DEPARTMENT OF
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State of Washington

Quality Assurance Project Plan

Upper Yakima River Basin
Water Quality Monitoring for Aquatic Life Parameters:
Water Temperature, Dissolved Oxygen, and pH

September 2019
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This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1903112.html

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Quality Assurance Project Plan

Upper Yakima River Basin, Water Quality Monitoring for Aquatic Life Parameters: Water Temperature, Dissolved Oxygen, and pH

September 2019

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EAP: Environmental Assessment Program
WQP: Water Quality Program

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2.0 Abstract

Limited monitoring in the Yakima River near Nelson Siding has shown that the Upper Yakima River can have high water temperature and low dissolved oxygen levels that do not protect fish and other aquatic life that depend on cool, oxygenated water. A previous water quality project on the tributaries to the Upper Yakima River showed that the water temperature in some tributaries also do not protect fish and aquatic life (Creech and Stuart, 2014).

This project (water quality monitoring for aquatic life parameters) outlines an Ecology monitoring program to measure temperature, dissolved oxygen (DO), pH and other parameters associated with productivity during the 2019 calendar year. Ecology will also be conducting final status monitoring in 2019 to see if total suspended solids (TSS) and turbidity levels are meeting the final total maximum daily load (TMDL) targets set for TSS and turbidity in the Upper Yakima River watershed (Creech and Joy, 2002).

By organizing the data collection of temperature, DO, pH, nutrients, organic carbon, alkalinity and some additional field measurements, in addition to the extensive TSS and turbidity monitoring, Ecology can collect a complete data set that can be used to calibrate a future water quality model that simulates parameters important to aquatic life use in the basin, namely water temperature, DO and pH.

Sampling will occur from March through November 2019, capturing critical periods during the whole irrigation season, as well as some pre- and post-irrigation periods. Sampling will take place every two weeks at over 30 locations in the Upper Yakima River Basin.

3.0 Background

3.1 Introduction

Limited monitoring in the Yakima River near Nelson Siding has shown that the Yakima River can have high water temperature and low dissolved oxygen levels that do not protect fish and other aquatic life that depend on cool, oxygenated water. A previous water quality project on the tributaries to the Upper Yakima River showed that the water temperature in some tributaries also do not protect fish and aquatic life (Creech and Stuart, 2014).

Ecology will be conducting an effectiveness monitoring study in 2019 to evaluate a TSS and turbidity TMDL that was established in the Upper Yakima River (Joy, 2002; Creech and Joy, 2002).

This QAPP describes a complementary study that will monitor water quality parameters related to aquatic life that will be conducted in conjunction with the effectiveness monitoring study. The goal of this study is to collect a complete water quality data set that can be used to assess water temperature, DO, and pH levels in the Upper Yakima River Basin. Historical measurements of water temperature and DO at a long-term ambient monitoring station on the Yakima River (Yakima River near Cle Elum station #39A090) indicate potential water quality impairment for aquatic life use.

The field data collection for this study is specifically designed to generate an adequate data set that will allow future calibration of a water quality model that can simulate water temperature, DO, and pH in the Upper Yakima River. In conjunction with the TSS and turbidity effectiveness monitoring, this study and field data collection is specifically designed to collect a complete data set from all major sources to the Upper Yakima River.

3.2 Study area and surroundings

The study area is located within Water Resource Inventory Area (WRIA) 39, the Upper Yakima River Basin. It consists of the mainstem Yakima River and the mouths of its major tributaries from RM 121.7 (Harrison Bridge, near the town of Selah) upstream to Lake Easton (Figure 1).

The Yakima River Basin is located in south-central Washington State. The Yakima River flows 214.5 miles from the dam outlet of Lake Keechelus, southeasterly to its confluence with the Columbia River. The upper portion of the Yakima River Basin drains 2,139 square miles on the eastern slope of the Cascade Mountains. Land uses in the basin vary from forestland, rangeland, irrigated agriculture, and urban areas. A network of supply canals, diversions, and irrigation return drains are located all along the Upper Yakima River Basin but are especially concentrated in the lower Kittitas Valley. Water from the Yakima River and the streams flowing through the valley is directed through the irrigation network (Creech and Joy, 2002).

Below Lake Keechelus, the main tributaries to the Upper Yakima River are the Kachess River, Cle Elum River, and Teanaway River, but there are also many other smaller tributaries that will be sampled during this study. These tributaries include Taneum Creek, Manastash Creek, Wilson Creek, Naneum Creek, and Wenas Creek.

3.2.1 History of study area

Land uses in the Upper Yakima River watershed vary from wilderness, forestland, livestock range, and intensively irrigated agriculture to urban and suburban areas (Joy, 2002). The Yakima River Basin is one of the most irrigated areas in Washington. The Upper Yakima River Basin has approximately 85,000 acres of irrigated agriculture in the lower elevations. The majority of irrigated acreage drains to the tributaries of Wilson Creek, Manastash Creek, and Sorenson Creek (Anderson, 2008).

The United States Department of the Interior's Bureau of Reclamation (USBR) operates the Yakima Project, which greatly influences stream discharge volumes in the Yakima River and some of its tributaries. The USBR delivers water to meet downstream demands, such as irrigation, power production, and instream flow for fish protection. To meet these demands, the USBR releases water from three storage reservoirs in the Upper Yakima River watershed: Lake Keechelus, Lake Kachess and Lake Cle Elum. Some of the water released from the reservoirs meets irrigation demand in the Upper Yakima River watershed. However, much of the released water flows down the Yakima River through the project area to meet irrigation demands in the lower Yakima River watershed (Anderson, 2008).

In order to meet irrigation demands late in the irrigation season, the USBR uses a management strategy descriptively termed "flip-flop." In practice, flip-flop, which was conceived and initiated in 1981, consists of releasing most of the water needed by the lower valley irrigation users from the Upper Yakima reservoirs until September. During this time, releases from the lower reservoirs in the Naches Basin are minimized. In early September, the release pattern reverses, when the majority of the flow is provided from Naches Basin, and the Upper Yakima releases are curtailed (YSFWPB, 2004).

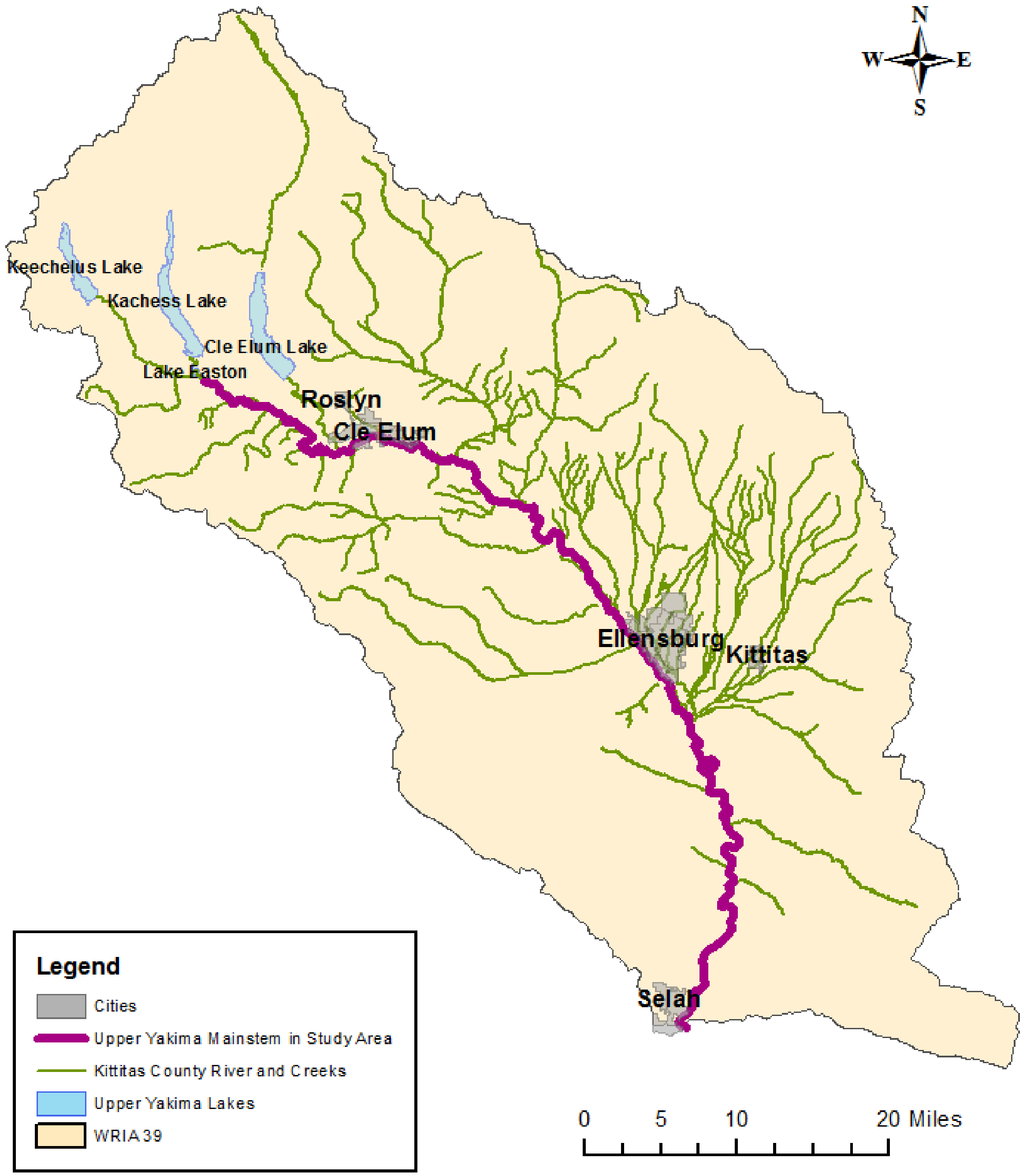

Figure 1. Study area for Upper Yakima River water quality monitoring for aquatic life parameters.

The purpose of the flip-flop operation is to encourage Chinook salmon, returning to the Upper Yakima in the fall, to spawn at lower river stages. This ensures that the flows required to keep the salmon redds watered and protected during the incubation period (November through March) are minimized; it is also consistent with the “normative” flow concept for the Upper Yakima arm of the basin (Bureau of Reclamation, 2004).

This activity often results in low water levels in the lower Yakima River Basin in the summer and fall, even though there is higher streamflow in the Upper Yakima River Basin during this time. The higher discharge volumes in the Upper Yakima River during July and August generally have a lower turbidity because of dilution from reservoirs, but carry higher loads of suspended sediment because of the larger flow volume (Anderson, 2008).

3.2.2 Parameters of interest

The parameters of interest targeted by this monitoring effort are water temperature, DO, pH, and other associated parameters that control primary productivity: nutrients (total nitrogen, nitrate, ammonia, total phosphorus, and orthophosphate), organic carbon, alkalinity, specific conductivity, as well as channel geometry, light characteristics in water, and water velocity.

3.2.3 Summary of previous studies and existing data

A water temperature study was conducted for the Upper Yakima River tributaries in 2005–2006 (Creech and Stuart, 2014). Some temperature data was also collected on the mainstem Yakima River during the study.

There have been no other large studies of DO and pH in the Upper Yakima River, but there has been selective monitoring that has resulted in some 303(d) listings (see below in Table 2).

TSS and turbidity data were collected for the TMDL in 1999 (Joy, 2002).

TSS and turbidity data were collected to check for interim TMDL targets in 2006 (Anderson, 2008).

Streamflow data has been collected in the Upper Yakima River Basin for decades (see Table 8.)

3.2.4 Regulatory criteria or standards

Designated and beneficial uses

Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A-200) establish beneficial uses of waters and incorporate specific numeric and narrative criteria for parameters such as turbidity. The criteria are intended to define the level of protection necessary to support the beneficial uses. Washington Administrative Code (WAC) 173-201A-600 and WAC 173-201A 602 list the use designations for specific areas (WAC 173-201A-600 and WAC 173-201A-602).

For the Upper Yakima River, the designated uses of the waters in this specific area are:

Aquatic Life Uses

- *Core Summer Salmonid Habitat*: Yakima River above the Cle Elum River, Teanaway River mainstem, and Manastash Creek.
- *Salmonid Spawning, Rearing, and Migration*: Yakima River and its tributaries, downstream from the Cle Elum River.

Recreation

- Fishing.
- Swimming.
- Rafting.

Water Supply (Municipal, Industrial, and Agricultural Water Supply and Stock Watering)

- Agricultural enterprises extract water for irrigation and livestock watering.
- The cities of Cle Elum and Ellensburg use the Upper Yakima River for a source of drinking water or other municipal uses.
- Other industries use Yakima River water for their operations.

Miscellaneous Uses (Wildlife Habitat, Harvesting, Commerce, Boating, and Aesthetics)

- Riparian areas are used by a variety of wildlife species that are dependent on the habitat.
- Various businesses and private entities use the river for miscellaneous ventures, such as guiding fly fishermen.

Criteria for designated aquatic life uses

The criteria used to protect the aquatic life uses are outlined in Table 1. The water quality standards also have the following special water temperature criteria for WRIA 39:

- Water temperature shall not exceed a 1-DMax (1-day daily maximum) of 21.0°C (69.8°F) due to human activities. When natural conditions exceed 21.0°C (69.8°F), no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C (0.54°F); nor shall such temperature increases, at any time, exceed $t=34/(T + 9)$.

In addition, a complete list of additional supplemental criteria can be found in the Water Quality Standards for Surface Waters of the State of Washington (Ecology, 2017), which includes the following special spawning and incubation water temperature criteria for the Cle Elum River and the Yakima River from the confluence of the Cle Elum River up to Lake Easton:

- To protect summer reproduction areas for salmon and trout within these Upper Yakima River waters designated with aquatic life uses of “Core Summer Salmonid Habitat,” the highest 7-DADMax temperature must not exceed 13.0°C (55.4°F) from September 15 to June 15 each year.

Table 1. Washington State water quality criteria for temperature, dissolved oxygen, and pH in the Upper Yakima River and tributaries.

Parameter	Criteria
Water Temperature	To protect the designated aquatic life uses of “Core Summer Salmonid Habitat,” the highest 7-DADMax temperature must not exceed 16.0°C (60.8°F) more than once every ten years on average.
	To protect the designated aquatic life uses of “Salmonid Spawning, Rearing, and Migration,” the highest 7-DADMax temperature must not exceed 17.5°C (63.5°F) more than once every ten years on average.
Dissolved Oxygen	To protect the designated aquatic life use of “Core Summer Salmonid Habitat,” the lowest 1-day minimum oxygen level must not fall below 9.5 mg/L more than once every ten years on average.
	To protect the designated aquatic life use of “Salmonid Spawning, Rearing, and Migration,” the lowest 1-day minimum oxygen level must not fall below 8.0 mg/L more than once every ten years on average.
pH	To protect the designated aquatic life uses of “Core Summer Salmonid Habitat,” pH must be kept within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.2 units.
	To protect the designated aquatic life uses of “Salmonid Spawning, Rearing, and Migration,” pH must be kept within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.5 units.

Current impairments for temperature, DO and pH

Table 2 lists the current listings on the 303(d) list (category 5 listings) for water temperature, DO, and pH in the Upper Yakima River (WRIA 39) below Lake Easton. The data set collected by this monitoring project will be suitable to validate these category 5 listings.

Table 2. Current category 5 listings for temperature, DO, and pH on the Upper Yakima River.

Listing ID	Assessment Unit ID	Parameter	Location ID for this study (see Table 8)	Location description
3727	17030001000538	Temperature	YKNS	Yakima River at Nelson Siding
11218	17030001000082	pH	YKHB	Yakima River at Harrison Bridge
11225	17030001000538	Dissolved Oxygen	YKNS	Yakima River at Nelson Siding

4.0 Project Description

4.1 Project goals

The goal of this study is to collect a complete data set that can be used to assess water temperature, DO, and pH levels in the Upper Yakima River Basin. Ecology will collect this data in conjunction with another Ecology effectiveness monitoring study measuring TSS and turbidity from all major sources to the Yakima River (Carroll and Urmos-Berry, 2019).

4.2 Project objectives

Fieldwork is planned from March 2019 through November 2019.

Specific objectives of the study are to:

- Collect biweekly samples of nutrients, organic carbon, and alkalinity in the Upper Yakima River mainstem and priority tributaries.
- Monitor continuous (diel) temperature, DO, pH, and conductivity at stations in the Upper Yakima River, and its tributaries.
- Obtain streamflow data from USBR, USGS, Ecology, and other sources.
- Collect measurements of light attenuation in water, water time-of-travel, channel geometry, and longitudinal water quality.
- Submit results of monitoring into Ecology's Environmental Information Management database, as appropriate.

4.3 External information needed and sources

Streamflow data will be needed for the Upper Yakima River and its tributaries from within the study area. It will be downloaded from various online streamflow databases from USBR, USGS, Ecology, and other sources.

4.4 Tasks required

The tasks required to meet project goals are discussed in Section 4.2. More details on field and lab tasks are described in Section 7.

4.5 Systematic planning process

This QAPP represents the systematic planning process.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Key responsibilities of individuals are listed in Table 3.

Table 3. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Jim Carroll Eastern Operations Unit Phone: 360-407-6196	EAP Client Project Manager	Writes the QAPP. Conducts QA review of data and analyzes and interprets data. Tracks schedule. Reviews and approves draft and final data summary report.
Eiko Urmos-Berry Eastern Operations Unit Phone: 509-575-2397	Principal Investigator	Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Co-writes the draft data summary report.
Evan Newell Eastern Operations Unit Phone: 509-575-2825	Co-Principle Investigator and Data Manager	Manages sample collection, monitoring, and field records information. Conducts QA review of data, analyzes and interprets data. Lead author of the draft and final data summary report.
George Onwumere Eastern Operations Section Phone: 509-454-4244	Section Manager	Reviews the project scope and budget, tracks budget and progress, reviews the draft QAPP, and approves the final QAPP.
Alan Rue Manchester Environmental Laboratory Phone: 360-871-8801	Director	Reviews and approves the final QAPP.
Arati Kaza Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the final QAPP.

EAP: Environmental Assessment Program
EIM: Environmental Information Management database
QAPP: Quality Assurance Project Plan

5.2 Special training and certifications

All field staff involved in this project either already have the relevant experience in the following SOPs or will be trained by more senior field staff who do. Any staff helping in the field who lack sufficient experience will always be paired with someone who does have the necessary training and experience and who will then lead the field data collection and oversee/mentor less experienced staff.

5.3 Organization chart

See Table 3, Section 5.1.

5.4 Project schedule

See Table 4 below for project schedule.

Table 4. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	Due date	Lead staff
Field work completed	November 2019	Eiko Urmos-Berry
Laboratory analyses completed	December 2019	
Environmental Information System (EIM) database		
EIM Study ID	jica0005	
Product	**Due date**	**Lead staff**
EIM data loaded	February 2020	Eiko Urmos-Berry
EIM data entry review	March 2020	TBD
EIM complete	December 2020	Eiko Urmos-Berry
Final data summary report		
Author lead / Support staff	Evan Newell/Eiko Urmos-Berry	
Schedule		
Final data summary report due on web	December 2020	

5.5 Limitations on schedule

Potential field-related constraints are addressed in Section 7.5. Any unforeseen limitations that would affect the project schedule will be discussed with the appropriate supervisor as needed.

5.6 Budget and funding

The budget in Table 5 assumes 19 sampling events.

Table 5. Tentative project budget.

Parameter	# of Samples	# of Field Duplicates	# of Blanks	Total # of Samples	MEL Cost Per Sample (25% discount)	MEL Subtotal
Alkalinity (carbonate & bicarbonate)	570	114	19	703	$15	$10,545
DOC	570	114	19	703	$33.75	$23,726
TOC	570	114	19	703	$26.25	$18,454
Ammonia - NH3	570	114	19	703	$11.25	$7,910
Orthophosphate - OP	570	114	19	703	$15	$10,545
Total Phosphorus - TP colorimetric	570	114	19	703	$15	$10,545
Nitrate/Nitrite - NO2/NO3	570	114	19	703	$11.25	$7,910
Total Persulfate Nitrogen	570	114	19	703	$15	$10,545
					Grand Total =	$100K

6.0 Quality Objectives

Quality objectives are statements of the precision, bias, and lower reporting limits necessary to meet project objectives. Precision and bias together express data accuracy. Other considerations of quality objectives include representativeness and completeness.

6.1 Decision Quality Objectives (DQOs)

All of the data collected for this project should meet the measurement quality objectives (MQO) to be used for the project goals. The project manager can make decisions on a case-by-case basis for data that do not meet the MQO as to whether the data can be used for project purposes (informational, estimated values, etc.)

6.2 Measurement Quality Objectives

Field sampling procedures and laboratory analysis inherently have associated error. Measurement quality objectives state the allowable error for a project. Precision and bias provide measures of data quality and are used to assess agreement with measurement quality objectives.

6.2.1 Targets for precision, bias, and sensitivity

6.2.1.1 Precision

Precision is a measure of the variability in the results of replicate measurements due to random error. Precision is usually assessed by analyzing duplicate field measurements or lab samples. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation (e.g., field and laboratory procedures). Table 5 of the Programmatic QAPP (McCarthy and Mathieu, 2017) presents field measurement MQOs for precision and bias, as well as the manufacturer's stated accuracy, resolution, and range for the field equipment that will be used in this study.

6.2.1.2 Bias

Bias is the difference between the population mean and the true value of the parameter measured. Bias is usually addressed by calibrating field and laboratory instruments, and by analyzing lab control samples, matrix spikes, and standard reference materials. Laboratory QC procedures such as blanks, check standards, and spiked samples will provide a measure of any bias affecting sampling and analytical procedures for this project.

The MQOs for water samples taken in the field and associated laboratory analyses are shown in Table 5 of the Programmatic QAPP (McCarthy and Mathieu, 2017). Table 6 in the Programmatic QAPP (McCarthy and Mathieu, 2017) outlines analytical methods, expected precision of sample duplicates, and method reporting limits. The target expectations for precision of field duplicates are based on historical performance by MEL for environmental samples taken around the state by EAP (Mathieu, 2006). The reporting limits of the methods listed in the table are appropriate for the expected range of results and the required level of sensitivity to meet project objectives.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as detection limit. In a regulatory sense, the method detection limit (MDL) is usually used to describe sensitivity. The method reporting limit and the reporting limits are the same for the parameters of interest for this project. See Table 6 in the Programmatic QAPP (McCarthy and Mathieu, 2017) for MDLs for this project.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

See Section 6.2.2.1 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

6.2.2.2 Representativeness

See Section 6.2.2.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

6.2.2.3 Completeness

See Section 6.2.2.3 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

7.0 Study Design

7.1 Study boundaries

The study area is within WRIA 39, the Upper Yakima River Basin. Figure 1 shows the boundary of WRIA 39 and highlights the section of the Yakima River that pertains to the project study area.

The Water Resource Inventory Area (WRIA) and 8-digit Hydrologic Unit Code (HUC) numbers for the study area are:

- WRIA: 39, Upper Yakima
- HUC number: 17030001

7.2 Field data collection

7.2.1 Sampling location and frequency

Water sample collection will be conducted on a bi-weekly basis from March–November 2019. The first sampling will occur before the start of the irrigation season and conclude with samplings after the end of the irrigation season. This will capture conditions as they change and transition into and out of the irrigation season in the Upper Yakima River Basin.

At least 30 site locations are being considered: 10 on the mainstem of the Yakima River and 20 in tributaries and background tributaries. Many of the sites were also previously sampled in the original 1999 TMDL study (Joy, 2002). Alternate or additional sites may be added if found necessary. Figure 2 shows a general map of site locations, and Table 6 shows a list of site locations.

7.2.2 Field parameters and laboratory analytes to be measured

The parameters to be determined via field data collection are discussed below and shown in Table 7.

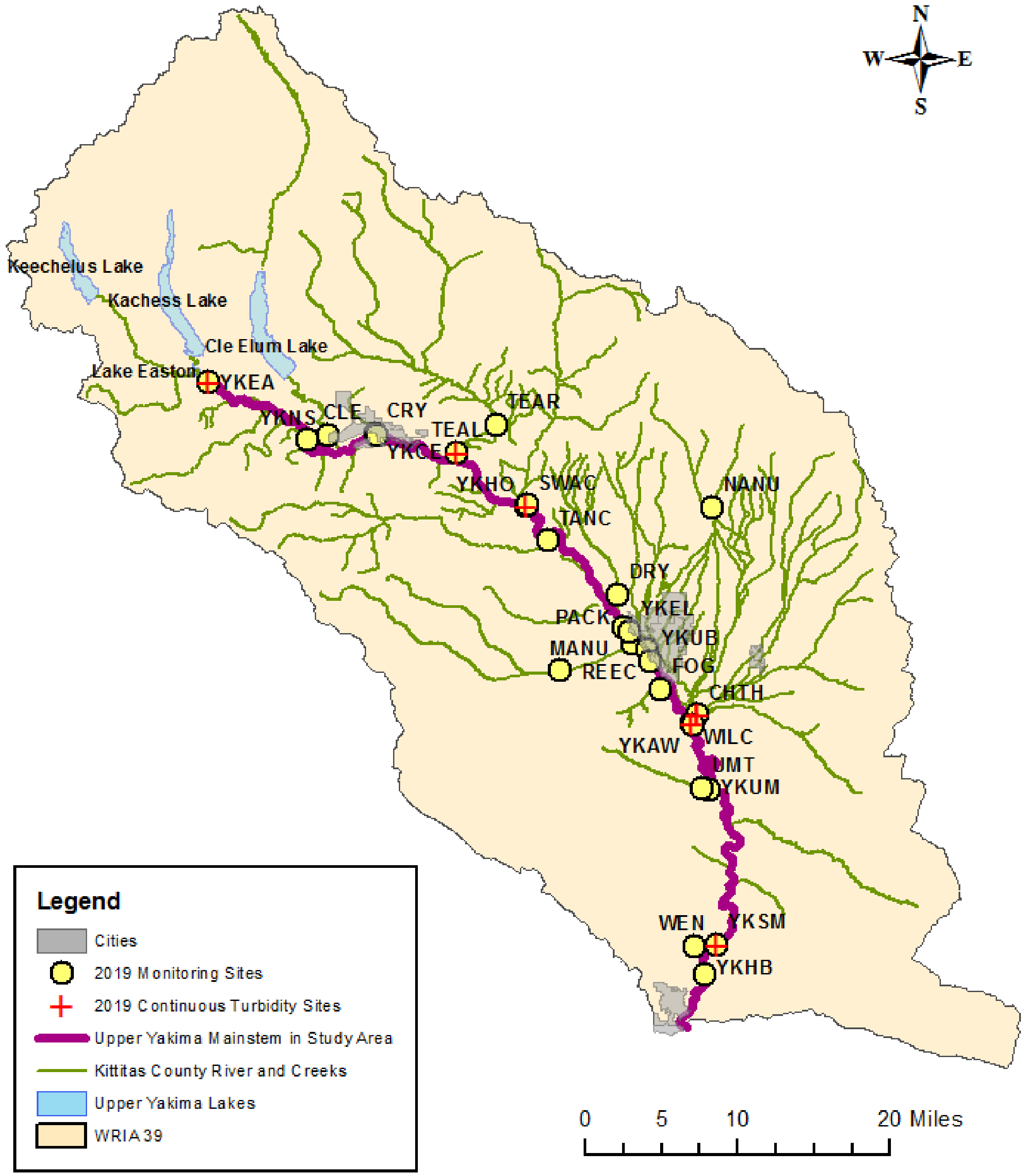

Figure 2. **Map of proposed site locations.**

Table 6. List of proposed site locations.

Site ID	TSS study ID	Monitoring sites	Latitude	Longitude
YKEA	***	Yakima River below Lake Easton	47.240387	-121.181637
BIGC	***	Big Creek	47.212749	-121.103480
LITC	***	Little Creek	47.204571	-121.080339
YKNS	01-YKI	Yakima River @ Nelson Siding	47.18565	-121.04451
CLE	07-CLE	Cle Elum River @ Bullfrog Rd bridge	47.191110	-121.015550
CRY	08-CRY	Crystal Creek	47.193050	-120.948873
YKCE	***	Veolia WTP site		
YKAT	***	Yakima River above Teanaway River	47.170847	-120.845315
TEAU	***	Teanaway River @ Red Bridge Rd	47.201111	-120.781500
TEAL	09-TEA	Teanaway River @ Lambert Road	47.174900	-120.836100
YKHO	***	Yakima River @ Horlick	47.123900	-120.739400
SWAC	10-SWA	Swauk Creek at mouth	47.125050	-120.737399
NANU	26-NN	Naneum Creek @ Naneum Road	47.12354	-120.47989
CLPOTW	***	Cle Elum wastewater treatment plant	47.188949	-120.912940
TANC	11-TAN	Taneum Creek at mouth	47.09189	-120.70926
PACK	12-PAC	Packwood Canal	47.00990	-120.60425
MANU	01-MAN	Manastash Creek @ Manastash Road	46.96810	-120.69128
MANL	13-MAN	Manastash Creek @ Brown Rd	46.99456	-120.59077
YKEL	***	Yakima River near Ellensburg	47.005230	-120.596160
DRYM	14-DRY	Dry Creek @ mouth	47.040784	-120.611469
REEC	15-REE	Reecer Creek in Irene Rinehart Park	46.988099	-120.570698
YKUB	04-YKIR	Yakima River at Umptanum Rd bridge	46.977725	-120.567419
FOG	16-FOG	Sorenson/Fogerty @ Riverbottom Road	46.95135	-120.55221
ELPOTW	***	Ellensburg wastewater treatment plant	46.968998	-120.539779
YKAW	***	Yakima River above Wilson Creek	46.918545	-120.510049
WLTH	25-WLTH	Wilson Creek @ Thrall Road	46.926312	-120.501684
CHTH	***	Cherry Creek @ Thrall Road	46.926258	-120.500591
WILC	17-WIL	Wilson Creek @ Hwy 821	46.91716	-120.50810
YKUM	05-YKUM	Yakima River @ Umtanum Creek Bridge	46.85568	-120.48417
UMT	18-UMT	Umtanum Creek	46.857274	-120.495666
WEN	19-WEN	Wenas Creek above mouth	46.70657	-120.50589
YKSM	***	Yakima River at Selah Moxee diversion	46.708100	-120.474220
YKHB	06-YKHA	Yakima River @ Harrison Bridge	46.67946	-120.49120

*** These are new locations that were not included in the original TSS and turbidity study (Joy, 2002).

Table 7. List of measurements and parameters to be determined at each site location.

Site ID	Monitoring sites	Cont. flow	Check flow	Inst. flow	Water pressure transducer	Water/air temp datalogger	Type of sample grab/composite/ integrated	Cont. turb./ HL	Short-term HL or DO datalogger	Field measurements and samples	Light meter
YKEA	Yakima River below Lake Easton	X	X			X	LB grab	X		X	
BIGC	Big Creek			X	X	X	RB grab			X	
LITC	Little Creek			X			LB grab			X	
YKNS	Yakima River @ Nelson Siding		X		X	X	LB RB comp		X	X	
CLE	Cle Elum River @ Bullfrog Rd bridge		X	X	X	X	1X bridge grab		X	X	
CRY	Crystal Creek			X			RB grab			X	
YKCE	Veolia WTP site (Yakima at Cle Elum)	X	X	X	X	X	1X bridge grab			X	
YKAT	Yakima River above Teanaway					X	LB grab			X	
TEAL	Teanaway River @ Lambert Road	X	X	X			3X bridge comp	X (no HL)	X	X	
YKHO	Yakima River @ Horlick	X	X			X	LB grab	X		X	X
SWAC	Swauk Creek at mouth			X	X	X	RB grab		X	X	
CLPOTW	Cle Elum POTW	X				X	24 hour comp			X	
TANC	Taneum Creek at mouth			X	X	X	LB grab		X	X	
PACK	Packwood Canal			X	X	X	LB grab	X (no HL)	X	X	
MANL	Manastash Creek @ Brown Rd			X	X		grab	X (no HL)	X	X	
YKEL	Yakima River near Ellensburg	X	X	X		X	2X bridge comp		X	X	
DRYM	Dry Creek @ mouth			X	X	X	grab		X	X	
REEC	Reecer Creek in Irene Rinehart Park			X	X	X	grab		X	X	
FOG	Sorenson/Fogerty @ Riverbottom Rd			X	X		LB grab	X (no HL)		X	
ELPOTW	Ellensburg POTW	X				X	24 hour comp			X	
YKAW	Yakima River above Wilson Creek		X			X	LB grab	X		X	X
WLTH	Wilson Creek @ Thrall Road	X		X	X		1X bridge grab	X (no HL)		X	
CHTH	Cherry Creek @ Thrall Road	X		X	X		1X bridge grab	X (no HL)		X	
WILC	Wilson Creek @ Hwy 821		X			X	LB grab		X	X	
YKUM	Yakima River @ Umtanum Ck Bridge	X				X	3X bridge comp		X	X	
UMT	Umtanum Creek			X			grab			X	
WEN	Wenas Creek above mouth			X	X	X	grab			X	
YKSM	Yakima R. at Selah Moxee diversion					X	grab	X		X	X
YKHB	Yakima River @ Harrison Bridge						2X bridge comp			X	

Abbreviations:

TSS = total suspended solids
Turb. = turbidity
Integrated = depth integrated samples
grab = grab sample
comp. = composite sample

Cont. = continuous
Inst. = instantaneous
Temp. = temperature.
cond. = specific conductivity
TOC = total organic carbon

DOC = dissolved organic carbon
HL = Hydrolab multi-meter datalogger
DO = dissolved oxygen

Streamflow measurements
Ecology will take streamflow measurements during each survey at tributary locations that do not have continuous streamflow gage stations. Streamflow measurements are made following Ecology protocols (Kardouni, 2013).

Streamflow data for the Upper Yakima River and its tributaries will be acquired from USBR, USGS, and Ecology, as well as measured in the field. Several agencies already measure continuous streamflow at several location on the Mainstem Yakima River as well as some tributaries. Table 8 shows the location and station names of the gages that this project will use to determine streamflow for the project. Ecology will take periodic streamflow measurements at locations measured by other agencies to conduct quality control checks.

Table 8. List of continuous streamflow gages.

Agency	Agency Site ID	Gage Site Location
USBR	EASW	Yakima River near Easton
USBR	YUMW	Yakima River at Cle Elum
USBR	YRWW	Yakima River near Horlick
USBR	ELNW	Yakima River @ Ellensburg
USGS	12484500	Yakima River @ Umtanum
USBR	RBDW	Yakima River below Roza Dam
Ecology	39D110	Teanaway River @ Red Bridge Rd
USBR	TEAW	Teanaway River @ Lambert Rd
Ecology	39M130	Swauk Ck below First Ck.
USBR	WONW	Wilson Creek @ Thrall Rd
USBR	CHRW	Cherry Creek @ Thrall Rd
Ecology	39J070	Manastash Creek @ Cove Rd

Continuous water quality monitoring
Ecology's Freshwater Monitoring Unit will install continuous turbidity meters at several locations for the TSS and turbidity effectiveness monitoring project (Carroll and Urmos-Berry, 2019). Most of these stations will be associated with a continuous streamflow gaging station (Table 8).

Four locations will also be configured to run continuous dissolved oxygen and pH probes (Table 9). Meters will be installed and maintained following Ecology's statewide ambient monitoring program protocols (Hallock, 2009) and continuous water quality monitoring protocols established by the USGS (Wagner et al., 2006). In addition to the four continuous water quality stations, some tributaries will have periodic, short-term deployments of water quality dataloggers (at least 24 hours) to capture diel characteristics of DO and pH from those tributaries.

Continuous water and air temperature will be measured at all locations with deployed temperature dataloggers.

Table 9. List of continuous turbidity monitoring sites where DO and pH will be continuously monitored.

Site ID	Continuous Monitoring Sites	DO and pH probes
YKEA	Yakima River below Lake Easton	continuous
YKHO	Yakima River @ Horlick	continuous
YKAW	Yakima River above Wilson Creek	continuous
YKSM	Yakima River at Selah Moxee	continuous

Special studies

Measurements of light extinction, time-of-travel, channel geometry, and other parameters that fill data gaps needed to complete model set up and calibration will be collected throughout the study period.

7.3 Maps or diagram

A map of proposed monitoring locations can be found in Figure 2.

7.4 Assumptions underlying design

This field data collection is specifically designed to generate an adequate data set that will allow future calibration of a water quality model that can simulate water temperature, DO and pH in the Upper Yakima River. In conjunction with the TSS and turbidity monitoring, this study and field data collection is specifically designed to develop a complete data set, including all major tributary sources to the Yakima River.

7.5 Possible challenges and contingencies

See Section 7.5 in the Programmatic QAPP (McCarthy and Mathieu, 2017) for a list of potential logistical problems, practical constraints, and schedule limitations.

8.0 Field Sampling Procedures

8.1 Invasive species evaluation

See Section 8.1 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.2 Measurement and sampling procedures

Some samples will be collected using depth-integrated samplers, usually at larger cross sections, when a bridge can be safely used. If streamflow in some of the tributary locations is too low or too high to use the depth-integrated samplers, grab samples will be taken. The following exceptions also apply:

- At the Wilson Creek site on Canyon River Road, samples will be collected using grab sampling techniques due to safety concerns on the bridge.
- When the turbidity levels in tributaries drop below 5 NTU (historically in June), grab sampling techniques will be used.

See Section 8.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017). Table 9 in the Programmatic QAPP (McCarthy and Mathieu, 2017) lists the field activities and their associated SOPs used to collect different types of data.

Ecology Standard Operating Procedures (SOPs) can be found on Ecology's website[1].

8.3 Containers, preservation methods, holding times

See Section 8.3 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.4 Equipment decontamination

See Section 8.4 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.5 Sample ID

See Section 8.5 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.6 Chain of custody, if required

See Section 8.6 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.7 Field log requirements

See Section 8.7 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.8 Other activities

See Section 8.8 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

[1] https://www.ecology.wa.gov/quality

9.0 Laboratory Procedures

9.1 Lab procedures table

See Table 11 in the Programmatic QAPP (McCarthy and Mathieu, 2017) for lab methods (including sample matrix, expected range of results, and method detection limit).

9.2 Sample preparation method(s)

See Section 9.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

9.3 Special method requirements

No special methods will be used for this study.

9.4 Lab(s) accredited for method(s)

All chemical analysis will be performed at MEL, which is accredited for all methods.

10.0 Quality Control (QC) Procedures

See Section 10.0 in the Programmatic QAPP (McCarthy and Mathieu, 2017) for a list of field and laboratory quality control procedures.

10.1 Table of field and laboratory quality control

See Section 10.1 (Table 13) in the Programmatic QAPP (McCarthy and Mathieu, 2017) for list of the types and frequency of quality control samples needed for laboratory and field samples.

10.2 Corrective action processes

See Section 10.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

See Section 11.1 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

11.2 Laboratory data package requirements

See Section 11.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

11.3 Electronic transfer requirements

See Section 11.3 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

11.4 EIM data upload procedures

See Section 11.4 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

No audits are planned for this study. However, there could be a field consistency review by another experienced EAP field staff member during this project. The aim of this review is to improve fieldwork consistency, improve adherence to SOPs, provide a forum for sharing innovations, and strengthen our data QA program.

12.2 Responsible personnel

See Table 3 found in Section 5.1.

12.3 Frequency and distribution of report

A summary of the data collected under this project will be published in a formal, peer-reviewed report that includes results, methods, and data quality assessment. The final report will be published according to the project schedule in Table 4, Section 5.4.

12.4 Responsibility for reports

The project manager and principal investigators will co-author the final data summary report.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

See Section 13.1 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

13.2 Verification of laboratory data

See Section 13.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

13.3 Validation requirements, if necessary

See Section 13.3 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether project objectives have been met

See Section 14.1 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

14.2 Treatment of non-detects

See Section 14.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

14.3 Data analysis and presentation methods

See Section 14.3 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

14.4 Sampling design evaluation

See Section 14.4 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

14.5 Documentation of assessment

See Section 14.5 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

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16.0 Appendices

Appendix A. Glossaries, Acronyms, and Abbreviations

Appendix C in the Programmatic QAPP (McCarthy and Mathieu, 2017) has a glossary of general terms and a separate glossary of Quality Assurance terms, as well as a list of common acronyms and abbreviations used.