Appendices

WRIA 12 Chambers-Clover Watershed

The following appendices are linked to the report at:

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Appendix B – Glossary

Acronym	Definition
AE	Application Efficiency
AFY	Acre-Feet per Year
CFS	Cubic Feet per Second
CU	Consumptive Use
CUF	Consumptive Use Factor
GPD	Gallons per Day
GIS	Geographic Information System
IR	Irrigation Requirements
LID	Low Impact Development
LIO	Local Integrating Organization
MAR	Managed Aquifer Recharge
NEB	Net Ecological Benefit
PE	Permit-Exempt
RCW	Revised Code of Washington
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Areas

Acre-feet (AF): A unit of volume equal to the volume of a sheet of water one acre in area and one foot in depth. (USGS)

Adaptive Management: An iterative and systematic decision-making process that aims to reduce uncertainty over time and help meet project, action, and plan performance goals by learning from the implementation and outcomes of projects and actions. (NEB)

Annual Average Withdrawal: RCW 90.94.030 (4)(a)(vi)(B) refers to the amount of water allowed for withdrawal per connection as the annual average withdrawal. As an example, a homeowner could withdraw 4,000 gallons on a summer day, so long as they did not do so often enough that their annual average exceeds the 950 gpd.

Beaver Dam Analogue (BDA): BDAs are man-made structures designed to mimic the form and function of a natural beaver dam. They can be used to increase the probability of successful beaver translocation and function as a simple, cost-effective, non-intrusive approach to stream restoration. (From Anabranch Solutions)

Critical Flow Period: The time period of low streamflow (generally described in bi-monthly or monthly time steps) that has the greatest likelihood to negatively impact the survival and recovery of threatened or endangered salmonids or other fish species targeted by the planning group. The planning group should discuss with Ecology, local tribal and WDFW biologists to determine the critical flow period in those reaches under the planning group's evaluation. (NEB)

Cubic feet per second (CFS): A rate of the flow in streams and rivers. It is equal to a volume of water one foot high and one foot wide flowing a distance of one foot in one second (about the size of one archive file box or a basketball). (USGS)

Domestic Use: In the context of Chapter 90.94 RCW, "domestic use" and the withdrawal limits from permit-exempt domestic wells include both indoor and outdoor household uses, and watering of a lawn and noncommercial garden. (NEB)

ESSB 6091: In January 2018, the Legislature passed Engrossed Substitute Senate Bill (ESSB) 6091 in response to the Hirst decision. In the Whatcom County vs. Hirst, Futurewise, et al. decision (often referred to as the "Hirst decision"), the court ruled that the county failed to comply with the Growth Management Act requirements to protect water resources. The ruling required the county to make an independent decision about legal water availability. ESSB 6091 addresses the court's decision by allowing landowners to obtain a building permit for a new home relying on a permit-exempt well. ESSB 6091 is codified as Chapter 90.94 RCW. (ECY)

Evolutionarily Significant Unit (ESU): A population of organisms that is considered distinct for purposes of conservation. For Puget Sound Chinook, the ESU includes naturally spawned Chinook salmon originating from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound and the Strait of Georgia. Also, Chinook salmon from 26 artificial propagation programs. (NOAA)

Foster Pilots and Foster Task Force: To address the impacts of the 2015 Foster decision, Chapter 90.94 RCW established a Task Force on Water Resource Mitigation and authorized the Department of Ecology to issue permit decisions for up to five water mitigation pilot projects. These pilot projects will address issues such as the treatment of surface water and groundwater appropriations and include management strategies to monitor how these appropriations affect instream flows and fish habitats. The joint legislative Task Force will (1) review the treatment of surface water and groundwater appropriations as they relate to instream flows and fish habitat, (2) develop and recommend a mitigation sequencing process and scoring system to address such appropriations, and (3) review the Washington Supreme Court decision in Foster v. Department of Ecology. The Task Force is responsible for overseeing the five pilot projects. (ECY)

Four Year Work Plans: Four year plans are developed by salmon recovery lead entities in Puget Sound to describe each lead entity's accomplishments during the previous year, to identify the current status of recovery actions, any changes in recovery strategies, and to propose future actions anticipated over the next four years. Regional experts conduct technical and policy reviews of each watershed's four year work plan update to evaluate the consistency and appropriate sequencing of actions with the Puget Sound Salmon Recovery Plan. (Partnership)

Gallons per day (GPD): An expression of the average rate of domestic and commercial water use. 1 million gallons per day is equivalent to 1.547 cubic feet per second.

Group A public water systems: Group A water systems have 15 or more service connections or serve 25 or more people per day. Chapter 246-290 WAC (Group A Public Water Supplies), outlines the purpose, applicability, enforcement, and other policies related to Group A water systems. (WAC)

Group B public water systems: Group B public water systems serve fewer than 15 connections **and** fewer than 25 people per day. Chapter 246-291 WAC (Group B Public Water Systems), outlines the purpose, applicability, enforcement, and other policies related to Group B water systems.(WAC)

Growth Management Act (GMA): Passed by the Washington Legislature and enacted in 1990, this act guides planning for growth and development in Washington State. The act requires local governments in fast growing and densely populated counties to develop, adopt, and periodically update comprehensive plans.

Home: A general term referring to any house, household, or other Equivalent Residential Unit. (Policy and Interpretive Statement)

Hydrologic Unit Code (HUC): Hydrologic unit codes refer to the USGS's division and sub-division of the watersheds into successively smaller hydrologic units. The units are classified into four levels: regions, sub-regions, accounting units, and cataloging units, and are arranged within each other from the largest geographic area to the smallest. Each unit is classified by a unit code (HUC) composed of two to eight digits based on the four levels of the classification in the hydrologic unit system (two digit units are largest and eight digits are smallest). (USGS)

Impact: For the purpose of streamflow restoration planning, impact is the same as new consumptive water use (see definition below). As provided in Ecology WR POL 2094 "Though the statute requires the offset of 'consumptive impacts to instream flows associated with permit-exempt domestic water use' (RCW 90.94.020(4)(b)) and 90.94.030(3)(b)), watershed plans should address the consumptive use of new permit-exempt domestic well withdrawals. Ecology recommends consumptive use as a surrogate for consumptive impact to eliminate the need for detailed hydrogeologic modeling, which is costly and unlikely feasible to complete within the limited planning timeframes provided in chapter 90.94 RCW. " (NEB)

Instream Flows: a designated flow (also in cfs) that is set by rule as the amount of water needed to protect beneficial uses and used for determining whether there is water available for appropriation. Flow levels set as Instream Flows do not reflect the actual amount of water flowing at a given time. They are designated, or administrative numbers (flow levels) that are set for periods of time (bi-weekly to several months) throughout the year. The instream flows vary by season and account for different instream resource needs (such as fish spawning, rearing and migration). When (actual) stream flow is lower than the Instream Flow, there is not water available for appropriation (Instream Flows are not being met) and water users whose water rights are junior to the Instream Flows must discontinue water use under that right.

Instream Flow Rule: An administrative rule that establishes Instream Flows. (ECY)

Instream Resources Protection Program (IRPP): The IRPP was initiated by the Department of Ecology in September 1978 with the purpose of developing and adopting instream resource protection measures for Water Resource Inventory Areas (WRIAs) (see definition below) in Western Washington as authorized in the Water Resources Act of 1971 (RCW 90.54), and in accordance with the Water Resources Management Program (WAC 175-500).

Instream Resources: Fish and related aquatic resources. (NEB)

Large woody debris (LWD): LWD refers to the fallen trees, logs and stumps, root wads, and piles of branches along the edges of streams, rivers, lakes and Puget Sound. Wood helps stabilize shorelines and provides vital habitat for salmon and other aquatic life. Preserving the debris along shorelines is important for keeping aquatic ecosystems healthy and improving the survival of native salmon. (King County)

Lead Entities (LE): Lead Entities are local, citizen-based organizations in Puget Sound that coordinate salmon recovery strategies in their local watershed. Lead entities work with local and state agencies, tribes, citizens, and other community groups to adaptively manage their local salmon recovery chapters and ensure recovery actions are implemented. (Partnership)

Listed Species: Before a species can receive the protection provided by the Endangered Species Act (ESA), it must first be added to the federal lists of endangered and threatened wildlife and plants. The List of Endangered and Threatened Wildlife (50 CFR 17.11) and the List of Endangered and Threatened Plants (50 CFR 17.12) contain the names of all species that have been determined by the U.S. Fish and Wildlife Service (Service) or the National Marine Fisheries Service (for most marine life) to be in the greatest need of federal protection. A species is added to the list when it is determined to be endangered or threatened because of any of the following factors: the present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting its survival. (USFWS)

Local Integrating Organizations (LIO): Local Integrating Organizations are local forums in Puget Sound that collaboratively work to develop, coordinate, and implement strategies and actions that contribute to the protection and recovery of the local ecosystem. Funded and supported by the Puget Sound Partnership, the LIOs are recognized as the local expert bodies for ecosystem recovery in nine unique ecosystems across Puget Sound. (Partnership)

Low Impact Development (LID): Low Impact Development (LID) is a stormwater and land-use management strategy that tries to mimic natural hydrologic conditions by emphasizing techniques including conservation, use of on-site natural features, site planning, and distributed stormwater best management practices (BMPs) integrated into a project design. (ECY)

Managed Aquifer Recharge (MAR): Managed aquifer recharge projects involve the addition of water to an aquifer through infiltration basins, injection wells, or other methods. The stored water can then be used to benefit stream flows, especially during critical flow periods. (NEB)

National Pollutant Discharge Elimination System (NPDES): The NPDES permit program addresses water pollution by regulating point sources that discharge pollutants to waters of the United States. Created by the Clean Water Act in 1972, the EPA authorizes state governments to perform many permitting, administrative, and enforcement aspects of the program. (EPA)

Net Ecological Benefit (NEB): Net Ecological Benefit is a term used in ESSB 6091 as a standard that watershed plans (see below for definition) must meet. The outcome that is anticipated to occur through implementation of projects and actions in a plan to yield offsets that exceed impacts within: a) the planning horizon; and, b) the relevant WRIA boundary. See *Final Guidance for Determining Net Ecological Benefit - Guid-2094 Water Resources Program Guidance.* (NEB)

Net Ecological Benefit Determination: Occurs solely upon Ecology's conclusion after its review of a watershed plan submitted to Ecology by appropriate procedures, that the plan does or does not achieves a NEB as defined in the Net Ecological Benefit guidance. The Director of Ecology will issue the results of that review and the NEB determination in the form of an order. (NEB)

Net Ecological Benefit Evaluation: A planning group's demonstration, using NEB Guidance and as reflected in their watershed plan, that their plan has or has not achieved a NEB. (NEB)

New Consumptive Water Use: The consumptive water use from the permit-exempt domestic groundwater withdrawals estimated to be initiated within the planning horizon. For the purpose of RCW 90.94, consumptive water use is considered water that is evaporated, transpired, consumed by humans, or otherwise removed from an immediate water environment due to the use of new permit-exempt domestic wells. (NEB)

Office of Financial Management (OFM): OFM is a Washington state agency that develops official state and local population estimates and projections for use in local growth management planning. (OFM)

Offset: The anticipated ability of a project or action to counterbalance some amount of the new consumptive water use over the planning horizon. Offsets need to continue beyond the planning horizon for as long as new well pumping continues. (NEB)

Permit exempt wells: The Groundwater Code (RCW 90.44), identified four "small withdrawals" of groundwater as exempt from the permitting process. Permit-exempt groundwater wells often provide water where a community supply is not available, serving single homes, small developments, irrigation of small lawns and gardens, industry, and stock watering.

Permit-exempt uses: Groundwater permit exemptions allow four small uses of groundwater without a water right permit: domestic uses of less than 5,000 gallons per day, industrial uses of less than 5,000 gallons per day, irrigation of a lawn or non-commercial garden, a half-acre or less in size, or stock water. Although exempt groundwater withdrawals don't require a water right permit, they are always subject to state water law. (ECY)

Planning groups: A general term that refers to either initiating governments, in consultation with the planning unit, preparing a watershed plan update required by Chapter 90.94.020 RCW, or a watershed restoration and enhancement committee preparing a plan required by Chapter 90.94.030 RCW. (NEB)

Planning Horizon: The 20-year period beginning on January 19, 2018 and ending on January 18, 2038, over which new consumptive water use by permit-exempt domestic withdrawals within a WRIA must be addressed, based on the requirements set forth in Chapter 90.94 RCW. (NEB)

Precautionary Principle: Erring on the side of not harming resources when faced with uncertainty, especially for potential harm that is essentially irreversible. Utilizing a precautionary approach in land use planning involves: (1) taking preventive action (avoiding impacts); (2) shifting the burden of proof to the project proponents; (3) exploring a wide range of potential alternatives; and/or (4) including multiple stakeholders and disciplines in decision making. (WDFW)

Projects and Actions: General terms describing any activities in watershed plans to offset impacts from new consumptive water use and/or contribute to NEB. (NEB)

Puget Sound Acquisition and Restoration (PSAR) fund: This fund supports projects that recover salmon and protect and recover salmon habitat in Puget Sound. The state legislature appropriates money for PSAR every 2 years in the Capital Budget. PSAR is co-managed by the Puget Sound Partnership and the Recreation and Conservation Office, and local entities identify and propose PSAR projects. (Partnership)

Puget Sound Partnership (Partnership): The Puget Sound Partnership is the state agency leading the region's collective effort to restore and protect Puget Sound and its watersheds. The organization brings together hundreds of partners to mobilize partner action around a common agenda, advance Sound investments, and advance priority actions by supporting partners. (Partnership)

Puget Sound Regional Council (PSRC): PSRC develops policies and coordinates decisions about regional growth, transportation and economic development planning within King, Pierce, Snohomish and Kitsap counties. (PSRC)

RCW 90.03 **(Water Code)**: This chapter outlines the role of the Department of Ecology in regulating and controlling the waters within the state. The code describes policies surrounding surface water and groundwater uses, the process of determining water rights, compliance measures and civil penalties, and various legal procedures.

RCW 90.44 **(Groundwater Regulations)**: RCW 90.44 details regulations and policies concerning groundwater use in Washington state, and declares that public groundwaters belong to the public and are subject to appropriation for beneficial use under the terms of the chapter. The rights to appropriate surface waters of the state are not affected by the provisions of this chapter.

RCW 90.44.050 **(Groundwater permit exemption)**: This code states that any withdrawal of public groundwaters after June 6, 1945 must have an associated water right from the Department of Ecology. However, any withdrawal of public groundwaters for stock-watering purposes, or for the watering of a lawn or of a noncommercial garden not exceeding one-half acre in area, or for single or group domestic uses in an amount not exceeding five thousand gallons a day, or for an industrial purpose in an amount not exceeding five thousand gallons a day, is exempt from the provisions of this section and does not need a water right.

RCW 90.54 (**Water Resources Act of 1971**): This act set the stage for the series of rules that set instream flow levels as water rights, as well as a compliance effort to protect those flows.

RCW 90.82 **(Watershed Planning)**: Watershed Planning was passed in 1997 with the purpose of developing a more thorough and cooperative method of determining what the current water resource situation is in each water resource inventory area of the state and to provide local citizens with the maximum possible input concerning their goals and objectives for water resource management and development.

RCW 90.94 **(Streamflow Restoration)**: This chapter of the Revised Code of Washington codifies ESSB 6091, including watershed planning efforts, streamflow restoration funding program and the joint legislative task force on water resource mitigation and mitigation pilot projects (Foster task force and pilot projects).

Reasonable Assurance: Explicit statement(s) in a watershed plan that the plan's content is realistic regarding the outcomes anticipated by the plan, and that the plan content is supported with scientifically rigorous documentation of the methods, assumptions, data, and implementation considerations used by the planning group. (NEB)

Revised Code of Washington (RCW): The revised code is a compilation of all permanent laws now in force for the state of Washington. The RCWs are organized by subject area into Titles, Chapters, and Sections.

Salmon Recovery Funding Board (SRFB): Pronounced "surf board", this state and federal board provides grants to protect and restore salmon habitat. Administered by a 10-member State Board that includes five governor-appointed citizens and five natural resource agency directors, the board brings together the experiences and viewpoints of citizens and the major state natural resource agencies. For watersheds planning under Section 203, the Department of Ecology will submit final draft WRE Plans not adopted by the prescribed deadline to SRFB for a technical review (RCO and Policy and Interpretive Statement).

Section 202 or Section 020: Refers to Section 202 of ESSB 6091 or Section 020 of RCW 90.94 respectively. The code provides policies and requirements for new domestic groundwater withdrawals exempt from permitting with a potential impact on a closed water body and potential impairment to an instream flow. This section includes WRIAs 1, 11, 22, 23, 49, 59 and 55, are required to update watershed plans completed under RCW 90.82 and to limit new permit-exempt withdrawals to 3000 gpd annual average.

Section 203 or Section 030: Refers to Section 203 of ESSB 6091 or Section 030 of RCW 90.94 respectively. The section details the role of WRE committees and WRE plans (see definitions below) in ensuring the protection and enhancement of instream resources and watershed functions. This section includes WRIAs 7, 8, 9, 10, 12, 13, 14 and 15. New permit-exempt withdrawals are limited to 950 gpd annual average.

SEPA and SEPA Review: SEPA is the State Environmental Policy Act. SEPA identifies and analyzes environmental impacts associated with governmental decisions. These decisions may be related to issuing permits for private projects, constructing public facilitates, or adopting regulations, policies, and plans. SEPA review is a process which helps agency decision-makers, applications, and the public understand how the entire proposal will affect the environment. These reviews are necessary prior to Ecology adopting a plan or plan update and may be completed by Ecology or by a local government. (Ecology)

Stream Flow: a specific flow level measured at a specific location in a given stream, usually described as a rate, such as cfs. Stream flow is the actual amount of real water at a specific place and at a given moment. Stream flows can change from moment to moment.

Subbasins: A geographic subarea within a WRIA, equivalent to the words "same basin or tributary" as used in RCW 90.94.020(4)(b) and RCW 90.94.030 (3)(b). In some instances, subbasins may not correspond with hydrologic or geologic basin delineations (e.g. watershed divides). (NEB)

Trust Water Right Program: The program allows the Department of Ecology to hold water rights for future uses without the risk of relinquishment. Water rights held in trust contribute to streamflows and groundwater recharge, while retaining their original priority date. Ecology uses the Trust Water Right Program to manage acquisitions and accept temporary donations. The program provides flexibility to enhance flows, bank or temporarily donate water rights. (ECY)

Urban Growth Area (UGA): UGAs are unincorporated areas outside of city limits where urban growth is encouraged. Each city that is located in a GMA fully-planning county includes an urban growth area where the city can grow into through annexation. An urban growth area may include more than a single city. An urban growth area may include territory that is located outside of a city in some cases. Urban growth areas are under county jurisdiction until they are annexed or incorporated as a city. Zoning in UGAs generally reflect the city zoning, and public utilities and roads are generally built to city standards with the expectation that when annexed, the UGA will transition seamlessly into the urban fabric. Areas outside of the UGA are generally considered rural. UGA boundaries are reviewed and sometimes adjusted during periodic comprehensive plan updates. UGAs are further defined in RCW 36.70.

WAC 173-566 **(Streamflow Restoration Funding Rule)**: On June 25, 2019 the Department of Ecology adopted this rule for funding projects under RCW 90.94. This rule establishes processes and criteria for prioritizing and approving grants consistent with legislative intent, thus making Ecology's funding decision and contracting more transparent, consistent, and defensible.

Washington Administrative Code (WAC): The WAC contains the current and permanent rules and regulations of state agencies. It is arranged by agency and new editions are published every two years. (Washington State Legislature)

Washington Department of Ecology (DOE/ECY): The Washington State Department of Ecology is an environmental regulatory agency for the State of Washington. The department administers laws and regulations pertaining to the areas of water quality, water rights and water resources, shoreline management, toxics clean-up, nuclear and hazardous waste, and air quality.

Washington Department of Fish and Wildlife (WDFW): An agency dedicated to preserving, protecting, and perpetuating the state's fish, wildlife, and ecosystems while providing sustainable fish and wildlife recreational and commercial opportunities. Headquartered in Olympia, the department maintains six regional offices and manages dozens of wildlife areas around the state, offering fishing, hunting, wildlife viewing, and other recreational opportunities for the residents of Washington. With the tribes, WDFW is a co-manager of the state salmon fishery. (WDFW)

Washington Department of Natural Resources (WADNR or DNR): The department manages over 3,000,000 acres of forest, range, agricultural, and commercial lands in the U.S. state of Washington. The DNR also manages 2,600,000 acres of aquatic areas which include shorelines, tidelands, lands under Puget Sound and the coast, and navigable lakes and rivers. Part of the DNR's management responsibility includes monitoring of mining cleanup, environmental restoration, providing scientific information about earthquakes, landslides, and ecologically sensitive areas. (WADNR)

Water Resources (WR): The Water Resources program at Department of Ecology supports sustainable water resources management to meet the present and future water needs of people and the natural environment, in partnership with Washington communities. (ECY)

Water Resources Advisory Committee (WRAC): Established in 1996, the Water Resources Advisory Committee is a forum for issues related to water resource management in Washington State. This stakeholder group is comprised of 40 people representing state agencies, local governments, water utilities, tribes, environmental groups, consultants, law firms, and other water stakeholders. (ECY)

Watershed Plan: A general term that refers to either: a watershed plan update prepared by a WRIA's initiating governments, in collaboration with the WRIA's planning unit, per RCW 90.94.020; or a watershed restoration and enhancement plan prepared by a watershed restoration and enhancement committee, per RCW 90.94.030. This term does not refer to RCW 90.82.020(6). (NEB)

Watershed Restoration and Enhancement Plan (WRE Plan): The Watershed Restoration and Enhancement Plan is directed by Section 203 of ESSB 6091 and requires that by June 30, 2021, the Department of Ecology will prepare and adopt a watershed restoration and enhancement plan for WRIAs 7, 8, 9, 10, 12, 13, 14 and 15, in collaboration with the watershed restoration and enhancement committee. The plan should, at a minimum, offset the consumptive impact of new permit-exempt domestic water use, but may also include recommendations for projects and actions that will measure, protect, and enhance instream resources that support the recovery of threatened and endangered salmonids. Prior to adoption of an updated plan, Department of Ecology must determine that the actions in the plan will result in a “net ecological benefit” to instream resources in the WRIA. The planning group may recommend out-of-kind projects to help achieve this standard.

WRIA: Water Resource Inventory Area. WRIAs are also called basins or watersheds. There are 62 across the state and each are assigned a number and name. They were defined in 1979 for the purpose of monitoring water availability. A complete map is available here: https://ecology.wa.gov/Water-Shorelines/Water-supply/Water-availability/Watershed-look-up.

Appendix C – Committee Roster

Entity	Primary and Alternate Representatives
Tribes	
Squaxin Island Tribe	Paul Pickett
Squaxin Island Tribe	Jeff Dickison
Puyallup Tribe of Indians	Russ Ladley
Puyallup Tribe of Indians	Char Naylor
County	
Pierce County	Dan Cardwell
Pierce County	Austin Jennings
Pierce County	Tom Kantz
Cities and Towns	
City of Lakewood	Paul Bucich
Town of Steilacoom	Paul Loveless
Town of Steilacoom	Mark Burlingame
Town of Steilacoom	Doug Fortner
City of Tacoma	Cal Taylor
City of Tacoma	Desiree Radice
Water Purveyor	
Lakewood Water District	Don Stanley
Lakewood Water District	Ian Black
Lakewood Water District	Randall Black
Building Industry Representative	
Master Builder Association of Pierce County	Jessie Gamble
Master Builder Association of Pierce County	Chuck Sundsmo
Environmental Representative	
Chambers-Clover Watershed Council	Kris Kaufman
Chambers-Clover Watershed Council	Renee Buck
Agriculture Representative	
Pierce Conservation District	Ryan Mello
Pierce Conservation District	Allan Warren
WA Department of Fish and Wildlife	
Washington Department of Fish and Wildlife	Liz Bockstiegel
Washington Department of Fish and Wildlife	Tristan Weiss
Department of Ecology	
Department of Ecology	Rebecca Brown
Department of Ecology	Mike Noone
Ex Officio	
WRIA 10/12 Salmon Recovery Lead Entity	Lisa Spurrier
Joint Base Lewis McChord	Becky Kowalski

Appendix D – Aquifer Units in WRIA 12

The U.S. Geological Survey (USGS) described the hydrology of WRIA 12 in a hydrogeologic framework report for the Chambers-Clover Watershed based on previous studies and published reports for central Pierce County.[43] The hydrogeologic units of the area are described as being either water-bearing ("aquifer") and non-water-bearing ("aquitard" or "confining layer") sediments, without regard to geologic origin or age. Major groundwater aquifers are found in the unconsolidated glacial and interglacial sediments throughout the central and lower regions of the watershed. Two follow-on studies were completed by the USGS. The first created a numerical groundwater flow model and the second refined the definitions of the Puyallup River valley as part of a larger regional study for WRIA 10.[44]

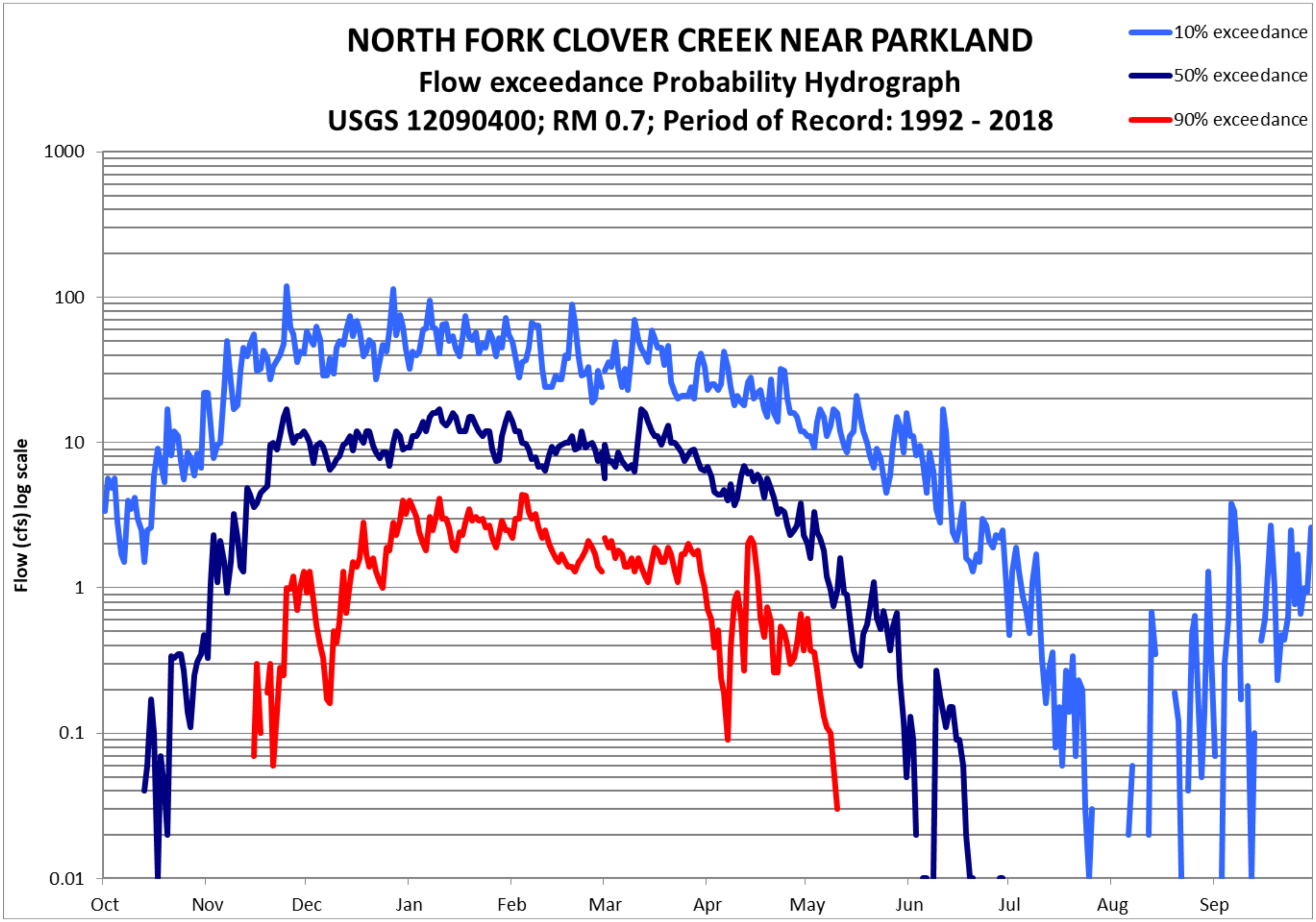
The USGS describes the hydrogeology of the watershed as 12 units, typically alternating between aquifer and non-aquifer layers. Five of the eight aquifer layers are included in the USGS definitions are present throughout watershed (Table 1). These aquifers are the most likely sources for new permit-exempt wells. The upper three units will also be the main source of direct recharge or baseflow to the surface water system. Aquifers C and E do not have surface expressions except below sea level into Puget Sound.

[43] Savoca and others, 2010
[44] Johnson and others, 2011; Welch and others, 2015

Aquifer	Description	Typical Thickness
A1	Often present at land surface, this aquifer primarily consists of stratified silt, sand, and gravel deposits of Vashon recessional outwash (Qvr) of the Frasier glaciation. Locally, this unit includes very coarse outwash gravels of the Steilacoom Gravel (Qvs) in broad plains to the west and in the bottoms of outwash channels (the channels were originally described by Walters and Kimmel, 1968).	A few feet up to about 50 feet thick. Where saturated, the unit represents a water-table aquifer and is often in direct continuity with surface-water bodies.
A3	This aquifer is mainly composed of deposits from the Vashon advance outwash (Qva). In some areas, older, pre-Fraser coarse-grained non-glacial deposits are also included in this unit. The deposits are usually well-sorted sand or sand and gravel, sometimes with lenses of silt or clay. The unit is generally confined by the overlying glacial till (Confining layer A2).	The thickness varies from being absent up to about 110 feet.
C	Sometimes also called the "sea-level aquifer" due its coincident elevation, this system is usually sand and gravel deposits of pre-Olympia age glacial drift, but lower-permeability deposits of silt, clay, or till are sometimes encountered.	70 to 150 feet thick in most places in the area. Productive zones in this unit seem to be more discontinuous across the region than is the case with Aquifer A3 or Aquifer E.
E	Aquifer E is dominated by glacial drift deposits that appear to correlate with the Stuck Glaciation as defined by Walters and Kimmel (1968). It mainly consists of deposits of silt, sand, and gravel. The aquifer is typically highly confined and regionally extensive.	The unit ranges in thickness from a few tens of feet to over 200 feet.

Two additional layers are included in the USGS reports, but do not occur in WRIA 12. One final aquifer (Aquifer G) occurs only at very deep depths in the watershed (typically over 800 feet). Future permit-exempt wells are unlikely to access water from this layer due to prohibitively expensive drilling costs.

Appendix E – WRIA 12 Hydrographs


NORTH FORK CLOVER CREEK NEAR PARKLAND
Flow exceedance Probability Hydrograph
USGS 12090400; RM 0.7; Period of Record: 1992 - 2018
10% exceedance
50% exceedance
90% exceedance
Flow (cfs) log scale
1000
100
10
1
0.1
0.01
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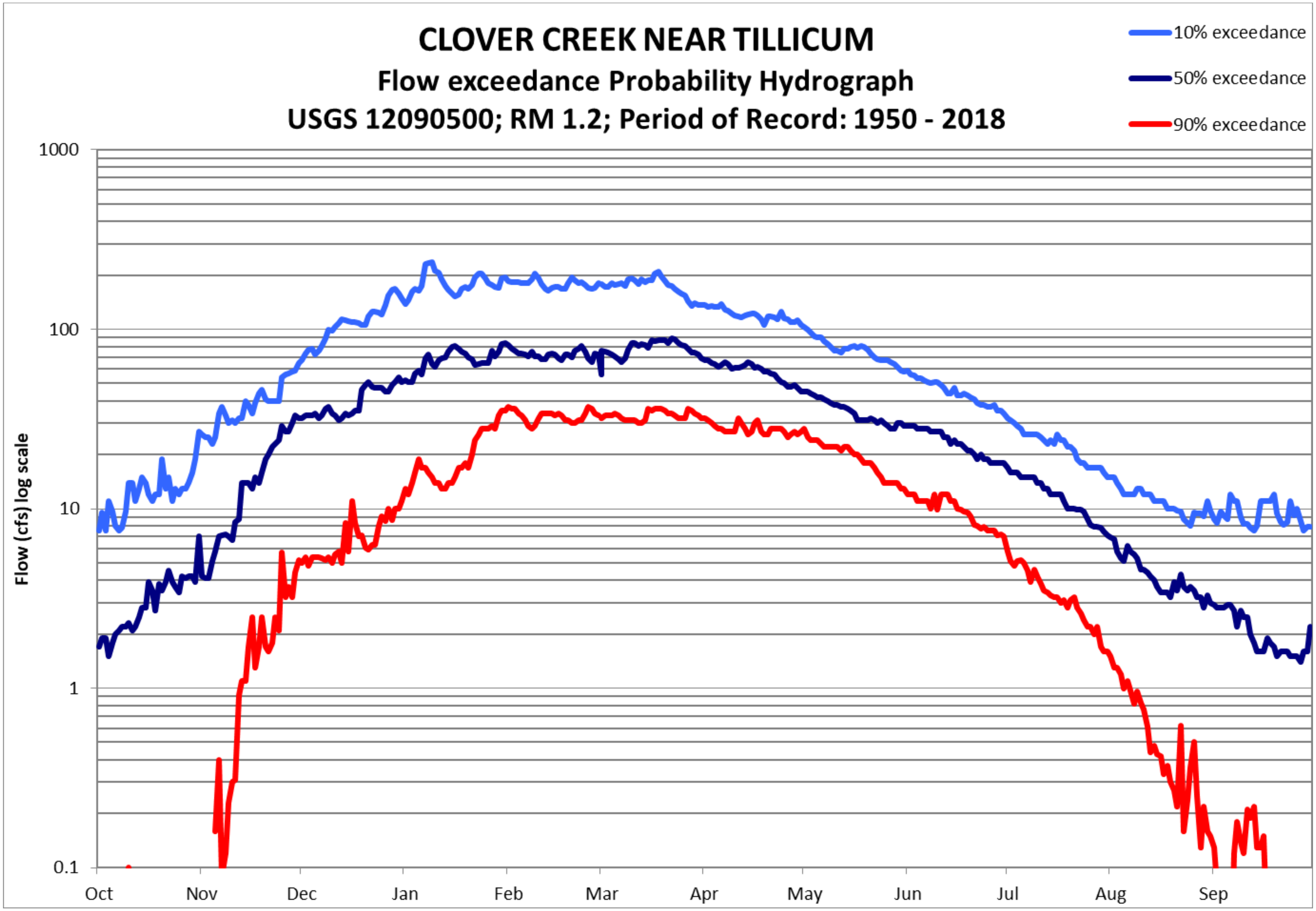
CLOVER CREEK NEAR TILLICUM
Flow exceedance Probability Hydrograph
USGS 12090500; RM 1.2; Period of Record: 1950 - 2018
10% exceedance
50% exceedance
90% exceedance
Flow (cfs) log scale
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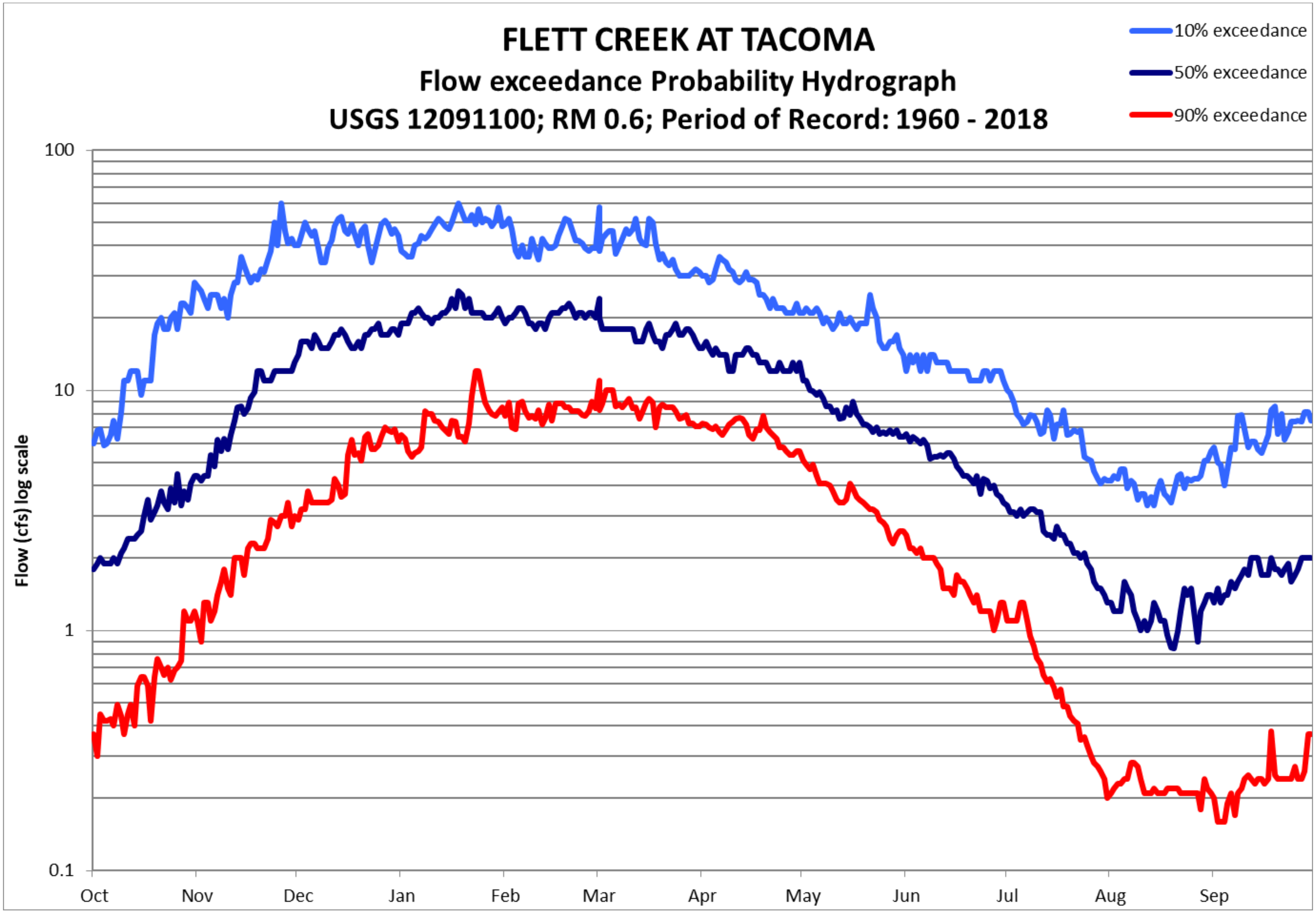
FLETT CREEK AT TACOMA
Flow exceedance Probability Hydrograph
USGS 12091100; RM 0.6; Period of Record: 1960 - 2018
10% exceedance
50% exceedance
90% exceedance
Flow (cfs) log scale
100
10
1
0.1
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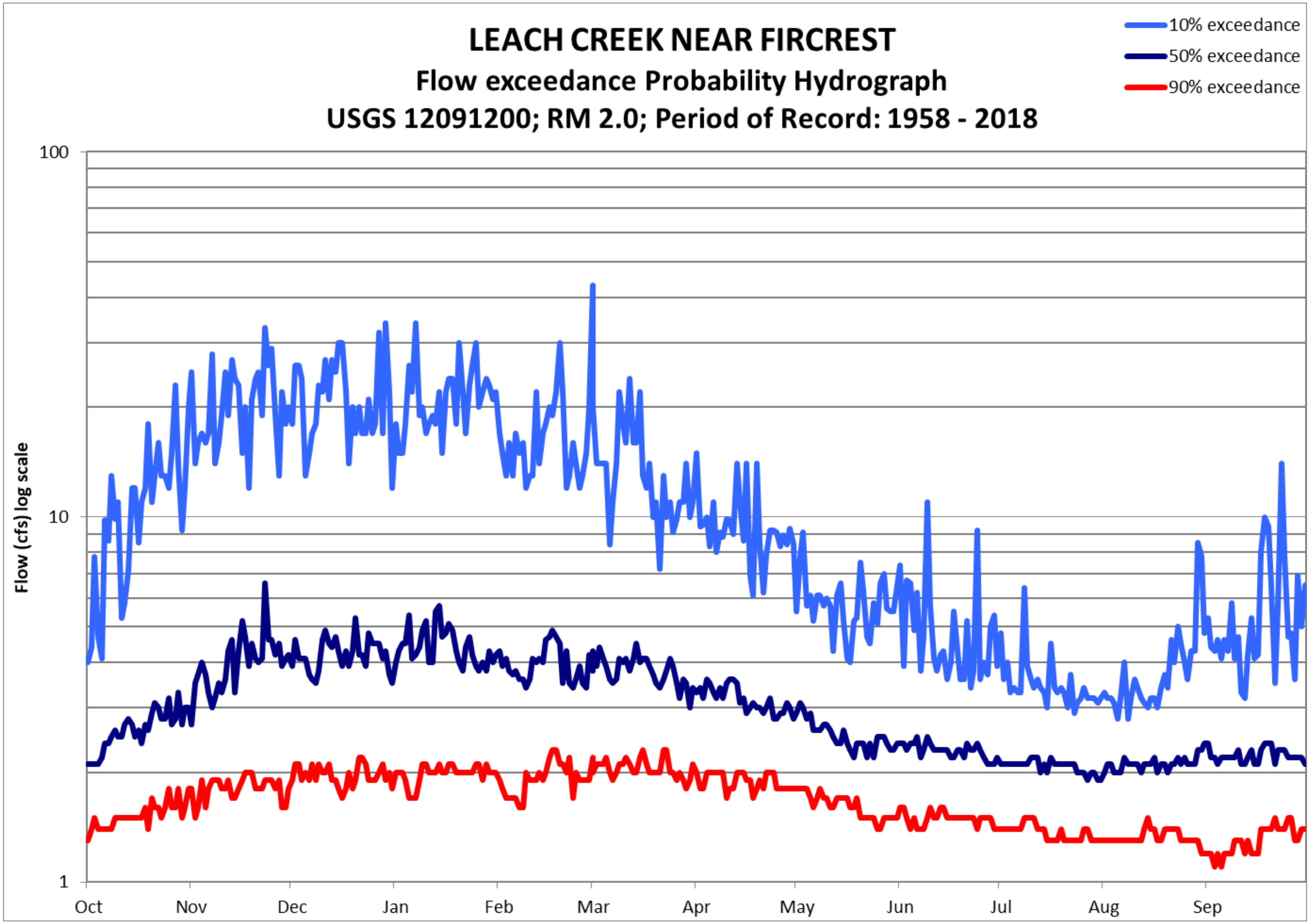
LEACH CREEK NEAR FIRCREST
Flow exceedance Probability Hydrograph
USGS 12091200; RM 2.0; Period of Record: 1958 - 2018
10% exceedance
50% exceedance
90% exceedance
Flow (cfs) log scale
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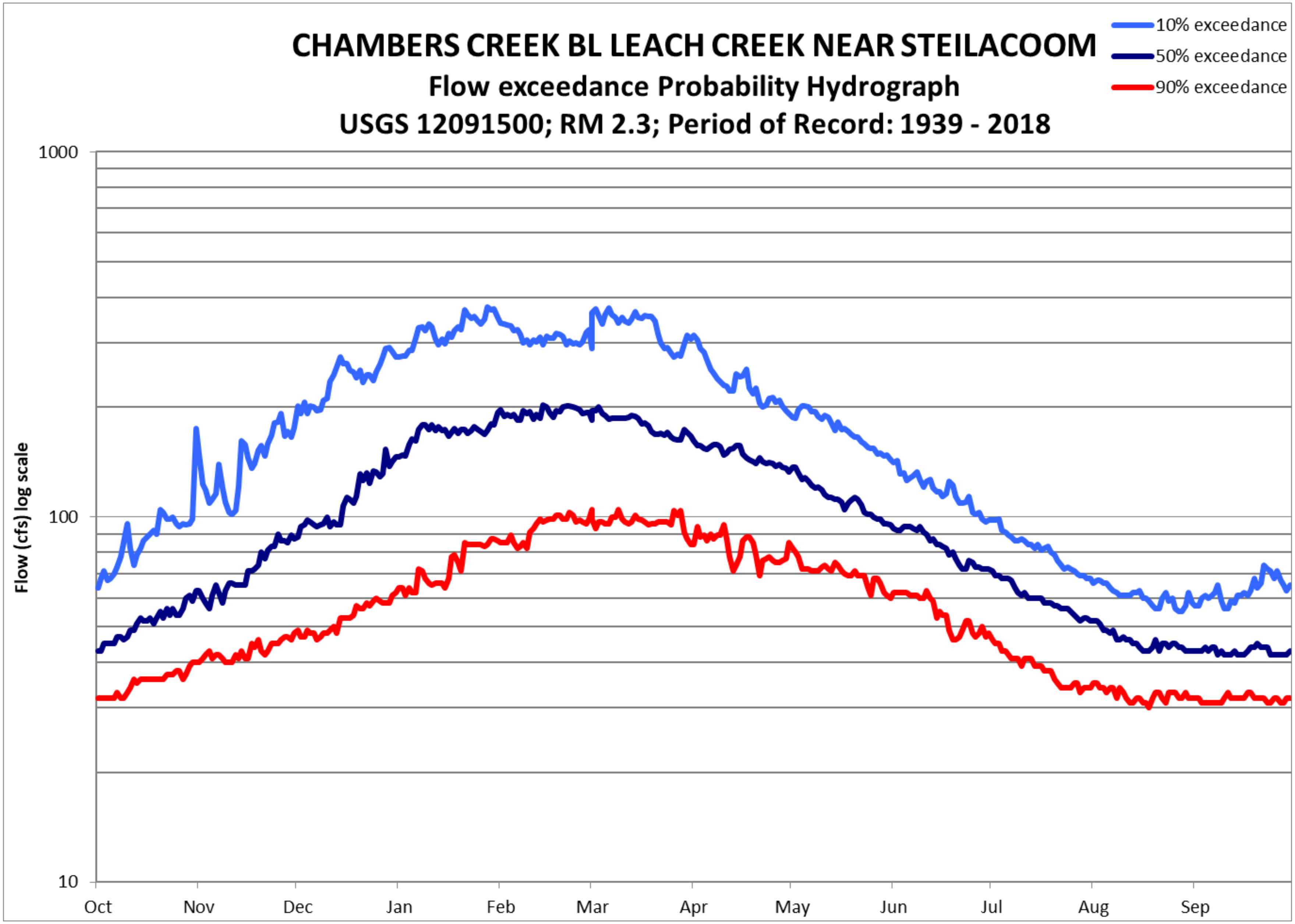
CHAMBERS CREEK BL LEACH CREEK NEAR STEILACOOM
Flow exceedance Probability Hydrograph
USGS 12091500; RM 2.3; Period of Record: 1939 - 2018
10% exceedance
50% exceedance
90% exceedance
Flow (cfs) log scale
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Appendix F – 303d Listed Streams in WRIA 12

Ecology evaluates surface waters in WRIA 12 periodically with a water quality assessment. The assessment evaluates existing water quality data and classifies waterbodies into the following categories:

- Category 1: Meets tested standards for clean waters.
- Category 2: Waters of concern; Waters in this category have some evidence of a water quality problem, but not enough to show persistent impairment.
- Category 3: Insufficient data.
- Category 4: Impaired waters that do not require a TMDL.
- Category 5: Polluted waters that require a water improvement project.

The 303d Category listings for WRIA 12 are in Table 1. This data excludes Marine listings and Categories 1 and 2 in WRIA 12.

Table 1: 303d Listed Lakes and Streams in WRIA 12

Listing ID[45]	303d Category	TMDL Name	Waterbody Name	Pollutant Name	Medium Name
3741	5		LEACH CREEK	Copper	Water
3745	5		LEACH CREEK	Mercury	Water
5847	5	Clover Creek DO, fecal coliform, and temperature TMDL	UNNAMED CREEK (TRIB TO CLOVER CREEK AT BINGHAM AVE)	Bacteria	Water
5848	5	Clover Creek DO, fecal coliform, and temperature TMDL	UNNAMED CREEK (TRIB TO CLOVER CREEK)	Bacteria	Water
6118	5		SPANAWAY LAKE	Bacteria	Water
6323	5		WAPATO LAKE	Bacteria	Water
6374	5		STEILACOOM LAKE	Total Phosphorus	Water
7543	5		CLOVER CREEK	Dissolved Oxygen	Water
7545	5	Clover Creek DO, fecal coliform, and temperature TMDL	CLOVER CREEK	Bacteria	Water
7547	5	Clover Creek DO, fecal coliform, and temperature TMDL	CLOVER CREEK	Bacteria	Water

[45] Data from Washington State Water Quality Assessment webpage, accessed September 17, 2020.

Listing ID[45]	303d Category	TMDL Name	Waterbody Name	Pollutant Name	Medium Name
7548	5	Clover Creek DO, fecal coliform, and temperature TMDL	CLOVER CREEK	Bacteria	Water
7549	5	Clover Creek DO, fecal coliform, and temperature TMDL	CLOVER CREEK	Bacteria	Water
7553	5	Clover Creek DO, fecal coliform, and temperature TMDL	CLOVER CREEK	Temperature	Water
7557	5	Clover Creek DO, fecal coliform, and temperature TMDL	SPANAWAY CREEK	Temperature	Water
8247	5		CHAMBERS CREEK	Dissolved Oxygen	Water
8684	5		CHAMBERS CREEK	Copper	Water
16720	5	Clover Creek DO, fecal coliform, and temperature TMDL	CHAMBERS CREEK	Bacteria	Water
42168	5		AMERICAN LAKE	Dieldrin	Tissue
42169	5		AMERICAN LAKE	Polychlorinated Biphenyls (PCBs)	Tissue
42443	5		AMERICAN LAKE	2,3,7,8-TCDD (Dioxin)	Tissue
74642	5		LEACH CREEK	Bacteria	Water
74650	5		AMERICAN LAKE	Bacteria	Water

Appendix G – WRIA 12 Subbasin Delineation Memo

Technical Memorandum
WRE Committees Technical Support

To:	Angela Johnson, Washington State Department of Ecology
From:	Chad Wiseman, HDR
Copy:	
Date:	June 26, 2019
Subject:	WRIA 12 Draft Subbasin Delineation (Work Assignment WA-01, Task 2)

1.0 Introduction

HDR is providing technical support to the Washington State Department of Ecology and the Watershed Restoration and Enhancement (WRE) committee for Water Resource Inventory Area (WRIA) 12. The Streamflow Restoration law (Revised Code of Washington [RCW] Chapter 90.94) requires that WRE plans include actions to offset new consumptive-use impacts associated with permit-exempt domestic water use. RCW 90.94.030(3)(b) states, "The highest priority recommendations must include replacing the quantity of consumptive water use during the same time as the impact and in the same basin or tributary." Therefore, delineations must be developed for the subbasins in WRIA 12 that will be used as a spatial framework for growth projections, consumptive-use estimates, and priority offset projects. The Net Ecological Benefit (NEB) evaluation will also be based on this framework. This technical memorandum addresses the basis for subbasin delineation in WRIA 12 (Chambers-Clover).

2.0 Subbasin Delineation

This section explains the initial and draft delineations for WRIA 12.

2.1 Initial Delineation

The WRIA 12 workgroup (a subcommittee of the WRE committee) was tasked to delineate subbasin boundaries for discussion at WRE committee meetings.

The WRIA 12 workgroup started with 12th-field hydrologic unit codes (HUCs) (USGS 2013) as an initial delineation. In the May 8, 2019 WRE committee meeting, comments were made that the Chambers Creek watershed (i.e., downstream of Steilacoom Lake and tributaries) were more important to fish than the Clover Creek watershed (i.e., upstream tributary of Steilacoom Lake and tributaries). Several stretches of Clover Creek and its tributaries are known to be naturally dry during different times of the year, and have less fish use.

2.2 Draft Delineation

During the June 12, 2019 WRE committee meeting, a draft subbasin delineation was agreed upon. The subbasins were groups of 12th-field HUCs grouped into the following subbasins:

- Chambers: Chambers Creek watershed and multiple small drainages discharging directly to Puget Sound and Commencement Bay; the lower portion of Clover Creek, downstream of the confluence with Clover Creek and Morey Creek
- Clover: Clover Creek upstream of the confluence with Morey Creek; Morey Creek and Spanaway Creek
- Sequilatchew Creek watershed, American Lake, and tributaries

The WRE committee indicated that the topographic divide between Chambers Bay and the Sequilatchew Creek watershed was not reflected with the 12th-field HUC boundaries and needed to be delineated. HDR delineated the boundary and developed the draft delineation (Figure 1). This map was presented to the WRIA 12 workgroup on June 17, 2019. The workgroup agreed to recommend that this subbasin delineation reflected the WRE committee's instructions, and therefore this draft delineation is approved.

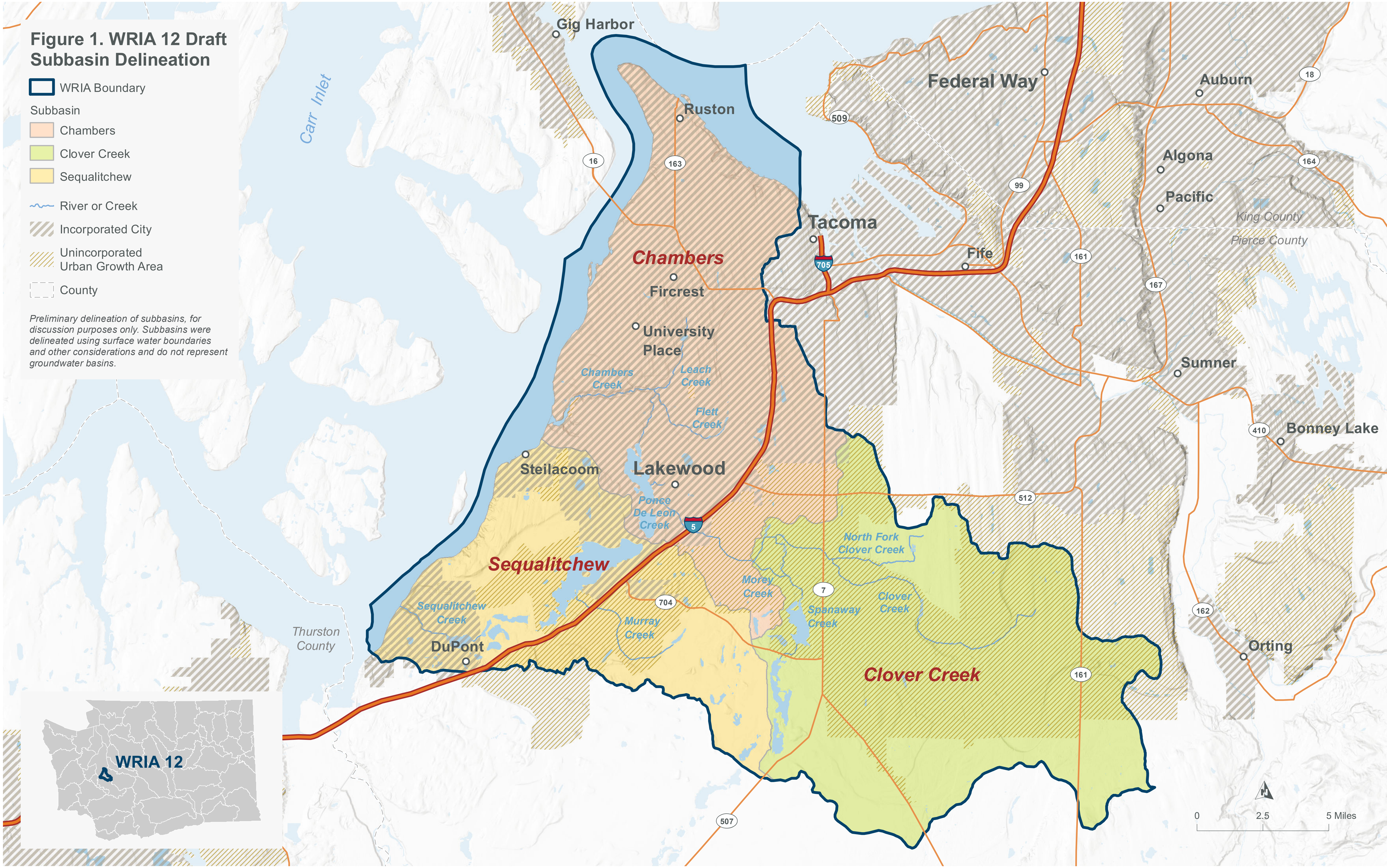
3.0 Conclusion

The WRIA 12 workgroup draft subbasin delineation will be used as an organizational framework for growth projection and consumptive-use scenarios. The draft subbasin delineation is subject to change after evaluation with the growth projection and consumptive-use scenarios. The final subbasin delineation will be used as a framework for consumptive-use impacts and offset benefit accounting and for the NEB evaluation.

4.0 References

Revised Code of Washington (RCW). 2019. Streamflow Restoration, Chapter 90.94 RCW. Accessed June 23, 2019, at https://app.leg.wa.gov/RCW/default.aspx?cite=90.94.

U.S. Geological Survey and U.S. Department of Agriculture, Natural Resources Conservation Service (USGS). 2013. Federal Standards and Procedures for the National Watershed Boundary Dataset (WBD) (4 ed.): Techniques and Methods 11–A3, 63 p., https://pubs.usgs.gov/tm/11/a3/.



DATA SOURCES: USGS, WA DEPT. OF ECOLOGY, WSDOT

DATE: 6/26/2019

Appendix H – WRIA 12 Permit-Exempt Growth and Consumptive Use Summary

Technical Memorandum DRAFT

To:	Angela Johnson, Washington State Department of Ecology
From:	Chad Wiseman, HDR
Copy:	Lisa Dally Wilson (DE) and Bob Montgomery (Anchor QEA)
Date:	December 18, 2020
Subject:	WRIA 12 Permit-Exempt Growth and Consumptive Use Summary (Work Assignment 2, Tasks 2 and 3)

1.0 Introduction

HDR is providing technical support to the Washington State Department of Ecology (Ecology) and the Watershed Restoration and Enhancement (WRE) committees for Water Resource Inventory Areas (WRIAs) 10, 12, 13, 14, and 15. This memorandum provides a summary of the analytical methods used for Work Assignment 2 Task 2: Consumptive Use (CU) Estimates, and the final estimates of consumptive water use for WRIA 12.

Under Revised Code of Washington (RCW) 90.94, consumptive water use by permit-exempt (PE) domestic wells and connections occurring over the next 20 years must be estimated to establish the water use that watershed restoration plans and plan updates are required to address and offset. This memorandum describes PE domestic wells and connections and related consumptive use of groundwater that is projected to impact WRIA 12 over the 20-year planning horizon.

This memorandum includes:

- Methods and results of WRIA 12 baseline PE growth and an alternative scenario of PE growth.
- Methods and results of WRIA 12 baseline and alternative scenario consumptive use using two different methods.

2.0 WRIA 12 PE Growth Projection Methods

WRIA 12 is entirely within Pierce County. The following methods were used to project growth over the planning horizon:

1) Growth projection method: calculate historical growth rates of PE wells for each subbasin using the Tacoma-Pierce County Health District (TPCHD) well database (1999–2018).
2) Forecast growth of future PE well connections for the 20-year planning horizon, based on the subbasin-specific historical growth rate.
3) Allocate growth of PE wells within each subbasin spatially, based upon buildable-lands analysis (Attachment A) (i.e., parcel must be outside of the urban growth area, not in a water and wastewater system boundary, not already built upon, or have a zoning category that allows for domestic use).

4) Use the buildable-lands analysis to calculate the number of parcels outside of a water system service area available for residential development (i.e., not already built upon, and in a zoning category that allows for residential development). There are 23 of these parcels in WRIA 12.

5) In addition to a baseline PE well-growth scenario, the WRIA 12 WRE committee agreed to develop high- and low-growth projection scenarios based on varying Pierce County projections. The WRIA 12 WRE committee agreed to use different time periods in the historical TPCHD well database to project baseline, low-growth, and high-growth PE connection scenarios during the 20-year planning horizon in WRIA 12. Baseline projections used the entire record from 1999 through 2018. The 1999–2008 time period was a time of relatively high PE connection growth and was selected for a "high-growth" scenario. The 2009–2018 time period was a time of relatively low PE connection growth and was selected to represent the rate of PE growth for the "low-growth" scenario.

3.0 WRIA 12 Consumptive Use Methods

Under RCW 90.94, consumptive water use (consumptive use) by permit-exempt connections that are forecast to be installed over the planning horizon to service rural growth must be estimated to establish the water offsets required under the Streamflow Restoration law. The following definitions from the *Final Guidance for Determining Net Ecological Benefit - ESSB 6091 - Recommendations for Water Use Estimates* (Ecology's Final NEB Guidance) are used in this memorandum as a guide to estimate consumptive water use by permit-exempt connections (Ecology 2019).

- Consumptive use: water that evaporates, transpires, is consumed by humans, or otherwise removed from an immediate water environment.
- Domestic Use: includes both indoor and outdoor household uses, and watering of a lawn and noncommercial garden.
- New Consumptive Water Use: The consumptive water use from the permit-exempt domestic groundwater withdrawals estimated to be initiated within the 20 year planning horizon (2020–2040) (planning horizon). The required water offset is equal to new consumptive water use.
- Net Ecological Benefit: The outcome that is anticipated to occur through implementation of projects and actions in a plan to yield offsets that exceed impacts within: a) the planning horizon; and, b) the relevant WRIA boundary.
- Water Offsets: Projects that put water back into aquifers or streams that offset new consumptive water use.

Ecology has provided guidance for estimating indoor and outdoor consumptive water use in their Final NEB Guidance (Ecology 2019).

Consumptive use estimates are divided into two components: the indoor and outdoor portions of use. The use patterns and consumptive portions of indoor versus outdoor use associated with permit-exempt connections are different; therefore, separate approaches within each method that account for these differences are used to estimate consumptive use.

Ecology's indoor consumptive water use guidance includes literature-based assumptions on per-capita indoor water use and the consumptive proportion. Outdoor consumptive water use guidance includes methods for the estimation of irrigated area, assumed irrigation requirements, irrigation efficiency, and the consumptive proportion. Ecology's guidance also recommends local corroboration using water system meter data for both indoor and outdoor estimates (Ecology 2019). For purposes of this technical memorandum, Ecology's recommended method for estimating consumptive use is called the Irrigated Area method, and estimation of consumptive use using local water system meter data is called the Water System Data method.

Consistent with the Final NEB guidance, the Committee assumed that impacts from consumptive use on surface water are steady-state, meaning that impacts to the stream from pumping do not change over time. This assumption is based on the wide distribution of future well locations and depths across varying hydrogeological conditions.

3.1 Irrigated Area Method

Consumptive use was calculated using Ecology's recommended assumptions for indoor and outdoor consumptive use (Ecology 2019).

3.1.1 Indoor Consumptive Use – Irrigated Area Method

Ecology (2019) recommends the following assumptions for estimating indoor consumptive water use:

- 60 gallons per day (gpd) per person within a household
- 2.5 persons per household (or as otherwise defined by the Counties)
- 10 percent of indoor use is consumptively used

Most homes served by a PE well use septic systems for wastewater. This method assumes that 10 percent of water entering the septic system will evaporate out of the septic drain field and the rest will be returned to the groundwater system.

The above assumptions were used to estimate indoor consumptive water use by occupants of a single dwelling unit. Assuming that there is one PE well connection per dwelling unit, a "per PE well connection" consumptive use factor was applied to the growth projections forecast in each subbasin to determine total indoor consumptive use per subbasin. This method is summarized by the following equation:

$$HCIWU\ (gpd) = 60\frac{gal}{day * person} * \ 2.5\frac{people}{household} * CUF$$

Where:

HCIWU = Household Consumptive Indoor Water Use (gpd)

CUF = Consumptive use factor; assumed to be 10 percent (factor expressed as 0.10)

This estimate of indoor consumptive use per household per day is 15 gpd and can be annualized and converted to acre-feet per year of cubic feet per second.

3.1.2 Outdoor Consumptive Use – Irrigated Area Method

To calculate the consumptive portion of total outdoor water required per parcel/connection over a single growing season, Ecology recommends:

- Estimating the average irrigated lawn area (pasture/turf grass) per parcel;
- Applying crop irrigation requirements;

- Correcting for application efficiency (75 percent efficiency recommended by Ecology guidance) to determine the total outdoor water required over a single growing season; and
- Applying a percentage of outdoor water that is assumed to be consumptive. This method assumes that 80 percent of outdoor domestic water use is consumed by evaporation and transpiration.

Future outdoor water use may be based, in part, on an estimate of the average outdoor irrigated area for existing homes served by PE domestic wells (Ecology 2019). HDR estimated the average irrigated lawn area for WRIA 12 by delineating the apparent irrigated area in 80 parcels identified as containing a dwelling unit served by a PE well in WRIA 12, and averaging them (Attachment B). The 80 parcels were selected from a pool of all parcels with single-family residential use and only located outside water service areas. The pool of potential parcels was classified by property value (48 percent less than $350,000, 44 percent between $350,000 and $600,000, 8 percent greater than $600,000), and the proportion of parcels within each class were defined. The 80 parcels were apportioned according to this sample pool and randomly selected from throughout the WRIA.

The irrigated areas were delineated using one technician and a standard method. The average irrigated area per PE connection in WRIA 12 was estimated to be 0.15 acre. Many of the parcels evaluated did not have an apparent irrigated area (i.e., most parcels had zero irrigated area).

Bias in the delineation methods was evaluated by doing a side-by-side comparison study with another consulting firm that was providing similar technical support for the WRIAs 7, 8, and 9 WRE plans (Attachment C). This comparability study concluded that there was no inherent bias in the methods.

Overall method bias was also evaluated by comparing the consumptive use calculated with this irrigated area method to specific parcels with meter records (Appendix D). The irrigated area method overestimated overall water use, relative to the actual metered use.

Because of the high proportion of zero irrigated acreage measurements contributing to the 0.15 irrigated acreage average, and because of the large variability in the results (e.g., large standard deviation), HDR proposed a range of alternatives to mitigate that uncertainty:

- To account for uncertainty of detecting small areas of irrigation, the Committee could impute the zero values with a “minimum detection” irrigated area of 0.05 acre, which would result in a 0.17-acre average irrigated area size. To account for potential methodological limitations on detecting irrigation, a minimum value of 0.05 acre of irrigation was assumed to occur, even if there were no indications of irrigation from aerial photo interpretation. This value was approximately the minimum value of detected irrigation in the data set.
- HDR completed a statistical analysis of their data, and has determined that using the 95 percent Upper Confidence Limit of the data (based on imputing 0.05 acre for parcels that did not have an apparent irrigated area) could be an additional way to account for uncertainty, which would result in a 0.21 acre average irrigated area size (Appendix B. The irrigated area data set did not have a normal distribution, because over half of the parcels had zero irrigated area (i.e., the data were left-censored). However, when the zero values were replaced with 0.05-acre values (as an imputed detection limit), the data followed a gamma distribution. For gamma distributed detected data, UCLs may be computed using gamma distribution on a Kaplan-Meier (KM) statistic, using a Chi Square approximation (USEPA 2015).

The Committee moved forward with the 95 percent upper confidence limit of 0.21 acre as the assumed irrigated area to calculate outdoor consumptive use.

Crop irrigation requirements, irrigation efficiency and outdoor use assumptions were also made to estimate outdoor consumptive use. An average crop irrigation requirement was estimated for pasture/turf grass from Puyallup and Tacoma weather stations as provided in the Washington Irrigation Guide (NRCS-USDA 1997). A weighted average of 20.3 inches per year was calculated based on the number of connections closest to the stations. Irrigation application efficiency (i.e., the percent of water used that actually reaches the turf) was assumed to be 75 percent, consistent with Ecology (2018, 2019) recommendations. Finally, the consumptive portion of total amount of water used for outdoor use was assumed to be 80 percent.

This method is summarized in the following equation:

$$HCOWU\ (afy) = A\ (acres) * IR(feet) * AE * CUF$$

Where:

HCOWU = Household Consumptive Outdoor Water Use (gpd)

afy = acre feet per year

A = Irrigated Area (acres)

IR = Irrigation Requirement over one irrigation season (feet)

AE = Application efficiency; assumed to be 75 percent (factor expressed as 1/0.75)

CUF = Consumptive use factor; assumed to be 80 percent (factor expressed as 0.80)

This estimate of outdoor consumptive water use per household per day can be annualized and converted to gallons per day (gpd) or cubic feet per second (cfs).

Conversion Factors:

gpd = afy * 0.001120

cfs = afy * 723.97

This estimate of outdoor consumptive use per household per day is 338 gpd and can be annualized and converted to 0.379 acre-feet per year or 0.000524 cubic feet per second.

Seasonal consumptive use was estimated on a monthly basis by allocating total outdoor consumptive use proportional to the monthly irrigation requirement. The monthly irrigation requirement was defined by the Washington Irrigation Guidance.

4.0 Water System Data Method

Consumptive use by PE connections may also be estimated using metered connections from water systems. Water systems required to plan per WAC 246-290 must install meters on all customer connections. Smaller water systems that do not have state planning requirements may choose to meter their customer connections if the system bills based on a tiered rate structure (i.e., increasing costs per unit of water consumed coincident with higher total use in the billing period).

Some systems bill customers a flat rate (i.e., same bill every month regardless of consumption). The lack of a tiered rate structure reduces the financial incentive to conserve water, which may result in consumption patterns more similar to those observed on a PE connection. These systems may or may not choose to meter their customers if meters are not required by law.

No water use meter data were available for systems that uses a flat-rate structure. The Spanaway Water System, which operates under a tiered rate structure in WRIA 12, was utilized for this analysis.

4.1 Indoor Use

Average daily use in December, January, and February was assumed to be representative of year-round daily indoor use. Average daily system-wide use was divided by the number of connections (assuming all connections are residential), to determine average daily indoor use per connection. A 10 percent consumptive use factor was applied to the average daily use in the winter months to determine the consumptive portion of indoor water use per connection.

4.2 Outdoor Water Use

Average daily use in December, January, and February is representative of year-round daily indoor use. Total annual indoor use was subtracted from total annual use by a water system to estimate total annual outdoor use. An 80 percent consumptive factor was applied to determine the consumptive portion of outdoor use.

Outdoor consumptive use was also estimated on a seasonal basis. Seasonal outdoor water use was assumed to occur over a period of 6 months (April through September). Average daily indoor use was multiplied by the number of days in the irrigation season to calculate total indoor use for the irrigation season. Total irrigation season indoor use was then subtracted from total season use to determine total outdoor use for the irrigation season. The value was proportionally allocated to each month in the irrigation season using the requirements from the Washington Irrigation Guide. An 80 percent consumptive factor was applied to determine the consumptive portion of outdoor use.

5.0 Results

5.1 PE Connection Growth

Growth projections are predicted to vary among 145, 78, and 227 connections for baseline, low, and high-growth scenarios, respectively (Table 1). Growth is projected to occur primarily in the far eastern section of the Clover Creek subbasin (Figure 1). Estimated consumptive use is relatively small in this WRIA due to general urbanization and the small area that is subject to future rural development without available water system service.

Table 1. WRIA 12 Alternative Growth Projection Scenarios (Pierce County)

Number of Permit-Exempt Wells Added between 2018 and 2038			
Subbasin	Baseline (1999–2018)	Low Growth (2009–2018)	High Growth (1999–2008)
Chambers	4	2	7
Clover Creek	141	76	220
Sequalitchew	--	--	--
Total	145	78	227

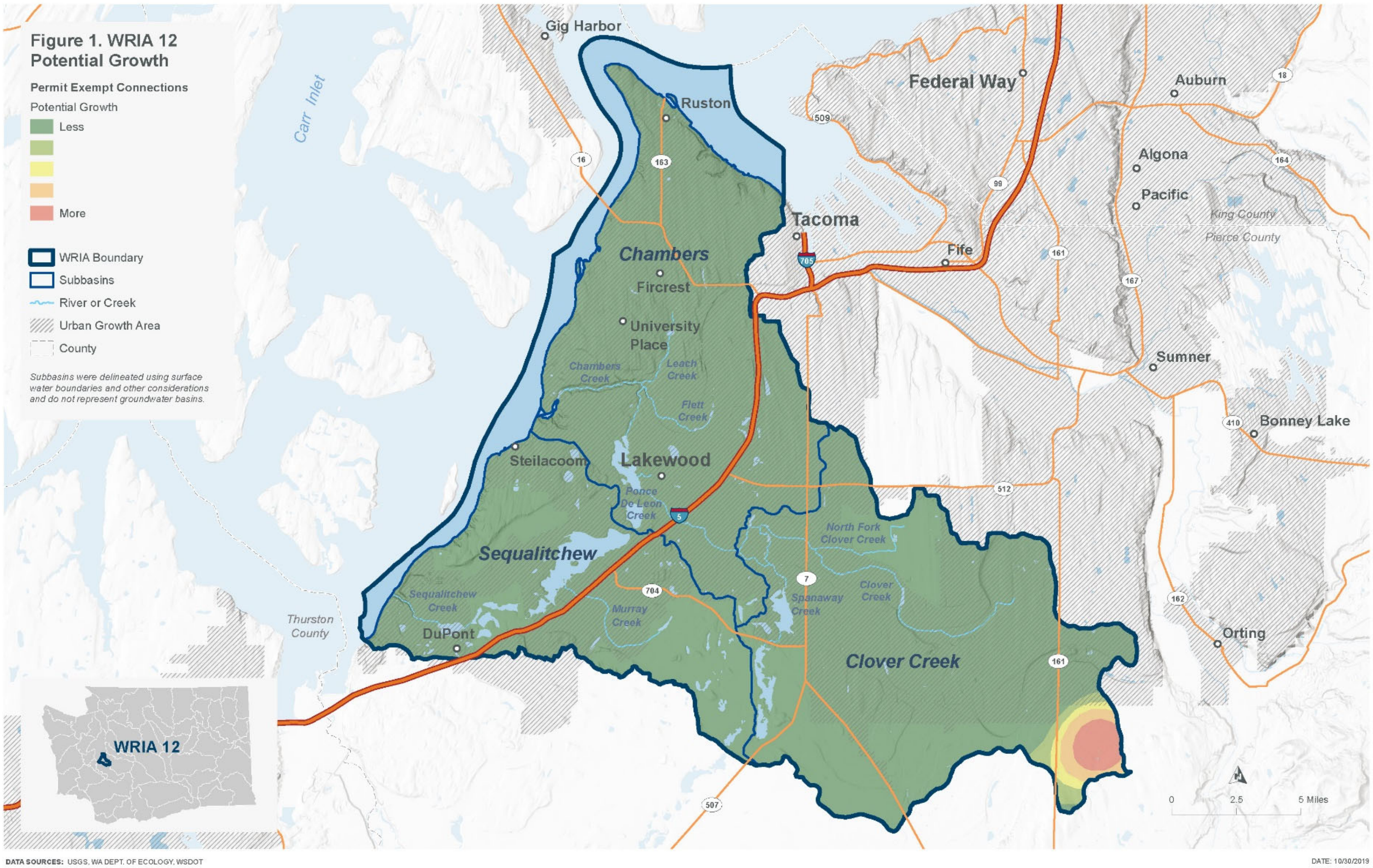


Figure 1. WRIA 12 Projected PE Connection Growth

5.2 Consumptive Use

Table 2 presents the consumptive use projections for WRIA 12 for baseline, low-growth, and high-growth scenarios. The water system data analysis was conducted using tiered rate data from the Spanaway Water System. Consumptive use projections were 0.0119, 0.0064, and 0.0186 cfs for the baseline, low, and high alternative growth scenarios, respectively, when the Water System Data method was used.

Consumptive use projections were 0.079, 0.043, and 0.124 cfs for the baseline, low, and high alternative growth scenarios, respectively, when the Irrigated Area method was used.

For WRIA 12 scenarios, consumptive use is 84 percent higher in the baseline scenario than the low-growth scenario, and 57 percent higher in the high-growth scenario than the baseline scenario. The estimates of consumptive use using the Irrigated Area method are over six times higher than the water system data estimate. The WRIA 12 WRE Committee selected the baseline and high growth PE well projections and the Irrigated Area consumptive use estimate method for consumptive use estimates of 0.08 cfs and 0.12 cfs that will need to be offset.

Table 2. Annualized Average Consumptive Use Estimates for WRIA 12

Growth Projection Scenario/Subbasin	Projected PE Well Connections	Annual Consumptive Use: Water System Estimate			Annual Consumptive Use: Irrigated Area Estimate (per Ecology Guidance)		
		afy	GPM	cfs	afy	GPM	cfs
Baseline							
Clover Creek	141	8.4	5.2	0.0116	55.8	34.6	0.077
Sequalitchew		0.0	0.0	0.0000	0.0	0.0	0.000
Chambers	4	0.2	0.1	0.0003	1.6	1.0	0.002
Total	**145**	**8.6**	**5.3**	**0.0119**	**57.4**	**35.6**	**0.079**
Low-Growth							
Clover Creek	76	4.5	2.8	0.0062	30.1	18.6	0.042
Sequalitchew		0.0	0.0	0.0000	0.0	0.0	0.000
Chambers	2	0.1	0.1	0.0002	0.8	0.5	0.001
Total	**78**	**4.6**	**2.9**	**0.0064**	**30.9**	**19.1**	**0.043**
High-Growth							
Clover Creek	220	13.1	8.1	0.0181	87.1	54.0	0.120
Sequalitchew		0.0	0.0	0.0000	0.0	0.0	0.000
Chambers	7	0.4	0.3	0.0006	2.8	1.7	0.004
Total	**227**	**13.5**	**8.4**	**0.0186**	**89.8**	**55.7**	**0.124**

Note: GPM = gallons per minute

6.0 Seasonal Use

Monthly outdoor water use was calculated as part of the consumptive use analysis for the Irrigated Area method. Seasonal water use by month is reported by subbasin and scenario (Table 3). The month of July has the highest irrigation requirement, resulting in the highest monthly consumptive use impact. This information may be used during evaluation of projects designed to offset subbasin- and season-specific impacts.

Table 3. WRIA 12 Monthly Consumptive Water Use

Subbasin	Projected No. PE Wells	Consumptive Use by Month (cfs)											
		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Baseline													
Clover Creek	141	0.001	0.001	0.001	0.060	0.142	0.176	0.233	0.183	0.095	0.001	0.001	0.001
Sequalitchew	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chambers	4	0.000	0.000	0.000	0.002	0.004	0.005	0.007	0.005	0.003	0.000	0.000	0.000
Totals	**145**	**0.001**	**0.001**	**0.001**	**0.062**	**0.146**	**0.181**	**0.240**	**0.188**	**0.097**	**0.001**	**0.001**	**0.001**
Low Growth													
Clover Creek	76	0.001	0.001	0.001	0.032	0.077	0.095	0.126	0.098	0.051	0.001	0.001	0.001
Sequalitchew	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chambers	2	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.003	0.001	0.000	0.000	0.000
Totals	**78**	**0.001**	**0.001**	**0.001**	**0.033**	**0.079**	**0.097**	**0.129**	**0.101**	**0.052**	**0.001**	**0.001**	**0.001**
High Growth													
Clover Creek	220	0.002	0.002	0.002	0.094	0.222	0.274	0.364	0.285	0.147	0.002	0.002	0.002
Sequalitchew	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chambers	7	0.000	0.000	0.000	0.003	0.007	0.009	0.012	0.009	0.005	0.000	0.000	0.000
Totals	**227**	**0.002**	**0.002**	**0.002**	**0.097**	**0.229**	**0.283**	**0.376**	**0.294**	**0.152**	**0.002**	**0.002**	**0.002**

7.0 References

DeOreo, W., P. Mayer, B. Dziegielewski, and J. Kiefer. 2016. *Residential End Uses of Water, Version 2*. Water Research Foundation, Report #4309b.

Dunn, A.B., and A. Neff. 2018. *Potential Consumptive Use Impacts of Domestic Groundwater Permit-Exempt Wells Over the Next 20 Years in WRIA 1 – Version 2 Technical Memorandum*. RH2 Engineering.

Ecology. 2019. Final Guidance for Determining Net Ecological Benefit. Washington State Department of Ecology, Publication 19-11-079.

Einberger, C., C. Pitre, and D. Banton, D. 2014. *Skagit County Exempt Well Metering Program – 2012-2013 Technical Memorandum*. Washington State Department of Ecology.

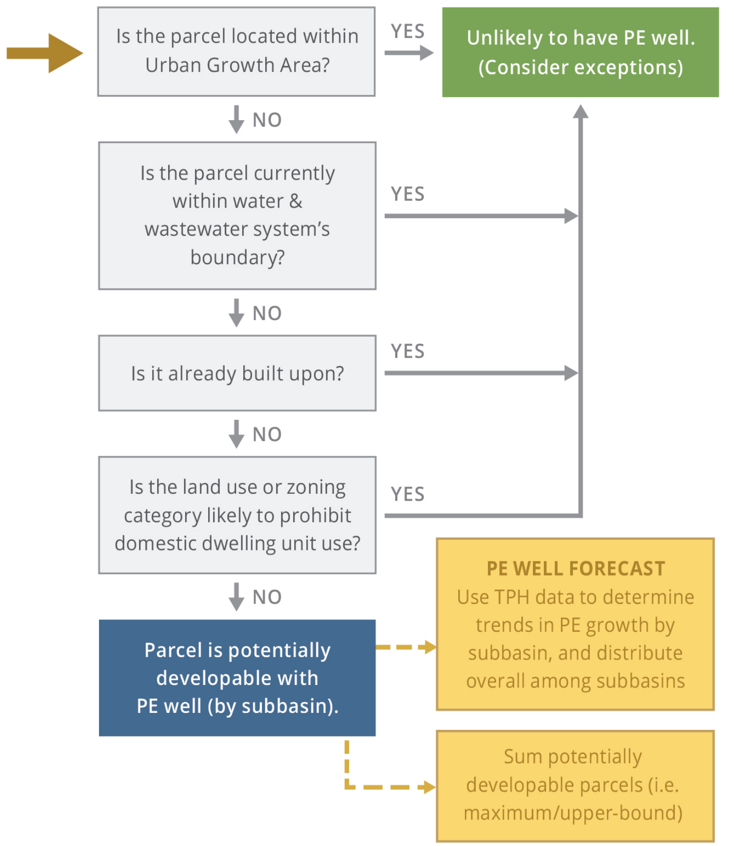
Natural Resource Conservation Service. 1997. Washington Irrigation Guide (WAIG). U.S. Department of Agriculture.

Welch, W.B, L.M. Frans, and T.D. Olsen. 2014. *Hydrogeologic Framework, Groundwater Movement and Water Budget of the Kitsap Peninsula, West-Central Washington*, Scientific Investigation Report 2014-5106.

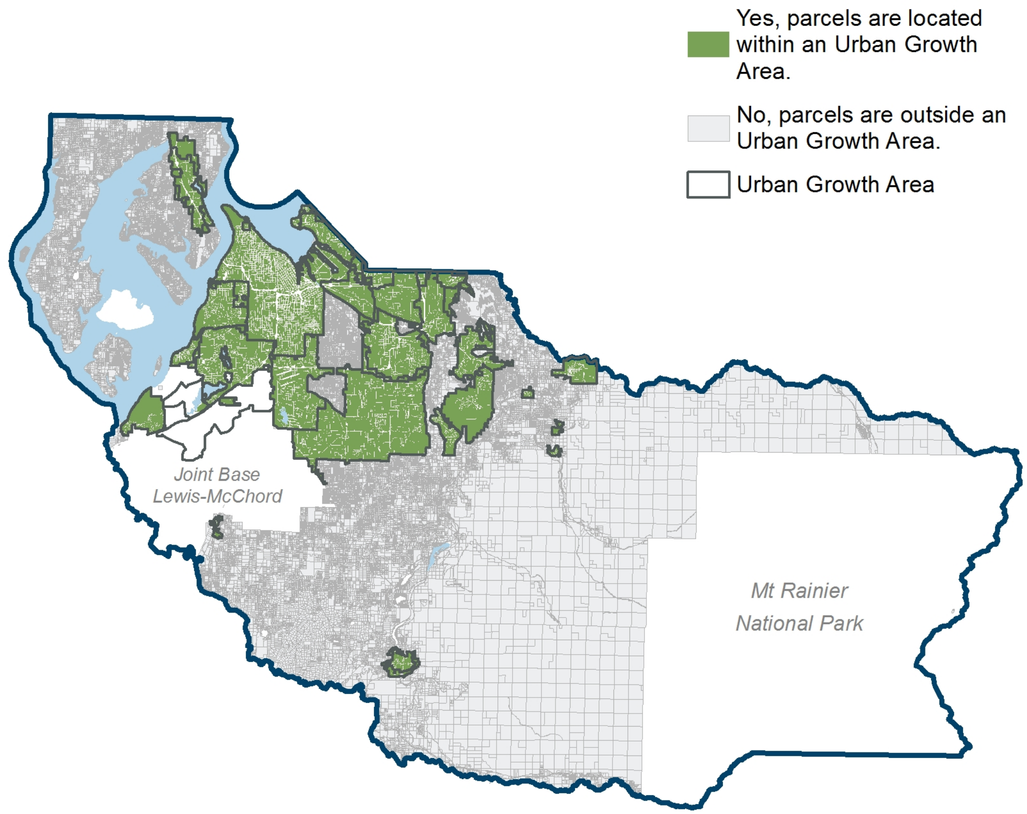
Attachment A

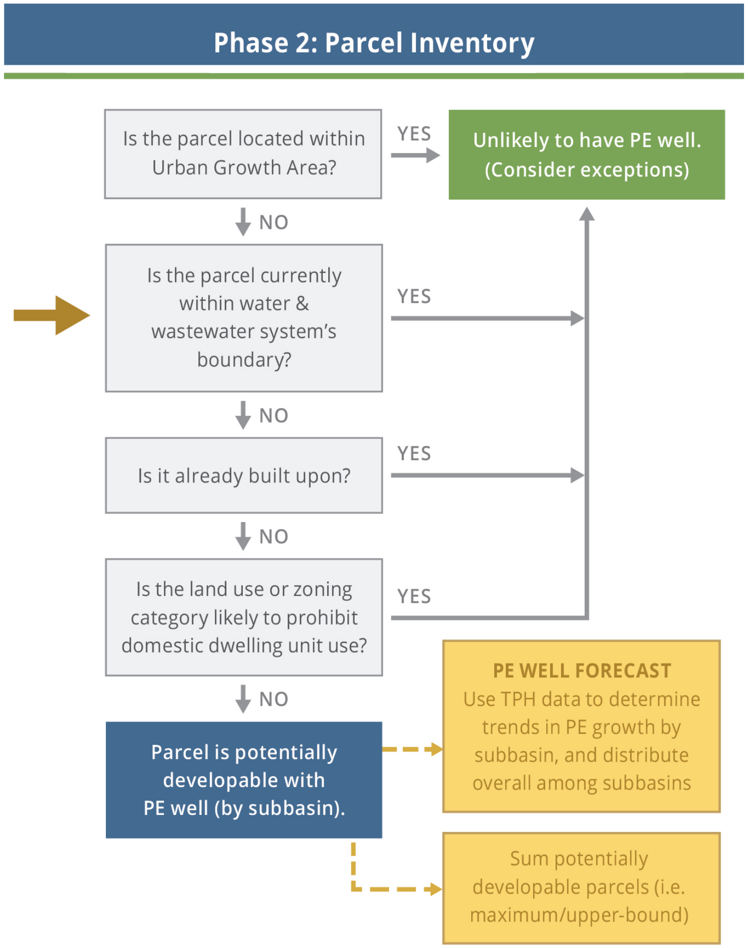
Pierce County PE Growth Methods and Buildable Lands Analysis

Phase 2: Parcel Inventory

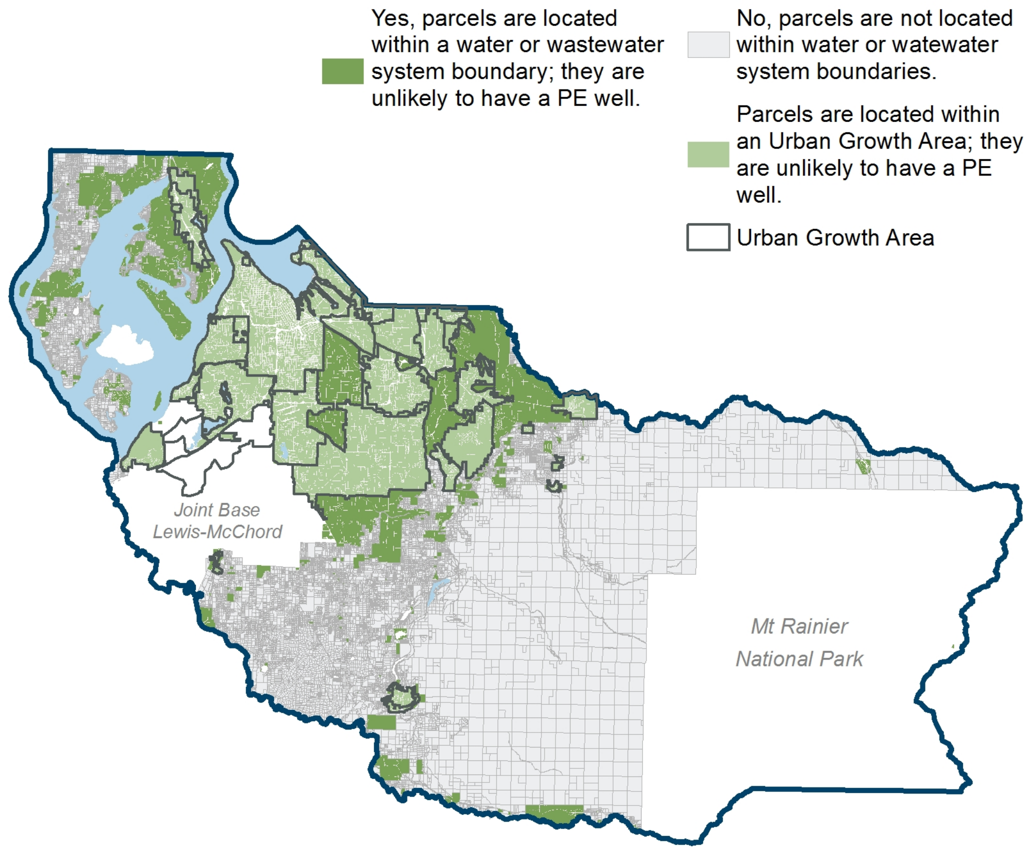


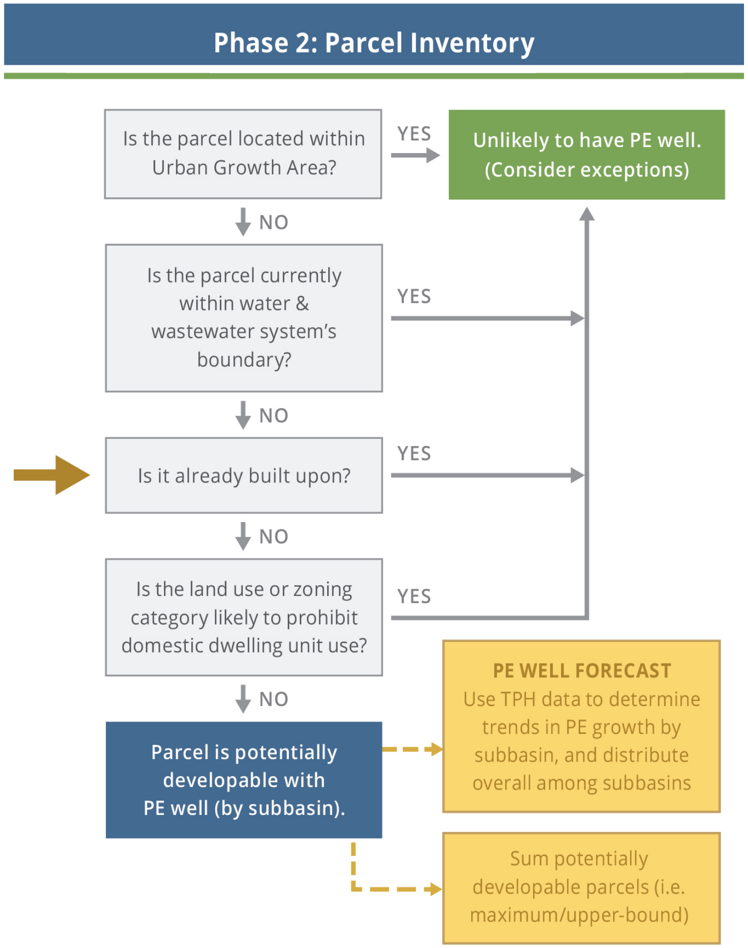
Is the parcel located within an Urban Growth Area (UGA)?



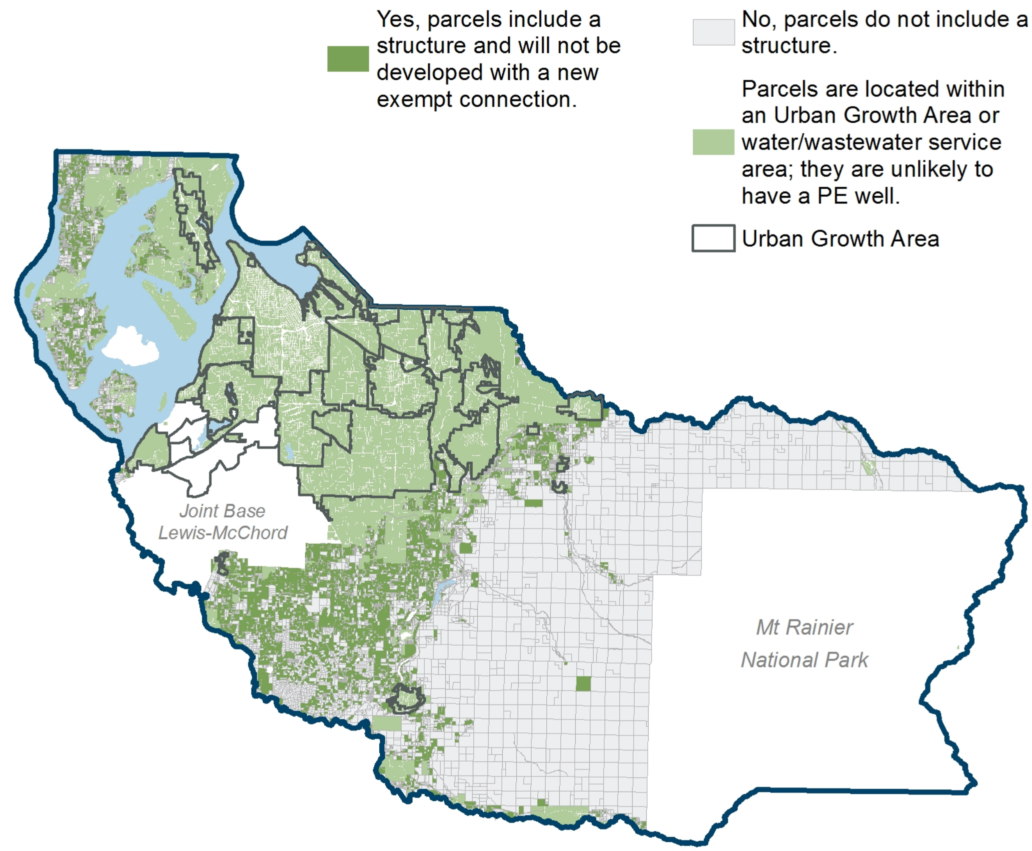


Is the parcel located within a water or wastewater system boundary?

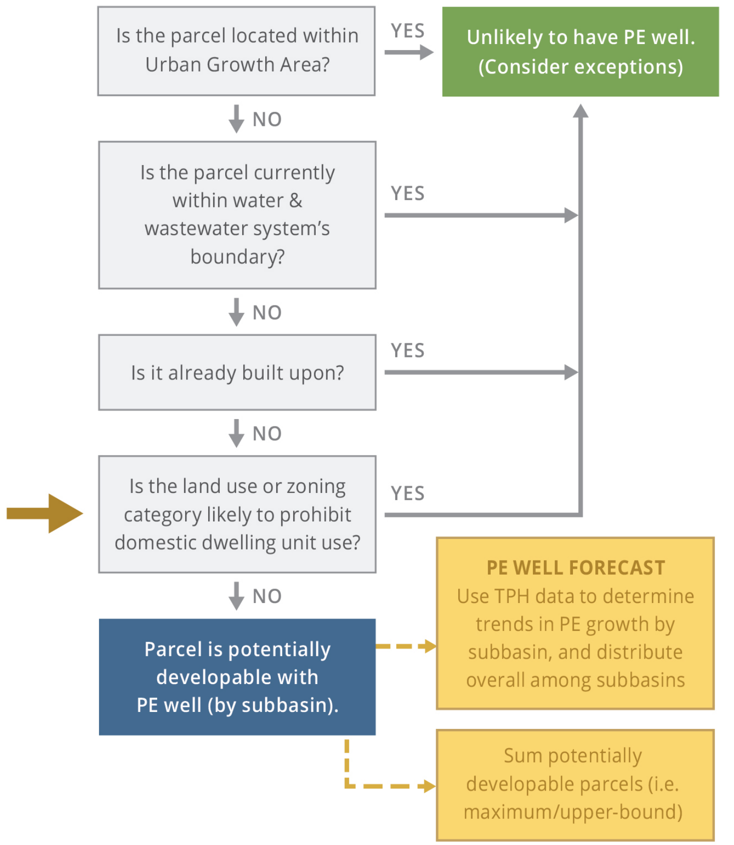




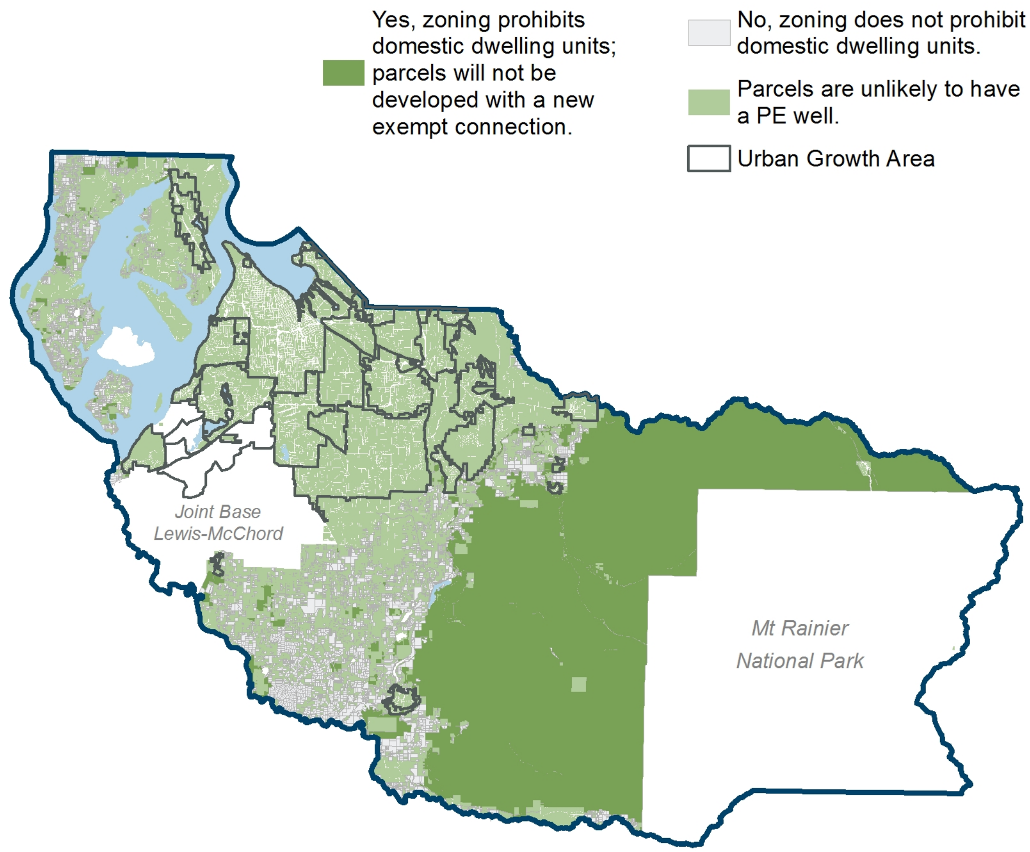
Is the parcel already built upon?

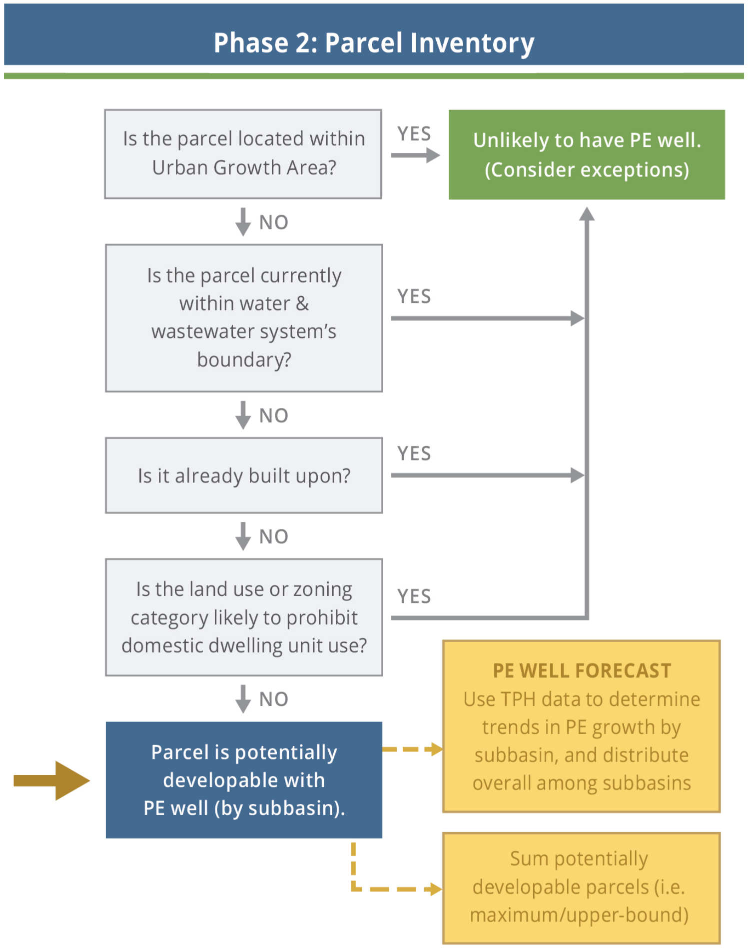


Phase 2: Parcel Inventory

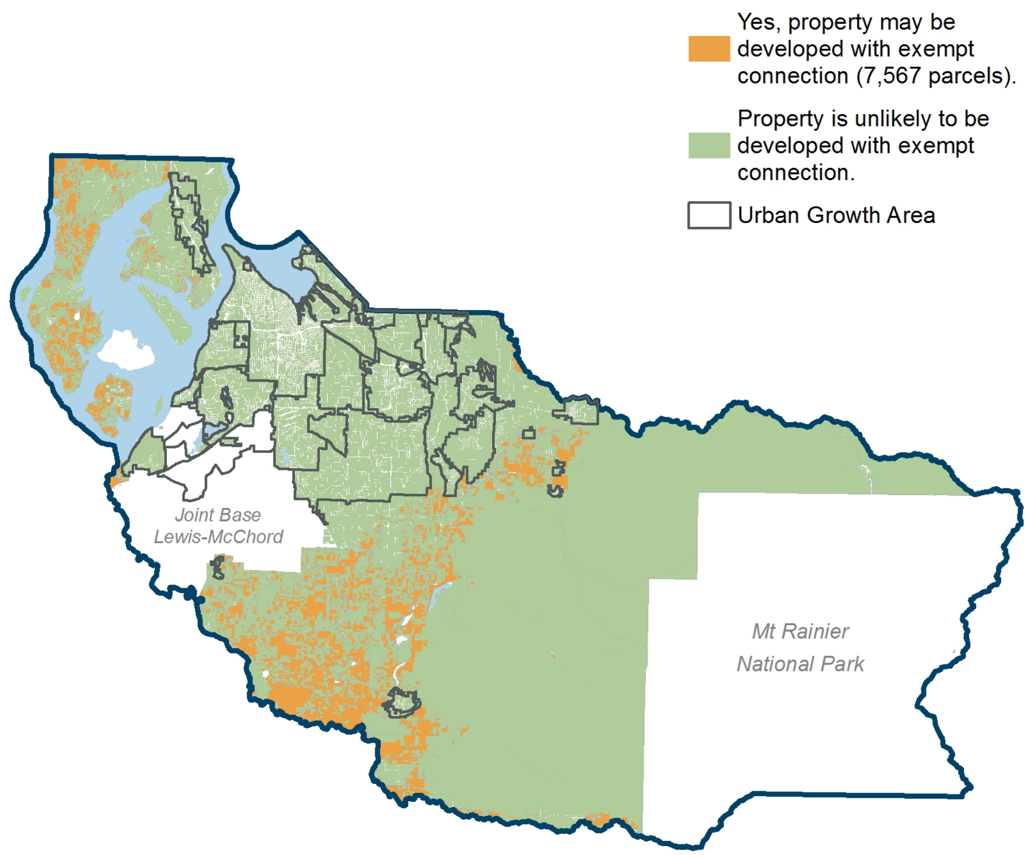


Does the land use or zoning prohibit domestic dwelling units?

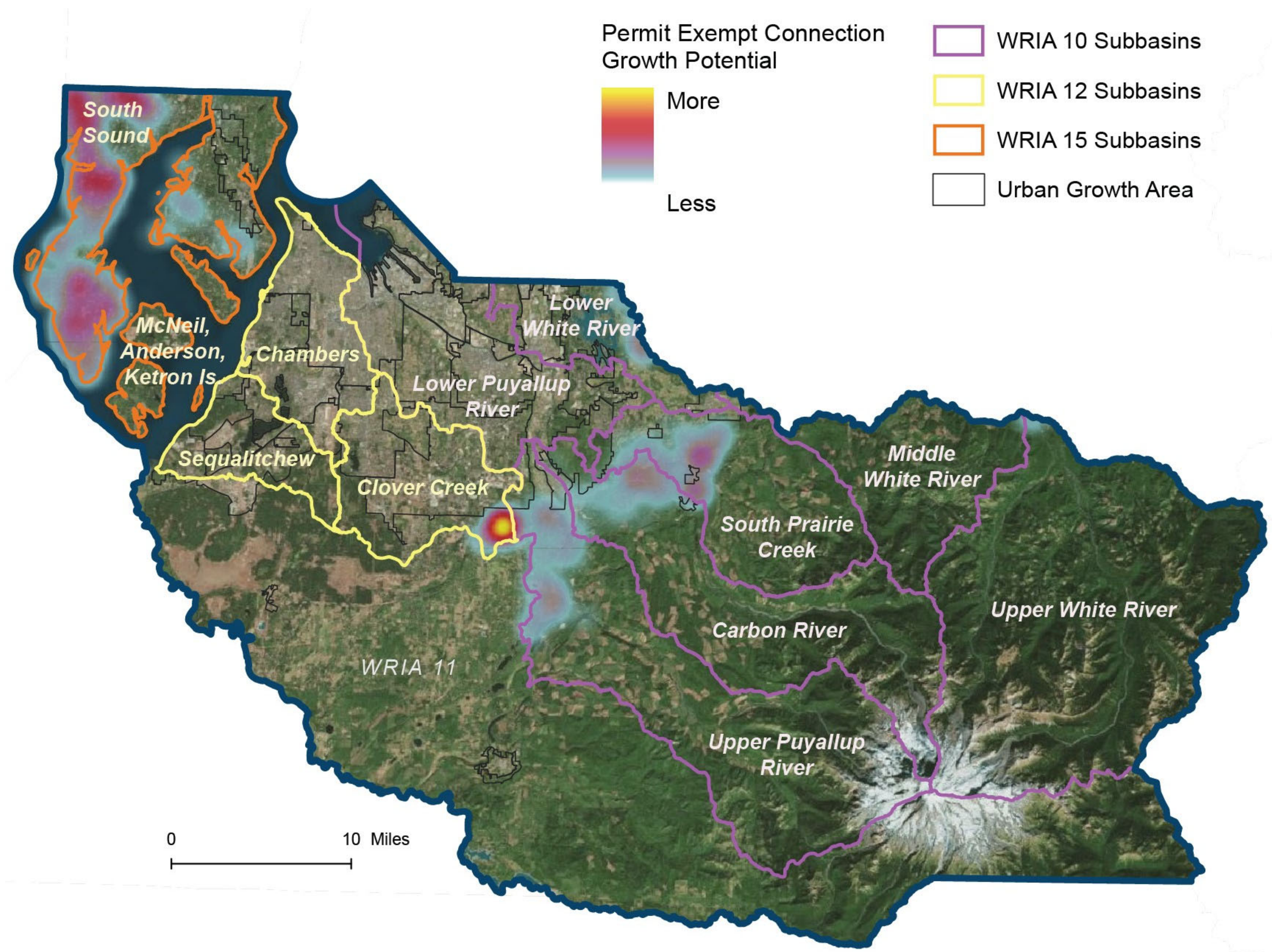




Parcel is potentially developable with PE well.



Pierce County Growth Projection Analysis



Attachment B

Estimation of Average Irrigated Area

Methods

1. 80 parcels representing an existing dwelling served by a permit-exempt well or connection was defined.
    a. A pool of parcels with an existing dwelling served by a permit-exempt well or connection was defined.
    b. The selection pool was classified by property value. The classes were (1) Under $350,000, (2) $350,000–$600,000, and (3) over $600,000.
    c. Eighty parcels were randomly drawn from the selection pool, weighted by the proportion of property value class membership.
    d. Additional parcels were randomly selected as alternates, in case any of the primary (80) samples were able to be interpreted to irrigated area.
    e. All parcels were provided in a Google Earth .kmz file.
2. The irrigated area in each parcel was delineated according to the following procedure:
    a. Used a single technician to minimize operator variability.
    b. Irrigated area delineations were made using Google Earth aerial imagery taken during drier summer months (i.e., July and August). Unirrigated lawns (pasture/turf) go dormant in the dry summer months and turn brown. As such, areas that remain green in the summer imagery were considered irrigated.
    c. Aerial imagery from winter months was reviewed alongside summer imagery to reveal which lawn areas change from green to brown. Those areas that do not change color, or moderately change color but remain green, were considered irrigated.
    d. If available, multiple years of aerial imagery were used to corroborate the irrigated area delineation.
    e. Landscaped shrub/flower bed areas within a larger irrigated footprint were included. Shrub and flower bed areas outside of the irrigated footprint were excluded.
    f. If the irrigated area extended beyond the parcel boundary, those areas were included.
    g. Parcels with no visible signs of irrigation were assumed to have zero irrigated acres.
    h. Areas that appeared to be native forest or unmaintained grass were not included in the irrigated footprint.
    i. Parcels with homes or accessory dwelling units (ADUs) under construction in the most recent Google Earth imagery were excluded from the analysis, and an alternate parcel was evaluated.

    Figures B-1 through B-4 illustrate some example delineations.

Figure B-1. No irrigated areas visible in most recent google earth aerial imagery.

Figure B-2. Area in white includes maintained grass. Residence constructed between June 2017 and July 2018. Therefore, historical irrigation of property is unavailable in GoogleEarth imagery.

Figure B-3. Irrigated area includes landscaped area in driveway, maintained yard around residence, garden area, and maintained grass near garden area.

Figure B-4. No irrigated area. Assumption that green vegeation on southern portion of parcel is due to proximity to Spurgeon Creek since clear delineation of irrigated area is not present on aerial. Green area near residence appears to be tree and shrubs, not maintained landscaping, and is excluded.

Results

Eighty parcels were evaluated for irrigated acreage (Figure B-5). Average irrigated acreage was 0.15 acre (Table B-1). In all WRIAs evaluated, most of the parcels had zero irrigated acres (Figure B-6). The distribution of irrigated acreages for all WRIAs were skewed because of the large percentage of parcels that had zero irrigated acres. Some parcels had an irrigated area nearly an order of magnitude larger than the mean, resulting in a large standard deviation. The 95 percent upper confidence limit of the mean could be fit with a gamma distribution and was 0.21 acre (0.06 acre larger than the calculated arithmetic mean).

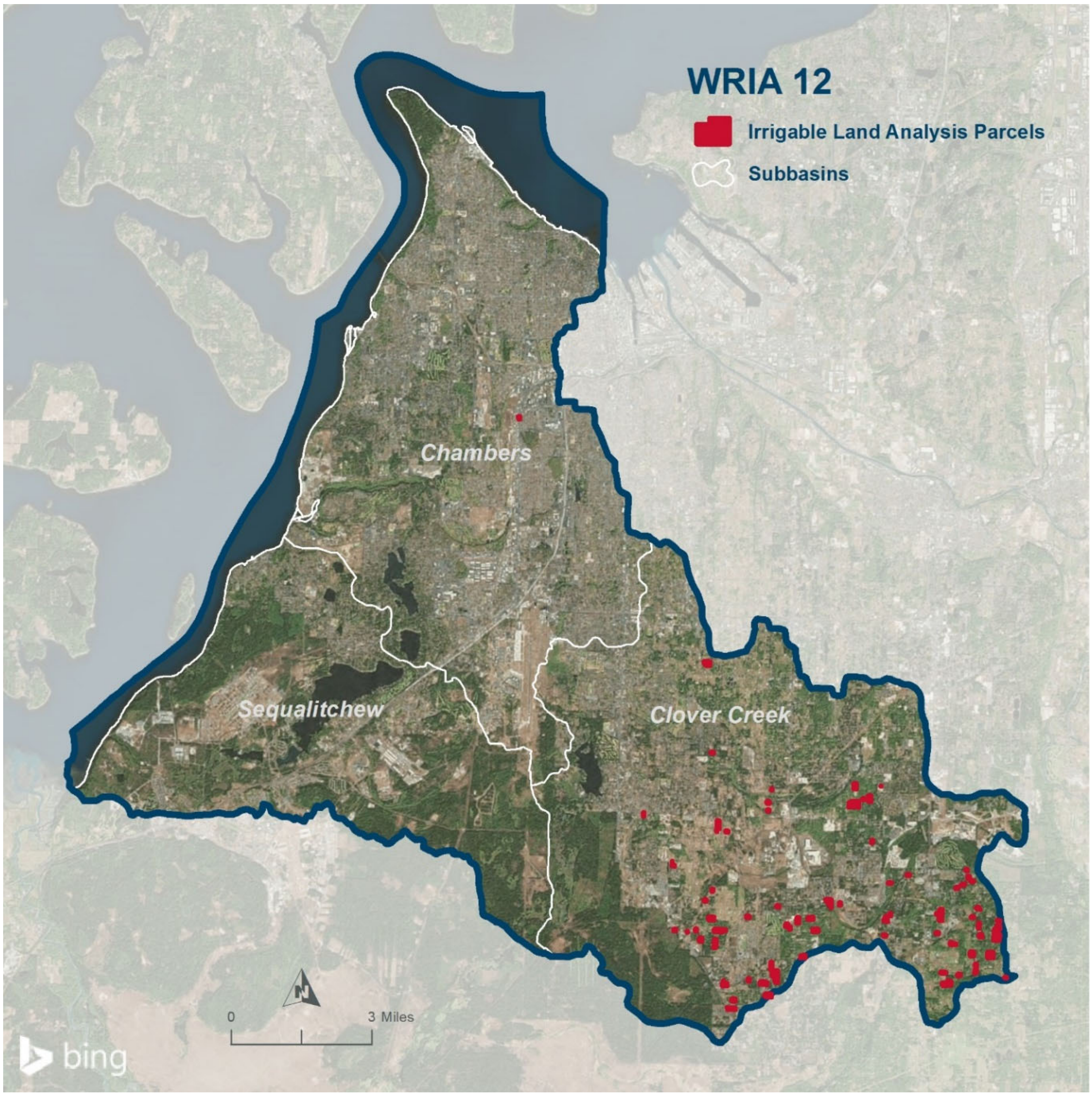


Figure B-5. Parcels selected in WRIA 12 with existing PE connections that were delineated for apparent irrigated areas.

Table B-1. Irrigated acreage delineation results

Statistic	Units	WRIA 12
PE Parcel Sample Pool	Parcels	137
Sample Size	Parcels	80
Mean (with zero acreage values)	Acres	0.15
Standard Deviation (with zero acreage values)	Acres	0.22
Mean (with minimum 0.5 acres)	Acres	0.17
Standard Deviation (with minimum 0.5 acres)	Acres	0.21
95% UCL (with minimum 0.5 acres)	Acres	0.21

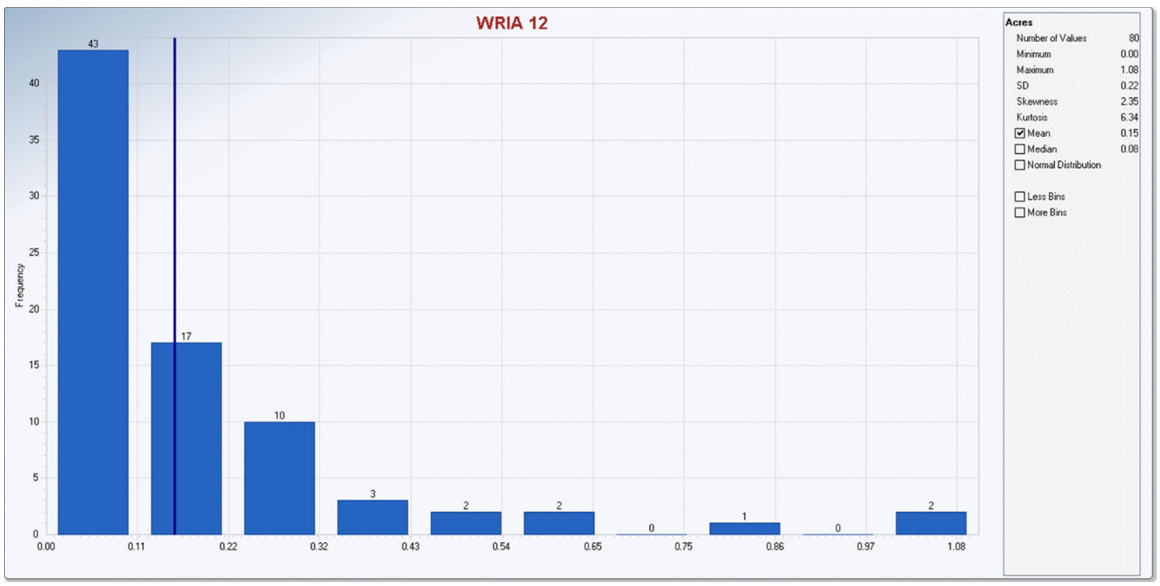


Figure B-6. Histogram of WRIA 12 irrigated acreage delineation results.

Attachment C

Irrigated Acreage Comparability Study

Technical Memorandum

To:	Angela Johnson, Rebecca Brown, Ingria Jones, Stephanie Potts, Stacy Vynne McKinstry, John Covert, and Tom Culhane (Ecology)
From:	Chad Wiseman (HDR) and Bridget August (GeoEngineers)
Date:	January 16, 2020
Subject:	Draft Irrigated Acreage Comparability Study

1.0 Executive Summary

The purpose of this technical memorandum is to summarize the Draft Irrigated Acreage Comparability Study undertaken as a joint exercise by the GEI and HDR technical teams and to provide a recommendation to Ecology on whether variability between GEI and HDR irrigated area delineations warrants data qualification or updates. This study was conducted at the request of the Ecology team indicated as the recipients of this memo. The Ecology team requested we undertake this study as part of on-going quality assurance work associated with development of products for use by the Watershed Restoration and Enhancement (WRE) committees. The need for this specific study was identified because of perceived differences in specific draft, interim results from the two firms related to the analysis of outdoor irrigation area of existing homes served by permit-exempt (PE) wells. The goals of this study were to: 1) to determine if there was a difference in the mean irrigated areas between the HDR and GEI delineations, 2) to identify the reasons for those differences, and 3) to determine the implications, if any, of these differences for the work of the WRE committees. This memorandum details the reasons for the differences and ultimately concludes that the differences will not have an impact on the work of the WRE committees and the WRE committees may accept the irrigated area results completed by the GEI and HDR without qualification. The results of the comparability study, and subsequent review with Ecology, indicate the following:

- It is our recommendation that Ecology and the WRE committees should accept the irrigated area results completed by the GEI and HDR teams. The differences will have no impact on the work of the WRE committees. Furthermore, our analysis and comparability results indicate there is no need for a systematic reevaluation of the primary data sets or methodologies. The GEI and HDR teams have confidence in their completed work and, notably, in each other's work for their respective WRIAs.
- The outdoor irrigation method is conservative because it assigns outdoor watering rates equivalent to those for crops described in the Washington Irrigation Guide such as to produce commercial pasture/turf grass.
- There is inherent subjectivity and variability associated with estimating irrigated areas from manual aerial photo interpretation.
- There are a continuum of possibilities between slightly watered areas and those have been watered at rates similar to those presented in the Washington Irrigation Guide, and because

of this range there are also ranges of "correct" answers to the question of which outdoor watering areas should be counted.

- While it can be relatively straight-forward to delineate the irrigated footprints for parcels on the extreme – either brown lawns or lush, golf-course green lawns- it can be much harder to make delineations for the rest of the parcels.

2.0 Introduction

GeoEngineers, Inc. (GEI) and HDR, Inc., (HDR) are providing technical support to the Washington State Department of Ecology (Ecology) and the Watershed Restoration and Enhancement (WRE) committees. GEI is providing support for Water Resource Inventory Areas (WRIAs) 7, 8, and 9, while HDR is supporting WRIAs 10, 12, 13, 14, and 15.

Under RCW 90.94, consumptive water use by new permit-exempt (PE) domestic wells must be estimated to establish the water use that watershed restoration and enhancement (WRE) plans are required to address and offset. Consumptive use is water that evaporates, transpires, is consumed by humans, or otherwise removed from an immediate water environment. Appendix A in the *Final Guidance for Determining Net Ecological Benefit* (July 2019) recommends using more than one method for calculating consumptive water use: a method based on analysis of outdoor irrigation; and a method based on location-specific small- to medium-sized water system data. GEI and HDR are developing results for both methods in each of the WRIAs. This memo only addresses a quality review for the outdoor irrigation method. The outdoor irrigation method is based, in part, on an estimate of the average irrigated area anticipated for new PE wells. This average irrigated area is estimated by delineating the apparent irrigated area of existing homes served by PE domestic wells.

Both HDR and GEI drew from the recent building permit or well databases in selecting parcels for irrigated area delineations. HDR delineated the irrigated area for 80 parcels in each of its assigned five WRIAs, and GEI delineated 393, 153 and 221 parcels in WRIAs 7, 8 and 9, respectively. One analyst from each firm conducted the delineations for consistency, and each analyst followed the prescribed methodology outlined in their respective consumptive use methodology memoranda (excerpts included in Attachments A and B). Following the delineation for each parcel, the irrigated area was calculated, then the mean irrigated area for each subbasin was calculated. The results of this work for all the WRE WRIAs are summarized in Table 1.

The average irrigated footprint results for WRIAs 7, 8, and 9 were generally higher than those for WRIAs 10, 12, 13, 14, and 15. Because of this difference, Ecology asked GEI and HDR to conduct a blind comparability study on a subset of common parcels. The objectives of the comparison were to determine if there was a difference in the mean irrigated areas between the HDR and GEI delineations and to identify the reasons for those differences, if they occurred. This memo further describes the methods and results of the comparison study and provides a recommendation on how Ecology and the WRE Committees can move forward.

Table 1. Irrigated acreage statistical summary.

WRIA	GEI			HDR				
	7	8	9	10	12	13	14	15
Sample Size (PE Parcels)	393	153	221	80	80	80	80	80
Mean Irrigated Area per Parcel	0.21	0.32	0.30	0.17	0.15	0.06	0.07	0.08

3.0 Methods

All irrigated area delineations were done on the Google Earth platform. HDR and GEI each provided a Google Earth spatial data file (KMZ file) containing a randomly selected subset of 10 PE parcels from one WRIA that had been delineated as part of the original irrigated area analysis. GEI provided HDR a KMZ file with 10 parcels from WRIA 9, and HDR provided GEI a KMZ file with 10 parcels from WRIA 10. Only parcel numbers and boundaries were provided in the KMZ file; the results of the original irrigated area delineations from each analyst were not provided to the other consultant.

Each consultant delineated irrigated areas for the 10 parcels provided by the other consultant, using the same analyst and methods as was used for the original WRIA analyses (Attachments A and B). In general, the irrigated areas included turf (residential lawn or pasture), gardens, and landscaping. Unirrigated lawns go dormant in the dry summer months and turn brown. Consultants used summer and winter imagery publically available in Google Earth to determine which areas of the parcel were dormant in the summer. Two or more years of aerial imagery was used when available. Consultants compared winter imagery, when precipitation turns lawns green naturally, to summer imagery, when the study areas receive little to no precipitation and lawns that are not irrigated typically go brown. Areas that remained green in the summer imagery were considered irrigated. Those areas that did not change color from winter to summer, or moderately changed color but remained green through the summer months, were considered irrigated. Consultants also compared each subject parcel to surrounding parcels with managed turf to differentiate the irrigated versus non-irrigated color signatures. Each analyst took notes detailing the rationale for inclusion or exclusion of an area for each delineation and documented the date(s) of the aerial photography utilized to make that determination.

After the analysts completed the additional delineations, HDR and GEI provided their delineated areas (KMZ files and tabular data) and notes to the other consultant to compare results. A conference call with a shared screen was held with Ecology on November 12, 2019, to discuss the delineated areas on Google Earth and calculated acreage results on a parcel by parcel basis. The rationale for inclusion or exclusion of an area from an irrigated footprint delineation was discussed.

After this initial conference call, analysts from HDR and GEI were each asked to re-delineate all 20 parcels a second time to determine if the delineated acreage from each consultant would be closer in value following this reconciliation of differences in methodology by parcel. A conference call was held with Ecology after this second delineation on November 26, 2019, to compare the new mean irrigated acreage between HDR and GEI.

4.0 Results

On average, GEI delineated larger irrigated areas than HDR during both rounds of comparative analyses. The first round had the largest differences. GEIs irrigated areas were estimated to be 0.27 and 0.14 acre larger than HDRs estimates for WRIAs 10 and 9, respectively (Table 2). While most of the delineated areas were similar (i.e., within 0.10 acre) between analysts, there were large differences (i.e., greater than 0.10 acre difference) in five parcels in WRIA 10 and three parcels in WRIA 9. The complete results table with notes is included in Attachment C. During the November 12, 2019 meeting, the following differences in evaluation accounted for most of these differences in irrigated acreages:

- Per GEI's methods (Attachment A), landscaping outside of but adjacent to irrigated lawn areas were included within irrigated acreage. HDR excluded these areas per their methods (Attachment B).
- GEI was more inclusive of additional acreage under the tree canopy within the irrigated footprint.
- HDR did not identify some gardens that should have been included within the irrigated footprint.
- HDR utilized a more restrictive seasonal range of aerial photography to determine irrigated versus dormant turf (residential lawn and pasture) color signatures. For some parcels, GEI used more recent June and early July imagery, if available, to determine if an area was irrigated. HDR only used imagery from late July to early September to differentiate dormant versus irrigated turf. The different aerial imagery being evaluated by GEI and HDR resulted in some different interpretations of irrigated acreage.
- In some cases, there was a difference in analyst interpretation of areas that would plausibly be managed as irrigated turf (i.e., based off of fence lines and apparent uses).
- In some cases, there was a difference in analyst interpretation of whether or not the turf in the subject parcel was "greener" than turf in the surrounding parcels that was also managed (i.e. as residential yards or pastures) but was not irrigated (assuming that at least some people do not irrigate their lawns and pastures). For example, if the subject parcel had green grass in their yard, but other yards in the area had brown grass (indicating dormancy from no irrigation), the green area in the subject parcel would be delineated. These comparisons and decisions can be subjective.

Following the discussion on November 12, 2019, outlining these differences in methodology and subsequent re-delineation of the 20 parcels, the average irrigated acreages calculated by HDR and GEI were much closer in value, with a difference on average of 0.05 and 0.06 acre in WRIA 9 and 10 respectively (Table 2). GEI reduced the irrigated area, particularly under tree canopies, while HDR slightly expanded irrigated areas for gardens and turf. The GEI mean irrigated areas were reduced by 0.2 and 0.03 acre for WRIAs 10 and 9, respectively. The HDR mean irrigated areas were increased by 0.02 and 0.05 acre for WRIAs 10 and 9, respectively.

Table 2. GEI and HDR irrigated area comparability study results.

Parcel No.	WRIA	Delineated Irrigated Acreage Initial Comparison Analysis			Delineated Irrigated Acreage following Methodology Reconciliation		
		GEI	HDR	Difference	GEI	HDR	Difference
A	10	0.50	0.09	0.41	0.09	0.09	0.00
B	10	0.00	0.00	0.00	0.00	0.00	0.00
C	10	0.00	0.00	0.00	0.00	0.00	0.00
D	10	0.82	0.13	0.68	0.38	0.22	0.16
E	10	0.29	0.31	-0.02	0.23	0.36	-0.13
F	10	0.15	0.15	0.01	0.15	0.15	0.01
G	10	0.10	0.00	0.10	0.10	0.05	0.06
H	10	0.25	0.00	0.25	0.25	0.01	0.24
I	10	0.31	0.00	0.31	0.02	0.01	0.01
J	10	0.91	0	0.91	0.12	0.00	0.12

Parcel No.	WRIA	Delineated Irrigated Acreage Initial Comparison Analysis			Delineated Irrigated Acreage following Methodology Reconciliation		
		GEI	HDR	Difference	GEI	HDR	Difference
K	9	0.23	0.21	0.02	0.23	0.21	0.01
L	9	0.42	0.44	-0.02	0.42	0.54	-0.13
M	9	0.46	0.37	0.09	0.46	0.38	0.09
N	9	0.00	0.00	0.00	0.00	0.00	0.00
O	9	0.65	0.00	0.65	0.48	0.00	0.48
P	9	2.28	1.92	0.36	2.28	1.95	0.34
Q	9	0.18	0.09	0.09	0.18	0.09	0.09
R	9	0.34	0.22	0.12	0.25	0.23	0.02
S	9	0.00	0.00	0.00	0.00	0.00	0.00
T	9	0.11	0.05	0.05	0.11	0.06	0.05
WRIA 10 Average		**0.33**	**0.07**	**0.27**	**0.13**	**0.09**	**0.05**
WRIA 9 Average		**0.47**	**0.33**	**0.14**	**0.44**	**0.38**	**0.06**

5.0 Discussion

What became evident during this exercise is that while it can be relatively straight-forward to delineate the irrigated footprints for parcels on the extreme – either brown lawns or lush, golf-course green lawns- it can be much harder to make delineations for the rest of the parcels. Studies from municipal water suppliers around North America have shown that many homeowners apply outdoor water sparingly, with just enough to prevent landscaping from dying or at least far short of what is needed for maximum growth (DeOreo, et al., 2016. Residential End Uses of Water, Version 2)..

Another important conclusion that can be made from this work is that in many cases using remote sensing to delineate outdoor water areas will not resolve all questions about what outdoor areas were irrigated. This is because that answer depends on how much outdoor watering needs to have occurred in order to be counted. For example, if a lawn has been watered just once during a dry season or just 5 times, and it is not dormant but far from green, is that sufficient to call that area an outdoor watered area? And, if so, is it reasonable to expect a technician to be able to delineate that area using aerial images? In reality, there are a continuum of possibilities between slightly watered areas and those have been watered at rates similar to those presented in the Washington Irrigation Guide (WAIG). Because of this range in watering, there are also ranges of “correct” answers to the question of which outdoor watering areas should be counted.

One important implication of variable watering rates is that the outdoor irrigation method described in Appendix A of the *Final Guidance for Determining Net Ecological Benefit* and the method used by both GEI and HDR for calculating consumptive use is conservative. This is because it assigns outdoor watering rates equivalent to those for crops described in the WAIG, such as for the production of commercial pasture/turf grass. Many of the lawns that are delineated as “irrigated” may not apply water at these rates, resulting in conservatively high consumptive use estimates. At the subbasin and WRIA scale, we are confident that our estimate of the water used for outdoor watering is larger than what is actually being used by permit-exempt domestic well owners. This assumption was corroborated with a comparison of irrigated areas in specific parcels that had metered water use data (HDR 2019).

Based on the above considerations and the results of this comparison exercise, there is inherent subjectivity and variability associated with estimating irrigated areas from manual aerial photo interpretation. Although these results indicate that additional training (or cross-training) may have reduced this variability between analysts, differences are still to be expected. Furthermore, the original differences in mean irrigated areas are generally within the 95 percent confidence interval for the primary data sets. Therefore, these comparability results do not indicate a need for a systematic reevaluation of the primary data sets. The GEI and HDR teams have confidence in their completed work and in each other's work for their respective WRIAs. It is GEI's and HDR's opinion that Ecology and the WRE committees may accept the irrigated area results completed by the GEI and HDR teams without qualification. The WRE committees may consider investigating the sensitivity of consumptive use based on mean irrigated areas for each WRIA and/or at upper or lower 95 percent confidence limits.

Attachment A

GEI Irrigated Footprint Analysis Methods

Irrigated Footprint Analysis Methods

The GEI team conducted an aerial photo-based analysis of irrigated lawn and garden area for 393 parcels in the 16 WRIA 7 subbasins, 153 parcels in seven of the WRIA 8 subbasins, and 211 parcels in eight of the WRIA 9 subbasins. Parcels used for the irrigated footprint analysis were selected based on recent (2006−2017) building permits for new single-family residential homes not served by public water. Permits for accessory dwelling units (ADUs) or reconstruction/remodel were excluded. All new home building permit sites in WRIA 9 were included in the analysis, however, a subset of building permits were selected for WRIAs 7 and 8. The target sample size for WRIAs 7 and 8 was set to provide a 95 percent confidence level (i.e., 95 percent certainty of the sample capturing the true mean of the population). Sample parcels were selected by assigning a random number to each building permit, and then evaluating sites in rank order up to the target sample size. Using a random selection from the permit list avoids the bias that could be introduced if selecting from the imagery.

Each parcel was evaluated visually in Google Earth for irrigated lawn areas. Google Earth's historical imagery collection allowed for clearer identification of irrigated areas than available orthophotos because it was possible to compare aerial photos spanning multiple seasons and years. Late summer imagery was particularly helpful in determining boundaries of irrigated (green) vs. non-irrigated (brown) grass areas. Often, the parcels did not demonstrate such a clear-cut distinction between green and brown spaces. It appears that many homeowners irrigate enough to keep lawns alive but not lush (or comparable to commercial turf grass/golf course green). Delineating these irrigated spaces is subjective and the GEI team minimized potential for additional bias to the results by having one GIS analyst evaluate all of the permit parcels in the WRIA. The irrigated area was delineated for each parcel based on several key assumptions:

- Landscaped shrub/flower bed areas were included in the irrigated footprint (not just lawn areas).
- Homes that did not show visible signs of irrigation were tracked as zero irrigated footprint, and this was included in the calculated results.
- Homes or landscaping still under construction in the most recent Google Earth imagery were excluded.
- Native forest or unmaintained grass/pasture were not included in the irrigated footprint.
- Pre-existing agricultural land use was not considered part of the residential irrigation footprint.

The following examples illustrate selected delineations.

Figure 1 shows examples of irrigated area delineation for two representative parcels in the Patterson (left) and Upper Skykomish (right) subbasins in WRIA 7. On each photo, the parcel boundary is shown in yellow and the area identified as irrigated in white. Large homes and extensive irrigated lawn and garden areas were much more common in the Patterson, Pilchuck, and Raging subbasins compared to the rest of the WRIA.


Figure 1. Example Irrigated Area Delineations, Patterson subbasin (left) and Upper Skykomish subbasin (right), WRIA 7

Figure 2 shows examples of irrigated area delineation for two parcels in the Bear/Evans subbasin in WRIA 8. On each photo, the parcel boundary is shown in light blue and the area identified as irrigated in white. For the example on the left, photos at different times of year showed a clear break between irrigated and non-irrigated grass.


Figure 2. Example Irrigated Area Delineations, Bear/Evans subbasin, WRIA 8

Figure 3 shows examples of irrigated area delineation for two parcels in the Covington Creek subbasin in WRIA 9. On each photo, the parcel boundary is shown in orange and the area identified as irrigated in white. For the example on the left, photos at different times of year showed a clear break between irrigated and non-irrigated grass.

Figure 3. Example Irrigated Area Delineations, Covington Creek Subbasin, WRIA 9

Attachment B

HDR Irrigated Area Analysis Methods

Irrigated Area Analysis Methods

1. The GIS technician selected four sample parcels from the WRIA 13 parcel selection pool to draft preliminary delineations. Parcels that displayed a range of potential irrigation situations (e.g., unirrigated lawns, lawns requiring tree/shadow interpolations, minimally irrigated area) were selected for the preliminary analysis.
2. Polygons were created in Google Earth representing the irrigated area within a given tax parcel. The GIS technician made several judgments and assumptions:
   a. Landscaped shrub/flower bed areas within a larger irrigated footprint were included. Shrub and flower bed areas outside of the irrigated footprint were excluded.
   b. If the irrigated area extends beyond the parcel boundary, those areas were included.
   c. Parcels with no visible signs of irrigation were tracked as zero irrigated footprint.
   d. Areas that appeared to be native forest or unmaintained grass were not included in the irrigated footprint.
   e. Parcels with homes under construction in the most recent Google Earth imagery were excluded from the analysis.
   f. New construction due to additional dwelling units (ADUs) were not counted.

   The following examples illustrate example delineations.

Figure 1. No irrigated areas visible in most recent google earth aerial imagery.

Figure 2. Area in white includes maintained grass. Residence constructed between June 2017 and July 2018. Therefore, historical irrigation of property is unavailable in GoogleEarth imagery.

Figure 3. Irrigated area includes landscaped area in driveway, maintained yard around residence, garden area, and maintained grass near garden area.

Figure 4. No irrigated area. Assumption that green vegeation on southern portion of parcel is due to proximity to Spurgeon Creek since clear delineation of irrigated area is not present on aerial. Green area near residence appears to be tree and shrubs, not maintained landscaping and is excluded.

Attachment C

Results Table

Parcel	WRIA	GEI Notes	HDR Notes	Geo Acres	*HDR Acres*	Diff	Geo Adj Acres	*HDR Adj Acres*	Adj Diff	Geo Adjusted Notes	HDR Adjusted Notes
A	10	8/2006 ; 8/2011 - difficult to distinguish if western portion of home are is irrigated	Front yard delineated based on 9/2009 and 8/2011 imagery.	**0.50**	*0.09*	0.41	**0.09**	*0.09*	0.00	tightened lawn area, omitted truck/boat parking	No change
B	10	No apparent irrigation, landscaping not established yet	zero irrigated footprint	**0.00**	*0.00*	0.00	**0.00**	*0.00*	0.00	no change	No change
C	10	No apparent irrigation ; 7/2014 ; 7/2012	zero irrigated footprint (9/2009 and 8/2011)	**0.00**	*0.00*	0.00	**0.00**	*0.00*	0.00	no change	No change
D	10	6/2016 - extensive landscaping and garden area, difficult to discern extent of irrigated lawn ; 7/2014 ; 7/2012	area delineated	**0.82**	*0.13*	0.68	**0.38**	*0.22*	0.16	tightened lawn area to within fenceline, omitted truck/boat area	Garden area SW of home included
E	10	6/27/2016 - areas outside of the riding ring near the house are landscaped and appear irrigated ; 7/2014 - lawn area - compare to western pasture inside parcel	delineated yard area (8/2006 image)	**0.29**	*0.31*	-0.02	**0.23**	*0.36*	-0.13	tightened lawn area to within fenceline, omitted area near garage/barn	reduced front yard area
F	10	7/2014 ; 7/2012 - compare to neighboring lawns	Yard area delineated. 7/2018 image	**0.15**	*0.15*	0.01	**0.15**	*0.15*	0.01	no change	No change
G	10	7/2014 - small hayfield? compare lawn/landscaping (NE of corner of house) area around house to neighbor to the WNW 7/2012 - compare to neighbor's lawn to the NW ; 9/2009 - blurry but hayfield area is bright green	zero irrigated footprint. 7/2018 and 7/2006, 9/2009 imagery	**0.10**	*0.00*	0.10	**0.10**	*0.05*	0.06	no change	Added garden bed northwest
H	10	8/2011 - compare lawn to NW portion of property, lawn areas to the NE, particularly the watered lawn to the NE, SW side of house	zero irrigated area 9/2009	**0.25**	*0.00*	0.25	**0.25**	*0.01*	0.24	no change	Added garden area between barn and shop
I	10	7/2014 - garden area and lawn tight to house 6/2016 - compare to house/lawn to the southeast	zero irrigated footprint. 8/2011 and 11/2011	**0.31**	*0.00*	0.31	**0.02**	*0.01*	0.01	only included raised garden bed	Added garden bed northeast of house
J	10	8/2011 - compare to lawn at home 750ft E 7/2012 - home to the NW across street is brown comparatively	zero irrigated footprint	**0.91**	*0*	0.91	**0.12**	*0.00*	0.12	hard to discern lawn area, kept tight to house where grass is green compared to house to west 7/2014	no change
K	9	moderate gardening area	maintained lawn areas and garden area delineated.	**0.23**	*0.21*	0.02	**0.23**	*0.21*	0.01	no change	Addition of garden area on north section of lawn
L	9		area irrigated based on 4/2015 imagery. Although not summer, clear area of irrigation defined.	**0.42**	*0.44*	-0.02	**0.42**	*0.54*	-0.13	no change	Slightly expanded irrigated in the backyard further east.
M	9	includes golf practice green	area delineated 7/13/2017 imagery. Golf bunkers not included. Vegetation on east side of partial either dormant or unmaintained and well as vegetation between irrigated lawn and golf area.	**0.46**	*0.37*	0.09	**0.46**	*0.38*	0.09	no change	Slightly expanded area near golf bunkers. No other change.

Parcel	WRIA	GEI Notes	HDR Notes	Geo Acres	*HDR Acres*	Diff	Geo Adj Acres	*HDR Adj Acres*	Adj Diff	Geo Adjusted Notes	HDR Adjusted Notes
N	9	No apparent irrigation	zero irrigated footprint. Lawn dormant in 7/30/2006, 8/17/2006, 9/10/2009 photo. Green patches of lawn in 7/13/2017 not clearly defined and could be drain field	**0.00**	*0.00*	0.00	**0.00**		0.00	no change	No change
O	9		zero irrigated footprint. Only early July summer imagery available. In HDR analysis, would've selected new parcel.	**0.65**	*0.00*	0.65	**0.48**	*0.00*	0.48	removed western portion of property beyond fenceline	No change
P	9	large 2ac+ landscaped home	area delineated 8/2011 imagery. Eastern portion of parcel excluded, not maintained and vegetation dormant. Landscaping outside of footprint not included	**2.28**	*1.92*	0.36	**2.28**	*1.95*	0.34	no change	Slightly expanded area in backyard to include irrigated area near patio.
Q	9	front half of yard apparently hardscaped	area delineated based on 8/2011 and 5/2018 imagery. Front yard is completely landscaped and not included in irrigated footprint.	**0.18**	*0.09*	0.09	**0.18**	*0.09*	0.09	no change	No change
R	9		Area delineated. However, early 7/2014 was only summer imagery available. Backyard partially obscured by tree canopy. In HDR analysis, would've selected new parcel to delineate due to lack of summer imagery.	**0.34**	*0.22*	0.12	**0.25**	*0.23*	0.02	tightened up area along tree line	Expanded eastern boundary of delineation
S	9	No apparent irrigation	zero irrigated footprint. No maintained vegetation. Drainage ditch appears to traverse southern portion of parcel. Vegetation color matches vegetation on undeveloped parcel adjacent to the east.	**0.00**	*0.00*	0.00	**0.00**	*0.00*	0.00	no change	No Change
T	9		area delineated based on 9/10/2009 imagery showing area of green near front of home and 7/10/2012 imagery of maintained green lawn near home. Area of green south of home looks to be unmaintained.	**0.11**	*0.05*	0.05	**0.11**	*0.06*	0.05	no change	Slightly expanded area in front yard.
			WRIA 10 Total	**3.34**	***0.68***	**2.66**	**1.35**	***0.88***	**0.47**		
			WRIA 9 Total	**4.66**	*3.30*	**1.36**	**4.41**	*3.46*	**0.95**		
			WRIA 10 Average	**0.33**	*0.07*	**0.27**	**0.13**	*0.09*	**0.05**		
			WRIA 9 Average	**0.47**	*0.33*	**0.14**	**0.44**	*0.38*	**0.06**		
				GEI	*HDR*						
			WRIA 10 Change	**-0.20**	*0.02*						
			WRIA 9 Change	**-0.03**	*0.05*						

Attachment D

Consumptive Use Corroboration Analysis

Thurston, Mason, and Kitsap PUDs provided water consumption data for several systems with a small number of connections. These systems were analyzed using both consumptive use estimation methods. All parcels in each system were analyzed for irrigated area, providing a direct comparison between the water estimated using the Irrigated Area method and the actual measured consumption by the water system. Table D-1 contains the results of the corroboration analysis.

Table D-1: Annual and Seasonal Consumptive Use Corroboration Analysis

WRIA – Water System	Annual Consumptive Use (gpd per household)			Seasonal Consumptive Use (gpd per household)					
				Summer			Winter		
	Water System Data	Irrigated Area Method	Percent Difference[1]	Water System Data	Irrigated Area Method	Percent Difference1	Water System Data	Irrigated Area Method	Percent Difference[1]
WRIA 12 – Whiskey Hollow	53.6	181.1	238	85.8	346.3	304	11.2	15.0	34
WRIA 13 – Rich Road	52.6	113.2	115	86.8	210.8	143	7.3	15.0	107
WRIA 14 – Canyonwood Beach	29.3	86.4	195	51.2	157.4	207	7.2	15.0	107
WRIA 15 – Echo Valley	76.7	75.5	-2	137.9	135.7	-2	15.2	15.0	-1

[1]Change in consumptive use from the Water System Data Method to the Irrigated Area Method.

The Irrigated Area method estimated consumptive use values at least double those estimated from the Water System Data method in WRIAs 12, 13, and 14. This is true for both indoor and outdoor use. The exception is winter consumptive use in the Whiskey Hollow system, which suggests customers purchasing water from Whiskey Hollow use indoor water at a rate similar to that assumed in the Irrigated Area method (i.e., 60 gpd per person). The Echo Valley system in WRIA 15 has a slight decrease in estimated consumptive use in the Irrigated Area method compared to the Water System Data method. Customers in this system may heavily irrigate their lawns, or the estimate of total irrigated area in the system may be biased low. No small water system data were provided in WRIA 10.

Appendix I – Projects

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.

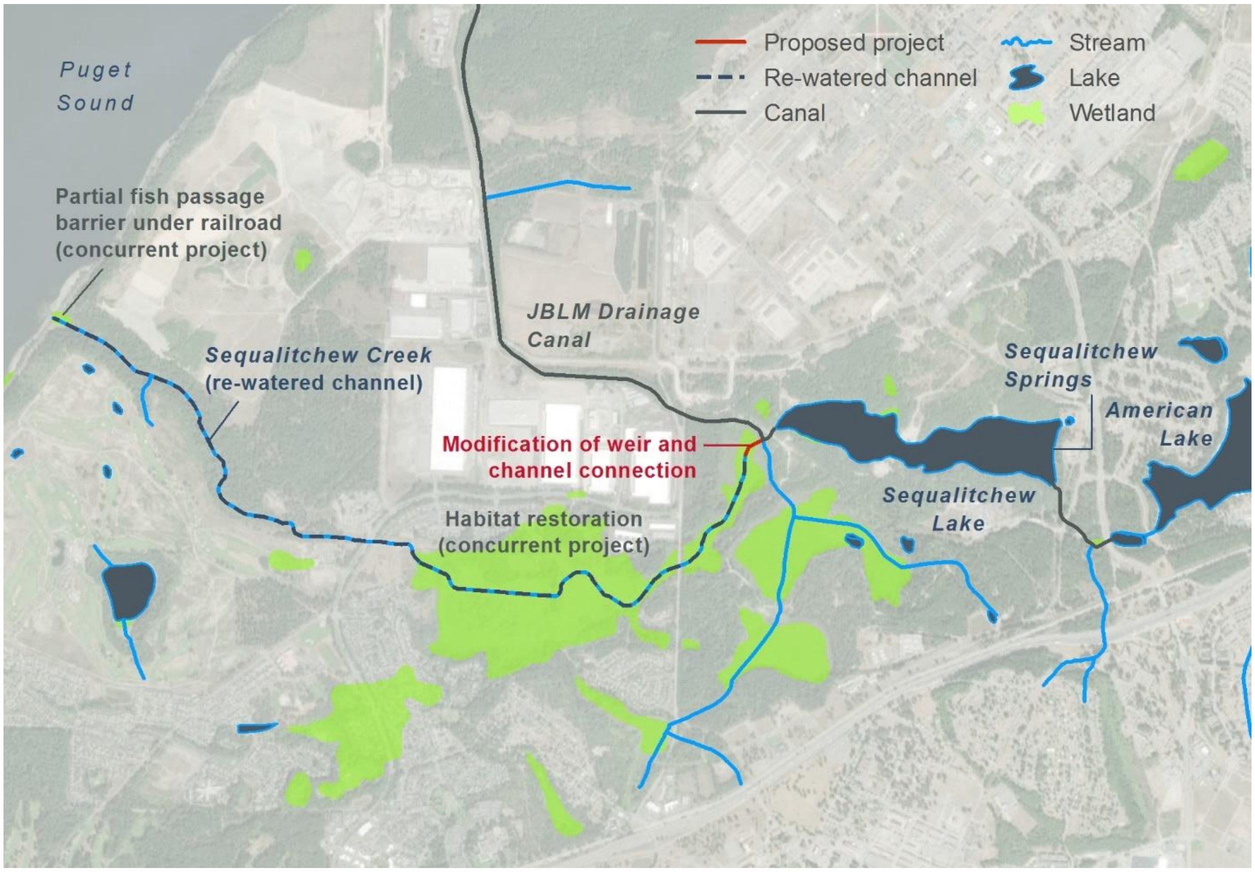


Figure 1. Sequalitchew Lake outlet modification and re-watered Sequalitchew Creek channel.

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.

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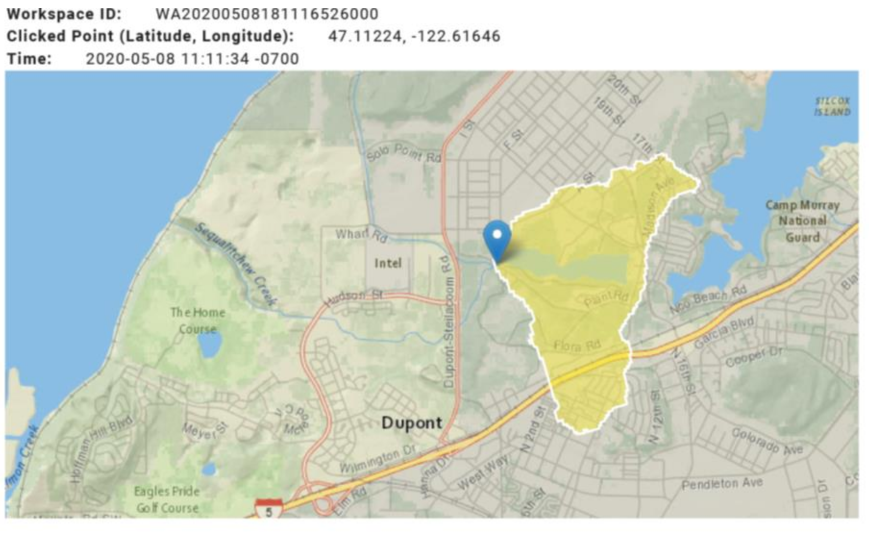
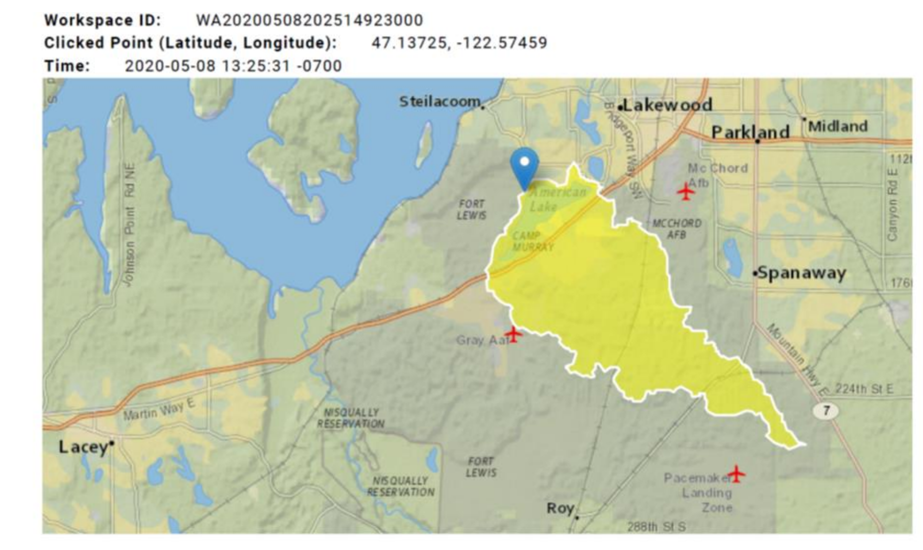
Appendix A- Flow Estimation



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

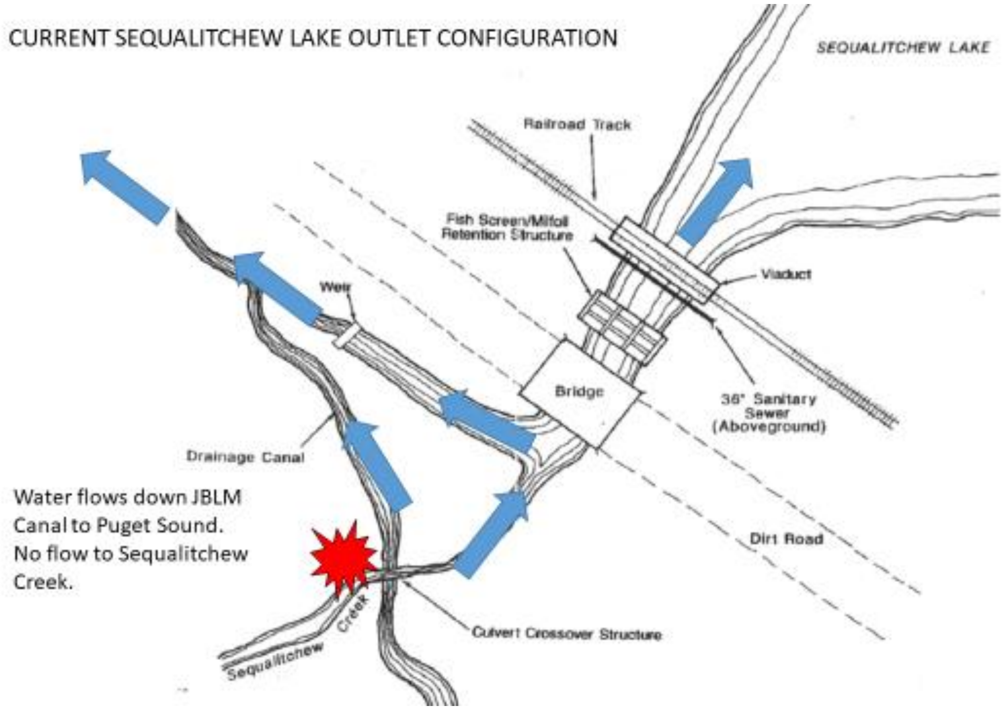
Table A-2. Average flows from Chambers Creek, below Leach Creek (USGS Station 12091500) and calculated average flows in Sequalitchew Creek based on assumed proportional watershed areas and average flows.

	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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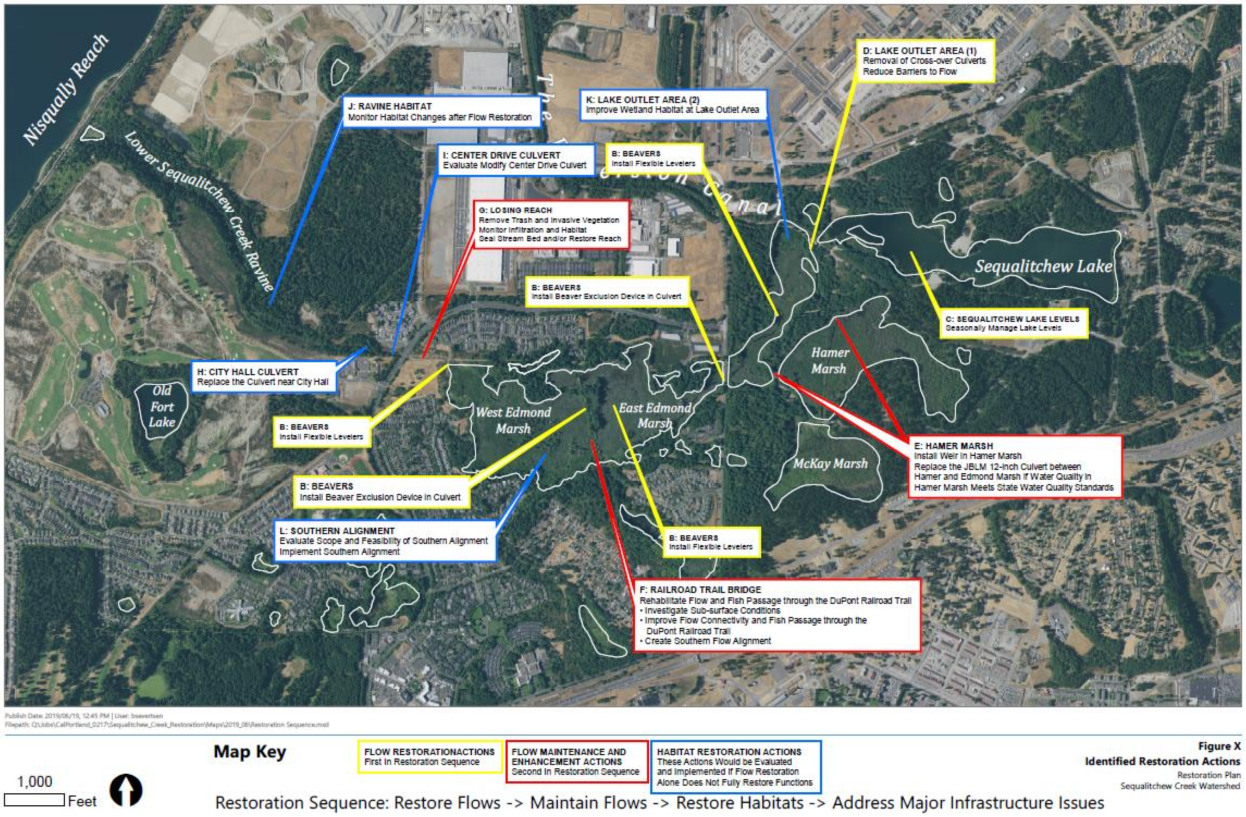

Nisqually Reach
Lower Sequalitchew Creek Ravine
J: RAVINE HABITAT
Monitor Habitat Changes after Flow Restoration
K: LAKE OUTLET AREA (2)
Improve Wetland Habitat at Lake Outlet Area
D: LAKE OUTLET AREA (1)
Removal of Cross-over Culverts
Reduce Barriers to Flow
I: CENTER DRIVE CULVERT
Evaluate Modify Center 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
Sequalitchew Lake
C: SEQUALITCHEW LAKE LEVELS
Seasonally Manage Lake Levels
Hamer Marsh
H: CITY HALL CULVERT
Replace the Culvert near City Hall
Old Fort Lake
B: BEAVERS
Install Flexible Levelers
West Edmond Marsh
East Edmond Marsh
McKay Marsh
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).

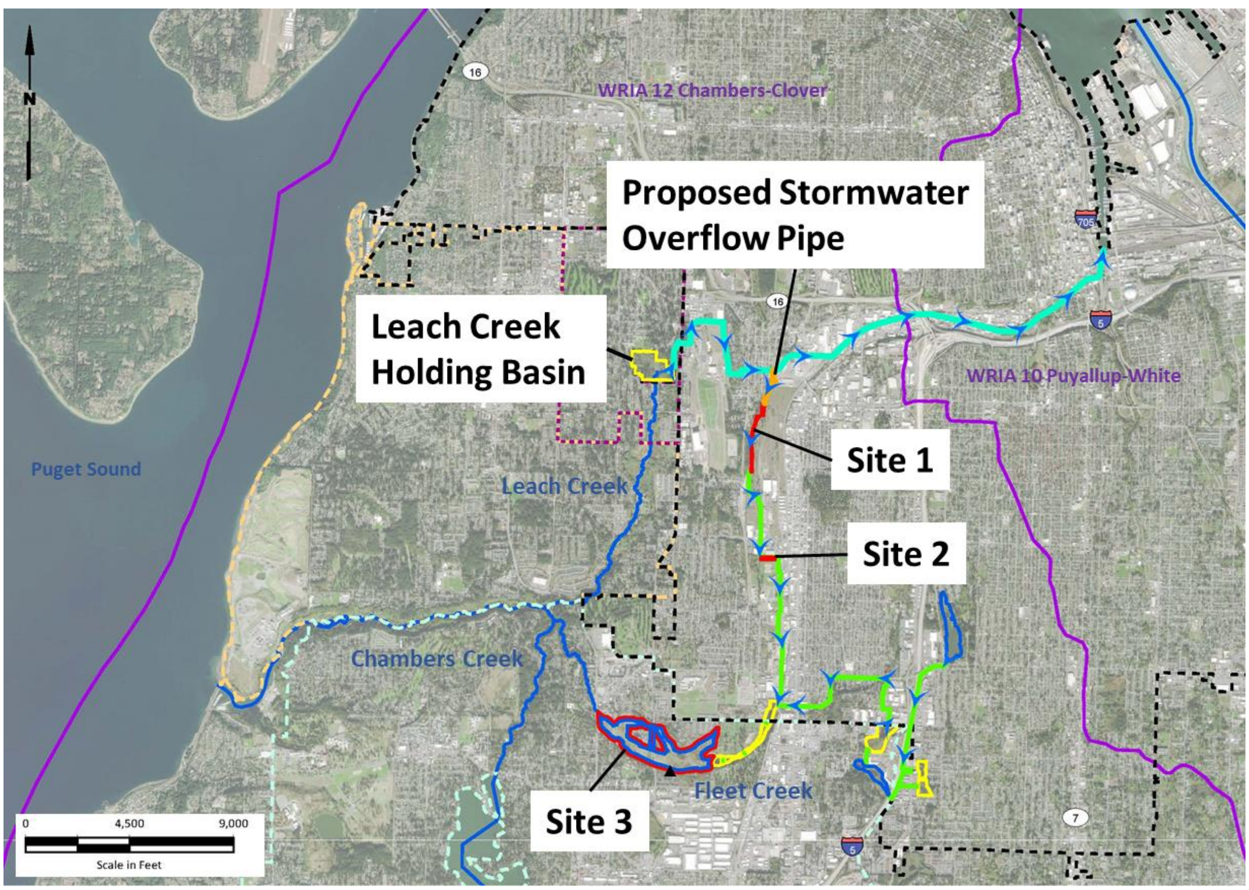


Figure 1. Locations of proposed infiltration areas (Sites 1 and 2), channel restoration (Site 3), and stormwater overflow pipe within the Flett Creek drainage basin, Tacoma, WA (Appendices A-C). Existing holding basins are identified by yellow outline. Proposed infiltration and channel restoration sites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

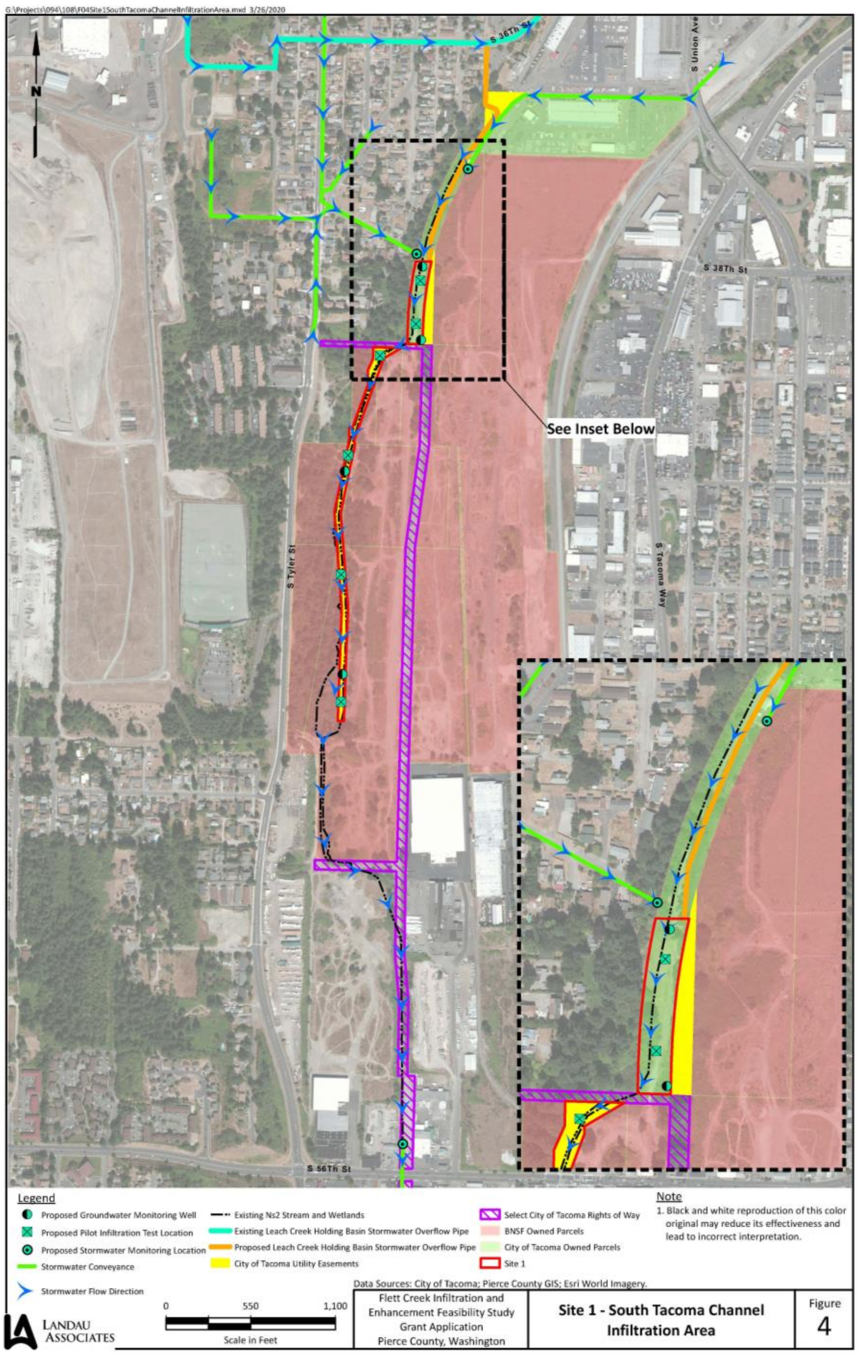
Landau Associates. 2020. Streamflow Enhancement Estimation, South Tacoma Channel Stormwater Infiltration Project Feasibility Study, Tacoma, Washington, Project No. 0094108.010.01. Technical Memorandum Prepared for the City of Tacoma on March 26, 2020.

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.

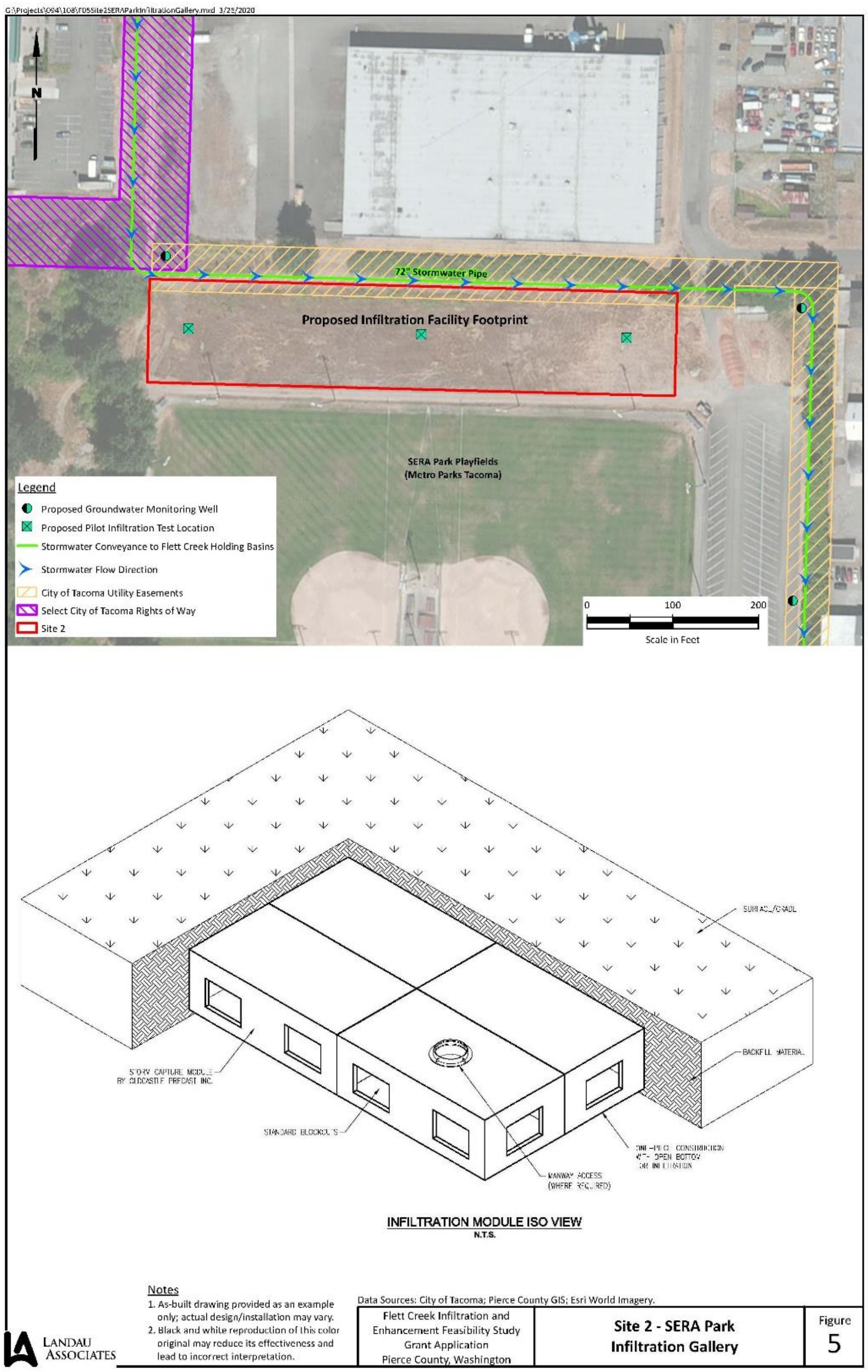
Appendix A

Site 1 – South Tacoma Channel Infiltration



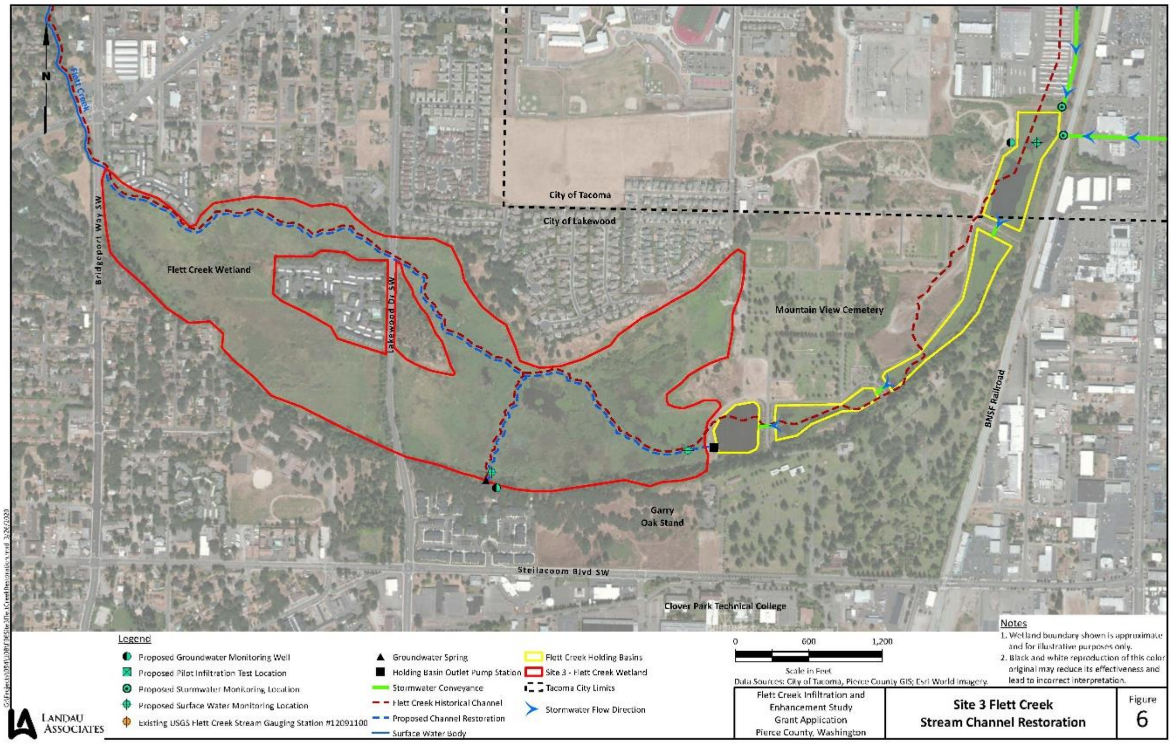
Appendix B

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.

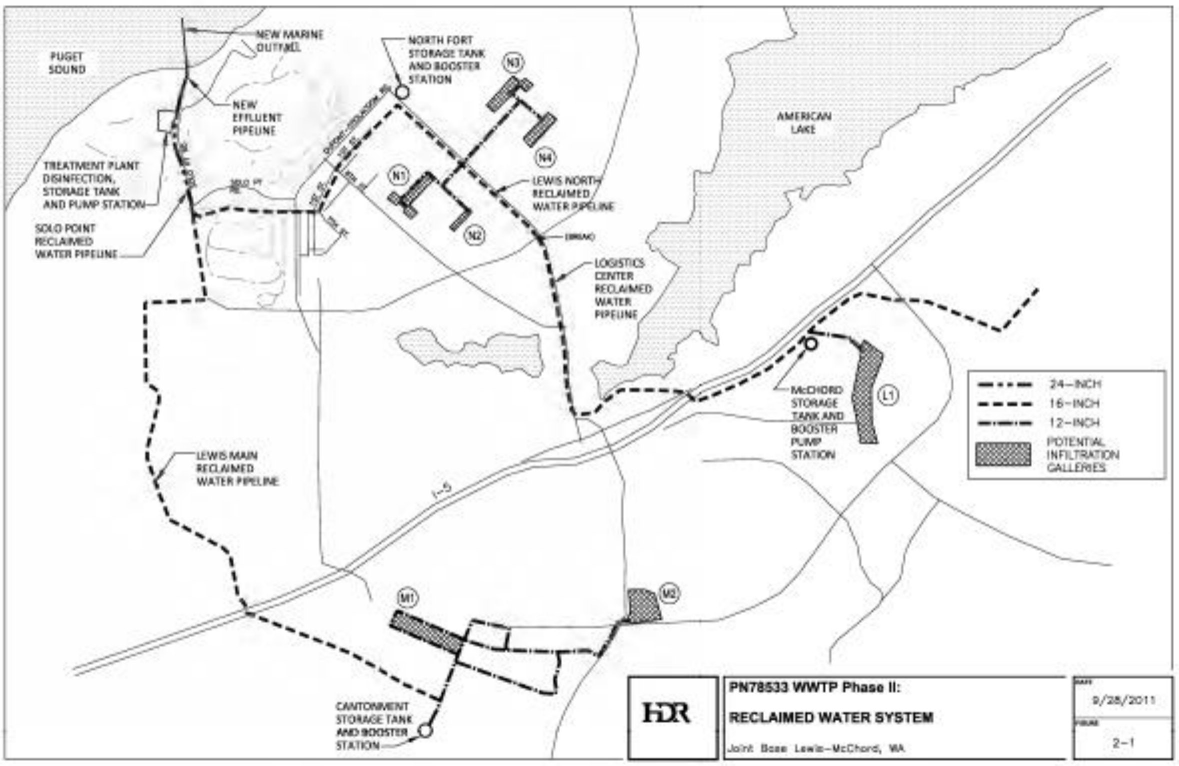


Figure 1. Location of pipeline to JBLM Solo WWTP and to infiltration area (from HDR 2012)

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.

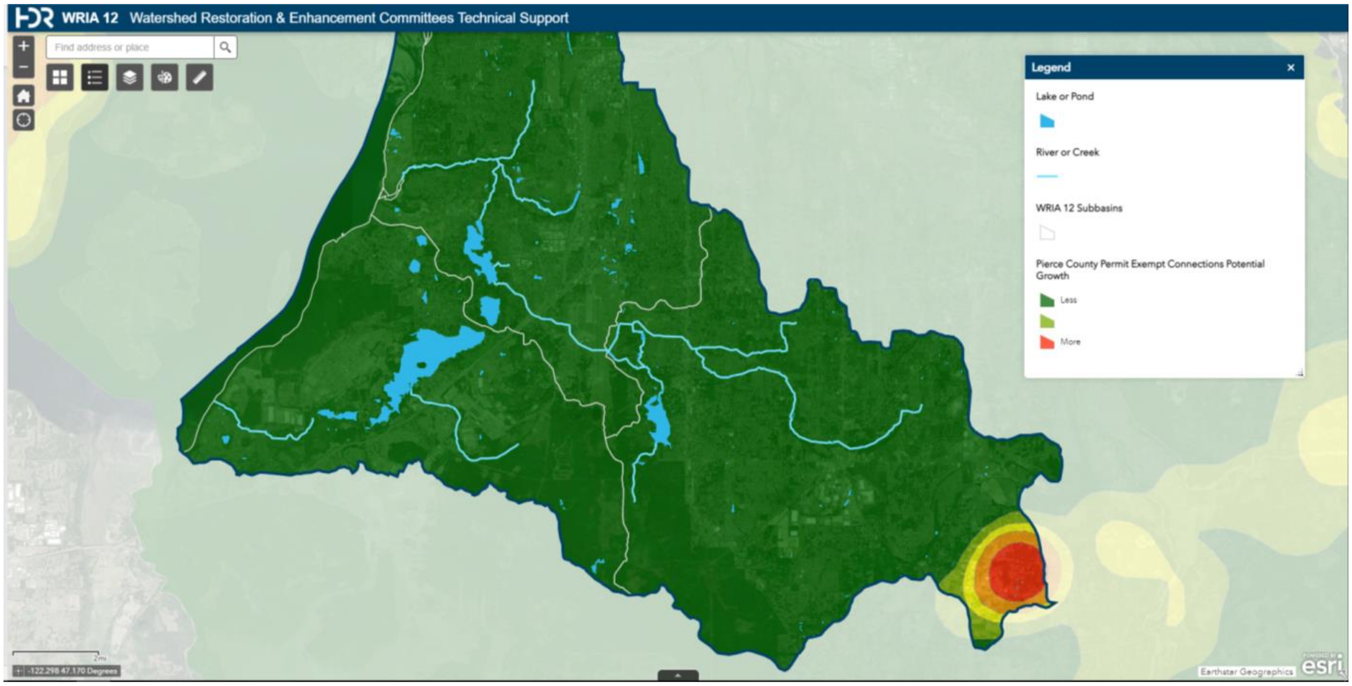


Figure 1. WRIA 12 permit exempt well potential growth and priority streams

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.

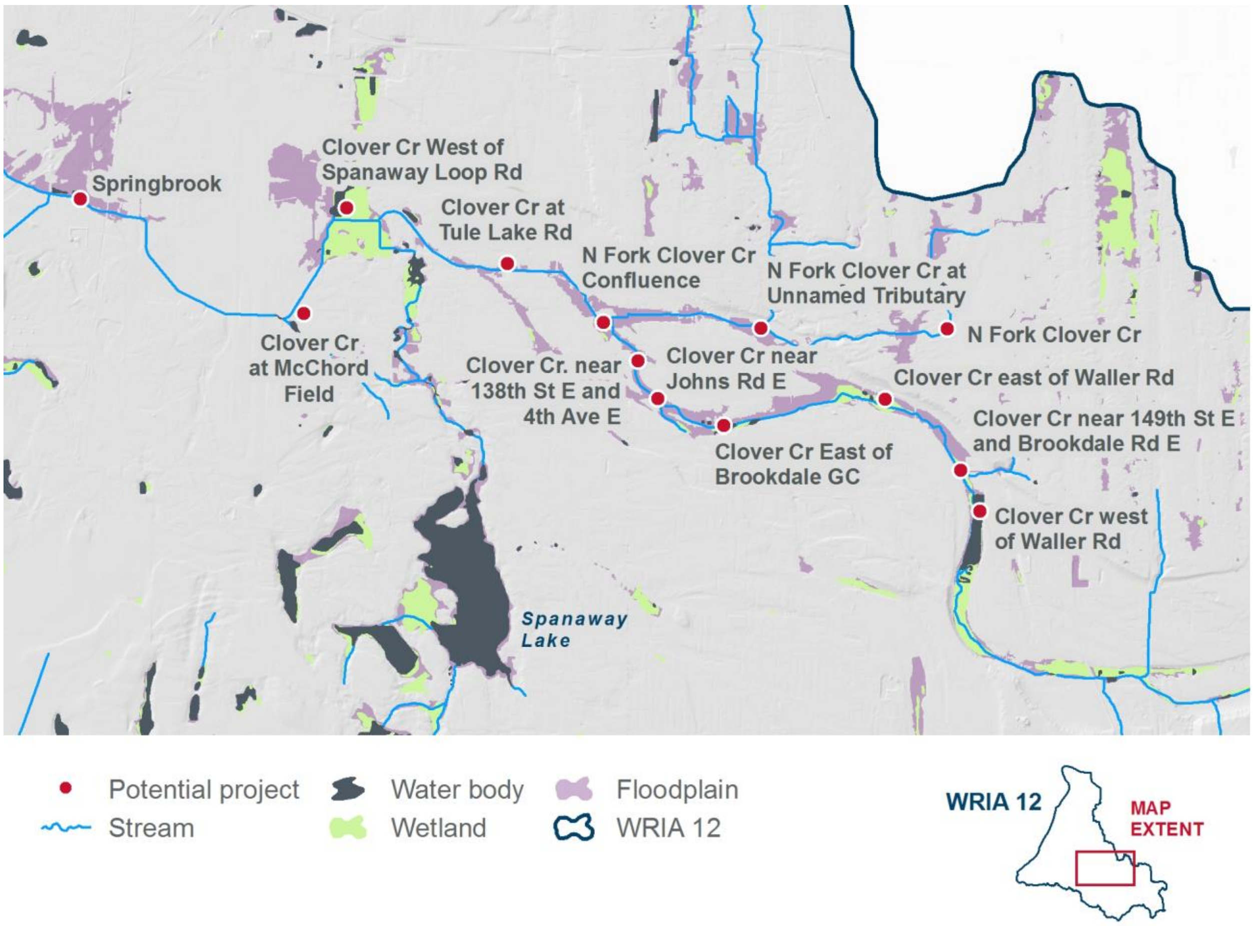


Figure 1. Potential Clover Creek floodplain restoration project locations.

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

Clothier, Burt G., et al. 2003. Chambers-Clover Management Plan Technical Assessment. Prepared for the Tacoma-Pierce County Health Department.

Puyallup and Chambers Watersheds Salmon Recovery Lead Entity (Lead Entity). 2018. Salmon Habitat Protection and Restoration Strategy for Puyallup and Chambers Watersheds. June. https://www.piercecountywa.org/ArchiveCenter/ViewFile/Item/6075

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

Tetra Tech/KCM, Inc. 2002. Pierce County Clover Creek Basin Plan; Draft. Seattle: Pierce County.

Tobiason, Fred L. April 2003. Historic Flows, Flow Problems and Fish Presence in Clover Creek: 1924-1942; Interviews with Early Residents. Tacoma.

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

Appendix J – Water Rights Report

Technical Memorandum

To: Department of Ecology WRIA 12 Watershed Restoration and Enhancement Committee

From: Burt Clothier, LHG

Joe Morrice, LHG

Re: Water Right Screening Methodology

Date: December 1, 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 Chambers - Clover Creek Water Resources Inventory Area (WRIA) 12. This work was completed by Pacific Groundwater Group (PGG) on behalf of the WRIA 12 Watershed Restoration and Enhancement (WRE) Committee (the 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 and offset 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 12, PGG assisted the Committee in selecting a focused set of water rights for further review to assess potential benefits and 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 12. 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 excluded.

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

The Committee's desire was to identify classes or groups of water rights that could potentially be converted, purchased, or retired as mitigation water. The hope being that rights in key sub-basins could be found that, if applicable and available, could be use to off-set the projected impacts of future permit exempt wells and/or provide an environmental benefit to local surface water bodies. Such mitigation projects require the combination of available water (legally and physically), willing seller and buyers, and methods to apply the water to the proposed mitigation purpose. This ranges from simply retiring the right back to the State where no further action is assumed and the water simply ceases to be used for its prior purpose up to more complex efforts where a right is changed to a new use or a new location (or both) and directly applied to the mitigation project (e.g. streamflow augmentation or groundwater recharge).

The tables of active water rights included over 2,700 water right files within WRIA 12. Following consultation with the Committee, PGG limited the water rights under consideration to certificates and permits[1] that included commercial and Industrial (CI), stockwater (S), or irrigation (IR) uses. Municipal and domestic (or multiple domestic) categories were excluded based on the expectation that these rights would not be available for conversion into sources of mitigation water. Irrigation rights were also classified based on the reported irrigated acreage.

The list of active water right permits and certificates was further reduced by removing any with a priority date later than the December 12, 1979 adoption date of Chapter 173-512 WAC, the instream flow rule for WRIA 12.

The list of active permits and certificates with CI, IR, and/or ST uses was reduced again based on authorized instantaneous (Qi) and annual (Qa) quantities. Water rights with both a Qi of less than 0.1 cfs (45 gpm) and a Qa of less than 10 acre-feet per year were excluded from further consideration. This was an arbitrary cut-off intended to focus the search toward high-value possibilities over smaller ones and provide for more manageably sized lists.

At the direction of the Committee, water rights within the Clover Creek subbasin were prioritized for evaluation. Fifty-seven water rights meeting the above criteria were identified in the Clover Creek subbasin. The Committee reviewed this initial list and provided feedback and commentary. The final list was reduced to 25 water rights for consideration of their potential as sources of mitigation.

The Committee has identified several options to provide the desired offset targets for the watershed. As these projects do not include or require water right related projects, the Committee decided to retain the water right list as a supplemental source of information.

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

Appendix K – Policy and Regulatory Actions Considered by the Committee

The WRIA 12 Committee considered a number of policy and regulatory actions to include in the plan. Committee members submitted these ideas. Through an iterative process, the Committee narrowed down the list to a selection of recommendations that had support from the full Committee. The plan incorporates those recommendations with Committee support into Chapter 5 (Projects) as programmatic actions, or in Chapter 6 (Implementation) as Policy Recommendations or Adaptive Management.

Many recommendations were not included in the final plan for reasons that generally fall into the following categories:

- Expense, either to jurisdictions or to individual homeowners.
- Beyond plan scope.
- Limited benefit to WRIA 12.
- Concerns for private property rights.
- Feasibility of implementation.
- Already addressed by existing laws, policies, or agency work.

Notes from WRIA 12 committee and workgroup meetings on specific polices are available on the WRIA 12 webpage.

The policy and regulatory actions that the WRIA 12 Committee submitted and considered is listed below:

Policy and Regulatory Ideas
• Update Ecology's well log database
• Secure ongoing funding for adaptive management and implementation from the legislature.
• Track projects and offsets through a centralized database
• Track wells that are decommissioned through land acquisition projects
• Education programs on native plant landscaping that is drought-resilient and has low water needs
• Ecology rule-making to implement key elements of the plan.
• Identify and describe in the Plan mechanisms that document commitment to implement the plan, such as: past practices; established policies and procedures; and linkage of the plan to existing County codes and plans, such as the comprehensive plan.
• Develop and implement voluntary water conservation programs
• Water system rate structure changes for conservation (separate recommendation?). Permit exempt well fee with built-in incentives.
• Establish a program for habitat and NEB monitoring
• Project implementation and effectiveness monitoring
• Develop a mechanism to assess whether the assumptions used in the plan (e.g. growth, outdoor watering, etc.) are validated over time or will need to be revisited as part of adaptive management.
• Incentivize drilling of deeper wells to protect shallow aquifers
• Fund Ecology to lead implementation of the plan and fund committee members to participate

Policy and Regulatory Ideas
• A five-year report that includes information from the previous 5 years: (1) gaged streamflows; (2) status of Plan implementation, including, project and actions; (3) mitigation; (4) meter information on water use; (5) accounting on successful completion of offset use and restoration projects and number of new PE wells and connections.
• Improve ground water information – data, maps, and models • Quantify impervious surface and critical recharge zones • Ongoing improvement of regional groundwater models • Map flow paths and rates for stream baseflow • Expand ground water monitoring
• Conduct a study of how planning and permitting in the four south sound counties supports protection and enhancement of streamflow restoration, through protection and enhancement of groundwater recharge and other mechanisms. The study would evaluate how and why county programs have been effective; gaps or areas where planning has been less effective in promoting streamflow restoration; and propose ways to improve rules to promote recharge enhancement and streamflow restoration.
• Programs to encourage and support rain gardens and other residential infiltration facilities
• Develop an annual summary report of the PE wells installed in the previous year, and the offset projects completed in the previous year.
• Permit exempt well fee (building permit fee) collected by Ecology is invested in projects in WRIA 12.
• Rulemaking to change drought restrictions to allow outdoor watering for gardens during droughts
• Identify and obtain funding for monitoring and research
• Incentives for building and subdivision plans that conserve water and optimize recharge
• Increase PE well fees
• Conduct a voluntary metering program
• Change the gallon per day withdrawal limit
• Develop the following information: o Past permit exempt domestic water wells and water use o All projected water use for the next 20 years ▪ Permit exempt wells ▪ Inchoate municipal water rights brought into active use • Mitigated versus unmitigated o New water rights o A screening level analysis will be included in the plan, and a detailed analysis in the first year.
• Water use assessment or monitoring
• Tighten standards for hookup to Group A systems for all new construction in system boundaries
• Conduct a mandatory metering program
• Fund a different organization to lead implementation of the plan and fund committee members to participate
• Develop and implement a compliance and enforcement program for drought water use limitations
• Fund the cost of hooking up to municipal water
• Propose legislation to apply drought water use restrictions to all PE wells
• Create a South Sound Water Master position, which would address illegal uses, monitor instream flows, provide education and technical assistance for PE wells, respond to complaints, and participate in drought response
• Have the South Sound Water Master enforce drought restrictions

Appendix L – Proposed Improvements to Department of Ecology's Well Reporting Processes

Proposed Improvements to the Department of Ecology's Well Reporting Processes (The "Upgrade Well Reporting" Proposal)

Developed by the Squaxin Island Tribe in consultation with Ecology's Well Construction and Licensing Office

Contributors: Ecology - Joe Witczak, Scott Malone, and Tara Roberts
Squaxin Island Tribe - Erica Marbet

Final Draft May 28, 2020

Purpose:
Accurate well data is critical for all parties to make water management decisions that are protective of the environment and beneficial to communities. The quality of well data in Washington State can be improved with changes to how the State collects information from drillers. These improvements are essential for monitoring and management of shared water resources in the State of Washington.

Background:
In 2018, at the request of the Squaxin Island Tribe, Ecology assigned staff to assess the accuracy of water well location reporting in Mason County. The project checked 187 water well reports (2.1% of the 8,910 water well reports from the county). Ecology uses the Public Land Survey system (PLS) to record well locations by township, range, section, quarter and quarter-quarter. Currently wells are mapped by 40-acre quarter-quarter centroids on the State Well Report Viewer. The results showed that 79% of well locations could be verified with the information on the report. Of those that could be verified, 33% had incorrectly reported PLS locations. Ecology performed a similar, statewide assessment of well location data and found a 24% error rate for all types of regulated wells.

As Tribes utilize Ecology's well report database frequently, tribal staff would benefit by improving well location data management and processes. In discussions between Ecology, Squaxin, and Mason County, all agreed that improvements to Ecology's well reporting processes could help reduce the error in water well location reporting.

Ecology is eager to expand their web-based well reporting options. In 2019, Ecology surveyed well drillers to determine their preferences regarding format and features. Of 133 respondents, 63% placed a high importance on a new well location mapping tool that would use recent aerial imagery to determine a well's PLS location and coordinates. Only 6% responded that this effort would be of low importance. These results showed drillers preferred to submit well reports from a web form in the current well report format.

We propose the following changes to Ecology's well data processes:

1. **New well location mapping tool for drillers**
   An interactive web-based mapping tool that provides an intuitive means of determining PLS location has been implemented in Oregon recently. Ecology is interested in developing their own web tool which provides the PLS and coordinates location (latitude/longitude) for a new well automatically. The Notice of Intent web form would shell into a new GIS application utilizing recent aerial imagery, a parcel overlay, and a tool that updates the quarter-quarter and coordinates on the NOI. The well driller need only click on the interactive map to generate a well location. When a driller finishes a well report, they can utilize the same tool to refine their coordinates and PLS location.

2. **Require coordinates on well reports**
   Coordinates can perfectly describe a well location within a parcel. Adding latitude and longitude on well reports will serve to verify a well's location on the ground accurately and easily. Ecology intends to require well coordinates on reports, though a WAC change may eventually be needed.

3. **New web-based well reporting application**
   Ecology is determining the best approach for implementing a new web-based well reporting application. According to a recent survey of drillers and their support staff, a web-form mimicking the current well report forms that uploads directly to Ecology's database is desired. The benefits of using a web-based well reporting process are numerous:

   - Less backlog of scanning and data entry - more time for Ecology staff to vet well reports
   - Legible text, fewer written responses
   - Digitizing all well report data, not just the fields that were captured by Ecology staff during the scanning process
   - A smart form format can eliminate out-of-range entries

   By capturing digitized well location data, it would be feasible in the future to automate the process of verifying well locations and water right information. Tracking well location and permit-exempt wells is a need of users who download geospatial datasets from Ecology’s GIS data page (https://ecology.wa.gov/Research-Data/Data-resources/Geographic-Information-Systems-GIS/Data).

The Well Construction and Licensing Office at Ecology needs more capacity to vet well reports. Automation from web-based reporting would free up staff to do more vetting, because the office’s staff would not have to do as much scanning of paper documents and manual entry of data fields for each report. They need more automation, not FTEs.

Please share this proposal with your RCW 90.94 watershed planning committees ask members to support it. This would include adding it as a proposed action in a watershed plan.

Please contact Mary Verner, Manager of Ecology’s Water Resources Program and Tyson Oreiro, Ecology’s Tribal Liaison to express your support for the “Upgrade Well Reporting” proposal.

See next two pages for figures.

https://appswr.ecology.wa.gov/wellconstruction/Wells/NoticeOfIntentForm.aspx?form=noiwaterwellform

DEPARTMENT OF ECOLOGY
State of Washington

About us

Laws, Regs and Rules | Notice of Intent Forms | Contact Us

Well Construction and Licensing Search Tools

Step 1 of 3: Enter Information

An asterisk (*) designates the field as required.

Notice of Intent Form to Construct a Water Well

Property Owner Contact Information

‡An organization name or the first and last property owner name is required.

Organization Name‡ (e.g. Daisy Farms LLC)

OR

Last Name‡

First Name‡

Email Address*

Confirm Email Address*

Mailing Address*

City*

State*

Zip*

Phone ( )

International customers cannot submit online. Contact us for assistance.

Add interactive map to automatically identify township, range, section, latitude, and longitude

Consulting Firm Contact Information

Firm Name

Well Location

Township*

Range*

Section*

Latitude

Longitude

Make Optional

* Quarter-Quarter Section:

NW	NE	NW	NE
SW	SE	SW	SE
NW	NE	NW	NE
SW	SE	SW	SE

Well Street Address

Well City

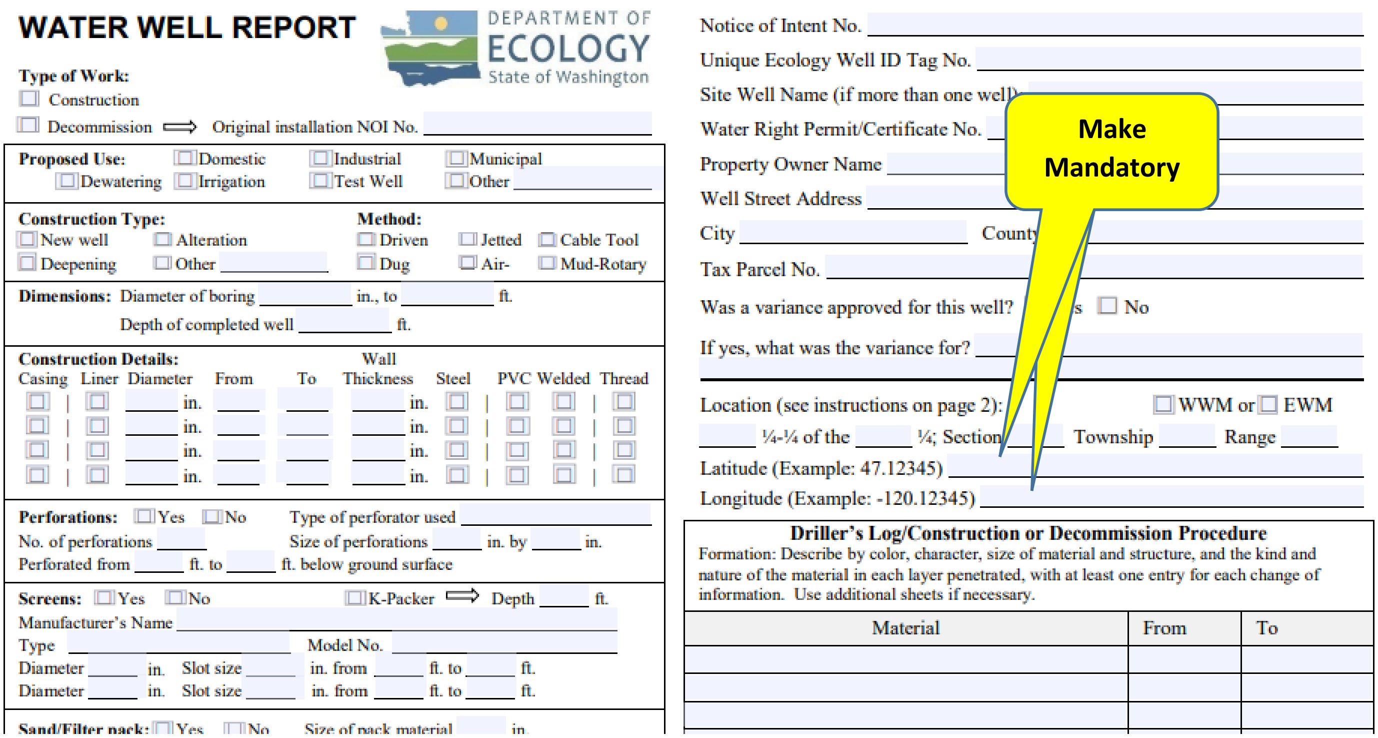
Well Zip Code

Tax Parcel Number

County*

Make Mandatory

https://fortress.wa.gov/ecy/publications/documents/ecy050120.pdf



WATER WELL REPORT

DEPARTMENT OF ECOLOGY
State of Washington

Type of Work:
☐ Construction
☐ Decommission ⇒ Original installation NOI No. ______

Proposed Use: ☐Domestic ☐Industrial ☐Municipal ☐Dewatering ☐Irrigation ☐Test Well ☐Other ______

Construction Type: ☐ New well ☐ Alteration ☐ Deepening ☐ Other ______

Method: ☐ Driven ☐ Jetted ☐ Cable Tool ☐ Dug ☐ Air- ☐ Mud-Rotary

Dimensions: Diameter of boring ______ in., to ______ ft.
Depth of completed well ______ ft.

Construction Details:

Casing	Liner	Diameter	From	To	Wall Thickness	Steel	PVC	Welded	Thread
☐	☐	___ in.	___	___	___ in.	☐	☐	☐	☐
☐	☐	___ in.	___	___	___ in.	☐	☐	☐	☐
☐	☐	___ in.	___	___	___ in.	☐	☐	☐	☐
☐	☐	___ in.	___	___	___ in.	☐	☐	☐	☐

Perforations: ☐Yes ☐No Type of perforator used ______
No. of perforations ______ Size of perforations ______ in. by ______ in.
Perforated from ______ ft. to ______ ft. below ground surface

Screens: ☐Yes ☐No ☐K-Packer ⇒ Depth ______ ft.
Manufacturer's Name ______
Type ______ Model No. ______
Diameter ______ in. Slot size ______ in. from ______ ft. to ______ ft.
Diameter ______ in. Slot size ______ in. from ______ ft. to ______ ft.

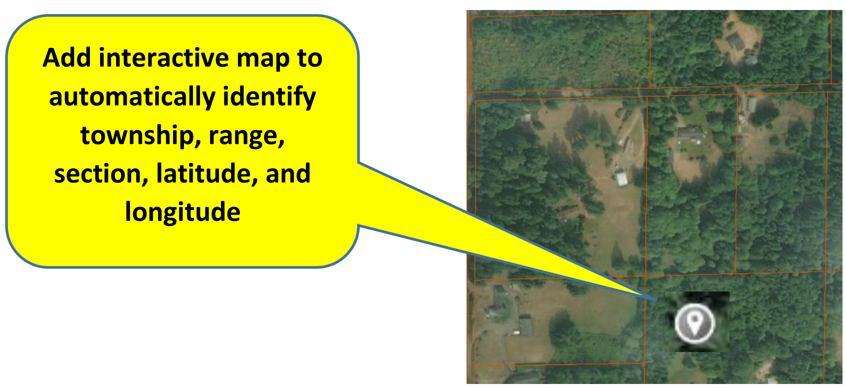
Sand/Filter pack: ☐Yes ☐No Size of pack material ______ in.

Notice of Intent No. ______
Unique Ecology Well ID Tag No. ______
Site Well Name (if more than one well) ______
Water Right Permit/Certificate No. ______
Property Owner Name ______
Well Street Address ______
City ______ County ______
Tax Parcel No. ______
Was a variance approved for this well? ☐ Yes ☐ No
If yes, what was the variance for? ______

Location (see instructions on page 2): ☐ WWM or ☐ EWM
______ ¼-¼ of the ______ ¼; Section ______ Township ______ Range ______
Latitude (Example: 47.12345) ______
Longitude (Example: -120.12345) ______

Driller's Log/Construction or Decommission Procedure
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each layer penetrated, with at least one entry for each change of information. Use additional sheets if necessary.

Material	From	To



Change this water well report into a web form.