DEPARTMENT OF ECOLOGY
State of Washington

Quality Assurance Project Plan

Interactions Between Groundwater and Surface Water on Manastash Alluvial Fan

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Quality Assurance Project Plan

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September 2025

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Ecology Agreement No. WRYBIP-2325-KITTRD-00044

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1.0 Background and Project Description

During the severe drought of 2015, the Kittitas Reclamation District (KRD) secured outside funding to conduct tributary supplementation, including supplementing flows in Manastash Creek. This was accomplished by using KRD canals to convey Yakima Basin Project water that was designated for use in the lower Yakima River Basin. This water was used throughout the summer to hydrate multiple tributaries that had or were going dry due to the extraordinary drought conditions in the Yakima Basin.

KRD's Stream Supplementation Program has restored streamflow in Manastash Creek (Figure 1) below the KRD's South Branch Canal during critical low flow periods. Manastash Creek's streambed is composed of coarse grained, highly permeable gravel and cobbles allowing a direct hydraulic connection between the creek and underlying sediment and unconfined shallow aquifer, which suggests supplementation water likely induces groundwater recharge. Ecology provided funding to KRD under agreement WRYBIP-2325-KITTRD-00044 to study the impact of stream supplementation on the shallow aquifer and estimate recharge benefits along Manastash Creek.

Figure 1. Study Site – Manastash Creek

The primary objective of this study is to quantify supplementation water's contribution to the underlying groundwater system. The complexity of alluvial fan channeling and extensive irrigation infrastructure, with high frequency monitoring on the fan (Figure 2), supports a secondary objective that includes estimating the timing of return flows and the interconnectivity to the underlying aquifer along individual creek reaches. This will provide additional characteristics of surface and groundwater interactions and perhaps allow for future targeted management applications along the fan.

This study benefits from currently operating high-frequency stream monitoring along the creek conducted by the Kittitas County Conservation District (KCCD) and the KRD as shown in Figure 2. The KRD sites include an ultrasonic bridge sensor and two in-stream data loggers, all outfitted with telemetry described in Ecology Agreement WRYBIP-2325-KittRd-00053.

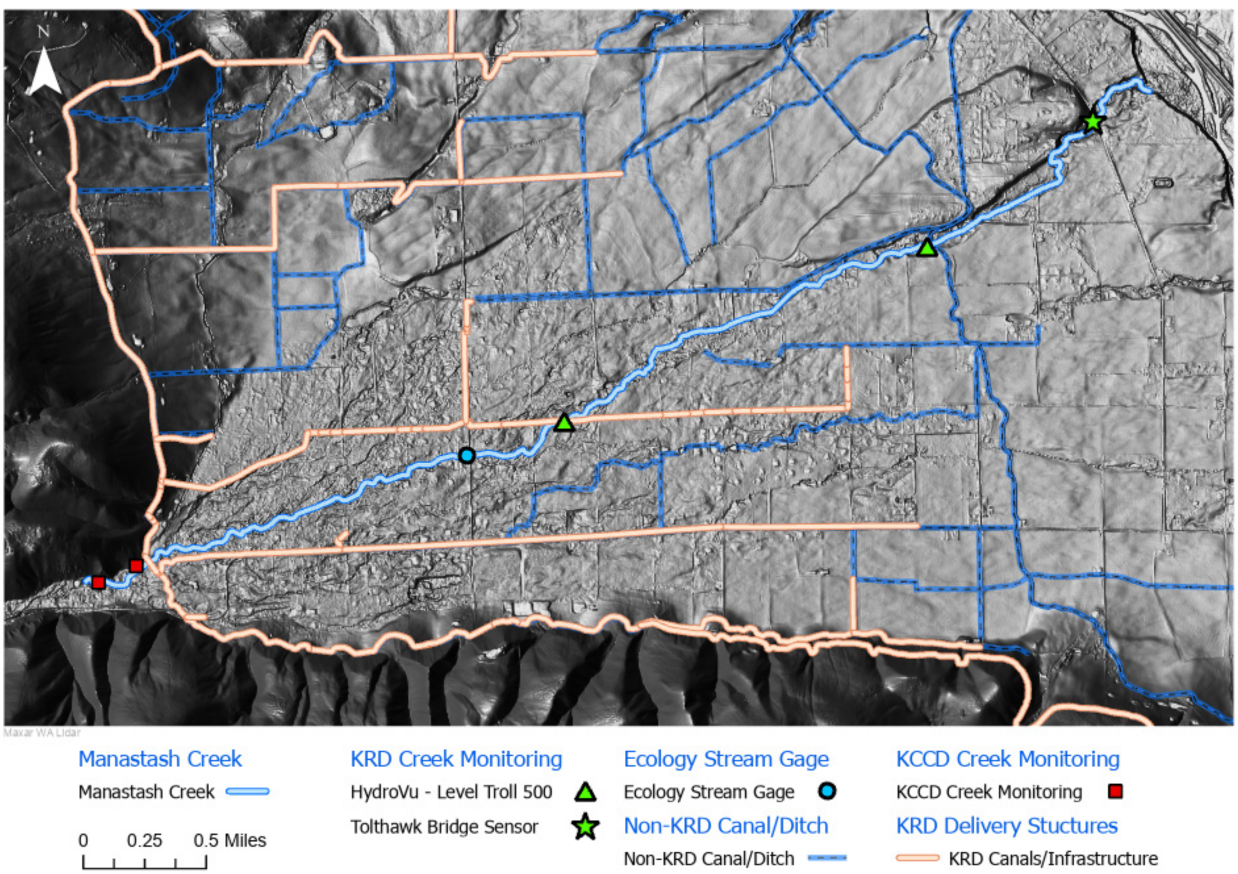

Figure 2. Infrastructure and monitoring along Manastash Fan.

2.0 Organization and Schedule

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 2 field assistants (Table 1).

Table 1. Organization of project staff and responsibilities.

Staff	Title & Phone #	Responsibilities
Jen Bader Jacobs	Project Manager 509.317.8843	Project oversight, conducts field work, data analysis, quality control/assurance, reporting
Maria Daugherty Jacobs	Deputy Project Manager 541.214.5599	Project oversight, conducts field work, data management and analysis, reporting
Elyse Woda Jacobs	Field Assistant 509.317.8843	Conducts field work and EIM upload
Cassidy Hawkins Jacobs	Field Assistant 509.317.8843	Conducts field work
Craig Broadhead Jacobs	Contract Manager 509-312-0375	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	Secretary/ Assistant Manager 509-925-6158	General liaison between grant and technical managers and other KRD management
Urban Eberhart Kittitas Reclamation District	Secretary/Manager 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 (509) 268-1784	Manages Ecology grant activities and conducts field investigation, data analysis review, and coordination with YBIP partners
McKenna Murray Washington Department of Ecology	Office of Columbia River Quality Assurance Coordinator 509-823-0996	Reviews and approves QAPP

Collectively, key staff have extensive experience in the following:

- Geology: Jeff Dermond, Maria Daugherty
- Hydrogeology: Jeff Dermond, Maria Daugherty
- Hydrology: Jeff Dermond, Maria Daugherty
- 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 seepage runs, 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, an electrical tape to measure depth to groundwater, and be trained in the appropriate software for data download. 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.

A schedule and description, including lead members, is shown in Table 2.

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

Description	Due Date	Lead
Stakeholder coordination meetings	Monthly	Kat Satnik, Jen Bader, Maria Daugherty
Ecology approval of QAPP	September 2025	Jeff Dermond, McKenna Murray
Data Downloads Estimates; will be conducted in coordination with Ecology	10/2025 – 9/2026	Field Staff
Seepage Runs	Summer/Spring 25-26	Field Staff and Key Personnel
Final Technical Report	9/31/2026	Jen Bader, Maria Daugherty

3.0 Quality Objectives

Data will be collected in a manner consistent with the MQOs defined below.

Measurement Quality Objectives

To ensure the project goals are quantifiable, project-specific, and align with Ecology's requirements for non-water quality projects, the following MQOs apply, with additional equipment information listed in Table 3:

Seepage Runs – Seepage Runs (open channel velocity) measurements will be collected using a Marsh McBirney FLO-MATE 2000.

Precision:

- MQO Threshold: Up to 15% RPD between replicate measurements at same cross-section (Sauer 2002; adjusted for propagated uncertainty)
- Verification Method: Calculated relative percent difference (%RPD)
- Threshold Rationale: To ensure detected seepage differences exceed the combined uncertainty of discharge measurements which includes propagated error from velocity, width, and depth measurements under typical field conditions.

Bias:

- MQO Threshold: +/- 3% of reference value (based on user manufacturer's specs)
- Verification Method Pre/post run calibration check
- Threshold Rationale: Matches manufacturers stated accuracy of +/- 3%

Sensitivity:

- Detect velocity greater than 0.1 ft/s (based on manufacturer's specifications)
- Avoids missing seepage loss conditions

Completeness:

- 100% of planned transects completed per run, unless otherwise stated in the field log due to unexpected circumstances.
- Verification Method: field log review

Irrigation Diversion Monitoring: flow rates for the irrigation diversions will be incorporated from the existing, custom monitored system (Righton submerged orifice with differential bubblers with 1% accuracy) provided by the Kittitas County Conservation District.

A 15% RPD threshold accounts for the propagated uncertainty from all discharge calculation
components (velocity, width, depth) and ensures observed changes reflect true hydrologic shifts rather than cumulated measurement error.

Groundwater Monitoring – Measurements will be collected using In-Situ Rugged Troll 100.

Head Measurement Precision:

- MQO Threshold: Up to 0.02 ft set to hourly readings (based on manufacturer's specifications)
- Verification Method: Compare with e-tape measurements (Table 3)
- Threshold Rationale: To detect subtle storage changes (+/- 0.1 ft)

Bias:

- MQO Threshold: +/- 0.01 ft against manual reference (manufacturer's specification)
- Threshold Rationale: To determine if sensor accuracy is exceeded

Sensitivity:

- MQO Threshold: changes up to 0.05 ft (manufacturer's specification)
- Threshold Rationale: Captures recharge signals

Completeness:

- MQO Threshold: Greater than 95% hourly data recovery for each download to ensure data gathering is adequate for the project and EIM upload.
- Verification Method: data logger report

In Summary:

Precision: Seepage run precision for replicates is expressed as relative percent difference (%RPD) or absolute error and assessed following the parameters outlined in Table 3 and described above.

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.

Sensitivity: Sensitivity, described by equipment range, accuracy, and resolution, is reported in Table 3. The recorded values shown in this table represent a measure of the capacity of the equipment.

Table 3. Parameters, equipment, and their associated range, accuracy, and resolution.

Parameter	Equipment	Equipment Information			Precision Field Replicates	Expected Range/Notes
		Accuracy	Resolution	Range		
Continuous Surface Water Monitoring						
Water Levels	*ToltHawk 4.5 L	20+ feet accuracy is 0.39"; Less than 20' accuracy is 0.20"	0.039"	9" to 160'	-	0 to 30 ft
Air Temperature		+/-0.1°F	0.1°F	-20°F to 140°F	-	-5° to 105°F
Water Levels	*In-Situ LevelTROLL® Loggers LT500	+/-0.05% FS from 23° to 122°F	+/- 0.005% FS or better	0 to 1153 ft	-	0 to 15 ft
Water Temperature		+/-0.54°F	0.018 °F or better	4° to 176°F	-	33° to 70°F
Irrigation Diversions						
Diversion Flow Rate	Submerged orifice system with differential bubblers customed designed and built by Righton	Factory calibrated to accuracy within 1% of flow rate			-	Up to 5 cfs
Seepage Runs						
Stage Height	SOP EAP056, (Ecology 2018a)	-	-	-	10% RPD	0.01 to 3 ft
Open Channel Velocity (Seepage Run Events)	Marsh McBirney FLO-MATE 2000®	+/-2%+0.05 ft/s	0.01 ft/s	-0.5 to 13 ft/s	-	0.1 to 10 ft/s
	SonTek Flow Tracker2 Handheld-ADV	.+/- 1% +/-0.008 ft/s	.0003 ft/s	.003 to 13 f/s	-	0.1 to 10 ft/s
Atmospheric Conditions						
Barometric Pressure	In-Situ VuLink Data Logger and Telemetry	+/-0.05% FS from 0° to 122°F	+/- 0.01% FS or better	7 to 30 psi	-	-
Air Temperature		+/-0.54°F	0.018 °F or better	-4° to 122°F	-	5° to 110°F
Groundwater Level Measurements						
Depth to Water Table	Water Level Meter, P7/LM3/30m	0.05 ft	0.01 ft	0 to 300 ft	-	0 to 10 ft

Parameter	Equipment	Equipment Information			Precision Field Replicates	Expected Range/Notes
		Accuracy	Resolution	Range		
Water Well Levels (Absolute pressure)	In-Situ RuggedTROLL® Loggers RT100	+/-0.05% FS from 32° to 122°F	-/+ 0.01% FS or better	0 to 100 ft	-	0 to 10 ft
Absolute Water Pressure		+/-0.05% from 0° to 122°F	+/-0.01% FS or better	16 to 162 ft	-	0 to 15 ft
Water Temperature		+/-0.54°F	0.018 °F or better	23° to 122°F	-	40° to 60°F
Geolocating Locations						
GPS Locations (Ground surface Locations)	iPad Mini - Esri's 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

%RPD: relative percent difference

* Equipment installed under agreement WRYBIP-2325-KittRd-00053 (EIM ID: WRYBIP-2325-KittRD)

4.0 Study Design

This research analyzes the extent to which water from the KRD stream supplementation project interacts with groundwater within the Manastash Creek fan. The fan extends generally eastward from the mouth of Manastash Canyon to the terminus of the creek at river mile 154.5 of the Yakima River (see Figure 1). New data to be collected for this study includes stream discharge and groundwater elevations. Utilization of surface water monitoring equipment, installation of piezometers to monitor local groundwater levels, seepage runs will provide the data necessary to determine gaining and losing reaches along Manastash Creek during the observation period and achieve the project objectives of understanding the relationship between groundwater conditions and stream supplementation in the project area.

Study Boundary: the study boundary is along Manastash Creek with piezometer install within the banks of the creek as shown in Figure 3. The piezometer and seepage run locations were identified based on historical creek conditions prior to supplementation and obtained by personnel with first-hand accounts, photos, and monitoring reports of these conditions. The study site and design will verify the historically dry reach and flowing sections.

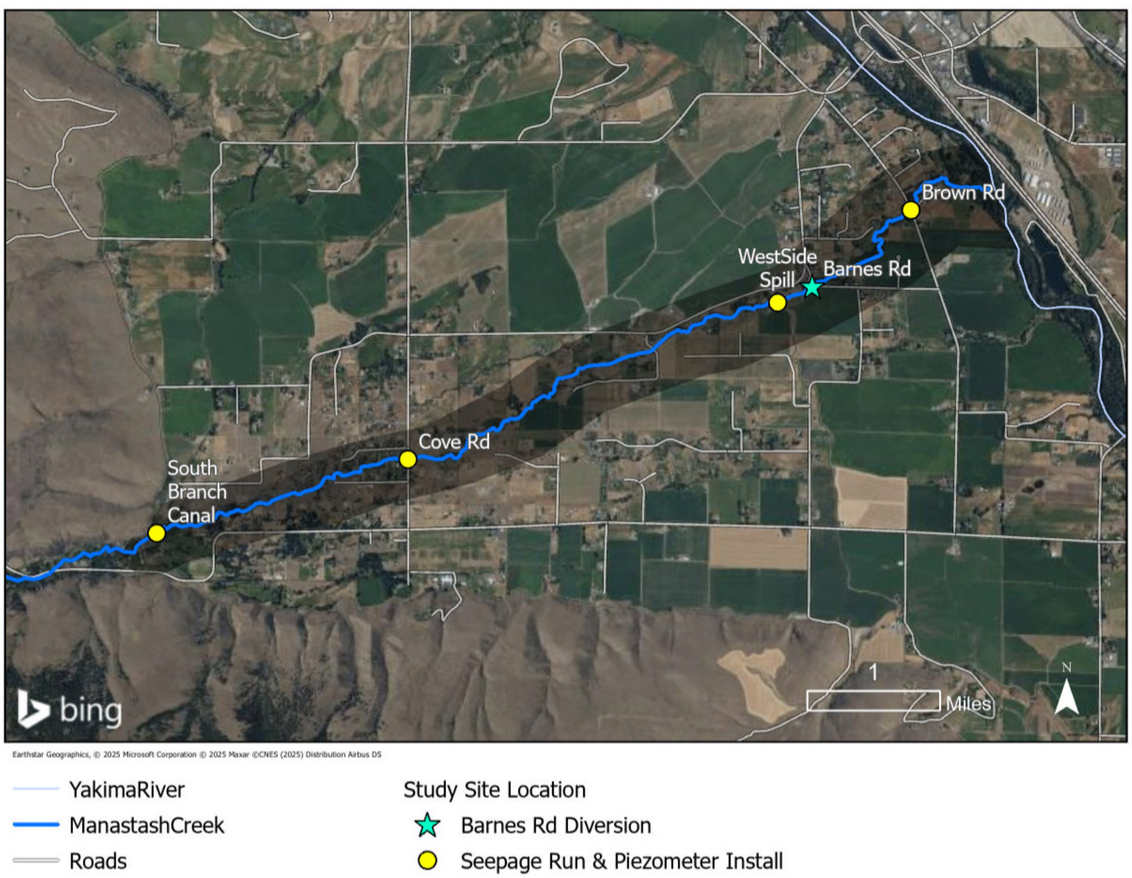

Figure 3. Study boundary, monitoring locations, and diversions.

Study Design and Field Data Collection:

The study design uses new and existing data to measure groundwater and surface water levels before and during the KRD's release of water for Tributary Supplementation on Manastash Creek as described below. The study design consists of four seepage run events to capture ephemeral flows and the aquifer's response with piezometers outfitted with pressure transducers (Figure 4).

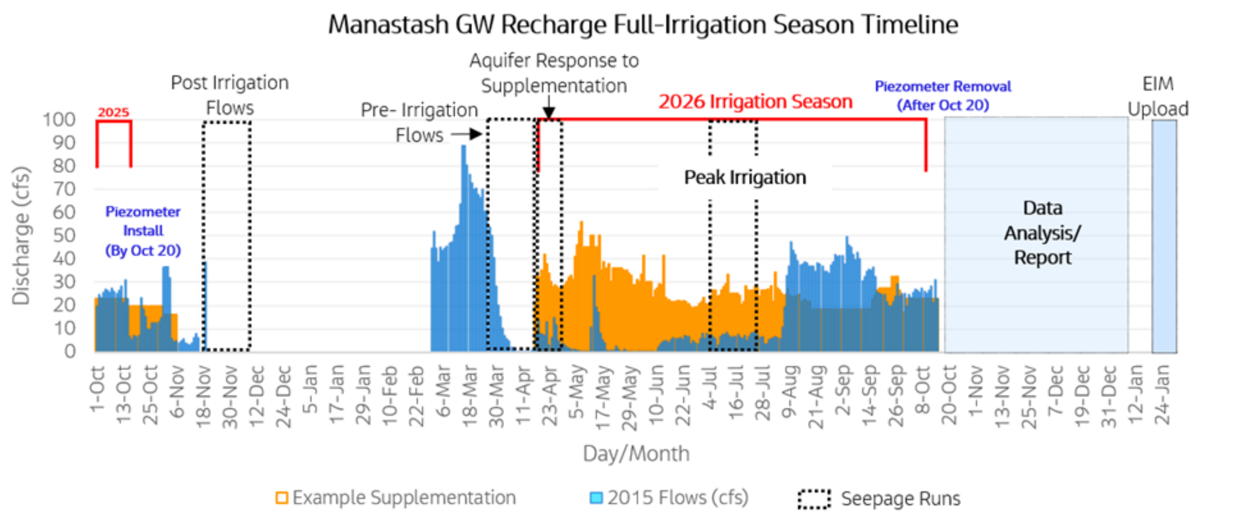

Figure 4. Seepage run and piezometer operations timeline outlined against historical flow and supplementation data.

Existing sources of data include previous studies performed under an Ecology-approved QAPP by the KRD and others, including Central Washington University research in the area. Two stream gages installed in 2024 in Manastash Creek under Ecology agreement WRYBIP-2325-KITTRD-00053 will be utilized in this project as well as data obtained from Ecology's Cove Road gage (ID# 39J070). Equipment at these sites records water column depth and ambient temperature on an hourly basis. Figure 5 shows the study design workflow and is described below.

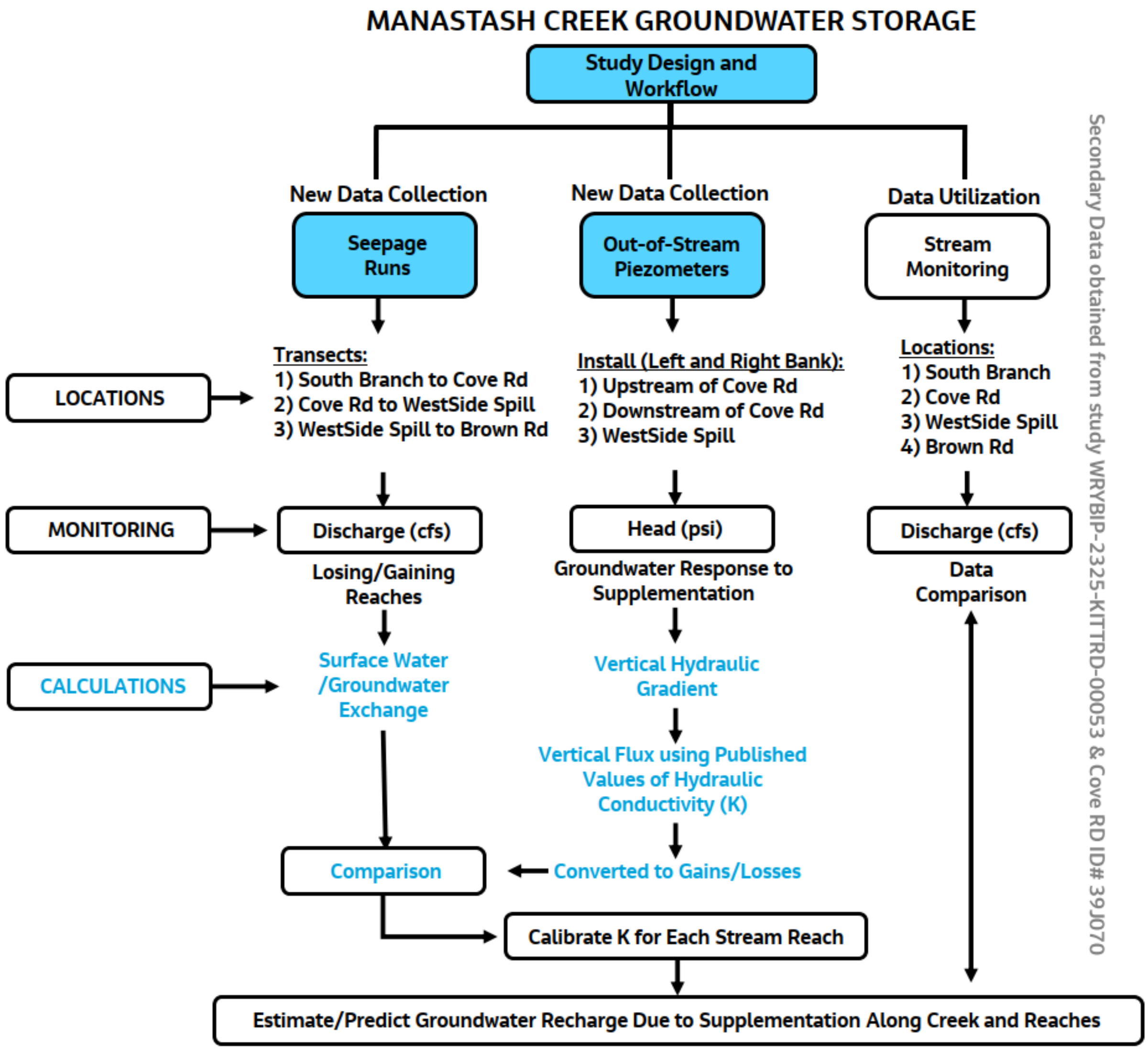

Figure 5. Study Design and Workflow

Piezometer Placement:

Piezometers will be installed out of stream, preferably within the banks, and less than 10 feet deep. Installation distance will depend on site-specific conditions and land access. Installation depth of less than 10 feet eliminates the need for permitting and additional agency coordination. This depth is sufficient to capture changes in groundwater head.

Piezometer installation and hourly data logging of water pressure (converted to depth) will occur at the following locations:

1. Upstream of Cove Road (within the upper historically flowing reach): left and right bank
2. Downstream of Cove Road (within the historically dry reach): left and right bank
3. WestSide Spill (within the historically flowing lower reach): left and right bank
4. Brown Road: left and right bank

The objective for each site is to install 2 piezometers, one on the left bank and one on the right bank, to estimate groundwater elevations at the center of the stream since piezometers will not be installed directly in the streambed. Install locations were determined by transition points between historically flowing and dry reaches along the creek (Figure 3). Exact piezometer locations will be determined by GPS and recorded during the installation event.

Barometric pressure, used for compensation calculations of groundwater elevations, will be obtained from currently installed stream monitoring with telemetry on Manastash Creek, which are updated hourly and available for online download.

Ideal Piezometer Placement Configuration:

The ideal configuration is to install piezometers in pairs on opposite banks, aligned perpendicular to the channel.

- Distance from creek: Piezometers will be placed within 10 feet of the top of bank to ensure the water level in the piezometer is a reliable indicator of the water pressure below the streambed
- Depth: All piezometers will be installed no deeper than 10 feet below ground surface to avoid triggering additional permitting.
- Alignment: Paired piezometers will be installed on opposite banks as close as practicable to a line perpendicular to the channel to ensure accurate measurement of the hydraulic gradient beneath the creek.

Piezometer Placement Contingency:

If site conditions (e.g., large cobbles, land access, infrastructure) prevent installation in the ideal configuration, the following hierarchy of contingency actions will be followed:

1. Priority 1 (Maintain Perpendicular): First, attempt to move the installation point along the original perpendicular transect line, either further from the creek or slightly upstream/downstream
2. Priority 2 (New Transect): If the original transect is entirely infeasible, establish a new transect perpendicular to the channel within 50 feet (upstream or downstream) of the original target location.

3. Documentation: Any deviation from the ideal configuration will be thoroughly documented in the field log, including GPS coordinates, photos of the constraints (e.g., cobbles, utilities), and a clear justification for the final chosen location.

Seepage Runs:

Seepage run locations will occur at Cove Road, WestSide Spill, and Brown Road (Figure 3). At least two seepage run events will take place to capture ephemeral flows and the aquifer's response to supplementation (Figure 4). Seepage run transects (distance between seepage run points) will be defined as:

1. South Branch to Cove Road
2. Cove Road to WestSide Spill
3. WestSide Spill to Brown Road

Table 4 summarizes the field parameters, frequency and equipment. Respective Standard Operating Procedures for field methods and data collection are discussed in section 6.0.

Table 4. Field Parameters, frequency, and equipment table

Environmental Parameters	Frequency	Equipment	Model
Open Channel Flow Velocity (Seepage Runs)	At least 2 events along 3 transects	Marsh McBirney FLO-MATE	2000
Groundwater Levels	Hourly	In-Situ RuggedTROLL® Loggers	RT100
Stream Monitoring	15 minutes	ToltHawk	45L
Barometric Pressure	Hourly	In-Situ VuLink	-
Streamflow Water Pressure	Hourly	In-Situ RuggedTROLL® Loggers	RT500/MicroRXWL
Streamflow Water Temperature	Hourly	In-Situ RuggedTROLL® Loggers	RT500/MicroRXWL
Air Temperature	Hourly	In-Situ Rugged BaroTROLL	Baro
Depth to water	During Seepage Runs	Solinist Water Level Meter (E-tape)	P7/LM3/30m
Irrigation Diversion	Provided by operator and converted to ensure compatibility with study timestep	Custom designed submerged orifice system with differential bubblers	

Methods: the following discusses analytical techniques utilized to achieve objectives discussed in section 1.0.

Seepage Loss Calculations: for each reach transect:

$$\Delta Q = (Q_{start} - Q_{End}) - Q_{div}$$

Where,
Q_{start}: Discharge at start of reach (cubic length/time)
Q_{End}: Discharge at end of reach (cubic length/time)
ΔQ: Water exchange during supplementation (cubic length/time)
Q_{div}: Discharge at irrigation diversions

Volume Exchange with Groundwater will be calculated as

$$V_{exchange} = \Delta Q x\, T$$

Where,

T=Duration of supplementation (time)

Vertical Hydraulic Gradient Calculation: for each piezometer the following will be calculated

$$VHG = \frac{H_{Creek} - H_{Piezo}}{\Delta_z}$$

Where,
VHG: Vertical Hydraulic Gradient (unitless)
H_{Creek}: Water surface elevation of the creek (length)
H_{Piezo}: Water elevation inside the piezometer (length)
Δ_z: Depth from streambed to the midpoint of the piezometer 's screened interval (length)

If,

VHG>0: Creek is losing water to groundwater
VHG<0: Creek is gaining water from groundwater
VHG=0: No vertical exchange

Compensation for no streambed piezometer: it will be assumed the water table beneath the creek is approximately linear within the banks of the creek. Elevation within the center of the creek will be estimated by:

$$h_c = \frac{h_L + h_r}{2}$$

Where,
h_c: Head at center of creek (length)
h_L: Head in left bank piezometer (length)
h_r: Head in right bank piezometer (length)

Reconcile Seepage Runs with Groundwater Monitoring Data Against Vertical Flux: to reconcile actual water gain/loss between two seepage run points, Darcy flux estimates will be calculated to estimate theoretical gains/losses based on aquifer properties in order to confirm measured gains/losses are realistic (Freeze and Cherry, 1979). Vertical Hydraulic Gradient will be calculated at each transect. Vertical flux is calculated by the following,

$$q = K * VHG$$

Where,

q: vertical flux (length/time)
K= hydraulic conductivity (length/time)

Hydraulic conductivity will be obtained using published values for alluvial fan sediments.

Vertical Flux Conversion to Volumetric Gain/Loss Rate: the flux rate will be converted to volumetric loss/gain rate by the following,

$$Gain/Loss\ Rate = q * \ Width * \ Reach_{\ Length}$$

Where,

$Width$: Average wetted width of the creek (obtained during seepage runs) (length)
$Reach_{\ Length}$: Distance between seepage run transects (length)

The K value for each stream reach will be calibrated by comparing the Darcy-derived flux with the measured seepage runs gains/losses. This process compensates for the lack of direct measurements from streambed piezometers.

An iterative process will be used: a literature-based value of K will be used in the Darcy flux equation initially. The resulting theoretical gain/loss rate will be compared to the measured gains/losses. The value of K will then be adjusted until the Darcy-derived flus converges with the measured gains/losses.

Once a K value is calibrated for each reach, it can be used with the measured vertical hydraulic gradient to estimate gains or losses between seepage runs during irrigation pulses, or to predict the impacts of changes in supplementation.

Calibrate K between each stream reach will be calculated to compensate for no streambed piezometers. Darcy-derived gains/losses will be compared with measured seepage run gains/losses. If Darcy's rate is approximately:

$$\frac{\Delta Q}{time}$$

Then K is accurate, otherwise K will be iteratively determined, as described above, until Darcy and ΔQ converge. Once calibrated, Darcy flux can be used to estimate gains or losses between seepage runs during irrigation pulses or predict impacts of changes in supplementation.

The following describes the assumptions, constraints, logistics, and contingencies associated with this study.

Summary of Assumptions: For aquifer properties, assumptions include homogeneous, isotropic alluvium using literature-based K, calibrated with seepage runs. Hydraulic gradients are assumed linear between bank piezometers and dominated by vertical flows. Seepage losses are assumed to be linear between transects.

Summary of Constraints: constraints include the following: K is not obtained in the field through slug testing, piezometers are restricted to less than 10 feet deep, no streambed piezometers will be deployed, site access may be restricted by landowners, and streambed conditions may result in an offset in left and right bank piezometer placement or some other configuration due to site-specific conditions.

Logistics: After piezometer installation, 3 people will be on-site at the time of seepage runs (2 for seepage runs and 1 for piezometer e-tape measurements.

Additional challenges and contingencies

Logistical Problems:

- Seepage run measurements may not be possible if flood conditions are present at the time of measurement.
- 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, variable backwater/unsteady flow, aquatic growth in the river channel, and bank overflow during varying stages of flow.
- Logistical problems at observation wells may include vandalism, borehole stability problems, incrustation, corrosion, etc.

Practical Constraints: Practical constraints for collecting streamflow and well data include scheduling issues, budgetary constraints, unreliable transportation, road conditions, and unavailability of or changes in site access agreements.

Schedule Limitations: Schedule conflicts may limit staff availability to measure streamflow.

5.0 Field Procedures

Measurement and sampling procedures

Seepage runs and piezometer data collection procedures will follow all SOPs listed in Table 5.

Table 5. Standard Operating Procedures (SOP) for field logs and records of measurement requirements in this QAPP.

Application	SOP Document ID	Name
Stream Discharge-Open Channel Velocity for Seepage Runs	SOP EAP056, v. 1.3 (Ecology 2018a)	Measuring and Calculating Stream Discharge
	SOP EAP057, v. 1.2, (Ecology 2019c)	Conducting Stream Hydrology Site Visit
	SOP EAP082, v. 1.2 (Ecology 2019a)	Correction of Continuous Stage Records Subject to Instrument Drift
	Sauer, 2002 (Appendix A-3)	Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods
Aquifer Data and Water Level Information	SOP EAP061 v. 2.1 (Ecology 2018b)	Installing, Monitoring, and Decommissioning Hand-driven In-Water Piezometers
	SOP EAP052, v. 1.4 (Ecology 2023)	Manual Well-Depth and Depth to Water Measurements
	SOP EAP074 v. 1.2 (Ecology 2019b)	Use of Submersible Pressure Transducers During Groundwater Studies
	SOP EAP082 v. 1.2 (Ecology 2019a)	Correction of Continuous Stage Records Subject to Instrument Drift
	ECY Pub: No. 17-11-005, 2017 (Ecology 2017)	Integrated Statewide Groundwater Monitoring Strategy
	Cunningham and Schalk, 2011 (Appendix A-4)	Groundwater Technical Procedures of the U.S. Geological Survey

Dataloggers

Four types of dataloggers will be installed for the duration of this project—ToltHawk loggers that record the distance from the mount location to the surface of the water, automatically uploaded to a public online portal; HydroVu LevelTroll data loggers of two types, one that automatically uploads to a project-specific online portal and one that is downloaded in the field manually prior to addition to the portal; and a standard piezometer type to be used in the wells that cannot be uploaded to either of the portals used for the other loggers.

Datalogger downloading at the sites that require manual downloads will follow guidelines outlined in ECY Pub: No. 17-11-005, (Ecology 2017) and SOP EAP074 v. 1.2 (Ecology 2019b) for observation well procedures. The barometric pressure data obtained from VuLink will be downloaded from HydroVu and used to correct the non-vented dataloggers for barometric pressure.

The in-stream dataloggers' collected data will be assessed for issues such as equipment failure or anomalous data. For telemetry sites, data will be examined bi-weekly, for non-telemetry sites data will be downloaded in accordance with agreement WRYBIP-2325-KittRd-00053, with additional downloads as needed. Staff gage levels will be recorded in order to identify drift or changes to the mounted hardware, and in accordance with agreement WRYBIP-2325-KittRd-00053.

It is not anticipated that any datalogger will reach measurement capacity over the course of this project, so none will be restarted unless necessary. The dataloggers installed in the piezometers will record at the top of every hour and data collection will be initiated prior to deployment. Once-hourly data recording will capture the required hydrogeological results for this project while optimizing data management. An hourly interval will generate a sufficient dataset to capture sustained volumes of recharge over the duration of a year while eliminating sub-hourly noise.

Final data download will occur in Spring 2026. After project completion some loggers may remain in place for use by the KRD and/or other agencies to continue streamflow monitoring efforts at these important sites.

Stream Monitoring Equipment

Stream gauge dataloggers will be installed in accordance with SOP EAP056, v. 1.3 (Ecology 2018a).

Streamflow Discharge

Field measurements will be conducted in accordance with guidelines set forth in SOP EAP056, v. 1.3 (Ecology 2018a). The Marsh McBirney FLO-MATE will be operated in real-time for streamflow measurements during low and high flows, respectively.

Groundwater Monitoring

Groundwater will be monitored at locations along the project site described in section 4.0. The installed piezometers will be equipped with In-Situ RuggedTROLL® RT100 transducers. Piezometers will be installed using a hand-driven method described in SOP EAP074 v. 1.2 (Ecology 2019b).

Measurements will be obtained in accordance with SOP EAP052, v. 1.4 (Ecology 2023). A measuring point at the top of each piezometer casing will be established upon installation, geolocated with the iPad Mini, and used for all subsequent manual measurements. The height of the MP and the date it is established will be recorded.

For each piezometer, the data will be recorded in compliance with ECY Pub: No. 17-11-005, 2017. During 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 measured with an e-tape will be replicated in the field as described in SOP EAP052, v 1.4.

6.0 Quality Control

Quality control procedures, safety measures, stream measurements and piezometer measurements will be followed according to documents listed in Table 6 (next page). Calibration and testing of field equipment prior to deployment is specified within each SOP listed in Table 6.

Datafiles obtained from monitoring equipment will be visually examined for unreliable datapoints, or malfunctions. Any field parameters that do not meet the MQOs in Section 3 will be discarded. Each transducer will be programmed to record a data point at the top of each hour. For scheduled downloads, transducers will be pulled, downloaded, and replaced between xx:05 and xx:50 to avoid logging spurious data points. 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. Field quality controls will be followed in accordance with documents listed in Table 6.

In addition to the corrective process listed in Table 6, 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 per the device manual. 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).

<u>Well Station Data</u>

The corrective action processes for measurements obtained at well stations are detailed in Ecology (2017) and listed in Table 6.

Table 6. Field Quality Controls

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, (Ecology 2018a), p.37)		
Stream measurements – Open Channel Velocity – Seepage Runs	Each visit	Review equipment checklist: ensure station information and forms are on hand; test stream measurement equipment for proper operation (SOP EAP056 (Ecology 2018a); check recent and upcoming weather reports for possible adverse access and site conditions	Detailed steps described in SOP: EAP056, (Ecology 2018a); section 6.2 through 6.16.10	Horizontal, vertical, and single-point velocity variation; Adjusting velocities of oblique flow angles, measuring discharge when stage fluctuates rapidly, and calculating mean gauge height when stage fluctuates rapidly: SOP EAP056, 2018a, section 6.6 through 6.10
Manual well measurements and pressure transducer water level measurements	Each visit or if a problem becomes apparent in the field	SOP EAP052, (Ecology 2023): 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, 2017: E-tape calibrated against steel tapes ECY Pub: No.17-11-005, 2017: Pressure transducer benched tested	SOP EAP052, (Ecology 2023) Depth-to-water measurements with electric-tape (section 6.0 to 6.8.18. ECY Pub: No.17-11-005, 2017: Multiple e-tape measurements to represent true static water level	SOP EAP052 (Ecology 2023): 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, 2017: Failed equipment test – return to manufacture for repair or retire equipment

6.1 Steps in preparation of field work

Water level measuring equipment will be cleaned and disinfected prior to and after use in each monitoring well as outlined in SOP EAP052, v. 1.4 (Ecology 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. Additionally, the following will be done prior to conducting field work:

- Briefings and trainings for field staff
- Daily field safety meeting
- Periodic maintenance for field instrumentation
  - Includes examination of field instruments prior to use.

All equipment will be calibrated prior to deployment. Data loggers will be operated within the period of calibration. If drift is observed during this period, the equipment will be sent in for calibration.

6.2 Steps taken in field

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,
- New measurements (flow or staff gage readings) will be taken if staff identify issues in their data sheet review.
- After the site visit:
- Staff will upload data, scanned field notes, and photos taken during the field event to the Jacobs server.
- Data and uploaded items will be reviewed by Project Managers for accuracy.

7.0 Data Management Procedures

Groundwater well data will be downloaded directly to individual comma-delimited ascii-files in the field. Each file will be labeled with the transducer serial number and common name of the surface location. 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. Raw files will be duplicated, with the duplicate file trimmed to exclude data on the ends of the dataset unrepresentative of groundwater conditions based on criteria described in Kennedy (1984).

The raw data files will be uploaded to the Jacobs project database. An electronic copy of the raw data will be named "Well_name_Location_Date".

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 0.01 ft will cause the loggers to be flagged for recalibration. Additional detection includes seepage runs showing opposite conditions to bank piezometers (e.g., loss vs gains)

All data will be formatted and entered into Ecology's EIM system under Study ID: WRYBIP-2325-00044.

8.0 Reporting and Field Activity Assessments

Report Procedures: procedures will be followed as outlined in the QAPP. Technical System Audits will occur on the streamflow and groundwater data collection process by project management. 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 three weeks of data collection. As the project progresses, monitoring needs and objectives will be re-examined and updated as necessary. Should any changes to monitoring locations, including equipment relocation, be necessary, an addendum to this QAPP will be written in consultation with and approved by Ecology prior to field adjustments.

Responsible personnel include the following:

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

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 partners. A draft will be distributed for review and comment prior to EAGL submission.

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.

9.0 References

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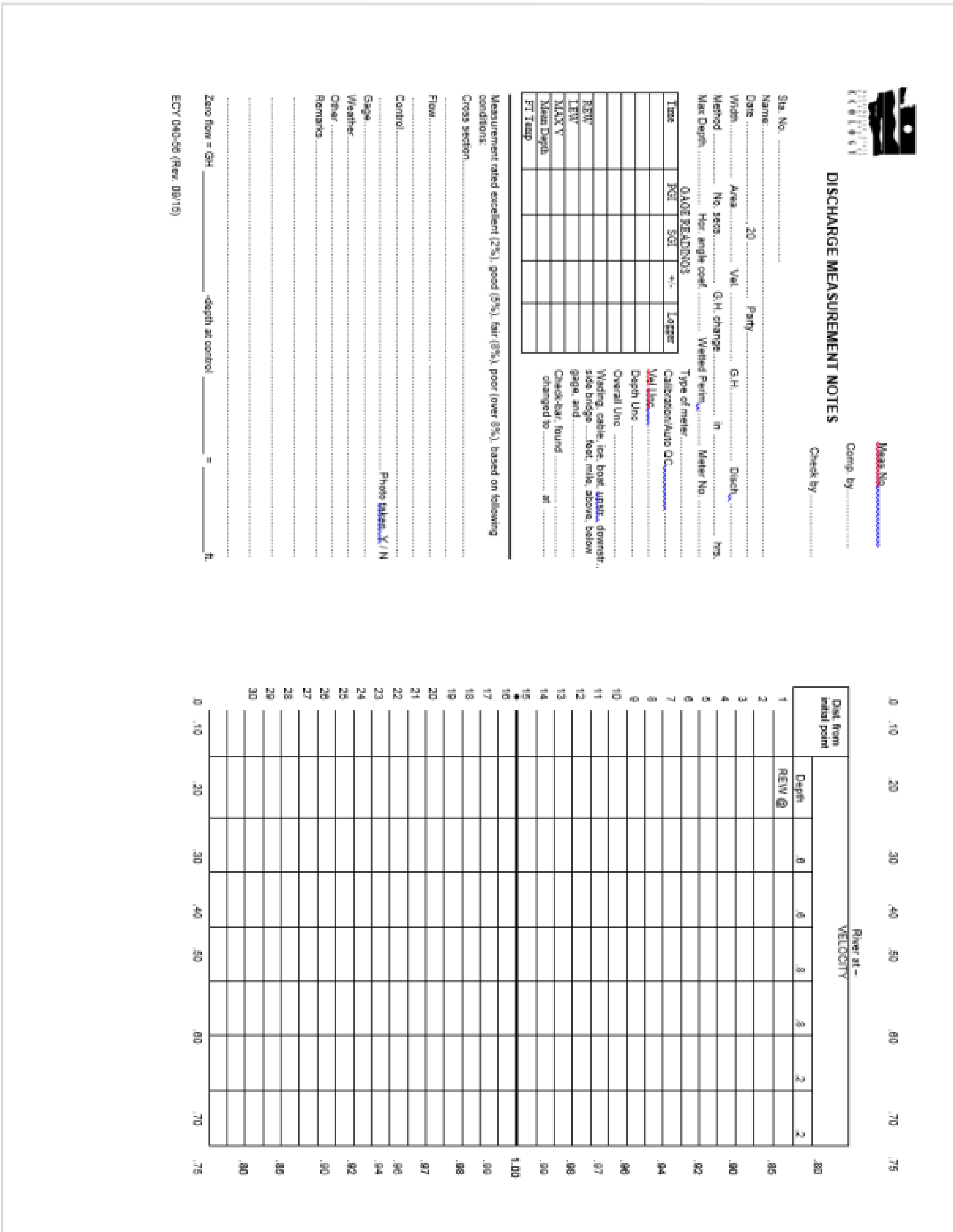
10.0 Appendix A: Field Forms

Figure A-1: Seepage Run Field Form


DISCHARGE MEASUREMENT NOTES

Meas No. ______
Comp. by ______
Check by ______

Sta. No. ______
Name ______
Date ______ 20 ______ Party ______
Width ______ Area ______ Vel. ______ G.H. ______ Disch. ______
Method ______ No. secs. ______ G.H. change ______ in ______ hrs.
Max Depth ______ Hor. angle coef. ______ Wetted Perim. ______ Meter No. ______
Type of meter ______
Calibration/Auto QC ______
Vel Unc ______
Depth Unc ______
Overall Unc ______
Wading, cable, ice, boat, upstr., downstr., side bridge ___ feet, mile, above, below gage, and ______
Check-bar, found ______ changed to ______ at ______

GAGE READINGS

Time	PGI	SGI	+/-	Logger
REW				
LEW				
MAX V				
Mean Depth				
FT Temp				

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following conditions:
Cross section ______
Flow ______
Control ______
Gage ______ Photo taken Y / N
Weather ______
Other ______
Remarks ______

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

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Figure A-2: Groundwater Well Monitoring Transducer Download Field Sheet

TRANSDUCER DOWNLOAD AND SITE VISIT RECORD **Form A-6**

Project: ___________________________ Project Well No. _________________ Well Tag ID: _________

TRANSDUCER DOWNLOAD AND SITE VISIT RECORD			**Form A-6**
Project:Project Well No: ________ Well Tag ID: _____ _			
Background Information			
Date of site visit (mm/dd/yyyy):			
Field personnel initials:			
Manual GW Level Measurement			
Measuring point ID number:			
Measuring point description:			
Water level watch time (hh.mm):	PST PDT	PST PDT	PST PDT
WL measurement method:	(Steel Tape or E-tape)	(Steel Tape or E-tape)	(Steel Tape or E-tape)
WL accuracy(+/-ft):	(0.01) (0.1) (0.5) (1.0J (>1)	(0.01) (0.1) (0.5) (1.0J (>1)	(0.01) (0.1) (0.5) (1.0J (>1)
Manual WL hold value (ft):			
WL cut value (ft):			
Manual WL depth below MP (ft):			
Manual WL depth below LS (ft):			
Submersible Transducer Information			
Model:			
Serial number:			
Download time (hh:mm):	PST PDT	PST PDT	PST PDT
Download file name:			
Battery voltage (percent):			
Remaining memory:			
Re-deployment time (hh:mm):			
Pressure value (ft of H_2O):			
Barometric Transducer Information			
Model:			
Serial Number:			
Download time (hh:mm):	PST PDT	PST PDT	PST PDT
Download file name:			
Battery voltage (percent):			
Remaining memory:			
Re-deployment time (hh:mm):			
Pressure value (ft of H_2O):			
Additional Observations of Comments			