	10.27	9.40
Skykomish Mainstem	10.90	9.69
Upper Skykomish	8.89	8.59
Cherry-Harris	11.99	10.46
Snoqualmie North	12.86	10.92
Snoqualmie South	11.78	10.32
Patterson	14.02	11.62
Raging	13.04	11.08
Upper Snoqualmie	10.18	9.35
WRIA Average	**10.66**	**9.57**

TOTAL CONSUMPTIVE USE

The methods described above were used to compute indoor and outdoor consumptive use per PE well connection. Totals for each subbasin were then computed by multiplying per home values by the projected number of PE well connections in each subbasin. The GeoEngineers team developed a consumptive use calculator (Excel spreadsheet) to compute consumptive use for projected PE well connections for each subbasin and the WRIA as a whole. Table 4 summarizes the consumptive use estimate, which assumes one home with the measured subbasin-average yard area per PE well. The WRIA-aggregated irrigated area in Table 4 is based on subbasin-average yard sizes weighted by projected PE well connections per subbasin and thus differs slightly from the average footprint in Table 2, which is the direct average of irrigated areas from all parcels analyzed. The consumptive use estimate for WRIA 7 is 797.4 acre-feet per year, as shown on Figure 3. Note that the consumptive use estimates shown in Figure 3 are rounded.

TABLE 4. ANNUAL CONSUMPTIVE USE FOR ONE HOME WITH SUBBASIN AVERAGE YARD

Subbasin ID	# PE Wells Anticipated in Subbasin	Irrigated Area per Well (ac)	Per Well Consumptive Use (gpd)			Total Consumptive Use (af/yr)
			Indoor	Outdoor	Total	
Tulalip	468	0.09	16.5	94.4	110.9	58.1
Quilceda-Allen	338	0.15	16.5	147.6	164.1	62.1
Estuary/Snohomish Mainstem	331	0.29	16.5	295.7	312.2	115.8
Little Pilchuck	294	0.20	16.5	194.4	210.9	69.5
Pilchuck	280	0.37	16.5	337.3	353.8	111.0
Woods	224	0.12	16.5	109.1	125.6	31.5
Sultan	55	0.11	16.5	89.2	105.7	6.5
Lower Mid-Skykomish	60	0.14	16.5	114.1	130.6	8.8
Skykomish Mainstem	185	0.16	16.5	138.4	154.9	32.1
Upper Skykomish	103	0.05	16.4	35.3	51.7	6.0
Cherry-Harris	214	0.16	16.4	152.2	168.6	40.4
Snoqualmie North	338	0.21	16.4	214.3	230.7	87.4
Snoqualmie South	169	0.21	16.4	196.3	212.7	40.3
Patterson	104	0.41	16.4	456.1	472.5	55.0
Raging	75	0.43	16.4	444.9	461.3	38.8
Upper Snoqualmie	151	0.23	16.4	185.8	202.2	34.2
WRIA 7 Aggregated	**3,389**	**0.20**	**16.5**	**193.6**	**210.0**	**797.4**

Note: Values in table have been rounded.

CONSUMPTIVE WATER USE SCENARIOS

The consumptive use calculator was also used to explore additional consumptive use scenarios. “Default” input parameters and values discussed in the methods section above can be modified to explore the effect of changes or uncertainties in individual assumptions. Based on requests from the technical workgroup and WRIA 7 Committee, two additional scenarios were computed, and annual consumptive use results are summarized in Table 5 and Table 6:

1. One home with legal maximum 0.5-acre irrigated lawn area per PE well. Assumes 60 gallons per day per person indoor use and outdoor use to irrigate 0.5-acre lawn.
2. Legal right to 950 gallons per day (maximum annual average withdrawal) per well connection for indoor and outdoor household use. Assumes 60 gallons per day per person indoor use and remainder to outdoor use.

TABLE 5. ANNUAL CONSUMPTIVE USE FOR ONE HOME WITH 0.5-AC YARD

Subbasin ID	# PE Wells Anticipated in Subbasin	Irrigated Area per Well (ac)	Per Well Consumptive Use (gpd)			Total Consumptive Use (af/yr)
			Indoor	Outdoor	Total	
Tulalip	468	0.50	16.5	524.5	541.0	283.6
Quilceda-Allen	338	0.50	16.5	492.0	508.5	192.5
Estuary/Snohomish Mainstem	331	0.50	16.5	509.8	526.3	195.2
Little Pilchuck	294	0.50	16.5	486.0	502.5	165.5
Pilchuck	280	0.50	16.5	455.9	472.4	148.2
Woods	224	0.50	16.5	454.7	471.2	118.2
Sultan	55	0.50	16.5	405.5	422.0	26.0
Lower Mid-Skykomish	60	0.50	16.5	407.5	424.0	28.5
Skykomish Mainstem	185	0.50	16.5	432.5	449.0	93.0
Upper Skykomish	103	0.50	16.4	352.7	369.1	42.6
Cherry-Harris	214	0.50	16.4	475.7	492.1	118.0
Snoqualmie North	338	0.50	16.4	510.2	526.6	199.4
Snoqualmie South	169	0.50	16.4	467.4	483.7	91.6
Patterson	104	0.50	16.4	556.2	572.6	66.7
Raging	75	0.50	16.4	517.4	533.7	44.8
Upper Snoqualmie	151	0.50	16.4	403.9	420.3	71.1
WRIA 7 Aggregated	**3,389**	**0.50**	**16.5**	**480.0**	**496.5**	**1,884.9**

Note: Values in table have been rounded.

TABLE 6. ANNUAL CONSUMPTIVE USE FOR ANNUAL AVERAGE 950 GPD WATER USE PER CONNECTION

Subbasin ID	# PE Wells Anticipated in Subbasin	Irrigated Area per Well (ac)	Per Well Consumptive Use (gpd)			Total Consumptive Use (af/yr)
			Indoor	Outdoor	Total	
Tulalip	468	0.60	16.5	628.0	644.5	337.9
Quilceda-Allen	338	0.64	16.5	628.0	644.5	244.0
Estuary/Snohomish Mainstem	331	0.62	16.5	628.0	644.5	239.0
Little Pilchuck	294	0.65	16.5	628.0	644.5	212.3
Pilchuck	280	0.69	16.5	628.0	644.5	202.2
Woods	224	0.69	16.5	628.0	644.5	161.7
Sultan	55	0.77	16.5	628.0	644.5	39.7
Lower Mid-Skykomish	60	0.77	16.5	628.0	644.5	43.3
Skykomish Mainstem	185	0.73	16.5	628.0	644.5	133.6
Upper Skykomish	103	0.89	16.4	628.5	644.9	74.4
Cherry-Harris	214	0.66	16.4	628.9	645.3	154.7
Snoqualmie North	338	0.62	16.4	628.7	645.1	244.3
Snoqualmie South	169	0.67	16.4	629.0	645.3	122.2
Patterson	104	0.57	16.4	629.0	645.3	75.2
Raging	75	0.61	16.4	629.0	645.3	54.2
Upper Snoqualmie	151	0.78	16.4	629.0	645.3	109.2
WRIA 7 Aggregated	**3,389**	**0.66**	**16.5**	**628.3**	**644.7**	**2,447.7**

Note: Values in table have been rounded.

Daily usage rates shown in Table 4 through Table 6 represent annual average values. While indoor use generally does not vary much from month to month, outdoor water needs range from zero during the winter rainy season to more than three times the annual average during the peak of the summer. Since streamflows are lowest in late summer for most western Washington streams, the Committee may consider peak summer water use along with annual use when developing the watershed plan. It is important to remember that pumping rates are likely not equivalent to consumptive use impacts on stream depletion. While the Final NEB Guidance recommends considering stream depletion impacts to be a steady-state equivalent, there may be circumstances within a watershed where that is not appropriate.

Total Water Use and Comparison to Water Purveyor Data

Water use data from water purveyors serving rural areas in the central Puget Sound were obtained as one benchmark for comparison with estimated PE well usage. Snohomish County Public Utilities District #1 (Snohomish County PUD), serving about 20,000 customers in central and northern Snohomish County, and Covington Water District, serving about 18,000 customers in southern King County, each provided metered water use data from 2015 and 2017. In addition, Snohomish County compiled annual water demand forecasts from water system plans for 17 water purveyors operating in the county. Table 7 summarizes the available water purveyor data. Reported values are total water use, not consumptive use. For the two metered systems providing data, the average annual use is approximately 220 gallons per day (gpd) per household. About 160 gpd is attributed to indoor uses (year-round) and 50 to 70 gpd (averaged over 12 months) to outdoor uses.

Note that outdoor use is typically concentrated over about 3 months during the summer, which equates to rates of 150 to 200 gpd of outdoor watering for those 3 months.[2]

TABLE 7. WATER PURVEYOR HOUSEHOLD WATER USE DATA

Water Purveyor	Average Annual Water Use (gpd)	Average Winter Water Use (gpd)	Average Summer Water Use (gpd)
***Metered Water Use Data*†**			
Snohomish County PUD‡	237	170	370
Covington Water District	200	150	300
Comprehensive Plan Forecast			
Alderwood	169		
Cross Valley*	234		
Edmonds	201		
Gold Bar	171		
Highland*	200		
Marysville	168		
Monroe	170		
Mukilteo	179		
Olympic View	189		
Roosevelt*	383		
Silver Lake	177		
Snohomish	190		
Snohomish County PUD*	190		
Stanwood	282		
Startup*	250		
Sultan	190		
Three Lakes*	191		
**Average Rural Non-City*	*241*		

Note: Reported values are total water use, not consumptive use.
†Data from 2015 and 2017 ‡Average use for parcels ≥1 acre *Rural water provider

Since most water purveyors charge customers by the amount of water delivered (not just consumptively used)—and in some cases at increased rates as water use goes up—metered water users may exhibit more water conservation behaviors than unmetered users. Total water use breakdowns for the projected PE well scenarios are presented in Table 8. Estimated indoor use of 165 gpd for the PE well scenarios is very consistent with the water purveyor data (based on metered winter water use), between 150 and 170 gpd.

Average annual total use for PE wells estimated from this analysis (see Table 8) are considerably higher, however, due to outdoor use estimates 4 to 6 times greater than average metered use: 240 gpd estimated for PE wells versus 50 to 70 gpd for metered users on an average annual basis or 820 gpd estimated for PE wells versus 150 to 200 gpd[3] for metered users on average during the summer. The magnitude of this difference

[2] 50 gpd over 12 months is equivalent to 200 gpd over 3 months, both totaling about 18,000 gallons
[3] Metered summer usage for several individual homes in the Covington Water District showed outdoor usage ranging from 25 gpd to 2,693 gpd for July-August 2015.

seems unlikely to be accounted for strictly by price pressures and thus suggests that assumptions in this analysis regarding watering behavior are generally conservative. For example, studies have shown that most residential lawn watering is conducted at a deficit level to maintain some growth and green color (Water Research Foundation 2016), versus the assumption of watering for optimal growth of commercial crops (like a sod farm for turf grass) implicit in the WAIG crop irrigation requirements. Because of uncertainty inherent in estimating growth patterns, domestic PE well pumping rates, and potential changes in outdoor watering practices, conservative assumptions for future new household water use, and outdoor water use in particular, are justified.

TABLE 8. ESTIMATED PERMIT-EXEMPT WELL TOTAL WATER USE

Scenario	Average Annual Water Use (gpd)	Average Indoor Use (gpd)	Average Annual Outdoor Use (gpd)	Average Summer Outdoor Use (gpd)
1 home, average measured yard	407	165	242	817
1 home, 0.5 ac yard	765	165	600	2,026
1 home using 950 gpd (annual average)	950	165	785	n/a

Note: Reported values are total water use, not consumptive use.

REFERENCES

GeoEngineers, Inc. (GeoEngineers). 2019. Draft Work Plan, Consumptive Water Use Estimates. Work Plan prepared for WRIA 7 WREC Technical Workgroup. October 2019.

GeoEngineers. 2021a. WRIA 7 PE Well Projection. Technical memorandum prepared for Washington State Department of Ecology. January 2021.

GeoEngineers. 2021b. WRIA 7 Subbasin Delineations. Technical memorandum prepared for Washington State Department of Ecology. January 2021.

Natural Resources Conservation Service (NRCS), 1997. Irrigation Guide. National Engineering Handbook, Part 652. U.S. Department of Agriculture, Natural Resources Conservation Service. Issued September 1997.

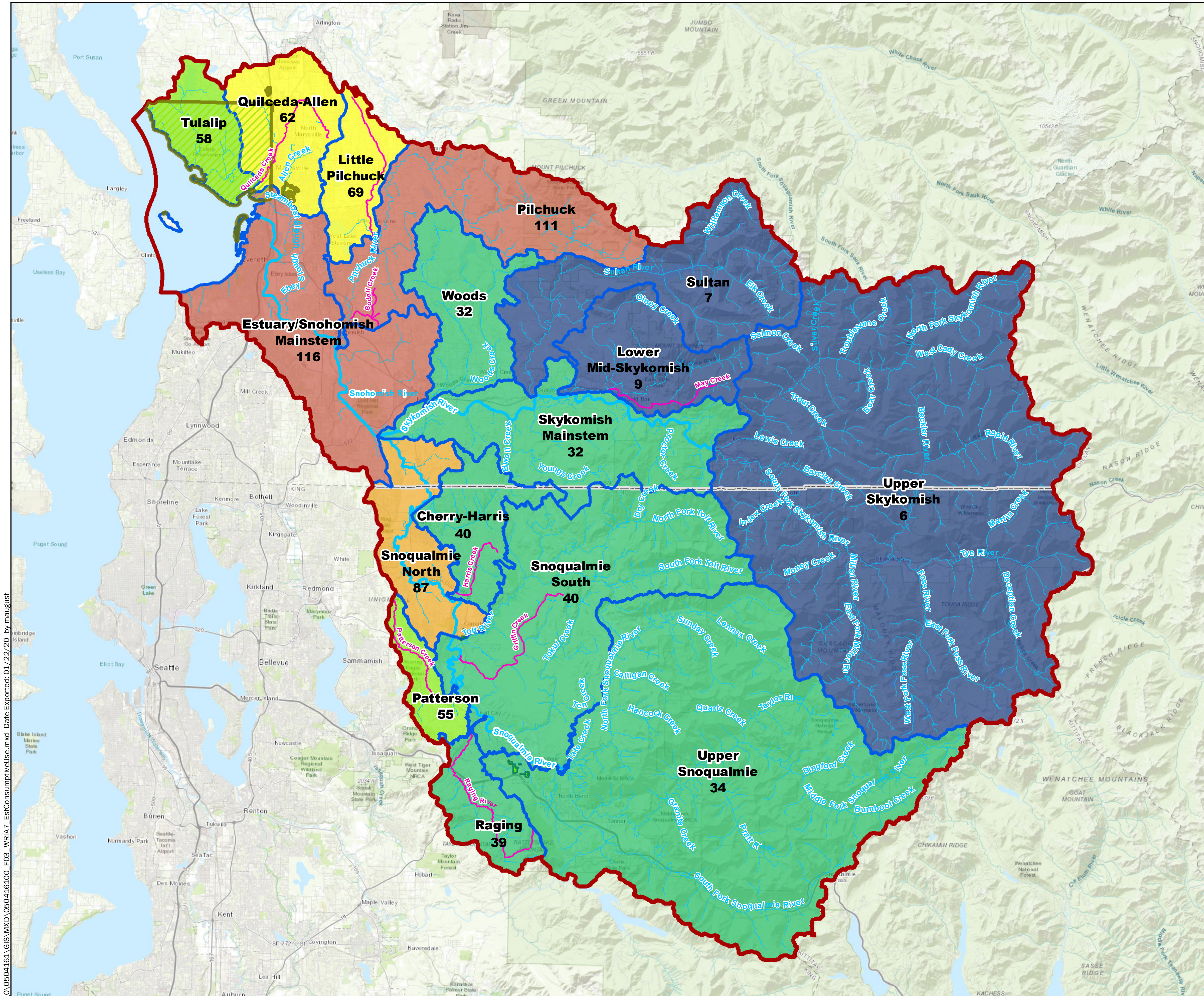
Peters, R.T., L. Nelson, and T. Karimi, 2019. Consumptive Use and Irrigation Water Requirements for Washington. Washington State University Irrigated Agriculture Research and Extension Center. Not yet published, provided 26 September 2019. Associated database: WA Irrigation Water Reqs.mdb.

Washington State Department of Ecology (Ecology). 2019. Final Guidance for Determining Net Ecological Benefit, GUID-2094 Water Resources Program Guidance. Washington State, Department of Ecology, Publication 19-11-079, p. 131. https://fortress.wa.gov/ecy/publications/documents/1911079.pdf.

Water Research Foundation, 2016. Residential End Uses of Water, Version 2. Executive Report. Published April 2016.

Attachment:

Figure 3. WRIA 7 Estimated Consumptive Use from Projected Permit-exempt Wells 2018-2038



Legend

- WRIA 7 Boundary
- WRIA7 Subbasins
- Snoqualmie Tribe Reservation
- Tulalip Tribes Reservation
- Surface Water Closures[3]

Consumptive Water Use Estimate (acre-feet/year)

- 0 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80
- 81 - 90
- 91 - 100
- >100

Projected WRIA 7
Consumptive Use Total = 797.4 acre-feet per year

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Closed stream s represen t GeoEngineers' interpretation of the language in WAC 173-507 and this m ap is to only be used for plan ning purposes.

Data Source: ESRI Topographic Map Base

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

N
W E
S

5 0 5
Miles

WRIA 7 Estimated Consumptive Use from Projected Permit-Exempt Wells 2018-2038

Watershed Restoration and Enhancement Plan
Snohomish and King Counties, Washington

GeoEngineers

Figure 3

P:\0\0504161\GIS\MXD\0504161100_F03_WRIA7_EstConsumptiveUse.mxd Date Exported: 01/22/20 by maugust