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Permit-Exempt Domestic Well Use in Washington State

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Permit-Exempt Domestic Well Use in Washington State

by
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Executive Summary

Washington State's groundwater permit exemption allows for single or group domestic[1] well water use up to 5,000 gallons per day without first obtaining water right permits. The purpose of this study is to evaluate the significance of these wells by looking at the number of such wells and their associated consumptive[2] water use. Analyses were conducted for wells that fall under the category of "self-supplied domestic use," which includes both permit-exempt domestic wells and a small number of Group B[3] water system wells that use water under water right permits.

Two methods were used to estimate the increase in the number of permit-exempt domestic wells: one based on Department of Ecology (Ecology) well construction data, and a second using a combination of Washington Department of health (WDOH) Group A Public Water Supply system data and U.S. Census Bureau data. Study results suggest data from Ecology's well construction database provide the best estimates of the number of new permit-exempt domestic wells. Using various assumptions, we conclude approximately 17,200 permit-exempt domestic wells were drilled statewide from 2008 through September 4, 2014, ranging from about 17 wells in Garfield County to 1,238 wells in Okanagan County.

Consumptive water use estimates were based on 2005 USGS total water use estimates (Lane, 2009), and many assumptions. Some key assumptions regarding permit-exempt domestic wells included: all outdoor water use occurred within a 4-month irrigation season, indoor water use equals 57.1 gallons per day per person, and 10 percent of indoor use and 80 percent of outdoor water use is consumptive. Based on these and other assumptions, Ecology estimates that statewide, during the irrigation season, self-supplied wells account for about 0.9 percent of the overall consumptive water use. However, according to our estimates even public water supply systems account for only about 4.6 percent of consumptive water use, and overall most consumptive water use is due to irrigation.

It is critical to view our study's consumptive use estimates in the context of method limitations. From a water management perspective, scenarios of greatest concern involve: (1) relatively small watersheds where many permit-exempt domestic wells are drilled in aquifers highly connected to small streams, (2) a considerable amount of outdoor watering, and/or (3) surface water depletion in endangered aquatic species habitat.

Consumptive water use in areas with high concentrations of permit-exempt domestic wells was not specifically addressed during this study. Nonetheless, our analysis indicates that the greatest return, from a water management perspective, would be gained by focusing on those areas where potential impacts are greatest.

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[1] "Domestic" water use includes normal in-home uses such as drinking, cooking, bathing, washing dishes and clothes, and so on; and may include residential outdoor uses such as lawn and garden irrigation, and washing cars.
[2] "Consumptive" use is that portion of the withdrawal that is lost to the system, and is the difference between the quantity withdrawn and the quantity of return-flow from septic systems, and so on.
[3] Group B public water systems have less than 14 connections, whereas Group A systems have 15 or more.

Introduction

The groundwater permit exemption provided in Section 90.44.050 of the Revised Code of Washington (RCW) allows certain uses of groundwater to be established without first obtaining water right permits. One such use includes single homes or groups of homes that use no more than 5,000 gallons per day. In this paper we use existing data and make simplifying assumptions to estimate the number of permit-exempt domestic wells in Washington, and the consumptive water use associated with those wells compared to other uses. This analysis does not address other types of permit-exempt groundwater uses, such as stockwatering and commercial industrial uses.

Purpose

The purpose of this investigation is to provide insights into the potential impacts of domestic permit-exempt well use within Washington. In this study, we evaluate rates of well construction, and compare the relative water consumption by permit-exempt domestic wells with other consumptive uses. Our statewide and county-by-county analyses will help frame the Department of Ecology's (Ecology's) discussion on how to regulate permit-exempt domestic wells in the future. This study does not evaluate how consumptive water use by permit-exempt domestic wells actually affects streamflows, nor other hydrologic impacts from rural development such as altered streamflow resulting from land cover changes.

Methodology

Although the goal of this analysis was to evaluate consumptive water use associated with permit-exempt domestic wells in Washington, due to data limitations the analyses conducted were for self-supplied domestic use. Self-supplied domestic use includes single and group domestic water use allowed under the permit exemption, and Group B water system use covered under a water right permit. Group B water systems may use water legally either under the exemption or through a water right permit, depending upon the quantity of use.

While this study made no distinction between permit-exempt domestic water use and some Group B system water use covered under water right permits, our analysis indicates that it mainly includes the former. From Washington State Department of Health (WDOH) data, there are only about 120,000 people served statewide by Group B systems. Our analysis suggests that about two thirds of these people are served by systems with 6 connections or less, and able to

make use of the permit-exemption. This suggests the remaining one third of the Group B self-supplied domestic population are likely served by systems with water right permits.

To place these numbers in perspective, according to the U.S. Geological Survey (USGS) Scientific Investigations Report (SIR) 2009–5128 (Lane, 2009) the state's total self-supplied domestic population in 2005 was about 904,000. Therefore statewide only about 4 percent (40,000 divided by 904,000) of the self-supplied domestic population is served water under a water right permit. For this reason we are using the term permit-exempt domestic wells to refer to self-supplied domestic wells throughout this document, although it also includes a small portion of permitted Group B public water systems.

Predictors of Future Permit-Exempt Domestic Wells

Two methods were used to estimate the increase in permit-exempt domestic wells. The number of new wells per county was estimated by querying Ecology's Well Construction and Licensing System database for January 1, 2008 through September 4, 2014. We then refined the search results to eliminate wells for other purposes such as agricultural irrigation, municipal, or test wells. This analysis also attempted to discern whether water wells with a "no use" category reported were likely to be permit-exempt wells or fall under the category of construction dewatering wells. In addition, we estimated county populations using self-supplied domestic groundwater by subtracting the population served by Group A systems (WDOH 2013 data), for each county, from total county population numbers (as reported in 2013 U.S. Census Bureau data).

U.S. Geological Survey Total Water Use Estimates

The consumptive water use estimates produced during this Ecology study are based on total water use estimates contained in the 2009 USGS publication, "Estimated Water Use in Washington, 2005" by R. C. Lane[4]. This report presents state and county estimates of self-supplied and public domestic water use, as well as irrigation, livestock, aquaculture, industrial, and mining water use in Washington in 2005. In 2014, the USGS indicated that the population values (used in public- and self-supplied estimates) published in the 2009 report were incorrect and republished a new data table in a web-only format. Those new numbers have been incorporated into our analysis.

The 2009 USGS study derived self-supplied and public-supplied domestic water use numbers from several sources. For public-supplied water use, the USGS obtained system-specific withdrawal and use information from representative Group A systems, which they used to calculate per-capita rates for each system. Using those results combined with population and data for the non-reporting systems, they estimated the total population served by public-supplied water for each county. Self-supplied domestic use was then estimated using the difference

[4] USGS Scientific Investigations Report (SIR) 2009–5128

between estimated populations served by Group A systems and U.S. Census Bureau population estimates. A weakness with this approach is that it relies on data reported by Group A water systems to WDOH, which may or may not be accurate.

The 2009 USGS investigation estimated irrigation of crops and golf courses based on representative water use data extrapolated to larger areas based on acreage. The report's industrial use data are the most suspect due to very limited source information; however, this does not affect the conclusions significantly because industrial use tends to be small compared to other uses.

Total versus Consumptive Water Use

Total water use includes both consumptive water use (water lost to evaporation and transpiration), and unconsumed water (water that drains through the soil to recharge groundwater). When evaluating the relationship between total use and consumptive use, one key publication relied upon was the report, "Consumptive Water-Use Coefficients for the Great Lakes Basin and Climatically Similar Areas" by K. H. Shaffer and D. L. Runkle (USGS SIR 2007–5197, 2007). For the purposes of that study, consumptive water use was defined as:

> "…water that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from an immediate water environment (water body, surface- or ground-water source, basin). Water-resource planners and managers use consumptive water use to understand the effect of human use of water on the hydrologic system."

Two common methods of computing consumptive use are water-balance equations and consumptive-use coefficients. The Shaffer and Runkle study relied upon the latter. The report contains statistical analyses of coefficients generated by many other studies for the Great Lakes Basin (the focus of that study) and areas throughout the world with a similar climate (Figure 1). For this evaluation Ecology used the median values from this Shaffer and Runkle study. In keeping with the Great Lakes Basin medians, for irrigation and mining we used the round values of 90 percent and 10 percent, respectively. The selection of 5 percent consumptive use from aquaculture was simply a small number chosen to represent a small amount of consumptive loss from aquaculture operations.

Outdoor Water Use

Generally the growing season for much of western Washington occurs from the latter half of April through mid-October, while a typical growing season in eastern Washington occurs April through September. Data in the 1985 Washington Irrigation Guide (WAIG) illustrates the varying length of irrigation schedules for pasture/turf for six Washington stations.[5] (Figure 2).

[5] From 1985 WAIG, Appendix B, crop water use tables (with tables provided in Attachment A in the USDA, National Engineering Handbook, WAIG, September 1997)

[Great Lakes Basin refers to basins, parts of states, and states in the Great Lakes Basin. Climatically similar areas are basins and states that are climatically similar in the Great Lakes Basin but not in the Great Lakes Basin. Great Lakes and climatically similar references are the combination of references from these two areas. References are only from publications after either 1975 (mining and commercial), 1980 (industrial, irrigation, thermoelectric, livestock), or 1985 (domestic and public supply) and do not include all the Canada coefficients, all the United States coefficients, or continent coefficients because these include areas that are not climatically similar to the Great Lakes. Minimum (min), median, maximum (max), the 25th percentile, and the 75th percentile are in percent. N is the number of references used in the statistical analysis]

Water-use category	Statistics					
	Min	25th	Median	75th	Max	N
Great Lakes Basin						
Domestic and Public Supply	0	10	12	15	74	161
Industrial	0	7	10	14	35	122
Thermoelectric Power	0	1	2	2	21	141
Irrigation	70	90	90	96	100	95
Livestock	0[1]	80	83	90	100	85
Commercial	4	8	10	15	26	29
Mining	0	7	10	25	58	58
Climatically similar areas						
Domestic and Public Supply	6	10	15	20	70	68
Industrial	0	4	10	13	34	97
Thermoelectric Power	0	0	2	4	75	75
Irrigation	37	90	100	100	100	75
Livestock[2]	10[2]	86	100	100	100	73
Commercial	3	8	10	13	33	61
Mining	0	10	14	20	86	83
Great Lakes Basin and climatically similar areas						
Domestic and public supply	0	10	13	15	74	229
Industrial	0	6	10	13	35	219
Thermoelectric power	0	1	2	3	75	216
Irrigation	37	90	91	100	100	170
Livestock[1,2]	0[1,2]	80	90	100	100	158
Commercial	3	8	10	13	33	90
Mining	0	8	13	22	86	141
World						
Domestic and public supply	14	16	16	18	19	4
Industrial	9	10	10	11	11	4
Agriculture	65	65	68	72	78	4

[1] The livestock low coefficient minimum (0 percent) is from Great Lakes Commission (2005a) in which Minnesota reported 0.25 Mgal/d total withdrawn in 1998 and 0.0 Mgal/d consumptive use. The next lowest coefficient for the Great Lakes Basin was 66 percent.

[2] The livestock low minimum coefficients are from Solley and others (1988) and may be the result of their adding animal specialties, including fish farming, into the livestock water-use category. In previous and subsequent USGS reports, fish farming was in different water-use categories.

Figure 1. Consumptive-use coefficients for water use categories for the Great Lakes Basin and the world (Table 9 in USGS SIR 2007–5197, 2007).

Outdoor irrigation varies significantly across the state and on a month-by-month basis. For this investigation, however, Ecology assumed that outdoor permit-exempt domestic and public-supplied water use occurred at constant rates over a 4-month irrigation season. Obviously this is a simplification of a complex situation. However, this assumption is more accurate then assuming a constant rate throughout the year, as summer-season low stream flows are typically most influenced by peak water use during the summer.

Consumptive Water Use Analysis Assumptions

Assumptions made when estimating consumptive water use fell into two categories: those associated with permit-exempt domestic water use, and those associated with other types of uses.

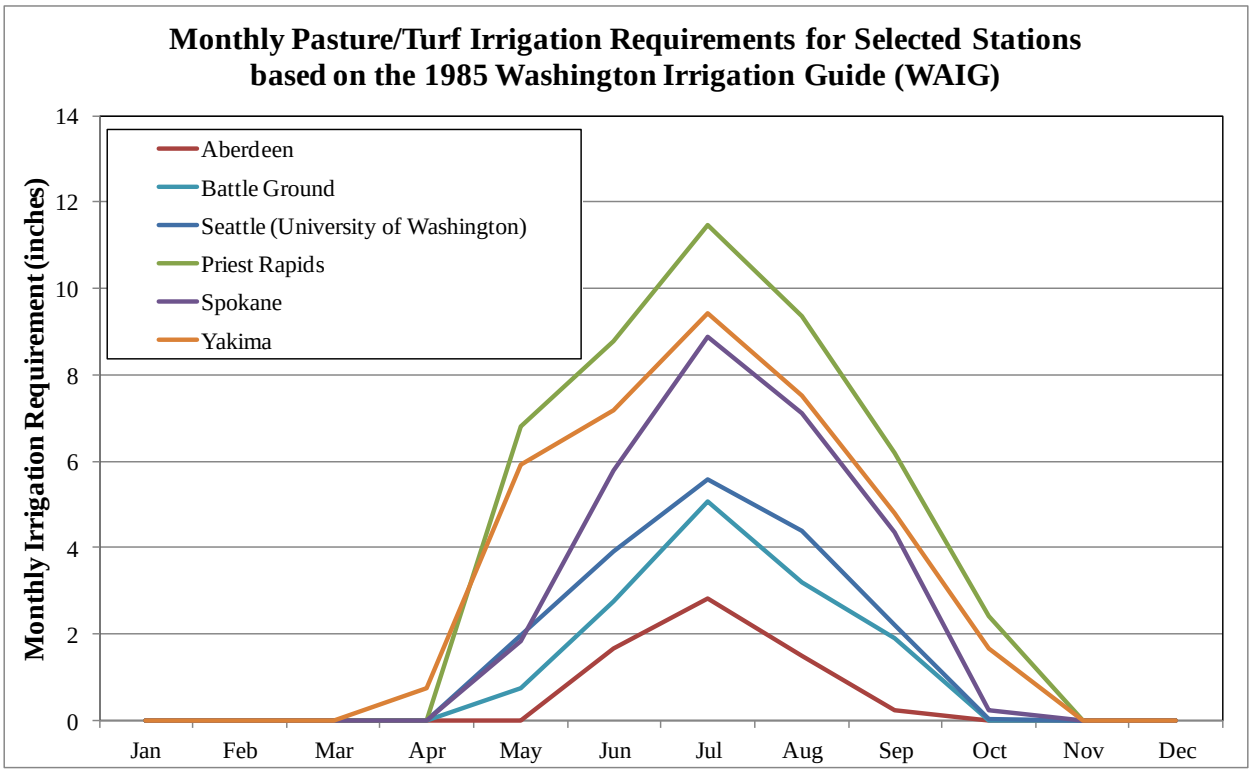

Figure 2. Monthly pasture/turf irrigation requirements for selected Washington stations.

Significant methods/assumptions made when estimating permit-exempt domestic well water consumptive use included:

- Estimates of populations and water use of individuals using permit-exempt domestic groundwater were derived from USGS SIR 2009-5128. This USGS investigation generated these estimates based on a subtraction of Group A Public Water Supply system population values from U.S. Census Bureau data.

- All outdoor water use occurred entirely within a 4-month irrigation season.

- Estimates of the number of people per household per county in 2011 were derived from the U.S. Census Bureau (2014), and ranged from 1.92 (San Juan County) to 3.36 (Franklin County) people per household.

- Indoor water use equals 57.1 gallons per day (gpd) per person based on *Residential End Uses of Water* by the American Water Works Association Research Foundation (Mayer and DeOreo, 1999). They derived this number based on actual logging of water use in 100 Seattle single-family homes (statistically selected to be representative).

- Volumetrically, 10 percent of indoor use is consumptive and 80 percent of outdoor water use is consumptive. These estimates are consistent with several Colorado studies including Oad, Lusk, Podmore (1997), and Oad and DiSpigno (1997).

When estimating consumptive use for other types of use (public-supplied domestic use, irrigation, livestock, aquaculture, industrial, and mining), significant methods/assumptions included:

- All outdoor water use occurred entirely within a 4-month irrigation season.

- On a county-by-county basis, public-supplied domestic consumptive use for both indoor and outdoor purposes was assumed to be the same percent as that calculated for permit-exempt domestic water use. This appears justified given similar per capita water use figures for permit-exempt and public-supplied water use.

- Percent consumptive water use values associated with total water use for other water use categories were based on the USGS Great Lakes Basin study. Consumptive water use compared to total water use for agricultural irrigation was assumed to be 90 percent as opposed to the 80 percent assumed for domestic outdoor water use, which reflects assumed greater efficiency in commercial operations.

Findings

Increase in Permit-Exempt Domestic Wells

A query of Ecology's Well Construction and Licensing System database indicates 33,434 entries representing all water wells installed from January 1, 2008 through September 4, 2014. Type of use entries in the database include: commercial, domestic, domestic single, group domestic, agricultural irrigation, individual irrigation, irrigation unknown, parks & recreation, stock water, municipal, other, or test well. However, during our analysis we determined that due to a high percentage of null entries, it is not always possible to precisely determine the number of wells drilled under the water right permit exemption (see Table 1).

The results in Table 1 indicate significant challenges in working with Ecology's Well Construction and Licensing System data. For example, statewide the sum of entries in the column labeled "Use categories assumed to result in permit-exempt domestic wells" yields a total of 15,852 wells, which is nearly the same as the number of wells listed as "null", (16,223). Since most "null" entries are likely associated with dewatering wells, a different database query was made with results reported in the column labeled "Dewatering wells reported in separate Ecology database". That query yielded a total of 14,918 dewatering wells statewide, which is close to but somewhat different than the 16,223 "null" entries.

Table 1. Water wells by use category according to Ecology well construction data - January 1, 2008 through September 4, 2014.

	Wells drilled by reported by use-types 2008 through August 2014 per Ecology Start Card database																
	Potential permit-exempt well use categories								Likely non-exempt well use categories								
	Domestic			Other than domestic													
	Domestic	Domestic Single	Group Domestic	Commercial	Individual Irrigation	Irrigation Unknown	Parks & Recreation	Stock Water	Agricultural Irrigation	Municipal	Other	Test Well	Null (no use category reported)	Use categories assumed to result in permit-exempt domestic wells	Dewatering wells reported in separate Ecology data base	Null minus dewatering wells	Estimated permit-exempt domestic wells*
Adams	42	30	6		3	7		19	14	2	2		11	78	0	11	89
Asotin	22	60		2				3					5	82	0	5	87
Benton	239	298	18	7	2		1	6	9	2	2	19	488	555	466	22	577
Chelan	220	302	39	7	3	3	8	3	21	2	2	16	124	561	114	10	571
Clallam	163	317	4	5	2	2	1			6	1	2	44	484	5	39	523
Clark	273	148	3	7	4	5	2		7	3	6	1	164	424	49	115	539
Columbia	22	5		1	4			4					5	27	0	5	32
Cowlitz	199	234	23	2	1		2	1	4	4		3	507	456	416	91	547
Douglas	57	133	29		2	2		13	16	3		2	7	219	0	7	226
Ferry	88	148	2	1		1	1	1	2	1		2	24	238	0	24	262
Franklin	101	75	4	2	1	1		9	5	1	3	2	22	180	0	22	202
Garfield	6	11						1			1	1		17	0	0	17
Grant	211	333	30	9	19	22		19	46	5	5	31	400	574	376	24	598
Grays Harbor	58	92	7	1	3			3		1	1	1	711	157	658	53	210
Island	91	163	20	2					2	1		2	70	274	3	67	341
Jefferson	52	151	14	2	2	3	1		1	2	7	5	34	217	0	34	251
King	115	279	18	13	65	18	3	3	9	78	18	3	4477	412	4,658	-181	231
Kitsap	156	238	53	4	16	2			1	6	1	3	157	447	168	-11	436
Kittitas	196	417	26	2	1	1	1	10		14	1	1	20	639	12	8	647
Klickitat	145	231	9	6	1	1	1	7	1	3	1	2	9	385	0	9	394
Lewis	283	462	15	10	2	1	2	2	4	4	2	4	111	760	1	110	870
Lincoln	91	131	14	1		1	1	8	9	1	3	2	14	236	0	14	250
Mason	152	286	53	5	3	1				3			131	491	62	69	560
Okanogan	362	780	60	2	11	12	4	8	7	4	2	17	124	1,202	88	36	1,238
Pacific	42	99	1		9	3	1		3	1		2	33	142	5	28	170
Pend Oreille	111	175	1		1	1				1		2	21	287	0	21	308
Pierce	192	276	16	11	18	3	1		3	23	1	4	2081	484	2,102	-21	463
San Juan	59	164	7		2			1					82	230	0	82	312
Skagit	130	233	2	1	8	1	1	7	6	1	2		963	365	903	60	425
Skamania	61	58	11	1		1	1				3	5	18	130	0	18	148
Snohomish	234	445	33	2	11	4	2		3	4	3	1	2627	712	2,746	-119	593
Spokane	519	493	2	8	1			1		8	6	1	155	1,014	0	155	1,169
Stevens	348	428	5	1	1			1		4		5	195	781	0	195	976
Thurston	334	350	16	9	10	2		1		8	2	7	411	700	271	140	840
Wahkiakum	11	16											30	27	21	9	36
Walla Walla	75	56	4	2	14	8	1	2	21	5			27	135	0	27	162
Whatcom	187	272	18	2	17	4		2	20	5	1	3	1730	477	1,642	88	565
Whitman	43	63	1	1				7	1	3			17	107	0	17	124
Yakima	433	689	24	2	2	9	2	11	17	13	1		174	1,146	152	22	1,168
Totals	**6,123**	**9,141**	**588**	**131**	**239**	**119**	**37**	**153**	**232**	**222**	**77**	**149**	**16,223**	**15,852**	**14,918**	**1,305**	**17,157**

* Estimate made by adding "Use categories assumed to result in exempt wells" plus "Null minus dewatering wells"

Despite all these data limitations, we estimated the number of permit-exempt domestic wells drilled (the far right column in Table 1) by combining entries from "Use category assumed to result in permit-exempt domestic wells," plus "null minus dewatering wells". Based on this method we estimate that approximately 17,200 permit-exempt domestic wells were drilled statewide from 2008 through September 4, 2014. The numbers per county ranged from about 17 new wells drilled in Garfield County to 1,238 new wells drilled in Okanagan County.

Figure 3 depicts the significant drop in the number of new permit-exempt wells that followed the recession of 2009, and illustrates that permit-exempt domestic wells far outnumber wells for other permit-exempt use.

Ecology also subtracted 2013 WDOH Group A public water system population data from U.S. Census Bureau population numbers on a county-by-county basis to estimate the increase in permit-exempt domestic well users. Table 2 provides the results of that analysis, as well as 2005 "self-supplied domestic" results from SIR 2009–5128 (Lane, 2009) generated using a similar method. This table suggests that the population served in 2013 was actually less than the population served in 2005 for 19 of 39 counties.

Such trends are inconsistent with the results of our analysis based on driller entries in the Well Construction and Licensing System database. The well construction data analysis indicates an increase in the number of permit-exempt domestic wells for every county from 2008 through January 4, 2014. Since Ecology's well database information is more directly linked to actual wells drilled, Ecology concludes that the well construction data are likely a better indicator of increased permit-exempt domestic well use.

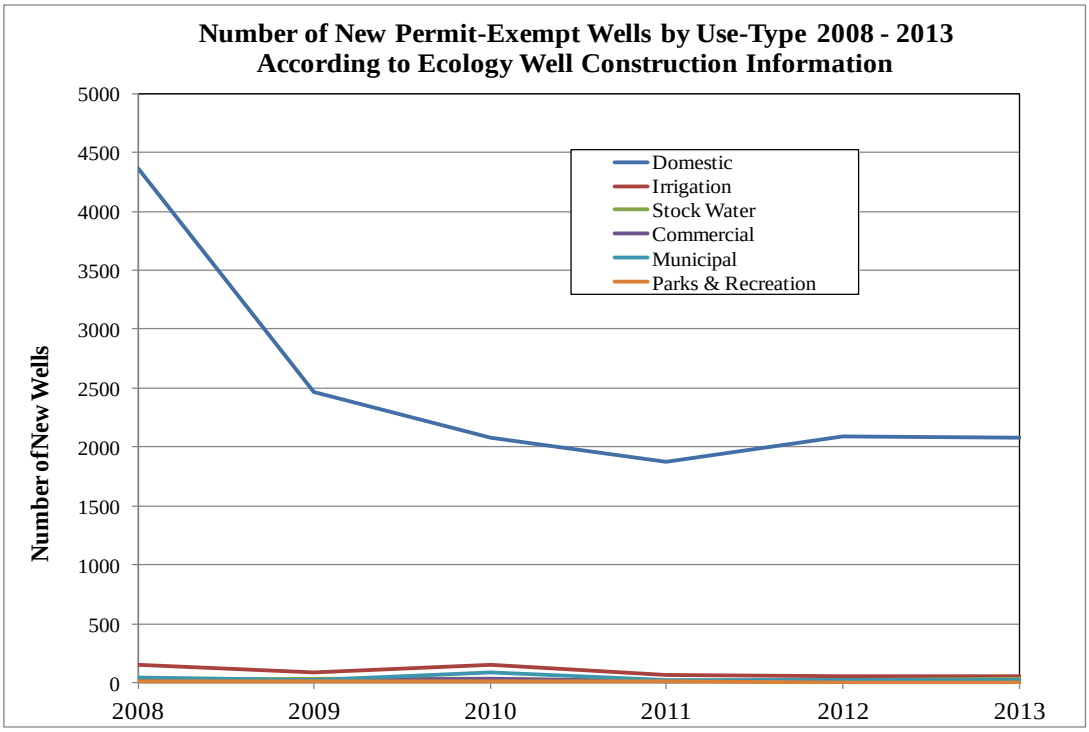

Figure 3. Number of new permit-exempt wells drilled in Washington by use-type 2008 through 2013.

Table 2. Estimates of permit-exempt domestic groundwater populations, based on subtraction of WDOH Class A public-supply systems data from U.S. Census Bureau data.

	2005 total popuation x 1000*	2005 self-supplied population x 1000**	Percent self-supplied population in 2005	2013 total population x 1000*	2013 self-supplied population x1000**	Percent self-supplied population in 2013	Increase in self-supplied Population x 1000
Adams	16.8	4.82	29%	19.2	6.4	34%	1.6
Asotin	21.2	0.83	4%	21.8	1.4	6%	0.6
Benton	158	25.5	16%	183.4	25.5	14%	0.0
Chelan	69.8	14.4	21%	73.6	12.8	17%	-1.6
Clallam	69.7	18.0	26%	72.4	17.1	24%	-0.9
Clark	404	113	28%	435.5	59.4	14%	-53.6
Columbia	4.13	1.24	30%	4.1	1.2	30%	0.0
Cowlitz	97.3	25.8	27%	103.3	25.9	25%	0.1
Douglas	35	4.58	13%	39.3	6.7	17%	2.1
Ferry	7.54	5.14	68%	7.7	5.0	65%	-0.2
Franklin	63	12.7	20%	84.8	25.0	29%	12.3
Garfield	2.34	0.92	39%	2.3	0.8	33%	-0.2
Grant	81.2	26.7	33%	91.8	28.8	31%	2.1
Grays Harbor	70.9	17.8	25%	73.2	13.6	19%	-4.2
Island	79.3	12.1	15%	79.7	12.2	15%	0.1
Jefferson	28.7	8.32	29%	30.3	5.4	18%	-2.9
King	1,790	31.5	2%	1981.9	65.7	3%	34.2
Kitsap	241	47.9	20%	254.0	44.1	17%	-3.8
Kittitas	36.8	12.3	33%	41.9	15.6	37%	3.3
Klickitat	19.8	7.82	39%	20.7	8.0	39%	0.2
Lewis	72.4	37.8	52%	76.2	37.2	49%	-0.6
Lincoln	10.4	4.09	39%	10.7	4.3	40%	0.2
Mason	54.4	20.1	37%	61.8	23.2	38%	3.1
Okanogan	39.8	19.8	50%	41.5	20.5	49%	0.7
Pacific	21.6	2.93	14%	21.0	0.4	2%	-2.5
Pend Oreille	12.7	8.23	65%	13.2	8.5	65%	0.3
Pierce	754	50.5	7%	814.5	48.3	6%	-2.2
San Juan	15.3	7.66	50%	16.0	7.3	46%	-0.3
Skagit	113	21.3	19%	118.6	25.4	21%	4.1
Skamania	10.7	4.59	43%	11.3	4.4	39%	-0.2
Snohomish	656	78.6	12%	730.5	67.8	9%	-10.8
Spokane	441	65.3	15%	480.0	50.9	11%	-14.4
Stevens	42	19.3	46%	43.8	20.9	48%	1.6
Thurston	229	54.6	24%	260.1	53.0	20%	-1.6
Wahkiakum	3.85	0.97	25%	4.0	0.4	10%	-0.6
Walla Walla	57.6	8.10	14%	59.5	6.9	12%	-1.2
Whatcom	183	32.7	18%	205.8	37.3	18%	4.6
Whitman	40.2	2.95	7%	46.0	5.2	11%	2.2
Yakima	232	73.4	32%	247.3	69.7	28%	-3.7
* Data from U.S. Census Bureau							
** Calculated by subtracting WDOH Group A water system data from U.S. Census Bureau Total Population							

State-Wide and County-Wide Consumptive Use Analysis

During this study Ecology also conducted a 4-month irrigation season consumptive-use-rate analysis for various use categories within Washington. Figure 4 below provides the results on a statewide basis, while Figures 5 and 6 (both figures depict the same data at different scales) and Table 3 provide results on a county-by-county basis.

Ecology based its analysis on information found in the USGS SIR 2009–5128 report, that in part was based on WDOH Group A water system data. As discussed previously, there are a number of concerns regarding the WDOH Group A water system data, therefore use of these results requires exercising caution.

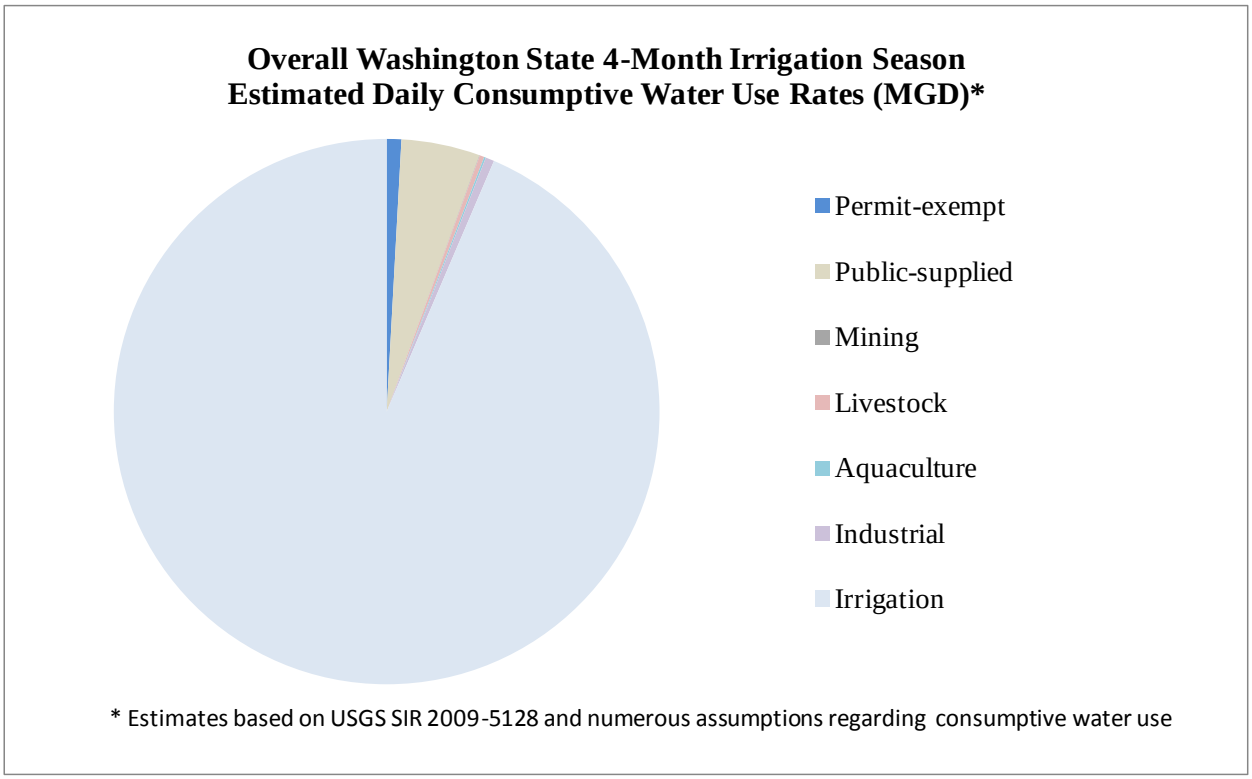

Figure 4. Statewide Washington growing-season estimated consumptive use rates.

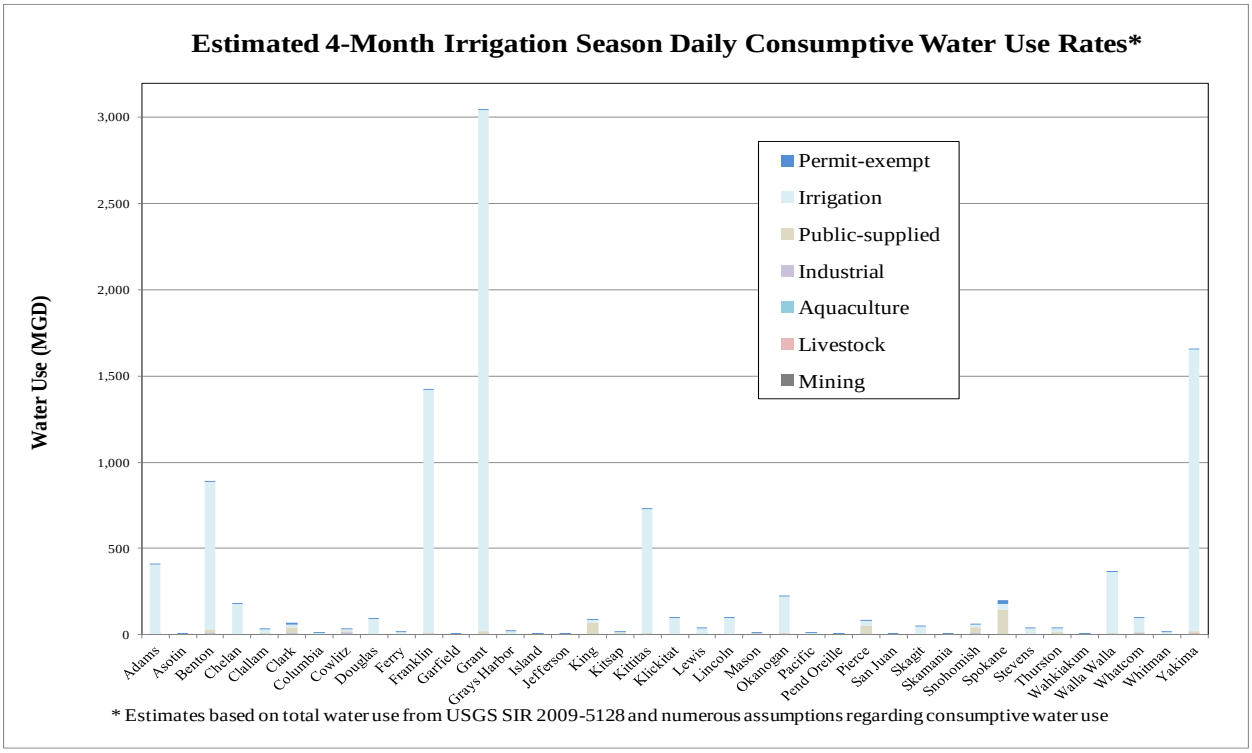

Figure 5. Washington growing season estimated consumptive use rates (same as Figure 6, at different scale).

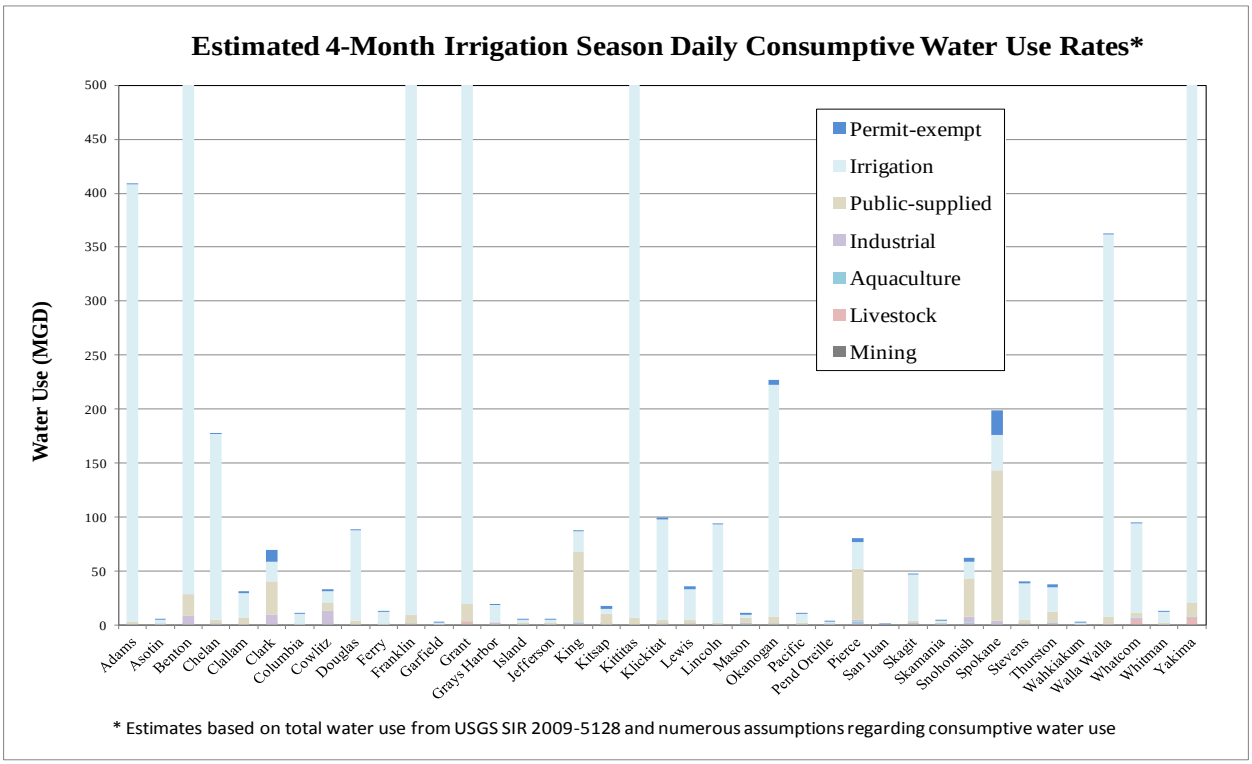

Figure 6. Washington growing season estimated consumptive use rates (same as Figure 5, at different scale).

Table 3. Washington growing-season estimated consumptive use rates by county.

All values in Million Gallons per Day (MGD)	Existing Consumptive Use								Estimated percent of total water use attributable to permit-exempt well use
	Permit-exempt	Public-supplied	Mining	Livestock	Aquaculture	Industrial	Irrigation	Total	
Adams	0.7	2.2	0.00	0.8	0.0	0.3	405.0	409.3	0.2%
Asotin	0.0	1.2	0.04	0.1	0.0	0.0	3.3	4.7	0.7%
Benton	3.5	20.0	0.08	0.5	0.2	7.4	858.6	890.3	0.4%
Chelan	0.5	3.7	0.00	0.0	0.4	1.0	172.3	177.9	0.3%
Clallam	1.9	6.0	0.02	0.1	0.3	0.0	22.8	31.2	6.1%
Clark	10.4	30.6	0.08	0.5	0.1	9.0	18.6	69.2	15.0%
Columbia	0.1	0.2	0.01	0.1	0.1	0.0	10.3	10.8	0.7%
Cowlitz	2.3	7.4	0.02	0.1	0.3	12.3	10.7	33.2	7.0%
Douglas	0.5	3.8	0.03	0.1	0.2	0.2	83.4	88.3	0.6%
Ferry	0.4	0.3	0.00	0.1	0.1	0.0	11.9	12.9	3.1%
Franklin	1.9	7.8	0.06	0.9	0.2	0.4	1412.1	1423.3	0.1%
Garfield	0.1	0.2	0.00	0.1	0.1	0.0	1.9	2.4	3.9%
Grant	4.6	16.1	0.03	2.7	0.4	0.3	3024.0	3048.2	0.1%
Grays Harbor	0.2	0.9	0.03	0.3	0.5	1.1	15.5	18.5	1.0%
Island	0.3	2.0	0.02	0.1	0.0	0.0	2.8	5.3	6.2%
Jefferson	0.4	1.3	0.05	0.1	0.1	0.2	3.4	5.6	7.5%
King	0.9	64.9	0.50	1.0	0.4	0.8	18.8	87.4	1.0%
Kitsap	2.6	10.2	0.05	0.0	0.3	0.1	4.1	17.4	15.0%
Kittitas	1.5	6.0	0.05	0.4	0.0	0.1	720.9	729.0	0.2%
Klickitat	1.9	3.6	0.05	0.3	0.5	0.1	92.9	99.3	1.9%
Lewis	2.8	3.7	0.14	1.0	0.2	0.3	28.1	36.2	7.8%
Lincoln	0.8	1.7	0.01	0.3	0.0	0.0	91.5	94.3	0.8%
Mason	1.3	4.1	0.03	0.0	1.4	0.9	3.2	11.0	12.2%
Okanogan	4.5	6.2	0.02	0.5	0.5	0.2	214.9	226.9	2.0%
Pacific	0.5	1.9	0.02	0.2	0.1	0.1	8.2	11.0	4.1%
Pend Oreille	0.7	0.7	0.12	0.1	0.0	0.1	1.9	3.6	20.7%
Pierce	2.9	47.1	0.50	0.5	1.8	2.3	25.0	80.2	3.6%
San Juan	0.2	0.3	0.01	0.0	0.0	0.0	0.3	0.9	25.8%
Skagit	0.3	2.0	0.04	1.4	0.1	0.4	42.7	46.9	0.7%
Skamania	0.1	0.3	0.00	0.0	0.8	0.7	2.0	4.0	3.6%
Snohomish	3.9	35.8	0.20	1.3	0.3	5.5	15.1	62.2	6.3%
Spokane	22.6	138.9	0.21	0.5	0.1	3.4	33.2	198.9	11.4%
Stevens	2.5	4.3	0.05	0.5	0.4	0.0	32.9	40.8	6.2%
Thurston	3.1	10.1	0.10	1.0	0.6	0.4	22.4	37.6	8.1%
Wahkiakum	0.0	0.1	0.01	0.1	0.0	0.0	1.7	2.0	2.0%
Walla Walla	1.0	6.5	0.00	0.3	0.0	1.1	353.7	362.6	0.3%
Whatcom	0.6	4.5	0.06	4.8	0.1	2.2	82.9	95.2	0.7%
Whitman	0.1	2.3	0.00	0.2	0.0	0.1	9.6	12.4	1.1%
Yakima	5.0	13.2	0.02	6.4	0.1	0.7	1636.2	1661.6	0.3%
Total	87.8	472.7	2.7	27.7	10.5	52.0	9498.7	10152.4	0.9%

Taking into account the totals for all counties combined for the various use categories, the statewide percent of total water use due to permit-exempt domestic water use on a 4-month irrigation season consumptive use basis is estimated to be about 0.9 percent. However, it is critical to recognize that this result is skewed by the large consumptive water use due to irrigation. To help place this in perspective, the second largest water use category, public water supply, also makes up a relatively small portion of consumptive water use, at about 4.6 percent.

It is important to understand the method limitations when interpreting these results. Due to the source data used (Lane, 2009), the most specific consumptive water use estimates we provide are on a county-wide basis. However, even county-specific estimates do not account for the frequent clustering of wells within certain portions of counties.

An analysis based on a watershed or a sub-basin scale would be much more effective when evaluating the relative hydrological and ecological significance of permit-exempt domestic well use. Unfortunately, while the permit-exempt domestic well use data would lend itself to such detailed analyses, it would be difficult to geographically break out the total water use estimates for the other categories of use. However, since geographical distribution is important, we conducted GIS analyses to illustrate the distribution differences of three major categories of water use.

Figures 7 and 8 present the following information:

- Locations of domestic and other use wells (thus a statewide total of 17,800 wells versus the 17,200 permit-exempt domestic wells) drilled January 1, 2008 - September 4, 2014, that potentially are permit exempt
- USGS Hydrologic Unit Code (HUC) 12 boundaries
- Public Land Survey (PLS) sections with irrigated acreage
- Water system service areas
- County boundaries
- Water Resources Inventory Area (WRIA) boundaries

The PLS sections with irrigated acreage represent data presented in the 2010 WSDA Crop Distribution Geodatabase, created and maintained by the Washington State Department of Agriculture. These delineations do not represent exact areas where irrigation water was used, and instead represent PLS sections (typically 1 square mile areas) where at least some irrigation is occurring. Regarding water system service areas, it is important to bear in mind that the sources for these water systems may be located outside of the service area boundaries. The WRIA boundaries depicted in Figures 7 and 8 represent 63 watersheds designated by Ecology. The USGS HUC 12 boundaries represent subbasins within the watersheds, based on a multi-level, hierarchical drainage classification scheme that divides all watersheds in the United States according to hydrographic and topographic criteria.

While the information in Figures 4, 5 and 6 and Table 3 pertain to all permit-exempt domestic wells, well locations depicted in Figures 7 and 8 only pertain to those wells drilled since January 1, 2008.

Taken collectively, the permit-exempt domestic well locations, the polygons representing irrigated acreage and the water system service areas provide the geographic distribution of three major categories of water use.

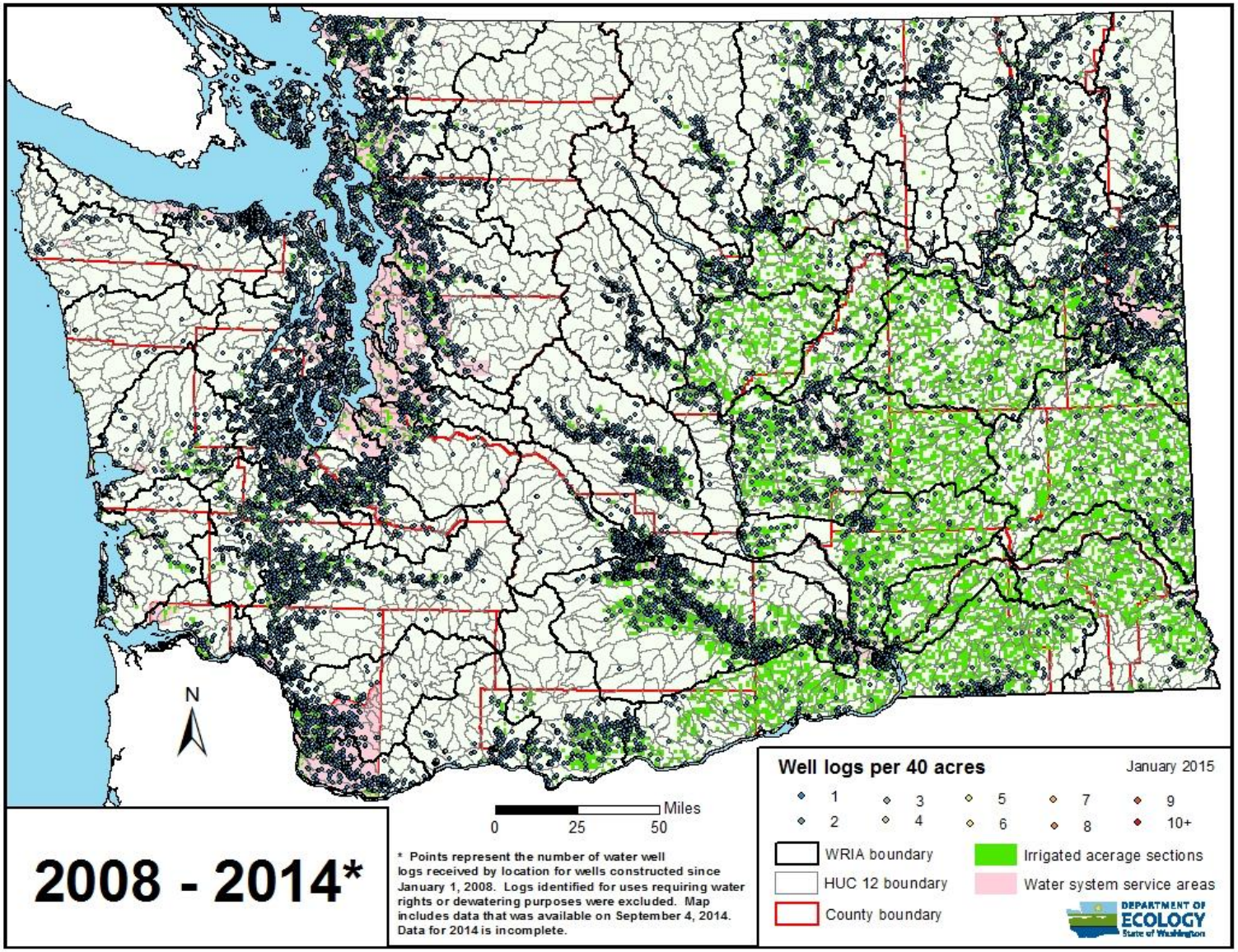

Figure 7. Statewide permit-exempt wells (all types of use), irrigated acreage, and water system service areas.

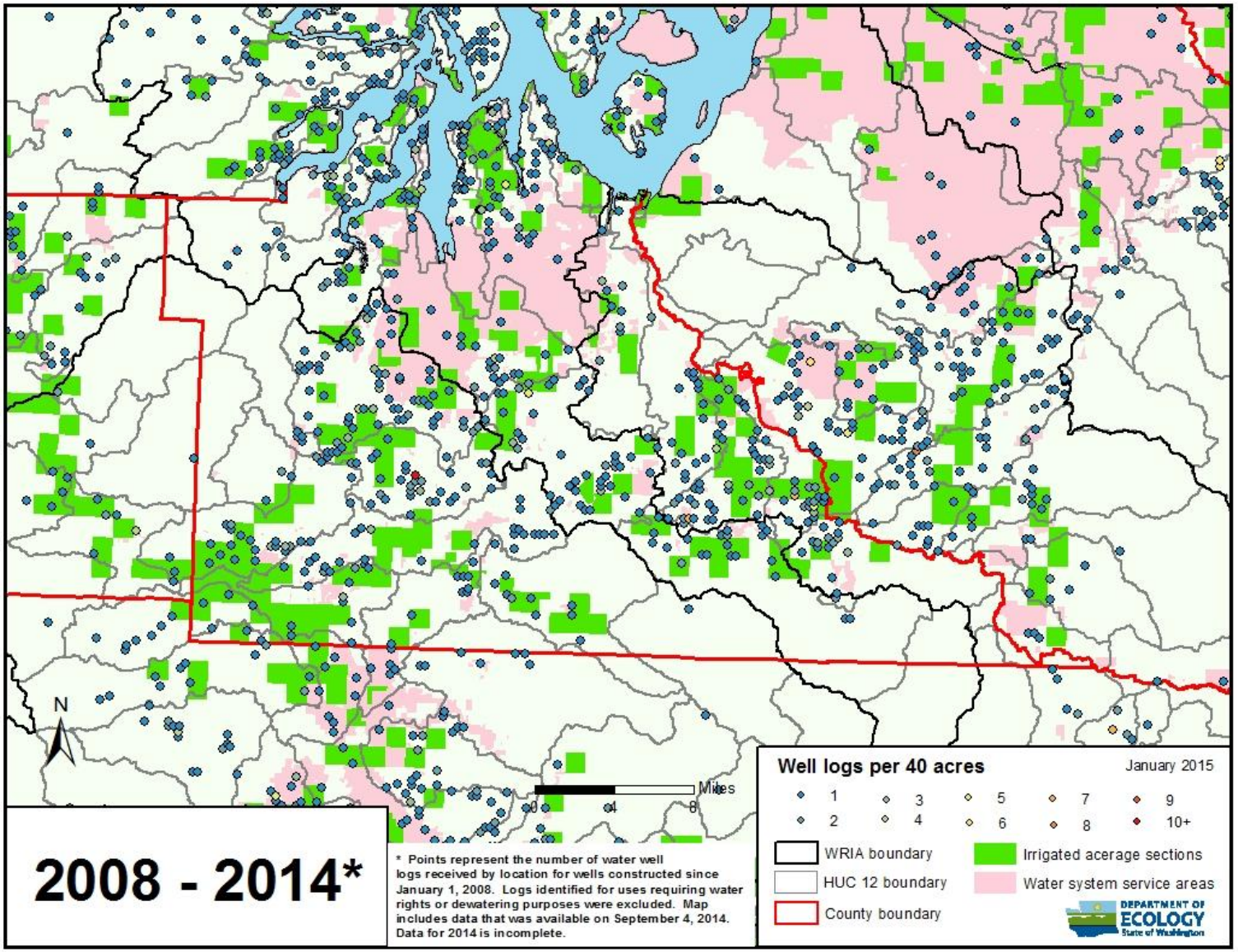

Figure 8. Thurston County and vicinity permit-exempt wells (all types of use), irrigated acreage, and water system service areas.

What is evident in Figures 7 and 8 is that county-wide results often miss critical detail with respect to the permit-exempt domestic use. This is indicated on the statewide map in counties where specific subbasins have greater densities of permit-exempt domestic wells. Figure 8, depicting Thurston County, illustrates that while certain HUC 12 subbasins are largely supplied by public water; other adjacent subbasins receive little or no public water and therefore have a greater number of permit-exempt domestic wells.

Differences in well distribution on a sub-basin basis are also seen in the Skagit River watershed (WRIA 3). A GIS analysis of the density of these wells was conducted using utility information in Skagit County parcel data; along with Ecology's land use parcel layer for portions of Lower Skagit, Fisher Creek, Everett Creek, and unassigned Upper Skagit subbasins in Snohomish County.

This analysis included a number of simplifying assumptions, such as grouping properties within subbasin boundaries based on property centroids[6] and parcel layer subsets. Based on this analysis and as shown in Table 4, the estimated density of Skagit County permit-exempt domestic wells ranged from 0.1 well per square mile in the Finney Creek and Illabot Creek subbasins, to 37 wells per square mile in the Fisher Creek subbasin. This range of permit-exempt well density for WRIA 3 – Lower Skagit Watershed is also shown in Figure 9.

Table 4. Estimated well density in the Skagit River watershed subbasins.

Lower Skagit	Density (wells per square mile)	Middle Skagit	Density (wells per square mile)	Upper Skagit	Density (wells per square mile)
Fisher Creek	37.0	Alder Creek	1.1	Grandy Creek	4.7
Carpenter Creek	6.2	Anderson/Parker/Sorenson Creeks	4.4	Barr Creek	1.1
Hansen Creek	20.0	Careys Creek	11.7	Corkindale Creek	2.0
Nookachamps Creek - East Fork	1.5	Childs/Tank Creek	17.5	Diobsud Creek	0.6
Nookachamps Creek - Upper	7.7	Coal Creek	25.5	Finney Creek	0.1
Skagit-Lower	5.3	Day Creek	1.4	Gravel Creek	1.6
		Gilligan Creek	1.0	Illabot Creek	0.1
		Jones Creek	4.2	Jackman Creek	0.4
		Loretta Creek	1.4	Olson Creek	1.5
		Mansser Creek	16.4	Prairie Creek	1.5
		Morgan Creek	13.1	Rocky Creek	0.3
		Muddy Creek	14.2	Hobbit Creek	0.9
		O'Toole Creek	0.0	Everett Creek	11.9
		Red Cabin Creek	4.5	Skagit-Upper unassigned	0.6
		Salmon/Stevens Creeks	9.5		
		Wiseman Creek	11.5		
		Skagit-Middle	12.9		

[6] A "centroid" is the geometric center of a surface area. If a straight line were to slice the area into two equal portions, it would always pass through this point, no matter the angle.

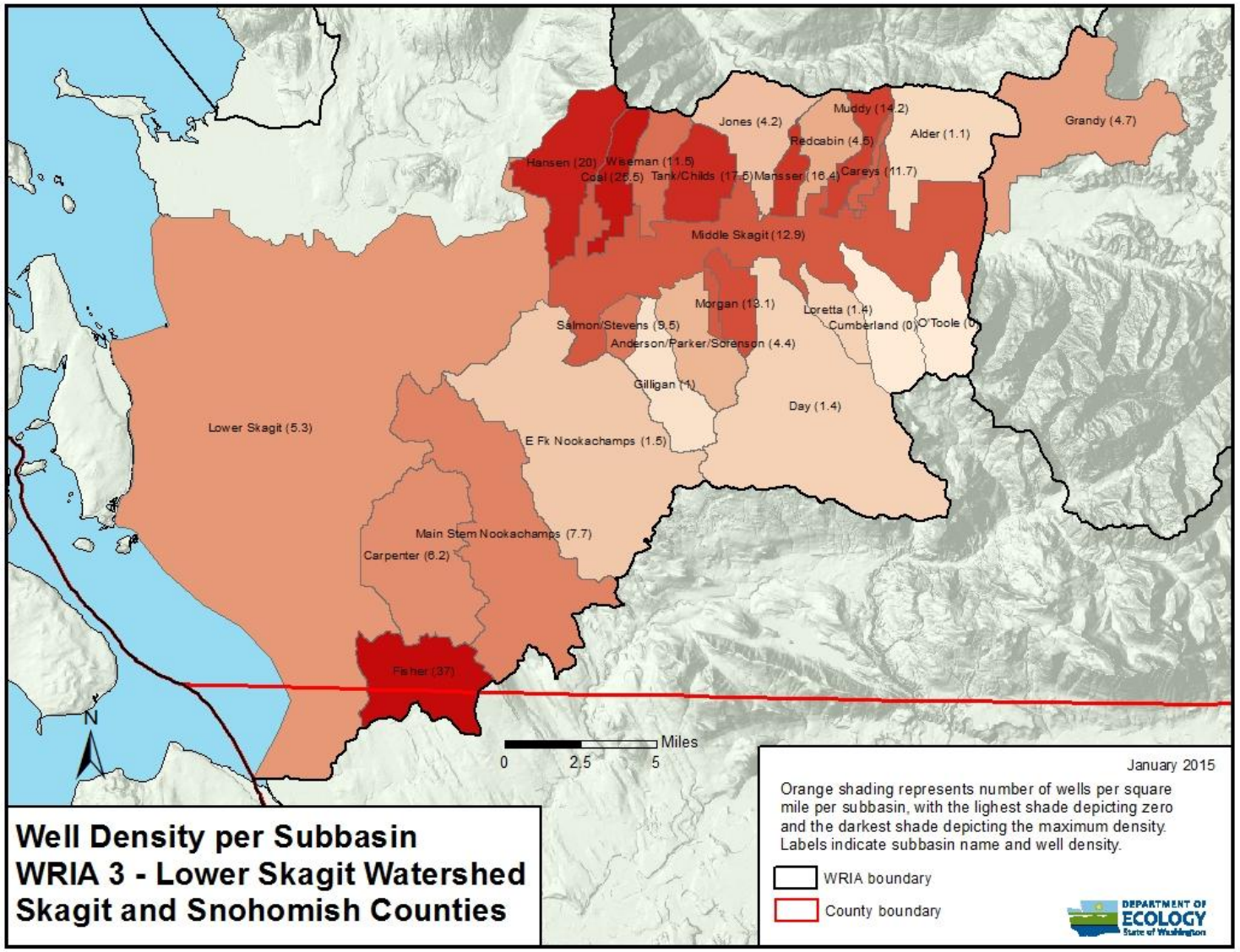

Figure 9. Range of permit-exempt well density in WRIA 3 – the Lower Skagit Watershed.

Other Washington Studies

Beyond statewide estimates of Washington water use produced by the USGS every five years, there have been several localized water use studies.

Skagit Basin Investigation

Golder Associates studied permit-exempt well water use in the Skagit Basin (WRIA 3). This work was initially conducted under contract to the Skagit County Public Works Department during a project jointly funded by Skagit County, Ecology, and the City of Anacortes (Golder Associates, 2013). The project was then extended a second year under an additional contract with Ecology (Golder Associates, 2014). The primary objectives of that study were to:

- Identify a network of volunteer permit-exempt well users to install meters and collect monitoring data on water use over a period of at least one year.
- Create a database for managing information collected from the metering program.
- Statistically analyze attributes of the metered properties in comparison to other parcels in the Fisher-Carpenter and Upper Nookachamps (also referred to as the Main Stem Nookachamps) sub-basins.
- Estimate indoor versus outdoor use, where feasible, based on the metering records.

During this study, 18 properties served by permit-exempt wells in the Carpenter-Fisher and Upper Nookachamps sub-basins were supplied flow meters and monitored for groundwater use. Estimates of indoor versus outdoor use were developed, where feasible, based on the metering records. A statistical analysis of the data was conducted to determine if the data from the monitored properties was representative of unmonitored parcels. Some conclusions from this study include:

- For combined 2012-2013 data, total average annual daily use ranged from 68 to 723 gpd, with an average for all of the properties of 188 gpd.
- The estimated average annual indoor daily use ranged from 41 to 289 gpd, with an average of 131 gpd for the 17 properties where it was estimated. Average annual outdoor daily use ranged from 6 to 112 gpd with an average of 56 gpd for the 10 properties where it was estimated.
- Precipitation at the WSU Mount Vernon station during the expected outdoor watering season (May through October) was evaluated and compared to other years.

- Comparing the available data for 1994 through 2012, low amounts of precipitation during the 2012 irrigation season resulted in a relatively high level of total water use compared to a typical year.

- Comparing the available data for 1994 through 2013, low amounts of precipitation data during the 2013 irrigation season again resulted in significantly more outdoor water use compared to a typical year.

- Based on the study results, total water use during the irrigation season (May through September) was 265 gpd (131 gpd indoor plus 134 gpd outdoor), and consumptive water use during the irrigation season was 134.1 gpd (13.1 gpd indoor plus 121 gpd outdoor).

Figure 10 below presents mean daily groundwater use (weekly average) for all metered properties during this Golder study.

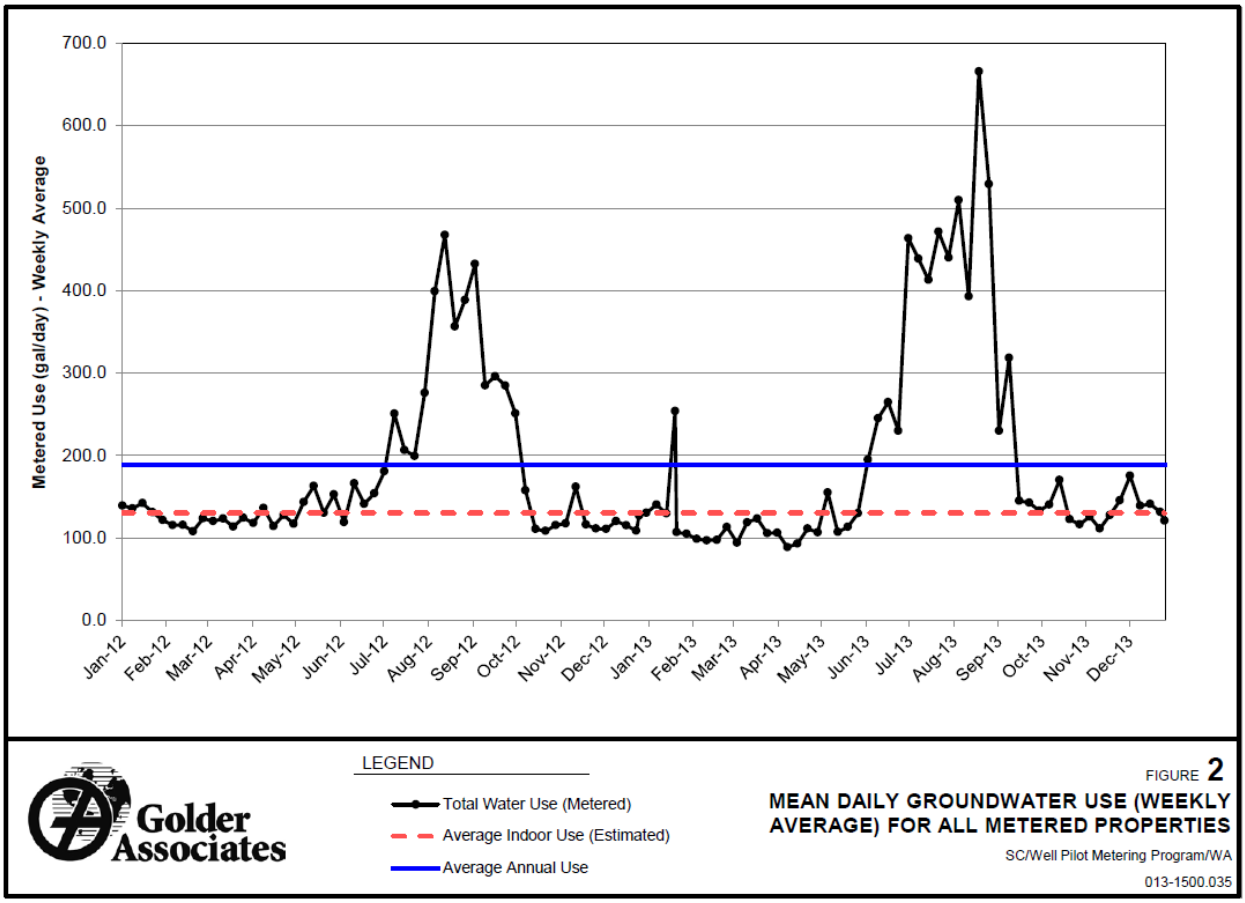

Figure 10. Skagit County permit-exempt well metering program mean daily groundwater use (weekly average) for all metered properties (Figure 2 in Golder Associates, 2014).

Spokane County Water Resources Investigation

In 2010, Spokane County Water Resources, in conjunction with Tetra Tech and Camp Dresser & McKee Inc., developed a county-wide water demand forecast model (Spokane County Water Resources, 2011 and 2013). The model is capable of forecasting demand for numerous water use sectors, at various spatial scales and time horizons. In order to extend the more-detailed public supply water use data to rural residential water use, the county also conducted a Spokane County Residential Water Use Survey. Survey results suggest that single family self- supplied residential water use is similar to public water systems. Therefore, the single family public supply (SFPS) model was used for the rural residential water sector with some modifications to account for differences.

One important finding of Spokane County's investigation was that while the self-supplied residential sector represents only approximately 7 to8 percent of total water demand, the associated water use can be significant at the sub-basin level. This is because several streams within Spokane County have summer low flows near 1 cfs. For example, in the California – Lower Rock Creek sub-basin, the forecasted increase in summer withdrawal was between 57 and 255 percent of stream flow. Although, the report notes the specific hydrogeology needed to evaluate the impacts of withdrawals on streams is not fully understood, Table 16 in the report (Table 5 below) presents stream flow and projected increases for average and July rates of withdrawal for selected sub-basins. Based on the information presented, it can be inferred that increased withdrawal could cause significant impacts to these streams.

Table 5. Stream flow and withdrawal increases for selected Spokane County sub-basins (Table 16 in Spokane County Water Resources, 2011).

Subbasin	Minimum Summer Low Flow (CFS)	Maximum Summer Low Flow (CFS)	Average Withdrawal (CFS)				July Withdrawal (CFS)			
			2010	2040	Change	% Increase	2010	2040	Change	% Increase
California – Lower Rock Creek	0.42	1.87	0.94	1.40	0.46	49%	2.17	3.25	1.07	49%
Latah Creek	5.10	14.0	1.28	2.29	1.01	79%	3.04	5.44	2.40	79%
Marshall Creek	1.60		0.62	1.28	0.66	106%	1.38	2.85	1.47	106%
Deep Creek	1.5 – 0.6		1.23	2.03	0.79	64%	2.76	4.54	1.78	64%

Notes: California-Lower Rock Creek values are a combination of flow measurements taken at the outlet of each creek. The California-Lower Rock Creek and Latah Creek minimum and maximum values measured by the Spokane County Conservation District (SCCD) between 2001-2010. The Marshall Creek value was measured by SCCD on September 8, 2010. Deep Creek values taken from the *Draft Technical Memorandum Field Data Collection and Phosphorus Loading Summary, Deep Creek Field Data Collection Area, HDR and GeoEngineers, 2010.*

The results of the Spokane County investigation can also be used to evaluate the validity of estimates in our report. Ecology contacted Spokane County and obtained 2010 water use estimates that were developed as part of the study, but not included in the county's reports. Specifically, the following estimates were obtained for single-family, self-supplied residences, average use per connection, consumptive use:

May	815 gpd
June	830 gpd
July	1,204 gpd
August	1,128 gpd

This results in an average consumptive use of 995 gpd for that time period.

Washougal River Watershed

Pacific Groundwater Group (PGG) estimated the effect of permit-exempt wells on baseflow[7] in the Washougal River watershed on behalf of the WRIA 27/28 watershed planning unit (PGG, 2003). The number of permit-exempt wells in each sub-watershed was estimated by counting well logs in Ecology's well log database (Figure 11 below). The groundwater withdrawal for each permit-exempt well was assumed to average 290 gallons per day (gpd), and return flow to the uppermost aquifer through septic systems and excess irrigation was assumed to be 70 percent of 290 gpd. Therefore, water consumption was estimated to be 87 gpd per well.

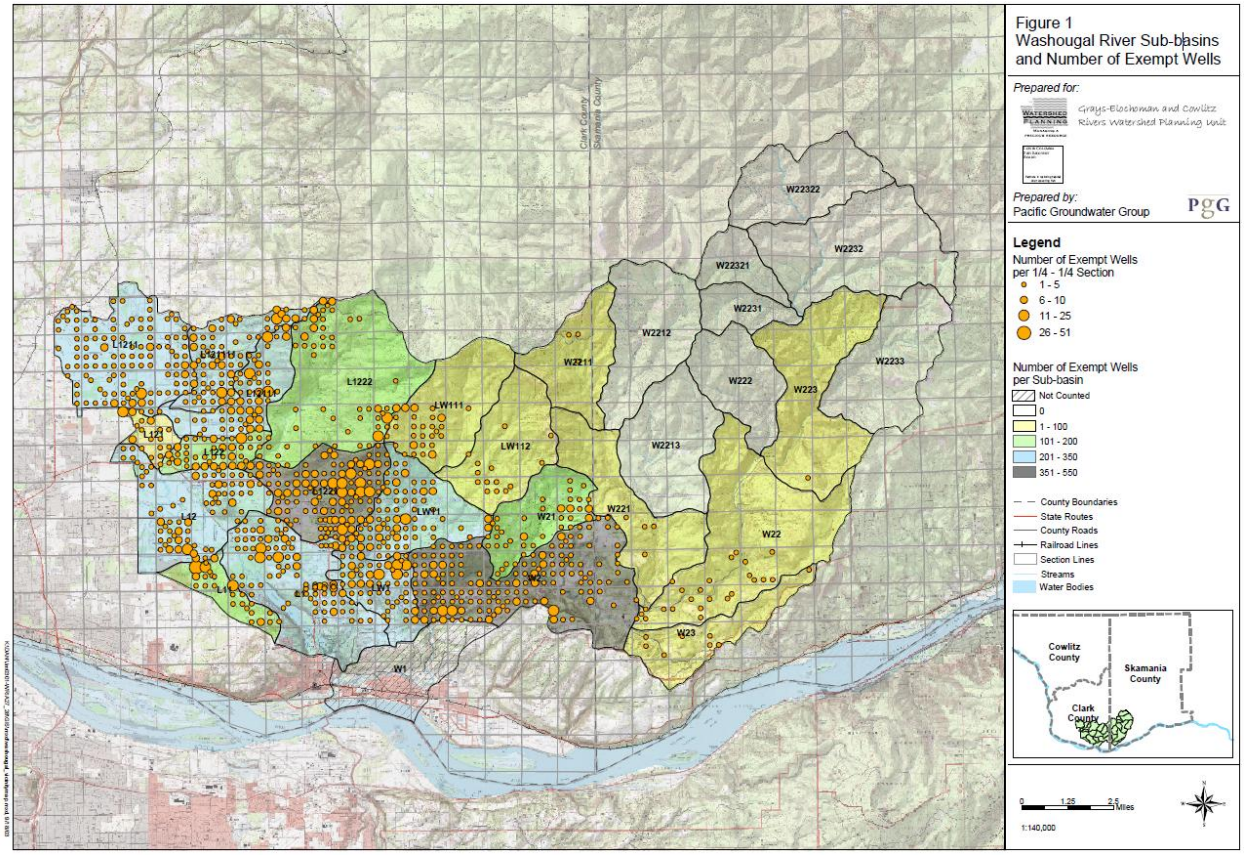

Figure 11. Washougal River watershed permit-exempt wells (Figure 1 in PGG, 2003).

A critical assumption during PGG's study stemmed from the relative hydrogeologic homogeneity and elevation consistency within the bedrock and Upper Troutdale aquifers. The sub-basin from which a given well captured all its consumed surface water was identified by comparing well bottom elevations to the streambed elevation at the mouth. If a well did not penetrate below the elevation of the sub-basin outlet, it was assumed that it captured most of its water from the sub-basin in which it was located. Otherwise, it was assumed that it most likely captured its water from the first downstream sub-basin to have an outlet elevation lower than the well bottom. To estimate the percent of baseflow that would be captured by permit-exempt

[7] "Baseflow" is the stream flow resulting from groundwater discharge to the stream.

wells, the 70 percent return flow from each well was assumed to return to the unconfined aquifer of the sub-basin where the well was located.

Based on this methodology, PGG report concluded that the baseflow capture per sub-basin ranged from gains of up to 0.06 cfs and losses of up to 0.34 cfs. The report concluded that capture losses were as much as 3.3 percent of estimated lowest mean monthly baseflow, and capture gains were as much as 6.8 percent of baseflow. Net baseflow gains were assumed to occur when return flow from deeper wells in a sub-basin exceeded the capture by shallower wells in the sub-basin and any deeper wells in an upstream sub-basin. A key assumption for net gain was that all groundwater pumped by the deeper wells was captured from a downstream sub-basin, whereas 70 percent of the withdrawal returned to the sub-basin where the well was located.

Tallying all of the sub-basin results in PGG's report, produces an estimated net flow loss of 0.453 cfs for the watershed. However, technically this is not equivalent to the net flow change in the Washougal River as a result of permit-exempt well use, since exempt wells in sub-basin W1 were not counted during this study.

Discussion

Ecology's Well Construction and Licensing System database cannot yield precise numbers regarding the number of new permit-exempt domestic wells. However, making various assumptions we conclude that approximately 17,200 permit-exempt domestic wells were drilled statewide from 2008 through September 4, 2014 - ranging from about 17 wells in Garfield County to 1,238 wells in Okanagan County. There are many reasons for the large increase in Okanagan County, including that it is the largest county in the state and nearly all growth is occurring in rural areas outside of municipal supply areas. Other useful information in Ecology's database is that there was a substantial drop in the development of new permit-exempt domestic wells after the recession of 2009, and these wells far outnumber wells for other types of uses.

During this investigation, WDOH Group A public water systems data was also subtracted from U.S. Census Bureau population data on a county-by-county basis to estimate the populations using permit-exempt domestic wells. Results from this analysis suggest that the population served in 2013 was actually less than the population served in 2005 for 19 of 39 counties. Such trends are inconsistent with results of the analysis based on Ecology's Well Construction and Licensing System database, since the latter indicates an increase in the number of permit-exempt domestic well use for every county from 2008 through January 4, 2014.

As discussed in the "U.S. Geological Survey Total Water Use Estimates" section on page 2, there are reasons to question the accuracy of the WDOH Group A public water systems data, since it is based on data reported by public water systems. Similarly, it is known that in some cases non-residential populations have been included along with residential populations. Based

on these concerns and the fact that Ecology's well database information is more directly linked to actual wells drilled, we conclude that Ecology's well drilling data is likely a better indicator of increasing permit-exempt domestic well use. That said, there is no way of knowing to what extent these new permit-exempt domestic wells are actually in use.

In addition to Ecology's analysis of the increase in the number of permit-exempt domestic wells, this study evaluated consumptive water use for all water uses. One significant limitation with Ecology's method involved an assumption that all outdoor water use occurred within a 4-month irrigation season. Outdoor irrigation actually varies widely across the state and on a month-by-month basis, and there are other types of outdoor water use such as that associated with year-round dairy and feedlot operations. However, from an environmental protection standpoint Ecology is most interested in the effects that self-supplied domestic withdrawals have upon summer-season low flows. Therefore, although this study does not evaluate how consumptive water use by permit-exempt domestic wells actually affects streamflows, concentrating outdoor water use into a narrower 4-month time frame provides a more useful gauge of consumptive water use.

A more significant issue with our consumptive water use analysis is that it was based largely on estimates provided in USGS SIR 2009–5128. That report based much of its self-supplied and public-supplied total water use analyses on WDOH Group A water system data. As discussed above, a comparison of actual well drilling data and results of an analysis based on WDOH Group A water system data suggests the latter is inaccurate. Therefore, as there are significant concerns with the SIR 2009–5128 self-supplied results, there are also concerns with Ecology's analyses based on that report's information. That said, SIR 2009-5128 is the only readily available source of information on total water use for different use categories throughout the state, and differences between self-supplied domestic use and other types of use generally are large. Consequently, Ecology believes results of its consumptive water use analysis are instructive.

Bearing in mind the stated limitations on Ecology's analysis, our results suggest the percent of total water use due to permit-exempt domestic water use on a 4-month irrigation season consumptive use basis (the last column in Table 3) ranged from 0.1 percent in Grant and Franklin counties to nearly 26 percent in San Juan County, for an overall statewide proportion of about 0.9 percent. However, it is critical to recognize that this result is skewed by the large role irrigation plays statewide when it comes to consumptive water use. For example, the second largest water use category, public water supply, also constitutes a relatively small percentage of total consumptive water use, as it comprises only about 4.6 percent.

It is also important to understand the method limitations when interpreting these results. Due to the source data used (Lane, 2009), the most specific consumptive water use estimates provided are on a county-wide basis. However, the effects of well use are not constrained by county boundaries. Although an analysis based on a watershed or a subbasin basis would be much more accurate, the base data for the other use categories makes it very difficult to estimate their consumptive water use on a geographic basis.

As a check of Ecology's methods, our results were compared to results from other studies addressing consumptive use within Washington. Golder Associates studied permit-exempt well water use in the Skagit Basin by monitoring groundwater use at 18 properties with permit-exempt wells in the Carpenter-Fisher and Upper Nookachamps sub-basins. Based on Golder's results, total water use during the irrigation season (May through September) was 265 gpd, and consumptive water use during the irrigation season was 134.1 gpd. These numbers differ from our study's Skagit County permit-exempt domestic, 4-month irrigation season estimates, which were 174 gpd for total water-use and 38 gpd for consumptive water use (numbers from spreadsheet calculations that led to results in Table 3). Therefore our results suggest significantly less total and consumptive water use. In part this difference relates to the fact that Golder's data were drawn from only a subset of Skagit Watershed subbasins. Also, as illustrated in Figure 9, there is considerable well density variation throughout the Skagit River watershed.

During another study conducted by Spokane County Water Resources in 2010, they developed estimates of single-family, permit-exempt residential water use based on relationships with single-family public supply data. Results based on their data lead to an estimate of 995 gpd average consumptive water use, for these wells during May through August. This compares with our permit-exempt domestic, consumptive water-use estimate of 838 gpd for Spokane County (from spreadsheet calculations that led to results in Table 3). This indicates our result is about 16 percent less than the Spokane County Water Resources estimate.

To properly evaluate the impacts of permit-exempt domestic wells on streamflow, specific watershed hydrogeology must be considered. If wells are completed in confined aquifers with restricted connections to surface water, the effects of groundwater pumping on nearby streams may be negligible. Moreover, in situations where water discharges from a watershed via both stream discharge and groundwater discharge, any reductions due to consumptive use by permit-exempt domestic wells is divided between reduced surface water flow and reduced groundwater discharge.

PGG attempted to account for both the stream discharge and groundwater discharge pathways when estimating the effects of permit-exempt wells on baseflow in the Washougal River watershed. During that study, assumptions were made regarding two primary aquifers tapped by domestic wells and what that meant for stream capture at the mouth of each sub-basin. As a result, PGG concluded that baseflow capture per sub-basin in the Washougal River watershed ranged from gains of up to 0.06 cfs and losses of up to 0.34 cfs. Tallying the results for all sub-basins produces a net flow decrease of 0.453 cfs. Theoretically this translates to the net flow change in the Washougal River as a result of permit-exempt well use (minus the effects of exempt wells in the lower-most sub-basin). However, due to numerous assumptions, the results are suspect.

One significant limitation inherent in this Ecology statewide assessment is that it essentially assumes an even distribution of permit-exempt domestic wells across each county. Obviously this is not the case, and if a large number of wells are clustered within a small watershed the effects of those wells can be much more substantial. However, while this sort of scenario may exist in some areas, most permit-exempt domestic well water-use scenarios in Washington are

not so dramatic. In situations where any of the following apply, well development would result in smaller summer low-flow effects:

- Discharge from the watershed is a combination of surface and subsurface flow.
- There are a small number of permit-exempt wells.
- Homes have little to no landscaping/use highly efficient landscape irrigation systems.
- Residences are used as vacation homes only.
- Wells are completed in confined aquifers with restricted connections to streams.
- Each well supplies only one single family residence.
- Stream flows are high during summer months.

Conclusions

The number of permit-exempt domestic wells throughout Washington has grown significantly. Our analysis suggests that statewide, during the irrigation season, self-supplied wells account for about 0.9 percent of the overall consumptive water use. However, according to our estimates even public water supply systems account for only about 4.6 percent of consumptive water use in Washington, and overall most consumptive water use is due to irrigation.

It is critical to view this study's consumptive use estimates in the context of method limitations. From a water management perspective, scenarios of greatest concern involve: (1) relatively small watersheds where many permit-exempt domestic wells are drilled in aquifers highly connected to small streams, (2) a considerable amount of outdoor watering, and/or (3) surface water use in endangered aquatic species habitat.

Areas with high concentrations of permit-exempt domestic wells were not specifically addressed during this study. However, that does not diminish this study's usefulness. Analyses indicate that permit-exempt domestic wells may have a relatively small impact related to total consumptive use when looked at countywide or statewide. Still, there are areas with high densities of permit-exempt domestic wells where the impacts on streams can be significant. Ecology suggests that the greatest return from a water management perspective will be gained by focussing on areas where the potential impact is greatest. These types of scenarios can only be analyzed with detailed analyses that evaluate factors such as hydrogeology, site-specific outdoor water use, detailed distributions of wells, legal water availability, and so on. Such factors were not considered during this analysis; however, Ecology may explore these variables for representative situations during future focused studies in selected basins.

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