Appendix I – Detailed Project Descriptions

1) Chambers Creek Habitat Project
2) Donnelley Drive Infiltration Galleries
3) Floodplain Restoration
4) Forest Stand-Age
5) Hicks Lake SW Retrofit
6) Managed Aquifer Recharge Projects in WRIA 13
7) Schneider's Prairie Off-Channel Storage and Release
8) Small-Scale LID Project Development
9) Spurgeon Creek Remeander Habitat Project
10) Water Right Opportunities
11) Woodard Creek

Chambers Creek Habitat Project

Project Description

Description

Chambers Creek is a tributary of the Deschutes River in Thurston County and is listed as high priority for restoration (SIT 2015). Thurston County is proposing to re-meander a series of ditched channels through the adjacent wet fields south of Yelm Highway and east of Rich Road (Figure 1). The proposed project is intended to improve aquatic and salmonid habitat. The project has the potential to provide a connection to existing Coho Salmon spawning habitat in the lower basin.

The goal of the project is to improve fish productivity and survival within Chambers Creek by enhancing the quality and quantity of instream habitat within the project reach. Habitat within Chambers Creek is currently impaired, by lack of riparian vegetation and large woody debris, simplification of instream habitats, poor floodplain connectivity, channel incision and poor water quality.

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

The Chambers Creek restoration project is located at the confluence with Chambers Ditch, in Thurston County. At the project location, Chambers Creek, Chambers Ditch, and an unnamed tributary converge, and are ditched through a wet field (Figure 1). The proposed project area is both in designated wetland and floodplain. Thurston County will work with the landowners to recreate the natural stream sinuosity and the surrounding wetland. Additionally, wood structures will be added that offer refuge from predators and opportunities for salmon to feed, while the wetland offers slower water during high flow events. Native plants will be planted throughout the ¾-acre project area that will recruit wood and provide shade into the future.

Chambers Creek is a lowland tributary to the Deschutes River and a critical contributor of cold water. Overall, the Chambers Creek basin is composed of 8,323 acres that drain to Chambers, Little Chambers, Smith Lake, Chambers Ditch, and Chambers Creek. Chambers/Little Chambers Lake complex is the largest waterbody in the basin. It does not have a feeder system, but Little Chambers Lake does form the headwaters for Chambers Ditch. Smith Lake is a 12-acre, groundwater-fed lake (Thurston County, 1995). Chambers Ditch is a seasonal stream that was ditched for most of its length early in the century. Chambers Ditch flows from Chambers Lake south to its juncture with Chambers Creek and the South Tributary upstream of Rich Road. Chambers Creek is a natural stream with year-round flow through most of its length. Chambers Creek flows into the Deschutes River. The South Tributary is a network of natural channels, artificial ditches, and poorly defined wetlands, which flows intermittently and remains dry most of the year (Thurston County, 1995).

The proposed project is intended to improve water quality and increase salmon rearing habitat for juvenile Coho Salmon. The system is modeled as habitat for Fall Chinook, Coho and Chum Salmon. Specifically, the project will designed to accomplish the following:

- Increase stream length by at least 1/8 miles.
- Restore at least 1/3 mile of creek.
- Increase instream shading.
- Increase instream complexity by adding Large Woody Debris (LWD).
- Increase community involvement.

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

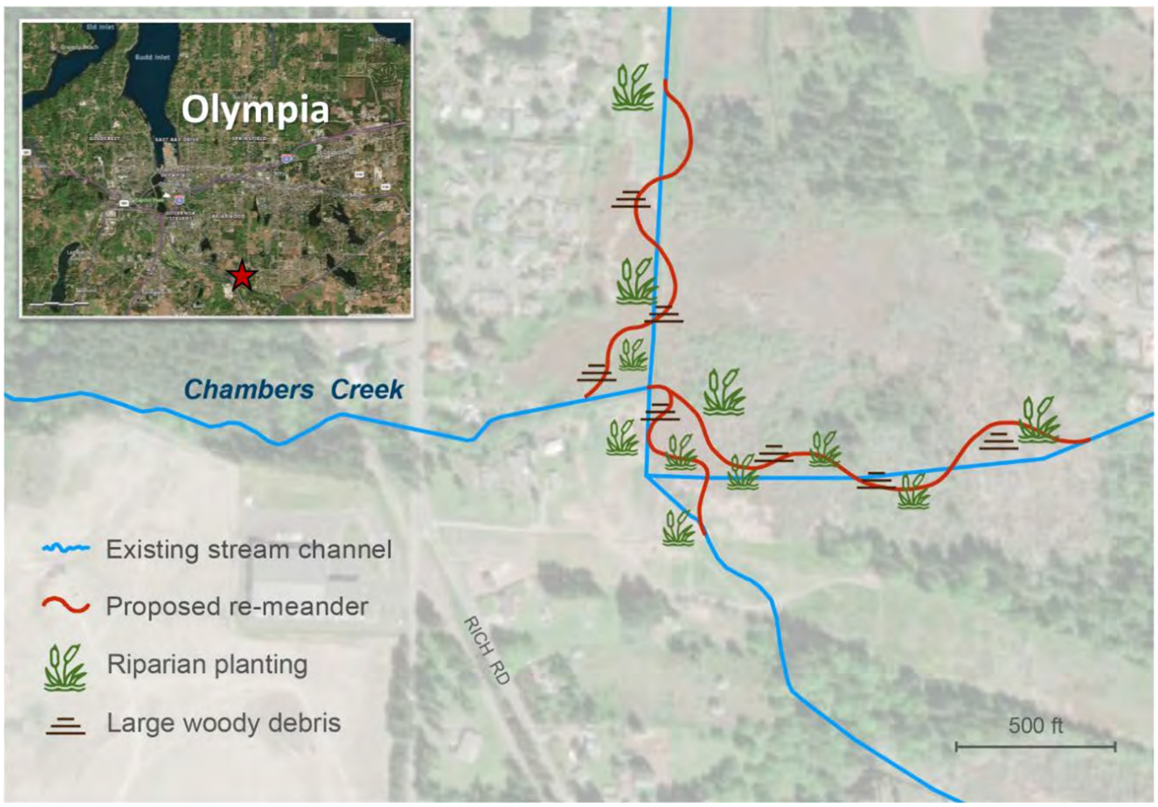

Figure 1. Location of proposed Chambers Creek remeander project in Thurston County.

Description of the anticipated spatial distribution of likely benefits

The proposed project site is approximately 3 acres. Within that footprint, the length of Chambers Creek is expected to be increased by increasing the sinuosity. The new channel alignment will have improved instream habitat, floodplain connectivity (i.e. local flooding from increased sinuosity channel roughness elements), and increased groundwater storage (i.e. in terms of saturated soils from increased local flooding.

Performance goals and measures.

The performance goals are to increase channel sinuosity and length, increase instream habitat complexity, and channel roughness. Specific metrics and measures will be defined when during feasibility and 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 and Fall Chinook are present in Chambers Creek and that Coho Salmon and Fall Chinook have access to Chambers Creek (WDFW Salmonscape 2020). WDFW (2020) documents spawning in Chambers Creek and small areas in the lowermost reaches (WDFW 2020). The Washington Stream Catalog indicates that both Coho, Chum, and Chinook salmon were historically present in Chambers Creek which is identified as an important tributary to the Deschutes River (WDF 1975). Chambers Creek also provides habitat for reticulate sculpin, Olympic mudminnow, wood duck, and waterfowl overwintering.

Chambers Creek has inadequate spawning gravel and low summer flows (Haring and Konovsky, 1999). Chambers Creek offers three types of coho habitat. The segment near the mouth contains a few spawning sites. The lower section provides year-round rearing habitat from the springs below Rich Road to the mouth. The portion from the springs below Rich Road up to a point below Yelm Highway provides winter habitat as long as the creek is flowing. The area near the mouth of Chambers Creek is the best remaining habitat for anadromous fish in the basin with relatively clean gravel, large trees, and a well-developed understory near the creek that provides shading. Upstream from the mouth, the habitat quality declines. The riparian cover gives way to open fields south of the creek below Rich Road (Thurston County, 1995). The lower quarter mile of the South Tributary upstream of Rich Road contains viable seasonal habitat for migrating fish, with fair overhanging cover and in-stream woody debris. However, upstream, it has been channelized through agricultural lands, and disappears frequently in the wetlands. There is poor substrate and very little large organic debris in the channel (Thurston County, 1995).

Identification of anticipated support and barriers to completion.

Thurston County has indicated support for this project. The primary barrier to completion is likely to be land acquisition or obtaining conservation easements. The proposed project area includes privately owned parcels.

Potential budget and O&M costs.

The total costs of construction, engineering, permitting, and cultural assessments are estimated to be <$1 million, based on an order of magnitude estimate (includes engineering and construction costs).

Anticipated durability and resiliency.

The project would have lasting benefits as it would be actively managed by Thurston County or their future project partner. The restored stream section would be designed to be compatible with natural ecological processes to be self-sustaining and resilient to perturbations to minimize long-term maintenance costs.

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

The project sponsor is Thurston County and is ready to implement the project. Implementation would require an evaluation of feasibility.

References

Haring,D. and J. Konovsky. 1999. Salmon Habitat Limiting Factors Final Report. Water Resource Inventory Area 13. Washington State Conservation Commission.

Thurston County Storm and Surface Water Program. (1995a). Chambers/Ward/Hewitt Comprehensive Drainage Basin Plan. Prepared for the City of Olympia and Thurston County.

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Donnelly Drive Infiltration Galleries

To: Angela Johnson (Ecology and Kaitlynn Nelson (Thurston County)
From: HDR
Date: May 20, 2020
Subject: Donnelly Drive Infiltration Gallery Analysis

Background

Portions of Donnelly Drive SE, and Normandy Drive SE flood during major rainfalls and impacts public property and reduces public safety. Thurston County Roads Maintenance has routinely responded to calls from residents for assistance. It is proposed to install treatment devices and infiltration systems in the Donnelly Drive vicinity to reduce flooding of public streets and promote infiltration to groundwater. There are five locations in the area which see flood issues as shown on Figure 1. Each of these locations are a low point where an existing drywell is located to infiltrate stormwater.

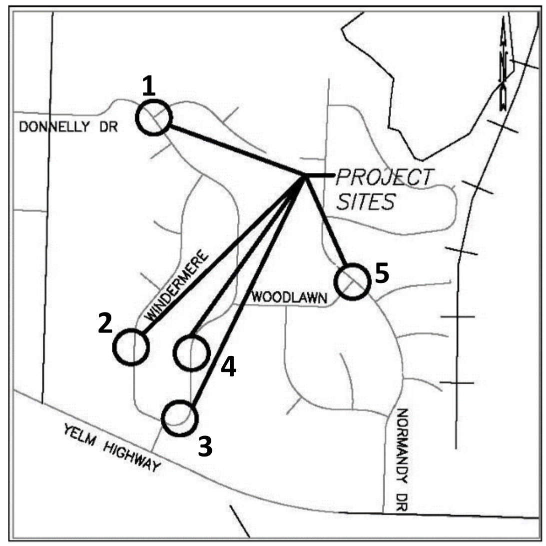


Figure 6. Flooding areas

At Location 1 (at the intersection of Donnelly Drive SE and Glendale Drive SE) is a single drywell installed at some point after the original neighborhood was built.

At location 2 (along Windermere Drive SE) are two drywells installed on either side of the roadway. The drywells are original to the initial construction of the neighborhood.

At location 3 (at the intersection of Donnelly Drive SE and Windemere Drive SE near Yelm Highway), are three drywells installed on all sides of the intersection, all of which were installed at some point after the original neighborhood was built.

At location 4 (along Donnelly Drive SE) are two drywells installed on either side of the roadway. The drywells are original to the initial construction of the neighborhood.

At location 5 (intersection of Woodlawn Drive SE and Normandy Drive SE), are three inlet inlets. Two of these are located on the west side of the intersection and one is located on the south side of the intersection. It is unclear how many of these are drywells.

Analysis and Results

Site Visit

During the rainfall event, it was observed that the drywells at Locations 2 and 4 were fully surcharged and bypassing all flow reaching them with negligible infiltration.

At Location 5, the northern most inlet was surcharged while the inlet on the west side of the intersection had a water surface elevation approximately 2-inches below the rim. The southern inlet was surcharges with flow slightly greater in the curb downstream of the inlet than upstream. A slow rise of particles was seen out of the inlet indicating flow was coming out of the inlet. If this inlet/drywell is connected to the inlet on the other side of the street, this may indicate that the flow to the combined structures exceeded the infiltration capacity and is surcharging. If not connected, this may indicate groundwater coming up out of the inlet.

Locations 1 and 3 were not surcharging during the May 2, 2020 rainfall event and fully infiltrating.

Basin Delineation

The contributing stormwater basins to each flooding area was delineating by using topography data from the 2011 Thurston County LiDAR survey and verified with a site visit during a rainfall event occurring on May 2, 2020. Five basins were delineated and shown on Figure 2 with each basin flowing towards one of the flooding areas.

For determining basin areas for sizing infiltration galleries, only the directed connected impervious area of the roadway and driveways was considered.

Assumed Infiltration Rate

According to the NRCS Web Soil Survey, the soils in the area consist primarily of sandy loams. Table A.1 of the Thurston County Drainage Manual lists the estimated design (long-term) infiltration rate for sandy loam as 0.25 inches per hour. Past project experience in this area also has found infiltration rates similar to 0.25 inches per hour. The analysis looks into sizing assuming a 0.25 inch per hour infiltration rate as well as 0.5 inches per hour.

Infiltration Gallery Sizing

The required infiltration gallery size was determined using the Western Washington Hydrology Model (WWHM). The model assumed an infiltration gallery cross-section similar to what was installed at Husky Way which had a width of 8 feet, height of 4 feet, and a 24-inch diameter perforated pipe.

The required length of infiltration gallery for each basin is given in Table 1 for three different scenarios these include:

- Infiltration rate of 0.25 inches per hour and sized to infiltrate for all but the two largest storms
- Infiltration rate of 0.25 inches per hour and sized for 100 percent infiltration
- Infiltration rate of 0.50 inches per hour and sized to infiltrate for all but the two largest storms

The reason for sizing for all but the two largest storms is that getting to 100 percent infiltration causes the galleries to be unfeasibly large (approximately 67 percent larger). An example of the stage height seen in each infiltration gallery when not sized for 100 percent infiltration is shown on Figure 2.

Figure 2. Drainage basins

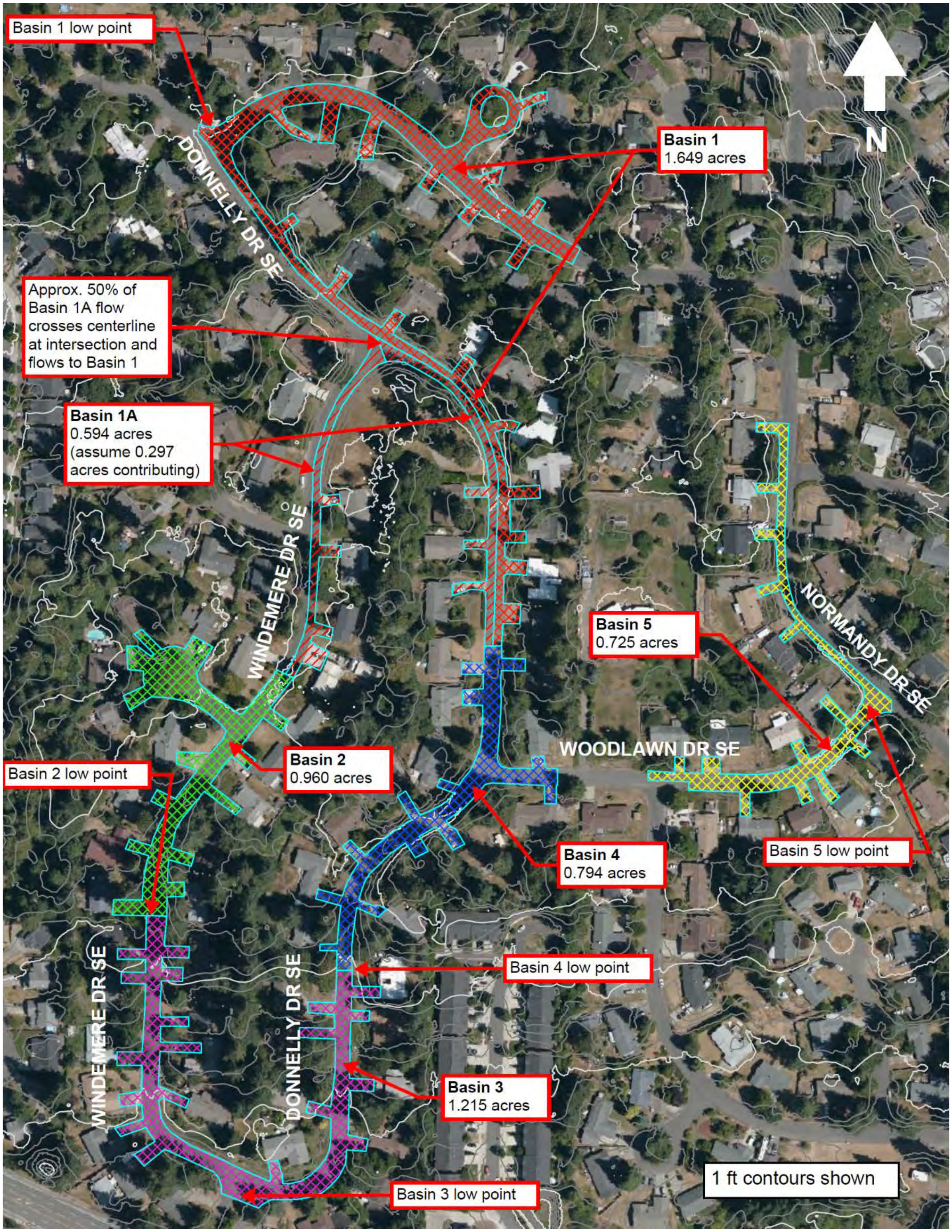


Figure 3.

Table 14. Infiltration gallery length

Basin	Calculated infiltration gallery length (feet)		
	0.25 inch/hour	0.25 inch/hour – 100% infiltration	0.5 inch/hour
1	1,800	3,000	1,450
2	900	1,500	725
3	1,150	1,900	900
4	750	1,250	600
5	675	1,150	550
TOTAL	5,275	8,800	4,225

Figure 7. Drainage basins

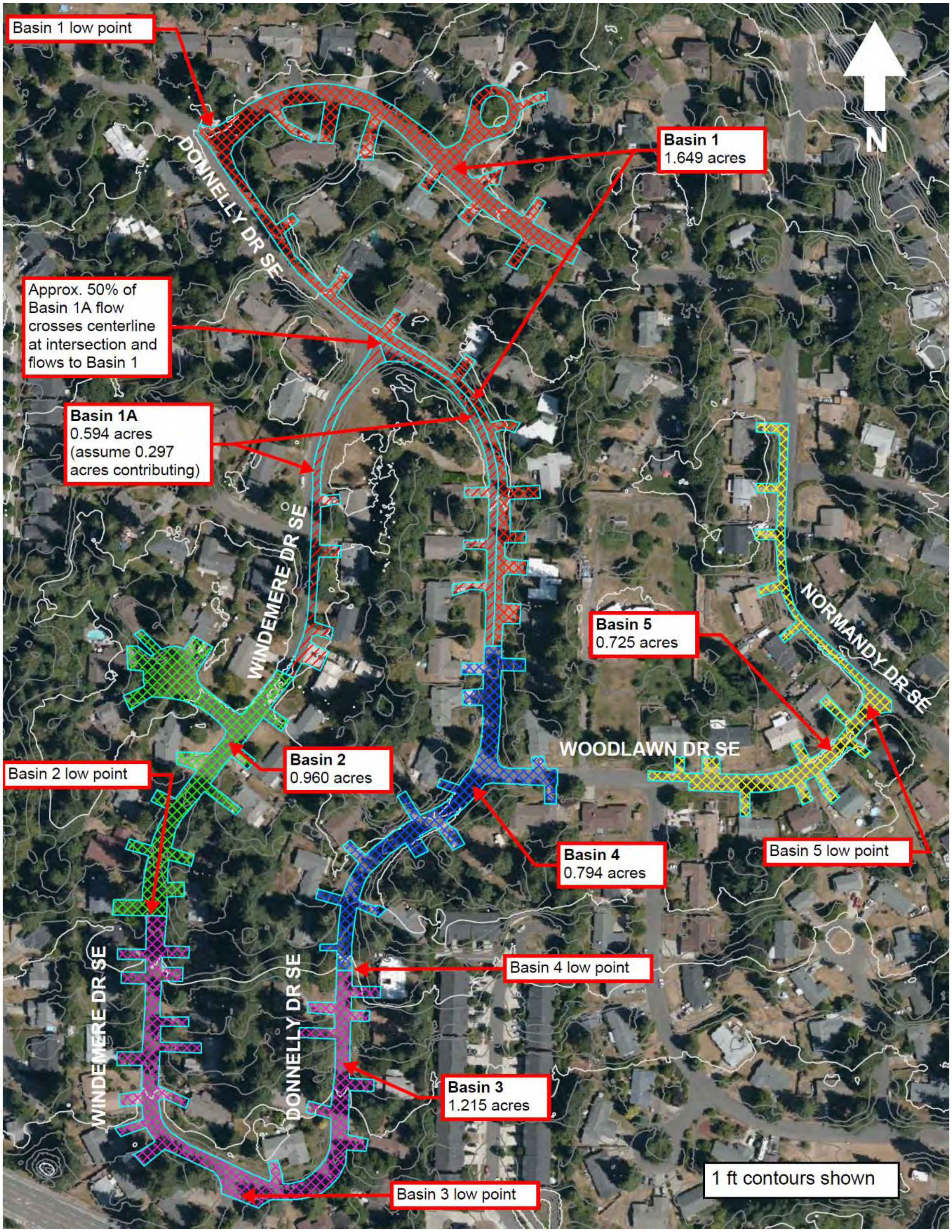
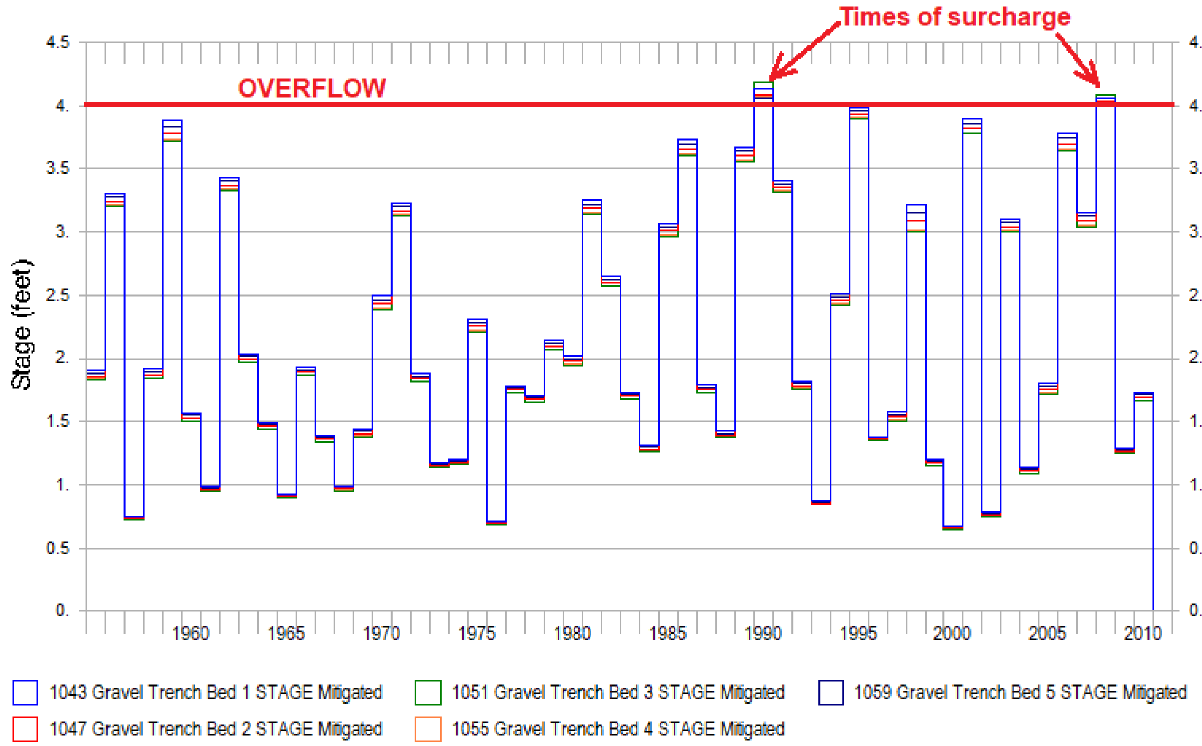


Figure 8. Times of surcharge across WWHM model run



If the infiltration rate were to increase to 0.5 inches per hour from 0.25 inches per hour, the length of infiltration gallery needed would decrease by approximately 20 percent.

Stormwater Infiltration Volume

The Donnelly Drive project is being considered to not only reduce the flood nuisance but to also provide additional groundwater recharge for mitigation purposes. WWHM was used to estimate the increase in volume infiltrated.

Table 15. Stormwater infiltration volume

Scenario	Annual average infiltrated volume (acre-feet)	Increase in annual average infiltrated volume over existing (acre-feet)
Existing	5.53	0
Galleries sized to infiltrate for all but the two largest storms	19.31	13.78
Galleries sized for 100% infiltration	19.35	13.82

Opinion of Probable Construction Cost

The Husky Way infiltration gallery project was used as a basis to estimate the linear foot construction cost of an infiltration gallery. The engineers estimate, done in 2012, for Husky Way had a construction cost of $166,757 to build 335 feet of infiltration gallery, excluding tax. Inflated to today’s dollars and including tax, this corresponds to a cost of approximately $684 per foot of infiltration gallery.

On top of the construction cost the cost estimate also includes the following costs based on a percentage of the construction cost: (1) 30 percent contingency; (2) 15 percent for geotechnical investigation; (3) 15 percent for engineering; (4) 10 percent for administrative costs; (5) 5 percent for permitting.

Due to the low infiltration rates expected in the area, a substantial area is needed for infiltration with infiltration galleries running along the length of most of the streets within the basins. To further design, additional geotechnical investigation should be completed to verify infiltration rates as infiltration rates higher than what is assumed could substantially lower the cost of the project by reducing the length of infiltration gallery needed.

Table 3 provides a summary of opinion of probable construction costs by project scenario.

Table 16. Opinion of probable construction cost

Cost item	Costs by scenario		
	0.25 inch/hour	0.25 inch/hour for 100% infiltration	0.50 inch/hour
Construction Cost	$3,608,043	$6,019,105	$2,889,855
Contingency (30%)	$1,082,413	$1,082,413	$1,082,413
Geotechnical (30%)	$541,206	$541,206	$541,206
Engineering (15%)	$541,206	$541,206	$541,206
Admin (10%)	$360,804	$360,804	$360,804
Permitting (5%)	$180,402	$180,402	$180,402
Total Cost	$6,310,000	$8,730,000	$5,600,000

Floodplain Restoration

General Project Description for Opportunities in WRIA 13

Narrative description, including goals and objectives.

The Deschutes River originates on Cougar Mountain in Lewis County and flows 57 miles, mostly within Thurston County, with several smaller independent tributaries that drain into three saltwater inlets: Henderson, Budd, and Eld. Other principal streams include Woodard and Woodland Creeks which are the largest of the major tributaries to Henderson Inlet. Key limiting factors for salmonid habitat and productivity in Water Resource Inventory Area (WRIA) 13 were identified in Haring & Konovsky (1999), Thurston Conservation District (2004), and Confluence Environmental (2015).

- Natural stream processes have been significantly altered due to adjacent land uses including timber harvest, agricultural uses, and residential and commercial development,
- Fine sediment (<.85 mm) levels are high, reducing spawning habitat quality,
- Lack of large wood in streams, particularly larger key pieces that are stable and most capable in forming pools and other instream habitats and retaining sediment and smaller wood,
- Lack of adequate pool frequency and particularly a lack of large, deep pools that are key habitats for rearing juvenile salmonids and adult salmonids on their upstream migration,
- Naturally high rates of channel migration occur in this geologically young basin with easily erodible glacial outwash soils, but exacerbated rates of streambank erosion and substrate instability due to intermittent bank armoring and removal of forested riparian vegetation and subsequent loss of bank strength and stability,
- Loss of riparian function due to removal/alteration of natural riparian vegetation, which affects water quality, cover, shading, instream habitat conditions, sediment deposition, and wildlife habitat,
- The presence of a significant number of fish passage barriers that inhibit upstream or downstream access to juvenile and adult salmonids,
- Significant alterations to the natural hydrology in streams where the uplands have been heavily developed, which has led to increased peak flows and decreased low flows that cause bed scour, bank erosion, and reduced water quality; and the threat of similar impacts to streams that are experiencing current and future development growth, and
- Estuarine habitat quantity and quality is significantly impacted by physical alteration of the natural estuary, such as by the dam and creation of Capitol Lake that dramatically reduced the area of estuarine habitat, dredging, fill, poor water quality in the estuary, and by significant alteration of nearshore ecological function due to shoreline armoring.

WRIA 13 restoration projects would address functional loss of water storage, low flows and water quality within the Deschutes River and other streams and rivers throughout WRIA 13. 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 lost processes and functions 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 13 floodplain project recommendations from the WRIA 13 committee. The following data and reasoning was used to select candidate sites in WRIA 13:
- 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.

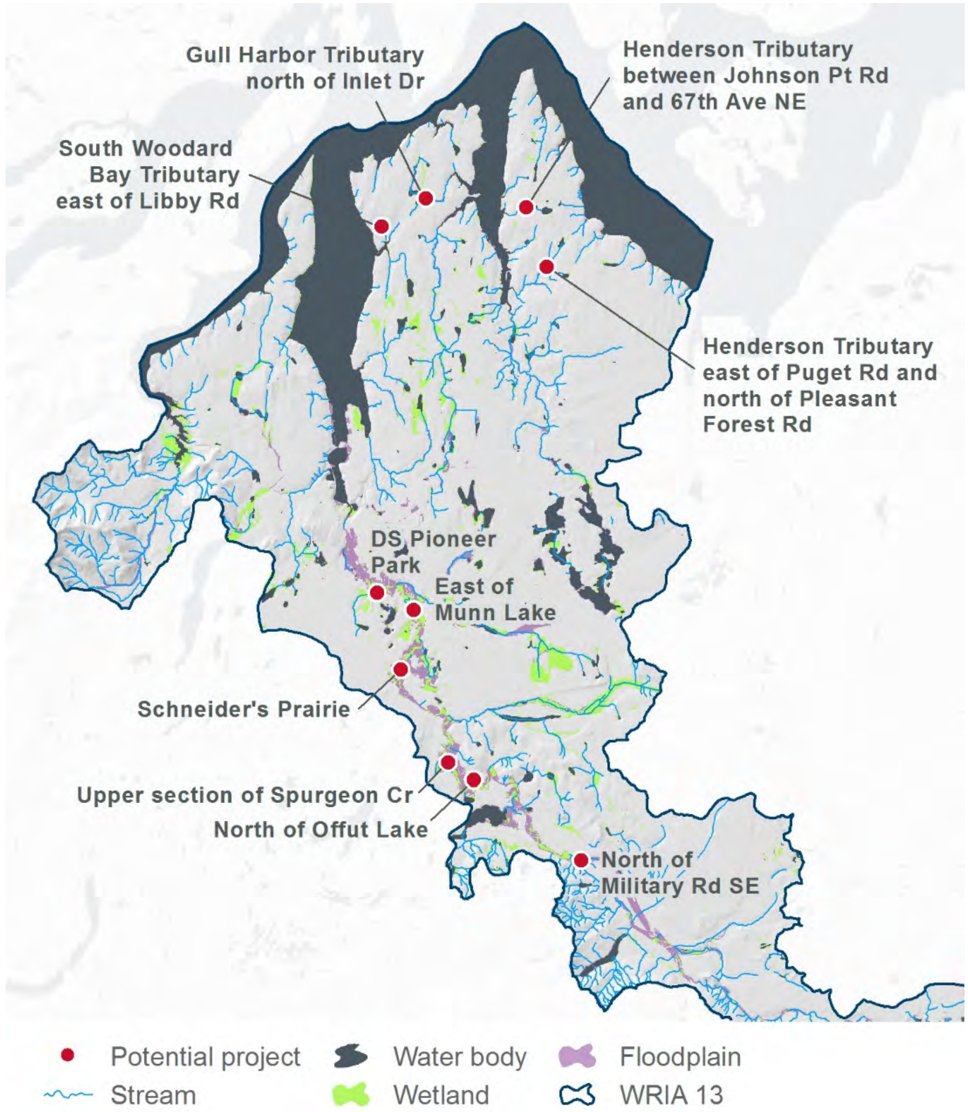


Figure 1. Potential floodplain restoration project locations.

Project locations identified by the committee include the following:

- Tributary to Woodard Bay, east of Libby Road
- Tributary to Gull Harbor, north of Inlet Drive
- Tributary to Henderson Inlet, between Johnson Point Road and 67th Avenue NE
- Tributary to Henderson Inlet, east of Puget Road and north of Pleasant Forest Road

- Deschutes River, downstream of Pioneer Park
- Deschutes River, east of Munn Lake
- Deschutes River, Schneider's Prairie
- Upper Spurgeon Creek
- Deschutes River, north of Offut Lake
- Deschutes River, North of Military Rd SE

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.

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.

The Deschutes River watershed (WRIA 13) contains the Deschutes River and its tributaries, along with 22 independent drainages that enter Henderson, Budd, and Eld inlets. The primary independent drainages are McLane, Woodward, and Woodland creeks.

Potential floodplain restoration projects have been identified in the upper reaches of several small tributaries to Budd and Henderson inlets that historically had more extensive wetlands in their headwaters. Restoring floodplain connectivity, along with riparian and wetland habitats could benefit up to 5 miles of these tributaries and their associated tributaries by storing direct precipitation as well as stormwater runoff in the headwaters and floodplain areas, contributing additional flows during low flow periods.

Potential floodplain restoration projects have been identified in multiple floodplain reaches of the Deschutes River and one potential project in the upper reaches of Spurgeon Creek (primary tributary to the Deschutes River). Restoring floodplain connectivity, along with instream, riparian, and wetland habitats could benefit up to 16 miles of the Deschutes River, plus up to 5 miles in Spurgeon Creek by storing direct precipitation as well as stormwater and flood storage in floodplain areas that could contribute additional flows during low flow periods. The Deschutes River has been noted for low summer/fall flows for decades (WDF 1975) and

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 fall Chinook, coho, and chum salmon, and winter steelhead trout are present in the Deschutes River and the independent drainages in WRIA 13. Chinook salmon are hatchery origin, but the other species are wild or of mixed origin (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. The alteration of natural stream hydrology has been identified as a high priority limiting factor in WRIA 13 (Haring & Konovsky 1999; Confluence Environmental 2015) 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, contributing to flood storage, groundwater recharge, recruitment of large wood, and creation of habitats. Floodplain reconnection projects that provide the river with more room to meander and more ways to hold water in the hyporheic zone and porous floodplain soils are important solutions 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.

References

Confluence Environmental Company. 2015. *Deschutes River Coho Salmon Biological Recovery Plan*. Prepared for the Squaxin Island Tribe Natural Resources Department, September 2015.

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Forest stand age and flow restoration

Concept paper Paul J. Pickett

For the Squaxin Island Tribe
January 21, 2021

Background

Technical appendix G of the Nisqually Watershed Plan Addendum (Nisqually Indian Tribe, 2019) provided a detailed technical analysis of a Community forest project designed to manage forest stand age to improve stream flows. Excerpts from that document describe some of the technical background for this project concept:

A significant body of field evidence, research and important new modeling indicates that large streamflow benefits can accrue from increasing forest stand age through Managed Forestry:

- *Perry and Jones (2016) used paired forest stands comparable to those in the Nisqually River watershed to show that after a forest stand age of 40 years, re-growing forests contribute significantly to streamflow.*
- *Abdelnour et al (2011 and 2013) confirm that the findings of Perry and Jones (2016) can be reproduced using numerical modeling with the VELMA model code.*
- *McKane et al (2018) has modeled the Mashel River sub-basin using the VELMA model. Preliminary results indicate that streamflows increase substantially when forest stand ages increase.*
- *Managed Forest practices are already being implemented in the Nisqually Community Forest, which include over 1,900 acres already purchased and under protection. This ongoing program (limited only by funding) indicates the viability of the long-term managed forest concept.*

The work of Perry and Jones (2016) is critical to the understanding of the streamflow benefits of Managed Forests. Figure 6b is extracted below for reference from their paper, Summer streamflow deficits from regenerating Douglas-fir forest in the Pacific Northwest, USA:

In this figure, streamflows are compared between pairs of test basins: one cut and the other uncut. Their streamflows are expressed as the percent difference between the reference (uncut) streamflow and the clear-cut basin streamflow – over a test period of 35 to 45 years.

- *Initially, streamflows rise rapidly in the cut basin, relative to the uncut partner basin.*
- *Streamflows then decline rapidly as vegetation re-growth uses more water relative to the uncut partner basin.*
- *In forests older than 35-40 years, streamflows then stabilize at 50% to 70% lower than in the uncut partner basin.*

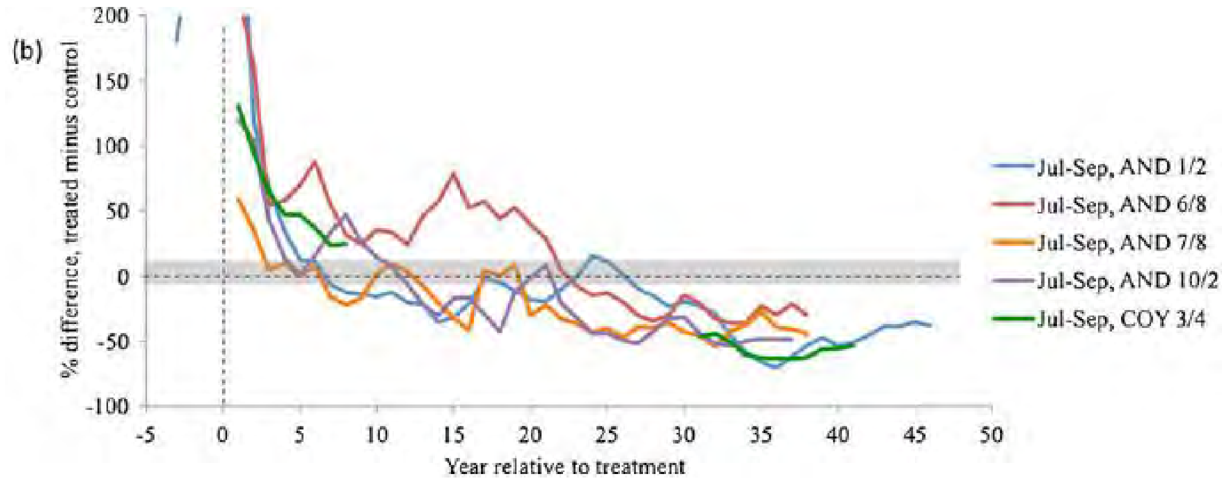

Figure 6b, (excerpted from Perry and Jones (2016).

Computer modeling using the VELMA modeling software (McKane et al) was able to reproduce this sequence – both the hydrology and forest cover changes – for the Mashel River sub-shed (McKane et al, 2018) – at 10 reach locations. Reach 0 at the west end of the model domain represents the simulation of USGS gage 12087000:

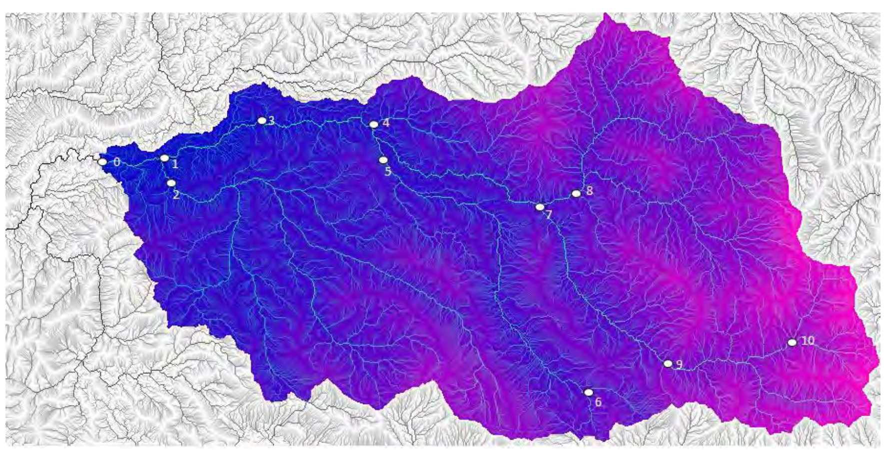

Figure: VELMA model domain for the Mashel Sub-basin showing the stream network, simulated gages at key reaches and boundary view (reproduced from McKane et al, 2018).

The VELMA modeling made a good approximation of the actual discharge in the Mashel River. Three other scenarios were simulated in the modeling: 1 year after clear-cut, 40 years after clear-cut and 240 years after clear-cut. The streamflow from the 240-year old forest stand is reported to be nearly indistinguishable at the streamflow from a 100-year-old forest stand (McKane, 2018; Abdelnour 2011; Abdelnour 2013). Lowest modeled streamflows were found at 40 years after clear-cut, while from 40 to 100 years, streamflows returned, approaching un-cut old-growth streamflows in the 100-year-old stand age modeling.

A recent study by Coble et al. (2020)[1] describes studies of the effect of forest stand age on stream low flows. A summary of effects from Coble et al (2020) and others describes a general pattern observed in response to clearcut:

1. Initial response: increased stream flow compared to pre-harvest (mature forest)
2. Regenerating stands: small, mixed, or variable responses (modern cutting programs may provide some improved recharge compared to historic clearcut methods)
3. Continued growth: decline in low flows
4. Mature forest: low flows return to pre-harvest conditions

The graph in Figure 1 summarizes the results from 19 catchments from a variety of studies. Flow reductions in Hydrologic period 3 were found in 17 of 19 studies.

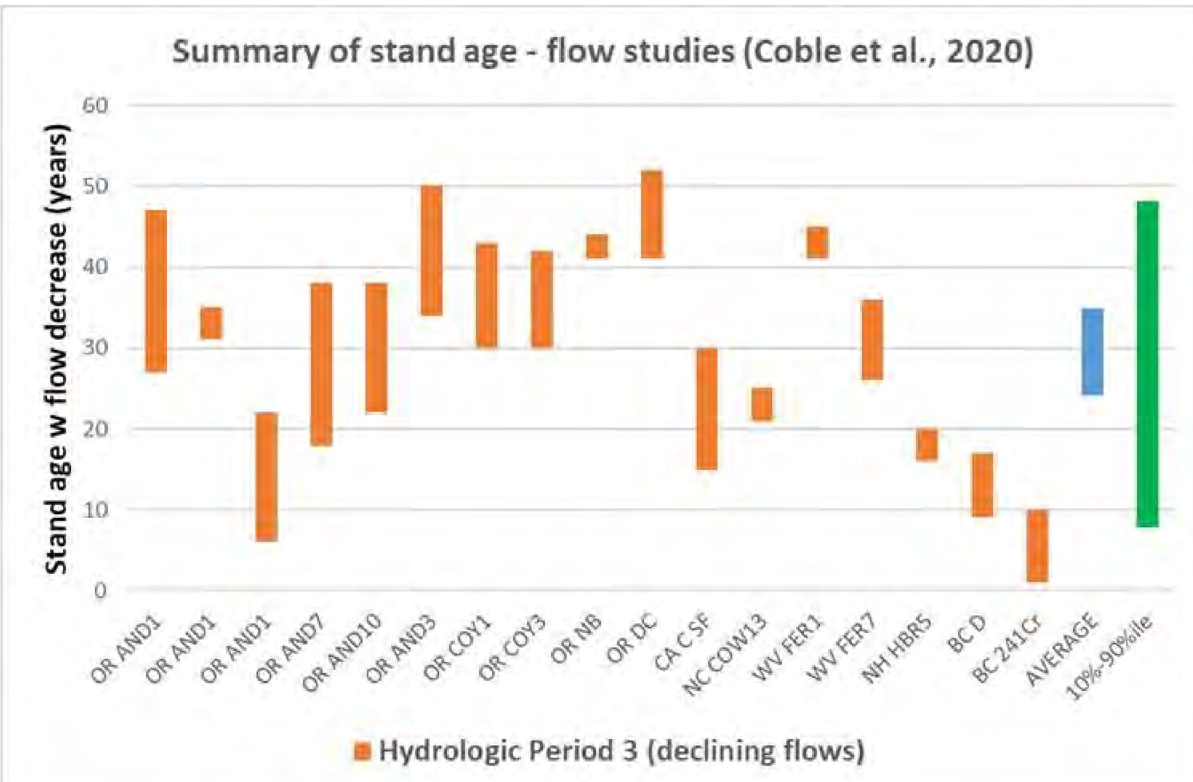

Figure 1. Summary of stand age studies (Coble et al., 2020)

This graph illustrates the effect of stand age. Study results indicate that stream flows decrease with stand ages from 10 to 50 years (10th percentile of onset year to 90th percentile of final year), and on the average between 25 and 35 years (average onset year to average final year). Commercial cut rotations tend to occur between 40 and 60 years.). In most cases, stream flows rebound to pre-harvest conditions at 35 to 50 years.

[1] Long-term hydrological response to forest harvest during seasonal low flow: Potential implications for current forest practices. Science of the Total Environment 730 (2020) 138926

Bob McKane from the EPA Corvallis Laboratory has developed a method to model the flow effects of stand age using the VELMA model. He applied this model to a study of the Nisqually Community Forest.[2] Figure 2 compares streamflows at 40- and 100-year forest stand ages.

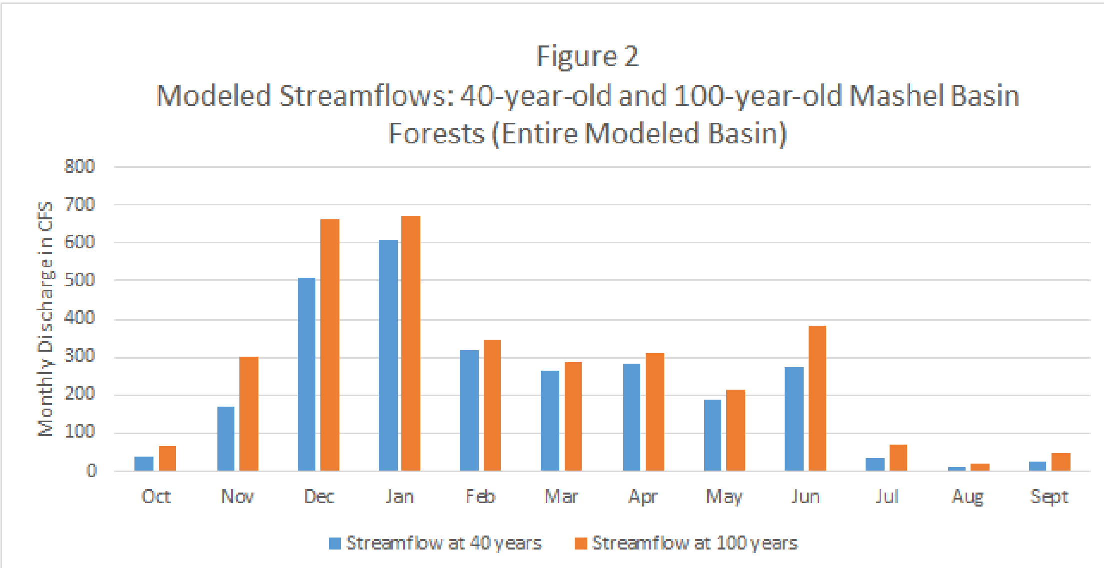

Figure 2. Modeled streamflows in the Mashel River basin (Nisqually Indian Tribe, 2019)

Using these assumptions, differences between monthly flows in the 40-year-old and 100-year-old VELMA simulations can be used to determine a unit acre of per-year streamflow increase that can be reasonably achieved for new Managed Forestry lands added to the potentially protected forest.

The uncertainties in this analysis must be acknowledged. Forest stand age affects hydrology through a complex variety of factors, which include:

- Geophysical and climate factors across any specific watershed, such as: latitude, climate, local weather patterns; watershed elevation, slope, and aspect; soils; and underlying geology.
- Average stand age, tree species composition, and parcel-scale cut patterns across the watershed.
- Patterns of forest harvest, such as the extent of clear-cut, patchy cutting strategies, riparian areas left intact, and management of debris.
- Other factors such as soil compaction and roads.

There are also possible differences between the effects in research study areas and effects in working forests subject to regional regulation, such Washington's Forests & Fish program and Habitat Conservation Plans.

[2] https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=CPHEA&dirEntryId=348155

Project concept

To meet the requirement of a project under RCW 90.94, a project just provide benefits indefinitely. From the research cited above, this suggests that protecting a forest stand so that it either: 1) remains uncut; or 2) is cut in a rotation of 80 years or more, could provide baseflow benefits. EPA's VELMA modeling tool could help to quantify those benefits.

Funding is limited for streamflow restoration, so directly funding fee-simple forest land acquisition is possible, but difficult. However, there may be opportunities to leverage acquisition for multiple purposes using a combination of Streamflow Restoration grants and other funding sources. Note that the focus of this proposal is projects with the voluntary cooperation of a landowner, and is not intended to address legal or regulatory issues.

Several kinds of forest protection projects appear to be viable for this kind of synergy: setting aside an area as conservation or community forest; habitat protection; and carbon sequestration. A project such as these that provides permanent protection for forest lands might meet Ecology criteria for a water offset if the benefits could be quantified. Another window of opportunity could be a project that would protect forest with low timber value, and where a project is on the borderline for water offset – but might be a candidate for funding with habitat or carbon sequestration funding. By adding in Streamflow Restoration grant funding, a project may be realized that would otherwise not reach financial viability.

With this in mind, a forest stand age project might include these elements:

- Project would need to be an area currently managed for timber harvest.
- Stand age management for streamflow protection can be either forest protection (total elimination of harvest), or management to an average stand age of 80 years or more.
- A project could access supplemental Streamflow Restoration funding to support permanent forest protection or stand age management, and also conduct the offset analysis to quantify benefits.
- If a project is funded through other sources and provides permanent forest protection or stand age management, only an offset analysis would be needed to quantify baseflow enhancement benefits.

Several factors would need to be evaluated as part of a feasibility study:

- Whether the project is in a basin with baseflow enhancement needs, including tributaries where perennial flows are threatened.
- Whether the project is large enough to provide significant baseflow enhancement downstream. Specific project areas could be of any size, but the greater the coverage of a tributary watershed, the more the presumed benefits.
- The ability to selectively harvest trees for a longer cut rotation. The literature suggests other methods could enhance streamflow, such as selective patchy cutting.
- Evaluation of the effect of site-specific factors through a spatial and modeling analysis.
- The economic implications for lengthening harvest or taking timber out of production, including

reduced employment and local revenues.

- There are corollary environmental and economic benefits from longer cut rotations that could be evaluated and quantified.

Next steps

- Include a categorical project that would allow for future specific projects, or support further research into this type of project to more clearly define the availability, structure, and suitability of potential projects, including assessing the potential social, economic, and environmental positive and negative impacts to the watershed and local communities.
- Identify specific opportunities that could be put forward for a suitable project.

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Hicks Lake stormwater retrofit

Description

The Ruddell Road Stormwater Facility was constructed by the City of Lacey in 1999, consisting of a pretreatment settling basin that flows to constructed wetlands; ultimately flowing into Hicks Lake. Although the facility is an improvement to the previous, untreated condition, the limited water quality wet pool volume, relatively high inflows, and flow-through design conditions, limit water quality treatment and provides minimal, if any, infiltration benefit. Therefore, the City is investigating the feasibility of an offset infiltration facility as an upgrade to the current system.

The proposed project would provide water offsets and ecological benefit (per RCW 90.94.030) to the Woodland Creek sub-basin. The improvements are expected to provide a significant shallow groundwater recharge component, and augment base flow to Hicks, Pattison, and Long Lakes, ultimately benefitting Woodland Creek, which is currently impaired by low instream flow (303d listing 6169). Proposed upgrades to the facility include a flow splitting manhole, filtration treatment BMP, infiltration gallery and an overflow structure to the existing wetland.

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

The delineated basin contributing to the existing stormwater system has an approximate total area of 346.46 acres. Stormwater runoff was modeled for the catchment by characterizing precipitation, soils, impervious surfaces, and land use composition. The proposed infiltration facility was sized according to potential stormwater flows, an assumed soil infiltration rate, and soil characteristics. A range of diversion flows were modeled (1cfs, 2cfs, and 3 cfs) were modeled and resulted in a corresponding range of average annual infiltration of 167, 244, and 296 afy, respectively. All flows, up to 3.5 cfs are expected to be 100% infiltrated, but infiltrating up to 3cfs accounts for reduction in infiltration capacity over time. Therefore, infiltrating up to 3 cfs for an offset benefit of 296 cfs is reasonable.

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

Figure 1 shows the general layout of the proposed infiltration facility, in series with the existing stormwater (water quality) treatment facility. Up to 3 cfs in stormwater flow would be directed to and infiltrated in the proposed facility. Any stormwater not infiltrated would still over into the existing facility, and flow into Hicks Lake.

Figure 1. Layout of Proposed Infiltration Facility

Description of the anticipated spatial distribution of likely benefits

The infiltrated stormwater would seep into Hicks Lake. Hicks Lake is the headwaters of the Woodland Creek watershed. Water in Hicks Lake flows through Pattison Lake, Long Lake, and then into Woodland Creek. Infiltrated stormwater would reduce flood flows and presumably increase base flows in the entire system during non-storm periods.

Performance goals and measures.

Performance will be measured in terms of infiltration. Stormwater flows and infiltration capacity (or bypass to the water quality BMP) will be measured or observed, for effectiveness.

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

Woodland Creek supports spawning populations of coho, chum, and Chinook salmon (WDF 1975; WDFW 2020). Steelhead trout has documented presence. These salmonids are present from Henderson Inlet to Long Lake. Within this reach, the creek is seasonally dry from Lake Lois to Beatty Springs, north of Martin Way. The watershed is heavily urbanized in the headwaters, contributing to reduced summer flows. This project will contribute to moderating the effects of urban stormwater impacts.

Identification of anticipated support and barriers to completion.

The City supports this project. The project will be on property the City is planning to purchase, and the City does not anticipate any barriers to completion.

Potential budget and O&M costs.

The preliminary OPCC totals approximately $3.3 million for the proposed facilities as currently envisioned (Attachment A).

Anticipated durability and resiliency.

The project would have lasting benefits as it would be actively managed by City.

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

The project sponsor is the City of Lacey. The City is ready to implement this stormwater retrofit project, commensurate with funding.

References

WDF (Washington Department of Fisheries), 1975. "A Catalog of Washington Streams and Salmon Utilization, WRIA 13."

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

Attachment A - Opinion of Probable Costs of Construction (OPCC) - Concept Plan Level

Note: Preliminary OPCC does not include sales tax, design, CM, property acquisition, legal, and other administrative/legal costs

Total OPCC: $3,295,000

Item	Description	Unit	Unit Cost	Qty	Cost	Comments
	General Requirements - Stormwater Facilities					
1	Mob/Demob, Survey, Temp Facilities, Utilities Protection, Traffic Control, etc.	ls	331,000	1	$331,000	15% of Items below
	Flow Splitter at Connection to Existing SD					
2	Flow Splitter Vault with Adjustable High Flow Bypass Weir	ls	$60,000	1	$60,000	Precast vault with interior lateral weir wall with alluminum adjustable weir plate - assume 8'X16' vault size
	Water Quality Pre-Treatment					
3	Pre-treatment Facilities Prior to Groundwater Discharge	cfs	$80,000	3	$240,000	Pre-settling vault and/or hydrodynamic separator(s) - allowance for 3 cfs capacity
	Drainage Conveyance System					
4	12" Dia. Storm Drain (Polypropylene)	lf	$60	700	$42,000	Collective 12" conveyance SD; 4' - 6' Depth
5	Catch Basin Type 1	ea	$4,000	4	$16,000	Collective Type 1 CBs, 5' Std Depth
6	Catch Basin Type 2	ea	$7,000	2	$14,000	Collective Type 2 CBs, 6' - 10' Depth

7	Catch Basin Type 2 Emergency Overflow w/Debris Rack	ea	$10,000	1	$10,000	Overflow spillway from infiltration gallery to existing constructed wetland; debris cage
8	Trench Excavation Safety Systems	ls	$7,000	1	$7,000	All conveyance facilities
	Earthwork					
9	Construction TESC Control and Compliance	ls	$70,000	1	$70,000	CSWPPP, TESC, SPCC, Temp Treatment, Discharge, CSGP Monitoring/Compliance
10	Clearing, Grubbing, Disposal	ac	$14,000	3.0	$42,000	Forrested parcel; on-site processing with grinder assumed
11	Infiltration Facility Pad Excavation Incl Haul, Disposal	cy	$20	32,000	$640,000	Assumes excess material disposal within 5 mi
12	Infiltration Gallery Footprint Excavation, Haul, Disposal	cy	$24	6,500	$156,000	Assumes excess material disposal within 5 mi
13	Shoring or Extra Excavation	ls	$15,000	1	$15,000	Temporary shoring for gallery excavation
	Infiltration Gallery					
14	Storm HDPE Arch Infiltration Chambers	lf	$40	12,000	$480,000	16" high HDPE arch infiltration chambers
15	Crushed Stone - 1.5" Fractured/Washed	cy	$55	4,500	$247,500	Infiltration chambers zone backfill
16	Geotextile	sy	$4	5,500	$22,000	Separation geotextile from overlying soils
17	Topsoil	cy	$40	1,100	$44,000	Topsoil above gallery and in disturbed fringe areas
18	Access Road Restoration - AC Pavement	sy	$36	1,200	$43,200	Perimeter 1,100' X 10'W access road and connection to Ruddell Rd
19	Gallery Footprint Restoration Seeding	ls	$5,000	1	$5,000	Grass surface restoration above infiltration gallery
20	Perimeter landscape Plantings and Irrigation	ls	$50,000	1	$50,000	Landscaping allowance

Subtotal	**$2,534,700**
Construction Contingency (Planning Level, 30%)	**$760,410**

Managed Aquifer Recharge Projects in WRIA 13

Description

The WRIA 13 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.

The total potential offset from all project locations is 909 acre-feet/year (AFY); however ,the Committee acknowledged that potential projects located in streams with year-round closures (Chapter 173-513 WAC) should be removed from the overall total, resulting in a potential offset of 811 AFY.

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

Potential MAR locations were determined based on a screening process (Attachment A). Areas in WRIA 13 with the following features were considered for candidate locations:

- Favorable soils and surficial geology-
    - Soils mapped in hydrologic groups A and B with all soil layers having a permeability greater than 2 inches per hour.
    - Surficial geology primarily composed of sand and/or gravel.
    - Exclude areas with low permeability surficial geology (i.e. silt, clay, bedrock).
    - Exclude wetlands, lakes, and high groundwater areas.

- Depth and thickness of aquifer
    - o Depth to water of 8 feet or greater.
    - o Surficial aquifer saturated thickness of 10 feet or greater.
- Distance to potential water source
    - o Favorable MAR locations were defined as those within 0.25 and 0.5 miles from a potential donor stream or river.

This screening resulted in favorable areas and specific locations for consideration during WRE Plan implementation (Figure 1; Table 1). Tier 1 locations are favorable in terms of land ownership, property size, and relative net ecological benefit (i.e. significant use by anadromous salmonids). Tier 2 locations are either located farther than 0.5 miles from a stream or are near a source water closed to further appropriation. At the WRIA 13 committee's request, potential locations were identified on the Cooper Point, Boston Harbor, and Johnson Point, and Woodland Creek subbasins with less restrictive criteria (Appendix A). Many tier 2 locations were identified that do not have nearby source waters. These sites may be considered for future stormwater infiltration projects.

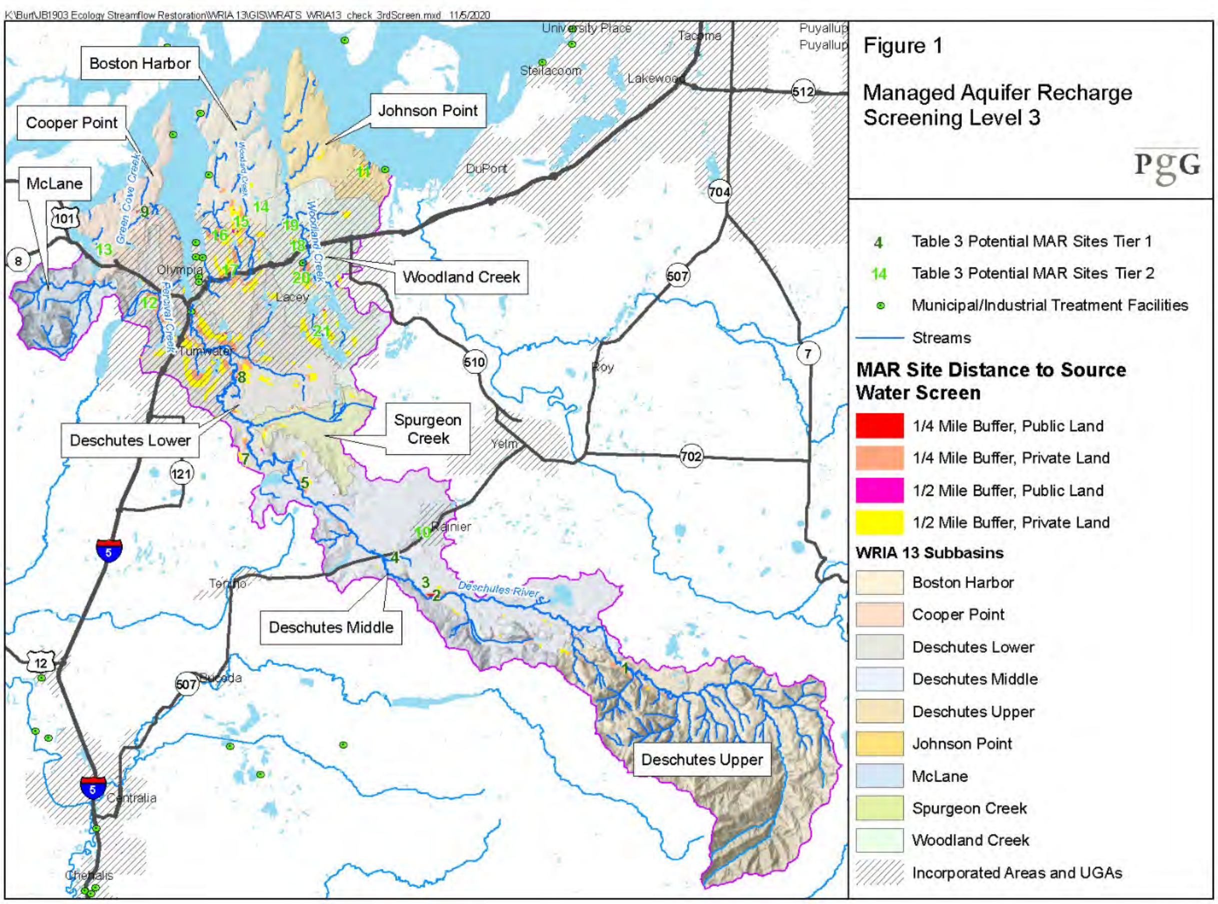

Figure 1. Areas favorable for MAR locations and potential MAR sites.

Table 1. Potential managed aquifer recharge locations.

Tier	Site #	Subbasin	Location	Source Stream
1	1	Deschutes Upper	South of Clear Lake	Deschutes River
1	2	Deschutes Middle	Rainier View Park	Deschutes River
1	3	Deschutes Middle	North of Rainier View Park	Deschutes River
1	4	Deschutes Middle	Route 507, SW of Raymond	Deschutes River
1	5	Deschutes Middle	East of Offut Lake	Deschutes River
1	6	Deschutes Lower	Thurston County Roads Gravel Pit, Waldrick Rd SE	Deschutes River
1	7	Deschutes Lower	Middle Deschutes Property	Deschutes River
1	8	Deschutes Lower	Alpine Sand and Gravel, Rixie Road	Deschutes River
1	9	Cooper Point	Cooper Point	Green Cove Creek
2	12	Deschutes Lower	Lower Percival Creek, SPSCC	Percival Creek
2	14	Boston Harbor	Former borrow pit	Woodard Creek
2	15	Boston Harbor	Private	Woodard Creek
2	16	Boston Harbor	Mission creek	Mission creek
2	17	Boston Harbor	Near 4th Avenue E and Interstate 5	Indian Creek
2	18	Woodland Creek	Property with kettle pond on 15th Avenue NE	Woodland Creek
2	19	Woodland Creek	Near Pleasant Glade Road	Woodland Creek
2	20	Woodland Creek	Near Dept. of Ecology Headquarters	Woodland Creek

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.

Source Water Availability and MAR Facility Sizing

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 and the number of days when flows may be diverted were determine in two different ways, depending on whether the stream has minimum instream flows or not.

Diversion flows were proposed based on maintaining minimum instream flows and habitat forming processes (i.e. ecological flows). Diversion flows in streams and rivers with minimum instream flows (i.e. the Deschutes River) were set at 2 percent of wet season (November – April) minimum flows (e.g. 2% of 400 cfs equals 8 cfs for the Deschutes River). 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. These "diversion days" were summed across the wet season (November – April) for each water year in the flow record. The average and minimum number of diversion days were calculated across all water years in the flow record.

When a stream or river does not have minimum instream flows, the 75th percentile flows for each month across the entire flow period of record was calculated. Diversion flows were proposed based on 2% of the average 75% percentile flows during November – April. Diversion of flow to an MAR facility could occur during days when flows exceed 75th percentile flows. Flows would exceed 75% percentile flows 25% of the time (i.e. 45 days during the November – April wet season).

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.

Deschutes Upper and Middle

Water availability in the upper to middle Deschutes may be approximated by flows the USGS 12079000 gage near Rainier, WA (Figure 2). The Deschutes River is closed to consumptive appropriations between April 15 – October 15 (Chapter 173-513 WAC). From October 16 – April 14, there are variable minimum flows, with the greatest minimum flow of 400 cfs, as measured at the downstream control point, the USGS 12080010 gage at Tumwater, WA.

The capacity and appropriateness of potential MAR projects in the Upper and Middle Deschutes should be guided by local flows, but the maximum quantity of potential MAR diversion flows is based on meeting minimum instream flows at the downstream control point, the USGS 12080010 gage at Tumwater, WA (see Deschutes Lower Section).

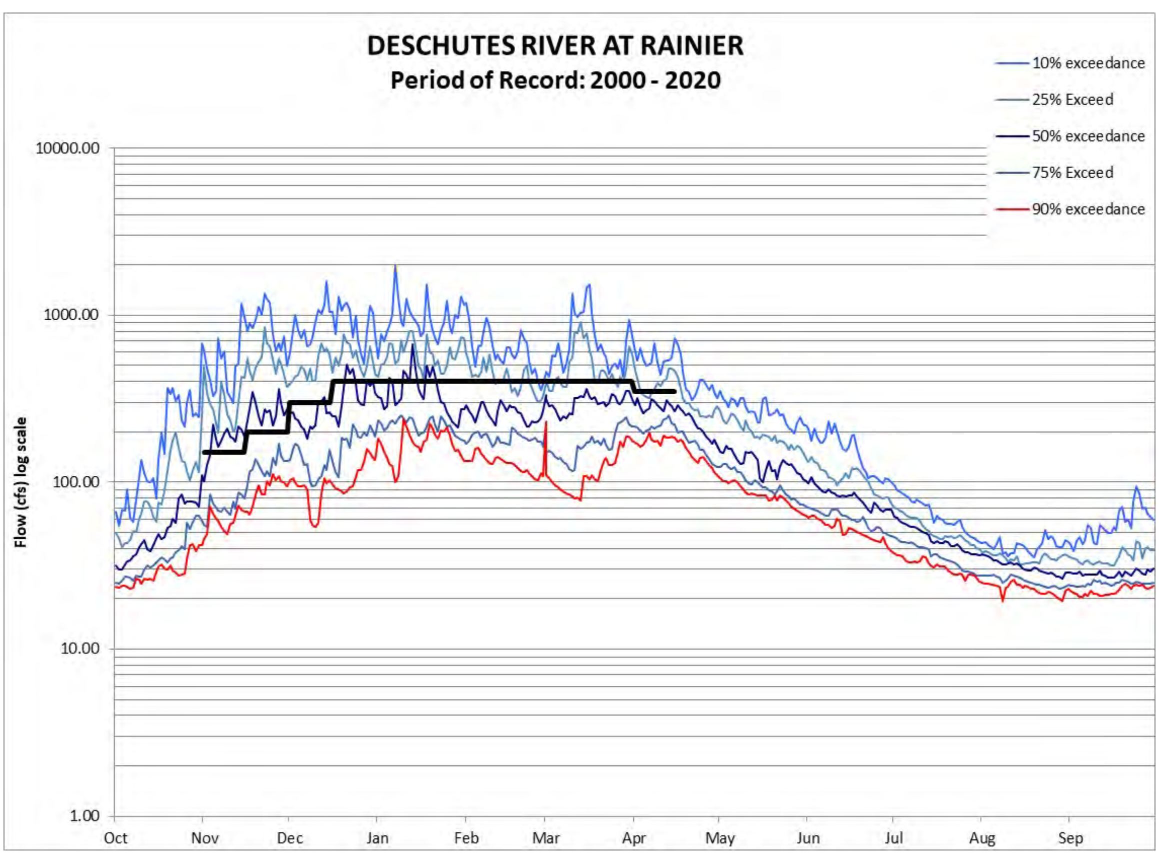

Figure 2. Deschutes River at Rainier (USGS Station 12079000) daily flow exceedances, from 2000 – 2020.

Deschutes Lower

Water availability in the Lower Deschutes may be approximated by flows the USGS 12080010 gage at Tumwater, WA (Figure 3). The Deschutes River is closed to consumptive appropriations between April 15 – October 15 (Chapter 173-513 WAC). From October 16 – April 14, there are variable minimum flows, with the greatest minimum flow of 400 cfs.

Potential diversion flows for the Deschutes River is two percent of maximum wet season minimum flows (400 cfs), or approximately 8 cfs. Potential diversion days range from 50 – 108 days per year (Table 2). Diverting 8 cfs for 50 – 108 days, would equal 792 – 1,712 afy of water diverted and infiltrated for subsequent seepage into the river throughout the year. These flows could be diverted and conveyed to one or more MAR facilities. A scenario of splitting the 8 cfs among four MAR sites is depicted in Table 5.

In the Lower Deschutes subbasin, a potential MAR location was also identified near Percival Creek (Figure 1; Table 1). Percival Creek is a closed stream (Chapter 173-513 WAC). However, diverting water from the stream for MAR infiltration may be feasible with a rule change to accommodate these flow restoration projects. Measured flows near the potential MAR location are near zero in the summer and range from 11 - 15 cfs in the wet season (Table 3). If an MAR project were to occur at this location, it could be small-scale, approximately 0.2 cfs diversion when flows exceed 10 cfs (Table 5). The diversion period is likely around 45 days per year. This would result in an offset of around 18 afy (Table 5).

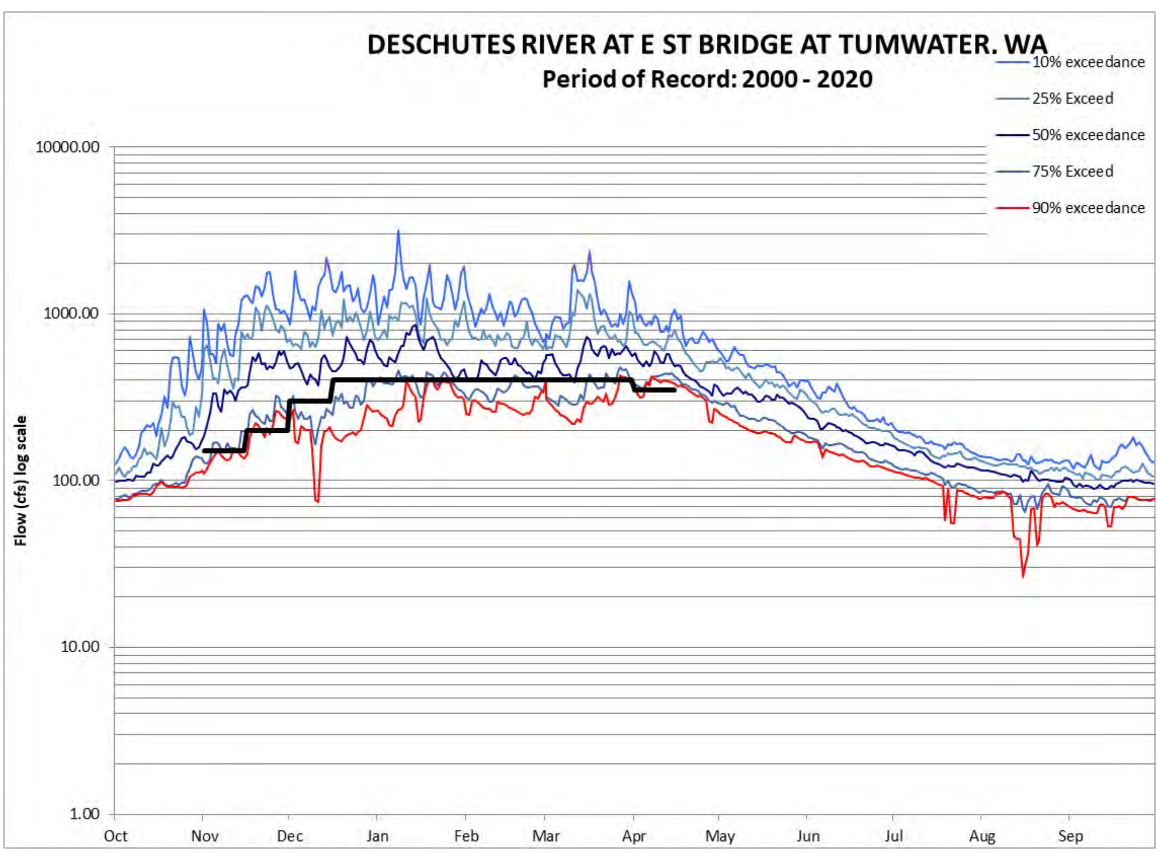

Figure 3. Deschutes River at Tumwater (USGS Station XXX) daily flow exceedances, from 2000 – 2020.

Table 2. Number of days when flows are at least five percent greater than minimum flows during the wet season (November – April). Deschutes River At E St Bridge at Tumwater, WA (USGS 12080010).

Month	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
January	25	0	31	17	21	8	31	29	25	25	26	29	22	20	11	22	31	12	31	16	30
February	27	2	28	16	20	0	21	13	22	1	10	11	29	15	19	12	27	24	26	13	21
March	30	0	29	24	6	5	0	31	25	16	9	31	31	24	31	17	31	31	20	3	2
April	6	3	9	15	0	15	0	15	15	15	15	15	15	12	14	15	15	15	10	9	6
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
November	6	22	1	15	17	26	27	19	22	30	30	26	30	29	30	30	30	26	19	0	7
December	2	31	10	26	10	13	31	30	4	13	31	8	29	7	24	30	29	21	22	9	0
Sum	**96**	**58**	**108**	**113**	**74**	**67**	**110**	**137**	**113**	**100**	**121**	**120**	**156**	**107**	**129**	**126**	**163**	**129**	**128**	**50**	**66**
Min	**50**																				
Avg	**108**																				

Cooper Point

In the Cooper Point subbasin, a potential MAR location was identified near Green Cove Creek (Figure 1; Table 1). Green Cove Creek does not have any instream flow closures or minimum flows (Chapter 173-513 WAC). Measured flows near the potential MAR location are near zero in the summer and range from 7 – 11 cfs in the wet season (Table 3). If an MAR project were to occur at this location, it could be small-scale, approximately 0.2 cfs diversion when flows exceed 10 cfs (Table 5). The diversion period is likely around 45 days per year. This would result in an offset of around 18 afy (Table 5).

Boston Harbor

In the Boston Harbor subbasin, potential MAR locations were identified near Woodard Creek (Figure 1; Table 1). Woodard Creek is a closed stream (Chapter 173-513 WAC). However, diverting water from the stream for MAR infiltration may be feasible with a rule change to accommodate these flow restoration projects. Measured flows near the potential MAR location are near zero in the summer and range from 10 – 17 cfs in the wet season (Table 3). If an MAR project were to occur at this location, it could be small-scale, approximately 0.2 cfs diversion when flows exceed 10 cfs (Table 4). The diversion period is likely around 45 days per year. This would result in an offset of around 18 afy (Table 5).

Potential MAR locations were also identified near Mission Creek and Indian Creek (Figure 1; Table 1). However, flow in these streams are very small during all seasons (Table 3) and also have very little value for anadromous salmonids. Therefore, diverting water from these streams for MAR infiltration may not be feasible.

Woodland Creek

In the Woodland Creek subbasin, potential MAR locations were identified near Woodland Creek (Figure 1; Table 1). Woodland Creek is a closed stream (Chapter 173-513 WAC). However, diverting water from the stream for MAR infiltration may be feasible with a rule change to accommodate these flow restoration projects. Measured flows near the potential MAR location are near zero in the summer and range from 10 – 17 cfs in the wet season (Table 3). If an MAR project were to occur at this location, it could be small-scale, approximately 0.7 cfs diversion when flows exceed 48 cfs (Table 4). The diversion period is likely around 45 days per year. This would result in an offset of around 62 afy (Table 5).

If fully implemented, the total quantity of water potentially diverted and infiltrated at MAR sites in WRIA 13 range from 909 – 1,830 afy (Table 5).

Table 3. Average measured monthly flow at Green Cove, Indian, Mission, Percival, Woodard, and Woodland Creeks.

Month	Green Cove Creek @ 36th Avenue NW	Indian Creek Mouth @ Quince Street SE	Mission Creek @ Boston Harbor Road	Percival Creek @ Pedestrian Footbridge	Woodard Creek @ 36th Ave NE	Woodland Creek @ Pleasant Glade Road	Woodland Creek @ Desmond Drive Ecology HQ
January	10.9	6.0	2.2	11.8	13.9	44.8	12.8
February	7.2	5.2	1.2	15.1	12.9	45.7	9.4
March	10.1	7.1	1.6	11.9	16.6	51.2	8.0
April	4.7	3.3	0.8	9.0	12.7	44.3	17.9
May	2.5	2.9	0.6	8.7	10.0	34.1	8.6
June	1.0	2.0	0.4	6.7	7.3	24.4	4.1
July	0.3	1.4	0.5	3.3	5.4	17.8	2.0
August	0.2	1.2	0.3	2.7	4.4	14.6	1.4
September	0.6	1.1	0.3	3.3	4.7	14.3	0.5
October	2.1	2.4	0.9	6.4	6.2	16.0	0.1
November	7.6	4.5	0.4	14.1	10.2	24.5	1.0
December	11.2	5.8	1.9	11.6	12.4	35.3	5.5

Table 4. Seventy-Fifth percentile of monthly flows during the period of record at Green Cove, Woodland, and Woodard Creek and monthly average flows for Percival Creek.

Month	**Green Cove Creek at Bulter Cove FS**	**Woodland Creek at Pleasant Glade Rd.**	**Woodard Creek at 36th Ave NE**	**Percival Creek at SPSCC**
Period of Record	2009 - 2020	2008 - 2020	2008 - 2020	2009 - 2015
January	15.9	51.9	14.9	11.8
February	9.0	52.3	14.9	15.1
March	12.4	56.7	18.7	11.9
April	5.5	53.8	14.7	9.0
May	3.1	40.8	11.1	8.7
June	1.8	28.6	8.2	6.7
July	0.6	21.1	6.0	3.3
August	0.2	16.2	4.4	2.7
September	0.3	16.3	4.7	3.3
October	1.5	19.1	5.8	6.4

November	8.1	30.8	10.8	14.1
December	11.6	44.3	13.8	11.6
Average	**10.4**	**48.3**	**14.6**	**12.3**
Diversion	**0.2**	**0.7**	**0.2**	**0.2**
Diversion Days	**45**	**45**	**45**	**45**

Table 5. Potential MAR site locations, facility sizes, and water offsets.

Subbasin	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)
Deschutes Upper	Deschutes River	South of Clear Lake	12,400	2	50	8,640,000	198	108	18,662,400	428
Deschutes Middle	Deschutes River	Rainier View Park	12,400	2	50	8,640,000	198	108	18,662,400	428
Deschutes Middle	Deschutes River	North of Rainier View Park	12,400	2	50	8,640,000	198	108	18,662,400	428
Deschutes Middle	Deschutes River	Route 507, SW of Raymond	12,400	2	50	8,640,000	198	108	18,662,400	428
Deschutes Middle	Deschutes River	East of Offut Lake	Reserve		Reserve			Reserve		
Deschutes Lower	Deschutes River	TC Roads Gravel Pit, Waldrick Rd SE	Reserve		Reserve			Reserve		
Deschutes Lower	Deschutes River	Middle Deschutes Property	Reserve		Reserve			Reserve		
Deschutes Lower	Deschutes River	Alpine Sand and Gravel, Rixie Road	Reserve		Reserve			Reserve		
Cooper Point	Green Cove Creek	Cooper Point	1,240	0.2	45	777,600	18	45	777,600	18
Deschutes Lower	Percival Creek	Lower Percival Creek, SPSCC	1,240	0.2	45	777,600	18	45	777,600	18

Boston Harbor	Woodard Creek	Former borrow pit	1,240	0.2	45	777,600	18	45	777,600	18
Boston Harbor	Woodard Creek	Private	Reserve		Reserve			Reserve		
Boston Harbor	Mission creek	Mission creek	Inadequate Flow		Inadequate Flow			Inadequate Flow		
Boston Harbor	Indian Creek	Near 4th Avenue E and Interstate 5	Inadequate Flow		Inadequate Flow			Inadequate Flow		
Woodland Creek	Woodland Creek	Property with kettle pond on 15th Avenue NE		0.7	45	2,721,600	62	45	2,721,600	62
Woodland Creek	Woodland Creek	Near Pleasant Glade Road	Reserve		Reserve			Reserve		
Woodland Creek	Woodland Creek	Near Dept. of Ecology Headquarters	Reserve		Reserve			Reserve		
						Total	909		Total	1,830

Diversion

Capture and recovery methods would vary by water source but would likely 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 13 Committee acknowledges that some diversion methods including in-channel structures may pose an impact to fish habitat, and strongly advocates 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 13 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.

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.

Thurston County will likely support and implement these projects, with potential support from other partners and an implementation group.

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 811 AFY estimated as potential offset for WRIA 13 (does not include streams closed year-round this would equate to ~$2.8 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 has indicated that they will take a lead role in implementing these projects. However, other project partners and sponsors may occur and would benefit implementation.

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

Favorable MAR Areas and Potential Locations

Technical Memorandum

To: Department of Ecology WRIA 13 Watershed Restoration and Enhancement Committee

From: Glenn Mutti-Driscoll, LHG Pacific Groundwater Group

Re: 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 Water Resources Inventory Area (WRIA) 13, Deschutes. MAR project sites potentially can support watershed restoration and enhancement projects within the WRIA. This work was completed by Pacific Groundwater Group (PGG) on behalf of the WRIA 13 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 13, PGG used regional data to assist the Committee in selecting properties within WRIA 13 that appear to have favorable infiltration characteristics and a close enough proximity to water so that MAR may occur. MAR projects could potentially offset the impacts of permit exempt wells on WRIA 13 streams. This memorandum outlines the methodology used to identify potentially favorable MAR project sites.

PROCEDURE

Regional soils, geologic, and hydrologic data coverages were compiled for WRIA 13 using Geographic Information System (GIS) software. A series of screening criteria were then applied to identify sites that appear most favorable.

Screening Level 1- Soils and Surficial Geology

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

- Soils types mapped on the County level by NRCS (Pringle, 1990) were reviewed and only soils in hydrologic groups A and B where all layers within the mapped soil type had a permeability greater than or equal to 2 inches per hour were retained as favorable for infiltration. **Table 1** lists these soils.

- 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. 1:24,000 geologic maps by the Washington State Department of Natural Resources (DNR) exist for most of WRIA 13 (including Logan and others (2003); Logan and others (2009); Walsh and others (2003); and Walsh and others (2005)), in areas of the upper watershed where 1:24,000 geologic mapping does not exist a regional 1:100,000 map by DNR was used (Schasse, 1987). **Table 2** lists geologic units identified as favorable for MAR.
- Wetlands, lakes, and high groundwater areas as mapped by Thurston County were excluded from favorable infiltration areas.

Areas that meet the Level 1 screening criteria are shown in **Figure 1**.

Screening Level 2 – Depth and Thickness of Aquifer

The second screen focused on removing areas with potentially shallow groundwater or a thin aquifer that may prevent it from transmitting infiltrated water away from a MAR facility. Thurston County provided output from its county-wide groundwater flow model[78] for use in assessing the water-table depth and the surficial aquifer saturated thickness. No regional-scale piezometric surface map exists for the surficial aquifer, and therefore output from Thurston County's groundwater model is considered the best available data source[79]. The following screening criteria were applied to areas identified as having favorable infiltration characteristics from the first level screen:

- A depth-to-water in the surficial aquifer of eight feet or greater was assumed necessary for MAR to be feasible. This depth was selected to allow a groundwater mound of at least five to develop under an infiltration trench or basin, with the uppermost three feet assumed necessary for basin/trench construction and to provide a vadose zone between the base of the infiltration facility and the top of the groundwater mound. This assumed eight foot depth-to-water screening value is somewhat arbitrary (in actuality groundwater mounding beneath a MAR site will be dependent on local soil and aquifer permeabilities), but was applied to screen out areas having marginal vadose zone thickness that most likely could not support long-term concentrated infiltration.
- A surficial aquifer saturated thickness of 10 feet or greater was assumed necessary for MAR to be feasible. The surficial aquifer saturated thickness was calculated using layer thicknesses and

[78] Head data from groundwater flow model version 186 and layer thicknesses from model version 169 were used for this analysis. It should be noted that Thurston County's groundwater flow model continues to be locally improved and calibrated, therefore water level and aquifer thickness values applied for this analysis may differ from values obtained from a later version of the model.

[79] Though the Thurston County groundwater model is the best available data source for county-wide water level data, considerable uncertainty is present in modeled shallow aquifer water levels due to limited calibration data (most water supply wells are installed in deeper aquifers than the water table aquifer).

simulated water table elevations from the Thurston County groundwater flow model. Generally the surficial aquifer saturated thickness equaled the saturated thickness of model Layer 1 (representing Vashon recessional outwash or alluvium), but in areas where the Layer 2 aquitard (Vashon till) was absent, the saturated thickness was calculated using the combined saturated thickness of model Layers 1, 2, and 3 (including representation of Vashon advance outwash). The 10-foot saturated thickness screening criteria applied is also somewhat arbitrary (local hydraulic conductivity values will have a significant impact on aquifer transmissivity), but is intended to remove areas where the aquifer transmissivity may be too low efficiently transmit infiltrated water away from the MAR facility.

Areas that meet the Level 2 screening criteria are shown in **Figure 2**.

Screening Level 3- Distance to Potential Source Water

The third screen focused on identifying areas in close proximity to potential MAR source waters. The following screening criteria were applied to areas identified as having favorable infiltration characteristics from the second level screen:

- Favorable MAR areas were defined as those within ¼ and ½ mile from a potential source water.
- Locations within ¼ and ½ mile from a potential source waters were subdivided into publicly or land-trust owned lands and privately owned lands. Public and land-trust lands potentially are more likely to be developed into MAR sites based on the conservation goals of those entities, and therefore were specifically identified where applicable.
- Potential source water locations included streams and municipal or industrial wastewater treatment plants (WWTPs). In addition to envisioned MAR approaches for stream and water treatment plant source waters, other potential source waters and guiding concepts were considered but not analyzed, as listed below.
    - For stream sources MAR would occur in the wet season (roughly November to mid-April) when instream flow requirements are met on the Deschutes River and its tributaries. Optimally, stream water recharged in the wet season would return to the stream during periods of water scarcity (e.g. summer and fall). Both distance-to-stream and aquifer properties control the timing for seasonal recharge to reach targeted streams.
    - For WWTP sources, treated effluent would be used for infiltration. In practice no potentially favorable sites reliant on treated water were identified, but if a site is identified in the future, a site-specific review of effluent and aquifer water quality criteria would be necessary.
    - Existing and planned reclaimed water pipelines were not included in this analysis as LOTT is not currently producing excess reclaimed water. However, changes in reclaimed water production, demand, and the construction of future conveyance pipelines could make reclaimed water be a more viable MAR source water in the future.

- Stormwater was not included in this analysis as no potential future projects were identified in the areas of interest by the Committee. However, this does not preclude runoff generated from future stormwater projects being used as a source water in areas with favorable soils and geology.
- Source water from wells pumping deeper aquifers was not considered as part of this analysis because water right acquisition would likely be required.
- A MAR approach that was not investigated but could be pursued in the future for glacial till areas is the injection of water through wells into the underlying Vashon advance outwash, which has significantly higher permeability than glacial till. Underground Injection Control regulations and source water quality criteria would need close review as part of this analysis.

Areas meeting the Level 3 screening criteria are shown in **Figure 3**. PGG also identified potential Tier 1 MAR sites based on the above screening criteria along with consideration of land ownership, property size, and relative net ecological benefit (NEB). Potential Tier 1 MAR sites are numbered on **Figure 3** and listed in **Table 3. Table 3** notes whether target receiving streams are salmon-bearing, if gopher soils are present on the site, associated flow restriction periods for the source water, and other relevant observations.

Figure 3 and **Table 3** also identify potential Tier 2 MAR sites. Tier 2 sites are either located farther than ½ mile from a stream or WWTP or are near a source water closed to further appropriation. The relative NEB for these sites will vary from relatively low (for sites located far from streams) to very high (for sites located by streams closed to further appropriation). At the Committee's request PGG reviewed the Deschutes Middle, Johnson Point, Cooper Point, Boston Harbor, and Woodland Creek subbasins to identify potential Tier 2 MAR sites. MAR at Tier 2 sites likely could occur with the identification of other non-stream/WWTP source waters. Tier 2 MAR sites are good potential candidates for future stormwater infiltration projects.

FUTURE STEPS

Site specific feasibility analyses for Tier 1 properties listed on **Table 3** should be pursued, and possibly for Tier 2 sites as well. Initial feasibility considerations will include 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.

Sites listed on **Table 3** are specific properties that have been identified as likely having favorable MAR characteristics. It is likely that favorable MAR sites exist elsewhere in WRIA 13 but were not identified in this analysis based on the regional nature of the available data and the focus of surficial infiltration (and not subsurface injection). Though **Figure 3** is the best approximation of favorable surficial infiltration MAR sites in WRIA 13 using available data, the lack of local water level and geologic data most likely has caused areas with favorable MAR characteristics to not be identified. The set of regional screening maps (**Figures 1 – 3**) can and should be used for the future evaluation of properties, but results from any local or site specific hydrogeologic studies should generally be deferred to over the findings of this regional inventory. Local soil or geologic heterogeneities are generally not reflected in regional data sets, and observed depth to groundwater data will be more accurate than the regionally modeled depths used for this analysis. PGG (2019) presents a more localized infiltration analysis based on observed water levels in portions of the Deschutes Lower and Deschutes Middle subbasins that should also be referred to if future identified sites are within the report study area.

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JB1903

Schneider's Prairie Off-Channel Storage-and-Release

(Thurston County ID 122)

PROJECT DESCRIPTION

Description

The Schneider's Prairie Off-Channel Storage-and-Release Project (Project) is located on the east (right) bank of the Deschutes River, west of the Keanland Park Lane SE, in north-central Thurston County (Figure 1), Deschutes River (Mainstem Lower) draft management unit. The Project includes Ayers Spring/Pond and Ayer Creek within Schneider's Prairie (Figure 2).

This project will restore hydrologic connectivity between the Deschutes River and Schneider's Prairie. Schneider's Prairie is a depressional feature that contains the Ayer Creek drainage. Paleochannels apparent from aerial photos and LiDAR images show that multiple channels historically connected the Deschutes River with Schneider's Prairie. Reconnecting the Deschutes River with Schneider's Prairie and Ayer Creek would provide rearing habitat and flood refugia for juvenile salmonids, stormflow attenuation, and water infiltration for later-season release to augment flow in the lower Deschutes River.

The project concept is to deepen an existing floodplain paleochannel that would hydrologically connect the Deschutes River to Schneider's Prairie (Figure 2). Schneider's Prairie contains Ayers Pond and Ayers Creek. The deepened paleochannel would be connected to the existing Ayers Creek that runs north and back to the Deschutes River. The paleochannel and Ayers Creek would be roughened with large woody debris (LWD) and beaver dams (analogs and beaver introduction) to flood adjacent floodplain habitat and pond creek flow. Ayers Creek would be realigned with a meander pattern (correcting historical ditching). Ayers Creek would be modified near the mouth using biotechnical techniques (e.g. buried logs and log jams) to maintain grade control at an elevation that would inundate a portion of the off-channel area during high flow events (152 ft NAVD88). The seasonal inundation would result in infiltration and subsequent seepage back to the river on the time scale of days to months.

The existing paleochannel will be deepened to convey water from the Deschutes River to Ayers Creek, within the off-channel feature. The connection point of the paleochannel to the Deschutes River will be through an abandoned oxbow that fills with river water from the downstream end during moderate and high flows. Connecting the paleochannel to the Deschutes River through the oxbow is expected to provide a stable, low-energy connection to the river, and it appears that the paleochannel naturally connects there. The deepened paleochannel could have an invert elevation of 155 ft (NAVD88) that would convey water from the river to the off-channel feature when Deschutes River flows are above 400 cfs. In this design scenario, when the river is flowing above 400 cfs, the channel would begin conveying water to the off-channel feature.

Schneider's Prairie is a broad depressional off-channel feature that contains an extensive wetland, including Ayers Springs and Ayers Creek. Diverted floodwaters would inundate about 52 acres of this feature, below an elevation of 152 ft (NAVD 88 datum), frequently during the months of November – April, and infrequently during the shoulder months of May, June, September, and October. Ponded water will infiltrate and seep back into the Deschutes River over time.

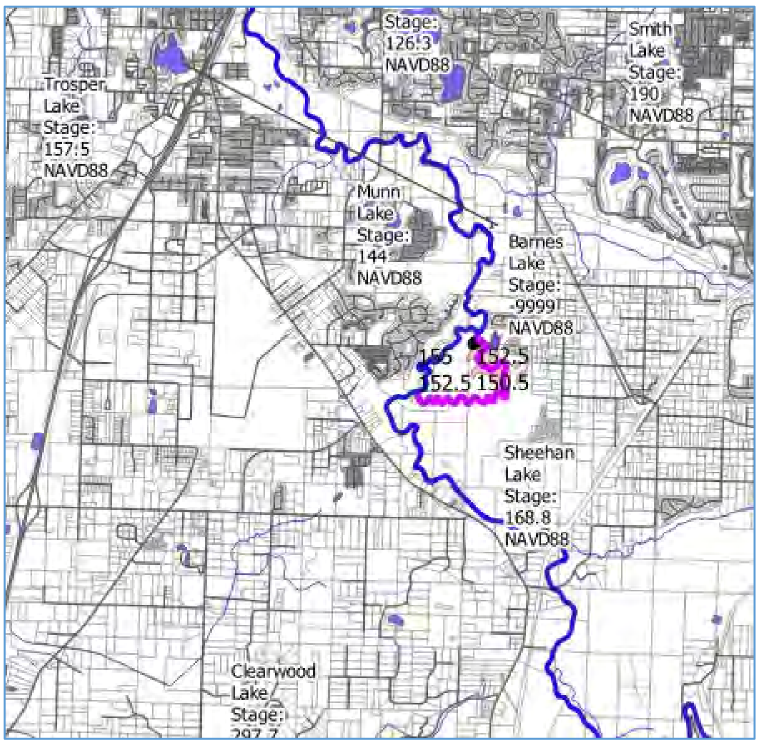

Figure 1. Site Location

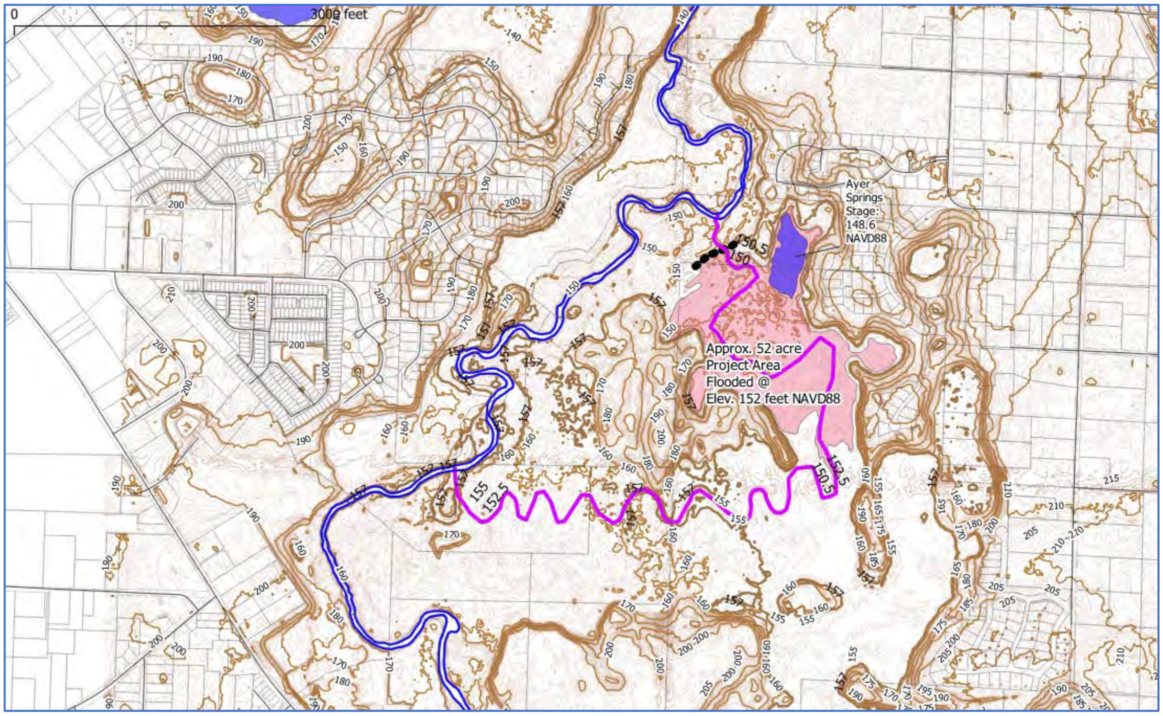

Figure 2. Project Area showing conceptual off-channel storage area and new stream channel.

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

Water offset benefits were calculated by estimating inlet flows into the Schneider's Prairie off-channel feature, inundation extent and depth, and seepage back to the Deschutes River.

Inflows from the Deschutes River to the Schneider's Prairie off-channel area were estimated on a cumulative monthly basis during November – April season (Table 1). Monthly inflows were developed based on assumed inlet channel geometry, daily river flow values river at the USGS E Street Gage in Tumwater, WA (USGS Gage 12080010) and corresponding river elevations derived from the HEC-RAS hydrologic model developed by FEMA for the Deschutes River. Only River flow values greater than 400 cfs caused inflows into the Schneider's Prairie off-channel area, and inflows were restricted to the November – April season.

The inlet channel was added to the existing HEC-RAS model using a standard channel geometry. The surface of the banks and floodplain were built from LiDAR data. Using the 2011 LiDAR terrain contours, a storage area of about 52 acres was considered practical for seasonal inundation – see flooded area polygon (Figure 2). Water depths of 1 to 3 feet were considered potentially obtainable using either surface roughness (natural) or a low dike to retain water, at an elevation of 152 (NAVD88 datum). Modifications to the mouth of Ayers Creek with grade control at 152 feet may be required but would require fish passage for both adult and juvenile salmonids.

Inflows from the Deschutes River were compared to the maximum infiltration capacity of the off-channel area (i.e. 52 acres). Maximum infiltration capacity was estimated using Darcy's Law calculations. The smaller of the two values were used as an assumed infiltration quantity (Table 1). River inflows that exceeded the infiltration capacity were assumed to be retained as ponded water in the Schneider's Prairie feature. This retained inflow volume was assumed to infiltrate during the late spring, when river inflows were no longer occurring.

These monthly infiltration quantities were used to model streamflow benefits (i.e. seepage back to the Deschutes River) over time. Seepage was modeled using STRMDPLT08. Seepage back to the Deschutes River increases over time, because of the cumulative effect of infiltrating additional water. This cumulative increase reaches an asymptote (i.e. additional benefits are minimal) after about 50 years of infiltration (Table 2). Seepage back to river does not change substantially with season, but slightly more seepage occurs during the May – October period, relative to the November – April period. Streamflow benefits during the May – October period are predicted to be 285, 681, 958, and 1,310 acre-feet per year during the first, fifth, tenth, and fiftieth year of infiltration, respectively.

Table 1. Maximum Infiltration and Diversion quantities.

Month	Monthly Deschutes River Inflow (acre-ft)	Maximum Monthly Volume Capacity (acre-ft)	Uninfiltrated Water Remaining (acre-ft)	Remaining Water Infiltrated (Acre-ft)	Monthly Volume Infiltrated (acre-ft)
January	717	435	282		435
February	568	393	175		393
March	505	435	70		435
April	229	421	0	192	421
May	0	435	0	435	435
June	0	421	0	175	175
July	0	435	0		0
August	0	435	0		0
September	0	421	0		0
October	0	435	0		0
November	415	421	0		415
December	709	435	274		435
Total Annual	**3,143**	**4,683**	**802**	**802**	**3,143**

Table 2. Modeled streamflow benefits over time.

Modeled Benefit by Year After Project Start	Total Water Year Benefit acre-feet	Percent of Diversion	May - October Benefit (acre-ft)	Percent of Diversion
Year 1	316	10%	285	9%
Year 5	1,235	39%	681	22%
Year 10	1,824	58%	958	30%
Year 50	2,537	81%	1,310	42%

Notes:

Transmissivity = 1,400 ft^2/d

Streambed Conductance = 1 ft/d

Wetlands Hydraulic Conductivity = 0.20 ft/day

Total Annual Diversion Applied to Groundwater Recharge = 3,143 acre-feet

The attenuation of these high river flows to increased and steady seepage back to the river will increase flow between flooding events, benefitting fish and overall ecological function. Increased base flow during the summer will increase usable aquatic habitat for fish and would also reduce temperatures and effects of euthrophication on dissolved oxygen and pH.

Finally, off-channel fish habitat will be created in the paleochannel and in the inundated floodplain area in Schneider's Prairie. The inlet and outlet will be designed to be low energy with fish cover and habitat complexity. The inlet and outlet channels will allow for fish ingress and egress. It is expected that this would likely improve habitat for Coho salmon and numerous other species, as well as capturing silt and nutrients. Habitat and water offsets may be improved by increasing channel roughness. For example, beaver habitat/ponding, woody structures in the channels/floodplain, or mature forest land cover would slow down and spread out flow entering and flowing through the off-channel feature. These elements would also increase habitat value for juvenile salmonid rearing.

Description of the anticipated spatial distribution of likely benefits

Streamflow benefits would occur in the Deschutes River adjacent to the Project area, to the confluence with Capital Lake. Off-channel rearing benefits would occur within the inlet channel, within the off-channel area, Ayers Creek, and in the Deschutes River, downstream of the confluence with Ayer Creek. The length of additional wetted channel and volume of water offset would require calculation during the Feasibility Study process.

In addition, Ayers Creek currently has TMDLs proposed by the USEPA for water temperature, dissolved oxygen, and pH. Surface water connectivity to the river and increased seepage during the critical period may improve water quality.

Uncertainties and Assumptions

The WRIA 13 Committee identified project uncertainties from the modeling analysis was not able to account for or where assumptions were made, including:

1. Evapotranspiration
2. Amount of infiltration
3. Climate change
4. Dropping flow trend of the Deschutes
5. Sediment issues in the Deschutes
6. Modeling assumptions including transmissivity of aquifer, and streambed conductance
7. Modeling represents average conditions, not dry year conditions

Performance goals and measures.

Streamflow and groundwater level monitoring may be required, subject to the refined concept, feasibility study, and design.

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

This Project would provide off-channel rearing habitat during the winter period, when the inlet channel and wetland area is inundated. This habitat would primarily benefit coho salmon. Seepage back to the Deschutes River during the summer and early fall would benefit all fish species by providing cool water and increasing flows.

Identification of anticipated support and barriers to completion.

Capitol Land Trust owns part of the project area. Other water offset and habitat protection projects have been envisioned nearby, including Allen Creek Restoration Project (Habitat Work Schedule project ID 12-1109) by Wild Fish Conservancy but encountered land development pressures. This project would be an element of a larger “Floodplains by Design” grant proposal and concept design.

This area is already under consideration by other entities water, protection and habitat improvement projects. Capitol Land Trust owns part of the project area. The WRIA 13 Salmon Lead Entity is organizing potential partners for a larger Deschutes River project encompassing this area. Because of these efforts, this water offset project is best conceived as one component of the larger effort to protect this part of the lower Deschutes River, an area of substantial ecological and hydrologic value.

Potential budget and O&M costs.

Potential (Class V, order of magnitude) capital costs, including design, permitting, property acquisition, and construction, are approximately $5,000,000.

Anticipated durability and resiliency.

The project would require regular operation and maintenance.

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

Thurston County and WRIA 13 implementation partners

Sources of Information

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

Small-scale LID Project Development/Implementation for WRIA 13

Sponsor: Thurston Conservation District

Problem:

In undeveloped landscapes, most rainfall typically soaks into the ground, recharging shallow groundwater. As development occurs, stormwater runoff is generated in areas where compacted soils, impervious roofs, driveways and parking lots concentrate surface flow that can no longer infiltrate into the ground. These impervious surfaces concentrate rainfall and it often flows as stormwater runoff into conveyance systems, whether roadside ditches or buried pipes. Recent adoption of Low Impact Development (LID) practices for new development begins to address this issue. However, in all urbanized areas of WRIA 13 a significant legacy of conventional development continues to generate large volumes of runoff flowing untreated into stormwater systems, and this water ends up in treatment facilities or is discharged – untreated - into local streams and into Puget Sound.

Project Description/Solution: By strategically concentrating small-scale LID retrofit work in urbanized settings and by partnering with residential and commercial community members to redirect runoff away from stormwater conveyance systems and into green stormwater infiltration facilities, this work will help to conserve in-stream flow. In rural settings, efforts can explore additional opportunities to slow and infiltrate stormwater runoff that would otherwise rapidly discharge into nearby waterways.

Thurston Conservation District will work with partners to identify and implement retrofit projects to benefit groundwater recharge. Creative partnerships with local jurisdictions could result in incentive programs and a focus on areas of interest that will benefit stormwater programs as well as in-stream flow. Given short-term uncertainties about project development and measurable benefits, small-scale LID retrofit projects won't be counted towards initial offsets in the plan. However, long-term benefits will be quantified and tracked as projects are developed and implemented in regions with appropriate soils, willing partners, and waterways that can benefit from this work. The use of small-scale LID retrofit projects is an important tool to integrate into long-term planning for in-stream flow preservation. Construction of numerous, clustered infiltration facilities including rain gardens and biofiltration swales will eventually result in a measurable impact and benefit.

Project Benefits: Infiltrating stormwater runoff into strategic, well-planned and concentrated clusters of LID retrofit projects offers an important opportunity to recharge shallow groundwater in areas where MARs or other large-scale projects are unlikely or infeasible. Small-scale LID retrofits can also (importantly) directly engage residential and commercial partners to contribute to in-stream flow preservation. This work will also immediately benefit water quality in nearby streams, which would otherwise receive untreated runoff and continue to experience flashy flow events along with the input of concentrated pollution.

Spurgeon Creek Remeander Habitat Project

PROJECT DESCRIPTION

Description

Spurgeon Creek is the largest lowland tributary of the Deschutes River in Thurston County and is listed as high priority for restoration (SIT 2015). The South Puget Sound Salmon Enhancement Group (SPSSEG) is currently proposing to re-meander a ditched channel through the adjacent wet fields just south of a private driveway and north of and below the Fox Hill development (Figure 1). The proposed project is intended to improve water quality as well as salmonid, aquatic, and riparian habitat by increasing habitat area and floodplain activity. The project also has the potential to provide salmon viewing and educational opportunities to local residents and the public at large.

The goal of the project is to improve fish productivity and survival within Spurgeon Creek by enhancing the quality and quantity of instream habitat within the project reach. Habitat within Spurgeon Creek is currently impaired, particularly within the lower portion of the project reach, by lack of riparian vegetation and large woody debris, simplification of instream habitats, poor floodplain connectivity, channel incision and poor water quality.

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

The Spurgeon Creek restoration project is located near the head waters of Spurgeon Creek in Thurston County. At the project location, the creek is currently ditched through a field (Figure 1). The South Puget Sound Salmon Enhancement Group has been working with the landowners to recreate the natural stream sinuosity through a wetland. Additionally, wood structures would be added that offer refuge from predators and opportunities for salmon to feed, while the wetland offers slower water during high flow events. Native plants would be planted throughout the ¾-acre project area that will recruit wood and provide shade into the future.

Spurgeon Creek is the largest lowland tributary to the Deschutes River and a critical contributor of cold water. The proposed project is intended to improve water quality and increase salmon rearing habitat for juvenile Coho Salmon. Specifically, the project will designed to accomplish the following:

- Increase stream length by 1/8 miles.
- Restore 1/3 mile of creek.
- Increase instream shading by 20%.
- Increase instream complexity by adding Large Woody Debris (LWD).

- Increase community involvement.

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

Figures 1-2 show the location of the proposed project.

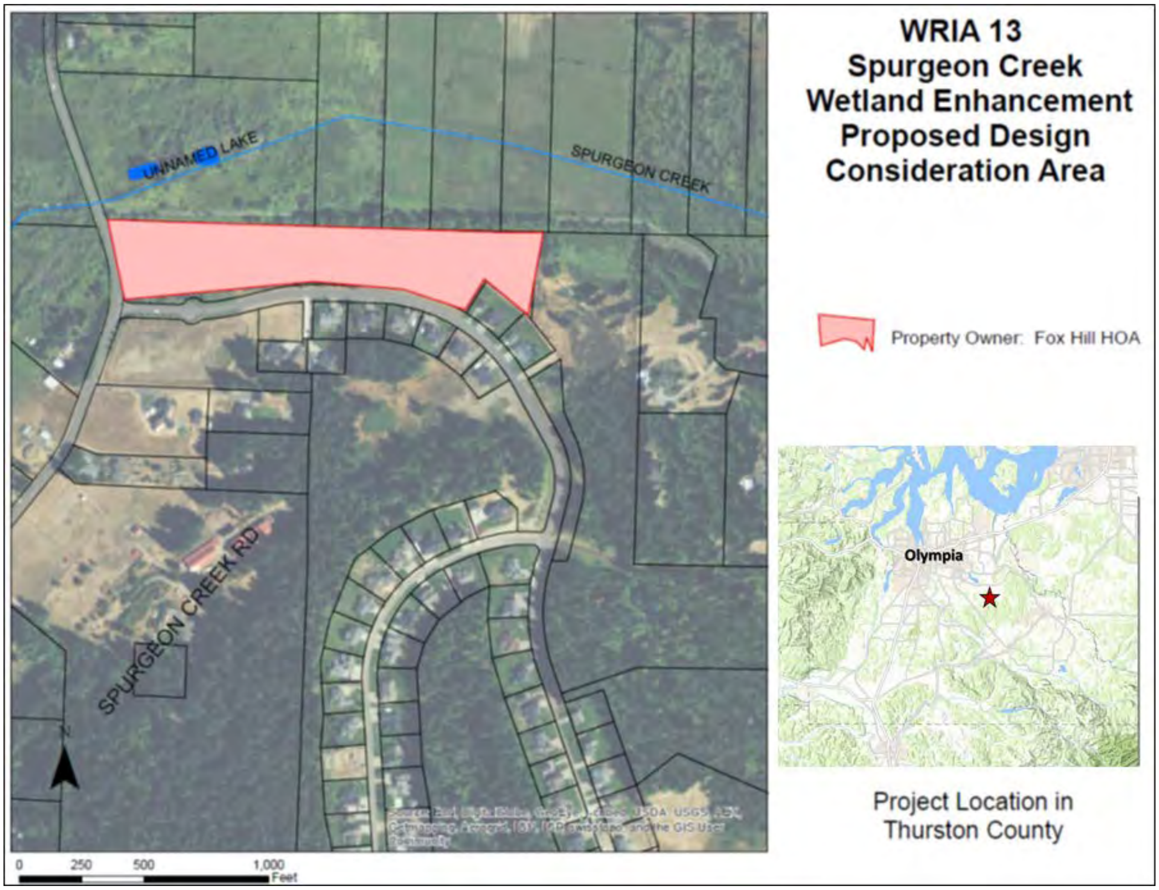

Figure 1. Location of proposed Spurgeon Creek remeander project in Thurston County.

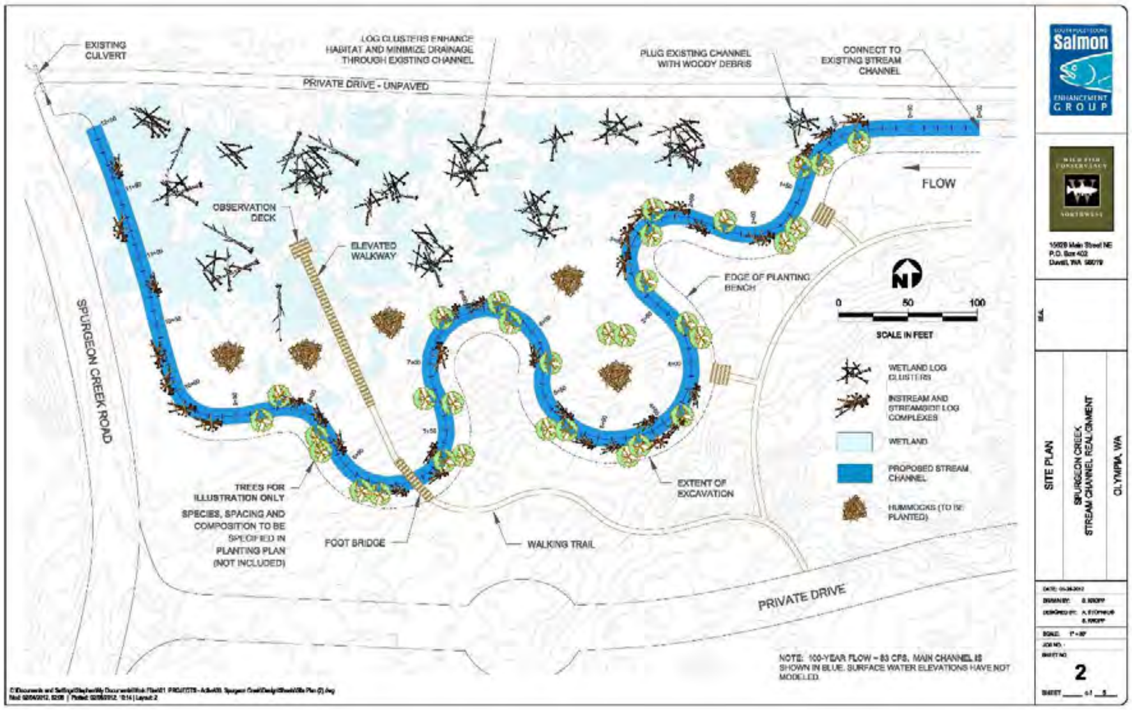

Figure 2. Conceptual drawing of Spurgeon Creek remeander project from 30% site plan (January 2012).

Description of the anticipated spatial distribution of likely benefits

The proposed project site is approximately ¾ of an acre. Within that footprint, Spurgeon Creek is expected to be increased by 1/8 miles, effectively restoring 1/3 of the creek. Water quality benefits will extend 2 miles downstream of the restoration site.

Performance goals and measures.

The performance goals are to increase stream length by 1/8 miles, restore 1/3 mile of creek, increase instream complexity by adding LWD, increase instream shading by 20%, and increase community involvement. Water quality benefits will extend 2 miles downstream of the restoration site.

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 and Fall Chinook are present in Spurgeon Creek and that Chum Salmon and winter steelhead have access to Spurgeon Creek (WDFW Salmonscape 2020). WDFW (2015) documents spawning in Spurgeon Creek and small areas in the lowermost reaches of a limited number of other middle and lower tributaries are shown as supporting spawning (WDFW 2002, cited in Anchor 2008). The Washington Stream Catalog indicates that both Coho, Chum, and Chinook Salmon were historically present in Spurgeon Creek which is identified as an important tributary to the

Deschutes River (WDF 1975). Spurgeon Creek also provides habitat for reticulate sculpin, Olympic mudminnow, wood duck, and waterfowl overwintering.

The portion of Spurgeon Creek proposed for restoration has the potential to provide rearing and foraging habitat for the aforementioned salmon and trout populations year round. Increased base streamflow, improved water quality, and reduced water temperatures would primarily benefit juvenile salmonid rearing habitats by providing increased area and quality of summer stream rearing habitat. This would improve both productivity and survival of juveniles. The alteration of natural stream hydrology has been identified as a high priority limiting factor and streamflow is important for supporting riparian vegetation and wetlands that provide shading, food web support, and flood and sediment attenuation functions (NOAA 2007).

Identification of anticipated support and barriers to completion.

The actions included in this project are recommended by the WRIA 13 Four-Year Work Plan and the Squaxin Island Tribe Natural Resources Deschutes Coho study (SIT 2015). This project has support from the Fox Hill Homeowners Association, the Washington Department of Fish and Wildlife, and the Squaxin Island Tribe. Spurgeon Creek is a high a priority for restoration based on the Deschutes River Coho Salmon Biological Recover Plan and would help address water temperature issues for protecting salmonid spawning and rearing.

The proposed project area lies in the transition between wetland soils and glacial till which may limit the ability to create and effectively sustain wetland habitat due to drainage issues. The soils present onsite are adequate for growing coniferous trees, but not for supporting wetland creation and enhancement (Winecka 2019). The project design envisions moving the creek out of its confined channel on the eastern extent of the HOA property, and re-engaging wetlands and expanding Coho rearing opportunities. However, property boundary issues, existing property disputes, and less than full support from neighboring, non-HOA parcels may limit the ability to move Spurgeon Creek out of its confined channel to recreate natural stream sinuosity (Walley 2019).

The main barrier to completion is adjacent landowner concerns at the project site.

Potential budget and O&M costs.

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

Anticipated durability and resiliency.

The project would have lasting benefits as it would be actively managed by the South Puget Sound Salmon Enhancement Group. The restored stream section would be designed to mimic natural fluvial and ecological processes to be self-sustaining and resilient to perturbations to minimize long-term maintenance costs.

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

The project sponsor is currently the South Puget Sound Salmon Enhancement Group. A 30% plan set was completed by the South Puget Sound Salmon Enhancement Group and the Wild Fish Conservancy. In addition, stakeholder coordination and public involvement was performed and there is general support for this project. The project team will also engage with watershed partners based on their level of interest and ability to be involved with the study. Potential Project partners who have indicated their interest include: The Fox Hill Homeowners Association, the Washington Department of Fish and Wildlife, and the Squaxin Island Tribe.

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Winecka. 2019. Scope change request for the Spurgeon Creek Wetland Restoration project (16-1408). Email from Amy Hatch-Winecka to Amee Bahr, Grant Manager. October 11, 2019.

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Water Right Opportunities in WRIA 13

Technical Memorandum

To: Department of Ecology WRIA 13 Watershed Restoration and Enhancement Committee

From: Glenn Mutti-Driscoll, LHG Pacific Groundwater Group

Burt Clothier, LHG Pacific Groundwater Group

Re: Water Right Screening Methodology

Date: December 18, 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 Deschutes River Watershed, Water Resources Inventory Area (WRIA) 13. This work was completed by Pacific Groundwater Group (PGG) on behalf of the WRIA 13 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 13, 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 13. 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.

WRIA 13 permit exempt (PE) well growth projections were then compared by subbasin in addition to potential mitigation and habitat restoration projects, managed aquifer recharge projects, and the presence of priority salmon streams. From this evaluation, subbasins with the greatest projected PE well growth and consumptive use (Deschutes Middle with 122 acft/yr from 734 wells and Johnson Point with 86 acft/yr from 520 wells) were identified as having relatively few mitigation and restoration projects relative to expected PE well impacts. Therefore, water rights primarily within these subbasins were prioritized to identify potential rights that could be acquired, relinquished to trust, or whose owners could be engaged regarding implementation of water saving or conservation practices.

Over 850 active water right files were identified in the Deschutes Middle and Johnson Point subbasins. Following consultation with the Committee, PGG limited the water rights under consideration to certificates and permits[80] that included commercial and industrial (CI), irrigation (IR), and domestic multiple (DM) uses. DM water rights were included within the query since nearby municipal water systems (Lacey for the Johnson Point subbasin and Raymond for Deschutes Middle subbasin) 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 query based on the expectation that these rights would be unavailable for mitigation or small.

The list of active permits and certificates with CI, IR, and/or DM uses was reduced again based on authorized annual (Qa) quantities. For the Deschutes Middle and Johnson Point subbasin, rights with a Qa of less than 10 acft/yr were removed. This arbitrary cut-off rate was intended to focus on higher-value possibilities and provide a more manageably sized list. In general, larger water rights are considered higher value since they will provide greater flow benefits to a stream. Although not used for filtering, it’s worth noting that surface water rights are considered higher value mitigation rights than groundwater rights since they will have an immediate, direct, and easily quantifiable benefit to a stream.

This list was further refined with Committee input regarding the inclusion/exclusion of specific rights, and rights from the neighboring Woodland Creek and Deschutes Lower subbasins were added based on input that they may be acquirable. Rights specifically identified by the Committee did not have the 10 acft/yr general screening criteria applied.

Table 1 lists the identified WRIA 13 water rights that could potentially be converted, purchased, or retired as mitigation water, while **Table 2** is a general summary of the focused water right list. These rights have been identified as having the greatest potential benefit to instream flows in the Johnson Point and Deschutes Middle subbasin vicinities by applying the criteria outlined above. However, this list 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.

[80] This includes certificates, certificates of change, permits, and superseding permits.

POTENTIAL FUTURE PROJECTS

Multiple conservation and water-right related offshoot projects were identified through the water right screening process and discussion with the Committee. Potential future opportunities for further study are listed below, all of which could potentially provide Net Ecological Benefit (NEB). Most projects listed provide hydrologic benefit through water offsets (as is noted below) since increases in streamflow generally provide greater NEB than habitat restoration projects.

- Outreach and potential quantification of water saved by implementing Best Management Practices (BMPs) for improving irrigation efficiencies at golf courses and on irrigated lands. Opportunities to improve irrigation efficiencies could be analyzed on a water right or project area scale to assess if hydrologic benefit and/or NEB is likely to occur[81]. Projects that result in NEB would be incentivized as feasible.
- Outreach and potential quantification of water saved through the repair of leaky water system pipes. A review of water system plans for public water systems within the WRIA could be pursued to identify systems with the greatest leakage losses, and if infrastructure repair appears to provide hydrologic benefit and/or NEB[2], incentives could be provided to systems that chose to upgrade.
- Incentivize off channel storage projects during the wet season for agricultural water right holders. Hydrologic benefit potentially can occur if impacts of summer pumping are offset by increases in summer streamflow.
- Create a water bank or other structure to track water quantities voluntarily conserved by agricultural water right holders. Some of the conserved quantities could be leased for other agricultural uses, while some would remain unused or put into temporary trust to provide hydrologic benefit and increase instream flows.
- Connect small water systems to nearby municipal water systems. The transfer of small-system water users to larger municipal water systems would be accommodated by the municipal system as part of its growth projections, while the smaller water system right would be relinquished or permanently donated to trust (providing hydrologic benefit).
- Partial or full relinquishment of water rights into permanent trust for hydrologic benefit.
- Outreach to golf courses, particularly those on salmon bearing streams or in close proximity to Puget Sound, regarding the Salmon Safe Certification program and BMPs. This project would primarily result in habitat benefits.

[81]Projects improving water management efficiencies will need to show how consumptive use is reduced through the upgrade. Upgrades that result in decreased recharge to the shallow aquifer (which would be a decrease in non-consumptive use) are unlikely to result in significant hydrologic benefit.

Woodard Creek Project

PROJECT DESCRIPTION

Description

Woodard Creek basin is located in central Thurston County; it includes a mix of urban and rural areas and is crossed by Interstate-5, a major transportation corridor in the region (Figure 1). Woodard Creek flows into Henderson Inlet. The hydrology of the area has been extensively modified by development in the upstream (southern) portion of the basin, resulting in stormwater impacts.

In 2014, a study done on Woodard Creek basin identified and ranked two potential stormwater retrofit sites that would have a positive impact on the Woodard Creek water quality (AHBL 2014a; 2014b). Since 2014, two sites have been completed, 1 site has been dropped because of issues, and the two remaining sites are in the process of being completed. All of the proposed sites identified in AHBL (2014a; 2014b) address water quality and do not address any flow control issues.

The goal of the Woodard Creek Project (Project) is to address the water quantity impacts of stormwater by attenuating flood flows by increasing stream bed roughness and restoring the channel sinuosity. This would increase floodplain connectivity and overall floodplain storage capacity. Increasing streambed roughness with biotechnical techniques (e.g. large woody debris) would also enhance the quality and quantity of instream habitat within the project reach. Habitat within Woodard Creek is currently impaired, particularly within the northern portion of the project reach, by lack of riparian vegetation and large woody debris, simplification of instream habitats, poor floodplain connectivity, channel incision and poor water quality. Therefore, the focus of this project is increase stream length, increase water transit time, and increase habitat complexity by modifying portions of stream in the northern end of the basin.

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

The Project is composed of a number of candidate locations or stream reaches. The Project sponsor will work with the landowners to identify reaches available for restoration. Restoration reaches will have large woody debris added to suitable or reference densities. The LWD will provide fish cover, hydraulic complexity, and will increase pool density and depth. Coho will benefit from increased pool density, in terms of juvenile rearing and adult holding. Riparian vegetation will be planted, as necessary throughout the restoration reaches that will recruit wood and provide shade into the future.

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

Figures 1-2 show the location of the proposed project.

Figure 1. Location of Woodard Creek basin in Thurston County. Potential project locations are outlined by red boxes (A-C).

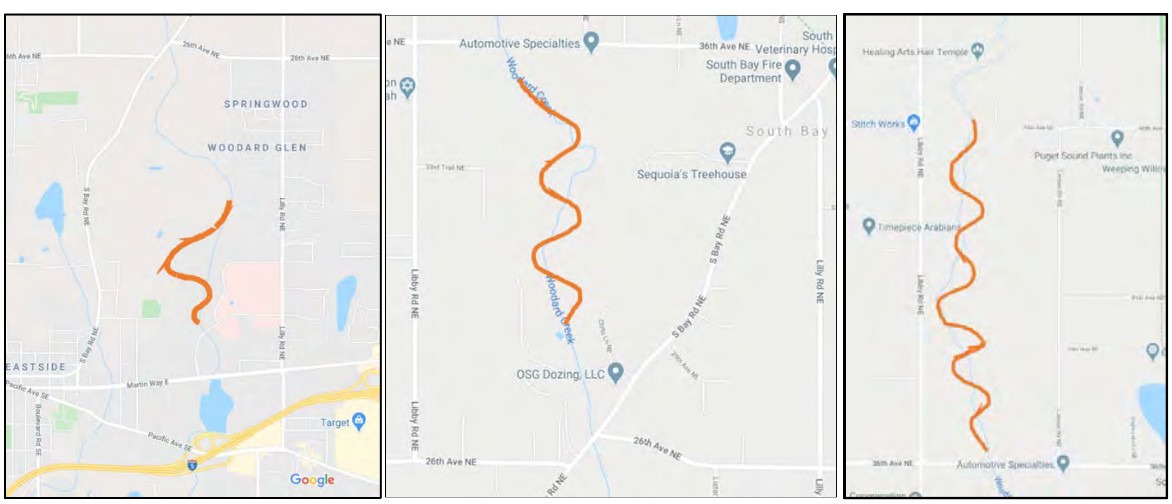

Figure 2. Conceptual drawing of Woodard Creek project locations at sites A, B, and C.

Description of the anticipated spatial distribution of likely benefits

The proposed stream restoration will benefit Woodard Creek. The benefits will be reach-specific..

Performance goals and measures.

The performance goals are to increase channel sinuosity and length, increase instream habitat complexity, and channel roughness. Specific metrics and measures will be defined when during feasibility and design.

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

Although portions of the area have been highly urbanized, Woodard Creek basin supports a variety of wildlife. Many species of fish utilize the creek, including coho, chum, steelhead, and cutthroat trout, and Olympic mudminnow have been noted in the creek near the I-5 interchange, though high winter flows and low summer flows in the river have reduced the usability of this habitat (Thurston County 2015). There are a number of bald eagle nesting sites within the basin, as well as a purple martin breeding area. There are several large wetland areas in the basin, including along Ensign and South Bay Roads.

Woodard Creek has historically supported native runs of coho, chum, cutthroat, and winter steelhead (Thurston County 2015). Limiting factors identified for the creek include alteration of the natural flow regime from increased impervious surfaces, lack of large woody debris (LWD), and barriers to fish passage. The riparian corridor has been impaired by the removal of vegetation in some areas, a lack of conifers in the remaining vegetation, and direct animal access to the stream. Fine sediment may also be a naturally occurring barrier.

The Washington Department of Fish and Wildlife has identified that Coho Salmon, Chum Salmon, Winter steelhead are present in Woodard Creek and that Fall Chinook Salmon have access to Woodard Creek (WDFW Salmonscape 2020). WDFW (2020) documents spawning in Woodard Creek (WDFW 2020). The Washington Stream Catalog indicates that both Coho, Chum, and Chinook Salmon were historically present in Woodard Creek (WDF 1975). Woodard Creek also provides habitat for reticulate sculpin, Olympic mudminnow, wood duck, and waterfowl overwintering.

The reaches of Woodard Creek proposed for restoration has the potential to provide rearing and foraging habitat for the aforementioned salmon and trout populations year round.

Identification of anticipated support and barriers to completion.

Thurston County has indicated support for this project. The primary barrier to completion is likely to be land acquisition or obtaining conservation easements. The proposed project area includes privately owned parcels.

Potential budget and O&M costs.

The total costs of construction, engineering, permitting, and cultural assessments are estimated to be <$1 million, based on an order of magnitude estimate (includes engineering and construction costs).

Anticipated durability and resiliency.

The project would have lasting benefits as it would be actively managed by Thurston County or their future project partner. The restored stream section would be designed to be compatible with natural ecological processes to be self-sustaining and resilient to perturbations to minimize long-term maintenance costs.

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

The project sponsor is Thurston County and is ready to implement the project. Implementation would require an evaluation of feasibility.

References

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