DEPARTMENT OF ECOLOGY
State of Washington

Concise Explanatory Statement Appendices

Amendment to Chapter 173-501 WAC Instream Resources Protection Program - Nooksack Water Resource Inventory Area (WRIA) 1

Appendices of comment attachments

May 2020

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Publication and Contact Information

The main Concise Explanatory Statement and this separate appendices document are available on the Department of Ecology's website at: https://fortress.wa.gov/ecy/publications/summarypages/2011078.html

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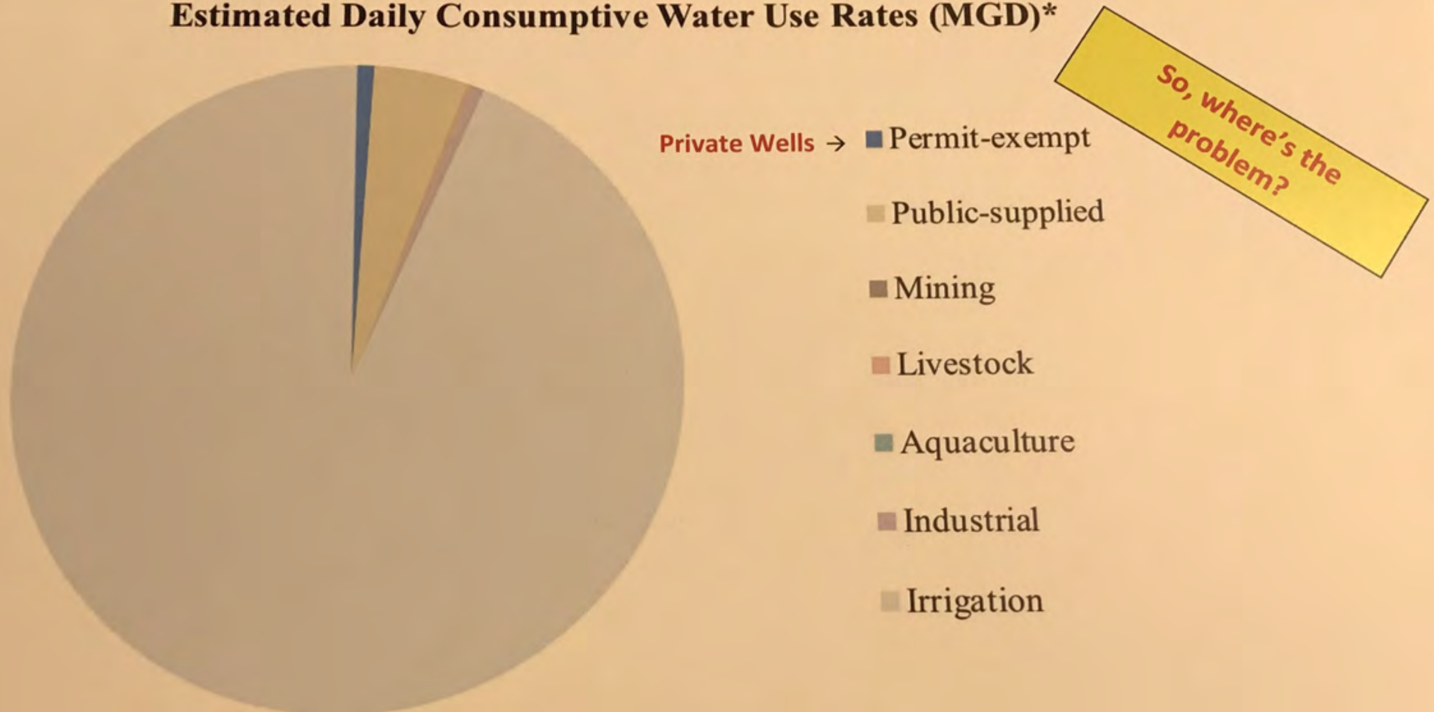
Appendix A

Visual Aid referenced in Comment OTH-5-2 (Public Hearing, January 9, 2020)

Estimated Daily Consumptive Water Use Rates (MGD)*



* Estimates based on USGS SIR 2009-5128 and numerous assumptions regarding consumptive water use

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

United States, Culhane, Tom, and Dave Nazy. "Permit - Exempt Domestic Well Use in Washington State." *Permit - Exempt Domestic Well Use in Washington State*, Water Resources Program, 2015. *Washington State Department of Ecology*, fortress.wa.gov/ecy/publications/SummaryPages/1511006.html.

Appendix B

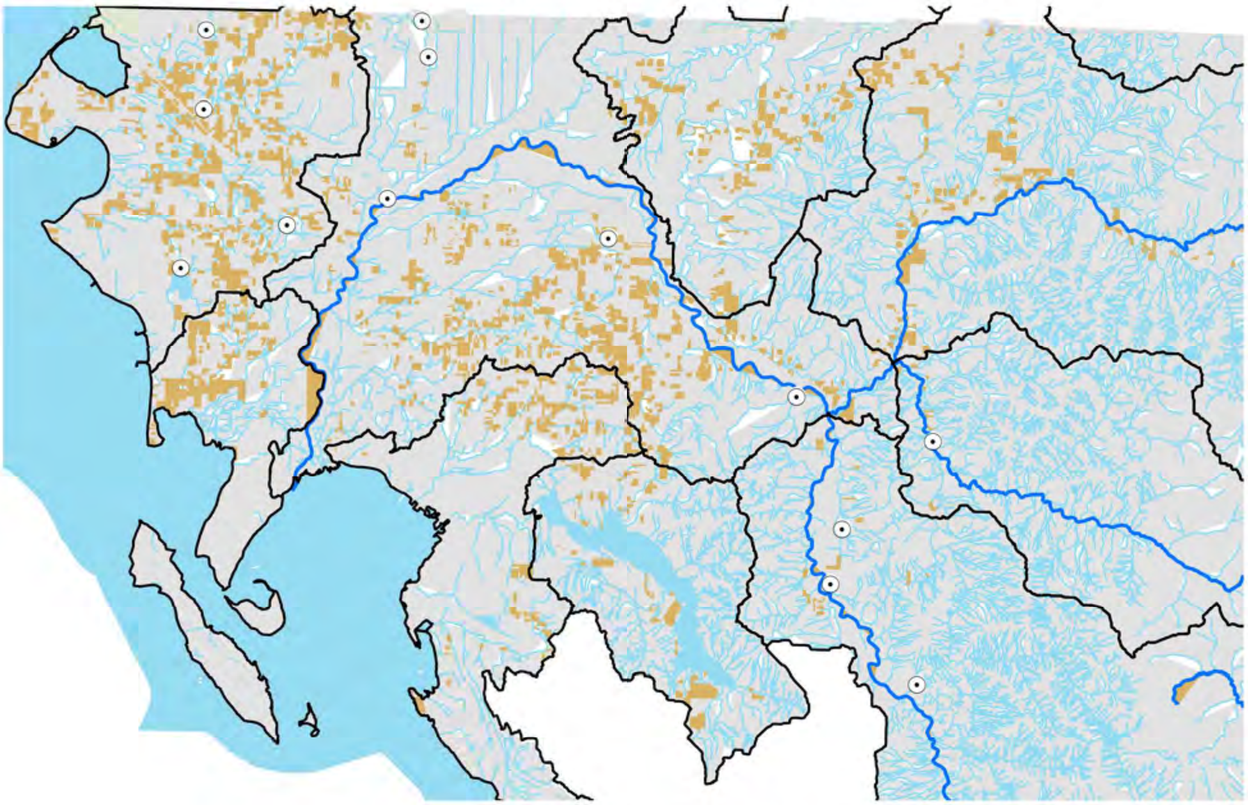
Attachment to Comment T-2-2 (Merle Jefferson, Lummi Indian Business Council, January 14, 2020)

Enclosure 2

Assessing the Ecological Effects of WRIA 1 Watershed Plan Update. Technical Memo Prepared in Support of WRIA 1 Watershed Plan Update
12/5/2018 Interim Work Product

Assessing the Ecological Effects of WRIA 1 Watershed Plan Update

Technical Memo Prepared in Support of WRIA 1 Watershed Plan Update



12/5/2018 Interim Work Product

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Introduction

In January 2018, the Washington State legislature passed ESSB 6091, now codified as RCW 90.94 Streamflow Restoration, which authorizes potential impacts on a closed water body and potential impairment to an instream flow of new domestic groundwater permit-exempt (DGWPE) well withdrawals, provided that applicants pay a $500 fee and restricted water use to no more than 3000 gallons per day annual average. The law also establishes planning requirements specific to water resource inventory areas. For Water Resource Inventory Area (WRIA) 1, the Nooksack Basin[1], the following requirements were established (boldface emphasis added):

- 90.94.020 (4)(a): ***In collaboration with the planning unit, the initiating governments must update the watershed plan to include recommendations for projects and actions that will measure, protect, and enhance instream resources and improve watershed functions that support the recovery of threatened and endangered salmonids.*** *Watershed plan recommendations may include, but are not limited to, acquiring senior water rights, water conservation, water reuse, stream gaging, groundwater monitoring, and developing natural and constructed infrastructure, which includes, but is not limited to, such projects as floodplain restoration, off-channel storage, and aquifer recharge.* ***Qualifying projects must be specifically designed to enhance streamflows and not result in negative impacts to ecological functions or critical habitat.***
- 90.94.020 (4)(b): ***At a minimum, the watershed plan must include those actions that the planning units determine to be necessary to offset potential impacts to instream flows associated with permit-exempt domestic water use.*** *The highest priority recommendations must include replacing the quantity of consumptive water use during the same time as the impact and in the same basin or tributary. Lower priority projects include projects not in the same basin or tributary and projects that replace consumptive water supply impacts only during critical flow periods. The watershed plan may include projects that protect or improve instream resources without replacing the consumptive quantity of water where such projects are in addition to those actions that the planning unit determines to be necessary to offset potential consumptive impacts to instream flows associated with permit-exempt domestic water use.*
- 90.94.020 (4)(c): *Prior to adoption of the updated watershed plan,* ***the department must determine that actions identified in the watershed plan****, after accounting for new projected uses of water over the subsequent twenty years,* ***will result in a net ecological benefit to instream resources within the water resource inventory area****.*

In its *Interim Guidance for Determining Net Ecological Benefit* (Ecology 2018), Ecology further specified that plans should address the following elements:

1. *Characterize and quantify potential impacts to instream resources from the projected 20- year new domestic permit-exempt water use at a scale that allows meaningful determinations of whether the proposed offset is in-time and/or in the same subbasin.*
2. *Describe and evaluate individual offset projects.*

[1] WRIA 1, the Nooksack Basin, includes the Nooksack River watershed, as well as the watersheds of tributaries to the Fraser River (Chilliwack and Sumas Rivers) and independent tributaries to the Salish Sea from the Canadian border south to Colony Creek in Skagit County.

3. *Explain how the planned projects are linked or coordinated with other existing plans and actions underway to address existing factors impacting instream resources.*
4. *Provide a narrative description and quantitative evaluation (to the extent practical) of the net ecological effect of the plan.*

The purpose of this report is to describe and report on the detailed findings of an assessment of the ecological effects of the WRIA 1 Watershed Plan Update, to address element 4 of the *Interim Guidance*. Specifically, this report evaluates the ecological effects of both the impacts of DGWPE wells in WRIA 1 over the next 20 years (2018-2038) and actions identified to offset those impacts[2]. Consistent with Ecology's guidance, this report is intended to provide the transparent, structured evaluation that will inform determination of net ecological benefit of the WRIA 1 Watershed Plan Update.

Methods

While annualized DGWPE consumptive use was estimated at the aggregated subbasin scale (Dunn and Neff 2018), evaluating the cumulative ecological effects of DGWPE consumptive use and plan actions requires understanding effects at finer spatial and temporal scales. As such, this assessment begins with estimates of the finer-scale spatial and temporal distribution of DGWPE well consumptive use impacts relative to selected actions to offset those impacts, followed by a discussion of the ecological implications of both cumulative streamflow effects and other ecological effects to instream resources. This analysis is based on water use scenarios and options for the projected number of new DGWPE wells that are described by RH2 (Bucknell et al. 2018; Dunn and Neff 2018) and does not incorporate variation described in the analyses of uncertainty around consumptive use impacts or actions. Spatial and temporal analysis methods are described below.

Spatial Distribution of Impacts and Actions

Consumptive Impacts

Evaluation of the spatial distribution of consumptive use impacts is based on the following assumptions:

- Groundwater flow paths match surface topography.
- 100% of consumptive use from DGWPE wells results in flow deficit to closest stream segment.
- There is synchrony in timing of streamflow deficit (including for streams segments downstream).

For the WRIA 1 Watershed Plan update, BERK Consulting developed a scenario for rural growth (i.e. growth outside of urban growth areas) in WRIA 1 over the next twenty years (2018-2038) that was based on work they had completed to support the 2016 Whatcom County Comprehensive Plan update (Ramsey & Silver 2018). The BERK growth scenario allocated growth at the parcel scale based on available land capacity and other factors that influence the distribution of new development. Geospatial data[3] were obtained from Whatcom County (Figure 1) showing parcels attributed with population growth, number of new households, and other growth statistics. There were discrepancies between these data (population growth 9388) and the projections used for consumptive use estimates (9932;

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[2] The actions evaluated in this report are those identified in *Watershed Staff Team Suite of Projects Pending Net Ecological Benefit (NEB) Evaluation*, dated October 4, 2018, and distributed for the October 24, 2018, WRIA 1 Planning Unit meeting.

[3] *WRIA1_GrowthLayers_20180802.gdb* (*PreferredAlt_NonUGA_GrowthOnly_NoLummiEliza_Final_2018_0802*) provided by Cliff Strong (Whatcom County PDS) via email, August, 8, 2018.

Ramsey and Silver 2018), since growth data are for rural growth in Whatcom County only and do not include Skagit County and there were continued adjustments in the calculation of new growth that may not be reflected in the geospatial data. These data represent a plausible scenario for the general spatial distribution of rural growth across WRIA 1, although the number of buildable parcels in Whatcom County far exceeds the projected number of new housing units needed to accommodate growth over the next twenty years and actual growth pattern may vary accordingly.

Since some new rural development can be served by existing water associations and water districts, a subset of BERK's projected rural growth is expected to use DGWPE wells. RH2 developed 5 options for estimating the number of new DGWPE connections (Dunn and Neff 2018), and option 4 was selected by the WRIA 1 Watershed Staff Team and the WRIA 1 Planning Unit, for an estimate of 2150 new DGWPE connections in WRIA 1 for the planning period. Time and data constraints prevented development of a new spatially- explicit growth scenario that would be consistent with option 4. Instead, aggregated subbasin-specific consumptive water use estimates developed by RH2 (Dunn & Neff 2018) were assigned to the BERK parcels as follows: (1) calculate the per household consumptive use by subbasin (i.e. the aggregated subbasin-specific consumptive use estimates divided by the number of households associated with the growth parcels in each subbasin); and (2) assign consumptive use to parcels (i.e. multiply the subbasin-specific per household consumptive use by the number of new households in the parcel). Because the growth scenario does not necessarily reflect the number and location of new DGWPE wells (i.e. for parcels that may fall within water district and water association service areas), the results may not be accurate on a parcel-by-parcel basis. However, total consumptive use by subbasin is equivalent to that estimated by Dunn and Neff (2018) RH2 and the results represent a reasonable approximation of the spatial distribution of consumptive use.

Parcel-level consumptive use was attributed to adjacent stream segments and accumulated downstream as follows:

- Geometric network creation.
  - A 2013 SSHIAP (Salmon and Steelhead Habitat Inventory and Assessment Program) stream layer dataset, edited to remove braids, was used to create a geometric network. Data were edited to enforce flow direction such that each line's geometry pointed in a downhill direction. Topology rules were applied, and the data further manually edited to remove any self intersecting lines and to ensure no dangles or unconnected lines existed in any given river system.
  - Growth polygons (parcels) from the BERK dataset were converted to points using the geometric center (centroid) of each polygon. A near table was generated resulting in coordinates that listed the polygon centroid location and the intersecting coordinates of the closest line based on Euclidian distance. A new feature layer was created from these coordinates and appended to the stream line work. Data were then edited to split the lines at each line intersection. These split data were used to create a geometric network data model inside of an ArcGIS 10.5 geodatabase-feature-class-feature-dataset and flow direction was assigned to the network based on the existing line geometry.
- Flag Creation.
  - Both start and end vertices were generated from the split line work as two separate spatial datasets. Any end nodes that were not coincident with a start node were

exported to a new dataset called *flags*. Flags was edited using ArcGIS Toolbox tools to remove spatially duplicate flags.

- Python Script Development.
  - A Python v2.7 tool was developed to automate upstream tracing and summation of the consumptive use estimates for each scenario. This tool used a search cursor to select each flag. The selected flag served as an input into an upstream accumulation trace of the geometric network (all upstream line connections). The resulting line selection was used to select all growth points that intersected the selection. The growth points selection was exported to a Numeric Python Library (NUMPY) array for summation. The tool then selected the currently evaluated flag's intersecting downstream line and populated a text file with the summed consumptive use values for that upstream accumulation trace. The text file was joined to the line work based on line object ID and exported to a new feature class.
- Screening out of segments coincident with lakes
  - Stream segments coincident with lakes over 23 acres in area were removed using the ArcGIS erase function, and segment lengths recalculated to facilitate length summarization.

Consumptive water use estimates were spatially distributed for the following water use scenarios:

- Scenario 4. One home; outdoor irrigation varies by aggregated subbasin (0.064 to 0.322 acres) and is based on aerial photography-based irrigated acreage analysis (modified means) of new homes constructed and served water by a DGWPE well between 2000 and 2014.
- Scenario 5A. One home, ½ acre of outdoor irrigation, plus excess water use up to 3000 gallons per day (maximum annual average withdrawal limit).
- Scenario 6. One home, ½ acre of outdoor irrigation, plus excess water use up to 5000 gallons per day (maximum daily withdrawal limit).

Scenario 4 was the water use scenario selected by the WRIA 1 Watershed Staff Team and the WRIA 1 Planning Unit as representing a reasonable planning-level estimate of DGWPE well consumptive water use across WRIA 1. Scenarios 5A and 6 were also evaluated to buffer against the considerable uncertainty in estimating consumptive water use, and because both scenarios represent legally and currently permissible water use scenarios—the 3000 gpd average annual limit allows for use of 5000 gpd (daily)[4]. In addition, RH2's consumptive use estimates (Dunn & Neff 2018), when converted to cubic feet per second, represent annually-averaged estimates and thus underestimate peak seasonal consumptive use (see Table 2).

Actions to Offset Impacts

The suite of projects evaluated for ecological effects were those identified in the *Watershed Staff Team Suite of Projects Pending Net Ecological Benefit (NEB) Evaluation* (dated 10/4/2018 and distributed to WRIA 1 Planning Unit 10/24/2018). A shape file with approximate project locations[5] was obtained from

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[4] For example, if five hundred (500) gpd is withdrawn from Oct. 20 through the end of March, five thousand (5,000) gpd can be withdrawn from April 1 through October 19 without exceeding the three thousand (3,000) gpd annual average.

[5] *Potential Projects_44.shp.*

RH2. Streamflow impacts from these projects were incorporated into the stream feature class described above by adding a table attribute for each project with an estimated offset[6], then selecting and assigning offset amount to stream segments downstream of the project location (see Appendix A for how offset was assigned for each project). If a range of offset was estimated, the lower end of the range was used. For interbasin transfers (# 24 Birch Bay Water & Sewer District Deep Wells; #45: PUD #1: Lake Terrell), the stream system in the receiving basin closest to project location was assumed to benefit from offset. The offset associated with #21 Stewart Mountain/SF Conservation Site was assumed to benefit three subbasins (South Fork Nooksack, Lower Nooksack, Lake Whatcom) proportional to the acquisition area in each subbasin, so offset was distributed accordingly; it is worth noting that this project had the greatest estimated offset among all projects, and there is a great deal of uncertainty in the offset estimate. For the two projects that would increase diversion of streamflow from the Lower Nooksack River (#44 PUD #1: Vista Road Project; #45 PUD #1: Lake Terrell), the associated flow deficit was attributed to Nooksack River segments downstream of Plant 2[7]. Actions lacking quantification of offsets (WRIA 1-wide Conservation Program, MAR Feasibility Study, Purchase of Development Rights Program, Glacier WD Groundwater Study and Augmentation, NF Maple Reach Restoration) were not included in quantitative analyses but are discussed qualitatively in results.

Net streamflow impact was calculated at the stream segment level by summing any project offsets, subtracting the accumulated streamflow deficit from DGWPE consumptive use, and converting to cubic feet per second (cfs) using the factor 0.00138128 cfs/acre-foot·year^{-1}. Only streams with net streamflow impact (positive or negative) were used in subsequent analysis (Figure 2).

Hydrologic Context

It is important to understand the net streamflow impact in the context of existing hydrologic regime. Estimates of existing streamflow regime are available at 337 point locations (generally corresponding to drainage outlets and other points of interest) throughout WRIA 1 based on hydrologic modeling conducted in 2007 to support the WRIA 1 Watershed Management Project (Bandaragoda and Greenberg 2013); 138 of these locations are associated with streams affected by projected consumptive use and offset actions. Hydrologic data in the form of geospatial and corresponding tabular data with exceedance flows by percentile and month[8] were assembled and made available through the 2013 Data Integration Project (Bandaragoda and Greenberg 2013). While the hydrology modeling was subsequently updated and refined in 2012 (Bandaragoda et al. 2012), 2012 model data were only available for 37 nodes so the older hydrology modeling was used. The 50th percentile and 95th percentile exceedance flows for July were selected as the streamflows of greatest interest, even though streamflows are lowest in most locations throughout the Nooksack Basin lowlands in September or October. According to monthly crop irrigation requirements from the Washington Irrigation Guide (NRCS 1992), July is the month of peak irrigation. The 50th percentile July streamflow is an indicator of

[6] Estimated offset has not been quantified for the following projects: North Fork Maple Reach Restoration Phase 1, Glacier WD Groundawter Study and Augmentation, WRIA 1-Wide Conservation Program, MAR Feasibility Study, and Purchase of Development Rights Program.

[7] The authors acknowledge that the PUD has sufficient water rights to accommodate the proposed interbasin transfers, but have deemed it important to account for the negative ecological impact to the Lower Nooksack River.

[8] WRIA1DataIntegration2013.gdb, Wria1_337_nodes); Existing_ExceedanceTables_337nodes_cfs.xls

relatively normal July conditions, while the 95th percentile July streamflow represents a less common extreme low flow, since only 5% of July streamflows fall below that streamflow.

Net streamflow impact data were spatially joined to 2007 hydrology nodes. Since the stream dataset used for net streamflow impact differed from that associated with the 2007 hydrology nodes[9], all nodes were reviewed to verify assignment accuracy of spatial joins. Nodes without a net streamflow change (positive or negative) were deleted and excluded from further analysis; see Figure 2 for the resulting analysis nodes. The 50th percentile and 95th percentile exceedance flows for July were subsequently joined to the 2007 hydrology nodes. July was selected as the most relevant month, since crop irrigation requirements peak in July (NRCS 1992; see also temporal analyses below). The 50th percentile exceedance flow was selected to represent the average flow for July, and the 95% percentile exceedance flow to represent a less common extreme low flow (i.e. the flow level at which only 5% of streamflows would equal or fall below it). Net flow impact for each node was then calculated for the three water use scenarios (Scenario 4, 5A, 6) as a proportion of the two July exceedance flows.

Temporal Analyses

Temporal patterns, both seasonal (intra-annual) and over the 20-year planning period (interannual), of project streamflow benefits relative to projected impacts were evaluated.

Seasonal Pattern

Appendix A of RH2's consumptive use memo (Dunn and Neff 2018) estimates the total annual consumptive water use associated with DGWPE wells in acre-feet per year. Annual consumptive use can be converted to cubic feet per second, but the result is an annual average. Although indoor domestic use is consistent through the year, total and consumptive outdoor use vary seasonally. Seasonal variation in streamflow impact was evaluated in each subbasin on a monthly basis by calculating monthly consumptive water use and comparing to the sum of project offsets provided by month.

Since RH2's calculations for consumptive use (Dunn and Neff 2018) were not available, new calculation worksheets were developed based on methods and results described in the RH2 memo and which duplicated RH2's total annual consumptive use estimates. Monthly consumptive use estimates were then calculated by replacing annual crop irrigation requirements (CIR) with monthly CIR values from the Washington Irrigation Guide (NRCS 1992), which provides both annual and monthly crop irrigation requirements for three climate stations in WRIA 1: Bellingham, Blaine, and Clearbrook. The method for developing subbasin-specific estimates of monthly CIR requirements was consistent with that used by RH2 (Table 7 in Dunn & Neff 2018). Consistent with RH2's estimates, CIRs for pasture/turf were used. To ensure calculation accuracy, monthly consumptive use estimates were aggregated into annual consumptive use estimates by subbasin and scenario and compared to RH2's respective annual consumptive use estimates. All calculations were within 0.41% of RH2's estimates, and many were within 0.01% Monthly consumptive water use was calculated for the following scenarios (all based on option 4 for the number of new DGWPE connections):

- Scenario 4. One home; outdoor irrigation varies by aggregated subbasin (0.064 to 0.322 acres) and is based on aerial photography-based irrigated acreage analysis (modified means).
- Scenario 5B. One home, ½ acre of outdoor irrigation.

[9] WRIA1DataIntegration2013.gdb, TopnetWMStreamNetwork

- Scenario 5A. One home, ½ acre of outdoor irrigation, plus excess water use up to 3000 gallons per day (maximum annual average withdrawal limit). Monthly fraction of annual indoor and outdoor water use from Scenario 5B was used to calculate the monthly total water use that would average to 3000 gallons per day annual average. Monthly total water use was not constrained to the 5000 gallons per day maximum daily withdrawal limit, and exceeded 8000 gallons per day during July when CIRs are highest.
- Scenario 5A Alternative: One home, ½ acre of outdoor irrigation, plus excess water use up to 3000 gallons per day (maximum annual average withdrawal limit). Monthly total water use from Scenario 5A was constrained to not exceed maximum daily withdrawal limit of 5000 gallons per day; excess monthly total water use was distributed to other months proportionally to monthly fraction of annual indoor and outdoor water use from Scenario 5B to maintain annual average of 3000 gallons per day. This process often required multiple iterations so that no months exceeded 5000 gallons per day total water use.

Scenario 6, which assumes daily withdrawals up to the maximum daily withdrawals limit (5000 gallons per day) was not evaluated as consumptive use would vary little over the year.

Projects were categorized by status ("conceptual", "in design", "seeking funding", "underway") and offsets were attributed based on RH2 Task 2 Memo Appendix A (Time of Year Water Replaced; Bucknell et al. 2018). Lacking information about seasonal variation in project offset, 100% of the estimated offset was assumed to be provided in a month as long as that month was included in the "Time of Year Water Replaced". As described under *Spatial Analysis*, the offset for the Stewart Mountain/SF Nooksack Conservation Sale (#21) project was proportionally applied to subbasins based on area of the acquisition area in each subbasin, and the negative flow impacts to the Lower Nooksack subbasin of the PUD #1 Vista Rd. and Lake Terrell Projects (#44, #45) were accounted for in that subbasin.

Finally, monthly consumptive use estimates by scenario and project offsets by status were plotted against month of year for each subbasin and WRIA 1 in aggregate. The net streamflow impact (monthly project offsets in the subbasin minus monthly consumptive use estimates) were also plotted by month for each subbasin and WRIA 1.

Planning Period

RH2's DGWPE consumptive use estimates (Dunn and Neff 2018) represent the total use after twenty years of growth. To compare the change in consumptive use over the twenty year planning period with project offsets, the number of connections by subbasin and year were back-calculated using the 1.28% average annual growth that was the basis of the population growth estimates. Aggregated subbasin consumptive use (using option 4 for number of new DGWPE connections) by scenario were then scaled to the number of connections in each year. Projects were categorized by status (conceptual, in design, seeking funding, underway) based on RH2 Task 2 Memo Appendix A (Bucknell et al. 2018). For each subbasin and for WRIA 1 in aggregate, consumptive use estimates were plotted by year against project offsets by status for the water use scenarios used in the spatial analysis: Scenario 4, Scenario 5A, and Scenario 6.

As with the spatial analysis, actions lacking quantification of offset (WRIA 1-wide Conservation Program, MAR Feasibility Study, Purchase of Development Rights Program, Glacier WD Groundwater Study and

Augmentation, NF Maple Reach Restoration) were not included in the quantitative temporal analyses but are discussed qualitatively in results

Results

Spatial Analysis

Table 1 summarizes the length of stream with net positive and net negative streamflow impact for each scenario. The total length of stream with net negative impact increases slightly from scenario 4 to scenario 5A and scenario 6.

Table 1. Length of affected streams by water use scenario.

Water Use Scenario	Net streamflow benefit (miles of stream)	Net streamflow deficit (miles of stream)
4	118	501
5A	90	529
6	83	536

Magnitude of Impact

The estimated magnitude of streamflow impact (annually-averaged) from consumptive use associated with new DGWPE wells over the next 20 years for water use scenarios 4, 5A, and 6- as well as the net streamflow impact with offset actions –is shown in Figures 3 through 5. For water use scenario 4 (Figure 3, upper panel), annually-averaged streamflow impact from DGWPE consumptive use (annually-averaged) is less than 0.3 cubic feet per second (cfs) throughout WRIA 1. Streamflow impact accumulates downstream, so it is greatest for the lower Nooksack River and, to a lesser extent, larger tributaries in the lower Basin. With offsets accounted for (Figure 3, lower panel), net streamflow benefit is greatest for the lower Nooksack River (from 6 cfs near the Forks to >11 cfs near the mouth), followed by the South Fork (>6 cfs at mouth), and Bertrand Creek (>2.5 cfs at mouth). The Middle Fork, as well as Dakota, Tenmile, Whatcom, Terrell, and California Creeks also show a net streamflow benefit of 0.5 cfs or less. A number of streams show a net streamflow deficit, although net deficit is less than 0.1 cfs.

For water use scenario 5A (Figure 4, upper panel), annually-averaged streamflow impact from consumptive use (annually-averaged) increases in the Nooksack River from about 0.5 cfs near the Forks to 2 cfs downstream of Ferndale. Outside of the lower Nooksack, streamflow impact from consumptive use is greatest (0.5 to 1 cfs) in Dakota and lower Squalicum Creeks. Throughout most of the affected area, streamflow impact from consumptive use is <0.1 cfs. Accounting for project offsets (Figure 4, lower panel), net streamflow benefit is again greatest for the Nooksack River, which benefits from projects improving streamflow in its tributaries; net streamflow impact is from just under 6 cfs at the Forks confluence to just over 12 cfs at the mouth. Net streamflow benefit is also evident in the South Fork, and Bertrand and Whatcom Creeks, as well as in stream segments in the Dakota Creek, Terrell, Tenmile, and California Creek watersheds, although benefits in those watersheds are negated downstream by consumptive use impacts and creek mouths all show net streamflow deficit.

For water use scenario 6 (Figure 5, upper panel), annually-averaged streamflow impact from consumptive use increases in the lower Nooksack River from around 0.8 cfs near the Forks confluence to

3.6 cfs at the mouth. Streamflow impact near the mouth exceeds 1 cfs in Dakota and Squalicum Creeks and exceeds 0.5 cfs in the lower North Fork, and in the Sumas River and lower Whatcom, California, and Terrell creeks. For this water use scenario, with offsets accounted for, only the lower Nookasck River, Bertrand Creek, the South Fork Nooksack River, and tributary segments of the Dakota Creek, Terrell, California, Lake Whatcom, and other smaller watersheds, show a net streamflow benefit. Net streamflow deficit is greatest (>0.85 cfs) in Dakota, Tenmile, and Squalicum Creeks, followed by the North Fork and Sumas River and California Creek (>0.5 cfs). Similar to water use scenarios 4 and 5A, net streamflow deficit throughout much of the affected area is <0.1 cfs.

Hydrologic Context

In addition to evaluating the absolute magnitude of net streamflow impact, it is important to understand the relative impact, or the magnitude of flow impact relative to the existing streamflow regime. As described in *Methods*, the 50th percentile and 95th percentile exceedance flows for July were selected as the streamflows of greatest interest, because July is the month of peak irrigation and thus consumptive use impact (see section *Temporal Analyses: Seasonal Pattern* below). The 50th percentile July streamflow is an indicator of relatively normal July conditions, while the 95th percentile July streamflow represents a less common extreme low flow, since only 5% of July streamflows fall below that streamflow. Figures 6 and 7 present the net streamflow impact of DGWPE well consumptive and offset actions as a percentage of the 50th and 95th percentile July streamflows at locations (nodes) for which we have hydrologic modeling data.

For water use scenario 4, and assuming relatively normal July streamflows, relative net streamflow deficit (Figure 6) is greatest for Silver and Deer Creeks where the estimated deficit exceeds average July flows. For water use scenarios 5A, relative net streamflow deficit also exceeds 50th percentile July streamflows in Tenmile and lower Squalicum Creeks. The Dakota Creek system is also vulnerable, with relative net streamflow deficit >50% of 50th percentile streamflow at 3 of 15 locations and 25-50% of 50th percentile July streamflow at 4 of 15 locations. Under water use scenario 6, relative net streamflow deficit exceeds the 50th percentile July streamflow at the same locations as in scenarios 4 and 5A, as well as 3 locations in the Dakota drainage, lower Squalicum Creek and Onion Creek, a tributary to Lummi Bay. Other locations in the Squalicum and Dakota Creek watersheds are vulnerable, with relative net streamflow deficit of at least 25%. Wiser Lake Creek, Sumas River, and a tributary to Bellingham Bay are also vulnerable in this water use scenario. Under even lower flow conditions (i.e. 95th percentile July streamflows), relative net streamflow deficit constitutes a higher proportion of streamflow, especially at higher water use scenarios (Figure 7).

Relative net streamflow impact (positive or negative) is less than 10% for most of the 138 hydrologic modeling nodes in WRIA 1 that are affected by DGWPE consumptive impacts and/or offset actions (Figure 8). Under normal July streamflows (e.g. 50th percentile July streamflow; Figure 6, upper panel), relative net streamflow deficit is less than 10% for 64% of nodes under water use scenario 4, 59% of nodes under water use scenario 5A, and 54% of nodes under water use scenario 6. Relative net streamflow deficits are greater than 10% for 2.9%, 17%, and 24% under water use scenarios 4, 5A, and 6, respectively; significant deficits (>50% of 50th percentile flows) are evident for a smaller proportion (Scenario 4 – 2.1%, Scenario 5A – 5.8%, Scenario 6 – 8.0%). Relative net streamflow benefit is evident for 10% of nodes under water use scenario 4 and only 4.3% under scenarios 5A and 6. At times of abnormally low streamflow (e.g. 95th percentile July flows), relative net streamflow deficits increase

(Figure 8, lower panel), with 4.4%, 17%, and 28% of nodes with greater than 10% net streamflow deficit under scenarios 4, 5A, and 6.

Temporal Analysis

Seasonal

The spatial analysis described above is based on estimates of annually-averaged consumptive use. The actual pattern of consumptive use is expected to vary through the year with seasonal changes in irrigation. According to monthly crop irrigation requirements in the *Washington Irrigation Guide*, irrigation season is April to September (NRCS 1992) for pasture/turf under the cooler climatic conditions than are occurring now or predicted for the future (i.e. 1951-1980 is the period used to develop the CIR and was predominantly in the cool-phase of the Pacific Decadal Oscillation (PDO)). Table 2 shows estimates of per-household monthly consumptive water use for two subbasins, one with the highest annual crop irrigation requirement and highest irrigated acreage in scenario 4 (Coastal West) and another with a low annual crop irrigation requirement and lowest irrigated acreage in scenario 4 (Middle Fork). Both indicate that peak household monthly consumptive water use (which occurs in July) can be over 3-fold greater than the annually-averaged estimate. Household monthly consumptive use also exceeds the annual average through much of the irrigation season, from April or May through August or September, depending on water use scenario.

Accordingly, aggregating across WRIA 1, DGWPE well consumptive use exhibits a strong seasonal pattern, peaking in July and trailing off before and after (Figure 9, upper panel). Lowest consumptive use is from October through March, when monthly crop irrigation requirement is zero (based on average conditions during the 1951-1980 period). Comparing across water use scenarios, monthly consumptive water use is higher in scenario 5B relative to scenario 4 April through September, but equivalent outside the irrigation season. The seasonal patterns for Scenario 5A varies depending on whether the maximum daily limit of 5000 gallons per day is applied. Constraining water use to 5000 gallons per day or less while maintaining the 3000 gallon per day average (Scenario 5A) would lessen the peaks but increase consumptive water use September through May relative to the alternative (Scenario 5A-Alt). Even if average per-household water use across WRIA 1 is more consistent with scenario 4, for DGWPE well users using greater amounts of water (up to legal limits, i.e. consistent with Scenarios 5A and 5B), Figure 7 indicates what the localized impacts would be relative to the lower water use scenario for the month of July.

To the extent that action offsets have been quantified, the vast majority of offsets are associated with projects that are in conceptual status and thus lower in implementation certainty (Figure 9, upper panel). A small proportion of offsets are associated with projects that are underway. Although there is some seasonal variation in offsets and the quantified offset was applied year-round, most projects were characterized as having year-round timing of benefit, which may overrepresent the offset in some months. If fully implemented and effective, projects will offset total WRIA 1 consumptive water use in all months and for all three scenarios evaluated, except in June through August for the Scenario 5A Alternative where maximum daily use is not constrained to 5000 gallons per day or less (Figure 9, lower panel). As described in *Spatial Analysis* above, however, it is important to remember that a considerable length of streams will not benefit from offset projects.

Evaluated at the subbasin scale (see Appendix B), the pattern is more nuanced. Offsets far exceed total consumptive water use throughout the year for all four scenarios evaluated in the Lower Nooksack and

South Fork subbasins, although most offsets are associated with projects that are in conceptual status. With water use scenario 4, offsets exceed monthly consumptive use throughout the year for Coastal North, Lake Whatcom, Lower Nooksack, Middle Fork Nooksack and South Fork Nooksack subbasins. In Coastal West, monthly consumptive use exceeds offsets May through September. For water use scenario 5B, there is a seasonal net deficit for Coastal North, Coastal West, and Middle Fork. Seasonal net deficit also is evident through much of the irrigation period in Coastal North, Coastal West, and Middle Fork and Lake Whatcom subbasins for both Scenario 5A alternatives. As with other subbasins, offsets are largely associated with conceptual projects. No offsets have been quantified for the Coastal South, North Fork and Sumas basins.

Table 2. Comparison of annually-averaged household water use with peak monthly household water use for different water use scenarios for two aggregated subbasins (units in gallons per day).

Aggregated Subbasin	Water Use Scenario	Annually-Averaged	Peak Monthly (July)	
		Household consumptive water use (gpd[1])	Household total water use (gpd)	Household consumptive water use (gpd)
Coastal West	4[2]	428	1870	1388
	5B[3]	657	2818	2147
	5A[4]	2062	5000	3647
	5A-Alternative[5]	2062	8859	6299
	6[6]	3437	5000	3647
Middle Fork	4	85	478	275
	5B	559	2688	2043
	5A	2013	5000	3594
	5A-Alternative	2013	9676	6732
	6	3355	5000	3594

[1] Calculated by dividing estimate from Dunn & Neff (2018) Appendix A by number of connections and converting to gallons per day.

[2] 0.064 acres irrigated

[3] 0.5 acres irrigated

[4] Annual average water use 3000 gallons per day: 0.5 acres irrigated, assume excess water use 68% consumptive, constrain monthly water use to no more than 5000 gallons per day.

[5] Same as above but without application of 5000 gallons per day limit.

[6] Maximum daily water use 5000 gallons per day: 0.5 acres irrigated, assume excess water use ~68% consumptive

Planning Period (2018-2038)

Consumptive water use has been estimated for 20 years of new DGWPE well connections, but consumptive water use will increase over time (Figure 10). Assuming water use scenario 4 and an annual population growth rate over the 20-year planning period consistent with projections, and assuming that project offsets accrue within the planning period, offsets associated with projects underway would exceed consumptive use until 2031, when they would be outpaced by consumptive use. If most of the offset associated with conceptual projects is realized, even the higher water use scenarios of 5A and 6 are offset at the WRIA 1 scale. It is important to note that two projects (#19, #21) require mature forest to provide full benefit and thus offsets associated with those projects, which comprise 71% of the offset quantified for WRIA 1, are not expected to fully accrue within the planning period

At the aggregated subbasin scale, the spatial distribution of growth may vary over time and, thus, rate of increase in consumptive use over time within subbasins is likely more variable than at the broader WRIA 1 scale. Nonetheless, it is clear that within many subbasins (Appendix C), an offset gap is likely early on because no or few projects are underway while growth is proceeding. There is also a potential for an offset gap later in time if growth outpaces implementation.

Ecological Implications

Viability of salmonids and other instream resources in freshwater is a function of both habitat conditions (physical habitat characteristics and water quality) and the ecosystem processes that form and maintain those conditions, including hydrology, sediment dynamics, riparian, floodplain-channel interactions, habitat connectivity, organic matter, and nutrient supply (PSRITT 2015). While the focus of this assessment is an evaluation of the cumulative effects of DGWPE consumptive use impacts and projects on hydrologic regime, it is important to consider ecological effects more broadly.

Hydrologic Regime

Annually-averaged estimates of DGWPE consumptive use vary by subbasin but total 0.9 cfs, 6.80 cfs, and 11.80 cfs for water use scenarios 4, 5A, and 6, respectively. Accounting for both DGWPE consumptive use impacts and projects, there is a considerable spatial gap evident, with the vast majority (>80%, >500 miles) of affected stream length showing a net negative streamflow impact under all three water use scenarios evaluated (scenario 4, 5A, and 6). Absolute magnitude of cumulative DGWPE consumptive impact within any single stream segment is relatively low for much of the affected stream length, with less than 0.3 cfs under water use scenario 4, increasing to maxima of 2 cfs and 3.6 cfs at the mouth of the Nooksack River under legally permissible water use scenarios 5A and 6. Accounting for offsets, net streamflow benefit is evident for the Nooksack River, South Fork, Bertrand Creek, and in portions of some independent tributary watersheds (Dakota, Terrell, California, Whatcom/Lake Whatcom, and other smaller watersheds). At the highest water use scenario 6, net streamflow deficit is greatest (>0.5 cfs) in Dakota, Tenmile, Squalicum, and California Creeks, and the North Fork and Sumas River. Relative net streamflow impact under relatively normal July streamflow conditions (i.e. impact relative to 50th percentile exceedance flow for July) is less than 10% for most of the locations for which hydrologic modeling is available. However, significant net streamflow deficits are evident in the Silver, Dakota, Tenmile/Deer, lower Squalicum Creek, and Wiser Lake Creeks and Sumas River, especially at higher water use scenarios. During more extreme July low streamflows (i.e. when flows are at or below 95th percentile exceedance flows), 4.5%, 17%, and 28% of locations (nodes) show a greater than 10% net streamflow deficit under water use scenarios 4, 5A, and 6.

Since it is based on annually-averaged estimates of new DGWPE well consumptive use, the spatial analysis likely underestimates impacts during irrigation season (April to September; NRCS 1992), especially during peak irrigation. To the extent that action offsets have been quantified, the vast majority of offsets are associated with projects that are in conceptual status and thus lower in implementation certainty. If fully implemented and effective, projects across WRIA 1 offset consumptive use impacts through the year for scenario 4, spatial gaps notwithstanding, but not for the water use scenario 5A (3000 gallons per day annual average) with no constraint on daily maximum withdrawal). Quantified offsets, associated largely with conceptual projects, in Lower Nooksack and South Fork aggregated subbasins far exceed DGWPE consumptive use. Seasonal gaps are evident for Coastal West subbasin under water use scenario 4, and for Coastal North, Coastal West, Middle Fork, and Lake Whatcom under higher water use scenarios. No offsets have been quantified for the Coastal South, North Fork and Sumas subbasins.

Given that many of the projects are in conceptual status, the timing of the onset of offsets have not been well-characterized and benefits may not accrue during the planning period. This may hold most true for projects involving restoration of hydrologic processes (e.g. Middle Fork Porter Creek Alluvial Fan project; Stewart Mountain/Sf Nooksack Conservation Sale; Wetland Restoration, Enhancement, and/or Creation on Ecology-approved NEP parcels; Skookum Creek Restoration), even though such restoration may provide the most sustainable streamflow benefits into perpetuity. Lifespan of benefits is also a concern: although consumptive use impacts will presumably last, many of the identified projects will require ongoing maintenance and operations funding for offsets to persist into perpetuity.

Other Ecological Effects

Although the magnitude of cumulative streamflow impacts is relatively small through much of WRIA 1, it is significant in some stream systems, and even minor impacts will exacerbate degraded water quality conditions, especially high stream temperatures and low dissolved oxygen, that exist through much of the Nooksack Basin. A number of streams throughout WRIA 1 have been listed as impaired for low dissolved oxygen and high stream temperature on Washington State's 303(d) list (Figure 10), many of which will be impacted by DGWPE consumptive use.

Although most projects are designed to offset DGWPE consumptive use impacts to streamflow, several projects will have other ecological benefits (Bucknell et al. 2018), albeit more localized to the project area. Table 9 summarizes other (non-hydrologic) ecological benefits of projects. Except for the PDR program, all would benefit areas considered high priority for Nooksack chinook recovery.

Salmonid Impacts

As described in the *WRIA 1 Salmonid Recovery Plan* (WRIA 1 SRB 2005), stream flow exerts a strong influence over salmonid habitat by regulating wetted surface area and thus the amount of available habitat, as well as by controlling the spatial distribution of depths and velocities. In addition to generally reducing habitat availability, low streamflows also affect salmonids as follows: (1) impeded upstream migration for prespawn migrants, especially in tributaries; (2) reduced availability of habitat for spawners, which require sufficient depth and velocities in areas with suitable spawning substrate;

Table 3. Summary of Other (Non-Hydrologic) Ecological Effects of Projects.

	Habitat Conditions				Ecosystem Processes			
Project	Physical Habitat Structure	Water Quality	Sediment Dynamics	Riparian	Floodplain-Channel Interactions	Habitat Connectivity	Organic Matter	Nutrient Supply
Middle Fork Porter Creek Alluvial Fan Project	X	X	X		X	X		
Wetland Restoration, Enhancement, and/or Creation on Ecology-Approved NEP Parcels		X		X				
Skookum Creek Restoration	X	X	X	X	X		X	X
Stewart Mountain/SF Nooksack Conservation Sale		X		X	X		X	X
North Fork Maple Reach Restoration Phase 1	X		X	X	X		X	X
Purchase of Development Rights Program			X	X	X		X	X

redd dewatering, since incubating embryos require sufficient intragravel flow to maintain adequate temperature and dissolved oxygen and to eliminate waste; (4) dewatering and/or reduced connectivity of secondary channels and complex edge habitat, affecting fry; (5) decreased survival of rearing juveniles due to increased vulnerability to terrestrial predators in shallow depths; and (6) degraded water quality, including increased temperatures and concentration of contaminants and reduced dissolved oxygen.

Salmonid species distribution by aggregated subbasin is shown in Table 3. Negative impacts of DGWPE consumptive use to ESA-listed salmonid species is expected to be greatest for steelhead, which are broadly distributed throughout much of the WRIA 1 lowlands, and especially the Nooksack River Winter Run, Drayton Harbor Tributaries Winter Run, and Samish River/Bellingham Bay Tributaries Winter Run demographically independent populations. Fall chinook and foraging and overwintering bull trout will also likely be negatively impacted. Where spatial and temporal gaps exist, life stages present during low-flow conditions, especially juvenile rearing but also upstream migration for summer-migrating species (Chinook, Sockeye, and Pink salmon; summer steelhead; bull trout), are the most vulnerable (Table 4).

Net Ecological Benefit

In conclusion, there is low certainty that the cumulative impacts of both the projected DGWPE consumptive use over the next 20 years and the streamflow and other ecological benefits associated with selected actions will result in a net ecological benefit in perpetuity. **Conversely, there is reasonable certainty that the cumulative impacts will rather result in a net ecological deficit,** to instream resources, including salmonids, in WRIA 1 due to the considerable spatial gap between estimated annualized consumptive use impacts and project offsets (as currently quantified) and other ecological benefits, the significant magnitude of net streamflow deficit at selected locations, the temporal gap in project offsets during peak irrigation (including during drought periods) in areas benefitting from offsets, uncertainty in magnitude and spatial distribution of future DGWPE consumptive use impacts, and uncertainty about project implementation, effectiveness, and magnitude, seasonal timing, and onset of streamflow offsets . Measures that would increase certainty of net ecological benefit include:

- Fully mitigating (in-kind, in time, in place) DGWPE consumptive use impacts in all affected streams (e.g. through onsite mitigation by each well owner or other means) year-round, including during drought periods.
- Increasing the number, magnitude, and/or location of project offsets to provide a factor of safety to buffer against uncertainty in DGWPE consumptive use impacts and project offsets.
- Implementing policies and programs that:
  - Avoid or minimize impact (e.g. reducing withdrawal limits; water conservation)
  - Reduce uncertainty in consumptive use impacts (e.g. metering; stream monitoring)
  - Reduce uncertainty in project implementation and effectiveness (e.g. ensure sufficient funding available; implement strong monitoring and adaptive management program).

Table 4. Salmonid species presence by aggregated subbasin.

		Coastal North	Coastal South	Coastal West	Lake Whatcom	Lower Nooksack	Middle Fork	North Fork	South Fork	Sumas
Nooksack Early Chinook	NF/MF Nooksack Early Chinook					X	X	X		
	SF Nooksack Early Chinook					X			X	
Puget Sound Steelhead	Drayton Harbor Tributaries Winter Run	X								
	Nooksack River Winter Run					X	X	X	X	
	South Fork Nooksack River Summer Run					X			X	
	Samish River, Bellingham Bay Tributaries		X							
Bull Trout	Nooksack Core Area					X	X	X	X	
	Chilliwack Core Area									X
Fall chinook salmon		X	X	X		X	X	X	X	X
Coho salmon		X	X	X		X	X	X	X	X
Chum salmon		X	X	X		X	X	X	X	X
Pink salmon		X	X	X		X	X	X	X	X
Sockeye salmon			X	X		X	X	X	X	X
Coastal cutthroat trout		X	X	X	X	X	X	X	X	X
Kokanee					X					

Table 5. Salmon life stage periodicity relative to seasonal variation in DGWPE consumptive use impacts (color indicates relative magnitude of monthly consumptive use).

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Spring Chinook Salmon	River Entry		X	X	X	X	X	X	X				
	Upstream Migration / Holding		X	X	X	X	X	X	X	X	X		
	Spawning							X	X	X	X		
	Intragravel Development	X	X	X				X	X	X	X	X	X
	Age-0 rearing[a]	X	X	X	X	X	X	X	X	X	X	X	X
	Age-0 outmigration[a]	X	X	X	X	X	X	X	X	X	X	X	
	Age-1+ rearing[b]	X	X	X	X	X	X	X	X	X	X	X	X
	Age-1+ outmigration[b]	X	X	X	X	X	X	X	X	?	?	?	?
Fall Chinook Salmon	River Entry						?	X	X	X	X	?	
	Upstream Migration / Holding						?	X	X	X	X	X	?
	Spawning									X	X	X	?
	Intragravel Development	X	X	X	X					X	X	X	X
	Fry <~55mm	X	X	X	X	X	X						
	Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
	Outmigration		X	X	X	X	X	X	X	X	X	X	
Coho Salmon	River Entry	X	?					X	X	X	X	X	X
	Upstream Migration / Holding	X	X					X	X	X	X	X	X
	Spawning	X	?								X	X	X
	Intragravel Development	X	X	X	X	X					X	X	X
	Fry <~55mm		X	X	X	X	X						
	Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
	Outmigration			X	X	X	X	X					
Chum Salmon	River Entry	X							X	X	X	X	X
	Upstream Migration / Holding	X	X						X	X	X	X	X
	Spawning	X	X								X	X	X
	Intragravel Development	X	X	X	X						X	X	X
	Fry		X	X	X	X	X	X					
	Juvenile Rearing (not applicable)												
	Outmigration		X	X	X	X	X	X					
Pink Salmon	River Entry						?	X	X	X			
	Upstream Migration / Holding						?	X	X	X	X		
	Spawning								X	X	X		
	Intragravel Development	X	X	X	X	X			X	X	X	X	X
	Fry	X	X	X	X	X	X						X
	Juvenile Rearing (not applicable)												
	Outmigration	X	X	X	X	X	X						
Sockeye salmon	River Entry				X	X	X	X	X	X	X		
	Upstream Migration / Holding				X	X	X	X	X	X	X	X	
	Spawning								X	X	X	X	
	Intragravel Development	X	X	X	X				X	X	X	X	X
	Fry and Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
	Outmigration			X	X	X	X	X					

Notes: (a) Age-0 refers to fish that outmigrate as subyearlings.
(b) Age-1+ refers to fish that outmigrate as yearlings or older.

Legend:
X — Months in which the species lifestage occurs in WRIA 1.
? — Months in which there is a question whether the species lifestage occurs in WRIA 1.

Table 6. Life stage periodicity for other salmonids relative to seasonal variation in DGWPE consumptive use (color indicates relative magnitude of monthly consumptive use).

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Summer Steelhead	Upstream Migration				X	X	X	X	X	X	X		
	Holding	X	X	X	X	X	X	X	X	X	X	X	X
	Spawning		X	X	X								
	Adult Outmigration		X	X	X	X							
	Intragravel Development		X	X	X	X	X						
	Fry <~55mm	X			X	X	X	X	X	X	X	X	X
	Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
	Juvenile Outmigration		X	X	X	X	X	X	X				
Winter Steelhead	Upstream Migration	X	X	X	X	X	X				X	X	X
	Holding	X	X	X	X	X	X	X			X	X	X
	Spawning	X	X	X	X	X	X	X					X
	Adult Outmigration	X	X	X	X	X	X	X					X
	Intragravel Development	X	X	X	X	X	X	X	X				X
	Fry <~55mm	X		X	X	X	X	X	X	X	X	X	X
	Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
	Juvenile Outmigration		X	X	X	X	X	X	X				
Coastal Cutthroat (anad.)	Upstream Migration	X	X	X	X	X	X	X	X	X	X	X	X
	Holding	X	X	X	X	X	X	X	X	X	X	X	X
	Spawning	X	X	X	X	X	X	X					
	Adult Outmigration	X	X	X	X	X	X						
	Intragravel Development	X	X	X	X	X	X	X	X	X			
	Fry <~55mm	X	X	X	X	X	X	X	X	X	X	X	X
	Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
	Juvenile Outmigration		X	X	X	X	X	X	X				
Bull Trout/Dolly Varden (anad.)	Upstream Migration					X	X	X	X	X	X	X	
	Subadult Upstream Migration								X	X	X	X	
	Subadult Overwinter Holding	X	X	X	X	X			X	X	X	X	X
	Holding	X	X	X	X	X	X	X	X	X	X	X	X
	Spawning								X	X	X	X	X
	Adult Outmigration	X	X	X	X	X	X	X					
	Intragravel Development	X	X	X	X				X	X	X	X	X
	Fry <~55mm		X	X	X	X	X	X	X				
	Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
	Juvenile Outmigration			X	X	X	X	X	?				

Analysis Limitations and Uncertainty

Time and resource constraints strongly limited the depth and breadth of this ecological assessment. RCW 90.94 established a very tight timeframe (February 1, 2019) for adoption of the WRIA 1 Watershed Plan update, leaving less than 10 months to conduct the technical analyses and develop the preliminary draft of the WRIA 1 Watershed Plan update. Ecology's *Net Ecological Benefit* guidance (Ecology 2018), published in June 2018, provided guidance but not specific methods for evaluating net ecological effects, so new methods based on best professional judgement were developed. As time allows, this assessment will be updated and refined.

Sources of uncertainty in the ecological assessment include:

- Uncertainty in magnitude, spatial distribution, and timing of consumptive use associated with new DGWPE wells
- Uncertainty in magnitude, spatial distribution, and timing of offsets from actions
- Uncertainty in the implementation and effectiveness of actions
- Assumptions underlying analysis methods

Input Data

Population growth rate, proportion of growth outside of urban areas, and water source (i.e. whether new development connects to an existing water association or water district) will all affect the number of new DGWPE wells through 2038. Estimates of consumptive use are a function of the number of connections and household water use, which in turn is based on irrigation needs, area irrigated, and other factors. The climate is warmer since the period upon which crop irrigation requirements are based (1951-1980; NRCS 1992) and is predicted to continue to warm, which will further increase water used for irrigation. The growth scenario used in this analysis is a reasonable estimate of the spatial distribution of growth across WRIA 1 and perhaps at the scale of aggregated subbasins, but there is greater uncertainty at the parcel level, as the number of buildable parcels outside of UGAs far exceed the projected rural growth over the next 20 years.

The project list has been evolving through the process, and not all of the projects are characterized in the RH2 Task 2 memo (Bucknell et al. 2018). Level of detail available varies by project, and information about project benefits is especially limited for conceptual projects. Several projects lack quantification of offsets, including the Managed Aquifer Recharge Feasibility Study, the Purchase of Development Rights program, the WRIA 1-wide conservation program, and the North Fork Maple Reach Restoration Phase 1 project. Excluding these from quantitative analyses may underestimate their associated streamflow benefits. However, there is also high uncertainty around (and possibly overestimate of) the magnitude of offset for the two projects with the largest offsets – Skookum Creek Restoration and Stewart Mountain/SF Conservation Sale. There is also uncertainty in project locations – offset was attributed to downstream stream segments based on geospatial (point) data provided by RH2, but the analysis could be refined later with more detailed location information, such as that available in the RH2 Task 2 memo. Finally, there is a high degree of uncertainty that offsets will be realized, especially for conceptual projects, due to uncertain feasibility, low certainty of implementation success, and low certainty of effectiveness.

Analysis Methods

Analysis methods also introduced uncertainty in the location and magnitude of impact to streamflow. Since there were no geospatial data available that would align with the selected option (option 4) for the number of new DGWPE connections over the next twenty years, total consumptive use within a subbasin was distributed to each parcel in the growth scenario proportional to the number of projected new households associated with the parcel. As such, consumptive use was attributed to some parcels that fall within (and may ultimately upon development be connected to) existing water service and water association boundaries. Consumptive use was also attributed to parcel centroids, whereas actual location of consumptive use will depend on where in the parcel the well is drilled.

Other potentially significant sources of uncertainty are the assumptions underlying the spatial analysis. The assumption that groundwater flow paths match surface topography is generally supported, although there are notable discrepancies, including in the northeast corner of Coastal North subbasin, northeast corner of Lower Nookasck, and the Coastal West subbasin (Dunn and Neff 2018). However, assuming that 100% of consumptive use from DGWPE wells results in flow deficit to closest stream segment and that the timing of deficit is immediate and synchronous with deficits elsewhere likely overestimates the impact of consumptive use on streamflow. However, the spatial analysis is based on estimates of annually-averaged consumptive use and likely underestimates consumptive use during peak irrigation season, except for water use scenario 6, which assumes withdrawal of 5000 gallons per day throughout the year.

As with RH2's estimates of total consumptive use, estimating monthly consumptive use for scenarios 5A and 6 requires assumptions about consumptive use and timing of "excess water use" (i.e. that required to achieve established daily or average annual maxima). This assessment is consistent with RH2's method regarding consumptive rates for "excess" water. It is generally assumed valid that the timing of excess water use parallels the combined indoor domestic and outdoor water use. Finally, estimates of increase in DGWPE well consumptive use over time assume a constant rate of population growth. While that assumption may generally be valid at the broader WRIA 1 scale, certainty decreases at finer spatial scales (i.e. at the subbasin level) due to uneven spatial distribution of rural growth from one year to the next.

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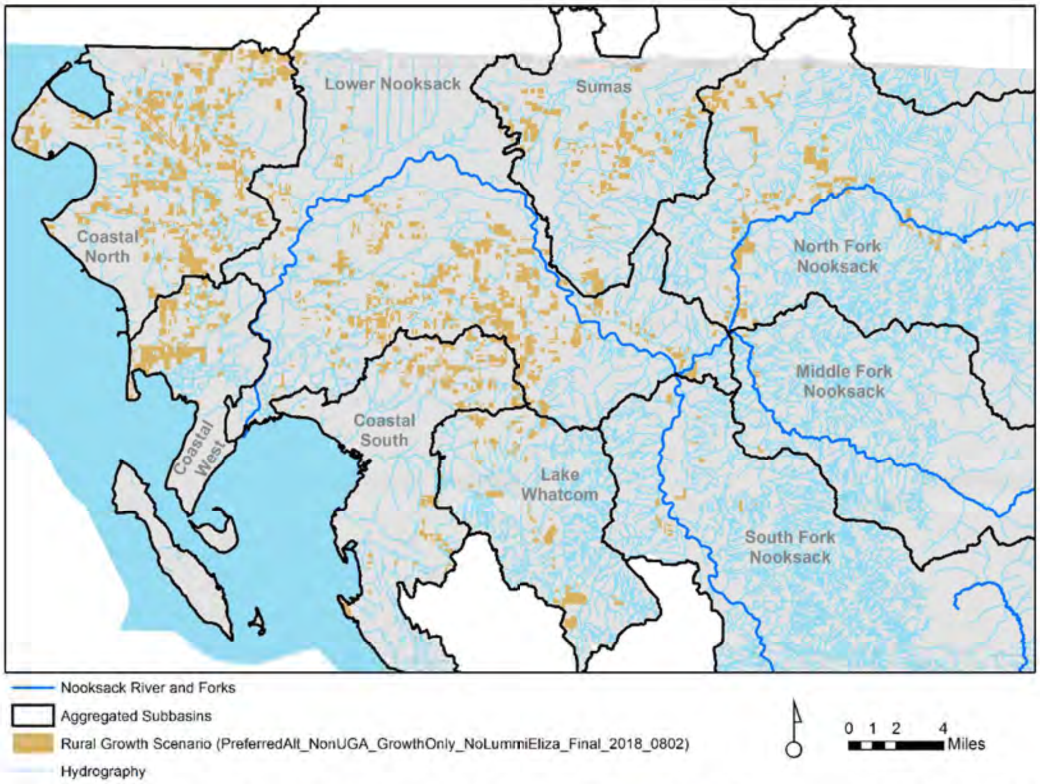


Figure 1. Rural growth scenario used in analysis (Source: Whatcom County Planning & Development).

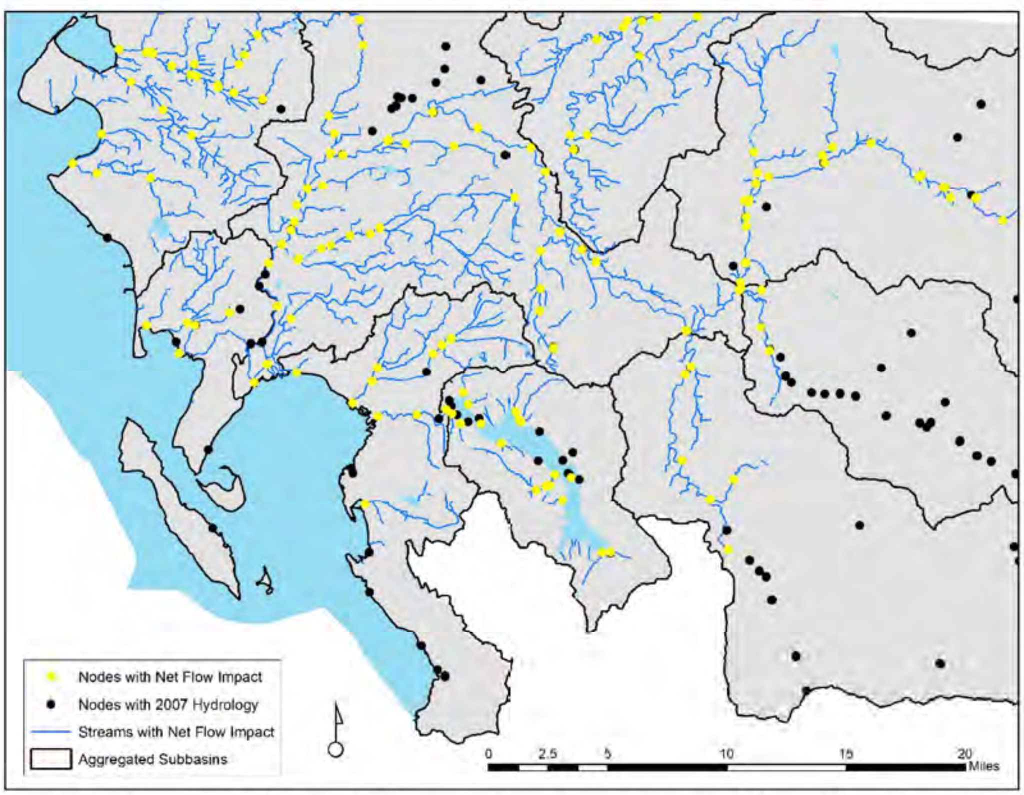


Figure 2. Nodes and streams with net flow impact (positive or negative) from DGWPE well consumptive use and/or selected actions.

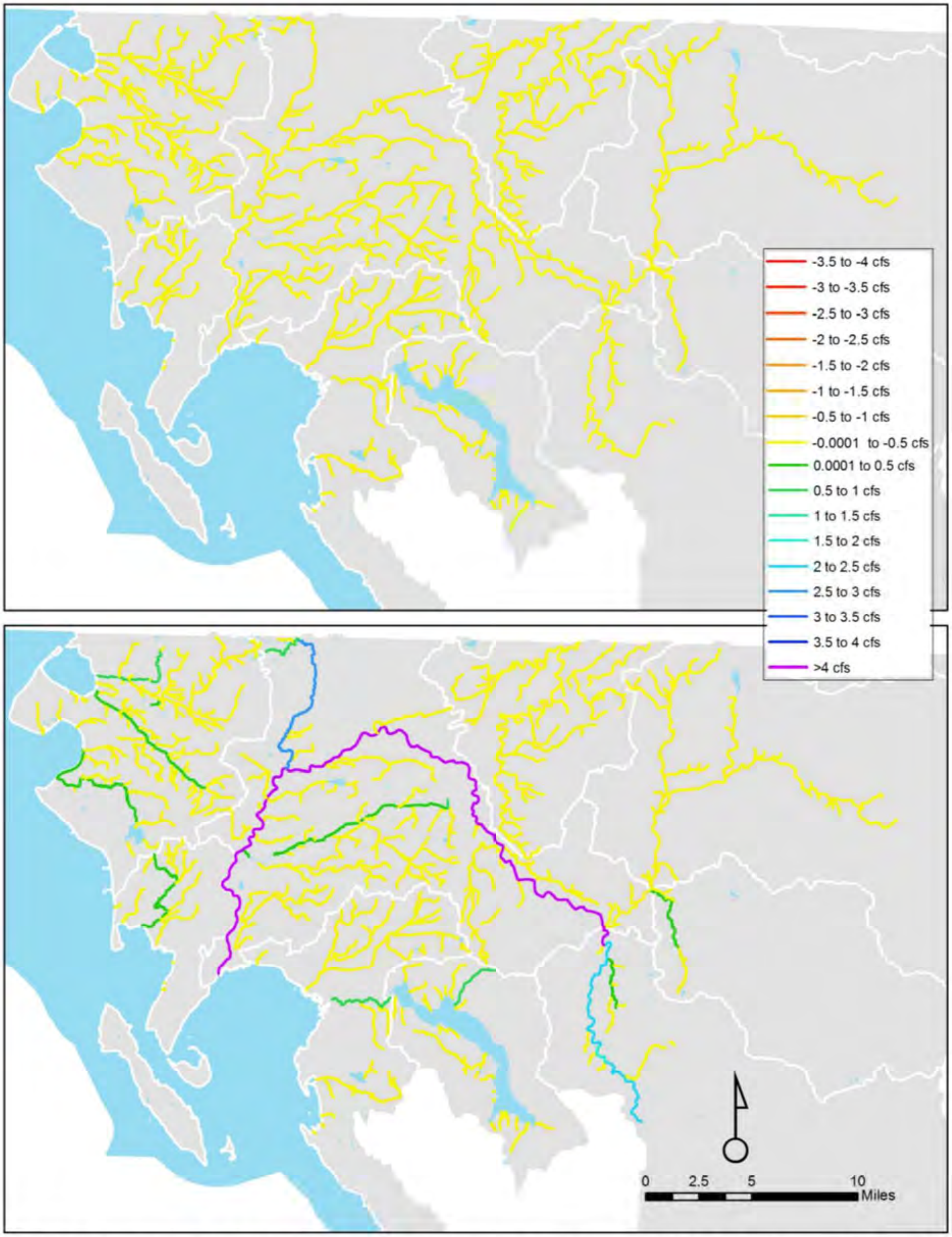


Figure 3. Cumulative streamflow impact (annually-averaged) from DGWPE well consumptive use (upper) and net streamflow impact with offset actions added (lower) under water use scenario 4 (option 4). In the lower panel, note that warmer colors (yellow to red) indicate net streamflow deficit and cooler colors (green to purple) indicate net streamflow benefit.

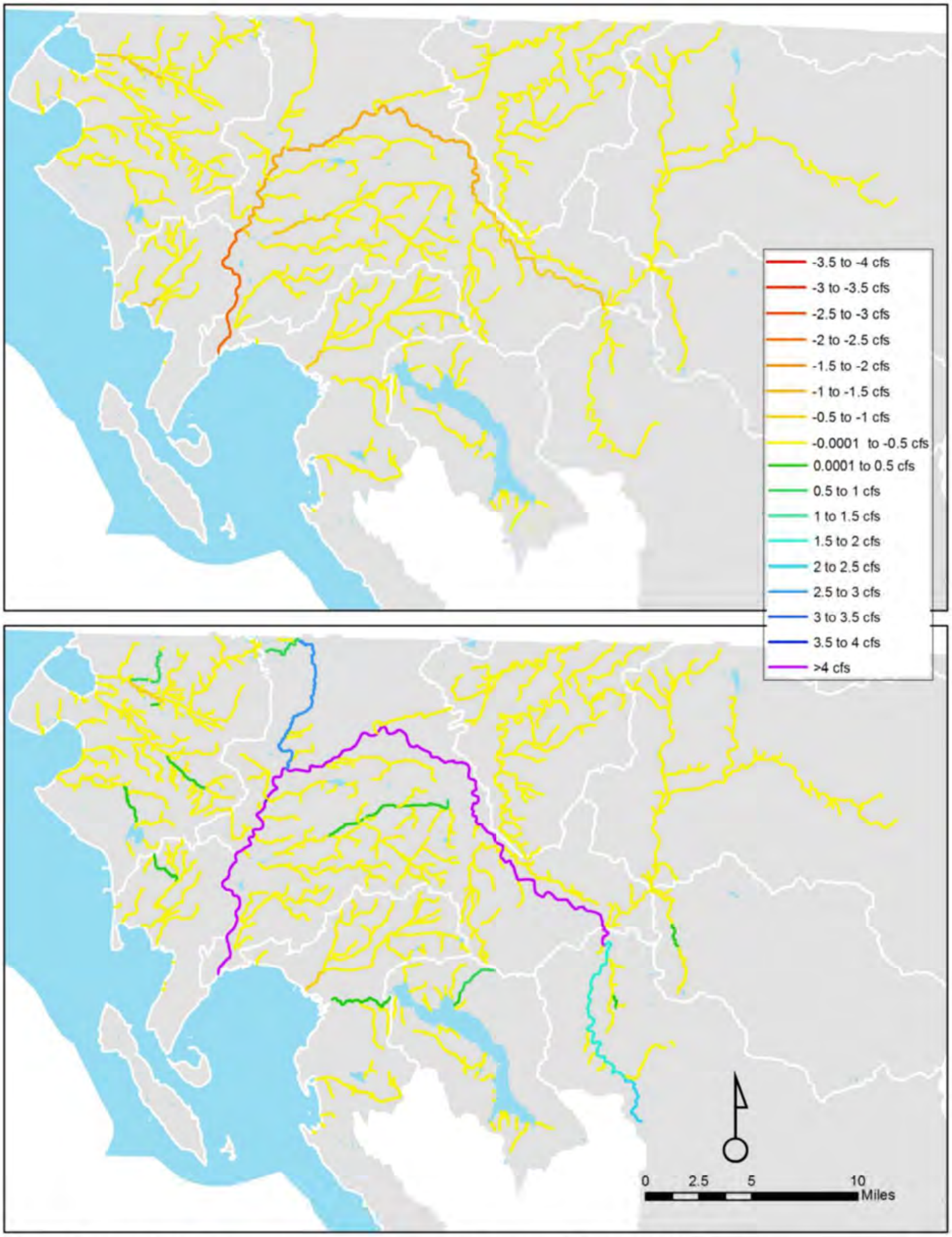


Figure 4. Cumulative streamflow impact (annually-averaged) from DGWPE well consumptive use (upper) and net streamflow impact with offset actions added (lower) under water use scenario 5A (option 4). In the lower panel, note that warmer colors (yellow to red) indicate net streamflow deficit and cooler colors (green to purple) indicate net streamflow benefit.

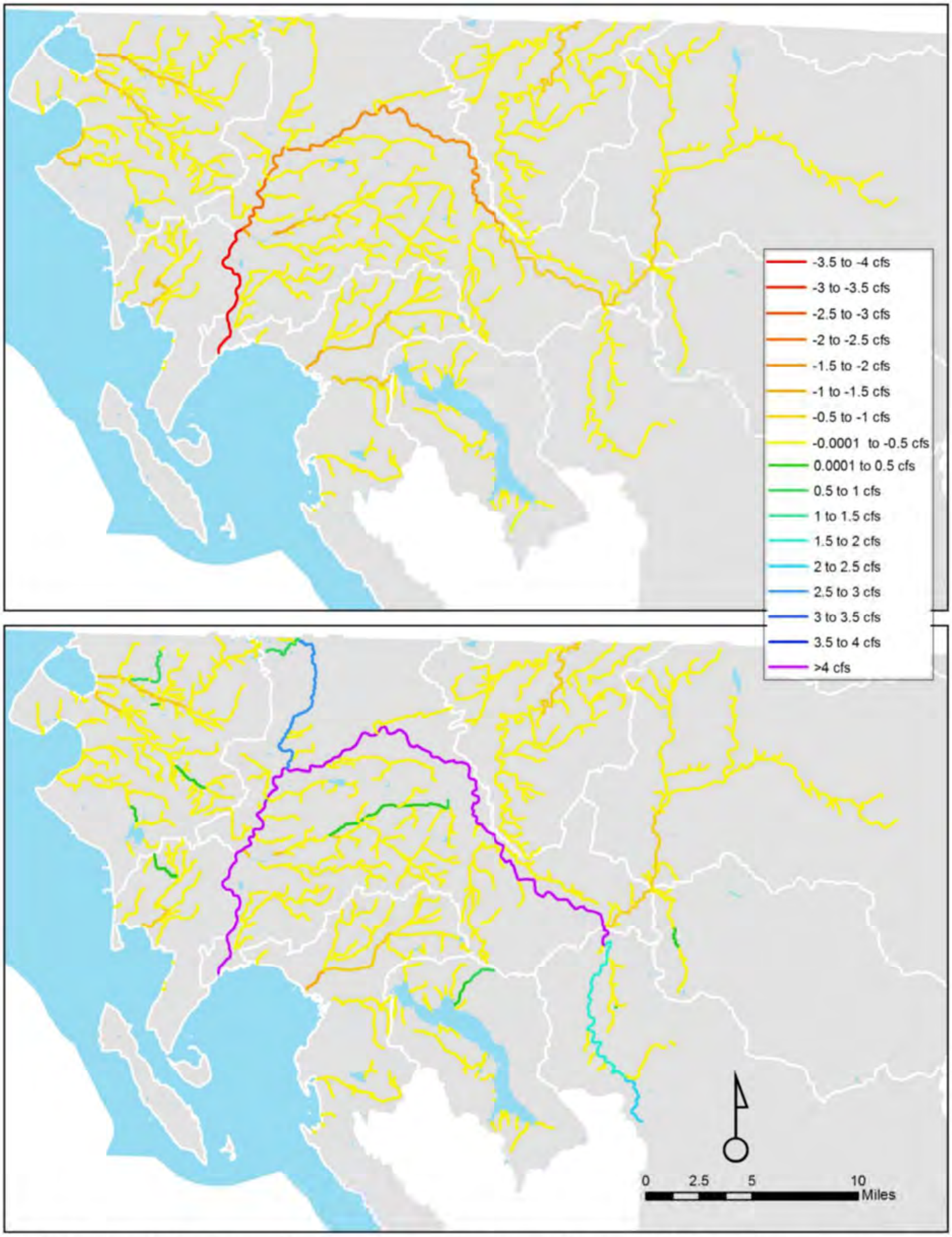


Figure 5. Cumulative streamflow impact (annually-averaged) from DGWPE well consumptive use (upper) and net streamflow impact with offset actions added (lower) under water use scenario 6 (option 4). In the lower panel, note that warmer colors (yellow to red) indicate net streamflow deficit and cooler colors (green to purple) indicate net streamflow benefit.

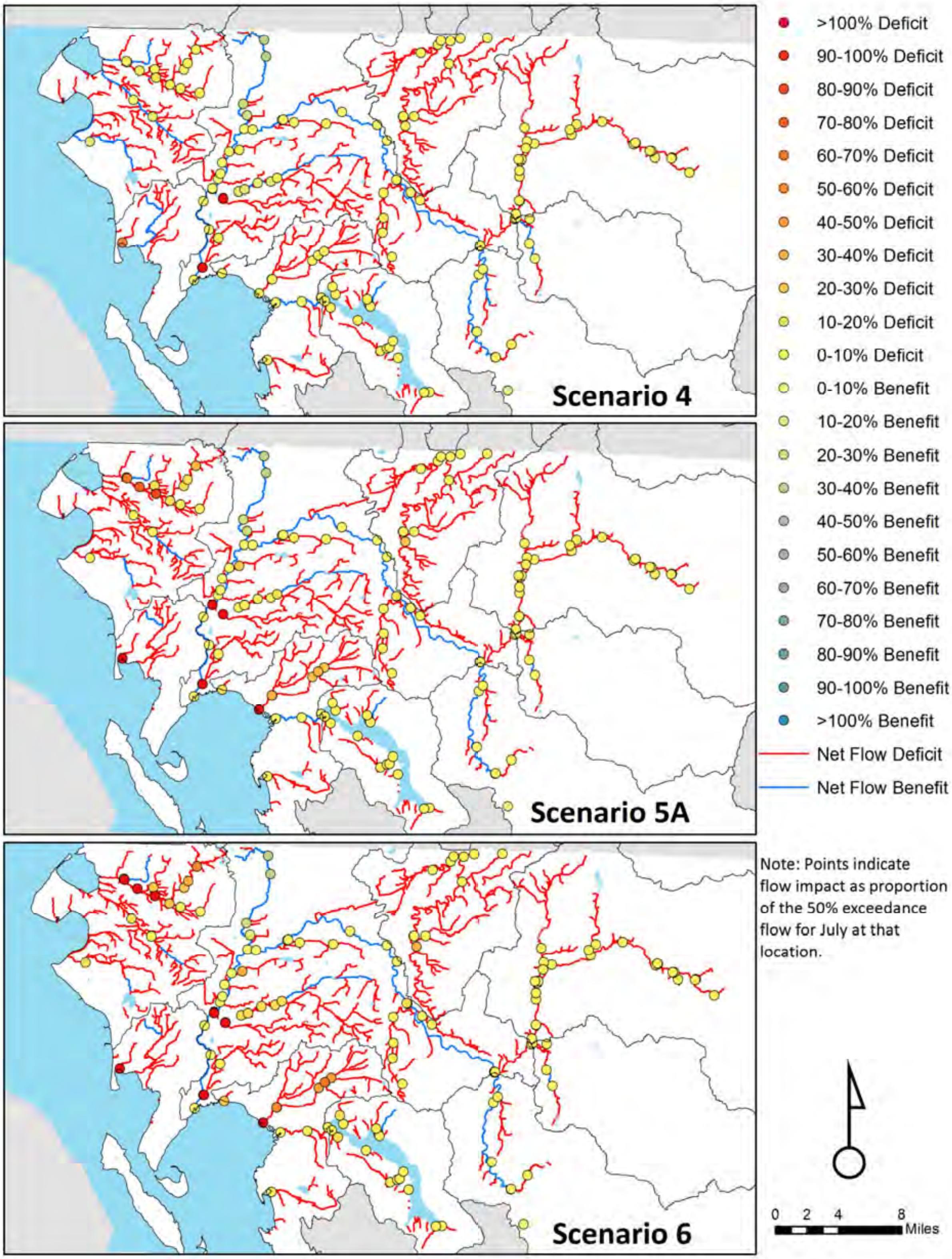


Figure 6. Cumulative streamflow impact from DGWPE well consumptive use and offset actions as a percentage of the 50th percentile July exceedance flow (relatively normal July streamflow).

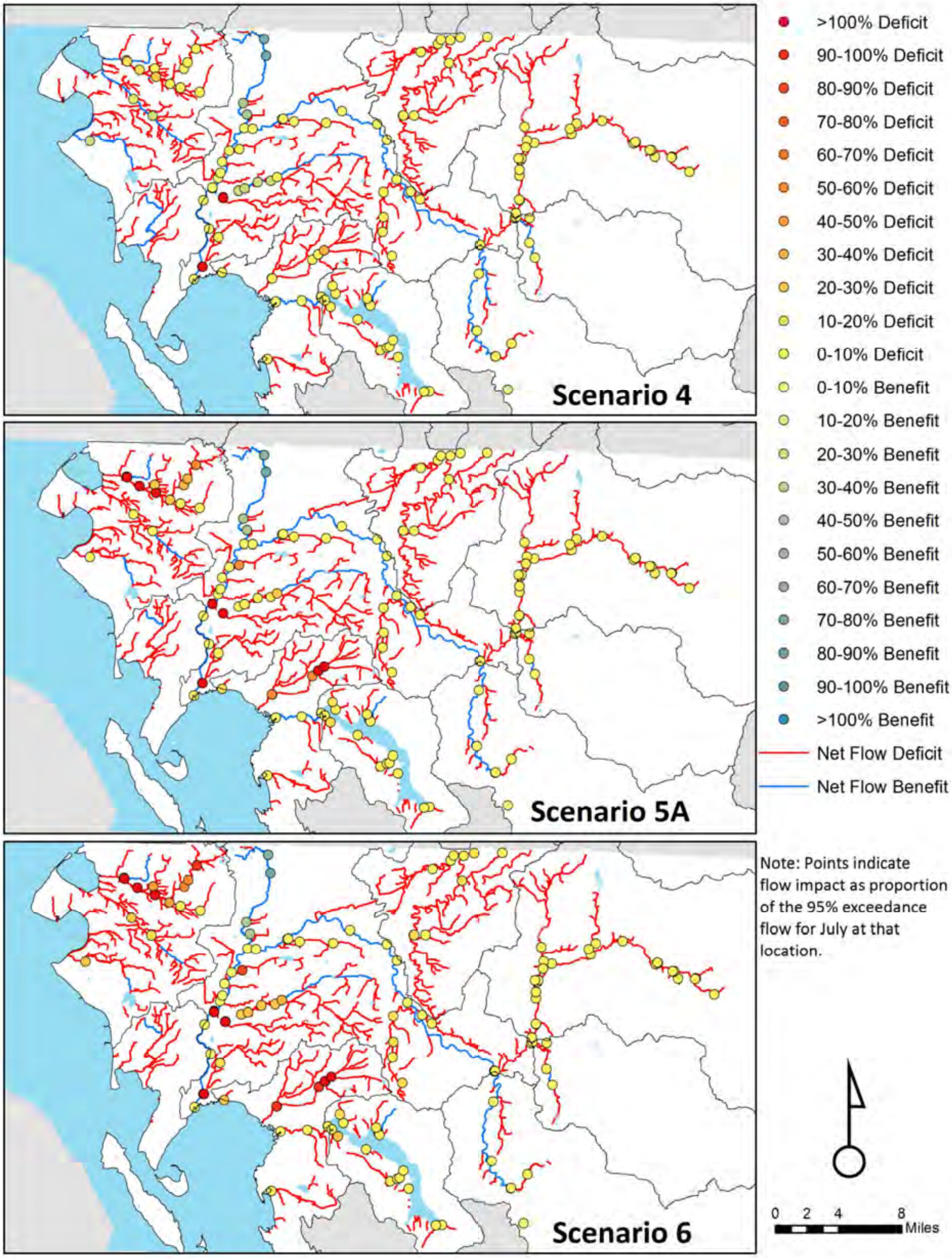


Figure 7. Cumulative streamflow impact from DGWPE well consumptive use and offset actions as a percentage of the 95th percentile July exceedance flow (less common July low flow).

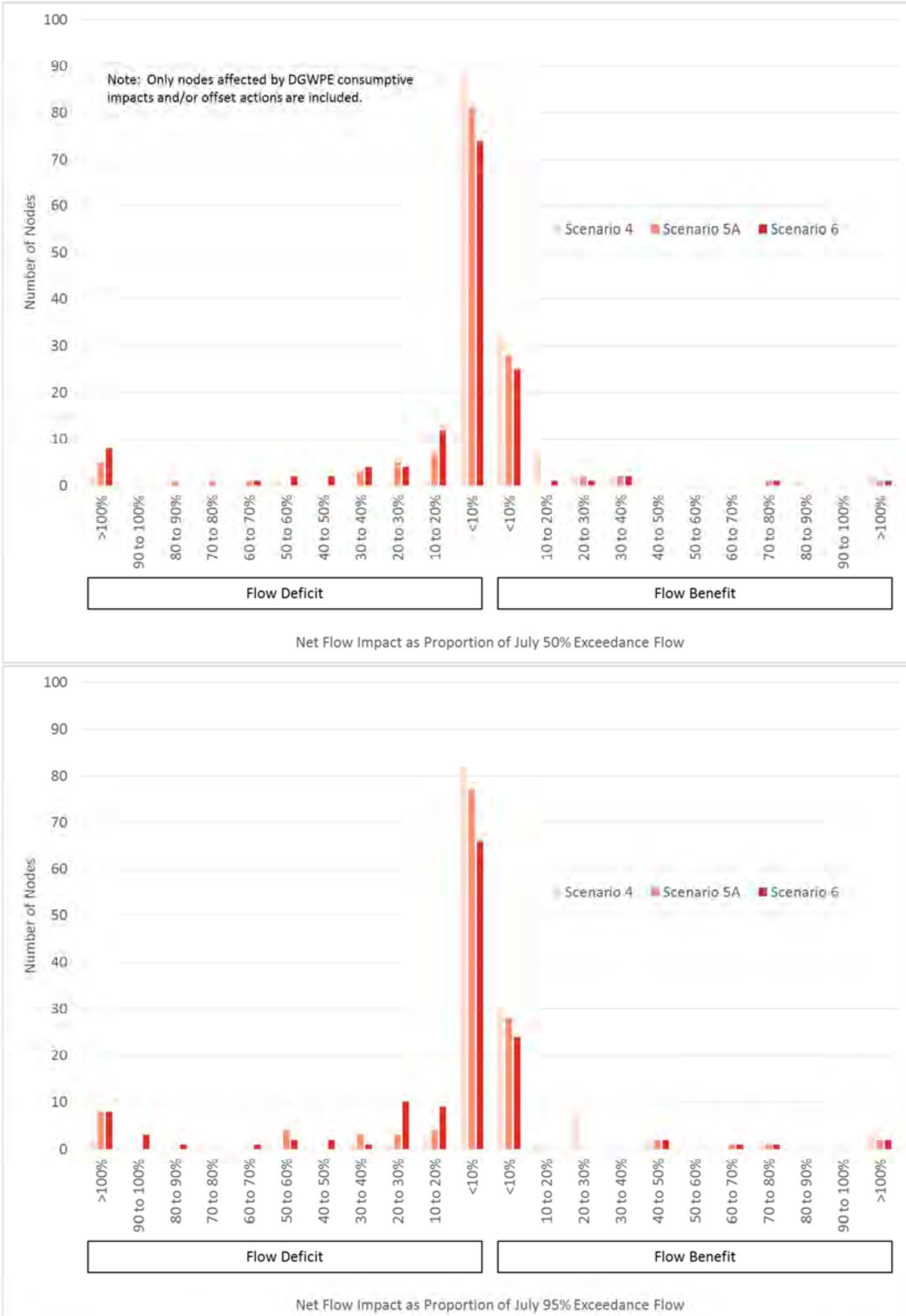
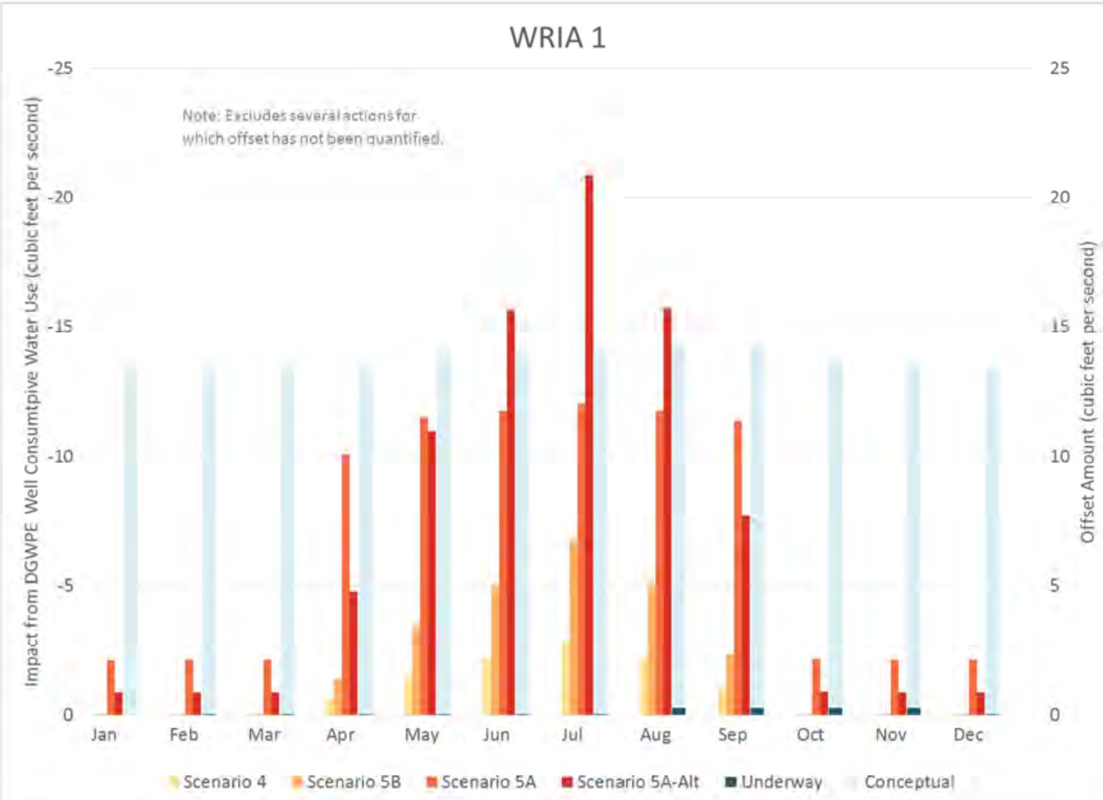


Figure 8. Frequency histograms for relative net streamflow impact (deficit or benefit). Upper panel: net streamflow impact as proportion of 50th percentile exceedance flow for July (representative of relatively normal July streamflows). Lower panel: net streamflow impact as proportion of 95th percentile exceedance flow for July (representative of less common extreme low flow).



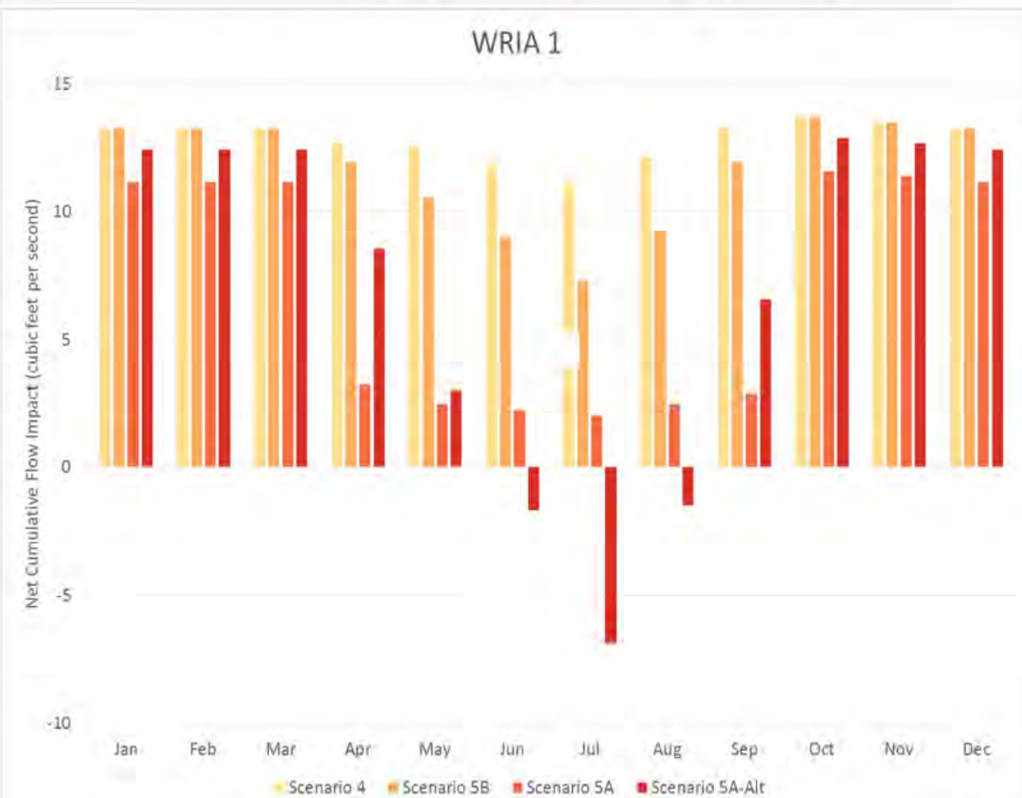


Figure 9. Seasonal variation in streamflow impact from DGWPE well consumptive water use and offset actions across WRIA 1 (upper panel) and net cumulative streamflow impact (lower panel) across WRIA 1.

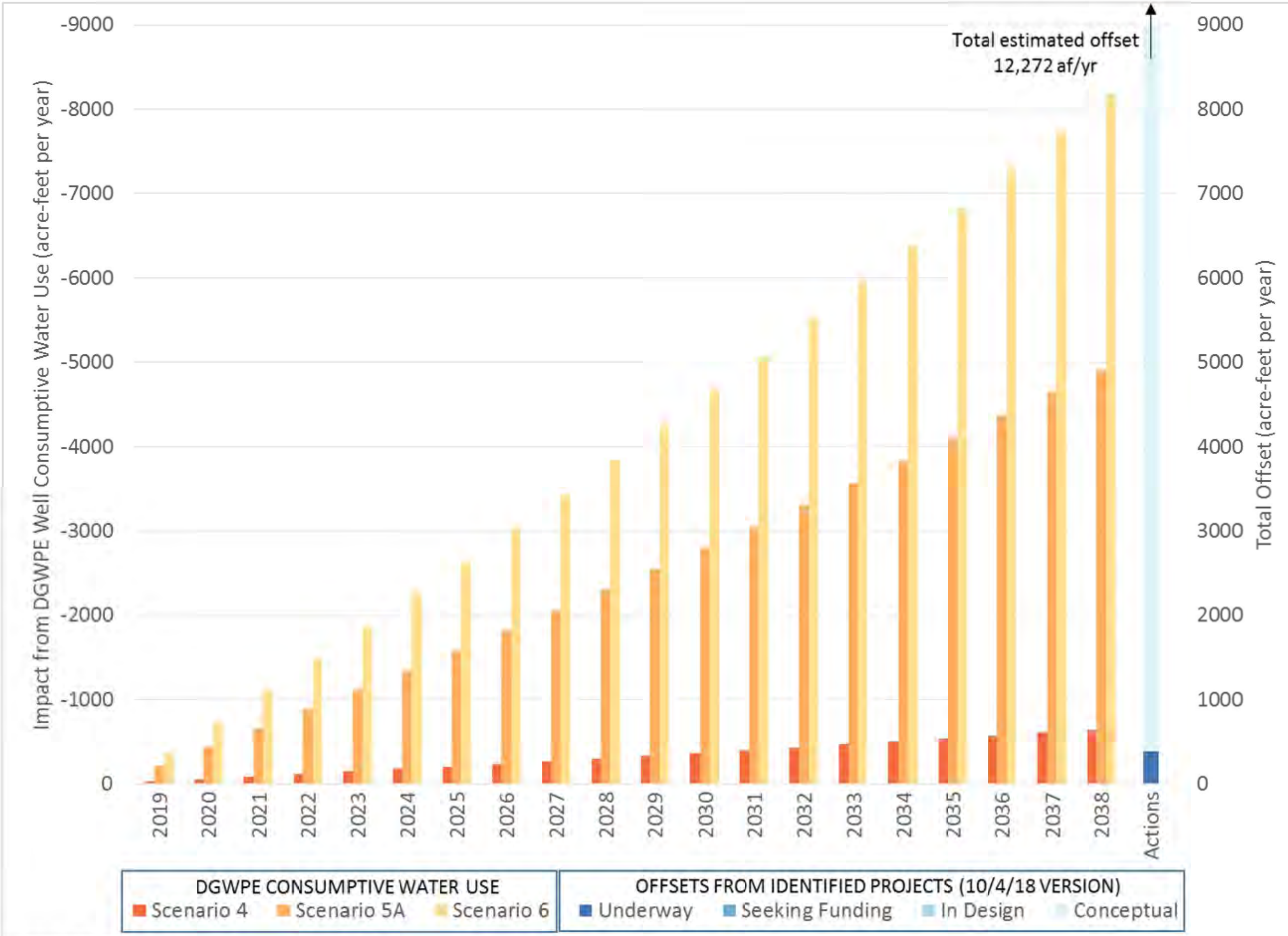


Figure 10. Anticipated increase in new DGWPE well consumptive water use over time relative to project offsets.

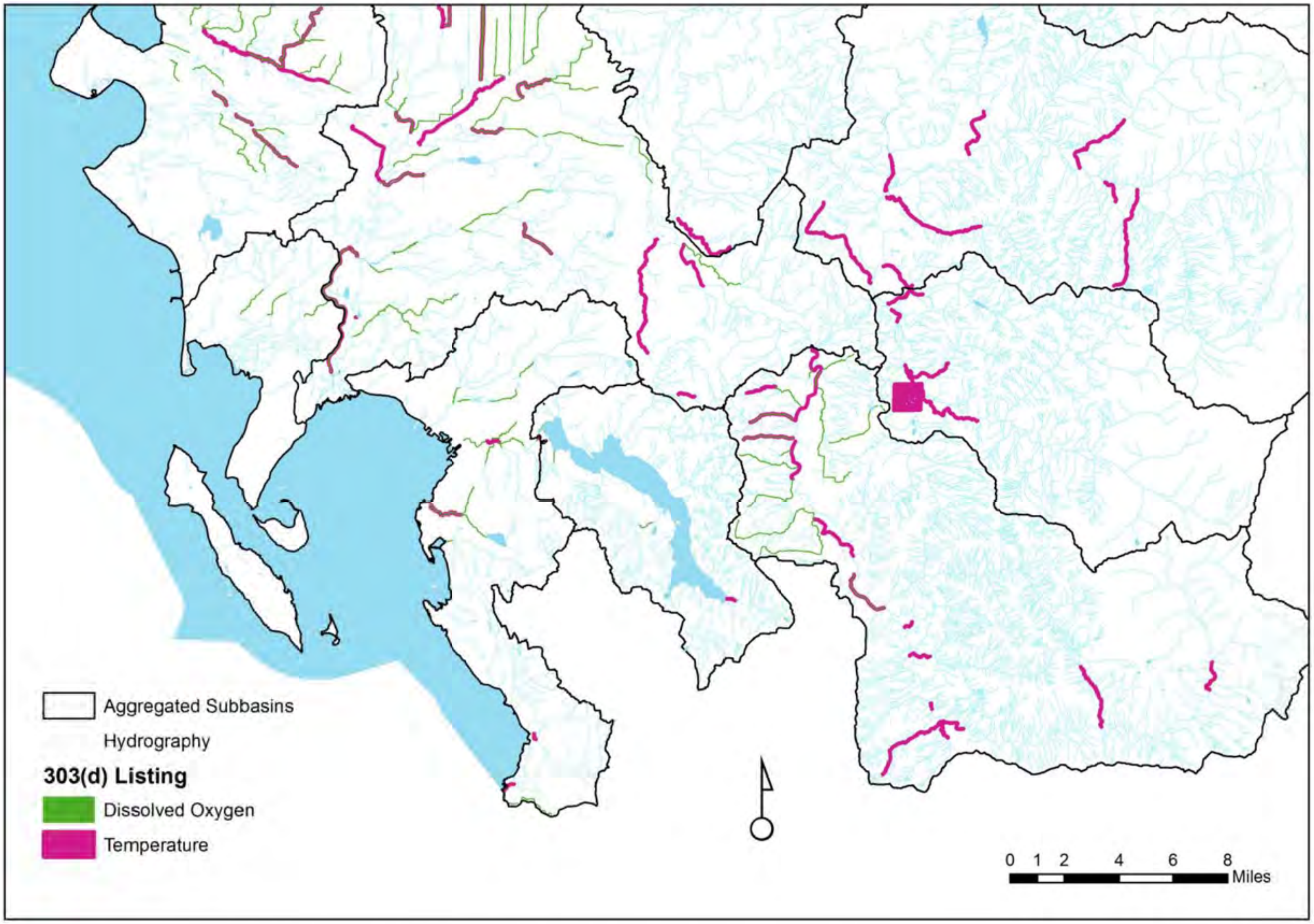
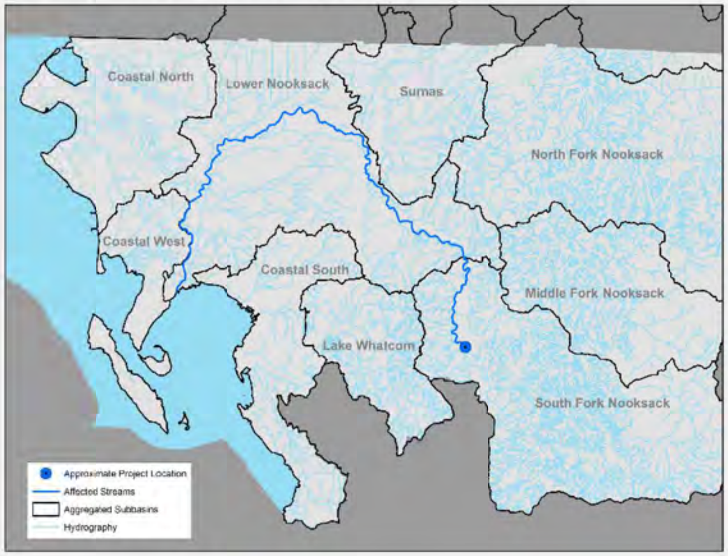


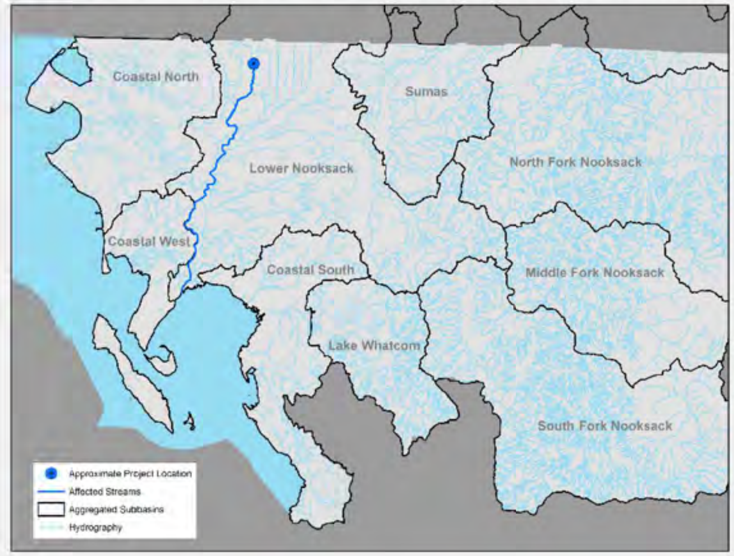
Figure 11. Stream segments on the 303(d) list for high stream temperature and low dissolved oxygen (Source: WA Department of Ecology).

Appendix A: Assignment of Project Offsets to Streams

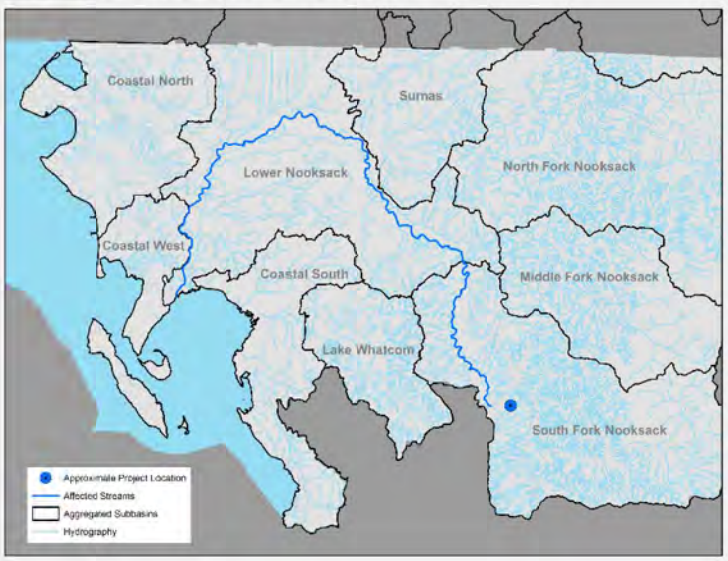
#1 Dairy Waste Processing/Treatment



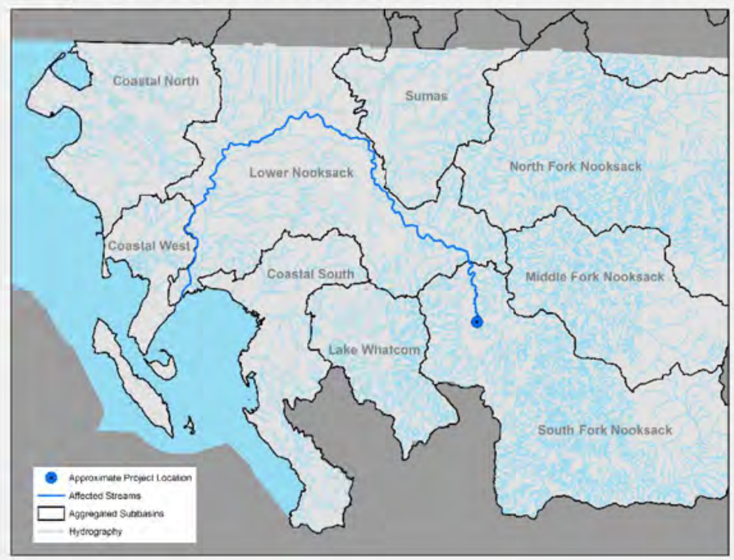
#2 Bertrand WID Ground Water Augmentation of Tributaries



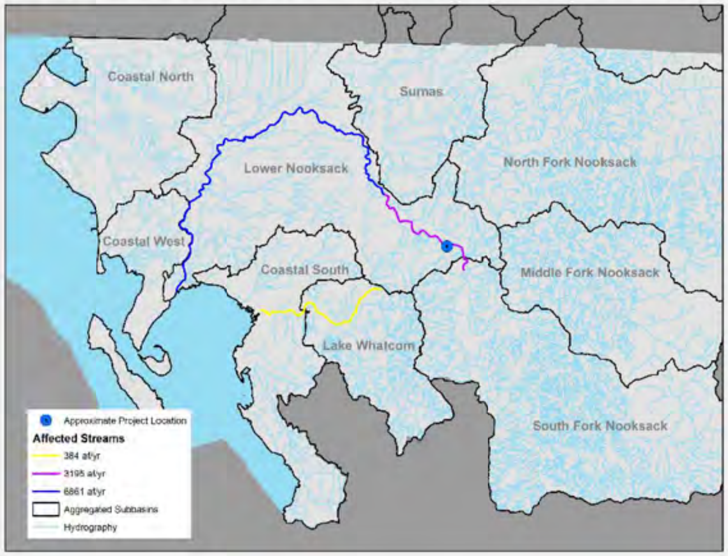
#19 Skookum Creek Restoration



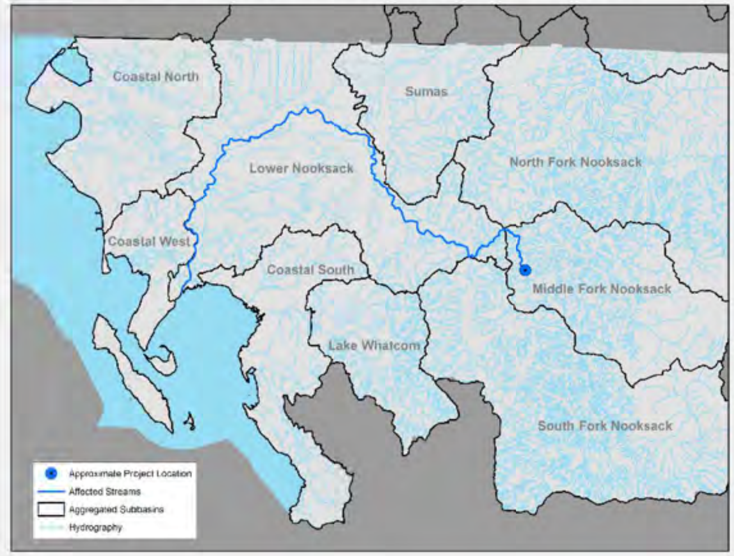
#19NG NEP Wetland Restoration/Enhancement Creation



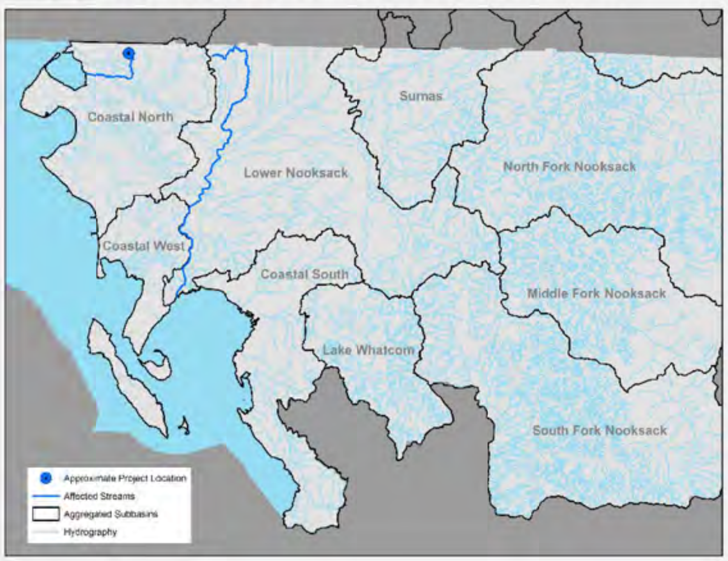
#21 Stewart Mountain/SF Nooksack Conservation Sale



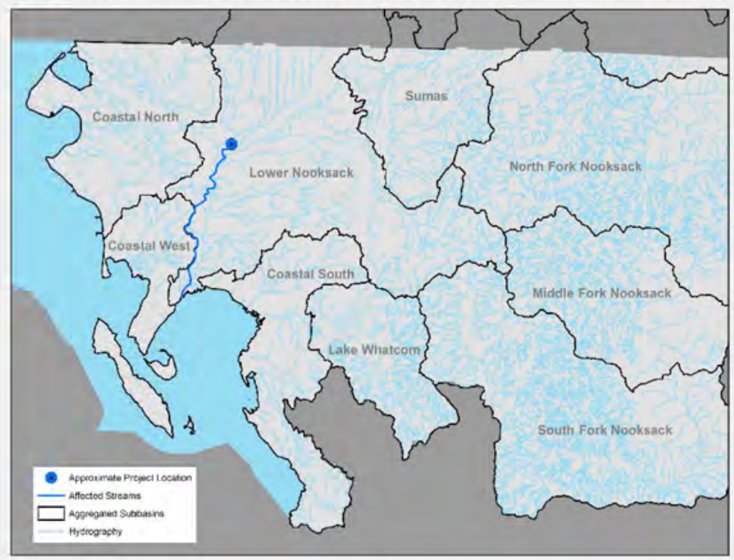
#23 Middle Fork Porter Creek Alluvial Fan Project



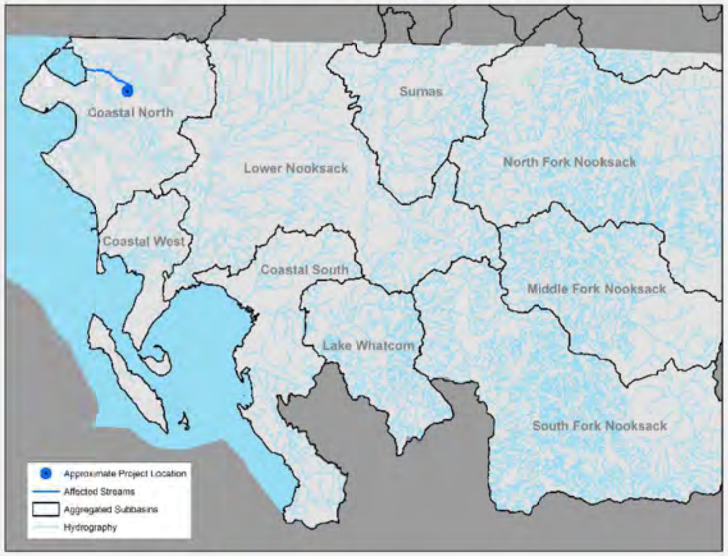
#24 Birch Bay Water & Sewer District Deep Wells



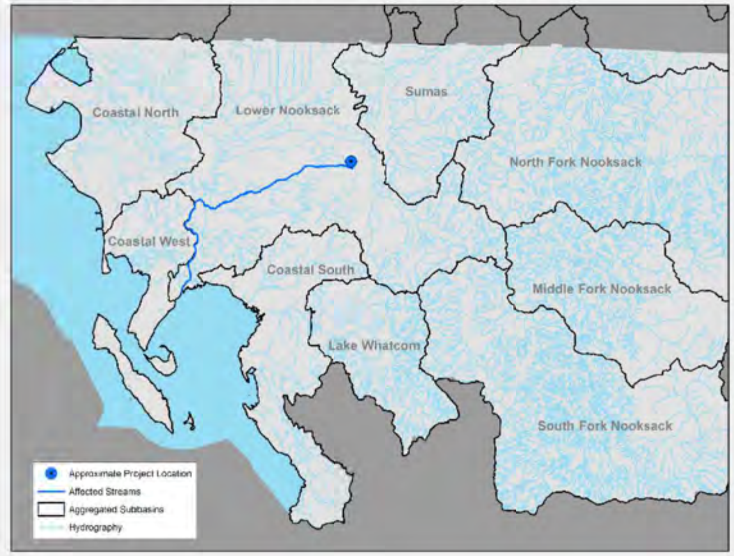
#26 Lower Nooksack-Convert Surface Use to Groundwater Use



#27 Coastal North-Convert Surface Use to Groundwater Use

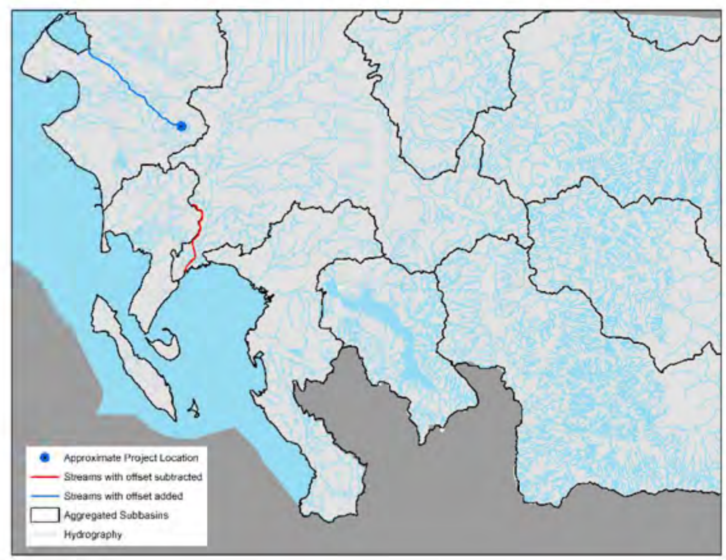


#28 Storage Projects including Gravel Pits

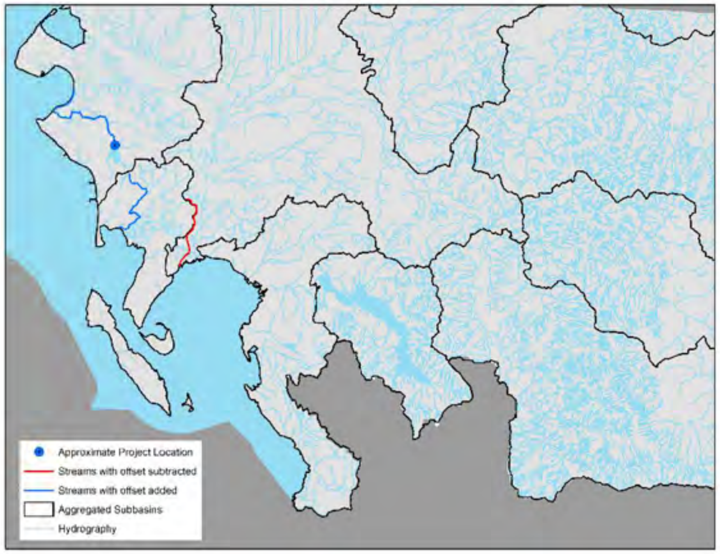


#43 PUD #1: Pipeline from Mainstem to Tributaries

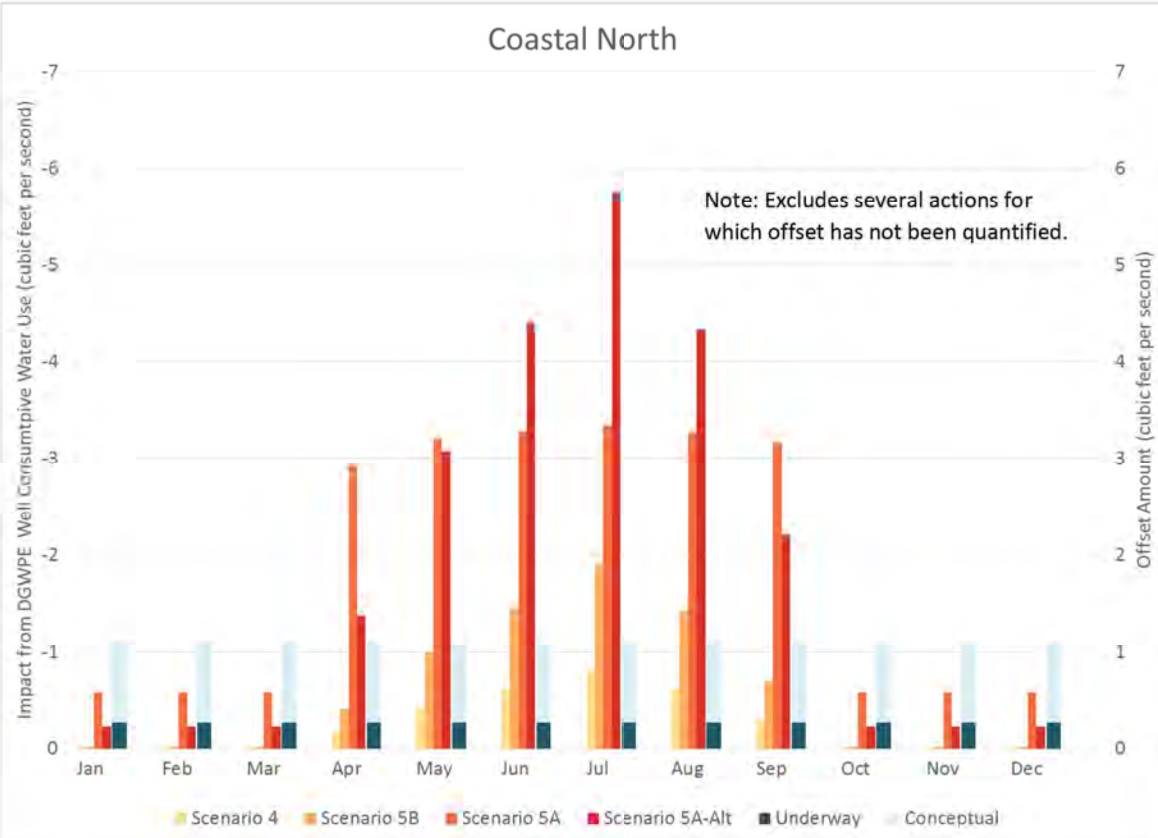
#44 PUD #1: Vista Road Project



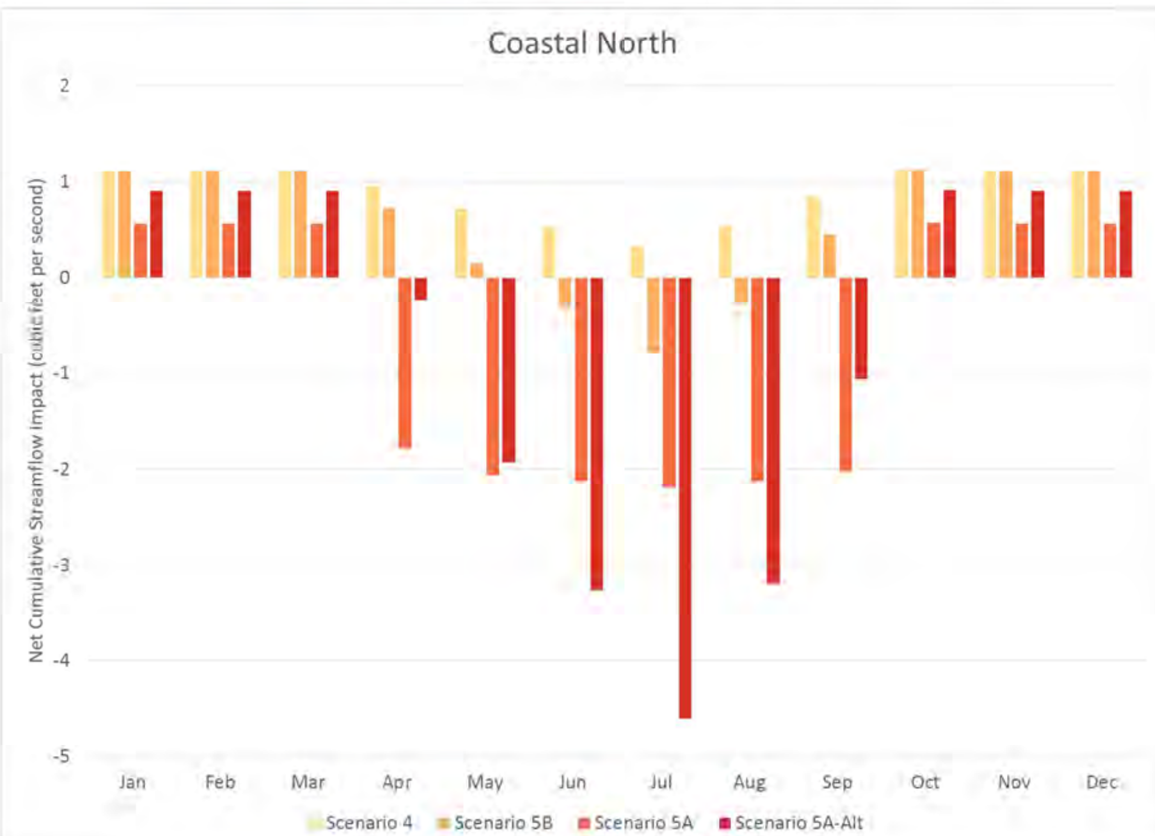
#45 PUD #1: Lake Terrell



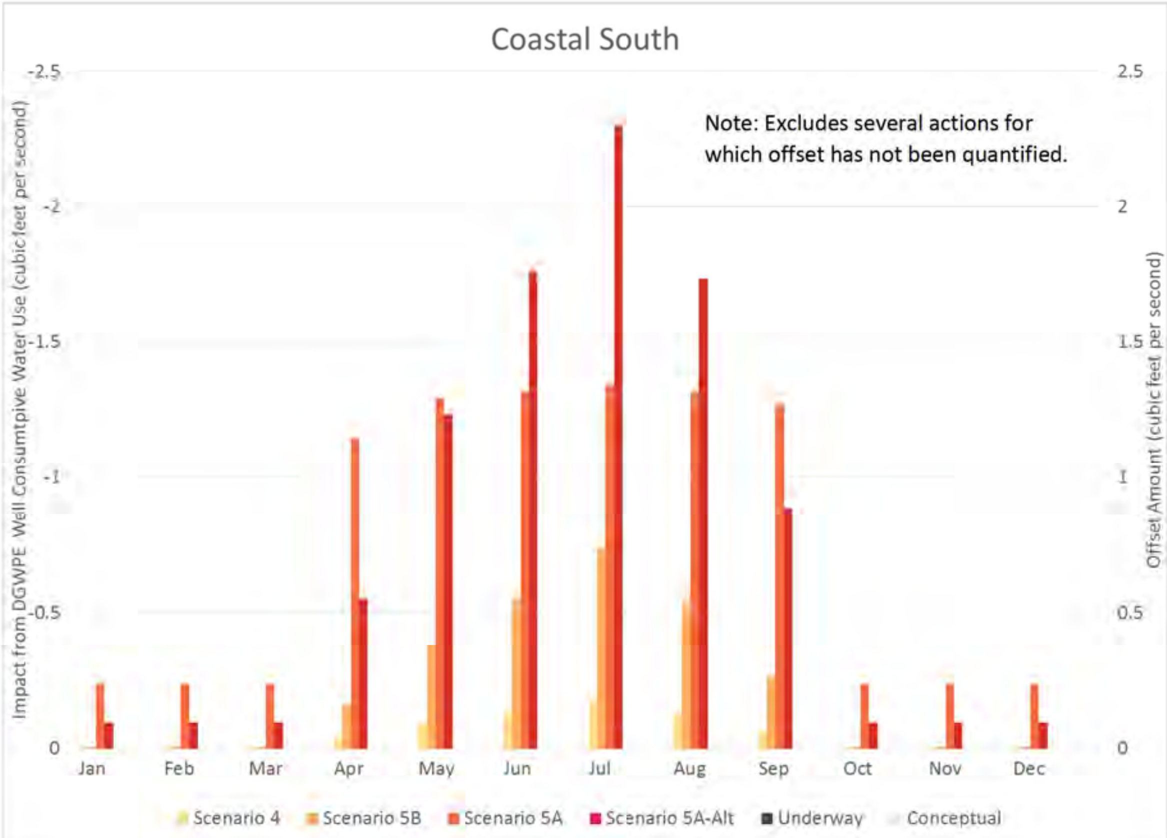
Appendix B: Seasonal Variation in Streamflow Impact by Aggregated Subbasin

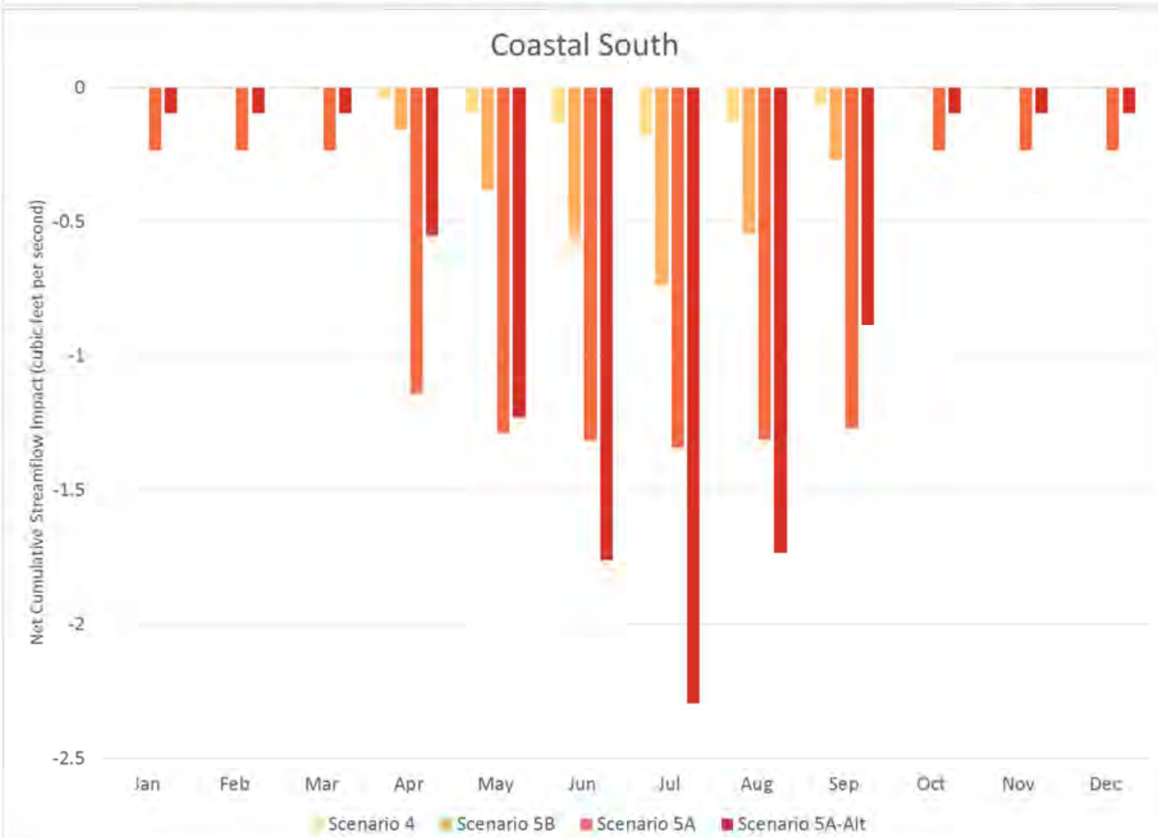


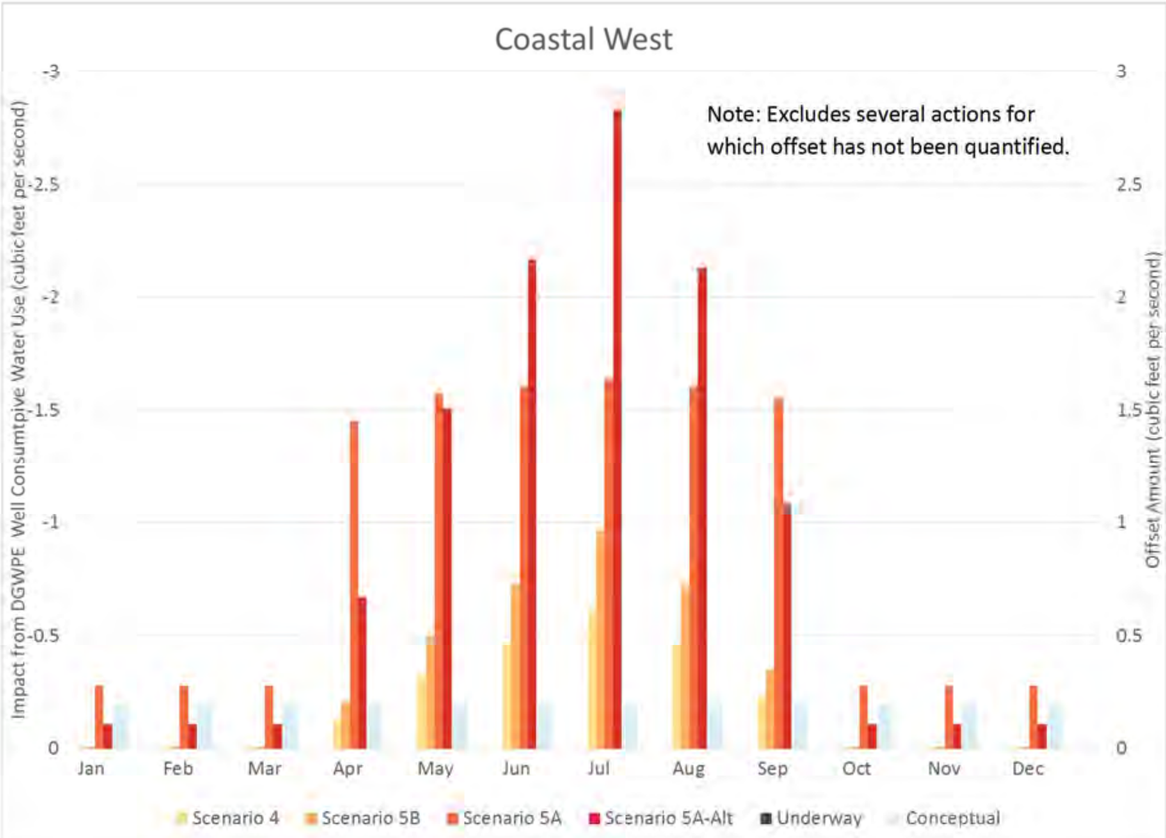
Coastal North
Impact from DGWPE Well Consumptive Water Use (cubic feet per second)
Offset Amount (cubic feet per second)
Note: Excludes several actions for which offset has not been quantified.
-7
-6
-5
-4
-3
-2
-1
0
7
6
5
4
3
2
1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt
Underway
Conceptual

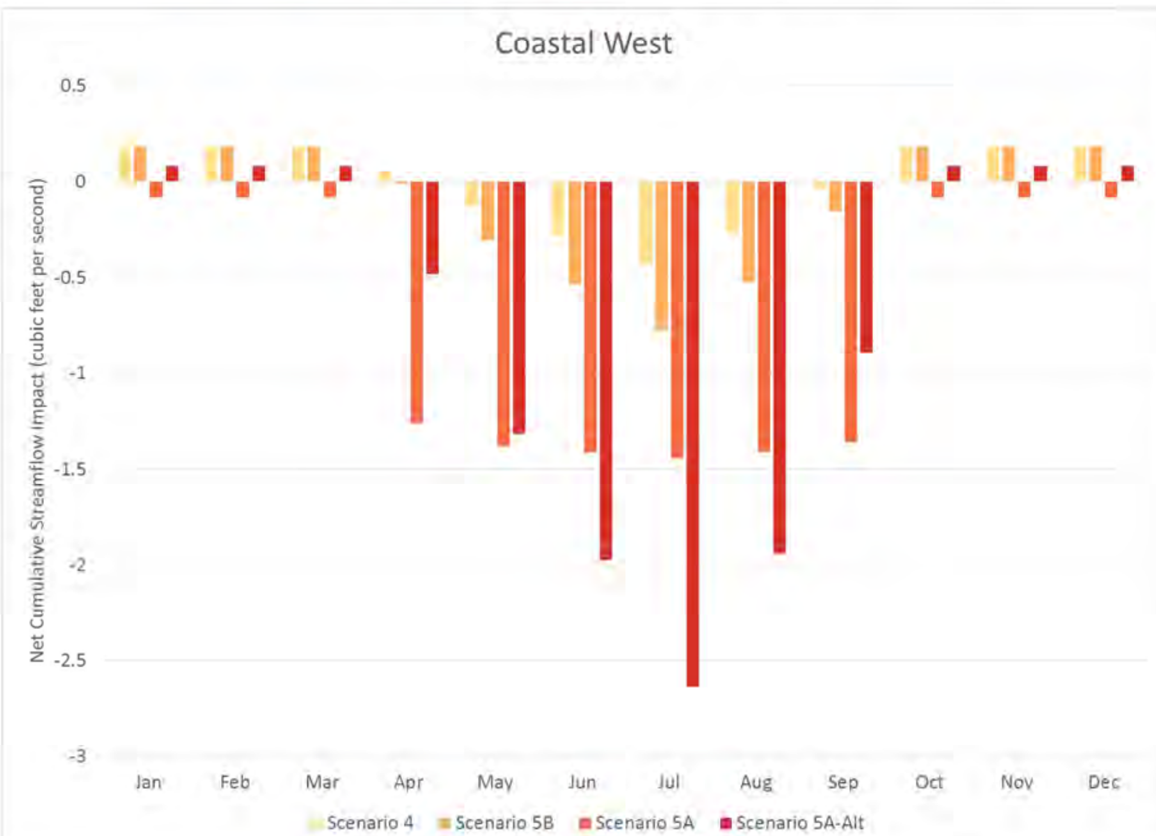


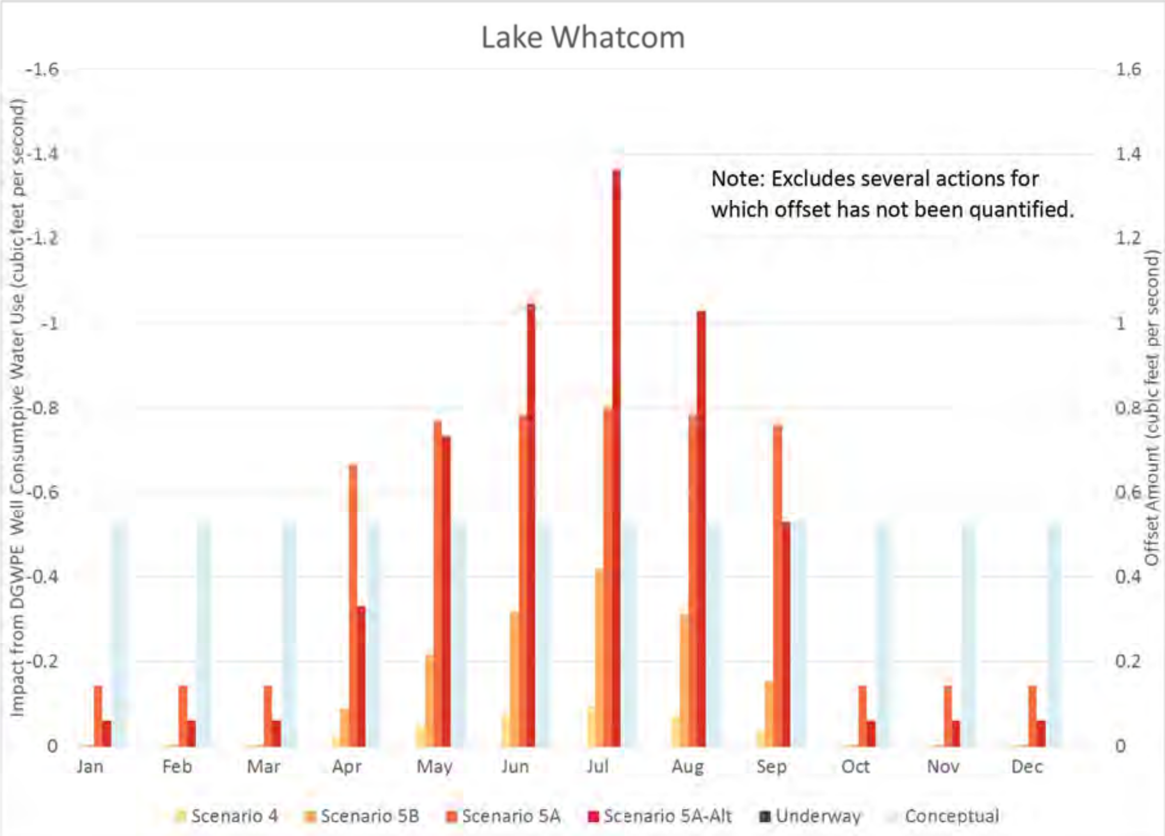
Coastal North
Net Cumulative Streamflow Impact (cubic feet per second)
2
1
0
-1
-2
-3
-4
-5
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt

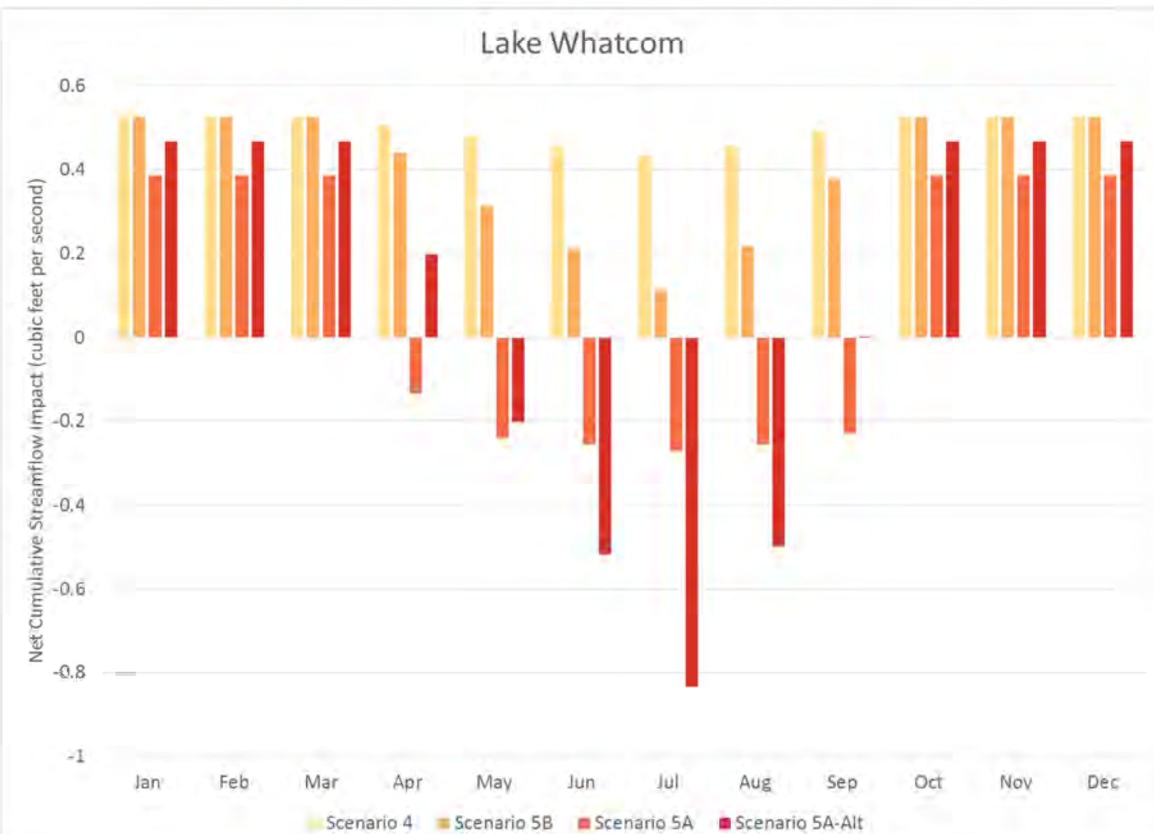

Coastal South
Note: Excludes several actions for which offset has not been quantified.
Impact from DGWPE Well Consumtpive Water Use (cubic feet per second)
Offset Amount (cubic feet per second)
-2.5
-2
-1.5
-1
-0.5
0
2.5
2
1.5
1
0.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt
Underway
Conceptual

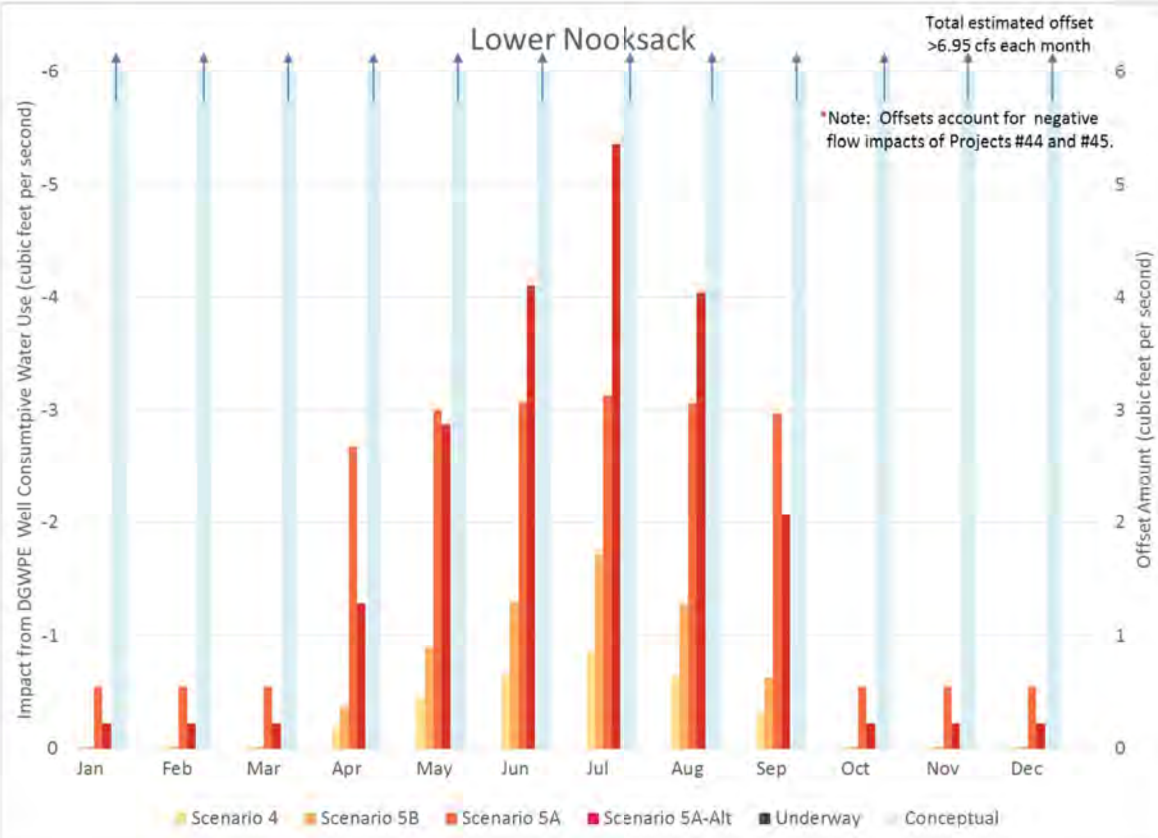

Coastal South
Net Cumulative Streamflow Impact (cubic feet per second)
0
-0.5
-1
-1.5
-2
-2.5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt

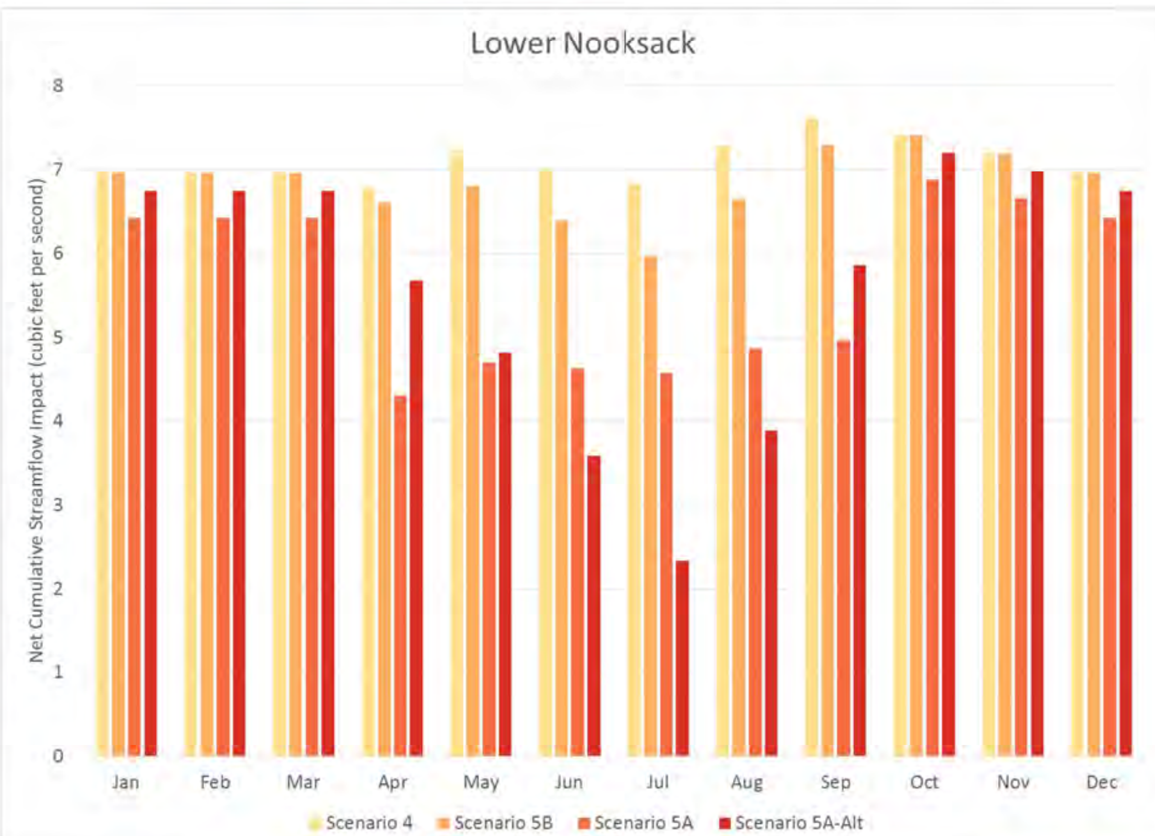

Coastal West
Note: Excludes several actions for which offset has not been quantified.
Impact from DGWPE Well Consumptive Water Use (cubic feet per second)
Offset Amount (cubic feet per second)
-3
-2.5
-2
-1.5
-1
-0.5
0
3
2.5
2
1.5
1
0.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt
Underway
Conceptual

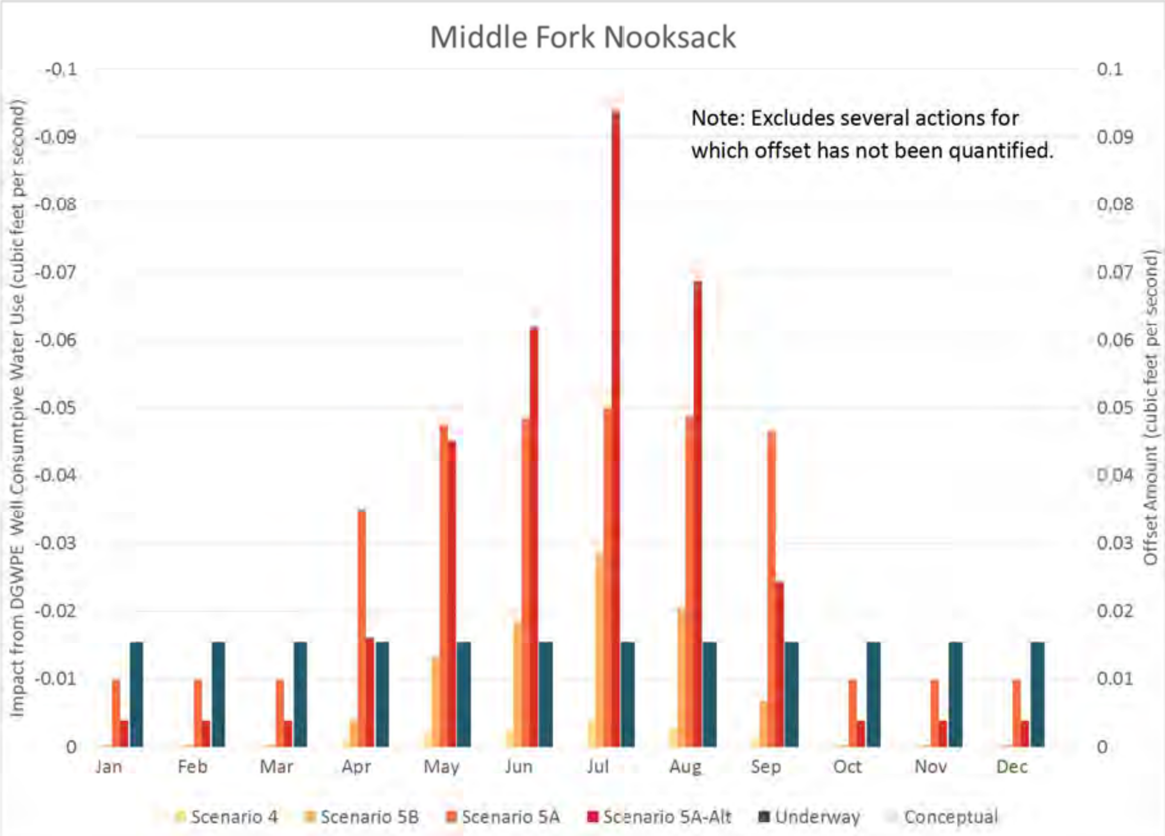

Coastal West
Net Cumulative Streamflow Impact (cubic feet per second)
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt


Lake Whatcom
Note: Excludes several actions for which offset has not been quantified.
Impact from DGWPE Well Consumtpive Water Use (cubic feet per second)
Offset Amount (cubic feet per second)
-1.6
-1.4
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt
Underway
Conceptual

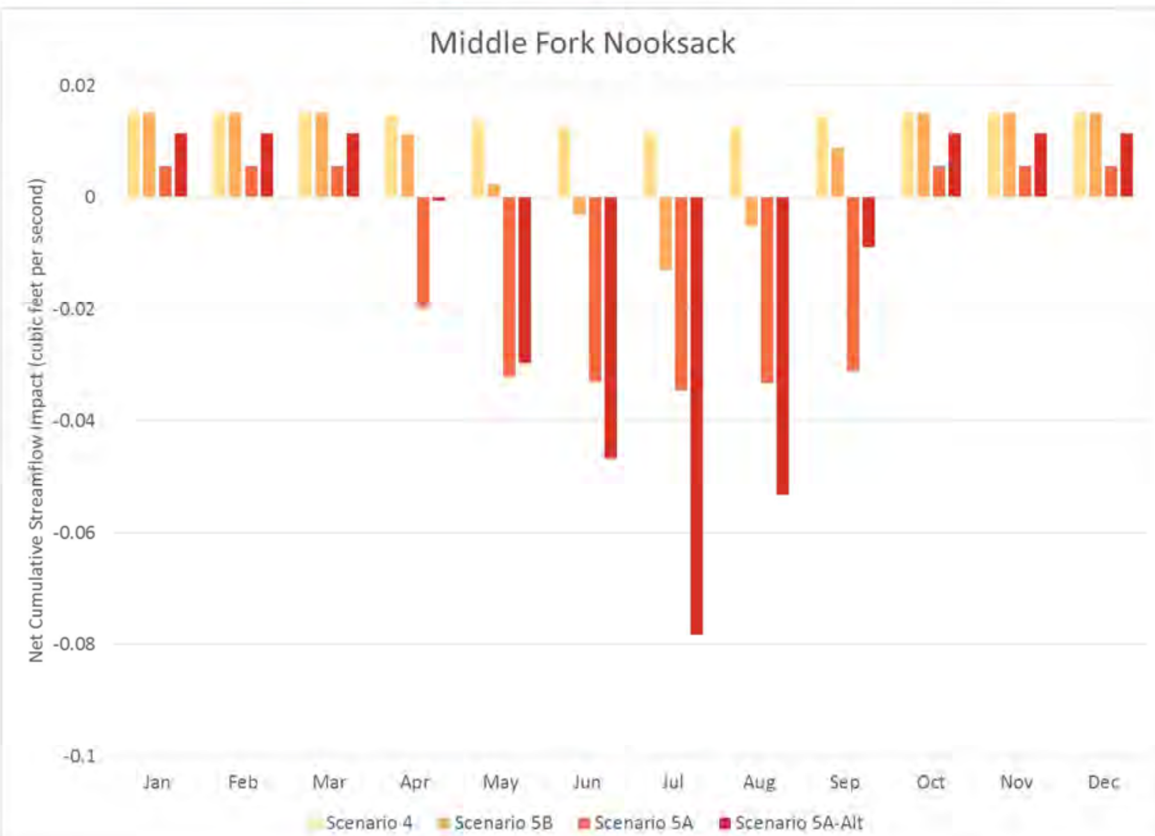

Lake Whatcom
Net Cumulative Streamflow Impact (cubic feet per second)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt


Lower Nooksack
Total estimated offset
>6.95 cfs each month
*Note: Offsets account for negative flow impacts of Projects #44 and #45.
Impact from DGWPE Well Consumtpive Water Use (cubic feet per second)
Offset Amount (cubic feet per second)
-6
-5
-4
-3
-2
-1
0
6
5
4
3
2
1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt
Underway
Conceptual

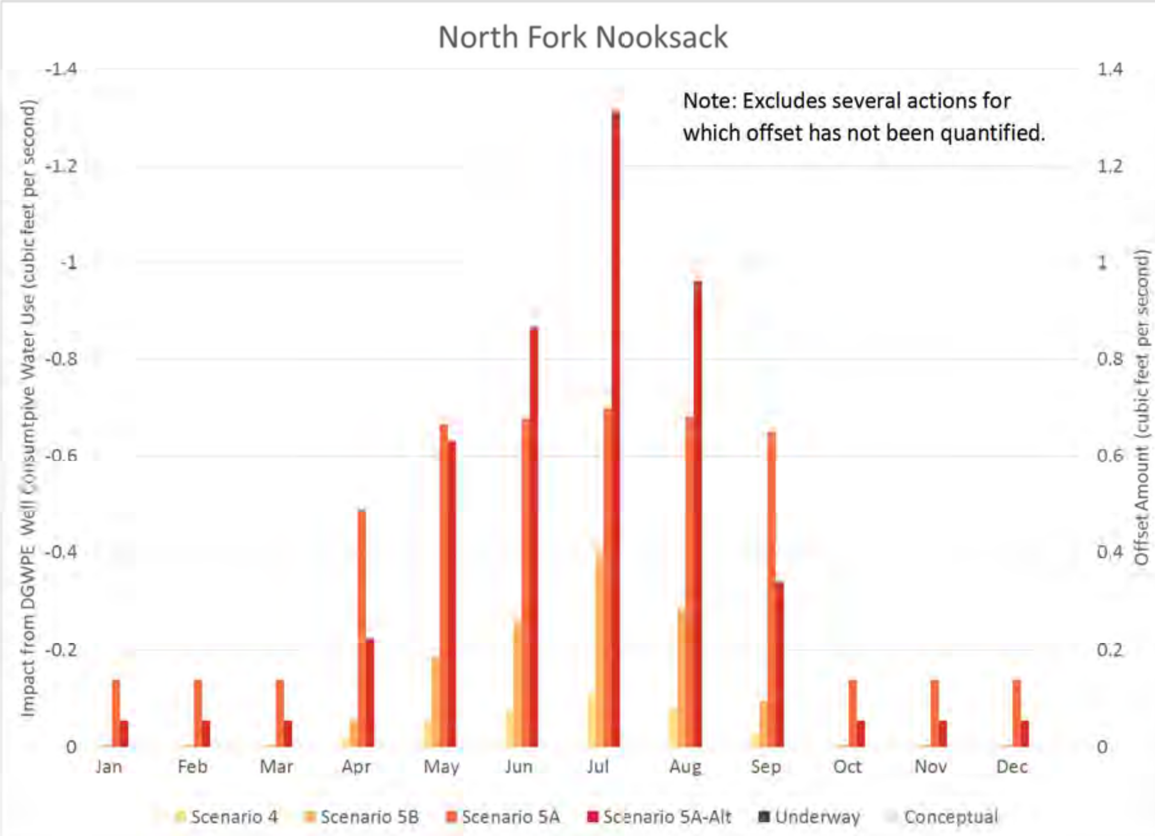

Lower Nooksack
Net Cumulative Streamflow Impact (cubic feet per second)
8
7
6
5
4
3
2
1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt

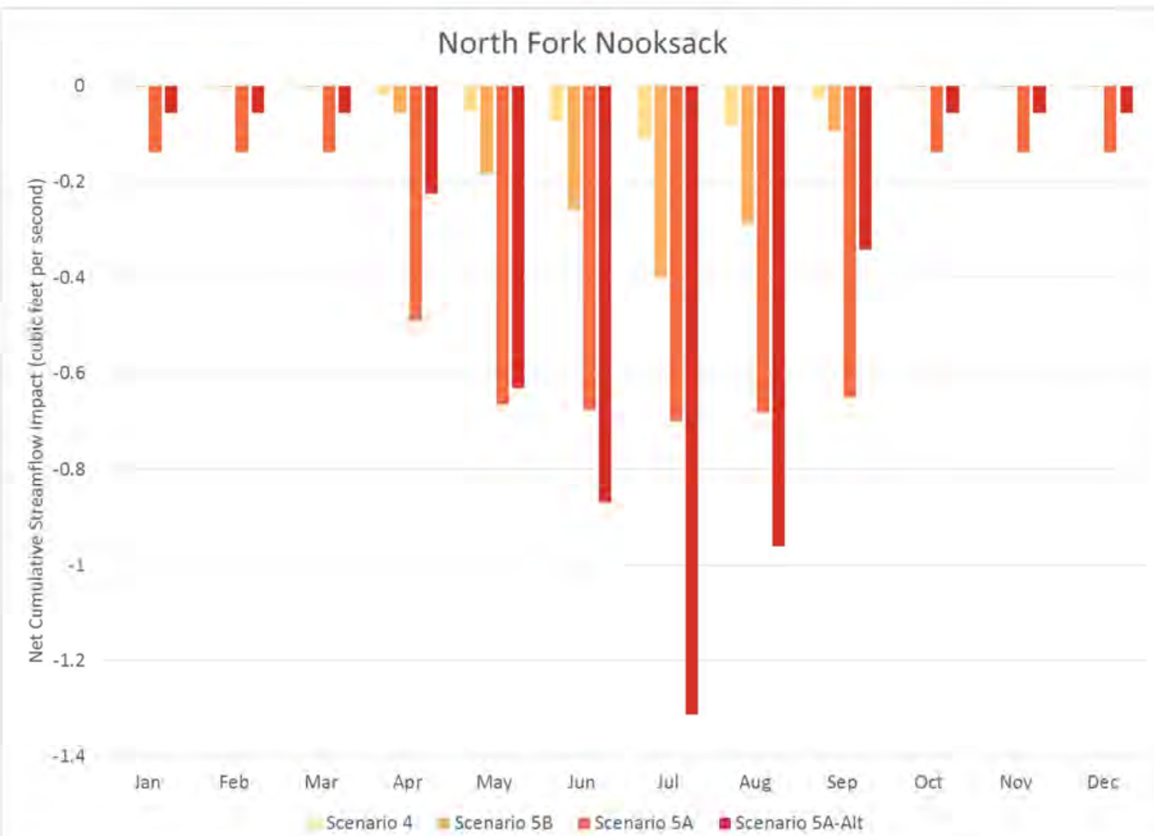


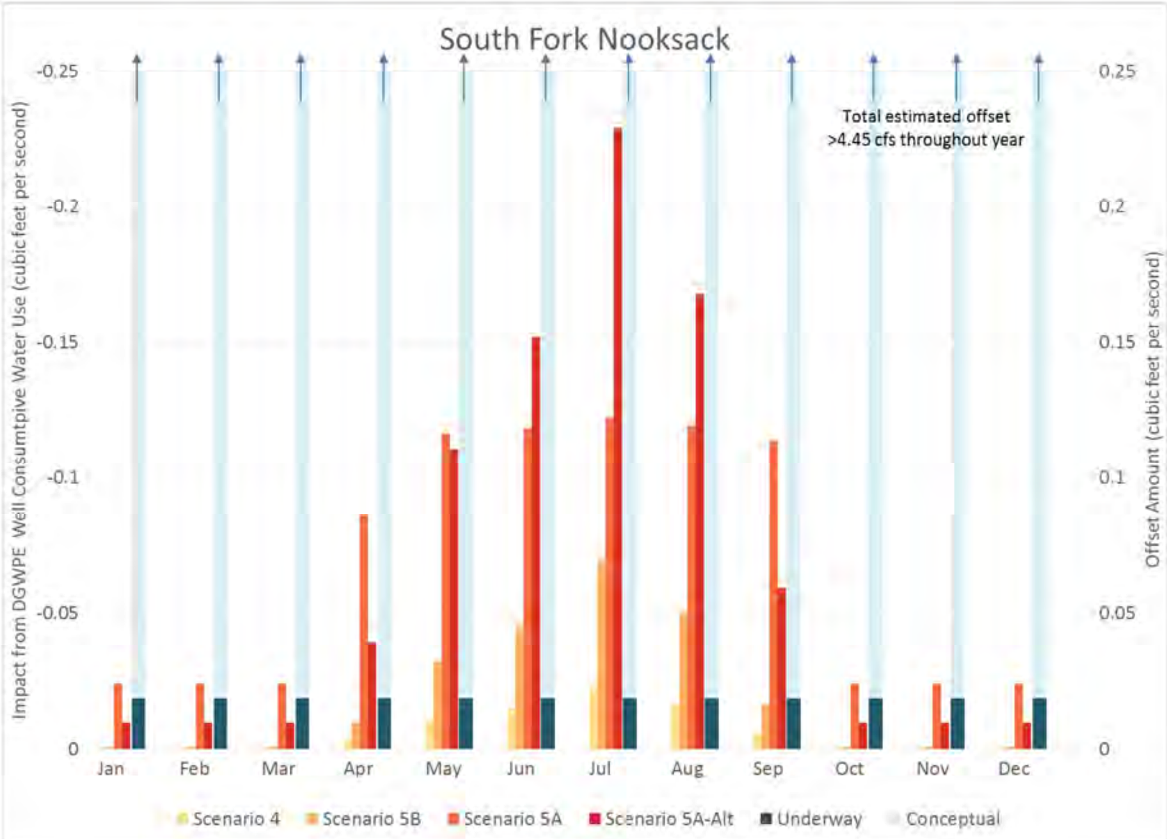
Middle Fork Nooksack
Note: Excludes several actions for which offset has not been quantified.
Impact from DGWPE Well Consumtpive Water Use (cubic feet per second)
Offset Amount (cubic feet per second)
-0.1
-0.09
-0.08
-0.07
-0.06
-0.05
-0.04
-0.03
-0.02
-0.01
0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt
Underway
Conceptual



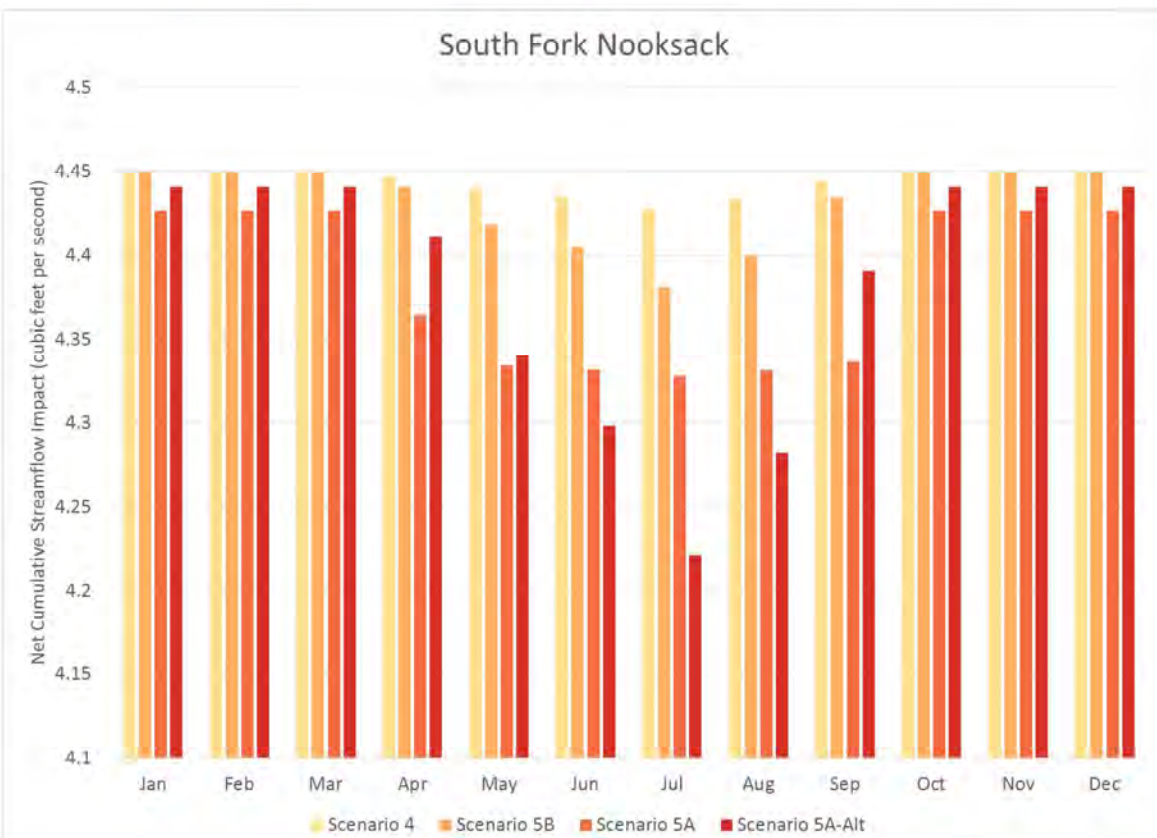
Middle Fork Nooksack
Net Cumulative Streamflow Impact (cubic feet per second)
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt


North Fork Nooksack
Note: Excludes several actions for which offset has not been quantified.
Impact from DGWPE Well Consumtpive Water Use (cubic feet per second)
Offset Amount (cubic feet per second)
-1.4
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt
Underway
Conceptual

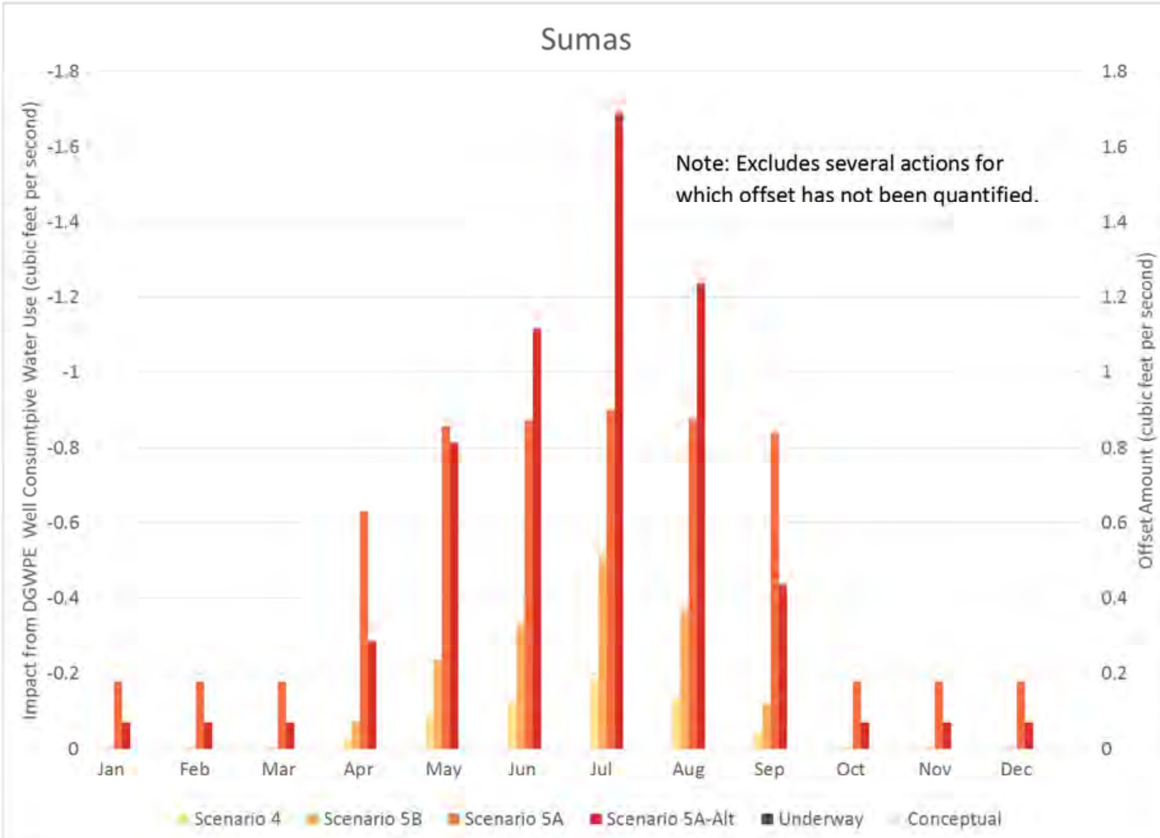

North Fork Nooksack
Net Cumulative Streamflow Impact (cubic feet per second)
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt

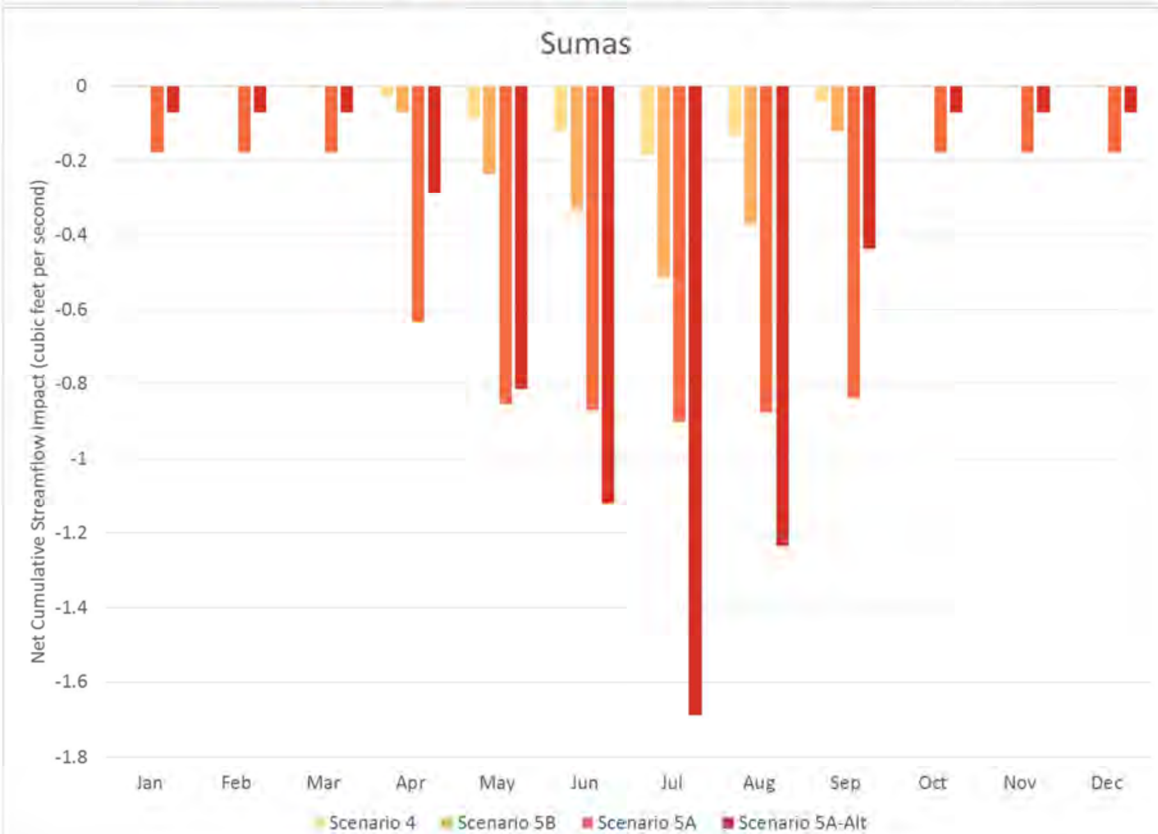


South Fork Nooksack
Impact from DGWPE Well Consumtpive Water Use (cubic feet per second)
Offset Amount (cubic feet per second)
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.25
0.2
0.15
0.1
0.05
0
Total estimated offset
>4.45 cfs throughout year
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt
Underway
Conceptual

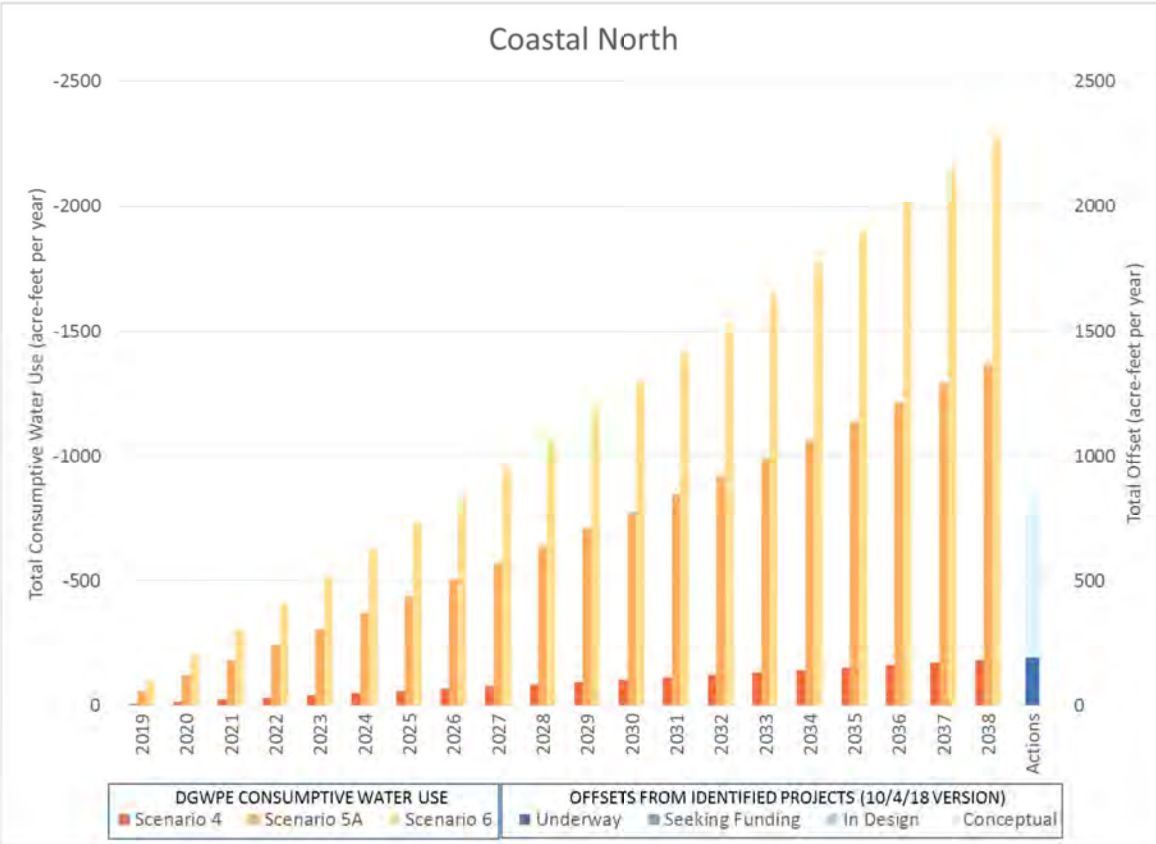


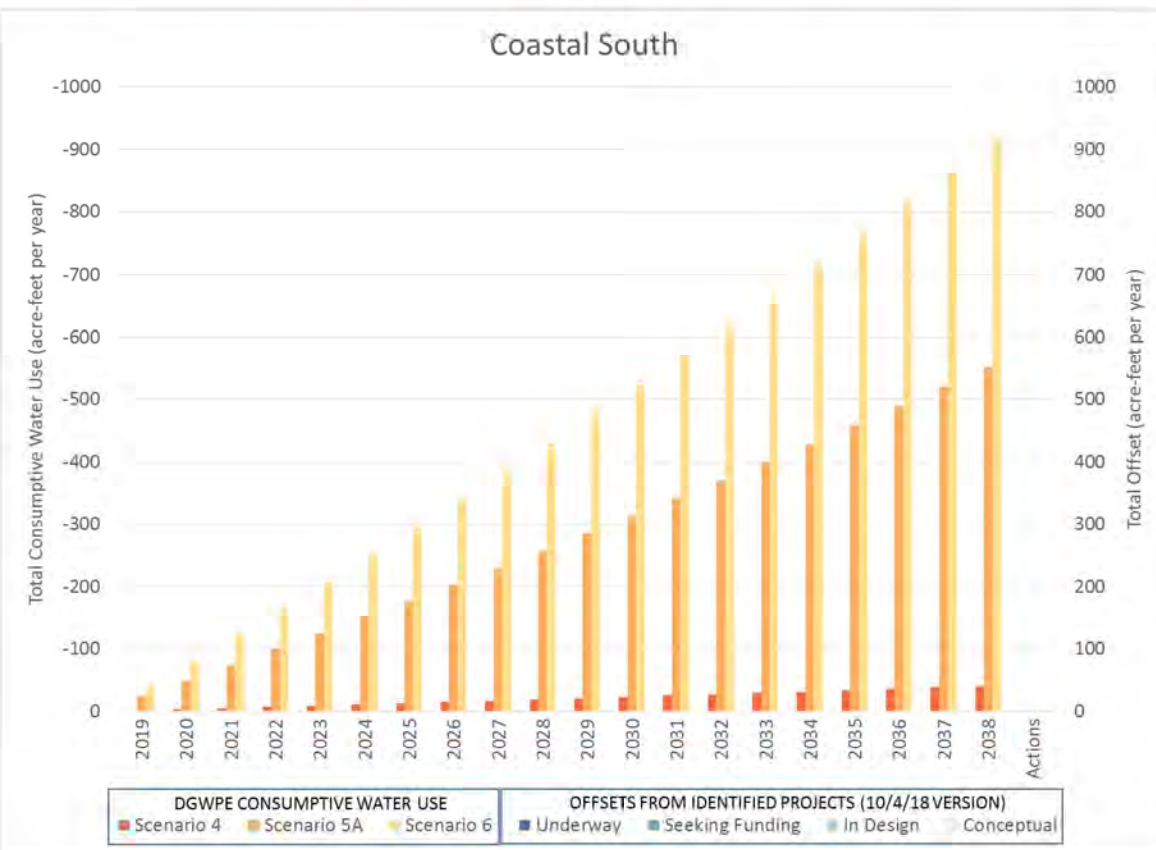
South Fork Nooksack
Net Cumulative Streamflow Impact (cubic feet per second)
4.5
4.45
4.4
4.35
4.3
4.25
4.2
4.15
4.1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt


Sumas
Note: Excludes several actions for which offset has not been quantified.
Impact from DGWPE Well Consumtpive Water Use (cubic feet per second)
Offset Amount (cubic feet per second)
-1.8
-1.6
-1.4
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt
Underway
Conceptual


Sumas
Net Cumulative Streamflow Impact (cubic feet per second)
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Scenario 4
Scenario 5B
Scenario 5A
Scenario 5A-Alt

Appendix C: New DGWPE well consumptive water Use over time relative to project offsets over time by Aggregated Subbasin


Coastal North
Total Consumptive Water Use (acre-feet per year)
Total Offset (acre-feet per year)
-2500
-2000
-1500
-1000
-500
0
2500
2000
1500
1000
500
0
2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 Actions
DGWPE CONSUMPTIVE WATER USE
Scenario 4
Scenario 5A
Scenario 6
OFFSETS FROM IDENTIFIED PROJECTS (10/4/18 VERSION)
Underway
Seeking Funding
In Design
Conceptual


Coastal South
Total Consumptive Water Use (acre-feet per year)
Total Offset (acre-feet per year)
-1000
-900
-800
-700
-600
-500
-400
-300
-200
-100
0
1000
900
800
700
600
500
400
300
200
100
0
2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 Actions
DGWPE CONSUMPTIVE WATER USE
Scenario 4
Scenario 5A
Scenario 6
OFFSETS FROM IDENTIFIED PROJECTS (10/4/18 VERSION)
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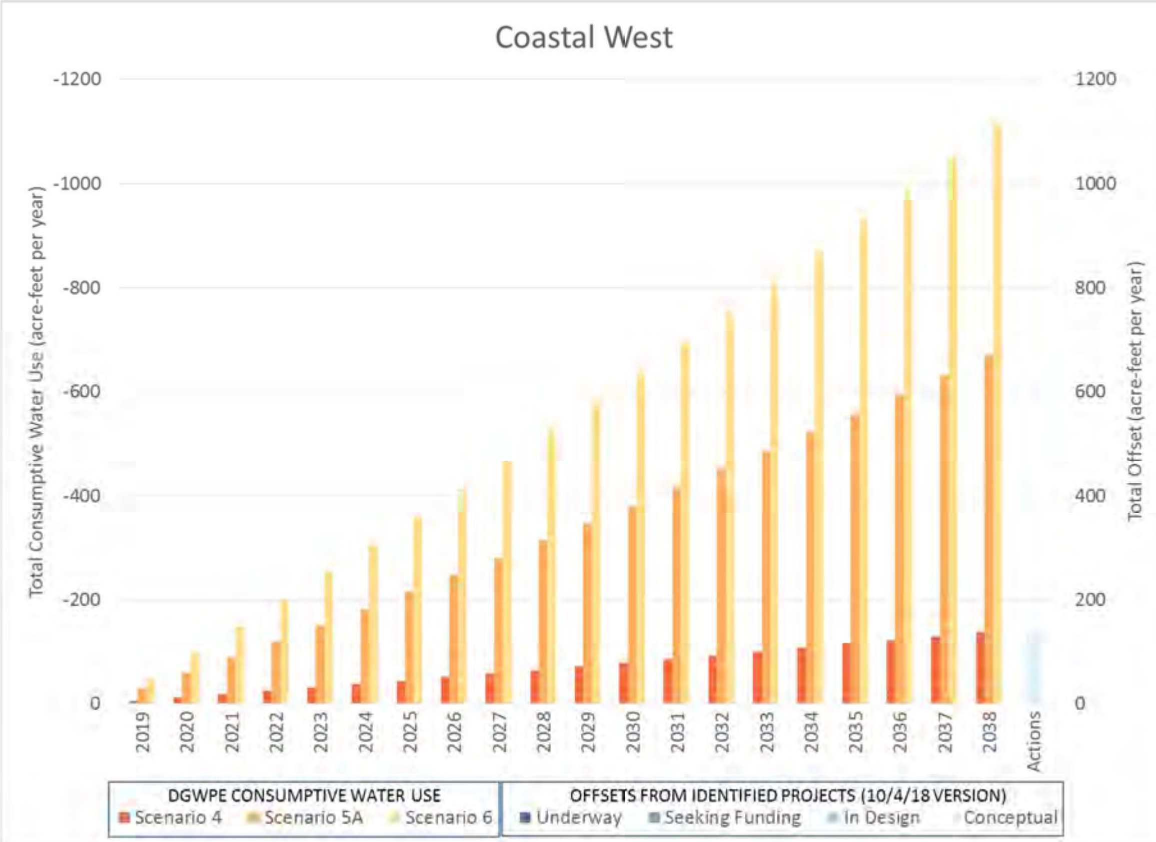
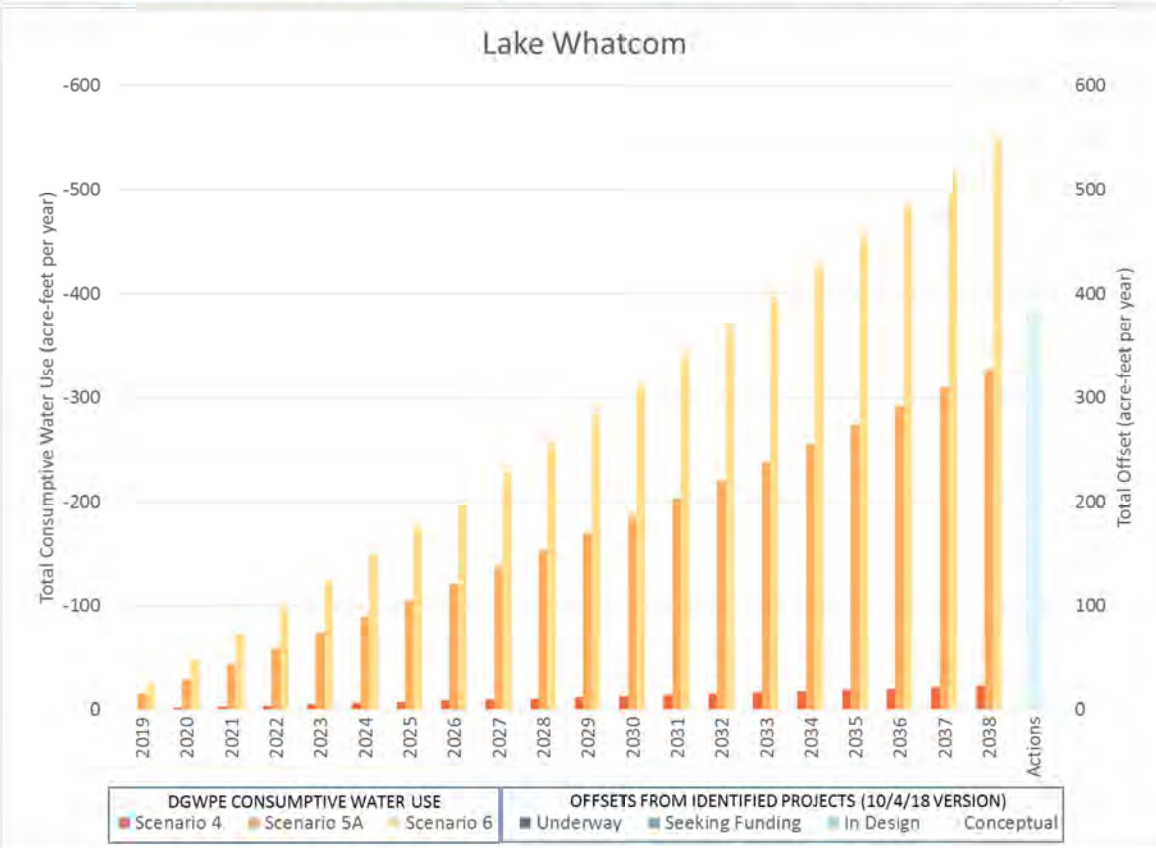
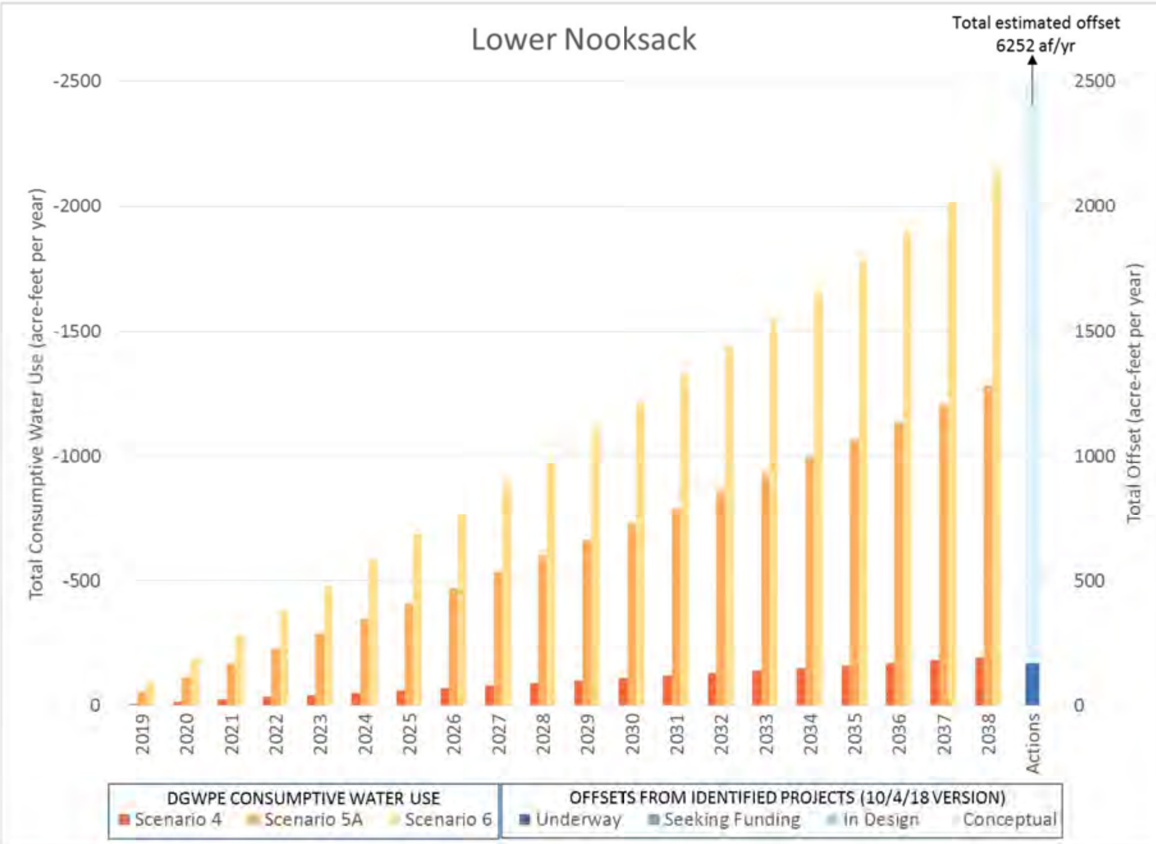
Seeking Funding
In Design
Conceptual



Coastal West
Total Consumptive Water Use (acre-feet per year)
Total Offset (acre-feet per year)
-1200
-1000
-800
-600
-400
-200
0
1200
1000
800
600
400
200
0
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Actions
DGWPE CONSUMPTIVE WATER USE
Scenario 4
Scenario 5A
Scenario 6
OFFSETS FROM IDENTIFIED PROJECTS (10/4/18 VERSION)
Underway
Seeking Funding
In Design
Conceptual



Lake Whatcom
Total Consumptive Water Use (acre-feet per year)
Total Offset (acre-feet per year)
-600
-500
-400
-300
-200
-100
0
600
500
400
300
200
100
0
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Actions
DGWPE CONSUMPTIVE WATER USE
Scenario 4
Scenario 5A
Scenario 6
OFFSETS FROM IDENTIFIED PROJECTS (10/4/18 VERSION)
Underway
Seeking Funding
In Design
Conceptual


Lower Nooksack
Total estimated offset
6252 af/yr
-2500
-2000
-1500
-1000
-500
0
2500
2000
1500
1000
500
0
Total Consumptive Water Use (acre-feet per year)
Total Offset (acre-feet per year)
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Actions
DGWPE CONSUMPTIVE WATER USE
Scenario 4
Scenario 5A
Scenario 6
OFFSETS FROM IDENTIFIED PROJECTS (10/4/18 VERSION)
Underway
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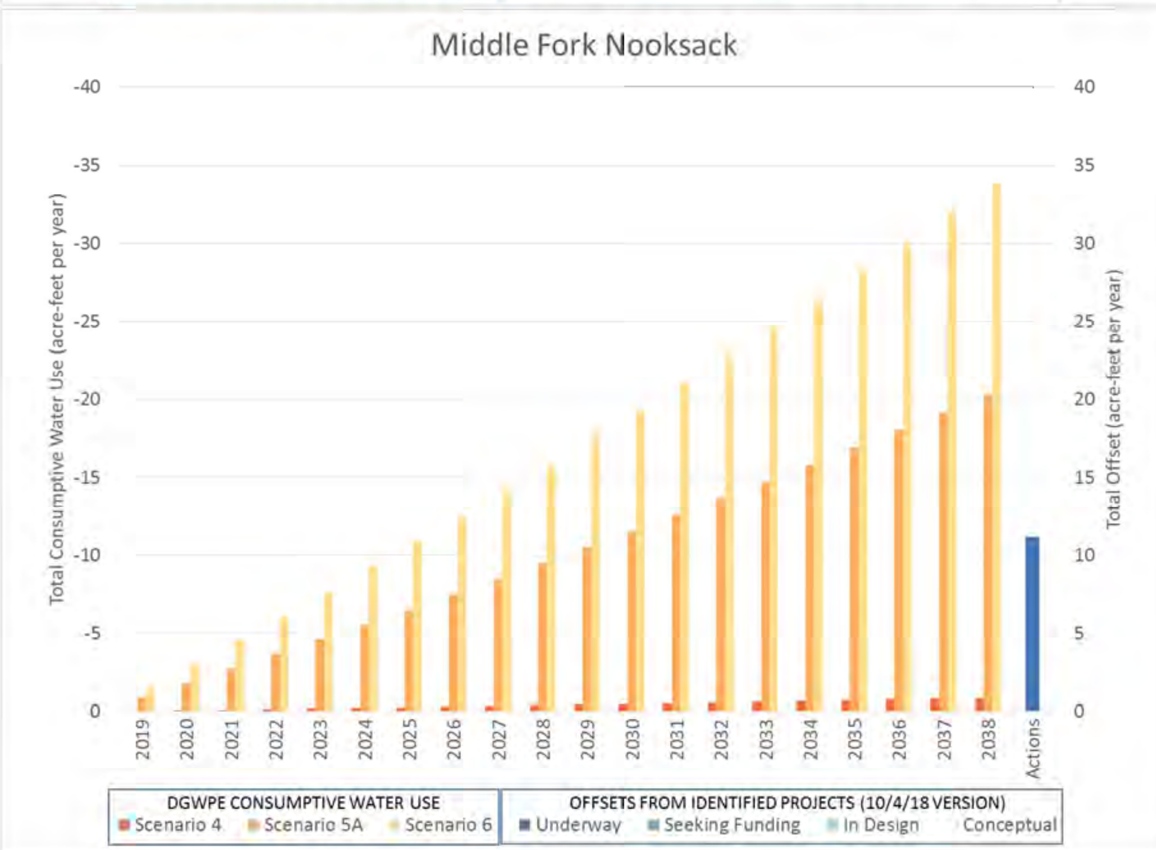
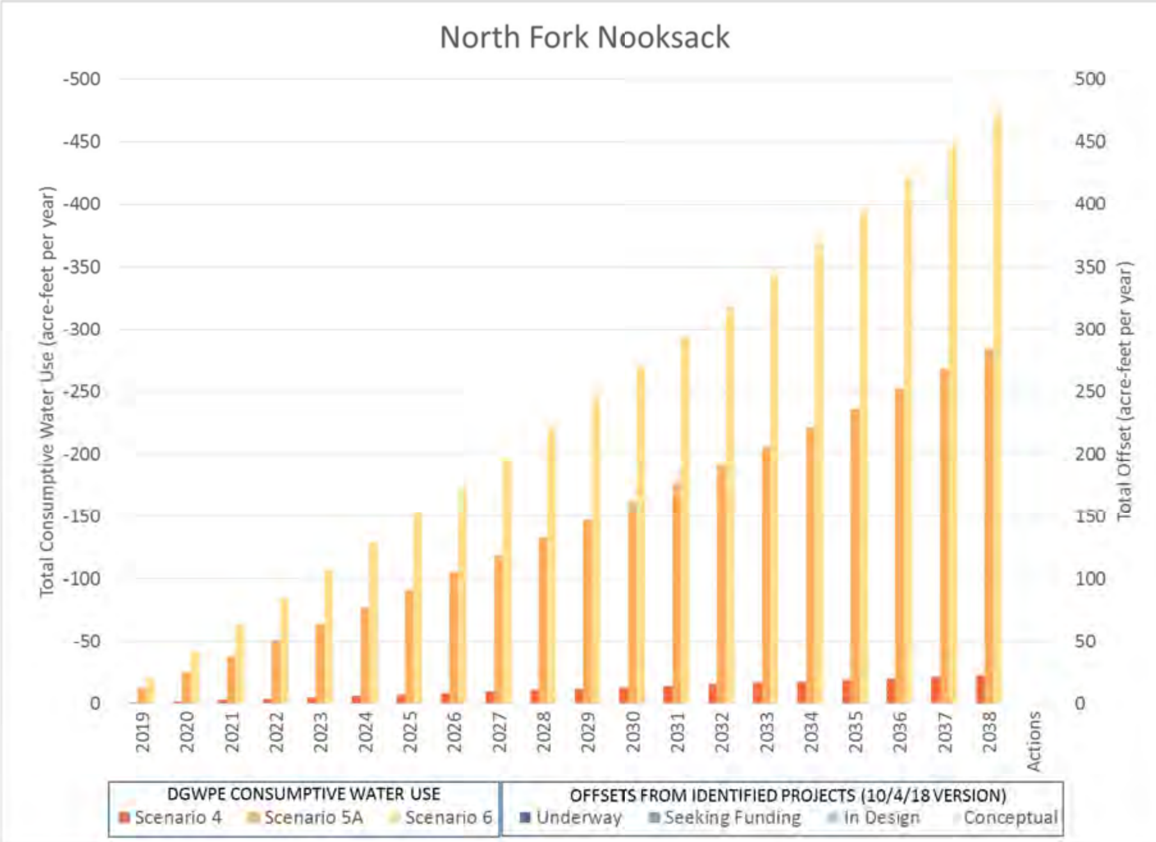
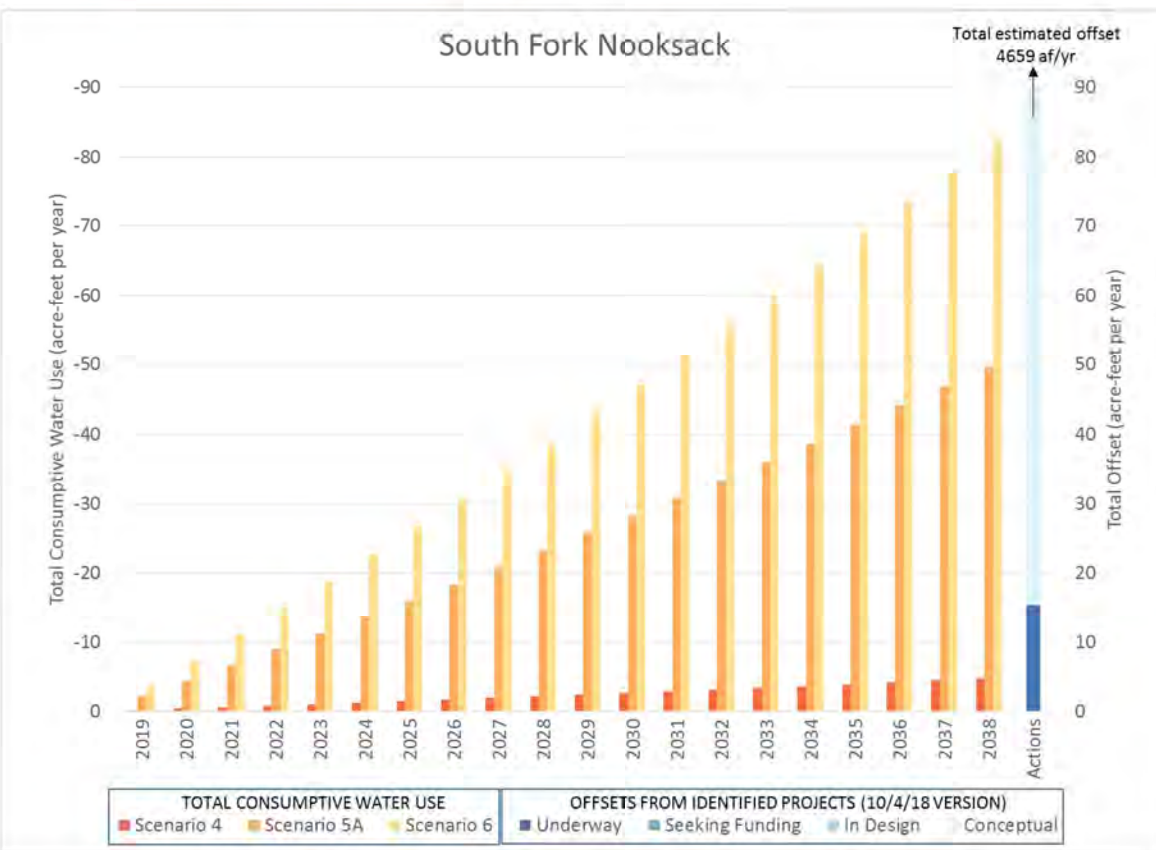
In Design
Conceptual

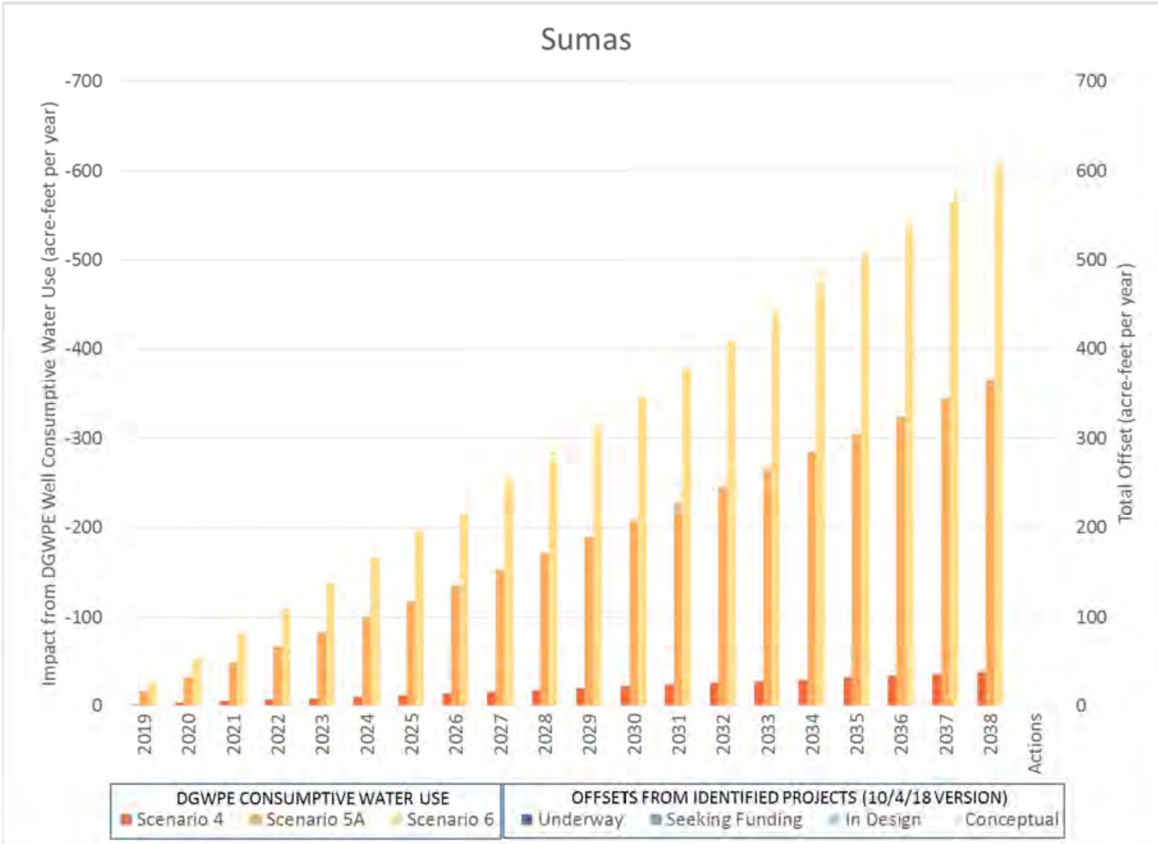

Middle Fork Nooksack
-40
-35
-30
-25
-20
-15
-10
-5
0
40
35
30
25
20
15
10
5
0
Total Consumptive Water Use (acre-feet per year)
Total Offset (acre-feet per year)
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Actions
DGWPE CONSUMPTIVE WATER USE
Scenario 4
Scenario 5A
Scenario 6
OFFSETS FROM IDENTIFIED PROJECTS (10/4/18 VERSION)
Underway
Seeking Funding
In Design
Conceptual



North Fork Nooksack
Total Consumptive Water Use (acre-feet per year)
Total Offset (acre-feet per year)
-500
-450
-400
-350
-300
-250
-200
-150
-100
-50
0
500
450
400
350
300
250
200
150
100
50
0
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Actions
DGWPE CONSUMPTIVE WATER USE
Scenario 4
Scenario 5A
Scenario 6
OFFSETS FROM IDENTIFIED PROJECTS (10/4/18 VERSION)
Underway
Seeking Funding
In Design
Conceptual



South Fork Nooksack
Total estimated offset
4659 af/yr
Total Consumptive Water Use (acre-feet per year)
Total Offset (acre-feet per year)
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
90
80
70
60
50
40
30
20
10
0
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Actions
TOTAL CONSUMPTIVE WATER USE
Scenario 4
Scenario 5A
Scenario 6
OFFSETS FROM IDENTIFIED PROJECTS (10/4/18 VERSION)
Underway
Seeking Funding
In Design
Conceptual


Sumas
Impact from DGWPE Well Consumptive Water Use (acre-feet per year)
Total Offset (acre-feet per year)
-700
-600
-500
-400
-300
-200
-100
0
700
600
500
400
300
200
100
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Actions
DGWPE CONSUMPTIVE WATER USE
Scenario 4
Scenario 5A
Scenario 6
OFFSETS FROM IDENTIFIED PROJECTS (10/4/18 VERSION)
Underway
Seeking Funding
In Design
Conceptual

Appendix C

Attachment 1 to Comment O-7-9 (Washington REALTORS, January 17, 2020, Robinson & Noble - Water Balance Analysis, Typical Rural Large Lot Residential Developments in Western Washington)

WASHINGTON REALTORS
TYPICAL RURAL LARGE LOT RESIDENTIAL
DEVELOPMENTS IN WESTERN WASHINGTON

NOVEMBER 29, 2018

by

Michael F. Piechowski, LHG
Principal Hydrogeologist

Water-Balance Analysis
Typical Rural Large Lot Residential Developments in Western Washington
November 29, 2018

Introduction and Scope

This narrative has been prepared for Bill Clarke and Washington REALTORS® documenting our water-balance analysis of typical rural large-lot residential developments in Western Washington. This evaluation is based on our analysis of an existing development in Thurston County (County) with ten adjacent 5-acre parcels and focuses on the changes to the total water balance as a result of development. This example is considered to have pre- and post-development conditions that are typical of rural, exempt well-based development in much of Western Washington.

Our approach used aerial imagery available from Thurston County and through Google Earth. We traced the outlines of the homes, driveways, roads, and cleared areas on each of the ten parcels, then calculated the relative areas of each parcel that changed from pre-development conditions (which appeared to be a second-growth forest based on the earliest aerial imagery reviewed). For this discussion, we presumed that each of the homes is served by an individual well and individual on-site septic system and calculated water use based on recent census data and regional studies.

Site Setting and Topography

The study area is located near the northern margin of the Maytown Upland in Thurston County, south of Tumwater. The study area is situated on the southern margin of a small upland. The upland has an undulatory surface that was sculpted by the most recent continental glaciation. The features in this area generally trend from the north-northeast to the south-southwest, with lineations corresponding to the presumed direction of glacial motion. According to the USGS topographic quadrangle of the area, the site has an elevation of approximately 370 feet along the northern margin; the elevation steadily drops to 310 feet at the southern boundary of the study area.

General drainage patterns in the area tend to follow the local topography. This portion of the upland containing the study area generally slopes to the south, so surficial drainage generally flows to the south. The slope is relatively gentle, with approximately five feet of drop per hundred feet.

Surface Water

The site is located in Water Resource Inventory Area 23, specifically within the Salmon Creek basin. The local surface water drainage is towards the south, but shifts to a more westerly direction approximately one mile south of the site. The nearest significant surface water is Pitman Lake, approximately 5,600 feet to the south. The nearest significant surface stream is the Deschutes River which is approximately 1.5 miles to the east of the property. However, the USGS quadrangle indicates a number of marshy areas in the low-lying regions to the south of the site and ephemeral tributary creeks to Salmon Creek beginning approximately 1,000 feet east and west of the property. Salmon Creek is a tributary to the Black River, which flows into the Chehalis River, ultimately discharging to the Pacific Ocean at Grays Harbor.

Soils and Vegetation

The study area is mostly covered with Alderwood gravelly sandy loam with 8 to 15 percent slopes; a small portion of the site near the southern boundary has steeper slopes (US Department of Agriculture, Soil Conservation Service). The Alderwood gravelly sandy loam is a moderately well-drained soil. It forms on the top of glacial drift and generally has a dense low-permeability layer that restricts infiltration within 39 inches of land surface. This soil is considered to be a part of Hydrologic Group B and is not considered a hydric soil.

Site Geology

Site geology was determined by reviewing published geologic maps of the region. Logan (2009) mapped the site and surrounding area as Vashon till, which is a highly-compacted mixture of sand, gravel, silt, and clay that was deposited beneath and overridden by the latest continental glaciation. Typically, till has a relatively low permeability, though it may vary locally based on the composition and the degree of compaction. Review of nearby water well reports suggests that the till is generally over 50 feet thick in the area.

Water Balance Analysis

To assess potential post-development changes to the water balance of the groundwater and surface water systems in the area, we completed a water-balance evaluation of the property and proposed development on an annualized basis. This analysis concentrated on the changes to the property from the pre-development conditions (mature second-growth forest). We analyzed two water use scenarios.

The first water use scenario is based on the Washington State Department of Ecology (Ecology) guidance document, ESSB 6091 Streamflow Restoration Recommendations for Water Use Estimates. The water use estimates from Ecology's ESSB 6091 guidance document are higher than other water use estimates used by Ecology or in other studies, but are used for purposes of this analysis as the "High Water Use Scenario." Under the High Water Use Scenario, Ecology uses an average value of 60 gallons of indoor water use per day (gpd) per capita, a household size of 2.5 persons, and consumptive use of 10%. This results in 0.017 acre-feet per year (AF/year) of indoor consumptive water use. Ecology uses a figure of 0.39 AF/year of outdoor consumptive water use. This totals 0.407 AF/year of consumptive use, which averages to 363 gallons per day.

The second water use scenario is based on water use estimates that more closely track prior Ecology water use estimates, though are still conservative and so would tend to overestimate, rather than underestimate, consumptive water use. The second scenario is referred to in the analysis as "Moderate Water Use Scenario." Under this second scenario, water use is based on an average value of 66 gallons of indoor water use per day (gpd) per capita (Welch, 2014). Welch (2014) estimates outdoor water use per capita at 4, 29, 60, 86, 97, and 30 gpd for May, June, July, August, September, and October, respectively. Outdoor water use is presumed to be zero gpd per capita for the rest of the year. The Ecology guidance document uses 2.5 people per residence, so we used that same value in the Moderate Water Use Scenario. This value is consistent with the US Census, which calculated an average of 2.54 persons per household in Thurston County. The per-capita water use numbers listed above were multiplied by 2.5 to calculate total household use. With indoor consumptive use of 10% and outdoor consumptive use of 80%, the moderate water use scenario uses 0.018 AF/year as consumptive indoor use and 0.057 AF/year as outdoor consumptive use, for a total annual consumptive use of 0.076 AF/year, or about 68 gallons per day on average.

Under both scenarios, we presumed that water was withdrawn from a single private well on each parcel, with waste water dispersed via an on-site septic system for each parcel. The total water use (includes both consumptive and non-consumptive uses) in the Moderate Water Use Scenario is 0.25 AF/year. The daily use amounts in this scenario are approximately double those presented in Culhane and Nazy (2015) and Golder (2013), but these amounts were used in order to complete a conservative analysis. The total water use under the High Water Use Scenario, based on the ESSB 6091 Guidance Document is 0.67 AF/year, which is over 2.5 times more than the Moderate Use Scenario, and approximately five times that presented in Culhane and Nazy (2015) and Golder (2013).

Culhane and Nazy (2015) state that indoor use is only 10% consumptive, the remaining 90% is returned via septic infiltration, and that residential outdoor use is considered to be 80% consumptive, with 20% returned via infiltration. Other sources, such as Savoca (2010) suggest outdoor return flow can be as high as 40%. To stay conservative in our approach, we used the 80% consumptive value.

We used information presented in Drost (1999) to determine the rainfall and infiltration rate of the site. Based on information presented in Figures 4, 16, and 17 of Drost (1999), the study area receives 48 inches of rainfall, with 18 inches of that resulting in recharge to the aquifers beneath the site.

In a typical large-lot residential development, a portion of the lot is cleared for development and a home and driveway are constructed, adding impermeable surfaces to the property and potentially increasing runoff. In some cases, outbuildings such as garages, shops, or barns are also added. In Thurston County, site development is currently held to the standards presented in Chapter 15.05 of the Thurston County Code (County Code) and the 2016 Edition of the Drainage Design and Erosion Control Manual for Thurston County (Manual).

These standards require infiltration or dispersion of stormwater falling on impervious surfaces, with the intent to reduce runoff and erosion and enhance recharge to the subsurface. Additionally, per the County Code and the Manual, any disturbed soil must be amended to enhance infiltration, which will also serve to reduce runoff from the site. Studies indicate a significant increase in the infiltration rate of tilled, compost-amended soils (Brown and Cotton, 2011; Kays, et al, 2015). This is generally consistent with language in ESSB 6091 providing that "an applicant shall manage stormwater runoff on-site to the extent practicable by maximizing infiltration, including using low-impact development techniques, or pursuant to stormwater management requirements adopted by the local permitting authority, if locally adopted requirements are more stringent."

In a typical project, site development activities will be confined to the area immediately surrounding the home and outbuildings, septic drainfield, driveway, and yard. Figure 1 presents an aerial image of the ten parcels in essentially their current condition. Figure 2 presents a historical aerial image from 1996 when only three of the sites were developed or under development and, what appears to be, second-growth forest covering the remaining seven parcels. Based on our analysis of the development pattern of these ten parcels, an average of 75,200 square feet of each lot was cleared for construction and landscaping, or approximately 34% of a 5-acre lot. Within the cleared area, approximately 16,900 square feet of impermeable surfaces (buildings and driveways) were added, approximately 8% of a 5-acre lot. The remaining cleared area (approximately 58,300 square feet, or 27% of a 5-acre lot, was generally converted to lawn and landscaped areas.

We have presumed that the soils disturbed during the clearing, grading, and development of the site were amended, tilled, and graded in accordance with County Code and Manual requirements. We have also presumed that water falling on impervious surfaces added during development will be infiltrated on site. The change from mature trees to grass lawn results in a reduced amount of canopy capture and evapotranspiration, the magnitude of this reduction is approximately 20% (Zhang, et al, 2004; Sanford and Selnick, 2013).

Additionally, where impervious surfaces, such as the house and driveway, occur no vegetation will grow and the evapotranspiration will be nearly zero. To be conservative, we estimate the evapotranspiration will decline in these areas by 90%.

The pre-development water balance of the property can be calculated using the following factors: precipitation, runoff, evapotranspiration, and recharge. The relationship between these factors can be described as follows:

$$N_P - N_R - N_{ET} = Recharge$$

Where:

$N_P = Precipitation$

$N_R = Runoff$

$N_{ET} = Evapotranspiration$

In the pre-development condition, the site receives 48 inches of precipitation (Drost, 1999). Evapotranspiration in Thurston County is generally estimated at 18 inches per year (Biever, 2017). Based on the surface geology, recharge is estimated at 18 inches per year (Drost, 1999), so the remaining 12 inches must be considered runoff.

The post-development condition is somewhat more complicated, as the consumptive use calculated earlier must be accounted for and the changes in the nature of the site must be evaluated. Precipitation remains unchanged. Approximately 65% of the 5-acre lot will also remain untouched. Therefore, this analysis only focuses on the portion of the lot that was changed during site development—the 35% of the area that was cleared during construction. Homes, outbuildings, and driveways were added, though compliance with current County stormwater requirements means that the water falling directly on these impermeable surfaces will be re-routed and infiltrated into the subsurface. These impervious surfaces will cover about 8% of a 5-acre lot.

The nature of the ground cover changed from mature trees to a grass lawn where the yard, drainfield, and reserve drainfield are located, other cleared areas were landscaped. This results in a commensurate decrease in evapotranspirative demand discussed earlier. However, in order to keep our analysis conservative, we elected to use three quarters of the earlier-stated decrease (15%). As stated earlier, for the impervious areas, the evapotranspiration rate will be reduced by approximately 90%. The amended soils in this area will have an enhanced infiltration capacity and will more readily accept rainfall, and County regulations require infiltration and dispersion of runoff, significantly reducing runoff from this portion of the property. As a conservative value, we reduced runoff by a quarter, to a value of nine inches per year.

Septic return flow will offset some of the water use on the property. Typically, 90% of the indoor use is considered to be returned to the drainfield (Culhane and Nazy, 2015, and Washington State Department of Ecology, 2018). However, we applied an evapotranspirative loss factor (ranging from 10% in May up to 30% in July and August) to the septic effluent return flow, as laterals may be within reach of plant and turf roots, resulting in the uptake of some of the effluent during hotter months. Finally, the water used outdoors is considered to be a largely consumptive use, with only 20% infiltrated into the subsurface (Culhane and Nazy, 2015).

With these factors, we are able to calculate a post-development water budget via the following relationship:

$$N_P - N_R - N_{ET} - N_{WW} + N_{OR} + N_{SR} = Recharge$$

Where:

$N_P = Precipitation$

$N_R = Runoff$

$N_{ET} = Evapotranspiration$

$N_{WW} = Well\ Withdrawal$

$N_{OR} = Outdoor\ Use\ Return\ Flow$

$N_{SR} = Septic\ Return\ Flow$

The results of this calculation are presented in Table 1.

Table 1: Pre- and post-development annual average water balance

Pre-development			Post Development (High Water Use, using Ecology's ESSB 6091 guidance)		Post Development (Moderate Water Use)	
	in/yr	gal/day	in/yr	gal/day	in/yr	gal/day
Precipitation	48	6,164	48	6,164	48	6,164
Runoff	-12	-1541	-9	-1156	-9	-1156
Evapotranspiration[1]	-18	-2,312	-11.6	-1486	-11.6	-1486
Well Withdrawal	0	0	-11.7	-597	-4.5	-229
Septic Return	0	0	2.6	135	2.9	149
Outdoor Return	0	0	1.7	89	0.3	13
Recharge	18	2,312	20.0	2,589	26.1	3353
			Total Change	277		1041

[1] Reduction prorated for combination of pervious and impervious surfaces

In the post-development condition, groundwater use from the planned well is partially offset by the infiltration of septic return flow and the partial infiltration of water used outside the home. The decrease in evapotranspiration of the developed area of the property, when coupled with the decreased runoff and increased infiltration capacity of the amended soils, results in an increase in the amount of water recharging the subsurface. Our analysis suggests that the resulting water balance of a project like this, under either water use scenario, more than completely offsets the consumptive use from the proposed well on the property, providing an increased amount of groundwater recharge under the post-development condition.

Seasonal Consideration

Under Ecology's ESSB 6091 water use estimates, the annual water balance indicates a 277 gallon per day increase per lot in average groundwater recharge. Using the lower water use estimates, as published by Culhane and Nazy (2015) and Golder (2013), the annual water balance indicates a 1,041 gallon per day increase per lot in average recharge due to the development.

However, these increases in groundwater recharge do not occur evenly over the year. The increase in recharge due to the reduction in runoff will occur mainly in the wet season. The reduction in evapotranspiration will occur mostly in the dry season. Water use, and consequently well production, will be higher in the dry season. Return from outdoor water use will occur mainly in the dry season. Returns from indoor use will occur year-round, largely unaffected by the seasonal changes in outdoor use.

If we consider the dry season to occur from May and October, assign the changes in water balance between wet and dry seasons accordingly, and presume that all the changes in recharge occur during this season, we can develop an approximate change in recharge for the dry season as shown on Table 2.

Table 2: Dry season change in recharge

	High Water Use	Moderate Water Use
	gal/day	gal/day
Precipitation	0	0
Runoff reduction	0	0
Evapotranspiration reduction	826	826
Well Withdrawal [1]	-1037	-292
Outdoor Return	89	13
Septic Return [2]	135	149
Total Change	13	695

[1] Average well production from May through October
[2] Average septic return flow from May through October

The effects of both the well production and the recharge will be attenuated relative to aquifer discharges to surface water due to both vertical and horizontal distance and the fact that the aquifers have substantial storage. Timing of recharge entering the aquifer will be attenuated by the sediments between the land surface and the aquifer. However, as indicated by Table 2, the increase in recharge even during the dry season should be larger than the consumptive use. Because of attenuation effects, the system should act largely in a steady-state manner. And certainly, any transient analysis on a time period shorter than wet and dry seasons is not warranted.

Conclusion

Based on our analysis of the historical development of ten five-acre lots, we have concluded that the consumptive water use and groundwater withdrawals of such a typical development are more than completely offset by the changes in evapotranspiration, reduction in runoff, and the septic return flows associated with the development. The year-round net annual water balance in the post-development condition is positive and results in additional infiltration to the subsurface.

The statements, conclusions, and recommendations provided in this report are to be exclusively used within the context of this document. They are based upon generally accepted environmental and hydrogeologic practices and are the result of analysis by Robinson Noble, Inc. staff. This report, and any attachments to it, is for the exclusive use of Bill Clarke and Washington REALTORS®. Unless specifically stated in the document, no warranty, expressed or implied, is made.

Attachments

Figure 1 – Current Aerial Map
Figure 2 – Historical Aerial Map

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Biever, M., 2017, Water year report summary of Thurston County precipitation, groundwater, stream and lake data from October 2016 to September 2017, Thurston County Water Resources – Environmental Monitoring Program: https://www.thurstoncountywa.gov/sw/swmonitoringdocuments/Water%20Year%202017%20Final%20Report.pdf

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ATTACHMENTS

ROBINSON NOBLE	Note: Imagery from Thurston County GIS 2015 Aerials	PM: MFP November 2018 3321-001A	Thurston County T 17 N/R 02 W - 25 Scale 1" = 600'	Figure 1 Current Aerial Map Washington Realtors: Water Balance Analysis

ROBINSON NOBLE	Note: Imagery from Thurston County GIS 1996 Aerials	PM: MFP November 2018 3321-001A	Thurston County T 17 N/R 02 W - 25 Scale 1" = 600'	Figure 2 Historical Aerial Map Washington Realtors: Water Balance Analysis

Appendix D

Attachment 2 to Comment O-7-9 (Washington REALTORS, January 17, 2020, Robinson & Noble – Pierce County/Sullivan Project Water Balance Analysis)

ROBINSON
NOBLE

JULIANN AND PAT SULLIVAN
HYDROGEOLOGIC ASSESSMENT
15712 28TH AVENUE NORTHWEST
PIERCE COUNTY PARCEL 0222171053

FEBRUARY, 2017

by

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Pat and Juli Sullivan
Pierce County Parcel 0222171053
15712 28th Avenue Northwest
Hydrogeologic Assessment
February 17, 2017

Introduction and Scope

This assessment has been prepared for Pat and Juli Sullivan to meet the requirements stated in Pierce County Policy Number DW2016-02, which requires a hydrogeologic assessment to determine if the proposed exempt well for a building project "impacts or impairs a senior water rights holder, and impacts or impairs established instream flows and closures as identified by the State." This policy is applicable in certain areas of Pierce County including portions of the Kitsap Watershed (WRIA 15). The site is located within the Crescent Valley drainage, an area that is seasonally closed to surface water appropriations, so it is included in this policy.

The site is located on the western side of 28th Avenue NW, north of Gig Harbor, Washington in unincorporated Pierce County. This area is within the Kitsap Watershed. The street address is 15712 28th Ave. NW, the Pierce County tax parcel number is 0222171053. The surrounding properties are generally developed with single-family residences on large lots. Figure 1 presents a site map, including the boundaries of the parcel and the location of wells evaluated for this assessment.

We understand that the proposed project involves the construction of a three-bedroom single-family residence to be served by an individual well and septic system. We reviewed a provided plat plan, wetland delineation report, and septic design for the proposed project. The proposed well is located on the parcel such that the 100-foot sanitary control radius does not overlap the planned septic drainfield or reserve area. The sanitary control radius does extend onto the neighboring property to the east, but a signed affidavit from that landowner has been filed with the County, so no well variance is required.

Site Setting and Topography

The site is located in the in the Crescent Valley area, on an upland above Crescent Lake, the source of Crescent Creek. The upland has an undulatory surface that was sculpted by the most recent continental glaciation. The features in this area generally trend from the north-northeast to the south-southwest, with lineations corresponding to the presumed direction of glacial motion. The property has a rectangular shape, 325 feet in a north-south direction, and 650 feet in an east-west direction. According to the USGS topographic quadrangle of the area, the site has an elevation of approximately 355 feet along the eastern margin, then with a gentle drop to 345 feet approximately 1/3 to the way to the western margin, then the elevation rises to 370 feet at the western margin.

We recently visited the site. No standing water was observed on the eastern portion of property, nor was any standing water observed in septic test pits on the property. The site is covered with mature trees, a mix of coniferous (Douglas fir, western red cedar, and hemlock) and deciduous (red alder and big-leaf maple). The understory was fairly clear, though some salal and blackberry were observed. At the time of our site visit, the home site and a portion of the proposed drainfield were partially cleared and the home location staked out. It may be necessary to remove additional trees within the footprint of the home, driveway, and septic drainfield to develop the property as planned.

General drainage patterns in the area follow the local topography. The upland containing the property generally slopes to the southeast, and the site is situated across a slight valley that drains to the south, so surficial drainage generally flows to the south towards Crescent Lake and Crescent Creek.

Surface Water

The site is located in Water Resource Inventory Area 15, specifically within the Crescent Creek basin. The local surface water drainage is towards the south. The nearest significant surface water is Crescent Lake, approximately 3,200 feet to the southeast. The nearest significant surface stream is Crescent Creek which is approximately 4,500 feet to the south of the property, though the USGS quadrangle shows a small tributary creek to Crescent Lake beginning approximately 2,000 feet directly south of the property. During periods of significant runoff, it is likely this small creek has an ephemeral appearance on the property. Crescent Creek flows out of Crescent Lake toward the south and discharges into Puget Sound at Gig Harbor.

Soils and Vegetation

The five-acre site is mostly covered with the Harstine gravelly ashy sandy loam with 6 to 15 percent slopes, a small portion of the site near the western boundary has steeper slopes (US Department of Agriculture, Soil Conservation Service). The Harstine loam is a moderately well-drained soil. It forms on the top of sandy glacial drift and generally contains volcanic ash. This soil is considered to be a part of Hydrologic Group C and is not considered a hydric soil. Our observations of the material on site are consistent with the soil survey data; we observed a tan to brown gravelly, sandy silty loam with occasional larger cobbles. Soils information is presented in Appendix A.

Site Geology

Site geology was determined by reviewing published geologic maps of the region. Booth and Troost (2005) map the site and surrounding area as the Vashon till, which is a highly-compacted mixture of sand, gravel, silt and clay that was deposited beneath and overridden by the latest continental glaciation. Typically, till has a relatively low permeability, though it may vary locally based on the composition and the degree of compaction. Review of nearby water well reports suggests that the till is generally over 50 feet thick in the area.

Conceptual Hydrogeologic Understanding

To better understand the relationships between aquifers, confining units, groundwater, and surface water features, we developed a conceptual model of the study area. The site is located on the eastern margin of the glaciated upland that forms the Kitsap Peninsula. Puget Sound borders the peninsula to the east, south, and southwest, and glaciated upland plains extend to the north and west towards Sinclair Inlet and Hood Canal, respectively.

The top of the upland is capped with the Vashon till, which forms a relatively low-permeability confining unit. A thin veneer of Vashon outwash deposits may be locally present over the top of the till, but in the vicinity of the site, the till is present at the surface. Geologic maps and well logs suggest the thickness of the till is at least 90 feet in the vicinity of the site. The till surface is gently rolling; there are lineations that trend north-northeast to the south-southwest, corresponding to the presumed direction of glacial motion.

The Vashon advance outwash (Qva) sand is present beneath the till. Pre-Vashon deposits are not specifically named in Welch (2014) or Booth and Troost (2005), but rather are described texturally. For the purposes of this study, the descriptions in Welch will be used, with no discussion of deposits deeper than the sea level Aquifer (QA1), as the deepest wells reviewed do not even reach sea level. The unconsolidated sediments in this portion of Pierce County exceed 1,000 feet thick.

The first principal aquifer in the region is a confined aquifer formed in the Vashon advance outwash sand. The Vashon advance outwash sand is well-sorted sand with occasional gravel; it may also contain silty zones. While it may be unconfined, a review of well logs completed within the advance sand suggest that it is fully saturated in this area, and therefore, is confined in this area. Its thickness ranges from 20 to 240 feet, averaging 85 feet in the Kitsap Peninsula area (Welch, 2014).

Well logs from the area around the property indicate the Vashon advance outwash generally has two zones of sand and gravel separated by silty zone (clay is sometimes described as well, though the presence of true clay in Vashon outwash sediments should be limited). It appears most well require drilling into the deeper zone to find an adequate supply.

A deeper aquifer also exists in the area. Welch identifies this deeper aquifer the sea level aquifer (QA1) (Welch, 2014). Typically, it is separated from the advance sands by a thick clay or silt. The aquifer material is typically described as water-bearing sand, occasionally having some gravel.

The Vashon advance outwash is exposed at lower elevations where valleys have been eroded through the till. The valley containing Crescent Lake and Crescent Creek have significant outcrops of the Vashon advance outwash. Spring discharge and seepage is common along the walls of these valleys. The valleys floors are covered with the Vashon recessional outwash, which is a coarser sand and gravel deposited by glacial meltwater as the glaciers retreated.

As the aquifer deposits within the Vashon advance outwash and the QA1 have a significant regional extent in this watershed, recharge to the aquifers results from the infiltration of precipitation throughout the region, and gradients tend to be regionally influenced. The general flow direction within the Qva aqufier is towards the south in the vicinity of the site. The flow in the QA1 aquifer is southeasterly toward Colvos Passage (Welch, 2014).

Though some water undoubtedly runs off the upland via surface drainage, a significant portion infiltrates where slopes are not extreme or where it is captured in depressions. A portion of this water discharges as spring flow along the valley walls, but some fraction infiltrates deeper and is the fundamental mechanism for aquifer recharge. Based on the observed head relationship between the noted aquifer zones, some portion of the water in the shallower zone infiltrates and provides recharge to the deeper aquifer systems evaluated.

The discharge points for the shallow Qva aquifer include springs and seepage along the valley containing Crescent Lake and Crescent Creek to the south of the property and to Colvos Passage coastline to the east. The site straddles a small valley within the upland, so surficial runoff and shallow groundwater are presumed to also flow in a southerly direction towards Crescent Lake and Crescent Creek. Given the relative elevations, there isn't a local discharge point for the QA1 aquifer system. Based on groundwater flow information presented in Welch and our regional understanding of groundwater flow, the QA1aquifer generally flows in east-southeasterly and discharges in Colvos Passage (Welch, 2014).

Well Analysis

As described above, there are several aquifers in the region that supply water to domestic wells. We reviewed well logs in the vicinity of the proposed project, geocoding the well locations to the degree possible given the information on the water well reports. We also evaluated the stratigraphic logs and well completion information to determine depths and type of aquifer present near this location.

Well depths in the vicinity range from 53 to 218 feet deep. Of the 39 wells evaluated for this study, 14 are located within 1,500 feet of the proposed well. These were analyzed further, and the logs of these wells are included in Appendix B. Of these, 3 are completed at approximately 55 feet deep and 3 are completed at around 100 feet; these are all completed in the Qva aquifer. The remaining 6 are completed in the deep QA1aquifer, found at 170 feet. The depths to water are typically 20 to 50 in the shallow aquifer and around 90 feet in the deeper system. This increasing depth to water (decreasing head with increasing depth) indicates that this area is an aquifer recharge area.

We calculated aquifer characteristics using the pumping test information recorded on the logs following the methods described in Welch (2014). When the water well report included information from a pump or bailer test, we calculated aquifer transmissivity via the modified Theis formula presented in Ferris (1962). In cases where the well was tested with an air test, we used the equation developed by Bear (1979) to calculate a hydraulic conductivity for the aquifer material, then calculated aquifer transmissivity by multiplying the calculated hydraulic conductivity by the thickness of the water-bearing deposit. Aquifer parameters were tabulated, then averaged. At this location, it is apparent that two separate aquifer zones are present, we so we calculated average values for each aquifer.

Table 1: Wells within 1,500 feet

Well ID	Tag	Radial Distance (ft)	Depth (ft)	Depth to Water (ft)	Aquifer Zone	Theis Transmissivity (gpd/ft)	Bear Transmissivity (gpd/ft)
358079	ABA-064	250	102	65	Qva	679	
55131	ABP-815	390	178	107	QA1	1490	
55134	ABP-828	460	119	72	Qva	5580	
509961	BAT-439	540	148	83	QA1	1042	
1568113	BIY-098	680	98	40	Qva	1931	
1568407	BJN-278	820	151	74	QA1	1051	
511663	APR-640	890	160	108	QA1	2297	
43804		920	90	45	Qva	2988	
47822		1030	86	46	Qva	863	
52826		1060	53	20	Qva	2097	
583877	ABG-626	1065	53	22	Qva		2513
48908		1120	161	90	QA1	3621	

Well ID	Tag	Radial Dis-tance (ft)	Depth (ft)	Depth to Water (ft)	Aquifer Zone	Theis Transmis-sivity (gpd/ft)	Bear Trans-missivity (gpd/ft)
360212	AGE-533	1480	218	92.5	QA1	568	
48966		1490	63	25	Qva	1117	

The shallow aquifer transmissivity values average approximately 2,100 gallons per day per foot of aquifer width (gpd/ft), though wells in the shallower portion of the aquifer show a slightly smaller transmissivity at about 1,900 gpd/ft and those in the deeper portion a slightly higher value averaging around 2,400 gpd/ft. The deep aquifer has an average transmissivity of about 1,700 gpd/ft.

Using these values, we evaluated the potential for the new well to impair existing wells by calculating the interference drawdown for each of the neighboring wells as a result of the proposed new well. The Theis equation (Theis, 1935) for calculating steady-state drawdown at a radial distance was used, though due to the scarcity of data, we relied upon an assumed storage coefficient of 0.0001, as used by Welch (2014), which, though conservative, is an appropriate value for confined sand and gravel aquifer materials.

We selected a pumping rate based on information tabulated in Welch (2014). The evaluation of 27 years of water use in the Kitsap Peninsula indicates that indoor use averages 66 gallons per day (gpd) per person. Outdoor use ranges from 0 to a maximum of 97 gpd per person depending on the month, and we calculated an average of 61 gpd for the 6-month growing season (May through October). The US Census calculated an average of 2.65 persons per household in Pierce County, so the per-person water use numbers were multiplied by this amount. These calculations indicate an indoor water use, growing-season outdoor water use, and total water use of 175, 162, and 337 gpd, respectively. These values are approximately double those presented in Culhane and Nazy (2015) and Golder (2013), but were used to complete a conservative analysis. Culhane and Nazy (2015) state that indoor use is only 10% consumptive, the remaining 90% is returned via septic infiltration, and that residential outdoor use is considered to be 80% consumptive, with 20% returned via infiltration. Other sources, such as Savoca (2010) suggest outdoor return flow can be as high as 40%. To stay conservative in our approach, we used the 80% consumptive value.

A rate of 337 gpd was selected to calculate the potential for impact during the highest-use period. Under steady-state conditions, this equates to slightly more than 0.2 gallons per minute (gpm). Using the equations presented in Theis (1935), we calculated the predicted drawdowns at each of the wells within 1,000 feet of the proposed well after 184 days (May – October) of continuous pumping, representing the conditions at the end of the summer season.

Table 2: Predicted drawdown after 100 days of pumping

Well ID	Tag	Radial Distance (ft.)	Aquifer	Predicted Drawdown (ft.)
358079	ABA-064	250	Qva	0.11
55131	ABP-815	390	QA1	0.14
55134	ABP-828	460	Qva	0.10
509961	BAT-439	540	QA1	0.13
1568113	BIY-098	680	Qva	0.09

Well ID	Tag	Radial Distance (ft.)	Aquifer	Predicted Drawdown (ft.)
1568407	BJN-278	820	QA1	0.12
511663	APR-640	890	QA1	0.11
43804		920	Qva	0.08
47822		1030	Qva	0.08
52826		1060	Qva	0.10
583877	ABG-626	1065	Qva	0.10
48908		1120	QA1	0.11
360212	AGE-533	1480	QA1	0.10
48966		1490	Qva	0.09

The nearest well in the upper portion of the Qva aquifer is 1,060 feet away. The conservative 184-day prediction results in 0.10 feet of drawdown at this radial distance, which does not represent an impairment in a well with over 30 feet of available drawdown. The nearest well in the deeper portion of the Qva aquifer is 250 feet away. A similar calculation predicts a drawdown of 0.11 feet. Similarly, this does not represent an impairment, as wells completed in the deeper portion of the Qva typically have over 50 feet of drawdown available. The nearest well in the deep QA1 aquifer is 390 feet away. The predicted drawdown at this location is 0.14 feet, which does not represent an impairment in a well that has over 70 feet of available drawdown. These small values of predicted drawdown approach the accuracy limit of the Theis approach as applied to the available dataset.

Water Balance Analysis

To assess impacts to Crescent Lake and Creek and other surface waters in the area, we completed a water balance evaluation of the property and proposed development on an annualized basis. This analysis concentrated on the changes as a result of the proposed project from the pre-development conditions.

We used information presented in Garling and Molenaar (1965) and Welch (2014) to determine the rainfall and infiltration rate of the site. Based on those publications, the site and surrounding area receive 48 inches of rainfall, with 14.5 inches of that resulting in recharge to the aquifers beneath the site

As we understand the project, there will be a home and driveway constructed on the eastern margin of the site, forming impermeable surfaces and potentially increasing runoff. In Pierce County, site development is held to the standards presented in Title 17A of the Pierce County Code and the Pierce County Stormwater Management and Site Development Manual, these require infiltration or dispersion of stormwater falling on impervious surfaces, with the intent to reduce runoff and erosion and enhance recharge to the subsurface. Additionally, per the County Code and Manual, any disturbed soil must be amended to enhance infiltration, which will also serve to reduce runoff from the site. Studies indicate a significant increase in the infiltration rate of tilled, compost-amended soils (Brown and Cotton, 2011; Kays, et al, 2015).

As we understand the project, site development activities will be confined to the area immediately surrounding the proposed home, septic drainfield, driveway, and yard. As planned, there will be several fir and alder trees removed, but incidental clearing will be limited to the eastern portion of the property. For the purposes of this assessment, we have calculated that no clearing or grading will take place further west than the edge of the mapped wetland buffer, yielding a project area of approximately 30,000 square feet. We have presumed that the soils disturbed during the clearing, grading, and development of the site will be amended, tilled, and graded in accordance with County Code and Manual requirements. We have also presumed that all water falling on impervious surfaces added during development will be infiltrated on site. The change from mature trees to a grass lawn in this area of the property will result in a reduced amount of canopy capture and evapotranspiration, the magnitude of this reduction is approximately 20% (Zhang, et al, 2004; Sanford and Selnick, 2013).

Additionally, where impervious surfaces, such as the house and driveway, occur no vegetation will grow and the evapotranspiration will be nearly zero. To be conservative, we estimate the evapotranspiration will decline in these areas by 90%.

The pre-development water balance of the property can be calculated using the following factors: precipitation, runoff, evapotranspiration, and recharge. The relationship between these factors can be described as follows:

$$N_P - N_R - N_{ET} = Recharge$$

Where:

$N_P = Precipitation$

$N_R = Runoff$

$N_{ET} = Evapotranspiration$

In the pre-development condition, the site receives 48 inches of precipitation Garling and Molenaar, 1965). Evapotranspiration in Pierce County is generally estimated at 22 inches per year (Savoca, 2010). Based on the surface geology, recharge is estimated at 15 inches per year (Welch, 2014; Savoca, 2010), so the remaining 11 inches must be considered runoff.

The post-development condition is somewhat more complicated, as the consumptive use calculated earlier must be accounted for and the changes in the nature of the site must be evaluated. Precipitation remains unchanged. Approximately 86% of the area of the site will also remain untouched. The remaining 14% of the site will be cleared, graded, and changed as discussed earlier. A home and driveway will be added, though compliance with County stormwater requirements means that the water falling directly on these impermeable surfaces will be re-routed and infiltrated into the subsurface. These impervious surfaces will cover about 2% of the site.

The nature of the groundcover will change from mature trees to a grass lawn in the area where the yard, drainfield, and reserve drainfield will be located. This will result in a commensurate decrease in evapotranspirative demand discussed earlier. However, in order to keep our analysis conservative, we elected to use three quarters of the earlier-stated decrease (15%). As stated earlier, for the impervious areas, the evapotranspiration rate will be reduced by approximately 90%. The amended soils in this area will have an enhanced infiltration capacity and will more readily accept rainfall, and County regulations require infiltration and dispersion of runoff, significantly reducing runoff from this portion of the property. As a conservative value, we reduced runoff by a half, to a value of 5.5 inches per year.

Septic return flow will offset some of the water use on the property. Typically, 90% of the indoor use is considered to be returned to the drainfield (Culhand and Nazy, 2015). However, we applied an evapotranspirative loss factor (ranging from 10% in May up to 30% in July and August) to the septic effluent return flow, as laterals may be within reach of plant and turf roots, resulting in the uptake of some of the effluent during hotter months. Finally, the water used outdoors is considered to be a largely consumptive use, with only 20% infiltrated into the subsurface (Culhane and Nazy, 2015).

With these factors, we are able to calculate a post-development water budget via the following relationship:

$$N_P - N_R - N_{ET} - N_{WW} + N_{OR} + N_{SR} = Recharge$$

Where:

N_P = *Precipitation*

N_R = *Runoff*

N_{ET} = *Evapotranspiration*

N_{WW} = *Well Withdrawal*

N_{OR} = *Outdoor Use Return Flow*

N_{SR} = *Septic Return Flow*

The results of this calculation are presented in Table 3.

Table 3: Pre- and post-development annual water balance

Pre-development		
	in/yr	gal/day
Precipitation	48	2459
Runoff	-11	-564
Evapotranspiration	-22	-1127
Well Withdrawal	0	0
Septic Return	0	0
Outdoor Return	0	0
Recharge	15	768

Post-development		
	in/yr	gal/day
Precipitation	48	2459
Runoff (-50%)	-5.5	-282
Evapotranspiration (-74.2%)[1]	-16.3	-836
Well Withdrawal	-4.7	-243
Outdoor Return (20%)	0.3	14
Septic Return (63% to 90%)[2]	2.8	142
Recharge	24.5	1254
Total Change		485

[1] Reduction prorated for combination of pervious and impervious surfaces

[2] 90% return flow in wet season ranging downward to 63% in dry season due to ET uptake above drain field

In the post-development condition, groundwater use from the planned well is partially offset by the infiltration of septic return flow and the partial infiltration of water used outside the home. The decrease in evapotranspiration of the developed area of the property, when coupled with the decreased runoff and increased infiltration capacity of the amended soils, will result in an increase to the amount of water recharging the subsurface. The resulting water balance of this project entirely offsets the consumptive use from the proposed well on the property and provides an increase in recharge as a result of the post-development condition.

Seasonal Consideration

The annual water balance indicates an increase in average recharge at the property of 485 gallons per day due to the development. However, this increase in recharge will not occur evenly over the year. The increase in recharge due to the reduction in runoff will occur mainly in the wet season. The reduction in evapotranspiration will occur mostly in the dry season. Water use, and consequently well production, will be higher in the dry season. Return from outdoor water use will occur mainly in the dry season. And return from indoor use will occur year-round, but will be higher in the wet season due to possible uptake by plants above the drain field.

If we consider the dry season to occur from May and October, assign the changes in water balance between wet and dry seasons accordingly, and presume that all the changes in recharge occur during this season, we can develop an approximate change in recharge for the dry season as shown on Table 4.

Table 4: Dry season change in recharge

	gal/day
Precipitation	0
Runoff reduction	0
Evapotranspiration reduction	291
Well Withdrawal [1]	-310
Outdoor Return	14
Septic Return [2]	126
Total Change	121

[1] Average well production from May through October
[2] Average septic return flow from May through October

The effects of both the well production and the recharge will be attenuated relative to aquifer discharges to surface water due to both vertical and horizontal distance and the fact that the aquifers have substantial storage. Timing of recharge entering the aquifer will be attenuated by the approximately 50 feet of sediments between the surface and the upper aquifer. However, as indicated by Table 4, the increase in recharge even during the dry season should be larger than the consumptive use.

In the case of the well, if it is placed in the Qva aquifer, it will be roughly 4,000 to 5,000 feet from the nearest downgradient aquifer discharge point in the Crescent Valley Creek. If it is placed in the lower portion of the QA1 aquifer, it will be 6,000 to 7,000 feet from the likely aquifer discharge points at Colvos Passage. Considering that the highest daily average production rate will be approximately 0.3 gpm, resulting in drawdown in the aquifer outside the wellbore of less than one foot, the change in gradient driving the change in aquifer discharge will be extremely small. Further, this change in gradient should be offset by the increase in recharge. In the case of a well in the Qva aquifer, the production and increase in recharge occur in the same aquifer, negating effects to the nearby creek and lake, which receives discharge from that aquifer. In the case of the well being completed in the QA1 aquifer, the increase in recharge to the shallow aquifer will increase flows to Crescent Creek, while the pumping impact from the well will mostly occur as a smaller discharge directly to Puget Sound. Pumping from the QA1 aquifer may slightly increase leakage downward out the Qva, causing an extremely small decrease in discharge to Crescent Lake and Creek from the Qva, but this will be greatly offset by the increase in recharge to the Qva.

Because of attenuation effects, the system should act largely in a steady-state manner. And certainly, any transient analysis on a time period shorter than wet and dry seasons is not warranted.

Recommendations

Consider drilling the proposed well to at least 100 feet deep in order to complete the well in the deeper portion of the Qva aquifer. The shallower wells have a higher susceptibility to impacts due to surficial contamination and are more likely to experience seasonal deficiencies. Additionally, the wells completed in the deeper portion of the Qva and the Qa1 aquifer have twice the available drawdown, so they should prove to be a more reliable water source over the long term.

Conclusion

Based on our analysis of the information provided, the well proposed to supply this project will not impact or impair a senior water rights holder, and will not impact or impair established instream flows and closures as identified by the State. As the net annual water balance in the post-development condition is positive and results in additional infiltration, no mitigation is required.

The statements, conclusions, and recommendations provided in this report are to be exclusively used within the context of this document. They are based upon generally accepted environmental and hydrogeologic practices and are the result of analysis by Robinson Noble, Inc. staff. This report, and any attachments to it, is for the exclusive use of Pat and Juli Sullivan. Unless specifically stated in the document, no warranty, expressed or implied, is made.

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US Census Bureau QuickFacts: http://www.census.gov/quickfacts/table/PST045216/53053,00

United States Department of Agriculture, Soil Conservation Service, in cooperation with the Washington Agricultural Experiment Station, Soil survey of Pierce County area, Washington: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

United States Geologic Survey, 2013, 7.5-Minute topographic quadrangle, Olalla, Washington, scale 1:24,000

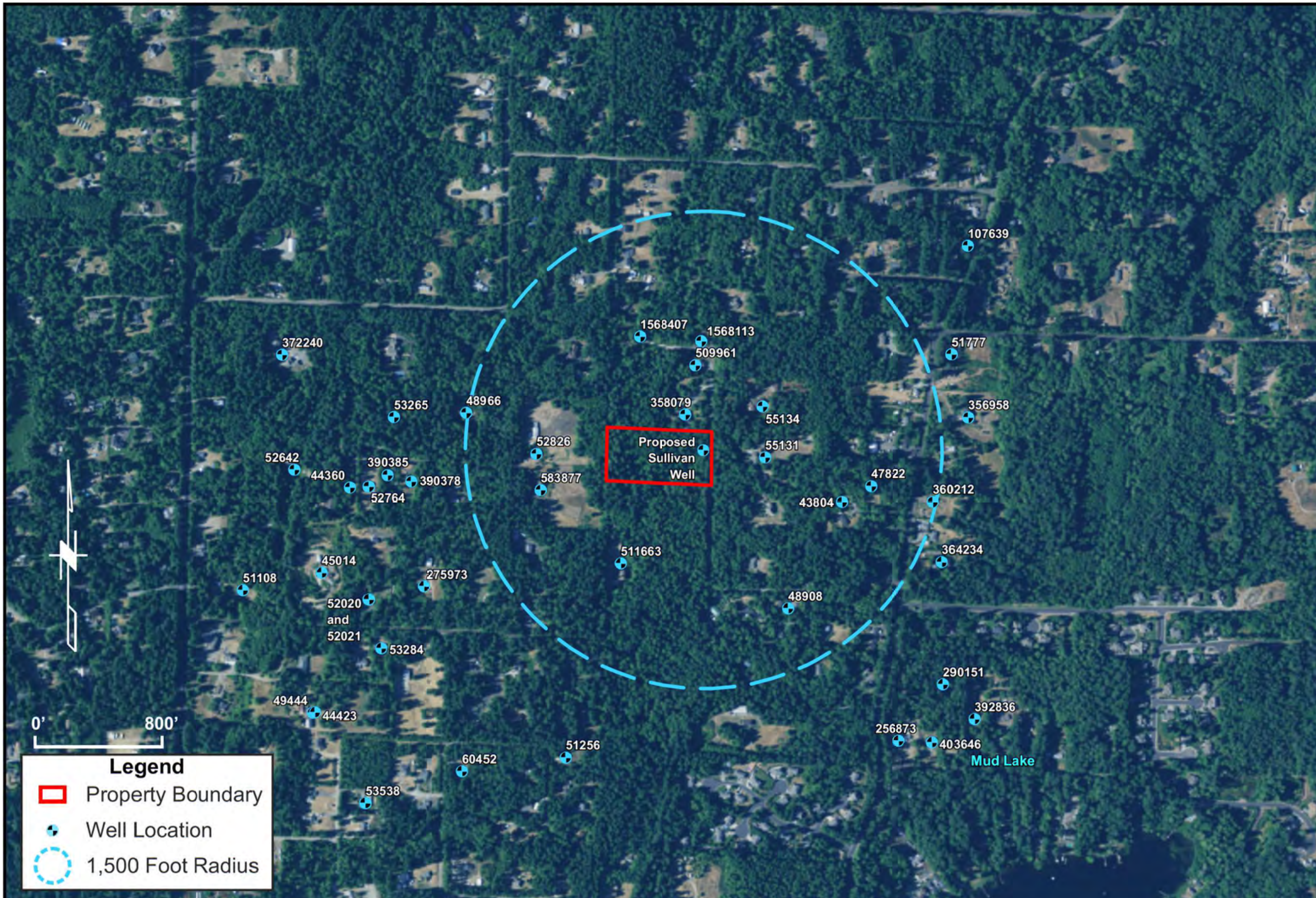
Welch, W.B., et al, 2014, Hydrogeologic framework, groundwater movement, and water budget of the Kitsap Peninsula, west-central Washington: United States Geological Survey Scientific Investigations Report 2014-5106

Zhang, L., K. Hickel, W. R. Dawes, F. H. S. Chiew, A. W. Western, and P. R. Briggs, 2004, A rational function approach for estimating mean annual evapotranspiration: Water Resources Research, vol. 40, W02502, doi:10.1029/2003WR002710

Attachments

Appendix A Figure 1 – Well Location and Vicinity Map
Appendix B Well Logs
Appendix C Soil Logs

APPENDIX A -- FIGURES



ROBINSON NOBLE	Note: Image from ESRI ArcGIS	PM: MFP February 2017 3175-001A	Pierce County T 22 N/R 02 E - 17 Scale 1" = 800'	Figure 1 **Well Location and Vicinity Map** Pat & Juli Sullivan: Hydrogeologic Assessment

APPENDIX B

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Airport Application No.
Permit No.

(1) **OWNER:** Name A. L. Hart (Tallman) Address 15616 Crescent Valley Dr. N.W. Gig Harbor, Wn.

(2) **LOCATION OF WELL:** County Pierce — NE ¼ NE ¼ Sec. 17 T. 22 N., R. 2E W.M.
Bearing and distance from section or subdivision corner A

(3) **PROPOSED USE:** Domestic [x] Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one)....
New well [x] Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 90 ft. Depth of completed well 90 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 6" Diam. from 0 ft. to 85½ ft.
Threaded ☐ " Diam. from ft. to ft.
Welded [x] " Diam. from ft. to ft.

Perforations: Yes ☐ No [x]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [x] No ☐
Manufacturer's Name Johnson
Type stainless steel Model No.
Diam. 6 Slot size 35 from 85 ft. to 90 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No [x] Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☐ No [x] To what depth? ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ~340 ft.
Static level 45 ft. below top of well Date 10-16-62
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 10-16-62
Bailer test 40 gal./min. with 25 ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG:**
Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Topsoil	0	2
Sand & gravel brown hardpan	2	37
Blue sand & gravel hardpan	37	53
Sand & gravel some water	53	63
Gray hardpan some seepage	63	84
Sand & gravel water bearing	84	90

RECEIVED
JUN 12 1975
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

22/2E-17A

Work started 10-13-, 1962. Completed 10-16-, 1962

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Harbor Pump & Drilling Co., Inc. (Person, firm, or corporation) (Type or print)
Address 7825 46th Ave. N.W. Gig Harbor, Wn. 98335
[Signed] Byrl Gustin By: M. Butler (Well Driller)
License No. 0476 223-01-8455 Date 6-11-, 1974

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No
Permit No

(1) **OWNER:** Name Harvey Brown Address 15712 Crescent Valley Dr. NW Gig Hrb

(2) **LOCATION OF WELL:** County Pierce — NE ¼ NE ¼ Sec. 17 T. 22 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one)
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 86' ft. Depth of completed well 86' ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6" Diam. from 0 ft. to 82 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type stainless steel Model No.
Diam. 6 Slot size 60 from 82 ft. to 86 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite 100 lbs.
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name Berkeley
Type: Submersible H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 46 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 10 gal./min. with 20 ft. drawdown after 2 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Brown top soil	0	3
Gray Hard pan	3	26
Sandy brown hard pan	26	31
Brown sand, some seepage	31	38
Brown sandy clay	38	43
Gray sandy hard pan	43	60
Gray Hard pan	60	68
Gray hard pan with clay	68	74
Gray sand and gravel, - water bearing	74	77
Hard packed sand & gravel	77	82
Gray sand & gravel, water	82	86
Gard packed sand & gravel	86	-

RECEIVED
MAY 22 1980
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 4-24 19 80 Completed 4-28 19 80

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME HARBOR PUMP & DRILLING CO., INC. (Person, firm, or corporation) (Type or print)

Address 11302 Burnham Dr. NW Gig Harbor, WA

[Signed] Wade [signature] By: P. Miller (Well Driller)

License No. 223-01-8455 597 Date April 29, 19 80

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

[redacted]

Water Right Permit No. ______

(1) **OWNER:** Name John Berry [redacted] Rd.

(2) **LOCATION OF WELL:** County Pierce SW ¼ NE ¼ Sec 17 T 22 N., R 2E W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address) [redacted] 98335

(3) **PROPOSED USE:** ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ______

Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well Six inches.
Drilled 151 feet. Depth of completed well 151 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6 " Diam. from +1 ft. to 146 ft.
Welded ☒ ______ " Diam. from ______ ft. to ______ ft.
Liner installed ☐
Threaded ☐ ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Cook
Type Stainless Model No. ______
Diam. 6 Slot size 12 from 146 ft. to 151 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) **PUMP:** Manufacturer's Name Goulds
Type: Submersible H.P. 3/4

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ______ ft.
Static level 90 ft. below top of well Date 2-21-91
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? P&P
Yield: 14 gal./min. with 7 ft. drawdown after 2 hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
6	97				
2	90				

Date of test ______
Bailer test 20 gal./min. with 10 ft. drawdown after 1 hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Top Soil	0	2
Sand Brown	2	13
Hard Pan	13	33
Sand + Gravel (seeping)	33	35
Clay (Blue)	35	122
Hard Pan	122	128
Sand + Gravel (H2O)	128	151

Work started Aug-30, 1990 Completed Sept. 6, 1990

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME P&P Well Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address Port Orchard
(Signed) Pat Nolley (WELL DRILLER) License No. 0521
Contractor's Registration No. PP Well DRC Date Sept 10, 1990

(USE ADDITIONAL SHEETS IF NECESSARY)

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. 065839
Water Right Permit No.

(1) OWNER: Name STACY BRIAN Address 1211 SUNSET DR S TACOMA, WA 98465-

(2) LOCATION OF WELL: County PIERCE - NE 1/4 NW 1/4 Sec 17 T 22 N., R 2E WM
(2a) STREET ADDRESS OF WELL (or nearest address) 3103 196TH ST NW

(3) PROPOSED USE: DOMESTIC

(4) TYPE OF WORK: Owner's Number of well (If more than one)
NEW WELL Method: AIR ROTARY

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 53 ft. Depth of completed well 47 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Dia. from 0 ft. to 47 ft.
WELDED " Dia. from ft. to ft.
" Dia. from ft. to ft.

Perforations: NO
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: NO
Manufacturer's Name
Type Model No.
Diam. slot size from ft. to ft.
Diam. slot size from ft. to ft.

Gravel packed: NO Size of gravel
Gravel placed from ft. to ft.

Surface seal: YES To what depth? 18 ft.
Material used in seal BENTONITE CLAY
Did any strata contain unusable water? NO
Type of water? Depth of strata ft.
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 20 ft. below top of well Date 12/06/90
Artesian Pressure lbs. per square inch Date / /
Artesian water controlled by

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? NO If yes, by whom?
Yield: gal./min with ft. drawdown after hrs.

Recovery data
Time Water Level Time Water Level Time Water Level

Date of test / /
Bailer test 30 gal/min. 25 ft. drawdown after 1 hrs.
Air test gal/min. w/ stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? NO

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
SANDY TOPSOIL	0	2
SAND AND SOME GRAVEL	2	9
COMPACTED SAND	9	14
COMPACTED SAND AND CLAY	14	24
SEEPAGE SAND CLAY	24	26
HARDPAN	26	42
WATER SAND & GRAVEL	42	47
DIRTY SAND	47	53

Work started 11/30/90 Completed 12/03/90

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME RICHARDSON WELL DRILLING
(Person, firm, or corporation) (Type or print)

ADDRESS PO BOX 44427 TAC WA 98444

[SIGNED] License No. 0284

Contractor's
Registration No. RICHAW*3210B Date 01/22/91

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W052689
UNIQUE WELL I.D. # ABP815
Water Right Permit No.

(1) **OWNER:** Name PEDRO AND WENDY PINTO Address 22404 Military Road S., Sea-Tac, WA 98198

(2) **LOCATION OF WELL:** County Pierce — NW 1/4 NE 1/4 Sec 17 T 22 N., R 2E W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address) off Crescent Valley Road

(3) **PROPOSED USE:** [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) **TYPE OF WORK:** Owner's number of well (If more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 178 feet. Depth of completed well 178 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 6 " Diam. from 0 ft. to 178 ft.
Welded [X] " Diam. from ft. to ft.
Liner installed [ ] " Diam. from ft. to ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [XX] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name Goulds
Type: submersible 10GS10 H.P. 1

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 107 ft. below top of well Date 5/02/95
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [X] No [ ] If yes, by whom? Gresham
Yield: 15 gal./min. with 18 ft. drawdown after 2 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
Full recov. in 5 min.					

Date of test 5/02/95
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 20+ gal./min. with stem set at 170 ft. for 1 hrs.
Artesian flow g.p.m. Date
Temperature of water 50 Was a chemical analysis made? Yes [X] No [ ]

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown topsoil	0	4
Gray hardpan	4	27
Gray silty sand & gravel	27	69
Gray hardpan	69	93
Gray silty sand & gravel	93	131
Gray hardpan	131	164
Gray clay w/gravel	164	167
Gray silty coarse sand & gravel, H20	167	178

RECEIVED '95 MAY 15 A10:08

Work Started 4/26/95, 19. Completed 4/27/95, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Gresham Well Drilling, Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 3105 NW Lakeness Rd.,Poulsbo, WA 98370
(Signed) [signature] (WELL DRILLER) License No. 0761
Contractor's Registration No. GRESHWD055BC Date 5/04/95, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W053930
UNIQUE WELL I.D. # ABP828
Water Right Permit No. ______

(1) **OWNER:** Name MARK KNOWLES Address 21600 24TH AVE.S.#E101, DES MOINES,WA 98198

(2) **LOCATION OF WELL:** County PIERCE NW 1/4 NE 1/4 Sec 17 T. 22 N., R 2E W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address) 15821 28TH AVENUE NW, GIG HARBOR

(3) **PROPOSED USE:** [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) **TYPE OF WORK:** Owner's number of well (If more than one) ______
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [XX] Bored [ ] Driven [ ] Jetted [ ]

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 119 feet. Depth of completed well 119 ft.

(6) **CONSTRUCTION DETAILS:**
Casing Installed: 6" Diam. from 0 ft. to 119 ft.
Welded [X] " Diam. from ____ ft. to ____ ft.
Liner installed [ ] " Diam. from ____ ft. to ____ ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes [ ] No [XX]
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ____ Slot size ______ from ______ ft. to ______ ft.
Diam. ____ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) **PUMP:** Manufacturer's Name GOULDS
Type: SUBMERSIBLE 10GS10 H.P. 1

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ______ ft.
Static level 72 ft. below top of well Date 6/09/95
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [XX] No [ ] If yes, by whom? GRESHAM
Yield: 15 gal./min. with 5 ft. drawdown after 1 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
FULL RECOV. IN 2 MIN.					

Date of test 6/09/95
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 20 gal./min. with stem set at 115 ft. for 1 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water 50 Was a chemical analysis made? Yes [XX] No [ ]

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
OVERBURDEN	0	4
GRAY HARDPAN	4	28
GRAY SAND & GRAVEL	28	52
BLUE CLAY	52	78
GRAVEL, H20 - 2GPM	78	79
GRAY HARDPAN	79	112
GRAVEL, H20	112	119

Work Started 6/07/95, 19. Completed 6/07/95, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME GRESHAM WELL DRILLING, INC. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 3105 NW LAKENESS RD.,POULSBO,WA 98370
(Signed) [signature] (WELL DRILLER) License No. 0761
Contractor's Registration No. GRESHWD055BC Date 6/16/95, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

WATER WELL REPORT

Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

Construction/Decommission *("x" in circle)*
- ⦿ Construction
- ○ Decommission *ORIGINAL CONSTRUCTION Notice* 127549 *of Intent Number*

CURRENT Notice of Intent No. W061595

Unique Ecology Well ID Tag No. ABA-064

Water Right Permit No.

Property Owner Name JOE LAW

Well Street Address 18826 28th AVE N.W.

City GIG HARBOR County: PIERCE

Location NE 1/4-1/4 NW 1/4 Sec 17 Twn 22 R 2 (EWM) circle one or WWM

Lat/Long: (s,t,r still REQUIRED) Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____

Tax Parcel No. 0222171054

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other

TYPE OF WORK: Owner's number of well (if more than one) ____
☒ New Well ☐ Reconditioned *Method* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☒ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 102 ft
Depth of completed well 103 ft

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6" Diam from 0 ft. to 103 ft
☐ Liner installed ____" Diam from ____ ft. to ____ ft
☐ Threaded ____" Diam. from ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____
SIZE of perfs ____ in by ____ in and no of perfs ____ from ____ ft to ____ ft

Screens: ☒ Yes ☐ No ☒ K-Pac Location 96
Manufacturer's Name Johnson
Type Stainless Steel Model No ____
Diam 5" Slot Size 10 from 102 ft to 96 ft
Diam ____ Slot Size ____ from ____ ft to ____ ft

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ____
Materials placed from ____ ft to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 19 ft
Materials used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name ____
Type ____ H P ____

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 65 ft below top of well Date ____
Artesian pressure ____ lbs per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? ____
Yield 10 gal./min with 25' ft drawdown after 2 hrs
Yield ____ gal./min with ____ ft drawdown after ____ hrs
Yield ____ gal./min with ____ ft drawdown after ____ hrs

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
15 min	74'				
1 min	67'				

Date of test ____
Bailer test 12 gal./min with ____ ft drawdown after 2 hrs
Airtest ____ gal./min with stem set at ____ ft for ____ hrs
Artesian flow ____ g p m Date ____
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information Indicate all water encountered (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Top soil	0	4
clay-gravel	4	11
clay-gravel-boulder	11	16
brown sand	16	47
gravel-sand-clay	47	83
gray clay-sand	83	85
gravel-sand-clay	85	96
sand gray WB.	96	102

RECEIVED
JAN 16 2003
Washington State Department of Ecology

Start Date 12/4/02 Completed Date 12/23/02

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Bruce Lewis
Driller/Engineer/Trainee Signature Bruce Lewis
Driller or Trainee License No. 2627

If trainee, licensed driller's Signature and License no. ____

Drilling Company HARBOR PUMP CO. INC
Address P.O. Box 330
City, State, Zip BURLEY WA. 98322
Contractor's Registration No HARBOPC114DH Date 1/13/03

Ecology is an Equal Opportunity Employer ECY 050-1-20 (Rev 4/01)

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

Construction/Decommission *("x" in circle)*
☒ Construction
○ Decommission *ORIGINAL CONSTRUCTION Notice* 130700 *of Intent Number*

CURRENT Notice of Intent No. W162612

Unique Ecology Well ID Tag No. AGE 533

Water Right Permit No. ______

Property Owner Name ANN Lemieux

Well Street Address 15625 CrescentVy Dr NW

City Gig Harbor County: Pierce

Location NE 1/4-1/4 NE 1/4 Sec 17 Twn 22 R 2 EWM (circle one) or WWM

Lat/Long: (s,t,r still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. 0222171065

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______
☒ New Well ☐ Reconditioned ☐ Deepened
Method: ☐ Dug ☐ Bored ☐ Driven ☒ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 218 ft
Depth of completed well 218 ft

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6" Diam from +1 ft to 213 ft
☐ Liner installed ______" Diam from ______ ft to ______ ft
☐ Threaded ______" Diam from ______ ft to ______ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ______
SIZE of perfs ______ in by ______ in. and no of perfs ______ from ______ ft to ______ ft

Screens: ☒ Yes ☐ No ☐ K-Pac Location ______
Manufacturer's Name ______
Type S/S Model No ______
Diam 6T Slot Size .010 from 213 ft to 218 ft
Diam ______ Slot Size ______ from ______ ft to ______ ft

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ______
Materials placed from ______ ft to ______ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft
Materials used in seal Holeplug
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name Gould
Type Submersible HP 3/4

WATER LEVELS: Land-surface elevation above mean sea level ______ ft
Static level 92.5 ft below top of well Date 3/5/03
Artesian pressure ______ lbs per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? by Driller
Yield 16 gal./min with 45 ft. drawdown after 1 hrs
Yield ______ gal./min with ______ ft drawdown after ______ hrs
Yield ______ gal./min with ______ ft drawdown after ______ hrs

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0.00	137	20.10	92.5		
5.00	110				
10.10	96				

Date of test ______
Bailer test ______ gal./min with ______ ft. drawdown after ______ hrs
Airtest ______ gal./min with stem set at ______ ft for ______ hrs
Artesian flow ______ g p m Date ______
Temperature of water ______ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Top soil	0	1
Sand & gravel	1	5
gravely Hardpan	5	60
Hard Pan	60	88
Sand	88	91
Clayish Hardpan + gravel	91	194
Fine Sand	194	210
Sand	210	218

RECEIVED APR 04 2003 DEPARTMENT OF ECOLOGY WELL DRILLING UNIT

DEPT. OF ECOLOGY FISCAL & BUDGET '03 APR 1 P1:04

Start Date 2/17/03 Completed Date 3/4/03

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Wesley Glessner
Driller/Engineer/Trainee Signature Wesley Glessner
Driller or Trainee License No. 0154

If trainee, licensed driller's Signature and License no. ______

Drilling Company Wes Glessner Drilling
Address PO Box 487
City, State, Zip Burley Wa 98322
Contractor's Registration No. WESGLD*082P6 Date 3/5/03

Ecology is an Equal Opportunity Employer ECY 050-1-20 (Rev 4/01)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)* 282131

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION*

Notice of Intent Number ______

CURRENT

Notice of Intent No. WEO7604

Unique Ecology Well ID Tag No. BAT439

Water Right Permit No. ______

Property Owner Name WILLIAM SARNO

Well Street Address 15905 28TH AVE NW

City GIG HARBOR County PIERCE

Location NW1/4-1/4 NE1/4 Sec 17 Twn 22 R 2E EWM ☒ Or WWM ☐

(s, t, r Still REQUIRED)

Lat/Long Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____

Tax Parcel No. (Required) 0222175005

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ____

☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 148 ft.
Depth of completed well 148 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6" Diam. from 0 ft. to 233 ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft
☐ Threaded ____" Diam From ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No

Type of perforator used ______

SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☒ Yes ☐ No ☒ K-Pac Location 141' 10-3/4"

Manufacturer's Name JNSN

Type SS Model No. TELES

Diam. 5" Slot size 18 from 143 ft. to 148 ft.

Diam ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ____

Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft

Material used in seal BENTONITE

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.

Static level 83 ft below top of well Date 11/13/2007

Artesian pressure ____ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☐ No If yes, by whom? ______

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test 15 gal./min. with 24 ft drawdown after 1 hrs.

Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.

Artesian flow ____ g.p.m. Date ______

Temperature of water ____ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
PIPE STICK UP	0	1
BROWN SAND, CLAY, GRAVEL	1	16
GRAY SAND, GRAVEL, WET	16	21
BROWN SAND, GOME GRAVEL, WET	21	41
GRAY SAND, CLAY, GRAVEL,	41	
SEAMS WET		61
GRAY SILT, SAND, GRAVEL	61	85
GRAY SAND, GRAVEL, SEAMS WATR	85	109
GRAY SILT, SAND, GRAVEL, CLAY	109	140
GRAY SAND, GRAVEL, SEAMS WATR	140	148

RECEIVED
DEC 10 2007
Washington State
Department of Ecology

Start Date 11/7/2007 Completed Date 11/13/2007

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) JOHN SULLIVAN

Driller/Engineer/Trainee Signature [signature]

Driller or trainee License No. 2218

IF TRAINEE: Driller's License No:

Driller's Signature:

Drilling Company NICHOLSON DRILLING INC

Address PO BOX 123

City, State, Zip PORT ORCHARD, WA, 98366

Contractor's Registration No. NICHODI1370M Date 11/30/2007

22-2E-20F

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Construction/Decommission (*"x" in circle*)
☒ Construction
○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* 285208

CURRENT
Notice of Intent No. W216866

Unique Ecology Well ID Tag No. APR640
Water Right Permit No.
Property Owner Name Swen Weinmann
Well Street Address 15515 30th AVE NW
City Gig Harbor County Pierce
Location SE 1/4-1/4 NW 1/4 Sec 20 Twn 22N R 2E EWM or WWM (circle one)
Lat/Long (s, t, r Still **REQUIRED**) Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____
Tax Parcel No. 0222171051

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ____

TYPE OF WORK: Owner's number of well (if more than one) ____
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☒ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 160 ft.
Depth of completed well 160 ft.

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6" Diam. from +1 ft. to 155 ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft.
☐ Threaded ____" Diam. from ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____
SIZE of perfs ---- in. by ---- in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☒ Yes ☐ No ☒ K-Pac Location 154
Manufacturer's Name Johnson
Type Stainless steel Model No. ____
Diam. 5 Slot size 14 from 155 ft. to 160 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ____
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name Goulds
Type: Submersible H.P. 1

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 108 ft. below top of well Date 10/25/07
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? Olsen Drl.
Yield: 15 gal./min. with 9 ft. drawdown after 1 hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0	117'	3 m	108'		
1 m	111'				
2 m	104'				

Date of test 10/25/07
Bailer test 10 gal./min. with 8 ft. drawdown after 2 hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? ☒ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Brown sand	0	37
Grey till	37	132
Grey clay	132	136
Grey sand	136	145
Grey sand w/b	145	160
Grey tight sand	160	----

RECEIVED
NOV 14 2007
DEPT. OF ECOLOGY

Start Date 9/20/07 Completed Date 10/25/07

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Matt Olsen
Driller/Engineer/Trainee Signature Matt Olsen
Driller or trainee License No. 2337

If TRAINEE,
Driller's Licensed No. ____
Driller's Signature ____

Drilling Company Olsen Drilling
Address PO Box 1554
City, State, Zip Port Orchard, WA 98366
Contractor's Registration No. OLSEND101LJ Date 11/9/07

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

339850

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 34136
UNIQUE WELL I.D. # ABG 626
Water Right Permit No. ______

(1) OWNER: Name Hallstrom, Mark Address 4911 No. Highland, Tacoma WA

(2) LOCATION OF WELL: County Pierce NW 1/4 NW 1/4 Sec 17 T. 22N N., R. 2E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 3025 150th St. N.W., Gig Harbor, WA.

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) TYPE OF WORK: Owner's number of well (If more than one) ______
☐ Abandoned ☒ New well ☐ Deepened ☐ Reconditioned
Method: ☐ Dug ☐ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 53 feet. Depth of completed well 53 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 6" Diam. from +2 ft. to 53 ft.
☒ Welded ______ Diam. from ______ ft. to ______ ft.
☐ Liner installed
☐ Threaded ______ Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 19.5 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 22 ft. below top of well Date Nov. 3, 1994
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 9-10 gal./min. with stem set at 53' ft. for 1.0 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Top Soil	0	2
Brn Sands some Traces of Brn Silts	2	11
Brn Silts & medium Sands & small angular Gravels	11	31
Silty Gray Sands Sticky	31	36
Gravels & Sands water Bearing	36	53

RECEIVED 94 DEC 12 A9:47

Work Started Nov 2, 19__ Completed Nov 3, 1994

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Holt Testing Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10621 Todd Rd., Puyallup
(Signed) [signature] (WELL DRILLER) License No. 2148
Contractor's Registration No. HOLTT108707 Date Nov 3, 1994

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050 1-20 (2/93)

DEPARTMENT OF ECOLOGY State of Washington

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*

- [x] Construction
- [ ] Decommission *ORIGINAL INSTALLATION*

Notice of Intent Number WE21844

PROPOSED USE: [x] Domestic [ ] Industrial [ ] Municipal [ ] DeWater [ ] Irrigation [ ] Test Well [ ] Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______
[x] New well [ ] Reconditioned *Method:* [ ] Dug [ ] Bored [ ] Driven
[ ] Deepened [ ] Cable [x] Rotary [ ] Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 98 ft.
Depth of completed well 98 ft.

CONSTRUCTION DETAILS

Casing Installed: [x] Welded 6" Diam. from 0 ft. to 96 ft.
[ ] Liner installed ___" Diam. from ___ ft. to ___ ft.
[ ] Threaded ___" Diam. From ___ ft. to ___ ft.

Perforations: [ ] Yes [x] No
Type of perforator used ______
SIZE of perfs ___ in. by ___ in. and no. of perfs ___ from ___ ft. to ___ ft.

Screens: [x] Yes [ ] No [ ] K-Pac Location ______
Manufacturer's Name JOHNSON
Type STAINLESS STEEL Model No. TELESCOPE
Diam. 6 Slot size 16 from 93 ft. to 98 ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel/Filter packed: [ ] Yes [x] No Size of gravel/sand ______
Materials placed from ___ ft. to ___ ft.

Surface Seal: [x] Yes [ ] No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? [ ] Yes [x] No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ___ ft.
Static level 40 ft. below top of well Date ______
Artesian pressure ___ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? [ ] Yes [x] No If yes, by whom? ______
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test 10 gal./min. with 9 ft. drawdown after 1 hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ______
Temperature of water ___ Was a chemical analysis made? [ ] Yes [x] No

CURRENT

Notice of Intent No. WE21844
Unique Ecology Well ID Tag No. BHY 098
Water Right Permit No. ______
Property Owner Name David and Liz Stanton
Well Street Address 2811 159th ST CT NW
City Gig Harbor County Pierce
Location ne 1/4-1/4 ne 1/4 Sec 17 Twn 22 R 2E EWM [x] Or WWM [ ]
(s, t, r Still REQUIRED)

Lat/Long
Lat Deg ___ Lat Min/Sec ___
Long Deg ___ Long Min/Sec ___

Tax parcel No. (Required) 022175008

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Pipe stick up	0	1
Brown grey fill	1	3
Grey sand gravel clay wet	3	16
Grey sand gravel water	16	34
Grey sand gravel clay wet	34	77
Grey sand gravel water	77	98

RECEIVED
MAY 27 2016
WA State Department of Ecology (SWRO)

Start Date 01/10/2016 Completed Date 01/20/2016

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

[x] Driller [ ] Engineer [ ] Trainee Name Nic Sample
Driller/Engineer/Trainee Signature [signature]
Driller or trainee License No. 2770
IF TRAINEE: Driller's License No:
Driller's Signature:

Drilling Company Nicholson Drilling INC.
Address PO BOX 123
City, State, Zip Port Orchard, WA, 98367
Contractor's Registration No. NICHODI137OM Date 02/15/2016

ECY 050-1-20 (Rev 02-2010) To request ADA accommodation including materials in a format for the visually impaired, call Ecology Water Resources Program at 360-407-6872. Persons with impaired hearing may call Washington Relay Service at 711. Persons with speech disability may call TTY at 877-833-6341.

DEPARTMENT OF ECOLOGY State of Washington

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*

☒ Construction
☐ Decommission *ORIGINAL INSTALLATION*
Notice of Intent Number WE21843

CURRENT

Notice of Intent No. WE21843
Unique Ecology Well ID Tag No. BJN 278
Water Right Permit No.
Property Owner Name DAVID STANTON
Well Street Address 2917 159TH ST CT NW
City GIG HARBOR County PIERCE
Location nw1/4-1/4 ne 1/4 Sec 17 Twn 22 R 2E EWM ☒ Or WWM ☐
(s, t, r Still REQUIRED)

Lat/Long
Lat Deg ____ Lat Min/Sec ____
Long Deg ____ Long Min/Sec ____

Tax parcel No. (Required) 0222175007

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ____

TYPE OF WORK: Owner's number of well (if more than one) ____
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 151 ft.
Depth of completed well 151 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6 " Diam. from 0 ft. to 151 ft.
☐ Liner installed ____ " Diam. from ____ ft. to ____ ft.
☐ Threaded ____ " Diam. From ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____
SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ____
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ____
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 74 ft. below top of well Date ____
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test 17 gal./min. with 27 ft. drawdown after 1 hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Pipe stick up	0	1
Grey sand gravel clay wet	1	13
Grey clay	13	24
Brown sand silt wet	24	33
Brey sand gravel cley damp	33	109
Grey clay	109	136
Grey sand gravel clay	136	145
Grey coarse sand gravel water	145	151

RECEIVED
JUN 09 2016
WA State Department of Ecology (SWRO)

Start Date 02/02/16 Completed Date 02/04/16

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name NIC SAMPLE
Driller/Engineer/Trainee Signature [signature]
Driller or trainee License No. 2770
IF TRAINEE: Driller's License No:
Driller's Signature:

Drilling Company NICHOLSON DRILLING INC.
Address PO BOX 123
City, State, Zip PORT ORCHARD, WA, 98367
Contractor's Registration No. NICHODI137OM Date 06/06/2016

ECY 050-1-20 (Rev 02-2010) To request ADA accommodation including materials in a format for the visually impaired, call Ecology Water Resources Program at 360-407-6872. Persons with impaired hearing may call Washington Relay Service at 711. Persons with speech disability may call TTY at 877-833-6341.

APPENDIX C

Soil Map—Pierce County Area, Washington
(Sullivan_3175-001A_Parcel)

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 11, Sep 9, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 1, 2011—Aug 20, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Pierce County Area, Washington (WA653)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
16C	Harstine gravelly ashy sandy loam, 6 to 15 percent slopes	4.5	88.4%
16D	Harstine gravelly ashy sandy loam, 15 to 30 percent slopes	0.6	11.6%
Totals for Area of Interest		**5.1**	**100.0%**

Pierce County Area, Washington

16C—Harstine gravelly ashy sandy loam, 6 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2rtvj
Elevation: 200 to 390 feet
Mean annual precipitation: 30 to 55 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Harstine and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harstine

Setting

Landform: Ridges
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Nose slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Sandy glacial drift with an influence of volcanic ash over dense glaciomarine deposits

Typical profile

Oi - 0 to 0 inches: slightly decomposed plant material
Oe - 0 to 1 inches: moderately decomposed plant material
Bw1 - 1 to 6 inches: gravelly ashy sandy loam
Bw2 - 6 to 14 inches: gravelly ashy sandy loam
Bw3 - 14 to 22 inches: gravelly ashy sandy loam
Bw4 - 22 to 32 inches: gravelly ashy sandy loam
2Cd1 - 32 to 38 inches: gravelly loamy sand
2Cd2 - 38 to 61 inches: gravelly loamy sand

Properties and qualities

Slope: 6 to 15 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Depth to water table: About 24 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: C
Other vegetative classification: Limited Depth Soils (G002XN302WA)
Hydric soil rating: No

Minor Components

Indianola

Percent of map unit: 5 percent
Landform: Eskers, kames, terraces
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Norma

Percent of map unit: 3 percent
Landform: Depressions, drainageways
Landform position (three-dimensional): Dip
Down-slope shape: Concave, linear
Across-slope shape: Concave
Hydric soil rating: Yes

Dupont

Percent of map unit: 3 percent
Landform: Depressions, troughs
Landform position (three-dimensional): Dip
Down-slope shape: Concave, linear
Across-slope shape: Concave
Hydric soil rating: Yes

Neilton

Percent of map unit: 2 percent
Landform: Outwash terraces
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Mckenna

Percent of map unit: 2 percent
Landform: Depressions, drainageways
Landform position (three-dimensional): Dip
Down-slope shape: Concave, linear
Across-slope shape: Concave

Hydric soil rating: Yes

Data Source Information

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 11, Sep 9, 2016

Pierce County Area, Washington

16D—Harstine gravelly ashy sandy loam, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: 2rtvk
Elevation: 200 to 390 feet
Mean annual precipitation: 30 to 55 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Harstine and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harstine

Setting

Landform: Ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Sandy glacial drift with an influence of volcanic ash over dense glaciomarine deposits

Typical profile

Oi - 0 to 0 inches: slightly decomposed plant material
Oe - 0 to 1 inches: moderately decomposed plant material
Bw1 - 1 to 6 inches: gravelly ashy sandy loam
Bw2 - 6 to 14 inches: gravelly ashy sandy loam
Bw3 - 14 to 22 inches: gravelly ashy sandy loam
Bw4 - 22 to 32 inches: gravelly ashy sandy loam
2Cd1 - 32 to 38 inches: gravelly loamy sand
2Cd2 - 38 to 61 inches: gravelly loamy sand

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Depth to water table: About 24 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Other vegetative classification: Limited Depth Soils (G002XN302WA)
Hydric soil rating: No

Minor Components

Indianola

Percent of map unit: 5 percent
Landform: Eskers, kames, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Neilton

Percent of map unit: 5 percent
Landform: Outwash terraces
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Data Source Information

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 11, Sep 9, 2016

APPENDIX C

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Airport Application No ......
Permit No. ......

(1) OWNER: Name A. L. Hart (Tallman) Address 15616 Crescent Valley Dr. N.W. Gig Harbor, Wn.

(2) LOCATION OF WELL: County Pierce — NE ¼ NE ¼ Sec. 17 T. 22 N., R. 2E W.M.
Bearing and distance from section or subdivision corner A

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ......
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 90 ft. Depth of completed well 90 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 85½ ft.
Threaded ☐ ...... " Diam. from ...... ft. to ...... ft.
Welded ☒ ...... " Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type stainless steel Model No. ......
Diam. 6 Slot size 35 from 85 ft. to 90 ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☐ No ☒ To what depth? ...... ft.
Material used in seal ......
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name ......
Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ~340 ft.
Static level 45 ft. below top of well Date 10-16-62
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ......
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 10-16-62
Bailer test 40 gal./min. with 25 ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Topsoil	0	2
Sand & gravel brown hardpan	2	37
Blue sand & gravel hardpan	37	53
Sand & gravel some water	53	63
Gray hardpan some seepage	63	84
Sand & gravel water bearing	84	90

RECEIVED
JUN 12 1975
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

22/2E-17A

Work started 10-13-, 19 62. Completed 10-16-, 19 62

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Harbor Pump & Drilling Co., Inc. (Person, firm, or corporation) (Type or print)

Address 7825 46th Ave. N.W. Gig Harbor, Wa 98335

[Signed] Byrd Gustin By: M. Butler (Well Driller)

License No. 0476 223-01-8455 Date 6-11-, 19 74

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No
Permit No.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

(1) OWNER: Name Harvey Brown Address 15712 Crescent Valley Dr. NW Gig Hrb

(2) LOCATION OF WELL: County Pierce — NE ¼ NE ¼ Sec. 17 T. 22 N., R. 2E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 86' ft. Depth of completed well 86' ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 82 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type stainless steel Model No.
Diam. 6 Slot size 60 from 82 ft. to 86 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite 100 lbs.
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name Berkeley
Type: Submersible H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 46 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 10 gal./min. with 20 ft. drawdown after 2 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Brown top soil	0	3
Gray Hard pan	3	26
Sandy brown hard pan	26	31
Brown sand, some seepage	31	38
Brown sandy clay	38	43
Gray sandy hard pan	43	60
Gray Hard pan	60	68
Gray hard pan with clay	68	74
Gray sand and gravel, - water bearing	74	77
Hard packed sand & gravel	77	82
Gray sand & gravel, water	82	86
Gard packed sand & gravel	86	-

RECEIVED
MAY 22 1980
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 4-24, 19 80 Completed 4-28, 19 80

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME HARBOR PUMP & DRILLING CO., INC.
(Person, firm, or corporation) (Type or print)

Address 11302 Burnham Dr. NW Gig Harbor, W

[Signed] Wade Jackson By: P. Miller
(Well Driller)

License No. 223-01-8455 597 Date April 29, 19 80

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

[redacted]

Water Right Permit No. ______

(1) OWNER: Name John Berry [redacted]

(2) LOCATION OF WELL: County Pierce SW ¼ NE ¼ Sec 17 T 22 N., R 2E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) [redacted] 98336

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one) ______
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well Six inches.
Drilled 151 feet. Depth of completed well 151 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 146 ft.
Welded ☒ ______ " Diam. from ______ ft. to ______ ft.
Liner installed ☐
Threaded ☐ ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Cook
Type Stainless Model No. ______
Diam. 6 Slot size 12 from 146 ft. to 151 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name Goulds
Type: Submersible H.P. 3/4

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 90 ft. below top of well Date 2-21-91
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? P+P
Yield: 14 gal./min. with 7 ft. drawdown after 2 hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
6	97				
2	90				

Date of test ______
Bailer test 20 gal./min. with 10 ft. drawdown after 1 hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Top Soil	0	2
Sand Brown	2	13
Hard Pan	13	33
Sand + Gravel (seepage)	33	35
Clay (Blue)	35	122
Hard Pan	122	128
Sand + Gravel (W.B.)	128	151

Work started Aug - 30, 1990 Completed Sept. 6, 1990

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME P+P Well Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address Port Orchard
(Signed) P. Woolley (WELL DRILLER) License No. 0531
Contractor's Registration No. PP well inc Date Sept 10, 1990

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10 87) -1329-

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. 065839
Water Right Permit No.

(1) OWNER: Name STACY BRIAN   Address 1211 SUNSET DR S TACOMA, WA 98465-

(2) LOCATION OF WELL: County PIERCE   - NE 1/4 NW 1/4 Sec 17 T 22 N., R 2E WM
(2a) STREET ADDRESS OF WELL (or nearest address) 3103 1[illegible]TH ST SW

(3) PROPOSED USE: DOMESTIC

(4) TYPE OF WORK: Owner's Number of well (If more than one)
NEW WELL   Method: AIR ROTARY

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 53 ft. Depth of completed well 47 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Dia. from 0 ft. to 47 ft.
WELDED " Dia. from ft. to ft.
" Dia. from ft. to ft.

Perforations: NO
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: NO
Manufacturer's Name
Type   Model No.
Diam. slot size from ft. to ft.
Diam. slot size from ft. to ft.

Gravel packed: NO   Size of gravel
Gravel placed from ft. to ft.

Surface seal: YES   To what depth? 18 ft.
Material used in seal BENTONITE CLAY
Did any strata contain unusable water? NO
Type of water?   Depth of strata ft.
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type   H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 20 ft. below top of well Date 12/06/90
Artesian Pressure lbs. per square inch Date / /
Artesian water controlled by

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? NO If yes, by whom?
Yield: gal./min with ft. drawdown after hrs.

Recovery data
Time Water Level Time Water Level Time Water Level

Date of test / /
Bailer test 30 gal/min. 25 ft. drawdown after 1 hrs.
Air test gal/min. w/ stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water   Was a chemical analysis made? NO

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratus penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
SANDY TOPSOIL	0	2
SAND AND SOME GRAVEL	2	9
COMPACTED SAND	9	14
COMPACTED SAND AND CLAY	14	24
SEEPAGE SAND CLAY	24	26
HARDPAN	26	42
WATER SAND & GRAVEL	42	47
DIRTY SAND	47	53

Work started 11/30/90   Completed 12/03/90

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME RICHARDSON WELL DRILLING
(Person, firm, or corporation) (Type or print)

ADDRESS PO BOX 44427 TAC WA 98444

[SIGNED]   License No. 0284

Contractor's Registration No. RICHAW*321OB   Date 01/22/91

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W052689
UNIQUE WELL I.D. # ABP815
Water Right Permit No. ____

(1) OWNER: Name PEDRO AND WENDY PINTO Address 22404 Military Road S., Sea-Tac, WA 98198

(2) LOCATION OF WELL: County Pierce NW 1/4 NE 1/4 Sec 17 T. 22 N., R 2E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) off Crescent Valley Road

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (If more than one) ____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 178 feet. Depth of completed well 178 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from 0 ft. to 178 ft.
Welded [X] ____ " Diam. from ____ ft. to ____ ft.
Liner installed [ ] ____ " Diam. from ____ ft. to ____ ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes [ ] No [XX] Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name Goulds
Type: submersible 10GS10 H.P. 1

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 107 ft. below top of well Date 5/02/95
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [X] No [ ] If yes, by whom? Gresham
Yield: 15 gal./min. with 18 ft. drawdown after 2 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
Full recov. in 5 min.					

Date of test 5/02/95
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest 20+ gal./min. with stem set at 170 ft. for 1 hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water 50 Was a chemical analysis made? Yes [X] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown topsoil	0	4
Gray hardpan	4	27
Gray silty sand & gravel	27	69
Gray hardpan	69	93
Gray silty sand & gravel	93	131
Gray hardpan	131	164
Gray clay w/gravel	164	167
Gray silty coarse sand & gravel, H2O	167	178

RECEIVED '95 MAY 15 AM 10:08

Work Started 4/26/95, 19. Completed 4/27/95, 19__

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Gresham Well Drilling, Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 3105 NW Lakeness Rd., Poulsbo, WA 98370
(Signed) [signature] (WELL DRILLER) License No. 0761
Contractor's Registration No. GRESHWD055BC Date 5/04/95, 19__

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W053930
UNIQUE WELL I.D. # ABP828
Water Right Permit No.

(1) OWNER: Name MARK KNOWLES Address 21600 24TH AVE.S.#E101, DES MOINES,WA 98198

(2) LOCATION OF WELL: County PIERCE NW 1/4 NE 1/4 Sec 17 T. 22 N., R 2E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 15821 28TH AVENUE NW, GIG HARBOR

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (if more than one) ____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary XX Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 119 feet. Depth of completed well 119 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 6 " Diam. from 0 ft. to 119 ft.
Welded [X] ____ " Diam. from ____ ft. to ____ ft.
Liner installed [ ] ____ " Diam. from ____ ft. to ____ ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes [ ] No XX
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name GOULDS
Type: SUBMERSIBLE 10GS10 H.P. 1

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 72 ft. below top of well Date 6/09/95
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes XX No [ ] If yes, by whom? GRESHAM
Yield: 15 gal./min. with 5 ft. drawdown after 1 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)
Time / Water Level / Time / Water Level / Time / Water Level
FULL RECOV. IN 2 MIN.

Date of test 6/09/95
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest 20 gal./min. with stem set at 115 ft. for 1 hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water 50 Was a chemical analysis made? Yes XX No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
OVERBURDEN	0	4
GRAY HARDPAN	4	28
GRAY SAND & GRAVEL	28	52
BLUE CLAY	52	78
GRAVEL, H20 - 2GPM	78	79
GRAY HARDPAN	79	112
GRAVEL, H20	112	119

Work Started 6/07/95, 19. Completed 6/07/95, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME GRESHAM WELL DRILLING, INC. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 3105 NW LAKENESS RD.,POULSBO,WA 98370
(Signed) [signature] (WELL DRILLER) License No. 0761
Contractor's Registration No. GRESHWD055BC Date 6/16/95, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

CURRENT Notice of Intent No. W061595

Unique Ecology Well ID Tag No. ABA-064

Water Right Permit No.

Construction/Decommission *("x" in circle)*
- ⦿ Construction
- ○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* 127549

Property Owner Name JOE LAW

Well Street Address 18826 28th AVE N.W.

City GIG HARBOR County: PIERCE

Location NE 1/4-1/4 NW 1/4 Sec 17 Twn 22 R 2 (EWM) circle one or WWM

Lat/Long: (s,t,r still REQUIRED) Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____

Tax Parcel No. 0222171054

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other

TYPE OF WORK: Owner's number of well (if more than one) ____
☒ New Well ☐ Reconditioned *Method* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☒ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 102 ft
Depth of completed well 103 ft

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6" Diam from 0 ft. to 103 ft
☐ Liner installed ___" Diam from ___ ft. to ___ ft
☐ Threaded ___" Diam. from ___ ft. to ___ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____
SIZE of perfs ___ in by ___ in and no of perfs ___ from ___ ft to ___ ft

Screens: ☒ Yes ☐ No ☒ K-Pac Location 96
Manufacturer's Name Johnson
Type Stainless Steel Model No ____
Diam 5" Slot Size 10 from 102 ft to 96 ft
Diam ___ Slot Size ___ from ___ ft to ___ ft

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ____
Materials placed from ___ ft to ___ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 19 ft
Materials used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name ____
Type ____ H P ____

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 65 ft below top of well Date ____
Artesian pressure ___ lbs per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? ____
Yield 10 gal./min with 25' ft drawdown after 2 hrs
Yield ___ gal./min with ___ ft drawdown after ___ hrs
Yield ___ gal./min with ___ ft drawdown after ___ hrs

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
[illegible] min	74'				
1 min	67'				

Date of test ____
Bailer test 12 gal./min with ___ ft drawdown after 2 hrs
Airtest ___ gal./min with stem set at ___ ft for ___ hrs
Artesian flow ___ g p m Date ____
Temperature of water ___ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information Indicate all water encountered (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Top soil	0	4
clay-gravel	4	11
clay-gravel-boulder	11	16
brown sand	16	47
gravel-sand-clay	47	83
gray clay-sand	83	85
gravel-sand-clay	85	96
sand gray W.B.	96	102

RECEIVED
JAN 16 2003
Washington State Department of Ecology

Start Date 12/4/02 Completed Date 12/23/02

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Bruce Lewis
Driller/Engineer/Trainee Signature Bruce Lewis
Driller or Trainee License No. 2627

If trainee, licensed driller's Signature and License no. ____

Drilling Company Harbor Pump Co. Inc.
Address P.O. Box 330
City, State, Zip Burley WA. 98322
Contractor's Registration No. HARBOPC114D4 Date 1/13/03

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

Construction/Decommission *("x" in circle)*

☒ Construction

○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* 130700

CURRENT Notice of Intent No. W162612

Unique Ecology Well ID Tag No. AGE 533

Water Right Permit No.

Property Owner Name ANN Lemieux

Well Street Address 15625 Crescent Vy Dr NW

City Gig Harbor County: Pierce

Location NE 1/4-1/4 NE 1/4 Sec 17 Twn 22 R 2 EWM (circle one) or WWM

Lat/Long: (s,t,r still REQUIRED) Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____

Tax Parcel No. 0222171065

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other

TYPE OF WORK: Owner's number of well (if more than one) ____

☒ New Well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven

☐ Deepened ☒ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 218 ft

Depth of completed well 218 ft

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6" Diam from +1 ft to 213 ft

☐ Liner installed ____" Diam from ____ ft to ____ ft

☐ Threaded ____" Diam from ____ ft to ____ ft

Perforations: ☐ Yes ☒ No

Type of perforator used ____

SIZE of perfs ____ in by ____ in and no of perfs ____ from ____ ft to ____ ft

Screens: ☒ Yes ☐ No ☐ K-Pac Location ____

Manufacturer's Name ____

Type S/S Model No ____

Diam 6T Slot Size .010 from 213 ft to 218 ft

Diam ____ Slot Size ____ from ____ ft to ____ ft

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ____

Materials placed from ____ ft to ____ ft

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft

Materials used in seal Holeplug

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? ____ Depth of strata ____

Method of sealing strata off ____

PUMP: Manufacturer's Name Gould

Type Submersible HP 3/4

WATER LEVELS: Land-surface elevation above mean sea level ____ ft

Static level 92.5 ft below top of well Date 3/5/03

Artesian pressure ____ lbs per square inch Date ____

Artesian water is controlled by ____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☒ Yes ☐ No If yes, by whom? by Driller

Yield 16 gal./min with 45 ft. drawdown after 1 hrs

Yield ____ gal./min with ____ ft drawdown after ____ hrs

Yield ____ gal./min with ____ ft drawdown after ____ hrs

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0.00	137	20:10	92.5		
5:00	110				
10:00	96				

Date of test ____

Bailer test ____ gal./min with ____ ft. drawdown after ____ hrs

Airtest ____ gal./min with stem set at ____ ft for ____ hrs

Artesian flow ____ g p m Date ____

Temperature of water ____ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered (USE ADDITIONAL SHEETS IF NECESSARY)

MATERIAL	FROM	TO
Top soil	0	1
Sand & gravel	1	5
gravely Hardpan	5	60
Hardpan	60	88
Sand	88	91
Clayish Hardpan + gravel	91	194
Fine Sand	194	210
Sand	210	218

RECEIVED APR 04 2003 DEPARTMENT OF ECOLOGY WELL DRILLING UNIT

DEPT. OF ECOLOGY FISCAL & BUDGET '03 APR 1 P1:04

Start Date 2/17/03 Completed Date 3/4/03

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Wesley Glessner

Driller/Engineer/Trainee Signature Wesley Glessner

Driller or Trainee License No. 0154

If trainee, licensed driller's Signature and License no. ____

Drilling Company Wes Glessner Drilling

Address PO Box 487

City, State, Zip Burley Wa 98322

Contractor's Registration No WESGLD*** Date 3/5/03

WASHINGTON STATE DEPARTMENT OF ECOLOGY

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

CURRENT

Construction/Decommission *("x" in circle)* 282131

☒ Construction
☐ Decommission *ORIGINAL INSTALLATION*
Notice of Intent Number ______

Notice of Intent No. WEO7604
Unique Ecology Well ID Tag No. BAT439
Water Right Permit No. ______
Property Owner Name WILLIAM SARNO
Well Street Address 15905 28TH AVE NW
City GIG HARBOR County PIERCE
Location NW1/4-1/4 NE1/4 Sec 17 Twn 22 R 2E EWM ☒ Or WWM ☐
(s, t, r Still REQUIRED)

Lat/Long Lat Deg ____ Lat Min/Sec ____
Long Deg ____ Long Min/Sec ____
Tax Parcel No. (Required) 0222175005

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other

TYPE OF WORK: Owner's number of well (if more than one) ____
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 148 ft.
Depth of completed well 148 ft.

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6" Diam. from 0 ft. to 233 ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft
☐ Threaded ____" Diam From ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ______
SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☒ Yes ☐ No ☒ K-Pac Location 141' 10-3/4"
Manufacturer's Name JNSN
Type SS Model No. TELES
Diam. 5" Slot size 18 from 143 ft. to 148 ft.
Diam ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ____
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft
Material used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 83 ft below top of well Date 11/13/2007
Artesian pressure ____ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom? ______
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test 15 gal./min. with 24 ft drawdown after 1 hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ______
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
PIPE STICK UP	0	1
BROWN SAND, CLAY, GRAVEL	1	16
GRAY SAND, GRAVEL, WET	16	21
BROWN SAND, GOME GRAVEL, WET	21	41
GRAY SAND, CLAY, GRAVEL,	41	
SEAMS WET		61
GRAY SILT, SAND, GRAVEL	61	85
GRAY SAND, GRAVEL, SEAMS WATR	85	109
GRAY SILT, SAND, GRAVEL, CLAY	109	140
GRAY SAND, GRAVEL, SEAMS WATR	140	148

RECEIVED
DEC 10 2007
Washington State Department of Ecology

Start Date 11/7/2007 Completed Date 11/13/2007

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) JOHN SULLIVAN
Driller/Engineer/Trainee Signature [signature]
Driller or trainee License No. 2218
IF TRAINEE: Driller's License No:
Driller's Signature:

Drilling Company NICHOLSON DRILLING INC
Address PO BOX 123
City, State, Zip PORT ORCHARD, WA, 98366
Contractor's Registration No. NICHODI1370M Date 11/30/2007

22-2E-20F

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

WASHINGTON STATE DEPARTMENT OF ECOLOGY

CURRENT
Notice of Intent No. W216866

Unique Ecology Well ID Tag No. APR640

Water Right Permit No.

Property Owner Name Swen Weinmann

Well Street Address 15515 30th AVE NW

City Gig Harbor County Pierce

Location SE 1/4-1/4 NW 1/4 Sec 20 Twn 22N R 2E EWM or WWM (circle one)

Lat/Long (s, t, r Still **REQUIRED**) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. 0222171051

Construction/Decommission (*"x" in circle*)
☒ Construction
☐ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* 285208

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other

TYPE OF WORK: Owner's number of well (if more than one)
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☒ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 160 ft.
Depth of completed well 160 ft.

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6" Diam. from +1 ft. to 155 ft.
☐ Liner installed " Diam. from ft. to ft.
☐ Threaded " Diam. from ft. to ft.

Perforations: ☐ Yes ☒ No
Type of perforator used
SIZE of perfs in. by in. and no. of perfs from ft. to ft.

Screens: ☒ Yes ☐ No ☒ K-Pac Location 154
Manufacturer's Name Johnson
Type Stainless steel Model No.
Diam. 5 Slot size 14 from 155 ft. to 160 ft.
Diam. Slot size from ft. to ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand
Materials placed from ft. to ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? Depth of strata
Method of sealing strata off

PUMP: Manufacturer's Name Goulds
Type: Submersible H.P. 1

WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 108 ft. below top of well Date 10/25/07
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? Olsen Drl.
Yield: 15 gal./min. with 9 ft. drawdown after 1 hrs.
Yield: gal./min. with ft. drawdown after hrs.
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0	117'	3 m	108'		
1 m	111'				
2 m	104'				

Date of test 10/25/07
Bailer test 10 gal./min. with 8 ft. drawdown after 2 hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? ☒ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Brown sand	0	37
Grey till	37	132
Grey clay	132	136
Grey sand	136	145
Grey sand w/b	145	160
Grey tight sand	160	----

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DEPT. OF ECOLOGY

Start Date 9/20/07 Completed Date 10/25/07

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Matt Olsen
Driller/Engineer/Trainee Signature Matt Olsen
Driller or trainee License No. 2337

If TRAINEE,
Driller's Licensed No.
Driller's Signature

Drilling Company Olsen Drilling
Address PO Box 1554
City, State, Zip Port Orchard, WA 98366
Contractor's Registration No. OLSEND101LJ Date 11/9/07

Ecology is an Equal Opportunity Employer.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

339850

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 34136
UNIQUE WELL I.D. # ABG 626
Water Right Permit No. ______

(1) OWNER: Name Hallstrom, Mark Address 4911 No. Highland, Tacoma WA

(2) LOCATION OF WELL: County Pierce NW 1/4 NW 1/4 Sec 17 T. 22N N., R. 2E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 3025 13th St. N.W., Gig Harbor, WA

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one) ______
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 53 feet. Depth of completed well 53 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +2 ft. to 53 ft.
Welded ☒ ______ Diam. from ______ ft. to ______ ft.
Liner installed ☐ ______ Diam. from ______ ft. to ______ ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 19.5 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______
Static level 22 ft. below top of well Date Nov. 3, 1994
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 9-10 gal./min. with stem set at 53' ft. for 2.0 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Top Soil	0	2
Brn Sands some Traces of Brn Silts	2	11
Brn Silts & medium Sands & small Angular Gravels	11	31
Silty Gray Sands Sticky	31	36
Gravels & Sands water Bearing	36	53

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Work Started Nov 2, 19__ Completed Nov 3, 1994

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Holt Testing Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10621 Todd Rd., Puyallup
(Signed) [signature] (WELL DRILLER) License No. 2148
Contractor's Registration No. HOLTT10870J Date Nov 3, 1994

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050 1-20 (2/93)

DEPARTMENT OF ECOLOGY State of Washington

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*

[X] Construction

[ ] Decommission *ORIGINAL INSTALLATION*

Notice of Intent Number WE21844

CURRENT

Notice of Intent No. WE21844

Unique Ecology Well ID Tag No. BHY 098

Water Right Permit No. ______

Property Owner Name David and Liz Stanton

Well Street Address 2811 159th ST CT NW

City Gig Harbor County Pierce

Location ne 1/4-1/4 ne 1/4 Sec 17 Twn 22 R 2E EWM [X] Or WWM [ ]

(s, t, r Still REQUIRED)

Lat/Long

Lat Deg ______ Lat Min/Sec ______

Long Deg ______ Long Min/Sec ______

Tax parcel No. (Required) 022175008

PROPOSED USE: [X] Domestic [ ] Industrial [ ] Municipal [ ] DeWater [ ] Irrigation [ ] Test Well [ ] Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______

[X] New well [ ] Reconditioned *Method:* [ ] Dug [ ] Bored [ ] Driven

[ ] Deepened [ ] Cable [X] Rotary [ ] Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 98 ft.

Depth of completed well 98 ft.

CONSTRUCTION DETAILS

Casing Installed: [X] Welded 6" Diam. from 0 ft. to 96 ft.

[ ] Liner installed ______" Diam. from ______ ft. to ______ ft.

[ ] Threaded ______" Diam. From ______ ft. to ______ ft.

Perforations: [ ] Yes [X] No

Type of perforator used ______

SIZE of perfs ______ in. by ______ in. and no. of perfs ______ from ______ ft. to ______ ft.

Screens: [X] Yes [ ] No [ ] K-Pac Location ______

Manufacturer's Name JOHNSON

Type STAINLESS STEEL Model No. TELESCOPE

Diam. 6 Slot size 16 from 93 ft. to 98 ft.

Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: [ ] Yes [X] No Size of gravel/sand ______

Materials placed from ______ ft. to ______ ft.

Surface Seal: [X] Yes [ ] No To what depth? 18 ft.

Material used in seal Bentonite

Did any strata contain unusable water? [ ] Yes [X] No

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.

Static level 40 ft. below top of well Date ______

Artesian pressure ______ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? [ ] Yes [X] No If yes, by whom? ______

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test 10 gal./min. with 9 ft. drawdown after 1 hrs.

Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.

Artesian flow ______ g.p.m. Date ______

Temperature of water ______ Was a chemical analysis made? [ ] Yes [X] No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Pipe stick up	0	1
Brown grey fill	1	3
Grey sand gravel clay wet	3	16
Grey sand gravel water	16	34
Grey sand gravel clay wet	34	77
Grey sand gravel water	77	98

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MAY 27 2016

WA State Department of Ecology (SWRO)

Start Date 01/10/2016 Completed Date 01/20/2016

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

[X] Driller [ ] Engineer [ ] Trainee Name Nic Sample

Driller/Engineer/Trainee Signature [signature]

Driller or trainee License No. 2770

IF TRAINEE: Driller's License No:

Driller's Signature:

Drilling Company Nicholson Drilling INC.

Address PO BOX 123

City, State, Zip Port Orchard, WA, 98367

Contractor's Registration No. NICHODI137OM Date 02/15/2016

ECY 050-1-20 (Rev 02-2010) To request ADA accommodation including materials in a format for the visually impaired, call Ecology Water Resources Program at 360-407-6872. Persons with impaired hearing may call Washington Relay Service at 711. Persons with speech disability may call TTY at 877-833-6341.

DEPARTMENT OF ECOLOGY State of Washington

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*

☒ Construction
☐ Decommission *ORIGINAL INSTALLATION*

Notice of Intent Number WE21843

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 151 ft.
Depth of completed well 151 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6" Diam. from 0 ft. to 151 ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft.
☐ Threaded ____" Diam. From ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ______
SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ______
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 74 ft. below top of well Date ______
Artesian pressure ____ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test 17 gal./min. with 27 ft. drawdown after 1 hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ______
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

CURRENT

Notice of Intent No. WE21843
Unique Ecology Well ID Tag No. BJN 278
Water Right Permit No. ______
Property Owner Name DAVID STANTON
Well Street Address 2917 159TH ST CT NW
City GIG HARBOR County PIERCE
Location nw1/4-1/4 ne 1/4 Sec 17 Twn 22 R 2E EWM ☒ Or WWM ☐
(s, t, r Still REQUIRED)

Lat/Long
Lat Deg ____ Lat Min/Sec ____
Long Deg ____ Long Min/Sec ____

Tax parcel No. (Required) 0222175007

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Pipe stick up	0	1
Grey sand gravel clay wet	1	13
Grey clay	13	24
Brown sand silt wet	24	33
Brey sand gravel cley damp	33	109
Grey clay	109	136
Grey sand gravel clay	136	145
Grey coarse sand gravel water	145	151

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JUN 09 2016
WA State Department of Ecology (SWRO)

Start Date 02/02/16 Completed Date 02/04/16

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name NIC SAMPLE
Driller/Engineer/Trainee Signature [signature]
Driller or trainee License No. 2770
IF TRAINEE: Driller's License No:
Driller's Signature:

Drilling Company NICHOLSON DRILLING INC.
Address PO BOX 123
City, State, Zip PORT ORCHARD, WA, 98367
Contractor's Registration No. NICHODI137OM Date 06/06/2016

ECY 050-1-20 (Rev 02-2010) To request ADA accommodation including materials in a format for the visually impaired, call Ecology Water Resources Program at 360-407-6872. Persons with impaired hearing may call Washington Relay Service at 711. Persons with speech disability may call TTY at 877-833-6341.