Appendix I

WRIA 12 Project Inventory

Project Name	Project Type and Brief Description	Water Offset (AFY)	Timing of Offset Benefits	Additional Benefits	Project Sponsor	Project Stage	Estimated Costs
Sequalitchew Subbasin							
Repair Diversion Structure at Lake Sequalitchew	Currently, stormwater and water from Sequalitchew Creek is diverted down the stormwater canal straight to the Puget Sound, leaving the creek dry. The project will install a diversion structure to regulate flow between Sequalitchew Creek and stormwater canal, install a gaging station, remove cross culvert, reroute stormwater, install berm, remove fish screen and install beaver control.	724	Year-round	The project corresponds with a barrier removal project at the mouth of Sequalitchew Creek.	JBLM and South Puget Sound Salmon Enhancement Group	100% design. This project is a priority for JBLM and salmon recovery.	$2,681,000
Chambers Subbasin							
South Tacoma Channel Stormwater Infiltration Project	Direct stormwater flows to large-scale infiltration facilities within the South Tacoma Channel (STC) (Sites 1 and 2) to enhance streamflow and function of lower Flett Creek and Flett Wetland (Site 3).	701	Year-round	Increase baseflow in summer in lower Flett Creek and Flett Wetland (Site 3) by about 0.5 cfs. Reduce water temperatures.	City of Tacoma	Feasibility. Feasibility study funded by Streamflow Restoration Grant Program in 2020	$3,850,000
Clover Creek Springbrook Restoration Project	Restoration of the stream banks would include invasive species removal, streamside plantings with native species, location of LWD within the stream channel as appropriate, evaluating and repurposing of an existing pond currently connected to the stream for high flows through the use of old concrete structures (to be removed) along with potential deepening and expansion of the pond for off-channel refugia during high flows.	N/A		Restore up to 1600 lineal feet of Clover Creek in the Springbrook neighborhood of the City of Lakewood.	City of Lakewood	Planning/Feasibility	$150,000
Chambers Creek Restoration	Restore the lower reach from RM 2.7 to RM 6 of Chambers Creek by removing rip rap banks, slowing down erosion of tributaries, increasing short -term wood loading and promoting long-term forest recovery in the lower Chambers Creek Valley. The project will build on the Chambers Creek Habitat Assessment and Conceptual Restoration design Alternatives, October, 2019.	N/A		Habitat restoration of 3.3 river miles. Potential to quantify storage opportunities.	Puyallup Tribe	Design	$2,500,000
Peach Creek	Roughening and hyporheic exchange. Addressing stream incision, erosion.	N/A		Habitat improvements	Potential: Pierce County	Conceptual	

Project Name	Project Type and Brief Description	Water Offset (AFY)	Timing of Offset Benefits	Additional Benefits	Project Sponsor	Project Stage	Estimated Costs
Chambers Bay Estuarine and Riparian Enhancement	Restore and enhance the estuarine habitat structure within Chambers Bay, including removal of the Chambers Dam, removal of shoreline armoring, addition of large woody debris, enhancement of riparian vegetation.	N/A			South Puget Sound Salmon Enhancement Group	Planning/Design. High priority for WRIA 10/12 Salmon Recovery Lead Entity strategy.	$5,000,000
Titlow Estuary Restoration	Restore Titlow Lagoon to a connected and productive estuary.	N/A		Increase habitat, remove fish barriers, expand lagoon, and install woody habitat structure.	South Puget Sound Salmon Enhancement Group	Planning/Design. High priority for WRIA 10/12 Salmon Recovery Lead Entity strategy.	$7,000,000
Clover Subbasin							
Water right acquisition	Acquire water rights from PGG assessment and put into trust either through a direct transaction or through water conservation and efficiency upgrades. Anticipate a fraction of reviewed rights will be counted as offset.	TBD	Irrigation season		TBD	Conceptual	$2600/AF
Streambed pavement removal (Mayfair Park)	Restore Clover Creek by removing the asphalt, re-meandering the channel, and adding large woody debris and native vegetation. Pierce County Parks owns additional reaches of Clover Creek where this restoration can continue.	N/A		Removing asphalt enhances the habitat, but may also create space for infiltration.	Pierce County	Conceptual	TBD
Streambed pavement removal (Parkland Prairie)	Restore Clover Creek by removing the asphalt, re-meandering the channel, and adding large woody debris and native vegetation. Pierce County Parks owns additional reaches of Clover Creek where this restoration can continue.	N/A		Removing asphalt enhances the habitat, but may also create space for infiltration.	Pierce County	Conceptual	TBD
Clover Creek Floodplain Restoration	Floodplain restoration in a number of locations as identified by the Committee. Projects would include: Floodplain reconnection, pavement removal, log jams,	N/A		Off-channel rearing, high flow refugia, instream cover, instream habitat complexity.	Potential: Puyallup Tribe, Pierce County	Conceptual	TBD
Habitat Assessment	Conduct habitat assessment for riparian buffers, floodplain reconnections, and stream channel improvements	N/A		Identify needs and opportunities for habitat projects, identifying appropriate treatments for each reach.	Potential: Puyallup Tribe		TBD
WRIA-Wide							

Project Name	Project Type and Brief Description	Water Offset (AFY)	Timing of Offset Benefits	Additional Benefits	Project Sponsor	Project Stage	Estimated Costs
Reclaimed Water Infiltration	Infiltrate reclaimed water or treated wastewater on location at satellite treatment plans.	TBD	Year-round	Reduce nutrients entering Puget Sound	Potential: JBLM or local government	Conceptual	TBD
Green Stormwater Infrastructure Program	Provide financial assistance for property owners to install GSI through traditional means or through a revolving loan fund. Certain soils, certain areas of the basin. North Fork Clover prioritized. Average of 0.15 AFY per project.	TBD	Year-round	Address water quality issues such as fecal coliform and temperature.	Pierce Conservation District	Planning	$5,000/per project
Public Education Program	Public information campaign to explain the hydrology and hydrogeology of WRIA 12, and what makes it unique (dry stream beds, groundwater flooding, etc.).	N/A		Increased public understanding of the watershed.	Potential: Chambers Clover Watershed Council	Conceptual	TBD

JBLM- Sequalitchew Lake Repair Project

PROJECT DESCRIPTION

Description

Sequalitchew Creek is a small stream in WRIA 12 very much connected to the Chambers-Clover Creek system by the underlying shallow Vashon Aquifer and through American Lake stormwater surge overflow connections to Sequalitchew Lake The stream is formed from the outflow of Sequalitchew Lake; it flows east to west through low gradient wetlands and is channelized through Edmonds Marsh and past the historic 1843 Fort Nisqually site and DuPont City Hall, where the creek has become a losing reach ending in a hanging culvert. The creek quickly emerges again in the fairly well shaded ravine from aquifer seeps to flow on through the salt marsh estuary entering the Salish Sea at the Nisqually River nearshore through a 5 foot box culvert under the rail berm. (Figure 1). Sequalitchew Lake drains an area of 34.2 sq. mi., has a surface area of 91 acres, a mean depth of five feet, and contains a volume of 470 acre-feet. Sequalitchew Lake gains water from surface tributaries and groundwater inflow. American Lake contributes groundwater flow to Sequalitchew Lake and surface flow at high lake levels. Sequalitchew Creek is very flat (i.e. low slope) in the marsh areas (approximately river miles 1.3 – 3), where surface water tends to pool to form extensive wetlands. Groundwater heavily influences the hydrologic regime in Sequalitchew Creek and surrounding area. Hammer Marsh, McKay Marsh, and Bell Marsh drain subsurface into Sequalitchew Creek. The ravine (approximately river mile 0 – 1.3) is flowing because of the groundwater gain and currently supports salmonid use Historically, the creek supported salmon up to Sequalitchew Lake; it was over 20' wide near the Fort Nisqually site with a well-connected salt marsh estuary approximately 135' foot wide. Sequalitchew Creek is currently impacted through hydrologic, instream habitat, and fish passage modifications. Sequalitchew Springs, at the east end of Sequalitchew Lake, provides domestic and emergency water supply for the Joint Base Lewis McChord (JBLM) installation year round. In the 1950's the Department of Defense constructed the Sequalitchew Creek drainage canal and crossover culverts. All surface flow from Sequalitchew Lake and Hammer Marsh is intercepted by the failed crossover culvert system, and redirected to, or sent directly to the diversion canal and discharging to Puget Sound near Solo Point. (Figure 1).The drainage canal diversion was constructed to avoid flooding of the Sequalitchew Spring water source for Fort Lewis. The drainage canal is an engineered channel with no aquatic habitat value. Beaver have responded to channelization and culverts in the low gradient wetlands (RM 1.5 – 3), with dam proliferation which has altered the capacity of the channelized creek to convey water and increased the floodplain of Edmonds Marsh in the City of DuPont. Finally, the railroad embankment at the mouth of Sequalitchew Creek currently disconnects the salt marshes estuary from natural tidal flows, completely at lower tides, and reduces fish access from Puget Sound to the creek.

JBLM is proposing to modify an existing weir and diversion structure at the outlet of Sequalitchew Lake to protect their drinking water source and repair a failed storm system. As part of these modifications, surface flow exiting Sequalitchew Lake and surface flow from adjacent wetland drainages will be re-directed from the drainage canal back to then natural Sequalitchew Creek channel. A flow control structure would still divert flood flows (100 year flood flows and greater). The following project elements are proposed:

- Install diversion structure to regulate flow between creek and canal (high flows)

- Install telemetric gage to monitor flow and seasonally manage lake levels
- Remove cross culvert
- Reroute stormwater from Hamer Marsh to Sequalitchew Creek
- Install berm to separate canal from creek
- Remove fish screen structure near Sequalitchew Lake outlet
- Install beaver control devices at the two beaver dams in the project area

JBLM has a memorandum of agreement with the South Puget Sound Salmon Enhancement Group (SPSSEG) signed August 2020 to assist with beaver management under the Sequalitchew Creek Restoration Plan (Pers. Com. 2020). The SPSSEG will be restoring channel function in the Sequalitchew Creek channel that will be receiving the re-directed flows.

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

Average flow discharging from Sequalitchew Lake is expected to be 6 – 7 cfs (4,300 – 5,000 acre-feet/year) (Aspect 2009). This estimate was based on hydrologic modeling of Sequalitchew Lake. This flow would be re-directed to the natural channel of Sequalitchew Creek.

Although there is no continuous monitoring record of Sequalitchew Lake outlet flows, the following estimates (Appendix A) corroborate with the 6 – 7 cfs as a reasonable or conservative estimate of average flow:

- Quarterly flow monitoring in the drainage canal has an average flow of 26 cfs (JBLM 2020);
- The 7 day 10 year low flow estimate modeled in Streamstats (2020) is 3.9 cfs;
- When comparing the proportional flow of the drainage canal to corresponding flows in Chambers Creek, drainage canal flows are 13% of Chambers Creek flows. When applying that proportional flow relationship, the average flow in the drainage canal would be 14 cfs (as compared to Chambers Creek average flow).
- Current Sequalitchew Creek flow, just above the estuary at the metal bridge on Feb 29, 2020 - stream team calculation - was 6.16 ft3/sec. Historically, average flow was above 20 ft3/sec prior to the diversion canal (Renee Buck, pers. com 2020). The proposed project would provide an additional 6 – 7 ft3/sec of streamflow to Sequalitchew Creek.

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

Figure 1 shows the location of the facilities proposed for the project. Additional detail is provided in Attachment B.

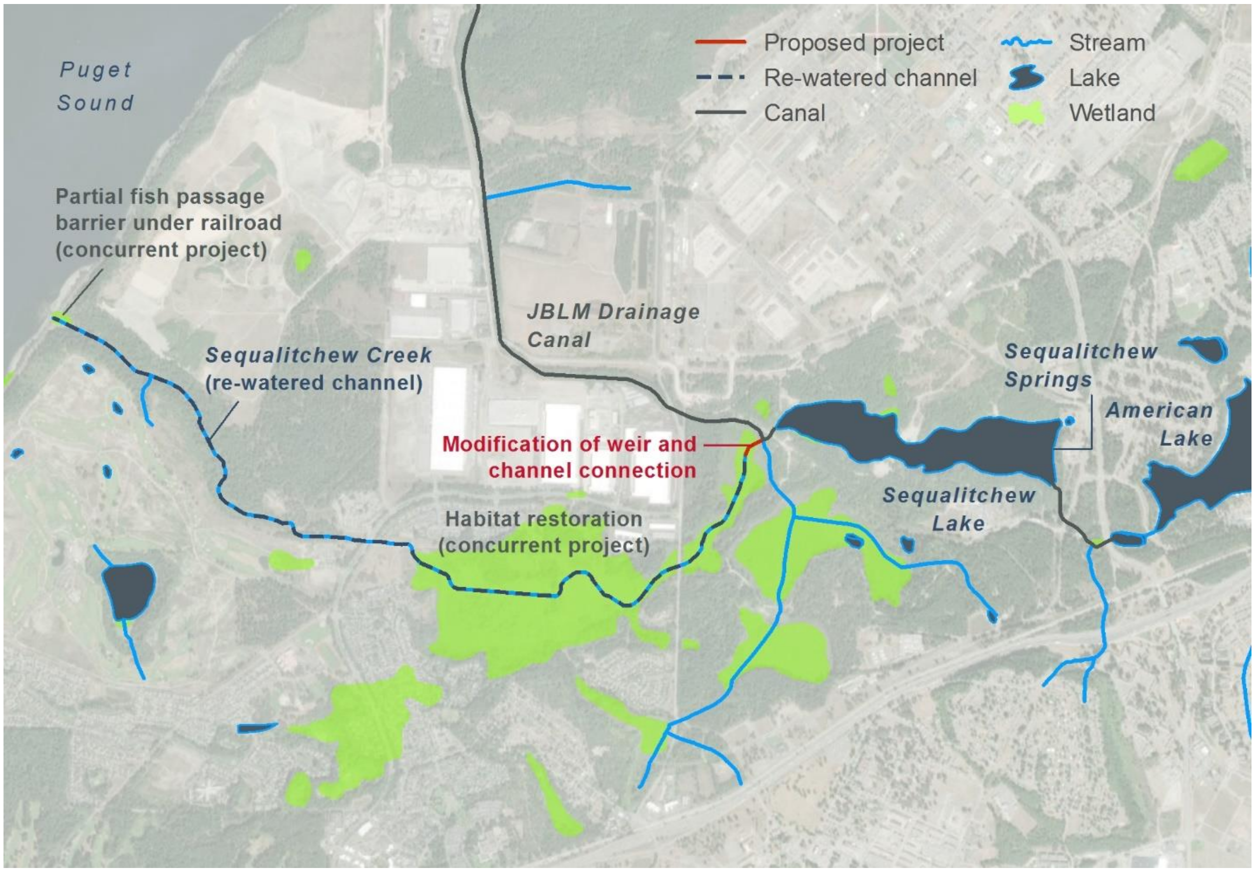


Figure 1. Sequalitchew Lake outlet modification and re-watered Sequalitchew Creek channel.

Description of the anticipated spatial distribution of likely benefits

Restored flows will directly benefit Sequalitchew Creek downstream of Sequalitchew Lake. This is approximately 3.2 miles of stream habitat (Figure 1).

Performance goals and measures.

Performance will primarily be evaluated in terms of restored flow the historic channel. Instream flow must be at least one cfs. Flow will be measured either at the new weir or in the natural channel, immediately downstream of the weir. Average flow may be estimated with either instantaneous measurements or with unattended continuous monitoring.

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

Sequalitchew Creek primarily supports cutthroat trout, coho, and chum salmon. These species currently use the most downstream portion of the Creek, where base flows are supported by groundwater inflow.

Restoring flow to the entire channel length downstream of Sequalitchew Lake may provide new aquatic habitat suitable for spawning, if adequate velocity, depth, temperature and sediment composition is formed with the restored flows. Suitable spawning habitat may be limited in the creek, as it winds through the marshes, because of the low gradient nature. The habitat may be suitable for chum, given their affinity for groundwater influence. The lower portion of the Creek likely has suitable spawning habitat for coho salmon, cutthroat trout, and chum salmon, and will likely be improved with increasing flows.

The upper portion of the creek that flows through the marshes will provide high quality rearing habitat for coho salmon and cutthroat trout. The existing habitat with added flows will provide a diverse array of main channel, off-channel, and floodplain rearing areas with low velocities, cover, and invertebrate prey item availability.

Identification of anticipated support and barriers to completion.

The JBLM identifies this project as a utility repair project that is independent of the habitat restoration plan, but nevertheless is expected to benefit stream flow (JBLM 2020). This project is not an obligation of JBLM or the United States Government, but there is an intent to fund and implement this project to maintain JBLMs drinking water utility.

Potential budget and O&M costs.

JBLM is planning on funding both capital and O&M costs with existing funds. Current costs are not available, but previous costs from an earlier project concept was estimated to be $2,681,000 (JBLM 2014).

Anticipated durability and resiliency.

The project would have lasting benefits as it would be actively managed by JBLM. O&M will be funded by JBLM. Outflows will likely remain stable but would vary by water year precipitation. The JBLM extracts groundwater from Sequalitchew Springs and increased use over time could result in decreased flows. JBLM has federal reserve water rights.

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

The project sponsor is the JBLM. A pre-design study is currently underway.

References

Aspect. 2009. Technical Memorandum, Modeling Analyses for Fort Lewis Sequalitchew Springs and Lake Area. Prepared for CalPortland on June 10, 2009.

Joint Base Lewis McChord [JBLM]. 2014. Final Briefing Memo, Sequalitchew Creek Watershed. Core Group Recommendations for a Restoration Plan. January 14, 2014.

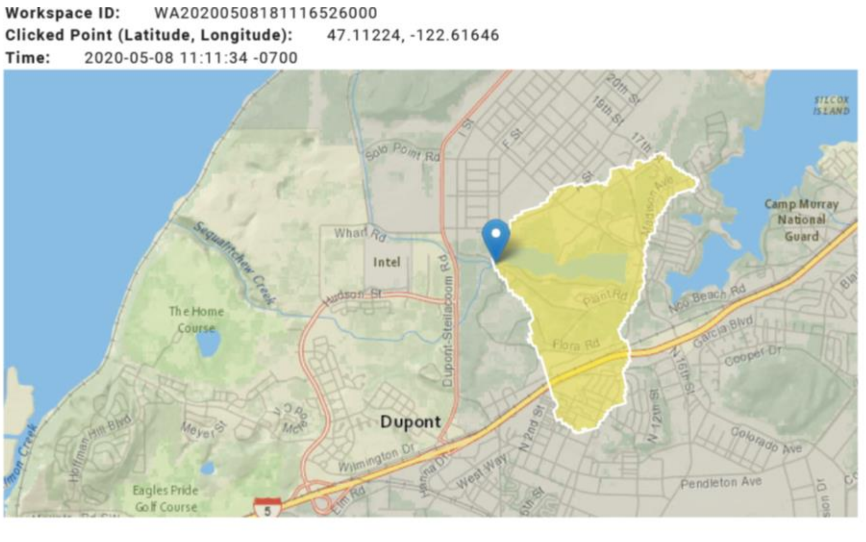
Joint Base Lewis McChord [JBLM], South Puget Sound Salmon Enhancement Group, CalPortland, and the Environmental Causus. 2020. Memorandum of Agreement Between Joint Base Lewis McChord and South Puget Sound Salmon Enhancement Group and CalPortland, and the Environmental Caucus for the Sequalitchew Creek Watershed, Agreement Number IM-W12KAA-20503.

NOAA (National Oceanic and Atmospheric Administration, National Marine Fisheries Service), 2007. Puget Sound Salmon Recovery Plan. Volume I. Adopted by the National Marine Fisheries Service, January 19, 2007.

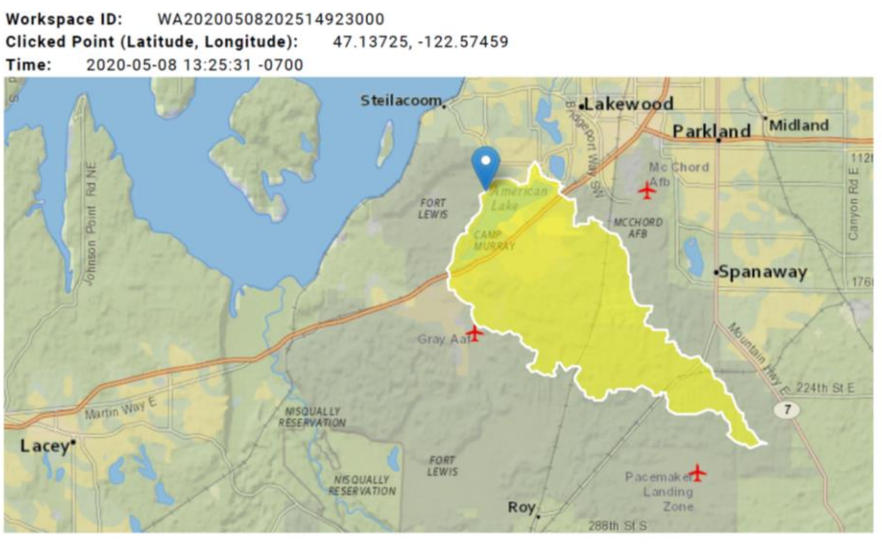
Personal Communication. 2020. Personal communication with Renee Buck, WDF (Washington Department of Fisheries), 1975. "A Catalog of Washington Streams and Salmon Utilization, WRIA 15." Accessed at: https://www.streamnetlibrary.org/?page_id=95.

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

Appendix A- Flow Estimation



Sequalitchew Watershed
7 Day 10 Year Low Flow = 0.125 cfs
2 Year Peak Flood = 27.1 cfs



American lake Watershed
7 Day 10 Year Low Flow = 3.8 cfs
2 Year Peak Flood = 382 cfs

Table A-1. JBLM Flow records in the diversion canal.

Sampling Period	Sample Collection Date	Flow (cfs)
FY16-2QTR	28-Jan-16	64.3
	11-Feb-16	58.0
	9-Mar-16	55.0
FY16-3QTR	14-Jun-16	11.9
FY16-4QTR	6-Sep-16	2.5
FY17-1QTR	13-Oct-16	3.5
FY17-2QTR	19-Jan-17	16.9
	9-Feb-17	34.6
	7-Mar-17	57.3
FY17-3QTR	5-May-17	65.1
FY17-4QTR	19-Sep-17	4.6
FY18-1QTR	30-Nov-17	51.9
FY18-2QTR	14-Mar-18	53.9
FY18-3QTR	13-Jun-18	18.4
FY18-4QTR	18-Sep-18	0
FY19-1QTR	19-Dec-18	9.25
FY19-2QTR	25-Mar-19	7.2
FY19-3QTR	20-Jun-19	0
FY19-4QTR	30-Sep-19	0
FY20-1QTR	30-Dec-19	6.3
Average Flow		26.0

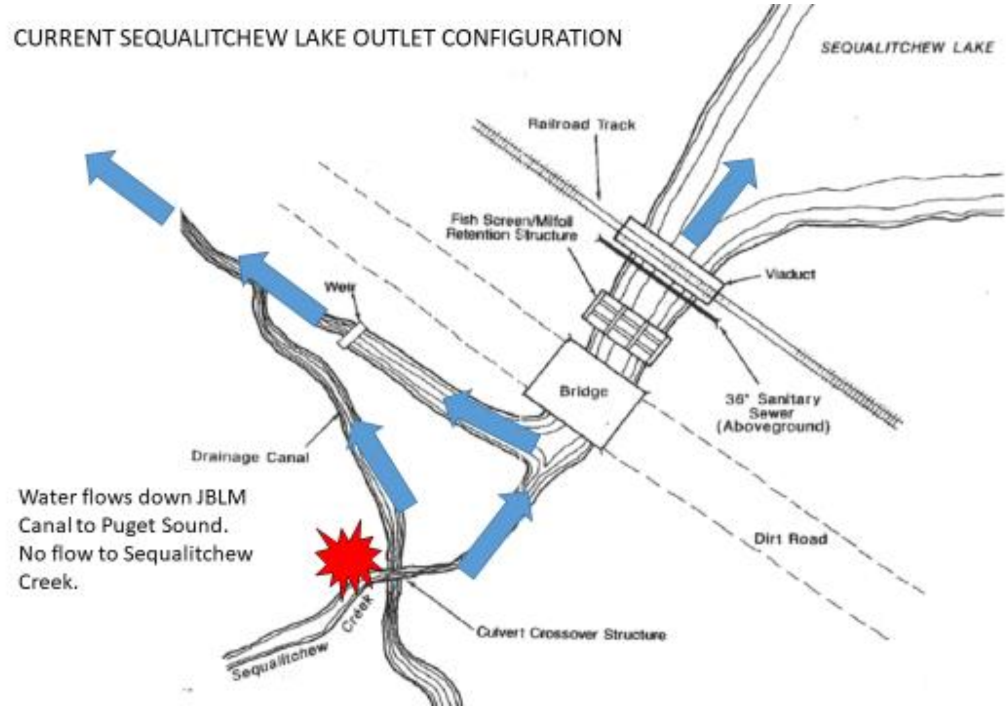
Table A-2. Average flows from Chambers Creek, below Leach Creek (USGS Station 12091500) and calculated average flows in Sequalitchew Creek based on assumed proportional watershed areas and average flows.

	Chambers	Sequalitchew	Percentage	Sequalitchew and American	Percentage
Area (sq mi)	104	1.49		27	
Average Flow (cfs)	112	**1.6**	1.4%	**34.2**	30.5%

Table A-3. Comparison of daily flows from Chambers Creek, below Leach Creek (USGS Station 12091500) with measured flows in the JBLM diversion canal, the percentage of flows between stations, and estimation of average flows in the JBLM diversion canal, assuming average proportional differences in flow.

Date	Chambers (cfs)	JBLM Diversion Canal (cfs)	Percentage
28-Jan-16	412	64.3	15.6%
11-Feb-16	266	58	21.8%
9-Mar-16	336	55	16.4%
14-Jun-16	79.7	11.9	14.9%
6-Sep-16	47.2	2.51	5.3%
13-Oct-16	118	3.46	2.9%
19-Jan-17	235	16.9	7.2%
9-Feb-17	262	34.6	13.2%
7-Mar-17	289	57.3	19.8%
5-May-17	227	65.1	28.7%
19-Sep-17	147	4.6	3.1%
30-Nov-17	170	51.9	30.5%
14-Mar-18	162	53.9	33.3%
13-Jun-18	70.4	18.4	26.1%
18-Sep-18	36.5	0	0.0%
19-Dec-18	110	9.25	8.4%
25-Mar-19	114	7.2	6.3%
20-Jun-19	40.7	0	0.0%
30-Sep-19	36.7	0	0.0%
30-Dec-19	166	6.3	3.8%
Average Percent of Chambers Cr Flow			12.9%
Average Chambers Creek Flow (cfs)			112
Imputed Average Sequalitchew Creek Flow (cfs)			**14**

Appendix B- Diversion Details


CURRENT SEQUALITCHEW LAKE OUTLET CONFIGURATION
SEQUALITCHEW LAKE
Railroad Track
Fish Screen/Milfoil Retention Structure
Viaduct
Weir
Bridge
36" Sanitary Sewer (Aboveground)
Drainage Canal
Water flows down JBLM Canal to Puget Sound. No flow to Sequalitchew Creek.
Dirt Road
Culvert Crossover Structure
Sequalitchew Creek

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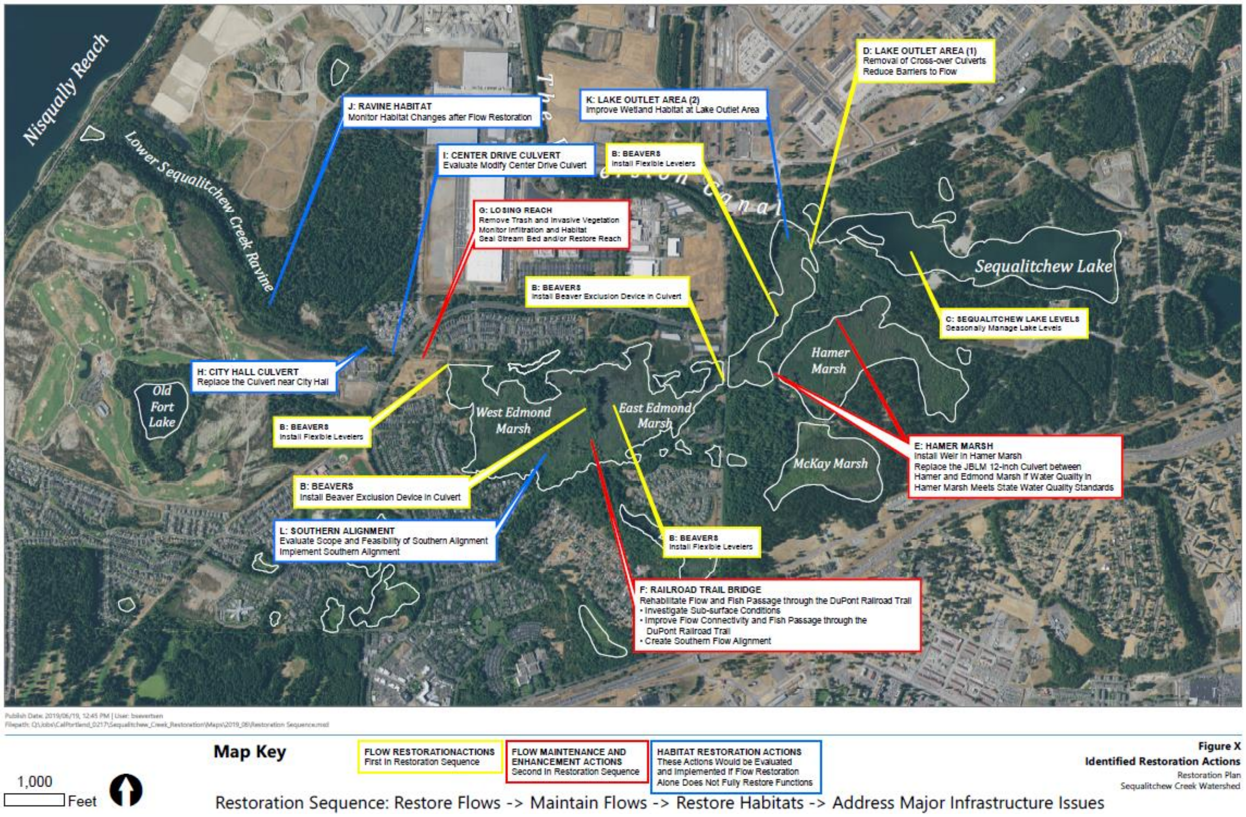

Nisqually Reach
Lower Sequalitchew Creek Ravine
The DuPont Canal
Old Fort Lake
West Edmond Marsh
East Edmond Marsh
Hamer Marsh
McKay Marsh
Sequalitchew Lake
J: RAVINE HABITAT
Monitor Habitat Changes after Flow Restoration
K: LAKE OUTLET AREA (2)
Improve Wetland Habitat at Lake Outlet Area
D: LAKE OUTLET AREA (1)
Removal of Cross-over Culverts
Reduce Barriers to Flow
I: CENTER DRIVE CULVERT
Evaluate Modify Center Drive Culvert
B: BEAVERS
Install Flexible Levelers
G: LOSING REACH
Remove Trash and Invasive Vegetation
Monitor Infiltration and Habitat
Seal Stream Bed and/or Restore Reach
B: BEAVERS
Install Beaver Exclusion Device in Culvert
C: SEQUALITCHEW LAKE LEVELS
Seasonally Manage Lake Levels
H: CITY HALL CULVERT
Replace the Culvert near City Hall
B: BEAVERS
Install Flexible Levelers
E: HAMER MARSH
Install Weir in Hamer Marsh
Replace the JBLM 12-inch Culvert between
Hamer and Edmond Marsh if Water Quality in
Hamer Marsh Meets State Water Quality Standards
B: BEAVERS
Install Beaver Exclusion Device in Culvert
L: SOUTHERN ALIGNMENT
Evaluate Scope and Feasibility of Southern Alignment
Implement Southern Alignment
B: BEAVERS
Install Flexible Levelers
F: RAILROAD TRAIL BRIDGE
Rehabilitate Flow and Fish Passage through the DuPont Railroad Trail
• Investigate Sub-surface Conditions
• Improve Flow Connectivity and Fish Passage through the DuPont Railroad Trail
• Create Southern Flow Alignment
Map Key
FLOW RESTORATIONACTIONS
First in Restoration Sequence
FLOW MAINTENANCE AND ENHANCEMENT ACTIONS
Second in Restoration Sequence
HABITAT RESTORATION ACTIONS
These Actions Would be Evaluated and Implemented if Flow Restoration Alone Does Not Fully Restore Functions
1,000 Feet
Restoration Sequence: Restore Flows -> Maintain Flows -> Restore Habitats -> Address Major Infrastructure Issues
Figure X
Identified Restoration Actions
Restoration Plan
Sequalitchew Creek Watershed

Appendix C- Photo Appendix

Figure C-1. Sequalitchew Lake, from the outlet (top left); Sequalitchew Lake outlet (top right); water control structure at diversion canal entrance (bottom left); Sequalitchew Creek downstream of lake outlet (bottom right).

Figure C-2. Mckay Marsh (top left); Hamer Marsh (top right).

Figure C-3. Wetlands along Sequalitchew Creek upstream of Dupont-Steilacoom Road (left); Edmonds Marsh along Sequalitchew Creek (ight).

Figure C-4. Dry Sequalitchew Creek channel upstream of Center Drive (left); dry Sequalitchew Creek channel near DuPont City Hall (right).

Figure C-4. Sequalitchew Creek delta upstream of the railroad and Puget Sound confluence (left); Sequalitchew Creek delta downstream of the railroad, along the Puget Sound shoreline (right).

SOUTH TACOMA CHANNEL STORMWATER INFILTRATION PROJECT DESCRIPTION

Description

The City of Tacoma (City) is proposing a multi-site project to enhance streamflow in the Flett Creek Watershed (Figure 1). The City is proposing to direct stormwater flows to large-scale infiltration facilities within the South Tacoma Channel (STC) (Sites 1 and 2) to enhance streamflow and function of lower Flett Creek and Flett Wetland (Site 3). The Project would enhance instream flows that have been negatively impacted over time by the progressive increase in urbanization, the City's historical stormwater management practices, and out-of-basin pumping of surface water to marine outfalls. Source stormwater would originate from throughout the Flett Creek Watershed and also from a redirection of current cross-basin flows from the Leach Creek Regional Stormwater Holding Basin (LCHB) to the Thea Foss Waterway (Commencement Bay outfall).

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

The main overall project components include (1) re-routing and infiltrating some of the City's stormwater flows, including high flows from the LCHB and other stormwater from the Flett Creek Watershed, (2) treating and infiltrating this water in the STC at Site 1 and Site 2 at the Metro Parks' South End Recreation & Adventure (SERA) athletic fields to re-time the current flow regime and enhance dry season baseflow to Flett Creek, and (3) restoring ecological function of the Flett Wetland and supplementing flows to the stream channel at Site 3. All three sites will be designed to work in conjunction to enhance streamflows and avoid negative impacts to wetland functions during critical summer low-flow periods.

Based on the results of the groundwater model (Landau Associates 2020), estimated streamflow enhancement to Flett Creek due to infiltration at Sites 1 and 2 may be on the order of 0.8 to 1.1 CFS, with the highest magnitude benefits occurring in the dry-season (summer) months (Table 1). The modeling indicates that Flett Creek streamflows may be enhanced both in terms of overall magnitude and timing of groundwater baseflow to provide targeted benefit during the dry-season months.

The water offset quantity for the WRIA 12 Watershed Plan is estimated to be 701 acre-feet per year.

Table 1. Estimated streamflow enhancement to Flett Creek with the completion of infiltration sites 1 and 2.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot
Acre-feet	51	48	58	61	67	67	69	67	63	51	49	51	701
Instantaneous Quantity (cfs)	0.83	0.86	0.94	1.02	1.09	1.12	1.12	1.10	1.06	0.83	0.83	0.82	--

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

Flett Creek is a tributary to Chambers Creek within WRIA 12. The very upstream portion of Flett Creek (Site 1), within the South Tacoma Channel, is channelized or piped as part of the City's stormwater sewer system and flows south toward Metro Parks' SERA athletic fields (Site 2). Site 3 is a large wetland at the boundary between Tacoma and Lakewood that has the potential to host salmon populations and other native aquatic species of concern. Water discharging from the wetland flows to a natural channelized portion of Flett Creek to its confluence with Leach Creek and Chambers Creek before flowing to the Puget Sound near Steilacoom (Figure 1).

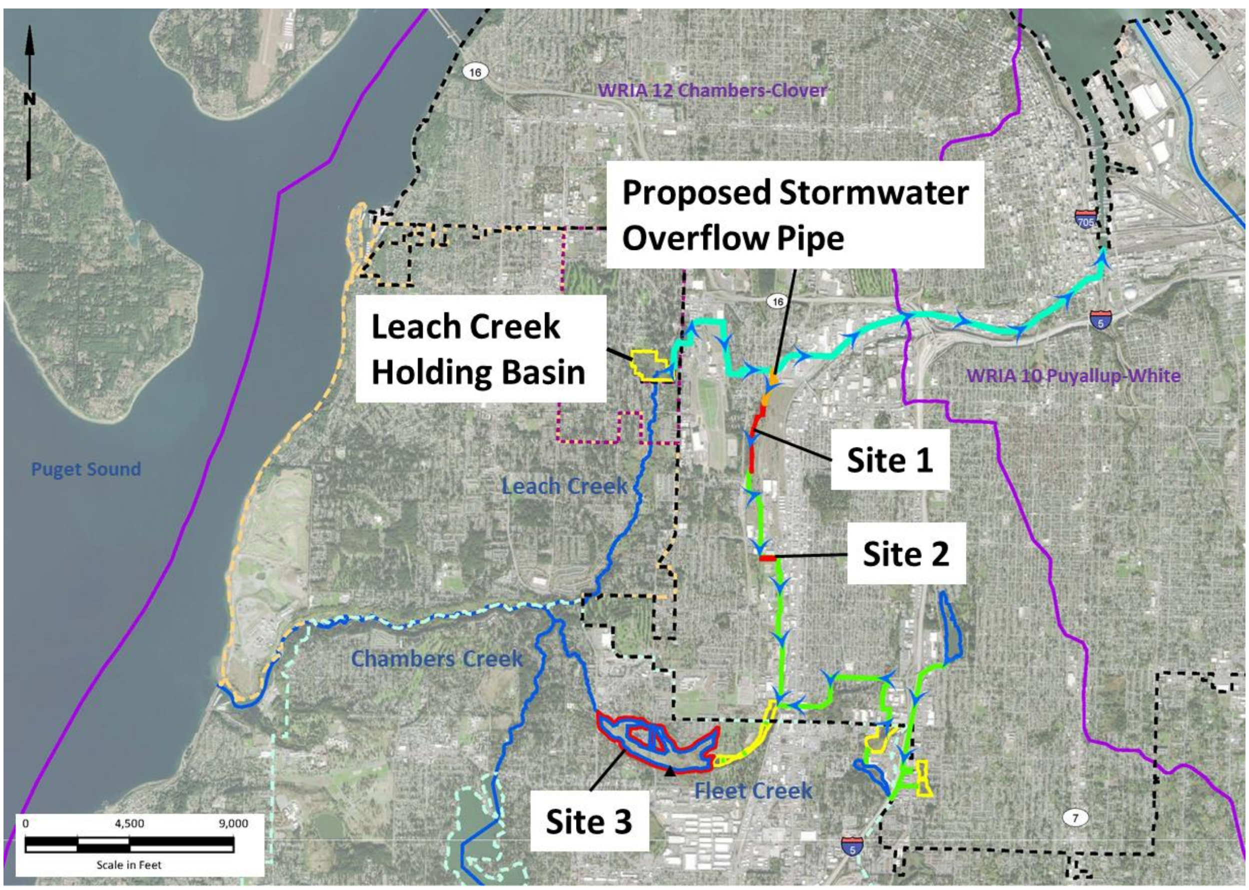


Figure 1. Locations of proposed infiltration areas (Sites 1 and 2), channel restoration (Site 3), and stormwater overflow pipe within the Flett Creek drainage basin, Tacoma, WA (Appendices A-C). Existing holding basins are identified by yellow outline. Proposed infiltration and channel restoration sites are identified by red outline. Existing stormwater conveyance is identified by green and blue/green highlighting.

Description of the anticipated spatial distribution of likely benefits

Water infiltration at Sites 1 and 2 could increase groundwater levels over approximately 701 acres of the headwaters of the Flett Creek Subbasin and provide increased groundwater inputs and flows into nearly two miles of perennial streams (Landau Associates 2020). Water infiltration could also enhance or restore wetlands associated with the creeks or headwater areas.

Performance goals and measures.

The performance goals are to direct stormwater flows to large-scale infiltration facilities within the STC (Sites 1 and 2) to enhance streamflow by 701 acre-feet per year and eliminate LCHB overflow which is currently pumped out-of-basin to the Thea Foss Waterway (Commencement Bay marine outfall). The measures will be an increase in baseflow in summer in lower Flett Creek and Flett Wetland (Site 3) by about 0.5 cfs. The increased baseflow should reduce water temperatures in those streams.

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

The southern portion of Flett Creek (downstream of the Flett Creek Holding Basins) flows through a natural wetland that provides habitat to several salmonid species and other native aquatic species of concern. Four populations of salmonids are presumed or documented as present in Flett Creek, according to WDFW's online SalmonScape mapping system:

1) Chambers Creek Coho salmon (*Oncorhynchus kisutch*) have been documented spawning west of Bridgeport Way immediately downstream of Flett Wetland, and are presumed to be present throughout the wetland up until the Holding Basins.

2) Chambers Creek Winter Chum salmon (*O. keta*) have been documented upstream of Bridgeport Way at the western end of Flett Wetland.

3) South Sound Tributaries Winter Steelhead (*O. mykiss*) have been documented upstream of Bridgeport Way (within Flett Wetland), and are presumed to be present throughout the wetland up until the Holding Basins. This population of steelhead is listed federally as a "threatened" evolutionarily significant unit (ESU).

4) West South Sound Coastal Cutthroat Trout (*O. clarkia*) have also been documented by City personnel in the Flett Wetland south of the Holding Basins.

While historically present in Flett Creek, Chinook salmon are currently captured at the Garrison Hatchery at the mouth of Chambers Creek and are no longer found in Flett Creek. A dam adjacent to the Garrison Hatchery at the mouth of Chambers Creek, which also serves to impede fish migration, is being considered for removal.

Table 2. Natural fish populations found within the Fleet Creek watershed within WRIA #12.

Population Name	Species	Federal Status
South Sound Tributaries Winter Steelhead	Steelhead	Threatened
Chambers Creek Coho	Coho	Candidate
Chambers Creek Summer Chum	Chum	Not Warranted
Chambers Creek Winter Chum	Chum	Not Warranted
West South Sound Coastal Cutthroat	Cutthroat	Not Warranted

(available online at: https://fortress.wa.gov/dfw/score/score/maps/map_details.jsp?geocode=wria&geoarea=WRIA12_Chambers_Clover)

The portion of Flett Creek downstream of the Flett Creek Holding Basins (i.e., Flett Wetland and steeper natural Flett Creek channel) has the potential to provide vital rearing and foraging habitat for the aforementioned salmon and trout populations year round, including the ESU threatened South Sound Winter Steelhead. While Coho have been documented spawning in Flett Creek just west of Flett Wetland, the targeted life history stage this proposed project is seeking to support is juvenile rearing.

Increased base streamflow 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 in WRIA 12 (NOAA 2007) and streamflow is important for supporting riparian vegetation and wetlands that provide shading, food web support, and flood and sediment attenuation functions.

During dry season summer months, a majority of Flett Wetland is completely dry, and saturated areas that do exist are fragmented, extremely shallow, and exceed the thermal tolerance limit of juvenile salmonids. Conversely, Flett Creek flows are at a maximum during wet season winter months, and have exceeded 90 CFS. During these high flow events, flooding of the Flett Wetland has impacted the Flett Creek Holding Basin pump station and adjacent Mountain View Cemetery, as well as reduced riparian habitat complexity and value. The dramatic fluctuation in streamflows, coupled with aquatic habitat degradation, have hindered the success of salmon populations in the Flett Wetland.

Improving upstream infiltration in the STC (Site 1) and SERA Playfields (Site 2) and modifying stormwater holding basin management strategies would reduce wet season maximum flows and increase dry season minimum flows. Retiming flows to enhance summertime baseflow will improve habitat quality and accessibility and provide thermal refuge for salmonid rearing within Flett Wetland and Creek. Habitat and channel restoration will also provide the gradient necessary to move water through the wetland to mitigate flooding during winter months.

Identification of anticipated support and barriers to completion.

The Project supports: (1) The City's Watershed Plan goals to prioritize stormwater management projects that promote the recovery of healthy stream hydrology and aquatic habitat (City of Tacoma 2019). (2) The Chambers-Clover Creek Watershed Council 2018-2023 Action Agenda goals of protection and recovery of priority waterbodies and improvement of ground and surface water (CCCWC 2018). (3) The Chambers Watershed Salmon Habitat Protection & Restoration Strategy (Lead Entity 2018). In addition, Flett Creek is one of the high priority tributaries for the Salmon Strategy with priority actions including restoring floodplain connection and off-channel habitat, habitat diversity and complexity, normal flow regimes, and riparian function (Lead Entity 2018).

Tacoma staff have met with the project site property owners, including BNSF, Metro Parks, Clover Park Technical College, and the City of Lakewood, to review the scope of the feasibility study and overall project and to gain the necessary landowner acknowledgement forms and approvals to access the project Sites for study. The City has access easements and access permission for project Site 1; Landowner Acknowledgment Form and access permission for project Site 2; and access easements, Landowner Acknowledgement Forms and access permission for project Site 3. City proponents shared the project proposal and have invited feedback from the WRIA 12 WREC committee members, Chambers-Clover Watershed Council, Washington Department of Fish and Wildlife, and Puyallup Tribal Council (via Char Naylor). The City has received letters of support from Pierce Conservation District, Clover Park Technical College (Flett wetland landowner), Metro Parks (SERA fields land owner), City of Lakewood (Flett wetland landowner), Lead Entity for Salmon Recovery for WRIA 12, and the Puyallup Tribe of Indians.

Uncertainties and risks associated with project implementation can be categorized as technical or regulatory, and will be further evaluated during the completion of a proposed feasibility study (Landau Associates 2020). Technical uncertainties and risks are associated with (1) infiltration capacities of the soils, (2) groundwater flow directions and velocities (3) possible environmental considerations, and (4) potential flooding or draining of the Flett Wetland. Regulatory uncertainties and risks are associated with federal, state, and local permitting requirements, which may impact the timeline and scope of work at all three sites. The following is a list of expected permits: (1) A Critical

Areas Preservation Ordinance permit review and City of Tacoma and/or City of Lakewood approval for work completed within wetlands or streams. (2) USACE and Ecology review and approval for federal Clean Water Act Section 404 and/or 401 Certification (with potential consultation with NOAA Fisheries and the U.S. Fish and Wildlife Service) for work completed within wetlands or streams. (3) Work within fish-bearing waters of the State requires a Hydraulic Project Approval from WDFW. (4) A cultural resource site investigation may be necessary. (5) The STC ditch is located within the STGPD and infiltration projects must be approved by the Tacoma Pierce County Health Department. (6) State Underground Injection Control regulations apply if the infiltration facilities consists of a perforated pipe. Injection wells must be registered with Ecology and a discharge permit may be required.

The main barrier to completion is funding for construction and O&M costs.

Potential budget and O&M costs.

The total construction costs of re-routing and infiltrating some of the City's stormwater flows, treating and infiltrating this water, and 3) restoring ecological function of the Flett Wetland and supplementing flows to the stream channel at Project Site 3 are estimated to be $3.85 million. This cost estimate should be considered preliminary and will be refined further as part of a proposed feasibility study (City of Tacoma 2020).

Anticipated durability and resiliency.

The project would have lasting benefits as it would be actively managed by the City's Environmental Services Department and O&M would likely be funded through ratepayers. Some water sources (e.g. stormwater) will increase with increasing rainfall due to climate change although these inputs would be flashy.

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

The primary project sponsors will be the City of Tacoma. The City has a team of experienced watershed planning, asset management, facility maintenance, and stormwater design staff, along with expert consultants, who have developed this Project together and will be ready to begin as soon as funding is approved. 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 Puyallup Tribe of Indians, Washington Department of Fish and Wildlife, Pierce Conservation District, City of Lakewood, Clover-Park Technical College, Chambers-Clover Watershed Council, and the Lead Entity for Salmon Recovery for WRIA 12.

References

Chambers Clover Creek Watershed Council (CCCWC). 2018. Chambers-Clover Creek Watershed Council 2018-2023 Action Agenda. April 6, 2018 DRAFT.

City of Tacoma. 2019. Tacoma Watershed Management Plan. February 2018.

City of Tacoma. 2020. Streamflow Restoration Grant Application. March 30, 2020.

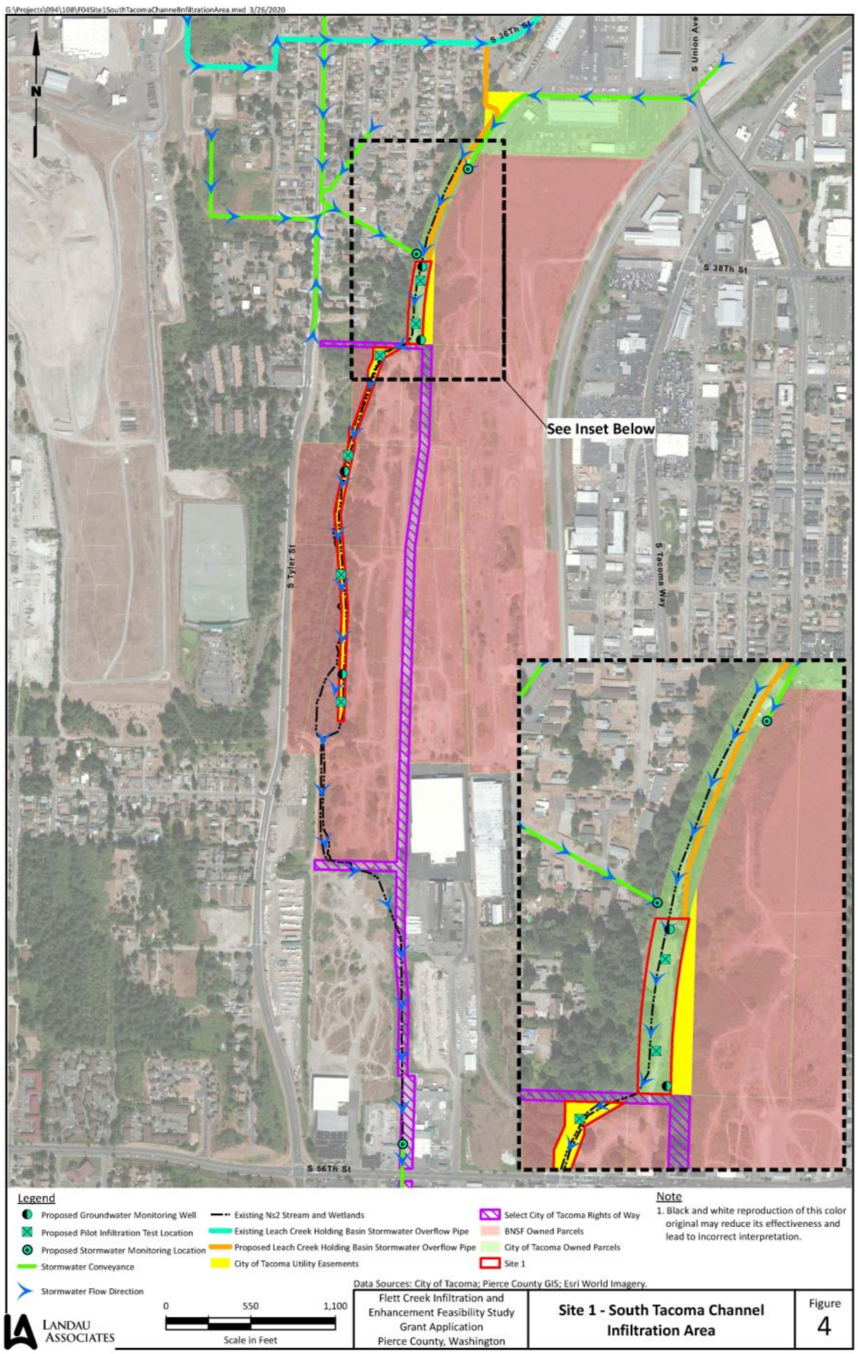
Landau Associates. 2020. Streamflow Enhancement Estimation, South Tacoma Channel Stormwater Infiltration Project Feasibility Study, Tacoma, Washington, Project No. 0094108.010.01. Technical Memorandum Prepared for the City of Tacoma on March 26, 2020.

National Oceanic and Atmospheric Administration (NOAA). 2017. Puget Sound Salmon Recovery Plan. January 19, 2007. https://repository.library.noaa.gov/view/noaa/16005.

Puyallup and Chambers Watersheds Salmon Recovery Lead Entity (Lead Entity). 2018. Salmon Habitat Protection and Restoration Strategy for Puyallup and Chambers Watersheds. June 2018.

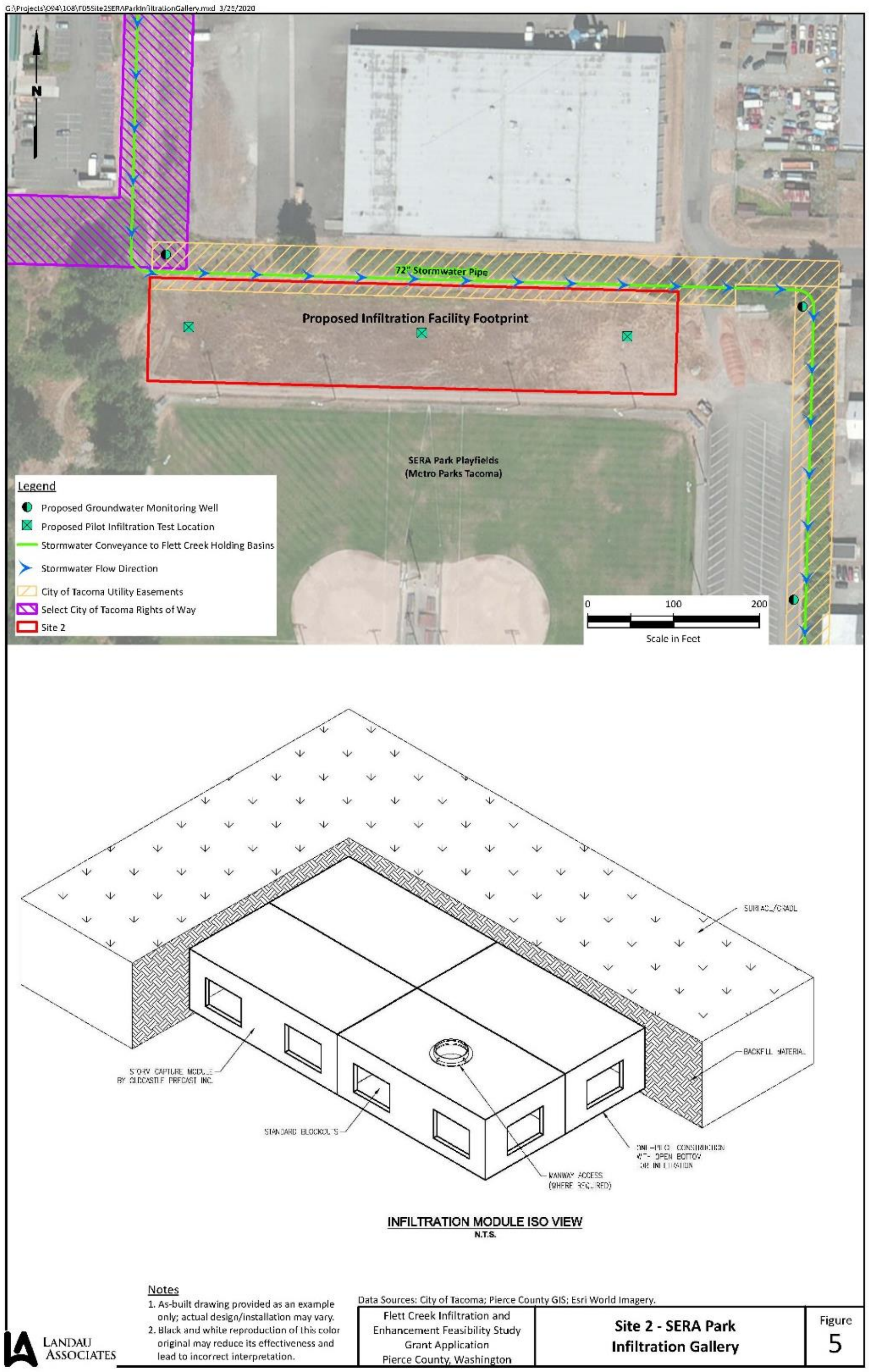
Appendix A

Site 1 – South Tacoma Channel Infiltration



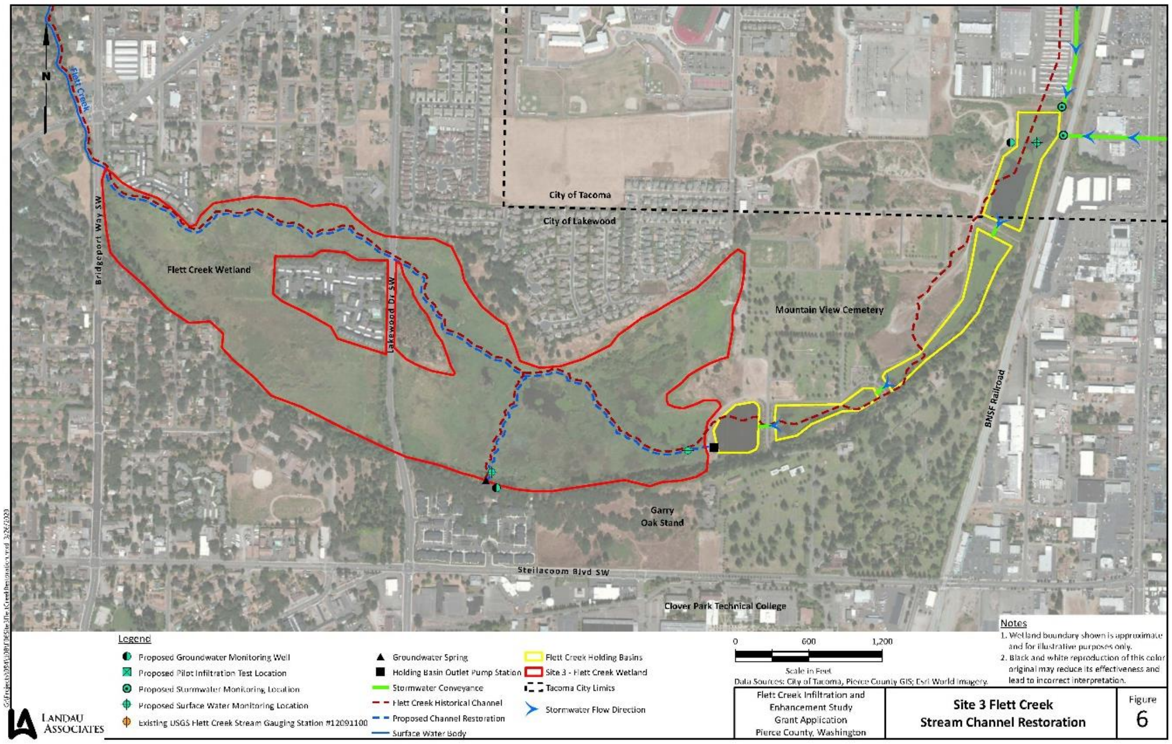
Appendix B

Site 2 – SERA Park Infiltration Gallery



Appendix C

Site 3 – Flett Creek Stream Channel Restoration



RECLAIMED WATER
PROJECT DESCRIPTION

Description

Reclaimed water is water that starts out as domestic wastewater, but then is treated and tested to use for specific purposes.[1] Reclaimed water can be used for beneficial uses in the watershed; one use is infiltration back to local aquifers. The Joint Base Lewis McChord (JBLM) and Pierce County may infiltrate reclaimed water back to local aquifers in the future, though there are no current plans. Infiltration of reclaimed water into local aquifers would result in local aquifer recharge and would offset local permit-exempt well consumptive use.

The JBLM currently produces Class A Reclaimed Water at the JBLM Solo Point Wastewater Treatment Plant (WWTP). The JBLM Solo Point WWTP is authorized to discharge reclaimed water to Puget Sound through an EPA administered National Pollutant Discharge Elimination System (NPDES) Permit (Permit No. WA-002195-4). In 2012, a Project Definition Report was prepared for the United States Army Corps of Engineers (USACE) Seattle District (HDR 2012) to construct facilities needed for Class A reclaimed water production and recharge. The analysis included a new booster pumping stations, storage tanks, and distribution system for Class A reclaimed water produced at JBLM Solo Point WWTP to locations throughout JBLM for water reuse to reduce potable water consumption and to recharge upstream aquifers. There are currently no infrastructure or plans to distribute reclaimed water to locations throughout JBLM for reuse and upstream aquifer recharge.

Pierce County does not currently produce reclaimed water at their Chambers Creek Regional Wastewater Treatment Plant.

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

There are currently no plans to infiltrate reclaimed water by the JBLM or Pierce County, respectively. Therefore, no offset benefits are currently anticipated. Additionally, the capacity for a series of conveyance and infiltration basins is unknown. Demand for reclaimed water is high during the dry summer months. However, reduced irrigation demand, high seasonal groundwater and other challenges make reclaimed water more difficult to manage in the wet season.

Water reclamation treatment would begin with wastewater treatment to secondary standards, including coagulation and filtration, and disinfecting to an advanced level. Siting for recharge basins would occur with the main criteria being those that are large, in locations that provide the greatest recharge of existing aquifers, but allow at least one year of storage from the time the reclaimed

[1] Department of Ecology. Reclaimed Water. https://ecology.wa.gov/Water-Shorelines/Water-quality/Reclaimed-water

water is infiltrated to the time it is withdrawn for potable use. Higher levels of reclaimed water treatment may be required prior to ground water recharge to control endocrine disruptors and other contaminants of emerging concern.

Reclaimed water may be infiltrated in the future, at the discretion of the JBLM and Pierce County, respectively. The timing, location, and quantity is currently undefined.

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

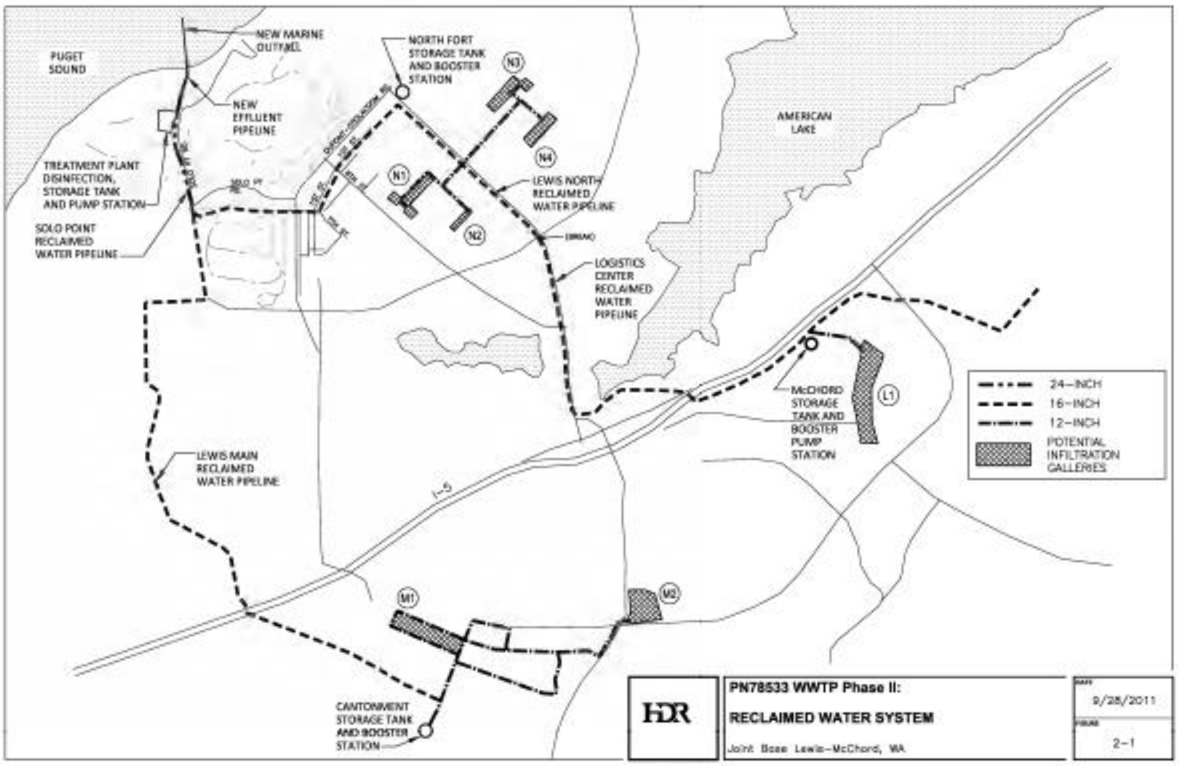


Figure 1. Location of pipeline to JBLM Solo WWTP and to infiltration area (from HDR 2012)

Description of the anticipated spatial distribution of likely benefits

JBLM reclaimed water infiltration would be limited to the JBLM. Pierce County satellite plans could be anywhere within Pierce County Sewer Division's service area, including WRIAs 10, 12, and 15.

Performance goals and measures.

If reclaimed water were to be produced and infiltrated in the WRIA 12 watershed, performance could be evaluated by measuring the quantity of water infiltrated and measuring local water table response (i.e. mounding).

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

Local stream flows may benefit from reclaimed water infiltration, though specific locations of future infiltration and streams benefitting from that infiltration are not currently defined.

Identification of anticipated support and barriers to completion.

Future reclaimed water infiltration by the JBLM would require future programmatic and budget support. Programmatic support would be consistent with the goals of the Grow the Army initiative, which supports continued growth of JBLM population. Infiltration of reclaimed water would decrease net potable water consumption, pursuant to the JBLM Net Zero water sustainability goal. The primary barrier would be project prioritization and the availability of funding for the construction and O&M costs.

Future reclaimed water production and infiltration by Pierce County is subject to future planning, prioritization, and funding.

Potential budget and O&M costs.

Costs would be determined if and when projects are defined.

Anticipated durability and resiliency.

Reclaimed water infiltration benefits would be durable, since it would be actively managed by JBLM or Pierce County, respectively. The source of water (wastewater) would be predictable.

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

The JBLM and Pierce County have the large WWTPs in WRIA 12. However, neither organization has committed to conveying and infiltrating reclaimed water to local aquifers.

Other Reclaimed Water Project(s) within the Region

The Pierce County Sewer Division started work on an update to their comprehensive planning document, known as the Unified Sewer Plan, in 2020. This update will include an evaluation of reclaimed water production and the development of satellite treatment facilities within its service area. Adoption of the updated plan is anticipated to occur in 2022.

References

HDR. 2012. Project Definition Report FY13 Water Reclamation System PN 78533 Joint Base Lewis-McChord, WA. Prepared for U.S. Army Corps of Engineers Seattle District CENWS-PM-MB on January 18, 2012.

WRIA 12 RAIN GARDEN AND GREEN STORMWATER INFRASTRUCTURE PROGRAM PROJECT DESCRIPTION

Description

Rain gardens and Green Stormwater Infrastructure (GSI) retrofit projects could be applied to existing homes and driveways, roadways, parking lots and other impervious areas that generate stormwater. The techniques include rain gardens, planter boxes, bio-infiltration swales, permeable pavement and reducing the footprint of roadways and replacing with GSI (green streets).

Rain gardens are small stormwater facilities that collect, store, and filter rainwater and stormwater runoff from lawns, rooftops, sidewalks, driveways and other impervious surfaces. Designed as shallow, sunken planting beds with rain garden soil, runoff flows into them from nearby hard surfaces and connected downspouts. The rain gardens can also be designed to infiltrate water.

Planter boxes are urban rain gardens with vertical walls and either open or closed bottoms. They collect and absorb runoff from sidewalks, parking lots, and streets and are ideal for space-limited sites in dense urban areas and as a streetscaping element.

Bioswales are vegetated, mulched, or xeriscaped channels that provide treatment and retention as they move stormwater from one place to another. Vegetated swales slow, infiltrate, and filter stormwater flows. As linear features, they are particularly well suited to being placed along streets and parking lots. Bio-infiltration swales are specifically designed to infiltrate stormwater.

Permeable pavements infiltrate, treat, and/or store rainwater where it falls. They can be made of pervious concrete, porous asphalt, or permeable interlocking pavers. Permeable pavements can be installed in sections of a parking lot and rain gardens and bioswales can be included in medians and along the parking lot perimeter.

Green streets are created by integrating green infrastructure elements into their design to store, infiltrate, and evapotranspire stormwater. Permeable pavement, bioswales, planter boxes, and trees are among the elements that can be woven into street or alley design.

In WRIA 12, Pierce Conservation District has assisted residences in rain garden design and construction and the Conservation District has indicated they would be willing to help implement a program of additional rain garden and GSI construction. Links to information on these techniques:

- https://piercecd.org/244/Rain-Gardens
- https://www.cityofpuyallup.org/192/Puyallup-Rain-Gardens
- https://www.co.pierce.wa.us/2812/Rain-Gardens
- https://kitsapcd.org/programs/raingarden-lid/rgbasics

- https://fortress.wa.gov/ecy/publications/publications/1310027.pdf
- http://www.seattle.gov/utilities/your-services/sewer-and-drainage/green-stormwater-infrastructure
- https://www.epa.gov/green-infrastructure

The goal of this project would be to support the implementation of rain gardens and GSI across WRIA 12, with an emphasis on subbasins that will experience the most growth and/or contain priority streams, as defined by the WRIA 12 Committee.

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

The draft Watershed Restoration and Enhancement Committee identified rain gardens and GSI projects as having potential for implementation to help meet water offsets. The Committee set the goal for implementation at 10 projects per year.

The water offset from rain gardens and GSI projects was estimated using analyses performed for a Mason County rooftop runoff infiltration analysis. To estimate the potential water offset, the soil type, impervious area rain is collected from, the rain garden size and annual precipitation is required. For planning purposes, it is assumed Type B soils are present, a rooftop or driveway area of 2,000 square feet is directed to a rain garden, the rain garden has a 200 square feet infiltration area and the annual precipitation is between 40 and 50 inches. The estimated infiltration volume is 0.14 acre-feet per year for annual precipitation of 40 inches and 0.17 acre-feet per year for annual precipitation of 50 inches. Calculations are shown in the Appendix. The timing of the streamflow will depend on the location of the project and geologic conditions. With a number of rain garden and GSI projects implemented, it is expected their would be a range of timing of benefits and benefits would occur year-round.

The water offset benefit of adding 10 rain garden type projects per year is about 1.5 acre-feet per year, using an average of the 40- and 50-inch precipitation values. Over 18 years of plan implementation, the water offset benefit would add up to 27 acre-feet per year. If GSI projects were implemented that have greater impervious area, the water offset would be higher.

Description of the anticipated spatial distribution of likely benefits

The projects can occur in any subbasin and this program is described in the Watershed Restoration and Enhancement Plan as a WRIA-wide project. A committee goal is to focus the program on subbasins that will experience the most growth and/or contain priority streams. Figure 1 shows WRIA 12 with the areas of highest growth in permit-exempt wells in yellow to red and priority stream in orange and yellow.

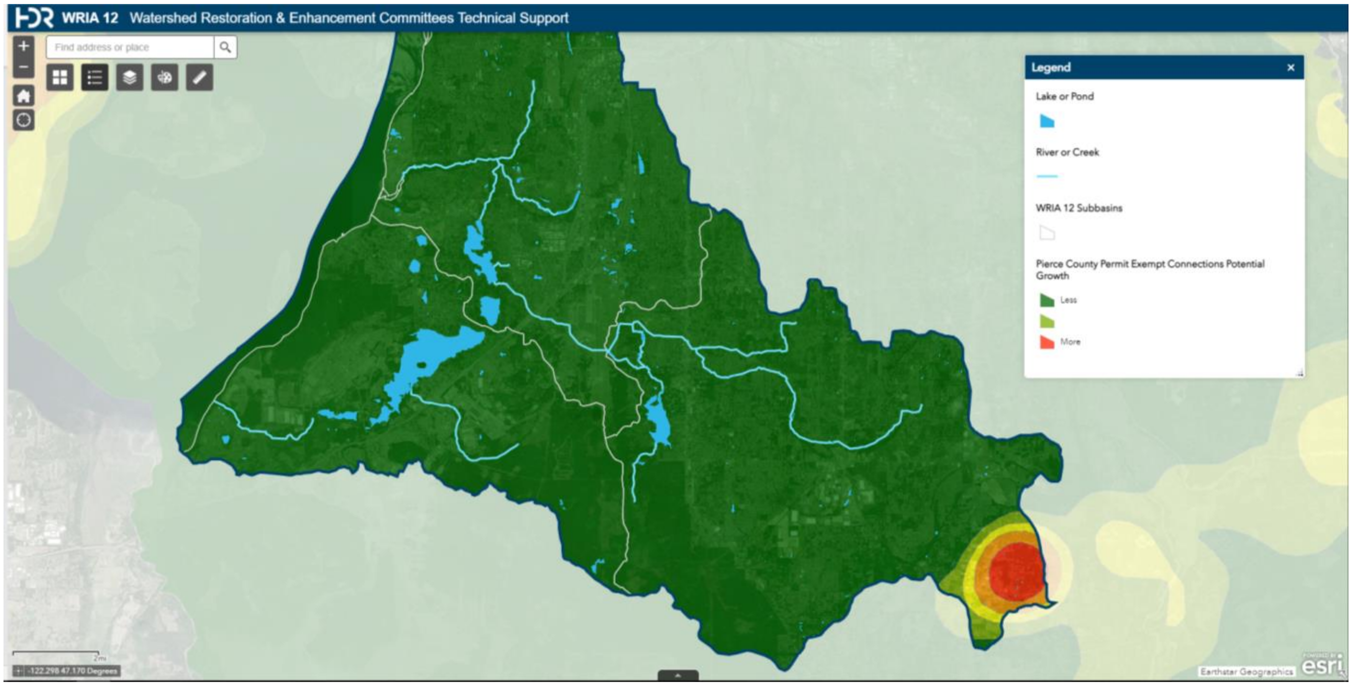


Figure 1. WRIA 12 permit exempt well potential growth and priority streams

Performance goals and measures.

This project would be measured by the number of functional raingardens or GSI projects installed within WRIA 12, which is planned to be 10 per year. The number may vary depending on factors such as finding suitable areas to retrofit, funding and capacity of project sponsors.

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

Projects that infiltrate water will increase groundwater recharge, provide more baseflow in summer and fall by increasing groundwater discharge, reduce summer and fall stream temperatures because of increased groundwater discharge and increase groundwater availability to riparian and near-shore plants.

The primary limiting factors in the Chambers-Clover Watershed (Runge et al. 2003; Lead Entity, 2018) which would be addressed through this program include:

- Stream flow, especially summer low flows
- Water quality, especially water temperature

Identification of anticipated support and barriers to completion.

Pierce Conservation District is primary sponsor and supports this program. The primary barrier is the availability of funding for the construction of rain gardens and GSI projects. Other barriers include private landowner willingness and potentially a limited number of projects in basins with higher estimated growth in permit-exempt wells and priority streams.

Potential budget and O&M costs.

The construction cost for a rain garden or GSI project is $15-$30 per square foot of infiltration trench constructed. Assuming a 200 square foot infiltration trench, the construction cost would be $3,000 - $4,500 each. Additional costs for program management would be incurred. For planning purposes, a cost of $5,000 each is likely conservative. For construction of 10 per year, the annual cost would be about $50,000.

Anticipated durability and resiliency.

The projects would have lasting benefits. Pierce Conservation District and other entities will manage the implementation of rain gardens and GSI projects.

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

Pierce Conservation District would be the main project sponsor and would be ready to proceed immediately if the program were supported. Pierce Conservation District has been successfully installing rain gardens and GSI projects. If funding is increased, the primary barrier would be private landowner willingness to install projects

Sources of Information

Puyallup and Chambers Watersheds Salmon Recovery Lead Entity (Lead Entity). 2018. Salmon Habitat Protection and Restoration Strategy for Puyallup and Chambers Watersheds. June.

Runge, J., M. Marcantonio, and M. Mahan. 2003. Salmonid Habitat Limiting Factors Analysis, Chambers-Clover Creek Watershed WRIA 12.

Appendix
Infiltration Volume Calculations

Estimated Water Offset for Typical Pierce Conservation District Raingarden Projects
December 28, 2020

Introduction

The purpose of this document is to estimate the water offset for future Pierce Conservation District (Pierce CD) rain garden projects. Calculations of the annual recharge are presented that are based upon hydrologic modeling performed by HDR for the Mason County Rooftop Infiltration Project (HDR, 2020). For these calculations it is assumed rain gardens will be installed on houses that are currently connected to a storm drainage system, so that the entire infiltration volume will be counted as a water offset. A lesser infiltration volume and water offset would be realized for houses that are not currently connected to a storm drainage system as roof downspouts may splash onto the ground and partially or totally infiltrate.

Calculations

Calculations are provided using a range of potential rain garden sizes. To allow an estimate of the potential water offset, an estimate of the average infiltration trench area and impervious area captured is required. Data from the Kitsap Conservation District (KCD) shows the average rain garden they have constructed since 2010 has an infiltration trench area of 200 square feet (sf) and captures 1,900 sf of impervious surface which are roofs, driveways and other impervious surfaces. They have constructed 320 rain garden projects since 2010. That is the best information we have on rain garden installations in the Puget Sound region.

To provide a range of potential Infiltration volumes are calculated using rain garden sizes of 100, 150, and 200 sf, as well as impervious surfaces of 1,600, 2,000 and 2,800 sf. The Mason County Rooftop Infiltration Project assumed 2,800 sf as the impervious surface that would be captured, based upon an average roof and driveway size. The infiltration rate used in the calculations corresponds to Group B soils as rain gardens use amended soils which are similar to Group B. The infiltration rate used for Group B soils is 2 inches/hour.

HDR's hydrologic modeling estimated the average annual recharge for an infiltration trench that is 80 sf to be 0.14 acre-feet/year. That was part of their calculation of baseline conditions assuming a minimum trench size of 80 sf under current regulations. The modeling was performed using an annual average of 70 inches precipitation, which occurs in Mason County. The average annual recharge equates to 26 inches per year over the 2,800-sf impervious surface.

A larger infiltration trench will infiltrate more water; there is a proportional relationship between infiltration area and infiltration capacity. There is also a proportional relationship to the amount of runoff to the impervious area, assuming all the runoff is captured. A limit to the amount of infiltration is the volume of annual precipitation minus potential losses due to evaporation. To estimate the amount of water that will be infiltrated in a Pierce CD rain garden the HDR results were proportionally scaled up by the amount of infiltration area (100 – 200 sf) and scaled down by the amount of impervious area (1,600 – 2,800 sf). Those calculations are summarized in Table 1.

Table 1. Percentage Change in Infiltration Capacity and Corresponding Infiltration Volume

Impervious Surface Captured, sf	Infiltration Trench Size, sf/Infiltration Volume, acre-feet							
	80 (Mason County Study)		100		150		200	
	%	Volume	%	Volume	%	Volume	%	Volume
1,600	64%	0.090	80%	0.113	121%	0.169	161%	0.225
2,000	71%	0.100	89%	0.125	134%	0.188	179%	0.250
2,800	100%	0.140	125%	0.175	188%	0.263	250%	0.350

The equivalent values in terms of rainfall infiltrated is provided in Table 2.

Table 2. Volume of Rainfall Potentially Infiltrated

Infiltration Trench Size, sf			
80 (Mason County Study)	100	150	200
26 inches	32.7 inches	49.0 inches	65.3 inches

The calculations indicate that the rain gardens KCD is installing have, on average, the capacity to infiltrate 65.3 inches of precipitation, or 0.25 acre-ft per installation per year, based upon an infiltration trench size of 200 sf. The amount infiltrated is less than the capacity when precipitation is less than 65 inches.

The same calculation applies to Pierce County and demonstrates that the infiltration capacity of a 200 sf infiltration trench is not limited by the amount of precipitation that occurs in most areas of Pierce County, which is 40-50 inches per year. Table 3 provides infiltration volumes for varying precipitation volumes and an average impervious area of 2,000 sf. To be conservative, 10% loss due to evaporation or other losses are assumed.

Table 3. Estimate of Annual Volume Infiltrated for Pierce CD Rain Garden Projects

Average Annual Precipitation, inches	Annual Volume Infiltrated, Inches	Annual Volume Infiltrated, acre-feet
40	36	0.138
50	45	0.172
60	54	0.207

These volumes can be used as estimates of the water offset quantity for Pierce CD rain garden projects. The actual values will need to be tracked during implementation, but the quantities shown in Table 3 provide a planning-level estimate of water offsets from rain garden projects that capture 2,000 sf of impervious area and are constructed using a 200 sf infiltration trench is Group B soils. It is recommended that the average of the volume infiltrated between 40- and 50-inches annual precipitation be used for estimating water offsets in WRIA 12. That equals 0.15 acre-feet per rain garden.

References

HDR, 2020. Spreadsheet: WRIA14-Projects-Supplemental Data-RooftopRunoff_MGSFlood Results.xlsx. Accessed through Box at https://app.box.com/s/c2858d6mjdtoo41i4ahxqj55hz66mbzf

CLOVER CREEK FLOODPLAIN RESTORATION
PROJECT DESCRIPTION

Narrative description, including goals and objectives.

Clover Creek is a tributary to Steilacoom Lake and Chambers Creek. Clover Creek originates from springs and groundwater drainage approximately 6.0 miles east of Spanaway in the Spanaway-Parkland residential districts east of McChord Air Force Base. It drains northwesterly through McChord Field into the high-density residential and business district of Lakewood where it enters Steilacoom Lake. The two primary tributaries to Clover Creek are the North Fork Clover Creek and Spanaway Creek. The North Fork of Clover Creek is a right bank tributary draining the Summit area. It is 3.2 miles long and enters Clover Creek at ~RM 12.25. Spanaway Creek originates in several springs and marshes, including Spanaway Marsh, on the Joint Base Lewis McChord. Locally it is referred to as Coffee Creek until it enters Spanaway Lake. It continues as the outlet for Spanaway Lake. The stream channel splits, also providing flow for Morey Creek, and eventually enters Clover Creek about 0.25 mi. downstream of Tule Lake at RM 9.85 as a left bank tributary. After the stream flows through McChord Field and the I-5 freeway, Clover Creek flows into Steilacoom lake. Steilacoom Lake has an outlet into Chambers Creek. Chambers Creek flows four miles before emptying to Chambers Bay and Puget Sound.

Clover Creek has been historically routed through a 0.6-mile-long culvert under the McChord Air Force Base runways that posed a fish passage barrier. The culverts have recently been replaced with a wider bridge structure, restoring fish passage at this location. The wider bridge structure improves passage is a key restoration milestone that increases the importance of Clover Creek for habitat restoration.

Dense residential, commercial, and military development encroaches upon most of the Clover Creek main stem from Steilacoom Lake to the confluence with the North Fork (Tetra Tech/KCM 2002). Encroaching development is also a problem on the North Fork of Clover Creek, from the downstream end of Tule Lake Road to 138th Street East. Low-density residential development and agricultural practices frequently encroach upon the banks of Clover Creek upstream of the North Fork confluence. In addition, dredging and channeling of the creek throughout this subbasin have contributed to intermittent flows and water loss (Tetra Tech/KCM 2002).

Aquatic life use in Clover Creek is limited by water quality, flow, and physical habitat (Lead Entity 2018; Runge et al. 2003). Loss of flow, and dewatering in summer months in the central section of Clover Creek's mainstem and North Fork Clover Creek creates a passage barrier as well as a loss of habitat area. Poor water quality has led to fish kills in the past. A retrospective analysis based on interviews of long-time residents and other sources provides evidence that until about 1940, Clover Creek sustained perennial flow (Tobiason, 2003). Restoration of flow to the lower sections of Clover Creek, from Steilacoom Lake upstream to above the North Fork confluence was identified as necessary to achieve the benefits of habitat restoration actions. The following reaches are routinely dry during the summer months:

- Over a mile of channel routinely dewaters in summer months in the central section of Clover Creek's mainstem, resulting in loss of habitat and a passage barrier.

- Sections of North Fork Clover Creek also dewater during summer months. When water levels drop too low, it can create a series of pools that are not connected to each other or separated by dry creek bed. This occurrence traps all the fish present within that reach of the stream in small pools, where habitat and food are limited resources.
- Stranding has been documented in Clover Creek between 138th St. South and the Brookdale Golf Course (although with a different set of circumstances) (Clothier, et al 2003).

Past restoration planning has identified high priorities for protection actions of Upper Clover Creek from Spanaway Creek confluence to source springs near the headwaters, which was identified as having relatively good habitat quality and perennial flow. The habitat above Spanaway Lake that is protected by the Joint Base Lewis McCord military reservation appeared to have the most potential for productive coho salmon spawning, once barriers were removed. The principal factors that ranked highest for coho salmon restoration benefit were generally sediment load, substrate stability, diverse and complex instream habitat types, water quality, and obstructions to fish passage.

Clover Creek floodplain restoration projects would address functional loss of water storage within the subbasin. The specific actions on 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 that are provided by floodplain reconnection. 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,
- Local terrace formation (i.e. scrape down),
- Side channel and off-channel feature creation or enhancement.

Conceptual-level map of the project and location.

A mapping utility was used to solicit Clover Creek floodplain project recommendations from the WRIA 12 committee. The following data and reasoning were used to select candidate sites along Clover Creek:

- Identify reaches that are unconfined. Unconfined reaches do not have hill slopes that would preclude flooding.

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

Project locations identified by the committee include the following:

- Clover Cr at McChord Field
- NF Clover Confluence
- NF Clover Creek
- Clover Cr at near Johns Road East
- Clover Cr West of Spanaway Loop Road
- Clover Cr at Tule Lake Road
- NF Clover Cr at Unnamed Tributary
- Clover Cr East of Brookdale Golf Course
- Clover Cr east of Waller Road
- Clover Ck nr 138th St E & 4th Ave East
- Clover Creek at Springbrook

High quality stream and floodplain habitat could also be protected through acquisition or conservation easements. For example, high quality stream and floodplain on Coffee Creek and Spanaway Creek could be considered for protection.

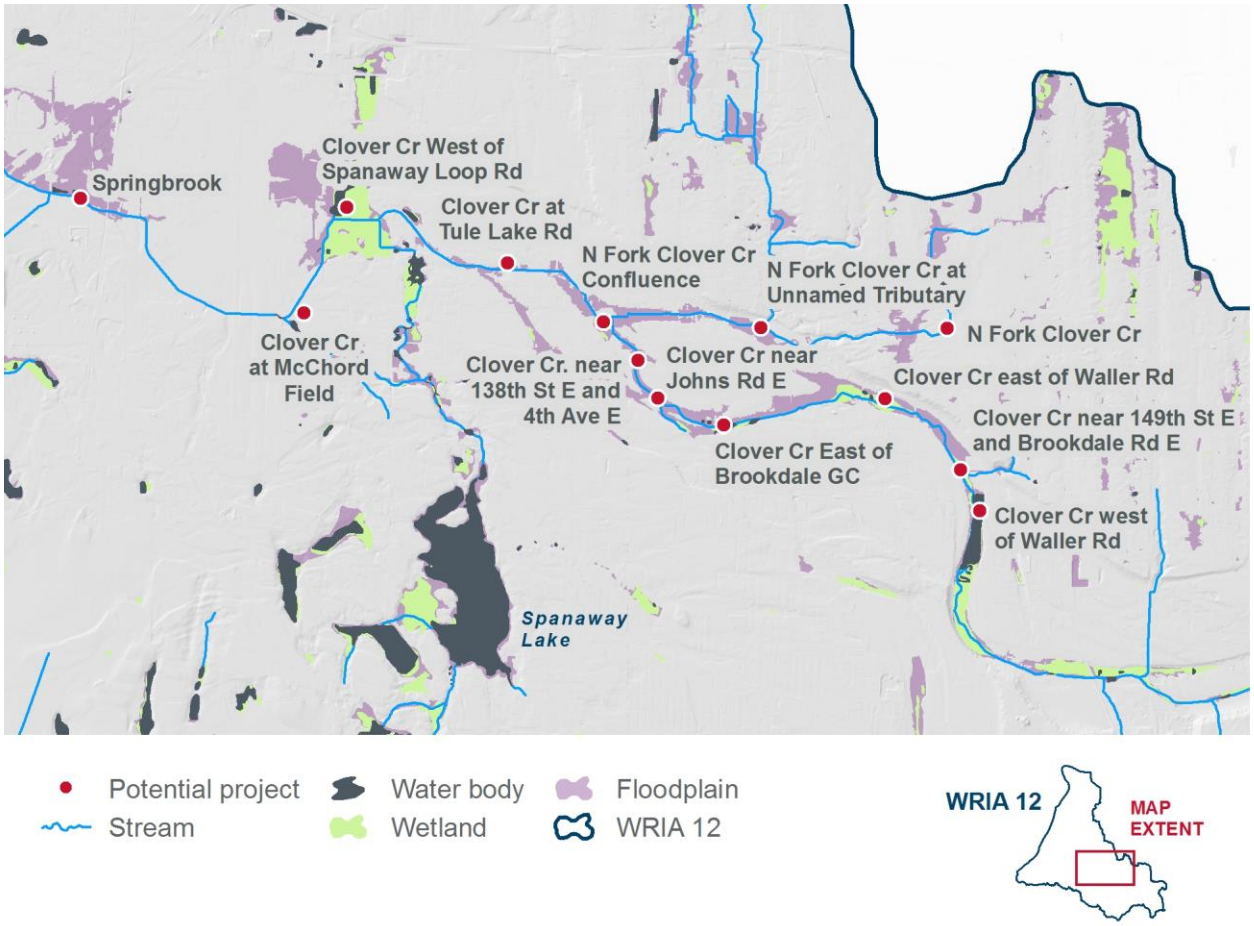


Figure 1. Potential Clover Creek floodplain restoration project locations.

A stream habitat and floodplain restoration plan is recommended to identify specific projects and prioritize them in terms of habitat benefit and cost. The restoration plan should leverage local knowledge of historical conditions and modifications that have been made over time. Pierce County mapping data and online- mapping utilities could be used as a platform to evaluate future projects, with respect to floodplains, wetlands, parcel development status, and parcel ownership. Stream reaches should be related to potential habitat capacity and fish use (e.g. EDT model results). Field evaluation of each reach should identify the presence of hydromodifications, in-channel habitat conditions, floodplain impacts, and the potential for restoration. Restoration concepts, metrics, and costs should be developed to allow for a cost to benefit evaluation and project prioritization. Projects prioritized for implementation would be subject to evaluation of feasibility as part of the restoration plan or as part of conceptual design.

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 purpose. The measures would be consistent with the design requirements.

Description of the anticipated spatial distribution of likely benefits.

Benefits to stream processes will occur in Clover Creek as these projects are implemented. Resident fishes and anadromous salmonids in Clover Creek will benefit from increased habitat and reduced peak flow and sediment input.

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

Coho salmon, coastal cutthroat trout, steelhead trout, and lamprey are known to occur in the Clover Creek watershed. Steelhead identified in Morey pond are known to occur in Clover Creek and would benefit from floodplain restoration. Coho would benefit from off-channel rearing areas. Reduced peak flow and sediment inputs would increase spawning suitability in the creek for both salmonid species.

Identification of anticipated support and barriers to completion.

No specific projects have been identified.

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

No specific projects have been identified.

Anticipated durability and resiliency.

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

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

No specific projects have been identified.

References

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APPENDIX A

A Virtual Tour of Clover Creek


Shera Falls


Dry Season


Wet Season Lower Clover Creek


Clover Creek at Tule Lake Road

Clover Creek at Tule Lake Road

Dry Season Clover Creek just above Pacific Avenue

Wet Season Clover Creek just above Pacific Avenue

Parkland Prairie Restoration Site


Clay Liner at Parkland Prairie Restoration Site


Wet Season Flow at Parkland Prairie Site


Parkland Prairie Restoration Site


Parkland Prairie Restoration Site


Parkland Prairie Restoration Site


The Work of Junior Engineers at Parkland Prairie


Dry Season at Parkland Prairie Restoration Site


Dry Season Reed Canary Grass at Parkland Prairie


Dry Season Growth at Parkand Prairie Restoration Site


Dry Season at B Street Clover Creek Restoration Site


Wet Season at B Street Restoration Site


138 to 136 Street E Restoration Site


Dry Season 138 to 136 Street E Restoration Site


Dry Season Stagnant Pool at 138 to 136 Street E Restoration Site


Runoff in North Fork Clove r Creek at Brookdale Road