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Quality Assurance Project Plan

Cowiche Creek
Vegetation and Shade Study

September 2013

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Publication Information

Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1303118.html

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Author and Contact Information

Tighe Stuart
4601 N. Monroe St.
Environmental Assessment Program
Washington State Department of Ecology
Spokane, WA 99205-1295

For more information contact: Communications Consultant, phone 360-407-6834.

Washington State Department of Ecology - www.ecy.wa.gov/

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

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Approved by:

Signature: Date: September 2013
Laine Young, TMDL Lead, Client, Water Quality Program, Central Regional Office

Signature: Date: September 2013
Chris Coffin, Client's Unit Supervisor, Water Quality Program, Central Regional Office

Signature: Date: September 2013
Charles McKinney, Client's Section Manager, Water Quality Program, Central Regional Office

Signature: Date: September 2013
Tighe Stuart, Author / Project Manager, EAP

Signature: Date: September 2013
Eiko Urmos-Berry / Principal Investigator, EAP

Signature: Date: September 2013
Jim Ross, Author's Unit Supervisor, EAP

Signature: Date: September 2013
Tom Mackie, Author's Section Manager, EAP

Signature: Date: September 2013
Bill Kammin, Ecology Quality Assurance Officer

Signatures are not available on the Internet version.
EAP: Environmental Assessment Program

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Abstract

This project will assist with the implementation of the Upper Naches River and Cowiche Creek Temperature Total Maximum Daily Load (TMDL) in the Cowiche Creek watershed, which is a sub-watershed of the Naches River. Current and potential vegetation and shade will be described and mapped on Cowiche Creek and its major tributaries. Hemispherical photography and brief vegetation surveys will be performed at selected locations. Models of shade under current and system potential vegetation conditions will be produced.

Background

In 2011, the Department of Ecology (Ecology) completed a Total Maximum Daily Load (TMDL) for temperature on the upper Naches River and Cowiche Creek (Brock, 2008; Whiley, 2003; Peterschmidt, 2010). The TMDL established load and wasteload allocations to reduce water temperatures and included a detailed assessment of current and system potential shade and temperature for the upper Naches River. The initial study of conditions in Cowiche Creek revealed that there were a number of additional factors that needed to be further studied to draft an implementation plan for the TMDL.

A study of vegetation and shade in the Cowiche Creek watershed will support implementation of the existing TMDL by detailing current and system potential shade and providing a description of system potential vegetation throughout the watershed.

Study Area

Cowiche Creek and its tributaries drain a range of foothills of the eastern Cascade Mountains in central Washington, emptying into the Naches River near Yakima (Figure 1). The watershed is within WRIA 38 (Naches). It encompasses 120 square miles (approximately 77,100 acres). Major streams in the Cowiche watershed include South Fork (SF) Cowiche Creek, North Fork (NF) Cowiche Creek, and Reynolds Creek. The watershed spans two major ecoregions: the Eastern Cascades Slopes and Foothills, and the Columbia Plateau. The climate within the watershed varies dramatically, with parts of the Divide Range along the western edge of the watershed receiving as much as 50 inches of precipitation per year, while the eastern edge of the watershed receives less than 10 inches of precipitation per year. Natural land cover reflects this, with thick forests in the west giving way to desert in the east.

The main land uses in the watershed are canyon/rangeland (40%), forest (32%), and agriculture (28%). Urban areas including the towns of Tieton and Cowiche cover 0.5% of the watershed. Land ownership within the watershed is a mix of public (40%) and private (60%). Public lands in the watershed are managed primarily by the Washington State Department of Natural Resources (29% of watershed), Washington Department of Fish and Wildlife (7% of watershed), and the U.S. Forest Service (3% of watershed).

The Tieton Canal carries water from the Tieton River into the Cowiche watershed. The canal empties into the French Canyon Reservoir, which is created by a dam on North Fork Cowiche Creek, for storage for irrigation. North Fork Cowiche Creek upstream of the French Canyon Reservoir is an intermittent stream. Downstream of the reservoir, North Fork Cowiche Creek is strongly influenced by water from the Tieton Canal system, irrigation withdrawals, and returns. South Fork Cowiche Creek, on the other hand, receives water mainly from its headwater streams in the foothills of the Cascade Mountains.

Cowiche Creek supports steelhead and coho salmon (Haring, 2001). Spring chinook salmon have been found at the confluence of Cowiche Creek and the Naches River (Yakima Basin Fish and Wildlife Recovery Board, 2013) but it is unknown if they use Cowiche Creek for spawning. Bull trout have been reported in the upper watershed, but it is unknown if there is currently a resident population (Tobin, personal communication).

There are six fruit packing facilities and one wastewater treatment plant that discharge to streams in the Cowiche watershed. In 2012 one of the fruit packing facilities closed, but it will likely reopen as a fruit packing facility in the future. Wasteload allocations for temperature for these facilities were calculated in the Upper Naches River and Cowiche Creek Temperature TMDL.

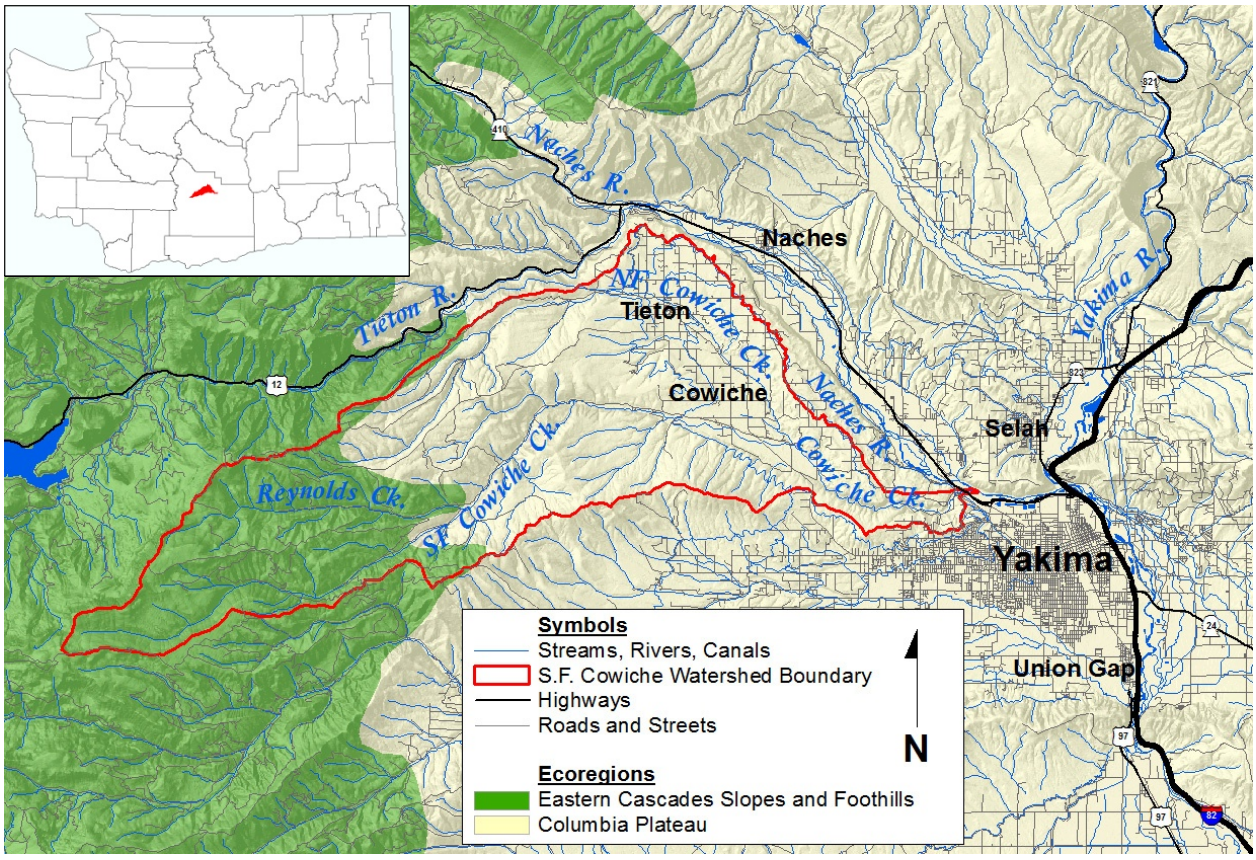

Figure 1. Location of Cowiche Creek watershed in central Washington.

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

Water Resource Inventory Area (WRIA):

- 38 (Naches)

Eight-digit Hydrologic Unit Code (HUC) number:

- 17030002

Past Studies/Existing Data

During the data collection for the Upper Naches River and Cowiche Creek Temperature TMDL, hemispherical photos of riparian vegetation were taken at a number of locations on Cowiche Creek, SF Cowiche Creek, Reynolds Creek, and NF Cowiche Creek. Channel surveys including bankfull width and other measures relating to channel geometry were performed at sites on Cowiche Creek and SF Cowiche Creek.

Project Description

This project has two goals:

1. Quantify current vegetation and shade throughout the Cowiche Creek watershed.
2. Characterize system potential riparian vegetation and quantify system potential shade throughout the Cowiche Creek watershed.

This assessment will serve three primary objectives:

1. Information about where shade is most needed, as well as site-specific details about system potential riparian vegetation, will be needed for implementation of the Cowiche portion of the Upper Naches River and Cowiche Creek Temperature TMDL.
2. Water quality modeling analyses will likely be needed in the future in the Cowiche watershed to further understand how best to reduce stream temperatures, as well as to address other impaired parameters such as dissolved oxygen and pH. The vegetation map and shade model produced by this study is expected to be an important first step for such a modeling analysis.
3. Other nearby streams flow through landscapes similar to Cowiche Creek's. The descriptions of system potential riparian vegetation in the Cowiche Creek watershed will be a useful starting point for analyzing system potential vegetation in other nearby watersheds.

Vegetation and Shade Measurements

To assess current and system potential vegetation and shade, field measurements will be taken at sites which meet either or both of the following criteria:

- Sites which fill longitudinal gaps in shade and vegetation data collected during the Upper Naches River and Cowiche Creek TMDL study.
- Reference sites which best represent undisturbed natural riparian vegetation in different parts of the watershed. Reference sites with mature riparian vegetation and a diversity of native trees and shrubs will be chosen.

Each site will be visited once during the growing season (leaf-on) of 2013. The following activities will be performed at all sites, regardless of which purpose the site was selected for.

- Hemispherical canopy photographs will be taken from the stream center to measure effective shade on the stream.
- Hemispherical canopy photographs will be taken in the riparian zone along the streambanks to measure canopy density.
- Bankfull width and stream aspect will be measured at the point where the hemispherical photograph is taken.
- A brief vegetation survey will record overstory species present, understory species present, and vegetation height.
- A simple map will be made by drawing on orthophotos, showing where different vegetation species and heights occur, to aid with GIS mapping of vegetation.

Table 1 lists sites where measurements are planned. This list may change, depending on site accessibility or on what data are deemed necessary as the study progresses. For example, in instances where four or five sites represent one potential vegetation type, it may not be necessary to take field measurements at all of the sites. Figure 2 shows a map of the proposed sites, as well as sites where hemispherical photography, channel survey, and/or vegetation surveys were performed previously.

Table 1. Proposed vegetation measurement sites

Site ID	Description	Latitude	Longitude	Purpose
38-SFC-21.8	SF Cowiche Ck. abv Fall Ck.	46.5795	-121.0335	Fill data gap for upper SF Cowiche. Reference sites for conifer forest areas
38-SFC-20.6	SF Cowiche Ck. blw Fall Ck.	46.5883	-121.0126	
38-SFC-19.1	SF Cowiche Ck. 2 mi blw Fall Ck.	46.5828	-120.9807	
38-SFC-07.8	SF Cowiche Ck. Oak Ck. Wildlife Area 1	46.6647	-120.8234	Reference sites for mid-watershed deciduous riparian vegetation
38-SFC-07.7	SF Cowiche Ck. Oak Ck. Wildlife Area 2	46.6649	-120.8218	
38-SFC-07.4	SF Cowiche Ck. Oak Ck. Wildlife Area 3	46.6657	-120.8172	
38-SFC-06.5	SF Cowiche Ck. Oak Ck. Wildlife Area 4	46.6628	-120.8026	
38-SFC-06.0	SF Cowiche Ck. Oak Ck. Wildlife Area 5	46.6623	-120.7930	
38-SFC-04.2	SF Cowiche Ck. CCC upper land, Sunset Rd.	46.6589	-120.7606	
38-SFC-00.6	SF Cowiche Ck.blw Summitview Rd.	46.6470	-120.6919	
38-REY-07.0	Reynolds Ck. headwaters	46.6152	-121.0275	Fill data gap for upper Reynolds. Reference sites for conifer forest areas
38-REY-04.3	Reynolds Ck. T13N R15E s17	46.6195	-120.9762	
38-NFC-07.1	NF Cowiche Ck. Noye Rd.	46.7110	-120.7755	Fill data gap for upper NF Cowiche
38-NFC-06.2	NF Cowiche Ck. Washington St. in Tieton	46.7066	-120.7574	
38-NFC-04.8	NF Cowiche Ck. nr Tieton WWTP	46.6950	-120.7346	
38-COW-05.3	Cowiche Ck. Cowiche Canyon 1	46.6253	-120.6539	Reference sites for canyon vegetation
38-COW-04.5	Cowiche Ck. Cowiche Canyon 2	46.6237	-120.6433	
38-COW-04.2	Cowiche Ck. Cowiche Canyon 3	46.6214	-120.6375	
38-COW-03.7	Cowiche Ck. Cowiche Canyon 4	46.6194	-120.6308	
38-COW-00.0	Cowiche Ck. at mouth	46.6277	-120.5697	Reference site for Naches River lowland vegetation

CCC: Cowiche Canyon Conservancy

WWTP: Wastewater treatment plant

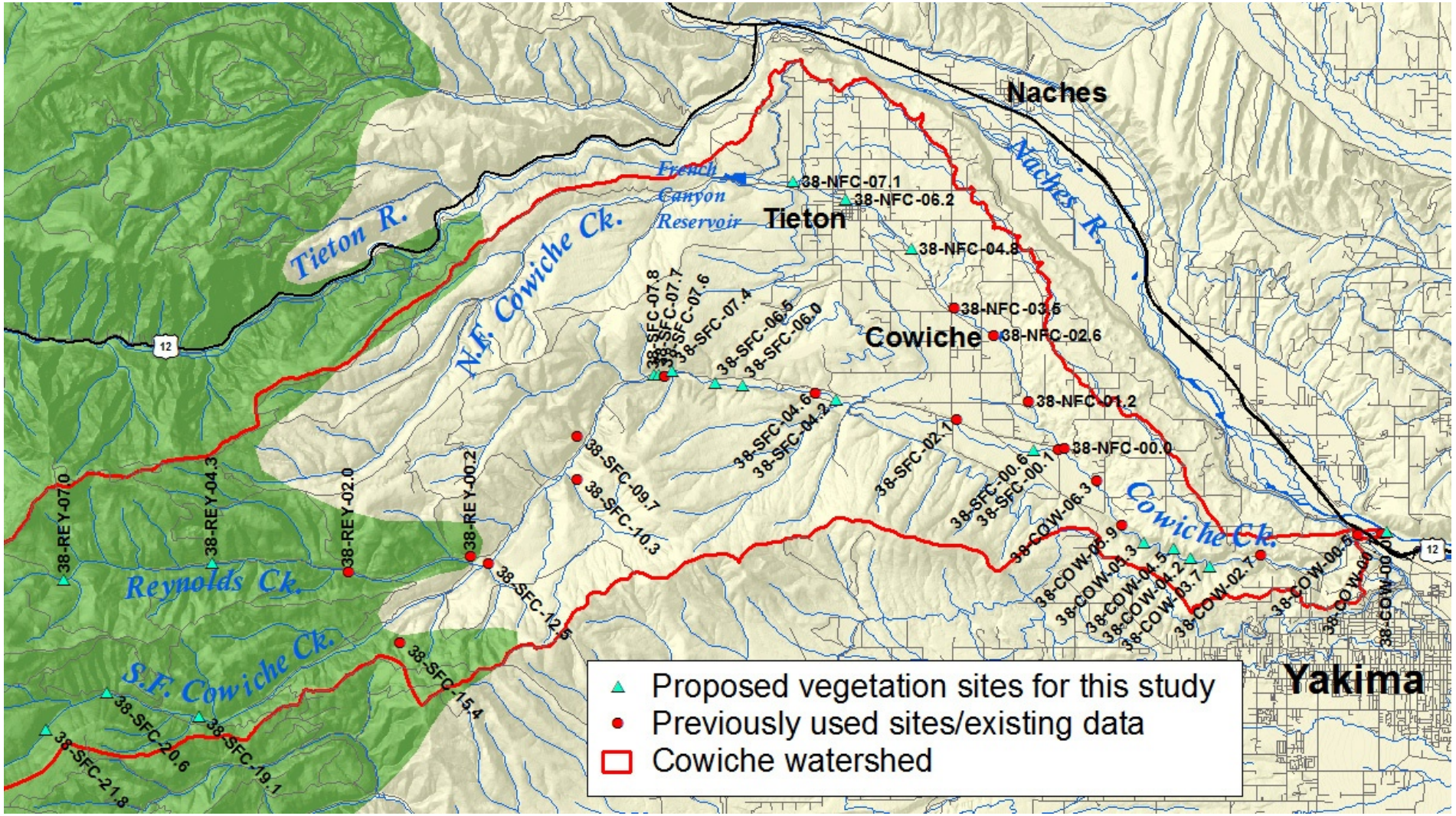

Figure 2. Proposed vegetation measurement sites, along with past sites.

Current Vegetation and Shade

To assess current vegetation and shade, maps of near-stream vegetation within 500 ft of the stream center will be produced for Cowiche Creek, N.F Cowiche Creek up to the French Canyon Dam, SF Cowiche Creek, and Reynolds Creek. Polygons delineating different types of vegetation will be digitized at a 1:2000 (or closer) scale using ArcGIS®. Each polygon will be assigned a vegetation category based on vegetation height, density, and overhang. The resulting GIS vegetation layer will be sampled using TTools (ODEQ, 2005) to produce inputs to Ecology's Shade model (Ecology, 2003). Shade model results will be verified using effective shade calculations from hemispherical photos. Hemispherical photos will be analyzed using HemiView canopy analysis software (University of Kansas, 1996).

System Potential Vegetation and Shade

System potential mature riparian vegetation is defined as: *that vegetation which can grow and reproduce on a site, given: climate, elevation, soil properties, plant biology, and hydrologic processes* (Brock, 2008). A soils-based potential vegetation analysis will result in a map of distinct zones, each with different system potential vegetation characteristics. It is expected that about three zones will be needed for the Cowiche Creek watershed. This analysis will be based on weight of evidence from the following sources, depending on availability and usefulness:

- **USDA Ecological Site/Plant Association data** – For each soil type in the U.S. Department of Agriculture (USDA)/Natural Resource Conservation Service (NRCS) soil survey, the characteristic associated forest and/or rangeland plant community has been defined.
- **DNR Soils Site Index** – For forestland, the Washington State Department of Natural Resources (DNR) has assigned a site index for each soil type, which is defined as the height of mature trees on that soil type. For lands east of the Cascade mountain crest, the site index value is a height at age 100 years.
- **General Land Office (GLO) surveys** – The General Land Office surveyed all township and section lines during the late 1800s. Surveyors often made notes of vegetation present along streams.
- **Reference Site Data** – Vegetation survey data from reference sites visited during this project.
- **Existing LiDAR data** – LiDAR (Light Distance and Ranging) data are collected using a scanning laser rangefinder mounted to an airplane. The scanner can record the elevation of the tree tops as well as the elevation of the ground, giving a measure of tree height. A 2005 LiDAR flight in Yakima County covered much of Cowiche Creek and South Fork Cowiche Creek.
- **National Wetland Inventory (NWI)** – The U.S. Fish and Wildlife Service National Wetlands Inventory provides maps of wetland coverage.

System potential vegetation height, density, and overhang values will be defined for each vegetation zone, based primarily on data collected at reference sites. Estimates of system potential shade at various bankfull widths and aspects will be verified to stream-center hemispherical photos taken at reference sites. Then, using the map of potential vegetation zones and the characteristics of each potential vegetation type, the shade model will be used to estimate system potential shade on all the same stream reaches covered by the model of current shade.

Organization and Schedule

Table 1 lists the people involved in this project. All are employees of the Washington State Department of Ecology. Table 2 presents the proposed schedule for this project.

Table 2. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
Laine Young Water Quality Program Central Regional Office Phone: 509-575-2642	TMDL Lead; EAP Client	Clarifies scopes of the project. Provides internal review of the QAPP and approves the final QAPP.
Tighe Stuart Directed Studies Unit Eastern Operations Section Phone: 509-329-3476	Project Manager	Writes the QAPP. Oversees field sampling. Conducts QA review of data, oversees analysis and interpretation of data. Writes the draft report and final report.
Eiko Urmos-Berry Directed Studies Unit Eastern Operations Section Phone: 509-575-2397	Principal Investigator	Provides internal review of QAPP. Conducts field sampling. Assists with analysis and interpretation of data. Assists writing draft report and final report.
Jim Ross Directed Studies Unit Eastern Operations Section Phone: 509-329-3425	Unit Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Tom Mackie Eastern Operations Section Phone: 509-454-4244	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Joel Bird Manchester Environmental Laboratory Phone: 360-871-8801	Director	Approves the final QAPP.
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

EAP: Environmental Assessment Program
QAPP: Quality Assurance Project Plan

Table 3. 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	September 2013	Tighe Stuart
Environmental Information System (EIM) database		
No data will be produced that needs entry into EIM.		
Final report		
Author lead / Support staff	Tighe Stuart / Eiko Urmos-Berry	
Schedule		
Draft due to supervisor	April 2014	
Draft due to client/peer reviewer	May 2014	
Draft due to external reviewer(s)	June 2014	
Final (all reviews done) due to publications coordinator	September 2014	
Final report due on web	October 2014	

Measurement Procedures

Field procedures will follow approved Environmental Assessment Program Standard operating procedures (SOP) (Ecology, 2013):

- EAP013 - Determining Coordinates via hand-held Global Positioning System (GPS) Receivers
- EAP045 - Hemispherical Digital Photography Field Surveys Collected as part of a Temperature Total Maximum Daily Load (TMDL) or Forests and Fish Unit Technical Study
- EAP046 - Computer Analysis of Hemispherical Digital Images Collected as part of a Temperature Total Maximum Daily Load (TMDL) or Forests and Fish Unit Technical Study
- EAP070 - Minimizing the Spread of Aquatic Invasive Species

Exact locations of hemispherical photos will be located on maps and in field notes, and deviations will be recorded. If the site location does not have easily recognizable landmarks, a GPS reading will be taken to obtain accurate latitude and longitude. These notes will be precise enough to allow field crews to return in future years to take photos from the same location.

Hemispherical photos will be taken as follows:

- At sites which are only for the purpose of filling data gaps in current vegetation, one photo will be taken from the stream center.

- At reference sites which represent system potential vegetation, one photo will be taken from the stream center, one in the left bank riparian zone underneath representative vegetation, and one in the right bank riparian zone underneath representative vegetation.

At all sites, representative vegetation heights will be measured using an electronic forestry range finder/clinometer. Three-point measurement mode will be used, wherein the distance to the trunk is shot first, then the angle to the top of the tree, then the angle to the bottom of the tree. The location of each measured tree will be mapped on a printed orthophoto. Additional notes about vegetation types and locations will be made on the printed orthophoto to aid with later GIS mapping of vegetation. At all sites, bankfull width and stream aspect will be measured and recorded.

At reference sites, all overstory and understory tree and shrub species will be noted, along with their relative density. Tree and shrub species will be identified to species level where possible. Forbs and grasses will be noted if they are particularly abundant or are apparently contributing to stream shading or bank stabilization in a significant way.

At sites where black cottonwood (*Populus trichocarpa*) forms a significant part of the overstory, a simple survey of cottonwood age distribution will be conducted. A representative circular plot 60 ft in diameter will be chosen. The portion of the ground covered by cottonwood canopy will be estimated, and a hemispherical photo will be taken to estimate total canopy cover. All cottonwoods inside the plot will be counted and categorized as saplings (0 to 5 ft tall), immature (5 to 20 ft), or mature (greater than 20 ft). This will help provide general information on cottonwood recruitment, which has been a problem in the Yakima basin (Braatne et.al, 2007) but may or may not be an issue in the Cowiche subbasin.

Quality Objectives

Bias

Bias is defined as the difference between the population mean and the true value of the parameter being measured (Lombard and Kirchmer, 2004). Bias attributed to sampling and field measurement techniques will be minimized by following appropriate protocol and SOPs discussed and referenced in this QA Project Plan. The primary attribute being measured in this study is effective shade, which is highly variable and heterogeneous. Therefore, avoiding measurement bias is largely a matter of choosing representative locations for measurements. Procedures provided in this QA Project Plan are used to collect representative field measurements of the highest quality possible.

Precision

Precision is the measure of variability in the results of replicate measurements due to random error (Lombard and Kirchmer, 2004). This random error is inherently associated with field

sampling and laboratory analysis. Field errors are minimized by adhering to strict measurement protocols.

Measurement Quality Objectives

U.S. Environmental Protection Agency (EPA) defines measurement quality objectives (MQOs) as:

> "acceptance criteria" for the quality attributes measured by project data quality indicators. [They are] quantitative measures of performance (EPA, 2002).

No MQOs are established for effective shade or vegetation height measurements as these measurement types are not typically duplicated. These attributes are typically heterogeneous and variable across space. Therefore it is more important for the purposes of this project to account for the spatial variability of these measurements than the precision at a single location.

Quality Control Procedures

Effective shade can be quite variable spatially, even within one vegetation type. To insure that measured effective shade values are representative, the following will be done:

- At all sites, the hemispherical photo will be taken from a location judged to be representative, as explained in SOP EAP045.
- At 1/5 of sites, an additional stream center Hemiview photo will be taken far enough upstream or downstream from the initial photo that none of the same shrubs or trees shown in the initial photo are shown in the duplicate one. These duplicate photos will give an indication of the amount of spatial variability in shade in a single vegetation zone.
- Multiple (3+) reference sites will be chosen in each likely vegetation zone except for the Naches River riparian area, which only represents a tiny fraction of the Cowiche watershed and may not represent a distinct vegetation zone.

Duplicate measurements are not technically necessary, nor are they typically included in temperature TMDL studies. They are included in this study to help gauge the level of variability within each vegetation zone, particularly because the characteristics of potential vegetation will be evaluated partially from this data.

Vegetation heights can also be quite variable. To ensure that measured vegetation heights are representative, at least two height measurements will be taken of each dominant vegetation type at each reference site. For example, if the riparian vegetation at a site consists of mixed cottonwoods and ponderosa pine with an alder understory, then at least two cottonwoods, two pines, and two alders will be measured.

Shade model results for current vegetation conditions will be compared to Hemiview results to check whether model estimates of current shade are accurate. Shade model results for system potential vegetation conditions will be compared to only those Hemiview results from reference sites.

Data Management Procedures

Field measurements will be recorded in a field book with waterproof paper. Data will then be entered into EXCEL® spreadsheets (Microsoft, 2007) as soon as practical after returning from the field. These spreadsheets will be used for data analysis.

The types of data being collected during this study are not typically entered into EIM.

All spreadsheet files, paper field notes, and Geographic Information System (GIS) products created as part of the data analysis will be kept with the project data files.

Audits and Reports

The project manager will prepare and submit a report of the findings of this study to the client at the end of the project. This report will include:

- Modeled shade results under current and system potential vegetation conditions for Cowiche Creek, NF Cowiche Creek up to French Canyon Dam, SF Cowiche Creek, and Reynolds Creek
- Descriptions of the potential vegetation types occurring in the Cowiche Creek watershed
- A map showing where these potential vegetation types occur
- A map comparing current and system potential shade throughout the watershed
- A summary of the data collected during this study

Data Verification

Field staff will check field notebooks for missing or improbable measurements before leaving each site. The EXCEL® workbook file containing field data will be labeled DRAFT until data verification is complete. Data entry will be checked against the field notebook data for errors and omissions. Missing or unusual data will be brought to the attention of the project manager for consultation. Valid data will be moved to a separate file labeled FINAL.

Data Quality (Usability) Assessment

The project lead will verify that all field measurements have met the appropriate quality objective. For this project, that will mean verifying that enough measurements have been taken to assess field variability of the attributes being measured and to find a reasonable average value for these attributes at each site and for each vegetation zone. If the results are not adequate, then the project lead will determine how or whether to use that data for analysis.

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Appendix. Glossary, Acronyms, and Abbreviations

Glossary

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Hemispherical Photography: A method of assessing effective shade and other attributes of the solar radiation environment below the forest canopy. Software is used to analyze a photo of the forest canopy taken using a hemispherical (fish-eye) lens.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities. This includes, but is not limited to, atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Reach: A specific portion or segment of a stream.

Riparian: Relating to the banks along a natural course of water.

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

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standard and are not expected to improve within the next two years.

Acronyms and Abbreviations

DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
ft	feet
GIS	Geographic Information System software
GPS	Global Positioning System
MQO	Measurement quality objective
NF	North Fork
NPDES	(See Glossary above)
QA	Quality assurance
SF	South Fork
SOP	Standard operating procedures
TMDL	(See Glossary above)
WRIA	Water Resource Inventory Area