I-90 Snoqualmie Pass East Project
Phase 3 and West Bound Widening Project

Kittitas County Shoreline Application

Exhibit H

I-90 Phase 3 and 4 Feasibility Study and Impairment Analysis of Potential Water Sources

Washington State
Department of Transportation

I-90 Snoqualmie Pass East Project Phases 3 and 4

Feasibility Study and Impairment Analysis of Potential Water Sources

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1.0 Introduction and Purpose

The Washington State Department of Transportation is considering the following sites to provide water for construction (e.g., embankment compaction, dust control) and watering for plant establishment at mitigation/restoration areas for the remaining I-90 Snoqualmie Pass East Project Phases 3 and 4 (Figure 1):

- Easton Stockpile Area (potential well/groundwater withdrawal)
- Crystal Springs Sno Park (potential well/groundwater withdrawal)
- Kachess River at the I-90 bridges (potential surface water withdrawal)
- Yakima River at the Stampede Pass Road bridge (potential surface water withdrawal)

This report describes the project water needs and proposed mitigation strategy to offset impacts to downstream water rights, and assesses the feasibility and localized impacts of each potential withdrawal site. For the groundwater sites the report describes the local hydrogeology, nearby water wells, potential water bearing formations, and risks of impacts to nearby wells. For surface water sites the report describes seasonal river flow conditions and assesses potential impacts to local water levels and nearby water rights.

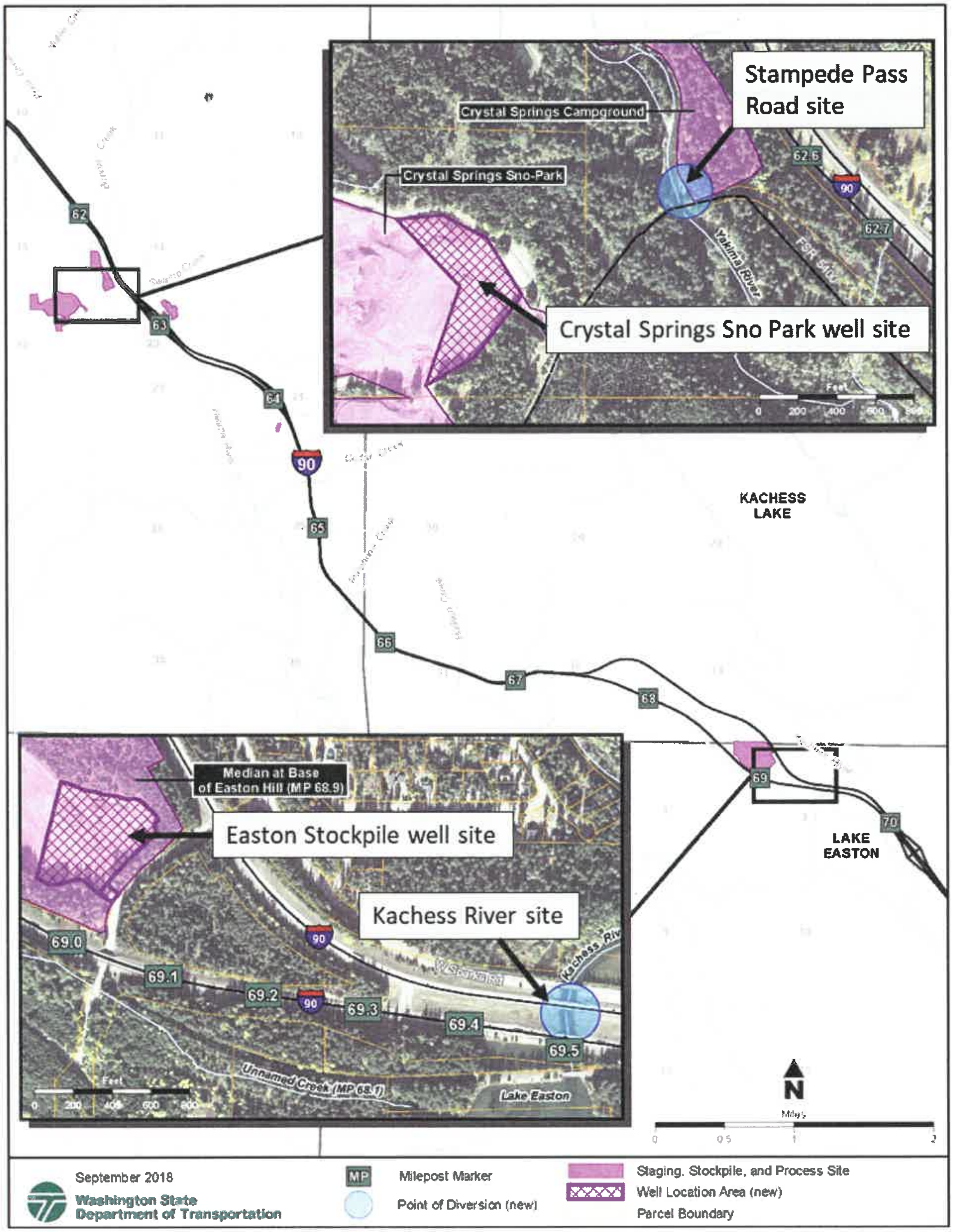

Figure 1. Site location map.

2.0 Methods and Data Sources

General site conditions and surficial geology are based on GIS data layers available in WSDOT's Geodatabase Catalog, including:

- Wa. State Department of Natural Resources (DNR) 100K Surficial Geology
- U.S. Dept. of Agriculture Natural Resources Conservation Service (NRCS) soils
- Washington State 2017 orthophoto coverage, 1 foot resolution

Topography was derived from a 2014 Yakima Valley LiDAR coverage obtained from the Washington State DNR LiDAR Portal (https://www.dnr.wa.gov/lidar#lidar-portal, accessed June 2018).

Boring logs for wells and geotechnical exploration holes were obtained from the following sources:

- Wa. State Department of Ecology (Ecology) Well Report Viewer (https://fortress.wa.gov/ecy/waterresources/map/WCLSWebMap/default.aspx. Accessed June 19, 2018). Boring locations in this database are based on the quarter-quarter section reported by the driller, and therefore can be as much as 1000 feet off from the actual location.
- WSDOT boring logs provided as a geodatabase by WSDOT's Materials Lab. This includes historical geotechnical borings from previous highway projects as well as more recent exploration efforts for the I-90 Snoqualmie Pass East Project.

Other water well data were derived from:

- GIS layer of public water wells obtained from Kittitas County, http://data-kitcogis.opendata.arcgis.com/datasets/wells (accessed September 5, 2018). This layer lists well locations, well depths and capacities of Group A and B public wells.
- WSDOT Geodatabase Catalog, Public Drinking Water Wells (Group A and B), Well Zone Protection Areas, and Designated Sole Source Aquifers. WSDOT obtained the source location data from the Washington State Department of Health, Office of Drinking Water.
- Surface and Groundwater rights listed on Wa. State Dept. of Ecology's on-line Washington Water Resources Explorer (https://fortress.wa.gov/ecy/waterresources/map/WaterResourcesExplorer.aspx. Accessed July 3, 2018.)

River flow conditions were characterized using information provided in the Supplemental Draft Environmental Impacts Statement (EIS) for the Kachess Drought Relief Pumping Plant and Keechelus Reservoir-to-Kachess Reservoir Conveyance project (U.S. Bureau of Reclamation, 2018).

3.0 Project Water Needs and General Mitigation Strategy

3.1 Estimated I-90 Project Water Needs

Based on historic construction demand, the estimated average annual water need is 30 acre-feet per year for the next ten years to complete the I-90 Project. This includes a peak need of 40,000 gallons per day or 5 ac-ft. for the entire peak month. This translates to a peak daily average flow of 0.08 cubic feet per second (cfs). This analysis assumes the entire annual amount will be used either near Easton or near Stampede Pass, depending on construction activities and locations.

	May	June	July	August	September	October	November	TOTAL
Monthly water needs (Acre-feet)	3	5	5	5	5	5	2	30

Table 1 Estimated Water Needs for the Project

The remaining phases of the I-90 Project are from the I-90 Stampede Pass Interchange (Milepost 62) to the community of Easton (Milepost 70) with construction starting in fall 2020 or spring 2021 through fall 2035. Diversion from Lake Keechelus will not be accessible upon requiring WSDOT to secure new water sources closer to the construction project. The intent of this report is to identify and determine feasibility and any potential impairment issues of potential locations for temporary water withdrawal or diversion points using WSDOT's water right claim as mitigation. Proximity of the water source with the construction limits is an important factor. One example of a location close to I-90 near Easton would be a temporary surface water withdraw at Kachess River or a well at WSDOT's Easton median stockpile site to serve a six-mile section of the project starting in 2020 and ending in 2030. After that, the final three mile phase between Amabilis Mountain and Stampede Pass will occur, prompting a need for a diversion at the Yakima River bridge crossing on Road 5400 and/or a well at Crystal Springs Sno-park during the 2025-2035 construction years.

3.2 WSDOT Water Right Mitigation Strategy

This section describes how WSDOT will mitigate the impacts the proposed water withdrawals may have on downstream water rights in the Yakima basin. The availability of water is vital to WSDOT for constructing, maintaining and operating the state's transportation system. Over the years the availability of water has become more challenging to obtain and permit in parts of Washington State and especially in upper Kittitas County.

In 2008, WSDOT began the process of acquiring a reliable source of water for highway construction, maintenance and operational requirements, specifically the Interstate 90 Snoqualmie Pass East Project in Kittitas County. In 2009, WSDOT acquired the following water right claim as a construction water supply source for this 15-mile corridor project:

Yakima River Basin - Claim #00366, Subbasin 09, Wilson Creek. Priority date of 5/24/1884. Total 350 acre/feet/year to seasonally irrigate 35 acres. Location near Interstate-90 /Ellensburg

WSDOT temporarily placed the claim in the State Trust Water Right Program through 2019 (See Report of Examination No. CS4-00366CTCLsb9@1). This approval included a temporary change of the purpose from irrigation to instream flow and mitigation of new water uses. Ecology determined that the consumptive use quantity for this claim was 113 acre-feet/year. As part of the temporary changes to this water right, WSDOT and Ecology entered into an agreement that defined uses, conditions and mitigation. The temporary water right decision also allows WSDOT to participate in Ecology's agreement with the US Bureau of Reclamation (USBR) to assign, store and deliver up to 1,000 acre feet (consisting of one or more water rights) in Keechelus Lake to mitigate for partial or year round periods of downstream water uses outside of normal water storage schedule. (See Ecology/US Bureau of Reclamation (USBR) Exchange Contract No. 09XX101700 (January 2009)

This mitigation strategy offsets impacts or impairment to other water rights, Total Water Supply Availability, instream flows, and USBR target flows. It also requires the USBR to store and release an equivalent quantity of water to offset approved downstream uses in the Yakima Basin.

Since 2010, WSDOT has diverted water from Keechelus Lake for construction water supply (See Ecology Temporary Authorization #S4-35746). In 2018, WSDOT filed a permanent change (See CS4-00366CTCLsb9@2) with Ecology to the purpose and place of use that includes a permanent trust donation to allow WSDOT to continue this temporary use for a temporary construction water supply and also for other temporary or permanent mitigated water uses. Specifically these uses include:

- Temporary surface water diversions along Kachess and Yakima River to serve construction of the remainder of the I-90 Project
- Temporary well at the Easton Crystal Springs Sno-park stockpile sites to serve as a construction water source. If made permanent in the future, the wells could serve as an industrial water (non-domestic) for maintenance purposes at these facility sites
- Temporary water supplies for other highway construction projects
- Permanent new, additive water rights for Indian John Safety Rest Area water needs
- Permanent other uses (e.g. water supplies for rest areas and maintenance sheds within the entire Yakima Basin to the confluence of the Columbia River and downstream to the Pacific Ocean)

4.0 Regional Hydrogeology

4.1 Geology of the Yakima and Kachess Valleys

The Yakima and Kachess rivers flow through valleys defined by ridges of Naches formation volcanic rocks mixed with interbedded sandstone, siltstone, and shale (Figure 2). The Naches formation rocks are underlain by Easton formation metamorphic rocks (U.S. Bureau of Reclamation, 2018).

The valley floors are covered by alluvium composed of silt, sand, gravel, cobbles, and boulders deposited by the Yakima and Kachess rivers. Immediately below the Keechelus and Kachess dams the alluvium is bordered by sloping terraces of alpine glacial drift. These terraces sit below the terminal moraines that formed the lakes during glacial advances, and consist of highly variable glaciolacustrine, till, outwash, and ice-contact deposits.

4.2 Aquifers in the Project Area

The Yakima River alluvium contains a water table aquifer that provides the shallowest and most readily-available groundwater source in the region. Water levels in this aquifer are closely associated with Yakima River levels, and wells tapping this aquifer are likely to draw a portion of their flow from the river.

Coarse glacial outwash deposits below the Kachess dam/moraine also form a productive aquifer. This is confined in some locations by overlying glacial till and other dense moraine deposits. This aquifer is partially fed by seepage that passes through the Kachess dam and flows down the river valley (U.S. Bureau of Reclamation, 2018). Wells on the Lake Easton shore and in subdivisions just below the dam tap this aquifer.

The glacial drift terraces at the Crystal Springs Sno Park and Easton stockpile sites are composed of clay layers or dense silty sands and gravels mixed with cobbles and boulders. The water table in the silty sands and gravels is highly seasonal and drops rapidly in the summer. Some of the shallower wells on these terraces tap layers of coarse gravels that underlie the dense silty sands, but these coarse layers are patchy and do not appear to form a continuous confined aquifer. Most wells on the terraces drill a hundred feet or more to tap water found in fractured bedrock beneath the glacial material. Wells on adjacent bedrock ridges are also very deep and depend on locally productive sandstone and fractured volcanic bedrock.

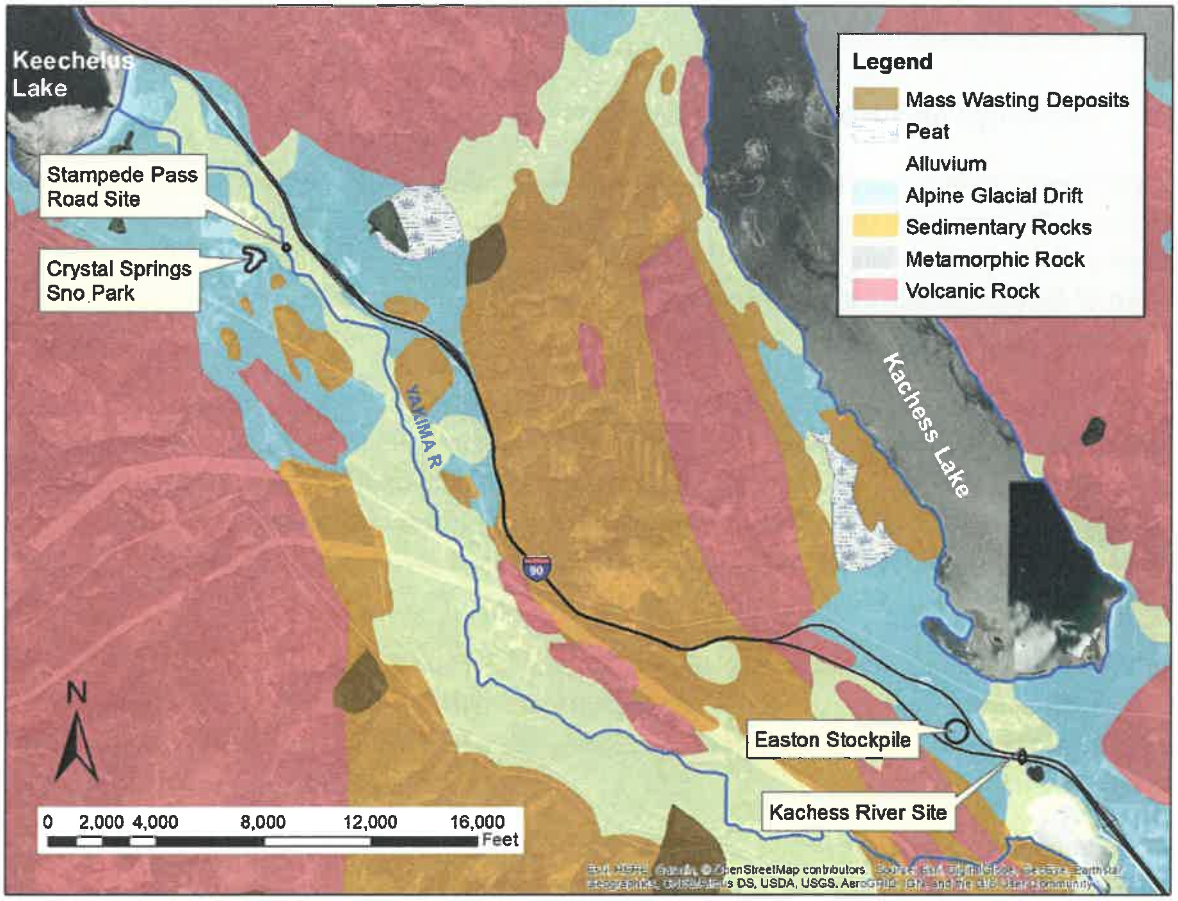

Figure 2. Surficial geology in the project corridor.

5.0 Analysis of the Easton Stockpile Well Site

5.1 Geology and Soils

Figures 3 and 4 show surficial geology, LiDAR topography, and water wells near the Easton Stockpile site. The Easton Stockpile Site is located on a terrace of alpine glacial drift deposited below the Kachess Lake moraine. The terrace sits at about 40 to 50 feet above the Kachess River floodplain. Soils at the site consist of Kachess gravelly ashy sandy loam, a deep, well-drained soil formed in glacial till over glaciofluvial deposits.

Figure 5 shows locations of WSDOT and other borings that border the site as identified by the Ecology Washington State Well Report Viewer and other databases. Note wells in the Ecology database are only located to the nearest quarter-quarter section, and locations of these shown on Figures 3, 4, and 5 may not be precise. In particular, the water well identified by Ecology on the stockpile site is probably actually located east of I90 near the Lake Easton Estates subdivision (based on the narrative description on the well log report).

WSDOT drilled 6 borings in the stockpile area in 2011. Holes P1 and P3 are within the potential well site. P1 encountered silty sand and gravel to a depth of 20 feet, underlain by basaltic andesite rock to 40 feet. P3 encountered silty sand to 6.5 feet underlain by sandstone to 21.5 feet. Water levels were not recorded for these holes.

2011 Borings just to the north (P2, P5, and P6) found silty sand and gravel to depths of 9 to 20 feet, underlain by either sandstone or dense silty sand and gravel mixed with clay.

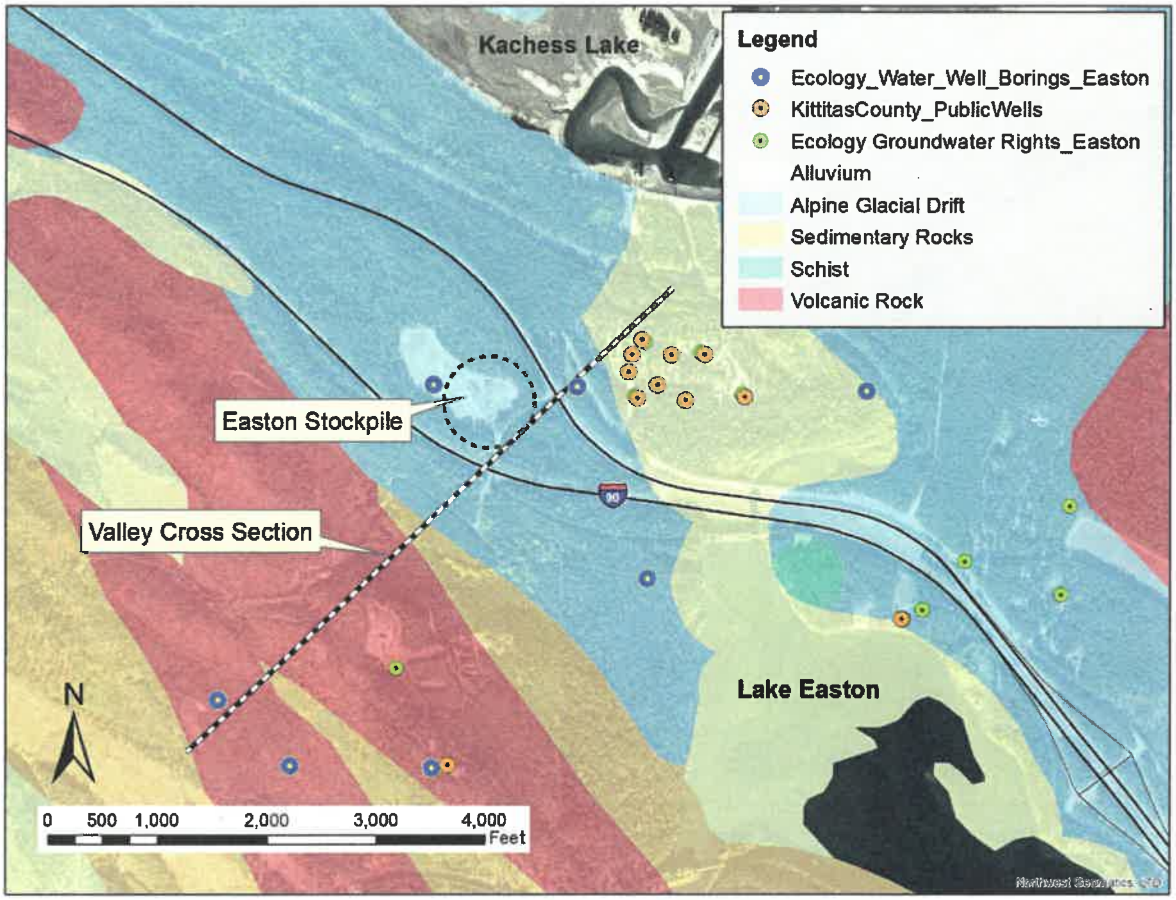

Figure 3. Surficial geology and water well locations near the Easton stockpile site.

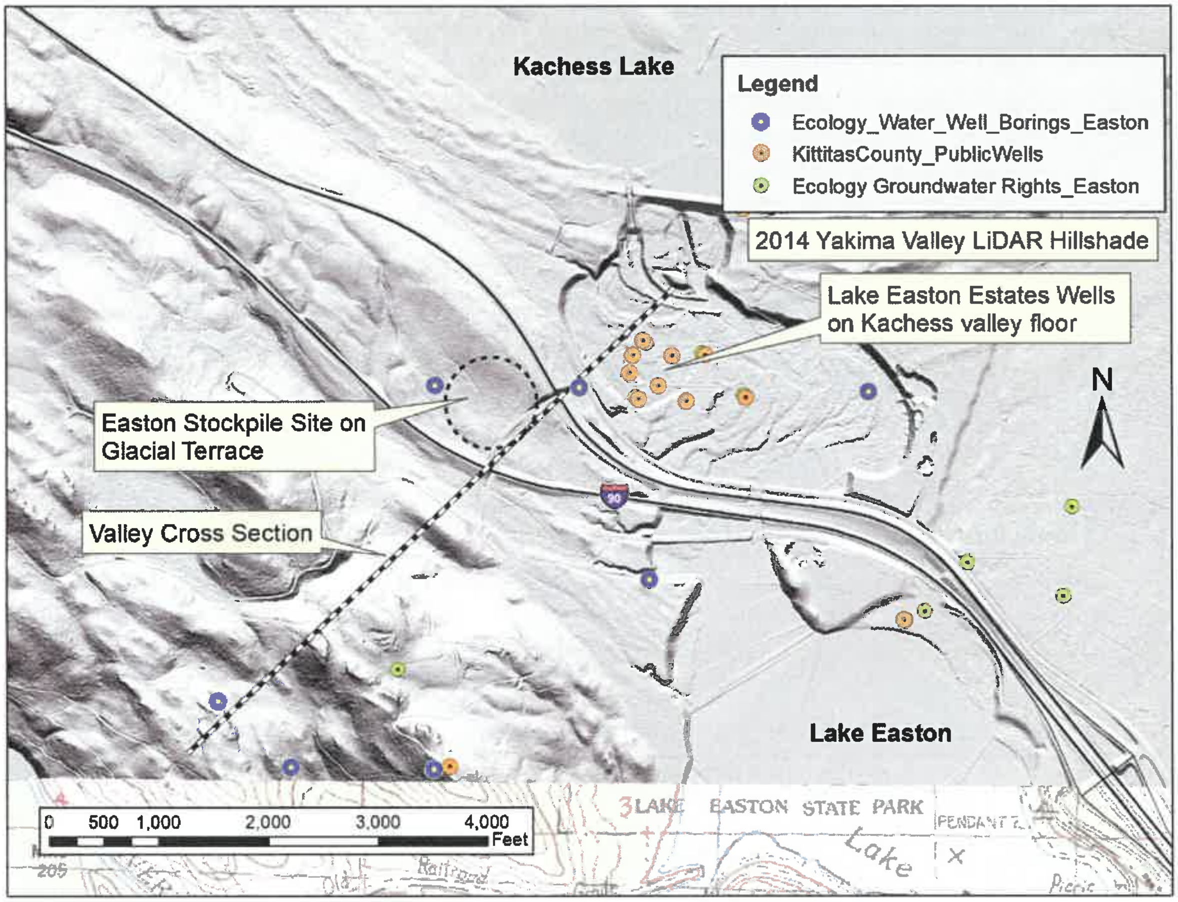

Figure 4. LiDAR topography and water wells near the Easton stockpile site.

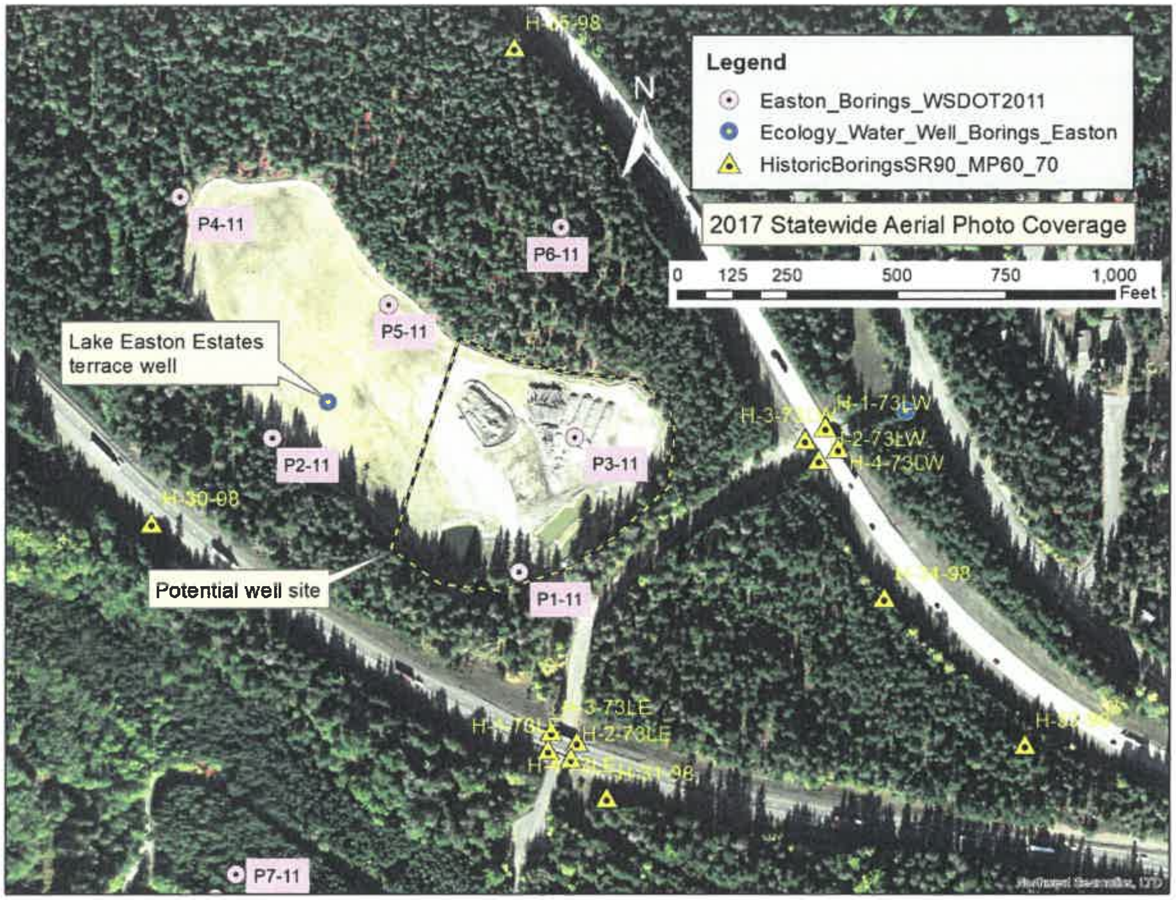

Figure 5. Locations of borings bordering the Easton stockpile site.

5.2 Aquifers and Likely Water Sources

WSDOT recorded water levels from 2011 to 2013 in holes P2 and P6 just north of the potential well site. The data show water rising to a maximum level in the winter 6 to 9 feet below ground. Over the course of the dry season water levels dropped steadily to the bottom of the upper silty sand and gravel layer at depths of 18 to 24 feet. This indicates there is a shallow unconfined aquifer in the silty sands and gravels that overlie compacted glacial sediments and bedrock at a typical depth of about 20 feet. This water table aquifer is probably not very productive, since water levels drop steadily after the end of the snowmelt/rainy season. No nearby wells tap this water table aquifer.

Table 2 lists nearby wells identified in the Ecology database as water wells, and Figure 6 shows these wells on a topographic cross section of the valley. Figures 3 and 4 show well locations. The Ecology well log database shows only one well in the same quarter-quarter section as the site. This well is listed as part of the Lake Easton Estates, a subdivision located about 900 feet east of the site on the other side of I90. This well has a boring profile that is consistent with the Easton Stockpile site's glacial terrace geology. The boring log describes 78 feet of boulder, silty sand, gravel, and clay overlying sandstone bedrock to a depth of 240 feet. The well is cased in the top 140 feet, and is therefore tapping water that enters from sandstone in the uncased portion of the hole between 140 and 240 feet depth. The static water level was not measured during drilling. This well is not included in the active wells mapped by Kittitas County for the subdivision, and may not be active since it is less productive than other Lake Easton Estate wells that tap a distinct aquifer in gravels on the Kachess River valley floor.

Based on this well and other nearby borings, the most reliable and steady groundwater under the stockpile site will most likely be found in highly variable pockets of fractured bedrock at a depth of around 140 feet. Shallower water is available in a water table aquifer that sits in unconsolidated sediments overlying bedrock, but this seasonal aquifer is probably not sufficiently productive for summer irrigation.

5.3 Potential Impacts to Nearby Wells

The nearest water wells are all Group B public water sources for the Lake Easton Estates subdivision. The active wells identified by Kittitas County are located on the Kachess River valley floor at least 1000 feet east of the site, and tap a highly productive unconfined aquifer made up of glacial outwash gravel. Borings collect by the Bureau of Reclamation show this aquifer is up to 90 feet thick and is underlain by sandstone bedrock (U.S. Bureau of Reclamation, 2018). It is directly connected to the Kachess River and is at least partially fed by seepage under the Kachess dam. This aquifer follows the river valley floor and does not extend beneath the terrace that contains the Easton Stockpile site. A well drilled into variable fractured bedrock under the stockpile site will therefore not affect water levels in this aquifer.

All other nearby wells on this side of the Kachess River are on the ridges southwest of the site, and tap groundwater found at variable depths in fractured basalt or granite (Figure 6). The closest of these wells is about 2000 feet from the project site. Groundwater in these variable fractured layers on the ridge does not form a distinct and connected aquifer, and is generally higher than the groundwater found on the site. A well drilled at the stockpile site will therefore not likely affect water levels on these ridge wells.

Owner	Location	Type	Depth (ft)	Casing	Water Producing Formation
HADLEY HACKNEY	Terrace just NW of WSDOT site	?	240	Top 140', no screen	Sandstone at bottom of casing
HADLEY HACKNEY	Lake Easton Estates	Group B	100	Top 100', no screen	Continuous gravel layer
HADLEY HACKNEY	Lake Easton Estates	Group B	100	Top 80', no screen	Continuous gravel layer
HADLEY HACKNEY	Lake Easton Estates	Group B	100	Top 80', no screen	Continuous gravel layer
HADLEY HACKNEY	Lake Easton Estates	Group B	100	Top 100', no screen	Continuous gravel layer
HOWARD KNOTT	Ridge SW of site	Group B	457	Cased to bottom, perforations lower 20'	Broken basalt at bottom
MICHAEL BUNDRICK	Ridge SW of site	Private	204	Cased to bottom, perforations lower 84'	Sandstone
PATRICK DEHUFF	Ridge SW of site	Private	179	Cased to bottom, perforations lower 80'	Broken granite
Easton Farms	Ridge SW of site	Private	NA	NA	NA
BROOKS TUTTLE	Ridge SW of site	Private	374	Cased to bottom, perforations lower 100'	Broken granite
VANG CHANG VANG	Ridge SW of site	Private	204	Cased to bottom, perforations lower 64'	Variable rock

Table 2 Summary of water wells located near the Easton stockpile site

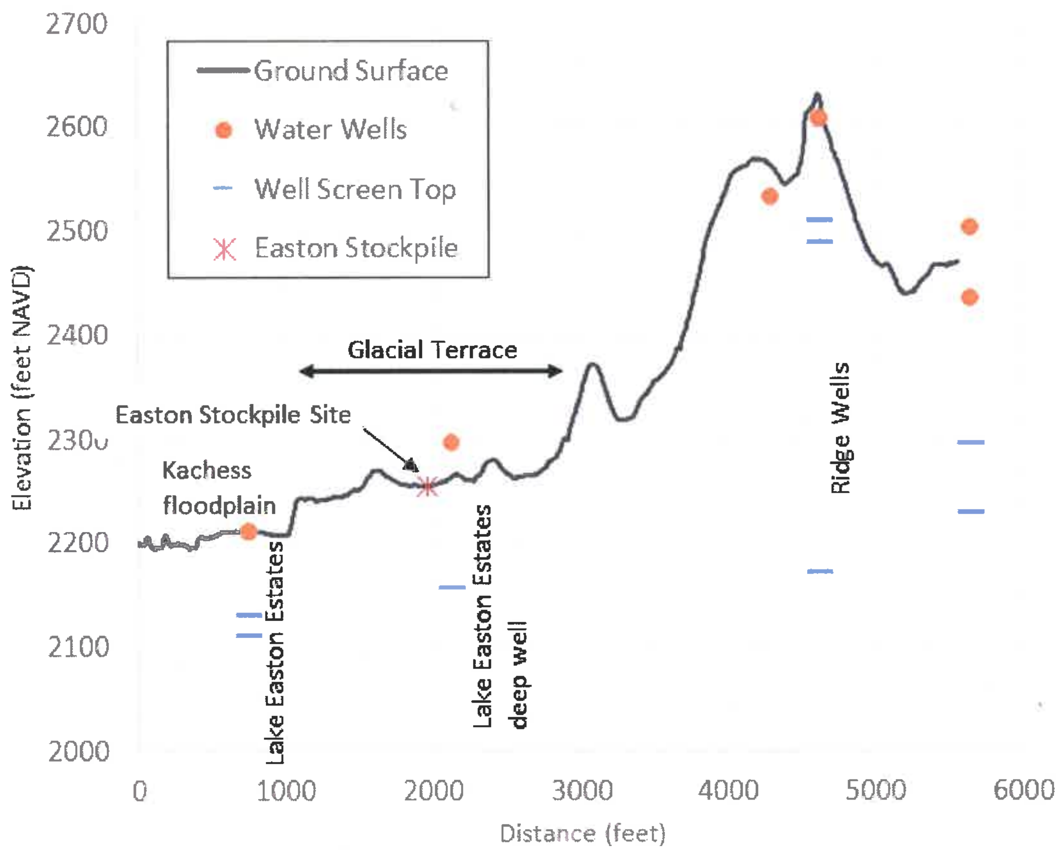

Figure 6. Valley cross section through the Easton stockpile site and nearby wells.

6.0 Analysis of the Crystal Springs Sno Park Well Site

6.1 Geology and Soils

Figures 7 and 8 show surficial geology, LiDAR topography, and water wells near the Crystal Springs Sno Park site. The site is located on a terrace of alpine glacial drift on the south side of the Yakima River valley. The terrace sits at about 30 to 40 feet above the Yakima River floodplain. NRCS maps soils at the site as modified pit soils surrounded by glacially-derived Kachess gravelly ashy sandy loam. The adjacent Yakima River floodplain is covered by coarse Fluvaquent soils.

The Ecology well log database shows three WSDOT borings in the quarter-quarter section that contains the Sno Park site. These range in depth from 17 to 26-feet, and generally encountered either very dense silty gravel with sand, or dense silty sand with gravel.

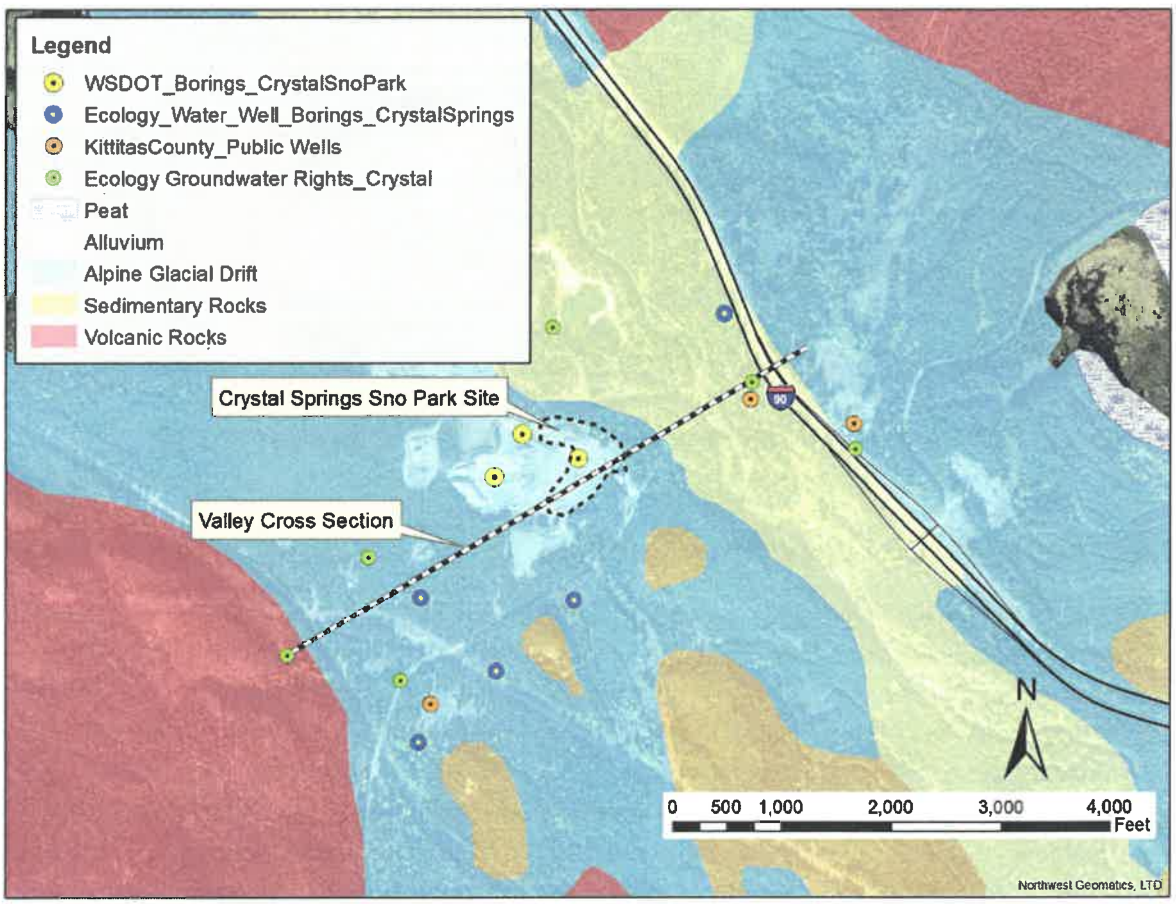

Figure 7. Surficial geology and water well locations near the Crystal Springs Sno Park.

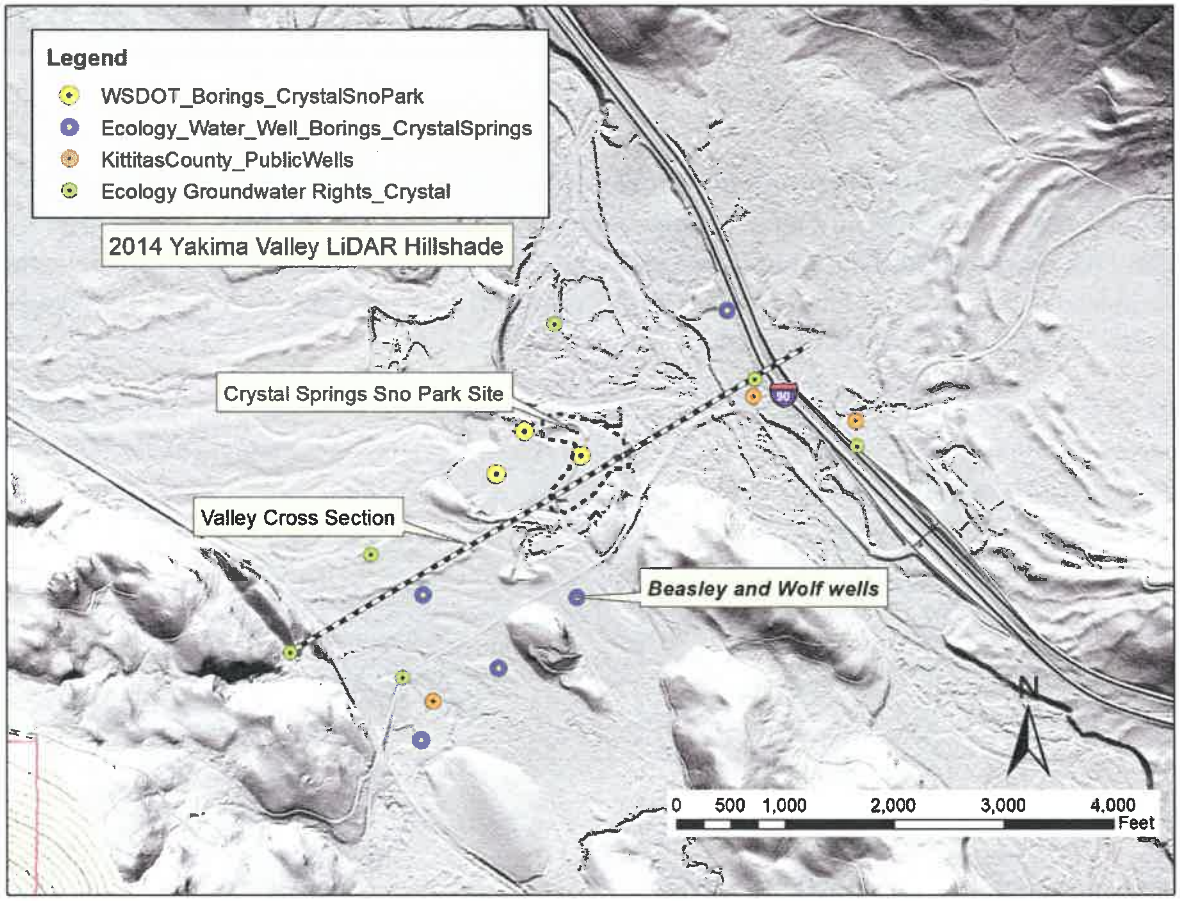

Figure 8. LiDAR topography and water wells near the Crystal Springs Sno Park.

6.2 Aquifers and Likely Water Sources

Table 3 lists nearby wells identified in the Ecology database as water wells, and Figure 9 shows these wells on a topographic cross section of the valley. Nine water wells are located on the glacial terrace upslope/southwest of the site, but only six have boring logs available on the Ecology database. All but one of the wells in the area are more than 200 feet deep. Two of these are cased to only 40-45 feet indicating that some water may enter the hole at shallower depths. These shallower formations were apparently not highly productive, so the wells were finished to allow water to enter the hole from a large depth range extending more than 160 feet below the bottom of the casing through variable layers of fractured rock. One well however did encounter a productive sand, gravel, and cobble layer at about 60-feet depth.

These data indicate there is no continuous aquifer under the site, but water can be found at depths starting around 40 to 60 feet in variable fractured rock and coarse sediment layers. The well will most likely need to be at least 200 feet deep to be productive.

6.3 Potential Impacts to Nearby Wells

The Beasley and Wolf wells are the closest to the site, in a quarter-quarter section whose center is about 800 feet from the southern edge of the project site (Figure 8). Aerial photos shows home sites in this area 1000 to 1200 feet from the site boundary. Because water on this terrace is found in discontinuous fractured rocks, it is not likely that a well drilled on the project site would directly impact these wells.

The USFS and Kachess Lodge have wells on the valley floor on the opposite side of the river about 1200 feet or more from the site boundary. These tap a productive alluvial aquifer that is directly connected to the Yakima River. This connection to the Yakima River minimizes any potential impacts from a well drilled in variable rock at the Sno Park site.

Owner	Location	Type	Depth (ft)	Casing	Water Producing Formation
CLE ELUM RANGER DIST	Valley floor on opposite side of river	Group A	71	Cased to screen in bottom 10 feet	Sand and gravel
Kachess Lodge	Valley floor on opposite side of river	Group B	NA	NA	NA
Nielsen	On terrace upslope of site	Group B	35	NA	NA
SONS OF NORWAY	On terrace upslope of site	Group B	200	Casing to 40 feet	Variable gray rock
BILL BEASLEY	On terrace upslope of site	Private	370	Casing to 45 feet	Variable rock
Casper W Wolf	On terrace upslope of site	Private	440	Cased to perforations in bottom 40'	Shale
LARRY OCONNOR	On terrace upslope of site	Private	80	Cased to 78 feet	sand, gravel, cobbles in bottom 20 feet
Hinterland Holdings	On terrace upslope of site	Private	NA	NA	NA
Kraft	On terrace upslope of site	Private	NA	NA	NA
RHETT A MCCORMICK	On terrace upslope of site	Private	400	Cased to perforations in bottom 40'	Decomposed basalt in bottom layer
RON GIARD	On terrace upslope of site	Private	400	Cased to perforations in bottom 20'	Shale and sandstone in bottom layers

Table 3 Summary of water wells located near the Crystal Springs Sno Park

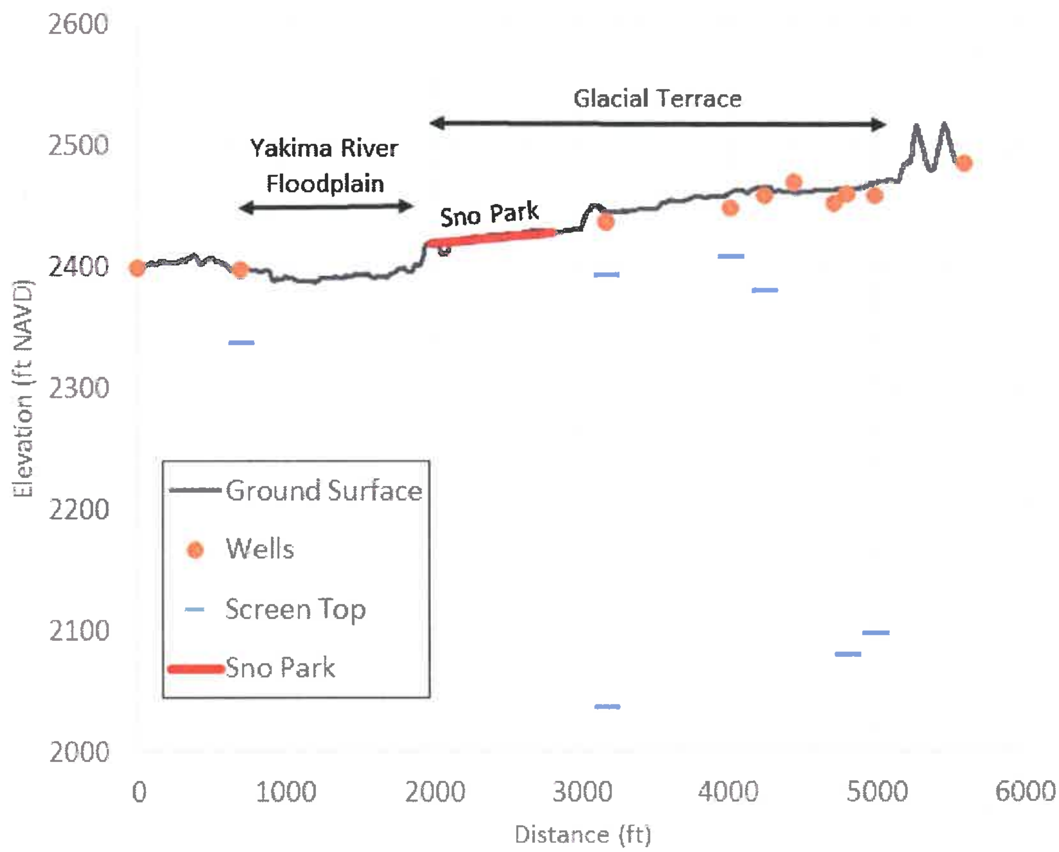

Figure 9. Valley cross section through the Crystal Springs Sno Park and nearby wells.

7.0 Surface Water Withdrawal Sites

7.1 Seasonal Flows in the Yakima and Kachess Rivers

Flows in these reaches of the Yakima and Kachess rivers are driven by releases from Keechelus and Kachess Reservoirs, and are described in the Supplemental Draft Environmental Impacts Statement (EIS) for the Kachess Drought Relief Pumping Plant and Keechelus Reservoir-to-Kachess Reservoir Conveyance project (U.S. Bureau of Reclamation, 2018). This Supplemental Draft EIS used flow data for November 1998 through October 2003 to characterize river flows in drought, average, and wet years. Modeling was used to develop hydrographs that reflect how modern reservoir operation rules would have affected river flows during this period. This allows project impacts to be assessed for river conditions that are likely to occur in the near future. The modeled period includes the critical 2001 drought year.

Figures 10 and 11 show the modeled hydrographs for the Yakima River below Crystal Springs and the Kachess River below Kachess dam. The reservoirs store water during the winter, spring, and early summer and release in the summer and early fall for irrigation. Yakima River flows are greatest during irrigation releases in July and August, with a typical range of 500 to 1200 cfs. Keechelus Reservoir releases are reduced in September and October to 80 to 120 cfs to minimize scour of salmon redds in the Yakima River above Easton.

Kachess River flows are lowest in May and June when the river drops to as low as 30 cfs. Flows increase in the July-August early irrigation season to a range of about 300 to 600 cfs. Kachess River releases are further increased in September and October to more than 1200 cfs to continue meeting irrigation demands in the lower Yakima Basin when Keechelus releases are reduced to protect salmon redds. This reservoir operation shift is referred to as the “mini flip-flop”.

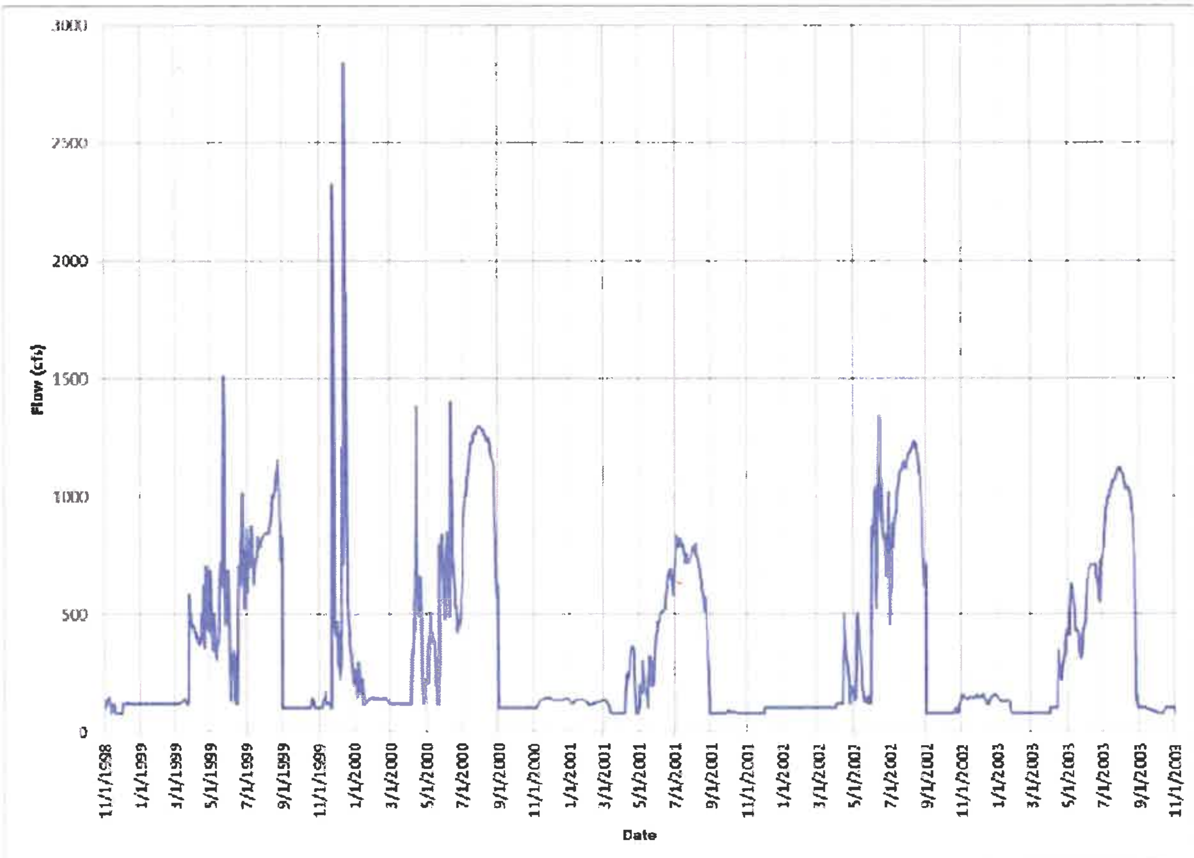

Figure 10. Modeled flows in the Yakima River below Crystal Springs (USBR, 2018).

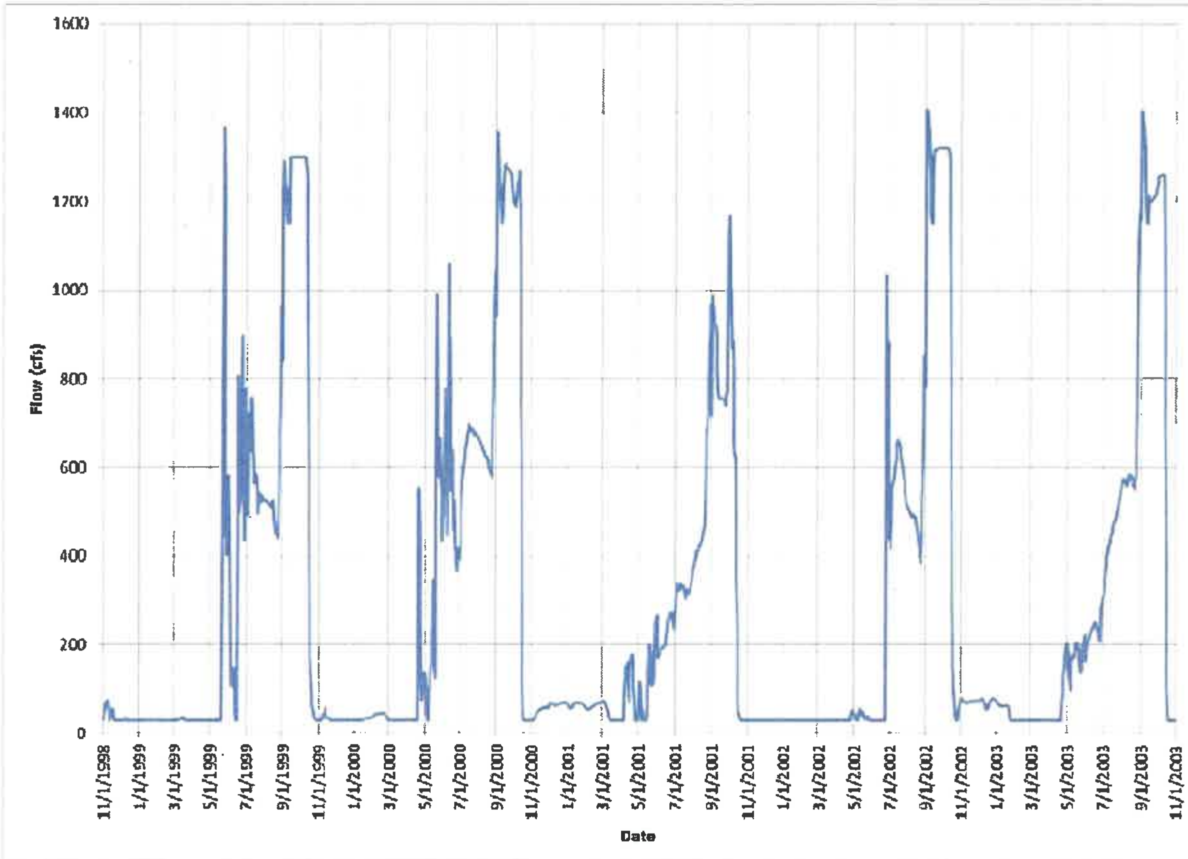

Figure 11. Modeled flows in the Kachess River below Kachess Dam (USBR, 2018).

7.2 Kachess River at the I-90 Bridge

The project will need a peak daily average flow of about 0.08 cfs from June through October to meet water needs for construction activities and for mitigation sites and plant establishment. This would be less than 0.3 percent of the minimum Kachess River flow of 30 cfs in June. A surface water withdrawal in this area will therefore have minimal impact on local river water levels and alluvial water table elevations.

Figure 12 shows water rights listed in the Dept. of Ecology's Water Resources Explorer database in the immediate vicinity of the potential withdrawal site. No existing surface water rights are shown on the Kachess River near the potential withdrawal site. The Bureau of Reclamation, Cascade Irrigation District, and Kittitas Reclamation District have water rights for the Yakima River at the outlet of Lake Easton. The minor loss of water available to these and other downstream surface rights in the basin would be offset by the mitigation strategy described in Section 3.2.

Groundwater rights for the Lake Easton Estates and other wells along Lake Easton tap aquifers that are connected to the river. The proposed withdrawal would have minimal impacts on water levels in the river and adjacent alluvial aquifers, and would therefore not impair these nearby groundwater rights.

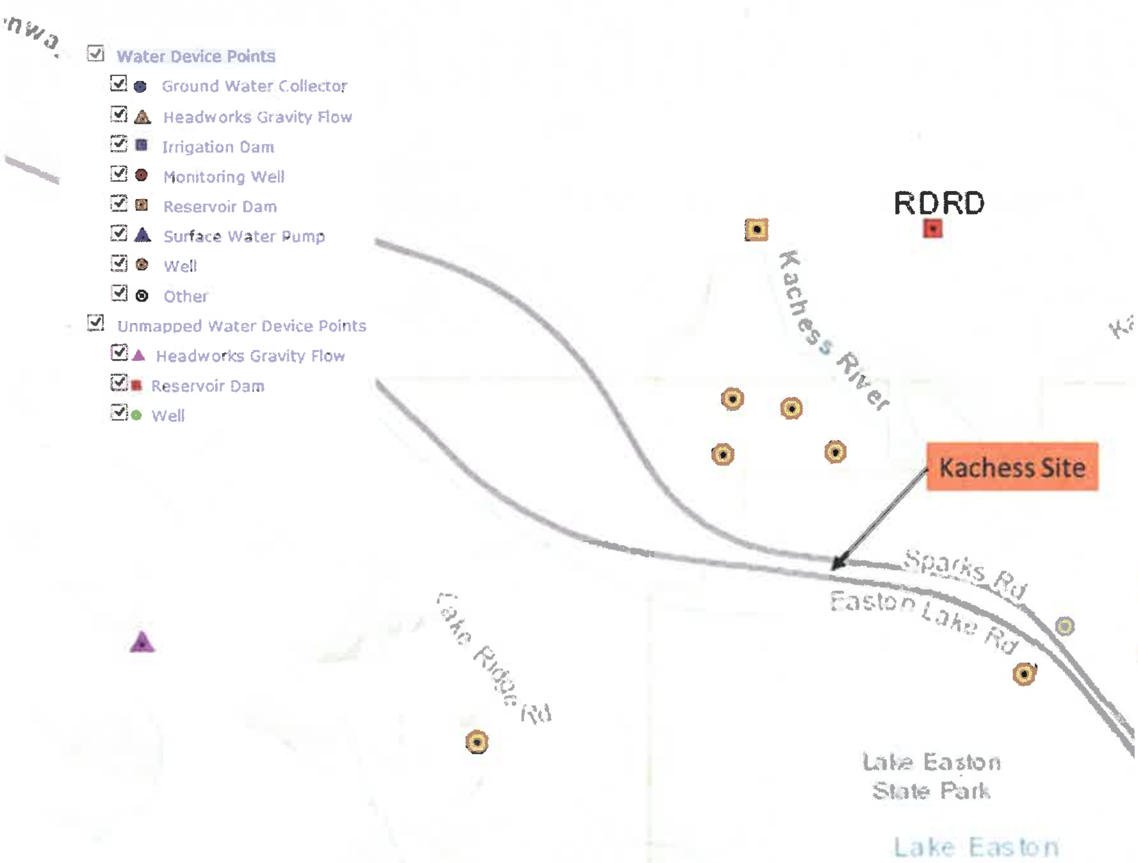

Figure 12. Water rights in the Ecology Water Resources Explorer database for the Kachess area.

7.3 Yakima River at the Stampede Pass Road Bridge

The project will need a peak daily average flow of about 0.08 cfs from June through October to meet irrigation demands for mitigation sites and plantings in this area. This would be about 0.1 percent of the minimum Yakima River flow of 80 cfs in September and October. A surface water withdrawal in this area will therefore have minimal impact on local river water levels and alluvial water table elevations.

Figure 13 shows water rights listed in the Dept. of Ecology's Water Resources Explorer database in the immediate vicinity of the potential withdrawal site. No existing surface water rights are shown near the potential withdrawal site. The proposed withdrawal would have minimal impacts on water levels in the river and adjacent alluvial aquifers, and would therefore not impair nearby groundwater rights. The minor loss of water available to downstream surface rights in the basin would be offset by the mitigation strategy described in Section 3.

Figure 13. Water rights in the Ecology Water Resources Explorer database for the Stampede Pass area.

8.0 Conclusions and Recommendations

The proposed water withdrawals are small relative to river flow rates, and will have minimal impact on river water levels and water availability for nearby surface and groundwater rights. The small impact on total water availability in the basin will be offset by the mitigation strategy described in Section 3.

The two potential well sites are located on glacial terraces. Wells on these sites would draw water from discontinuous lenses of coarse glacial outwash deposits and/or fractured bedrock. The nearest existing wells are about 1000 feet from the site boundaries. Domestic wells on these terraces are typically more than 200 feet deep and tap water found in variable fractured bedrock and sandstone. These pockets of water have little connectivity to nearby alluvial aquifers, so impacts to local wells are unlikely. However, this also means that wells at these sites may have to be more than 200 feet deep to provide sufficient water for summer irrigation, and there is risk in the highly variable geology that the drilled wells will not be productive. The surface water sites will likely provide a more cost effective and reliable water source.

References

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