Quality Assurance Project Plan

Field Assessments of High-Priority Managed Aquifer Recharge Sites in the Upper Yakima River Basin

Prepared for

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Each study, funded in whole or in part with Ecology funding, must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. Data for this project are available in the Ecology Environmental Information Management (EIM) database with study ID: KRDMON2023.

This Quality Assurance Project Plan is available via Ecology's publications database and upon request. The Ecology publication number for this Quality Assurance Project Plan is 23-12-001. Any use of product or firm names in this publication is for descriptive purposes only and does not imply endorsement by the author or the Department of Ecology.

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1.0 Background and Project Description

In the Yakima River Basin (Basin), current water storage capacity is insufficient to meet projected water demand. Managed Aquifer Recharge (MAR) is a cost-effective method that increases water storage by adding surface water to aquifers when excess flows are available. This work supports the goals and objectives of the Yakima Basin Integrated Plan.

A recent MAR assessment identified locations suitable for project implementation based on qualifying characteristics (EA et al., 2020). Taneum Creek, Naneum Creek, Little Creek, and Big Creek identified as high-priority locations potentially suitable for MAR because they have suitable geology and a reasonable opportunity for property access. They also have good access to flows both from KRD irrigation system and from potential seasonal flood flows and a good likelihood of in stream benefit of recharged water.

Empirical data on stream discharge and local groundwater conditions is necessary to increase confidence in further prioritizing and implementing MAR at identified sites. The objective of this study is to acquire real-time stream discharge rates at sites identified in the MAR assessment, the highest priority is Taneum Creek. These data will increase our understanding of water availability and occurrence in the Upper Yakima River Basin.

Data has been collected on the streams listed above since 2020 under Ecology agreement WRYBIP-1921-KittRD-0017. This QAPP expands that data gathering to other priority sites identified in the 2020 Assessment at Wenas, Cooke, Parke, Wilson, Robinson, Dry, Schnebly, Reecer, and Jones creeks in accordance with the 2022 amended project agreement.

This project QAPP is submitted for Ecology review and approval, in accordance with guidelines in Ecology Publication No. 17-11-013. This monitoring, combined with on-going monitoring being collected by others, will provide discharge data for source water for the 57 highest-ranking potential MAR locations identified in the 2020 Yakima Basin MAR Assessment Report (EA et al., 2020). This project moves us closer to filling these data gaps.

This study will extend and expand surface water flow data collection beyond that in the 2020 agreement (Taneum, Big, Little, and Naneum creeks) to Wenas, Cooke, Parke, Wilson, Robinson, Dry, Schnebly, Reecer, and Jones creeks (Figure 1).

It will provide information to further evaluate natural stream flow conditions at these proposed MAR sites about potential water available for MAR. To further assess MAR at high-ranked sites, additional data collection of stream discharge and local groundwater conditions is needed where current information is unavailable. Tracking real-time discharge rates at all sites and hydrogeologic conditions at Taneum Creek increases our understanding of water resources in the Upper Yakima River Basin. This project moves us closer to filling these data gaps. The study will perform field work through the 2023 field seasons.

Work at sites in the 2020 agreement, including monitoring of shallow monitoring wells at Taneum Creek, will continue. That continued work will provide water table information and aquifer properties near Taneum Creek. If necessary, temporary test pit will be constructed, and percolation test will be performed to determine the subsurface infiltration rate at the site. These data will also be made available and uploaded to the EIM. A report will be prepared and will focus on stream flow monitoring data collection and source water availability for MAR at Taneum Creek.

The project agreement amendment in 2022 added pilot testing at the Taneum Creek MAR site. Due to the complexity and inclusion of water quality data collection, a separate project QAPP for the Taneum Creek pilot test will be submitted to Ecology, in accordance with Ecology Publication No. 04-03-030. The Taneum Creek site specific tasks will be compiled in a standalone Taneum Creek MAR site assessment report.

Project goals

The major goals of this project include the following:

- Characterize flow rates on Taneum, Big, Little, Naneum, Wenas, Cooke, Parke, Wilson, Robinson, Dry, Schnebly, Reecer, and Jones creeks
- Identify water level conductions within the surficial aquifer at Taneum Creek.
- Estimate aquifer properties near Taneum Creek
- Estimate infiltration rates at the Taneum Creek MAR site.
- Provide temperature data recorded at stream gauges and observation wells for EIM
  Upload all data to EIM

Project objectives

The specific activities required to accomplish project goals include:

- Install dataloggers at Taneum, Big, Little, Naneum, Wenas, Cooke, Parke, Wilson, Robinson, Dry, Schnebly, Reecer, and Jones creeks
- Install observation wells at Taneum Creek according to Chapter 173-360 WAC: minimum standards for construction and maintenance of wells
- Install dataloggers in the observation wells
- Apposite water well tests to determine aquifer properties (Stallman, 1976)
- Conduct percolation test to determine soil infiltration rates
- Format data for upload to EIM
  Submit report summarizing data to Ecology

Tasks required

Tasks require for this project include:

- Construction of observation wells under Chapter 173-360 WAC.
- Deployment of In-Situ RuggedTROLL loggers will be used to measure water well levels, water pressure, and water temperature.
- Manual water level measurements will be conducted with an E-Tape at observation wells.
- Wadable streamflow measurements will be conducted with Marsh McBirney FLO-MATE 2000 to record open channel velocity using.
- Soil infiltration rates conducted according to EPA, 2009

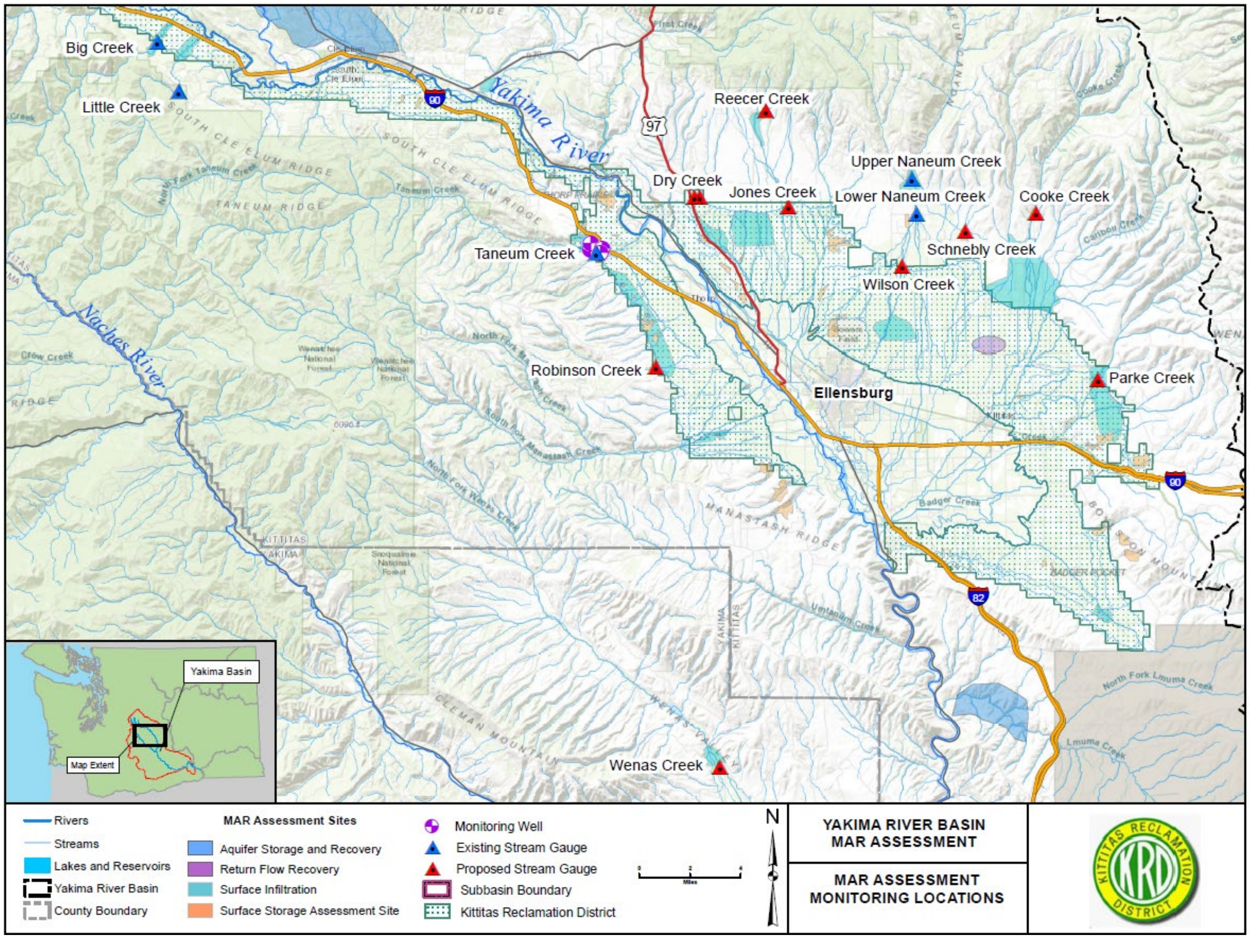


Figure 1 Location of proposed stream gauges in the Kittitas Subbasin

Study area and surroundings

This study continues work to identify and rank potential MAR sites completed under the previous agreement. Table 1 presents a summary of the top 54 ranked MAR sites and the status of source water monitoring for each location. Green sites are currently being monitored under the previous agreement, blue sites are new locations proposed for monitoring, and white sites are currently being monitored for other purposes. The addition of the blue sites to current monitoring efforts will provide physical water availability data on the top 54 out of 98 sites ranked in the initial KRD MAR Assessment Study. The discussion below describes the proposed monitoring locations at the green and blue locations listed in Table 1. For detailed discussion of prioritization and initial hydrogeologic assessment of individual sites, please refer to EA et. Al, 2020.

Table 1 Top 54 ranked MAR sites and monitoring status

RANK	Project Name	MAR Source/Stream	Gaging Site	Organization	Gage Name
1	Taneum Creek	Taneum Creek	Adjacent to MAR Site, ~2 miles upstream	Ecology/KRD	Taneum Creek, Taneum Cr. @ Brain Ranch
2	Big Creek	Big Creek	At KRD Main Canal	KRD	Big Creek
3	Tieton	Tieton River	Tieton River below Tieton Canal Diversion Dam	USBR	Tieton River below Tieton Canal Diversion Dam
4	Little Creek	Little Creek	Upstream of Power Lines	KRD	Little Creek
5	Naneum Creek	Naneum Creek	Naneum Cr. at End of Road, Naneum Cr. At Charleton Road	KRD	Naneum Creek (2 locations)
5	Rattlesnake	KRD South Branch	Easton Diversion	USBR	KRD South Branch
7	Cottonwood Creek	Cottonwood Creek	Cottonwood Creek Proposed by KRD	N/A	N/A
7	Roslyn - Cle Elum	KRD Conserved Water	Groundwater monitoring suggested by KRD	N/A	N/A
9	Smithson Road	Green Canyon Creek	Green Canyon Creek Proposed by KRD	N/A	N/A
9	Cle Elum	KRD Main Canal	Easton Diversion	USBR	KRD Easton Diversion
11	Naches River	Naches River	Naches River @ Oak Flats, Cliffdell, and Naches	Ecology/USBR	Naches River @ Oak Flats, Cliffdell, and Naches
11	Wenas	Wenas Creek	Wenas Creek Proposed by KRD	N/A	N/A
11	NB 16 South	Naneum Creek	Naneum Cr. at End of Road, Naneum Cr. at Charleton Road	KRD	Naneum Creek (2 locations)
14	Schnebly Canyon Public Land	Schnebly Creek	Schnebly Creek Proposed by KRD	N/A	N/A
14	Teanaway Gravel Pit	Teanaway River	Teanaway R @ Red Bridge Rd.	Ecology	Teanaway R @ Red Bridge Rd.
14	NB 15.2 East	Wilson Creek	Wilson Creek Proposed by KRD	N/A	N/A
14	NB 15.2-1.9 East	Wilson Creek	Wilson Creek Proposed by KRD	N/A	N/A
14	NB 15.2-1.9 West	Wilson Creek	Wilson Creek Proposed by KRD	N/A	N/A
19	South Branch Area	KRD South Branch/Robinson Creek	Robinson Creek Proposed by KRD	N/A	N/A
19	Kittitas Reclamation District	KRD North Branch	Easton Diversion	USBR	KRD North Branch
19	Roza Irrigation District	Roza Canals	Roza Diversion Dam	USBR	Roza Diversion Dam
19	Sunnyside Valley Irrigation District	SVID Canals	SVID Diversion Dam	USBR	SVID Diversion Dam
19	Wapato Irrigation Project	WIP Canals	WIP Diversion Dam	USBR	WIP Diversion Dam
19	Horseshoe	KRD South Branch	Easton Diversion	USBR	KRD South Branch
19	Morrison Canyon	KRD South Branch	Easton Diversion	USBR	KRD South Branch
26	Reecer Creek	Reecer Creek	Reecer Creek Proposed by KRD	N/A	N/A
27	Swauk Creek	Swauk Creek	Swauk Creek below First Creek	Ecology	Swauk Creek below First Creek
27	Erickson South	KRD South Branch	Easton Diversion	USBR	KRD South Branch
27	NB 16 North	Naneum Creek	Naneum Cr. at End of Road, Naneum Cr. at Charleton Road	KRD	Naneum Creek (2 locations)
30	Roza Moxee	Roza Canal	Roza Diversion Dam	USBR	Roza Diversion Dam
30	MB 16.6 East	KRD Main Canal	Easton Diversion	USBR	KRD Easton Diversion
30	MB 16.6 West	KRD Main Canal	Easton Diversion	USBR	KRD Easton Diversion
30	SB 11.7	KRD South Branch	Easton Diversion	USBR	KRD South Branch
30	Yakima	Swauk Creek	Swauk Creek below First Creek	Ecology	Swauk Creek below First Creek
35	Wipple	KRD North Branch	Easton Diversion	USBR	KRD North Branch
36	Badger Pocket	KRD South Branch	Easton Diversion	USBR	KRD South Branch
36	NB 14.7 #1	KRD North Branch	Easton Diversion	USBR	KRD North Branch
36	NB 14.7 #2	KRD South Branch	Easton Diversion	USBR	KRD South Branch
36	SB 16.7	KRD South Branch	Easton Diversion	USBR	KRD South Branch
36	Springwood	KRD North Branch	Easton Diversion	USBR	KRD North Branch
36	Turner	KRD South Branch	Easton Diversion	USBR	KRD South Branch
42	Dry Creek	Dry Creek/KRD North Branch	Dry Creek Proposed by KRD	Ecology	Dry Creek
43	Whiskey Dick Creek	Parke Creek/KRD North Branch	Parke Creek Proposed by KRD	N/A	N/A
43	South Branch Area	KRD South Branch/Robinson Creek	Robinson Creek Proposed by KRD	N/A	N/A
43	Pump Ditch East 1	KRD North Branch	Easton Diversion	USBR	KRD North Branch
43	Pump Ditch East 2	KRD North Branch	Easton Diversion	USBR	KRD North Branch
47	Manastash SAR	Manastash Creek	Manastash Cr @ Cove Rd.	Ecology	Manastash Cr @ Cove Rd.
47	Hayward Canyon Upper	KRD North Branch	Easton Diversion	USBR	KRD North Branch
47	SB 1.5	KRD South Branch	Easton Diversion	USBR	KRD South Branch
47	SB 1.71	KRD South Branch	Easton Diversion	USBR	KRD South Branch
47	Sheepdip Canyon Upper	KRD North Branch	Easton Diversion	USBR	KRD North Branch
52	Erickson North	KRD North Branch	Easton Diversion	USBR	KRD North Branch
52	NB 15.2-1.9	Naneum/Wilson creeks	Wilson Creek Proposed by KRD	KRD-N/A	N/A
52	NB 4.1 Winter	KRD North Branch	Easton Diversion	USBR	KRD North Branch
52	T 6.2	KRD North Branch	Easton Diversion	USBR	KRD North Branch
52	T 6.7	KRD North Branch	Easton Diversion	USBR	KRD North Branch
57	Coleman Caribou 1	Coleman/Cooke/Caribou creeks	Cooke Creek Proposed by KRD	N/A	N/A

On the following subbasin maps, existing and proposed stream monitoring locations are shown along with subbasin boundaries and the location of potential MAR sites that were ranked in the 2020 KRD MAR Assessment Report.

Taneum Creek

Located in Kittitas County, Taneum Creek stretches 30 miles before flowing into the Yakima River north of the city of Ellensburg. The area of the basin covers 76.43 square miles with an annual discharge of 66 cubic feet per second (Monk, 2015). EA et al. (2020) estimated a 2-year daily peak flow of 1,820 cubic feet per second for Taneum Creek using USGS's StreamStats, which provides streamflow statistics on ungauged streams.

A stream gauge has been established in Taneum Creek adjacent to the Taneum Creek MAR site. In addition, four monitoring wells have been installed on the site. Planning and preparation for conducting a pilot test at the Taneum Creek MAR site is underway. Documents regarding the conducting a pilot test at the Taneum Creek MAR site is underway. Documents regarding the pilot test, including a separate QAPP, are being prepared under separate cover for the planned 2023 pilot test.

The Taneum Creek MAR site is located near the mouth of Taneum Creek in the eastern end of the subbasin (Figure 2).

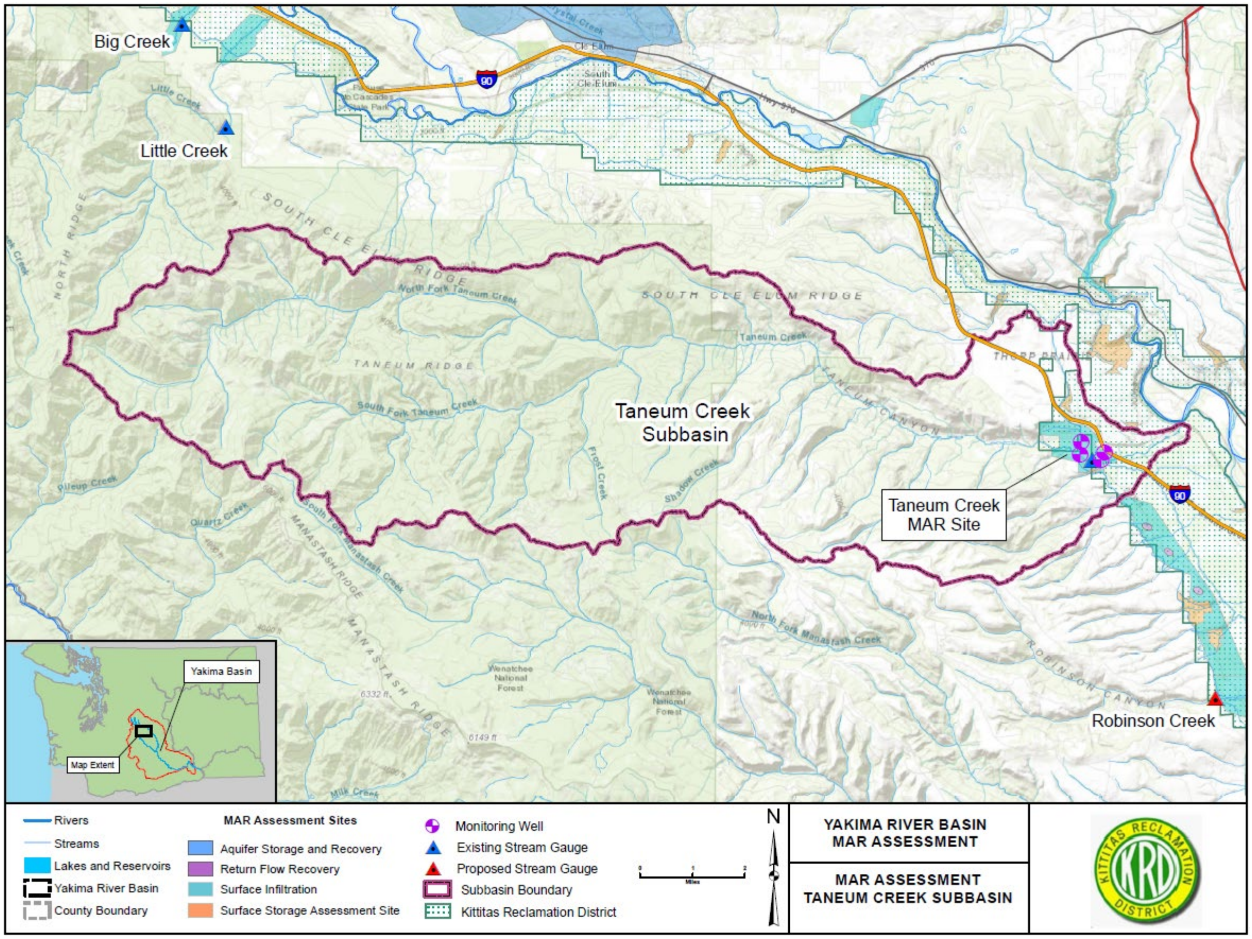


Figure 2 Location of stream gauge in the Taneum Creek Subbasin

Big Creek

Big Creek, located in Kittitas County, originates in the high Cascade Mountains. Its drainage area is estimated at 26.51 square miles, with a statistically projected 2-year daily peak flow of 2,370 cubic feet per second (EA et al., 2020). Flows shown in Figure 3 were monitored by the Department of Ecology from 2005 to 2009 (Creech & Stuart, 2015). The double-peak hydrograph shows characteristics of a snowpack-dominated watershed, which is influenced by springtime snowmelt and winter precipitation.

A stream gauge has been established in Big Creek just below the KRD Main Canal. The Big Creek MAR site is located near the mouth of Big Creek in the northern end of the subbasin (Figure 4).

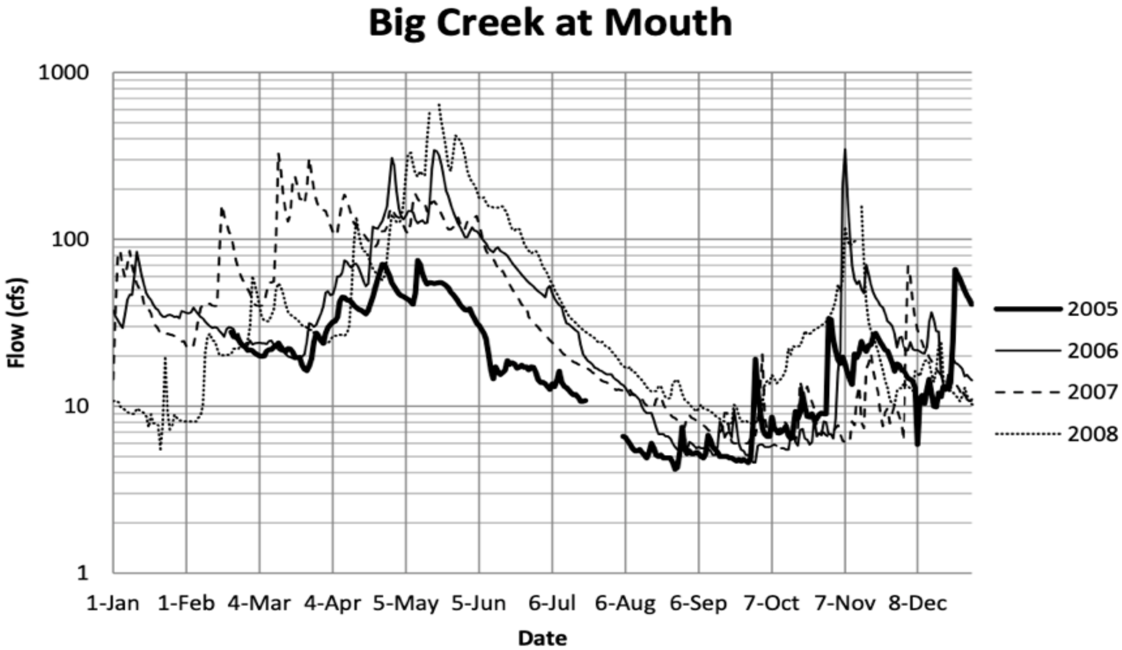


Figure 3 Big Creek hydrograph from Creech & Stuart, 2015 (p. 17) for years 2005 through 2008

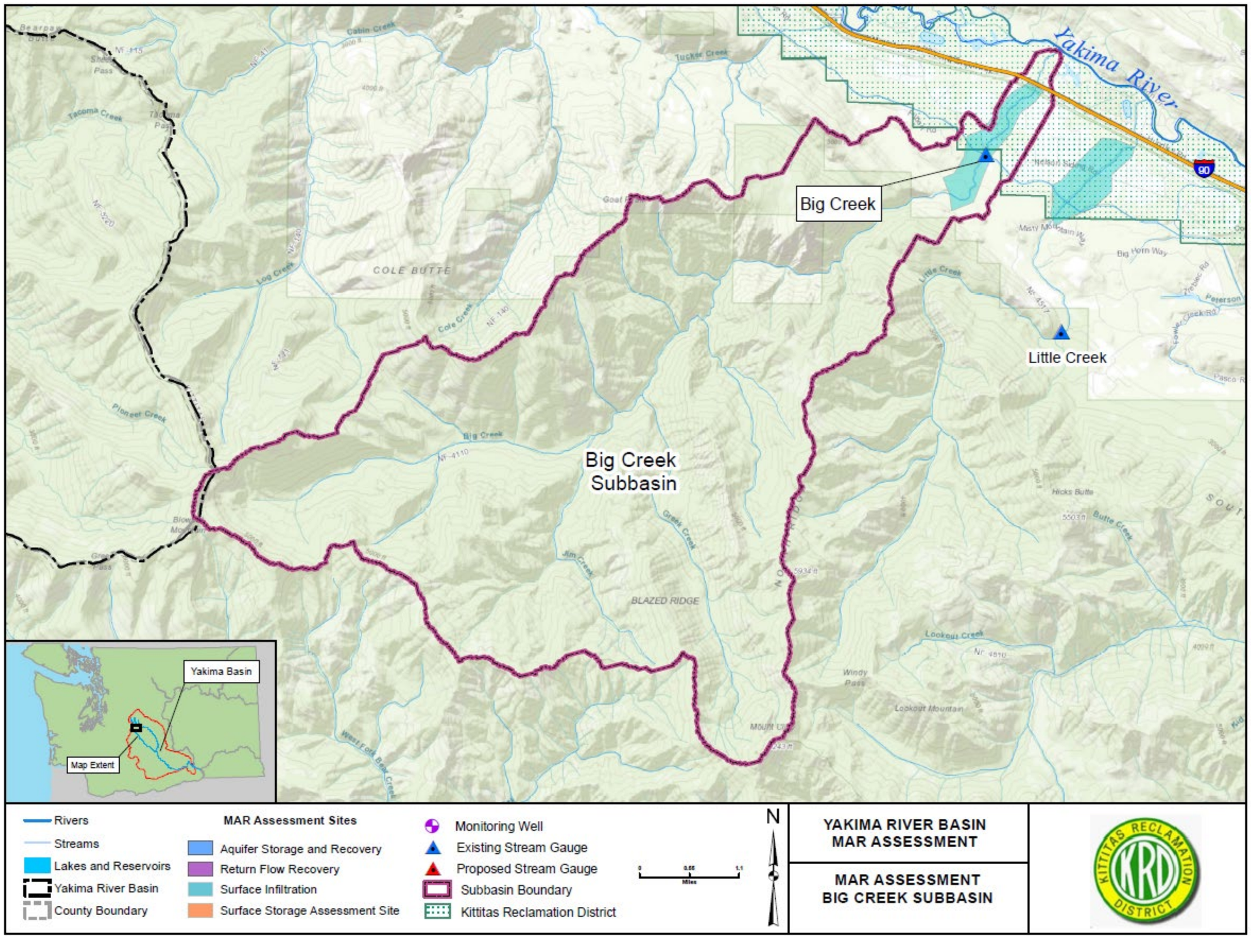


Figure 4 Location of stream gauge in the Big Creek Subbasin

Little Creek

Little Creek is located near the community of Easton in Kittitas County and has an estimated drainage area of 10 square miles. A single field measurement, taken by the USGS, recorded a streamflow of 5.88 cubic feet per second on August 9, 2011 (United States Geological Survey, 2011). In 2020, EA et al. statistically estimated a 2-year daily peak flow of 916 cubic feet per second.

A stream gauge has been established in Little Creek about a half mile above the KRD Main Canal. The Little Creek MAR site is located near the mouth of Little Creek in the northern end of the subbasin (Figure 5).

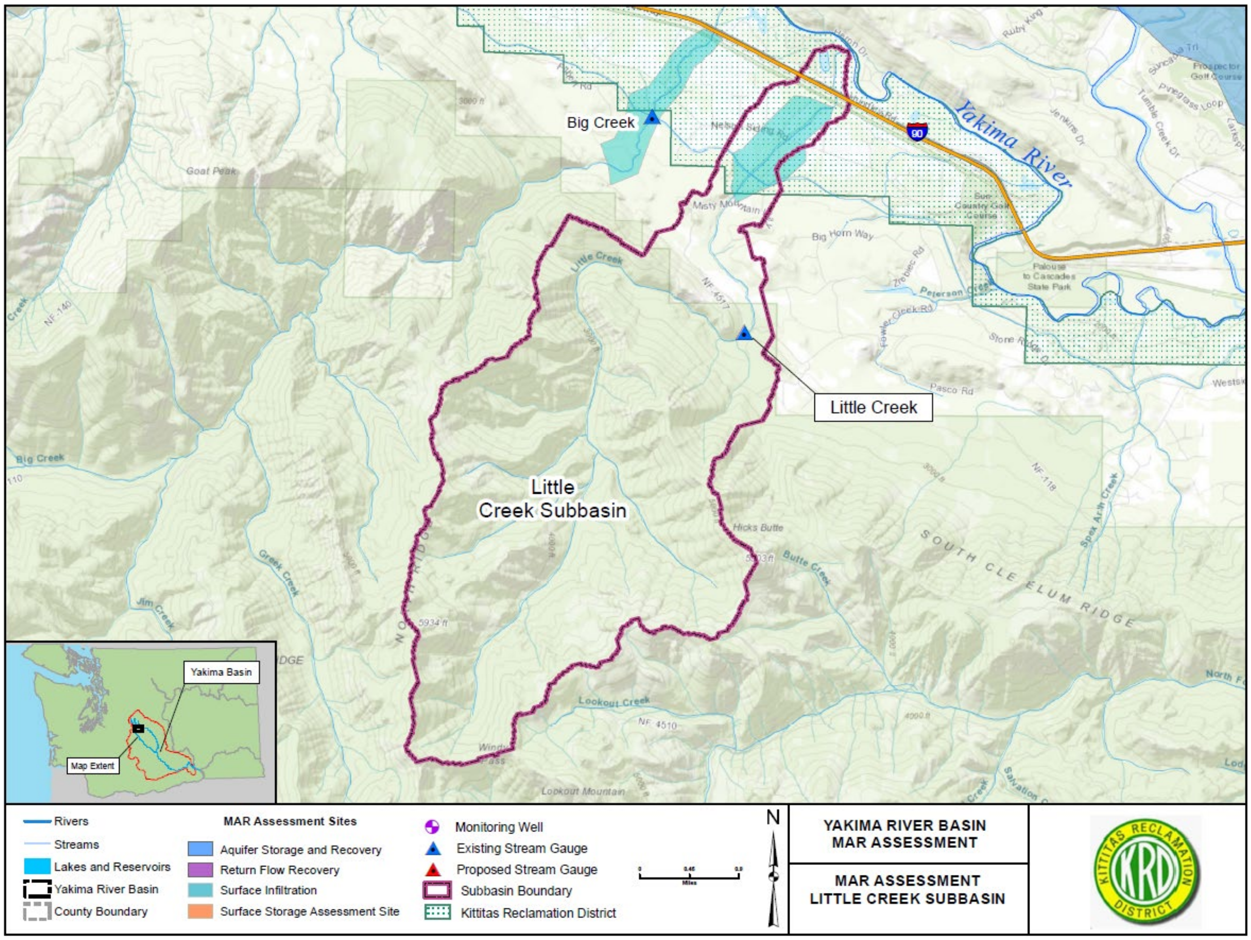


Figure 5 Location of stream gauge in the Little Creek Subbasin

Naneum Creek

Naneum Creek is located within Kittitas County. The creek is 35 miles in length and flows into Wilson Creek at the valley floor. The USGS recorded mean daily flows in the upper Naneum from 1957 to 1977 (United States Geological Survey, 2020). The highest annual peak streamflow during that period exceeded 950 cubic feet per second in 1964, and the lowest annual peak streamflow of 47 cubic feet per second in 1977 (United States Geological Survey, 2020). In 2020, EA et al. statistically estimated a 2-year daily peak flow of 391 cubic feet per second (Figure 6).

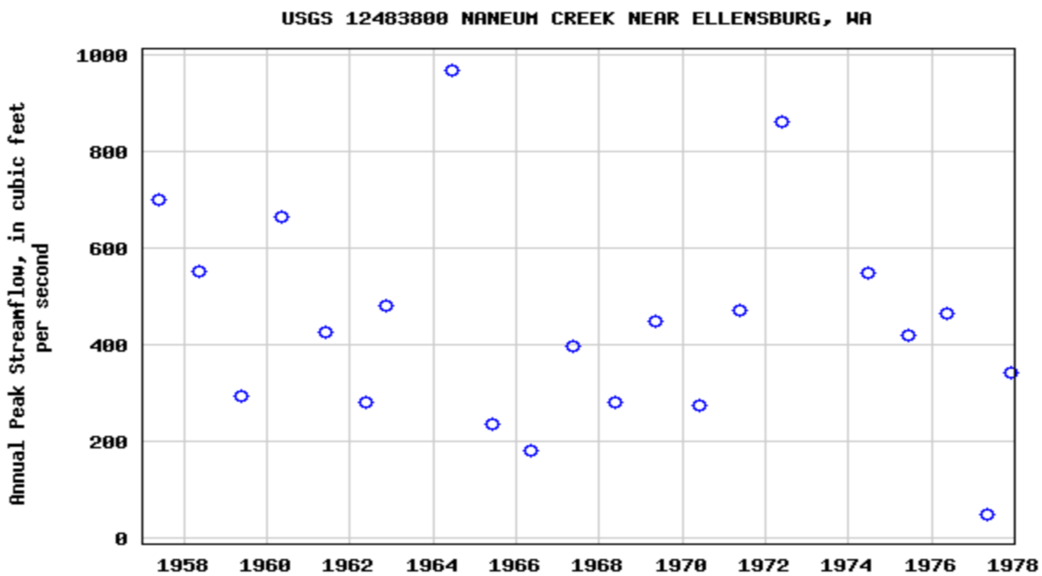


Figure 6 Naneum Creek annual peak streamflow from 1957 through 1978. Image obtained from the United States Geological Survey (2020)

Two stream gauges have been established in Naneum Creek in the upper part of the Naneum Creek subbasin above the KRD North Branch Canal. The Naneum Creek gauges are located both above and below a reach of stream where Wilson and Naneum Creek merge (Figure 7). Between the lower gauge and the Yakima River, both Wilson and Naneum Creeks have been altered and diverted for irrigation making delineation of a typical subbasin difficult. Wilson Creek is also proposed for monitoring and a location just above the KRD North Branch Canal.

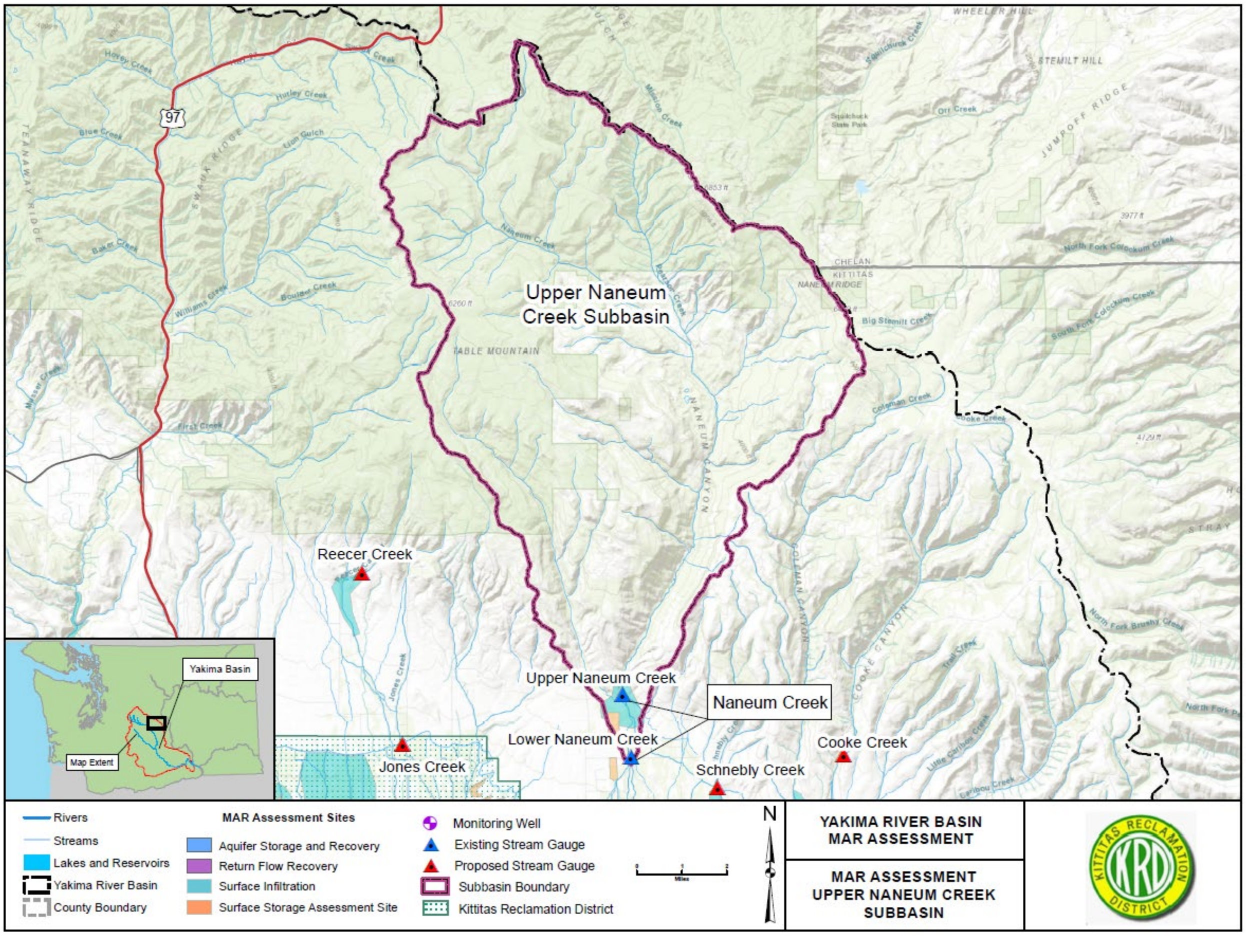


Figure 7 Location of stream gauges in the Naneum Creek Subbasin

Wenas Creek

Wenas Creek is located northwest of the town of Selah in Yakima County and has an estimated drainage area of 129 square miles at the proposed gauge location. USGS's StreamStats was used to generate streamflow statistics including an estimated a 2-year daily peak flow of 515 cubic feet per second at the proposed gauge location.

A stream gauge is proposed in Wenas Creek in the central part of the subbasin (Figure 8).

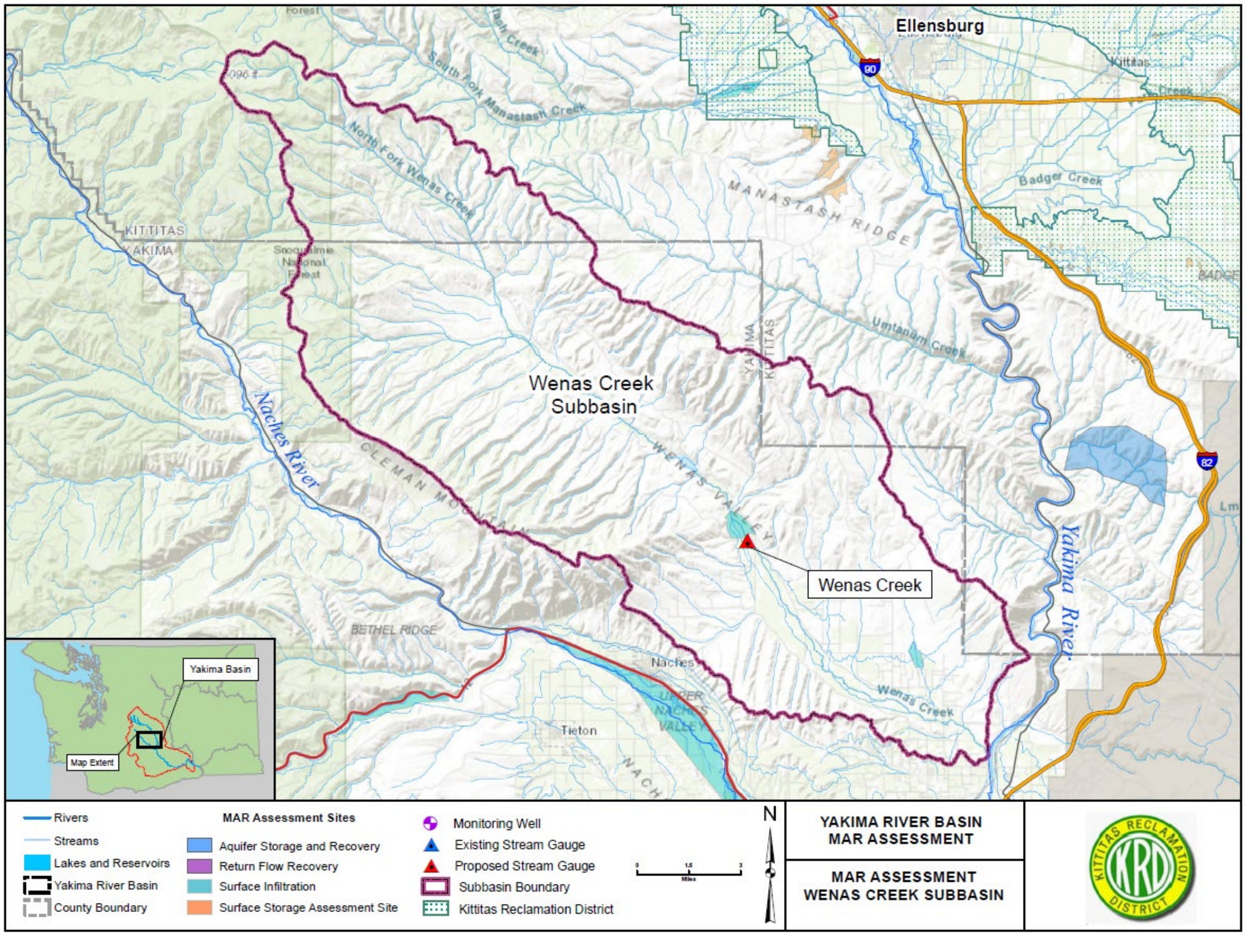


Figure 8 Location of proposed stream gauge in the Wenas Creek Subbasin

Cooke Creek

Cooke Creek is located northeast of Ellensburg in Kittitas County and has an estimated drainage area of 18 square miles at the proposed gauge location. USGS's StreamStats was used to generate streamflow statistics including an estimated a 2-year daily peak flow of 98 cubic feet per second at the proposed gauge location.

A stream gauge is proposed in Cooke Creek in the central part of the subbasin above the KRD North Branch Canal (Figure 9).

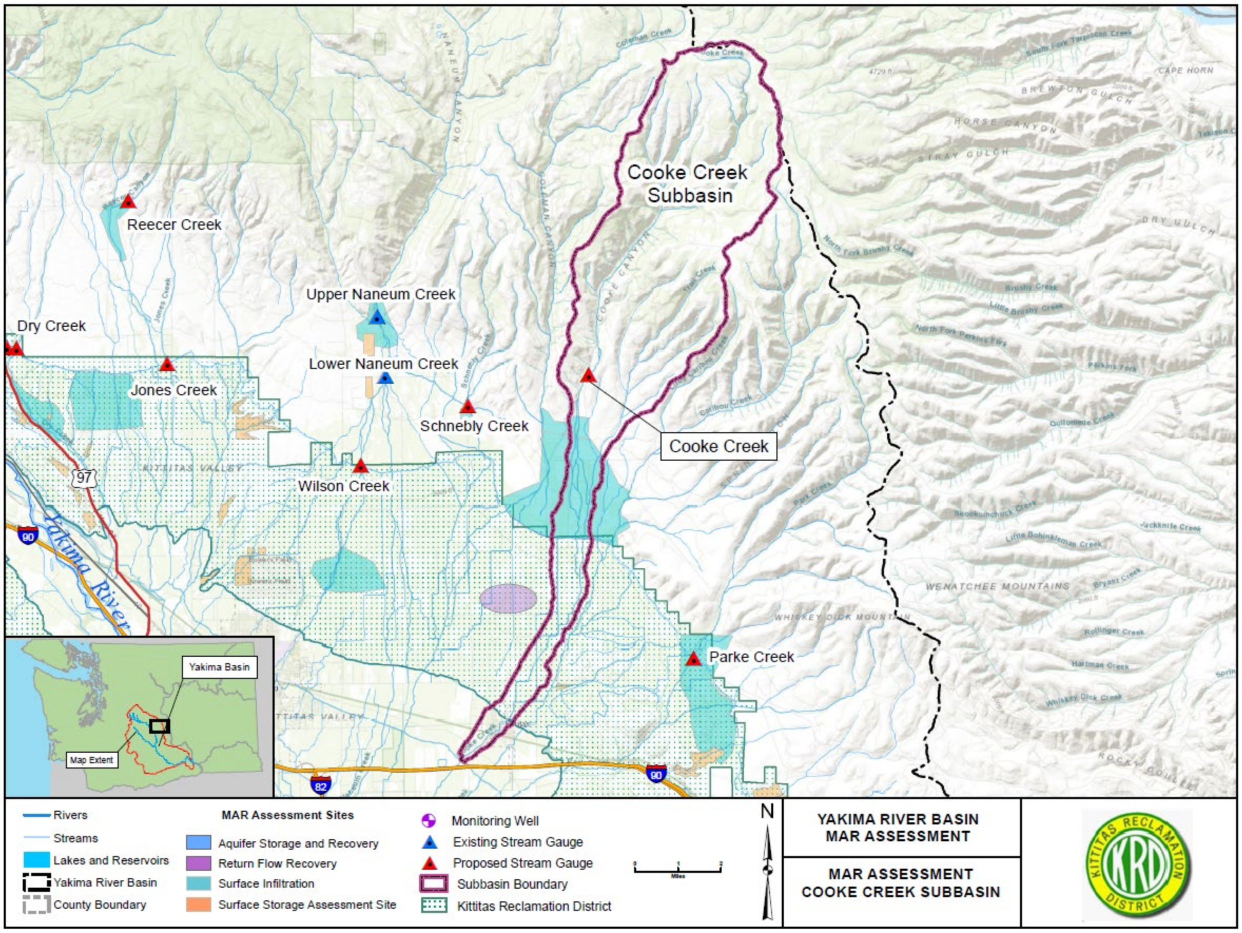


Figure 9 Location of proposed stream gauge in the Cooke Creek Subbasin

Parke Creek

Parke Creek is located east of Ellensburg in Kittitas County and has an estimated drainage area of 17 square miles at the proposed gauge location. USGS's StreamStats was used to generate streamflow statistics including an estimated a 2-year daily peak flow of 48 cubic feet per second at the proposed gauge location.

A stream gauge is proposed in Parke Creek in the central part of the subbasin just below the KRD North Branch Canal (Figure 10).

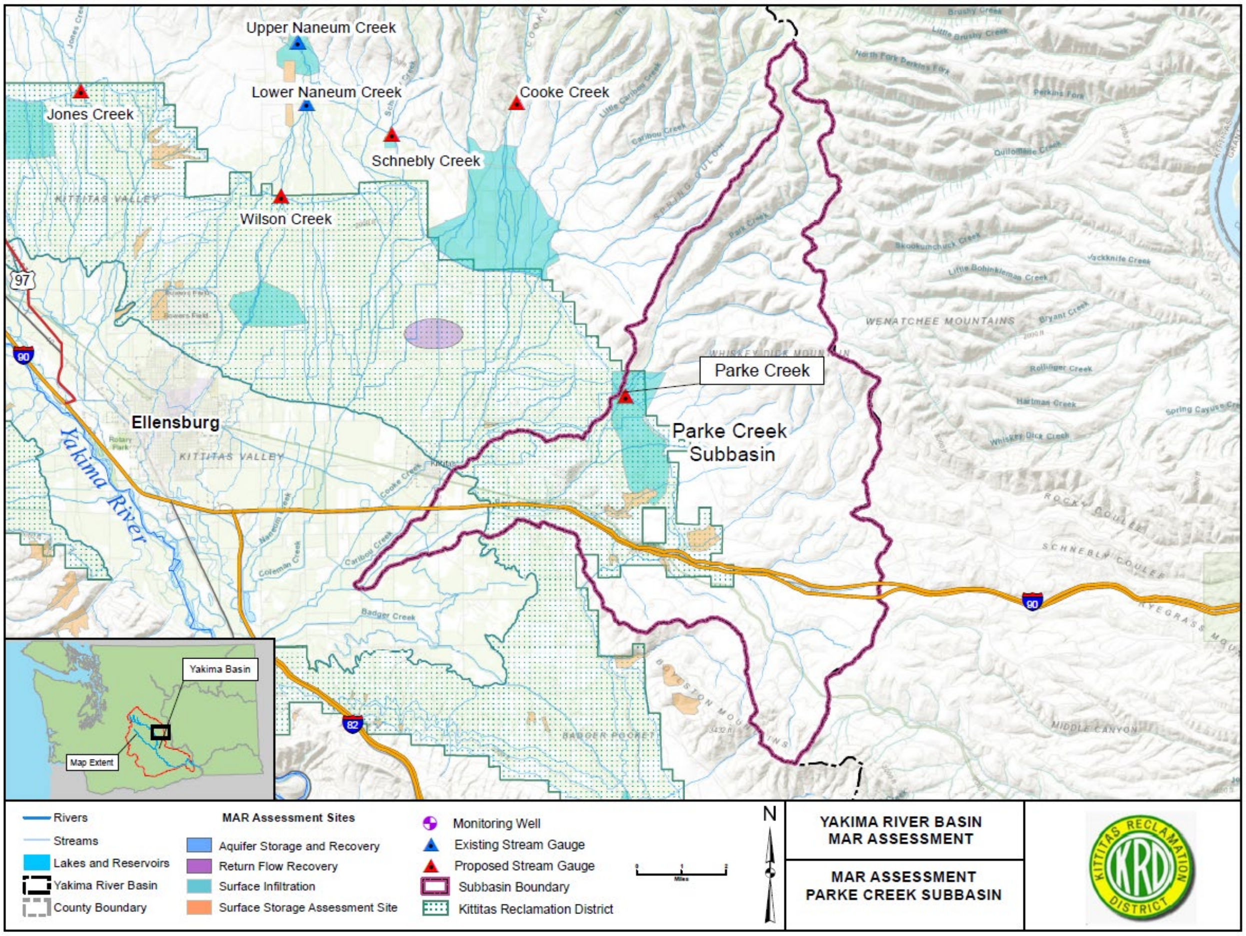


Figure 10 Location of proposed stream gauge in the Parke Creek Subbasin

Wilson Creek

Wilson Creek is located north of Ellensburg in Kittitas County and has an estimated drainage area of 91 square miles at the proposed gauge location. USGS's StreamStats was used to generate streamflow statistics including an estimated a 2-year daily peak flow of 386 cubic feet per second at the proposed gauge location.

As noted above, re-routing and diversion of Wilson and Naneum creeks have resulted in unnatural stream subbasins, making delineation of individual subbasins difficult. A stream gauge is proposed in Wilson Creek in the central part of the subbasin just above the KRD North Branch Canal (Figure 11).

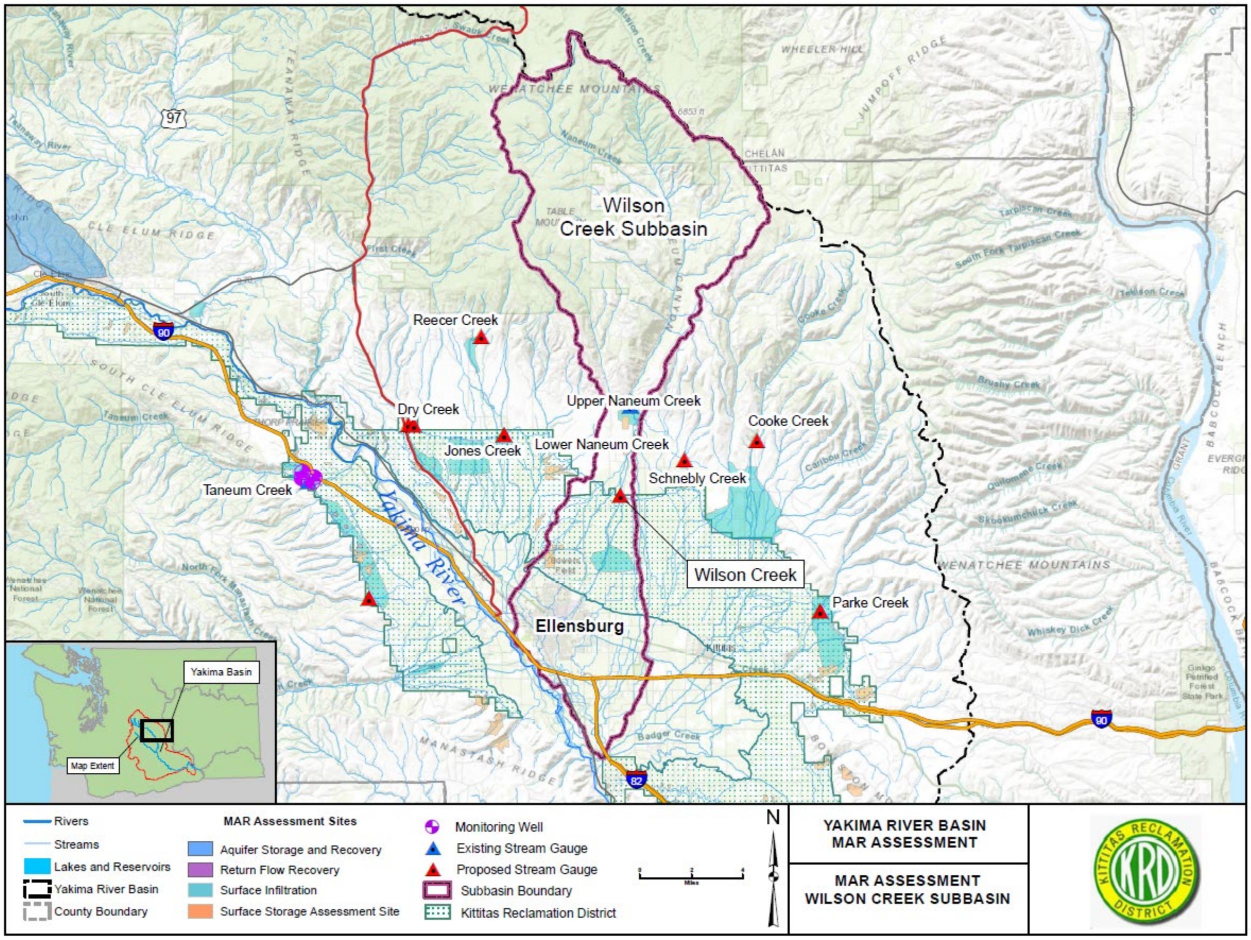


Figure 11 Location of proposed stream gauge in the Wilson Creek Subbasin

Robinson Creek

Robinson Creek is located north of Ellensburg in Kittitas County and has an estimated drainage area of 9.6 square miles at the proposed gauge location. USGS's StreamStats was used to generate streamflow statistics including an estimated a 2-year daily peak flow of 77 cubic feet per second at the proposed gauge location.

A stream gauge is proposed in Robinson Creek in the central part of the subbasin just above the KRD South Branch Canal (Figure 12).

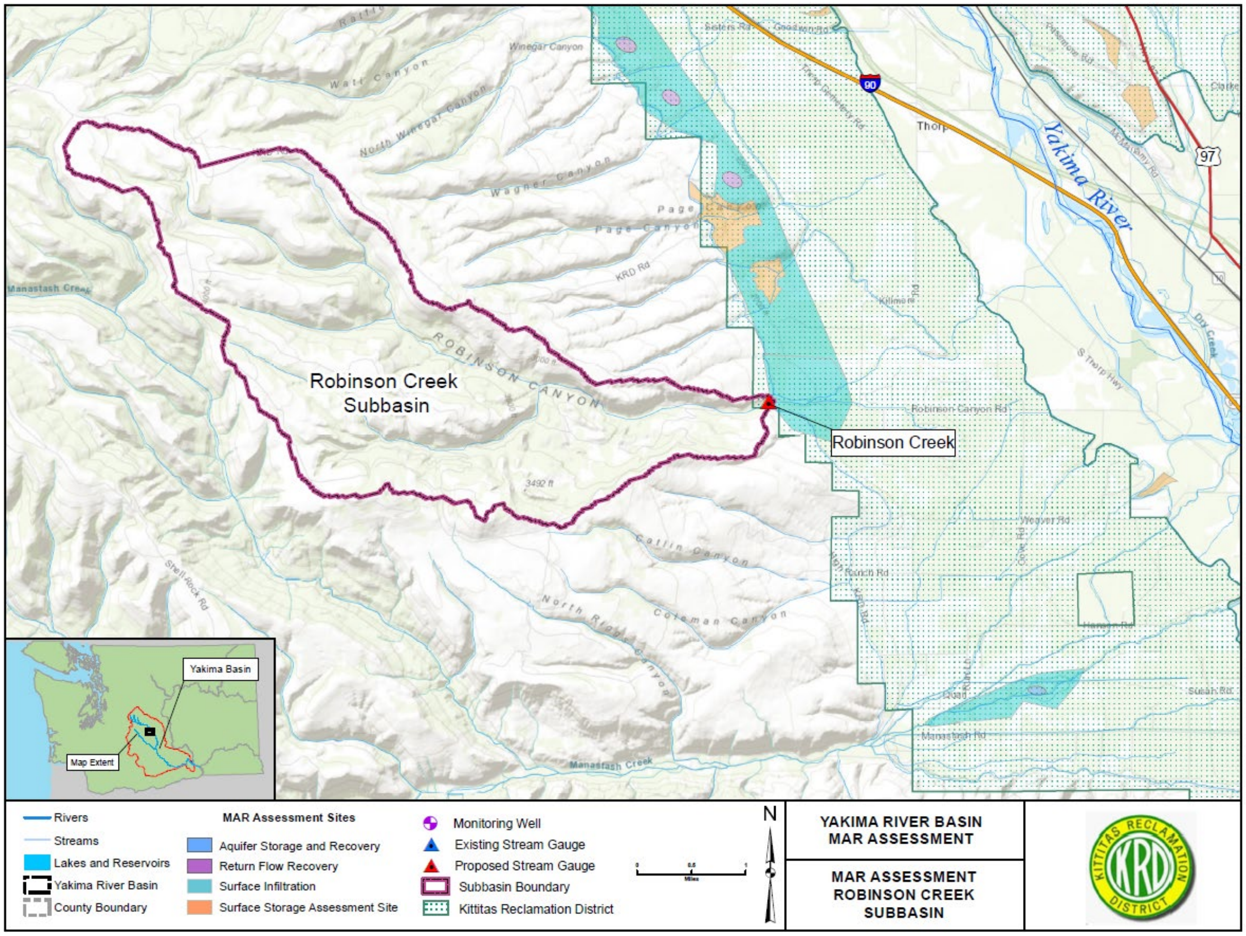


Figure 12 Location of proposed stream gauge in the Robinson Creek Subbasin

Dry Creek

Dry Creek is located north of Ellensburg in Kittitas County and has an estimated drainage area of 15 square miles at the proposed gauge location. USGS's StreamStats was used to generate streamflow statistics including an estimated a 2-year daily peak flow of 49 cubic feet per second at the proposed gauge location.

Ecology has monitored discharge in the two branches of Dry Creek at the KRD North Branch Canal for several years, although recently the gauge on the west branch has been vandalized and is no longer in use. Discharge monitoring at these locations is proposed in Dry Creek, although transducers might not be installed due to security concerns (Figure 13).

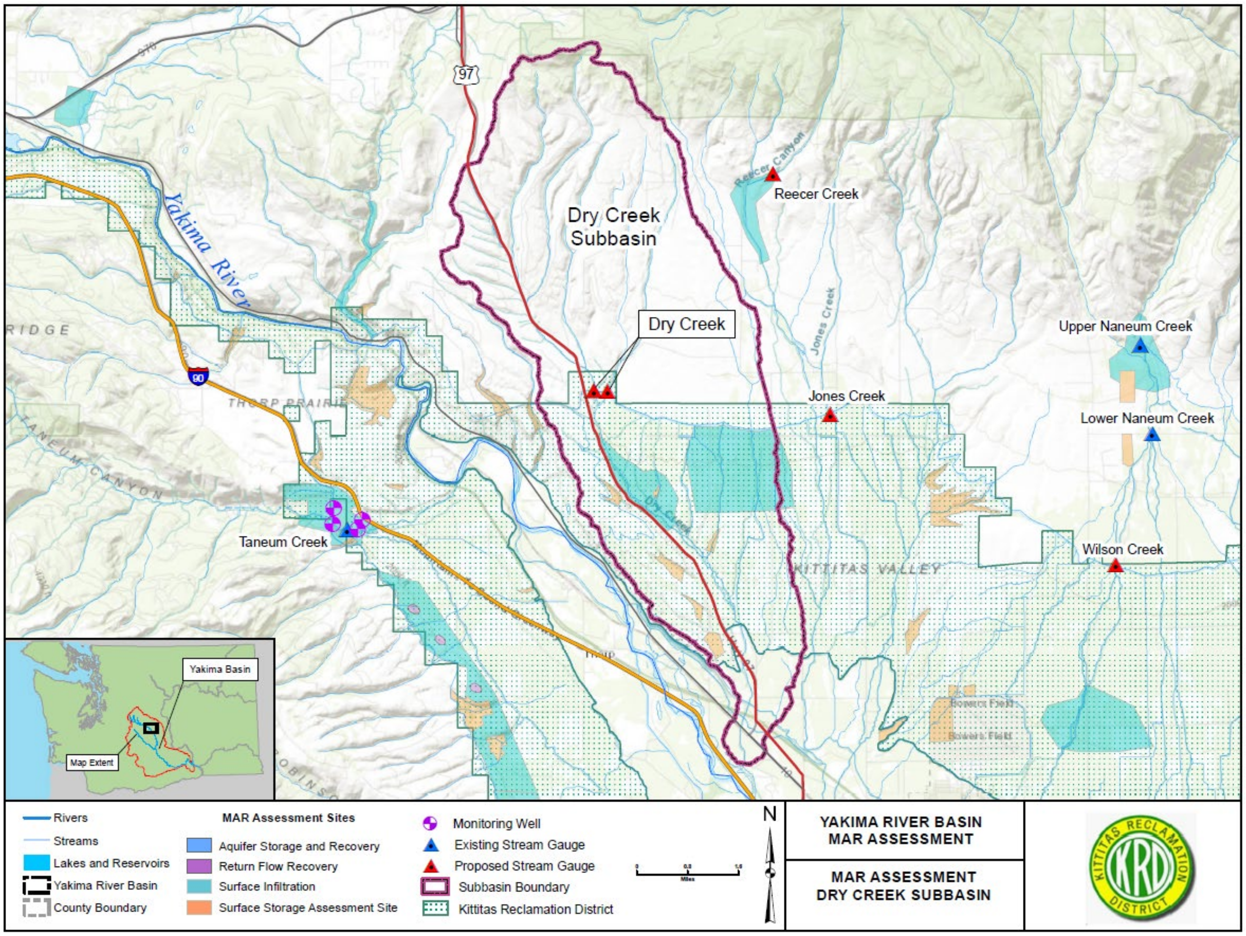


Figure 13 Location of proposed stream monitoring in the Dry Creek Subbasin

Schnebly Creek

Schnebly Creek is located north of Ellensburg in Kittitas County and has an estimated drainage area of 4 square miles at the proposed gauge location. USGS's StreamStats was used to generate streamflow statistics including an estimated a 2-year daily peak flow of 19.6 cubic feet per second at the proposed gauge location.

A stream gauge is proposed in Schnebly Creek in the central part of the subbasin above the KRD North Branch Canal (Figure 14).

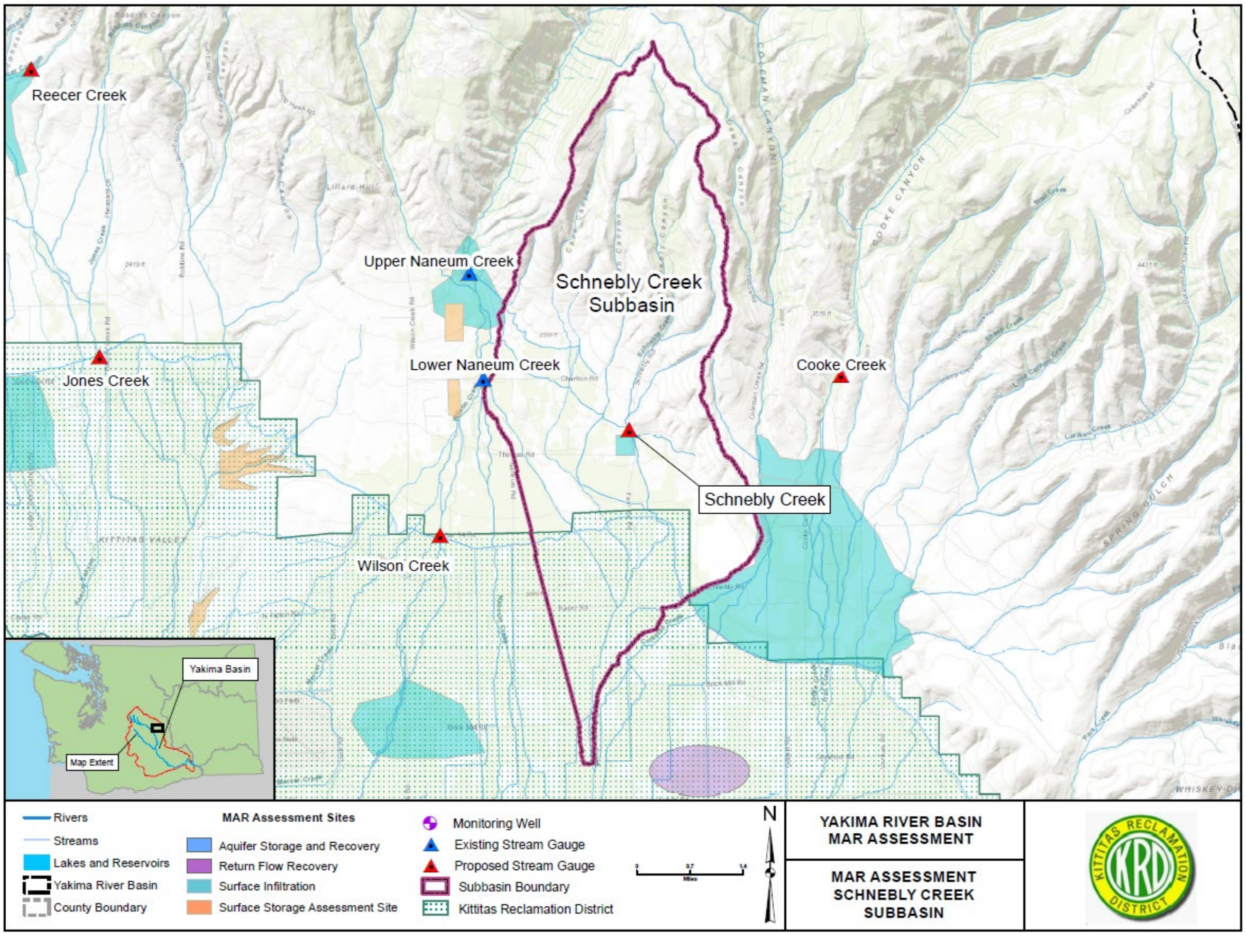


Figure 14 Location of proposed stream monitoring in the Schnebly Creek Subbasin

Reecer Creek

Reecer Creek is located north of Ellensburg in Kittitas County and has an estimated drainage area of 5 square miles at the proposed gauge location. USGS's StreamStats was used to generate streamflow statistics including an estimated a 2-year daily peak flow of 31 cubic feet per second at the proposed gauge location.

A stream gauge is proposed in Reecer Creek in the upper part of the subbasin above the KRD North Branch Canal (Figure 15).

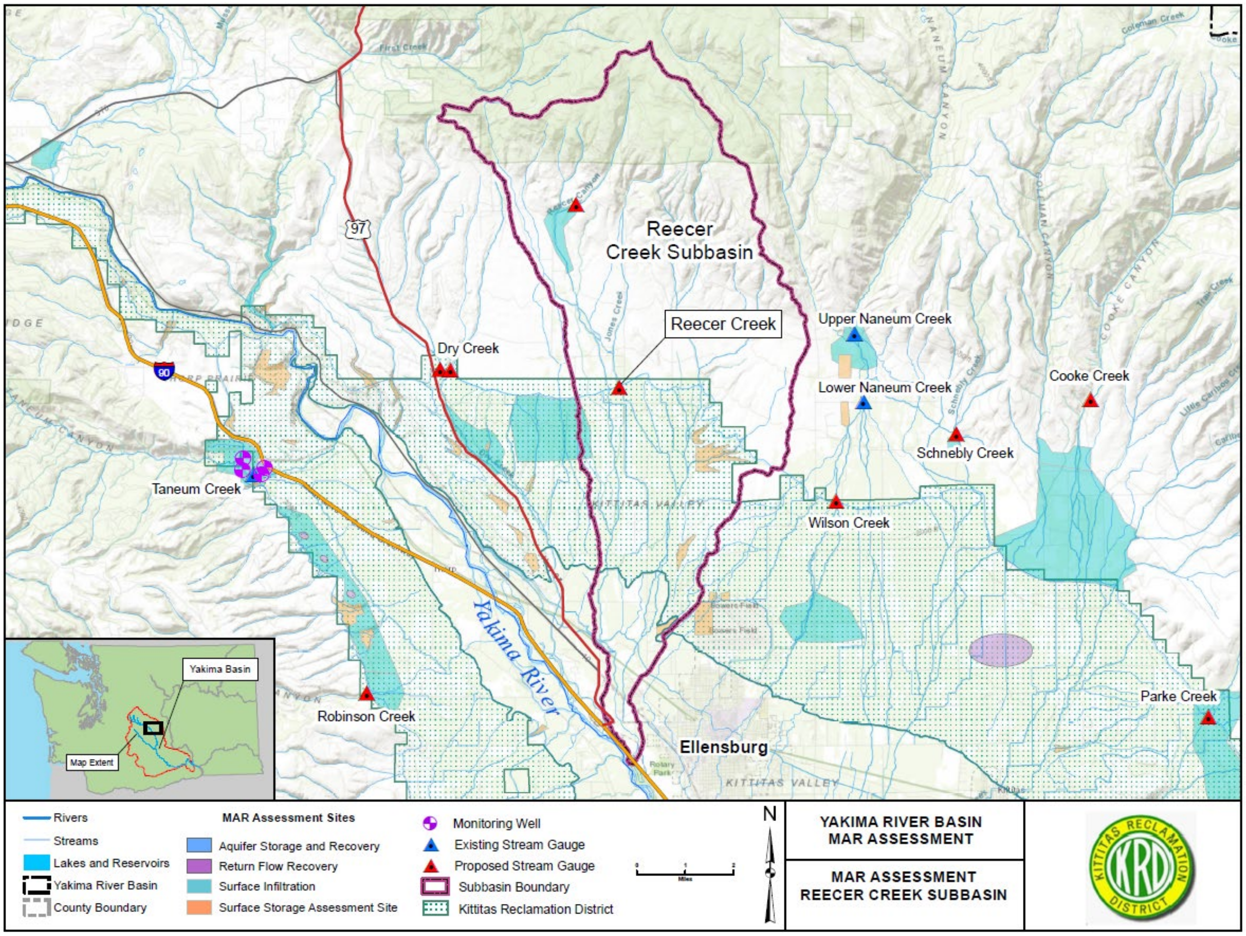


Figure 15 Location of proposed stream monitoring in the Reecer Creek Subbasin

Jones Creek

Jones Creek, a tributary to Reecer Creek, is located north of Ellensburg in Kittitas County and has an estimated drainage area of 3.8 square miles at the proposed gauge location. USGS's StreamStats was used to generate streamflow statistics including an estimated a 2-year daily peak flow of 19 cubic feet per second at the proposed gauge location.

A stream gauge is proposed in Jones Creek in the lower part of the subbasin just below the KRD North Branch Canal (Figure 16).

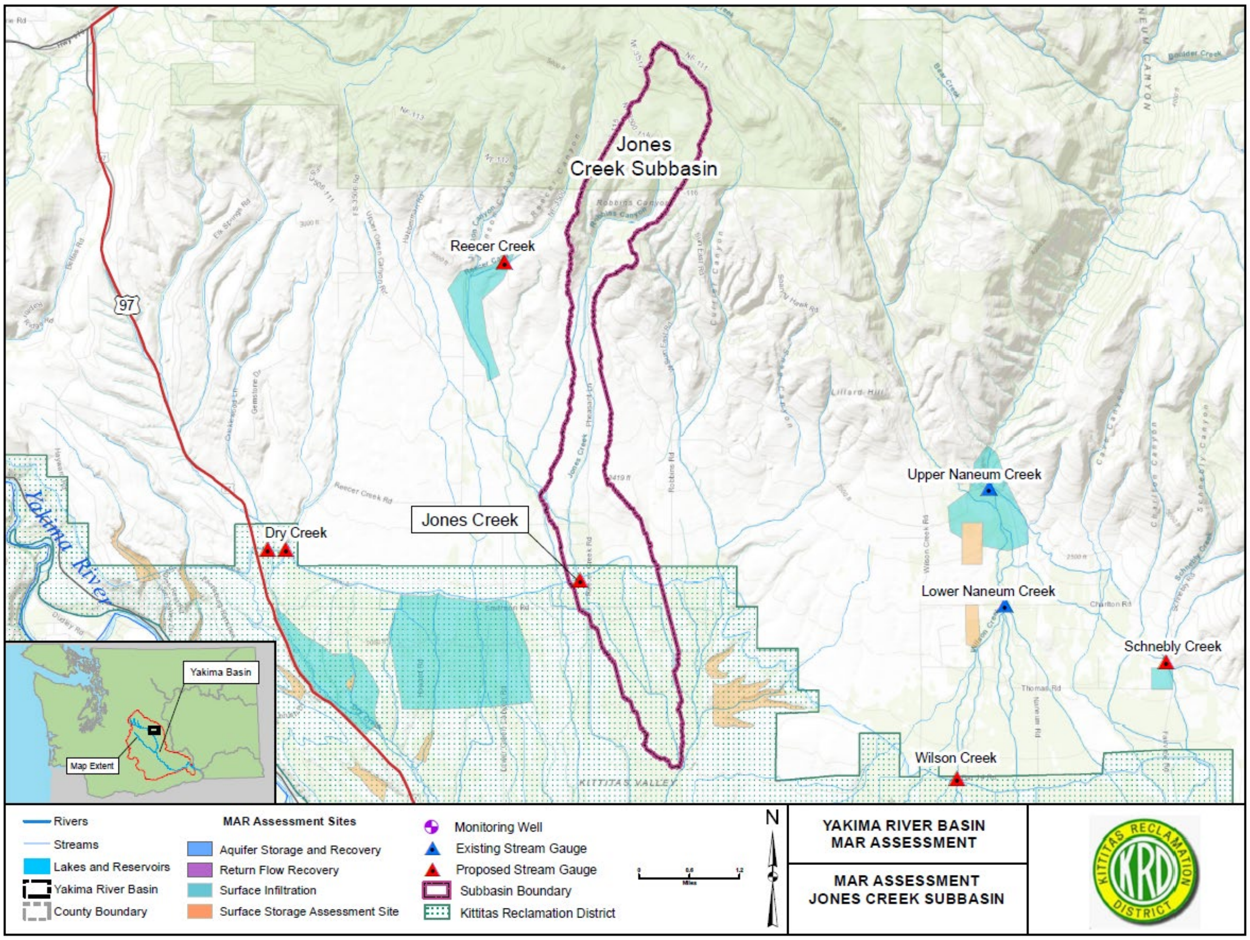


Figure 16 Location of proposed stream monitoring in the Jones Creek Subbasin

2.0 Organization and Schedule

Listed in the tables below are project personnel that will perform various aspects of the project, perform data collection and assess data.

Table 2 Organization of project staff and responsibilities

Staff	Title	Responsibilities
Dave Nazy **EA Engineering**	**Project Manager**	**EA project manager: conducts field work, data analysis, quality control/assurance, reporting**
Tim McCormack **EA Engineering**	**Senior Technical Reviewer**	**Provides internal review of the QAPP and approves the final QAPP.**
Kylan Hopper **EA Engineering**	**Field Assistant**	**Conducts field work, data management and analysis, reporting**
Drew Roberts **EA Engineering**	**Field Assistant**	**Conducts field work, data management and analysis, reporting**
Halie Hajek **EA Engineering**	**Field Assistant**	**Conducts field work, data management and analysis, reporting**
Guy Gregory **Gregory Geologic LLC**	**Project Manager**	**Project scoping and performance assessment, , field work, data analysis and reporting**
Julia Long **Jacobs Engineering**	**Project Manager**	**Project and contract management and permitting**
Craig Broadhead **Jacobs Engineering**	**Contract Manager**	**Overall project management**
Kat Satnik **Kittitas Reclamation District**	**Grant Manager, Project Manager, Field Assistant**	**Project and grant management**
Roger Satnik **Kittitas Reclamation District**	**Technical Advisor**	**KRD GIS and Technical advisor**
Kevin Eslinger **Kittitas Reclamation District**	**Technical Advisor**	**KRD Technical advisor**

Continued to next page

Staff	Title	Responsibilities
Joel Hubble **Kittitas Reclamation District**	**Technical Advisor**	**KRD Technical advisor, data analysis**
Walt Larrick **Kittitas Reclamation District**	**Technical Advisor**	**KRD Technical advisor, data analysis**
Urban Eberhart **Kittitas Reclamation District**	**Technical Advisor and Project Director**	**KRD project leader: technical and administrative oversight and data analysis; provides internal review and approval of the QAPP**
Chris Duncan **Washington Department of Ecology, Office of Columbia River**	**Project Manager**	**Manages Ecology grant activities**
Scott Tarbutton **Washington Department of Ecology, Office of Columbia River**	**QA Coordinator**	**Reviews the draft QAPP and approves the final QAPP**

QAPP: Quality Assurance Project Plan

Special training and certifications

Field activities will consist of stream discharge measurements, groundwater level measurements, data retrieval, well drilling oversight, and soil testing. Field staff conducting these activities will be required to proficiently operate the FLOW-MATE 2000 to measure stream discharge, electrical tape to measure depth to groundwater within the data quality objectives. They are also required to be able to retrieve data using the latest version of Win-Situ Software. A Washington State licensed hydrogeologist will oversee construction of logging of the monitoring wells and the percolation test.

Proposed project schedule

Table 3 Schedule for completing work

Description	Due Date	Completed
Project Initiation	August 2020	August, 2020
Field stations defined	August 2020	
Data Collection	September 2023	
Monitoring Well Construction	4/30/2021	4/30/2021
Draft Technical Report	11/30/2023	
Final Technical Report	1/31/2024	
Upload data to Ecology EIM system as appropriate	1/31/2024	

3.0 Quality Objectives

Data quality objectives

This project will be considered successful and complete after the following are determined: stream discharge rates, soil infiltration rates, and aquifer properties - including water well characterization.

Measurement quality objectives

Water well levels, streamflow temperature, streamflow velocity, locational data, and gauge height will be gathered to manufacturers' specifications in Table 3. Field duplicates for measurements will be taken in accordance with the referenced measurement standard operating procedure (Table 5) to evaluate and demonstrate measurement quality.

Table 4 Manufacturers specifications for equipment to be used

Equipment	Model	Data gathered	Accuracy	Resolution
Marsh McBirney	FLO-MATE 2000	Open Channel Flow Velocity	+/- 2% of reading ±0.05 ft/s	±0.05 ft/s
Garmin GPS	Vista Etrex	Latitude and Longitude	<10-15 meters 95% of the time and DGPS/WAAS is 3 meters 95%	1 degree
In-Situ RuggedTROLL® Loggers	RT100	Water Well Levels	+/- 0.01% of full scale or better	±0.01% FS or better
		Water Pressure	+/-0.05% FS from 0-50 ºC;	+/-0.01% FS or better
		Water Temperature	+/- 0.3ºC / 0.01 ºC or better	0.01° C or better
In-Situ Rugged BaroTROLL	Baro	Barometric Pressure	+/-0.05% FS from 0-50 ºC	+/-0.01% FS or better
		Air Temperature	+/- 0.3oC / 0.01 ºC or better	0.01° C or better
Acoustic Doppler Profiler	Son Tek RS5	Open Channel Discharge	1%, ±0.002 m/s	0.001 m/s
Slope Indicator Water Level Indicator (E-Tape)	300 ft.	Depth to water	+/- 0.02 feet	0.01 foot

A brief description of each data quality indicator is provided below, followed by a discussion of how these quality aspects apply to each type of data.

- **Precision** is the degree of agreement among repeated field measurements of the same indicator and gives information about the consistency of your methods. It is typically defined as relative percent difference (RPD).
- **Accuracy** is a measure of confidence that describes how close a measurement is to its "true" or expected value.
- **Representativeness** is the extent to which measurements represent the true environmental condition. Parameters such as site selection (including location of sampling point within the water column), time, and frequency of sample collection can all play a role in determining how representative a sample is.
- **Comparability** is the extent to which data can be compared between sample locations or periods of time within a project, or between different projects.
- **Completeness** is the comparison between the amounts of valid or usable data the program originally intended to collect versus how much was actually collected.

Precision

Observation Wells

The accuracy of water well levels for e-tape measurements are based on SOP within Ecology Publication: No.17-11-005 (p. 22), which states the following:

1) +/- 0.02 feet for depths of less than or about 250 feet
2) +/- 0.04 feet for depths between 250 and 500 feet
3) +/- 0.1 feet for depths in excess of 500 feet

Unless otherwise referenced in Ecology Publication: No.17-11-005, all other water well measurements will be considered acceptable as stated in Freeman et al. (2004) which includes, "The measurement error and accuracy standard for most situations are 0.1 feet, 0.1 percent of range in water-level fluctuation, or 0.01 percent of depth to the water above or below a measuring point, whichever is least restrictive."

Surface Water Measurements

The precision of surface water measurements will be considered acceptable based on USGS recommendations (Sauer, 2002) shown in Table 4. Duplicate measurements will be collected on 10 percent of the stream discharge measurements.

Table 5 Normal precision of measurements of surface water and related parameters obtained from Sauer (2002, p. 5)

Parameter	Precision of Measurements	
	English Units	Metric Units
Gage height or elevation of water surface	0.01 ft.	0.001 meter
Gage height of zero flow, natural channel	0.1 ft.	0.01 meter
Gage height of zero flow, manmade control structure	0.01 ft.	0.001 meter
Gage height of gage features	0.01 ft.	0.001 meter
Velocity (Electromagnetic meter (EM), ultrasonic velocity meter (UVM), Price current meter)	0.01 ft./s.	0.001 meters/s.
Depth (uneven streambed, deep streams)	0.1 ft.	0.01 meter
Depth (smooth streambed, shallow streams)	0.01 ft.	0.001 meter
Width (wading measurements, narrow cross sections)	0.1 ft.	0.01 meter
Width (bridge, cable, boat wide cross sections)	1 ft.	0.1 meter
Ground elevation (cross section)	0.1 ft.	0.01 meter
Reference and benchmarks	0.001 ft.	0.001 meter

Bias

Bias will be addressed by calibration of the equipment in Table 5. Calibration will be conducted to manufacturer specifications. Staff gauges either exist or will be installed and recorded with each field visit. Static water levels will be recorded on every visit to download data from each monitoring well. These field measurements will be used to assess drift in the transducer measurements.

Targets for comparability, representativeness, and completeness

Comparability

The standard operating procedures (SOP) for deriving streamflow data include SOPs for datalogger installation, field measurements, data download, correcting for instrument drift, and rating curve development. The SOPs for deriving aquifer properties and water level data include manual well measurements and datalogger/barometer installation. Streamflow data generated from this research will be compared to historic discharge data where available. The SOPs in this QAPP for stream measurements, aquifer information, and soil infiltration are listed in Tables 5-7, respectively.

Table 6 Standard Operating Procedures for stream measurements referenced throughout this QAPP

Stream Measurements	Standard Operating Procedure
Datalogger Installation	USGS (Kennedy, 1984); EPA (EPA/600/R-13/170F)
Data Download	EAP057, version 1.2
Stream Temperature	EPA (EPA/600/R-13/170F)
Field Measurements	EAP056, version 1.3; EAP042, version 1.2
Instrument Drift	EAP082, version 1.2
Rating Curve Development	USGS (Kennedy, 1984; Sauer, 2002)

Table 7 Standard Operating Procedures for aquifer information and obtaining water level data utilized in this QAPP

Aquifer Information and Water Well Data	Standard Operating Procedure
Datalogger/Barometer Installation	EAP074, version 1.2; EPA (Band, 2015)
Manual Measurements	EAP052, version 1.2
Instrument Drift	EAP082, version 1.2
Log/Record Management	ECY Publication: No.17-11-005

Table 8 Standard Operating Procedures for soil infiltration cited in this QAPP

Soil Infiltration Rates	Standard Operating Procedure
Percolation Test	USGS (Johnson, 1991)

Representativeness

One of the goals of this study is to collect data representative of the flow in the stream at the point of collection. General location of monitoring points for each stream have been selected at the location at or near where the stream channel emerges from mountainous terrain onto the valley environment. This effort is designed to minimize the effect of man-made actions on stream flow to represent natural flow/flood conditions more accurately through the year.

However, each individual site is only representative of the flow at that site including any flow conditions affecting that site.

Actual locations are chosen for clear flow conditions. A straight channel and a generally smooth stream bed profile are desirable to increase accuracy of the flow measurement. Taking enough measurements to construct a valid rating curve for the site increases the likelihood the station will provide representative flows. Coupling the individual stream flow measurements with stage data from pressure transducers and frequently observed staff gauges over the monitoring period increases confidence in the representativeness of the project measurement program.

Streamflow data will indicate flow variability with respect to seasonality, weather conditions, changes to stream channel, debris, and other factors which may alter data recording measurements.

Completeness

This study will be considered complete if data can be gathered over 95% of data collection.

Acceptance criteria for quality of existing data

Existing data in the specific study area will be evaluated for precision, accuracy, and completeness in accordance with this QAPP and any quality assurance documentation governing it's gathering. This study will produce new data at each site locations Existing data will be incorporated into the analysis as appropriate when necessary and available to evaluate conclusions.

4.0 Study Design

The primary purpose of investigating and developing MAR projects is to implement the goals and objectives of the Yakima Basin Integrated Plan (YBIP). MAR projects are designed to capture surface water when excess flows are available for storage in the aquifer. Stored groundwater is released back to tributary streams and, in this case, the Yakima River during periods of low tributary stream or river flow. Conjunctively, using surface water and groundwater storage will increase Total Water Supply Available (TWSA) and provide water for streamflow, which is central to improve salmonid populations and fish passage in the Yakima Basin. KRD will coordinate proposed work with YBIP partners to make use of regional understanding to achieve project benefits.

This study is designed to collect stream flow data at Taneum, Big, Little, Naneum, Wenas, Cooke, Parke, Wilson, Robinson, Dry, Schnebly, Reecer, and Jones creeks to further evaluate natural stream flow conditions at theses MAR sites related to potential water available for MAR. To further assess MAR at high-ranked sites, additional data collection of stream discharge and local groundwater conditions is needed where current information is unavailable. Tracking real-time discharge rates at all sites and hydrogeologic conditions at Taneum Creek increases our understanding of water resources in the Upper Yakima River Basin. This project moves us closer to filling these data gaps. The study will perform field work during the 2021 and 2022 field seasons.

Installation of stream gauges is necessary at all sites to collect continuous water level and flow data. Stream flow rating curves will be developed at these gauging stations to determine the flow regime during all seasons. Generally, six discharge measurements are made for each monitoring site over a range of streamflows sufficient to develop a rating curve using standard USGS procedures for drawing the curve. Preliminary curves may be developed for specific immediate needs with the caveat that they do not meet the RIFLS QAPP standards until the final curve is developed. A final curve may be developed with fewer than 6 discharge measurements only if a rating shift is detected before 6 measurements are made and the existing measurements cover most of the range of depths observed during the time period for which the curve will be used. Once enough discharge surveys have been performed, the Program Scientist or Instream Flow Specialist develop the rating curve using the same graphical software used by the USGS. USGS (Kennedy, 1984; Sauer, 2002).

Installation of shallow monitoring wells provides water table information and aquifer properties at the Taneum Creek site. The data will be used to evaluate groundwater and surface water interactions, provide a geologic site map and groundwater level maps. Temporary test pit may be constructed, and shallow subsurface percolations tests may be performed to further characterize surface water infiltration at the site. A pilot test is currently planned to gather similar data on a project-wide scale.

Study boundaries

The study is in the Upper Yakima River Basin at the Taneum, Big, Little, Naneum, Wenas, Cooke, Parke, Wilson, Robinson, Dry, Schnebly, Reecer, and Jones creeks. MAR sites identified in the Yakima Basin Manage Aquifer Recharge Study (EA et al., 2020). The study sites are shown in Figure 1.

Field data collection

The approximate location of stream gauges at Taneum, Big, Little, Naneum, Wenas, Cooke, Parke, Wilson, Robinson, Dry, Schnebly, Reecer, and Jones creeks are shown in Figure 1. The observation well placement at Taneum Creek and the MAR site is shown in the Figure 4. These are proposed approximate locations at the time of preparation of this document. The number and actual locations of monitoring wells will be confirmed in the field with Ecology and the Bureau of Reclamation prior to well construction.

Sampling locations and frequency

Measurement locations are identified in Figure 1 and Figure 4. Frequency of measurements with respect to installed equipment are in Table 8. Data will be retrieved and downloaded at least bi-monthly, weather permitting. Wadable stream measurements will be obtained during field visits but are weather dependent. Non-wadable stream discharge measurements will be obtained during higher flow events but are weather dependent. The respective Standard Operating Procedures are shown in Table 5 and include EAP057, EAP056, EAP042, EAP052, and ECY Publication: No.17-11-005.

Field parameters and laboratory analytes to be measured

The environmental parameters and respective frequency are shown in Table 8. Laboratory water quality analysis will not be performed as part of this QAPP.

Assumptions of study design

Assumptions associated with the development of rating curves are described in Kennedy (1984). The final report will include the assumptions built into the results of this study. In general, the streamflow measurements are being taken to provide empirical evidence of water volumes in the tributary streams. When compared to existing demand and environmental flows, this work will demonstrate the presence or absence of flood flows potentially available for MAR and the associated benefits in the upper Yakima Basin.

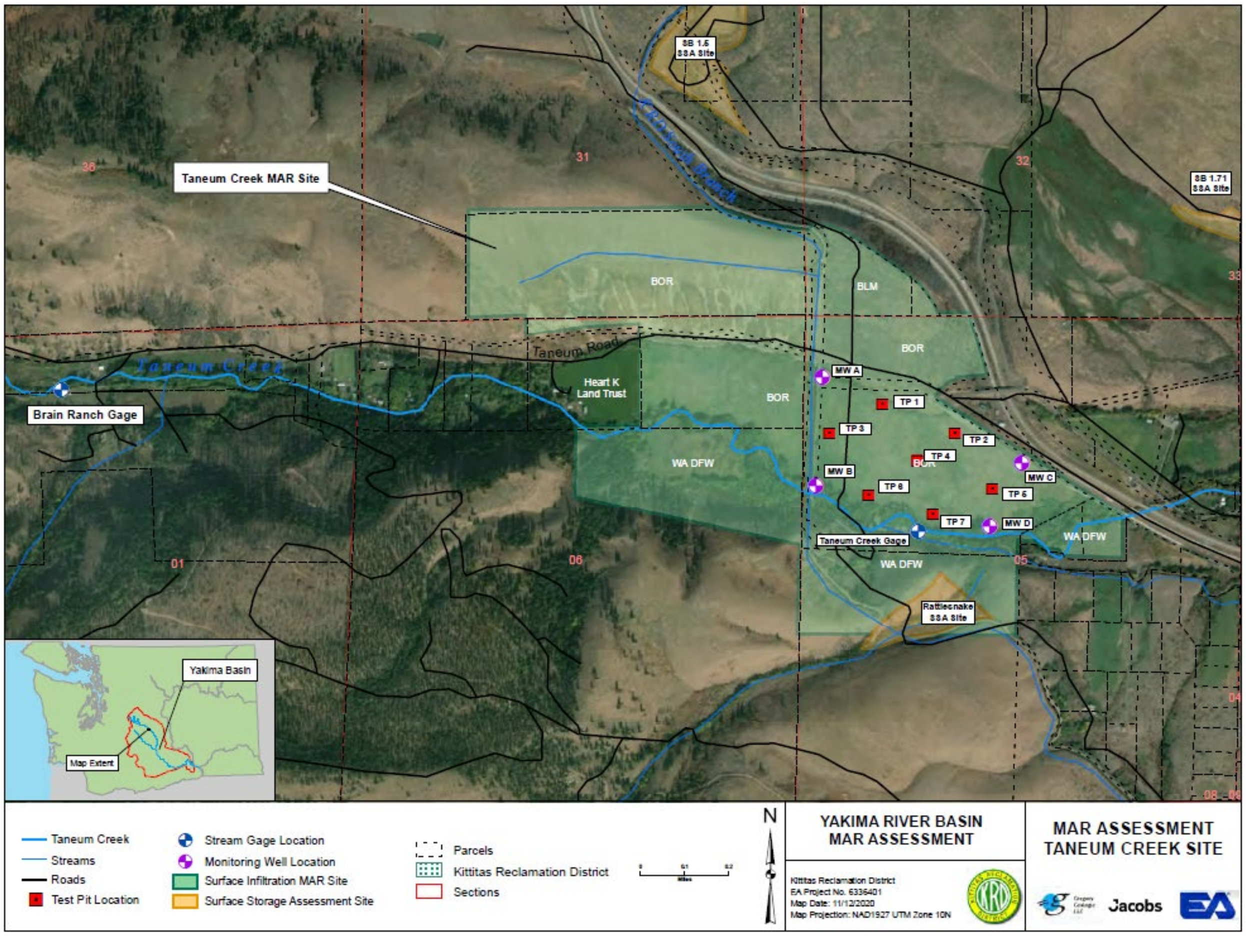


Figure 17 Proposed monitoring well and test pit locations near Taneum Creek

Table 9 The environmental parameters measured and respective frequencies

Environmental Parameters	Frequency	Equipment	Model
Open Channel Flow Velocity	Monthly, weather permitting	Marsh McBirney	FLO-MATE 2000
Open Channel Flow Discharge	Monthly, weather permitting	Acoustic Doppler Profiler	Son Tek RS5
Latitude and Longitude	Once when location is established.	Garmin GPS	Vista Etrex
Water Well Levels	Hourly	In-Situ RuggedTROLL® Loggers	RT100
Water Pressure	Hourly	In-Situ RuggedTROLL® Loggers	RT100

Water Temperature	Hourly	In-Situ RuggedTROLL® Loggers	RT100
Barometric Pressure	Hourly	In-Situ Rugged BaroTROLL	Baro
Air Temperature	Hourly	In-Situ Rugged BaroTROLL	Baro
Depth to water	IAs available, no less than quarterly	Slope Indicator Water Level Indicator (E-Tape)	300 ft.

Possible challenges and contingencies

Monthly wadable measurements may not be possible if flood conditions are present at the time of measurement. Ice may form in the winter in the small streams rendering transducer measurements unreliable. Vandalism and/or natural destruction of sampling equipment may limit data analysis. Other logistical problems that might impact accuracy of data collection include unstable stream channels, flash flood events, variable backwater/unsteady flow, aquatic growth in the river channel, and bank overflow during varying stages of flow. Standard gaging techniques and procedures reduce many of these issues. Common techniques used for resolving weather-related issues are detailed in Tilren (1986) and Cudworth (1989). Logistical problems at observation wells may include borehole stability problems, incrustation, corrosion, etc. Standards approaches for resolving well-related issues are described in Weight and Sonderegger (2001).

Practical constraints and schedule limitations

Equipment and staff availability may limit data retrieval, the study period and/or our ability for data analysis. The schedule may require revision if the review period for the QAPP and the draft of the final report are delayed. Other potential scheduling delays include driller's schedules and availability, site access constraints, adverse weather, COVID-19 restrictions and environmental regulations and permitting approvals.

5.0 Field Procedures

As detailed, a need exists for continuous stream measurements at Taneum, Big, Little, Naneum, Wenas, Cooke, Parke, Wilson, Robinson, Dry, Schnebly, Reecer, and Jones creeks, aquifer characteristics and groundwater levels near Taneum Creek with respective soil infiltration rates. The objective of this project will fulfil these gaps through 1) the monitoring of stream discharge, 2) the installation of observation wells at optimal locations, and 3) soil examinations at a potential MAR site.

This project will install data loggers and gauges in Taneum, Big, Little, Naneum, Wenas, Cooke, Parke, Wilson, Robinson, Dry, Schnebly, Reecer, and Jones creeks to measure stream discharge. Instantaneous flows will be measured at low, medium, and high flow stages, in addition to continuous stage readings, to develop rating curves allowing for the conversion of data to discharge rates. Continuous measurements of water level data at observation wells will provide daily and seasonal water table profiles. A percolation test will be conducted at the Taneum Creek MAR site to determine soil infiltration rates. Figure 6 shows the process and Standard Operating Procedures (SOP) described throughout this QAPP and utilized for this project. Details including descriptions of each SOP and guidelines are shown in Table 1, in addition to those available in the appendices.

The procedure for making a discharge measurement with the Marsh McBirney FLO-MATE and Acoustic Doppler Profiler follows the well-established methodology as outlined by Campbell (2015). This method is also referred to as the "Mid-Section method" of computing discharge.

The mid-section method involves making a series of velocity and depth measurements at a specific number of locations (more commonly known as stations, panels, or verticals) across a river cross-section. At each station, the depth and mean velocity profile are measured. The depth is computed using either the 4-velocity beams, the vertical beam, or manually measured (using a rod or other device) and entered into the software. The mean velocity profile for each station is computed from data from all valid cells above the riverbed. The width of a single station is determined to be the sum of half the distance to the previous station and half the distance to the following station. This method assumes that the velocity profile at each station represents the mean velocity for the entire rectangular station area.

Each station is measured for a significant time to remove any environmental and temporal variation in the water velocities. Typically, within the USGS, the recommended duration of measurement for a single station is 40 seconds. However, in particularly turbulent waters, extremely low-velocities, or in areas or rapidly changing water-level, a longer period may be required.

The key issues to consider when selecting the location of measurement cross-section are:

- Select an area of relatively uniform and steady flow. Try to avoid areas with standing eddies or strong turbulence. Note that a measurement may still be made in these areas however it may take longer to establish a mean profile (i.e., the averaging interval may need to be increased).

- The cross-section should have gradual changes in depth.

- Flow along the riverbanks should be low or close to zero.

To take a discharge measurement the operator starts at one edge (the start bank), recording the starting-edge location, water depth and gauge heights. The operator then proceeds to the first station and enters the station location, transducer depth, and gauge heights (not required). If ice is present, the values for the ice thickness, depth of water and slush thickness should also be entered. The RS5 is positioned with the transducers submerged and the system as vertical as possible. Ideally the system will be mounted to a platform, vessel, or mounting structure.

Data collection begins and the RS5 measures the 3D current velocities and bottom depth throughout the water column. Only the component of water velocity perpendicular to the transect line (or azimuth) is used to ensure proper discharge calculations, regardless of the flow direction. This normal component of the velocity is known as the “Normal Velocity.” The true flow direction or “True Velocity” is still measured, recorded and will be displayed on screen or as a comparison with the Normal Velocity. At the end of the averaging time for the measurement, the discharge is calculated using the formula shown in Figure 5. Repeat the steps above at each station along the transect until the last station is completed.

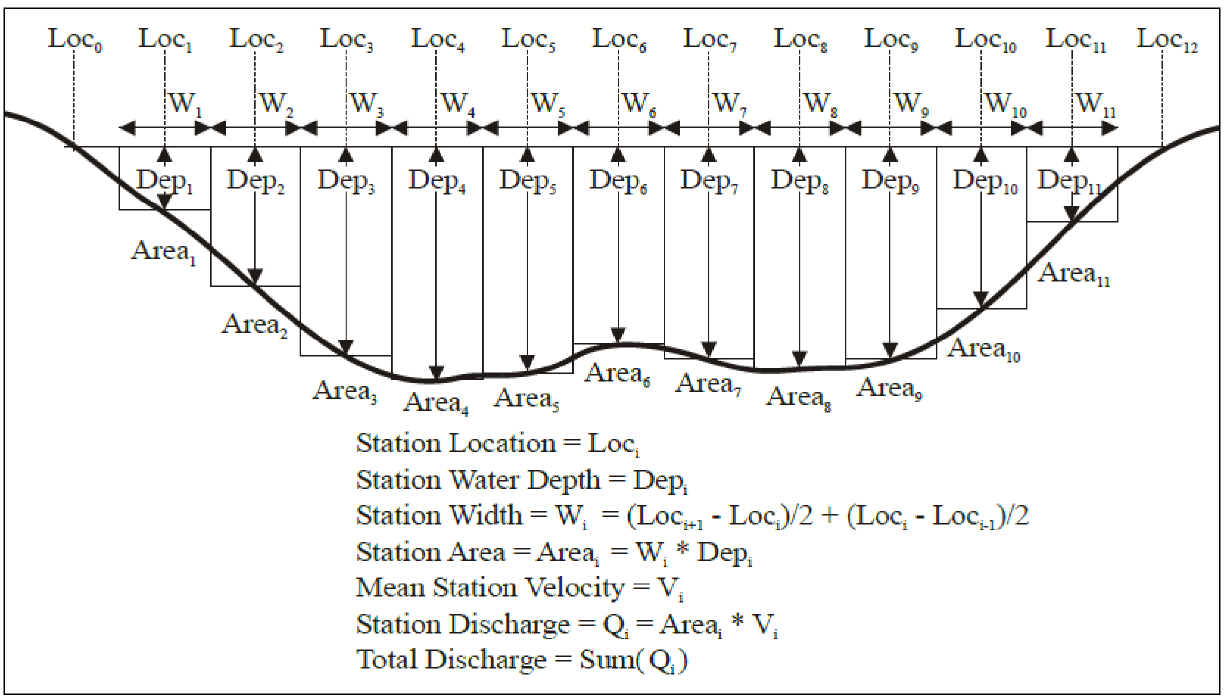


Figure 18 Mid-Section Method for Discharge Measurement

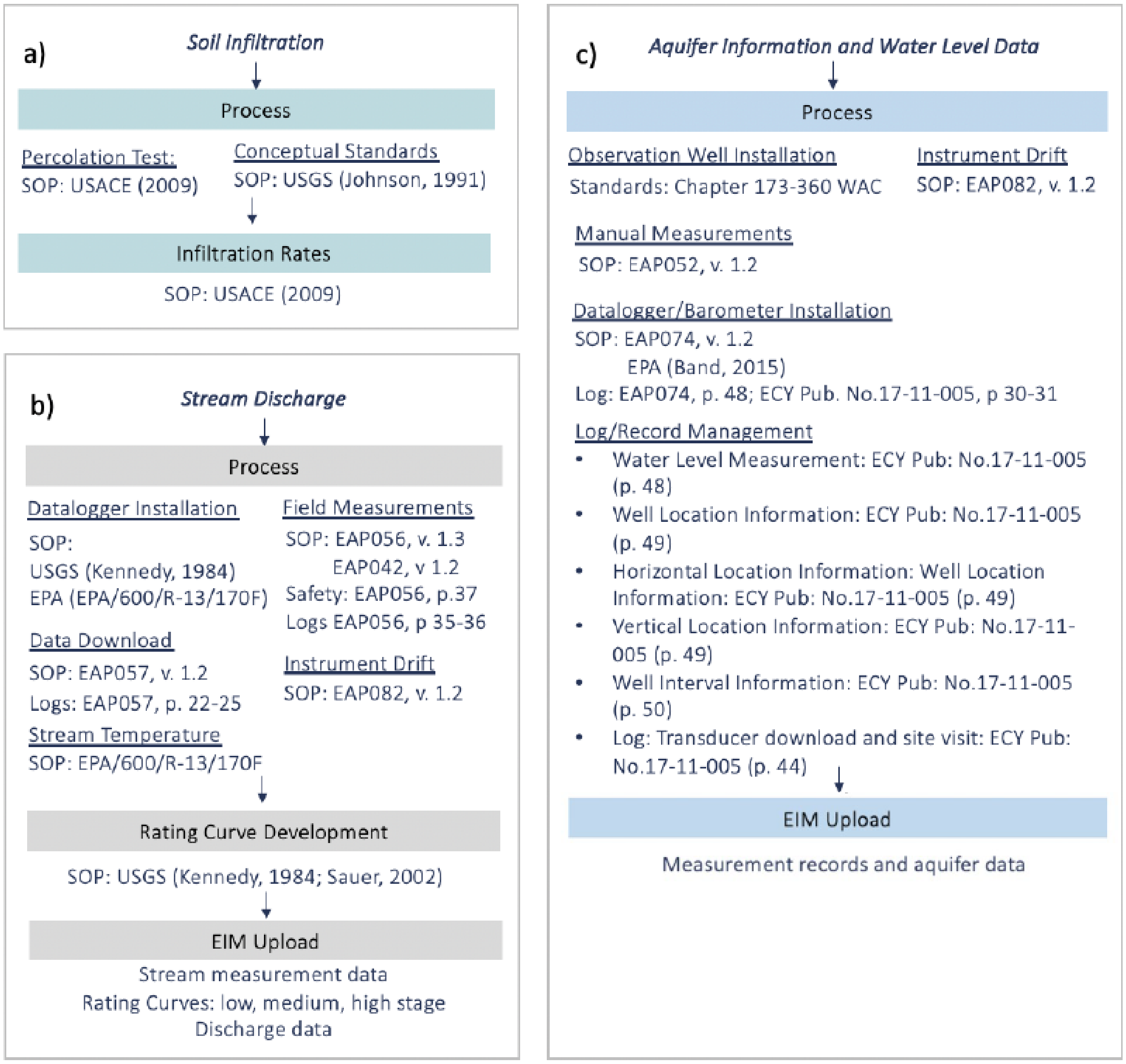


Figure 19 Target goals and the Standard Operating Procedures used to meet objectives described in this QAPP for a) soil infiltration rates, b) stream discharge, and c) aquifer information and water well levels

Table 10 Description of SOPs and guidelines used throughout this document

Application	Document ID	Name
Soil Infiltration	Johnson, 1991	A Field Method for Measurement of Infiltration.
	USACE, 2009[1]	AED Design Requirements: Sanitary Sewer and Septic System
Stream Discharge	EAP056, v. 1.3[2]	Measuring and Calculating Stream Discharge
	EAP042, v. 1.2[2]	Measuring Gauge Height of Streams
	EAP057, v. 1.2[2]	Conducting Stream Hydrology Site Visit
	EAP082, v. 1.2	Correction of Continuous Stage Records Subject to Instrument Drift
	EPA/600/R-13/170F	Best Practices for Continuous Monitoring of Temperature and Flow in Wadeable Streams
	Kennedy, 1984	Discharge Rating at Gaging Stations
	Sauer, 202	Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods
Aquifer Data and Water Level Information	EAP052, v. 1.2[3]	Manual Well-Depth and Depth to Water Measurements
	EAP074, v. 1.2[3]	Use of Submersible Pressure Transducers During Groundwater Studies
	EAP082, v. 1.2	Correction of Continuous Stage Records Subject to Instrument Drift
	ECY Pub: No. 17-11-005	Integrated Statewide Groundwater Monitoring Strategy
	ASTM D4050-20	Standard Test Method for (Field Procedure) for Withdrawal and Injection Well Testing for Determining Hydraulic Properties of Aquifer Systems
	Band, 2015	Standard Operating Procedure for the Standard/Well-Volume Method for Collecting Ground-Water Sample from Monitoring Wells for Site Characterization
	Cunningham and Schalk, 2011	Groundwater Technical Procedures of the U.S. Geological Survey

[1]Appendix A: SOP Surface Infiltration (Percolation Test: modified from USACE, 2009)

[2]Appendix B: ECY SOP: Stream Gauges

[3]Appendix C: SOP Aquifer Information and Water Level

Measurement and sampling procedures

Dataloggers

Datalogger download will follow guidelines outlined in SOP EAP057 for stream gauges and SOP ECY Publication: No.17-11-005 and EPA (Band, 2015) for observation well procedures.

The In-Situ RuggedTROLL® Dataloggers will be used for stream gauges and observation wells. They will be downloaded to field computers programmed with the latest version of Win-Situ Software. The BaroTROLL® datalogger data will be downloaded to a field computer programmed with Win-Situ Baro Merge® Software. The software will used to convert absolute pressure readings from non-vented dataloggers to water pressure values by subtracting the corresponding barometric pressure. The calculated water pressure value will be used determine a water level elevation. The dataloggers will be removed from the streams for data download on at least a bi-monthly basis. It is not anticipated that any datalogger will reach measurement capacity, so none will be restarted unless necessary.

The dataloggers will begin recording on the hour and will be launched prior to deployment. They will be deployed as soon as possible.

Stream Gauge

Stream gauge dataloggers will be installed in accordance with guidelines described by the EPA (EPA/600/R-13/170F). Additionally, the dataloggers will be deployed in plastic pipe attached to heavy-duty steel fenceposts driven using a slide hammer into the streambed. Plastic pipe will be of sufficient diameter to permit deployment of the datalogger and will be fitted with a bushing of appropriate diameter to retain the datalogger within the plastic pipe. The plastic pipe should protect the datalogger from consumption by beavers or other stream residents.

Gauge stations will be located with a field GPS unit using WGS 84 decimal degrees precise to 5 significant digits. The plastic pipe will be attached to the fencepost using screw-type clamps, and the datalogger will be deployed at or near the elevation of the stream bottom at that point.

A staff gauge will also be attached to the fencepost to assist in measurement.

During installation, the following record of data, described in EAP EAP057, will include:

- Unique identifier site number
- Names of personnel involved with the installation
- Date and time of installation
- Datalogger serial number
- GPS coordinates of the datalogger
- Elevation estimate
- Site condition
- Water temperature
- Photos of datalogger location

All time data will be collected in Pacific Daylight Time

Field measurements

Instantaneous stream flow measurements will be conducted at each site in accordance with SOP EAP056 and EAP042. The Marsh McBirney FLO-MATE, in possession of the Kittitas Reclamation District, will be operated in Real-Time which allows for streamflow velocity measurements. Stream measurements in conjunction with adjacent datalogger data will be used to develop rating curves for each location, correlating flow with water table elevation. Rating curves will be produced by plotting the instantaneous flow measurements and stage heights from each location using spreadsheets created in Microsoft Excel. Rating curve method depend upon recorded measurements; therefore, the following methods described in Kennedy (1984), EPA document EPA/600/R-13/170F, and Sauer (2002) will be chosen once measurement data become available.

Table 11 Stream Gauge and Monitoring Well Coordinates

Site Location	Type	Lat	Long
Big Ck	Stream Gage	47.2007	-121.1160
Little Ck	Stream Gage	47.1722	-121.0970
Taneum Ck. Gage and Barologger	Stream Gage	47.0811	-120.7450
Naneum Ck. Downstream	Stream Gage	47.1034	-120.4760
Naneum Ck. Up	Stream Gage	47.1236	-120.4800
Reecer Ck	Stream Gage	47.1627	-120.6030
Dry Ck	Stream Gage	47.1098	-120.6620
Robinson Ck	Stream Gage	47.0153	-120.6950
Jones Ck	Stream Gage	47.1077	-120.5840
Wilson Ck	Stream Gage	47.0733	-120.4890
Schnebly Ck	Stream Gage	47.0936	-120.4350
Cooke Ck	Stream Gage	47.1040	-120.3760
Parke Ck	Stream Gage	47.0083	-120.3240
Wenas Ck	Stream Gage	46.7858	-120.6410
MW B	Well	47.0826	-120.7500
MW A	Well	47.0861	-120.7500
MW C	Well	47.0833	-120.7400
MW D	Well	47.0813	-120.7420

Geographic Coordinate System: GCS North American 1927

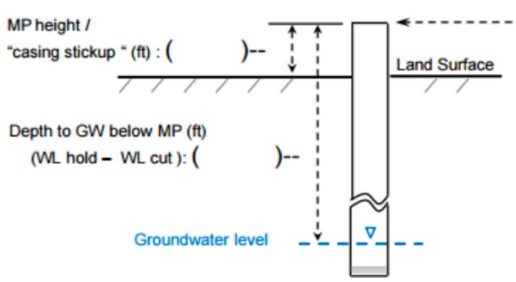
Date: ____________________ Field Crew: ___________________________

Basic Information

1. Site/project well ID name: ____
2. Owner name: ____
3. Owner phone number: ____
4. Renter information (if applicable): ____
5. Address, including county: ____
6. Well tag number: ____
7. Well use and status: ____
8. Access approval required: Yes/No
9. Special well access instructions ____
10. Photographs taken: Yes/No

Well Construction Information

Total well depth (ft):___________ Well diameter (in):_________ Drillers log available: (Y) (N)



WL measuring point ID: ___________

MP description: __________________ __________________

WL Time:__________ (PST) (PDT)

WL hold value (ft):__________

WL cut value (ft):__________

WL method:__________

WL accuracy:__________

Additional well construction information from the owner may be helpful, particularly if a driller's log is not available, including:

a. driller's name: ____
b. date drilled: ____
c. well type (drilled, bored, or dug):____
d. well finish (screen, open hole): ____
e. well yield/dependability: ______________________________________
f. amount of water use: ____
g. water quality: ____

Well Location Information

Lat (DD):______________ Long (DD):________________ Datum: NAD27/NAD83/WGS84

GPS indicated horizontal accuracy (ft): _________ # of satellites used for determination: ______

Site surface elevation (ft): ______ Elevation method: ___________ Elevation accuracy (ft): ____

Vertical datum: NGVD29/NAVD88

Water Level Measurement

Date: _________ Time: __________ Measuring Point (MP) ID: ___________________________

Depth below Measuring Point (MP) (ft) ___________ Well status: ______________

Measurement method: ____________ Measurement accuracy (1 ft, 0.1 ft, or 0.01 ft): ________

Figure 20 Well site documentation. Obtained from ECY Publication No.17-11-005 (p. 30-31)

Deployment of Dataloggers

Dataloggers will be suspended in wells using the Ecology ERO SOP (Band, 2015) of 30lb test low stretch fishing line, Berkley Fireline, or equivalent. The line will be approximately 1/3 of the rated pressure range of the unit. Static water level at each well will be determined by e-tape, per ECY EAP0502, Version 1.2, as available, but at least quarterly during the study period, and at the time of each datalogger data collection. Monitoring well measuring points have been surveyed for elevation and groundwater elevations will calculated using the surveyed elevation and static water level measurements. Manual measurements are performed for data logger deployment and used as a QA/QC check groundwater water level elevation. Elevation will be calculated in feet above mean sea level (NAVD 88)

Dataloggers will be deployed using ERO datalogger deployment protocol described in ECY Publication No.17-11-005, which generally consists of:

- Obtain water level with E-tape
- Attach decontaminated unit to Fireline or equivalent spool with a Uni-knot at proper depth (approximately 1/3 of the rated pressure range of the unit)
- The line is measured with a string-box survey instrument (hip-chain)
- A swivel will be attached to the unit Fireline then interlocked with a swivel attached to the well using a security measure (ring, zip tie, etc.)

When the study is ended, dataloggers will be collected, water levels taken in each individual well with E-tape, and data will be downloaded to individual comma-delimited ascii-files. Each file will be labeled with the serial number and common name of the well.

Files will be examined, and the dataset will be trimmed to exclude data on the ends of the dataset unrepresentative of aquifer or surface water conditions

Each file will contain the serial number, the GPS location of each well, the common name of the well, the data gathered by the datalogger, and the date and time of any E-tape water table elevation determinations for that well.

Percolation Test

Any percolation tests at the Taneum Creek site will follow SOP EPA, 2009, which describes a 5-step process summarized below:

1. Six or more tests will be made in separate test holes uniformly spaced over the proposed absorption field site.
2. Dig or bore a hole of size capable of accepting the amount of water available.
3. Add 50 mm of gravel (of the same size that is to be used in the absorption field) to the bottom of the hole.
4. Carefully fill the hole with clear water to a minimum depth of 300 mm above the gravel or sand. Keep water in the hole at least 4 hours.
5. The percolation-rate measurement is determined by one of the 3 methods; if water remains, if no water remains, or if the soil is sandy.

Field log requirements

A field log is an important component of this projects. Field logs will be used to record irreplaceable information, including:

- Name and location of project
- Field personnel
- Sequence of events
- Any changes or deviations from the QAPP or SOPs
- Environmental conditions
- Date, time, location, ID, and description of each sample
- Field instrument calibration procedures
- Field measurement results
- Identity of QC samples collected
- Unusual circumstances that might affect interpretation of results
- Field log practices include:
    - Use bound, waterproof notebooks
    - Make corrections with single line strikethroughs, initial and date corrections. Do not use correction fluid such as White-Out.
    - Electronic field logs may be used, they must have equivalent security to a waterproof, bound notebook.

Field log requirements will be guided by the SOPs listed in Table 11.

Table 12 Standard Operating Procedures for field logs and records of measurement requirements in this QAPP

Logs and Records of Measurements	Standard Operating Procedure
Data Download	
Stream Gauges	EAP057 (p. 22-25)
Stream Field Measurements	EAP056 (p.37)
Observation Well Field Measurements	ECY Publication No.17-11-005 (p. 30-31)
Datalogger/Barometer Installation	EAP074 (p.48)

Other activities

These will include:

- Briefings and trainings for field staff as necessary to engage new staff, and once annually to refresh.
- Daily field safety meeting, including discussion of COVID-19 safety protocols per KRD and State guidelines.
- Periodic maintenance for field instrumentation in accordance with manufacturers recommendations and as needed.

6.0 Quality Control

Quality control procedures and safety measures for stream measurements and observation well measurements are listed in Table 13 of section 10.1 below. Calibration and testing of field equipment prior to deployment is specified under the specific SOP listed in Table 12.

Table 13 Quality control samples, types, and frequency

Type	Frequency	Steps in preparation of fieldwork	Steps taken in the field	Corrective actions where applicable
Safety	Each visit	Vehicle and Equipment Checklist (SOP: EAP056, p.37)		
Stream measurements	Each visit	Review equipment checklist: ensure station information and forms are on hand; test stream measurement equipment for proper operation (SOP: EAP056)	Detailed steps described in SOP: EAP056 section 6.2 through 6.16.10	Horizontal, vertical, and single-point velocity variation; Adjusting velocities of oblique flow angles, measuring discharge when stage fluctuate rapidly, and calculating mean gauge height when stage fluctuate rapidly: SOP EAP056 section 6.6 through 6.10 Measuring Gauge Height: SOP EAP042 Section 8.0 through 8.5
Manual well measurements and pressure transducer water level measurements	Each visit, at least quarterly.	SOP EAP052: Review equipment checklist; ensure station information and forms are on hand (section 5.0 through 5.5.22), conduct electric tape maintenance and calibration (Section 6.7 through 6.7.2.3; 6.8.2) ECY Pub: No.17-11-005: E-tape calibrated against steel tapes ECY Pub: No.17-11-005: Pressure transducer benched tested	SOP EAP052: Depth-to-water measurements with electric-tape (section 6.0 to 6.8.18. ECY Pub: No.17-11-005: Multiple e-tape measurements to represent true static water level	SOP EAP052: If organic contaminants are suspected: section 6.8.4.1 When repeated check measurements are not reproducible: section 6.8.12.3 Physical changes in the field such as erosion and cracks refer to section 6.8.18 ECY Pub: No.17-11-005: Failed equipment test – return to manufacture for repair or retire equipment

Datafiles obtained from the dataloggers will be visually examined for obvious outlier results or malfunctions.

After deployment, lat/long location, location common name, date and time of deployment, frequency of collection and standard/daylight time, and any notes about access contacts, etc. are recorded on the logger location spreadsheet.

Corrective action processes

In addition to the corrective process listed in Table 13, during the real-time (wadable) streamflow measurements, readings with noise levels flagged by the flowmeter may require stabilization by averaging velocities over a fixed period. These adjustments will be done at time of measurement using the "Fixed Point Average/Time Constant Filtering" mode on the FLO-MATE device. The streamflow measurements will be made at the same location unless otherwise noted at the time of measurement. Alterations to physical conditions at the measurement site, including debris, changes in channel morphology, etc. will be recorded and resolved as described in Tilren (1986) and Cudworth (1989).

Data will be removed if a large amount of clock drift is present (generally > 10%). If errors are less than the accuracy of the sensors listed in Table 4, and are not easily corrected, data will remain as is. Corrections will not be made unless the cause(s) of error(s) can be validated or explained, and any discrepancies and actions taken will be documented. Flagged data will be qualified prior to EIM entry.

Well Station Data

The corrective action processes for measurements obtained at well stations are detailed in SOP EAP052, ECY Publication No.17-11-005 and listed in Table 12.

7.0 Data Management Procedures

Electronic Data Management and Environmental Information Management (EIM) system

All electronic transfer requirements will be executed in readily usable formats to minimize data entry problems and to facilitate data analysis. All data will be formatted and entered into Ecology's EIM system.

Stream Gauge

Data will be downloaded directly to individual comma-delimited ascii-files. Each file will be labeled with the serial number and common name of the surface location. Files will be examined, and the dataset will be trimmed to exclude data on the ends of the dataset unrepresentative of surface water conditions based on criteria described in Kennedy (1984). Additionally, each file will contain the datalogger serial number, the GPS location of each stream gauge location, the common name of the location, the hourly data gathered by the datalogger, and the date and time.

The raw data files will be preserved in a password-protected folder. An electronic copy of the raw data will be named" common name_serialnumber_raw.dat files".

Monitoring Wells

As described in ECY Publication No. 17-11-005, the data will be downloaded directly to individual comma-delimited ascii-files. Each file will be labeled with the serial number and common name of the well. Each file will contain the datalogger serial number, the GPS location of each well, the common name of the well, the hourly data gathered by the datalogger, and the date, time, and any water table and elevation measurements obtained by E-tape.

Additionally, the raw data files will be preserved in a password-protected folder. An electronic copy of the raw data will be named" common name_serialnumber_raw.dat files".

Each file will have e-tape determinations superimposed on the graphed data. This will key the dataset to a single datum and permit visual estimation of and (if necessary) numerical quantification of instrument drift. Should instrument drift be detected, it will be quantified, and the data corrected accordingly.

All hardcopy documentation will be kept and maintained by the project lead.

8.0 Reporting and Field Activity Assessments

Monthly reports summarizing project status and current and upcoming activities will be provided to Ecology via email. Project progress reports will be submitted quarterly and with each payment request.

Two technical reports will be prepared for the project. The first report will be composed of field data collected at the High-Priority MAR sites, with a focus on natural stream flow data collection. The report will present the data collected, analysis, conclusions, and preliminary MAR assessment recommendations towards the high-priority MAR sites. Additional relevant field data, collected by other agencies prior to this investigation (i.e., Kittitas County, WDFW) will be included in this report. A draft technical report will be submitted to Ecology by April 30, 2023, for review. A final technical report will be submitted by June 30, 2023.

The second technical report will be a MAR Assessment of the Taneum Creek site (as a stand-alone MAR assessment report). The report will include all information collected at the Taneum Creek site. The report will present field data and analysis, infrastructure data and analysis, permitting strategy and an assessment of MAR implementation at the Taneum Creek site with recommendations. A draft technical report will be submitted to Ecology by April 30, 2023, for review. A final technical report will be submitted by June 30, 2023.

9.0 References

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10.0 Appendices

Appendix A: SOP Surface Infiltration

Percolation Test: Obtained from (EPA, 2009)

Percolation Testing. The second step, once the site has been surveyed, is to perform percolation tests. While performing the tests, observe the soil characteristics and watch for groundwater within the test area. The site may be considered unsuitable if the following occurs: the soil appears to have too much sand or clay; groundwater is encountered; and/or the percolation rates are too slow. If the site is determined to be unsuitable, the septic system will need to be relocated. If another location cannot be found, then an alternative treatment system will need to be designed. If this happens, contact the COR.

Percolation testing may be carried out with a shovel, posthole digger, solid auger or other appropriate digging instruments. Percolation tests shall be accomplished uniformly throughout the area where the absorption field is to be located. Percolation tests determine the acceptability of the site and serve as the basis of design for the liquid absorption. Percolation tests will be made as follows (see Figure 5).

(1) Six or more tests will be made in separate test holes uniformly spaced over the proposed absorption field site. The average of the six tests shall be determined and will be used as the final result. ***The location of each test shall be clearly and accurately shown on the site plan submitted to AED***.

(2) Dig or bore a hole to the required depth of the proposed trenches or bed, with dimensions necessary to enable visual inspection during percolation testing.

(3) Carefully scratch the bottom and sides of the excavation with a knife blade or sharp- pointed instrument to remove any smeared soil surfaces and to provide a natural soil interface into which water may percolate. Add 50 mm of gravel (of the same size that is to be used in the absorption field) to the bottom of the hole. In some types of soils, the sidewalls of the test holes tend to cave in or slough off and settle to the bottom of the hole. It is most likely to occur when the soil is dry or when overnight soaking is required. The caving can be prevented and more accurate results obtained by placing in the test hole a wire cylinder surrounded by a minimum 25 mm layer of gravel (of the same size that is to be used in the absorption field.)

(4) Carefully fill the hole with clear water to a minimum depth of 300 mm above the gravel or sand. Keep water in the hole at least 4 hours and preferably overnight. In most soils it will be necessary to augment the water as time progresses. Determine the percolation rate 24 hours after water was first added to the hole. In sandy soils containing little clay, this pre- filling procedure is not essential and the test may be made after water from one filling of the hole has completely seeped away.

(5) The percolation-rate measurement is determined by one of the following methods:
(a) If water remains in the test hole overnight, adjust the water depth to approximately 150 mm above the gravel. From a reference batter board, as shown in Figure 5, measure the drop in water level over a 30-minute period. This drop is used to calculate the percolation rate.

(b) If no water remains in the hole the next day, add clean water to bring the depth to approximately 150 mm over the gravel. From the batter board, measure the drop in water level at 30-minute intervals for 4 hours, refilling to 150 mm over the gravel as necessary. The drop in water level that occurs during the final 30-minute period is used to calculate the percolation rate.

(c) In sandy soils (or other soils in which the first 150 mm of water seeps away in less than 30 minutes after the overnight period), the time interval between measurements will be taken as 10 minutes and the test run for 1 hour. The drop in water level that occurs during the final 10 minutes is used to calculate the percolation rate.

The percolation rate is the number of minutes it takes to drop 25 mm. On page 10, Table 2 lists percolation rates and the corresponding absorption field sizing factor (liters/m^2/day). The sizing factors are used, in conjunction with average daily demand (ADD), to determine the size of the absorption field. The following is an example of how to calculate the percolation rate:

Appendix B: ECY SOP: Stream Gauges

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Washington Department of Ecology. 2018. EAP072, Version 2. Standard Operating Procedure EAP072, Version 2.0: Basic Use and Maintenance of WaterLOG® Data Loggers and Peripheral Equipment, Publication 18-03-212. 25 p. https://apps.ecology.wa.gov/publications/SummaryPages/1803212.html

Measuring and Calculating Stream Discharge

Washington Department of Ecology. 2018 EAP056 , Version 1.3. Measuring and Calculating Stream Discharge. Publication No. 18-030-203. 39 p. https://apps.ecology.wa.gov/publications/SummaryPages/1803203.html

Appendix C: SOP Aquifer Information and Water Level

Measuring Gauge Height of Streams

Washington Department of Ecology. 2018. EAP042, Version 1.2. Measuring Gauge Height of Streams. Publication No. 18-03-232. 22 p. https://apps.ecology.wa.gov/publications/SummaryPages/1803232.html

Manual Well-Depth and Depth-to-Water Measurements

Washington Department of Ecology. 2019. EAP057, Version 1.2. Conducting Stream Hydrology Site Visit. Publication No. 19-03-209. 25 p. https://apps.ecology.wa.gov/publications/SummaryPages/1903209.html

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Washington Department of Ecology. 2019. EAP074, Version 1.2. Use of Submersible Pressure Transducers During Groundwater Studies. Publication 19-03-205. 55 p. https://apps.ecology.wa.gov/publications/SummaryPages/1903205.html

Appendix D. Glossaries, Acronyms, and Abbreviations

Units of Measurement

°C degrees centigrade

cfs cubic feet per second

cfu colony forming units

cms cubic meters per second, a unit of flow

dw dry weight

ft feet

g gram, a unit of mass

kcfs 1000 cubic feet per second

kg kilograms, a unit of mass equal to 1,000 grams

kg/d kilograms per day

km kilometer, a unit of length equal to 1,000 meters

L/s liters per second (0.03531 cubic foot per second)

m meter

mm millimeter

mg milligram

mgd million gallons per day

mg/d milligrams per day

mg/kg milligrams per kilogram (parts per million)

mg/L milligrams per liter (parts per million)

mg/L/hr milligrams per liter per hour

mL milliliter

mmol millimole or one-thousandth of a mole

mole an International System of Units (IS) unit of matter

ng/g nanograms per gram (parts per billion)

ng/kg nanograms per kilogram (parts per trillion)

ng/L nanograms per liter (parts per trillion)

NTU nephelometric turbidity units

pg/g picograms per gram (parts per trillion)

pg/L picograms per liter (parts per quadrillion) psu practical salinity units

s.u. standard units

μg/g micrograms per gram (parts per million)

μg/kg micrograms per kilogram (parts per billion)

μg/L micrograms per liter (parts per billion)

μm micrometer

μM micromolar (a chemistry unit)

μmhos/cm micromhos per centimeter

μS/cm microsiemens per centimeter, a unit of conductivity

ww wet weight

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data (Kammin, 2010). For Ecology, it is defined according to WAC 173-50-040: "Formal recognition by [Ecology] that an environmental laboratory is capable of producing accurate and defensible analytical data."

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms *precision* and *bias* be used to convey the information associated with the term *accuracy* (USEPA, 2014).

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella (Kammin, 2010).

Bias: Discrepancy between the expected value of an estimator and the population parameter being estimated (Gilbert, 1987; USEPA, 2014).

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process (USGS, 1998).

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured (Ecology, 2004).

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards but should be referred to by their actual designator, e.g., CRM, LCS (Kammin, 2010; Ecology, 2004).

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator (USEPA, 2014; USEPA, 2020).

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator (USEPA, 2014; USEPA 2020).

Continuing Calibration Verification Standard (CCV): A quality control (QC) sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run (Kammin, 2010).

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system (Kammin, 2010; Ecology 2004).

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean (Kammin, 2010).

Data integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading (Kammin, 2010).

Data quality indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity (USEPA, 2006).

Data quality objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 2006).

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010).

Data validation: The process of determining that the data satisfy the requirements as defined by the data user (USEPA, 2020). There are various levels of data validation (USEPA, 2009).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set (Ecology, 2004).

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero (Ecology, 2004).

Duplicate samples: Two samples taken from and representative of the same population and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis (USEPA, 2014).

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport (Ecology, 2004).

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples (Kammin, 2010).

Laboratory Control Sample (LCS)/LCS duplicate: A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. Monitors a lab's performance for bias and precision (USEPA, 2014).

Matrix spike/Matrix spike duplicate: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias and precision errors due to interference or matrix effects (Ecology, 2004).

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness (USEPA, 2006).

Measurement result: A value obtained by performing the procedure described in a method (Ecology, 2004).

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed (USEPA, 2001).

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples (Ecology, 2004; Kammin, 2010).

Method Detection Limit (MDL): The minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results (USEPA, 2016). MDL is a measure of the capability of an analytical method of distinguished samples that do not contain a specific analyte from a sample that contains a low concentration of the analyte (USEPA, 2020).

Minimum level: Either the sample concentration equivalent to the lowest calibration point in a method or a multiple of the method detection limit (MDL), whichever is higher. For the purposes of NPDES compliance monitoring, EPA considers the following terms to be synonymous: "quantitation limit," "reporting limit," and "minimum level" (40 CFR 136).

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all parameters (Kammin, 2010; Ecology, 2004).

Population: The hypothetical set of all possible observations of the type being investigated (Ecology, 2004).

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator (USGS, 1998).

Quality assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data (Kammin, 2010).

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives (Kammin, 2010; Ecology, 2004).

Quality control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data (Ecology, 2004).

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$RPD = [Abs(a-b)/((a + b)/2)] * 100\%$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Relative Standard Deviation (RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$RSD = (100\% * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled (USGS, 1998).

Reporting level: Unless specified otherwise by a regulatory authority or in a discharge permit, results for analytes that meet the identification criteria (i.e., rules for determining qualitative presence/absence of an analyte) are reported down to the concentration of the minimum level established by the laboratory through calibration of the instrument. EPA considers the terms "reporting limit," "quantitation limit," and "minimum level" to be synonymous (40 CFR 136).

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator (USGS, 1998).

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population (USGS, 1998).

Sample (statistical): A finite part or subset of a statistical population (USEPA, 1992).

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit (Ecology, 2004).

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method (USEPA, 2014).

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency (USEPA, 2014).

Split sample: A discrete sample subdivided into portions, usually duplicates (Kammin, 2010).

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity (Kammin, 2010).

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis (Kammin, 2010).

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning (USEPA, 2006).

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