UPPER SKAGIT BASIN RURAL GROWTH PERMIT-EXEMPT WELL ASSESSMENT

Prepared for: Washington State Department of Ecology

Project No. 150304-110-Task 4 • November 15, 2019

earth + water

Aspect CONSULTING

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Executive Summary

ESSB 6095 charged the Washington State Department of Ecology (Ecology) and the Skagit Joint Legislative Task Force on Water Supply (Task Force) to "evaluate instream flow needs and existing and future out-of-stream water use demands within the Skagit River water resource inventory area (WRIA) 4 (Upper Skagit) regulated by Chapter 173-503 WAC. " To support this evaluation, Ecology contracted with Aspect Consulting, LLC (Aspect) conducted a three-part assessment/study:

1. A rural growth estimate (i.e., forecasted new permit-exempt wells)—with a comparative assessment and review of prior population growth projection.
2. A review of the statistical analysis of the lowest consecutive 7-day average streamflow that occurs (on average) once every 10 years (7Q10).
3. Development of an independent determination of consumptive impacts (and review of prior approaches) to streamflows from future exempt uses in WRIA 4.

Rural Growth Estimates and Basins of Interest

Aspect's analysis and comparative assessment was limited to 34 subbasin areas within WRIA 4 (WRIA 4 Subbasins; the Study Area). Per Ecology, these are the subbasins where reservations had been established, but are no longer valid (because of the 2013 Swinomish court decision) and which are the most likely to experience growth.

Aspect's independent, parcel-scale analysis of current demand and projected growth in these WRIA 4 Study Area generally corroborates the demand projections findings in the "Skagit Demand Projections Tech Memo" (Ecosystem Economics, 2015)—particularly the broad conclusion that the WRIA 4 Subbasins (the 34 in this study) are unlikely to experience significant permit-exempt well growth or future demand through 2038.

Aspect's growth forecast suggests that the following subbasins (among the 34) will experience the most (albeit still modest, likely single-digit) future demand for permit-exempt wells through 2038: **Grandy Creek, Everett Creek, Prairie Creek, Diobsud Creek, and Gravel Creek.**

In total, Aspect estimates a future demand of 20 to 80 additional permit-exempt wells across the 34 subbasins studied. Notably, because it relies on a County-wide high-growth rate scenario (and rural growth is likely to lag behind urban growth), the upper estimate of additional permit-exempt wells (80) is especially conservative from a planning standpoint. Additionally, **this estimate represents the sum of high-growth scenarios** across all study area subbasins. It is more likely that if one basin sees proportionally higher growth, then another will see less (total demand held constant). The most likely scenario for total growth is in the middle to lower end of the total range (e.g., a total of 30 to 50 new permit-exempt exempt wells through 2038).

Based on the buildability/ownership of lands in the 34 WRIA 4 Study Subbasins, the balance of growth is far more likely to occur in areas near the confluences of tributaries with the mainstem Skagit and Sauk Rivers.

Review of 10-Year Annual Low-Flow Statistical Analysis (7Q10)

Aspect reviewed and reassessed previous low-flow statistical analysis conducted in support of Ecology's 2006 Skagit Rule Amendment (Ecology, 2006). That work included an analysis of flows throughout the Skagit Basin to assist in determining an appropriate reservation size to include in the rule amendment. The reservation was intended to be a quantity of water set aside to accommodate future water demand in WRIAs 3 and 4.

Few streams within the Upper and Lower Skagit subbasins have available long-term stream gauging records. For this reason, in the 2006 analysis, 7Q10 estimations were calculated for a limited number of gauged creeks within the Lower and Upper Skagit basins and extrapolated to other ungauged subbasins lacking long-term flow records. Within WRIA 4, Grandy Creek was the only Upper Skagit tributary to be treated as an individual tributary subbasin and, thus, initiate a 7Q10 estimate in the 2006 analysis. Except for the Grandy Creek subbasin, the entirety of WRIA 4 was treated as a single large subbasin (referred to as the Upper Skagit subbasin).

Based on an annual precipitation value of 75.45 inches for 2018, the Grandy Creek low-flow estimate increased from 11.4 to 13.5 cfs in the updated analysis conducted by Aspect. Low flows on the mainstem of the Upper Skagit were also recalculated with data, including flow values from 2006–2019 at the Marblemount gauge. Based on updated data, low-flow estimates on the mainstem of the Upper Skagit decreased from 3,879 to 3,240 cfs.

Determination of Consumptive Use Impacts

Based on comparison to prior studies and Ecology guidance documents, we estimated consumptive indoor use in the WRIA 4 Study Area to be 15 gallons per day (gpd; equivalent to 0.017 acre feet per year (afy)) per household. For outdoor irrigation, we estimated consumptive demand of 27 gpd (0.030 afy) per household.

Based on the above analysis, the estimated total household water use is 185 gpd (0.21 afy), with 42 gpd (0.047 afy) as consumptive use. These estimates are consistent with prior assessments in the Study Area and are likely conservative planning estimates for WRIA 4. As noted previously, Aspect estimates a future demand of 20 to 80 total exempt wells across the 34 subbasins by 2038. Applying use estimates per household to this 20 – 80 permit-exempt estimated range yields 4.2 afy to 17 afy for estimated total water use by these new households, and an estimated consumptive use of 1.0 afy to 4.0 afy.

Bringing the three components of this study together (population growth, instream low flows, and consumptive use estimates) helps to put the forecasted impacts in context. The total additional consumptive use estimate in Study Area subbasins (high-growth scenario, 4.0 afy/0.0055 cfs) correlates to less than 0.0002 percent of the 90 percent exceedance low flow calculated for the main stem Skagit River (3,240 cfs). The projected additional consumptive use from future exempt wells in the Grandy Creek subbasin (high-growth scenario, 0.90 afy/0.0012 cfs) would be less than 0.01 percent of the tributary's estimated 7Q10 low flow (13.5 cfs).

This executive summary should be used only in the context of the full report.

1 Introduction

This work was funded through Engrossed Substitute Senate Bill (ESSB) 6095, passed during the 2018 Legislative Session. ESSB 6095 charged the Washington State Department of Ecology (Ecology) and the Skagit Joint Legislative Task Force on Water Supply (Task Force) to "evaluate instream flow needs and existing and future out-of-stream water use demands within the Upper Skagit River, water resource inventory area (WRIA) 4, regulated by Chapter 173-503 WAC." To support this evaluation in the WRIA 4 study area (Study Area), Ecology contracted with Aspect Consulting, LLC (Aspect) to conduct a three-part assessment/study in select subbasins in water resource inventory area (WRIA) 4 (the Study), which includes:

1. A rural growth estimate (i.e., forecasted new permit-exempt wells[1])—with a comparative assessment and review of prior population growth projection.
2. A review and update of the statistical analysis of the lowest consecutive 7-day average streamflow that occurs (on average) once every 10 years (7Q10) and other low flow statistics associated with the 2006 amendments to the Skagit Rule (Ecology, 2006; WAC 173-503)[2].
3. Development of an independent determination of consumptive impacts (and review of prior approaches) to streamflows from future permit-exempt uses in the WRIA 4 Study Area (Section 4).

It is important to note that this Study did not focus on the entire area of WRIA 4 and was targeted at 34 subbasins within WRIA 4 (the Study Area) that were defined in the 2006

[1]A permit-exempt well is defined as a well that withdraws less than 5,000 gallons per day of groundwater for small domestic (and other non-commercial) uses such as a single home or small group of homes. Until recent legal challenges such as the Hirst and Swinomish decisions, these small domestic uses have historically been exempt from obtaining a formal water right permit from the state.

[2] The rule amendment and associated subbasin reservations were invalidated by the 2013 Washington State Supreme Court decision in Swinomish Indian Tribal Community v. Ecology (Swinomish, 2013). The Skagit River Basin Instream Resources Protection Program Rule (WAC 173-503; going into effect on April 14, 2001) established instream flows, protecting flow levels on the mainstem of the Skagit River at river mile 15.7 and on the Cultus Mountain tributaries of Mundt, Turner, Gilligan and Salmon Creeks. In 2006, the rule was amended to establish finite "reservations" of surface and groundwater for future out-of-stream uses (Ecology, 2006). Until rendered invalid, the reservations were intended to provide uninterruptible (year-round) water supplies for new agricultural, residential, commercial/industrial and livestock uses, distributed among 25 subbasins.

Skagit instream flow rule amendment (Ecology, 2006)[3]. Per Ecology, these subbasins represent non-mainstem (tributary) areas where population growth is reasonably likely (e.g., not remote basins in National Park areas) and where an estimate of future impacts is needed to inform mitigation planning efforts. GIS-based delineations of these subbasin areas were provided by Ecology and used as-is. Figure 1 shows the WRIA 4 subbasins included in this study.

In combining management of most of WRIA 4 under one reservation, Ecology considered that in most of the Upper Skagit subbasin water use is likely to occur in limited areas, generally in areas near the mainstems of the Skagit and Sauk rivers where most buildable parcels are located. Much of the Upper Skagit subbasin is in public ownership and is unlikely to experience significant demand for residential and business water uses.[4]

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[3] The 2006 rule amendment established reservations of surface and groundwater tied to some (but not all of) newly defined basins in both WRIA 4 and WRIA 3 (Lower Skagit). In WRIA 4, only the Grandy Creek subbasin (Figure 1) had a specific reservation established, while the remainder of WRIA 4 was treated as a single "Upper Skagit subbasin" for the purposes of the reservations.

[4] Ecology, 2006. Skagit Rule Amendment Rule Making Criteria: Background on the Reservations, Closures, and Hydraulic Continuity.

2 2015 Ecosystems Economics Skagit Demand Projections Memo

In 2015, Ecosystems Economics (EE) was contracted to develop a forecast of potential demand for groundwater mitigation for the Nookachamps subbasin of the Skagit River Basin. While EE's 2015 study emphasized the Nookachamps subbasin—which is fully in WRIA 3— they also included population growth estimates for WRIA 4.

One of the goals of this current investigation is to conduct an independent review of Skagit water demand projections presented by the 2015 EE study.

The 2015 analysis was completed under Washington Water Trust's (WWT) grant with Ecology and produced in the Skagit Demand Projections Technical Memorandum (hereafter referred to as the 2015 Demand Memo; EE, 2015). A summary of that memo's methodology and conclusions follow.

2.1 2015 Demand Memo Methodology

The 2015 Demand Memo developed a forecast of demand for mitigation in each of the subbasins of the Skagit River and its tributaries. First, the number of permit-exempt wells that were expected to need mitigation was determined and then the volume of water (measured in acre-feet per year (afy)) that those wells would need to mitigate was derived. The basic assumption was that all permit-exempt wells developed since the Skagit Rule (WAC 173-503) was implemented, as well as those that will likely develop over the next 20 years, represent the mitigation demand for each subbasin. During the period of time the 2015 Demand Memo reviewed—2001 to 2013 (i.e., the time the Skagit Rule reservation system was in place)—there were no new uses other than residential in the 2015 study area; therefore, the 2015 demand analysis assumed that only residential uses would comprise the future demand.

2.2 2015 Demand Memo Conclusions

The 2015 Demand Memo estimated that development pressures and trends will vary from subbasin to subbasin in the Skagit Basin. Overall, rural WRIA 4 was forecasted to face less demand for mitigation compared to WRIA 3. Most of the forecasted mitigation demand for permit-exempt wells/water use in WRIA 4 (~75 percent) was allocated to non-tributaries areas along the mainstem Skagit River.

For the whole of WRIA 4, the 2015 Demand Memo the estimated *total* permit-exempt well demand and consumptive use ("Impact/Demand") as:

- **Low growth:** 193 dwellings/permit-exempt wells, 17.7 afy consumptive use (0.092 afy/household, low water use scenario)
- **High growth:** 311 dwellings/permit-exempt wells, 68.7 afy consumptive use (0.221 afy/household. high water use scenario)

It is important to note that these estimates are not directly comparable to the subsequent results presented in this 2019 study for two key reasons:

1. The 2015 low and high growth estimates quantify **total demand in all of WRIA 4** (mainstem and tributaries), whereas this 2019 Study quantifies demand in *only* the 34 Study Area Subbasins (not mainstem).
2. The 2015 low and high growth estimates represent totals **inclusive of what the 2015 Demand Memo refers to as "Present Demand"**: permit-exempt wells (and associated consumptive use) developed between 2001 and 2013, that were debited against the former instream flow reservation (see footnotes in Section 1, above).

While not explicitly presented in the 2015 Demand Memo, more comparable results (to this 2019 study) can be *derived* from the 2015 Demand Memo's tables. Specifically, by subtracting the estimates of "Present Demand" from the total demand estimates, it is possible to isolate what could be called "future" or "new" demand (e.g., that which is not built yet). Additionally, tables in the 2015 Demand Memo's appendices make it possible to isolate estimates for tributary subbasins.

These derived results for **future (2016 to 2035) demand in tributary subbasins *only*** are:

- **Low growth:** 17 new dwellings/permit-exempt wells, 1.56 afy consumptive use (0.092 afy/household, low water use scenario)
- **High growth:** 55 new dwellings/permit-exempt wells, 12.16 afy consumptive use (0.221 afy/household, high water use scenario)

Among the tributary subbasins, the 2015 Demand Memo suggested that the Everett Creek subbasin will see the greatest amount of *new* demand for permit-exempt wells, with 19 new permit-exempt wells and 4.20 afy consumptive use in the high growth and high water use scenario. Next was Prairie Creek with 10 new permit-exempt wells and 2.21 afy. Notably, while it was forecasted that Grandy Creek would see a **total** demand for 25 permit-exempt wells (2.30 afy to 5.52 afy), all of these 25 wells are tallied as "present demand"—**suggesting that the 2015 Demand Memo forecasts no new growth in the Grandy Creek subbasin**. It is unclear what leads the authors to this conclusion as it is a finding that is inconsistent with the results of the 2015 study.

Table 1 (of this report) presents a summary of the results for WRIA 4 from the 2015 Demand Memo, including the derived results.

3 WRIA 4 Study Area Subbasins Permit-Exempt Well Estimate Methodology and Comparison of Results

This section summarizes current and forecasted permit-exempt well estimates and, therefore, estimated WRIA 4 rural growth in the 34 Study Area Subbasins. These estimates are based on a combined analysis of housing units and public water systems.

3.1 Current WRIA 4 Study Area Permit-Exempt Wells

To allocate current housing unit and/or permit-exempt well estimates to each Study Area subbasin, a parcel-scale estimate of residential development and water source was required. This estimate has two key elements:

1. An estimate of whether each individual parcel has one or more housing units (residential development)—primarily derived by cross referencing information in the Skagit and Snohomish Counties assessor's databases.
2. An estimate of whether a parcel is served (or not) by a permitted (water right) source such as a Group A or large Group B public water system. Residential parcels outside of permitted water service area boundaries are assumed to be self-supplied by a permit-exempt well.

3.1.1 Housing Unit Estimates (Parcel and Assessor Data)

WRIA 4 covers portions of Whatcom, Skagit, and Snohomish Counties (Figure 1). However, the area of WRIA 4 inside Whatcom County is composed entirely of federal land (Mt. Baker-Snoqualmie National Forest, Okanogan-Wenatchee National Forest, North Cascades National Park, and Ross Lake National Recreation Area). Moreover, among the 34 Study Area subbasins, only remote, unpopulated, federally owned portions of Bacon Creek and Diobsud Creek are within Whatcom County. Thus, for the purposes of this Study, only parcels and related data from Skagit and Snohomish Counties are used or considered.

Further, among the 34 Study Area subbasins, only five are partially within Snohomish County (All Creek, Everett Creek, Gravel Creek, Prairie Creek, and Tenas Creek). As a result, this study places a significant emphasis on Skagit County data, as it has a much greater impact on the methods and results.

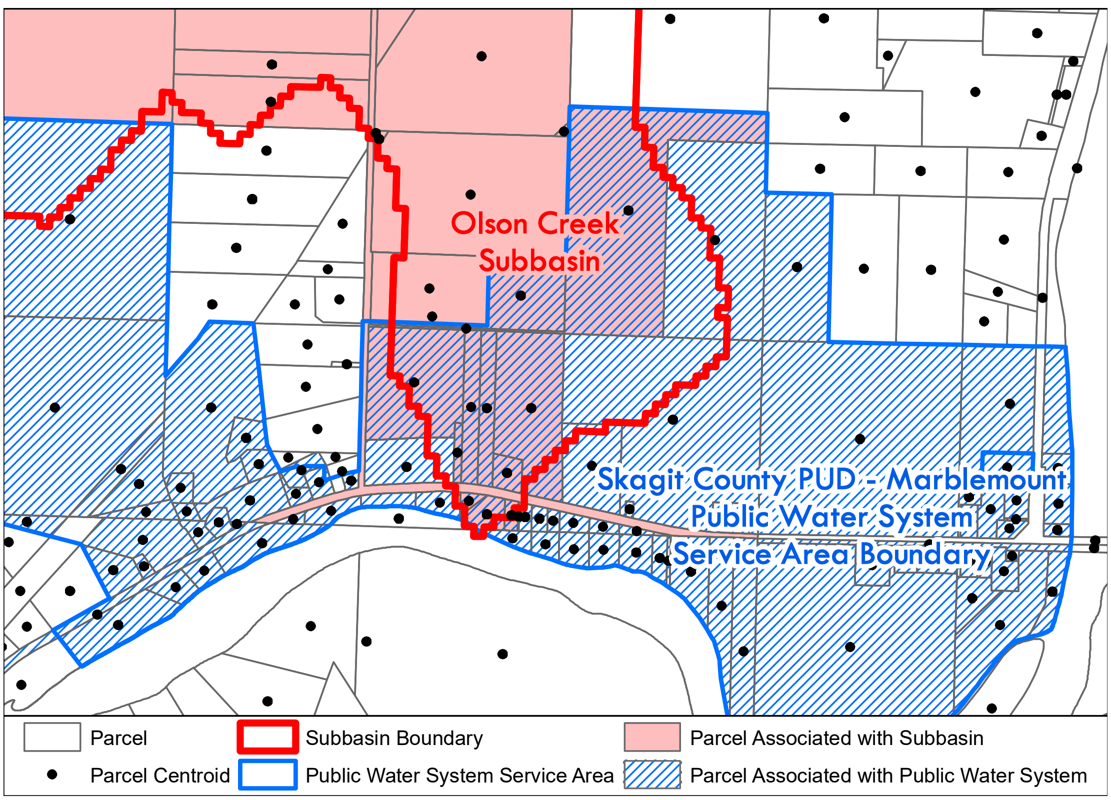
Table 2 provides a breakdown of WRIA 4 and the Study Area subbasins by county and land ownership/land use.

GIS parcel data and related assessor database data for Skagit and Snohomish Counties was requested and/or downloaded from each county. Parcels falling within WRIA 4 were extracted and combined into a single, unified dataset for analysis.

3.1.2 Association of Housing Units/Parcels to Subbasins

Some parcels span multiple subbasin areas—but to avoid double counting, parcels (and the associated housing unit estimates/impacts) can only be associated with a single subbasin. Therefore, parcels were tallied against a given subbasin based on the geographic center (termed "centroid") of the parcel. For example, if a parcel spans multiple subbasins, it was associated with the subbasin in which its centroid falls. Figure 2 (below) shows an example of the outputs of this process (in this case, which parcels were associated with the Olson Creek Subbasin near its mouth).

Figure 2. Example of Parcel Centroid Association with Subbasin and Public Water System Area



3.1.3 Current Housing Units in Skagit County

After a series of detailed consultations with the Skagit County GIS department in April and May 2019, it was determined that no single attribute from the Skagit County parcel or assessor database could be used to estimate whether a parcel contained one or more housing units. Instead, several attributes were considered to make this determination:

- **Living Area** – Parcels with entries in the assessor database of 200 or more square feet of living space were considered to have one or more housing units (consistent with the 2015 Demand Memo)

- **Bedrooms** – Parcels with one or more bedrooms were considered to have one or more housing units. This was almost always consistent with living area greater than or equal to 200 square feet. However, (in 11 instances) if a parcel had no data for living area but did have bedrooms, it was considered to have a housing unit.

- **Building-only records** – In certain cases, the Skagit County Assessor maintains "building-only" assessment records. These records represent dwellings and other buildings that have separate tax accounts than the land parcels that they are on. The assessor's database records for these dwellings and other buildings show up as points within the parcels. If building-only parcel record(s) matched the living area/bedroom criteria above, then the GIS parcel areas were considered to contain a corresponding number of housing units. *In this way, a single parcel can contain a number of separate housing units.*

- **Assessed land use, building style, and improvement value** – Parcels that had residential land use codes, residential building styles, **and** assessed improvement values above $20,000 were considered to contain housing units—regardless of entries for living area or bedrooms.

- **Building style and land use** (false positives) – In situations where living area was listed at 200 square feet or greater, but where the assessed building style was "COMMERCIAL REAL PROPERTY" **and** that parcel was given a non-residential land use, that parcel was considered to *not* have a residential housing unit.

- **Other considerations:**

    - Skagit County parcel GIS data represents **tax** lot areas, not necessarily whole land parcels. So, single parcels can be represented as multiple records in the GIS database. On the advice of the Skagit County GIS department, adjacent tax lots with matching Parcel ID numbers and matching owner names were merged into single records to prevent double counting.

    - In a limited number of instances, if parcel or assessor data suggested multiple housing units on a single parcel, Aspect conducted a review of aerial photos, building footprint data (provided by Skagit GIS), and Google Street View photos to make a best guess at the total number of housing units on the parcel (with a particular emphasis on parcels with the Study Area subbasins).

3.1.4 Current Housing Units in Snohomish County

Housing unit estimates by parcel in Snohomish County followed a simpler set of criteria than those in Skagit County. Chiefly, this is because of the difference in available data in the Snohomish County Assessor parcel dataset vs. the Skagit County Assessor parcel dataset. Moreover, a much smaller percentage of parcels inside the Study Area fall within Snohomish county (see Table 2). The criteria used for estimating housing units in Snohomish County parcels were:

- **Land use and improvement value** – If a parcel in Snohomish County was listed as having a residential land use code and that parcel had an assessed improvement value above $20,000, that parcel was estimated to have a housing unit.
- **Multiple dwelling land use** – If a Snohomish County parcel had a land use code that explicitly suggested a certain number of housing units (e.g. “124 Four Family Residence (Four Plex)”), that parcel was assumed to have that number of units (e.g. four in the previous example). In a handful of situations where a land use code suggested a range of multiple units (e.g. “150 Mobile Home Park 1 - 20 Units”), that parcel was reviewed on a high-resolution aerial photo (Google Earth) to make a best guess of total housing units. If no determination could be made, the middle number of the range was used (e.g., 10 units for code “150 Mobile Home Park 1 - 20 Units”).
- **Aerial photo and improvement value** – Because of the limited number of Snohomish County parcels falling within Study Area subbasins, all parcels with improvement values above $20,000 were reviewed on high-resolution aerial photos (Google Earth). Regardless of land use, if a parcel *clearly* appeared to have a home built on it, it was considered to have a housing unit.

3.1.5 Housing Unit Estimate Quality Control

Nearly all the approximately 500 privately-owned, non-commercial forest parcels lying within (by centroid) the 34 Study Area subbasins were briefly inspected in Google Earth to identify obvious false positives or false negatives for housing unit estimates. Only three *possible* false positives were identified (e.g. a parcel was flagged as having a residence, but no structure was visible on an aerial photo)[5]. No *definitive* false negatives were identified.

Additional aerial photo-based spot checks were conducted on approximately 100 parcels lying outside the Study Area subbasins. No definitive false positives or false negatives were identified.

[5] Since it could not be established based on aerial photo review alone that these “false positives” were definitively NOT residential, the “residential” identifier for these parcels was left as “True” (e.g. they remain in the tally of residential parcels in WRIA 4). It is possible that residential structures were simply obscured by trees or (less likely) that development occurred after the aerial photo was taken. The scope of this analysis did not allow for a more nuanced review on a parcel-by-parcel basis.

3.1.6 Comparison Against Office of Financial Management Small Area Estimates Program

The Washington State Office of Financial Management's (OFM) Small Area Estimates Program (SAEP) is often referenced (including in Ecology's *ESSB 6091 - Recommendations for Water Use Estimates* guidance document; Ecology, 2018) as a potential source for current population estimates. OFM's most current estimates for WRIA 4, published on 9/11/2019, put the total number of housing units in the WRIA at 3,992 (see Table 3 below). This is an 8.7 percent difference from the parcel-based housing unit estimate (3,670) in this 2019 Study.

Table 3. Current WRIA 4 Population Estimate

	2019 OFM SAEP WRIA 4 Estimate
Total Population	7,263
Total Housing Units	3,992
Occupied Housing Units	2,860

Perhaps more notably, there is a substantial difference (~40 percent) between OFM's estimate of total housing units and total *occupied* housing units. A high percentage of housing units tallied in WRIA 4 are seasonal or transient dwellings such as vacation cabins, mobile homes, and recreational vehicles (see Lake Tyee RV Park in the Grandy Creek subbasin). This potential difference between housing units and occupied housing units should be considered in the overall uncertainty of this analysis. Critically, it suggests that an overall demand estimate based on *total* (not occupied) housing units is likely a conservative estimate from a water use standpoint.

3.1.7 Comparison Against 2015 Demand Memo

Overall, this 2019 Study estimates that there are 3,670 housing units in WRIA 4. This compares favorably to the 2015 Demand Memo estimate of 3,565 total "dwellings" in WRIA 4 (see Table 4, below). The three percent difference in estimated housing units between the 2015 Demand Memo and this 2019 study tracks precisely with a subsequent "medium" year-over-year growth scenario (presented later in this memo). This suggests an expected overall 19 percent to 20 percent increase in housing units by 2038.

Table 4. Housing Unit Estimates by Subbasin (2015 vs. 2019)

Subbasin	Total Estimated Housing Units (This Study)	Total Estimated Housing Units ("Dwelling") - Ecosystem Economics, 2015
Aldon Creek	1	2
All Creek	0	0
Bacon Creek	3	2
Barr Creek	3	4
Big Creek	0	0
Boulder Creek	7	4
Boyd Creek	0	0
Clark Creek	2	0
Corkindale Creek	9	5
Diobsud Creek	18	12
Everett Creek	43	45
Finney Creek	7	15
Flume Creek	0	0
Grandy Creek	303	315
Gravel Creek	13	9
Hilt Creek	10	7
Hobbit Creek	1	2
Illabot Creek	6	6
Irene Creek	0	0
Jackman Creek	8	11
Jordan Creek	0	1
Mill Creek	0	0
Miller Creek	0	0
O'Brian Creek	0	0
Olson Creek	18	15
Ossterman Creek	1	1
Prairie Creek	21	25
Pressentin Creek	39	41
Rinker Creek	0	0
Rocky Creek	0	0
Savage Creek	0	0
Sutter Creek	2	4
Tenas Creek	0	0
White Creek	0	0
WRIA 4 (all other areas)	3,155	3,039
Grand Total	**3,670**	**3,565**

Source: EE, 2015. Appendix B: "WRIA 4 Green Zone Snapshot by Subbasin"

3.1.9 Estimating Permit-Exempt Wells from Housing Units and Public Water System Boundaries

After establishing a baseline estimate of which parcels contain residential housing units, Aspect estimated which units/parcels were served by permit-exempt wells (as opposed to permitted domestic supplies, i.e. Group A public water systems). To make this estimate, public water system service area boundaries were overlaid with parcel areas in GIS. A parcel (and its associated housing units) is assumed to be served by a given water system if its centroid falls within the service area boundary of that system (as illustrated in Figure 2). By process of elimination, housing units/residential parcels that fall outside these service areas were assumed to be supplied by exempt wells.

Washington State Department of Health (DOH) provides a GIS dataset of public water system service area boundaries. However, this dataset was not comprehensive of all Group A systems in WRIA 4—and did not include any service area delineations of Group B systems.

To establish which water system delineations were missing from the dataset, an extract of all active public water systems in WRIA 4 was downloaded from the DOH SENTRY Internet query page[6]. This list was then cross referenced with the initial GIS service area delineations to establish which Group A and larger (greater than six connections) Group B systems did *not* have boundaries in the GIS[7]. Six additional service area boundaries (two Group A and four Group B) were added to the GIS by finding corresponding water rights places-of-use (POU) in Ecology's Water Rights Tracking System (WRTS) and Geographic Water Information System (GWIS). The final GIS dataset contains 39 water system services area boundaries in WRIA 4. See Table 5 (attached) and Figure 3 (attached) for details on these water systems.

After cross referencing parcels with these service areas, there are an estimated 2,196 housing units receiving water from permitted public water systems in WRIA 4 (see Table 6, below). As a point of comparison (based on DOH SENTRY downloaded in July 2019) the total residential connections listed in DOH's water system data for the 39 systems in WRIA 4 is 2,145 (see Table 5).

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[6] https://fortress.wa.gov/doh/odwsentry/portal/odw/si/Intro.aspx

[7] Group B systems with six or fewer connections are (generally speaking) often supplied by permit-exempt wells—whereas larger Group B systems with more than six connections more often have a water right permit. Thus, identifying the service area boundaries for larger Group B systems was a relative priority. However, if a corresponding water right place of use was identified, Group B system boundaries were added to the service area boundary dataset regardless of the number of connections.

Table 6. Estimated Housing Units Inside and Outside Public Water System Service Areas in WRIA 4

Subbasin	Estimated Housing Units in PWS Service Areas	Estimated Housing Units Not in PWS Service Areas (exempt wells)	Subbasin	Estimated Housing Units in PWS Service Areas	Estimated Housing Units Not in PWS Service Areas (exempt wells)
Aldon Cr.	0	1	Illabot Cr.	0	6
All Cr.	0	0	Irene Cr.	0	0
Bacon Cr.	0	3	Jackman Cr.	0	8
Barr Cr.	0	3	Jordan Cr.	0	0
Big Cr.	0	0	Mill Cr.	0	0
Boulder Cr.	7	0	Miller Cr.	0	0
Boyd Cr.	0	0	O'Brian Cr.	0	0
Clark Cr.	0	2	Olson Cr.	10	8
Corkindale Cr.	2	7	Ossterman Cr.	0	1
Diobsud Cr.	0	18	Prairie Cr.	0	21
Everett Cr.	0	43	Pressentin Cr.	39	0
Finney Cr.	0	7	Rinker Cr.	0	0
Flume Cr.	0	0	Rocky Cr.	0	0
Grandy Cr.	226*	77	Savage Cr.	0	0
Gravel Cr.	0	13	Sutter Cr.	0	2
Hilt Cr.	0	10	Tenas Cr.	0	0
Hobbit Cr.	0	1	White Cr.	0	0
			Subtotal for Study Area Subbasins	**284**	**231**
			WRIA 4 (all other areas)	1,912	1,243
			Grand Total	**2,196**	**1,474**

**Includes Lake Tyee RV Park*

Comparison to 2015 Demand Memo

The 2015 Demand Memo does not explicitly tally an estimate of self-supplied, permit-exempt well housing units in WRIA 4 (or by subbasin), so no side-by-side comparison is available. However, the 2015 Demand Memo's approach to estimating permit-exempt wells was "non-spatial" (e.g., not parcel-specific). The 2015 Demand Memo instead derived what was referred to as a "well rate[8]" (perhaps only for the Nookachamps subbasin (which is entirely within WRIA 3)—it is unclear), which was a broadly-defined estimate of the percentage of housing units served by exempt wells .

The approach used in the 2015 Demand Memo would be problematic for the purposes of this Study, since it is not a realistic assumption that the "well rate" would be the same across all Study Area subbasins. In fact, the results in Table 6 above make it clear that certain WRIA 4 subbasins have vastly different conditions with respect to populations served by water systems versus wells (see: Pressentin Creek vs. Prairie Creek). By making water supply estimates at the parcel level, as this 2019 Study does, more refined estimates of existing permit-exempt well impacts and future forecasts by subbasins were possible.

3.2 Forecasted WRIA 4 Study Area Rural Growth and Permit-Exempt Well Demand

A subbasin-by-subbasin forecast of potential new permit-exempt wells in WRIA 4 up to the planning horizon of 2038 was estimated from two key factors:

1. An estimated rate (or range of rates) of population/housing unit growth over the planning horizon
2. An accounting of "buildout" potential (buildable lands)—establishing where (or if) a supply of appropriately-zoned, vacant or subdividable lots exist to support future residential development and (in areas outside existing public water systems boundaries) future exempt wells.

Unlike most county-wide planning estimates for population growth, which might forecast growth over an entire rural area, subbasin-level forecasts (appropriate for planning water-for-water/in-place mitigation) require starting from parcel-scale baseline estimates, as discussed in the previous section.

3.2.1 Population/Housing Unit Growth Rate

Three approaches of establishing a population/housing unit growth rate were considered or reviewed for this Study:

1. A derived growth rate from OFM small area estimates between 2010 and 2019—extrapolated forward
2. OFM low-, medium-, and high-growth population projections for Skagit County between 2019 and 2038

[8] First, the total number of wells was established by subtracting the estimated total number of water system connections in the Nookachamps subbasin (4,814) from the total estimated housing units in the Nookachamps subbasin (4,980). The resultant number of wells (166, per these numbers) was divided by the total number of housing units to establish a "well rate". However, the quoted well rate of 11.20% seems inconsistent with these numbers: $\frac{(4{,}980-4{,}814)}{4{,}980}$ = 3.3% (not 11.2%). It is unclear whether (or if) this impacted Ecosystem Economics' final WRIA 4 estimates.

3. Pre-established growth rate estimates from other studies

A discussion of each of these three approaches/data sources follows.

Derived Growth Rate from OFM (2010 to 2019 Estimates)

One primary recommendation for estimating future exempt well demand in Ecology's *ESSB 6091 - Recommendations for Water Use Estimates* (Ecology, 2018) is to use basin-specific, year-over-year growth numbers from OFM SAEP to extrapolate forward (based on the previous 10 years of data).

OFM's SAEP estimate for WRIA 4[9] puts the ten-year *population* change (2010 to 2019) at 8.3 percent **and the ten-year change in total housing units at 1.17 percent** (see Table 7). Extrapolated 20 years forward to 2038, this would imply 17.3 percent increase in population and a 2.3 percent increase in total housing units.

The discrepancy between the population growth rate and the housing unit growth rate in this estimate is notable. It implies that a permit-exempt well demand forecast that is predicated exclusively on population growth is likely conservative—as an increase in new dwellings and, by extension, wells will likely lag behind overall population increases. More specifically, some of the estimated new population will move into existing vacant properties/wells and some of the new population will be children born in existing households (for example).

Table 7. OFM Population Forecast for WRIA 4 2010-2019

	Total Population	Total Housing Units	Occupied Housing Units
2010	6,705	3,946	2,829
2011	6,716	3,953	2,829
2012	6,735	3,955	2,835
2013	6,743	3,963	2,837
2014	6,781	3,975	2,844
2015	6,843	3,958	2,828
2016	6,919	3,953	2,817
2017	7,077	3,962	2,839
2018	7,149	3,974	2,846
2019	7,263	3,992	2,860
10 Year Numeric Change	558	46	31
10 Year Percent Change	8.3%	1.2%	1.1%

[9] Updated 9/11/2019. https://www.ofm.wa.gov/washington-data-research/population-demographics/population-estimates/small-area-estimates-program

Though less specific to WRIA 4, another approach to using OFM projections in the context of future permit-exempt well demand would be to use OFM's more *official* "April 1st" population estimates[10] to establish a trend. In these estimates, OFM has "2010 Base Census Estimate of Total Housing Units" in *Unincorporated* Skagit County at 22,798 and "2019 Postcensal Estimate of Total Housing Units" in Unincorporated Skagit County at 23,532—a 3.2 percent increase over 10 years. Extrapolated forward to 2038, this would suggest a 6.5 percent increase in housing units for a 20-year planning horizon.

An important additional consideration/analytical limitation is whether the (modest) growth in WRIA 4 from 2010-2019 is necessarily predictive of future growth. The 2013 invalidation of the 2006 Skagit rule amendments and associated reservations clearly restricted growth based on use of rural permit-exempt wells in WRIA 4. It could be argued that development restrictions related to water supply have had a limiting effect on rural growth over the past 10 years. Future mitigation packages approved by Ecology may change this.

Growth Rate from OFM's Growth Management Act Projections for Skagit County

In collaboration with county agencies, OFM publishes county-specific, year-over-year population growth estimates[11] in support of the Growth Management Act (GMA). These estimates, which were last updated and published in 2017, forecast population growth out to 2050. OFM's GMA estimates are provided in low-, medium-, and high-growth scenarios. For Skagit County[12], OFM estimates the following population change percentages between 2019 and 2038:

- Low-growth scenario: 13 percent
- Medium-growth scenario: 25 percent
- High-growth scenario: 44 percent

It should be noted that these projections are for population change (not housing units) and for all of Skagit County, which is unlikely to be proportional to/representative of growth in the rural areas of WRIA 4[13]. Nonetheless, they are useful as possible conservative rate estimates (from an exempt well forecast standpoint).

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[10] https://www.ofm.wa.gov/washington-data-research/population-demographics/population-estimates/april-1-official-population-estimates

[11] https://www.ofm.wa.gov/washington-data-research/population-demographics/population-forecasts-and-projections/growth-management-act-county-projections

[12] Skagit County projections are used here in favor of Snohomish County since less than 10 percent of the estimated housing units in Study Area subbasins fall within Snohomish County (44 of 515).

[13] As discussed in the subsequent section, BERK Consulting's 2016 "Skagit County Growth Projections" memo forecasted an 18.6 percent 20-year increase in rural (non-urban growth area) population in Skagit County, compared to a 35.2 percent increase in urban growth areas.

Growth Rates Used in Other Studies

The 2015 Demand Memo does not explicitly present a total estimate number of new housing units over a 20-year planning horizon in WRIA 4. However, Table 2 in the 2015 Demand Memo references low, medium, and high population growth percentages (based on OFM's 2012 GMA projections). These values were 17 percent, 26 percent, and 42 percent, respectively. It is implied that these growth rates form the basis of the 2015 Demand Memo's final demand projections, but the results seem to incorporate a number of other variable rates as well (e.g. "well rate", "present demand percentage", etc.), making it difficult to validate and/or compare to this 2019 Study.

Another relevant growth rate projection comes from BERK Consulting's Memo *"Skagit County Growth Projections"* (published in 2014 and updated in 2016; BERK, 2016). Prepared in conjunction with Skagit County's Growth Management Act Technical Advisory Committee, this memo (among other things) allocates forecasted growth over a 20-year planning horizon (2015-2036) between urban and rural areas of Skagit County. Exhibit 3 of *"Skagit County Growth Projections"* forecasts the 20-year population growth in *rural* Skagit County at an 18.6 percent increase (from 38,515 in 2015 to 45,665 in 2036)[14].

Consideration for Variable Growth in Subbasins

It is unrealistic to assume that growth will be consistent across all the various subbasins in WRIA 4 (as was also pointed out in the 2015 Demand Memo). This is made apparent in looking back at housing unit changes over time in OFM's SAEP census block group GIS data. As shown in Figure 4 (attached), the total estimated 20-year change in housing units between 2000 and 2019 varies from +7.8 percent to +70.2 percent, with a median of about 20 percent[15].

Selecting Growth Rates for the Study

The potential growth rates calculated or cited above span a very wide range, from 2.3 percent (from OFM SAEP 2010-2019 change in total housing units in WRIA 4) to 44 percent (OFM's GMA population projection for high growth in all of Skagit County, 2019 to 2038).

For the purposes of estimating potential permit-exempt well growth in this Study (and in the interest of being conservative), the following growth rates are used:

- Low-growth scenario: **10 percent** (a compromise between 6.5 percent derived from OFM GMA housing unit estimates for rural Skagit County and the 13 percent overall OFM/GMA low-growth population scenario for Skagit County, rounded to reflect uncertainty)

[14] As a comparison, this memo estimates the 20-year change in population (2015 to 2036) in the urban growth areas of Skagit County to be 35.2 percent (from 81,186 in 2015 to 109,787 in 2036).

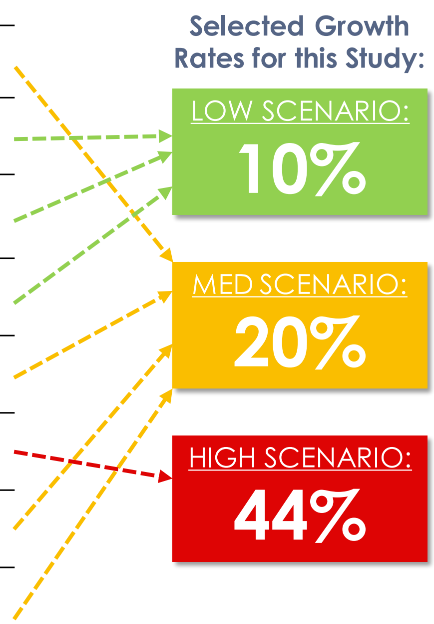
[15] This chart also supports the notion that the stagnant growth of the past decade may not be indicative or predictive of the overall growth trend. Growth in WRIA 4 was much greater in the years between 2000 and 2009 than it was between 2010 and 2019.

- Medium-growth scenario: **20 percent** (based on the BERK Consulting and GMA Technical Subcommittee estimate for rural population growth over a 20-year horizon, rounded to reflect uncertainty)[16].

- High-growth scenario: **44 percent** (a notably conservative estimate for planning purposes, based on OFM's high growth GMA population projections through 2038 for all of Skagit County)

Figure 6. Summary of Growth Rate Projections from Various Sources and Methods

Projection Source/Method	20-year Rate
OFM **Small Area Estimates for WRIA 4 Population** (2010 to 2019) Extrapolated Forward to 2038	17.3%
OFM **Small Area Estimates for WRIA 4 Housing Units** (2010 to 2019) Extrapolated Forward to 2038	2.3%
OFM **April 1st Estimates for Housing Units in Unincorporated Skagit County** (2010 to 2019) Extrapolated Forward to 2038	6.5%
OFM/Skagit Co. **GMA 2038 County-wide Population Forecast, Low Growth Scenario**	13%
OFM/Skagit Co. **GMA 2038 County-wide Population Forecast, Medium Growth Scenario**	25%
OFM/Skagit Co. **GMA 2038 County-wide Population Forecast, High Growth Scenario**	44%
BERK Consulting *Skagit County Growth Projections* **Rural Areas (non-UGA) Population, 2015 to 2036**	19%
OFM **Census Block Group Data** (blocks in WRIA 4), **Change in Housing Units from 2000 to 2019**	26%



3.2.2 Buildout Analysis

Like the notion that past growth at the subbasin-scale may not necessarily be a good predictor of future growth, the **buildability** of the parcels in each subbasin is a critical possible constraint to future growth. Conversely, subbasins that are relatively "buildable" may see disproportionately higher growth as a result. As such, a high-level "buildout analysis" was conducted in this study.

In the context presented here, a buildout assessment is a parcel-scale quantification of possible future residential development based on zoning-based restrictions (e.g. minimum lot size), existing development on a given parcel, current parcel ownership (e.g. federal),

[16] This number is also supported by looking at the median housing unit change rate in the 20-year interval from 2000-2019 across OFM's SAEP census block group estimates (below).

conservation easements, etc. It is meant to quantify how many residences *could* reasonably be added to a given lot/subbasin. it is not, by itself a prediction—nor should it be used as such. **In this Study, buildout potential was used as an upper bound on the 20-year development projection in each basin**[17].

To streamline this analysis: only parcels/zones that were associated with Study Area Subbasins were considered. **Buildout outside of the Study Area Subbasins is not calculated.**

Buildout Methodology (Zoning)

The primary consideration in the buildout analysis is zoning. WRIA 4 parcels were overlaid with GIS-based zoning boundaries from Skagit and Snohomish Counties. Like subbasins and public water systems, a parcel was "assigned" a single, given zone based on the location of the parcel's geographic center. In this way, parcels are assumed to fall only within a single zone.

Additionally, the land use and development codes of Skagit County (Skagit County Code Chapter 14.16) and Snohomish County (Snohomish County Unified Development Code, Title 30) were reviewed to establish a minimum allowable lot size (MLS) for each given zone in WRIA 4. It was also considered whether residential development is or is not allowable in a given zone.

Next, each parcel's current acreage was compared to the given MLS of its zone. If a parcel was subdividable based on this comparison (e.g. a 40-acre existing parcel in a zone that allows for 10-acre parcels could be subdivided into four future parcels), the number of possible future possible parcels was recorded. The buildout potential is, then, the number of developed residential parcels it *could be,* less one if it already contains a residence. For example:

- A 12-acre parcel *with an existing residence* in a zone that allows for an MLS of five acres would have a buildout potential of one additional residence. The 12-acre lot could be turned into a maximum of two. Since one residence already exists, the number of possible new residences is one.
- A 3-acre parcel in a zone that allows for 2.5 acre lots with residences—but that does not already have a residence on it would have a buildout potential of one.
- A 40-acre parcel in a zone that does not allow for residences would have a buildout potential of zero.

Figure 5 (attached) provides a map of the zoning designations in WRIA 4 (in both Skagit and Snohomish Counties).

Buildout Methodology (Land Ownership, Land Use)

Though almost always coincident with zoning codes that effectively disallow residential development (e.g. OSRSI- Public Open Space of Regional/Statewide Importance, NRI-Natural Resource Industrial), certain land ownership scenarios were assumed to

[17] It should be noted, however: we find it is an uncommon scenario in WRIA 4 that a subbasin's predicted 20-year growth outpaces buildout.

functionally eliminate (or make unlikely enough to practically eliminate) buildout potential. These included: US Federal Government, WDNR, WDFW, and others.

Additionally, right-of-way parcels and water area parcels were not considered for buildout.

Buildout Methodology (Conservation Easements)

If a parcel was listed in Skagit County Database Consortium (SCDC) conserved parcels dataset, it was considered to have no buildout potential.

Buildout Results by Subbasin

The buildout potential of each subbasin, as calculated in this analysis, can be found in Table 8 (attached). These numbers are displayed alongside the forecasted housing unit growth in each subbasin and used as an upper bound on the housing unit forecast for 2038 (where the buildout potential is less than the forecast for new units).

Buildout Limitations

A few important elements of a detailed buildout analysis were intentionally omitted in this analysis. A more detailed buildout assessment would consider additional development restrictions or impediments such as flood hazards, steep slopes, setbacks, proximity to roads, location of utilities, etc. **Additionally, this buildout assessment did not factor in the Skagit County Conservation and Reserve Developments (CaRD) program, nor did it consider the possibility of additional dwelling units.**

However, the projected growth rates in each subbasin (even in conservative, high-growth scenarios) are generally well below the buildout potential in each basin, which limits the usefulness of a more detailed buildout assessment.

3.3 Total and Consumptive Use Estimate

As documented previously in this report, Aspect's independent, parcel-scale analysis of current demand and projected growth in these WRIA 4 Subbasins generally corroborates and supports the demand projections findings in the 2015 Demand Memo. Aspect also reviewed the approach used in that document to assess consumptive use as discussed in this section.

In addition, Aspect reviewed and considered the results of a voluntary metering study of permit-exempt well use prepared by Golder Associates (2014), since it represents actual recorded rural permit-exempt well use for 18 properties within the Skagit watershed. This 2014 study was conducted in the Carpenter-Fisher and Upper Nookachamps subbasins within WRIA 3 during 2012 and 2013. While the data were not obtained directly from WRIA 4, we consider the results of this study to be a suitable for extrapolation to WRIA 4, and potentially more conservative in regard to outdoor use, given that an aerial photo review suggests that lawn sizes generally appear to be larger in WRIA 3 than in WRIA 4.

Aspect also reviewed small water system use based on a summary of DOH records provided by RH2 Engineering. RH2 is currently conducting a study of current water use under existing consumptive water rights within WRIA 4.

3.3.1 Indoor Use Estimates

The 2015 Demand Memo assumed 150 gallons per day (gpd) for total indoor use. For comparison, this value is consistent with that assumed for the Dungeness Water Exchange in WRIA 18 and is also in the range for total indoor use of 131 gpd estimated in the WRIA 3 metering study (Golder, 2014).

In addition to these studies, Aspect considered Ecology's recently issued *Recommendations for Water Use Estimates for ESSB 6091* (Ecology, 2018), which recommended 60 gpd per capita. We then reviewed U.S. Census Data on the average number of people per household in Skagit County, estimated to be 2.53, resulting in an estimated total indoor use per household of 152 gpd (0.17 acre-feet/year [afy]), which is comparable with previous estimates. Of the 152 gpd total indoor use per household, we considered 10 percent to be consumptive, which is consistent with both the 2015 report and the 2018 Ecology recommendations for estimating water use. This results in an estimated consumptive indoor use of 15 gpd (0.017 afy) per household.

3.3.2 Outdoor Use Estimates

Outdoor use estimates in the 2015 Demand Memo focused on set assumptions of lawn-size mitigation packages combined with application of Washington Irrigation Guide (WIG) demand estimates, rather than estimates of actual irrigated acreage associated with exempt well properties. Golder's 2014 WRIA 3 metering study provides a better basis for estimating outdoor use than the 2015 Demand Memo.

Golder's 2014 study (Golder, 2014) indicated that relatively limited outdoor lawn irrigation occurs, although some significant variability was noted. A total averaged annual outdoor daily use of 56 gpd (0.063 afy) was reported; however, this analysis was limited to 10 properties where it was clear that irrigation was occurring from season variations in water use. Thus, the number is biased high for outdoor use as an average considering that 7 other properties did not show evidence of irrigation based on the lack of increased use during the summer months.

If all 17 properties are taken into account (one of the 18 properties was only used seasonally and is excluded), the average total outdoor water use is approximately 33 gpd (0.037 afy). Aspect conducted WIG calculations based on the Sedro-Woolley station (closest to the metering study properties), assuming a 75 percent efficiency for lawn irrigation, to assess the equivalent average acreage associated with the 56 gpd of total outdoor water use. This equates to average lawn size associated with irrigation of approximately 1,300 square feet (0.03 acres).

Aspect's review of average irrigated lawn size in WRIA 4 through aerial photo analysis was limited by availability of dry season aerial coverage and tree cover, but it suggested that outdoor irrigation is generally minimal in WRIA 4. A detailed field survey of lawn irrigation was beyond the scope of this 2019 Study.

Aspect also reviewed water-use records from smaller public water systems in WRIA 4, which also supported the conclusion that very little outdoor irrigation is associated with permit-exempt well use in the watershed. For example, the Skagit County PUD – Rockport water system reported 0.18 afy of total use per connection for the period 2012-

2017, and the Sauk Mountain Estates water system reported 0.20 afy of total use per connection for the years 2015 and 2018 (2016 data were unavailable, and 2017 data were almost double that of the other years, suggesting unusually high use possibly associated with a maintenance issue during that year). When the estimated total indoor use of 0.17 afy assumed for this study is compared to these values, 0.01 to 0.03 afy remain for potential irrigation use, both of which are less than the 0.04 afy for total outdoor irrigation estimated from the Golder study.

With consideration to the 2014 Golder study and the review of water system data, we are assuming an average irrigated lawn size of 1,300 square feet (0.03 acres) per household and applied WIG demand estimates for pasture/turf at the Concrete station. This resulted in an estimated average total irrigation demand of 33 gpd (0.037 afy) per household in the WRIA 4 Study Area. Assuming a 75 percent efficiency for lawn irrigation and 10 percent evaporation, this results in an estimated consumptive irrigation demand of 27 gpd (0.030 afy) per household.[18]

3.3.3 Estimated Total Water Use Per Household

Considering the above analysis, the estimated total household water use in the WRIA 4 Study Area is 185 gpd (0.21 afy), with 42 gpd (0.047 afy) as consumptive use. This is based on a total indoor use estimate of 152 gpd (0.17 afy), with 15 gpd (0.017 afy) as consumptive indoor use, and on a total outdoor use estimate of 33 gpd[19] (0.037 afy) with 27 gpd (0.030 afy) as consumptive outdoor use (Table 9). This is generally consistent with the estimates developed in the WRIA 3 metering study by Golder (2014) and are likely conservative planning estimate for WRIA 4, given that lawn sizes are expected to be smaller than in WRIA 3.

Table 9. Summary of Estimated Total Use per Household

	Total Use (gpd)	Consumptive Use (gpd)	Total Use (afy)	Consumptive Use (afy)
Indoor Use	152	15	0.17	0.017
Outdoor Use	33	27	0.037	0.030
Indoor + Outdoor Use	185	42	0.21	0.047

[18] The use of efficiency and evaporation estimates is based on Ecology Water Resources Program Guidance GUID-1210. https://fortress.wa.gov/ecy/wrdocs/WaterRights/wrwebpdf/guid1210.pdf

[19] Irrigation is seasonal and this number represents an estimate applied to an annualized basis.

4 Review and Update of Low-Flow Statistics

Aspect reviewed and reassessed previous low-flow statistical analysis conducted in support of the 2006 Skagit Rule amendments (Ecology, 2006). The review of flows in WRIAs 3 and 4 were completed to assist in determining appropriate reservation sizes in tributary basins and on the mainstem of the Skagit River. The reservations were intended to be a fixed quantity of surface and groundwater set aside for future water uses, such that no negative impacts would occur on the fisheries population sustained by the Skagit River and its tributaries. While the amendment was overturned in 2013 by the Swinomish decision (Swinomish, 2013), the low flow analyses, including 7Q10 evaluations performed to determine reservation quantities remain relevant for assessing water availability determinations. The purpose of this summary is to review the original low flow calculation methodology specific to the WRIA 4 Study Area evaluation in this Study and provide updated estimates consistent with the previous methodology where possible.

4.1 Review of Ecology's 2006 Low-Flow Analysis

Among the Lower and Upper Skagit subbasins (WRIA 3 and 4, respectively), a reservation of 25 cubic feet per second (cfs) was to be set aside and divided between irrigation, stock watering and domestic, municipal, and commercial uses. WRIA 3 was further divided into subbasins based generally on individual tributaries to the Skagit River. Individual low flows were calculated for each tributary where a small percentage of each was debited to the total reservation quantity. Unlike WRIA 3, water use in WRIA 4 is generally limited to areas along the mainstem of the Skagit and Sauk rivers; much of the Upper Skagit subbasin is in public ownership and is unlikely to experience significant demand for residential and business water uses. Except for the Grandy Creek subbasin, the entirety of WRIA 4 was treated as a single large subbasin in this Study due to the land use patterns and unlikely future demand for residential and business water use.

Low flow calculations were conducted in two ways. For tributaries treated as individual subbasins as in WRIA 3 and Grandy Creek, a 7-day, 10-year (7Q10) annual low flow analysis was conducted. The 7Q10 statistic is based upon the lowest consecutive seven-day streamflow to occur an average of every 10 years. 7Q10 values are thought to be representative of a significant dry spell period that develops slowly over time and could result in profound economic and environmental impacts. The 7Q10 statistic is also thought to be generally comparable to a 90 percent exceedance flow during a low-flow month. Since the remainder of WRIA 4 was treated as a single large subbasin that drains the Upper Skagit River, a low flow value was calculated for the mainstem of the Upper Skagit River by conducting exceedance probability analysis.

Few streams within the Upper and Lower Skagit subbasins have available long-term stream gauging records. For this reason, 7Q10 estimations were calculated for a limited number of gauged creeks within the Lower and Upper Skagit Basins and extrapolated to other ungauged subbasins lacking long-term flow records.

Within WRIA 3, 7Q10 estimates were made for Alder Creek, Day Creek, Pilchuck Creek, East Fork Nookachamps Creek, and Wiseman Creek (all in WRIA 3) then scaled to create synthetic estimations for the other subbasins. Scaling was determined by basin drainage area, annual precipitation, and subsurface geology.

Within WRIA 4, Grandy Creek was the only Upper Skagit tributary to be treated as an individual tributary subbasin and thus receive a 7Q10 estimate.[20] A synthetic 7Q10 estimate of 11.4 cfs was determined for Grandy Creek, of which a small percentage was to be withheld for the reserve. Ecology considered 2 percent of the 7Q10 flows as a potential indicator of the upper limit on reservation size when determining the reservation quantities. Ecology considered that to be a very small impact on the long-term sustainability of the fish population while also providing for out-of-stream water uses (Ecology, 2006).

Exceedance probability calculations are commonly used to benchmark low flow frequencies on streams with long-term gauging records. The exceedance probability refers to the likelihood of a stream exceeding a given flow over a specified time interval. For example, a 90 percent exceedance probability refers to a flow that is likely to be exceeded 90 percent of the time, typically corresponding to low flows as 90 percent of the days on record exceed that flow. Conversely, a 10 percent exceedance probability corresponds to a high flow that is only exceeded 10 percent of the time. The probability is calculated as follows:

$$P = 100 * (\frac{m}{n+1})$$

where *P* is the exceedance probability, *m* is the numerical ranking of daily mean discharge from highest to lowest during the specified time interval, and *n* is the total number days in the period.

For the Upper Skagit subbasin, the exceedance probability was calculated with flow data from the Skagit River at Marblemount (USGS Gauge 12181000). The gauge has been monitored continually from 1943 to present with a 25-year gap in data collection between October 1951 and May 1976. With available data up to 2006, the 90 percent exceedance flow was calculated as 3,879 cfs for the Upper Skagit subbasin.

4.2 Updated WRIA 4 Study Area Low-Flow Analysis

As part of this investigation, low flow estimates for both Grandy Creek and the Upper Skagit subbasins were revised using new data, described below in Table 10. In the 2006 Skagit Rule Amendment, Alder Creek was used as a basis for creating a synthetic 7Q10 estimation for the Grandy Creek due to its proximity and similar geological conditions. Alder Creek is still ungauged, so the 2006 7Q10 statistic calculated with data from up to 1971 remains the best available low flow estimate. However, new precipitation data

[20] Based on its proximity to Alder Creek and similar geological characteristics between the two, the 7Q10 value for Alder Creek was used as a basis for the Grandy Creek low flow value. Alder Creek was gauged from September 1943 – September 1971. Using these flow data, a 7Q10 flow of 6.3 cfs or 0.59 cfs/square mile (CSM) was calculated. This value was divided by the annual precipitation for the Alder Creek subbasin (58 inches) to yield a value of 0.0102 CSM/inch, which was then scaled to Grandy Creek by multiplying by the drainage area (17.5 square miles) and annual precipitation (64 inches).

available from Oregon State University's PRISM High-Resolution Spatial Climate Dataset was used to re-scale the Alder Creek 7Q10 statistic to Grandy Creek. A 30-year normal annual precipitation value (1981-2010) that is geographically specific to the Grandy Creek subbasin was used for scaling as it was thought to be most representative of modern, long-term, average precipitation conditions. . Based on applying an annual precipitation value of 75.45 inches for 2018, the Grandy Creek low flow estimate increased from 11.4 to 13.5 cfs. Low flows on the mainstem of the Upper Skagit were also recalculated with data including flow values from 2006-2019 at the Marblemount gage (see Figure 1 for location). Based on updated data, the revised low flow estimate on the mainstem of the Upper Skagit decreased from 3,879 to 3,240 cfs.

Table 10. 2006 and 2019 Low Flow Estimates

WRIA 4 Delineation	2006	2019
Grandy Creek Subbasin	11.4 cfs	13.5 cfs
Upper Skagit Subbasin	3,879 cfs	3,240 cfs

It is notable that the updated 7Q10 analysis extrapolation for the Grandy Creek subbasin increased by approximately 18.4 percent, while the 90 percent exceedance probability for the Upper Skagit subbasin decreased by approximately 16.5 percent. Possible reasons for this may be related to the different methodologies used (PRISM data for the Grandy Creek subbasin, versus actual Marblemount gage data for the Upper Skagit subbasin) and associated data variability. There also may be differences over recent years in dam operations upstream of the Marblemount gage that may have impacted flows on the mainstem.

5 Notable Sources of Uncertainty and Conservatism in Estimates

Different components of the estimates in this study incorporate varying degrees of uncertainty. Where possible, this Study has conservatively estimated future consumptive use demand from permit-exempt wells. These considerations have been noted in prior sections of this report—but key sources of uncertainty and the effect on the overall estimates are summarized below.

- **Occupied housing units vs. total housing units:** OFM data indicate (Table 2) that there is a notable difference in the number of total housing units in WRIA 4 (3,992) vs. the number of housing units that are occupied full-time (2,860). The upper number is more in line with the parcel-based estimate of current housing units developed for this Study (3,670). For the purposes of estimating current and future water use, all residences/housing units/dwellings have been assumed to be occupied full-time. However, this is almost certainly not the case. Adjusting for estimated occupied residences would reduce the overall demand estimate.
- **Housing unit growth vs. population growth**: Many of the data sources and references used in this Study (and prior studies/guidance documents) to establish a 20-year growth rate are population-based, not housing unit-based. For example, the high growth scenario rate (+44 percent) selected in this Study is based on the 2038 GMA population estimates for Skagit County. However, it is unlikely that housing units/new exempt wells will grow at an equal rate as the overall population. This discrepancy can be seen in comparing OFM's 2010 to 2019 WRIA 4 estimates for total population to total housing units. OFM data suggest that the 10-year change in population was 8.3 percent, where the 10-year change in housing units was only 1.2 percent (Table 7). This suggests that a population-based rate/forecast likely overestimates future demand in terms of new wells.
- **County-wide growth vs. rural growth**: The high growth scenario rate (44 percent) is based on a Skagit County-wide estimate (inclusive of urban areas). However, a high rate of growth in Skagit County is likely to be driven by urban growth—with rural growth making up a smaller portion/percent. Again, this suggests that a 44 percent increase is likely to be a conservative (over-) estimate for rural growth.
- **Not all domestic water right permits accounted for**: The public water system service area boundaries used to identify parcels that are supplied by permitted sources (chiefly, Group A and larger Group B water systems) is not necessarily inclusive of every domestic water right permit in WRIA 4. It is reasonable to assume that some number (though perhaps a small number) of parcels outside these service area boundaries have domestic water supplies tied to water rights. Thus, the estimate of current (and by extension) and future parcels served by permit-exempt wells in WRIA 4 could be a slight overestimate.

- **Outdoor Water Use:** The review of average irrigated lawn size in WRIA 4 through aerial photo analysis was limited by availability of dry season aerial coverage and tree cover, but it suggested that outdoor irrigation is generally minimal in WRIA 4. A detailed field survey of lawn irrigation was beyond the scope of this 2019 Study. Estimates of lawn irrigation were primarily derived from data associated with the results of a voluntary metering study of permit-exempt well use in portions of WRIA 3 (Golder Associates, 2014), since it represents actual recorded rural permit-exempt well use for 18 properties within the Skagit watershed. We consider the results of this Study to be suitable for extrapolation to WRIA 4, and potentially more conservative in regard to outdoor use, given that an aerial photo review suggests that lawn sizes generally appear to be larger in WRIA 3 than in WRIA 4.
- **Low Flow Analysis:** The updated 7Q10 analysis extrapolation for the Grandy Creek subbasin increased by approximately 18.4 percent, while the 90 percent exceedance probability for the Upper Skagit subbasin (as measured at the Marblemount gage) decreased by approximately 16.5 percent. Possible reasons for the differing trends may be related to the methodologies used (PRISM data for the Grandy Creek subbasin, versus actual Marblemount gage data for the Upper Skagit subbasin) and associated data variability. There also may be differences over recent years in dam operations upstream of the Marblemount gage that may have impacted flows on the mainstem.

6 Conclusions of WRIA 4 Study Area Permit-Exempt Well Demand Forecast

Aspect's population forecast/buildout assessment suggests that the following subbasins (among the 34 in the Study Area) will experience the most (albeit *modest* and likely single-digit) future demand for permit-exempt wells through 2038: **Grandy Creek, Everett Creek, Prairie Creek, Diobsud Creek, and Gravel Creek.** Most of the forecasted future demand is located near the confluence of tributaries with the Skagit and Sauk rivers, and many of the more remote subbasins are predicted to have no future demand for permit-exempt wells. In total, Aspect estimates a future demand of 20 to 80 total permit-exempt wells across the 34 subbasins[21], depending on the growth scenario.

This Study estimated total household water use to be 185 gpd (0.21 afy), with 42 gpd (0.047 afy) as consumptive use. This is based on a total indoor use estimate of 152 gpd (0.17 afy), with 15 gpd (0.017 afy) as consumptive indoor use, and on a total outdoor use estimate of 33 gpd (0.037 afy) with 27 gpd (0.030 afy) as consumptive outdoor use. These estimates are generally consistent with prior assessments in the Study Area and are likely a conservative planning estimate for WRIA 4.

Table 8 and Table 11 and Figure 7 (all attached) presents a summary of the permit-exempt well demand forecast and corresponding water use estimates for the WRIA 4 Study Area. The summary is presented by subbasin and includes total use estimates and consumptive use estimates. The number of estimated permit-exempt wells (derived from reviewing other area studies and the buildout analysis in this report) are presented for the low, medium, and high growth scenarios. These are then combined with the estimated total and consumptive use numbers per household to yield estimates by subbasin (and in total for the subbasins combined).

The estimated total water demand for the WRIA 4 Study Area subbasins combined ranges from 4.2 afy (0.0058 cfs) for the low growth scenario to 17 afy (0.023 cfs) for the high growth scenario, with associated estimated consumptive use ranging from 1.0 afy (0.0014 cfs) to 4.0 afy (0.0055 cfs). The total additional consumptive use estimated in the study area combined subbasins for the high-growth scenario correlates to less than 0.0002 percent of the 90 percent exceedance low flow calculated for the mainstem Skagit River at Marblemount (3,240 cfs) [22].

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[21] This is a consistent result with the 2015 Demand Memo which estimates a range of 17 to 55 *new* exempt well dwellings in tributary (Study Area) subbasins (see Table 1).

22 As Figure 1 illustrates, WRIA 4 subbasins are located both upstream and downstream of the Marblemount gage, and the comparison is for illustrative purposes only and not intended as a direct measure of impacts at the gage).

Subbasins with the highest estimated future demand include Grandy, Everett, Prairie, and Diobsud Creeks. Of these, Grandy Creek has the highest estimated demand, representing a significant portion of the total demand for the combined subbasins, with 1.3 afy (0.0017 cfs) for the low growth scenario to 3.8 afy (0.0052 cfs) for the high growth scenario, with associated estimated consumptive use ranging from 0.30 afy (0.00041 cfs) to 0.90 afy (0.0012 cfs). For comparison purposes, the updated 7Q10 analysis for Grandy Creek indicated a low flow estimate of 13.5 cfs, which is less than 0.01 percent of the estimated high growth scenario future demand from permit-exempt wells in the Grandy Creek subbasin (Table 12).

Table 12. Low Flow Estimates Compared to High Growth Demand Scenario

	Estimated Low Flow	Estimated Future Consumptive Use Demand	Consumptive Use as % of Low Flow
Grandy Creek Subbasin	13.5 cfs	0.0012 cfs	<0.01
WRIA 4 Study Area Subbasins Combined	3,240 cfs	0.0055 cfs	<0.002

References

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Limitations

Work for this project was performed for the Washington State Department of Ecology (Client), and this report 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 report does not represent a legal opinion. No other warranty, expressed or implied, is made.

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TABLES

Table 1. Summary of WRIA 4 Results from Ecosystem Economics 2015 Demand Memo

Upper Skagit Basin Rural Growth Exempt Well Assessment (150304 ASP110)

Subbasin	Current Dwellings[1]	Present Demand[2]	2035 Low-Growth TOTAL Exempt Well/Dwelling Demand[3]	2035 Low-Growth, Low-Water Use TOTAL Consumptive Use Demand (afy)[4]	2035 High-Growth TOTAL Exempt Well/Dwelling Demand[5]	2035 High-Growth, High-Water Use TOTAL Consumptive Use Demand (afy)[4]	FUTURE Exempt Well/Dwelling Demand, Low-growth Scenario (2016 to 2035)[6]	FUTURE Consumptive Use Demand, Low-Growth/Low Water Use Scenario, 2016 to 2035 (afy)[7]	FUTURE Exempt Well/Dwelling Demand, High-growth Scenario, 2016 to 2035 (afy)[8]	FUTURE Consumptive Use Demand, Low-Growth/Low Water Use Scenario (2016 to 2035)[9]
Everett Creek	45	2	9	0.83	21	4.64	7	0.64	19	4.20
Prairie Creek	25	0	4	0.37	10	2.21	4	0.37	10	2.21
Finney Creek	15	0	2	0.18	6	1.32	2	0.18	6	1.33
Diobsud Creek	12	0	1	0.09	5	1.10	1	0.09	5	1.11
Gravel Creek	9	1	2	0.18	4	0.88	1	0.09	3	0.66
Jackman Creek	11	0	1	0.09	4	0.88	1	0.09	4	0.88
Hilt Creek	7	0	1	0.09	2	0.44	1	0.09	2	0.44
Grandy Creek	315	25	25	2.30	25	5.52	***0***	***0.00***	***0***	***0.00***
Corkindale Creek	5	1	1	0.09	3	0.66	0	0.00	2	0.44
Barr Creek	4	1	1	0.09	2	0.44	0	0.00	1	0.22
Illabot Creek	6	0	0	0.00	2	0.44	0	0.00	2	0.44
Sutter Creek	4	0	0	0.00	1	0.22	0	0.00	1	0.22
Aldon Creek	2	0	0	0.00	0	0.00	0	0.00	0	0.00
Bacon Creek	2	0	0	0.00	0	0.00	0	0.00	0	0.00
Boulder Creek	4	0	0	0.00	0	0.00	0	0.00	0	0.00
Hobbit Creek	2	0	0	0.00	0	0.00	0	0.00	0	0.00
Jordan Creek	1	0	0	0.00	0	0.00	0	0.00	0	0.00
Olson Creek	15	0	0	0.00	0	0.00	0	0.00	0	0.00
Ossterman Creek	1	0	0	0.00	0	0.00	0	0.00	0	0.00
Pressentin Creek	41	0	0	0.00	0	0.00	0	0.00	0	0.00
							results for comparison to this study			
Subtotal of Subbasins	***526***	***30***	***47***	***4.31***	***85***	***18.75***	***17***	***1.56***	***55***	***12.16***
"Undivided" (WRIA 4 all other areas)	3039	95	146	13.41	226	49.90	51	4.69	131	28.95
Totals	**3565**	**125**	**193**	**17.73**	**311**	**68.67**	**68**	**6.26**	**186**	**41.11**

NOTES:

1 *From Appendix B, "WRIA 4 Green Zone Snapshot by Subbasin", page 20.* This is the sum of estimated dwellings both inside and outside the "Green Zone".

2 *From Appendix B, "WRIA 4 Green Zone Snapshot by Subbasin", page 20.* This is the total estimated number of exempt wells developed between 2001 and 2013, debited against the *former* reservation (based on building permit data).

3 **Calculated** f*rom results in Appendix B, "WRIA 4 Impact/Demand, By Zone", page 22.* ***Divided consumptive use estimate by the low water use per-dwelling scenario estimate (0.092 afy)*** to calculate number of dwellings.

4 *From Appendix B, "WRIA 4 Impact/Demand, By Zone", page 22.* Per dwelling consuptive water use is estimated as 0.092 afy/dwelling for low-use scenario and 0.221 afy/dwelling for high-use scenario (per Table 8 in EE, 2015)

5 **Calculated** f*rom results in Appendix B, "WRIA 4 Impact/Demand, By Zone", page 22.* ***Divided consumptive use estimate by high water use scenario per-dwelling estimate (0.221 afy)*** to calculate number of dwellings.

6 **Calculated by subtracting "Present Demand"** (thrid column) from 2035 Low-Growth TOTAL Exempt Well/Dwelling Demand (fourth column)

7 **Calculated** by multiplying FUTURE Exempt Well/Dwelling Demand, Low-growth Scenario (2016 to 2035) by the EE, 2015 **low water use scenario per capita estimate (0.092 afy)**

8 **Calculated by subtracting "Present Demand"** (thrid column) from 2035 High-Growth TOTAL Exempt Well/Dwelling Demand (sixth column)

9 **Calculated** by multiplying FUTURE Exempt Well/Dwelling Demand, High-growth Scenario (2016 to 2035) by the EE, 2015 **high water use scenario per capita estimate (0.221 afy)**

afy = acre-feet/year

Table 2. Land Coverage Breakdown for WRIA 4 and Study Area Subbasins

Upper Skagit Basin Rural Growth Exempt Well Assessment (150304 ASP110)

		Subbasin Area - Percent by County			*Subbasin Area - Percent by Parcel/Assessor Land Ownership*						
Subbasin	**Total Acres**	**Skagit**	**Snohomish**	**Whatcom**	**State/Federal** (e.g. WA DNR, WA WDFW, US Parks Department)	**City, County, Utility, or Local Government-Owned**	**No Parcel Ownership Data or Parcel Number** (Implies Government or ROW)	**Right-of-Way (ROW)**	**Water**	**Timber/Designated Forest** (Privately-owned)	**Other**
Aldon Creek	372	100.0%	--	--	--	--	--	--	--	95.5%	4.5%
All Creek	1,782	74.8%	25.2%	--	56.9%	--	6.8%	--	--	27.6%	8.7%
Bacon Creek	32,507	24.3%	--	75.7%	77.6%	1.5%	20.1%	0.1%	0.1%	0.3%	0.3%
Barr Creek	1,788	100.0%	--	--	47.0%	--	50.1%	--	0.7%	--	2.2%
Big Creek	13,773	100.0%	--	--	95.9%	--	3.3%	--	0.8%	--	0.0%
Boulder Creek	5,184	100.0%	--	--	55.7%	21.2%	0.0%	--	3.7%	19.4%	0.1%
Boyd Creek	748	100.0%	--	--	16.7%	--	--	--	--	81.4%	1.9%
Clark Creek	799	100.0%	--	--	--	--	--	--	--	97.9%	2.1%
Corkindale Creek	2,867	100.0%	--	--	57.0%	--	32.7%	--	0.0%	1.0%	9.3%
Diobsud Creek	17,049	82.5%	--	17.5%	93.6%	0.2%	2.7%	--	0.1%	1.8%	1.7%
Everett Creek	2,289	2.8%	97.2%	--	45.9%	3.6%	0.0%	0.0%	--	24.5%	26.1%
Finney Creek	34,359	100.0%	--	--	57.3%	2.2%	4.6%	0.1%	0.0%	35.1%	0.7%
Flume Creek	1,328	100.0%	--	--	95.0%	--	--	--	--	5.0%	--
Grandy Creek	11,415	100.0%	--	--	28.6%	4.2%	0.0%	1.2%	1.3%	58.2%	6.4%
Gravel Creek	1,609	7.5%	92.5%	--	93.6%	2.0%	--	--	--	--	4.4%
Hilt Creek	3,794	100.0%	--	--	24.6%	1.7%	9.5%	0.2%	0.0%	61.2%	2.8%
Hobbit Creek	723	100.0%	--	--	--	6.9%	--	1.1%	--	85.6%	6.4%
Illabot Creek	29,626	100.0%	--	--	84.9%	7.2%	2.5%	0.0%	0.5%	3.1%	1.8%
Irene Creek	4,096	100.0%	--	--	97.8%	--	--	--	0.2%	2.0%	--
Jackman Creek	15,502	100.0%	--	--	50.4%	--	8.5%	0.0%	0.1%	40.1%	0.8%
Jordan Creek	7,894	100.0%	--	--	52.7%	--	0.0%	0.0%	2.6%	44.6%	0.1%
Mill Creek	2,779	100.0%	--	--	51.0%	1.0%	12.6%	--	--	35.4%	--
Miller Creek	1,328	100.0%	--	--	--	--	2.5%	0.8%	--	96.7%	--
O'Brian Creek	953	100.0%	--	--	63.6%	35.6%	--	0.8%	--	--	--
Olson Creek	4,228	100.0%	--	--	67.1%	0.0%	27.8%	0.2%	0.1%	1.1%	3.7%
Ossterman Creek	705	100.0%	--	--	--	--	--	0.2%	0.0%	96.1%	3.7%
Prairie Creek	2,940	77.3%	22.7%	--	27.9%	--	--	0.7%	--	43.6%	27.8%
Pressentin Creek	8,234	100.0%	--	--	66.2%	8.4%	--	0.1%	0.1%	24.7%	0.6%
Rinker Creek	3,222	100.0%	--	--	50.2%	--	20.3%	0.2%	--	29.3%	--
Rocky Creek	6,501	100.0%	--	--	77.5%	--	21.9%	--	0.1%	--	0.5%
Savage Creek	943	100.0%	--	--	--	15.0%	--	--	--	83.5%	1.5%
Sutter Creek	727	100.0%	--	--	90.4%	--	5.7%	--	--	2.7%	1.1%
Tenas Creek	6,702	97.5%	2.5%	--	92.2%	1.1%	4.6%	--	0.9%	--	1.1%
White Creek	5,789	100.0%	--	--	89.2%	--	--	0.0%	0.1%	4.9%	5.9%
WRIA 4 (other areas)	1,332,605	30.0%	26.4%	43.6%	85.6%	1.1%	1.8%	0.3%	1.1%	7.1%	3.0%
TOTAL	**1,567,160**	**38.4%**	**22.8%**	**38.8%**	**83.0%**	**1.3%**	**2.6%**	**0.3%**	**1.0%**	**8.9%**	**2.9%**

Table 5. WRIA 4 Public Water System Services Areas

Upper Skagit Basin Rural Growth Exempt Well Assessment (150304 ASP110)

Water System Name	Water System ID	System Group	System Type	Service Area Boundary Source	Ownership	Residential Connections	Full-time Residential Population	Maximum Total Population	Total System Connections	Total DOH Approved Connections	Number of Active Sources
CASCADIAN HOME FARM	02722	A	TNC	DOH GIS	Investor	2	10	143	4	5	1
CONCRETE UTILITIES	03950	A	Comm	DOH GIS	City/Town	484	732	732	484	577	1
RANDY CREEK GROCERY WATER SYSTEM	07145	A	TNC	DOH GIS	Private	2	5	207	4	4	1
CAPE HORN MAINTENANCE COMPANY	11060	A	Comm	DOH GIS	Private	455	700	940	561	581	3
CASCADE RIVER COMMUNITY CLUB	11494	A	Comm	DOH GIS	Private	105	30	71	452	416	1
SKAGIT CO PUD - CEDARGROVE	11917	A	Comm	DOH GIS	Special District	175	430	430	176	466	1
GLACIER PEAK RESORT AND WINERY	13344	A	TNC	DOH GIS	Investor	7	18	108	99	115	3
SAUK MOUNTAIN ESTATES	17049	A	Comm	DOH GIS	Private	20	45	45	20	24	1
GRANDY CREEK RESORT	28980	A	TNC	DOH GIS	Investor	1	4	224	125	179	1
LAKE TYEE	44970	A	TNC	DOH GIS	Association	2	4	254	884	1	1
ALPINE RV/MH PARK	51537	A	TNC	DOH GIS	Investor	2	4	10	31	31	1
SKAGIT RIVER COLONY	59244	A	TNC	DOH GIS	Private	3	2	11	21	0	1
PRESSENTIN CREEK WILDERNESS	69273	A	Comm	DOH GIS	Association	47	76	81	58	65	1
RIVER LANE COMMUNITY CLUB	72773	A	Comm	DOH GIS	Association	23	34	36	40	40	1
SKAGIT CO PUD ROCKPORT	73600	A	Comm	DOH GIS	Special District	53	140	190	59	106	1
TIMBERLINE TRAVELERS PARK	88398	A	Comm	DOH GIS	Investor	55	50	51	72	75	1
WILDERNESS VILLAGE TRAILER PARK	96875	A	TNC	DOH GIS	Investor	3	10	11	25	0	1
SKAGIT VIEW VILLAGE WATER SYSTEM	96879	A	Comm	DOH GIS	Special District	76	190	197	76	128	1
SKAGIT CO PUD - MARBLEMOUNT	AA642	A	Comm	DOH GIS	Special District	19	40	221	31	106	
MARBLEMOUNT RANGER STATION	NP600	A	TNC	DOH GIS	Federal	9	0	308	17	7	1
ROCKPORT STATE PARK	SP740	A	TNC	DOH GIS	State	1	1	34	6	1	1
DARRINGTON WATER ASSOCIATION	17945	A	Comm	DOH GIS	Association	17	42	42	17	21	2
DARRINGTON TOWN OF	17950	A	Comm	DOH GIS	City/Town	502	1350	2130	543	557	2
UPPER BAKER	05754	A	TNC	DOH GIS	Private	2	2	180	125	0	1
DIABLO WTR SYS-SEATTLE CITY LIGHT	19200	A	Comm	DOH GIS	City/Town	19	28	53	42	65	1
FT CREEK CAMPGROUND WATER SYSTEM	59394	A	TNC	DOH GIS	Federal	0	0	132	1	1	1
HORSESHOE COVE CAMPGROUND	FS377	A	TNC	DOH GIS	Federal	0	0	175	11	0	1
NEWHALEM CAMPGROUND & VISITOR CTR	NP012	A	TNC	DOH GIS	Federal	0	0	793	8	0	1
ORTH CASCADES ENV LEARNING CENTER	NP060	A	TNC	DOH GIS	Federal	7	11	48	15	18	1
COLONIAL CREEK CAMPGROUND	NP120	A	TNC	DOH GIS	Federal	1	0	406	28	28	1
ROSS LAKE RESORT	NP160	A	TNC	DOH GIS	Federal	3	4	119	18	0	1
GOODELL CAMPGROUND	NP310	A	TNC	DOH GIS	Federal	0	0	32	9	8	1
HOZOMEEN WATER SYSTEM	NP370	A	TNC	DOH GIS	Federal	5	0	47	25	103	1
NEWHALEM WATER SYSTEM	59250	A	Comm	Water Right POU (Doc ID=2278870)	City/Town	21	30	277	43	600	1
CREEKSIDE CAMPING	28977	A	Comm	Water Right POU (Doc ID=2279859) + Parcels	Investor	16	30	31	39	NA	1
MARBLEMOUNT COMMUNITY CLUB	03130	B	--	Water Right POU (Doc ID=2268166) + Parcel	Private	0	0	24	1	UND	1
SKAGITWILDE WATER SYSTEM	83360	B	--	Parcels + Water Right ROE Supporting Doc (Doc ID=2279323)	Private	2	4	6	8	UND	1
TOTEM TRAIL MOTEL	88880	B	--	Water Right POU (Doc ID=2248649)	Private	2	2	16	10	UND	1
BAKER RIVER WORK CENTER	FS026	B	--	Water Right POU (Doc ID=2253675) + Parcels	Federal	4	4	20	7	7	1
					TOTAL	***2,145***	***4,032***	***8,835***	***4,195***	***4,335***	

Table 8. Permit-Exempt Well Growth Forecast by WRIA 4 Subbasin

Upper Skagit Basin Rural Growth Exempt Well Assessment (150304 ASP110)

	Current Housing Units			*Buildout Estimate*		*Total Housing Unit Growth Estimates*			*Permit-Exempt Well Estimates*		
Subbasin	**Estimated Housing Units Inside Group A (or Group B w/ Water Right) Public Water Systems**	**Estimated Housing Units Presumed to be Self-Supplied (not in PWS)**	**Estimated Total Housing Units**	**Buildout Residential Parcels in Existing PWS Service Areas (does not imply service capacity)**	**Estimated Additional Buildout Capacity - not in PWS Service Area**	**TOTAL Additional Housing Unit Demand by 2038 (estimate 10% growth)**	**TOTAL Additional Housing Unit Demand by 2038 (estimate 20% growth)**	**TOTAL Additional Housing Unit Demand by 2038 (estimate 44% growth)**	**Exempt Well Demand Forecast (Low)[1]**	**Exempt Well Demand Forecast (Med)[1]**	**Exempt Well Demand Forecast (High)[1]**
GRANDY CREEK	6	76	82	2	18	8	16	36	6	14	18
EVERETT CREEK	—	41	41	—	98	4	8	18	4	8	18
PRAIRIE CREEK	—	21	21	—	17	2	4	9	2	4	9
DIOBSUD CREEK	—	18	18	—	23	2	4	8	2	4	8
GRAVEL CREEK	—	13	13	—	6	1	3	6	1	3	6
CORKINDALE CREEK	2	7	9	—	16	1	2	4	1	2	4
HILT CREEK	—	10	10	—	26	1	2	4	1	2	4
JACKMAN CREEK	—	8	8	—	11	1	2	4	1	2	4
FINNEY CREEK	—	7	7	—	34	1	1	3	1	1	3
ILLABOT CREEK	—	6	6	—	10	1	1	3	1	1	3
BACON CREEK	—	3	3	—	3	—	1	1	—	1	1
CLARK CREEK	—	2	2	—	16	—	—	1	—	—	1
SUTTER CREEK	—	2	2	—	2	—	—	1	—	—	1
PRESSENTIN CREEK	39	—	39	19	8	4	8	17	—	—	—
OLSON CREEK	10	8	18	14	7	2	4	8	—	—	—
BARR CREEK	—	3	3	—	—	—	1	1	—	—	—
BOULDER CREEK	7	—	7	8	2	1	1	3	—	—	—
ALDON CREEK	—	1	1	—	1	—	—	—	—	—	—
ALL CREEK	—	—	—	—	—	—	—	—	—	—	—
BIG CREEK	—	—	—	—	—	—	—	—	—	—	—
BOYD CREEK	—	—	—	—	—	—	—	—	—	—	—
FLUME CREEK	—	—	—	—	—	—	—	—	—	—	—
HOBBIT CREEK	—	1	1	—	1	—	—	—	—	—	—
IRENE CREEK	—	—	—	—	—	—	—	—	—	—	—
JORDAN CREEK	—	—	—	—	1	—	—	—	—	—	—
MILL CREEK	—	—	—	—	1	—	—	—	—	—	—
MILLER CREEK	—	—	—	—	—	—	—	—	—	—	—
OBRIAN CREEK	—	—	—	—	—	—	—	—	—	—	—
OSSTERMAN CREEK	—	1	1	—	8	—	—	—	—	—	—
RINKER CREEK	—	—	—	—	2	—	—	—	—	—	—
ROCKY CREEK	—	—	—	—	3	—	—	—	—	—	—
SAVAGE CREEK	—	—	—	—	—	—	—	—	—	—	—
TENAS CREEK	—	—	—	—	—	—	—	—	—	—	—
WHITE CREEK	—	—	—	—	—	—	—	—	—	—	—
TOTAL	**64**	**228**	**292**	**43**	**314**	**29**	**58**	**127**	**20**	**42**	**80**

Note

[1]Demand forecast assumes that existing public water system capacity will be consumed. Total growth is constrained at the upper end to the estimated additional buildout capacity in a given subbasin.

[2]Excludes Lake Tyee RV Park

Table 11. Consumptive and Total Water Use Estimates

Upper Skagit Basin Rural Growth Exempt Well Assessment (150304 ASP110)

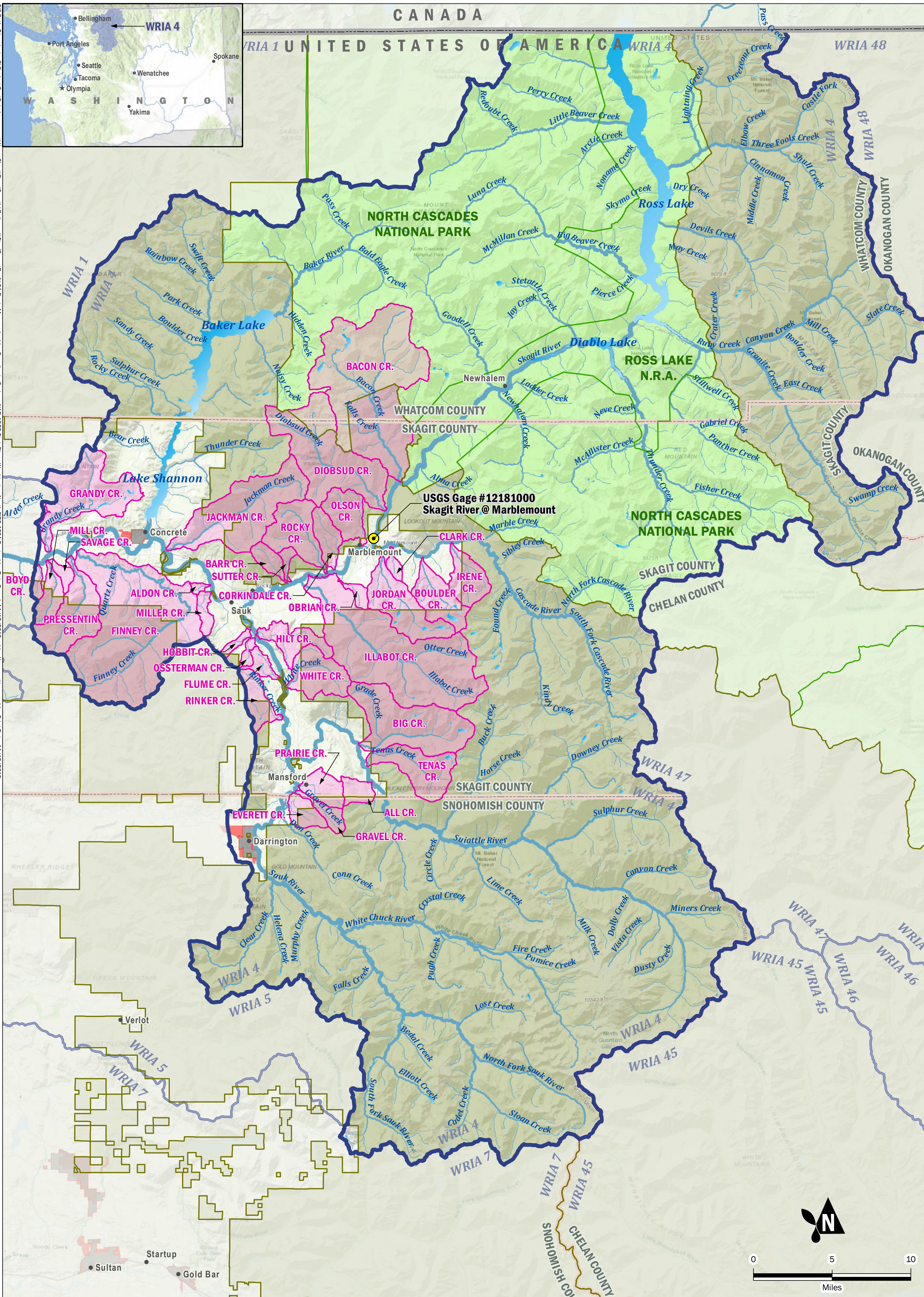
	Exempt Well Estimates				*Total Use Estimate*								*Consumptive Use Estimate*							
Subbasin	**Estimate of Current Exempt Wells**	**Permit-Exempt Well Demand Forecast (Low)[1]**	**Permit-Exempt Well Demand Forecast (Med)[1]**	**Permit-Exempt Well Demand Forecast (High)[1]**	**Total Water Use - Current Exempt Well Estimate**		**Total Water Use - Low Growth Exempt Well Estimate**		**Total Water Use - Medium Growth Exempt Well Estimate**		**Total Water Use - High Growth Exempt Well Estimate**		**Consumptive Water Use - Current Exempt Well Estimate**		**Consumptive Water Use - Low Growth Exempt Well Estimate**		**Consumptive Water Use - Medium Growth Exempt Well Estimate**		**Consumptive Water Use - High Growth Exempt Well Estimate**	
					afy	cfs	afy	cfs	afy	cfs	afy	cfs	afy	cfs	afy	cfs	afy	cfs	afy	cfs
GRANDY CREEK	76	6	14	18	16	2.2E-02	1.3	1.7E-03	2.9	4.1E-03	3.8	5.2E-03	3.8	5.2E-03	0.30	4.1E-04	0.70	9.7E-04	0.90	1.2E-03
EVERETT CREEK	41	4	8	18	8.6	1.2E-02	0.84	1.2E-03	1.7	2.3E-03	3.8	5.2E-03	2.1	2.8E-03	0.20	2.8E-04	0.40	5.5E-04	0.90	1.2E-03
PRAIRIE CREEK	21	2	4	9	4.4	6.1E-03	0.42	5.8E-04	0.84	1.2E-03	1.9	2.6E-03	1.1	1.4E-03	0.10	1.4E-04	0.20	2.8E-04	0.45	6.2E-04
DIOBSUD CREEK	18	2	4	8	3.8	5.2E-03	0.42	5.8E-04	0.84	1.2E-03	1.7	2.3E-03	0.90	1.2E-03	0.10	1.4E-04	0.20	2.8E-04	0.40	5.5E-04
GRAVEL CREEK	13	1	3	6	2.7	3.8E-03	0.21	2.9E-04	0.63	8.7E-04	1.3	1.7E-03	0.65	9.0E-04	0.05	6.9E-05	0.15	2.1E-04	0.30	4.1E-04
CORKINDALE CREEK	7	1	2	4	1.5	2.0E-03	0.21	2.9E-04	0.42	5.8E-04	0.84	1.2E-03	0.35	4.8E-04	0.05	6.9E-05	0.10	1.4E-04	0.20	2.8E-04
HILT CREEK	10	1	2	4	2.1	2.9E-03	0.21	2.9E-04	0.42	5.8E-04	0.84	1.2E-03	0.50	6.9E-04	0.05	6.9E-05	0.10	1.4E-04	0.20	2.8E-04
JACKMAN CREEK	8	1	2	4	1.7	2.3E-03	0.21	2.9E-04	0.42	5.8E-04	0.84	1.2E-03	0.40	5.5E-04	0.05	6.9E-05	0.10	1.4E-04	0.20	2.8E-04
FINNEY CREEK	7	1	1	3	1.5	2.0E-03	0.21	2.9E-04	0.21	2.9E-04	0.63	8.7E-04	0.35	4.8E-04	0.05	6.9E-05	0.05	6.9E-05	0.15	2.1E-04
ILLABOT CREEK	6	1	1	3	1.3	1.7E-03	0.21	2.9E-04	0.21	2.9E-04	0.63	8.7E-04	0.30	4.1E-04	0.05	6.9E-05	0.05	6.9E-05	0.15	2.1E-04
BACON CREEK	3	—	1	1	0.63	8.7E-04	—	—	0.21	2.9E-04	0.21	2.9E-04	0.15	2.1E-04	—	—	0.05	6.9E-05	0.05	6.9E-05
CLARK CREEK	2	—	—	1	0.42	5.8E-04	—	—	—	—	0.21	2.9E-04	0.10	1.4E-04	—	—	—	—	0.05	6.9E-05
SUTTER CREEK	2	—	—	1	0.42	5.8E-04	—	—	—	—	0.21	2.9E-04	0.10	1.4E-04	—	—	—	—	0.05	6.9E-05
PRESSENTIN CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
OLSON CREEK	8	—	—	—	1.7	2.3E-03	—	—	—	—	—	—	0.40	5.5E-04	—	—	—	—	—	—
BARR CREEK	3	—	—	—	0.63	8.7E-04	—	—	—	—	—	—	0.15	2.1E-04	—	—	—	—	—	—
BOULDER CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ALDON CREEK	1	—	—	—	0.21	2.9E-04	—	—	—	—	—	—	0.05	6.9E-05	—	—	—	—	—	—
ALL CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BIG CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BOYD CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
FLUME CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
HOBBIT CREEK	1	—	—	—	0.21	2.9E-04	—	—	—	—	—	—	0.05	6.9E-05	—	—	—	—	—	—
IRENE CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
JORDAN CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MILL CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MILLER CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
OBRIAN CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
OSSTERMAN CREEK	1	—	—	—	0.21	2.9E-04	—	—	—	—	—	—	0.05	6.9E-05	—	—	—	—	—	—
RINKER CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ROCKY CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SAVAGE CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TENAS CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
WHITE CREEK	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	**228**	**20**	**42**	**80**	**48**	**0.066**	**4.2**	**0.0058**	**8.8**	**0.012**	**17**	**0.023**	**11**	**0.016**	**1.0**	**0.0014**	**2.1**	**0.0029**	**4.0**	**0.0055**

Note

[1]Demand forecast assumes that existing public water system capacity will be consumed. Total growth is constrained at the upper end to the estimated additional buildout capacity in a given subbasin.

[2]Excludes Lake Tyee RV Park

FIGURES



WRIA 4 Boundary

Study Area Subbasin

Stream Gage (USGS #12181000)

County Area

National Park/National Recreation Area

National Forest Administrative Area

City Limit

Urban Growth Area

WRIA 4 and Study Area Subbasins

UPPER SKAGIT BASIN RURAL GROWTH
PERMIT-EXEMPT WELL ASSESSMENT
WRIA 4, Washington

Aspect CONSULTING

NOV-2019	BY: EAC / PPW	FIGURE NO.
PROJECT NO. 150304 - 010 ASP110	REVISED BY: - - -	1

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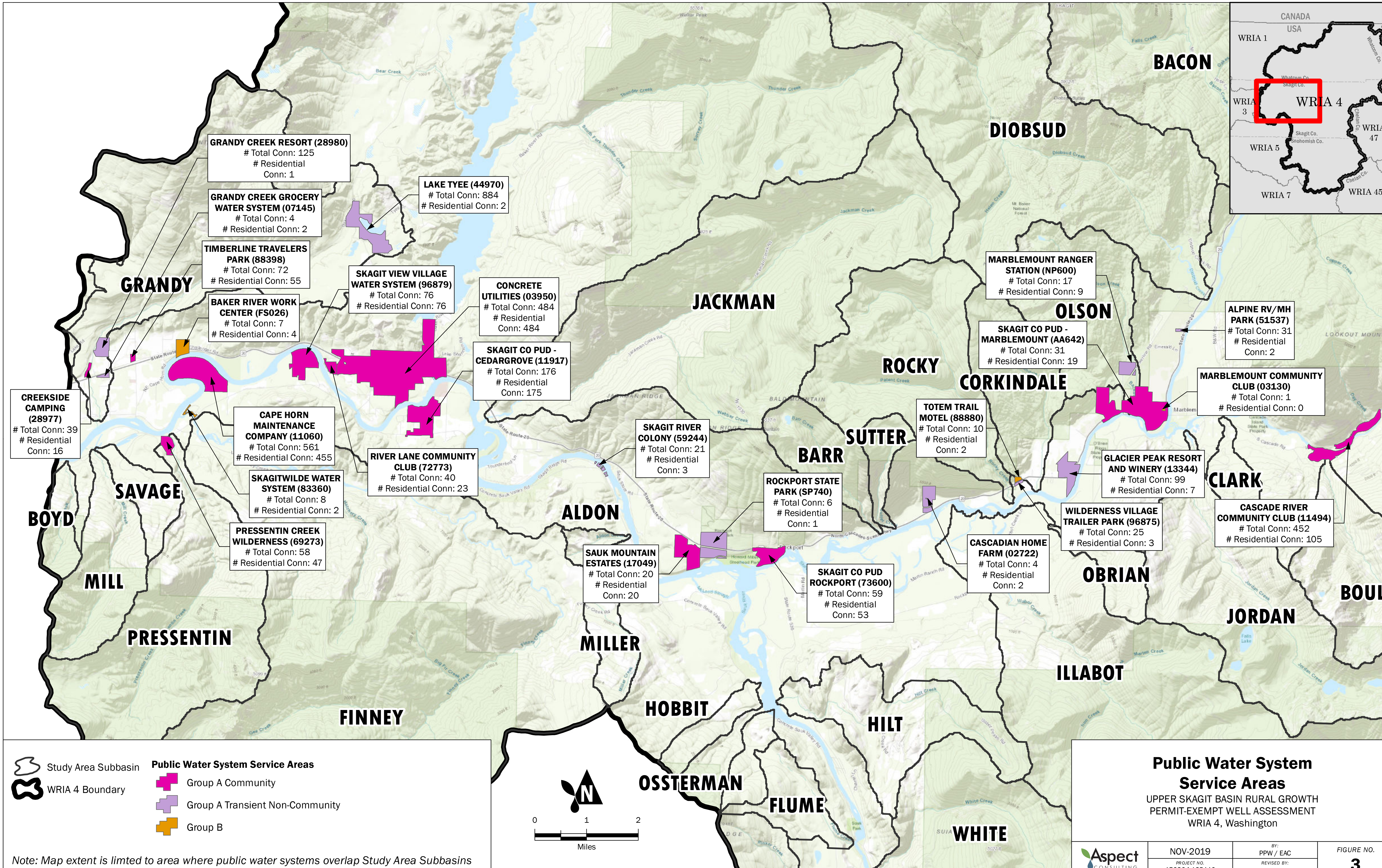

Public Water System Service Areas

UPPER SKAGIT BASIN RURAL GROWTH PERMIT-EXEMPT WELL ASSESSMENT
WRIA 4, Washington

Aspect CONSULTING | NOV-2019 | PROJECT NO. 150304-ASP110 | BY: PPW / EAC | REVISED BY: - - - | FIGURE NO. 3

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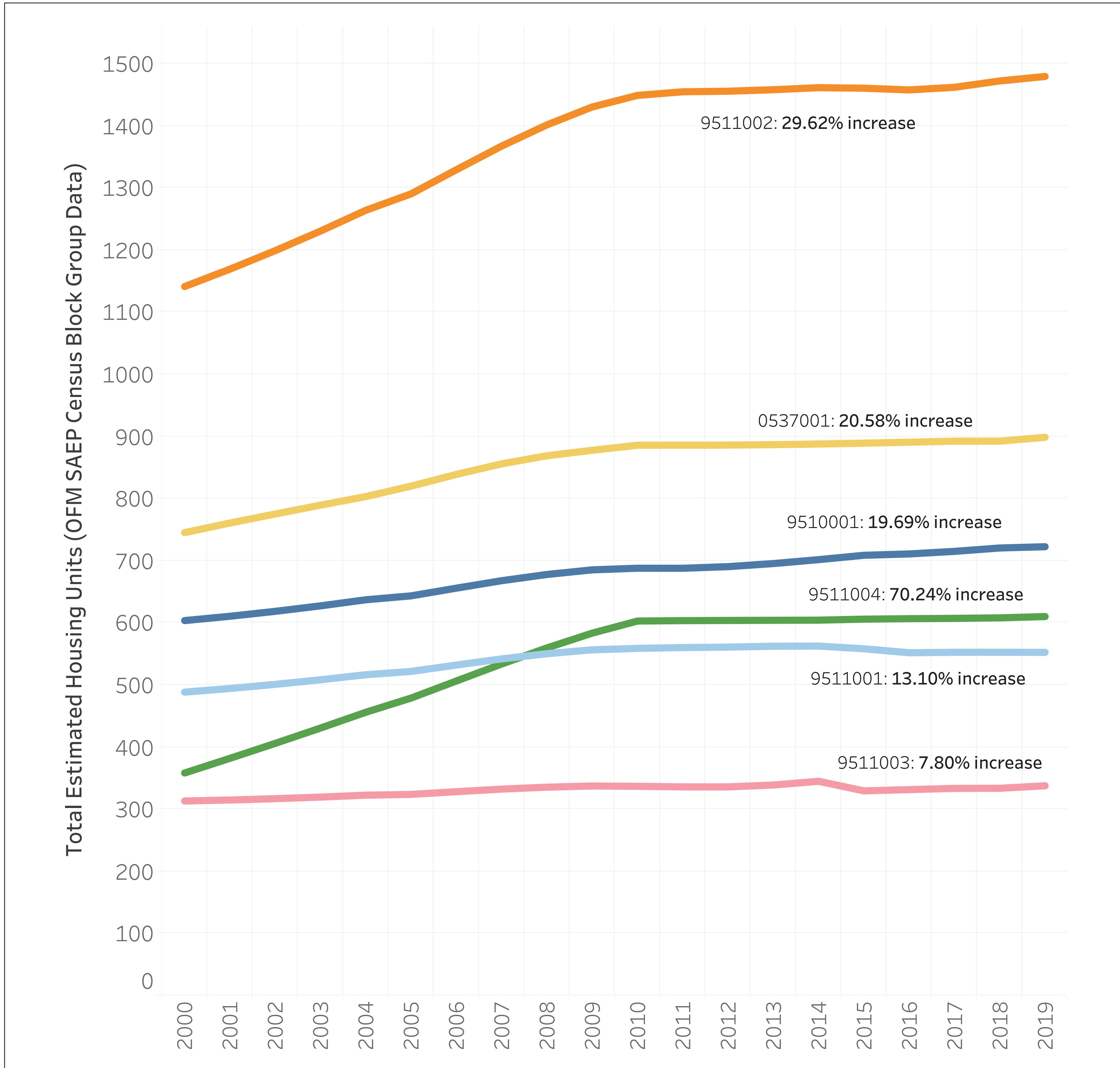
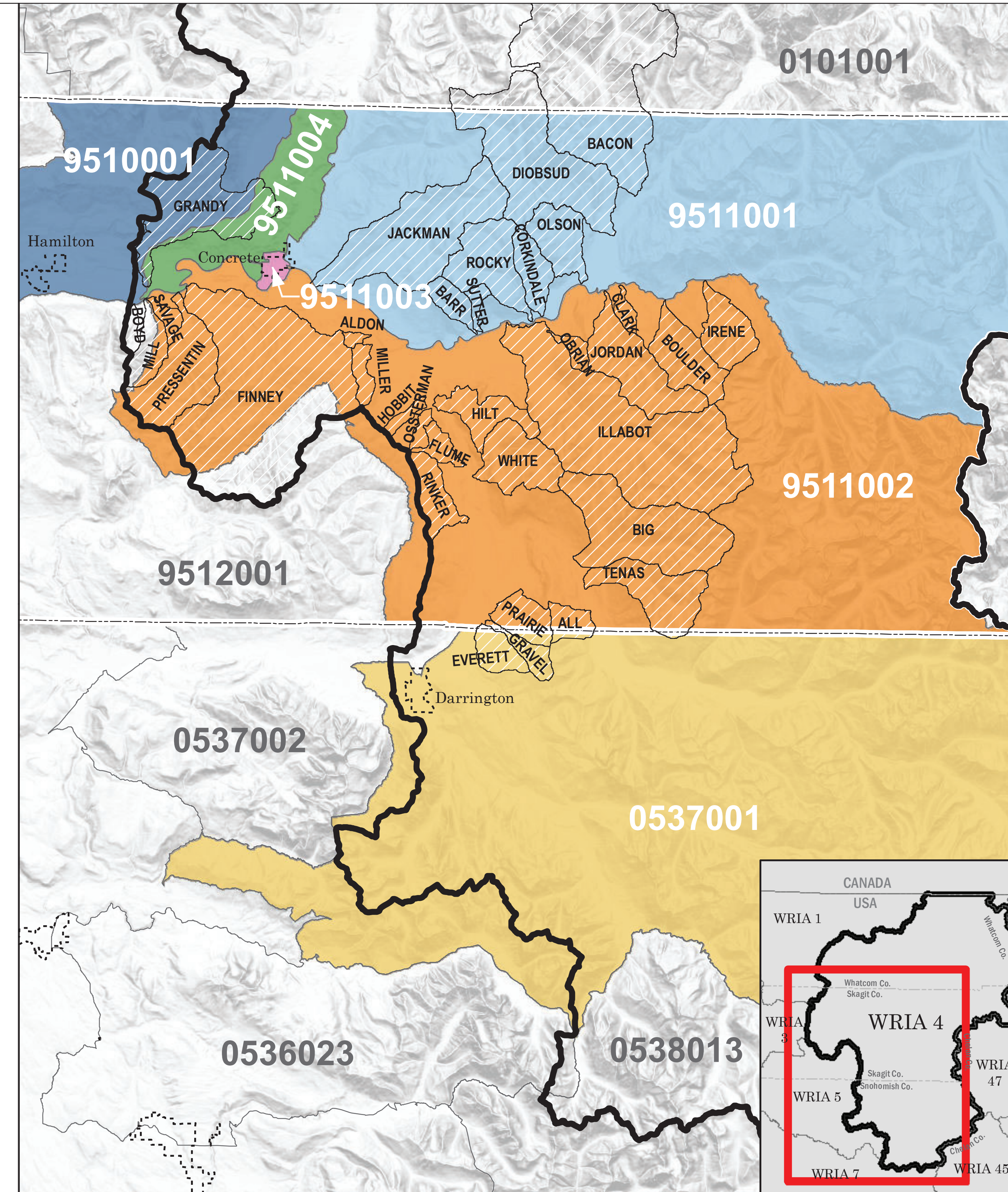




Census Block Groups

GEOID10

- 530579510001
- 530579511001
- 530579511002
- 530579511003
- 530579511004
- 530610537001

City Limit

Study Area Subbasin

County Boundary

WRIA 4 Boundary

0 2 4

Miles

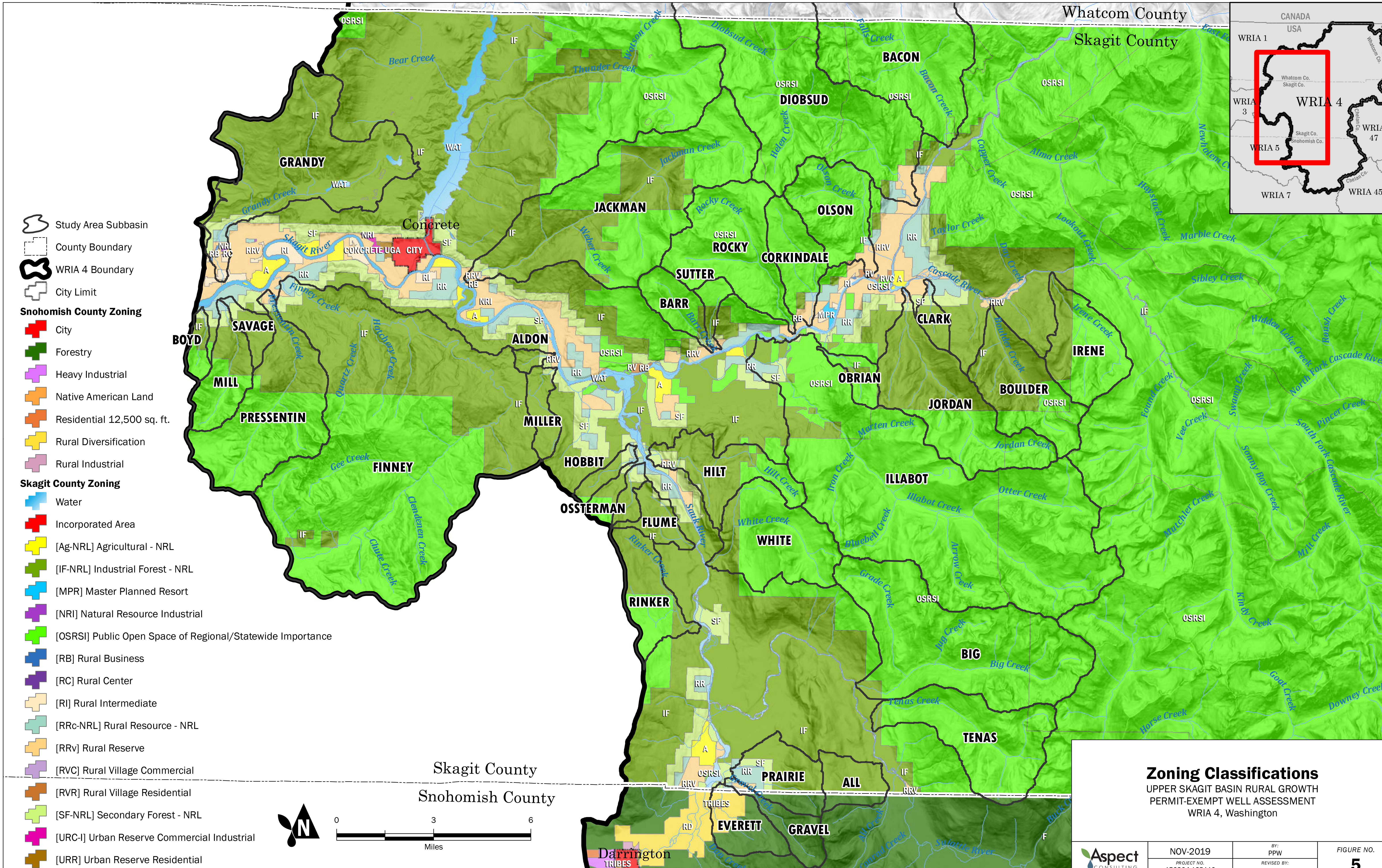
WRIA 4 Census Block Groups with Total Estimated Housing Unit Change 2000 to 2019

UPPER SKAGIT BASIN RURAL GROWTH

PERMIT-EXEMPT WELL ASSESSMENT

Aspect CONSULTING

NOV-2019	BY: PPW		FIGURE NO.
PROJECT NO. 150304-ASP110	REVISED BY: - - -		4



Whatcom County
Skagit County
Snohomish County
CANADA
USA
WRIA 1
WRIA 3
WRIA 4
WRIA 5
WRIA 7
WRIA 45
WRIA 47
Concrete
Darrington
GRANDY
BOYD
SAVAGE
MILL
PRESSENTIN
FINNEY
ALDON
MILLER
HOBBIT
OSSTERMAN
FLUME
RINKER
JACKMAN
ROCKY
SUTTER
BARR
CORKINDALE
OLSON
DIOBSUD
BACON
CLARK
OBRIAN
JORDAN
BOULDER
IRENE
HILT
WHITE
ILLABOT
BIG
TENAS
PRAIRIE
ALL
EVERETT
GRAVEL
Study Area Subbasin
County Boundary
WRIA 4 Boundary
City Limit
Snohomish County Zoning
City
Forestry
Heavy Industrial
Native American Land
Residential 12,500 sq. ft.
Rural Diversification
Rural Industrial
Skagit County Zoning
Water
Incorporated Area
[Ag-NRL] Agricultural - NRL
[IF-NRL] Industrial Forest - NRL
[MPR] Master Planned Resort
[NRI] Natural Resource Industrial
[OSRSI] Public Open Space of Regional/Statewide Importance
[RB] Rural Business
[RC] Rural Center
[RI] Rural Intermediate
[RRc-NRL] Rural Resource - NRL
[RRv] Rural Reserve
[RVC] Rural Village Commercial
[RVR] Rural Village Residential
[SF-NRL] Secondary Forest - NRL
[URC-I] Urban Reserve Commercial Industrial
[URR] Urban Reserve Residential
N
0
3
6
Miles
Zoning Classifications
UPPER SKAGIT BASIN RURAL GROWTH
PERMIT-EXEMPT WELL ASSESSMENT
WRIA 4, Washington
Aspect CONSULTING
NOV-2019
PROJECT NO.
150304-ASP110
BY:
PPW
REVISED BY:
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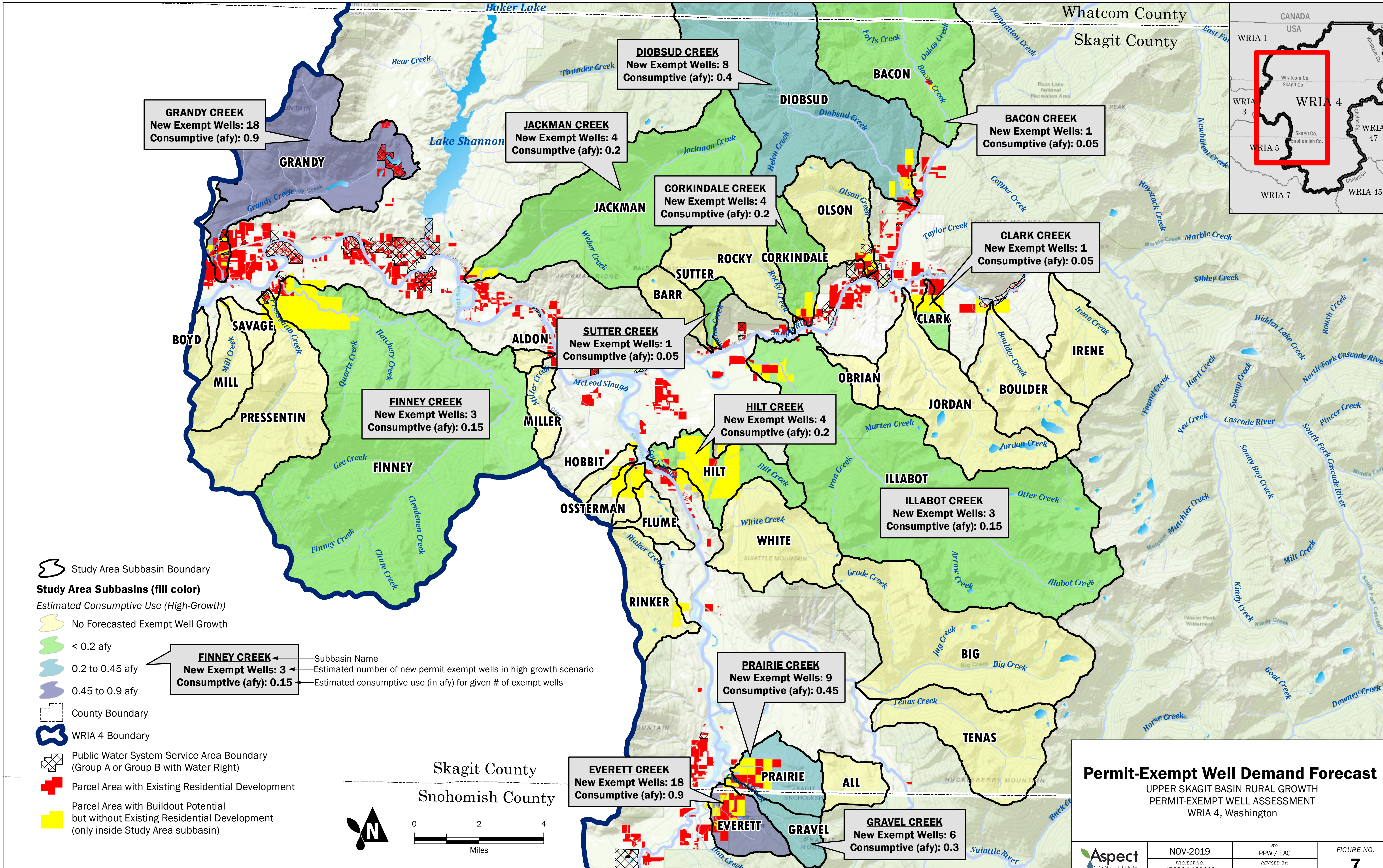
FIGURE NO.
5



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