

Quality Assurance Project Plan

Walla Walla River Tributaries Temperature Total Maximum Daily Load

by
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1998 303(d) listings addressed in this study:

Waterbody	T	R	S	New ID	Old WBID	Parameter
Mill Creek	07N	36E	23	SS77BG	WA-32-1070	Temperature
Touchet River	07N	33E	33	LV94PX	WA-32-1020	Temperature
Touchet River	10N	39E	30	LV94PX	WA-32-1020	Temperature

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Abstract

The Walla Walla River Tributaries have been selected for a temperature Total Maximum Daily Load (TMDL) study as required by the Federal Clean Water Act. Data gathered at the Washington State Department of Ecology's ambient monitoring stations were the basis for placing three stream segments on the 1998 303(d) list of impaired waterbodies. Additional studies by the Washington State Department of Fish and Wildlife, the Columbia Conservation District, and the Army Corps of Engineers show that high temperatures are prevalent throughout the basin. Stream temperatures can affect an organism's ability to live or reproduce and may compromise usage by Steelhead and Bull Trout which are listed as threatened under the Endangered Species Act.

Data collection, consisting of continuous temperature monitoring, thermal infrared imagery (TIR), stream flow monitoring, riparian surveys, and an extensive groundwater study is planned for the summer of 2002. Ecology is working cooperatively with the Washington State Department of Fish and Wildlife and the Walla Walla Technical Workgroup (TWG) to coordinate field work. Water temperature in the tributaries will be characterized and load and wasteload allocations established for heat sources to meet water quality standards.

Introduction

The purpose of the Walla Walla River Tributaries Temperature TMDL is to characterize the water temperature in the basin and establish load and wasteload allocations for the heat sources to meet water quality standards for surface water temperature. The high interest in water temperature issues in this basin is demonstrated by the level of cooperative sampling and by the initiation of streamflow and riparian vegetation improvement projects.

In total, the study area has three segments (Figure 1) that are listed for not meeting water quality criteria for temperature. Temperature problems in the basin are not limited to the three segments reported on the 303(d) list; therefore, this study concentrates not only on the temperature concerns of the listed segments but those in the entire study area as well. Mendel et al., (2000) documented temperatures in excess of 18°C (64.4°F) in 34 additional sites throughout the basin.

Figure 1: 1998 303d Listings for Temperature in the Walla Walla Basin (WIRA 32). See Appendix A.

Project Description

Study Area

The study area includes all major tributaries to the Walla Walla River (WIRA 32) in Washington State. The Walla Walla mainstem will be excluded from this study because the TMDL analysis

is being done by the Oregon Department of Environmental Quality (ODEQ) as part of a larger project. This larger project will address the entire Walla Walla mainstem, which lies in both states.

The Walla Walla Basin is a 1,758 square mile area with about 70% located in Washington State. The major tributaries of concern for this temperature TMDL are the Touchet River, Mill Creek, and Dry Creek drainages.

The four primary forks of the Touchet River (South Fork Touchet, North Fork Touchet, Wolf Fork, and Robinson Fork) originate deep in the Blue Mountains at an elevation of 6,074 feet. The four forks are mainly forested with only small farms in the valleys. The forks converge just above the City of Dayton to form the mainstem Touchet River. The Touchet River flows through the cities of Dayton, Waitsburg, and Prescott reaching its confluence with the Walla Walla River by the town of Touchet at an elevation of 420 feet. Land use in the Touchet basin from Dayton to the confluence of the Walla Walla River is predominantly agricultural with both irrigated and non-irrigated crops.

Dry Creek is a 239 square mile basin with elevations from 460 feet at the confluence with the Walla Walla River near Lowden to 4,600 feet in the Blue Mountains. Dry Creek's watershed is mainly used for dry wheat agriculture with only sparse amounts of forests in the headwaters.

Mill Creek headwaters are located in the Blue Mountains where 22,000 acres are preserved as a drinking water source for the city of Walla Walla. The 100 square mile drainage flows through Oregon and then through the city of Walla Walla. The city of Walla Walla and the Army Corps of Engineers built a control structure in the 1940s to stop catastrophic flooding during the spring months. Currently, a portion of Mill Creek's spring flow is diverted into Garrison Creek, Yellowhawk Creek, and Bennington Lake. Mill Creek's remaining flow passes through the city of Walla Walla in an engineered concrete channel. Mill Creek enters the Walla Walla River downstream of the city, near the historical Whitman Mission.

This region has a continental type climate with hot arid summers and cold wetter winters. Temperatures in the basin can easily reach 37.8°C (100°F) in the summer and below freezing in the winter. The lower portions of the basin receive less than 10 inches of annual precipitation and the upper sections, in the Blue Mountains, can receive up to 60 inches of annual precipitation. Most of the precipitation falls as snow in the winter months causing a significant accumulation of snowpack in the mountains. Spring thaw, compounded with rain showers, is the source of flooding for the basin.

Project Objectives

1. Characterize summer (June-October) stream temperature of the Walla Walla River tributaries (WIRA 32).

- Compile existing data, including:
 - Data collected by Washington State Department of Fish and Wildlife, Army Corps of Engineers, Columbia Conservation District, and other potential data sources that are discovered during the study.

- Qualitative historical data.
 - Collect additional data in cooperation with Washington State Department of Fish and Wildlife and other watershed groups.
2. Develop a predictive computer temperature model for the Touchet River, Upper Mill Creek, and selected additional Walla Walla River tributaries.
- Model the instream temperature regime at critical conditions.
 - Evaluate the ability of various watershed best management practices (BMPs) to reduce water temperature to meet water quality standards.
3. Establish a TMDL for temperature in the Walla Walla River watershed.
- Develop a TMDL for thermal load to the stream (usually expressed as incoming solar radiation in units of Langley's/day).
 - For ease of implementation, load allocations may be reported in terms of surrogates for solar radiation such as: shade, size of tree necessary in the riparian zone to produce adequate shade channel width, channel width-to-depth ratio, or miles of active eroding stream banks.

Sources of Thermal Pollution

Many environmental variables affect water temperature, including (Brown, 1969):

- Solar radiation.
- Air temperature.
- Stream width, depth, and velocity.
- Tributary and groundwater influence.

Sources of nonpoint thermal pollution are:

- Riparian vegetation disturbance and loss of shade due to:
 - Removal of trees and shrubs for pasture, crops, or timber harvest.
 - Heavy grazing by livestock.
 - Conversion of forest to pasture land.
- Channel morphology impacts resulting from:
 - Removal of large woody debris by commercial harvest and agriculture.
 - Increased sediment loading from agriculture, timber harvest, and roads.
 - Channel constraint/diking for agriculture and flood control.
 - Bank instability/erosion and sedimentation from removal of root structure and increased land-use practices in the watershed.
- Hydrologic changes influenced by:
 - Extraction and return of water for irrigation or other purposes.
 - Altered stream flow patterns from urbanized and timber harvest areas resulting in increased spring runoff and decreased summer baseflows.

These activities potentially raise the water temperature of rivers due to increased solar input resulting from lack of shade along streams, reduction of river water volume from withdrawals, and increased water surface area from sedimentation, making the channel wider and shallower.

Beneficial Uses

The tributaries of the Walla Walla River are classified as Class AA (extraordinary), Class A (excellent), and Class B (good), as defined by Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A-0303 WAC) (Table 1).

Table 1: Stream Classifications of the Walla Walla Tributaries as Defined by Water Quality Standards for Surface Waters of the State of Washington.

Tributary Name and Location	Classification
Mill Creek from mouth to 13 th bridge in Walla Walla (RM 6.4)	Class B
Mill Creek from 13 th bridge in Walla Walla (RM 6.4) to Walla Walla Waterworks Dam (RM 11.5)	Class A
Mill Creek and tributaries from city of Walla Walla Waterworks Dam (RM 21.6) to headwaters.	Class AA
North Fork Touchet River from Dayton water intake structure (RM 3.0) to headwaters.	Class AA
All non-specified stream reaches	Class A

The water quality standards establish beneficial uses of waters and incorporate specific numeric and narrative criteria for parameters such as water temperature. The criteria are intended to define the level of protection necessary to support the beneficial uses (Rashin and Graber, 1992). The beneficial uses of the waters in this specific area are:

- *Recreation:* Fishing and Swimming.
- *Fish and Shellfish:* Spring Chinook salmon (*Oncorhynchus tshawytscha*), Rainbow/Steelhead Trout (*Oncorhynchus mykiss*), Bull Trout (*Salvelinus confluentus*), and Mountain Whitefish (*Prosopium williamsoni*) are the salmonid species in the Walla Walla Basin. The lower reaches of the basin are mainly used by these species for migration and some rearing, while the headwaters provide a majority of the spawning habitat.
- *Water Supply and Stock Watering:* Agriculture extracts water for irrigation and stock watering, and the city of Walla Walla uses Mill Creek as a drinking water source.
- *Wildlife Habitat:* Riparian areas are used by a variety of wildlife species, which are dependent on the habitat.

Numeric freshwater water quality criteria for Class AA, Class A, and Class B state that temperature shall not exceed the following:

	Temperature Standard not to Exceed
Class AA (extraordinary)	16.0°C
Class A (excellent)	18.0°C
Class B (good)	21.0°C

When natural conditions exceed the temperature standard, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C. If natural conditions are below the temperature standard, incremental temperature increase resulting from

nonpoint source activities shall not exceed 2.8°C or bring the stream temperature above the specified standard of the class at any time (Chapter 173-201A-030 WAC).

An alternative to the current temperature standard has been under discussion for several years. This alternative would be based on the presence or absence of particular species and its temperature needs at various life-history stages. The most current information on this alternative can be found in a draft discussion paper by Hicks (2001).

Temperature is a water quality concern because most aquatic organisms, including salmonids, are cold-blooded and are strongly influenced by water temperature (Schuett-Hames et al., 1999). Temperature is a major concern in the Walla Walla River and its tributaries because of the use of its waters by steelhead and bull trout, and their listing as a threatened species under the Endangered Species Act. Elevated temperature and altered channel morphology resulting from various land-use activities (such as timber harvest, flood control, and agriculture) in the area limit available spawning and rearing habitat for salmonids. In the Walla Walla basin, temperature has been noted as being the most critical physiological barrier to salmonids, particularly for passage or rearing (Mendel et al., 2000).

Historical Data Review

Washington State Department of Fish and Wildlife

Mendel et al. (2000) of Washington State Department of Fish and Wildlife (WDFW) has collected water quality and biological information within the Walla Walla River and its tributaries. This is an ongoing effort by WDFW to continue monitoring andronomous fish species and their subsequent habitat within this basin, since 1996.

Mendel et al. observed especially low flow periods during the summer months throughout the basin. These reduced flows were attributed to the end of spring runoff, water diversions for agricultural uses, and the lack of summer precipitation. Some specific observations were:

- Dewatering of the Walla Walla River channel for about 0.5 miles around Tum-a-lum Bridge, in Oregon.
- Sharp flow reductions below the Burlingame Diversion in mid to late June and in mid October to mid November.
- Steep decline in flows on the lower Touchet River below Hofer Diversion in August.

Continuous water temperature monitors were deployed throughout the Walla Walla River basin. Temperatures measured in the summer of 2000 were similar to those measured during the summer of 1999. The coolest reaches were those associated with the Blue Mountains, with maximum daily temperatures less than 18°C (65°F). Sites with maximum daily temperatures high enough to inhibit fish propagation (> 68°F, 20°C) were found in the mid to lower stream reaches of the Walla Walla and Touchet basins. Sites with maximum daily temperatures lethal to salmonid species (> 75°F, 24°C) are listed in Table 2. Night conditions generally decreased the temperatures within reasonable physiological limits for steelhead/rainbow trout, however,

Mendel states, “Temperature represents the most critical physiological barrier to salmonids, particularly for passage or rearing.”

Table 2: Sites that Exceed the Lethal Temperatures for Salmonids (>75°F) (Mendel et al. 2000).

# Sites to exceed 75° F	Location
8	Walla Walla River
2	Yellowhawk Creek
1	Birch Creek
1	Caldwell Creek
2	Garrison Creek (1 & 2)
2	Mill Creek (1 & 2)
1	Mud Creek
1	Pine Creek
4	Touchet River Below Dayton
3	Dry Creek
1	Lower Robison Fork
1	Lower S.F. Touchet
1	South Patit Creek
1	Mainstem Coppei Creek

Mendel et al. surveyed the fish populations within the Walla Walla basin. The North Fork and South Fork of the Touchet River supported the highest abundances of salmonid species. Native salmon species identified were: Mountain whitefish (*Prosopium williamsoni*), bull trout (*Salvelinus confluentus*), and rainbow/steelhead trout (*Oncorhynchus mykiss*). Brown trout (*Salmo trutta*) was the only nonnative salmonid species discovered. Most spawning habitat was found in the upper reaches, while the lower reaches of the Touchet and Walla Walla Rivers are mainly used for fish migration with little rearing capability.

Oregon State Department of Environmental Quality (ODEQ)

ODEQ is currently working on a temperature TMDL for the mainstem of the Walla Walla River to its confluence with Lake Wallula. This project is currently in progress and unpublished but will be considered by WDOE as work progresses on the tributaries.

Columbia Conservation District

Krause et al. (2001) participated in a two-year water quality study of the upper section of the Touchet watershed located in Columbia County. The focus of the study was to address the water quality concerns within the area during the years of 1999 and 2000.

Krause et al. stated that temperature was their primary concern with seven of the nine sampling sites exceeding the 18°C (65°F) Class A standard. Fecal coliform levels also exceeded Washington State standards for Class A streams in seven of the nine sites sampled. During the fall and winter months, sediment load peaked with two violations of the Class A standard. Streamflow was a limiting factor for water quality during the summer and fall seasons with the

South Fork Touchet River and Patit Creek being the most limited. Overall, water quality degradation increases as one moves downstream through the sites.

Krause et al. recommended future water quality monitoring with special focus on temperature, sediment, fecal coliforms, and flow. Sites should be selected to properly assess loading of tributaries in order to pinpoint sources of degradation. Flow, sediment, and fecal coliforms should be measured more extensively to accurately address their sources.

United States Department of Agriculture

The United States Department of Agriculture (USDA) (1981) studied eight basins in Southeast Washington. The scope of the study was to evaluate present and potential agricultural productivity in regards to the region's natural resources. Each basin was separated into its own study to focus locally on the problems in this region of the state.

Walla Walla River

USDA (1981) performed a stream survey to address water quality concerns in the Walla Walla. Sheet and Rill erosion and low stream flows have the most significant adverse effects on the water quality. The study revealed that major portions of the Walla Walla River essentially did not flow during the arid months of the year, due to irrigation diversion. Other portions had severely reduced flows throughout the summer months. The lower parts of the watershed have streambeds composed primarily of fines and gravels. Twenty two percent of the stream banks are actively eroding and adding to the sediment load due to poor or lacking riparian vegetation. Further, lack of riparian habitat due to agricultural practices along 35% of the total stream bank causes significant erosion problems. These factors combine to cause high summer water temperatures, which often reach lethal levels for salmonids. USDA found high stream temperature and low stream discharge being primary water quality problems in the Walla Walla Watershed in 1981.

Solutions to these problems that will ultimately increase agricultural production and reduce stream degradation are the following: impose better tillage techniques, plant riparian vegetation, and augment stream flows during the summer season.

Dry Creek

USDA's study of Dry Creek proved similar to the Walla Walla River study. Sheet and rill erosion are the biggest problems in the Dry Creek Watershed. These problems are caused by land being fallow for too long throughout the year, in addition to the removal of riparian vegetation and channalization of streams. 186 miles (46%) of road banks were actively eroding which account for 2,528 tons of soil loss each year. This increases the sediment load of Dry Creek, which discharges into the Walla Walla River and subsequently loading sediment to that system.

USDA recommended treatments similar to those reported for the Walla Walla River. Conservation groups should reestablish riparian vegetation and farmers should shift planting

schedules to reduce large summer fallow periods. Terracing and better tillage techniques should be considered.

Touchet River

In the lower Touchet River, sheet and rill erosion were major problems to agricultural productivity and stream habitat. Lower sections of the river reported high turbidity and sediment loads relative to the upper sections. Riparian vegetation was lacking in one third of the lower sites due to grazing. Throughout the lower sections, temperature was high and thought to have reached 27°C (80°F) during the height of the summer season. Historically, the conversion of native vegetation to cropland has led to the tendency of peak flows to increase. During the dry season, water diversion caused extremely low flows that were unsuitable for fish migration.

The upper Touchet tended to have better conditions and better maintained riparian vegetation than the lower sections. Salmonid habitat within this region is more developed; as a result, the upper Touchet system supported a larger population of Salmonid species.

[Washington State Department of Ecology](#)

White et al. (1998) concluded that the College Place Waste Water Treatment Plant was adversely affecting Garrison Creek in 1996. Average daily stream temperatures in September were 18.3°C, 20.5°C, and 19.7°C. The maximum temperature recorded during the study was 27.1°C. During the summer months, stream flows become extremely low during summer agriculture diversion. Salmonid migration would probably not be supported when diversions were in place. Below the WWTP, toxic effects of chlorine and ammonia, habitat alteration, and high temperatures degraded benthic communities. Both water quality and biological surveys depicted unsuitable habitat for salmonid species below the facility and were only partially supported throughout the creek.

[Washington State Conservation Commission \(WCC\)](#)

Kuttle et al. (2001) assessed the limiting factors for salmonid habitat within WIRA 32. The WCC found that surface water withdrawals, dryland agriculture, and residential development have profound negative impacts on salmonid habitat. Many of the streams exhibit low or non-existent summer stream flows and water temperatures exceeding the tolerance level of salmonids. According to WCC, these conditions are a result of removal of riparian habitat, surface water withdrawals, disruption of surface water-ground water exchange, channel straightening and bank armoring, and diking of floodplains. Water diversions are improperly screened, and many stream reaches carry extremely high, fine sediment loads from agricultural erosion. The lack of large woody debris, pools, and off channel habitat compounds the problem and greatly reduces salmonid spawning/rearing habitat.

In contrast, habitat conditions on public lands managed by the United States Forest Service (USFS) are the last remaining refuge for salmonid species. Habitats within these reaches have the proper riparian shading, pool quantities, and LWD. This has maintained a slowly dwindling population of salmonid species. WCC noted these conditions are not “ideal” but are far more favorable than the lower privately owned reaches.

The WCC made some recommendations for restoration efforts to reduce the most major limiting factors for salmonid habitat (List 1). In addition, the Technical Advisory Group (TAG) listed the most important reaches to protect for salmonid habitat (List 2). The TAG is a local interest group made up of scientists and resource managers who worked with the WCC in the development of this report.

List 1: WCC Recommendations for Reducing Limiting Factors for Salmonid Habitat.

1. Restore instream flows on the Walla Walla River from Nursery Bridge downstream to the state line.
2. Conduct a comprehensive inventory of surface water diversions and ensure compliance with juvenile fish screening regulations, particularly on the highly developed Little Walla Walla River System.
3. Protect the remaining quality salmonid habitat located on USFS lands.
4. Restore floodplain connectivity and natural channel migration on the Walla Walla River from the North/South Fork confluence downstream to the state line.
5. Implement instream projects on the Walla Walla River from Milton-Freewater downstream to the state line to reduce surface water loss to the gravel aquifer and create a low flow channel.
6. Restore riparian zones throughout the subbasin.
7. Ensure coordination of flow management on the Little Walla Walla River System near the state line to prevent stranding or mortality of salmonids in the Washington portion of the system.
8. Reduce fine sediment inputs to streams by replacing conventional tillage with no-till farming practices.

List 2: Vital Areas for Improving or Maintaining Salmonid Habitat Selected by the Technical Advisory Group (TAG).

1. North Fork Touchet River from Lewis Creek upstream.
2. Wolf Fork from Whitney Creek upstream.
3. Mill Creek from Blue Creek upstream.
4. Yellowhawk Creek.
5. South Fork Coppei Creek from the North/South Fork confluence upstream.
6. South Fork Walla Walla River from the confluence to the headwaters.
7. North Fork Walla Walla River on USFS lands.

Study Design

Approach

The Walla Walla River Tributaries Temperature TMDL will be developed for heat, which is considered a pollutant under Section 502(6) of the Clean Water Act. Heat energy processes that control energy transfer to and from a given volume of water include:

- Shortwave solar radiation.
- Longwave radiation exchange between the stream and both the adjacent vegetation and the sky.
- Evaporative exchange between the stream and the air.
- Convective exchange between the stream and the air.
- Conduction transfer between the stream and the streambed.
- Groundwater exchange with the stream (Adams and Sullivan, 1989).

If the heat energy entering the water from these sources is greater than the heat energy leaving the water, then stream water temperature will rise. Water temperature change, which is an expression of heat energy exchange per unit volume (Equation 1), is most strongly influenced by solar radiation input (Adams and Sullivan, 1989; Matthews, 1992).

Equation 1. Relationship between Temperature and Heat Energy for Surface Waters.

$$\Delta Temperature = \frac{\Delta Heat Energy}{Volume}$$

Increased solar radiation levels at the stream surface due to anthropogenic causes result from the following conditions:

- Channel widening (increased width-to-depth ratios) that increases the stream surface area exposed to energy processes.
- Riparian vegetation disturbance that reduces stream surface shading through reductions in riparian vegetation height and density. (Shade is commonly measured as percent effective shade.)
- Reduced summer baseflows resulting from instream withdrawals, wells in hydraulic continuity with the stream, or altered stream flow patterns due to land-use practices that increase runoff instead of storage.

The sources of increased stream temperatures will be examined in this Walla Walla River Tributaries temperature TMDL to produce a loading capacity and load and wasteload allocations for the heat load sources. Loading capacity and allocations will be established via field surveys and development of a predictive computer temperature model. Field data collection and assessment will be governed by the data set requirements of the computer temperature model.

Data Collection and Ecology Field Surveys

Data collection, compilation, and assessment will be governed by the data set requirements of the computer temperature model (Table 3). The data will be assembled from local third party studies and Ecology field surveys. Local third party studies include investigations by Washington State Department of Fish and Wildlife, the Army Corps of Engineers, the Columbia County Conservation District, and other potential data sources that are discovered during the study.

Five types of Ecology field surveys will be conducted: 1) continuous flow monitoring at selected gaging stations, 2) continuous monitoring of water and air temperature and relative humidity, 3) riparian surveys of the streams and rivers in the study area, 4) groundwater monitoring, and 5) remote sensing of surface temperatures using thermal infrared (TIR) technology.

1. Stream Flow Monitoring

Five on-site continuous flow-monitoring stations will be established by Ecology's Environmental Assessment Program's Stream Hydrology Unit in the study area during the duration of the sampling season, June through October. The standard protocols for the on-site continuous data loggers will follow those currently established by the Stream Hydrology Unit (Ecology, 2000). Stations maintained by the USGS provide a continuous flow monitoring site on the Walla Walla River and two sites on Mill Creek (Figure 2). Additional sites established by the basin watermaster in cooperation with the Washington State Department of Fish and Wildlife will also be utilized during this project. Instantaneous flow measurements will be taken monthly at the continuous flow-monitoring stations and at most temperature sites. Instantaneous flows will also include a measurement taken during the synoptic flow survey that coincides with the TIR survey (below).

Figure 2: Proposed Continuous Flow Stations for the Walla Walla Temperature TMDL. See Appendix A

Table 3: Model Data Requirements and Collection Source.

	PARAMETER	Effective shade	Qual2K	TIR	WDFW	Ecology
Flow	discharge - tributary		x		x	x
	discharge (upstream & downstream)		x		x	x
	flow regression constants		x			
	flow velocity		x		x	x
	groundwater inflow rate/discharge		x			x
	travel time		x			
General	calendar day/date	x	x	All Data Collected Primarily from USGS or GIS Maps		
	duration of simulation	x	x			
	elevation - downstream	x	x			
	elevation - upstream	x	x			
	elevation/altitude	x	x			
	latitude	x	x			
	longitude	x	x			
time zone	x					
Physical	channel azimuth/stream aspect	x				
	cross-sectional area	x	x			x
	Manning's n value	x	x			
	percent bedrock	x	x			x
	reach length	x	x			x
	stream bank slope	x				x
	stream bed slope	x	x	Collect from USGS or GIS Maps		
	width - bankfull	x				x
	width - stream	x	x		x	x
Temperature	temperature - ground		x			x
	temperature - groundwater		x			x
	temperature - water downstream		x	x	x	x
	temperatures - water upstream		x	x	x	x
	temperature - air		x			x
	thermal gradient		x			
Vegetation	% forest cover on each side	x				x
	canopy-shading coefficient/veg density	x				x
	diameter of shade-tree crowns	x				x
	distance to shading vegetation	x				x
	topographic shade angle	x				x
	vegetation height	x				x
	vegetation shade angle	x				x
	vegetation width	x				x
Weather	relative humidity		x	Weather Staion/RH meters		
	% possible sun/cloud cover		x	Weather Station		
	solar radiation		x	Weather Station	Field	
	temperature - air		x	check/Weather Station	Weather	
	wind speed/velocity		x	Station		

2. Temperature Sites

Water temperature sites will be established at 28 locations (Figure 3) throughout the study area. Air temperature will be monitored at 20 of these sites, and relative humidity will be monitored at 3 of these sites. Water and air temperature will be measured with Onset StowAway Tidbits. Relative humidity will be measured with an Onset H8 Pro RH/temperature data logger. The temperature data loggers will be installed in a location in the stream or riparian forest which is shaded from direct sunlight. They will be placed in an area representative of the surrounding environment. The water temperature logger will be installed at approximately one-half of the water depth and as close to the center of the thalweg as possible. The installation site will be located where there is obvious water mixing and at a depth that will not become exposed if the water level drops but will not be affected by groundwater inflow or stratification. The air temperature data loggers will be installed adjacent to the water temperature probe about one to three meters into the riparian zone from the edge of the bankfull channel and about one meter off the ground.

Figure 3: Potential Temperature Monitoring Sites for the Walla Walla Temperature TMDL. See Appendix A

3. Riparian Stream and Habitat Surveys

Timber-Fish-Wildlife Stream Temperature Survey methods will be followed for the collection of data during thermal reach surveys (Schuett-Hames et al., 1999). The surveys will be conducted July to August 2002 at the temperature sites established by Ecology (Table 3). Field measurements will be taken at 6 to 10 locations over a 300-meter thermal reach and will consist of bankfull width and depth, wetted width and depth, effective shade, and channel type. Riparian Management Zone (RMZ) characteristics, such as active channel width, cover, size, density, and bank erosion, will also be recorded during the surveys. Hemispherical photography will be used to measure effective shade and canopy density at all water temperature stations, and at additional selected locations as necessary, to ground-truth the range of vegetation classes digitized from inspection of digital orthophotos.

4. Groundwater Survey

Mini-instream piezometers will be installed near selected bridge crossings of Yellowhawk and Mill Creeks and the Touchet River to define the vertical hydraulic gradient between area streams and the water-table aquifer. The piezometers consist of a seven-foot length of ½ inch diameter galvanized pipe, one end of which is crimped and slotted. The piezometers will be hand driven into the stream bed to a depth of approximately five feet.

Water levels in the piezometers will be measured monthly between June and Sept 2002 using a calibrated electric well probe or steel tape in accordance with standard USGS methodology (Stallman, 1983). The head difference between the internal piezometer water level and the external creek stage, provides an indication of the vertical hydraulic gradient and the direction of flow between the creek and groundwater. When the piezometer head exceeds the creek stage,

ground water discharge into the creek can be inferred. Similarly, when creek stage exceeds the head in the piezometer, loss of water from the creek to ground water storage can be inferred.

Surface water temperature, groundwater temperature, and conductivity will be measured during each of the monthly piezometer surveys. Stream reaches with significant groundwater input (especially during low flow periods) should have similar water chemistry to area groundwater. Measurements will be made with properly maintained and calibrated field meters in accordance with standard USGS methodology.

5. Thermal Infrared (TIR) Surveys

Approximately 100 miles of streams and rivers in the study area (Figure 5) will be flown to provide simultaneous thermal (TIR) and visible video coverage that are geographically linked through a Global Positioning System (GPS) and geo-referenced through a Geographic Information System (ArcView GIS). This area includes the Touchet River from the mouth to just above Dayton and portions of the North Fork Touchet, South Fork Touchet, and Wolf Creek. Yellowhawk Creek and Upper Mill Creek may be surveyed depending on stream size. Each thermal image will cover a ground area of approximately 100 x 150 meters and have a spatial resolution of less than 0.5 meters per pixel. The thermal imagery will be calibrated to measured water temperatures and will have an accuracy of approximately +/- 0.4 degrees C. The TIR survey will occur sometime between July 20 and August 20. Data collection will be timed to capture the maximum daily stream temperatures, which typically occur between 14:00 and 17:00 hours.

Figure 4: Potential TIR Sampling for the Walla Walla Temperature TMDL. See Appendix A.

Data Collection Timeline

The field schedule during 2002 shows approximate dates of datalogger installation, data download, and stream surveys:

May 10 - 30	Continuous flow monitoring devices installed and launched.
May 10 - June 15	Temperature data logger (tidbit) installed.
May 10 - Oct 30	Instantaneous flow measurements for rating curves.
June 18 - 30	Download temperature data from loggers and take instantaneous flow measurements.
July 18 - Aug 15	TIR survey (schedule depends on TIR contractor and weather).
July 1 - Aug 31	Stream and habitat surveys.
July 18 - Aug 15	Synoptic flow measurements taken on tributaries and mainstem, and download temperature data from loggers.
Aug 13 - 17	Download temperature data from loggers and take instantaneous flow measurements.
Sept 17 - 21	Download temperature data from loggers and take instantaneous flow measurements.
Oct 22 - 31	Download final temperature data, remove tidbits.

*Timeline may change due to irregularities in stream discharge and/or weather to ensure data quality.

Project Organization

The roles and responsibilities of Ecology staff involved in this project are provided below:

Anita Stohr: Temperature Study Project Manager, Watershed Ecology Section, Environmental Assessment Program. Responsible for overall project management. Defines project objectives, scope, and study design. Responsible for review of the project Quality Assurance (QA) Project Plan and final technical report. Manages data collection program. Writes TMDL technical study report.

Michael LeMoine: Temperature Study Lead Field Investigator, Watershed Ecology Section, Environmental Assessment Program. Coordinates and conducts field sampling and data collection. Assists in defining project objectives, scope, and study design. Assists with data analysis and modeling tasks. Responsible for writing the temperature portions of the QA Project Plan and portions of the final report relating to data collection, field methods, and data quality review and analysis.

Marcie Mangold: TMDL Lead, Water Quality Program, Eastern Regional Office, ERO. Reviews and comments on QA Project Plan and reports. Coordinates local outreach and information exchange about the technical study and local development of implementation and monitoring plans between Ecology and local planning groups. Supports data collection as part of the TMDL implementation monitoring.

Chuck Springer, and Chris Evans: Stream Hydrology Unit, Environmental Monitoring and Trends Section, Environmental Assessment Program. Responsible for the deployment and maintenance of continuous flow loggers and staff gages on mainstem tributaries. Responsible for producing records of hourly flow data at select sites for the study period.

Kirk Sinclair: Watershed Ecology Section, Environmental Assessment Program. Install mini-piezometer network for the purpose of sampling groundwater contribution.

Nancy Weller: Unit Supervisor, Water Quality Program, ERO. Reviews and comments on QAPP and reports. Responsible for approval of TMDL submittal to EPA.

Don Nichols: Acting Section Manager, Water Quality Program, ERO. Reviews and comments on QAPP and reports. Responsible for approval of TMDL submittal to EPA.

Will Kendra: Section Manager, Watershed Ecology Section, Environmental Assessment Program. Responsible for approval of the project QA Project Plan, and review of final technical report.

Darrel Anderson: Unit Supervisor, Nonpoint Studies Unit, Environmental Assessment Program. Responsible for the technical study budget, review of the project QA Project Plan, and review of the final technical report.

Cliff Kirchmer: Environmental Assessment Program, Quality Assurance Unit. Reviews and comments on the draft QA Project Plan and will be available for technical assistance on QA during the implementation and assessment phases of the project.

Valuable assistance for this project will be provided by outside support from Glen Mendel at the local Washington State Department of Fish and Wildlife. Glen Mendel has collected temperature data for the last few years within the basin and may provide a significant portion of the data needed for this project.

Data Quality Objectives

Accuracy objectives for field measurements are presented in Table 3. Experience at Ecology has shown that duplicate field thermometer readings consistently show a high level of precision, rarely varying by more than 0.2°C. Therefore, replicate field thermometer readings were not deemed to be necessary and will not be taken. Accuracy of the thermograph data loggers and the field thermometers will be maintained through pre- and post-calibration in accordance with TFW stream temperature survey protocol to document instrument bias and performance at representative temperatures. A certified reference thermometer will be used for the calibration. The certified reference thermometer, manufactured by HB Instrument Co. (part No. 61099-035, serial No. 2L2087) is certified to meet ISO9000 standards and calibrated against National Institute of Standards and Technology (NIST) traceable equipment. The field thermometer is a Brooklyn Alcohol Thermometer (model No. 67857). If there is a temperature difference of greater than 0.2°C, the field thermometer's temperature readings will be adjusted by the mean difference.

Manufacturer specifications report an accuracy of $\pm 0.2^{\circ}\text{C}$ for the Onset StowAway Tidbit (-5°C to $+37^{\circ}\text{C}$) and $\pm 0.4^{\circ}\text{C}$ for the Onset StowAway Tidbit (-20°C to $+50^{\circ}\text{C}$). If the mean difference between the NIST thermometer and the thermal data loggers differs by more than the manufacturer's reported specifications, the thermal data logger will not be used during field work.

Ecology will install two water temperature thermographs at three of the five sites where continuous flow is monitored. Accuracy of the data loggers will be evaluated by comparing data downloaded from the loggers to reference temperature readings taken with a calibrated field thermometer during site visits throughout the sampling season. The mean difference between the downloaded data and the reference thermometer readings will be calculated. Data are only acceptable if they do not exceed a maximum mean difference of 0.2C. The comparability of the data loggers will be determined by comparing the mean difference between each groups downloaded temperature data. The data are deemed acceptable if the mean difference does not exceed 0.2°C.

Representativeness of the data is achieved by a sampling scheme that accounts for land practices, flow contribution of tributaries, and seasonal variation of instream flow and temperatures in the basin. Extra calibrated field thermometers and thermograph data loggers will be taken in the field during site visits and surveys to minimize data loss due to damaged or lost equipment.

Table 4: Summary of Field Measurements, Target Accuracy or Reporting Values, and Methods

Parameter	Accuracy or Reporting Values	Method
Air Temperature Water Temperature	$\pm 0.4^{\circ}\text{C}$ $\pm 0.2^{\circ}\text{C}$	Onset Stowaway Tidbit Onset Stowaway Tidbit
Relative Humidity	$\pm 3\%$	Onset RH
Velocity	$\pm 2\%$ of reading	Marsh-McBirney Model 201 current Meter

Measurement and Sampling Procedures

Field sampling and measurement protocols will follow those described in the Timber-Fish-Wildlife (TFW) Stream Temperature Survey Manual (Schuett-Hames et al., 1999) and the Watershed Assessment Section (WAS) protocol manual (WAS, 1993). Temperature thermographs will be installed in the water and air in areas which are representative of the surrounding environment and are shaded from direct sunlight. To safeguard against data loss, data from the loggers will be downloaded midway through the sampling season. The stream surveys will collect data according to TFW protocols for bankfull width and depth, wetted width and depth, canopy closure, and channel type. Riparian management zone (RMZ) characteristics, such as width, cover, size, density, and windthrow, will also be recorded during the surveys. (Schuett-Hames et al., 1999).

Quality Control Procedures

Variation for field sampling will be addressed with a field check of the instruments with a handheld thermometer at all thermograph sites upon deployment, retrieval, and also once during the sampling season (mid-August). Field sampling and measurements will follow quality control protocols described in the WAS protocol manual (WAS, 1993) and the TFW stream temperature manual (Schuett-Hames et al., 1999). The Optic Stowaway Tidbits will be pre- and post-calibrated in accordance with TFW stream temperature survey protocol to document instrument bias and performance at representative temperatures. A certified reference thermometer will be used for the calibration.

Data Analysis and Modeling Procedures

From the raw data collected at each monitoring location, the maximum, minimum, and daily average will be determined. The data will be used to characterize the water temperature regime of the basin and to determine periods when the water temperatures are above state numeric water quality standards (16°C for Class AA, 18°C for Class A, and 21°C for Class B). Estimates of groundwater inflow will be calculated by constructing a water mass balance from continuous and instantaneous streamflow data and piezometer studies.

A model will be developed for observed and critical conditions. Critical conditions for temperature are characterized by a period of low flow and high water temperatures. The model will be used to develop load and wasteload allocations for heat energy to the stream. Sensitivity analysis will be run to assess the reliability of the model results.

Data collected during this TMDL effort will allow the development of a temperature simulation methodology that is both spatially continuous and which spans full-day lengths. The GIS and modeling analysis will be conducted using three specialized software tools:

- ODEQ's Ttools extension for Arcview (ODEQ, 2001) will be used to sample and process GIS data for input to the HeatSource/Shadealator and QUAL2K models.
- ODEQ's HeatSource/Shadealator model (ODEQ, 2000) will be used to estimate effective shade along the mainstems of the major tributaries in the Walla Walla River basin. Effective shade will be calculated at 50 to 100-meter intervals along the streams and then averaged over 500 to 1000-meter intervals for input to the QUAL2K model.
- The QUAL2K model (Chapra, 2001) will be used to calculate the components of the heat budget and simulate water temperatures. QUAL2K simulates diurnal variations in stream temperature for a steady flow condition. QUAL2K will be applied by assuming that flow remains constant for a given condition such as a 7-day or 1-day period, but key variables are allowed to vary with time over the course of a day. For temperature simulation, the solar radiation, air temperature, relative humidity, headwater temperature, and tributary water temperatures are specified or simulated as diurnally varying functions. QUAL2K uses the kinetic formulations for the components of the surface water heat budget that are described in Chapra (1997). Diurnally varying water temperatures at 500 to 1000-meter intervals along the streams in the Walla Walla River basin will be simulated using a finite difference numerical method. The water temperature model will be calibrated to in-stream data along the mainstem of the Touchet River and Upper Mill Creek. Modeling of Yellowhawk Creek and selected sections of the Wolf Fork, South Fork, and North Fork of the Touchet can occur depending on data availability, flow conditions, and desire of the watershed technical group.

At this point, Qual2K and HeatSource are the preferred tools to model temperature. HeatSource has a proven history in calculating effective shade in both Oregon and Washington temperature TMDLs. Qual2K can model various water quality parameters thus can incorporate temperature modeling with other TMDL efforts. This will be advantageous for Ecology's efforts for an "one entry TMDL."

Reporting Schedule

The reporting schedule for this project is as follows:

January 2004 Draft report due to Nonpoint Studies Unit Supervisor

March 2004 Draft report due to clients

April 2004 Draft report out for external review

June 2004 Final report to printer

References

- Adams, T. and K. Sullivan. 1989. The Physics of Forest Stream Heating: A Simple Model. Timber/Fish/Wildlife Rep. No. TFW-WQ3-90-007. Weyerhaeuser, Federal Way, WA.
- Brown, G. W. 1969. Predicting Temperatures of Small Streams. Water Resources Research. 3(1):68-75.
- Chapra, S. C. 2001. Water-Quality Modeling Workshop for TMDLs, Washington State Department of Ecology, Olympia, WA, June 25-28, 2001.
- Ecology. 2000. DRAFT - Instantaneous Flow Measurements: Determination of Instantaneous Flow Measurements of Rivers and Streams. Stream Hydrology Unit, Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. June.
- Ecology. 2000. Ecology's 1998 Section 303(d) List of Impaired and Threatened Waterbodies <http://www.ecy.wa.gov/programs/wq/303d/1998/1998-index.html>. Washington State Department of Ecology, Olympia, WA.
- Hicks, Mark, 2001. Evaluating Standards for Protecting Aquatic Life in Washington's Surface Water Quality Standards Temperature Criteria: Draft Discussion Paper and Literature Summary. Water Quality Program, Washington State Department of Ecology.
- Krause, T., S. Chen, L. Audin, A. Davidson, and D. Saul, 2001. Touchet River Water Quality Monitoring Report February 1999 - January 2001 Final Report. Prepared for the Columbia Conservation District, September, pp 34.
- Kuttel Jr., M. Washington State Conservation Commission, 2001. Salmonid Habitat Limiting Factors Water Resource Inventory Area 32: Walla Walla Watershed. Washington State Conservation Commission, April, pp 171.
- Mendel, G. 2002. Personal Communication. Washington State Department of Fish and Wildlife, Dayton, WA. March 7, April 8, and April 16, 2002.
- Mendel, G., D. Karl, and T. Coyle. Washington Department of Fish and Wildlife, 2000. Assessment of Salmonids and their Habitat Conditions in the Walla Walla River Basin of Washington: 2000 Annual Report, Report to Bonneville Power Administration, Contract No. 00000485, Project No. 199802000, pp 116.
- ODEQ. 2001. Ttools 3.0 User Manual. Oregon Department of Environmental Quality. Portland, OR. <http://www.deq.state.or.us/wq/TMDLs/WQAnalTools.htm>.
- ODEQ Website. 2000. Heat Source Methodology Review. <http://waterquality.deq.state.or.us/wq/HeatSource/HeatSource.htm>. Oregon Department of Environmental Quality.

Rashin, E. and C. Graber. 1992. Effectiveness of Washington's Forest Practice Riparian Management Zone Regulations for Protection of Stream Temperature. Timber/Fish/Wildlife Report No. TFW-WQ6-92-001. Ecology Publication No. 92-64. Washington State Department of Ecology, Olympia, WA. July.

Schuett-Hames, D., A. Pleus, E. Rashin, and J. Matthews. 1999. TFW Monitoring Program Method Manual for the Stream Temperature Survey. Prepared for the Washington State Department of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-005. DNR # 107. June.

Stallman, R. W., 1983. Aquifer-Test Design, Observation and Data Analysis: Techniques of Water-Resources Investigations of the United States Geological Survey, Book 3, Chapter B1, 26 p.

Sullivan, K., J. Tooley, K. Doughty, J. Caldwell, P. Knudsen. 1990. Evaluation of Predictions Models and Characterization of Stream Temperature Regimes in Washington. Timber/Fish/Wildlife Rep. No. TFW-WQ3-90-006. Washington State Department of Natural Resources, Olympia, WA. December.

USDA 1981. Southeast Washington Cooperative River Basin Study: Dry Creek Watershed, Soil Conservation Service.

USDA 1981. Southeast Washington Cooperative River Basin Study: Touchet River Watershed, Soil Conservation Service.

USDA 1981. Southeast Washington Cooperative River Basin Study: Walla Walla River Watershed, Soil Conservation Service.

WAS. 1993. Field Sampling and Measurement Protocols for the Watershed Assessments Section. Publication No. 93-e04. Washington State Department of Ecology, Olympia, WA.

White, J., E. Rashin, E. Nocon, and J. Summers. 1998. Garrison Creek Use-Based Receiving Water Study. Washington State Department of Ecology, Pub. No. 98-302, March, pp 64.

Appendix A

Maps and Figures

- Figure 1: 1998 303d Listings for Temperature in the Walla Walla Basin (WIRA 32).
- Figure 2: Proposed Continuous Flow Stations for the Walla Walla Tributaries Temperature TMDL.
- Figure 3: Potential Temperature Monitoring Sites for the Walla Walla Tributaries Temperature TMDL.
- Figure 4: Potential TIR Sampling for the Walla Walla Tributaries Temperature TMDL.

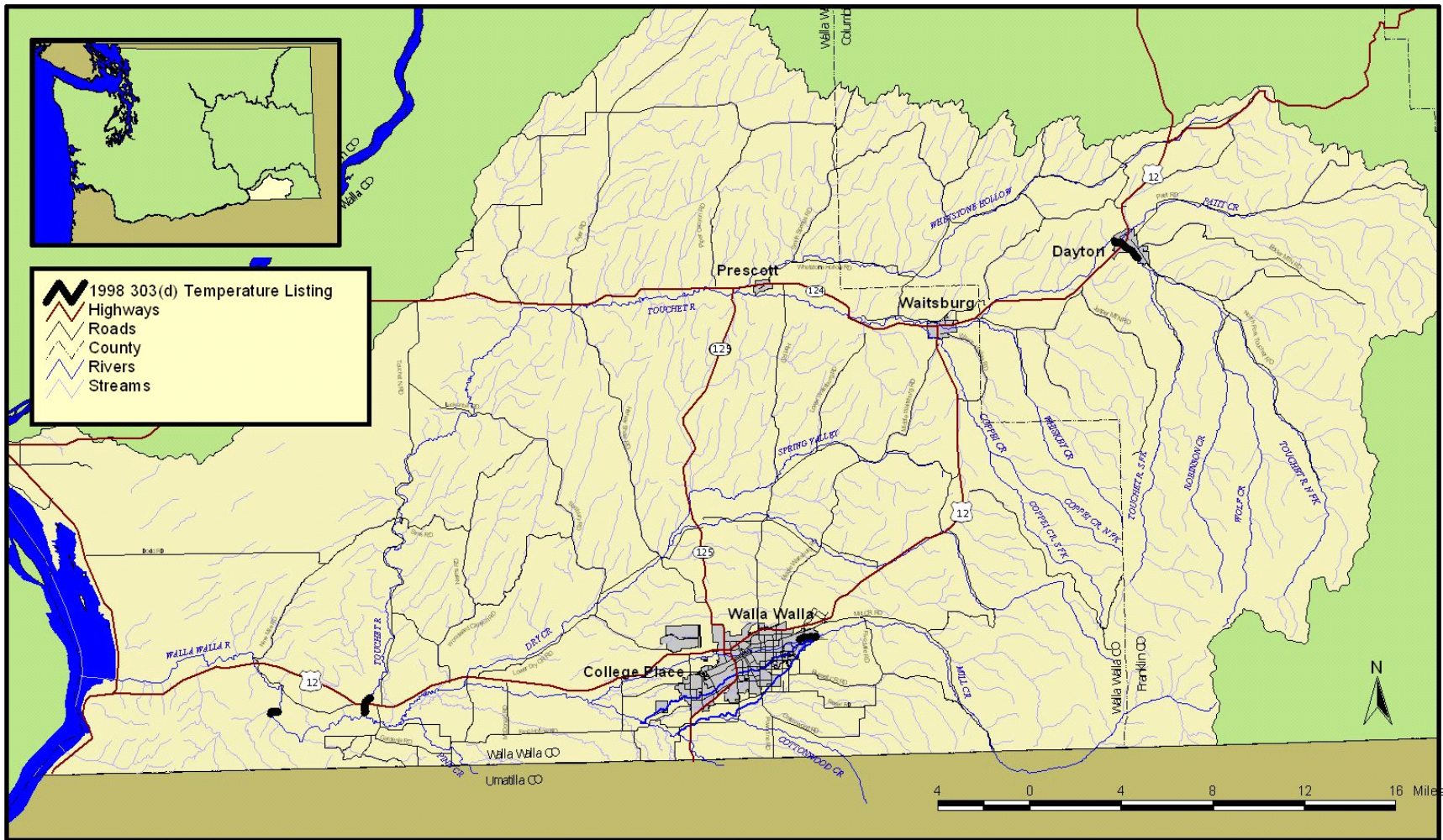


Figure 1: 1998 303d Listings for Temperature in the Walla Walla Basin (WIRA 32)

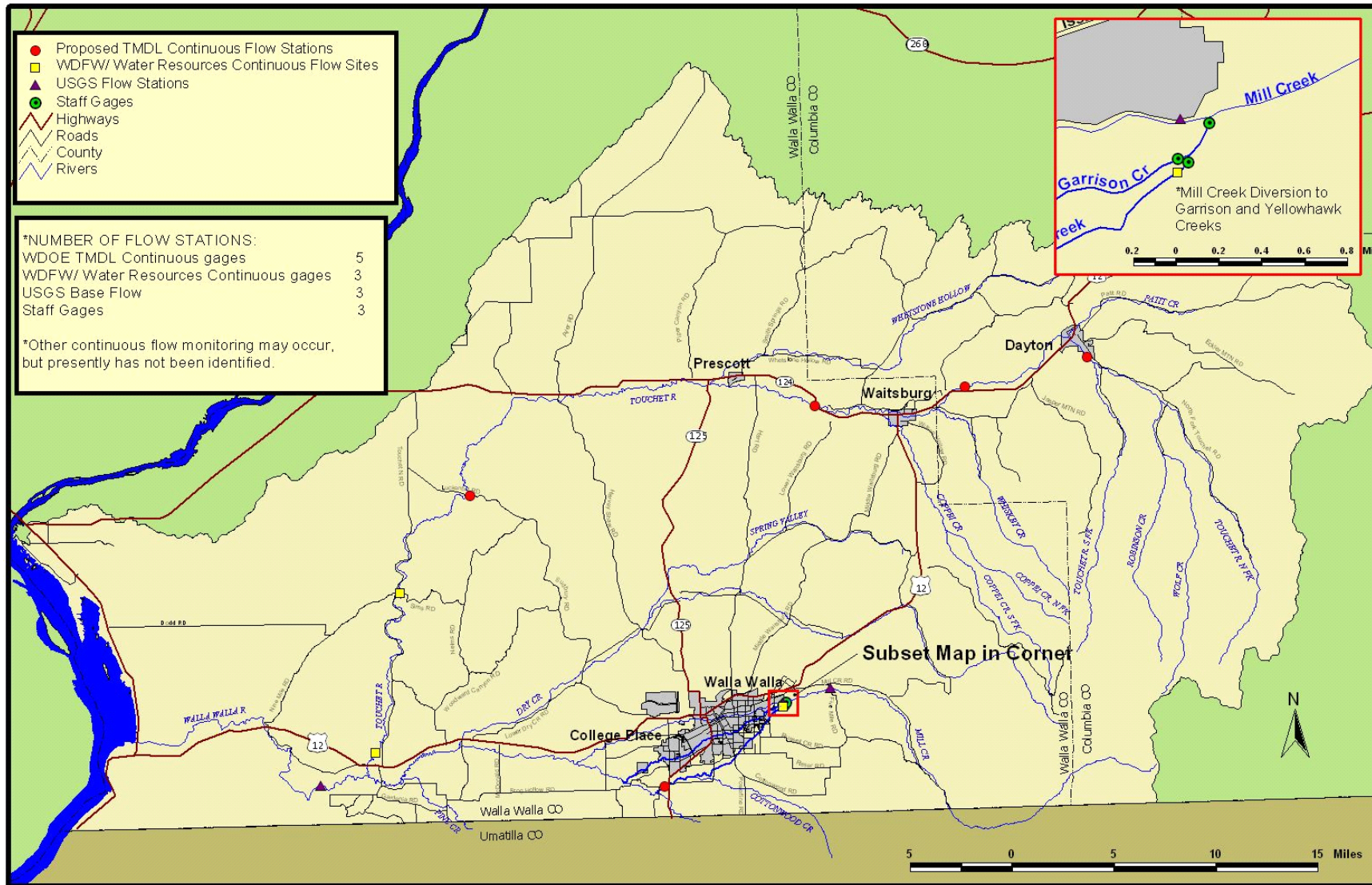


Figure 2: Proposed Continuous Flow Stations for the Walla Walla Tributaries Temperature TMDL

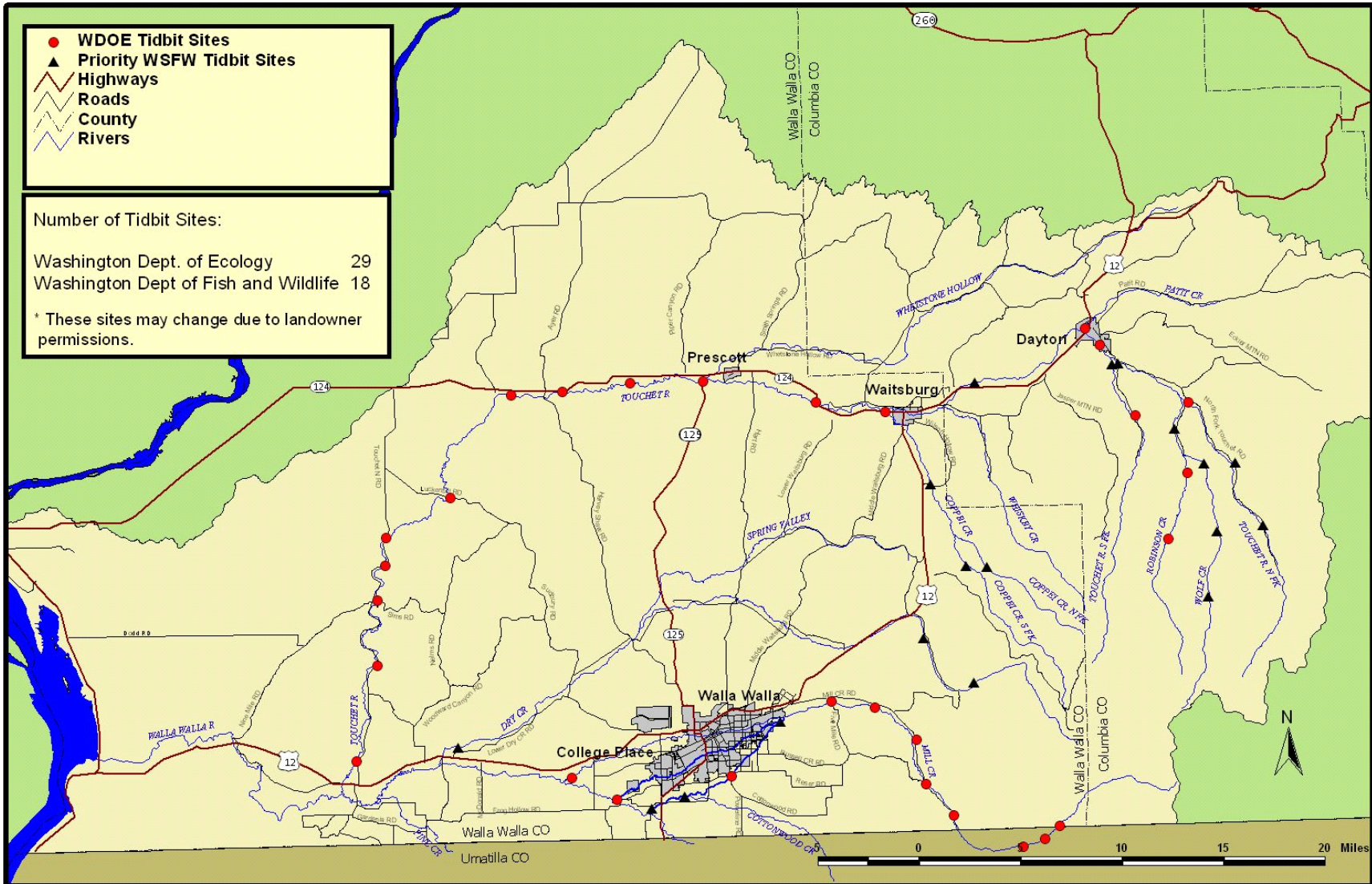


Figure 3: Potential Temperature Monitoring Sites for the Walla Walla Tributaries Temperature TMDL

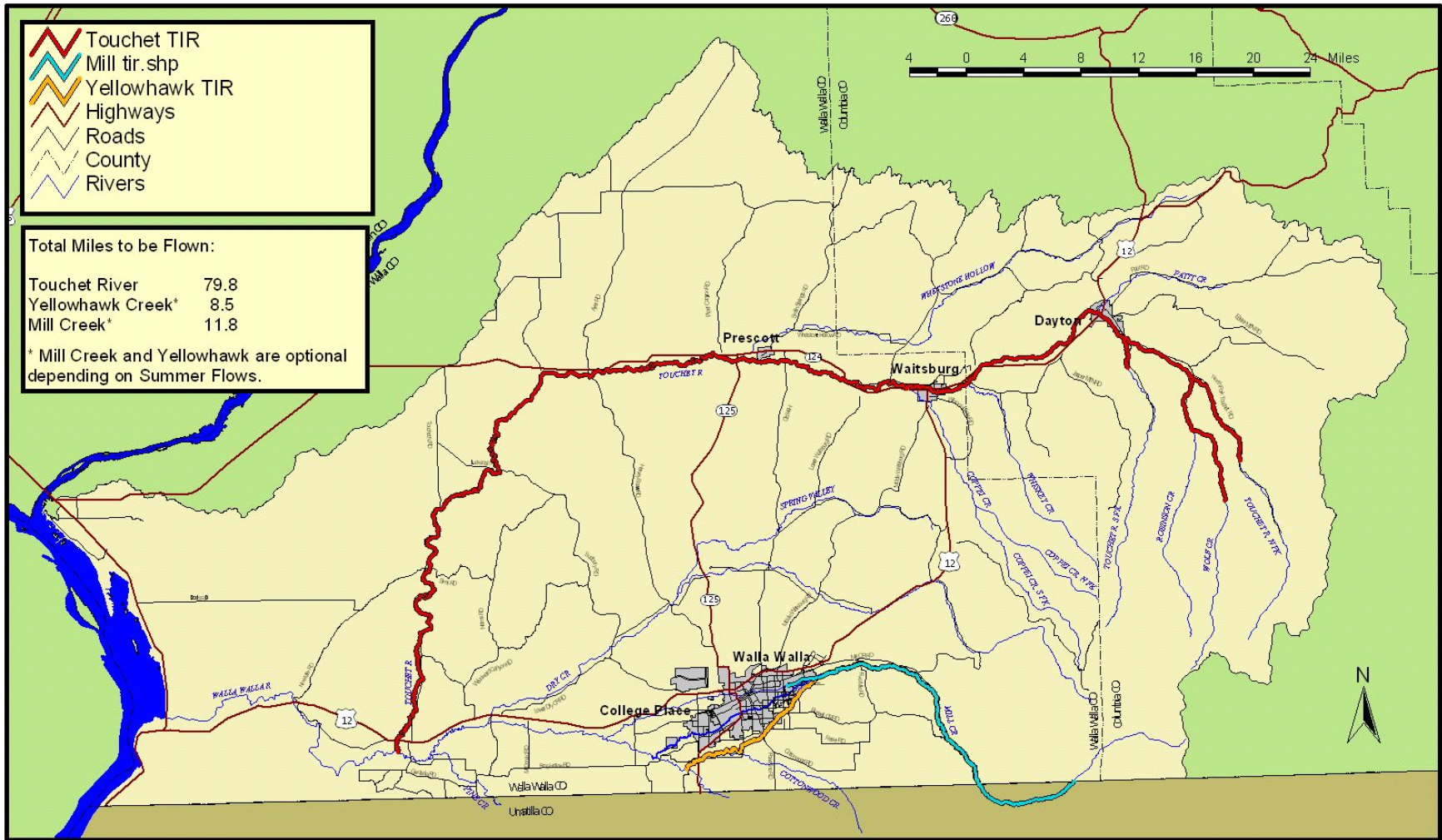


Figure 4: Potential TIR Sampling for the Walla Walla Tributaries Temperature TMD