# Quality Assurance Project Plan

## Monitoring Program for the Triple Creek Wetland Restoration Project

Agreement: WQC-2016-OkHiAl-00126

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Each study, funded in whole or in part with Ecology funding, must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives.

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Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm.

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April 2016

**Approved by*:**

| | |
|---|---|
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# 2.0 Abstract

The Okanogan Highlands Alliance (OHA), together with its partners Trout Unlimited (TU) and the US Fish and Wildlife Service (USFWS), will implement the *Triple Creek Water Quality Restoration Project* in the Myers Creek drainage located in north central Washington. This project is funded, in part, with Ecology agreement WQC-2016-OkHiAl-00126 and will use in-stream structures known as beaver dam analogs (BDAs). BDAs mimic beaver dams and are projected to aggrade the incised creek and re-connect the channel with its floodplain slowly over time. Water quality concerns will be addressed by reconnecting the floodplain and historic wetland, establishing riparian vegetation, and re-establishing wetland hydrologic functions.

The monitoring component of this project is the subject of this Quality Assurance Project Plan (QAPP). Monitoring will include the collection of surface water level, temperature, and dissolved oxygen data in-situ by data loggers. Groundwater monitoring wells containing water level loggers will monitor shallow groundwater levels. Annual floodplain maps will detail potential increases in water surface area and aggradation of the streambed. These maps will be created through the use of a total station and the collection of georeferenced coordinates throughout the project area. Finally, photo points will help ground-truth floodplain maps and provide additional documentation of geomorphological changes.

## 3.0 Background

On the western toe of Buckhorn Mountain, three creeks (Myers, Bolster, and Thorp) converge to form the 100 acre Triple Creek wetland (Figure 1). During the late 1990s, the Myers Creek channel incised 10–12 feet in some places and disconnected the channel from its floodplain, draining and degrading portions of the Triple Creek wetland (Figure 2). A number of factors may have contributed to the rapid incision of the channel including land use practices in the upper watershed, the breach of one or several large beaver ponds, and a high spring freshet. The Triple Creek wetland is part of 535 acres of forest, farm, and wetland owned in common by the Triple Creek community. The group has placed a conservation easement on the Triple Creek wetland and is working toward the restoration of healthy stream and wetland functions there.

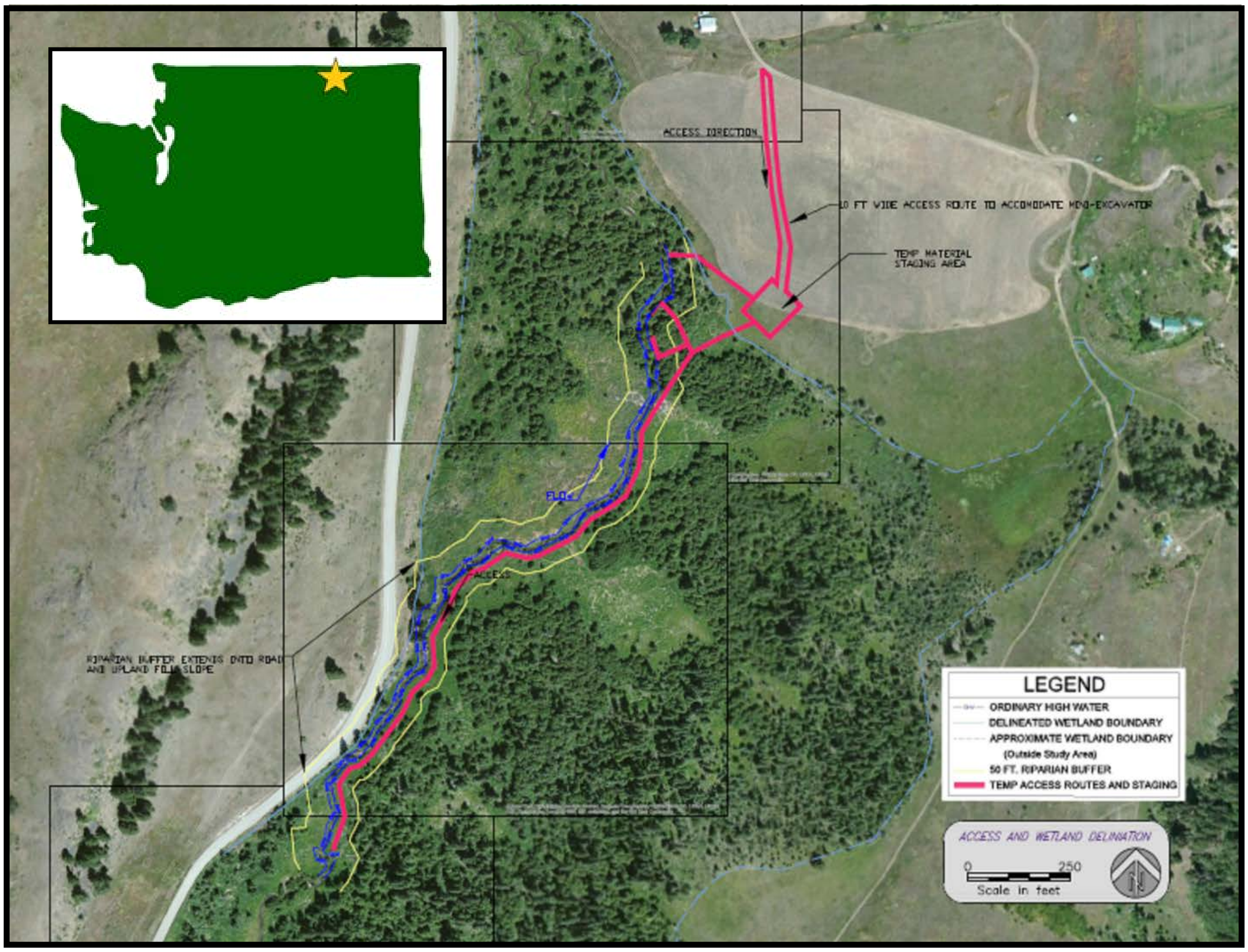

Figure 1. Project area map.

Wetlands and riparian areas typically occur as natural buffers between uplands and adjacent water bodies (Mitsch and Gosselink 2015). Loss of these systems allows for a more direct contribution of nonpoint source pollution to receiving waters. When Myers Creek incised, a substantial portion of these functions were lost.

Figure 2. Channel incision at Myers Creek (left photo taken July 2012, right taken April 2014).

The *Triple Creek Water Quality Restoration Project* is a habitat restoration project occurring near Chesaw, Washington. The project is a collaboration between OHA, a group of private landowners, TU, and USFWS. This project seeks to improve water quality by reconnecting the incised stream to its floodplain, thereby reestablishing wetland functions essential to water quality. The project's pre- and post-implementation data collection and monitoring are the subject of this QAPP.

The restoration project will include live planting methods, installation of large woody debris (LWD), and beaver dam analogs (BDAs). BDAs are wooden structures that both mimic the benefits of beaver dams and encourage beaver activity (Pollock et al. 2014). These will be installed at selected locations along a roughly one-third mile reach. Deflector dams (partially channel-spanning BDAs) and LWD will be strategically placed to encourage scour in places for meander development. BDAs will also be placed where a sediment supply is needed to aggrade the streambed. Downstream of scour features, BDAs will be constructed by placing a channel-spanning line of vertical pilings with live cuttings planted in the streambank and woven across the pilings. Additionally, exclusion fencing will be built around the site by the landowners, protecting a minimum 50-foot riparian buffer from livestock impacts.

After project implementation, BDAs should encourage sediment deposition by slowing flow velocity and increasing water depth and attenuation. This will create conditions needed for riparian plant establishment and channel aggradation. As riparian plants mature, they will encourage nutrient uptake and increase stream shading. An increase in riparian vegetation cover should lower the water temperature, increase the dissolved oxygen (DO), and otherwise improve habitat conditions for fish and other riparian species (Osborne and Kovacic 1993, Baxter et al. 2005, Cross et al. 2013). This project will develop heterogeneity in the stream and reestablish the hydrologic conditions necessary for the plant communities that beavers rely upon, which will encourage self-sustaining wetland development into the future.

The collection of monitoring data will help provide information about the effects of these treatments on the wetland/riparian environment. Monitoring associated with this restoration project will include the collection of temperature and DO data, measuring groundwater levels at various points in the floodplain, the annual creation of a floodplain map, and the collection of photographs at established photo points.

## 3.1 Study area and surroundings

### 3.1.1 Logistical problems

The study area is on private property, but a conservation easement has been obtained by OHA that guarantees access for data collection and monitoring in perpetuity.

Logistical concerns that may impact the collection of data include accessibility related to snow, ice, and high water. These are unlikely to hinder this study because manual data collection methods are minimized during the winter months.

### 3.1.2 History of the study area

The study area lies within water resource inventory area (WRIA) 60, three miles north of Chesaw, Washington. Indigenous people have traversed or inhabited this land since time immemorial. Anthropologists consider the area to be a part of the Columbian Plateau culture area (Oosahwee-Voss 2015). At the time of Euro-American contact, the area was inhabited by the Okanagan people. As is typical of early Euro-American contact in the Western Frontier, the first Euro-Americans that the Okanagan came in contact with were trappers, followed later by miners.

In 1872, the Colville Indian Reservation was created by executive order; the reservation boundaries included the study area. However, persistent problems caused by non-native trespassers seeking gold in the northern region of the reservation (including the study area), resulted in the federal government’s decision to reduce the reservation size by opening the North Half of the Colville Indian Reservation to the public domain in 1892.

The study area is just south of the turn-of-the-century mining boom town of Bolster, Washington. At its height, Bolster contained 90 buildings, but many of the residents had moved on by 1904. The study area itself had been part of two native allotments. Currently, the study area is owned wholly by one entity, Triple Creek, a non-profit corporation registered in Washington State.

The study area has historically been influenced by beaver activity. Aerial photos indicate the presence of large beaver dams adjacent to the main channel of Myers Creek (Figure 3). In the late 1990s, land-use practices (timber harvesting) in the upper Myers Creek watershed likely aggravated the effects of a large precipitation event that breached the beaver dams and drained the wetlands, culminating in the incision of Myers Creek (Figure 4).

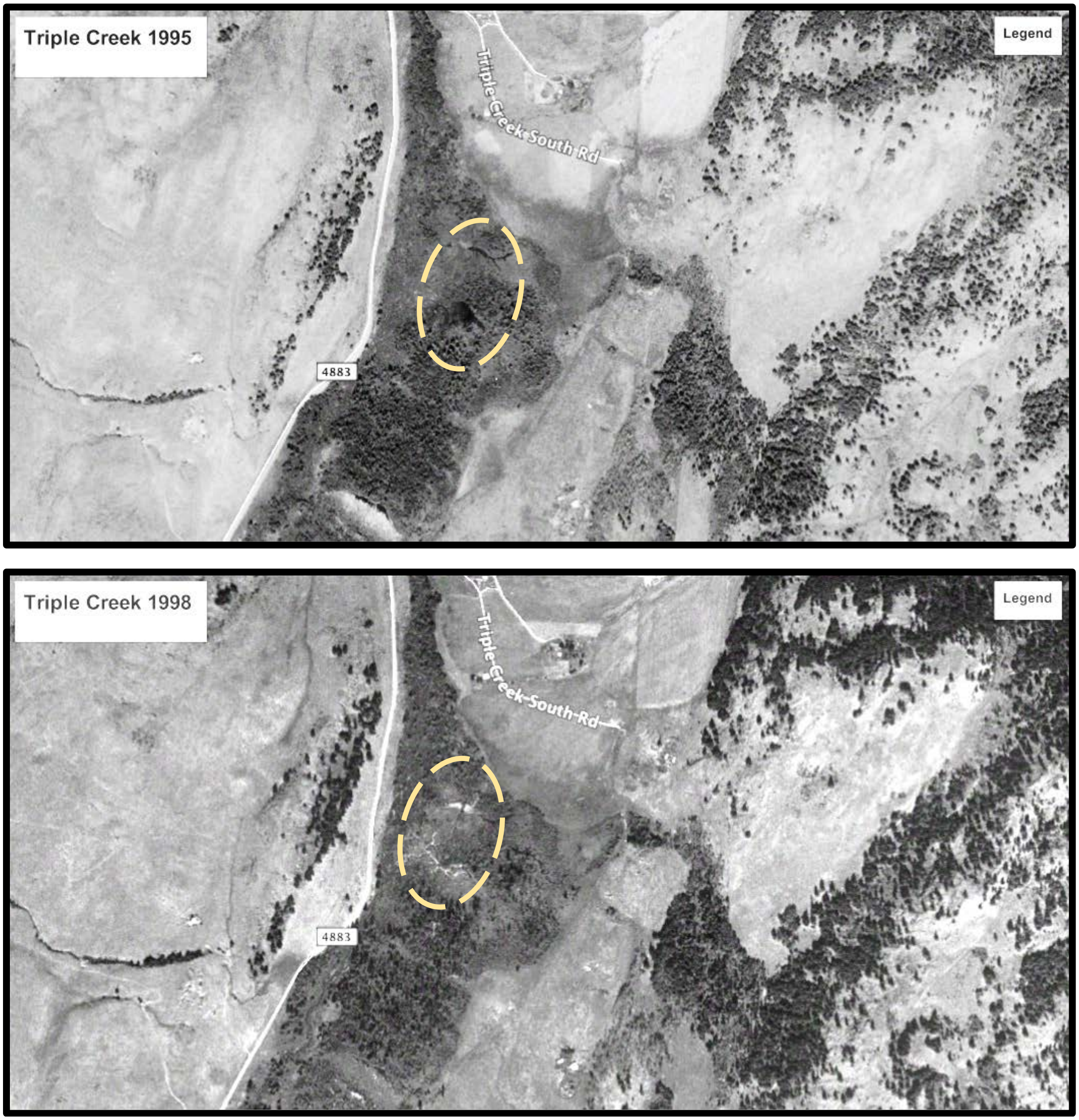

Figure 3. Aerial photographs of the study area in 1995 (upper) with a beaver pond circled and in 1998 (lower) with a breached beaver pond area circled.

In 1992, the Battle Mountain Gold Company proposed the Crown Jewel Project, an open-pit gold mine on Buckhorn Mountain, at the headwaters of some of Myers Creek's tributaries. Ultimately, this proposal was defeated in a legal action, but a new proposal for an underground mine was submitted and approved by state regulators.  The Buckhorn Mine began operation in 2007 and continues to operate in the Myers Creek headwaters.

Figure 4. A section of the incised Myers Creek channel (April 2014).

### 3.1.3 Contaminants of concern

Water temperature and DO are the primary water quality parameters to be monitored as part of this study.  Shallow groundwater levels will also be monitored with well level loggers across two floodplain transects.  In addition, this study will also investigate the recruitment and deposition of sediment and other geomorphological changes via an annual topographic survey.
Myers Creek is listed on the 303(d) water quality assessment as having a number of parameters with Category 3 (insufficient data) designations (Table 1).  A Category 3 designation means that one or more samples have been collected in which the waterbody did not meet state standards for the parameter of interest, but there is insufficient data to apply a Category 5 (Impaired) designation.

Table 1.Parameters listed on the 303(d) assessment for Meyers Creek**.**

| Parameter | Listing ID | Category |
|---|---|---|
| Arsenic | 17091, 17092 | 3 |
| Cadmium | 17093, 17094 | 3 |
| Copper | 17095, 17096 | 3 |
| Cyanide | 17097, 17098 | 3 |
| Lead | 17099, 17100 | 3 |
| Mercury | 17101, 17102 | 3 |
| pH | 17103, 17104 | 3 |
| Silver | 17105, 17106 | 3 |
| Temperature | 17107, 17108 | 3 |
| Zinc | 17109, 17110 | 3 |

### 3.1.4 Previous studies

Previous water quality studies have been completed that include some part of the Myers Creek watershed. Most were completed during the environmental analysis of the current underground gold mine on Buckhorn Mountain and a previously considered open pit mine on the same site (Table 2).

Table 2. Selected water quality and quantity studies in the Myers Creek watershed.

| Firm or Agency | Author | Document Title | Date | Scope of Study |
|---|---|---|---|---|
| WA Ecology | Robert L. Raforth, Art Johnson, David K. Norman | Screening Level Investigation of Water and Sediment Quality of Creeks in Ten Eastern Washington Mining Districts, with Emphasis on Metals | January 2000 | Water quality |
| Pommen Water Quality Consulting | | Water Quality Assessment of Myers Creek at the International Boundary 1998-2002 | November 2003 | Water quality |
| GeoEngineers | Keith Holliday | Level I Technical Assessment Water Resource Inventory Area 60 Kettle River Watershed | 3/16/2004 | Water quantity |

Previous studies that collected water quality data in the Myers Creek drainage have done so as part of a geographically broader study. Raforth et al. (2000) inquired into selected streams in ten historic northeast Washington mining districts and found that Myers Creek did exceed water quality standards in some parameters (i.e., iron and turbidity), but the study did not recommend further evaluation of the creek's water quality. A study funded by the Canadian government (Pommen 2003) also found high turbidity in Myers Creek, particularly during the spring freshet, which was also associated with higher concentrations of metals and phosphorus. An assessment seeking to better understand the water balance of WRIA 60 (Holiday 2004) concluded that Myers Creek was losing an average of 1.6 cubic feet per second (cfs) to shallow groundwater, and the low permeability streambed sediments limited surface water to groundwater interaction. Holiday (2004) also commented on previous hydrological inquiries into the Myers Creek watershed, stating:

*The majority of documents specific to streamflow conditions within WRIA 60 that were encountered were related to the Crown Jewel Project, located near Chesaw, Washington. These were largely specific to Myers Creek and/or its tributaries. Golder and Associates (1994b and 1994c) conducted a hydrologic investigation along Myers Creek near Myncaster, British Columbia to assess hydraulic continuity between Myers Creek and shallow groundwater in this area. This study concluded that approximately a 2.2-mile reach of Myers Creek was losing an average of 1.6 cubic feet per second (cfs) to shallow groundwater, and that surface water-groundwater interaction was somewhat limited by low permeability streambed sediments. Golder and Associates (1995b) and Hydro-Geo Consultants (1996) evaluated potential streamflow impacts within the Myers Creek catchment basin based on the proposed Crown Jewel Project. Golder Associates (1998) also prepared a streamflow mitigation plan in response to the anticipated streamflow impacts from the Crown Jewel Project. Golder Associates (1996b) measured GeoEngineers 10 File No. 3595-005-00/031604 streamflow at a variable interval during water year (WY) 1995 at 11 locations within the Myers Creek catchment basin. A wide range in flows were observed at each location, particularly in tributaries such as Gold Creek, Ethel Creek and Bolster Creek. Cascade Environmental Services, Inc. and Caldwell Associates (1996) used the Instream Flow Incremental Methodology (IFIM) to quantify potential physical habitat available to fish species within Myers Creek.*[1]

### 3.1.5 Regulatory standards

Regulatory standards for surface waters of Washington State are described in WAC 173-201A. Myers Creek is habitat to interior non-anadromous redband trout, and that distinction guides that applicability of state criteria (Table 3).

Table 3. Aquatic life water quality criteria for freshwater redband trout.

| Parameter | Limit |
|---|---|
| Temperature | 18$^{o}$C |
| Dissolved oxygen | 8 mg/L (lowest 1-day minimum) |
| Turbidity | 5 NTU over background when the background is 50 NTU or less; or<br>A 10 percent increase in turbidity when the background turbidity is more than 50 NTU. |
| Total dissolved gas | Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection. |
| pH | pH shall be within the range of 6.5 to 8.5 with a human-caused variation within the above range of less than 0.5 units. |

[1] The studies described in GeoEngineers were not individually reviewed, as they are not easily obtained (unpublished and the work product of a private consulting firm) and the review of their contents in Holliday provides sufficient detail about these studies, considering they are not water-quality studies. The full citation of these studies are provided in the references section of this document.

# 4.0 Project Description

The monitoring component of the *Triple Creek Water Quality Restoration Project* will consist of the following activities:

- Monitoring water temperatures at six locations in Myers Creek.
- Monitoring of DO at two locations in Myers Creek.
- Monitoring of surface water and groundwater levels at 11 locations in the Myers Creek floodplain.
- Annual mapping of the Myers Creek floodplain.
- Collecting of photo points along the stream.

## 4.1 Project goals

Project monitoring will identify water quality and related geomorphological impacts of the restoration project on various parameters at the Triple Creek wetland. The collection of this data will provide information about the outcomes of restoration implementation and advise future adaptive management of the area. Additionally, data will be made available to the restoration community at large, helping to inform other interested parties about the utilization of BDAs in the restoration of incised streams.

## 4.2 Project objectives

- Characterize water temperature and DO conditions within the study area.
- Characterize surface and subsurface water levels at various locations in the floodplain.
- Observe geomorphologic changes over time by annually mapping the floodplain and taking biannual photographs at specific points.
- Observe potential changes to water temperature, DO, surface, and groundwater levels as site hydrology response to the implementation of the project.

## 4.3 Information needed and sources

The information required to achieve the project goals and objectives will be collected from spring2016 throughout the three-year life of the Ecology funding agreement. During this time, Myers Creek surface water level, temperature, and DO data will be collected in-situ by data loggers. Groundwater monitoring wells containing water level loggers will collect data on shallow groundwater levels. Annual floodplain maps will detail potential increases in water surface area and aggradation of the streambed. These maps will be created through the use of a total station and the collection of georeferenced coordinates throughout the project area. Finally, photo point monitoring will help ground-truth floodplain maps and provide additional documentation of geomorphological changes.

## 4.4 Target population

This project is targeted towards developing an understanding of how the Triple Creek Wetland Restoration Project impacts temperature, DO, and floodplain processes, including streambed aggradation and changes in surface and groundwater levels.

## 4.5 Study boundaries

This monitoring effort will occur in and adjacent to the reach of Myers Creek where the project's restoration work will be implemented (Figure 5). The temporal bounds of this study reflect the project's Ecology budget funding cycle, concluding in 2018.

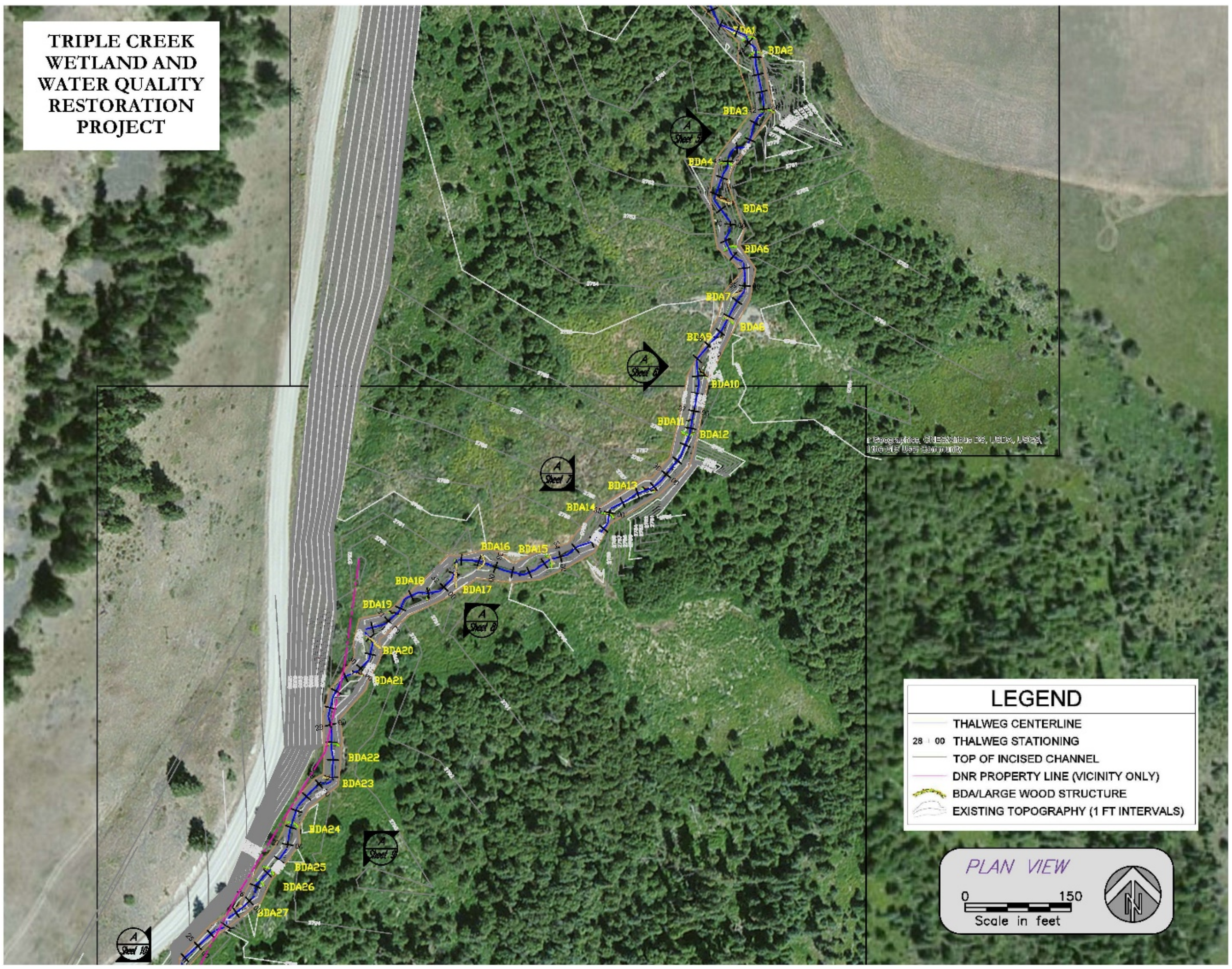

Figure 5. Project area map with BDA locations.

## 4.6 Tasks required

Several tasks (i.e., monitoring components) are required for the completion of this study (Table 4). Each monitoring component has associated data collection and management tasks. Quality assurance and control (QA/QC) measures will be implemented for each task.

Table 4. Monitoring components and associated data collection, data management, and QA/QC tasks.

| Monitoring Component | Data Collection Tasks | Data Management Tasks | QA/QC Tasks |
|---|---|---|---|
| Temperature and DO | • Anchor and deploy loggers.<br>• Describe conditions and placement in field notebook. | • Visually inspect data, flag outliers.<br>• Validate or remove flagged data from the dataset. | • Pre- and post-deployment instrument check<br>• Field instrument checks |
| Surface water levels | • Anchor and deploy loggers.<br>• Describe conditions and placement in field notebook. | • Visually inspect data, flag outliers.<br>• Validate or remove flagged data from the dataset. | • Pre- and post-deployment instrument check<br>• Field instrument checks |
| Subsurface water levels | • Install monitoring wells and deploy loggers.<br>• Describe conditions and placement in field notebook. | • Visually inspect data, flag outliers.<br>• Validate or remove flagged data from the dataset. | • Pre- and post-deployment instrument check<br>• Field instrument checks |
| Floodplain mapping | • Establish control point network.<br>• Collect topographic data of the channel and floodplain. | • Correct rod height errors.<br>• Georeference data to real-world coordinates.<br>• Maintain point file.<br>• Create TIN surface. | • Recalibrate total station every 2 years. |
| Photo point monitoring | • Using GPS, numbered staff gauge, and previous photos (when available), locate photo point position. | • Save photos to folder and backup files on either an external hard drive or via cloud. | • View photo to ensure it is from the same position as previous photo points from the same point. |

## 4.7 Practical constraints

Variables that have the potential to disrupt the proposed monitoring regime include the malfunctioning of equipment, access limitations resulting from weather or wildfire activity, extreme changes in geomorphology, loss, removal, or vandalism of control points, and high or low flow velocities.

## 4.8 Systematic planning process

This study plan is based on the collective experience of team members and informed by a review of relevant literature and monitoring/sampling protocols. The plan is driven by requirements contained in OHA's agreement WQC-2016-OkHiAl-00126 with Ecology and a desire to better understand the use of BDAs and their impacts on fluvial systems and floodplain dynamics.

# 5.0 Organization and Schedule

## 5.1 Key individuals and their responsibilities

OHA is the implementing agency for this QAPP. Key individuals with OHA, Ecology, and partnering organizations, and their responsibilities are provided in Table 5.

Table 5. Key individuals and their responsibilities.

| Staff Name | Organization | Responsibilities |
|---|---|---|
| David Kliegman | OHA | • Project management<br>• Project planning<br>• Landowner relations |
| Julie Ashmore | OHA | • Project planning<br>• Budget management<br>• Grant writing/administration<br>• Education/outreach and volunteer coordination<br>• Data collection and processing |
| Megan Kernan | OHA | • Financial and contract management<br>• QAPP design<br>• Project planning support<br>• Data collection and processing |
| Crystal Elliot-Perez | TU | • Project management<br>• Permitting<br>• Wetland delineation |
| Robes Parrish | USFWS | • Project planning<br>• Technical support<br>• Data collection and processing |
| Ken Muir | USFWS | • Project planning<br>• Technical support<br>• Data collection and processing |
| Heather Simmons | Ecology, Water Quality | • Grant manager, QAPP initial reviewer |
| Sarah Zehner | Ecology, Water Quality | • Financial manager |
| Mike Anderson | Ecology, EAP | • QAPP technical reviewer |
| Daniel Dugger | Ecology, EAP | • QAPP technical reviewer |

## 5.2 Special training and certification

Julie Ashmore has worked for OHA as Conservation Coordinator for five years. Julie graduated from the British Columbia Institute of Technology Environmental Engineering department as an Environmental Technologist, with training in water quality sampling and analysis, soil science, and analytical chemistry among other areas

Megan Kernan works for OHA as Conservation Associate. Megan obtained both a Juris Doctor and a MS in Water Resources from the University of Idaho. Megan's graduate coursework included the study of riparian ecology, fluvial geomorphology, water quality, and water resource management. A former employee of the US Forest Service's Fish and Aquatic Ecology Unit, Megan has significant effectiveness monitoring experience collecting water quality, botany, and geomorphology data in the field using the rigorous PIBO-EMP stream sampling protocol.

Robes Parrish is a hydrologist for USFWS who has been involved with habitat restoration projects for 14 years. He has an MS in Watershed Science from Utah State University and a BS in Ecology from the University of Vermont. He is currently working on completing the requirements for AIH certification as a licensed professional hydrologist through Oregon State University. He has been engaged with all aspects of habitat restoration including planning, design, permitting, construction, and monitoring for 150+ projects in the Pacific Northwest and Colorado.

Ken Muir is a USFWS fish biologist with a BS in biology from Texas Tech University.

## 5.3 Organizational chart

See Figure 6 for the chain of communication between OHA, Ecology, and other partners.

## 5.4 Project schedule

A tentative schedule for the project outlining activity timeframes is shown in Table 6.

Table 6. Project schedule documenting activity timelines.

| Project Activity | Dates |
| --- | --- |
| Project planning and permitting | Fall 2015 |
| Baseline data collection | 2016 – spring - late summer |
| Restoration implementation | Late summer/fall 2016 |
| Monitoring data collection | Fall 2016 – summer 2018 |
| Data reporting to Ecology | Summer 2018 |

## 5.5 Limitations on schedule

The schedule is subject to change pending permit and other project approvals and as a result of either the logistical problems of the practical constraints discussed previously in this document.

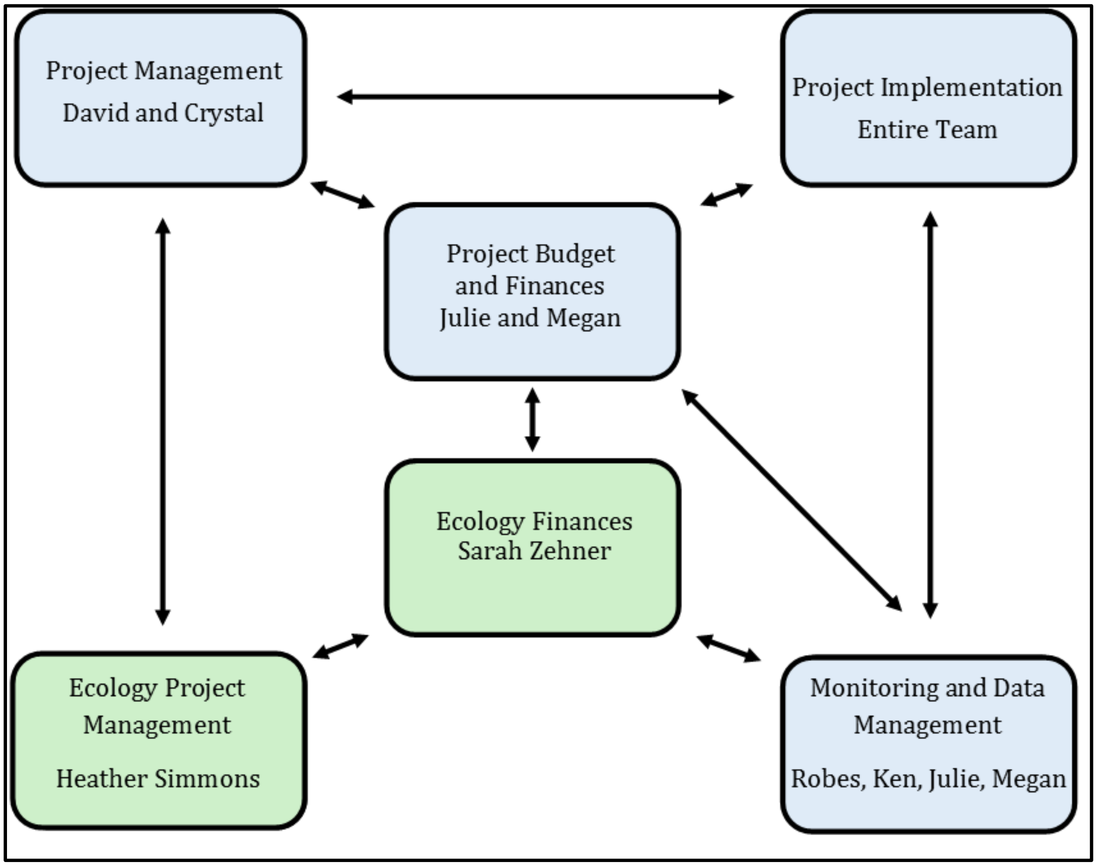


Figure 6. Organizational flow chart, blue boxes represent personnel outside of Ecology while green boxes represent Ecology personnel.

## 5.6 Budget and funding

Funding has been secured to implement the project from five sources. These sources are:

1. Clean Water Act Section 319 (319) grant administered by Ecology;
2. Supplement environmental project fund administered by Ecology;
3. Partners for Fish & Wildlife grant administered by USFWS;
4. OHA restoration funds; and
5. Various in-kind donations from OHA, TU, USFWS, National Oceanic and Atmospheric Administration (NOAA), and Washington Dept. of Fish and Wildlife (WDFW).

The entire project budget and an itemized budget for monitoring tasks, with respect to Ecology 319 funding, are documented below (Table 7 and Table 8).

Table 7. Total project cost by tasks with respective eligible reimbursement cost from Ecology 319 funds.

| Elements (tasks) | Total Project Cost | Total Eligible Cost |
|---|---|---|
| 1. Project administration/management | $34,660.00 | $24,590.00 |
| 2. Construction and installation of instream structures | $55,986.48 | $28,951.48 |
| 3. Riparian buffer establishment | $81,121.76 | $66,115.35 |
| 4. Project monitoring | $24,967.00 | $24,967.00 |
| 5. Stakeholder coordination, outreach, and education | $35,959.50 | $33,061.50 |
| **Total** | **$232,694.74** | **$177,685.33** |

Table 8. Itemized budget for monitoring tasks funded with the Ecology 319 grant.

| Item | Quantity | Unit | Estimated Unit Cost | Total Eligible Cost |
|---|---|---|---|---|
| OHA Executive Director | 16 | hours | $30.60 | $489.60 |
| OHA Conservation Coordinator | 220 | hours | $22.00 | $4,840.00 |
| OHA Conservation Associate | 354 | hours | $20.00 | $7,080.00 |
| OHA overhead | 12,409.60 | percent | 25% | $3,102.40 |
| Water level loggers | 11 | each | $349.00 | $3,839.00 |
| PVC, pipe clamps, filter, etc. | -- | -- | -- | $230.00 |
| Staff gauges | 19 | each | $50.00 | $950.00 |
| DO loggers | 2 | each | $1,468.00 | $2,936.00 |
| Training | -- | -- | -- | $1,500.00 |
| | | | **Total** | **$24,967.00** |

# 6.0 Quality Objectives

## 6.1 Decision quality objective

Water quality and hydrological data will be collected to monitor the potential effects of project implementation, but these data are unlikely to be used in decision-making unless they are collected over a longer period of time (i.e., 10 or more years). Geomorphological data will be collected to ascertain whether the project has been effective at aggrading the streambed. These data may be used in future adaptive management decisions.

## 6.2 Measurement quality objectives

The measurement quality objective is to collect data that accurately describes conditions occurring on the site. The development of this study was informed by various protocols that have been established by reputable institutions and were created with great attention to collecting data that is accurate and representative.

### 6.2.1 Targets for precision, bias, and sensitivity

#### 6.2.1.1 Precision

Field measurements temperature and water level measurements will be taken four times annually at each logger station to ensure data quality. Measurements will be collected at deployment, retrieval, and in June and September.

Dissolved oxygen loggers will be calibrated at deployment and during field visits in June and September of each field season.

Precision of topographic survey points will be ensured through the utilization of known control points, and by reshooting those points at the end of each annual survey.

#### 6.2.1.2 Bias

Opportunities for bias to impact the data collected in this study are greatly reduced by adherence to sampling protocols. Failure to follow the procedures outlined in this document and the referenced protocols could result in bias. Improper selection of sampling site locations, variation in sampling procedures, and variation in timing of data collection could also result in bias. Other biases could arise as a result of under sampling (i.e., funding only allows for limited samples to be collected and/or limited sampling locations). Adherence to the established sampling protocols for data collection and analysis, including corrective action, described in this QAPP will limit potential bias.

#### 6.2.1.3 Sensitivity

Sensitivity for this project will be the lowest concentration or degree to which a parameter can be measured. The expected range of the parameter is much greater than what the utilized instruments are capable of differentiating. All monitoring loggers have a factory-documented range, accuracy, and resolution for which data is collected (Table 9).

Table 9. Parameters measured with loggers and their respective range, accuracy, and resolution of data collection.

| Parameter | Range | Accuracy | Resolution |
|---|---|---|---|
| Temperature U20<br><br>Temperature U26<br><br>Temperature (audit thermometer) | -20–50°C<br><br>-5–40°C<br><br>-40–200°C | ±0.44°C (from 0–50°C)<br><br>±0.2°C<br><br>± .2°F/± 1°C | 0.1°C at 20°C<br><br>0.02°C<br><br>0.1°C |
| Water level logger<br><br>Tape Measure | Approximately 0–4 m (0–13 ft) of water depth at sea level<br><br>0-12 ft | Typical error: ±0.075% FS (full scale), 0.3 cm (0.01 ft) water. Maximum error: ±0.15% FS, 0.6 cm (0.02 ft) water<br><br>n/a | 0.14 cm<br><br>1/16$^{th}$ foot |
| Dissolved oxygen | 0–30 mg/L | 0.2 mg/L up to 8 mg/L; 0.5 mg/L from 8–20 mg/L | 0.02 mg/L |
| Topographic data | 1,000–5,800 m | ±(2mm +2ppm × D) m.s.e. | 10 mm (coarse measurement and tracking modes) |

### 6.2.2 Comparability, representativeness, and completeness

#### 6.2.2.1 Comparability

Data collected will be used to assess changes occurring in water quality and floodplain reconnection associated with project implementation. Data will be comparable across various timeframes based on data collection timing (see chapter 7.0 Sampling Process Design). Variations in annual climate make it difficult to compare water quality data over this study's short timeframe, but the hope is that monitoring data collection activities will continue past the life of the Ecology funded project to better identify the impacts of this project on water quality. Geomorphologic/topographic data will have greater comparability over the short-term of this project. Moreover, by adhering to scientifically defensible protocols and continuously collecting standardized data, issues associated with long-term comparability will be minimized.

#### 6.2.2.2 Representativeness

Water quality and water level data will be taken at frequent intervals to ensure that the data collected is representative of actual conditions occurring at the site. Water quality instruments will be placed in areas of the stream with adequate mixing to enable the collection of representative data. Manual measurements of temperature and water level will be taken in the field to corroborate measurements collected by loggers. DO loggers will be tested four times annually to ensure proper functioning.  Geomorphologic/topographic data will be collected following the CHaMP protocol (Bouwes et al. 2011), using georeferenced control points and a topographically stratified sampling method to collect representative data (Kiem et al. 1999).

#### 6.2.2.3 Completeness

Completeness will be determined by dividing the number of measurements collected by the number of measurements scheduled to be collected.  The project will be considered successfully completed if the resulting value is at least 80% for each parameter and perennial monitoring station.  Temperature data, DO, and water level data is considered 100% complete when data loggers have collected data during the time period and at the intervals described in this document.  Survey data is completed at 100% if enough survey points are taken annually in create a topographic map as described in this document.

# 7.0 Sampling Process Design

## 7.1 Study design

This study will be conducted in the project area of the *Triple Creek Water Quality Restoration Project* in and appurtenant to Myers Creek in WRIA 60 near Chesaw, Washington (Figure 1). The study will consist of four main monitoring components:

1. Stream temperature and DO.
2. Surface and subsurface water levels.
3. Annual topographic mapping of the wetland.
4. Photo point documentation throughout the project reach of Myers Creek.

### 7.1.1 Field measurements

Field measurements will be taken in situ using automated data loggers for temperature, DO, and water level. Field measurements for the development of the annual floodplain map will be collected by representatives from the USFWS. Additionally, a field technician will be present at the site four times during the field season to ensure loggers are in the correct location and to download data from loggers to ensure they are functioning properly. Field technicians will take the following manual measurements while on site:

- Water level measurements at seven monitoring well locations.
- Water level measurements at four surface water locations.
- Water temperature measurements at six instream locations.
- Re-calibrate DO loggers at 0 and 100 percent saturation.

### 7.1.2 Sampling location and frequency

All monitoring will occur within the project area, with the exception of monitoring wells upstream and downstream of the project area acting as controls. Water level, DO, and temperature loggers will be used to collect data from April 1 to October 15 at two hour intervals. Two hour intervals were chosen based on the findings of Dunham et al. (2005). Temperature data will be collected at the location of each DO and water level logger. Temperature data collected from monitoring wells will not be analyzed to provide information about changes in subsurface water temperatures.

Surface water levels will be monitored in the stream channel at four points within the project reach. The placement of two surface water level loggers will correspond with the groundwater monitoring well transects (Figure 7). The placement of the remaining two surface water level monitoring loggers will occur near the upstream and downstream areas of the reach, but not outside of the restoration implementation area.

To monitor ground water levels, monitoring wells will be spaced approximately 25 feet apart along two transects perpendicular to the stream channel within the project reach (Figure 7). Monitoring well transects will be placed at two locations on the floodplain where historic beaver dams and standing water previously existed, as indicated by historical aerial photographs and geomorphological features.  The exact location of the wells will vary according to practical concerns, such as the ability to dig a functioning well at a certain location and the presence of an obstruction, such as a large tree.

One DO logger will be placed upstream of the area impacted by the restoration project and one DO logger will be placed downstream of the restoration area with care taken to ensure temperatures and DO will be representative of in-stream conditions.  To ensure representativeness, locations that minimize the impacts of potentially confounding factors (e.g., confluences, groundwater seeps, impoundments) will be used (ODEQ 1999).

Annually, a floodplain map will be created by surveying the area within the incised channel using a total station according to protocol developed by Bouwes et al. (2011).  Greatest emphasis will be placed on documenting lateral and vertical changes within the incised stream channel. Since little would be expected to change on the historic floodplain/wetland until the channel aggrades 5-9 feet, annual data collection will focus largely on vertical aggradation of the streambed.

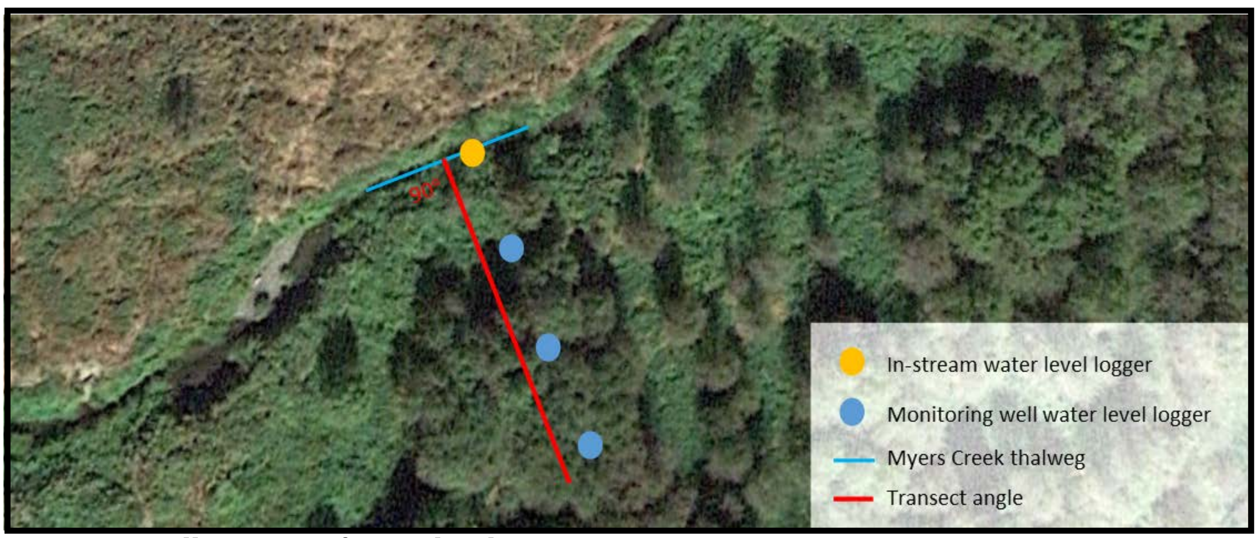

Figure 7. An illustration of water level monitoring transects.

Photographs will be taken twice annually at each photo point (during the spring freshet and during late summer low water) at 19 locations along the project reach.  Each photo point will be marked by a numbered staff gauge.

Four times during the six-month field season, a technician will be onsite to check instruments to ensure they are functioning properly and are in the correct location, and to take field measurements to corroborate the validity of the data collected via loggers.

#### 7.1.3 Parameters to be determined

The parameters to be determined include: temperature, DO, surface and subsurface water level, and topographic changes in the wetland landscape.

### 7.2 Maps or diagram

A map of the study area is shown as Figure 1.

### 7.3 Assumptions underlying design

Data collected is assumed to adequately represent conditions occurring at the project reach at the time of collection. It is also assumed that QA/QC procedures will ensure collected data allows for a meaningful characterization and interpretation of those data.

### 7.4 Relation to objectives and site characteristics

The study design is directly related to the goal of discovering new information about the employment of a specific wetlands restoration technique, BDAs. Specifically, all necessary environmental parameters will be monitored throughout the site in a manner that is directly linked to the objectives. The frequency and duration of data collection are intended to capture changes that are representative of conditions occurring in throughout the study site.

### 7.5 Characterization of existing data

Previous studies conducted in the area can be placed in either of two categories of study. The first are those conducted in anticipation of or during the operation of the Buckhorn Mountain gold mine. The second are those of the entire Myers Creek basin, or a larger watershed, of which Myers Creek is a part. Mining related studies generally focused on the headwaters of Myers Creek and do not provide detailed information about the project area. General studies of the entire Myers Creek basin do not include any data specific to the restoration site, but rather provide a generalized overview of the system.

Topographic data collected by the Natural Resources Conservation Service (NRCS) in 2009 and 2014 provides a landscape-scale baseline for comparison. Although the 2009 topographic data is greater in scale than our proposed treatment area, the data collected from within the treatment reach will be used for comparison of topographical conditions. Data collected in 2014 established a control network of georeferenced points for subsequent surveys.

# 8.0 Sampling Procedures

## 8.1 Field measurements and sampling SOPs

*Water temperature monitoring*

Water level and DO will be monitored using HOBO U20 water level data loggers and HOBO U26 DO data loggers, respectively, manufactured by Onset®. In addition to collecting water level and DO, these loggers collect water temperature data. Data loggers will collect data annually from April 1 to October 15 at two-hour intervals; this interval was selected based on the low probability of underestimating the maximum daily temperature by more than 1°C and considerations of simplifying data processing (Dunham et al. 2005). All temperature logger data will be downloaded twice annually following the procedures described below. Water temperature procedures are adapted from Water Quality Monitoring Technical Guide Book: Oregon Plan for Salmon and Watersheds (ODEQ 1999). Water level loggers will be deployed in either a monitoring well or a stilling well, depending on whether it is collecting subsurface or surface water level data.

Pre-deployment tasks:

1. Prior to deployment, the operators familiarize themselves with the computer software required to operate the loggers.
2. Water level/temperature data loggers are calibrated by the manufacturer and cannot be re-calibrated. Equipment accuracy is checked using the following two-point method:
    a. The "ice bucket method" described in the product manual (Onset Corporation 2014b) and included in Dunham et al. (2005). The following description details the steps include in this calibration method. This same methodology will be employed to ensure equipment accuracy post- retrieval and prior to re-deployment.
        i. Deploy data loggers at a short sampling interval (e.g., < 5 min).
        ii. Submerge loggers into cooler of well-mixed ice and water.
        iii. Use a thermometer to make sure water temperature is at 0°C.
        iv. Remove loggers from cooler after at least an hour and check temperature recordings. Temperature should level out at 0°C.
    b. A room temperature calibration.
        i. Deploy data loggers at a short sampling interval (e.g., < 5 min).
        ii. Submerge loggers into a container of water at room temperature. Water will be at room temperature if it has sat indoors for at least 24 hours.
        iii. Use a thermometer to take a reading. Allow loggers to log for at least five hours and then take another thermometer reading.
        iv. Remove loggers from container after at least five hours and compare temperature recordings.

3. After the accuracy test, but prior to deployment, start the temperature recording of the logger as directed in the product manual.

Deployment tasks:

1. Operators will carry a field notebook and record the time, date, weather conditions, and any other appropriate, relevant information in the field notebook.
2. Operator will take a field measurement of temperature and record in field notebook.
3. Operator will record the location of each logger using a GPS, collect a photo point, and, if warranted, draw an illustration of the deployment to aid in logger retrieval.

Field measurement tasks (adapted from ODEQ 1999):

1. Locate logger, note conditions in field notebook.
2. Operator will have a watch synchronized to the logger's internal clock and the laptop used to download logger data.
3. Check the temperature by placing the audit thermometer next to the continuous monitoring instrument's sensor. The temperature is recorded when a stable reading is obtained.
4. Record temperature and time.
5. Downloaded logger data will be compare logged temperature with field measurement.

Retrieval tasks:

1. Locate logger, note conditions in field notebook.
2. Operator will take a field measurement of temperature and record in field notebook.
3. Retrieve logger, upload data using a laptop computer and the logger specific computer software.
4. Check loggers to ensure accuracy as described above.

*Dissolved oxygen monitoring*

Dissolved oxygen will be monitored using HOBO U26 DO data loggers from April 1 to October 15. Loggers will collect data on a two hour interval for reasons discussed above. Data from both loggers will be downloaded three times during the field season (once at instrument retrieval, and once during June and August) following the procedures described below.

Pre-deployment tasks

1. Prior to deployment the operators familiarize themselves with the computer software required to operate the loggers.
2. Install the sensor cap as described in the product's manual (Onsite Corporation 2014a).

3. Calibrate DO logger using the manufacturer's lab calibration tool as described in the manufacturer's manual. After the accuracy test, but prior to deployment, start the data recording of the logger as directed by the instrument's manual.

Deployment tasks

1. Field calibrate the DO logger as described in the product's manual (Onsite Corporation 2014a).
2. Secure the logger in the stream using a cable attached to a solid object, either a t-post, tree, rock, or weights. This object will be substantial enough to withstand high flow events in the creek.
3. Operators will carry a field notebook and record the time, date, weather conditions, and any other appropriate, relevant information in the field notebook.

Maintenance tasks:

1. Sensor caps will be replaced annually as described in the manual (Onsite Corporation 2014a).
2. A field calibration of the logger will be performed before each data download and after sensor cap replacement.
3. DO senor will be manually cleaned after each data download unless a new sensor cap was just installed.

*Water level monitoring*

Surface water level monitoring will occur at four locations within the channel, recording the water level at four points. Additionally, groundwater level monitoring will occur at eleven points across the floodplain. Four of these groundwater monitoring wells are pre-existing and were installed by USFWS in the fall of 2014. A weather station that reads barometric pressure was also installed at the same time by USFWS and will be used to convert water depth in wells to georeferenced elevations.

Water temperature is also collected by water level loggers using the methods described above.

Groundwater level monitoring requires the installation of groundwater monitoring wells and the deployment of a water level monitoring device within the well. Seven groundwater monitoring wells will be installed using guidance provided in the Army Corps of Engineers Wetlands Regulatory Assistance Program and described below (Sprecher 2000). Monitoring well transects will be placed at two locations across the floodplain where historic beaver dams and standing water previously existed, as indicated by historical aerial photographs and geomorphological features.

Monitoring well installation tasks (adapted from Sprecher 2000):

1. Auger a hole in the ground with a 3-in. bucket auger to a depth approximately 2 in. deeper than the bottom of the well. (Well length is anticipated to be roughly 4 to 9 feet and will depend on the water levels present during installation at low water. Wells will be dug roughly 3 feet or greater than the low water level to ensure the full fluctuation of levels will be observed within the well.) Be sure the auger hole is vertical.
2. Scarify the sides of the auger hole if it was smeared during augering.
3. Place 2 inches of silica sand in the bottom of the hole.
4. Insert the well casing into the hole but not through the sand.
5. Pour and gently tamp more of the same sand in the annular space around the screen and 2 inches above the screen.

Well installers will report site conditions and any other information that may be unique to the well.

Water level logger pre-deployment tasks:

1. Prior to deployment, operators will familiarize themselves with the computer software required to operate the loggers.
2. A HOBO U20 logger is already deployed on-site to record barometric pressure to compensate for changes in barometric pressure relative to the atmospheric pressure recorded by the water level loggers within the monitoring wells.
3. Make sure that the logger is also configured to record temperature. Temperature data will be collected only to help convert atmospheric pressure to water level, not to render data that will be interpreted for any other purpose.

Water level logger deployment tasks (adapted from Onset Corporation 2014b):

1. Allow logger to come to temperature equilibrium by setting it out in the ambient environment for at least 20 minutes.
2. Make sure that the monitoring well is vented to the atmosphere, drill vent hole if needed.
3. Use a no-stretch wire to hang the water level logger. Pull the wire to make sure it does not stretch.
4. Cut wire to suspend logger. Measure the physical depth to the surface of the water from the suspension point. Cut wire so that the logger will be deep enough to always be in the water. Estimate the low water level and make the cable length such that the logger will be about 2 feet below that level.
5. Attach the wire to the suspension point and logger cap.
6. Relaunch the logger if desired (if a PC or a HOBO U-Shuttle is available).
7. Lower the logger into monitoring well.
8. Measure the water depth from the desired reference point (top of casing, ground level, or sea level) using a steel tape measure and following the method outlined in Marti (2009).

9. To maximize accuracy, allow 20 minutes after deploying the logger before measuring water depth to allow the logger to reach temperature equilibrium with the water. If the water level surface is below the reference point (such as referencing groundwater measurements to the top of the well), record the water level as a negative number.

Water level loggers placed within the stream will be deployed into a stilling well. The stilling well will be created by taking a piece of perforated vertical PVC pipe, or a galvanized steel pipe, stabilized either by burying it or by affixing it to a stable object, such as a firmly placed t-post. If PVC pipe is used, the pipe will be inspected at prior to deployment each year and replace if it show excessive wear. The logger will be deployed inside of the PVC pipe, and the pipe will protect the logger from vibration or movement. The pipe will have a vertical height long enough to keep the logger from movement at all discharges.

Water level field measurements for surface water sites (Shedd 2008):

1. Locate the reference point. The reference point will be the top of the casing of the stilling well.
2. Lower a weighted tape measure to the water surface. The weight should only touch the water surface enough to form a distinctive “V” shape on the water surface.
3. Read the tape at the edge of the reference point to one-hundredth of a foot.
4. Note any difficulties reading the tape caused by wind or wave action.
5. Because the weight is attached to the end of the fiberglass tape, a correction factor is applied to the reference point reading. Add the correction factor to the tape down and enter the sum to CORRECTED TD.

Annually, the surface water level will be measured in the field using a control point outside of the active channel. The reference point will be marked with capped rebar. The procedures for operating the total station and collecting data with that instrument is described below.

*Topographic data collection*

A fine scale topographic map of the incised channel will be created annually to observe geomorphological changes at the site. A Topcon GTS-223 electronic total station will be used to take four-dimensional (x,y,z, and time) measurements of points throughout the study area.

Survey procedure:

1. Establish control point network.
    a. Control points were established by the 2009 and 2015 NRCS survey using a Leica RTK GPS-enabled Total Station (Figure 9). The 2009 survey was conducted over a 1.25-mile reach and expansion of the specific control network within the treatment reach occurred in 2015.

b. Control points were established by pounding 4 foot lengths of rebar into the ground. Rebar was capped in orange and cited beside a wooden surveyor's stake for approximate location.
c. Points were submitted to the OPUS positioning service to establish georeferenced connections to the National Spatial Reference System (http://www.ngs.noaa.gov/OPUS/).

A 2015 USFWS topographic survey acquired several hundred additional points within the treatment reach for greater topographic resolution. Subsequent topographic data collection is accomplished by occupying and backsighting a control point and collecting new data. It is neither necessary nor an industry-standard to re-shoot original point locations exactly. Instead, a sufficient number of points is collected to represent a spatially heterogeneous environment and to provide reach-scale information about lateral and vertical geomorphic change. The collection of sampling points will follow the protocol outlined in section 7.2 of the CHaMP protocol (Bouwes et al. 2011).

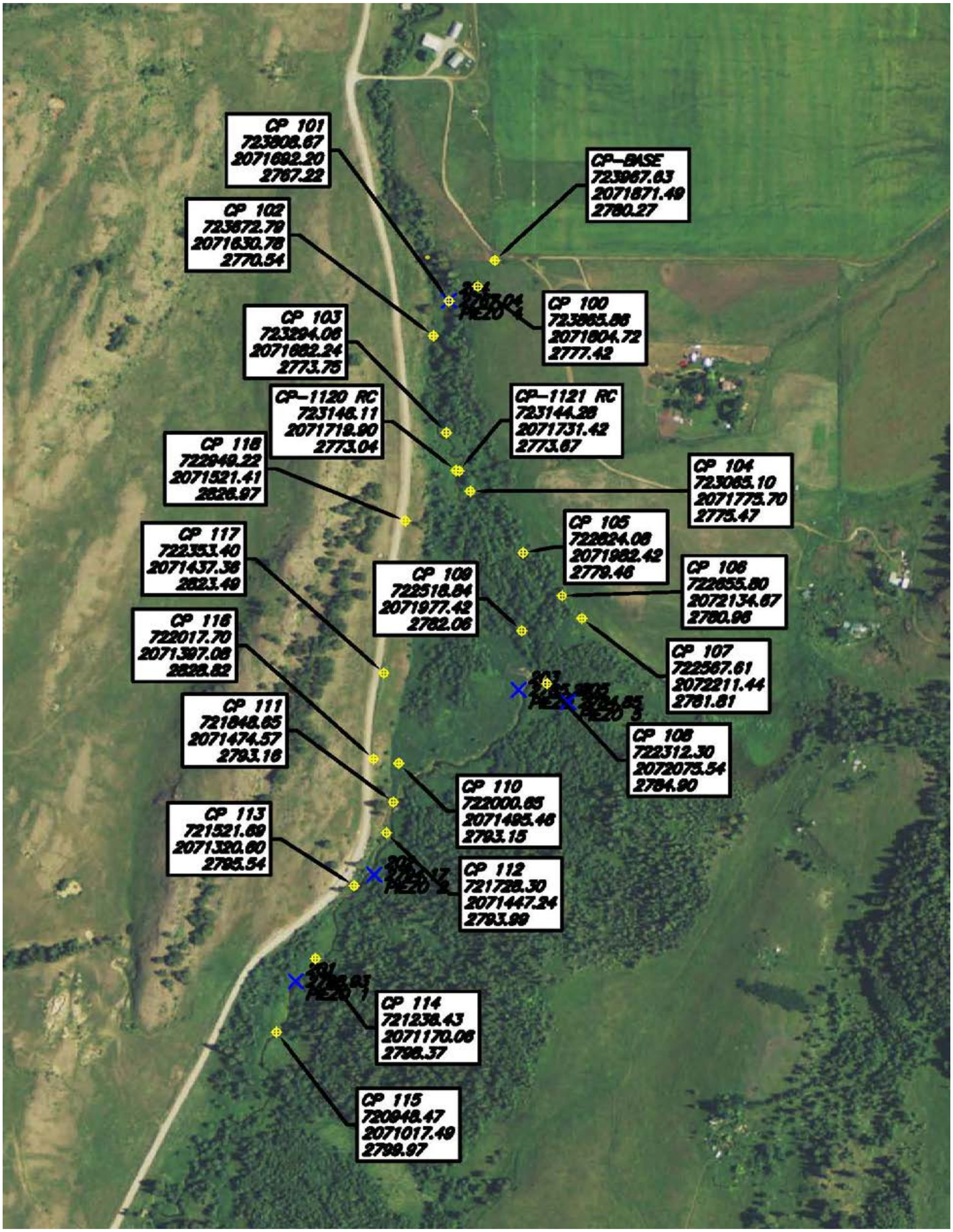

Figure 9. Control points used in the creation of a topographic survey.

*Photo point monitoring*

Photographs will be taken of 19 established photo points along the bank of Myers Creek in May and September of each field season. The purpose of this photo monitoring is to observe changes occurring at the project site over time, specifically the changes in water level as BDA structures in the stream channel impound water. The following procedures will be adhered to during the collection of photo points, adapted from Hamilton (undated).

1. The stream will be set up with 19 photo points and 19 corresponding camera points. Each photo point will be identified with a numbered staff gauge. Each camera point will be identified by a piece of capped rebar.
2. Before taking each photo, the photographer will record in a field notebook: the date and time, the image number from the camera’s data storage device, the photo point number (from the staff gauge), and any other relevant information.
3. Photo point is captured and viewed in the field to make sure the image was correctly captured, by looking at a previous photograph when necessary.
4. Photographs are backed up to a hard drive.

## 8.2 Containers, preservation, holding times

The study does not include the collection of physical water samples.

## 8.3 Invasive species evaluation

Equipment used to conduct this study will be used solely in the Myers Creek drainage with the exception of the annual use of the total station for the topographic survey. Therefore, minimal opportunities to transport aquatic invasive species exist.

## 8.4 Equipment decontamination

If field gear will be used outside of the Kettle drainage without an opportunity to completely air dry, field staff will decontaminate gear using Ecology’s *Standard Operating Procedures to Minimize the Spread of Invasive Species Version 2.0* (2012).

## 8.5 Sample ID

The study does not include the collection of physical water samples.

## 8.6 Chain of custody, if required

Non applicable.

## 8.7 Field log requirements

Field staff are required to keep a field notebook.  Within the notebook, field staff will record their name, the date, climatic conditions, conditions or occurrences that may impact data. Specific monitoring tasks may have additional required field notes, such as the completion of a well log during the installation of monitoring wells, which are described above.

## 8.8 Other activities

None.

# 9.0 Measurement Methods

## 9.1 Field procedures table

Field procedures are outlined in Table 10.

Table 10. Field procedures table.

| Analyte | Matrix | Number of Samples | Method | Resolution | Expected Range of Results |
|---|---|---|---|---|---|
| Temperature | Water | 12/day | HOBO U20 and U26 | 0.1°C at 20°C | 0-30°C |
| Dissolved Oxygen | Water | 12/day | HOBO U26 | 0.02 mg/L | 0-16 mg/L |
| Water level | Water | 12/day | HOBO U20 | 0.14 cm | -0.5-2.5m |
| Geomorphic | Topographic | 250+/annually | Bouwes 2011 | n/a | n/a |
| Geomorphic | Photographic | 38/annually | Digital camera | n/a | n/a |

## 9.2 Laboratory procedures table

No physical samples will be collected in this study and therefore no laboratory will be used.

# 10.0 Quality Control

## 10.1 Field quality control required

Data collection will follow protocols and/or manuals described in this document. Instruments will either be factory calibrated or calibrated prior to data collection and checked to ensure accuracy at deployment, retrieval, and once during June and August for a total of 4 times during the field season. Manual temperature and water level measurements will be taken four times annually at each logger.

## 10.2 Corrective action

If quality control checks identify issues, the following corrective actions may be taken as appropriate:

- Review pre- and post-calibration checks.
- If possible, retrieve missing information.
- If data errors are found, data will be rejected.

# 11.0 Data Management Procedures

## 11.1 Data recording/ reporting requirements

Water quality (temperature and DO) and water level data will be uploaded from sensor a minimum of three times annually during the field season, as described previously; these data will be downloaded into Microsoft Excel. Topographic data will be uploaded from equipment into GIS software once annually after the completion of the survey. All data will be saved in two or more locations.

## 11.2 Laboratory data package requirements

No laboratory work will be initiated as part of this study.

## 11.3 Electronic transfer requirements

All data collection described in this QAPP will be uploaded into Ecology's Environmental Information Management (EIM) system following the procedures outlined in Ecology's EIM User's Manual (WSDOE 2009).

## 11.4 Acceptance criteria for existing data

All data collected will be reviewed in a spreadsheet to ensure that the values fall within the expected range. If a value for a given parameters falls outside of the expected range for that parameter a project member will investigate any potential sources of error. Existing data used in this study include the survey points from prior NRCS topographic surveys in 2009 and 2015 (see above).

## 11.5 EIM/STORET data upload procedures

See section 10.3.

# 12.0 Audits and Reports

## 12.1 Audit number, frequency, type, and schedule

Audits are not planned for this study. Field notebooks and soil characteristic sheets will be reviewed for completeness.

If requested by Ecology, an Ecology staff person will accompany an OHA staff person during water quality data collection for the purpose of performing an audit.

## 12.2 Responsible personnel

See Table 5.

## 12.3 Frequency and distribution of reports

Regular reporting will be conducted as required by Ecology agreement, WQC-2016-Oh-kHiAl-00126, and are as follows.

Quarterly grant progress reports will be completed in the Ecology's Administration of Grants & Loans (EAGL) for the following schedule:

- January 1 through March 31
- April 1 through June 30
- July 1 through September 30
- October 1 through December 31

Annual water quality progress reports will be uploaded to EAGL between December and February following the conclusion of the monitoring season. A template will be used if provided by the Ecology Project Manager.

A final report will be submitted to the Ecology grant manager at least 45 days before the grant end date and a final, approved report will be uploaded to EAGL by the grant end date.

## 12.4 Responsibility for reports

All reporting will be generated by OHA with assistance from all project partners (Table 5). At a minimum, all partners will have the opportunity to review and edit the annual and final reports prior to final submission to Ecology.

# 13.0 Data Verification

## 13.1 Field data verification, requirements, and responsibilities

Proper deployment of instruments, biannual data downloads, and instrument accuracy checks will used to minimize data error. Field notes will verify that proper field procedures were carried out by field staff. Data will be scanned for outliers and outlier data will be flagged and then removed from the analysis if found to be an error.

## 13.2 Data lab verification

No laboratory analysis will be conducted as part of this study.

## 13.3 Validation requirements, if necessary

Data will be screened for outliers by plotting the data and analyzing summary statistics. Detected outliers will be flagged and the validity of the data further reviewed. Errors within the data will be removed if removal is justifiable (e.g., loggers were found out of water).

# 14.0 Data Quality (usability) Assessment

## 14.1 Process for determining whether project objectives have been met

The objectives for this project will be met if data were collected using the scientifically defensible protocols described above and presented to Ecology in the final document.

## 14.2 Data analysis and presentation methods

Summary statistics (mean, median, maximum, and minimum) will be presented by month with daily averages plotted for temperature, DO, and water level. Annual topographic maps, as well as pre and post project implementation photo point pictures, will be included in the final document.

## 14.3 Treatment of non-detects

Not applicable to this project.

## 14.4 Sampling design evaluation

The monitoring tasks described in this QAPP are based off of established protocols and guidance. Furthermore, the sampling design discussed in this document will be reviewed internally by OHA. Other team members (TU and USFWS) will have an opportunity to review and comment on this document. Ecology staff will review and approve this QAPP.

## 14.5 Documentation of assessment

The final report will document the usability and fitness of the data collected during this study. The period of time to adequately evaluate the restoration project impacts on water quality at the time of reporting to Ecology will be insufficient. The project will be considered successful if the BDAs and LWD are installed as planned, and if the parameters described in this QAPP are characterized using the data collected. Aggradation of the streambed up to the elevation of frequent inundation of the historical floodplain is believed possible, though the timeframe for achieving this is yet uncertain.

The data kept in spreadsheets and databases will be available for Ecology review upon request.

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# Appendix A: Logger accuracy check data sheets

## Temperature Logger Accuracy Checks

Date:
Performed by:

Start time 0°C Bath

| Time | Temperature |
|---|---|
| | |
| | |
| | |
| | |
| | |

Start time 20°C Bath

| Time | Temperature |
|---|---|
| | |
| | |
| | |
| | |
| | |

Dissolved Oxygen Logger Accuracy Checks

Date:

Performed by:

| |
|---|
| Barometric pressure reading: |
| Start time **0% saturation:** |
| Reading from DO logger after 15 minutes at 0% saturation: |
| DO calculation at 0% saturation: |
| Gain adjustment: |

| |
|---|
| Barometric pressure reading: |
| Start time **100% saturation:** |
| Reading from DO logger after 15 minutes at 100% saturation: |
| Offset adjustment: |

Water Level Manual Measurements

Date:

Performed by:

| | |
|---|---|
| Well/location number | |
| Distance between water level to top of casing/measuring point | |
| Distance between top of casing/measuring point and land surface | |

| | |
|---|---|
| Well/location number | |
| Distance between water level to top of casing/measuring point | |
| Distance between top of casing/measuring point and land surface | |

| | |
|---|---|
| Well/location number | |
| Distance between water level to top of casing/measuring point | |
| Distance between top of casing/measuring point and land surface | |

| | |
|---|---|
| Well/location number | |
| Distance between water level to top of casing/measuring point | |
| Distance between top of casing/measuring point and land surface | |

| | |
|---|---|
| Well/location number | |
| Distance between water level to top of casing/measuring point | |
| Distance between top of casing/measuring point and land surface | |

Photo-Point Monitoring Data Sheet

Date:

Performed by:

| | |
|---|---|
| Time | |
| Image # | |
| Photo point # | |

| | |
|---|---|
| Time | |
| Image # | |
| Photo point # | |

| | |
|---|---|
| Time | |
| Image # | |
| Photo point # | |

| | |
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| Time | |
| Image # | |
| Photo point # | |

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| Time | |
| Image # | |
| Photo point # | |

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| Time | |
| Image # | |
| Photo point # | |

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| Time | |
| Image # | |
| Photo point # | |

| | |
|---|---|
| Time | |
| Image # | |
| Photo point # | |