Appendix I – Detailed Project Descriptions

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City of Shelton Reclaimed water

PROJECT DESCRIPTION

Description

The City of Shelton (City) proposes to increase the quantity and rate of reclaimed water infiltration into the North Fork Goldsborough subbasin by increasing production of Class A reclaimed water (RW) and infiltrating to groundwater at the City RW spray field, near the Washington Corrections Center (WCC). This project will re-direct an annual average of 0.5 mgd of the City's wastewater in North Shelton from the WWTP to the Water Reclamation Plant (WRP). The additional flow will be treated to produce 0.5 mgd of RW for subsequent conveyance to the existing City spray field. The following infrastructure improvements must occur to facilitate this project:

- Conveyance of North Shelton wastewater to the WRP.
- A storage tank (0.750 mg) to store RW at the WRP.

The conveyance of North Shelton wastewater to the WRP is currently in its design phase is likely to include a sewage lift station, and 18 inch sewer main and would run from West Birch Street to reclaimed water satellite plant (approximately 9,000 linear feet). The RW storage tank serves to buffer variable production and use of RW. Reclaimed water produced from City wastewater may be used for City uses, including a backup for firefighting, and it allows strategic timing of application of reclaimed water to the ground to benefit aquifers and streams and wetlands. Streamflow restoration funds are currently supporting design options for the lift station, sewer main, storage tank, and cost estimates. The additional reclaimed water will be conveyed to the City's existing spray field near the WCC with and infiltrated to local groundwater.

The second component of this project is RW use at the WCC. The WCC proposes to use reclaimed water to irrigate their outdoor lawn, instead of water that they currently pump from their local well. Pumping from their local well has been shown to impact instream flows in the North Fork Goldsborough Creek.

Quantitative or qualitative assessment of how the project will function, including anticipated offset benefits, if applicable. Show how offset volume(s) were estimated.

Wastewater in the Shelton area is currently treated by the City at the Fairmont wastewater treatment plant (WWTP) and the Water Reclamation Plant (WRP). Approximately 1.3 million gallons per day (1,490 acre-feet/year) of treated effluent from the WWTP is discharged directly to Oakland Bay. Approximately 0.213 million gallons per day (239 acre-feet/year) of RW is currently produced at the WRP and is conveyed to a wooded area near the WCC and overland sprayed. This overland spraying area is adjacent to the North Fork Goldsborough Creek, and it is likely that water infiltrating to the local aquifer is in connection with North Fork Goldsborough Creek flows.

The water offset benefit from the North Shelton wastewater re-direct to the WRP, would be the result of infiltrating the reclaimed water produced from that waste stream. The North Shelton wastewater is currently treated at the WWTP and discharged to Oakland Bay. All 560 acre-feet/ year of reclaimed water produced from the North Shelton waste stream would be infiltrated into the proposed infiltration facility. Assuming an infiltration efficiency of 80%, this would result in between 448 afy infiltrated to the local aquifer (Table 1).

The use of RW for irrigation by the WCC will result in a water offset, because of reduced consumptive use of their locally pumped water. The WCC is currently pumping 67 acre-feet/yr of local groundwater for irrigation. Eighty percent of the water used for irrigation will be lost to evapotranspiration (Table 2). However, if RW was used for outdoor irrigation, it's assumed that as the WCC population grows, the same quantity of water will be used for indoor use. However, very little of that water will be consumptively used, because the wastewater will be conveyed to the WRP, treated to Class A RW, pumped to the City spray field and land applied at rates that result in 80% infiltration efficiency. The resulting quantity of locally pumped water that would be infiltrated because of the change to indoor use would be 38 acre-feet/yr (Table 2). The immediate benefit would be larger, because the growth of indoor use would be gradual, and immediately after the switch to RW for irrigation, the WCC would pump 67 acre-feet/yr less from their local well. Future WCC expansion include new buildings (i.e. health care building and Program building) where grey water piping will be incorporated. These and other potential expansions may increase RW use to approximately 134 acre-feet/year. If outdoor water use (i.e. irrigation) used the entire 134 acre-feet/year in the future, then that would result in a net savings of 75 acre-feet/yr (Table 3).

Table 1. Estimated quantity of infiltrated reclaimed water from North Shelton, Basin 7.

New North Shelton Reclaimed Water	Water Quantity (af/yr)
RW Quantity	560
RW Infiltration (80%)	448

Table 2. WCC consumptive use savings from using RW for immediate irrigation needs.

Outdoor Use	**Water Quantity (af/yr)**
Irrigation Quantity	67
Irrigation CU	53.6
Indoor Use	
Future Indoor Use	60
Future Indoor CU	6
CU Savings	
CU Savings	47.6
RW Infiltration (80% Efficiency)	38

Table 3. WCC consumptive use savings from using RW for future potential irrigation needs.

Outdoor Use	**Water Quantity (af/yr)**
Irrigation Quantity	134
Irrigation CU	107
Indoor Use	
Future Indoor Use	134
Future Indoor CU	13
CU Savings	
CU Savings	94
RW Infiltration (80% Efficiency)	75

Conceptual-level map and drawings of the project and location.

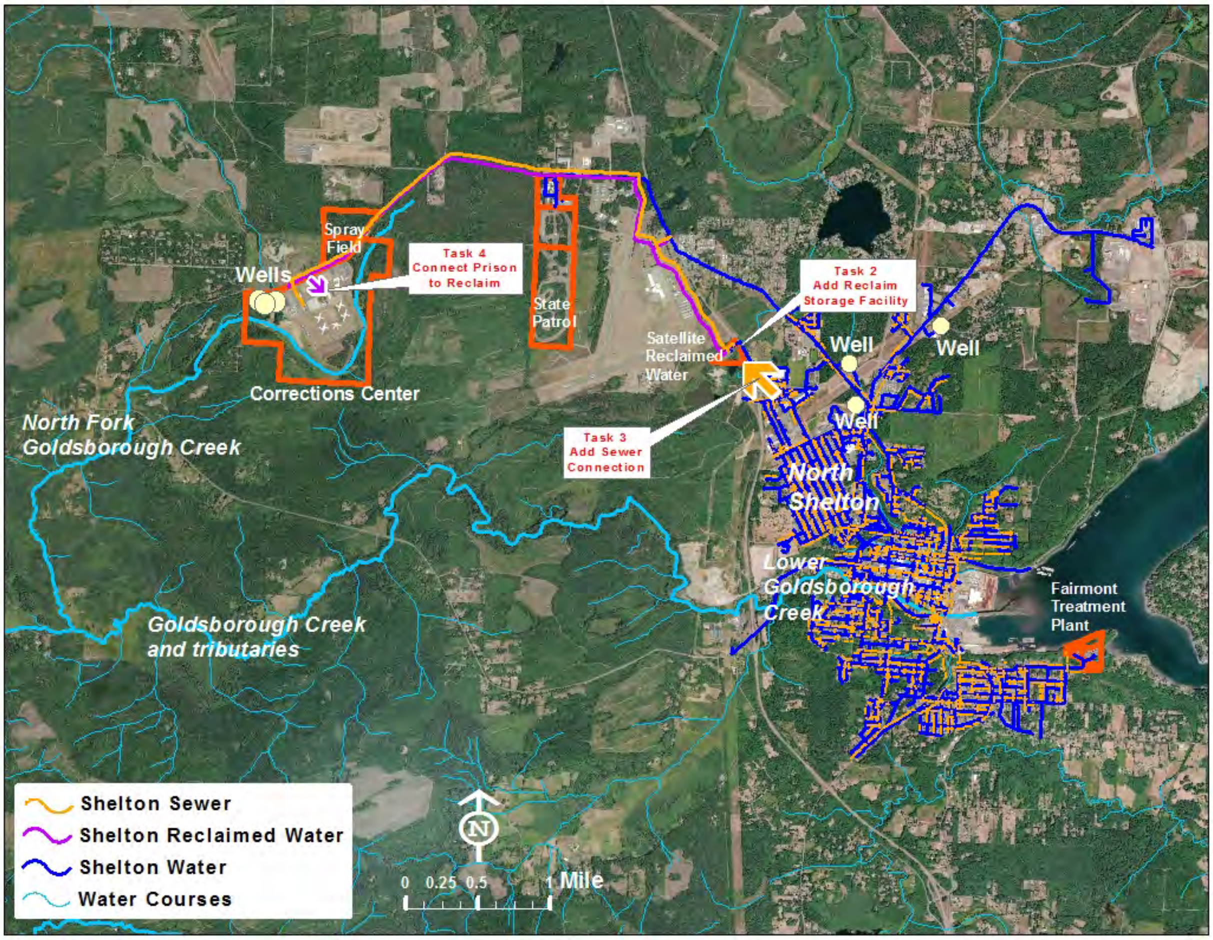

Figure 1. City of Shelton wastewaster collection network, wastewater treatment plants, and reclaimed water use at the WCC.

Description of the anticipated spatial distribution of likely benefits

RW infiltration will likely benefit stream flows in the North Fork Goldsborough Creek. The spray field is underlain by Vashon Recessional Outwash, as indicated by monitoring wells associated with reclaimed water permit ST6216 fact sheet. The spray field is up-gradient from the North Fork Goldsborough Creek to the west and south. On-site observations indicated significant swelling of the North Fork of Goldsborough Creek during rainfalls, suggesting that much of the water infiltrating in the immediate area discharges to the North Fork of Goldsborough Creek (Permit ST6216 fact sheet).

Performance goals and measures.

The following performance goals and measures will determine the success of this project:

- Annual average wastewater flow from the North Shelton neighborhood is 0.5 mgd (560 acre-feet/yr)

- Annual average RW production and conveyance to the infiltration facility is equal to the North Shelton and WCC input sources. Alternative uses of the reclaimed water originating from the WCC wastewater may be deducted from the total (i.e. separate accounting).

Descriptions of the species, life stages and specific ecosystem structure, composition, or function addressed.

Goldsborough Creek is designated habitat for ESA-listed winter steelhead. It is also home to populations of chum and coho salmon and anadromous cutthroat trout (WDFW 2020). This project will benefit North Fork Goldsborough Creek and Goldsborough Creek. Increased flow will increase usable aquatic habitat, and would have the greatest benefit during summer low flows.

Identification of anticipated support and barriers to completion.

This project is supported by the City, the WCC, and the Squaxin Island Tribe. No barriers to completion are currently foreseen.

Potential budget and O&M costs.

The City and the Squaxin Island Tribe are currently undergoing a feasibility study that includes capital and O&M costs. The current cost estimate is $1,673,000, based on similar work from an existing project grant from the Squaxin Island Tribe.

Anticipated durability and resiliency.

This project is expected to be durable, because the upgrades and RW quantities will be reflected by NPDES wastewater permit requirements that are designed to avoid and minimize treatment failure. Treatment upsets are generally avoided with design redundancy and safeguards, as defined in the reclaimed water permit ST6216.

Project sponsor(s) (if identified) and readiness to proceed/implement.

The project sponsor is the City of Shelton with the Squaxin Island Tribe as supporter. The WCC is a project stakeholder. All parties are currently proceeding with a feasibility study and are ready to implement the project, according to the results of the feasibility study.

References

Ecology (Washington State Department of Ecology). 2009. Fact Sheet for Reclaimed Water Permit Number ST 6216.

Ecology (Washington State Department of Ecology). 2016. Reclaimed Water Permit Number ST 6216.

WDFW (Washington Department of Fish and Wildlife), 2020. Salmonscape mapping of fish distribution. Available at: http://apps.wdfw.wa.gov/salmonscape/

Evergreen Mobile Home Estates Water Rights Acquisition

PROJECT DESCRIPTION

Description

Evergreen Mobile Home Estates (Evergreen Estates) Group A water system (PWSID# 24154) has been issued a compliance order to install CT6 disinfection (i.e. chlorination) to address failing on-site wastewater systems in close proximity to its wells. As an alternative to CT6 treatment, Evergreen Estates is considering connection to the City of Shelton's (City's) water system and abandoning its existing wells. The City has been pursuing consolidating the Evergreen Estates with the City drinking water system, and conducted a feasibility study to identify necessary infrastructure improvements to connect Evergreen Mobile Estates to its water system.

The Evergreen Estates installed five new sewer septic systems and a chlorination system at the wells. The property owner has indicated that the State has accepted their plan for onsite septic and chlorination improvements and that no further action on their part is needed (Carollo 2020). However, the Evergreen Estates owner did indicate that they would be amenable to water system consolidation if their costs were covered by others or with grant funding (HDR 2020).

The water system consolidation would result in the water rights of the Evergreen Mobile Estates Group A system to be unused. A water offset benefit would occur if that water right were to be put into permanent trust, per RCW 90.42.

Quantitative or qualitative assessment of how the project will function, including anticipated offset benefits, if applicable. Show how offset volume(s) were estimated.

The City of Shelton recently completed a consolidation feasibility study for the Evergreen Estates (Carollo 2020). The study identified the infrastructure that would need to be built by the City and by Evergreen Estates, respectively. The City would provide water service to the Evergreen Estates by providing an 8-inch water main for domestic supply and fire flows. Evergreen Estates would need to install a pressure reducing valve, a backflow prevention device, and potentially private fire hydrants.

The Evergreen Estates' available Water Use Efficiency reports indicated annual water production at the total authorized annual consumption of 26.9 acre-feet per year. However, the feasibility study estimated their likely annual water use to be 7.2 acre-feet per year. Therefore, if the City provided water to the Evergreen Estates, and the existing water right were to be put into permanent trust, the water offset value would be 7.2 acre-feet per year.

Conceptual-level map and drawings of the project and location.

The Evergreen Estates and water offset benefits would occur in the North Shelton area, in the Oakland subbasin (Figure 1).

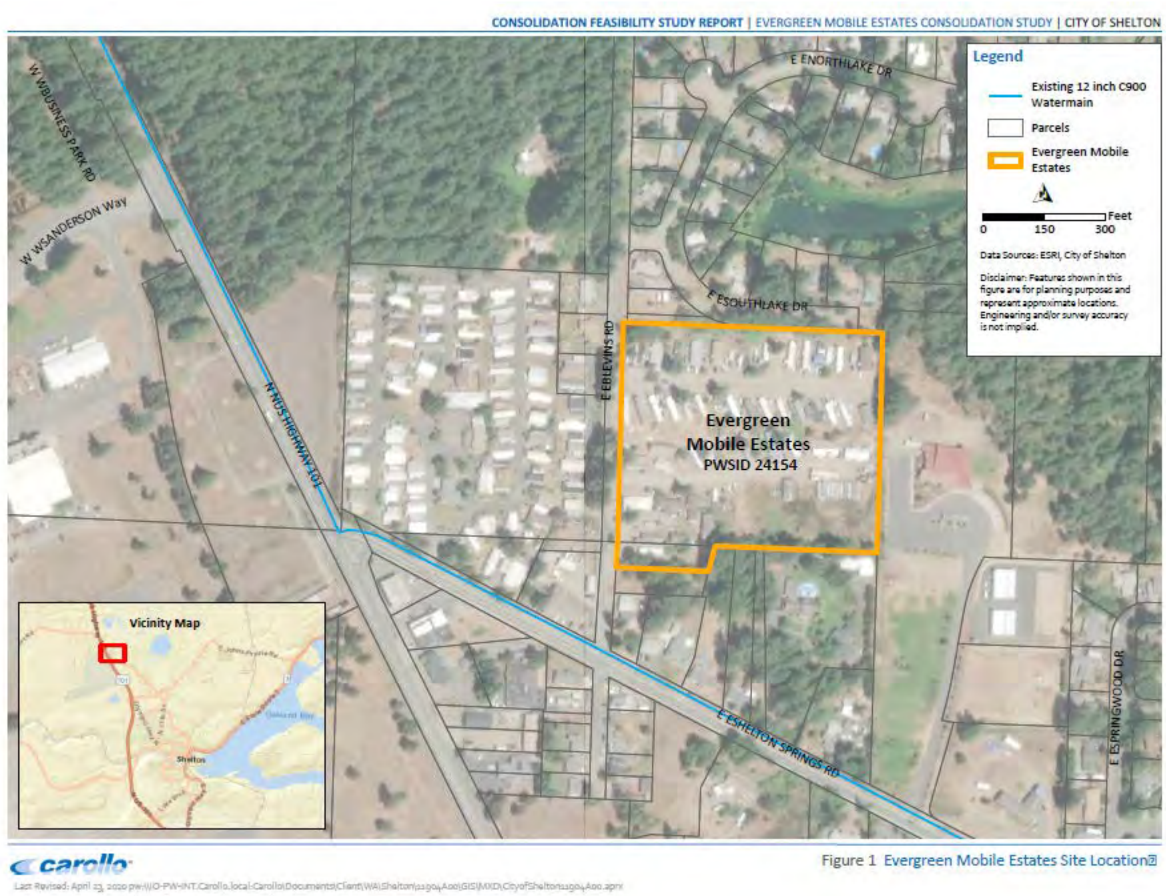

Figure 1. Evergreen Estates Site Location (from Carollo 2020).

Description of the anticipated spatial distribution of likely benefits

Elimination of pumping and consumptive use at the Evergreen Estates may benefit flow in John's Creek, in the Oakland subbasin. John's Creek is less than half a mile away from Evergreen Estates.

Performance goals and measures.

The performance goals would include completion of the legal mechanism of putting the Evergreen Estates water right into permanent trust, and permanent well closure.

Descriptions of the species, life stages and specific ecosystem structure, composition, or function addressed.

John's Creek supports coho, summer chum, fall chum, and winter steelhead (WDFW 2020). Increased summer low flows would support juvenile coho and winter steelhead juveniles. Chum species would benefit from continued groundwater connectivity during spawning and early rearing during the winter and early spring.

Identification of anticipated support and barriers to completion.

The primary barrier to this project is funding. Evergreen Estates has already invested in new septic systems and chlorination at their well. Consolidation may need to be fully funded by a grant(s).

Potential budget and O&M costs.

Costs are estimated at $474,000. Specific improvements and costs are currently being developed in a feasibility study that is being funded through a grant between the Department of Health (DOH) and the City (DOH Contract Number GVL24700).

Anticipated durability and resiliency.

The water rights acquisition would be a durable benefit, because it would be put into permanent trust. Although the City would need to pump more groundwater to provide water to the evergreen Estates, the City would still have the same maximum allowable use and number of connections, since they would not obtain the Evergreen Estates water right as part of their consolidation.

Project sponsor(s) (if identified) and readiness to proceed/implement.

The City is ready to proceed, if and when Evergreen Estates is ready. Evergreen Estates readiness is currently unclear and subject to future agreement.

References

Carollo. 2020. City of Shelton, Evergreen Mobile Estates Consolidation Study. Consolidation Feasibility Study Report. Final. September 2020.

WDFW (Washington Department of Fish and Wildlife), 2020. Salmonscape mapping of fish distribution. Available at: http://apps.wdfw.wa.gov/salmonscape/

General Floodplain Restoration

PROJECT DESCRIPTION

Narrative description, including goals and objectives.

The Kennedy-Goldsborough Watershed (WRIA 14) is within Mason and Thurston counties and includes an extensive network of independent streams that issue from springs, wetlands, small lakes, and surface water drainages. The Kennedy-Goldsborough Watershed has no major river system. These multiple small streams originate from the Black Hills and lower foothills of the Olympic Mountains, emptying into several shallow bays and inlets in South Puget Sound, including Eld, Totten, Skookum, Hammersley, and Case inlets. Principal drainages include (from north to south) Sherwood, Campbell, Deer, Cranberry, Johns, Goldsborough, Mill, Skookum, Schneider, Kennedy, and Perry creeks. The geomorphology of WRIA 14 is strongly influenced by glacial deposits of coarse materials that promote connectivity between surface and groundwaters and the headwaters of many of the stream systems are (or were) dominated by wetlands.

Limiting factors for salmon species in WRIA 14 have been identified by Kuttel (2002) and Mason CD (2004), and are briefly summarized below:

- Fish barriers such as dams, culverts, and grade control structures have inhibited fish passage in WRIA 14.
- Removal of native riparian vegetation and channel modifications have led to deteriorated streambank conditions and reduced quantity and quality of instream habitat.
- Reduced levels of large wood, particularly key pieces that promote the long-term formation of instream and off-channel habitats.
- Groundwater and surface water withdrawals, loss of forest canopy and impervious surfaces have increases in water temperature, reduced dissolved oxygen levels, and very low flows during summer and early fall.

WRIA 14 floodplain restoration projects would address loss of groundwater storage, low flows and water quality conditions. The specific actions proposed for any given project would be specific to the restoration opportunity and habitat capacity of that location. The goal of any given project would be to rehabilitate natural hydrologic and geomorphic processes that are provided by floodplain connectivity. More detailed objectives pursuant to this goal would be specific to each respective project.

Qualitative assessment of how the project will function.

Projects will vary depending on the stream setting, habitat capacity, the impact that has occurred, and the corresponding opportunities for restoration. Potential floodplain restoration actions include the following:

- Channel re-alignment (i.e. re-meander),
- Removing bank protection,
- Installation of large wood to promote hyporheic and floodplain water storage
- Removal of fill or creation of inset floodplain (i.e. excavation of terraces),
- Side channel and off-channel feature reconnections, creation or enhancement.

Conceptual-level map of the project and location.

A mapping utility was used to solicit WRIA 14 floodplain project recommendations from the WRIA 14 Committee. The following data and reasoning was used to select candidate sites in WRIA 14:

- Identify reaches that are unconfined with Lidar hillshade. Unconfined reaches have wider valleys and floodplains.
- Identify reaches in flood zones
- Identify land that is vacant, and therefore potentially available for acquisition and restoration.
- Identify land that is public and potentially easier to acquire for restoration.
- Identify areas of tributary inflow, because they are often areas of biological importance and habitat complexity. They may also be areas more prone to intermittent flooding.

Project locations identified by the Committee are shown in Figure 1 include the following:

- Schumacher – Beaver
- Deer Creek - Beaver
- Johns Creek – Beaver
- Campbell Creek, Upper
- Jarrell Creek
- Mill Creek above BNSF tracks

- Gosnell
- Skookum at Duck Pond
- Skookum, Eich Road
- Skookum, Upper
- Kennedy Creek flats
- Upper Schneider
- Perry Creek

All project locations would be subject to evaluation of feasibility during plan implementation. Other locations may be identified by Committee members or other project sponsors during plan implementation.

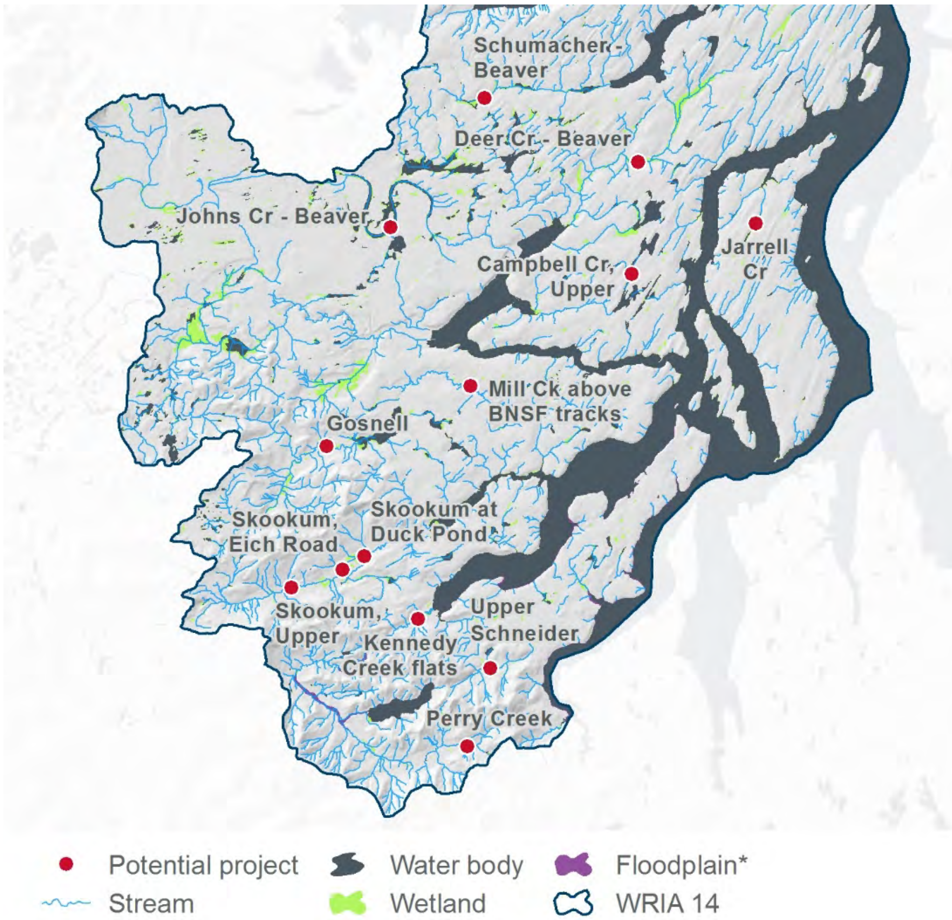

Figure 1. Potential floodplain restoration project locations.
**Floodplain data only available for southern areas in WRIA 14.*

Performance goals and measures.

Performance goals and measures will vary depending on the project. In general, the goals will be to implement the restoration actions with their intended quantity and purpose. The measures will be directly measurable elements such as acres of floodplain, wetland, or riparian habitats restored, stream-miles enhanced, predicted quantity of baseflow volume restored, predicted reduction of temperature, etc.

Description of the anticipated spatial distribution of likely benefits.

Potential floodplain restoration projects have been identified in suitable floodplain areas of Schumacher, Deer, Johns, Campbell, Jarrell, Mill, Gosnell, Skookum, Kennedy, Schneider, and Perry creeks. Restoring floodplain connectivity, along with riparian and wetland habitats could benefit between 2 and 6 miles of these tributaries by storing direct precipitation and floodwaters in these floodplain areas, contributing additional flows during low flow periods.

These streams have been noted for low summer/fall flows for decades (WDF 1975) and improvements to flows and temperatures, as well as floodplain and instream habitats, could provide substantially improved summer rearing habitat for juvenile coho salmon, steelhead and cutthroat trout. Improved flow conditions would also benefit upstream migration of adult Chinook, chum, and coho salmon.

Descriptions of the species, life stages and specific ecosystem structure, composition, or function addressed.

The Washington Department of Fish and Wildlife (WDFW 2020a) has identified that coho, and fall chum salmon, and winter steelhead trout are present in all the identified primary drainages in WRIA 14. Fall Chinook salmon are present in Sherwood/Schumacher, Deer, Cranberry, Goldsborough, and Mill creeks and summer chum are present in Sherwood/Schumacher, Deer, and Cranberry creeks. Most salmon species are of wild origin, although some mixed stocks are present from prior hatchery chum and coho releases (WDFW 2020b).

Increased floodplain habitats and improved riparian and instream habitat conditions would primarily benefit juvenile salmonid rearing habitats by providing increased area and quality of summer rearing habitats. This would improve both productivity and survival of juveniles, particularly coho and steelhead. The restoration of floodplain processes and functions could also improve summer/fall base flows and reduce water temperatures. This would improve both juvenile and adult migration conditions. Low flows have been identified as a high priority limiting factor in WRIA 14 (Kuttle 2002) and the restoration and reconnection of floodplain habitats and riparian enhancements provide shading, food web support, and flood and sediment attenuation functions.

Identification of anticipated support and barriers to completion.

No specific projects have been identified.

Potential budget and O&M costs (order of magnitude costs).

No specific projects have been identified.

Anticipated durability and resiliency.

Floodplain reconnection projects are durable as they restore natural processes to a reach of the river, allowing flooding and channel migration to occur unimpeded. Floodplain reconnection projects that provide the river with more room to meander and more ways to hold water for longer are important solutions to implement to restore watershed processes and to provide resiliency from a changing climate.

Project sponsor(s) (if identified) and readiness to proceed/implement.

No specific projects have been identified.

Documentation of sources, methods, and assumptions.

The following references were used:

Kuttel, M, 2002. *Salmonid Habitat Limiting Factors Water Resource Inventory Area 14, Kennedy-Goldsborough Basin*. Washington State Conservation Commission. November 2002.

Mason CD (Mason Conservation District Lead Entity), 2004. *Salmon Habitat Protection and Restoration Plan, Water Resource Inventory Area 14, Kennedy-Goldsborough*.

WDF (Washington Department of Fisheries), 1975. *A Catalog of Washington Streams and Salmon Utilization*, WRIA 14. Available at: https://www.streamnetlibrary.org/?page_id=95

WDFW, 2020a. Salmonscape. Available at: http://apps.wdfw.wa.gov/salmonscape/map.html

WDFW, 2020b. Salmon Conservation and Reporting Engine. Available at: https://fortress.wa.gov/dfw/score/score/maps/map_details.jsp?geocode=wria&geoarea=WRIA14_Kennedy_Goldsborough

Goldsborough Hilburn Restoration Project

PROJECT DESCRIPTION

Description

The Goldsborough Hilburn Restoration Project (Project) site is located approximately 500 feet upstream of Highway 101 near Shelton, WA, has been impacted by the placement of fill and armoring in the floodplain and immediate stream channel, resulting in a homogenous channel form that is mostly a riffle-glide complex.

The project involves removal of up to 7,800 cubic yards (CY) of artificial fill that is constricting Goldsborough Creek. The constriction is presumably causing higher-than-normal flow velocities during flood events, exacerbating the lack of flood refuge for salmonids, a problem also seen in other areas of Middle Goldsborough, and possibly causing channel incision (e.g. an existing, underground gas-line has been exposed, indicating active incising). Additionally, the project would widen the floodplain from 58 feet to 200 feet and add large wood and riparian vegetation, both of which are lacking in the project area.

Qualitative assessment of how the project will function.

Stream conditions at this site and reach provide little salmonid rearing habitat, holding water, covered pools, or floodplain off-channel areas. The site has a high potential for restoring natural processes and augmenting the habitat with in-stream woody elements, relative to reference quantities (Fox and Bolton 2007).

Conceptual-level map and drawings of the project and location.

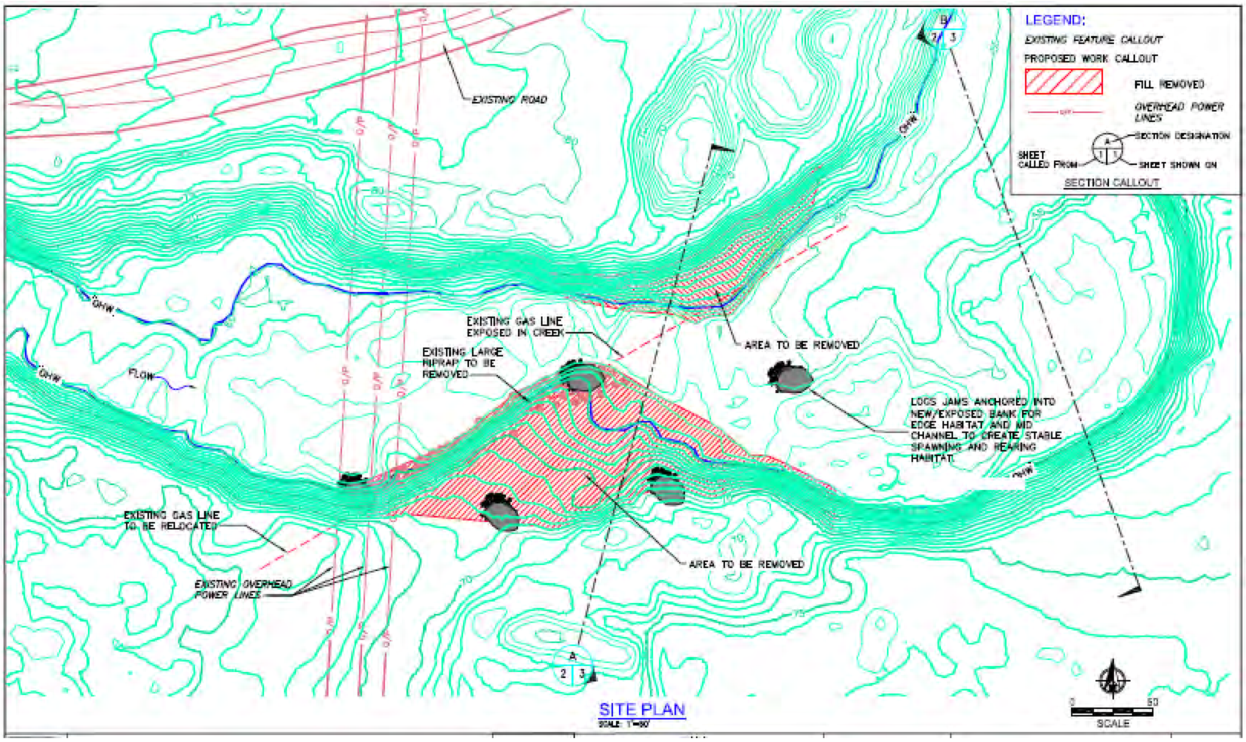

Figure 1. Goldsborough Creek Watershed Fish Habitat Enhancement Site Plan.

Description of the anticipated spatial distribution of likely benefit

The project would restore up to 500 feet of the Middle Goldsborough Segment. This will increase usable aquatic habitat.

Performance goals and measures.

The performance goals are to restore the natural processes and augment the habitat with in-stream woody elements, a need for this reach according. Specific metrics for these attributes will be defined based on the restoration design.

Descriptions of the species, life stages and specific ecosystem structure, composition, or function addressed.

This site and reach is used by multiple salmonid species including fall Chinook salmon (presence), coho salmon (spawning), fall chum salmon (spawning), and winter steelhead trout (spawning). Increasing hydraulic and habitat complexity with fill removal and LWD additions would increase habitat quantity and quality for pre-spawn holding in pools, variable current velocities, depths, and substrate composition that would be suitable spawning and rearing habitat for multiple species.

Identification of anticipated support and barriers to completion.

This project is supported by the South Puget Sound Salmon Enhancement Group and the WRIA 14 Lead Entity, but has not been developed enough to identify barriers to completion.

Potential budget and O&M costs.

The total costs of construction, engineering, permitting, and cultural assessments are estimated to be less than $1,000,000 (includes engineering and construction costs).

Anticipated durability and resiliency.

The project would have lasting benefits and would not require operation and maintenance, once it is established.

Project sponsor(s) (if identified) and readiness to proceed/implement.

The project sponsor would be South Puget Sound Salmon Enhancement Group.

References

Fox, M. and S. Bolton. 2007. A reginal and Geomorphic Reference for Quantities and Volumes of Instream Wood in Unmanaged Forested Basins for Washington state. North American Journal of Fisheries Management. Volume 27 (1): 342 – 359.

SPSSEG. 2010. Goldsborough Creek Constriction Removal Project. Salmonid Habitat Project Development. December 2010.

Managed Aquifer Recharge Projects in WRIA 14

PROJECT DESCRIPTION

Description

The WRIA 14 WRE Committee has identified managed aquifer recharge (MAR) projects as a viable approach to offsetting the consumptive use associated with permit exempt well growth. MAR projects may include many water sources, such as stormwater, Class A reclaimed water, and peak flows in rivers and streams. This general project is limited to MAR projects that divert, convey, and infiltrate peak seasonal river flows in engineered facilities that are in connection with the local alluvial aquifer that the donor stream or river is also in connection. Flows would be diverted in quantities that would not reduce habitat suitability for salmonids and that do not reduce habitat forming processes. Seepage back into the river would result in attenuation of these flows, increasing base flows across a broader time period, including the late summer and early fall, when flows are typically the lowest, and water demand for consumptive use is the highest.

This project description describes candidate MAR locations, potential methods for diversion and conveyance, potential diversion quantities, typical infiltration basins that would infiltrate those diversion quantities, and the associated offset benefits. Detailed feasibility analysis is not included in this project description and would occur during plan implementation for each specific location.

Quantitative or qualitative assessment of how the project will function, including anticipated offset benefits, if applicable. Show how offset volume(s) were estimated.

Potential MAR locations were determined based on a screening process (Attachment A). Areas in WRIA 14 with the following features were considered for candidate locations:

- Favorable soils and geology-
    - No wetlands, lakes, or high groundwater areas
    - Exposed till less than 10 feet estimated thickness
- Favorable Land Use
    - Undeveloped or Forestry
- Proximity to potential water source
    - Potential water sources included peak flows from Schumacher Creek, Sherwood Creek, Deer Creek, Cranberry Creek, Johns Creek, Goldsborough Creek, Mill Creek, Skookum Creek, Kennedy Creek, and Perry Creek
    - ½ mile from potential donor waterbody
- Land ownership

This screening resulted in favorable areas and specific locations for consideration during WRE Plan implementation (Figure 1). Additional candidate locations may be proposed during plan implementation. Additional candidate locations are likely to be within these favorable areas but may also be demonstrated as suitable for MAR based on an independent site-specific analysis.

Potential streams that could be part of MAR projects are those that have a flow record adequate for an assessment of flow diversion quantities and infiltration facility design. Diversion flows could be proposed based on maintaining minimum instream flows and habitat forming processes (i.e. ecological flows). Diversion flows were set at 2 percent of wet season (November – April) minimum flows. Diversion of flow to an MAR facility could occur during days when flows exceed minimum instream flows. These days were tallied for each day in the flow record and summed by month (Table 1). These "diversion days" were averaged across all water years in the flow record. Then those averages were summed during the wet season months. This number of "diversion days" for each site, represents the average number of diversion days.

A more conservative approach was also employed that summed the number of "diversion days" for the wet season (November – April) for each water year. Then, the smallest number of "diversion days" among the years in the flow record was selected (Table 2).

The minimum and average volume of water that could be diverted to one or more MAR facilities in each stream was calculated by multiplying the diversion flow by the number of diversion days, and transforming the volume to acre-feet/ year (Table 3).

Diversion

Typical capture and recovery methods vary by water source but include some combination of a screened gravity diversion/bypass, a screened water lift and/or pump system, or a series of below ground infiltration galleries/collector pipes (e.g. Raney wells) adjacent to source streams. All of these methods would need to be evaluated based on a number of factors including operation and maintenance, fish passage performance, permitting, reliability, public safety, construction and lifecycle cost, and available funding mechanisms (HDR 2017) in order to determine the best fit for the water source. Screened water gravity diversions require the most extensive infrastructure but would need the least amount of effort to get water into conveyance structures. Screened water lift and/or pump systems would require less infrastructure than a screened water gravity diversion however the risk of damage would be greater.

The WRIA 14 Committee acknowledges that some diversion methods including in-channel structures may pose an impact to fish habitat, and strongly advocates for the use of diversion methods that do not include in-channel structures. For example, diverted water could be conveyed through a collector well adjacent to the river (e.g. Ranney Collector well). The WRIA 14 Committee suggests that projects should be specifically designed to enhance streamflows and to avoid a negative impact to ecological functions and/or critical habitat needed to sustain threatened or endangered salmonids.

Conveyance

After capture and recovery, water would be transported to the MAR site through a conveyance system which would be some combination of open canals/ditches, surface and subsurface closed piping, tunnels, and trenches (e.g. lined and unlined). Conveyance can be facilitated through gravity fed structures or strategic pumping throughout the system. Once constructed or modified, maintenance – including repair, leakage control, preventing recontamination, and the operation of pumping stations where gravity pressure is not enough– has to be ensured. Ideally, source streams and MAR sites would be in close proximity to minimize the complexity of the conveyance system.

Storage and Infiltration

MAR sites (e.g. shallow aquifer recharge sites) are expected to consist of one or more small storage reservoirs (ideally less than 10 AF in volume or less than 6 feet in height). After water is captured during periods of excessive river flow, water will be conveyed into storage reservoirs and allowed to infiltrate into the local water table over time. Infiltration sites must be chosen carefully and evaluated for potential infiltration rates and volumes as well as anticipated hydrologic and water quality effects resulting from the project. Suitable sites would have permeable material at the surface and a water-table deep enough to allow levels to rise without causing problems, such as flooding.

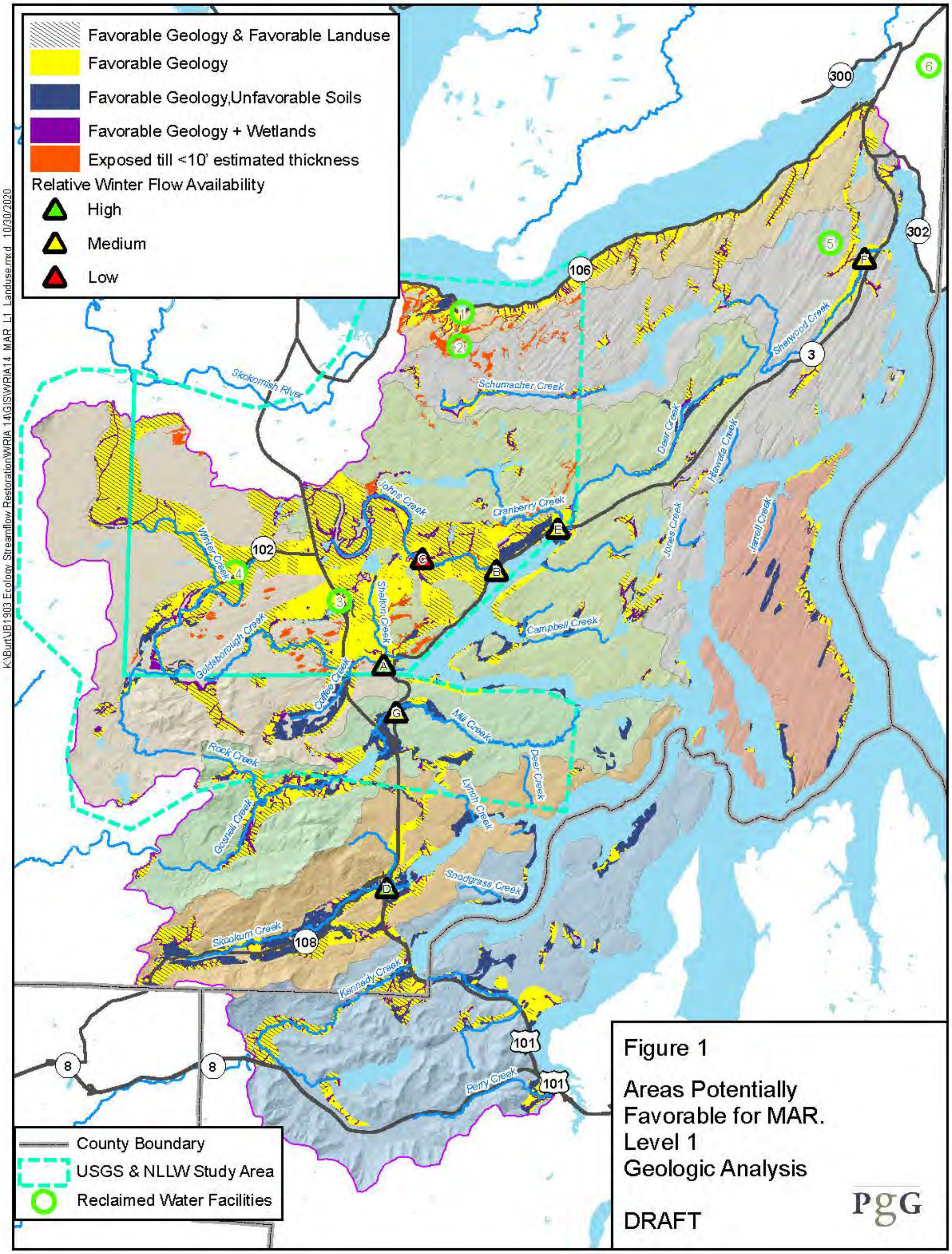

Figure 1. Favorable areas for MAR for feasibility analysis during plan implementation.

Table 1. Average measured monthly flow, minimum monthly instream flow, and the average number of days each month, where flows exceed minimum flows. Total number of days where flows exceed minimum flows during the wet season (November – April) are summed at the bottom. All flow values are in cubic feet per second.

	Kennedy Creek			Goldsborough (USGS) at S 7th St.			Johns 1 at Hwy. 3			Johns 2 at Johns Cr Rd.			Skookum at Hwy. 101			Mill at Hwy. 3			Cranberry at Hwy. 3			Sherwood at E Sherwood Cr Rd		
Month	Avg	Min. Inst	Days	Avg	Min. Inst	Days	Avg	Min. Inst	Days	Avg	Min. Inst	Days	Avg	Min. Inst	Days	Avg	Min. Inst	Days	Avg	Min. Inst	Days	Avg	Min. Inst	Days
Jan	119	NA	10	341	50	31	97	45	20	63	45	9	140	40	27	153	65	27	99	50	21	140	60	28
Feb	92	NA	10	250	85	28	69	45	12	47	45	13	87	40	19	116	65	21	66	50	16	106	60	22
Mar	100	NA	10	258	85	30	72	45	12	50	45	19	100	40	24	121	65	23	72	50	15	128	60	23
Apr	56	NA	0	196	85	29	54	45	7	38	45	9	57	40	17	81	65	16	48	50	12	79	60	19
May	38	NA	0	119	85	21	34	34	4	24	34	2	29	26	13	49	55	9	29	31	8	50	48	11
June	17	NA	0	75	85	7	21	20	3	15	20	0	13	11	13	29	40	3	17	18	10	32	29	15
July	8	NA	0	51	55	8	14	12	6	9	12	6	5	5	10	18	28	0	10	11	9	19	18	17
Aug	6	NA	0	41	48	2	11	7	13	7	7	11	2	3	5	13	20	0	7	8	6	14	11	15
Sept	5	NA	0	45	45	6	10	7	12	7	7	6	4	3	9	14	20	2	9	8	13	16	11	14
Oct	11	NA	0	82	50	16	17	7	19	12	7	7	22	6	17	32	20	14	18	15	11	34	19	19
Nov	57	NA	0	221	50	29	52	45	9	36	45	3	114	40	21	114	65	19	61	50	12	100	60	19
Dec	99	NA	10	274	50	31	78	45	15	50	45	5	114	40	23	124	65	22	80	50	17	144	60	22
Total			40			177			75			58			131			128			92			133

Table 2. Number of days that flows exceed minimum instream flows during the wet season (November – April) and the minimum number of days among all years for each flow station.

Flow Station	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Minimum
Skookum at Hwy. 101	84	113	117	104	122	158	133	165	104	146	129	157	164		84
Goldsborough (USGS) at S 7th St.		179	172	177	166	181	176	182	180	178	181	182	181	181	166
Johns 1 at Hwy. 3		91	159	87	36	123	151	132	110	74	106	149	181	128	36
Johns 2	14	104	80	38	41	74	82	111	25	64	75	143	113		14
Mill at Hwy. 3		116	127	86	89	145	139	164	89	134	129	159	157		86
Cranberry at Hwy. 3		111	106	50	45	106	87	135	35	87	86	143	118		35
Sherwood at E Sherwood Cr Rd				72	85	172	137	179	90	127	131	169	165		72

Table 3. Potential MAR site locations, facility sizes, and water offsets

Stream	Location	Facility Size (sq ft)	Diverstion Flow (cfs)	Minimum Days Exceeding Minimum Flows (Nov - Apr)			Average Days Exceeding Minimum Flows (Nov - Apr)		
				Total Days of Diversion	Total Water Per Year (cfy)	Total Water Per Year (afy)	Total Days of Diversion	Total Water Per Year (cfy)	Total Water Per Year (afy)
Kennedy Creek	Summit Lake outlet or RM 5	6,200	1	40	3,456,000	79	40	3,456,000	79
Skookum Creek	Downstream of Kamilche Cr; headwaters	3,100	0.5	84	3,628,800	83	131	5,659,200	130
Mill	Downstream of Lake Isabella	6,200	1	86	7,430,400	171	128	11,059,200	254
Goldsborough Creek	~River Mile 7	6,200	1	166	14,342,400	329	177	15,292,800	351
Johns Creek	Downstream of Johns Cr Rd	3,100	0.5	36	1,555,200	36	117	5,054,400	116
Cranberry Creek	~ RM3	6,200	1	35	3,024,000	69	92	7,948,800	182
Sherwood Creek	DS of Mason Lake	6,200	1	72	6,220,800	143	133	11,491,200	264
					Total	910			1,377

Potential streams for MAR diversion, infiltration, and low-flow return in WRIA 14 vary in terms of the quantity of available flows, the seasonality of available flows, and the suitability of soils for MAR sites.

Kennedy Subbasin

Kennedy Creek could have an MAR site(s) at near the outlet of Summit Lake or at approximately River Mile (RM) 5. Both of these areas are forested and have suitable geology and soils for infiltration. Average monthly flows near the mouth range between 92 – 119 cfs between November and March (Table 1). Since no minimum flows are set for Kennedy Creek, the average flows were used as a basis for setting diversion flow quantities. An MAR diversion of 1 cfs during period is proposed over this period, which would be less than 2% of average wet season flows. A conservative estimate of 40 days (a third of the time) is estimated to be above these average flows, while still accommodating a 1 cfs diversion. (Tables 1 and 3).

Skookum Subbasin

Skookum Creek has unfavorable soils for MAR infiltration along much of its stream alignment (Figure 1). However, there are some small areas of suitable geology and soils in the headwaters and near the confluence with Kamilche Creek. Average monthly flows at Highway 101 range between 57 – 140 cfs between November and April (Table 1). Assuming that flows are similar downstream of Kamilche Creek, an MAR diversion of 0.5 cfs (less than 2% of the lowest minimum instream flows) during period is proposed over this period. Between 84 - 131 days were above minimum instream flows, while still accommodating a 0.5 cfs diversion (Table 1 and 2), resulting a potential water offset of 83 – 130 acre-feet/year (Table 3).

Mill Subbasin

Soils and geology are favorable for MAR sites immediately downstream of Isabella Lake (Figure 1). This location would be useful, in terms of providing cool groundwater recharge downstream of the lake. Average monthly flows for Mill creek at Highway 3 range between 81 -153 cfs between November and April (Table 1). An MAR diversion of 1 cfs (less than 2% of the lowest minimum instream flows) during period is proposed over this period. Between 86 - 128 days were above minimum instream flows, while still accommodating a 1 cfs diversion (Table 1 and 2), resulting a potential water offset of 171 – 254 acre-feet/year (Table 3).

Goldsborough Subbasin

Soils and geology are favorable for MAR sites near Goldsborough Creek at multiple locations (Figure 1). Average monthly flows for Goldsborough Creek at S. 7th Street (USGS gage 12076800) range between 196 – 341 cfs between November and April (Table 1). An MAR diversion of 1 cfs (less than 2% of the lowest minimum instream flows) during period is proposed over this period. Between 166 - 177 days were above minimum instream flows, while still accommodating a 1 cfs diversion (Table 1 and 2), resulting a potential water offset of 329 – 351 acre-feet/year (Table 3).

Oakland Subbasin

Several streams are located in the Oakland Streams with available flow record include Johns Creek and Cranberry Creek. Average monthly flows for Johns Creek at Hwy 3 range between 81 – 153 cfs between November and April (Table 1). An MAR diversion of 0.5 cfs (less than 2% of the lowest minimum instream flows) during period is proposed over this period. Between 36 - 117 days were above minimum instream flows, while still accommodating a 1 cfs diversion (Table 1 and 2), resulting a potential water offset of 36 – 116 acre-feet/year (Table 3).

Average monthly flows for Cranberry Creek at Highway 3 range between 48 - 99 cfs between November and April (Table 1). An MAR diversion of 1 cfs (less than 2% of the lowest minimum instream flows) during period is proposed over this period. Between 35- 92 days were above minimum instream flows, while still accommodating a 1 cfs diversion (Table 1 and 2), resulting a potential water offset of 69 – 182 acre-feet/year (Table 3).

Case Subbasin

The primary streams in the Case subbasin include Schumacher Creek and Sherwood Creek. The two creeks are part of the same drainage, with Schumacher Creek flowing into Mason Lake, and Sherwood Creek flowing from Mason Lake (Figure 1). Average monthly flows for Sherwood Creek at Sherwood Cr Rd. range between 79 - 144 cfs between November and April (Table 1). Water could be diverted from the downstream end of Mason Lake and conveyed to an MAR site directly downstream of the lake outlet (Figure 1). An MAR diversion of 1 cfs (less than 2% of the lowest minimum instream flows) during period is proposed over this period. Between 72- 133 days were above minimum instream flows, while still accommodating a 1 cfs diversion (Table 1 and 2), resulting a potential water offset of 143 – 264 acre-feet/year (Table 3).

Hood Subbasin

Several small streams drain directly to Hood Canal. The unnamed stream that drains Devereaux Lake has suitable soils for an MAR site. This stream does not have flow data. Therefore, no MAR diversion scenario is currently proposed.

Harstine Subbasin

No candidate locations are proposed for the Harstine Subbasin. The only stream large enough to accommodate a small MAR project is Jarrell Creek. However, soils are generally unsuitable near the stream and on most of Harstine Island (Figure 1).

The total potential MAR diversion quantities for all streams proposed herein range between 910 – 1,377 acre-feet/year (Table 3).

Description of the anticipated spatial distribution of likely benefits

The benefits will vary depending on the Creek, fish use. MAR seepage back to any of the proposed creeks would target benefits to the low-flow summer and early fall period. This would benefit rearing for yearling salmonids such as coho, steelhead, and coastal cutthroat trout.

Performance goals and measures.

Performance goals would be the quantity of water diverted and infiltrated. This goal could be measured by metering the conveyance pipe flow and the water depth of the MAR infiltration basin. Secondarily, water table elevations between the MAR and receiving waters, flow in the receiving waters, and seepage observations could be done, as an indication of flow benefits.

Descriptions of the species, life stages and specific ecosystem structure, composition, or function addressed.

These MAR projects would increase flow during the summer and early fall periods, increasing usable aquatic habitat, overall.

Identification of anticipated support and barriers to completion.

Mason County may support and implement these projects, with potential support from the Squaxin Island Tribe.

Potential budget and O&M costs.

The estimated costs for MAR projects are based on an assumption of ~$3,443/acre-foot of estimated offset. For the total 910 AFY estimated as potential offset for WRIA 14, this would equate to ~$3 million.

Anticipated durability and resiliency.

The project would require regular operation and maintenance.

Project sponsor(s) (if identified) and readiness to proceed/implement.

Thurston County, Mason County, and Mason County PUD #1 have indicated that they would be likely project sponsors, depending on site locations and further review.

Sources of Information

WDFW (Washington Department of Fish and Wildlife), 2020. Salmonscape mapping of fish distribution. Available at: http://apps.wdfw.wa.gov/salmonscape/

Attachment A

Managed Aquifer Recharge Assessment Methodology

Technical Memorandum

To: Department of Ecology WRIA 14 Watershed Restoration and Enhancement Committee

From: Peter Schwartzman, LHG

Re: WRIA 14 Managed Aquifer Recharge Assessment Methodology

Date: December 18, 2020

This technical memorandum documents the methodology used to identify properties that appear to have characteristics favorable for Managed Aquifer Recharge (MAR) in Kennedy-Goldsborough Basin, Water Resources Inventory Area (WRIA) 14. This work was completed by Pacific Groundwater Group (PGG) on behalf of the WRIA 14 Watershed Restoration and Enhancement (WRE) Committee (Committee) and the Department of Ecology (Ecology). This work was performed under Ecology Contract Number C1700029, Work Assignment PGG104.

Under RCW 90.94.030, Ecology has the responsibility to convene WRE committees and prepare WRE plans for eight WRIAs in the Puget Sound and Hood Canal areas. The general purpose of the plans is to document potential offsets to projected depletion of instream flows resulting from new, permit-exempt domestic well uses in the WRIAs over the next 20 years.

MAR project sites potentially can support watershed restoration and enhancement projects within the WRIA by potentially offsetting the impacts of permit exempt wells on WRIA streams. For this evaluation, MAR was defined as recharge via infiltration of source water at or near the land surface. A portion of recharged water is expected to follow subsurface pathways and return to hydraulically connected streams. To support development of the WRE plan for WRIA 14, PGG used regional data to assist the Committee in selecting properties within WRIA 14 that appear to have favorable infiltration characteristics and a close enough proximity to source water so that MAR may occur with reasonable economic efficiency. This memorandum outlines the methodology used to identify potentially favorable MAR project sites.

PROCEDURE

Regional soils, geologic, wetlands and land-use coverages were compiled for WRIA 14 using Geographic Information System (GIS) software. A series of screening criteria were then applied to identify sites that appear most favorable.

Screening Level 1- Surficial Geology, Soils, Wetlands and Groundwater Flooding

The initial screen focused on areas where regionally mapped soil and geologic units appear favorable for infiltration. The following criteria were applied:

1. Surficial geologic maps were reviewed and geologic units primarily composed of sand

and/or gravel were identified as favorable for infiltration, while low permeability units (with higher silt and/or clay contents or bedrock) were excluded. Surficial geology was based on regional (1:100,000-scale mapping) by DNR (Schasse, 1987). Favorable geologic units were associated with alluvium, recessional glacial outwash and advance glacial outwash.

2. Areas with unfavorable geology (glacial till exposed at the land surface) were generally excluded; however, PGG identified areas where hydrogeologic characterization performed by the USGS (REF) suggested that the till may be sufficiently thin (<10 feet) that excavation could provide an infiltration pathway to underlying materials (typically advance glacial outwash). This approach differs from infiltration at the land surface in that recharge occurs deeper in the groundwater flow system. Additional hydrogeologic characterization would be required to assess the value of recharge the advance outwash. Although few streams are mapped as penetrating advance outwash, model simulations may suggest reasonable hydraulic connectivity between streams and advance outwash (Massman, 2020).
3. Soils types mapped by the Natural Resources Conservation Service[57] were reviewed and those classified in "Hydrologic Soil Groups[58]" (HSG's) with high runoff potential (low infiltration potential) were excluded from the areas of favorable surficial geology. Unfavorable soils were classified for HSG's "C" and "D", along with "dual hydrologic soil groups" associated with poorly-drained soils exhibiting a shallow water table (e.g. "A/D", "B/D"). Whereas "A" and "B" HSG's indicate low and moderately-low runoff potential, "C" and "D" HSG's indicate moderately-high and high runoff potential (NRCS, 2007).
4. Wetlands, lakes, and high groundwater areas (as mapped within and by Thurston County) were excluded from the favorable infiltration areas defined based on criteria in bullets #1 and #3 (above).

Hydrogeologically favorable areas that meet the Level 1 screening criteria are shown in **Figure 1**.

Screening Level 2 – Favorable Land Use for MAR

PGG obtained GIS coverages of land use from Thurston and Mason counties and identified those land uses that might be most amenable to installation of an infiltration facility where infiltration potential is favorable. Land use data were available for the entire WRIA, of which 15% was listed as "water". Out of the terrestrial portion of the WRIA, land uses deemed potentially favorable for MAR included: commercial lumber and wood (<0.1%), governmental services (2%), educational

[57] https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
[58] https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=22526.wba

services (0.15%), parks (1%) and designated forest land (56%). The remaining land use were deemed 41% of the terrestrial WRIA) were deemed likely unfavorable for MAR. PGG added diagonal hatches to the hydrogeologically favorable areas identified in Screening Level 1 (**Figure 1**).

Screening Level 3- Potential Source Water Considerations

Figure 1 also illustrates potential water sources for MAR. HDR assessed selected streams within WRIA 14 for flow availability by calculating the difference between monthly average flow and the minimum instream flow requirement (HDR, 2020). PGG used the magnitude of these monthly values for the months of November through April to classify steams as having relatively high, medium and low availabilities. Flow availability was evaluated at specific gaging stations within the WRIA, shown as triangles on **Figure 1**. The triangles were colored to indicate high, medium and low relative flow availability, and labeled to correspond to the table below.

Stream/Location	Winter (Nov-Apr) Availability	Map Symbol
Goldsborough (USGS) at S 7th St.	High	A
Johns 1 at Hwy. 3	Med	B
Johns 2 at Johns Cr Rd.	Low	C
Skookum at Hwy. 101	High	D
Mill at Hwy. 3	Med	G
Cranberry at Hwy. 3	Med	E
Sherwood at E Sherwood Cr Rd	Med	F

Figure 1 also includes the locations of reclaimed water facilities (provided to PGG by the Squaxin Tribe) as potential MAR, indexed using the ID numbers below:

ID	Name
1	Alderbrook Wastewater Plant
2	Alderbrook Golf Course
3	Shelton Reclaimed Water Plant
4	Shelton Reclaimed Water Sprayfield
5	Allyn Reclaimed Water Plant, Basins, Sprayfield
6	Belfair Reclaimed Water Plant, Basins, and sprayfield

ADDITIONAL CONSIDERATIONS

As noted above, MAR was defined herein as infiltration of source water at or near the land surface. Another mechanism for MAR would be injection of source waters to deeper portions of the groundwater flow system, most realistically the Vashon advance outwash that occurs beneath Vashon glacial till (hardpan). Recharge to the advance outwash via infiltration is mentioned above, but where the till is thicker, injection wells would need to be constructed to fully penetrate the till and deliver source water to the advance outwash. In some cases, the upper portion of the outwash may be unsaturated, and injection into this unsaturated zone would provide some level of treatment (similar to typical surface infiltration project designs). In some cases, the advance outwash will be fully saturated below the till. Injection directly into saturated advance outwash may require additional levels of pre-treatment. Although WRIA streams typically occur above the till, groundwater modeling has suggested a reasonable degree of hydraulic connection between the advance outwash aquifer and surficial streams (Massmann, 2020). Should MAR by injection be considered, additional modeling work would be needed to better understand the pathways, proportions and timing by which water injected into the advance outwash would return to streams.

Another factor worth considering is the distance between MAR sites and source waters. Close distances reduce the cost of conveyance between the source (stream, reclaimed water facility, etc.) and the MAR site, making MAR projects more economically appealing. However, based on distance and geologic conditions, MAR sites too close to streams may not provide the timing of subsurface return flow desired to enhance streamflow. For instance, if streamflow is available as an MARE source between November and April, one would want a substantial portion of subsurface return flow to reach the stream during alternate months (May thru October, with additional preference for the low-flow months in late-summer and fall). Where proximity and hydrogeologic conditions support quick return flows from the MAR site to the stream (e.g. days to weeks), flow benefit during the desired season is reduced. Effectiveness is improved where return flow timing is on the order of months or is more even year-round. Year-round availability is an express advantage of reclaimed water sources.

FUTURE STEPS

PGG recommends that individual properties within the areas of identified favorable geology *and* favorable land be identified, prioritized and selected for site specific feasibility analyses. Sponsors for planning, designing, constructing and maintaining MAR projects will also need to be identified and paired with individual projects. Initial project feasibility considerations will include site ownership (and if the owners would consider selling, leasing, or permitting easements on their property to allow MAR) and the relative cost and complexity of providing source water to the site. Different sites will likely have different conveyance requirements that could include pumps, pipelines with significant elevation gain, long-distance subsurface pipelines, and pipeline easements for each property crossed by the conveyance line. For sites that remain favorable following initial owner outreach and conveyance considerations, a site specific hydrogeologic evaluation should be performed to identify local soil and aquifer hydrologic properties, depth to groundwater, and groundwater flow direction and gradient. Groundwater mound height and return flow travel time estimates would be included in this evaluation, as well as potential water quality or treatment concerns (such as the removal of particulate matter) prior to infiltration.

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HDR, 2020. Personal communication between Chad Wiseman (HDR) and Peter Schwartzman (Pacific Groundwater Group) dated 9/3/2020.

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Mason County Rooftop Runoff

INFILTRATION RECHARGE ANALYSIS FOR STREAMFLOW AUGMENTATION NET BENEFITS

TECHNICAL MEMORANDUM

Date:	Tuesday, December 01, 2020
Project:	Watershed Restoration & Enhancement Committees Technical Support
To:	Angela Johnson (Ecology) and David Windom (Mason County)
From:	Chad Wiseman, Jerry Bibee, PE, and Grace Doran, EIT (HDR)
Subject:	Mason County WRIA 14 and 15 Rooftop Runoff Infiltration Recharge Analysis for Streamflow Augmentation Net Benefits

Background

This memorandum describes the evaluation of net water offset recharge benefit associated with Mason County's proposed Rooftop Runoff Infiltration Program requirement for new rural development. Mason County has proposed a possible modification of the County building code to require capture of roof runoff from new rural residential (RR) development, typically on 5 acre parcels or greater, with direct connection to home site infiltration facilities (i.e., parcel dry wells, infiltration trenches, infiltration galleries, or rain gardens). This proposed code revision would typically require infiltration facilities that achieve recharge of 85 percent of the annual average rooftop runoff for new RR parcel development roof, with some reduction possible in less permeable soils to limit infiltration facility sizes. Similar to assumptions regarding permit exempt well consumptive use withdrawals, the infiltrated runoff is assumed to result in shallow groundwater recharge to interflow, with an assumed down-gradient surface water benefit to receiving waters base flow augmentation.

RR growth outside of urban growth areas (UGAs) within Mason County has been projected by the Mason County Comprehensive Plan and for the development of the Watershed Resource Inventory (WRIA) 14 and 15 Watershed Restoration and Enhancement (WRE) Plans (HDR 2020a and 2020b). HDR modeled hydrologic response and infiltration potential for new RR parcel development under existing (baseline) development requirements and under the proposed infiltration program, and in variable soil types, to estimate water offsets to be gained through this low-impact development (LID) best management practice (BMP). The typical infiltration quantities per RR parcel for each respective soil type were then applied to the projected RR growth in rural Mason County and associated hydrologic soil group (HSG) types. The resulting net increases in recharge benefits (proposed minus baseline) were applied to projected RR growth in Mason County at the WRIA and subbasin scales. Mason County encompasses portions of WRIA 14 and WRIA 15, respectively (Figure 1). The WRIAs have nested subbasins (Figures 2 and 3).

The application of LID BMPs within the County are not specifically required at the current time since the County is not a NPDES MS4 Phase II community tied to onsite stormwater management practices otherwise required in the 2019 Ecology Stormwater Management Manual for Western Washington (SWMMWW). Therefore, this water offset would not have occurred, if it were not for Mason County's proposal to create this requirement as a contribution to offsetting consumptive water use from rural residential growth. For the purposes of the WRIA 14 and 15 Watershed Restoration and Enhancement (WRE) Plans, the net infiltration recharge of rooftop runoff is equivalent to a water offset per RCW 90.94. The water offset benefits could be credited incrementally with continued RR growth under the current Mason County NPDES program status and implemented Rooftop Runoff Infiltration Program.

Figure 6: WRIA and Washington Counties within Project area

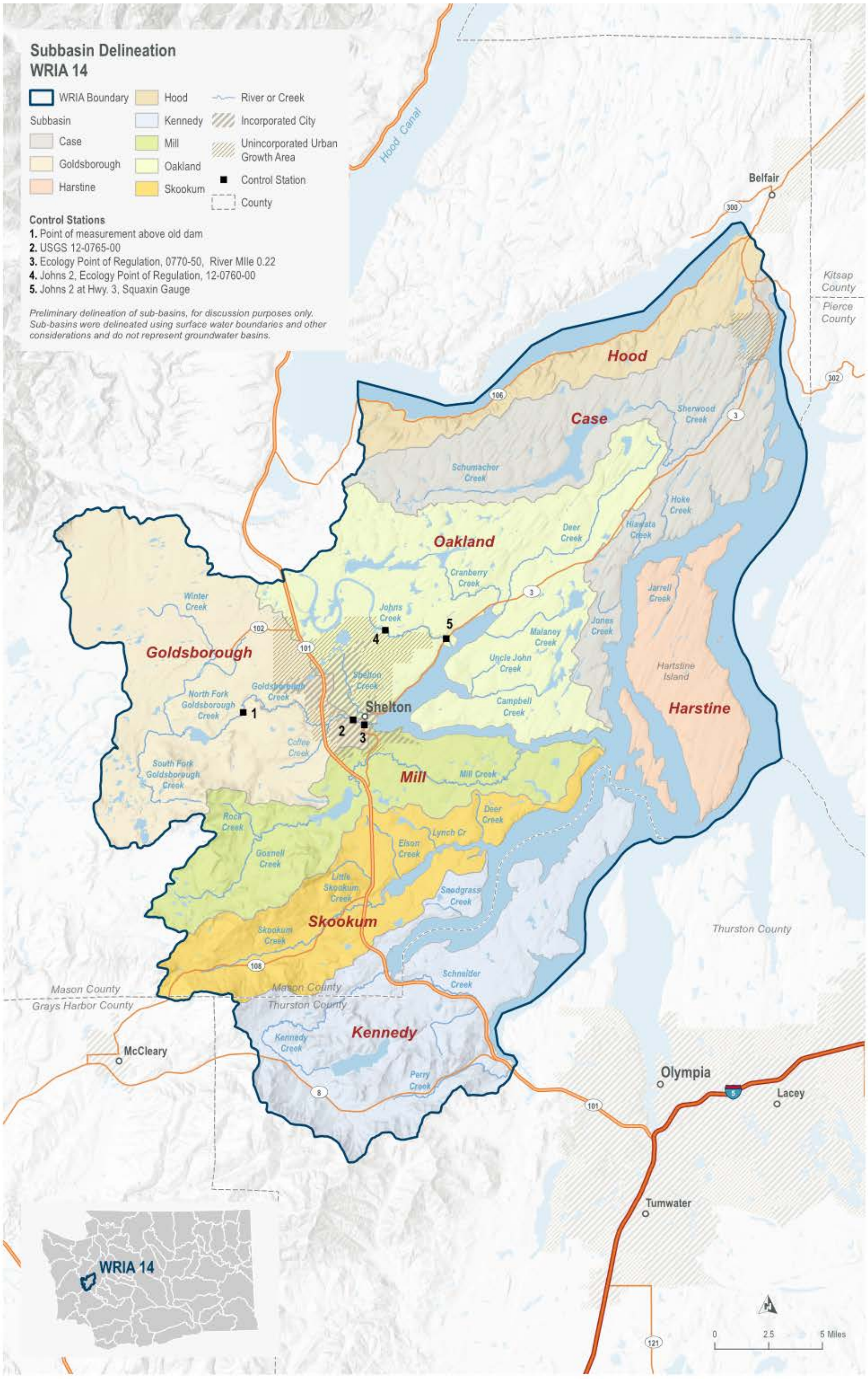


Figure 7: WRIA 14 subbasins

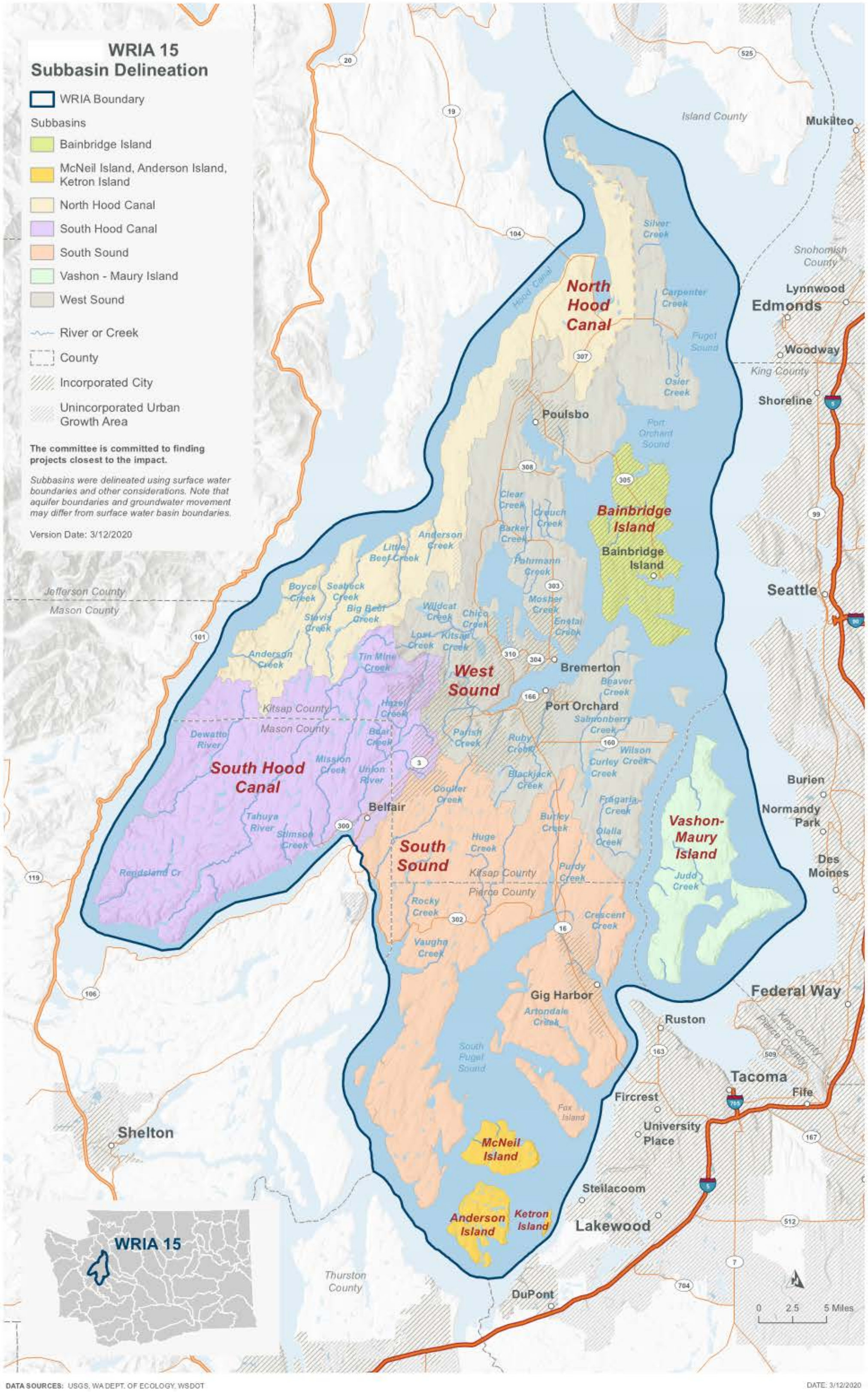


Figure 8: WRIA 15 subbasins

Analysis Methods and Assumptions

The following subsections describe the methods, conditions, and key assumptions underlying the Mason County Rooftop Runoff Infiltration Program analysis.

Analysis Approach Overview

Infiltration recharge volume estimates have been made for existing baseline conditions and standards, and for a proposal by Mason County to modify development standards to require direct infiltration of roof runoff. The analysis was conducted under an assumed set of typical parcel development conditions and under variable soil types. The resulting infiltration recharge volumes for each analysis condition were compared to establish the potential water offset net recharge benefit per RR development parcel under the evaluated soil types. Those parcel-level analysis results were then expanded to the WRIA 14 and 15 subbasins for characterization of the potential cumulative water offset benefits associated with this Mason County program proposal.

Characterization of Rural Residential Growth and Buildable Lands

The Mason County requirement to infiltrate rooftop runoff applies to buildable RR zoned lands, typically 5 acre and greater in parcel size (Figure 4). That collective land use totals approximately 186,000 acres of rural residential developable lands (Table 1), and with a total of 3,692 wells projected to service that area between 2018 and 2038. The projected 3,692 wells do not include the permit exempt wells that are anticipated to go into urban growth areas over that same period. The quantity of rural residences projected to be built in 2018 – 2038 in each subbasin were defined in the WRE Plan permit-exempt well and connection growth and consumptive use analysis (HDR 2020). The composition of HSG types (SWMMWW, Volume III-2.2) within the buildable lands were characterized within each subbasin (Figure 4). Group A, B, and C soils were evaluated, where Group A are outwash soils, Group B soils are transitional outwash to till soils, Group C are till soils. The transition in soils permeability from outwash to till soils ranges from high level to low level, with factored design infiltration rates ranging from 6.0 to 0.5 inches per hour evaluated. Group D soils are saturated/wetland soils and were not evaluated since achieving significant infiltration through them is not technically feasible.

Table 15: Total WRIA 14 and 15 RR developable area summarized by Hydrologic Soil Group

Hydrologic Soil Group	Cumulative Area of Soil Group (acres)
Group A	60,158
Group B	96,746
Group C	26,781
Group D	2,138
Total	**185,823**

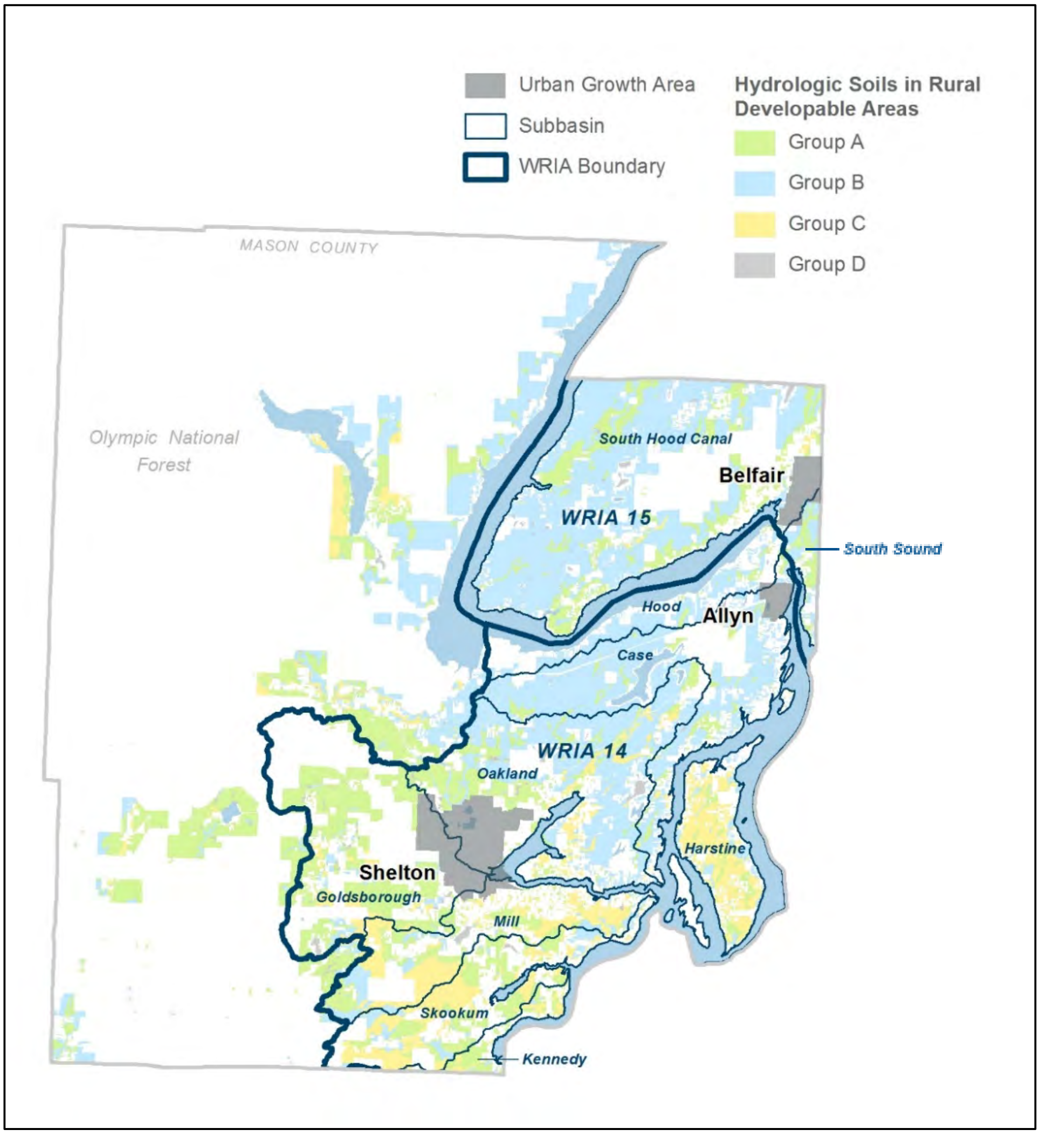


Figure 4: Rural residential buildable lands classified by hydrologic soil type.

Hydrologic Modeling Analysis Methods and Assumptions

MGSFlood, an Ecology-approved continuous simulation hydrologic model, was used to simulate RR parcel development area runoff and recharge through permeable surfaces in estimating the annual water balance to be applied to the WRIA subbasins rural residential developable lands. The analysis was conducted for a typical 5-acre developed parcel with typical land surface cover conversions as shown below. The analysis was conducted for the Group A, B, and C hydrologic soil classes, respectively, and using pervious land vegetation classes noted below. The following key assumptions were made for the MGSFlood hydrologic modeling analysis:

- Mean Annual Precipitation (MAP) is 70 inches (5.83 ft/yr)
- Individual parcel size is 5 acres
  - Cleared area of parcel is 1 acre (ac)
  - Typical house non-pollution generating impervious surface (NPGIS) area is 2,200 sf (0.05 ac)
  - Typical garage NPGIS roof area is 600 sf (0.014 ac)
  - Typical driveway pollution generating impervious surface (PGIS) is 1,200 sf (0.028 ac) (driveways were not considered for direct runoff recharge since they are pollution-generating surfaces)
  - Remainder of cleared site is grass
  - Remaining 4 acres is forested with native soil type
- Group A, B and C soils were evaluated with this analysis. For parcel runoff and infiltration simulation from pervious surfaces beyond roof runoff separately analyzed, Group B soils were proportionally split between outwash and till soils (the MGSFlood model does not include a Group B soil class)
- Group D soils were not included
- Soil permeability factored design rates for rooftop runoff infiltration trench analysis:
  - Group A = 4, 5, and 6 inches/hour (in/hr)
  - Group B = 1, 2, and 3 in/hr
  - Group C = 0.5 in/hr
- Infiltration facility depth of 2 feet
- The depth to water table beneath the infiltration facility is 5 feet or greater
- Filter strip soil permeability was assumed to be 3 in/hr to simulate a typical lawn topsoil or amended native soil, unless underlying native soil permeability was lower, in which case, it was set equivalent to that lower value

Parcel rooftop runoff was simulated using the MGSFlood model to evaluate rooftop runoff targeted for infiltration in each HSG, both under existing baseline condition development standards, and under the Mason County's proposed rooftop runoff modified development standard condition. The difference in recharge between those two conditions was used to assess the net increased benefit in recharge achieved. Separately, runoff from other parcel development area surfaces was evaluated as described in the following section, but since the infiltration characteristics of those surfaces under the two development standard conditions would not change, that analysis does not enter into the net recharge benefit evaluation.

Parcel Hydrologic Modeling Analysis (Beyond Roof)

To determine runoff and recharge for the entire 5-acre parcel, an MGSFlood model simulation was run to analyze the full recharge potential of the parcel. The roof infiltration changes from the baseline to proposed conditions was analyzed in a separate model simulation and was therefore not included in the full parcel analysis. Beyond the roof area, the analysis did not change between the baseline and proposed conditions. The land cover breakdown of a typical 5 acre parcel used for the MGSFlood analysis, excluding the 0.064 acres of roof area (house area, 0.050 ac, plus garage area, 0.014 ac), is shown in Table 2. Assuming 1 acre of the parcel would be developed, the soil group types of the remaining 4 acres of forested land was determined based on GIS analysis. As stated in the assumptions, Group B soil type was portioned out between Group A (outwash) and Group C (till) soils.

Table 16: MGSFlood Soils-Land Cover Input for typical 5-acre parcel development without roof area

MGSFlood Input	Area (ac)
Till Forest	1.232
Till Grass	0.230
Till Pasture	0.678
Outwash Forest	2.768
Impervious (beyond roof)	0.028
Total	**4.936**

Rooftop Runoff Baseline Condition Analysis

To complete the roof runoff recharge analysis for the assumed 0.064 acre roof area, a baseline analysis was completed to estimate how much runoff would infiltrate using existing Mason County development standards (Mason County Code, Title 14, Chapter 14.48). The Downspout Dispersion System BMP from the SWMMWW (BMP T5.10B) was considered the most representative for comparative analysis of infiltration recharge potential. This BMP for a single roof down-drain is applicable for 700 square foot (sf) of roof and requires a minimum 20 sf infiltration trench area. The developed parcel roof area was assumed to be 0.064 acres (2,800 sf), so 80 sf of infiltration trench area (2-foot width by 40-foot length) was modeled for the entire roof for baseline conditions applicable to all soil groups. For the baseline analysis, a filter strip (SWMMWW BMP T9.40) was linked downstream of the infiltration trench to route overflow runoff from the trench across it as sheet flow. As a linked element in MGSFlood, the filter strip only receives excess flow that is not infiltrated within the infiltration trench. The filter strip was conservatively assumed to have an area of 4,000 sf, 40 ft in width by 100 ft in length, and was intended to mimic a typical developed lawn surface (with topsoil or compost-amended native soil).

The infiltration recharge analysis was completed for each soil group, using the assumed design permeability rates applied to the infiltration trench area. The filter strip was analyzed with a typical topsoil infiltration rate of 3 in/hr. However, where the underlying native soils have a lower infiltration rate than 3 in/hr, the permeability of the filter strip was set to the limiting subgrade soils value.

Rooftop Runoff Proposed Condition Analysis

The proposed analysis was conducted under Mason County's proposed modified development standard requiring increased rooftop runoff infiltration. For this analysis, it was also assumed that a 0.064 acre roof is connected to an infiltration trench that would accommodate the majority of the roof annual runoff volume.. This was analyzed using the MGSFlood model infiltration trench BMP element without consideration of a filter strip downgradient of the infiltration trench for supplemental overflow infiltration benefit. The recharge analysis was completed for each soil group applying assumed design permeability rates.

The proposed condition infiltration analysis was initially conducted for a range of roof runoff values, ranging from 85 percent to 100 percent annual average infiltration volume in 5 percent increments to determine the required area of the infiltration trench or equivalent infiltration gallery area. Based on the analysis findings, Ecology staff consulted with Mason County staff on the desired target annual recharge value, and direction was subsequently provided by Ecology to HDR to use an 85% annual roof runoff infiltration target value. An exception to that was requested by Mason County for Group C soils, where annual recharge is limited by a maximum requested infiltration facility area footprint of 620 square feet.

Analysis Results

Parcel Runoff Analysis Findings

For the typical developed 5-acre parcel under the modeling assumptions listed above, it was estimated that the annual recharge volume over pervious surfaces, without including roof infiltration, is approximately 14.2 ac-ft/yr. This represents about 50 percent of the annual precipitation volume over the parcel area. This component of the analysis results remains the same between baseline and proposed development conditions. This analysis was completed to show that the change in rooftop runoff recharge is a smaller component of the overall typical 5-acre parcel infiltration recharge volume.

Rooftop Runoff Analysis Findings

For typical developed parcel roof recharge analysis, soil infiltration rates were the key factor in estimating infiltration trench BMP size needs and the net recharge gain. As the soil infiltration rate decreases, the size of the infiltration facility increases. As stated previously, the Group C soil infiltration facility was sized at 620 sf, equivalent to the 1 in/hr infiltration rate facility size, resulting in 69 percent average annual infiltration volume (versus the standard 85 percent). The net average annual recharge gain compared to baseline was greatest for soils with the lowest infiltration rates (Table 3 and Figure 4).

Table 17: Baseline and proposed (85 percent infiltration) roof recharge

Per Parcel Roof 85% Proposed Recharge*												
Hydrologic Soil Group	Baseline							Proposed		Net Average Annual Recharge Gain		
	Infiltration Facility		Filter Strip			Total						
	Area (SF)	Average Annual Recharge (ac-ft/yr)	Infiltration Rate (in/hr)	Area (SF)	Average Annual Recharge (ac-ft/yr)	Average Annual Recharge (ac-ft/yr)	Percent Recharge	Infiltration Facility Area (SF)	Average Annual Recharge (ac-ft/yr)	ac-ft/yr	cfs	gpm
Group A - 6 in/hr		0.219			0.037	0.256	76%	227	0.285	0.030	4.1E-05	0.018
Group A - 5 in/hr		0.204	3.0		0.041	0.245	73%	252	0.285	0.040	5.5E-05	0.025
Group A - 4 in/hr		0.188			0.046	0.234	70%	294	0.285	0.052	7.1E-05	0.032
Group B - 3 in/hr	80	0.167		4,000	0.053	0.220	66%	337	0.285	0.065	9.0E-05	0.041
Group B - 2 in/hr		0.140	2.0		0.046	0.186	56%	420	0.285	0.099	1.4E-04	0.061
Group B - 1 in/hr		0.102	1.0		0.031	0.133	40%	620	0.285	0.152	2.1E-04	0.094
Group C - 0.5 in/hr*		0.072	0.5		0.019	0.090	27%	620	0.230	0.140	1.9E-04	0.087

*Proposed C soils infiltrate 69%

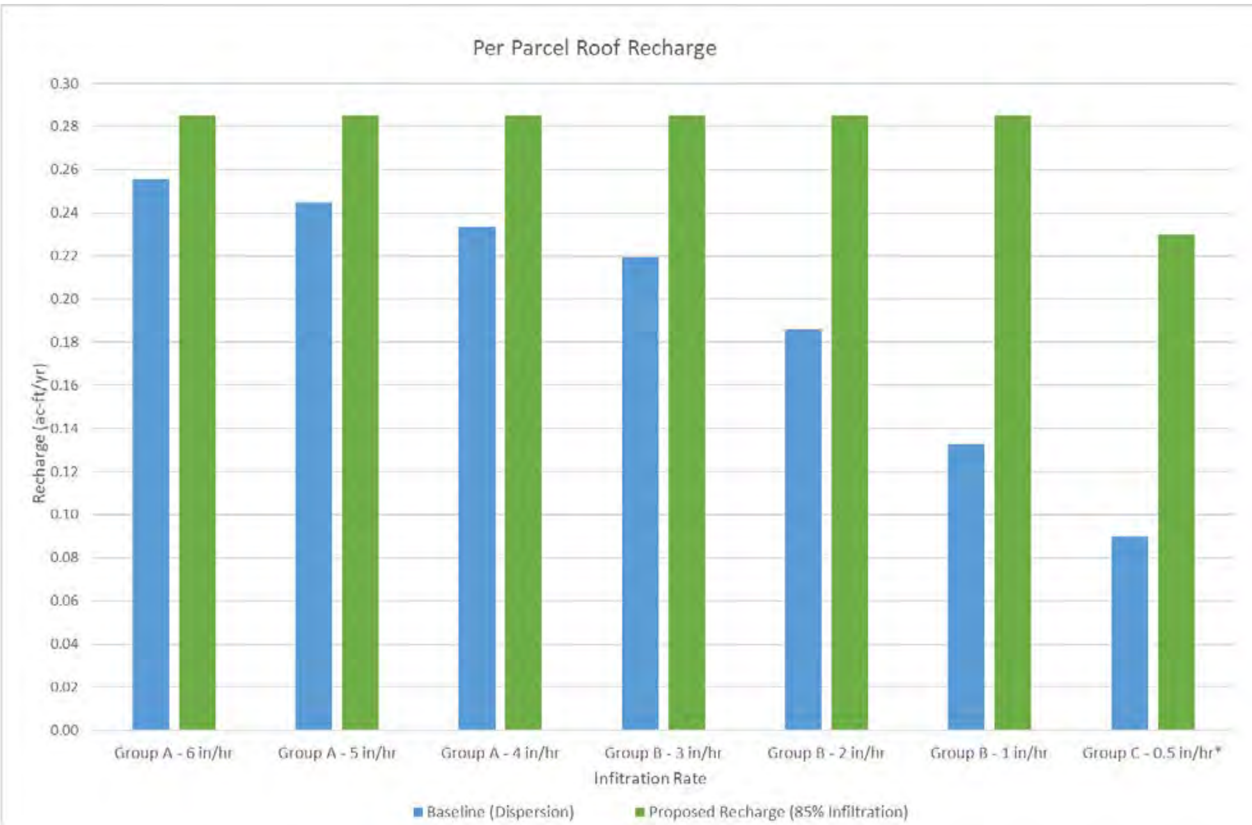


Figure 9: Parcel roof recharge comparison by soil group

Based on the parcel level analysis results, the typical net recharge gain for collective parcels in each soil group were extrapolated to the projected RR growth areas in the Mason County portions of WRIAs 14 and 15. The net recharge gain for proposed conditions infiltration capture compared to baseline conditions was used to estimate the projected offset for each soil group within each subbasin. For that evaluation, and the total potential offset for collective parcels apportioned to the estimated number of wells were estimated in accordance with the analysis assumptions. The average of each soil group infiltration rate was used to complete this analysis, with 5 in/hr for Group A soils, 2 in/hr for Group B soils, and 0.5 in/hr for Group C soils being applied.

Based on 2,766 wells apportioned to assumed full parcel buildout within the WRIA 14 Project area, this yielded a total potential projected water recharge offset of 249 ac-ft/yr, at 85 percent recharge on an average annual basis. (Table 5).

Based on 926 wells apportioned to assumed full parcel buildout within the WRIA 15 Project area, this yielded a total potential projected water recharge offset of 79 ac-ft/yr, at 85 percent recharge on an average annual basis. (Table 5).

Table 5: WRIA 14 and 15 project area roof 85 percent estimated recharge and projected water offset from baseline by subbasin

85% Infiltration*											
WRIA	Subbasin	Mason County Rural Projected No. Permit-Exempt Wells	Soil Type Proportion			Well Proportion			Projected Offset (ac-ft/yr)		
			A	B	C	A	B	C	A	B	C*
14	Case	396	0.11	0.88	0.02	42	347	7	2	34	1
14	Goldsborough	338	0.82	0.08	0.11	276	26	37	11	3	5
14	Harstine	143	0.14	0.18	0.69	20	25	98	1	2	14
14	Hood	78	0.09	0.91	0.01	7	71	0	0	7	0
14	Kennedy	59	0.61	0.05	0.34	36	3	20	1	0	3
14	Mill	434	0.30	0.19	0.51	132	80	221	5	8	31
14	Oakland	955	0.24	0.67	0.10	226	636	93	9	63	13
14	Skookum	363	0.39	0.14	0.47	141	51	172	6	5	24
	Totals	**2766**								**249**	
15	Sough Hood Canal	834	0.22	0.76	0.01	186	637	11	7	63	2
15	South Sound	92	0.46	0.52	0.02	42	48	2	2	5	0
	Totals	**926**								**79**	

*Proposed C soils only infiltrate 69%

Project Costs

At this time, all estimated project costs are expected to be included in costs of construction for new homes, which could range from $3,780-$9,300 per home. For WRIA 14, this results in a total of ~$17 million for the total project (based on total projected PE well growth).

Response to WRIA 14 and 15 Committee Comments on Draft Analysis Memorandum

Ecology provided HDR comments from various committee participants based on the HDR Draft Technical Memorandum summarizing this analysis, dated September 4, 2020. Those comments consider committee feedback received from presentation of this analysis at prior committee meetings. HDR's response to those comments is included as Appendix A.

Mason County Rooftop Runoff Appendix A - HDR Response to Committee Comments on Draft Technical Memorandum

Mason County Rooftop Runoff Project

Comments Received as of 10/5/2020

Paul Pickett (Squaxin Island Tribe) Comments sent to Angela Johnson 9/23/2020

- A factor should be included to reduce total offsets to account for properties where the facility cannot be installed (site limitations like wetlands, slope, other setbacks)

  HDR Response: We did exclude all parcels with Type D hydrologic soil group (HSG) (typically wetland soils where roof infiltration (and parcel development) would typically not be allowed or feasible. We did not consider steep slopes and other setbacks, but the assumption is that some portion of 5 ac parcels may still be developable. There are more existing parcels than PE Wells, so we factored back the number of parcels to match the # of PE Wells to evaluate on a consistent basis with consumptive use, allocated by the various HSG areas.

- Soils should be assessed in PE growth hot spots within subbasins, not the entire subbasin, because those are the areas that facilities would be installed.

  HDR Response: This evaluation addresses potential incremental benefits per parcel as development occurs in the various subbasins, so the net benefits would accrue with parcel development wherever it occurs as PEWs are installed to serve those parcels. This evaluation was intended to be high level for project screening evaluation of potential cumulative benefits over time, and was not intended to be parcel location specific.

  The proportion of HSG types used in this analysis are based on the same buildable lands analysis that was used to spatially allocate PE Well growth for the consumptive use analysis.

- Where did the infiltration value come from? No citation was provided.

  HDR Response: The citation will be added. They were assumed from expected average long-term design infiltration rates for the various HSGs (Type A = 4 in/hr; Type B = 2 in/hr, Type C = 0.5 in/hr). Design infiltration rates under Ecology SWMMWW guidance are factored values from field measured values, typically established from a Pilot Infiltration Test (PIT). Typically cumulative factoring back of measured rates for long-term design infiltration rates ranges from about 0.2 to 0.4. So for example, for Type A soils, measured PIT infiltration rates would need to be in the 10-20 in/hr range for a 4 in/hr factored design infiltration rate, which would be typical of Type A soils. The typical long-term, factored infiltration rate in a Type C soil is normally around 0.5 in/hr, but can be lower. Type B soils would fall in between, and can be highly variable, so 2 in/hr was assumed as a design infiltration rate for analysis. Therefore, the reference for this information is the Ecology SWMMWW (2019).

- How was the depth to water table determined? No citation was provided. Type C soils are likely to have shallow winter water tables. This is another factor that may make some parcels poor candidates for the facility.

  HDR Response: It was not determined at this screening level of analysis, but assumed to be of adequate depth (5 ft or greater from existing grade) to allow an infiltration trench BMP to be installed. This assumption can be added. Depth to water table would be variable depend on the depth of overburden soils (which may be more permeable) to underlying till. If adequate depth to shallow groundwater does not exist on a particular parcel, then those parcels may not be viable for this type of roof runoff infiltration BMP. Again, recharge benefits are incremental with parcel development, and associated only with parcels where the proposed County roof runoff development standard are technically feasible to implement.

- Average rainfall was used, but rainfall varies with time, and during wet spells soils may become saturated. Some analysis is needed for the amount of rainfall that would be in excess of infiltration capacity, based on patterns of rainfall in infiltration and soil saturation capacity. A factor should be applied for the reduction in potential infiltration.

  HDR Response: Rainfall variability is accounted for in the MGSFlood modeling analysis that is conducted using a long-term continuous time-series precipitation record and runoff simulation and recharge response to it. We're assuming a constant infiltration rate for subgrade soils based on soil type, even though some variability would likely exist over time. Generally, infiltration facilities tend to start with higher infiltration rates and performance, and can degrade over time with partial occlusion of subgrade soils. That effect is generically accounted for in the factored infiltration design rate.

- In Tables 3 and 4:

  - Only 15% of rainfall infiltrates in Group C soils. This suggests that 85% of the rainfall occurs at times when the soils are at capacity. Should the analysis assume that, if the soils can only infiltrate 15% of rainfall, it will also only infiltrate 15% of rooftop runoff?

    HDR Response: These values come from the MGSFlood continuous simulation modeling results. They suggest that under infiltration rates assumed for Type C (till) subgrade soils (0.5 in/hr design rate) that only 15% of the roof runoff volume would infiltrate in the infiltration trench area on an annual basis, under existing development standards (min trench area per standards), and that 85% would result in overflow. Additional incidental infiltration down-gradient of the infiltration trench BMP could result in additional infiltration (not modeled), but for Type C soils, that would likely be limited, and result primarily in surface runoff to collection systems.

- What does "Net Average Annual Recharge Volume Gain" mean, and why does it get larger with less porous soils? I would expect the less infiltration capacity, the less recharge volume would result.

  HDR Response: It is the difference in roof runoff recharge volume per parcel on an annual average basis between baseline conditions (infiltration BMPs following existing development standards) and parcel developed conditions (larger infiltration facilities with sizes targeted to achieve either 95% or 100% infiltration). We analyzed the infiltration facility area that is required to achieve those post-developed infiltration volumes, which of course gets significantly larger in tighter soils. Since there is more change from baseline infiltration for Type C soils compared to Type A soils, the net recharge volume increases. I would expect that if we consider incidental infiltration beyond the infiltration BMP, that for Type A soils, the baseline would come up significantly in value, but for Type C soils, I would expect very little increase in baseline infiltration, so the net benefit in those tighter soils per parcel should remain relatively consistent with reported values. Type B soils would fall in between. Based on the GIS analysis conducted, the largest number of PE Wells were shown to be in Type B soils.

- If infiltration decreases with the Soil Group, the amount of offset benefit should decrease by soil group. Nowhere in the memo is this relationship shown.

  HDR Response: It is accounted for in the design infiltration rate, which under baseline conditions, results in less annual volume of infiltration progressing from Type A to Type C soils. In the parcel developed condition, we are adding to the infiltration BMP surface area to with tighter soils to achieve either the 95% or 100% average annual volume of infiltration. Therefore, the incremental net recharge benefit increases from Type A to Type C soils, as is demonstrated with the reported modeling results.

WDFW Comments sent to Angela Johnson 10/5/2020

- This approach proposes increasing the rate of infiltration of roof-top intercepted rainwater; therefore, any benefits would accrue within a short time period of the rainfall. The impacts of permit exempt wells are presumed continuous across the year and are likely to increase during dry periods. This makes it unlikely that any benefits accrued from increased infiltration, would match the seasonal impacts of well withdrawals during critical flow periods.

HDR Response: Benefits from added recharge at parcels would primarily be seasonal (fall-spring) as noted, but the timing of those benefits to receiving water stream flow augmentation would be variable and extend over longer durations depending on hydrogeology/shallow groundwater interflow characteristics and travel paths to receiving waters. Agree that less recharge and stream flow augmentation benefit would be expected to occur in summer months. But the assumptions used in evaluation for annual volumes in water balance are the same as used in the for PE wells consumptive use evaluation for consistency.

- There are major assumptions imbedded throughout the technical memo including:
    - The analysis appears to only consider changes in infiltration based on soil type and roof/infiltration trench area. It is unclear whether the consumptive losses of evapotranspiration (ET) are considered in this analysis or accounted for in the MGSFlood model. ET losses could be significant but are not mentioned in the report.

      HDR Response: For the analysis, the estimated change in recharge compared to baseline applies only to the directly connected roof area. For the continuous simulation MGSFlood analysis, ET losses are built into the MGSFlood model runoff analysis, although I expect limited to evaporation that would be small for the impervious roof areas. For other parcel areas considered in a separate baseline analysis, ET losses are also evaluated in the runoff analysis from the various pervious area PERLND (soil type, veg cover) surfaces evaluated. That analysis doesn't enter into the net benefits evaluation.

    - It is unclear how the difference between pre-development infiltration and post-development infiltration is accounted for. The analysis appears to assume that nearly all water (95-100%) routed to the infiltration trench would contribute towards the estimated benefit.

      HDR Response: It is accounted for in the increased area of the infiltration trench BMP being used to simulate rooftop runoff infiltration characteristics and recharge quantities. For baseline conditions (existing County development standards), we set the roof infiltration trench length/area equal to the minimum development standard for that BMP type (20 sf per 700 sf of roof area) and evaluated for the various HSGs. For parcel developed conditions, we analyzed the required length/area of trench required to achieve annual infiltration volume of 95% and 100% of the annual roof runoff volume for the various HSGs based on assumed design infiltration rates (considered typical factored design values). There is a significant increase in infiltration facility size to go from 95% (approximately 2-yr event) to 100% full infiltration, so a slightly lower target (95%) makes more sense in setting a reasonable modified development standard for parcels infiltration facility sizing.

- Among other modelled assumptions, it is unclear how assumptions of average water table depth and average 1-acre clearing sizes were determined. Depth to water table and the effects of canopy interception from overhanging trees could significantly impact the estimated benefits.

  HDR Response: At this screening level of analysis, the assumption is that adequate depth to water table exists to apply a parcel development roof runoff infiltration BMP (typically 3 ft min from infiltration area subgrade, so 5 feet total including 2 ft depth of infiltration trench). The size of the cleared parcel is based on our understanding of what the County typically allows on a 5 ac parcel. We have not accounted for changes in recharge associated with the cleared area land cover area conversion at this level of analysis. Also, to our understanding, the County is not proposing a change in that criterion with the development standard change, which is focused on requiring only enhanced rooftop runoff infiltration) So that doesn't enter into the net benefits evaluation results as shown.

- There is no references section and the author of the memo is not listed.

  HDR Response: These will be added.

MEMO From Skokomish Tribe and Aspect Consulting with HDR Responses

Project No.: 190315

October 28, 2020

To:	Dana Sarff, Skokomish DNR
cc:	Seth Book, Skokomish DNR
From:	Jonathan Turk, LHG; Jay Pietraszek, LHG
Re:	**Technical Review of "Mason County WRIA 14 and 15 Rooftop Runoff Infiltration Recharge Analysis for Streamflow Augmentation Net Benefits"**

This memorandum presents Aspect's review of HDR's Technical Memorandum (Memo) "Mason County WRIA 14 and 15 Rooftop Runoff Infiltration Recharge Analysis for Streamflow Augmentation Net Benefits" (HDR 2020). The Memo was produced for the WRIA 14 and 15 Watershed Restoration & Enhancement Committees and documents the predicted benefits of capturing and infiltrating rooftop runoff for future rural residential (RR) development in Mason County. Aspect's review focused on the assumptions and methodology used by HDR. The model results and outputs presented in the Memo were not checked in detail.

Background

The Memo presents the predicted benefits to infiltration and recharge volumes from using rooftop collection and infiltration systems at future RR developments. Infiltration volumes were predicted for two conditions: a roof-down drain system (baseline) and infiltration trenches designed to capture all roof runoff (proposed) using MGSFlood, an Ecology-approved continuous simulation hydrologic model. The infiltration trenches under the proposed condition were varied in size based on soil hydrologic classifications. The increase in infiltration volumes under the proposed condition were extrapolated to represent the net-gain in recharge based on the proposed parcel buildouts in WRIA 14 and 15.

General Comments

We agree with the key principle behind the project: increasing infiltration of rooftop runoff will have a net benefit on groundwater recharge and streamflows and creates the potential for offset credits. We acknowledge that accurately quantifying the benefits is difficult. HDRs assumptions and methods produced results that may represent a best-case scenario but could be deemed unrealistic.

The simplified approach of extrapolating unit infiltration trench simulations to the watershed scale has inherent spatial and temporal limitations. Consideration of a more conservative approach and/or the use of a range of input values to account for uncertainties and unknown variability may be warranted. We recommend conditioning the interpretation of the results from the rooftop runoff analysis to consider:

- ***Water losses under the baseline condition:*** In the current model runoff that doesn't infiltrate into the roof-down drain system does not reinfiltrate and is considered lost (i.e., consumptive). In reality, at least a portion of this "overflow" could pond or disperse and eventually re-infiltrate. Some of the overflow may run onto an impervious surface and/or be lost to evapotranspiration. Differentiating between these portions may be needed to accurately assess the offset quantities

  HDR response: The analysis has been updated to estimate the extent of baseline conditions infiltration beyond the infiltration trench using a filter strip BMP (simulating an improved lawn area), conservatively sized, and analyzed within MGSFlood to estimate residual infiltration beyond the infiltration trench. Also note that a wider range of infiltration rates have been evaluated, and a slightly higher average infiltration rate (5 in/hr) has been applied for baseline analysis in Group A soils for the net recharge benefit analysis (Group B and C soils average infiltration rates remain the same).

- ***Differentiate between infiltration and recharge:*** The proposed modifications will increase the amount of roof runoff that will infiltrate into the soil. The infiltrated water will either remain in the soil, discharge to surface water as subsurface stormflow (i.e., interflow) or percolate and recharge shallow groundwater. Soil water may eventually be lost to evapotranspiration. Both the stormflow and groundwater recharge volumes may discharge to surface water (with variable time lags) or exit the basin as groundwater flow. Increasing the amount of infiltration will have a net benefit surface water but the timing and magnitude of the surface water benefits, and benefits to baseflows, are dependent on numerous factors. The implication in the Memo is that 100 percent of the infiltration will eventually report to surface water, which is not necessarily certain.

  HDR response: Comment acknowledged, but the scope of the analysis doesn't include more advanced hydrolgeologic analysis, and the database at this higher level of evaluation doesn't support that analysis. Evapotranspiration losses are considered in the MGSFlood model runoff analysis, but for runoff generated by rooftop surfaces, that component is minimized (it is a larger component of vegetated pervious areas runoff generation). Also, the assumptions pertaining to the timing of recharge are consistent with the consumptive use assumptions on PE well withdrawals.

Specific Questions/Comments and Recommendations

Background Section

1. Some terminology is presented in this section and used in later sections should be clarified. Specifically, the terms 'recharge', 'infiltration', 'infiltration recharge', 'roof infiltration', and 'groundwater recharge' are used somewhat interchangeably and should be defined in this section.

- Recommendation: Revise text to provide clarification to the terminology, particularly with the last sentence in the first paragraph.

  HDR response: The terminology regarding infiltration and recharge has been clarified as appropriate with revisions to the technical memorandum.

2. Is there anything that can be identified with respect to the design of a typical infiltration trenches (construction details, completion depths, etc.) to indicate that infiltration into a trench will be more efficient than a typical downspout dispersion system beyond simply the size?

   - Recommendation: Provide clarification and details in the text, if possible.

     HDR response: Mason County standards provide typical sections of infiltration trenches and other infiltration BMPs for rooftop runoff downspout infiltration. Infiltration through an infiltration trench sited appropriately on subgrade soils are typically more efficient than dispersion onto surficial soils with the same area footprint for the following reasons 1) an infiltration trench is a gravel lined facility intended to intersect more permeable subgrade soils, 2) it will allow up to 2 feet depth (per Mason County standards), increasing the hydraulic gradient and infiltration discharge for a given soil permeability value on the infiltrating surface, and 3) Surficial soils typically have more fines, which tend to limit the their permeability and infiltration rates through them. The filter strip analyzed in the revised analysis demonstrates that for limited infiltration volumes for a much larger area compared to the modeled infiltration trench larger infiltration volumes.

Methods Section

1. A single soil permeability rate (infiltration rate) for each soil type was used in the analyses. It would be helpful to provide a reference for these values. Further, there is considerable variability in infiltration rates and a single value may not be a representative of actual conditions, for Group C soils in particular. The infiltration rates for Group C soils may be much lower than the value used in the analyses. For example, the range of infiltration rates for Group C soils with turf vegetation is 0.03 to 0.06 inches per hour in the Western Washington Hydrologic Model (WWHM; Appendix B of the User's Manual)[59]. These rates are much lower than the 0.5 inches per hour used in the analyses.

   - Recommendation: Consider using a range of infiltration rates to illustrate variability. Using lower rates for Group C soils would result in much larger infiltration trenches than those already indicated. Consider the feasibility and practicality of the size requirements for the infiltration trenches in till soils.

     HDR response: The revised analysis does include a larger range of infiltration values, with an average value used for the net benefit analysis. HDR certainly understands

[59] WWHM is referenced in Volume III-2.2 SWMMWW as a recommended hydrologic model.

that infiltration rates can be highly variable in a given soil group, and the range of values applied is typical in western WA for long-term operational design using factored infiltration rates compared to field-measured rates in accordance with the 2019 Ecology SWMMWW. Some classes of till soils can have smaller infiltration rates, but the average value assumed for analysis is within a range of values that can extend up to or above 0.75 in/hr. For soils much less than 0.5 in/hr, infiltration facility sizes to accommodate target infiltration rates for proposed conditions would not be practical, and roof infiltration systems in those tighter soils are acknowledged as likely not feasible.

2. The analyses base the infiltration volumes as either 95 percent or 100 percent of the annual precipitation. This may be an overestimation. Consider, for example, that: (1) rooftop runoff coefficients may range from 0.75 to 0.95 (e.g., Dunne and Leopold 1978), and (2) correction factors are recommended to account for long-term reduction in infiltration system performance (due to clogging, etc.).

    - Recommendation: Consider using reducing the volumes available for infiltration to account for the inefficiencies described above.

      HDR response: The analysis was conducted using the MGSFlood model considering the roof as a non-pollution generating impervious surface. Loss rates are built into the model. Based on the modeling results, a typical 2,800 sf (0.0642 ac) roof generates an average runoff volume of 0.335 ac-ft/yr. Considering the modeling is done for a MAP of 70 inches, the precipitation volume falling on the roof is 0.375 ac-ft/yr, so the modeled roof runoff volume is approximately 89 percent of the precipitation volume, within the range of coefficients noted in the comment. Therefore, the analysis results do account for about 11 percent loss in runoff volume compared to precipitation volume.

Results Section

1. The results that show 50 percent of the annual precipitation is recharged over the pervious portions of the lots needs further clarification. The implication that 50 percent of the total precipitation on undeveloped land is recharged to groundwater is most likely an overestimation. It is understood that the analyses for pervious land infiltration was not used in the offset calculations.

    - Recommendation: Provide clarification.

      HDR response: The analysis results for a typical parcel development (beyond the roof area analyzed separately) are output from the MGSFlood model based on the collective land cover and area assumptions as stated. That result will vary with soil group, with a group A highly pervious soil generating significantly more runoff that a group C till soil. As noted, these results are only provided as background, and would be the same under both analysis scenarios, so they do not affect the net recharge benefit analysis results.

2. The results show that large infiltration trenches are required to infiltrate the full volumes in Group C soil types. Consideration of the practicality of constructing and maintain a large

trench, as well as, the long-term performance of an infiltration trench completed in a Group C (glacial till) soil (particularly with respect to the uncertainty with Group C soil infiltration rates described above).

- Recommendation: Consider the overall impact to the net recharge calculations of either removing the Group C soils from analyses entirely or assuming only a certain percentage of the residences with Group C soils will have functional infiltration trenches.

  HDR response: This has been addressed in the analysis based on discussions between and agreed to resolution between Ecology and Mason County staff. The outcome was to evaluate group C soils under proposed conditions using a maximum area infiltration trench that Mason County is in agreement with (620 sf), and determine the expected infiltration volume where less than the target value agreed to for other soil groups (85% annual infiltration volume typical). Based on the revised modeling at 0.5 in/hr permeability, the maximum volume accommodated by that size trench per parcel is 0.230 ac-ft/yr or 69 percent of the annual roof runoff volume.

Limitations

Work for this project was performed for the Skokomish Tribe (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

North Steamboat Project

PROJECT DESCRIPTION

Description

The Steamboat Island Peninsula has many small first order streams that originate from wetlands and flow to surrounding marine waters. On the north end of the peninsula, just south of the Carolyn Beach Homeowners Association water system, is a recently formed pond (Figure 1). The pond is on a private parcel that also contains a residential home. The pond appears to be a recent impoundment, with aerial imagery as recent as 2011 indicating timber and a field in the location of the current pond.

The pond is part of a sensitive groundwater zone with hydric soils (Bellingham silty clay loam). It's likely that the pond results in slow recharge back to the local aquifer and may be in connection with an intermittent stream that drains to the west in Eld Inlet.

The proposed project would increase the elevation and spatial extent of the pond, thereby increasing hydraulic gradient and increasing infiltration of water into the local aquifer. With the existing condition, that extra water would be presumably draining to the local intermittent stream. The pond could potentially be increased by two feet without causing flooding off of the current parcel.

Qualitative assessment of how the project will function.

A feasibility study would need to investigate the cause and use (if any) of the impoundment by contacting the private landowner. The feasibility study would evaluate the hydrologic accounting of the existing and proposed condition to determine if there is enough of a net gain in local groundwater and streamflow gain (during the low flow period) to warrant the project.

The project could be increased from an elevation of 78 to 80 ft in elevation without affecting other parcels (Figure 1)

Conceptual-level map and drawings of the project and location.

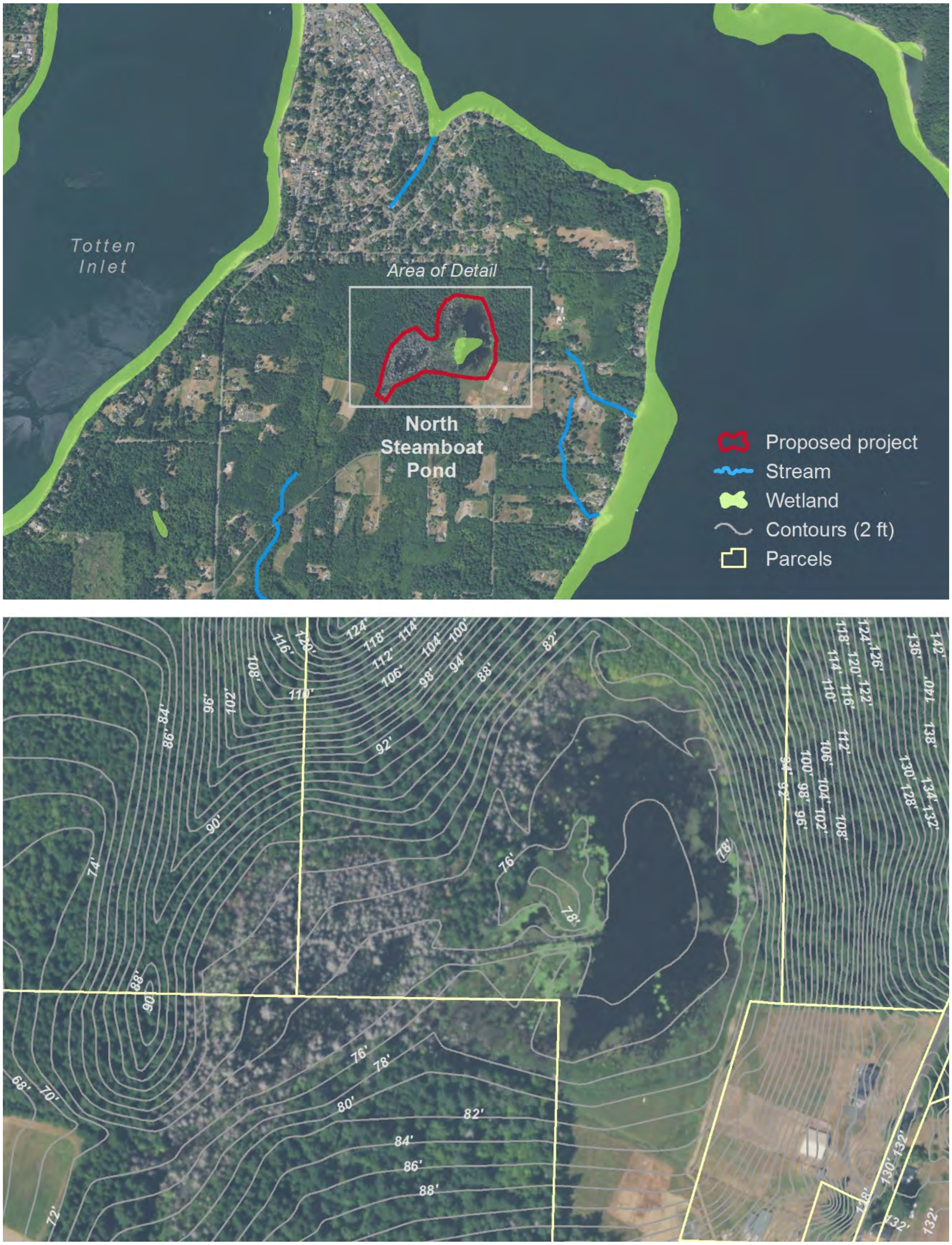


Figure 1. North Steamboat Pond.

Description of the anticipated spatial distribution of likely benefits

The Project will increase local aquifer storage and may increase streamflow in intermittent streams to the north, south and east (Figure 1).

Performance goals and measures.

The performance goals are to increase the pond elevation by up to two feet in elevation during the wet season, This performance goal could be measured with a staff gage in the pond. Increasing summer baseflow in the surrounding intermittent streams during the summer low-flow period is also a performance goal, but would be more difficult to discern, given seasonal and annual variation in flow. If pursued, measurement of this performance goal would require pre-project baseline and post-project monitoring for a sustained period of time to detect an increase in flow, if it occurred.

Descriptions of the species, life stages and specific ecosystem structure, composition, or function addressed.

No salmonid species appear to use the streams near the proposed project (WDFW Salmonscape 2020), presumably because of the intermittent nature of the streams. The streams may provide seasonal habitat for estuarine fish species and seasonal pocket estuaries for use of multiple aquatic species, including outmigrating subyearling Chinook and chum salmon.

Identification of anticipated support and barriers to completion.

The proposed Project is located on private land, and any would therefore require landowner permission, conservation easement, or land acquisition from the private landowner.

Potential budget and O&M costs.

Total costs are anticipated to be less than $1,000,000. Costs would include the potential need for land acquisition, and installation of a water control structure or berm.

Anticipated durability and resiliency.

The project would have lasting benefits and would not require minimal operation and maintenance, once it is established.

Project sponsor(s) (if identified) and readiness to proceed/implement.

The project sponsor would be the Thurston County. Thurston County would begin Project implementation with a feasibility and design study.

References

WDFW (Washington Department of Fish and Wildlife), 2020. Salmonscape mapping of fish distribution. Available at: http://apps.wdfw.wa.gov/salmonscape/

Skookum Valley Railroad Culvert Blockages

PROJECT DESCRIPTION

Description

Skookum Creek is a tributary that flows into Little Skookum Inlet in South Puget Sound. Skookum Creek and its tributaries support chum and coho salmon, as well as a prolific population of sea run cutthroat trout. Steelhead are present but rare. Multiple tributaries to Skookum Creek are blocked by culverts that run under the railroad on the north side of the valley. This railroad is called the Puget Sound and Pacific Railroad (PSAP), and it is owned by Genesee and Wyoming (Darien, Connecticut). Replacing those culverts could open up as much as 5 miles of spawning and rearing habitat in the Skookum watershed.

Qualitative assessment of how the project will function.

This is a proposal to replace a minimum of 8 culverts, perhaps as many as 15 culverts along the PSAP railroad that are full or partial barriers to upstream fish passage.

Tasks:

- Survey length of railroad through Skookum Valley to fully inventory all culverts.
- Field verify amount of available fish habitat upstream of blocking culverts. This will also involve field verification of stream location and correction on WDFW maps.
- Reach out to Genesee and Wyoming to ask for their cooperation to replace all blocking culverts.
- Set in place a culvert replacement schedule and plan with Genesee and Wyoming (PSAP).
- Work to ensure that the culvert replacement schedule is followed.
- Work with WRIA 14 Lead Entity on prioritization schedule for replacement based on their comprehensive barrier prioritization tool.

Conceptual-level map and drawings of the project and location.

See map on the next page of blocking culverts under the PSAP Railroad. The map was generated from the WDFW fish passage map and then annotated.

Listed below are the culvert ID numbers, as listed on WDFW's fish passage map. The number of miles of fish habitat upstream that would be accessible by fish, if these culverts were open to fish passage, has been estimated. Individual reports for each listed culvert can be accessed by clicking on the culvert location in the fish passage map.

MC263- ~2,400 ft

MC264- ~12,000 ft

MC265- ~1,200 ft

MC266- ~4,000 ft

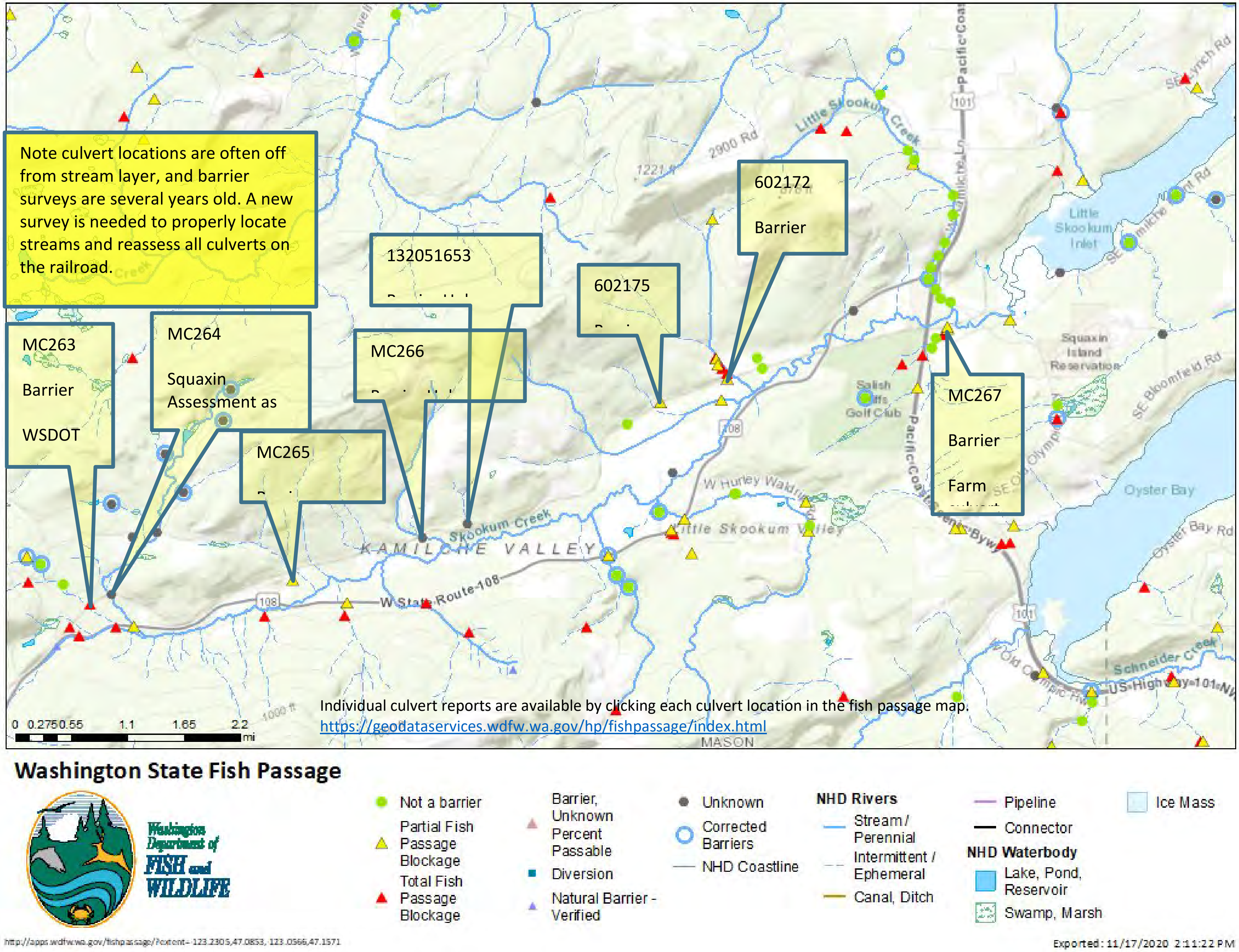
132051653- Unknown

602175- ~3,200 ft

602172- ~3,000 ft

MC267- ~1,800 ft

Total = ~27,600 or 5.2 miles of fish habitat could be made accessible again.


Note culvert locations are often off from stream layer, and barrier surveys are several years old. A new survey is needed to properly locate streams and reassess all culverts on the railroad.
MC263
Barrier
WSDOT
MC264
Squaxin
Assessment as
MC265
MC266
132051653
602175
602172
Barrier
MC267
Barrier
Farm
Individual culvert reports are available by clicking each culvert location in the fish passage map.
https://geodataservices.wdfw.wa.gov/hp/fishpassage/index.html
Skookum Creek
KAMILCHE VALLEY
Little Skookum Valley
Little Skookum Creek
W State Route 108
Little Skookum Inlet
Oyster Bay
Squaxin Island Reservation
Salish Cliffs Golf Club
Schneider Creek
MASON
0 0.275 0.55 1.1 1.65 2.2 mi
Washington State Fish Passage
Washington Department of FISH and WILDLIFE
Not a barrier
Partial Fish Passage Blockage
Total Fish Passage Blockage
Barrier, Unknown Percent Passable
Diversion
Natural Barrier - Verified
Unknown
Corrected Barriers
NHD Coastline
NHD Rivers
Stream / Perennial
Intermittent / Ephemeral
Canal, Ditch
Pipeline
Connector
NHD Waterbody
Lake, Pond, Reservoir
Swamp, Marsh
Ice Mass
http://apps.wdfw.wa.gov/fishpassage/?extent=-123.2305,47.0853,-123.0566,47.1571
Exported: 11/17/2020 2:11:22 PM

Description of the anticipated spatial distribution of likely benefits

Access to tributaries on the north side of Skookum Valley, from headwaters to Little Skookum Inlet on Puget Sound.

Performance goals and measures.

Number of miles of habitat made accessible to anadromous fish, as each culvert is removed.

Descriptions of the species, life stages and specific ecosystem structure, composition, or function addressed.

The Washington Department of Fish and Wildlife has identified that coho salmon, chum salmon, steelhead trout, and coastal cutthroat trout have spawning populations in Skookum Creek (WDFW Salmonscape 2020. Steelhead may be present, but are rare. The extent of fish depicted in Salmonscape is an underestimation.

Identification of anticipated support and barriers to completion.

It is likely that there will be broad support for a project like this in the WRIA 14 WREC Committee, as well as generally. The most difficult challenge in this project would be acquiring the cooperation of the Genesee and Wyoming Railroad Company.

Potential budget and O&M costs.

Costs are estimated to be between $1-5 million, depending on design.

Anticipated durability and resiliency.

Design life of these culverts would probably be at least 50 years.

Project sponsor(s) (if identified) and readiness to proceed/implement.

The project sponsor would be the SIT. The SIT would begin Project implementation with a feasibility and design study.

References

WDFW (Washington Department of Fish and Wildlife), 2020. Salmonscape mapping of fish distribution. Available at: http://apps.wdfw.wa.gov/salmonscape/

WDFW (Washington State Department of Fish and Wildlife). 2020. Fish passage map. https://geodataservices.wdfw.wa.gov/hp/fishpassage/index.html

Skookum Valley Ag Project

PROJECT DESCRIPTION

Description

Skookum Creek is a tributary that flows directly to Little Skookum Inlet and is important for supporting coho salmon, chum salmon, winter steelhead, and coastal cutthroat trout. Habitat in Skookum Creek has been simplified, in part, due to habitat simplification from agricultural land use within the Skookum Valley floodplain. Some reaches of the Creek have been moved to the edge of the valley wall to maximize agricultural production, and not allowed to meander through its channel migration zone. This has resulted in channel incision (streambed downcutting) loss of side channels, loss of off-channel habitat, and reduced floodplain connectivity.

The proposed Skookum Valley Ag Project (Project) will re-align a reach of the stream channel that is currently confined to the valley wall, back into its historical alignment and natural meander pattern. This Project is intended to be the first step in larger scale realignment into historical alignment and allowed to meander through its channel migration zone.

Qualitative assessment of how the project will function.

The proposed project will increase stream length from 920 feet to 1530 feet, an increase of 610 feet (Figure 1). The re-alignment will include instream structures (e.g. large woody debris and engineered log jams) that) that will increase habitat complexity. These structures will contribute to bedload retention and will contribute to reduction of channel incision, in combination with other future projects. Riparian vegetation will be established around the new stream alignment.

Conceptual-level map and drawings of the project and location.

Figure 1. Skookum Valley Ag channel relocation.

Description of the anticipated spatial distribution of likely benefits

The Project will increase channel length in Skookum Creek by 610 feet. This will increase usable aquatic habitat.

Performance goals and measures.

The performance goals are to increase stream length by 610 feet with an appropriate channel geometry, large woody debris density, pool density and residual depth, stable banks, and riparian zone establishment. Specific metrics for these attributes will be defined based on the restoration design.

Descriptions of the species, life stages and specific ecosystem structure, composition, or function addressed.

The Washington Department of Fish and Wildlife has identified that coho salmon, chum salmon, steelhead trout, and coastal cutthroat trout have spawning populations in Skookum Creek (WDFW Salmonscape 2020). WDFW (2020, 1975).

Skookum Creek has several habitat factors that are limiting to fish productivity, including low summer base flow, high summer water temperature, suboptimal large woody debris and pool density, and spawning gravel quality, This Project will contribute to addressing these factors at the reach scale. The increased channel length and re-alignment may allow for more groundwater contribution. The presence of the impoundment directly to the northwest of the proposed alignment would provide a hydraulic gradient to push cool groundwater into this stream alignment. The installation of large woody debris and establishment of riparian vegetation will contribute to optimal large woody debris density, pool density, and will create the hydraulic complexity to sort sediments, leading to pockets of suitable spawning gravels.

Identification of anticipated support and barriers to completion.

The proposed Project is located on land previously acquired by the Squaxin Island Tribe (SIT). The SIT is supportive of this Project.

Potential budget and O&M costs.

The total costs of construction, engineering, permitting, and cultural assessments are estimated to be <$1.0 million, based on an order of magnitude cost estimate (includes engineering and construction costs).

Anticipated durability and resiliency.

The project would have lasting benefits and would not require operation and maintenance, once it is established.

Project sponsor(s) (if identified) and readiness to proceed/implement.

The project sponsor would be the SIT. Project implementation would begin with a feasibility and design study.

References

WDF (Washington Department of Fisheries), 1975. "A Catalog of Washington Streams and Salmon Utilization, WRIA 15." Accessed at: https://www.streamnetlibrary.org/?page_id=95.

WDFW (Washington Department of Fish and Wildlife), 2020. Salmonscape mapping of fish distribution. Available at: http://apps.wdfw.wa.gov/salmonscape/

Water Right Screening Methodology

TECHNICAL MEMORANDUM

To: Department of Ecology WRIA 14 Watershed Restoration and Enhancement Committee

From: Peter Schwartzman, LHG

Burt Clothier, LHG

Re: Water Right Screening Methodology

Date: December 22, 2020

This technical memorandum documents the methodology used to screen and select water rights for potential use to support watershed restoration and enhancement projects in the Kennedy-Goldsborough Basin, Water Resources Inventory Area (WRIA) 14. This work was completed by Pacific Groundwater Group (PGG) on behalf of the WRIA 14 Watershed Restoration and Enhancement (WRE) Committee (Committee) and the Department of Ecology (Ecology). This work was performed under Ecology Contract Number C1700029, Work Assignment PGG104.

Under RCW 90.94.030, Ecology has the responsibility to convene WRE committees and prepare WRE plans for eight WRIAs in the Puget Sound and Hood Canal areas. The general purpose of the plans is to document potential offsets to projected depletion of instream flows resulting from new, permit-exempt domestic well uses in the WRIAs over the next 20 years.

To support development of the WRE plan for WRIA 14, PGG assisted the Committee in selecting a focused set of water rights for further review to assess potential benefits and their suitability in offsetting impacts from permit-exempt wells on instream flows. This memorandum outlines the methodology used to develop the focused list of water rights.

PROCEDURE

Ecology staff queried their Water Rights Tracking System (WRTS) database and provided tables and associated GIS data of all active water rights within WRIA 14. Inactive water rights (e.g., previously approved changes, cancelled or withdrawn applications) were excluded from the data provided by Ecology. Water right claims and pending applications for new water rights or water right changes were also removed during the screening process.

The provided GIS data included the mapped place of use and point(s) of diversion or withdrawal locations, where available. Where Ecology did not have detailed location information for points of diversion or withdrawal (or such information has not yet been added to their GIS dataset), the default location is generally the nearest quarter or quarter-quarter section, based on the water right file information.

The Committee identified several criteria for identifying potential water-rights where acquisition would have the greatest benefit:

- Surface-water sources were considered to be more useful than groundwater sources, as they provide direct improvement to streams.
- Preferred water-right purposes include irrigation (IR) and commercial/industrial (CI). Later in the process, PGG introduced consideration of domestic multiple (DM) water rights, since nearby municipal water systems (e.g. Shelton) potentially could have capacity to supply smaller Group A or B water systems. All other domestic categories (domestic single and domestic general) and municipal rights were excluded from the analysis based on the expectation that these rights would be unavailable for mitigation or too small (unless otherwise identified by the Committee).
- The Committee identified five priority subbasins (Goldsborough, Mill, Hood Canal, Oakland and Skookum) which include 11 key creeks: (Mill, Gosnell, Sherwood, Schumacher, Skookum, Goldsborough, Cranberry, Johns, Deer, Alderbrook and Twanoh). Prioritization was based on consideration of habitat (Salmon tier "A" and Salmonscape miles) and streamflow regulation (instream flow requirements and closures).

FINDINGS

Approximately 400 active water right files were identified within the five priority subbasins. PGG prepared histograms that sorted IR and CI water rights by quantity towards meeting the desired mitigation offset.

- Surface-water rights were initially sorted by instantaneous quantity (Qi). Among a total of 165 rights representing 672 cfs (159 IR and 6 CI rights), 70 had Qi less than 0.03 cfs and 150 had Qi less than 0.5 cfs. Five water rights were identified with Qi greater than 1 cfs, of which 3 are associated with CI (gravel mining/processing and timber processing) and two are associated with IR.
- Surface-water rights were also sorted by annual quantity (Qa); however, 87 of the 165 surface water rights had no stated Qa, For these cases, PGG estimated Qa based on stated irrigated acreage (77 of 87 rights had irrigated acreage listed) and an assumed irrigation duty of 2 feet. Out of 155 water rights with stated or calculated Qa totaling 4,053 acre-feet/year (af/yr), 96 had Qa less than 10 af/yr and 114 had Qa less than 20 af/yr. Sixteen "large" (>80 af/yr) rights were identified, of which 15 are associated with IR and one is associated with CI.
- Groundwater rights were sorted by annual quantity (Qa). Among 33 IR rights and 16 CI rights (a total of 49 rights representing 24,327 af/yr), 21 had Qa less than 10 af/yr and 30 had Qa less than 20 af/yr. Twelve "large" (>80 af/yr) rights were identified, of which 10 are associated with CI (timber processing, shellfish) and two are associated with irrigation.

In order to identify higher-value water-right acquisition possibilities and provide a more manageably sized list, water rights with a Qa of less than 10 af/yr were removed. This arbitrary cut-off resulted in reducing the list from 400 to 99 water rights with a combined allocated volume of 28,021 af/yr (24,242 from groundwater and 3,778 from surface water).

Table 1 lists the water rights in the five preferred subbasins that could potentially be converted, purchased, or retired as mitigation water, while **Table 2** is a general summary of the focused water right list. **Table 2** provides summed (total) Qa's for the water rights listed in **Table 1** for each priority subbasin, but does not provide summed Qi's because Qi is often not representative of the actual volume of water allocated. Some surface-water rights do not have Qa's listed (**Table 1**); therefore, these rights are not included in the totals on **Table 2**.

These summaries should not preclude the Committee from pursuing specific water rights in other subbasins that could be identified in the future by other means. Therefore, moving forward, the Committee should investigate the availability of rights in the focused study area as well as in the broader WRIA if specific rights are identified. In addition, the Committee may wish to investigate expected Qa for surface-water rights without specific Qa allocations.

It is understood that the offset credit from retiring or increasing the efficiency of IR rights is limited to the associated reduction in *consumptive* use rather than the reduction in *total* use. Similarly, CI water rights were recognized to have both consumptive and non-consumptive portions, of which only consumptive portions could be used for mitigation offsets. Some of the larger water rights listed in the attached tables are for CI purposes associated with timber and sand & gravel operations, and may include a significant portion of non-consumptive use.

The Committee provided input on known water rights. Several IR rights had been acquired by the Squaxin Tribe and were no longer available for mitigation. PGG used satellite imagery to assess evidence of irrigation for the largest 13 IR rights (50-200 irrigated acres) within the five preferred basins, and noted that while most had cleared (or potentially cultivated) land nearby, only four (two golf courses and two agricultural properties) showed observable evidence of irrigation. Committee members agreed that windshield or desktop surveys would better confirm the occurrence of active IR water rights. Thurston County staff performed a limited windshield survey and identified 14 IR rights in Thurston County (Kennedy subbasin) that appear to be in current use. The Squaxin Island Tribe performed additional desktop aerial surveys which resulted in a "targeted" list that the Committee has identified will be a priority for future investigation or acquisition.

Finally, PGG used GIS analysis to identify which smaller DM public water systems are located within or near the Shelton water system service area, with the idea that smaller systems could potentially be sourced from the Shelton system to make their water right available for mitigation offset. PGG identified 27 PWS located within a mile of the Shelton service area. The closest ones have relatively small water rights (Qa <40 af/yr). Larger systems had Qa's of 166 af/yr (2,700 feet away), 160 af/yr (a mile away) and 90 af/yr (4,900 feet away). The Committee considered it unlikely that these water systems would be able to "hook up" to Shelton and operate under their water right.

Source Substitution on Schneider Creek

Project Name:	Source Substitution on Schneider Creek (TC Project #143)
Project Location:	Kennedy Creek management unit in northwestern Thurston County. See Figures 1 and 2. *Lon. -123.05114 Lat. 47.09222*
Project Description:	☑ Water Right Acquisition ☑ Non-Acquisition Water Offset ☐ Habitat/Other **Project Overview** Conceptually this project involves the purchase and retirement of existing irrigation water right certificates, replacement with new irrigation source well(s) under a new water right permit, irrigation efficiency improvements, and ditch removal with stream restoration. See Figures 1 and 2 for maps of project details: • Water right certificates for consideration for possible full/partial retirement as part of a source-substitution project. • Future well location(s). The hypothetical new irrigation source wells would be located near well AKR885 (log attached) to substitute for part of the valid portion of these certificates. • WSDA pasture where irrigation was observed in the field, and where the proposed surface water rights' Place of Use may apply. • MODFLOW groundwater streamlines (steady-state) from the hypothetical well(s) pumping 300gpm. • Potential stream restoration zone along a Schneider Creek tributary. The current ditch draining wetlands could be replaced with a re-meandered stream approximately replicating the historic stream channel. The project involves a cluster of pastures on the north side of US101 along Schneider Creek that collectively appear to be associated with five certificated surface water rights (See Figure 1). The amount of potential water available is sizeable: +1.4cfs irrigation combined, with water rights that appear to be at least

	partially active. Field windshield screening indicated they have some visible irrigation works. These five certificates are as follows: 1. **Surface water certificate S2-*10859CWRIS** is the most significant in terms of the water it could provide – namely 1 cfs and enough water to irrigate 100 acres. Part of this use was field-verified in July 2020 by observing irrigation works and apparent be irrigation of 40 acres. The use period for this water right is April 15 through October 1. 2. **Surface water certificate S2-*09745CWRIS** is an irrigation-only water right with an April 15 through October 1 use period. 3. **Surface water certificate S2-*10229CWRIS** has irrigation and domestic purposes of use, and the use period for the irrigation portions end October 1st. 4. **Surface water certificate S2-*02995CWRIS** has irrigation and domestic purposes of use, and the use period for the irrigation portions end October 1st. 5. **Surface water certificate S2-*02996CWRIS** permits domestic water-use only. The attached copies of water right certificates indicate original authorizations to irrigate up to 150 acres of land. However, in Washington State, water rights are subject to a 5-year relinquishment standard and only remain valid to the extent they are thus put to use. Assuming an irrigation duty of 1.3 feet of water per season (the pasture annual irrigation rate for Shelton listed in the Washington Irrigation Guide), 150 acres of irrigated water use would require about 195 afy (acre-feet per year) of water towards a maximum of approximately 700 afy. However, due to Washington State's water right relinquishment standard, it is quite possible only a portion of that quantity is still valid. The project element involving ditch removal and stream restoration is highlighted on Figure 2. The ditched part of the wetlands on the north tributary of Schneider Creek is about 3,400 feet long. The current ditch drains wetlands, but that could be replaced with a re-meandered stream approximately replicating the historic stream channel, with significant habitat improvements. **Site Hydrogeology** Hydrogeology in the project vicinity has not been extensively studied. Thurston County has developed a groundwater flow model across the project area based on

	geologic mapping by the WA Geological Survey, and this is generally calibrated to approximate well water levels and streamflows. However, many questions remain. The site-specific hydrogeologic information used in this project summary comes from three main well logs (see attachments): • **Well AGK602 – Holiday Valley Estates (1968).** This older Holiday Valley well produced 233 gpm from torch-cut slots, with about 22 feet of drawdown over 4 hours, from a sand and gravel unit between 116-127 feet below ground surface. The well encountered several layers that appear to be aquitards. Please see the attached well log, and Figure 2 for the well location. • **Holiday Valley Estates (1981).** This 10-inch diameter cased-and-screened production well was drilled to 133.5 feet and terminated at basalt bedrock. From 117 to 133.5 feet below ground, in sand and gravel immediately above bedrock, the well produced 200 gpm with 26 feet of drawdown during a 4-hour test from two 5-foot screened sections. The well encountered several layers that appear to be aquitards. Please see the attached well log, and Figure 2 for the well location. • **Well AKR885 – Vaugh Litchfield (2004).** This 6” ID open pipe domestic well was drilled to 218 feet near Schneider Creek. The well produced 30 gpm during a one-hour open-pipe airlift test (i.e. no well screen, no measured drawdown). The well encountered several layers that appear to be aquitards. Please see the attached well log, and Figure 2 for the well location. In summary, according to testing performed at the time of drilling, yields from two wells were at/over 200 gpm, suggesting very productive rates were possible from the confined aquifer at the Holiday Valley water system wells. Well AKR885 produced at least 30 gpm from a short open section and no screen. These results suggest the following: • Assuming that even higher production rates will be possible with future wells, target irrigation flowrate of 300 gpm may be achievable using one to three new source wells (groundwater flow modeling assumed this rate in Figure 2). • The target aquifer is confined. Long-term well performance should be evaluated, including seawater intrusion and effects on other nearby wells.

	• Induced stream baseflow losses may be reduced near the new irrigation wells because confining layers exist. However, some stream baseflow losses may occur in more distant areas yet to be determined. • Current MODFLOW modeling suggests that source waters feeding the wellfield are from upland areas south of the wells (see Figure 2), but this must be evaluated during the project. • Modeled steady-state groundwater elevations with a pumping rate of 300 gpm are near/below sea level. Although the proposed pumping will be seasonal, induced saltwater intrusion and effects on nearby wells' water levels should be evaluated. **Background** Substituting a deep GW source for the current surface water irrigation will lessen the hydrologic impact to the stream overall (assuming that the deep aquifer primarily discharges to seawater). However, there are legal hurdles associated with this approach. Chapter 173-514 WAC places a seasonal closure on Schneider Creek from May through October. Although it has yet to be evaluated, it is quite possible that groundwater pumping associated with a new irrigation source would impact Schneider Creek baseflow. And, since the effects of seasonal pumping would take some time to work their way through the hydrogeologic system, under that scenario the effects of pumping on Schneider Creek would not cease on October 1st. At least the largest of the 5 subject water rights, S2-*10859CWRIS, has an October 1st cut-off date, so any effects due to groundwater pumping of that water right would spill over past that water right's authorized use period. Some of the other water rights may face similar hurdles, but more research would be needed to make that determination. In years past it might have been possible to mitigate impacts during the month of October more creatively. However, the 2015 Washington State Supreme Court Foster decision has changed the legal framework for source substitution projects. Due to the Foster decision, it is quite possible the only way to deal with the month of October would be to have a situation where there are no adverse impacts due to pumping during that month.

	At least part of the solution to reducing or eliminating potential October impacts could involve relinquishment of the water rights other than S2-*10859CWRIS. More research is needed, but if any of those water rights permit water use throughout October, those rights could be used to cover at least part of the late-season impacts. However, a cursory look at the other water rights suggests that only one, S2-*02996CWRIS, does not have an October 1st cutoff, and the Qi associated with S2-*02996CWRIS is only 0.02 cfs.
	
	Another potential option for reducing or eliminating October impacts would involve pairing this source substitution project with some sort of flow augmentation project or perhaps an MAR project that would somehow utilize water that is available at some other times of year to then provide an offset during October. However, this option may be cost prohibitive.
	
	Finally, there is the possibility that the Washington State legislature could change the law with a so-called "Foster fix, to allow more latitude with regard to source exchange projects in the future.
	
	Summary of Major Project Elements
	
	• Feasibility Study to determine what type of project is viable, including the following elements:
	    o Assessment of the extent and validity of the 5 certificates.
	    o Determine what fraction of the valid part of these rights can be retired.
	    o Install, aquifer test and model the effects of source substitution well(s).
	    o Determine the irrigated area and the efficiency of the new irrigated area for supply by the new wells.
	    o Negotiate the purchase, new irrigation configuration and partial retirement options for the five water rights.
	    o Determine the impacts to nearby streams and any resulting mitigation requirements.
	    o Evaluate the engineering feasibility and cost options for the project.
	• Following approval of a feasible option:
	    o Obtain a groundwater withdrawal permit(s) from Ecology
	    o Provide the production wells, irrigation works/modifications, utility connections and permits.
	    o Implement any permit-required mitigation.
	    o Implement the ditch removal and stream restoration elements of the project.

Description of Benefits:	1. **Summary of potential water offset benefits from the project: (**195 afy) x (0.33 irrigation efficiency improvement/retirement fraction) = (64 afy water offset benefit), depending on multiple factors. This assumes the benefit incorporates any mitigation required for the new groundwater permit. Water offset benefits may be smaller if groundwater permit mitigation complexities emerge. 2. **Increased streamflows on Schneider Creek.** 3. **Improvement in stream function for fish habitat.**
Is Water Quantity a Limiting Factor In this Subbasin?	Unknown.
Location & Spatial Extent of Benefits:	Flows could be increased in Schneider Creek from the area of stream restoration, through the area of the five water rights "Points of Diversion", then downstream to its confluence with Totten Inlet.
Anticipated Water Offset (if applicable):	**Summary of total potential water offset benefits** from the project: approximately 64 afy, depending on multiple factors.
Project-Type Specific Information	
Estimated Project Cost:	Several hundred thousand dollars, at minimum, for new source wells, engineering, permitting and new infrastructure.
Performance Goals & Measures:	Weather and water quality monitoring is already performed by Thurston County; however, additional monitoring is likely to be needed. (See: https://www.thurstoncountywa.gov/sw/Pages/monitoring-dashboard.aspx).
Anticipated Local and Partner Support & Barriers to Completion:	1. The Squaxin Island Tribe has indicated that it may support this project. 2. This project depends heavily on achieving sufficient new well yields. Significant questions exist regarding pumping well production. 3. Some form of required mitigation for the new groundwater permit is likely.

	4. Modeled steady-state groundwater elevations with a pumping rate of 300 gpm at the proposed new wellfield are near/below sea level. Although the proposed pumping is expected to be only seasonal, induced saltwater intrusion and effects on nearby wells' water levels should be evaluated.
Project Sponsor, Implementation Start Date and End Date:	Thurston County may sponsor this project, depending upon Feasibility Study outcomes. The project will need a thorough assessment of well yields, a Report of Examination from a CWRE, plus additional hydrogeological, legal, financing and engineering feasibility studies.

Steamboat Middle Storage Enhancement and Habitat Improvements

Project Name:	Steamboat Middle Storage Enhancement and Habitat Improvements (Thurston County ID 110)
Project Location:	Project is in WRIA 14 on the Steamboat Island peninsula, northwest of the City Olympia, north of US 101 and just south of Steamboat Island Road NW (see Figure 1). Kennedy Creek management unit. The project includes unnamed tributary streams feeding Young Cove. *Longitude: -122.9894, Latitude: 47.1208*

Project Description:	☐ Water Right Acquisition ☑ Non-Acquisition Water Offset ☐ Habitat/Other The Steamboat Middle project consists of expanded water storage in an existing forested/non-forested wetland. The project would expand water storage in a low-lying area between elevation 114 and 118 as depicted in Figure 1. Blue shading indicates the potential extent of additional water storage to max. elevation 118 (datum: NAVD88). Some additional habitat may be created during this project. This project concept envisions the retention an additional 28-121 acre-feet of wet season precipitation, of which half (14-61 acre-feet) would likely provide a water-offset benefit by seeping back into the unnamed tributaries feeding Young Cove. We assume that the remainder would be lost to evapotranspiration. The project area is very flat, with two main basins, each with a differing base elevation. The project area has existing wetlands and hydric soils, likely overlying glacial till based on nearby geology (see Attachment A Well Logs). All elevations are referenced herein using the NAVD88 datum and Thurston County's 2011 LiDAR data. Assuming a low dike and gate/outfall to sustain higher water levels up to approximately elevation 118, two configurations of the water storage area can be conceptually evaluated as follows: 1. At a **"Low Water Stand"** the northern basin could retain about one additional foot of water depth within the existing ponded area, for about 28 acre-feet of additional storage.

2. At a **“High Water Stand”** the southern basin would also fill, to a depth of 1.11 feet, on average. At a “High Water Stand,” the northern basin depth would increase to a depth of 2.35 feet, on average. Both average depths assume a maximum of 118 feet NAVD88, as controlled by a dike and gate with an outfall structure.

Table 1 Summarizes these features:

	Flooded Acres *	**Average Water Depth – Low Water Stand (ft)**	**Average Water Depth - High Water Stand (ft)**
Northern basin	28	1	2.35
Southern basin	50	0	1.11
	Storage acre-feet	28	121.3
	Water Offset Benefit With 50% ET losses	14	60.65

Site hydrogeology

a. **Geology:** probably shallow outwash gravels over glacial till.
b. **Depth to water:** ground surface – wetlands exist.
c. **Stream connection to aquifer:** Partial connection - Project-level calculations required. LiDAR flown in June 2011 did not indicate flow in the two unnamed tributary streams draining the project area. However, DFW modeling indicates fish presence is likely in both small tributaries.
d. **Estimated fraction of recharge that discharges to nearest streams:** Assumed 50% of additional storage reaches the two unnamed tributary streams as new base flow. Project-level calculations required.
e. **Initial estimate of streamflow benefit timing:** Project-level calculations required
f. **Suggested Plan benefit estimate:** 14 to 61 afy, based on 50% of storage reaching both streams.
g. **Probability of benefit:** High (i.e. use 100% of the calculated 14 to 61 afy benefit)
h. **Probability of construction:** Moderate – land access and permit questions will need further feasibility assessment.

	i. **Surface water source evaluation:** None yet - Project-level calculations required j. **Dates when streams are closed:** Discharges to salt water – closure status unknown k. **What type of water rights would need to be acquired to provide water from that source?** Unknown l. **What stream reach likely would benefit from this project?** Unnamed tributaries to Young Cove. m. **What is the anticipated benefit to that reach?** 14 to 61 afy additional streamflow, including flow from groundwater seepage. n. **What fish species will benefit?** WDFW data list fall chum salmon observed and resident coastal cutthroat presumed in the streams feeding Young Cove. MODFLOW groundwater flow modeling exists across this project site and can be used to test project concepts. In addition, significant LiDAR data are available for project assessment (one-foot LiDAR topography).
Description of Benefits:	• Conceptually, this project could provide infiltration of 14 to 61 afy water offset. • These benefits would require quantification as part of a Feasibility Study. • The project would improve streamflow later in the year, i.e. groundwater seepage that would provide stream base flow. • The length of additional wetted channel and volume of water offset would require calculation during the Feasibility Study process, and monitoring during operation. • Habitat could be incrementally improved. • Wetlands may expand as a result of the additional water storage area. • Habitat benefits/protection may be part of the project.
Is Water Quantity a Limiting Factor In this Sub-basin?	Unknown. Habit assessments would be required.
Location & Spatial Extent of Benefits:	Unnamed tributaries to Young Cove.
Anticipated Water Offset (if applicable):	14 to 61 acre-feet per year are anticipated. The WRIA 14 Committee conservatively claimed 14 AFY as a water offset to include in the plan.

Project-Type Specific Information	
Estimated Project Cost:	Feasibility study costs of ~$250,000, plus capital cost of several hundred thousand dollars for civil works, and the costs for land access rights or ownership. Operations & Maintenance costs expected. A cost estimate of $1 million is included in this watershed plan for planning purposes.
Performance Goals & Measures:	Streamflow, habitat or groundwater monitoring would likely be required for this project.
Anticipated Local and Partner Support & Barriers to Completion:	Unknown. Obstacles may include costs for land or rights to inundate lands adjacent to the project; conversely, landowner willingness to allow inundation may reduce the feasible water offset quantity.
Project Sponsor, Implementation Start Date and End Date:	Not yet sponsored.

Summit Lake Alternative Water Supply and Use

Project Name:	Summit Lake Alternative Water Supply and Use (TC Project #76)
Project Location:	Kennedy Creek management unit in northwestern Thurston County. See Figure 1. *Summit Lake Lon. -123.1064 Lat. 47.0538*
Project Description:	☑ Water Right Acquisition ☑ Non-Acquisition Water Offset ☐ Habitat/Other Conceptually this project involves determining alternative solutions for safe water supply to the Summit Lake community. It involves a substantial portion of the lakefront residents of south shore drive along Summit Lake currently using surface water from the lake itself. An alternative water supply could supply water and reduce the use/demand for 235 homes on south Summit Lake Shore Drive South. One potential source of water could include new source wells installed in aquifer material near the Boy Scouts of America Camp Thunderbird. Well yields of 10 gpm to 30 gpm have been identified in at least five existing wells – including the Camp Thunderbird well (rated by WA DOH as capable of serving 9,000 gpd). This could require obtaining a new water right in compliance with Chapter 173-514 WAC, which would be difficult with the current instream flow rules because the location is in direct hydraulic continuity with Kennedy Creek. There may also be conflicting legal concerns with obtaining a water right as a result of the Washington State Supreme Court Foster decision. Another potential source of water could be from piping water from a public water system located outside the Summit Lake drainage. This option could be more expensive but provide a more reliable water source and flow benefit to Kennedy Creek. Other water sources could also be explored, should the opportunity become available. A net water offset benefit could occur in two ways: 1) by limiting irrigation for homes newly connected to a new water supply, and 2) by retiring some non-certificated permits and purchase/retirement of some certificated water rights. Finding an alternative to surface water withdrawals for a portion of the Summit Lake community could result in the retirement of surface water withdrawal permits for homes with newly available supplies. Some of

	these permit revocations may include the 193 temporary withdrawal permits. These permits date to after 1992, when Ecology agreed with Thurston County to temporarily issue new permits for indoor water use only, with the condition that these rights be relinquished when a public water supply became available. Finding an alternative, safe water supply would reduce public health risk for residents and clarify uncertain permitting, including those undeveloped lots surrounding Summit Lake that are currently without access to water. **Background** The approximate altitude of the lake is 460 feet. The drainage is steep and rugged with ridges as high as 1200 feet and slopes up to 80 percent. There are numerous springs and intermittent streams that flow into the lake. The outlet at the west end of the lake is controlled by a dam with overflow flash boards, regulated under a superior court order issued under Chapter 90.24 RCW, which allows lake overflow to feed Kennedy Creek. Summit Lake is one of the deepest lakes in Thurston County, with a maximum depth of 30 meters (100 feet). Groundwater is difficult to find in the thick basalts surrounding the lake, typically requiring homeowners to rely on surface water instead of drilling a permit exempt well. It should also be noted that all Lake area parcels have on-site septic systems that ultimately discharge household wastewater back into the lake via shallow groundwater percolation. Prior to the passage of the Streamflow Restoration Act, significant streamflow concerns existed in the Kennedy Creek basin. For example, the Department of Ecology has noted that each new surface water withdrawal permit adds to ongoing impairment of the Kennedy Creek instream flow right and tribal rights, and the public interest test (RCW Chapter 90) is not met by incrementally diminishing critical instream flows (See Attachment A). Chapter 173-514 WAC, adopted in January 1984, closed Kennedy Creek and its tributaries to new appropriations of water from May 1 through November 15. While there is an exemption in WAC 173-514 for single domestic in-house use if no other source is available, Ecology has determined that the cumulative impact of the existing diversions under the existing water rights is resulting in harmful impacts to Kennedy Creek and its fisheries and the cumulative impact of existing diversions exceeds the available flow in Kennedy Creek during the WAC closure period, preventing any new water allocations from Summit Lake. Parcel owners may elect to install a permit exempt well in an attempt to find a sustainable water source, but that is likely to result in very deep "dry holes" due to inability to access groundwater. In 1992, there were 139 active surface water permits and certificates on Summit Lake, which Ecology agreed to issue as temporary permits with

	the condition that these rights be relinquished when a public water supply became available. Combined with the 193 temporary permits since 1992, there are 332 total known existing diversions of Lake water. Thurston County and Ecology independently determined that the +600 lots surrounding Summit Lake number greater than the permits on record. These include upland lots that require easements from lakefront property owners to install pumps and water lines. Thurston County has also provisionally identified up to 73 lots with possible permit-exempt wells. Note that the Streamflow Restoration Act does not apply to surface water withdrawals where a water right permit is required. Most Summit Lake water use is therefore <u>not</u> permit-exempt. In addition to water offset benefits, an important driver for the project is the toxicity of potential drinking water used by residents of Summit Lake. Water quality advisories have been issued for Summit Lake residents relying on surface water in 2014, 2016, 2017, 2018, 2019 and 2020. The concerns centered around detections of anatoxin-a above public health advisory concentrations. Anatoxin-a is a potent neurotoxin that is fast-acting and can cause serious illness or death. During health advisories issued in the above years, Thurston County Public Health and Social Services recommends that residents do not drink the lake water. The state advisory level for Anatoxin-a is one microgram per liter. These recurring lake advisories associated with detections of anatoxin-a in laboratory-analyzed surface water samples are now nearly annual. They have raised additional concerns about the reliability of Summit Lake as a safe source of drinking water for residents. During health advisories, the Boy Scouts of America have often donated water from their Camp Thunderbird well to supply some resident needs. **Major Project Elements** • **Conduct a feasibility study to determine the best alternative water source.** Pumping tests, sampling, and permitting research. • **Engineering feasibility study of production and water quality for the appropriate water source,** to develop an engineering basis and approximate costs for the alternative water supply. A crucial engineering feasibility cost-tradeoff analysis is required because of known prior limitations on well yield. • **Community outreach** will be an important element of evaluating cost-benefit tradeoffs because resident acceptance rates in the Summit Lake vicinity will likely be less than 100% (based on prior outreach efforts). This could also include educational aspects or working with residents to address their concerns. • **Identification of a process necessary to negotiate required water rights and any associated mitigation requirements** with the

	Department of Ecology. Relinquishment of some water right permits may be a part of this dialog. • **Identification and approval of a suitable funding mechanism(s).** • **Identification of next steps necessary for approvals of alternative water supply plan by local and state authorities.** • **Identification of financial impacts to residents**.
Description of Benefits:	1. **Potential water offset benefits from the project: 96.7 afy to 132.5 afy,** depending on multiple factors. Water offset benefits may be larger if demand reduction measures can be implemented successfully. 2. **Significant health risk reduction** and the improvement of public health outcomes by limiting surface water connections to Summit Lake at 235 homes. **3. Coho, steelhead, and cutthroat would benefit.** **4. Increased streamflows on Kennedy Creek.** 5. **Benefits are potentially scalable:** additional homes might be served if alternative water supply can be established. 6. **Dual permit/exempt benefits:** the proposed source substitution and re-configuration would include co-located benefits from both permit-required and permit exempt mitigation.
Is Water Quantity a Limiting Factor In this Subbasin?	The Department of Ecology has also noted that a water right comment letter dated January 2, 2018, from the Department of Fish and Wildlife (DFW), states that "…any further reduction in [Kennedy Creek] flows will be detrimental to production of coho, steelhead, and cutthroat and the cumulative impact of numerous small diversions from Summit Lake would reduce flow in Kennedy Creek." DFW further requests denial of applications for diversions of surface water from Summit Lake (see Attachment 1).
Location & Spatial Extent of Benefits:	Flows could be increased in Kennedy Creek from Summit Lake downstream to its confluence with Totten Inlet.
Anticipated Water Offset (if applicable):	**Reduction in demand for a water offset of 16.8 afy to 52.6 afy,** depending on the assessment assumptions and methodology (See Table 1), by restricting some types of outdoor water use (e.g. lawn watering). **Retirement of up to about 79.9 afy of permitted surface water rights at approximately 235 homes.** A source substitution would require about 54 afy pumping at a new downstream Group A wellfield, for a net water

	offset benefit of up to about 26 afy: (235 homes) x (0.34 afy/home median permitted water right) = (79.9 afy in estimated total permits). This calculation assumes that some method can be found to incentivize permit retirement. **Summary of total potential water offset benefits** from the project: 96.7 afy to 132.5 afy, depending on multiple factors. Water offset benefits may be larger if demand reduction measures can be implemented successfully.
Project-Type Specific Information	This project depends heavily on achieving sufficient new well yields downstream of Summit Lake or an alternative water source. Significant questions exist regarding pumping well production.
Estimated Project Cost:	Several million dollars, at minimum, for new source wells, engineering, permitting and new infrastructure.
Performance Goals & Measures:	Weather and lake water quality monitoring is already performed by Thurston County; however, additional monitoring is likely to be needed. (See: https://www.thurstoncountywa.gov/sw/Pages/monitoring-dashboard.aspx).
Anticipated Local and Partner Support & Barriers to Completion:	The Squaxin Island Tribe has indicated that it may support this project. Based on resident comments received in connection with similar proposals in the 1990s and again in 2018-2019, incentives and educational outreach may be required for residents to be supportive of alternative water supply solutions.
Project Sponsor, Implementation Start Date and End Date:	Thurston County may sponsor this project, depending upon Feasibility Study outcomes. The project will need a thorough assessment of well yields or other alternative water sources, a Report of Examination from a CWRE, plus additional hydrogeological, legal, financing, and engineering feasibility studies.