# Quality Assurance Project Plan

## Little Klickitat River & Swale Creek

## Water Quality

## Little Klickitat and Swale Creek TMDL Implementation Project

Agreement: WQC-2016-CKliCD-00003

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# Quality Assurance Project Plan

## Little Klickitat River
## And Swale Creek TMDL Implementation

July 2016

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# 2.0 Abstract

Segments of the Little Klickitat River, Swale Creek, and their tributaries were initially identified by the Washington State Department of Ecology (Ecology) as having temperatures exceeding state water quality standards for the 1996 Section 303(d) list of impaired waters. The Central Klickitat Conservation District (CKCD) has since been committed to watershed planning efforts, which enable us to gain understanding of issues affecting stream temperature conditions and to develop solutions. One action has been to establish and maintain a network of stream temperature monitoring sites and stream flow gage stations in the watershed. In partnership with involved agencies and local landowners, CKCD has moved forward to implement Best Management Practices (BMPs) in the Little Klickitat and Swale Creek watersheds that will address resource concerns, particularly water quality.

This Quality Assurance Project Plan (QAPP) is funded with Ecology agreement WQC-2016-CKliCD-00003 and supports baseline and effectiveness water quality monitoring for phase 7 BMP implementation of the Little Klickitat River Total Maximum Daily Load (TMDL) and phase 3 BMP implementation of the Swale Creek Straight to Implementation (STI) draft plan.

Also, as part of this agreement, various BMP projects will be implemented in the Little Klickitat and Swale Creek watersheds. These will include installing native riparian vegetation, which will provide more shade and floodplain complexity, and re-shaping and stabilizing stream banks, which will allow flood waters to return more slowly from the alluvium to the stream channel. These projects will help meet the objectives of the TMDL and STI draft plan by addressing sedimentation loads and shade issues that are major contributors to the higher water temperatures. Continued water quality monitoring will help measure, in the long term, water quality improvements.

# 3.0 Background

The Little Klickitat River has a TMDL for temperatures exceeding state standards. To address the TMDL, Ecology completed a Detailed Implementation Plan (DIP) for the temperature 303(d) listings for river or stream segments (Anderson 2005). In total, the Little Klickitat River has 14 sections that have water quality impairments.

The DIP for the Little Klickitat Watershed cites 1) low effective shade, 2) low in-stream flows, and 3) increased sediment loads as potential sources for elevated temperatures (Anderson, 2005).

Non-point sources affecting water quality in this basin include low streamside shade, increased channel width to depth ratios, low summer instream flows, bank instability, and agricultural and stormwater runoff. Potential causes of non-point sources include erosion, historic timber practices, sediment deposition, a changed hydrograph, loss of stream connectivity with the hyporheic zone due to channel straightening, bank armoring, agricultural practices, and livestock management.

There is also a point source from the Goldendale wastewater treatment plant. The effluent pipe confluences with the Little Klickitat River at river mile 14.2.

The DIP was finalized in March 2005. In it, Ecology predicted that stream temperatures could improve by as much as 18 degrees Fahrenheit (ºF) in some stream segments with improved conditions created by the restoration of riparian area vegetation, as well as improvements in channel morphology and in-stream flow. Table 1 shows the 303(d) listings for the Little Klickitat River Basin. The Little Klickitat River, Bowman Creek, Blockhouse Creek, and Bloodgood Creek were 303(d) listed for in-stream flows in 1996 and 1998. This TMDL does not set in-stream flow targets, but increased water volumes in the stream would make increased shading more effective at keeping water temperatures cool. These elevated temperatures directly affect the habitat of resident rainbow trout and downstream Steelhead, listed as threatened under the Endangered Species Act (ESA).

In the November 2006 revision of the surface water quality standards, Ecology designated a portion of Swale Creek from the mouth to nearly Harms Road (i.e., Swale Canyon) as waters requiring supplemental protection for salmonid spawning and incubation. This designation imposes a more stringent seasonal water temperature of 13º C during the salmonid spawning and incubation season (February 15 through June 1) and a temperature criterion of 17.5º C year around.

Since Swale Creek does not meet temperature requirements, it has been placed on the 303(d) list (category 5) for temperature and has an STI draft plan, currently being developed by Ecology in lieu of a TMDL. The STI will state that projects are needed to address shading and sedimentation in Swale Creek, especially the lower 3.1 miles.

Table 1. 2008 303(d) listings for the Little Klickitat River Watershed (segments listed as impaired, but not for temperature are shown in italics).

| Listing ID | Medium | Parameter | Waterbody Name | WRIA | Township | Range | Section | LLID | 2012 | 2008 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *6199* | *Habitat* | *Instream Flow* | *Blockhouse Creek* | *30- Klickitat* | *4N* | *15E* | *17* | *1209843458164* | *4C* | *4C* | *4C* |
| 48483 | Water | Temperature | Blockhouse Creek | 30- Klickitat | 4N | 15E | 17 | 1209843458164 | 4A | 4A | 3 |
| *6200* | *Habitat* | *Instream Flow* | *Bloodgood Creek* | *30- Klickitat* | *4N* | *16E* | *17* | *1208359458244* | *2* | *2* | *2* |
| 48476 | Water | Temperature | Bloodgood Creek | 30- Klickitat | 4N | 16E | 17 | 1208359458244 | 1 | 1 | 3 |
| *6201* | *Habitat* | *Instream Flow* | *Bowman Creek* | *30- Klickitat* | *5N* | *14E* | *35* | *1210387458548* | *4C* | *4C* | *4C* |
| 48485 | Water | Temperature | Bowman Creek | 30- Klickitat | 5N | 14E | 35 | 1210387458548 | 4A | 4A | 3 |
| 48486 | Water | Temperature | Bowman Creek | 30- Klickitat | 5N | 15E | 5 | 1210387458548 | 4A | 4A | 3 |
| 48487 | Water | Temperature | Bowman Creek | 30- Klickitat | 4N | 14E | 10 | 1210432458423 | 4A | 4A | 3 |
| 5891 | Water | Temperature | Butler Creek | 30- Klickitat | 5N | 17E | 17 | 1207058459164 | 4A | 4A | 4A |
| *6202* | *Habitat* | *Instream Flow* | *Little Klickitat River* | *30- Klickitat* | *4N* | *15E* | *28* | *1210619458451* | *2* | *2* | *2* |
| *6203* | *Habitat* | *Instream Flow* | *Little Klickitat River* | *30- Klickitat* | *4N* | *14E* | *9* | *1210619458451* | *2* | *2* | *2* |
| 11070 | Water | Temperature | Little Klickitat River | 30- Klickitat | 4N | 14E | 9 | 1210619458451 | 4A | 4A | 4A |
| 48489 | Water | Temperature | Little Klickitat River | 30- Klickitat | 4N | 15E | 28 | 1210619458451 | 4A | 4A | 3 |
| 48490 | Water | Temperature | Little Klickitat River | 30- Klickitat | 4N | 17E | 6 | 1210619458451 | 4A | 4A | 3 |
| 48491 | Water | Temperature | Little Klickitat River | 30- Klickitat | 5N | 17E | 31 | 1210619458451 | 4A | 4A | 3 |
| *50724* | *Water* | *pH* | *Little Klickitat River* | *30- Klickitat* | *4N* | *15E* | *22* | *1210619458451* | *2* | *2* | *3* |
| 7956 | Water | Temperature | Little Klickitat River, East Prong | 30- Klickitat | 5N | 17E | 16 | 1207057459114 | 4A | 4A | 4A |
| 7957 | Water | Temperature | Little Klickitat River, East Prong | 30- Klickitat | 5N | 17E | 10 | 1207057459114 | 4A | 4A | 4A |
| 7958 | Water | Temperature | Little Klickitat River, East Prong | 30- Klickitat | 5N | 17E | 9 | 1207057459114 | 4A | 4A | 4A |
| 7959 | Water | Temperature | Little Klickitat River, East Prong | 30- Klickitat | 5N | 17E | 3 | 1207057459114 | 4A | 4A | 4A |
| 7960 | Water | Temperature | Little Klickitat River, East Prong | 30- Klickitat | 6N | 17E | 35 | 1207057459114 | 4A | 4A | 4A |
| 7961 | Water | Temperature | Little Klickitat River, East Prong | 30- Klickitat | 5N | 17E | 18 | 1207057459114 | 4A | 4A | 4A |
| *6205* | *Habitat* | *Instream Flow* | *Mill Creek* | *30- Klickitat* | *4N* | *15E* | *5* | *1210104458355* | *4C* | *4C* | *4C* |
| 48484 | Water | Temperature | Mill Creek | 30- Klickitat | 4N | 15E | 5 | 1210104458355 | 4A | 4A | 3 |
| 48482 | Water | Temperature | Spring Creek | 30- Klickitat | 4N | 15E | 21 | 1209417458101 | 4A | 4A | 3 |

## 3.1 Study area and surroundings

The Little Klickitat River Basin is located in south-central Washington State. It flows from the southwest flank of the Simcoe Mountains, west across the Munson Prairie, and through the Little Klickitat canyon to its confluence with the Klickitat River.

The Little Klickitat Watershed encompasses approximately 285 square miles and lies solely within Klickitat County and CKCD. Land ownership in the basin is a mix of private, city of Goldendale, Washington Department of Natural Resources (DNR), Bureau of Land Management (BLM), and Yakama Nation. The elevation ranges from 600 feet at the confluence with the Klickitat River to 5,823 feet at Indian Rock in the Simcoe Mountain range. Land use in the area is comprised of agriculture (farming and ranching) in the lower elevations, forestry and timber management and limited mining in the upper elevations, and urban lands around the city of Goldendale. Most of the timberlands are currently leased for grazing. The higher elevation range areas are grazed in summer by cattle and during spring through fall by elk and deer.

The climate in the basin is characteristic of eastern Washington, consisting of warm, dry summers and cold winters with the majority of the precipitation falling from November to March. Snowmelt, surface runoff, and groundwater feed the Little Klickitat and its tributaries. The mainstem of the Little Klickitat begins with the convergence of the West Prong and East Prong Little Klickitat at River Mile (RM) 25.7. The river flows southwesterly across the Munson Prairie to the eastern edge of Goldendale at RM 16.3. At RM 14.1, the river passes the outfall of the Goldendale Wastewater Treatment Plant, just below the confluence of Bloodgood Creek, a natural source of cool water for the river. From Goldendale, the river continues westerly to RM 8.3 where it enters a 4.5-mile-long canyon, which cools the water before bending northwesterly and flowing on to its confluence with the Klickitat River (RM 19.8). Principle tributaries include Butler Creek (RM 26), Jenkins Creek (RM 20.2), Bloodgood Creek (RM 14.9), Spring Creek (RM 8.6), Blockhouse Creek (RM 6.3), Mill Creek (RM 3.6), Bowman Creek (RM 1.2), and Canyon Creek (RM 1.2).

The Swale Creek Basin is located in south-central Washington State. Swale Creek flows west from the Columbia Hills, through the Centerville Valley, and down Swale Canyon where it confluences with the Klickitat River. Three geomorphic areas make up the Swale Creek watershed. These include the headwaters, which drain rolling terrain, the Swale Creek valley, which is wide and flat, and the lower basin, which runs predominantly through a steep canyon. The elevation ranges from 3,220 feet in the Columbia Hills, east of Highway 97 to 540 feet at the confluence with the Klickitat River. Land use in the area is comprised of agriculture (farming and ranching), rural residential properties, and urban lands in the unincorporated city of Centerville.

Swale Creek, approximately between Highway 97 and Warwick, is fed by snowmelt, surface runoff, and groundwater and is an expression of the water table in the Alluvial Aquifer. As such, it is ephemeral (seasonal) and directly related to the groundwater level in the alluvium. In early spring, groundwater levels in the alluvium are generally high (shallow depth below the ground surface). This portion of the creek is generally dry by early summer and for the balance of the year as groundwater levels in the alluvium decline. In summer, open water is largely limited to a few standing pools (Aspect 2009).

See Figure 1 for a map of the Little Klickitat River and Swale Creek basin.

### 3.1.1 Logistical problems

Monitoring sites are chosen based upon several criteria, including physical characteristics that represent those found throughout the reach and accessibility. Logistical problems surround the issue of access. Sites that are too easily accessed tend to have a high level of activity, increasing the risk of data loggers being stolen or vandalized. Some of the current sites are near areas that may encounter activity by recreational users, causing us to have this concern. Remoteness can also be problematic for access. Landowner consent is also required for access to most sites and must allow for the locations to be available for several years of monitoring. Some ideal locations may not be available due to lack of landowner consent.

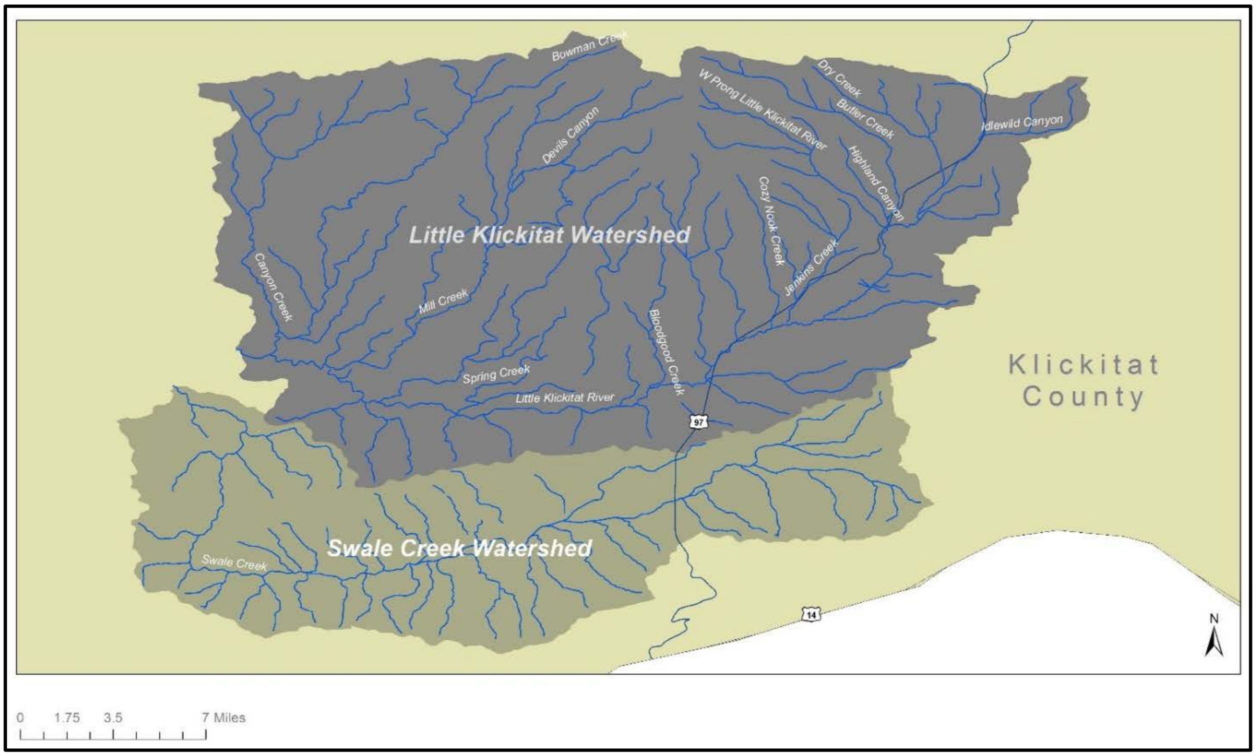


Figure 1. Little Klickitat and Swale Creek basins.

### 3.1.2 History of study area

Elmer (2015) has compiled a substantial amount of historical data on Goldendale and the use of the Little Klickitat watershed. In 1871, Goldendale, Washington was established and was quickly followed by Blockhouse and Cedar Valley.

The Little Klickitat River and its tributaries were an excellent source of water power that allowed Goldendale to grow into a self-sustaining community complete with power facilities and lumber and grain mills. Many diverse farms ranging from 150 to 1500 acres sprang up over this time. Sheep, cattle, and hogs were raised; wheat, red clover and alfalfa were farmed along with crates of berries and apples. Lumber mills were established on Spring Creek, Blockhouse Creek, and the Little Klickitat River. It was estimated that almost 90,000 sheep resided in the areas surrounding Goldendale, along with a large population of hogs. The yellow pines in the Simcoe Mountain range were harvested heavily and then turned into fruit production sites. The Simcoe Mountains also provided summer rangeland for the numerous livestock.

Over time, sheep were phased out and cattle became the dominant livestock. The lumber and grain mills shut down, but farming of wheat and alfalfa remained.

The Swale Creek watershed, with the exception of the canyon, has predominately been used for agricultural farming purposes since the early 1900’s. Much of the land has been in irrigation, flood or directly from the wells, for wheat and alfalfa production. Livestock have inhabited the upper watershed since Centerville was established, but there is a lack of data on numbers present throughout the years (Aspect and WPN 2004).

Geologically, the lower basin below Harms Road has remained unchanged since the decommissioning of the railroad, as land use is minimal. The construction and long-term maintenance of the existing railroad grade, built in 1902 and running along the entire length of Swale Canyon, has degraded the stream channel, principally by reducing the width of the channel and thus increasing the stream’s erosive energy, particularly during flood events and particularly in the upper reaches of the canyon (Inter Fluve 2002).

Flooding has a significant impact on Swale Creek. Substantial changes to vegetation is a frequent outcome of the periodic flooding. It was also reported, following the 1974 floods, that the railroad removed boulders in the lower reach of the canyon, further impacting the effects of the flood by reducing the channel roughness and pools (Aspect 2009).

General Land Office (GLO) surveys from 1860 were examined which provided some data on shade levels prior to the construction of the railroad bed. Riparian vegetation was described as non-existent or scattered in much of the watershed, with the lower reaches of the canyon having the greatest population. Pine and oak were noted in these areas. Based on observations of aerial photos, over the years, riparian vegetation appears to be somewhat cyclical, either increasing or decreasing over periods of 10-20 years. There is no definitive answer as to why vegetation is cyclic; factors may be attributed to the natural cycling of willows and shrubs, flooding, fires, grazing, or other human impacts. Vegetation has increased over the last 40 years and is attributed to increasingly effective fire suppression and increasingly stringent regulatory restrictions in riparian areas (Aspect and WPN 2004).

### 3.1.3 Parameters of interest

The streams to be sampled and the parameters to be measured are given in Table 2.
.

Table 2. Sites and parameters sampled.

| **Sites Monitored** | | **Analytes** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **ID** | | Specific Conductivity at 25 ºC | Dissolved Oxygen | Fecal Coliform | Flow | pH | Temper-ature | Turbidity |
| 1 | Bowman Creek #1 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 2 | Bowman Creek #2 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 3 | Bowman Creek #3 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 4 | Butler Creek #1 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 5 | Blockhouse Creek #2 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 6 | Bloodgood Creek #1b | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 7 | Mill Creek #1 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 8 | Mill Creek #3 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 9 | Little Klickitat River #1b and 1a[a] | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 10 | Little Klickitat River #2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 11 | Little Klickitat River #4 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 12 | Little Klickitat River #7 and 7a* | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 13 | Little Klickitat River #9 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 14 | Spring Creek #1 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 15 | Spring Creek #2 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 16 | Swale Creek #2 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 17 | Swale Creek #3 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |

[a]Air temperature also being monitored.

### 3.1.4 Results of previous studies

CKCD began collecting baseline stream temperature data in the Little Klickitat and Swale Creek watersheds in 1995. Reports were not generated from this time period, but data are available to the public at the CKCD office.

When the original TMDL was initiated in 1999 and the report titled *Little Klickitat River Watershed Temperature TMDL* (Brock and Stohr 2002) was published, CKCD decided to take a leading role in the monitoring of the streams in the watershed. Ecology grant G0100201, "Little Klickitat River TMDL Study", funded CKCD to monitor stream flow and temperature from 2002 – 2005 to establish baseline conditions in the Little Klickitat watershed. Subsequent grants funded by Ecology have allowed CKCD to maintain a network of monitoring sites in an ongoing effort to establish a baseline for water quality and temperature and to monitor the effectiveness of BMPs in the Little Klickitat watershed.

Parameters measured included stream and air temperature, conductivity, dissolved oxygen, fecal coliform bacteria, flow, pH, and turbidity. Since then, grants G0600283, G0800396, G0900052, G1100177, and G1200337 funded monitoring from 2007 to 2015. Currently, all monitoring activity is being collected through grants G1400424 for the Little Klickitat watershed and G1400428 for the Swale Creek watershed. Results from Ecology grant funded studies are available online in the Environmental Information Management (EIM) database (http://www.ecy.wa.gov/eim/) and are also contained in final grant reports.

Two stream gage stations on the Little Klickitat River and three stream gage stations on Swale Creek were installed in November 2008, and are operated and maintained by CKCD. The time period for data collection at the gage stations under grant G0900052 was from 2009 – 2011, 2012 – 2015 under grant G1200337, and is presently being collected under grants G1400424 and G1400428.

Ongoing water quality monitoring in the watersheds has helped to outline baseline conditions and to determine the effectiveness of the implemented BMPs associated with the grants. The DIP for the TMDL (Anderson 2005) states that "effectiveness monitoring evaluates whether the management activities achieved the desired effect or goal. Success may be measured against controls of baseline conditions, or desired future conditions". Monitoring is a valuable part of the implementation strategy of the TMDL. It serves to track and evaluate the effectiveness of the implementation measures.

Many of the stream reaches in the Little Klickitat and Swale Creek watersheds exceed the state water quality standard for temperature and site potential conditions. Elevated stream temperatures are particularly apparent from July through August, when air temperatures are hot and stream flow is low. A correlation between low summer stream flow and elevated stream temperatures exists. With regard to fecal coliform bacteria, three of the four sites monitored had samples that exceeded the state standard level of 100 colonies / 100 mL. The general pattern observed was elevated levels during the summer months, which coincides with the low stream flow period. For more detailed study results, CKCD recommends reading the reports generated for the grants, which are available upon request (Ecology 2016).

Recently, grant G1400424 funded the Little Klickitat Subbasin Water Temperature Trend Analysis, developed and implemented by Aspect Consulting (2015). Findings showed that with a statistical confidence level of 95 percent, six out of 17 monitoring stations exhibited a cooling trend. Reducing the statistical confidence level to 90 percent, three additional monitoring sites show a decreasing trend in the maximum water temperature over the past twenty years. Further information can also be found in this analysis.

Several studies have been produced with data from past Ecology grants for multiple agencies. The most recent being the *Little Klickitat Subbasin Water Temperature Trend Analysis* (Aspect 2015), followed by the *WRIA 30 Thermal Refuges and Fish Habitat Assessment* (Glass 2013), *Klickitat River Watershed Management Plan* (WPN and Aspect 2005), and the *WRIA 30*

*Detailed Implementation Plan* (Aspect 2008). The data attained through the monitoring programs have played an integral role in many decisions for WRIA 30 and the Klickitat County Natural Resources department, as well as the CKCD district.

### 3.1.5 Regulatory criteria or standards

WAC 173-201A-600 (WAC 2012) designates the default uses of fresh waters in Washington State as:

> *"All surface waters of the state not named in Table 602 are to be protected for the designated uses of: Salmonid spawning, rearing, and migration; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values."*

WAC (2012) lists WRIA 30, which includes the Little Klickitat River and all tributaries below the confluence with Cozy Nook Creek, as Salmonid Spawning, Rearing, and Migration Habitat ( Table 3). These sections of the Little Klickitat River and Swale Creek are also designated as Primary Contact Recreation (Table 4).

Table 3. Aquatic Life Designated Uses for WRIA 30 (WAC 2012).

| Designated Uses | Water Temp 7-DADMax [a] | pH | Turbidity Maximum | Dissolved Oxygen Lowest 1 Day Minimum |
|---|---|---|---|---|
| Salmonid Spawning, Rearing, Migration | 17.5° C (63.5 ° F) | 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. | ≤ 5 NTU over back ground when background is ≤ 50 NTU. Or ≤10% over background when background is >50 NTU | 8.0 mg/L |

[a]7-day average of the daily maximum temperatures.

In addition to the Designated Use criteria listed above, the following Supplemental Criteria for Salmon and Trout Spawning apply to highlighted freshwaters in the Little Klickitat and Swale Creek watersheds (Figure 2; Ecology 2011).

- ≤13° C from Feb. 15 – June 1
- ≤13° C from Feb. 15 – June 15

Figure 2 shows supplemental spawning and incubation for WRIA 30's non-Tribal lands. Fecal coliform standards for Washington State, specific to the Little Klickitat, are presented in Table 4.

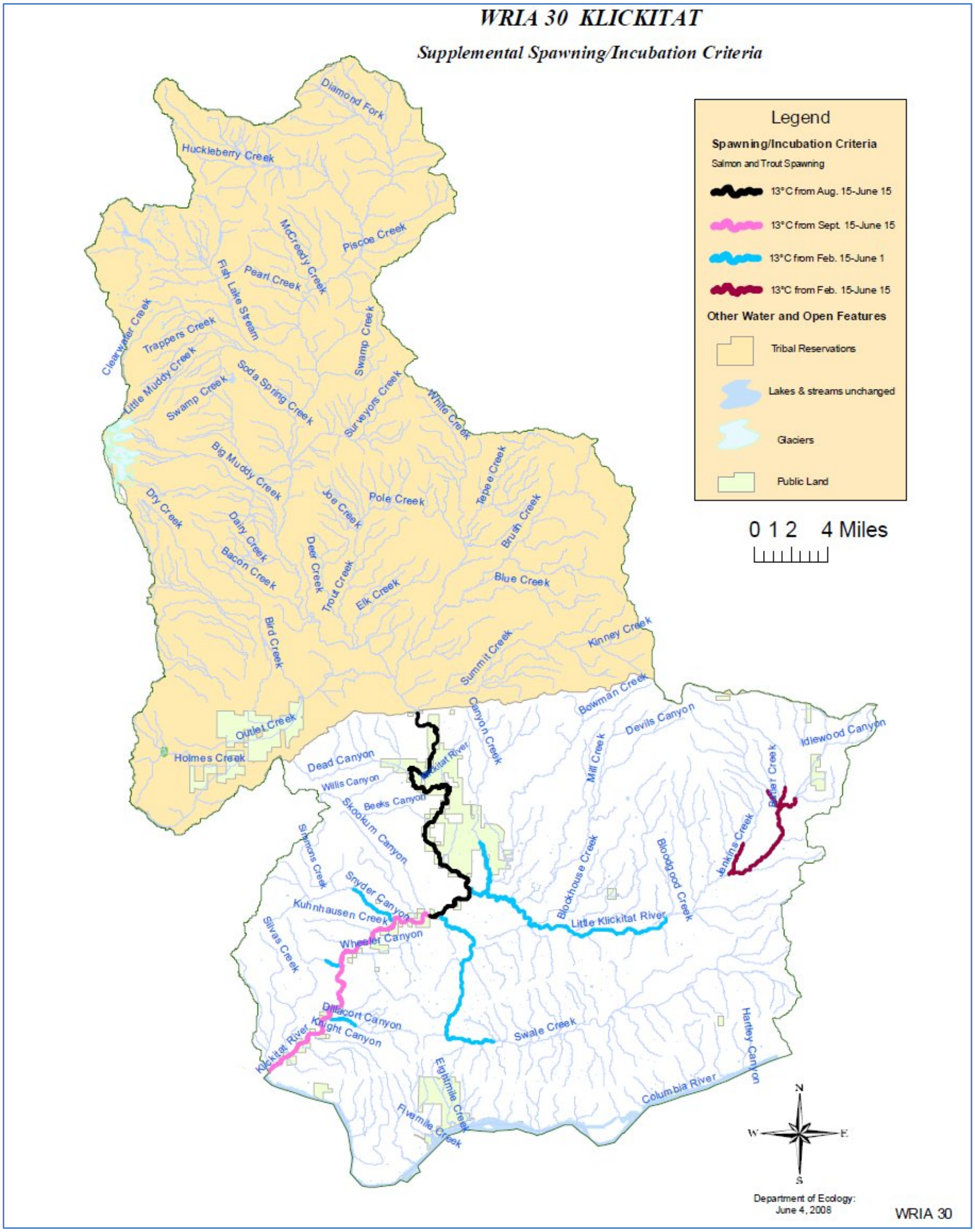


Figure 2. Supplemental Spawning & Incubation for WRIA 30 (Ecology 2011).

Table 4. Fecal coliform recreational standards (WAC 2006).

| Category | Bacteria Indicator (Geometric Mean Value) |
|---|---|
| Primary Contact Recreation | Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies /100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies /100 mL. |

# 4.0 Project Description

## 4.1 Project goals

This project is designed to help provide data, fill data gaps, and assess information to help determine the natural conditions of existing streams located in the CKCD and WRIA 30. It will collect data relating to water quality including:

- Water temperature
- Air temperature at selected sites
- Conductivity
- Dissolved oxygen
- Fecal coliform
- Flow
- pH
- Turbidity

This QAPP supports continued water quality monitoring with the goal of documenting the long-term water quality impacts from the implementation of BMPs initiated with previous and current grants for the Little Klickitat River and Swale Creek.

The water quality monitoring portion of the ongoing CKCD Little Klickitat and Swale Creek Watershed Projects was developed to be used as a tool to establish a baseline for water quality and temperatures. We are expecting that the baseline stream trend information will provide us with both historical reference and long-term data that will document achievements toward meeting water quality improvement goals in the watersheds.

Project goals for this study are:

- Collect in-situ measurements and samples from sites in WRIA 30 that are representative of the selected reaches.

- Obtain analytical results that minimize uncertainty and can be used to measure progress in meeting water quality standards.

## 4.2 Project objectives

Four general monitoring procedures are recommended in the DIP. Our project objective is to successfully continue three of these procedures:

**Procedure 1: Track Stream Temperature**

CKCD will continue to monitor stream temperatures at several sites within the watershed. Water temperature data loggers will be in place in the stream during the critical periods of summer, April through November. The relationship between stream temperature and air temperature will be plotted over time to determine whether stream temperatures are cooler for specific air temperatures, although a direct correlation with just one temperature parameter is not likely to be easily determined. The latitude and longitude locations for the monitoring sites are given in Table 5 and a map of locations are shown in Figure 3 and Figure 4. The site names and parameters to be sampled are given in Table 2. Sites and parameters sampled.

Table 5. Monitoring locations for Little Klickitat and Swale Creek watersheds.

| ID | Sample Site | Degrees, Minutes, Seconds |
|---|---|---|
| 1 | Bowman Creek #1 (BWC-1) | N 45° 50’ 59.6”<br>W 121° 07’ 28.7” |
| 2 | Bowman Creek #2 (BWC-2) | N 45° 52’ 09.2”<br>W 121° 00’ 56.5” |
| 3 | Bowman Creek #3 (BWC-3) | N 45° 57’ 20.5”<br>W 120° 57’ 13.1” |
| 4 | Butler Creek #1 (BC-1) | N 45° 55’ 32”<br>W 120° 42’ 06.2” |
| 5 | Blockhouse Creek #2 (BHC-2) | N 45° 49’ 47.7”<br>W 120° 57’ 39.8” |
| 6 | Bloodgood Creek #1 (BGC-1b) | N 45° 49’ 40.0”<br>W 120° 49’ 52.0” |
| 7 | Mill Creek #1 (MC-1) | N 45° 51’ 52.3”<br>W 120° 57’ 09.4” |
| 8 | Mill Creek #3 (MC-3) | N 45° 56’ 54.4”<br>W 120° 53’ 04.9” |
| 9 | Little Klickitat River #1 and 1a (air) (LK-1b) | N 45° 50’ 43.6”<br>W 121° 03’ 41.8” |
| 10 | Little Klickitat River #2 (LK-2) | N 45° 48’ 36.9”<br>W 120° 55’ 33.3” |
| 11 | Little Klickitat River #4 (LK-4) | N 45° 55’ 32.1”<br>W 120° 43’ 18.8” |
| 12 | Little Klickitat River #7 and 7a (air) (LK-7) | N 45° 55’ 42.4”<br>W 120° 41’ 03.1” |
| 13 | Little Klickitat River #9 (LK-9) | N 45° 51’ 57.8”<br>W 120° 44’ 04.7” |
| 14 | Spring Creek #1 (SPR-1) | N 45° 48’ 53.8”<br>W 120° 56’ 01.5” |
| 15 | Spring Creek #2 (SPR-2) | N 45° 49’ 30.0”<br>W 120° 53’ 40.0” |
| 16 | Swale Creek #2 (SWC-2) | N 45° 43’ 23”<br>W 121° 01’ 51” |
| 17 | Swale Creek #3 (SWC-3) | N 45° 49’ 20”<br>W 121° 05’ 42” |

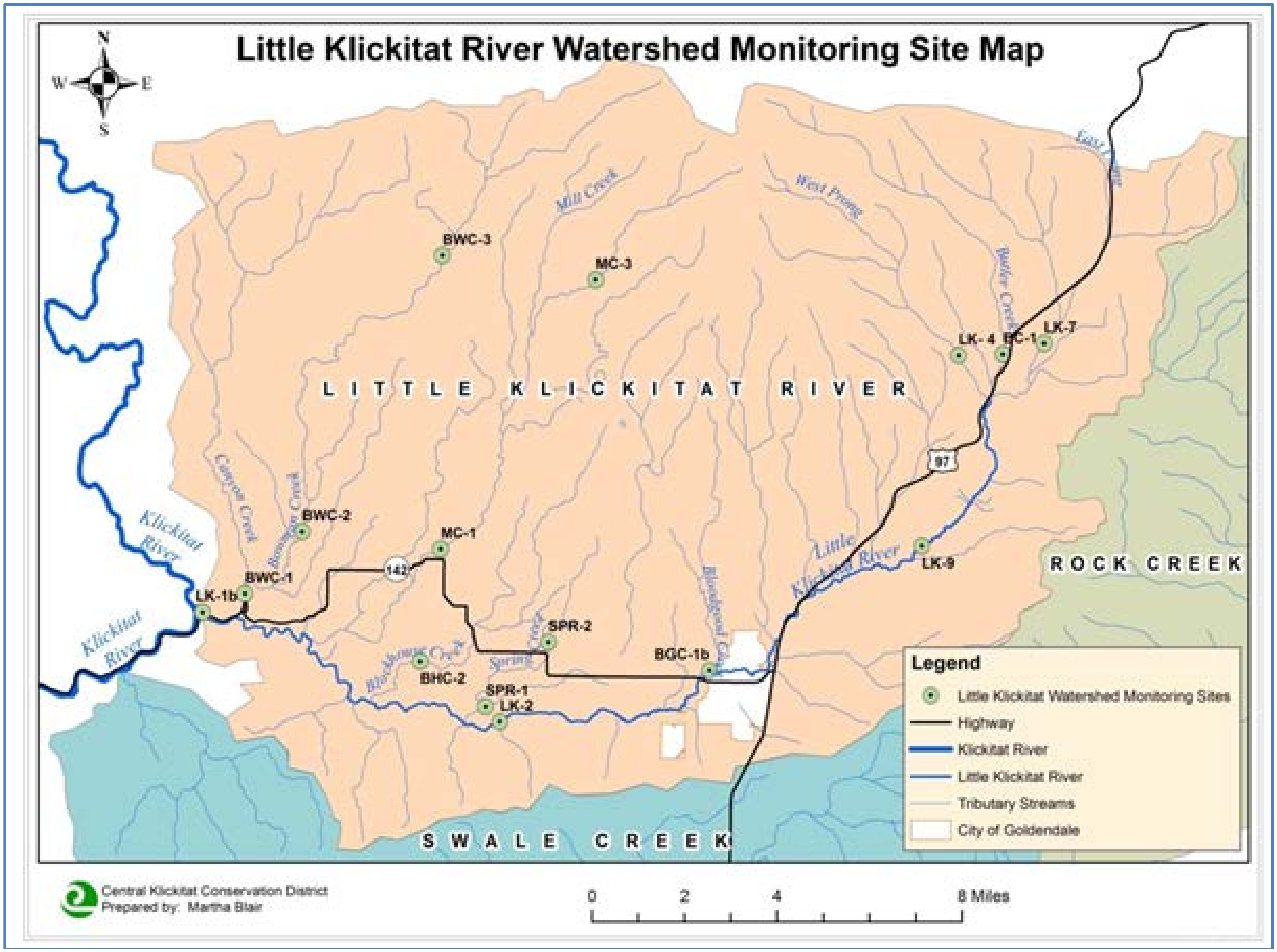


Figure 3. Monitoring locations in the Little Klickitat River.

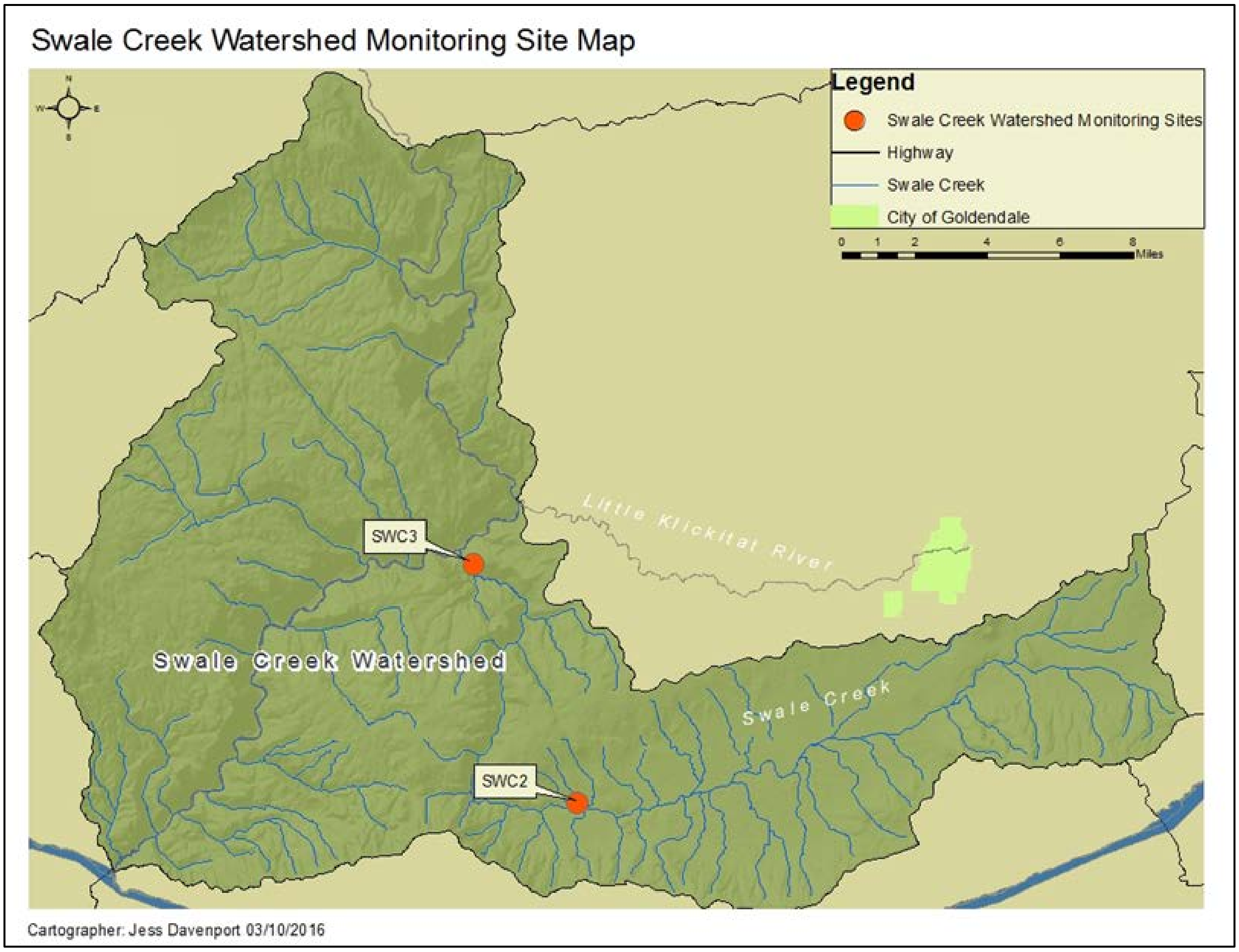

Figure 4. Monitoring locations in the Swale Creek watershed.

**Procedure 2: Monitor Physical Parameters Associated with Stream Temperatures**

Parameters that will be monitored by CKCD include air temperature, water temperature, and stream flow. Four sites will be sampled for fecal coliform. CKCD will also take readings on conductivity, pH, dissolved oxygen, and turbidity at each monitoring site.

## 4.3 Information needed and sources

Not applicable.

## 4.4 Target population

The target population are the streams in WRIA 30 chosen for data collection. Each site is representative of the conditions in that particular reach.

## 4.5 Study boundaries

The Little Klickitat and Swale Creek watersheds are located in the south central portion of Klickitat County and make up the south half of WRIA 30. Refer to Figure 1 for a map of the watersheds and to Table 6 for the hydrologic unit codes (HUCs).

Table 6. HUCs for WRIA 30.

| HUC 12 | Name |
|---|---|
| 170701060301 | Headwaters Little Klickitat River |
| 170701060302 | Upper Little Klickitat River |
| 170701060303 | Spring Creek |
| 170701060304 | Middle Little Klickitat River |
| 170701060305 | Devils Canyon |
| 170701060306 | Bowman Creek |
| 170701060307 | Lower Little Klickitat River |
| 170701060403 | Upper Swale Creek |
| 170701060404 | Middle Swale Creek |
| 170701060405 | Lower Swale Creek |

## 4.6 Tasks required

All monitoring equipment is calibrated once before use at the beginning of the season and during the season according to the Ecology and manufacturer approved process. The one exception are temperature data loggers, which cannot be calibrated, but are checked for drift twice annually: before deployment and following removal at the end of the monitoring season.

See the Standard Operating Procedures (SOPs) in Appendix A for calibration procedures.

Any temperature data loggers that do not calibrate within the accepted standards are either discarded or sent in for repair. At the end of the season, when the units are brought in, the calibration is checked again.

Each monitoring site is visited monthly from May through October and the temperature data are downloaded, then brought back to the office and uploaded.

During the site visit when the shuttles are downloaded the time and temperature are taken with the field meters for on-site comparison. The ProPlus and ProODO are checked weekly with the certified NIST thermometer to ensure there is no drift in the temperature readings prior to field visits. The pH is calibrated before each sample day and is checked at the end of the day. The specific conductivity is calibrated weekly and calibration checked before and after each sample day. Dissolved oxygen calibration will be checked each sample day and calibrated as needed (will hold calibration for months).

The SonTek FlowTracker ADV is used to measure stream flow. Duplicate measurements are taken once a month at a site and compared for a certain acceptable range of error associated with the measurements taken. A Quality Assurance (QA) check is also performed prior to flow measurement in the stream. If the QA is reading abnormally, the flow tracker is sent in for calibration.

The parameters sampled at each site are listed in Table 2. It is important to note that not all sites will be sampled for fecal coliform, just those streams where there are concerns of state water quality criteria exceedances.

## 4.7 Practical constraints

Constraints on the monitoring will most likely be high water flows in the spring or fall that will restrict safe access to the streams. During high flows, it may be possible to install temperature data loggers, but it may not be possible to take flow measurements and stream width and depth measurements. Care will need to be taken to not install the temperature loggers too shallow or they may be exposed when the flow subsides. As the season progresses and flow decreases, it may be necessary to reposition the data loggers to assure they remain in the stream. If we are unable to begin all of the monitoring because of high flow, we will wait until the water levels recede to a safe level before beginning the monitoring season.

Too little flow might mean there is not enough volume for clean samples or only stagnant water in the stream. In these cases, the field staff will record conditions in the field notebook and/or iPad and qualify the samples accordingly when submitting results to Ecology.

## 4.8 Systematic planning Process

The Performance and Acceptance Criteria (PAC) process is the systematic planning process being used.

The data collected may be used for:

- Adaptive management for this project, the DIP, or the STI draft.
- Identifying the best locations for BMPs of implementation projects.
- Implementing monitoring strategies to achieve the goals of the project.

# 5.0 Organization and Schedule

## 5.1 Key individuals and responsibilities

CKCD is the implementing agency for this QAPP. All CKCD and partner staff and their responsibilities are provided in Table 7.

CKCD is responsible for implementation, development, and management of the Little Klickitat River and Swale Creek TMDL Implementation agreement WQC-2016-CKliCD-00003. CKCD will be responsible for maintaining communications with the funding agency and ensuring compliance with specifications outlined in the project plan.

CKCD will be responsible for the development and implementation of conservation plans and BMPs as well as water quality monitoring for field measurements of conductivity, dissolved oxygen, fecal coliform, flow, pH, temperature, and turbidity in locations of interest. Contact info for CKCD is:

Central Klickitat Conservation District
1107 South Columbus Avenue, Goldendale, WA. 98620
(509) 773-5823

Ecology is the funding agency for the Little Klickitat River and Swale Creek TMDL Implementation Project. The responsibility of the funding agency is to ensure that all project requirements are met and that the data collection program as outlined here meets QA requirements. Contact info for Ecology is:

Washington State Department of Ecology
300 Desmond Drive, Lacey, WA 98503-1274
(360) 407-6000

Ecology's Project Manager for this grant is Heather Simmons. Her contact info is:

Heather Simmons, Grant Project Manager
Ecology, Water Quality, CRO
1250 West Alder St., Union Gap, WA 98903-0009
(509) 454-7207

The Public Works Laboratory for the city of Goldendale, an accredited laboratory, will perform the fecal coliform tests for the four sites on the Little Klickitat River.

Table 7. Organization of project staff and responsibilities.

| Staff | Title | Responsibilities |
|---|---|---|
| Kent Apostol | CKCD, District Manager | Overseeing the monitoring program. |
| Mindy Pomerinke | CKCD, Financial Administrator | Review of project scope and budget and tracking progress. |
| Kaci Bartkowski | CKCD, Water Quality Monitoring Technician | Development of the QAPP. Collection and compilation of all data for analysis and planning. Completion of final report. |
| Heather Simmons | Ecology, Water Quality, Project Manager | Providing initial review and feedback of QAPP and providing final approval. Review and approval of final report. |
| Daniel Dugger | Ecology, EAP, Technical Reviewer | Providing internal review of QAPP and review of final report. |

## 5.2 Special training and certificates

The Public Works Laboratory (accreditation # M1485) is located in Goldendale, Washington. Accredited parameters for this lab include *Fecal Coliform – count*, using the standard method 9222 D.

## 5.3 Organizational chart

See Figure 5 for the chain of communication between CKCD, Ecology, and other partners.

## 5.4 Project schedule

Water quality monitoring for this QAPP will begin December 2016 and continue through September 30, 2018. Activities and timelines within this period include:

- QAPP preparation and approval: January 2016 – November 2016.
- Annually:
  - Fieldwork conducted for monitoring sites: April to November.
  - Delivery of fecal samples to lab: April to November.
  - Data upload into Aquarius[1]: April to November.
  - Verification and validation of data: December to January.
  - EIM data entry completed: December to February.
  - Annual progress reports: December to February.
- Final report completed and approved: September 2018 (timing dependent on future funding availability).

[1] http://aquaticinformatics.com/

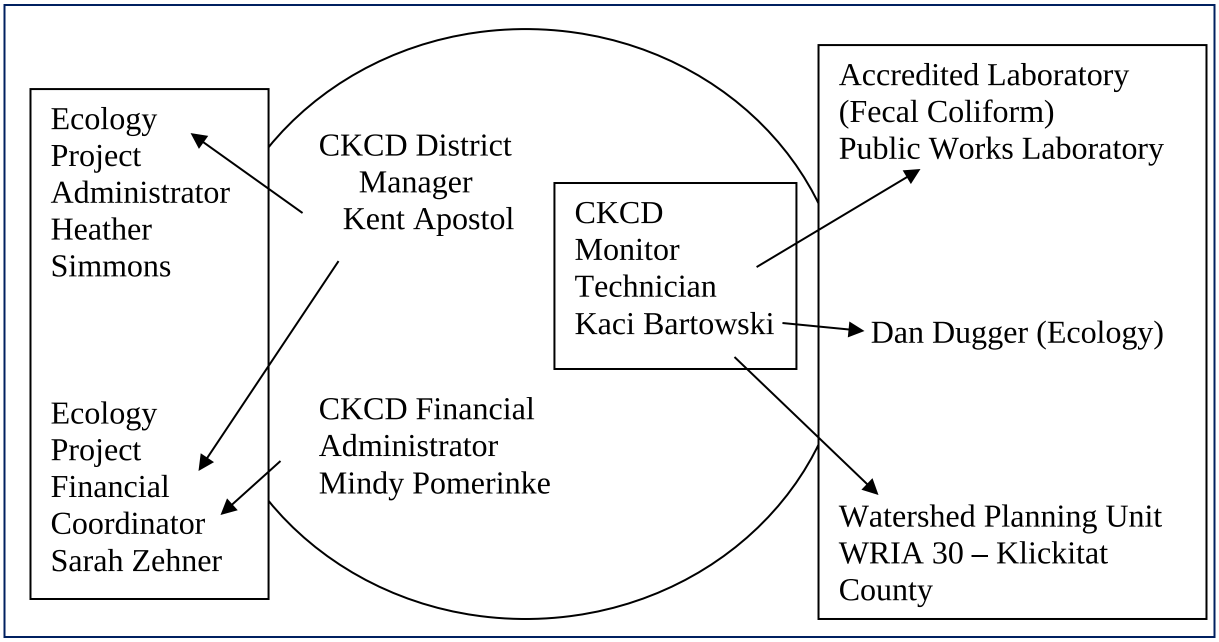

Figure 5. Chain of communication between CKCD, partners, and Ecology.

## 5.5 Limitations on schedule

Successful completion of all scheduled fieldwork may not be possible during entire monitoring season due to unsafe conditions such as wildfire threat and high water flow events. Software malfunction can delay data upload, annual progress reports, and final reports.

## 5.6 Budget and funding

Water quality monitoring under this QAPP is funded by Ecology agreement WQC-2016-CKliCD-00003 through September 30, 2018. A total of $92,100.33 is available for the monitoring technician, necessary equipment purchases and repairs, training, and expenses related to field work including the monthly site visits to the five permanent gauging stations. Laboratory services provided by the Public Works Laboratory are not charged to CKCD, but are instead used as in-kind match. Klickitat County Natural Resources contributes to stream gage monitoring. The cost of staff to do so is not charged to CKCD, but instead is used as match. The budget breakdown is provided Table 8.

Table 8. Costs and match associated with Task 2, monitoring efforts.

| Task | Allocated Amount |
|---|---|
| Monitoring activities | $88,600.33 |
| Equipment Purchases and Repairs | $2,500.00 |
| Training | $1,000.00 |
| Fecal Coliform Lab Costs | In-kind match |
| Klickitat County Natural Resources Match | $2,100.00[a] |

[a]This is an estimated amount as time needed to complete stream gage tasks varies month to month due to stream conditions.

# 6.0 Quality Objectives

## 6.1 Decision quality objectives

Not applicable.

## 6.2 Measurement quality objectives

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

When applicable, precision will be presented as standard deviation and relative standard deviation, and bias as relative percent bias. Calculations will be made using the equations presented in *Guidelines and Specifications for Preparing Quality Assurance Project Plans*, (Lombard and Kirchmer 2004).

**6.2.1.1 Precision**

*Precision* is a measure of the ability to consistently reproduce results. Precision will be evaluated by field checks of temperature loggers with field thermometers.

Experience at Ecology has shown that duplicate field thermometer readings consistently show a high level of precision, rarely varying by more than 0.2º C. Therefore, replicate field thermometer readings were deemed not necessary and will not be taken (Brock and Stohr 2000)**.**

The Measurement Quality Objectives (MQOs) for field measurements are presented in Table 9 and Table 10.

**6.2.1.2 Bias**

*Bias* is the systematic error due to contamination, sample preparation, calibration, or the analytical process. Most sources of bias are minimized by adherence to established protocols for the collection, preservation, transportation, storage, and analysis of samples. Table 9 contains the data quality bias objectives for both instrument drift and fouling checks.

For field measurements, CKCD staff will:

- Minimize bias in the field meter measurements by pre-calibrating before each run. A sample run is defined as monthly run to all monitoring sites.
- Assess any potential bias from instrument drift in probe measurements:
    - For pH and conductivity, pre-check the probes against National Institute of Standards and Technology (NIST) certified pH and conductivity standards.
    - For dissolved oxygen, pre-check the probe against 100% air saturated water.

- For temperature, check the probe's temperature readings before and after each run using a NIST certified thermometer.

Table 9. MQOs for field meter post-deployment checks, and replicates.

| Parameter | Units | Accept | Qualify [a] | Reject |
|---|---|---|---|---|
| Standard Checks | | | | |
| pH | std. units | ≤ + 0.2 | > + 0.2 and ≤+ 0.5 | > + 0.5 |
| Conductivity [a] | uS/cm | ≤ + 5% | > + 5% and ≤ + 15% | > + 15% |
| Temperature | ° C | ≤ + 0.2 | > + 0.2 and ≤ + 0.5 | > + 0.5 |
| Dissolved oxygen | % saturation | ≤+ 5% | > + 5% and ≤+ 10% | > + 10% |
| Replicates | | | | |
| Stream flow | % saturation | ≤10% RSD | > + 10% and ≤+ 20% | > + 20% |
| Temperature | ° C | ≤ + 0.2 | > + 0.2 and ≤ + 0.5 | > + 0.5 |
| Turbidity | ° C | ≤10% RSD | > + 10% and ≤+ 20% | > + 20% |
| Blanks | | | | |
| Fecal coliform | cfu | ≤5%[b] | > + 5% [b] and ≤+ 20% [b] | > + 20% [b] |

[a] Criteria expressed as a percentage of readings; for example, buffer = 100.2 uS/cm and Hydrolab = 98.7 uS/cm; (100.2-98.7)/100.2 = 1.49% variation, which would fall into the acceptable data criteria of less than 5%.

[b] Percent (%) of associated field sample. Blank acceptance criteria are based on the total percentage the blank sample represents of the associated field samples. For example; a blank detection of 5 cfu would reject associated samples ≤25 cfu, qualify as estimates any samples >25 cfu and ≤100 cfu, and would not qualify or reject any samples >100 cfu.

Table 10. MQOs for fecal coliform replicates.

| Parameter | Units | Accept |
|---|---|---|
| Fecal coliform replicates | cfu | 50% of the replicate pairs must be at or below 20% RSD, and 90% of the pairs must be at or below 50% RSD |

#### 6.2.1.3 Sensitivity

As a data quality indicator in this document, sensitivity can be defined as the lowest concentration of a substance that can be detected, or the lower limit of detection. Sensitivity is also described as a detection limit. See Table 11 for instrument accuracy and ranges.

Table 11. Method reporting limits and expected ranges for field measurements and samples.

| Parameter | Method/ Equipment | Method Lower Reporting Limit and/or Resolution | Expected Range |
|---|---|---|---|
| Continuous Water and Air Temperature | Onset Hobo Pro v2 | 0.01° C | 0 – 30° C |
| Water Temperature (field meter) | ProPlus, ProODO Handheld Multiparameter Instrument | 0.01° C | 0 – 30° C |
| pH | ProPlus Handheld Multiparameter Instrument | 0.01 s.u. | 6.5 to 9.0 s.u. |
| Dissolved Oxygen (luminescent) | ProODO Handheld Multiparameter Instrument | 0.1 mg/L | 0.1 – 15 mg/L |
| Specific Conductivity at 25° C | ProPlus Handheld Multiparameter Instrument | 1 µS/cm | 20 – 1000 uS/cm |
| Turbidity | Hach 2100Q | 0.01 NTU | 0 – 100 NTU |
| Stream Flow | SonTek FlowTracker ADV | 0.01 cfs | 0.01 – 1,000 cfs |
| Fecal coliform | Standard Methods 18 9222-B | 1 cfu | 0-1,000 cfu |

[a] N/A - not applicable.

## 6.2.2 Targets for comparability, representativeness, and completeness

### 6.2.2.1 Comparability

There have been numerous studies completed within this planning area and data collected under this project may be compared to previous results.

### 6.2.2.2 Representativeness

The data logger stations have been placed in such locations in each sub-watershed as logistical constraints have permitted and where the purpose of the monitoring program can be accomplished (Figure 3 and Figure 4). The majority of the stations have been monitored under CKCD's ambient monitoring program since 1995. Each station was initially chosen to be representative of typical stream conditions and surrounding land use practices. Site accessibility was also taken into consideration during the site selection process. CKCD feels that it is important for our study to utilize pre-existing monitoring sites, so that data collected during the course of this grant can be compared directly to historical data collected at the same locations.

To assess representativeness, the CKCD District Manager will review field monitoring documentation to determine if external circumstances may have affected the field measurements.

Water quality samples will be collected from stream locations that measure a representative sample of the stream. Samples should be collected from the main flow, but not in a backwater or eddy. When possible, grab samples should be collected far enough below the water surface to avoid sampling surface water. Temperature data loggers should not be placed too near the substrate in a groundwater upwelling reach, but deep enough to remain in the water at low flow.

Water quality samples are intended to be representative of stream conditions at the locations and time of collection. Monthly samples may estimate seasonal changes. Continuous temperature loggers will record every 30 minutes to estimate diurnal and seasonal temperature changes.

#### 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 90% for each parameter and perennial monitoring station. Temperature data are considered 100% complete when data loggers have collected data from May 1 to October 31 at 30-minute intervals. Other data are completed at 100% if readings and measurements are taken monthly from May through October. The completeness value of 90% was arrived at from past history with loggers and data collection.

# 7.0 Sampling Process Design

## 7.1 Study design

### 7.1.1 Field measurements

Field parameter measurements will be taken once per month April - November for each site. Please refer to Table 2 for the list of parameters.

Refer to Table 8 for specific equipment associated with each parameter.

### 7.1.2 Sampling location and frequency

There are fifteen monitoring stations in the Little Klickitat River watershed and two monitoring stations in the Swale Creek watershed, which can be found in Figure 3 and Figure 4 respectively. Sampling locations and coordinates are listed in Table 5.

Measurements and samples will be taken monthly starting in April and ending in November of each year.

### 7.1.3 Parameters to be determined

Parameters to be sampled are provided in Table 2.

Turbidity will be measured with a Hach 2100Q Turbidimeter, specific conductivity and pH will be collected using a ProPlus Handheld Multiparameter Instrument, and dissolved oxygen will be collected using a LDO probe (ProODO Handheld Optical Dissolved Oxygen Meter). The SonTek FlowTracker ADV will be used to measure stream flow.

## 7.2 Maps or diagram

Refer to Figure 1, Figure 2, Figure 3, and Figure 4.

## 7.3 Assumptions underlying design

We assume data gathered are representative for that particular stream reach at that particular time. We also assume any trends or patterns detected in analysis of these data represent real world patterns in the Little Klickitat River and Swale Creek watersheds.

## 7.4 Relation to objectives and site characteristics

The proposed frequency of measurements is intended to capture the expected temporal variability of the parameters of interest. The proposed monitoring locations were selected based on available access and a distribution that would represent significant watershed features within the Little Klickitat and Swale Creek watersheds.

## 7.5 Characteristics of existing data

Stream monitoring has been performed by CKCD at the majority of the site locations indicated for this study since 1995. Sources for existing data at these sites include CKCD's ambient monitoring program as well as previous Little Klickitat River TMDL studies implemented by CKCD (Ecology 2016). Historical data include stream temperature and flow. Ecology (Brock and Stohr 2002) conducted a study, which adds to the existing data for the watersheds. The city of Goldendale also maintains one active stream gauge station, at which water quality data are collected on a regular basis.

# 8.0 Sampling Procedures

## 8.1 Field measurement and field sampling SOPs

CKCD staff will follow the SOP’s and instrument calibration techniques outlined in Appendix A.

## 8.2 Containers, preservation, and holding times

Table 12 presents the fecal coliform container and preservation methods. All samples collected will be stored on ice for no more than 24 hours before testing. Prior arrangements are made with the Public Works Laboratory to insure the fecal coliform tests can be performed in a timely manner for the collection day. Sterilized sample bottles are provided by the lab for collection of fecal coliform samples.

Table 12. Fecal coliform container and preservation methods.

| Parameter | Matrix | Minimum Quantity Required | Container | Preservative | Holding Time |
|---|---|---|---|---|---|
| Fecal Coliform | Surface water | 100 ml | 100 ml wide mouth polyethylene[a] | Cool to 4°C | 24 hours |

[a]100 ml sample bottles provided by Laboratory.

## 8.3 Invasive species evaluation

Invasive species will be noted and reported to Klickitat County Weed Control Board if observed in field. CKCD maintains a close relationship with the county weed management and is updated yearly on invasive species lists. If new invasive species are identified within the county, the Klickitat County Weed Control Board will publish notifications in a monthly newsletter received by CKCD.

Field gear and equipment will not be used outside of Central and Eastern Klickitat’s watersheds, except for the use of the FlowTracker on rare occasions.

Field staff will attempt to minimize spread of invasive species by inspecting and cleaning field gear following procedures outlined in Ecology's publication *Standard Operating Procedures to Minimize the Spread of Invasive Species* (Ecology 2016).

> *Inspect and clean all equipment that contacted (terrestrial or aquatic) soil, vegetation, or water. Remove any visible vertebrates, invertebrates, plants, algae or sediment. If necessary, use a scrub brush and rinse with clean water either from the site or brought for that purpose. Continue this process until the equipment is clean. Drain all water in bilges, samplers or other equipment that could hold water from the site. Flush areas that can’t be seen with clean water until the rinse water is clean.*

## 8.4 Equipment decontamination

Not applicable.

## 8.5 Sample ID

An identification system has been established for fecal coliform samples collected during the course of this study. The site name and sample date are incorporated into the sample identification. As an example, a sample collected at site Little Klickitat #2 (LK2) on June 21$^{st}$, 2008, would be assigned the following sample ID: LK2_062108. A duplicate sample would have the letter D at the end of the sample ID. This identification system will be used consistently. Sample labels will include the information in Table 13.

Table 13. Sample custody procedures.

| **Sample Custody Procedures** |
|---|
| Each sample bottle will be labeled with the following information:<br>✓ Sample site<br>✓ Time<br>✓ Date<br>✓ Preservation methods used<br>✓ Initials of collector<br>✓ Sampling agency<br>✓ Parameters sample is to be tested for |

## 8.6 Chain of custody, if required

Sample bottles will not leave the possession of the CKCD technician until they are left with the laboratory technician. A Chain-of-Custody will not be used given these circumstances. If the procedure for delivering sample bottles is altered, CKCD will use a Chain-of-Custody that includes documentation of sample site, time of collection, date, preservation methods used, authorized personnel, name of sample collector and contact phone number, testing methods, and list of parameters to be tested on each sample.

## 8.7 Field log requirements

Table 14 shows the information the monitor technician will enter for each monitor site on each visit.

Table 14. Field collection documentation.

| Field Documentation |
|---|
| Field documentation will consist of a journal entry and data entry on standard data entry forms, upon each site visit.<br><br>Journal entries will contain:<br>✓ Weather Observation<br>✓ Antecedent Weather Conditions<br>✓ General Observations<br>✓ Personnel Performing Tasks<br>✓ Deviations from Standard Operating Procedures, Problems Encountered, Corrective Action Taken<br>✓ Date and Time<br><br>Field data entries will contain:<br>✓ Verification of Sampling (including sample bottle label information and QC samples collected or measurements taken)<br>✓ Water Temperature<br>✓ Dissolved Oxygen Reading<br>✓ pH Reading<br>✓ Stream Discharge Reading<br>✓ Turbidity Reading |

## 8.8 Other activities

Other activities may include:

- Periodic maintenance for field instrumentation.
- Trainings for field staff.

# 9.0 Measurement Methods

## 9.1 Field procedures table/field analysis table

Field procedures are outlined in Table 15.

Table 15. Field procedures.

| Parameter | Measurement/Sample Type | Field Protocol |
|---|---|---|
| Turbidity and Fecal Coliform | Discrete grab samples | Appendix A.7 Parameter Measured: Turbidity<br>Appendix A.2 Parameter Measured: Fecal coliform |
| Dissolved Oxygen and Temperature | Discrete field measurement / ProODO Handheld Instrument | Appendix A.1 Parameter Measured: Dissolved Oxygen<br>Appendix A.5 Parameter Measured: Temperature |
| pH, Specific Conductivity, and Temperature | Discrete field measurement / ProPlus Handheld Instrument | Appendix A.3 Parameter Measured: pH<br>Appendix A.4 Parameter Measured: Specific Conductivity<br>Appendix A.5 Parameter Measured: Temperature |
| Flow | Discrete field measurement / FlowTracker | Appendix A.8 Parameter Measured: Velocity |
| Air and Water Temperature | Continuous / Onset Hobo Pro v2 | Appendix A.6 Parameter Measured: Continuous Temperature |

## 9.2 Laboratory procedures table

CKCD will use the services of the Public Works Laboratory, a Washington State accredited laboratory. CKCD will emphasize quality control and require any internal laboratory problems related to sample analysis of this project to be documented and communicated to the CKCD.

The CKCD has corresponded with the Public Works Director by phone to provide the laboratory with information regarding the planned sampling schedule and other issues. CKCD may receive testing results from the laboratory via e-mail, regular mail, or courier. The fecal coliform sample method is displayed in Table 16.

Table 16. Fecal coliform sample method.

| Analyte | Matrix | Number of Samples | Expected Range of Results | Analytical Method | Sensitivity |
|---|---|---|---|---|---|
| Fecal Coliform | Surface Water | 5/month | 0-1,000 cfu | Standard Methods 18 9222-B | 1 cfu[a] |

[a]cfu=colony forming unit.

## 9.3 Sample preparation method(s)

Sample preparation procedures are specified in the analytical method for fecal coliform in Appendix A. The membrane filtration option is used by the lab for the procedure. An inhibitor is not used.

## 9.4 Special method requirements

There are no modifications to the standard method.

## 9.5 Lab(s) accredited for method(s)

The Public Works Laboratory (accreditation # M1485) is located in Goldendale, Washington. Accredited parameters for this lab include *Fecal Coliform – count*, using the standard method 9222 D. Fecal coliform samples collected during the course of this study will be analyzed at the Public Works Laboratory.

# 10.0 Quality Control (QC) Procedures

## 10.1 Table of field and lab QC required

The quality assurance sample and calibration schedule is presented in Table 17.

Field quality control samples will be submitted by the water monitoring technician to measure errors in fecal coliform sample collection, processing, and transport in the field. Two types of basic field quality control samples will be used in this study: field blanks and field replicates. These will be collected routinely throughout the period of data collection. One field blank and one field replicate will be collected per four samples, which is the extent of sampling to be performed each month. Results from these collections are used to estimate total precision for each parameter. Additional quality control samples may be collected only if the need arises, to locate problems or respond to a change in procedure or plans.

Sampling will be done in a manner to prevent cross-contamination of samples, especially with respect to fecal coliform. Sampling equipment will be cleaned prior to use. Problems with field quality control will be reported immediately to the CKCD District Manager, who will determine and implement the proper corrective action.

The temperature field meter will function as a duplicate for onset temperature logger readings at the time of the site visit. Time constraints will not allow for a duplication of the flow measurement process at every site, unless at a continuous reading site. However, a single site will be chosen at random for a duplicate reading each month.

We will use fresh pH and conductivity standards for field meter calibrations and checks. Luminescent dissolved oxygen calibrations and checks are conducted using 100% air saturated water.

The data received from this quality control sample will be recorded but not reported with the final assembled data. The results from these special analyses will be used to help ensure proper equipment and laboratory function and will be included in an appendix.

Accuracy of field measurements is ensured by proper equipment calibration per the SOPs indicated for the project. Equipment manuals and SOPs for field instruments will be followed closely regarding suggested routine and preventive maintenance, and will be checked upon return to office after every sampling period and stored in such a way as to minimize damage between sampling periods. Refer to the SOPs in Appendix A.

Table 17. Quality assurance sample and calibration schedule.

| Parameter | QA sample type | Frequency |
|---|---|---|
| Water Temperature | On site field thermometer checks of instream Hobo Pro v2 temperature loggers | 1 per site visit |
| Stream Flow | Duplicate measurement | 1 per sample month |
| Turbidity | Duplicate field samples | 1 per sample month |
| pH | Calibration | Before each sample day |
| | Standard check | Before and after each sample day |
| Specific conductivity at 25º C | Calibration | Before each sample run |
| | Standard check | Before each sample day |
| Dissolved oxygen (luminescent) | Calibration | Before each sample run |
| | Standard check | After each sample run |
| Fecal Coliform | Duplicate field samples | 1 for every 4 samples |
| | Field blanks | 1 for every 4 samples |

## 10.2 Corrective action processes

For fecal coliform samples, the Public Works Laboratory has specific quality control procedures that include criteria for initiating corrective action based on quality control results. These criteria and the proposed corrective action will be specified to the CKCD's District Manager and/or the Water Quality Monitoring Technician at the initiation of sample analysis. The District Manager and/or technician will be contacted when the laboratory has to initiate any corrective action.

The District Manager and/or technician will deal with any problems associated with the field data collection. A field data report form will be used to record data in the field. Once back in the office, data will then be processed and entered into the Aquarius database to be compiled and analyzed for errors, discrepancies, completeness, precision, and bias. If found, errors and discrepancies will be noted to be later included in the report. Corrective measures will be taken to eliminate errors and validate the quality of the data.

# 11.0 Data Management Procedures

## 11.1 Data Recording/reporting requirements

The Water Quality Monitoring Technician will be responsible for data management. The following steps should be followed:

1. Field meter calibration and check results will be recorded on a calibration form. Calibration records will be kept in a file for use as a reference when performing the data review.
2. Field measurements will be recorded with standardized field data collection forms.
3. Recorded field measurements from field notebook or iPad will be manually entered into CKCD's internal Aquarius database, designed to accommodate historic and current water quality monitoring data collected by CKCD staff.
4. Temperature data logger files will be offloaded from the Onset shuttle to a CKCD computer. Files are then uploaded to the Aquarius database.
5. Stream discharge, velocity, temperature, depth, and width measurements will be recorded in the Flowtracker instrument and offloaded into the Aquarius data management system. Measurements are also recorded in the field on the standardized field collection form.
6. While entering the field measurements results, the technician will compare recorded measurements to the expected range of results in Table 10. When applicable, if the results fall outside the expected range of results, the technician will investigate the problem and report the problem and possible reasons for error to the CKCD District Manager.
7. An automatic back-up system is in place for electronic data files. They are stored off-site by Carbonite[2].

## 11.2 Lab data package requirements

For fecal coliform, the lab data package will include sample results, including quality control results associated with the data. Quality control results will include lab blanks and analytical duplicates. Documentation will include a narrative discussing any problems with the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers.

## 11.3 Electronic transfer requirements

Data for all parameters will be transferred to Ecology's EIM Database annually, following the monitoring season. This process will involve exporting data from Aquarius to Excel spreadsheets, where it is re-formatted according to EIM requirements. The data spreadsheets are submitted to the Ecology's EIM database using the online process.

[2] http://www.carbonite.com/

## 11.4 Acceptance criteria for existing data

Not applicable.

## 11.5 EIM/STORET data upload procedures

Data will be transferred to Ecology's EIM system annually per online submittal guidelines. The EIM data coordinator will be consulted if data submittal problems arise. The Water Quality Monitoring Technician will complete EIM training offered by Ecology.

# 12.0 Audits and Reports

## 12.1 Number, frequency, type, and schedule of audits

A grant progress report will be submitted quarterly and a water quality monitoring progress report will be submitted annually, both for the life of the grant. Information will be summarized in narrative form as data become available.

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

## 12.2 Responsible personnel

The CKCD District Manager will complete all quarterly grant progress reports. The Water Quality Monitoring Technician for CKCD will be responsible for all monitoring reporting and audits in connection with this project. Internal audits will occur after field work is complete and consist of a review of field data records for verification and data discrepancy. This will also serve for EIM data upload verification as well as data reporting verification.

## 12.3 Frequency and distribution of reports

Grant progress reporting for this project will be completed according to the requirements outlined in WQC-2016-CKliCD-00003 between CKCD and Ecology. Quarterly grant progress reports will be completed by the following schedule:

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

Yearly water quality progress reports will be submitted between December and February following the conclusion of the monitoring season.

A final report will be submitted at least 45 days before the grant end date and a final, approved report will be submitted before the grant end date.

## 12.4 Responsibility for reports

For WQC-2016-CKliCD-0003, the CKCD District Manager, Administrative Assistant, and Resource Technician are responsible for writing all reports associated with all tasks other than the water quality task (Task 2). The Water Quality Monitoring Technician will be responsible for writing reports associated with water quality monitoring.

# 13.0 Data Verification

## 13.1 Field data verification, requirements, and responsibilities

The Water Quality Monitoring Technician is responsible for examining field data for errors or omission as well as for compliance with QC acceptance criteria. Field sheets will be reviewed for errors or omissions before leaving the site where measurements were made. The field records will be organized and reviewed for accuracy and completeness. At this time, it will also be determined if the MQOs for precision and bias have been met.

## 13.2 Laboratory data verification

Analytical data are expected to be received from the laboratory in hard copy. The data will be reviewed to ensure that all analytical requests are present, and will then be entered into electronic format. A complete set of data files, both hard copy and electronic, will be maintained in the project files.

Data from the laboratory analyses will be reviewed to ensure the data quality objectives have been achieved. Data quality will be assessed by using pooled estimates of the standard deviations and the relative standard deviation for each parameter.

The pooled estimate of the standard deviation (S) is given by:

Pooled $S = \sqrt{(\sum D^2 / 2m)}$, where:
D = sample value – duplicate value, and
m = the number of sample pairs;

The pooled relative standard deviation is given by the median value of the relative standard deviation estimated for each sample pair.

The relative standard deviation is given by:

$$\text{RSD (in \%)} = \frac{(|\text{sample value} - \text{duplicate value}| / \sqrt{2})}{(\text{sample value} + \text{duplicate value})/2} (100);$$

## 13.3 Validation requirements, if necessary

Not applicable.

# 14.0 Data Quality Assessment Procedure

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

If MQOs have been met, the quality of the data should be useable for meeting project objectives. We will assess the data to determine if they are the right quality and quantity to support the project objectives. This will include an assessment of whether the requirements for representativeness and comparability have been met. The number of valid measurements completed will be compared with those established.

## 14.2 Data analysis and presentation methods

Data collected will be compared to historical watershed data, when available. Historical data referenced are the result of Ecology, US Geological Survey, or CKCD’s previous water quality studies and sampling in WRIA 30 watersheds. Data from this project will be presented by submitting to the Ecology EIM database.

Some pertinent data are presented at local meetings or given to landowners associated with the monitoring location.

## 14.3 Treatment of non-detects

Non-detect sample results are not anticipated for this study. If a non-detect sample result does occur, it will be reported accordingly. During data analysis, any non-detect sample result will be valued as a split between the lower detection limit and zero.

## 14.4 Sampling design evaluation

The data will be evaluated to determine if the sampling design has been adequate and if it needs modification for future use. The sampling design is established in Section 7.0. The aspects to be evaluated include:

- Sampling locations.
- Frequency of sample collection.
- Parameters to be determined.
- Field measurements collected.

The evaluation will be based on whether or not the study questions were addressed with the data collected using the established sampling design.

## 14.5 Documentation of assessment

The CKCD District Manager and Water Quality Monitoring Technician will be responsible for the data quality assessment. The data kept in spreadsheets and databases will be available for Ecology review upon request.

# 15.0 References

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# Appendix A. Water Quality Monitoring SOP

**Water Quality Monitoring SOP**

## A.1 Parameter Measured: Dissolved Oxygen

**Instrument:** ProODO Handheld Multiparameter Instrument
**Sensor Type:** Optical (dynamic luminescence quenching lifetime detection)
**Range:** 0 to 50 mg/L
**Accuracy:** 0 to 20 mg/L, ± 0.1 mg/L or ± 1% of reading, whichever is greater; 20 to 50 mg/L, ± 10% of the reading
**Resolution:** 0.01 or 0.1 mg/L (auto-scaling)

**Calibration Procedure**

The ProODO sensor is an optical luminescent sensor which has great stability and is less susceptible to calibration drift than traditional electrochemistry sensors. This increased stability means that the instrument may hold its calibration for many months. However, for the highest data accuracy, YSI recommends verifying the instrument's calibration on a daily basis. To verify the instrument's calibration, place the sensor in its calibration environment and check to see that DO% is reading its calibration value based on the barometric pressure.

The ProODO offers several options for calibrating dissolved oxygen. The first and second methods calibrate the DO% saturation value to either water, saturated air, or air saturated water. CKCD will be using the air saturated water method outlined below, which is approved by the Department of Ecology (Ecology 2012d). It differs from methodology included in the manufacturer's manual.

<u>Calibrating DO% in Air Saturated Water: 1- Point Calibration</u>

1. Fill one gallon jug with tap water, and make sure that the temperature of the water you're using has stabilized and will not change more than 0.5 degrees C during calibration. Setting some tap water out overnight so the temperature stabilizes with the room temperature works well. Make sure there is a hold on the lid of the jug.
2. Shake the water for 40 seconds. Fill the calibration cup with this water and place the sensor in the air saturated water. Be sure to immerse both the ODO and the Temperature sensor into the water, and wait for the readings to stabilize (at least 2 minutes).
3. Press Calibration. If Probe ID or User ID are enabled in the System GLP menu you will be able to highlight these features and add, select, edit or delete an ID. When enabled, these IDs are stored with each calibration record in the GLP file.
4. After selecting the Probe ID and/or User ID if appropriate, highlight DO and press enter. Highlight **DO%** and press enter to confirm.

5. The instrument will use the value from the internal barometer and will display this value in brackets at the top of the display. Highlight the barometer value and press enter to adjust it if needed. If the barometer reading is incorrect, it is recommended that you calibrate your barometer. Note- the barometer should be reading "true" barometric pressure). If the value is acceptable, there is no need to change it or perform a barometer calibration.
6. Wait for the temperature and DO% values under "Actual Readings" to stabilize, then highlight **Accept Calibration** and press enter to calibrate. If User Field 1 or 2 are enabled, you will be prompted to select the fields and then press Cal to complete the calibration. The message line at the bottom of the screen will be prompted to select the fields and then press Cal to complete the calibration. The message line at the bottom of the screen will display "Calibrating Channel….." Followed by "Calibration Successful". Press Esc to cancel the calibration.

## A.2 Parameter Measured: Fecal coliform

**Container:** Sterilized 100 mL plastic bottle
**Storage:** Cool to 4°C and store in the dark
**Holding time:** Samples will be analyzed within 24 hours after collection

**Collection Procedure:**

1. Verify that the site label on the bottle matches the site being sampled.
2. Use only properly sterilized bottles.
3. Uncap the container just prior to sample collection to minimize possible contamination. Do not rinse bottle before collection of the sample. Do not touch inside of lid or bottle.
4. Facing upstream, grasp the container at the base, away from the mouth, and quickly submerge the bottle, mouth down, to prevent surface concentrations of bacteria from affecting the results.
5. Turn the bottle into the flow with the mouth angled slightly upward to allow air to escape and the bottle to fill.
6. If there is no current, create one by moving the bottle forward horizontally away from your hand.
7. Collect a grab sample such that any possible contamination sources on or of your person are downstream of the bottle.
8. Collect the sample from mid-stream of the main channel and at 6/10 depth from the surface.
9. Leave approximately 25 mL of the container volume as air space. Cap the container as quickly as possible.

**General Considerations:**

1. Do NOT rinse the sample bottle before collection.
2. Do NOT contaminate the lid or inside of the bottle with your fingers, dirt, dust, or anything else.
3. Do NOT pour water into the fecal coliform bottle from another container.

4. Air space is required to allow proper mixing before analysis.
5. Bacteria generally concentrate at the water surface, and this layer should be avoided by plunging the bottle with the mouth facing down.

## A.3 Parameter Measured: pH

**Instrument:** ProPlus Handheld Multiparameter Instrument
**Sensor Type:** pH (ISE)
**Range:** ± 6.5 to 9.0 units
**Accuracy:** ± 0.2 units
**Resolution:** 0.01 units

**Calibration Procedure**

pH should be calibrated once per sample day, and checked twice daily, before and after sampling, against a pH standard within the range of expected water quality results.

To prevent the electrode from dying out, the sensor is stored in a storage solution for long-term storage (i.e. between monitoring seasons). It is stored with a small amount of moisture in the transport/calibration cup for short-term storage (between monitoring outings). The sensor is calibrated using a 3-point calibration by the following procedure:

1. Begin by rinsing the sensor with a small amount of previously used pH buffer solution. Using a new buffer solution in a clean, dry calibration cup, starting with the 7 pH solution, fully immerse the sensor in the solution, making sure all bubbles are shaken loose.
2. Allow the temperature to come to equilibrium, then using the temperature/pH included with the buffer, determine the temperature correction for the buffer solution.
3. After ensuring that the pH reading has fully stabilized for at least 30 seconds, enter the proper pH value at the prompt on the instrument.
4. Repeat the above steps as prompted using the pH4 and pH10 buffer solutions to complete the 3-point calibration.

**Measurement Procedure**

Assuming the pH sensor has been properly calibrated, the following procedure is used:

1. Place the pH sensor in the water to be analyzed.
2. Allow the pH and Temperature readings to stabilize, such that there are no changes in the readings for at least 10 seconds.
3. Record the measurement.
4. Place the pH sensor in the transportation/calibration cup to prevent the electrode from drying out between monitoring sessions.

## A.4 Parameter Measured: Specific Conductivity

**Instrument:** ProPlus Handheld Multiparameter Instrument
**Sensor Type:** 6051030 ISE/Conductivity
**Range:** 0 to 200 mS/cm (auto range)
**Accuracy:** ±0.5% of reading or 0.001 mS/cm, whichever is greater
**Resolution:** 0 to 0.5 mS/cm = 0.001, 0.501 to 50.00 mS/cm = 0.01, 50.01 to 200 mS/cm = 0.1

**Calibration Procedure**

The specific conductivity meter should be calibrated at the beginning of each sample run and checked before and after sampling against a conductivity standard within the range of expected water quality results.

Measuring conductivity provides a measure of the dissolved salts in the water sample, such as salts used to deice roads. The calibration procedure involves exposing the sensor to a solution of known salinity. The salinity of the solution used for the calibration depends on whether the water to be monitored is fresh, brackish, or saltwater. In our district the water is exclusively fresh water, thus we use a conductivity standard that has a value of 0.1 mS/cm, in order that the calibration is performed near the range of expected values. The following procedure is used for calibration:

1. Fill a clean dry Transportation/Calibration cup with approximately 55mL of conductivity standard. Pre-rinse the sensor with conductivity standard, ensuring there are not salt crystals on the sensor that could affect the solution.
2. Place the sensor in the transportation/calibration cup, take care to eliminate all air bubbles on the sensor.
3. Allow the temperature to reach equilibrium, such that the readings do not change for 30 seconds.
4. Enter the value of the conductivity standard at 25ºC.
5. Rinse the sensor and cup with tap water.

## A.5 Parameter Measured: Temperature

**Instrument:** ProPlus Handheld Multiparameter Instrument
**Range:** -5 to 70ºC
**Accuracy:** +/- 0.2ºC
**Resolution:** 0.1ºC

**Calibration Procedure**

The temperature sensor is built into the quarto conductivity/temperature cable and is not required to be calibrated nor is it available to do so. A weekly check is performed and checked against the NIST certified mercury thermometer. If the drift is found to be of a non-constant or excessive nature (see Table 5 for criterion), the sensor will be replaced, which means the entire cable will need to be replaced.

**Measurement Procedure**

The measurement of temperature is done concurrently with the other parameters being measured by the ProPlus Handheld Multiparameter Instrument. Every attempt is made to take these measurements in a representative section of the stream. The following procedure is used:

1. Immerse the sensor in the main channel, in an area out of direct sunlight, if possible.
2. Allow the temperature to come to equilibrium, such that the reading does not change for at least 15 seconds.
3. Record the measurement in the instrument memory.

## A.6 Parameter Measured: Continuous Temperature

**Instrument:** HOBO U22 Water Temp Pro v2 logger
**Sensor Type:** Thermistor
**Range:** -20ºC to 50ºC
**Accuracy:** ±0.2ºC over 0ºC to 50ºC
**Resolution:** 0.02ºC at 25ºC
**Drift:** 0.1ºC per year
**Real-time clock:** ± 1 minute per month at 0ºC to 50ºC

**Calibration Procedure**

The logger cannot be calibrated, but should be checked for drift twice annually: before deployment and following removal at the end of monitoring season. This is best done using a NIST certified mercury thermometer to check the temperature recorded at several temperatures. A pre and post room temperature calibration and ice bath calibration will be performed annually. To perform room temperature calibration:

1. Prepare water night before by filling cooler with six inches of water. Add wire racks and then data loggers. Set loggers to start recording at one minute intervals in the morning, leave lid open
2. Stir water before recording begins and continue to gently stir
3. Record water temperature with NIST thermometer every minute for ten minutes
4. Read out data loggers and transfer to ice bath
5. While loggers are equilibrating in ice bath, upload room temperature data into Hoboware

To perform ice bath calibration:

1. Fill cooler with an ice-saturated bath (no open water without ice contact vertically and horizontally)

2. Place loggers set to record at one minute intervals in ice bath
3. Allow loggers to equilibrate for 30 minutes
4. After 30 minutes, begin stirring water slowly
5. Record temperature with NIST thermometer every minute for ten minutes
6. After ten minutes read out and stop data loggers.
7. Upload ice bath temperature data into Hoboware.

The certificate for the NIST thermometer used in this procedure will be kept current by annual recertification. If the NIST thermometer is found to be out of calibration during recertification, it will be replaced.

**Measurement Procedure**

Temperature measurement is taken at 30 minute intervals throughout the period of interest. Loggers are typically placed in April, and removed for the season in early November. The monitoring sites are visited monthly for data downloading and measurement of other water quality parameters. The placement of the loggers requires that they measure a representative temperature for the stream (e.g.; Temperature loggers should be placed in the main flow, but not in a backwater or eddy, and not placed too near the substrate in a groundwater upwelling reach). In placing the loggers, effort is made to place them where they will not be exposed by receding water levels. It is also desired that they be placed in a shaded area to eliminate possible radiation heating from affecting the readings. Before heading into the field to download the loggers, the data shuttle clock is synchronized with that of the PC, so that the clocks on the loggers with also be synchronized when they are re-launched after download.

## A.7 Parameter Measured: Turbidity

**Equipment:** Hach 2100Q Turbidimeter
**Range:** 0 – 1000 NTU with automatic decimal point placement
**Resolution:** 0.01 NTU on lowest range

**Calibration Procedure**

The turbidimeter should be calibrated at the beginning of each sample season.

The manufacturer recommends instrument recalibration with formazin once every three months, using StablCal® Stablized Fomazin standards to achieve consistent results. Sealed vials that have been sitting undisturbed longer than a month must be shaken to break the condensed suspension into its original particle size. The calibration steps are as follows:

1. Shake the standard vigorously for 2 – 3 minutes to re-suspend any particles.
2. Allow the standard to stand undisturbed for 5 minutes.
3. Gently invert the vial of StablCal® 5 to 7 times.
4. Prepare the vial for measurement using traditional preparation techniques. This consists of oiling the vial and marking the vial to maintain the same orientation in the sample cell compartment. This step will eliminate any optical variations in the sample vial.
5. Let the vial stand for one minute. The standard is now ready for use in the calibration procedure.
6. Insert the the StablCal® <0.1 NTU standard sample cell in the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid. Press **I/O.**
7. Press **CAL.** The **CAL** and **S0** icons will be displayed, as well as, the value of the S0 standard from the previous calibration.
8. Press **READ.** The instrument will count from 60 to 0, read the blank and use it to calculate a correction factor for the 20 NTU standard measurement. The display will automatically increment to the next standard. Remove the sample cell from the cell compartment.
9. The display will show the **S1** and 20 NTU or the value of the S1 standard for the previous calibration. After editing, insert StabCal® 20 NTU standard sample cell into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.
10. Press **READ**. The instrument will count from 60 to 0, measure the turbidity and store the value. The display will automatically increment to the next standard. Remove the sample cell from the compartment.
11. Repeat steps 9 and 10 for the **S2** – 100 NTU and **S3** – 800 NTU StablCal® standard samples.
12. Press **CAL** to accept the calibration.

### Measurement Procedure

Accurate turbidity measurement depends on good measurement technique by the analyst, such as using clean sample cell in good condition and removing air bubbles (degassing). Measurements may be made with the signal average mode on or off and in manual or automatic range selection mode. Using automatic range selection is recommended. Signal averaging measures and averages ten measurements while displaying intermediate results. The initial value is displayed after about 11 seconds and the display is updated every 1.2 seconds until all ten measurements are taken (about 20 seconds). The following instructions are given by Hach for the use of their kit:

1. Collect a representative sample in a clean container. Fill a sample cell to the line taking care to handle the sample cell by the top. Cap the cell.
2. Wipe the cell with a soft, lint free cloth to remove water spots and fingerprints.
3. Apply a thin film of silicone oil to the outside of the cell. Wipe with a soft cloth to obtain an even film over the entire surface.
4. Press I/O. The instrument will turn on. Place the instrument on a flat, sturdy surface.
5. Insert the sample cell in the instrument cell compartment so the diamond or orientation mark aligns with the raised orientation mark in from the cell compartment. **Close the lid.**
6. Select manual or automatic range selection by pressing the RANGE key. The display will show AUTO RNG when the instrument is in automatic range selection.
7. Select signal averaging mode by pressing the SIGNAL AVERAGE key.
8. Press READ. The display will show ------NTU, then the turbidity in NTU. Record the turbidity after the lamp symbol turns off.

## A.8 Parameter Measured: Velocity

**Instrument:** SonTek FlowTracker Handheld ADV® with top-setting wading rod
**Sensor Type:** Acoustic Doppler Velocimeter
**Range:** ±0.003 to 13 ft/sec
**Accuracy:** ±1% of measured velocity, ±0.25 cm/sec
**Resolution:** 0.0003 ft/sec

### Calibration Procedure

Simple diagnostic procedures are provided to verify system operation. ***Beam Check*** requires an external computer. The **Auto QC Test** procedure requires only a few minutes and can be performed in the field from the keypad interface. These should be performed before each data run.

***Beam Check*** is a diagnostic program that is used to verify FlowTracker performance. This is the same diagnostic program used at SonTek; it provides you with a powerful tool for understanding and verifying system performance. We recommend you become familiar with this software and use it on a regular basis. To run *Beam Check*:

1. Hold the FlowTracker in a bucket of water (or a natural environment) such that the probe is submerged and there is a boundary (surface, side, or bottom) within view.
    a. Ideally, the boundary should be placed 20-30 cm (8-12 in) from the probe.
    b. You may need to add a small amount of fine dirt or other seeding material and stir the bucket well for good test conditions. Regular tap water usually does not have enough scatterers (seeding) for a valid test.
2. Connect the FlowTracker to the PC and turn the system on.
    a. Run the *FlowTracker* software (click **Start | Programs | SonTek Software | FlowTracker**).
    b. Click **Connect**.
3. Select **Beam Check** on the left side of the screen; now:
4. Click **Start**.
5. Click **Record** to save all data to a file. Typically, a minimum of 20 pings is required for proper data analysis.
6. Click **Averaging** to average multiple pings together.

In ***Beam Check***, the FlowTracker sends a pulse of sound and outputs the return signal strength for each receiver as a function of time. Features in the signal strength profile verify different aspects of system performance.

1. The horizontal axis indicates the range from the FlowTracker probe (in cm).
2. The vertical axis is in internal signal strength units called counts (1 count = 0.43 dB).
3. *Ringing* from the transmit pulse appears on the left side of the graph.
4. The location of the *sampling volume* is indicated by increased signal strength in a bell-shaped curve.
    a. The sampling volume curve corresponds to the transmit pulse passing through the focal point of the receivers.
    b. The peak of this curve corresponds to the center of the sampling volume.
    c. The location of the sampling volume varies, but is typically 10-12 cm.
    d. All receivers (2 or 3) should see the peak in the same location, although there will be variation in the height and shape of the curve.
5. A sharp spike indicates a *boundary reflection* (if a boundary is within range).
    a. If the probe is close to a boundary, a sharp reflection should be seen.
    b. The size and shape of this reflection will vary depending on the nature of the boundary and its distance from the FlowTracker.
6. Signal strength decreases to the electronic *noise level* past the boundary.

When using ***Beam Check***, it is important to understand that the output plot will vary considerably because of the nature of acoustic scattering.

1. Each of the above items should be visible.
2. If no sampling volume peak can be seen, try adding some fine dirt or other seeding material and stirring the water to increase the signal strength.
3. If the *Beam Check* output differs significantly from the sample shown here, refer to the *FlowTracker Technical Manual* for more details about interpreting this data.

The **Auto QC Test** is an automated version of the *Beam Check* software (§4.1). It is performed in the field just prior to collecting a measurement. The procedure is as follows:

1. Place the probe in moving water away from underwater obstacles.
2. Data collection and analysis takes ≈30 seconds.
3. If any warnings are issued, you are given an option to repeat the test.
    a. We recommend repeating the test once, after first checking that the probe and sampling volume are well away from any underwater obstacles.
    b. If multiple warnings are received, run *Beam Check* from a PC (§4.1) to evaluate Flow-Tracker performance in more detail.

**Measurement Procedure**

In choosing a representative cross section for velocity measurements, the following characteristics are sought: a relatively straight length of channel approximately 300' long with a suitable measurement section approximately in the middle, or slightly downstream of the middle, a channel clear of vegetative matter and other obstructions such as large rocks, the flow should not have eddies or dead zones, avoid converging or diverging flow areas. When a suitable measurement site has been chosen the following procedure is used to obtain the velocity readings used to create a velocity profile.

Measurements will be made using the USGS standard mid-section method. This method involves measuring the channel cross sectional area and water velocity at multiple cells across the channel.

1. Establish channel cross-section by stringing a tape measure across the channel perpendicular to the flow direction.
2. Divide cross section in to approximately 25 to 30 cells, varied in width, such that the discharge in each cell is limited to 5% to 10% of the total discharge measurement. The goal will be to have five or fewer cells with greater than 5% of the total discharge and zero cells with greater than 10% of the total discharge. The number of cells in particularly narrow sections may be limited by a standard minimum spacing for velocity measurements of 0.3 feet. The characteristics for each cell are measured at observation points by recording:
    a. Horizontal position (read from the measuring tape);
    b. Depth to the channel bottom (measured vertically down from the water surface); and
    c. Average velocity (measured with the flow meter).
3. Velocity measurements will be taken at six-tenths the stream depth when the total stream depth is less than 1.5 feet and at two-tenths and eight-tenths of the total depth when the stream depth is 1.5 feet and greater. The average of the two velocity measurements is used for cells with a total depth greater than 1.5 feet.

# Appendix B. Manufacturer's Meter Specifications

Table 18. Manufacturer's meter specifications.

| Analyte | Method/ Equipment | Accuracy | Resolution | Expected Range of Results |
|---|---|---|---|---|
| Conductivity** | ProPlus Handheld Multiparameter Instrument | ±0.5% of reading or 0.001 mS/cm, whichever is greater (1-, 4-m cable) | 0 to 0.500 mS/cm = 0.001<br>0.501 to 50.00 mS/cm = 0.01<br>50.01 to 200 mS/cm = 0.1<br>(range dependent) | 0 to 200 mS/cm (auto range) |
| Flow** | SonTek FlowTracker ADV | ±1% of Measured Velocity ±0.25 cm/s | 0.0003 ft/sec | ±0.003 to 13.00 ft/sec |
| pH** | ProPlus Handheld Multiparameter Instrument | ±0.2 units | 0.01 units | 6.5 to 9.0 units |
| Temperature °C<br><br>Temperature °C | ProPlus Handheld Multiparameter Instrument<br><br>Hobo Water Pro V2 | +/- 0.2°C<br><br>±0.2°C | 0.1 °C<br><br>-5°C to 45°C | -5 to 70°C<br><br>0 to 28°C |
| Dissolved Oxygen | ProODO Handheld Optical Dissolved Oxygen Meter | 0 to 20 mg/L, ± 0.1 mg/L or ± 1% of reading, whichever is greater; 20 to 50 mg/L, ± 10% of the reading | 0.01 or 0.1 mg/L (auto-scaling) | 0 to 50 mg/L |
| Turbidity (NTU) | Hach 2100Q | +/- 2% of reading | 0.01 to 1000 NTU | 0 to 100 NTU |
| Fecal Coliform*** | **City of Goldendale Water Quality Laboratory** Standard Methods 18 9222-B | | 1 colony/100ml | 0 to 1000 cfu/100ml |

# Appendix C. QC and Field Sheets

| Date | Parameter | Reading | Reading | Temp |
|---|---|---|---|---|
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Figure 6. QC sheet for daily calibrated instruments.

TFW Monitoring Program | Stream Name | Page ___ of ___

# TEMPERATURE SURVEY — HEADER INFORMATION — FORM 8.0

**WRIA #** ___ ___ . ___ ___ ___ ___ | Unlisted Trib ○ RB ○ LB | **Segment #** ______ | Sub-Segment Code ___ | **Date** ___/___/___

**Study Design Information**

**Temperature Station #**

Begin Survey Date ___/___/___ (Installation)

End Survey Date ___/___/___ (Removal)

*Temperature Station Location*

WRIA River Mile ______

Station Elevation ______ ○ M ○ F

Township T______

Range R______

Section ______

Qtr of Qtr ___ of ___

Circle one

Water Quality Class **A AA B**

Temperature Region **W E**

*Forms Used:*

- ○ Data Logger Calibration Form 8.1L
- ○ Max/Min Calibration Form 8.1M
- ○ Station Documentation Form 8.2
- ○ Data Logger Field Check Form 8.2L
- ○ Max/Min Data Form 8.2M
- ○ Thermal Reach Header Form 8.3
- ○ Thermal Reach Data Form 8.3R
- ○ Other ______

○ CELSIUS *Water* ○ FAHRENHEIT

Data Logger/Thermometer

Make ______

Model ______

TI/PROBE ID # ______

Pre-Calib ___/___/___

Post-Calib ___/___/___

○ CELSIUS *Air* ○ FAHRENHEIT

Data Logger/Thermometer

Make ______

Model ______

TI/PROBE ID # ______

Pre-Calib ___/___/___

Post-Calib ___/___/___

**Survey Crew**

| *Name* | *Affiliation* |
|---|---|
| ______ | ______ (Lead) |
| ______ | ______ (Rec.) |
| ______ | ______ |

Crew Lead: Year of most recent TEMP Training ______ QA Review ______

**Survey Notes**

Sketch Map of Temperature Station Site

(1:24,000 topo map scale)

USGS 7.5 min Topographic Map Name

*Form 8.0*

Error Checked by: ____ Date: ___/___/___

*All Field Forms*

Error Checked by: ____ Date: ___/___/___

*All Data Entry*

Error Checked by: ____ Date: ___/___/___

Northwest Indian Fisheries Commission, 6730 Martin Way E., Olympia, WA 98516 (360)438-1180 | 5/19/99 | forms\99\f8-0.p65

Figure 7. Post monitoring field sheet.

## Discharge Measurement Notes

| | | | |
|---|---|---|---|
| Date | | | |
| Station Number | | | |
| Station Name | | | |
| Measurement Number | | | |
| Made by | | | |
| Method | | | |
| Number of Sections | | | |
| Gage Readings: | Time | S.G. | H-350 |
| | | | |
| | | | |
| | | | |
| G.H. Change | in hours | | |
| Type of Meter | Marsh McBirney / other | | |
| Date Calibrated | | | |
| Fresh Batteries | yes / no | | |
| Zero Check | yes / no | | |
| Method | wading / bridge / other | | |
| Location | feet above / below gage | | |
| Measurement rated | Excellent (2%) / Good (5%) /Fair (8%) | | |
| Based on: | Flow: steady / uniform / turbulent | | |
| | Velocities: low / normal / high | | |
| | Depths: shallow / normal / deep | | |
| | Cross Section: sand / gravel / cobbles / boulders | | |
| G.H. of Zero Flow | N/A / feet | | |
| Gage Control: | cobble - gravel riffle / clear / submerged / channel | | |
| Gage Operating | yes / no | | |
| Data Downloaded | yes / no | | |
| Battery Changed | yes / no Voltage before: after: | | |
| Width | | | |
| Area | | | |
| Velocity | | | |
| G.H. | | | |
| Discharge | | | |
| Comments | | | |

0.85 0.9 0.92 0.94 0.96 0.98 0.99 ◄1.00► 0.99 0.98 0.96 0.94 0.92 0.9 0.85

| Angle Coefficient | Station | Depth | Velocity (0.6) | Velocity (0.2) | Velocity (0.8) |
|---|---|---|---|---|---|
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Figure 8. Stream gage station field sheet.

# 2016 Water Quality Monitoring

## BASELINE DATA SHEET

**Stream name:** ______________________________

**Site or map number:** ______________________________

**Investigators:** ______________________________

**Date:** ________________ **Time:** ________________

**Photo:** ________________ **Photo:** ________________

**Comments:**

***Stream Flow***

| | |
|---|---|
| **Stream flow (cfs)** | |
| *Uncertainty (%)* | |
| **Stream width** | |
| **Stream Area** | |

***Site Parameters*** ***Measurement – on site***

| | | |
|---|---|---|
| **Water temperature** (°C) | | |
| **Conductivity** (mS) | mS/cm | |
| **pH** | | |
| **Dissolved Oxygen** | % | Mg/l |
| **Turbidity** (NTU) | | |

***Weather now:***

_____Storm (heavy rain)
_____Rain (steady rain)
_____Showers (intermittent rain)
_____Overcast
_____Mostly cloudy
_____Clear/Sunny
_____Partly cloudy
_____Breezy/windy
_____Calm

***Weather in past 24 hours:***

_____ Storm (heavy rain)
_____ Rain (steady rain)
_____ Showers (intermittent rain)
_____Overcast
_____Mostly cloudy
_____Clear/Sunny
_____Partly cloudy

**Current temperature** _______ °F

Figure 9. Field data sheet without fecal coliform.

# 2016 Water Quality Monitoring

## BASELINE DATA SHEET

**Stream name:** ______________________________

**Site or map number:** ______________________________

**Investigators:** ______________________________

**Date:** ________________ **Time:** ________________

**Photo:** ________________ **Photo:** ________________

**Comments:**

***Stream Flow***

| | |
|---|---|
| **Stream flow (cfs)** | |
| *Uncertainty (%)* | |
| **Stream width** | |
| **Stream Area** | |

| ***Site Parameters*** | ***Measurement – on site*** | |
|---|---|---|
| **Water temperature** (°C) | | |
| **Conductivity** (mS) | mS/cm | |
| **pH** | | |
| **Dissolved Oxygen** | % | Mg/l |
| **Turbidity** (NTU) | | |
| **Fecal Coliform** | | |

***Weather now:***

_____Storm (heavy rain)
_____Rain (steady rain)
_____Showers (intermittent rain)
_____Overcast
_____Mostly cloudy
_____Clear/Sunny
_____Partly cloudy
_____Breezy/windy
_____Calm

***Weather in past 24 hours:***

_____ Storm (heavy rain)
_____ Rain (steady rain)
_____ Showers (intermittent rain)
_____Overcast
_____Mostly cloudy
_____Clear/Sunny
_____Partly cloudy

**Current temperature** _______ °F

Figure 10. Field data sheet with fecal coliform.