Quality Assurance Project Plan

Kittitas Reclamation District's Targeted Managed Aquifer Recharge Project

Grant Agreement Number: WRYBIP-2325-KittRD-00053
EIM Study ID: WRYBIP-2325-KittRD
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Publication Information

This Quality Assurance Project Plan (QAPP) plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, the author will post the final report of the study to the YBIP Groundwater Subcommittee data repository website hosted by Central Washington University. This QAPP describes the project listed under WA Department of Ecology Office of Columbia River Grant Number WRYBIP-2325-KittRD-00053.

This Quality Assurance Project Plan is available online at https://apps.ecology.wa.gov/publications/SummaryPages/2412014.html

Data for this project will be available in Ecology's Environmental Information Management System (EIM) under EIM Study ID: WRYBIP-2325-KittRD. This QAPP is valid through September 2029.

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Cover photo: Taneum Creek at Mouth. Photo by KRD.

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September 2024

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2.0 Abstract

Managed Aquifer Recharge (MAR) is a cost-effective way to increase water storage. Previous MAR assessments conducted by the Kittitas Reclamation District (KRD) identified locations suitable for project implementation based on qualifying characteristics. High-priority locations were identified 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. Targeted research on stream discharge and local groundwater is required as we further prioritize sites for MAR implementation projects.

The objective of this study is to acquire real-time stream discharge rates at sites identified in the MAR assessment and at the four test wells previously installed at the Taneum Creek Shallow Aquifer Recharge (SAR) site. The new data will increase our understanding of water availability and occurrence in the Upper Yakima River Basin.

In cooperation with project partners/ Yakima Basin Integrated Plan (YBIP) Groundwater Subcommittee co-chairs, the KRD and their project contractor Jacobs Engineering established 11 sites where piezometers could be installed, flow metering conducted, and rating curves established. Data will be uploaded in near-real time and accessible to project partners.

Additionally, four test wells at the KRD’s Taneum Pilot Test site on Bureau of Reclamation Land at the base of Taneum Canyon will be monitored to track changes in groundwater levels due to natural conditions and to any potential aquifer recharge activities on that site.

Information gathered under the grant agreement will be available for use by the KRD, the YBIP Groundwater Subcommittee, and any other parties interested in flow data at the sites paving the way for future MAR/SAR projects or activities where knowing flow is important.

3.0 Background

3.1 Introduction and problem statement

The Kittitas Reclamation District (KRD) assessed MAR potential in the Kittitas Basin and identified 57 high-ranking locations (EA Engineering et al. 2020a). Work conducted at the top-ranking sites included installation of stream monitoring equipment and field site visits to estimate local streamflows at 14 locations to assess water availability for potential MAR projects (Jacobs, 2024; Ecology Grant Agreement WRYBIP-1921-KittRD-00017; EIM Study Number WRYBIP-1921-KittRD-00017-A). Results from this work showed water availability potential for MAR, however, installation of monitoring equipment with emphasis at Swauk Creek, Parke Creek, Cooke Creek, Upper and Lower Naneum Creek, Taneum Creek, Big Creek, Little Creek, and Wenas Creek is needed to increase confidence in data collection (Figure 1). Continued monitoring at the four monitoring wells installed for the Taneum Creek Pilot Test Shallow Aquifer Recharge (SAR) site (Figure 1) will expand on previous results described in Gregory Geologic and Jacobs (2024) (Ecology Grant Agreement WRYBIP-1921-KittRD-0017; EIM Study Number WRYBIP-1921-KittRD-00017-B

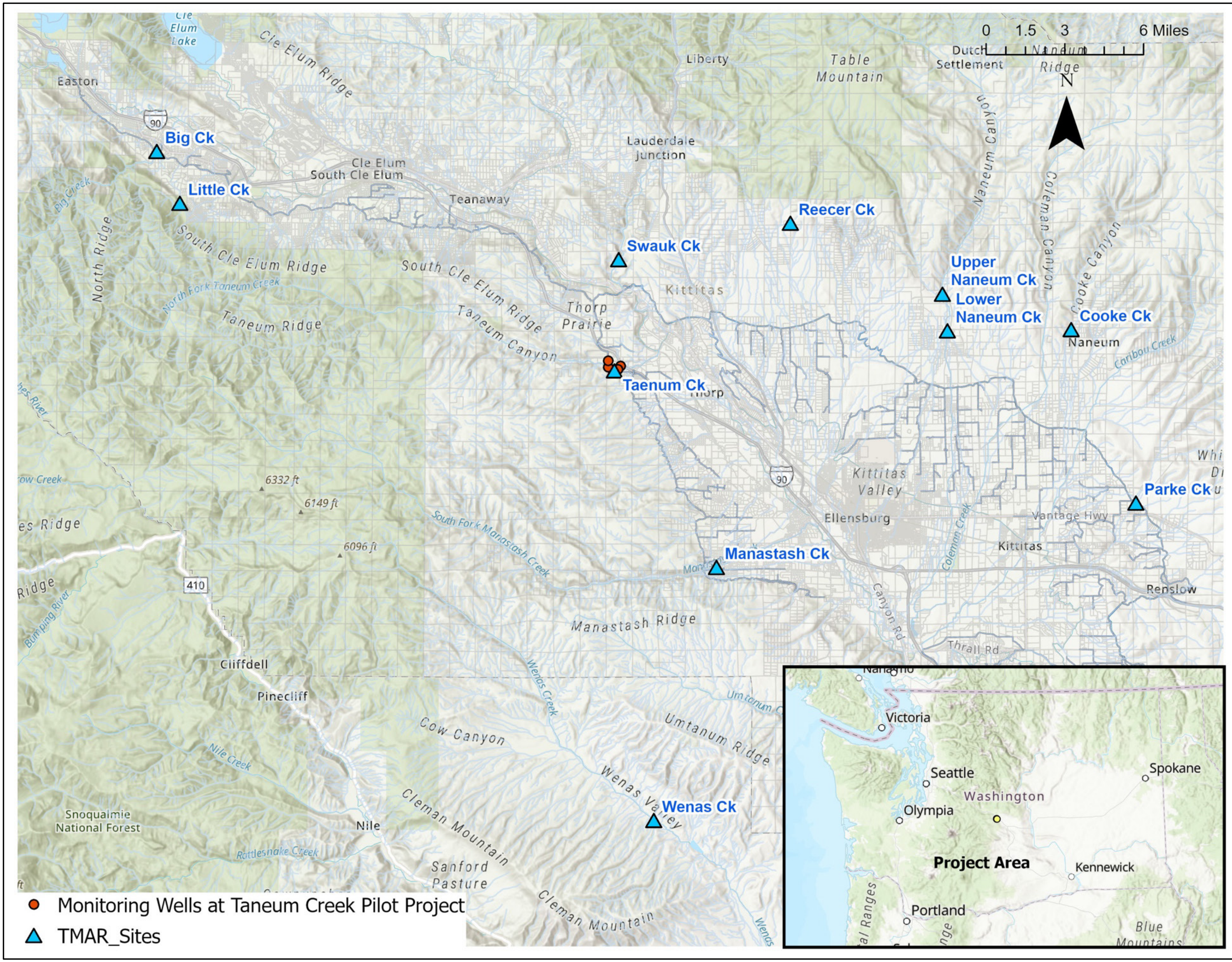


Figure 1. Map of study area in the Upper Yakima Basin

3.2 Study area and surroundings

Approximate stream monitoring locations are shown in Figure 1 and include the following descriptions:

<u>Proposed Stream Monitoring Location Details</u>

Swauk Creek originates northeast Kittitas County and flows south to the Yakima River. The Swauk Creek drainage area covers 81 square miles.

Taneum Creek originates in the foothills of the Cascade Mountains as the North Fork and South Fork Taneum Creek northwest of the Kittitas Valley and flows for 30 miles before its confluence with the Yakima River northeast of Ellensburg. The Taneum Creek drainage area covers 76 square miles.

Naneum Creek originates north of the Kittitas Valley in the Wenatchee Mountains and is 35 miles long with a drainage area of 178 square miles. Naneum converges with Wilson Creek in the Upper Yakima Basin.

Little Creek originates in the foothills of the Cascade Mountains northwest of the Kittitas Valley and has an estimated drainage area of 10 square miles.

Big Creek originates in the foothills of the Cascade Mountains northwest of the Kittitas Valley and has an estimated drainage area of 27 square miles.

Wenas Creek originates in the foothill of the Cascade Mountains southwest of the Kittitas Valley and has an estimated drainage area of 129 square miles.

Cooke Creek originates north of the Kittitas Valley in the Wenatchee Mountains and has an estimated drainage area of 18 square miles.

Parke Creek originates north of the Kittitas Valley in the Wenatchee Mountains and has an estimated drainage area of 17 square miles.

<u>Groundwater Monitoring Location</u>

The groundwater monitoring location is adjacent to Taneum Creek, which is a Yakima River tributary located near Thorp in Kittitas County, Washington. Four monitoring wells record continuous water pressure data located adjacent to Taneum Creek (Figure 2).

Figure 2. Site location of the Taneum Pilot Test monitoring wells and boundary of the Taneum Pilot Test site.

3.2.1 History of study area

This project is funded by a grant from the Yakima Basin Integrated Plan's Groundwater Storage Subcommittee. In the Yakima River Basin current water storage capacity is insufficient to meet projected water demand. The Yakima Basin Integrated Plan is a unified approach to water management in the Yakima Basin designed to address water issues, including drought, declining snowpack, fishery restoration, and ecosystem health. The plan contains the following seven elements:

- Reservoir Fish Passage
- Structural and Operational Changes
- Surface Water Storage
- Groundwater Storage
- Habitat/Watershed Protection
- Enhanced Water Conservation
- Market Reallocation

The Groundwater Storage element supports storing water in aquifers to meet demand and reduce temperatures. Managed Aquifer Recharge (and Shallow Aquifer Recharge, by extension) is a cost-effective method that increases water storage by utilizing an aquifer's storage capacity as a water reservoir. This can be accomplished through passive infiltration or injections wells. To-date no MAR/SAR project exists in the Upper Yakima Basin. This project intends to fill streamflow and groundwater data gaps where such implementation is considered favorable.

3.2.2 Summary of previous studies and existing data

Stream Monitoring

The KRD completed a MAR suitability assessment (EA Engineering 2020), with a subsequent phase that included the installation of a stream monitoring network at 14 select sites along 13 tributaries in the Upper Yakima Basin to examine flow trends for potential MAR use.

In 2020, the stream monitoring network included Big Creek, Little Creek, Naneum Creek, and Taneum Creek. In 2022, the KRD expanded the stream monitoring network at Cooke Creek, Dry Creek, Jones Creek, Parke Creek, Reecer Creek, Robinson Creek, Schnebly Creek, Wenas Creek, and Wilson Creek.

Site visits occurred between August 2020 and May 2023 and included up to 14 trips to download data, measure discharge and staff gauge measurements. The stream monitoring network consists of pressure transducers set to continuously record water pressure on an hourly basis. Transducer data was augmented by manual field measurements of stage height and stream discharge. During site visits, water pressures from the data loggers were downloaded and later converted to water depths. The depths were then corrected for barometric pressure, and rating curves were used to convert water depths to stream discharge.

To estimate the magnitude of high flows, daily average streamflow discharge at 10 percent exceedance, which is considered high flows, was converted to acre-feet over the period of record. Exceedance trends were then estimated by calculating the difference between the maximum measured discharge rate and the 10 percent exceedance rate. To further understand the trend of high magnitude flows over the period of record, 10-, 15-, 20-, and 25 percent exceedance volumes were calculated and graphed. This allowed for the visualization of high-flow trends by month and year.

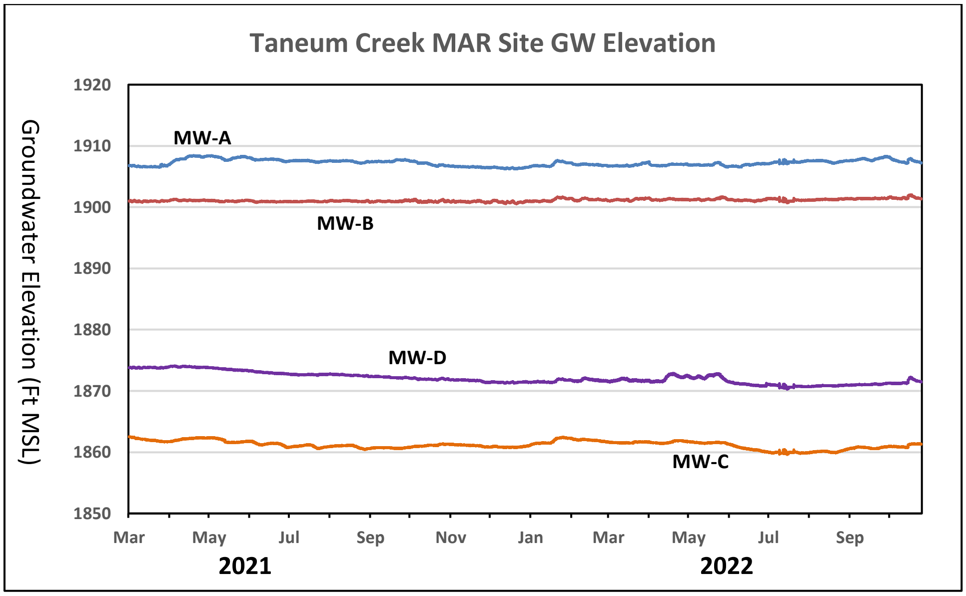
A cursory examination of potentially suitable locations for infiltration basins near stream monitoring locations and the KRD canals in the Big Creek, Little Creek and Naneum Creek areas were evaluated for suitability by restricting designated tax lots to areas with flat terrain. Results suggest excess flows are capable of meeting infiltration rates near these 5 sites, while additional data is required to adequately characterize flows at the remaining 9 sites.

This work was funded by Washington State Department of Ecology (Ecology) Grant Number WRYBIP-1921-KittRD-0017 (Environmental Information Management (EIM) Study ID: WRYBIP-1921-KittRD-0017A).

Groundwater Monitoring

Previous work conducted in 2021 through 2023 at the Taneum Creek Site included the installation of 4 shallow monitoring wells and a pilot test that was conducted under Ecology Grant WRYBIP-1921-KittRD-00017. The project included flooding a field to determine aquifer characteristics and recharge water fate. Data collected at the site under this grant included the depth to water level before, during, and after the pilot test and any changes in water quality. Groundwater elevation from 2021 to 2022 is shown in Figure 3.

Figure 3. Groundwater elevation of monitoring wells at the Taneum Pilot Test site from 2021-2022



The analyses conducted included specific yield, hydraulic conductivity, and velocity. Results from the test suggested water discharged at the site could be retimed by approximately 6 to 8 weeks with no degradation to water quality (Gregory Geologic and Jacobs, 2024). Recommendations for additional work included the continuation of groundwater monitoring to evaluate and refine trends in groundwater conditions. Data obtained under this grant can be found within Ecology's Environmental Information Management System (EIM) under Study ID: WRYBIP-1921-KittRD-0017-B.

3.2.3 Parameters of interest and potential sources

Parameters of interest for monitoring streamflows and groundwater are:

- Surface water column pressure – obtained through in-stream data loggers recording continuously for the duration of the project.
- Stream discharge – calculated from staff gage readings, manual streamflow discharge measurements, surface water pressure converted to elevation and subsequent rating curves.

- Monitoring well water column pressure – obtained through in-well data loggers recording continuously for the duration of the project. Pressure will be converted to groundwater elevation.
- Barometric pressure – obtained through barometric-specific data loggers recording continuously for the duration of the project.
- Groundwater temperature - obtained through in-well data loggers recording continuously for the duration of the project at the four monitoring wells.

Stream monitoring locations will occur on Swauk Creek, Parke Creek, Cooke Creek, Upper and Lower Naneum Creek, Reecer Creek, Taneum Creek, Big Creek, Little Creek, Manastash Creek and Wenas Creek. Monitoring of groundwater levels will continue at the four monitoring wells installed at the Taneum Pilot Test site.

3.2.4 Regulatory criteria or standards

Not applicable

3.3 Water quality impairment studies

Not applicable

3.4 Effectiveness monitoring studies

Not applicable

4.0 Project Description

Streamflow and groundwater data gaps exist throughout the Upper Yakima Basin, especially within tributary creeks of the Yakima River. Managed Aquifer Recharge is a viable method to enhance Total Water Supply Available (TWSA), improve aquatic habitat, and retime flows to reduce climate change and drought impacts. The implementation of MAR/SAR requires understanding the rate and volume of available source recharge water in addition to characterizing an aquifer's potential to store and release source water suitable to achieve project objectives.

Implementation of MAR/SAR throughout the Upper Yakima Basin requires collection of streamflow and groundwater data to assess suitable locations for future projects. Anticipated study outcomes include producing rating curves and hydrographs at Parke Creek, Cook Creek, Upper and Lower Naneum Creek, Reecer Creek, Taneum Creek, Big Creek, Little Creek, Manastash Creek, and Wenas Creek. Other outcomes include refining water level trends in the wells at the Taneum Creek site to determine trends in groundwater conditions and gradients.

4.1 Project goals

Data collected will be used to inform project decisions with respect to future MAR/SAR operations such as seasonal timing of flows and volume of available water for MAR. Stream monitoring equipment will be deployed at eleven locations. Data collected over the duration of the project will be used to produce hydrographs used to calculate flow exceedances, median flow rates, timing of high flows, and baseflow conditions. The goal of stream monitoring is characterization of hydrological conditions over time. The groundwater monitoring goal is reassessing hydrogeological conditions by extending data collection at the Taneum Pilot Test Site.

4.2 Project objectives

The project objectives include producing hydrographs for the eleven tributaries and water level profiles in four monitoring wells. Hydrograph development will allow for analysis of streamflow conditions and increase our understanding of temporal and weather-related water trends. Project objectives include:

- Develop rating curves for each monitoring location
- Develop hydrographs for each monitoring location
- Determine Percent Exceedances
- Characterize seasonal variations and trends with additional statistical methods not yet determined
- Create seasonal groundwater gradient maps for the Taneum Pilot Site
- Evaluate trends in groundwater levels

4.3 Information needed and sources

We identified stream monitoring sites that maintain suitable characteristics for measuring flows with improved accuracy. Groundwater trends were identified during the Taneum Pilot Test; however additional data is needed to evaluate seasonally changing water levels.

New data to be collected include:

- Surface water levels – derived from surface water elevation obtained from newly installed monitoring equipment
- In-stream stage – derived from in-person reading of staff gages
- Manual streamflow discharge measurements, obtained from either an acoustic doppler profiling system or Marsh McBirney FLO-MATE 2000®.
- Streamflow temperatures obtained from newly installed monitoring equipment
- Groundwater levels derived from water pressure – collect continually by transducers and obtained from discrete manual measurements with an e-tape.
- Groundwater temperature, recorded by transducers
- Barometric pressure and air temperature recorded by barometric data loggers

4.4 Tasks required

Tasks required to collect necessary data outlined in section 4.3 include:

- Install staff gages
- Install data loggers at each site to collect hourly water level data
- Manually collect streamflow discharge (Marsh McBirney FLO-MATE 2000® for low flow measurements and SonTek® RS5 for high flow measurements)
- Collect water level from staff gages (at least 10 times per site prior to establishment of rating curve)
- Adjust rating curve as indicated/allowed by new data
- Collect water pressure, level, and temperature data on an hourly basis through real-time recording via a cellular or satellite network
- Collect water levels in existing monitoring wells on an hourly timestep
- Collect temperature data in wells on an hourly timestep
- Manually measure static water level in wells using an E-tape

Field equipment will be deployed at stream locations and used to obtain continuous measurements on an hourly timestep. Each stream monitoring site will be visited as often as monthly and groundwater data will be downloaded at least 4 times per year.

Stream discharge measurements will be taken at 11 locations in the basin throughout the duration of the project with subsequent rating curves developed and used to convert streamflow water level to discharge. Groundwater levels will be collected, downloaded, and examined for additional trends beyond work conducted during the 2023 Taneum Pilot Test.

Rating curve development is dependent upon accurate staff gage readings. The objective to obtain at least 10 readings per site will improve confidence in the rating curves, which will subsequently improve confidence in the calculated stream discharge values.

4.5 Systematic planning process

This QAPP represents the systematic planning process. It includes:

- A description of the project, goals, and objectives
- The project organization, key staff, and schedule
- The study design
- The specification of quality assurance (QA) and quality control (QC) to assess the quality performance criteria
- The description of analyses, data storage, and reporting of acquired data

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

A total of 13 staff are associated with this project. Although some staff overlap in responsibilities, the staff includes 3 project managers, 1 deputy project manager, 1 contract manager, 1 project director, 5 technical advisors, and 3 field assistance people (Table 1).

Table 1. Organization of project staff and responsibilities.

Staff	Title & Phone #	Responsibilities
Jen Bader Jacobs	Project Manager	Project oversight, conducts field work, data analysis, quality control/assurance, reporting
Maria Daugherty Jacobs	Deputy Project Manager	Project oversight, conducts field work, data management and analysis, reporting
Elyse Woda Jacobs	Field Assistant	Conducts field work and EIM upload
Cassidy Hawkins Jacobs	Field Assistant	Conducts field work
Alex Gurrola-Beltran Jacobs	Field Assistant	Conducts field work
Craig Broadhead Jacobs	Contract Manager	Project oversight
Kat Satnik Kittitas Reclamation District	Grant Manager 509-925-6158	Grant management (reporting, invoicing, & uploading deliverables), liaison, project review, & limited field work
Roger Satnik Kittitas Reclamation District	Technical Advisor 509-925-6158	Project review, technical consulting, & GIS
Kevin Eslinger Kittitas Reclamation District	KRD Secretary/Manager 509-925-6158	General liaison between grant and technical managers and other KRD management
Urban Eberhart Kittitas Reclamation District	Secretary/Manager KRD 509-925-6158	Final approval on all project details
Walt Larrick Kittitas Reclamation District	Technical Advisor 509-930-5801	Technical consulting and data analysis
Joel Hubble Kittitas Reclamation District	Technical Advisor 509-480-2717	Technical consulting and data analysis
Jeff Dermond Washington Department of Ecology	Project Manager	Manages Ecology grant activities and conducts field investigation, data analysis review, and coordination with YBIP partners
Scott Tarbutton Washington Department of Ecology	Office of Columbia River Quality Assurance Coordinator 509-867-6534	Reviews and approves QAPP[1]

[1] QAPP: Quality Assurance Project Plan

5.2 Special training and certifications

Collectively key staff have extensive experience in the following:

- Geology: Jeff Dermond, Maria Daugherty, Joel Hubble, Walt Larrick
- Hydrogeology: Jeff Dermond, Maria Daugherty
- Hydrology: Jeff Dermond, Maria Daugherty, Joel Hubble, Walt Larrick
- Streamflow measurements: Jeff Dermond, Maria Daugherty, Jen Bader, Kat Satnik, Roger Satnik
- Biology: Jen Bader (Wetlands), Joel Hubble (Aquatic Habitat)

Field activities will consist of stream discharge measurements, groundwater level measurements, and data retrieval. Field staff conducting these activities will be required to proficiently operate the FLOW-MATE 2000 to measure stream discharge and an electrical tape to measure depth to groundwater. Only key personnel will operate the SonTek RS5 during high flow measurements. No certifications are required to conduct this work, however all staff obtaining streamflow discharge measurements will undergo safety training in accordance with approved safety plans.

5.3 Organization chart

Not applicable – See Table 1.

5.4 Proposed project schedule

Table 2. Schedule for completing the fieldwork and final report.

Description	Due Date	Lead
Field stations defined	July 2024	Jeff Dermond, Maria Daugherty, Jen Bader, Kat Satnik
Stakeholder coordination meetings	Monthly	Kat Satnik, Maria Daugherty
Ecology approval of QAPP	August 2024	Jeff Dermond, Scott Tarbutton
Install Stream Monitoring Equipment	August 2024	Maria Daugherty, Kat Satnik, Jeff Dermond
Data Collection	8/2024 – 8/2027	Field Staff
Discharge Measurements	8/2024 – 8/2027	Field Staff and Key Personnel trained in operating SonTek RS5 (Kat Satnik, Jeff Dermond)
Discharge Measurement and Equipment Memo	4/3/2027	Jen Bader, Maria Daugherty
Draft Technical Report	5/15/2027	Jen Bader, Maria Daugherty
Final Technical Report	7/31/2027	Jen Bader, Maria Daugherty
Upload data to Ecology EIM system as appropriate	7/31/2027	Elyse Woda

5.5 Budget and funding

The funding source was obtained and approved by the Yakima Basin Integrated Plan - Groundwater Storage Subcommittee and executed with Ecology agreement WRYBIP-2325-KittRD-00053. The total grant received equaled $183,004.00. Table 3 shows the budget breakdown.

Table 3. Project budget and funding

Cost Category	Cost ($)
Salary, benefits, and indirect/overhead	$146,004
Equipment	$33,000
Travel and other	$4,000

6.0 Quality Objectives

6.1 Data quality objectives

The main data quality objective (DQO) for this project is to collect streamflow discharge and groundwater elevation representative of the project location in a manner consistent with the measurement quality objectives (MQOs) described below, and to analyze these data to characterize surface water trends and refine groundwater conditions at each monitoring location. Data will be collected in a manner consistent with the MQOs defined below.

6.2 Measurement quality objectives

<u>Surface Water Stage Monitoring</u>
Surface water stage elevation monitoring equipment includes In-Situ LevelTroll transducers. The results will be used to produce streamflow discharge values and stream rating curves. Sites with cellular service will be outfitted with remote monitoring equipment that will allow for data access through a cloud platform. Data installation, collection, and will be conducted in accordance with respective SOPs listed in Table 6. The accuracy of the stage-discharge relationship is improved with increased measurements and considered acceptable when measurements obtained produce rating curves with little to no anomalies. This is expected to occur after ten discharge measurements are obtained that coincide with transducer depth data and staff gage readings. Professional judgement will be used to determine when monitoring capabilities is considered accurate based on field staff measurements.

<u>Discharge and staff gage measurements</u>
Discharge (open channel velocity) measurements collected during low flows will be obtained using a Marsh McBirney FLO-MATE 2000®. When flows are high, generally in spring and at the beginning of summer, for safety purposes the SonTek® RS5 will be deployed to prevent field staff from entering the water. Two discharge measurements will be conducted in sequence during 3 location measurements per year. A goal of 10% or less of the relative percent difference will be considered an acceptable measurement. It is expected accuracy of data collection for stream monitoring of the staff gage will be +/- 0.1 feet through visual examination. Staff will rate discharge measurements as poor, fair, good, and excellent and noted within the field notebook.

<u>Groundwater monitoring</u>
Groundwater is currently being monitored at the four monitoring wells located in the Taneum Pilot Test site. The installed piezometers are equipped with deployed In-Situ RuggedTROLL® RT100 transducers, formally installed under Ecology Agreement WRYBIP-1921-KittRD-00017. Measurements will be obtained in accordance with Marti (2023). A measuring point at the top of the casing at each location will be taken where previous measurements were obtained. During the initial data collection, field staff will examine each measuring point and update with a file, paint, or marker as needed then record this in field notes along with pictures. The staff

will use these manual measurements as an accuracy check of water level against the data loggers by using an e-tape to obtain the water depth. Water depth taken with an e-tape will be replicated in the field as needed (i.e., anomalous readings).

Water well levels, streamflow temperature, streamflow velocity, location data, and gage height will be gathered to manufacturer's specification in Table 4.

Table 4. Parameters measured with measurement instruments and their respective range, accuracy, and resolution.

Parameter	Equipment	Equipment Information			Precision Field Replicates	Expected Range/(Notes)
		Accuracy	Resolution	Range		
Continuous Surface Water Monitoring						
Water Levels	In-Situ LevelTROLL® Loggers LT500	+/-0.05% FS from 23o to 122oF	+/- 0.005% FS or better	0 to 1153 ft	-	0 to 40 ft
Water Temperature		+/-0.54oF	0.018 oF or better	4o to 176oF	-	33 o to 70 oF
Stream Discharge						
Stage Height	1SOP EAP056	-	-	-	10% RDP	0.01 to 3 ft
Open Channel Velocity	Marsh McBirney FLO-MATE 2000®	<0.03 ft/s	0.01 ft/s	0.003 to 13 ft/s	5% RPD	0.1 to 10 ft/s
Open Channel Velocity (High Flows)	SonTek® RS5	1% +/-0.0066 ft/s	0.0033 ft/s	+/-3.28 ft/s	5% RPD	5 to 15 ft/s
Atmospheric Conditions						
Barometric Pressure	In-Situ Rugged BaroTROLL® Baro	+/-0.05% FS from 0^{0} to 122^{o}F	+/- 0.01% FS or better	7 to 30 psi	-	-
Air Temperature		+/-0.54^{o}F	0.018 ^{o}F or better	-23^{o} to 122^{o}F	-	10^{o} to 110^{o}F
Groundwater Level Measurements						
Depth to Water Table	Solinst 101 Water Level Meter, P7/LM3/30m	0.05 ft	0.01 ft	0 to 300 ft	-	0 to 25 ft
Water Well Levels (Absolute pressure)	In-Situ RuggedTROLL® Loggers RT100	+/-0.05% FS from 32^{o} to 122^{o}F	-/+ 0.01% FS or better	0 to 100 ft	-	0 to 40 ft

Parameter	Equipment	Equipment Information			Precision Field Replicates	Expected Range/(Notes)
		Accuracy	Resolution	Range		
Absolute Water Pressure	In-Situ RuggedTROLL® Loggers RT100	+/-0.05% from 0º to 122ºF	+/-0.01% FS or better	16 to 162 ft	-	0 to 15 ft
Water Temperature		+/-0.54ºF	0.018 ºF or better	23º to 122ºF	-	40º to 60ºF
Geolocating Locations						
GPS Locations (Horizontal)	iPad Mini - Esri's Enterprise Portal Field Maps App	Open - 8.69 ft Light- Med canopy – 24.6 ft Heavy closed canopy – 26.9 ft		-	-	8.69 ft or better

%RDP: Percent relative percent difference
[1]Shedd, 2018a

6.2.1 Targets for precision, bias, and sensitivity

6.2.1.1 Precision

Water level measurements obtained from water well pressure transducers will be completed by obtaining measurements with an e-tape at the distance between the top of the casing and the water surface at the time data is downloaded. This will occur at least once a year. Precision for streamflow discharge measurements replicates will occur at a minimum of 3 replicates per year. Precision for replicates is expressed as percent relative percent difference (%RPD) or absolute error and assessed following the parameters outlined in Table 4.

6.2.1.2 Bias

Field bias will be reduced through calibration of instruments according to field measurement protocol, including verification of transducers and data loggers through manual field measurements. Other field biases include measurement procedures and will be minimized through protocol training and field visit expectations.

6.2.1.3 Sensitivity

Sensitivity, described by equipment range, accuracy, and resolution, is reported in Table 4. The recorded value shown in this table is a measure of the capacity of the equipment used to detect change. The factory-documented accuracy, range, and resolution for pressure transducers in Table 5 is considered sufficiently sensitive for anticipated changes in water level suitable for site conditions and continuous data collection.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Study comparability is influenced by data availability, collection approach and location, SOPs, and equipment installation. Field staff will adhere to field protocols and measurements according to the SOPs, listed in Section 8.2, to improve comparability.

Climate variability reduces water level comparability. Water level and groundwater monitoring will occur until June 2027. Although variation in annual weather reduced comparability over the short term, the monitoring duration improves comparability.

6.2.2.2 Representativeness

Streamflow will be considered representative of existing conditions based on flow variability with respect to seasonality, weather conditions, changes to stream channel, debris, and other factors which may alter data recording measurements.

6.2.2.3 Completeness

This study will be considered successful if measured data is gathered during 95% of the project duration. Completeness for continuous monitoring equipment may be impacted by equipment failure, vandalism, theft, and large-scale hydrologic events. If the 95% is not met, staff will determine which (if any) data is suitable to meet project objectives. If targets are not met, documentation of data completeness and subsequent impacts will be included in study reports.

6.3 Acceptance criteria for quality of existing data

Existing streamflow discharge data (WRYPIB-1921-KittRD-00017) were collected in close proximity to stream monitoring locations described in this QAPP. The previous monitoring efforts were conducted under a previously approved QAPP (EA Engineering et al., 2020b). These data will be integrated into the proposed dataset when acceptable rating curves are developed at the previous sites. The proposed monitoring locations will refine streamflow discharge data previously collected, as new locations reduce the likelihood for interference due to stream channel impediments affecting monitoring equipment. Collection of new data will provide a greater level of confidence in streamflow analyses. The groundwater data formally evaluated was verified by a registered hydrogeologist and are considered acceptable to use for examination of historical data.

6.4 Model quality objectives

Not applicable

7.0 Study Design

7.1 Study boundaries

The study involves numerous discrete sites, all within the larger study boundary of the Upper Yakima Basin (Figure 1).

7.2 Field data collection

The approximate location of stream gauges at Taneum Creek, Swauk Creek, Big Creek, Little Creek, Cooke Creek, Schnebly Creek, Reecer Creek, Park Creek, Wenas Creek, Upper Naneum Creek and Lower Naneum Creek are shown in Figure 1. The observation wells (MW-A through MW-D) at Taneum Creek are also shown in Figure 2.

7.2.1 Sampling locations and frequency

This QAPP discusses the general study design for specific monitoring locations and sampling density will vary with project site conditions. Stream monitoring equipment will record water column pressure (absolute at monitoring wells, gage pressure at streamflow locations), temperature, and atmospheric pressure on an hourly basis. Open channel velocity measurements will occur at least 12 times per year, but also depends on site conditions. Well data will be downloaded at a minimum of 4 times per year with static water level manually recorded during the site visit.

7.2.2 Field parameters and laboratory analytes to be measured

- Well data: water pressure and static water level
- Surface water pressure (converted to depth), temperature, and barometric pressure at each location
- Streamflow discharge will be collected at a minimum of 12 times per year
- Staff gage reading will be collected during each streamflow discharge site visit

Additional field parameters are shown in Table 5.

Table 5. Additional Field Parameters

Environmental Parameters	Frequency	Equipment	Model
Open Channel Flow Velocity	Monthly, weather permitting	Marsh McBirney; SonTek	FLO-MATE; 2000 RS5
Water Well Levels	Hourly	In-Situ RuggedTROLL® Loggers	RT100
Streamflow Water Pressure	Hourly	In-Situ RuggedTROLL® Loggers	RT500/MicroRXWL
Streamflow Water Temperature	Hourly	In-Situ RuggedTROLL® Loggers	RT500/MicroRXWL
Barometric Pressure	Hourly	In-Situ Rugged BaroTROLL	Baro
Air Temperature	Hourly	In-Situ Rugged BaroTROLL	Baro
Depth to water	Occasional, each visit to well.	Water Level Indicator	300 ft.

7.3 Modeling and analysis design

Not Applicable

7.3.1 Analytical framework

Not Applicable

7.3.2 Model setup and data needs

Not Applicable

7.4 Assumptions of study design

Data collection for each location is assumed to be sufficient to determine the variability of the parameters of interest (flow and water levels). The data will provide sufficient representative information of the time and location.

7.5 Possible challenges and contingencies

7.5.1 Logistical problems

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 staff availability, site access, 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).

7.5.2 Practical constraints

Practical constrains for collecting streamflow and well data include scheduling problems, budgetary constraints, unreliable transportation, road conditions, and changes in site access agreements.

7.5.3 Schedule limitations

Schedule conflicts may limit staff availability to measure flows. Equipment training on the SonTek RS5 is limited to key personnel and may limit data collection due to availability of key staff.

8.0 Field Procedures

8.1 Invasive species evaluation

Field staff will clean field gear in accordance with Myers (2019) to minimize the spread of invasive species. Staff will inspect and clean all equipment and use a scrub brush and rinse with clean water if needed. Field staff will follow Ecology procedures if an unexpected contamination incident occurs.

8.2 Measurement and sampling procedures

Streamflow and water well data collection procedures will follow all SOPs listed in Table 6.

Table 6. Standard Operating Procedures (SOP) for field logs and records of measurement requirements in this QAPP.

Application	SOP Document ID	Name
Stream Discharge	[1]EAP056, v. 1.3	Measuring and Calculating Stream Discharge
	[2]EAP042, v. 1.2	Measuring Gauge Height of Streams
	[3]EAP057, v. 1.2	Conducting Stream Hydrology Site Visit
	[4]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	[5]EAP052, v. 1.4	Manual Well-Depth and Depth to Water Measurements
	[6]EAP074, v. 1.2	Use of Submersible Pressure Transducers During Groundwater Studies
	[4]EAP082, v. 1.2	Correction of Continuous Stage Records Subject to Instrument Drift
	[7]ECY Pub: No. 17-11-005	Integrated Statewide Groundwater Monitoring Strategy
	Cunningham and Schalk, 2011	Groundwater Technical Procedures of the U.S. Geological Survey

[1]Shedd, 2018a
[2]Shedd, 2018b
[3]Myers, 2019
[4]Shedd and Springer, 2019
[5]Marti, 2023
[6]Sinclair and Pitz, 2019
[7] Culhane, 2017

<u>Dataloggers</u>
Datalogger download will follow guidelines outlined in Culhane (2017) and Sinclair and Pitz (2019) or observation well procedures. Additionally, the In-Situ RuggedTROLL® and HOBO® loggers will be downloaded from a cloud service on a monthly basis and does not require a field

site visit. Where cloud service is unavailable loggers 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 to correct the non-vented dataloggers for barometric pressure. The in-stream dataloggers without cloud service will be download every other month. It is not anticipated that any datalogger will reach measurement capacity, so none will be restarted unless necessary. The dataloggers will record at the top of every hour and will be launched prior to deployment.

Stream Monitoring Equipment

Stream gauge dataloggers will be installed in accordance with guidelines described by the Environmental Protection Agency (EPA, 2014) (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. Solar panels will be attached to bridges with the appropriate steel screws. Stream monitoring stations will be located with a GPS unit, built within a GPS tracking iPad. 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 Myers (2019) 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
- Site condition
- Water temperature
- Photos of datalogger location

All time data will be collected in Pacific Daylight Time

Streamflow Discharge

Field measurements will be conducted in accordance with Shedd (2018a) and Shedd (2018b). The Marsh McBirney FLO-MATE and SonTek RS5 will both be operated in real-time for streamflow measurements during low and high flows, respectively.

Groundwater Monitoring

Following guidelines described in Marti (2023) a permanent measuring point (MP) from which all depth to water levels was established for each well when it was installed as described in the well log. The clearly marked MP will be either the *Top of Casing* or as noted at time of installation. The MP will be referenced to a land surface datum, which will be approximately the average altitude of the ground surface of the well. The distance between the land surface datum and the MP will also be measured. If the MP is below land surface, it will be preceded by a minus sign. The height of the MP and the date it is established will be recorded. For each monitoring well, the data will be recorded in compliance with Culhane (2017).

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8.3 Containers, preservation methods, holding times

Not Applicable

8.4 Equipment decontamination

Water level measuring equipment will be cleaned and disinfected prior to and after use in each monitoring well (Marti, 2023). Gloves will be worn when cleaning measuring equipment. This will help maintain sanitary conditions of the cleaned tape and will protect the sampler from the cleaning products being used. When not in use, equipment will be placed on a clean surface, such as a clean plastic sheet and not on bare soil.

8.5 Sample ID

Not Applicable

8.6 Chain of custody

Not Applicable

8.7 Field log requirements

A field log is an important component of many projects. It is used to record irreplaceable information, such as:

- 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

Recommended field log practices include:

  - Use bound, waterproof notebooks with pre-numbered pages.
  - Use permanent, waterproof ink for all entries.

- 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 if they demonstrate equivalent security to a waterproof, bound notebook.

Field log requirements will be guided by the SOPs listed in Table 6 Example field logs are shown in Appendix A.

8.8 Other activities

Other activities will include:

- Briefings and trainings for field staff
- Daily field safety meeting
- Periodic maintenance for field instrumentation

9.0 Laboratory Procedures

9.1 Lab procedures table

Not Applicable

9.2 Sample preparation method(s)

Not Applicable

9.3 Special method requirements

Not Applicable

9.4 Laboratories accredited for methods

Not Applicable

10.0 Quality Control Procedures

Quality control procedures, safety measures, stream measurements and observation well measurements will be followed according to documents listed in Table 6. Calibration and testing of field equipment prior to deployment is specified under the specific SOP listed in Table 6.

Datafiles obtained from the dataloggers will be visually examined for unreliable datapoints, or malfunctions. Any field parameters that fall outside of an acceptable range will be either flagged or discarded. The transducer will record at the top of the hour, with scheduled downloads pulled and replaced prior to xx:05 and xx:50.

After deployment, lat/long location, location common name, date of deployment, frequency of collection and standard/daylight time, and any notes about access contacts, etc. will be recorded on the logger location spreadsheet and after each field visit within field notes similar to those in Appendix A.

10.1 Table of field and laboratory quality control

Field quality controls will be followed in accordance to documents listed in Table 6, and as described in Chapter 6.2 Measurement Quality Objectives, and as described in 8.0 Field Procedures.

10.2 Corrective action processes

Table 7. Corrective Action Process by Type

Type	Frequency	Steps in preparation of fieldwork	Steps taken in the field	Corrective actions where applicable
Safety	Each visit	Vehicle and Equipment Checklist ([1]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 ([1]SOP: EAP056); check recent and upcoming weather reports for possible adverse access and site conditions	Detailed steps described in [1]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: [1]SOP EAP056 section 6.6 through 6.10 Measuring Gauge Height: [2]SOP EAP042 Section 8.0 through 8.5
Manual well measurements and pressure transducer water level measurements	Each visit or if a problem becomes apparent in the field	[3]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) [4]ECY Pub: No.17-11-005: E-tape calibrated against steel tapes [4]ECY Pub: No.17-11-005: Pressure transducer benched tested	[3]SOP EAP052: Depth-to-water measurements with electric-tape (section 6.0 to 6.8.18. [4]ECY Pub: No.17-11-005: Multiple e-tape measurements to represent true static water level	[3]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 [4]ECY Pub: No.17-11-005: Failed equipment test – return to manufacture for repair or retire equipment

[1]Shedd, 2018a

[2]Shedd, 2018b

[3]Marti, 2023

[4] Culhane, 2017

In addition to the corrective process listed in Table 7, 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 or an algorithm that mimics an RC time constant. 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.

Well Station Data

The corrective action processes for measurements obtained at well stations are detailed in Culhane (2017) and listed in Table 7.

11.0 Data Management Procedures

11.1 Data recording and reporting requirements

Data loggers without remote monitoring systems will be downloaded directly to individual comma-delimited ascii-files. Each file will be labeled with the transducer 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 uploaded to the project database. An electronic copy of the raw data will be named ”common name_serialnumber_raw.dat files”.

Data with loggers outfitted with remote monitoring systems will be stored on the In-Situ HydroVu cloud platform. Data will be downloaded throughout the project, reviewed, and trimmed according to Kennedy (1984). Original file downloads will be retained allowing for review at any time.

<u>Groundwater Monitoring</u>

As described in Culhane (2017), 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 the project database. 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. Instrument drift of more than 10% is unacceptable.

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

11.2 Laboratory data package requirements

Not Applicable

11.3 Electronic transfer requirements

Not Applicable

11.4 Data upload procedures

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 under Study ID: WRYBIP-2325-KittRD.

11.5 Model information management

Not Applicable

12.0 Audits and Reports

12.1 Audits

Audit and report procedures will be followed as outlined in the QAPP. Technical System Audits will occur on the streamflow and groundwater data collection process within a week of initial data collection. Data collected on the cloud will be examined within the day of equipment deployment. The audit will consist of examination of field notes for inaccuracies including missing information and/or erroneous manual measurements. Photographs will be examined for accurate record keeping of staff gage measurements. Pressure transducer downloads will be examined for erroneous data points and data gaps within one week of data collection. As the project progresses, stream monitoring locations and objectives will be reexamined and updated as necessary. Any changes to monitoring locations, including equipment relocation, will be done in consultation with and approved by Ecology prior field adjustments.

12.2 Responsible personnel

Responsible personnel include the following:

- Field audit: project managers
- Field consistency review: experienced staff
- Data analysis: project manager and others familiar with analyses

12.3 Frequency and distribution of reports

A Technical Report will be drafted and submitted to the YBIP Groundwater Storage Subcommittee and Ecology's Administration of Grants and Loads (EAGL) system. The report will be distributed to all interested stakeholders. A draft will be distributed for reviews and comment prior to EAGL submission.

12.4 Responsibility for reports

The Deputy Project Manager for Jacobs will analyze data with assistance from field staff and others. The Project Manager and Deputy Project Manager from Jacobs, the KRD, Ecology, and other personnel, will be responsible for verifying completeness prior to producing the technical report or entering data into EIM.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

The following will be conducted to ensure verification is completed in the field prior to leaving a monitoring site:

- Field staff will review notebooks and electronic information (data logger downloads) for missing information and erroneous measurements.
- Data sheets will be reviewed for outliers and flagged, then repeated if possible.

After the site visit:

- Staff will upload data, scanned field notes, and photos taken during the field event.
- Data and uploaded items will be reviewed by Project Managers for accuracy within 1 week after upload.

13.2 Laboratory data verification

Not Applicable

13.3 Validation requirements, if necessary

Not Applicable

13.4 Model quality assessment

Not Applicable

13.4.1 Calibration and validation

Not Applicable

13.4.1.1 Precision

Not Applicable

13.4.1.2 Bias

Not Applicable

13.4.1.3 Representativeness

Not Applicable

13.4.1.4 Qualitative assessment

Not Applicable

13.4.2 Analysis of sensitivity and uncertainty

Not Applicable

14.0 Data Quality (Usability) Assessment

14.1 Process for determining project objectives were met

All data will be assessed to determine if data collection meets project objective and results will be verified against compliance with MQOs.

14.2 Treatment of non-detects

Not Applicable

14.3 Data analysis and presentation methods

Rating Curves

Data loggers continuously record hourly water pressure. During site visits, water pressure data from the data loggers, where necessary, will be downloaded and converted to water depths. The depths will be corrected for barometric pressure, and the rating curve equations (USGS 2023) will be used to convert water depths to stream discharge.

To characterize and determine high flows, field assessments will be conducted to obtain discharge rates, staff gauge measurements, and data logger downloads. Rating curves will be created to calculate stream-discharge relationships at sites when at least ten gage readings have been obtained.

Rating curve creation requires manual staff gage readings (stage height), and streamflow discharge measurements obtained with specialized equipment. The collected data points will be plotted, and a linear regression will be used to produce a rating curve equation and the coefficient of determination (r^2) for each site. r^2 is a number between 0 and 1 that indicates the degree to which observed data is scattered around the regression line. The closer r^2 is to 1, the better the correlation between stage height and discharge measurements.

Hydrograph Creation

Hydrographs will be created for sites when r^2 values are determined to be statistically meaningful ($r^2 > 0.93$) with hourly pressure data converted to daily average discharge rates. The hydrographs will be used to estimate high flows, observe trends in high flow days, and calculate the magnitude of high flows at a 10 percent exceedance threshold.

Percent Exceedance

A 10 percent exceedance, which indicates that only 10 percent of flows are higher, is chosen to define the magnitude of high flows at each site. An exceedance value is generally used to show high flow characteristics of a stream or creek (Searcy 1959). The percent exceedance is a variation of a streamflow percentile, which also uses a scale of one hundred but is typically used to describe flow patterns, rather than targeting high flow rates. The 10 percent exceedance, also known as the 90th percentile, is chosen as the high-magnitude flow threshold since the USGS and others (Richards 1990, USGS 2016) describe the percentage as "much above normal" or as "high flows". The 10 percent exceedance was used in a California Central Valley water banking study to characterize the magnitude, frequency, duration, and timing of high streamflows for 93 stream gauges (Kocis and Dahlke 2017).

The procedure to estimate the percent exceedance will include sorting and ranking discharge values for the period of record from the largest to the smallest, with a total of n values. Each discharge value will be assigned a rank, starting with 1 for the largest value. The exceeded probability is expressed as follows:

$$P = 100 * \frac{m}{n+1}$$

where,

P = the probability that a given flow will be equaled or exceeded (percent of time)

m = the ranked position on the list (dimensionless)

n = the number of events for the period of record (dimensionless)

Timing of Potential Source Water Availability

To evaluate potential source water for MAR requires understanding the timing and volume of streamflows, especially when demand is low and supply is available. To estimate the magnitude of high flows, daily average streamflow discharge at 10 percent exceedance will be converted to acre-feet over the period of record. Exceedance trends will be estimated by calculating the difference between the maximum measured discharge rate and the 10 percent exceedance rate. To further understand the trend of high magnitude flows over the period of record, 10-, 15-, 20-, and 25 percent exceedance volumes will also be calculated and graphed. Results will be discussed with Washington Fish and Wildlife and the Yakama Nation to determine additional factors that will affect source water availability and included in the final report.

Groundwater Monitoring

Well water level data will be reviewed to determine and revise groundwater gradients over different seasonal conditions. Gradients will be characterized using ArcPro. Water level data will be uploaded into ArcPro and the Spatial Analyst Tool will be used to interpolate water depth across the Taneum Pilot Test site. Additional statistical examination of water level data may be conducted if warranted.

14.4 Sampling design evaluation

The Project Manager and Deputy Project Manager, along with other key personnel will determine which data meets the MQOs. The study will be considered successful if the data collected is analyzed as intended. The end product, which is the final report, will provide a "proof of concept" for determining surface water availability and groundwater storage estimates for MAR/SAR purposes.

14.5 Documentation of assessment

The final report will include the data usability assessment.

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16.0 Appendices

Appendix A. Field Forms

Figure A-1: Example Forms for Streamflow Discharge Measurements

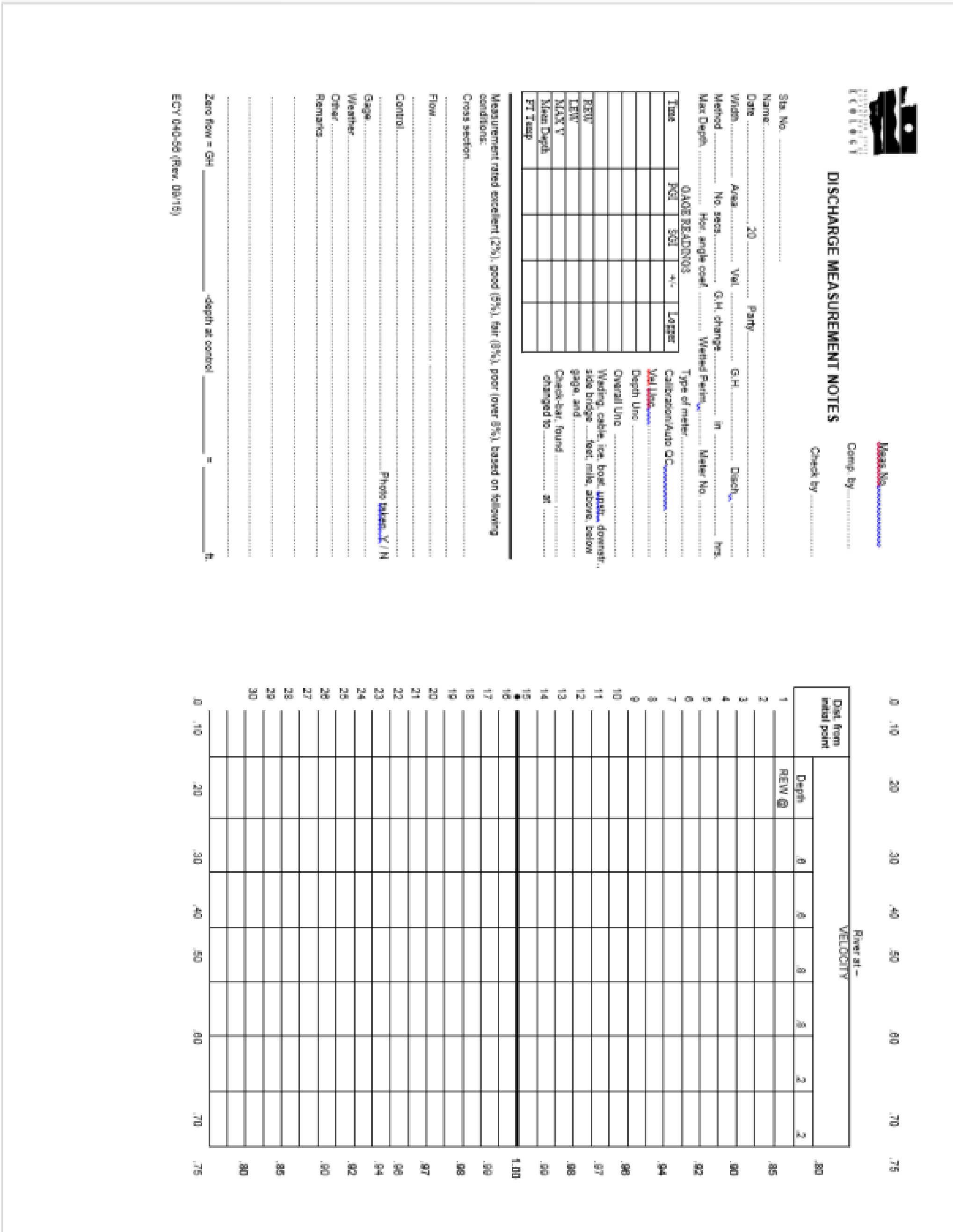

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Figure A-2: Example Discharge Notes Used for Acoustic Doppler Field Visit

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
ECOLOGY

ADCP
Discharge Measurement Notes

Meas. No ....
Comp. by ....
Check by ....

Sta. No. ....
Name ....
Date .... 20 ...... Party ....
Width ...... Area ...... Vel. ...... G.H. ...... Disch. ......
Method ...... Transects ...... G.H. change ...... in ...... hrs.
Max. Delta Q ...... Max Depth ...... Wetted Perim. ...... Meter No. ......

GAGE READINGS

Time	PGI	SGI	+/-	Logger

Type of meter ....
Q σ / x̄ ....
V σ / x̄ ....
A σ / x̄ ....
Wading, cable, ice, boat, upstr., downstr., side bridge .. feet, mile, above, below gage, and ....
Check-bar, found .... changed to .... at ....

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following conditions:
Cross section ....
Flow ....
Control ....
Gage ....
Weather ....
Other ....
Remarks ....

Zero flow = GH ______ -depth at control ______ = ______ ft

ECY 070-298 (08/15)

Measurement Notes

Test Ping Transect:
Right Edge Dist. ________
Left Edge Dist. ________
Max Depth ________
Max Velocity ________
Cell Size ________

File Name: ______________
Water Mode: ______________ Profiler depth ______________
Location on SD Card: ______________________
Moving Bed Test: Yes No ________ Ft. in ____________ Seconds
No. of Cells ____________ Deployment ______________________

Transect Number	Start Bank R/L	Start Time PST	Distance to Right Edge	Distance to Left Edge	Discharge	% Delta Q	Width	Area	Velocity
0									
1									
2									
3									
4									
5									
6									
7									
Averages									

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Appendix B. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

Bankfull stage: Formally defined as the stream level that "corresponds to the discharge at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels (Dunne and Leopold, 1978).

Baseflow: The component of total streamflow that originates from direct groundwater discharges to a stream.

Existing uses: Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

Reach: A specific portion or segment of a stream.

Sediment: Soil and organic matter that is covered with water (for example, river or lake bottom).

Streamflow: Discharge of water in a surface stream (river or creek).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
GIS	Geographic Information System
GPS	Global Positioning System
i.e.	In other words
QA	Quality assurance
QC	Quality control
RPD	Relative percent difference
SOP	Standard operating procedures
USGS	United States Geological Survey
YBIP	Yakima Basin Integrated Plan

Units of Measurement

cfs	cubic feet per second
ft	feet

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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