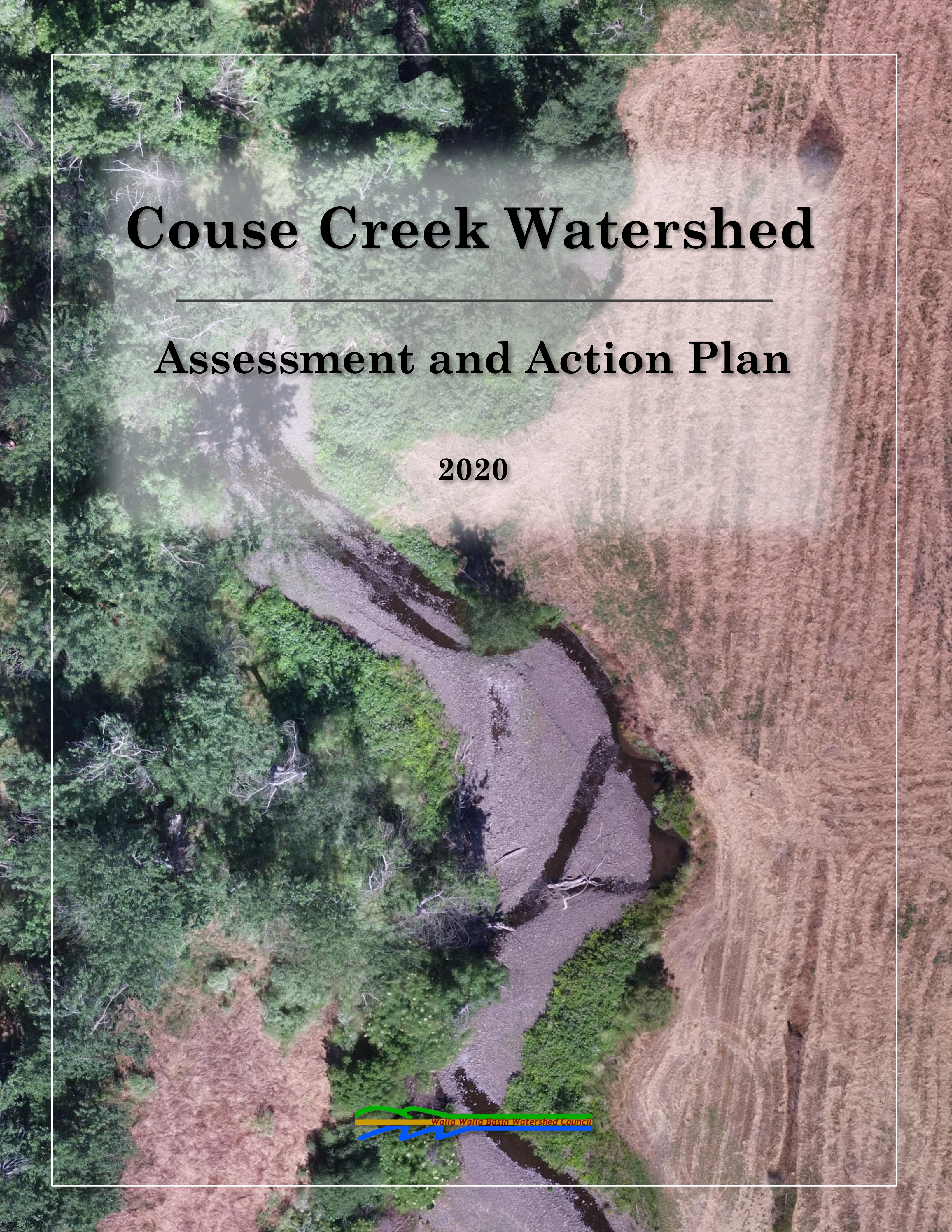

Couse Creek Watershed

Assessment and Action Plan

2020

Walla Walla Basin Watershed Council

COUSE CREEK WATERSHED ASSESSMENT AND ACTION PLAN

Walla Walla Basin Watershed Council

2020

This report can be found on the WWBWC website:
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LIST OF ABBREVIATIONS AND ACRONYMS

ac-ft	acre-feet
BPA	Bonneville Power Administration
bgs	below ground surface
cfs	cubic feet per second
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
DOGAMI	Oregon Department of Geology and Mineral Industries
LWD	Large woody debris
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
POD	Point of diversion
SWAT	Soil and Water Assessment Tool
USFS	United States Forest Service
USGS	United States Geological Survey
WEPP	Watershed Erosion Prediction Project Model
WWBWC	Walla Walla Basin Watershed Council

SUMMARY

The purpose of this assessment was to identify naturally functioning watershed components and to document impairments and opportunities to restore watershed processes to benefit fish and wildlife while supporting sustainable agricultural practices. WWBWC evaluated Couse Creek hydrology, water temperature, geology, geomorphology and fish habitat, and sediment inputs. Findings include the following:

- Flow and water temperature conditions are moderately suitable during peak steelhead migration, and favorable habitat conditions exist in Reaches 4 and 5.
- Summer and fall flows are low and intermittent with high water temperatures in the lower half of the watershed and portions of the upper reaches as well.
- Alluvial aquifer storage is not likely to be a useful tool for flow enhancement in the watershed because of steep slopes and shallow alluvial deposits. However, a better understanding of naturally occurring basalt aquifer recharge and identification of spring sources could lead to recommendations for protection and improvement.
- Floodplain connection is variable, with about a third of the surveyed channel being unconstrained with floodplain access. Hillslopes and terraces limit floodplain connectivity for much of the channel, and portions of Reach 1 are deeply incised.
- Instream habitat is strongly riffle-dominated and lacks complexity. Pool formation is limited.
- Substrate composition is dominated by gravel and cobble and provides moderately desirable habitat value.
- Much of Couse Creek is shaded by riparian vegetation with several notable exceptions. Riparian trees are smaller than desirable and the size and quantity of large woody debris was ranked poor but is adequate to affect channel changes, particularly in Reach 1.
- Roads, particularly where they cross drainages, are contributing sediment to the watershed stream network. Native surface farm roads along with steep county gravel roads are providing the majority of sediment to Couse Creek from the existing road network.
- Hillslope conditions range from full tree canopy closure with slope percentages of less than 10% to open grass/shrubland ecotypes with slope percentages of greater than 50%. Sediment yields are found to be higher in the steeper slope/loamy soils dominated by annual grasses and noxious weeds.

Recommended actions to enhance naturally functioning watershed processes are described in Section VI.

SECTION I: INTRODUCTION

Purpose and Background

Couse Creek is identified as an important area for steelhead production within the Walla Walla Subbasin, and degradation of this system could have a particularly harmful impact on the Walla Walla population (NWPCC, 2004). The 2020 Couse Creek Watershed Assessment and Action Plan provides the framework to protect and restore ecological function within the Couse Creek watershed for the benefit of native fish and wildlife while maintaining sustainable agricultural practices.

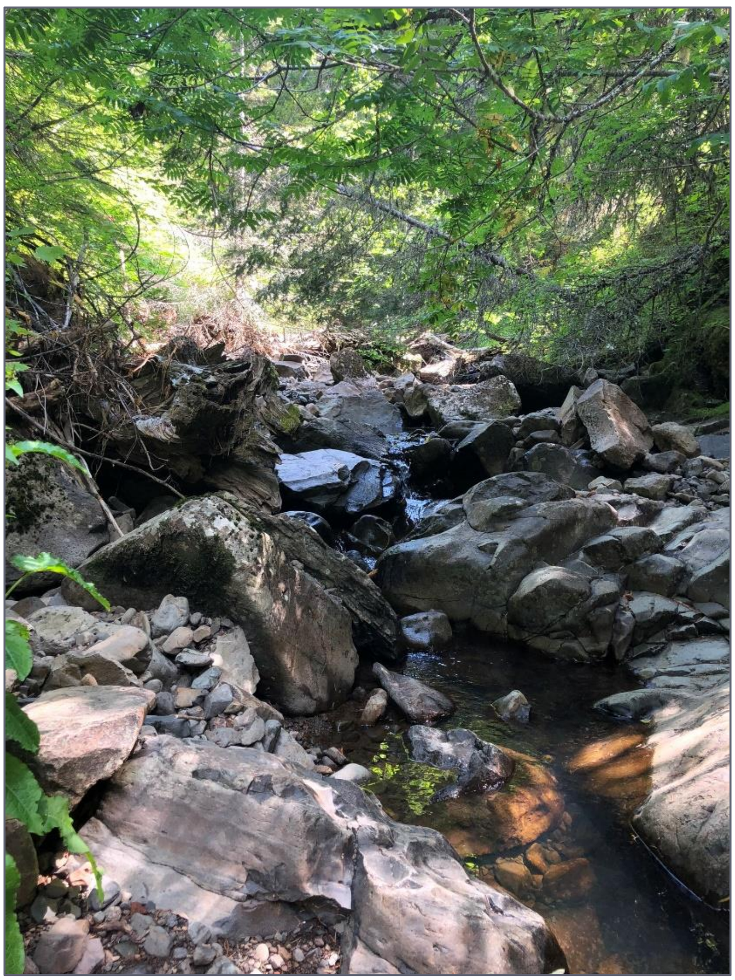
A tributary to the Walla Walla River, Couse Creek drains an area of approximately 25 square miles. Its headwaters are in the Blue Mountains just west of Tollgate, Oregon at an elevation of 4,300 feet. It enters the Walla Walla River just upstream of the City of Milton-Freewater, Oregon at 1,150 feet (Figure 1). Couse Creek has a rain, snow-melt and groundwater-based hydrology. Once the winter precipitation and spring freshet season ends, the almost exclusive source of water is groundwater entering the stream as springs or hyporheic (subsurface) flows. The watershed once supported a strong historic run of chinook salmon (personal communication, 1890) and is currently home to ESA-listed Mid-Columbia Basin summer steelhead. Major land uses include recreation (cabins and roads) in the uppermost portion of the watershed, logging and grazing at slightly lower elevations, dryland agriculture at mid-elevations, and rural residences at low elevations adjacent to the stream.

In collaboration with private landowners, the Couse Creek Watershed Assessment and Action Planning process was conducted by the Walla Walla Basin Watershed Council (WWBWC), a non-profit organization led by local stakeholders including water users, municipal leaders, business interests, landowners, citizens, water resource professionals, and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). WWBWC was formed in 1994 in response to pressing local watershed issues and continues operating with the mission to "enhance, restore and protect the Walla Walla Basin's native aquatic populations, watersheds, fish and wildlife habitat and water quality, while sustaining a healthy economy." Project partners include private landowners, the Oregon Department of Fish and Wildlife (ODFW), CTUIR, Oregon Department of Agriculture, and other basin stakeholders. Funding was provided by the Oregon Watershed Enhancement Board (OWEB) and the Oregon Department of Environmental Quality (ODEQ).

Previous assessments of the Walla Walla Basin, including the 2004 Walla Walla Subbasin Plan (NWPCC) and the 2005 Walla Walla Stream Temperature TMDL (ODEQ), have broadly documented limiting factors for Walla Walla River tributaries and some specifically related to Couse Creek but not with enough resolution to identify and prioritize areas for protection and for restoration. Watershed issues identified for Couse Creek include limited flow, elevated water temperatures, high sediment loads, reduced floodplain connectivity (including incised channels), reduced riparian vegetation, and fish passage obstructions.

To assess conditions in the watershed, existing data were compiled, landowners were interviewed, stream habitat conditions were surveyed, flow and water temperature data were collected, road conditions and hillslope erosion were assessed, and a geospatial database created. Based on the results of the assessment, an action plan was developed. This work will benefit habitat and water quality in two ways:

- First, it will identify areas with functioning instream components, riparian area or road conditions for protection to ensure these areas continue to function and do not degrade.
- Second, it will identify areas for possible restoration activities to restore lost instream, floodplain and riparian functions or improve road conditions to reduce sediment input.



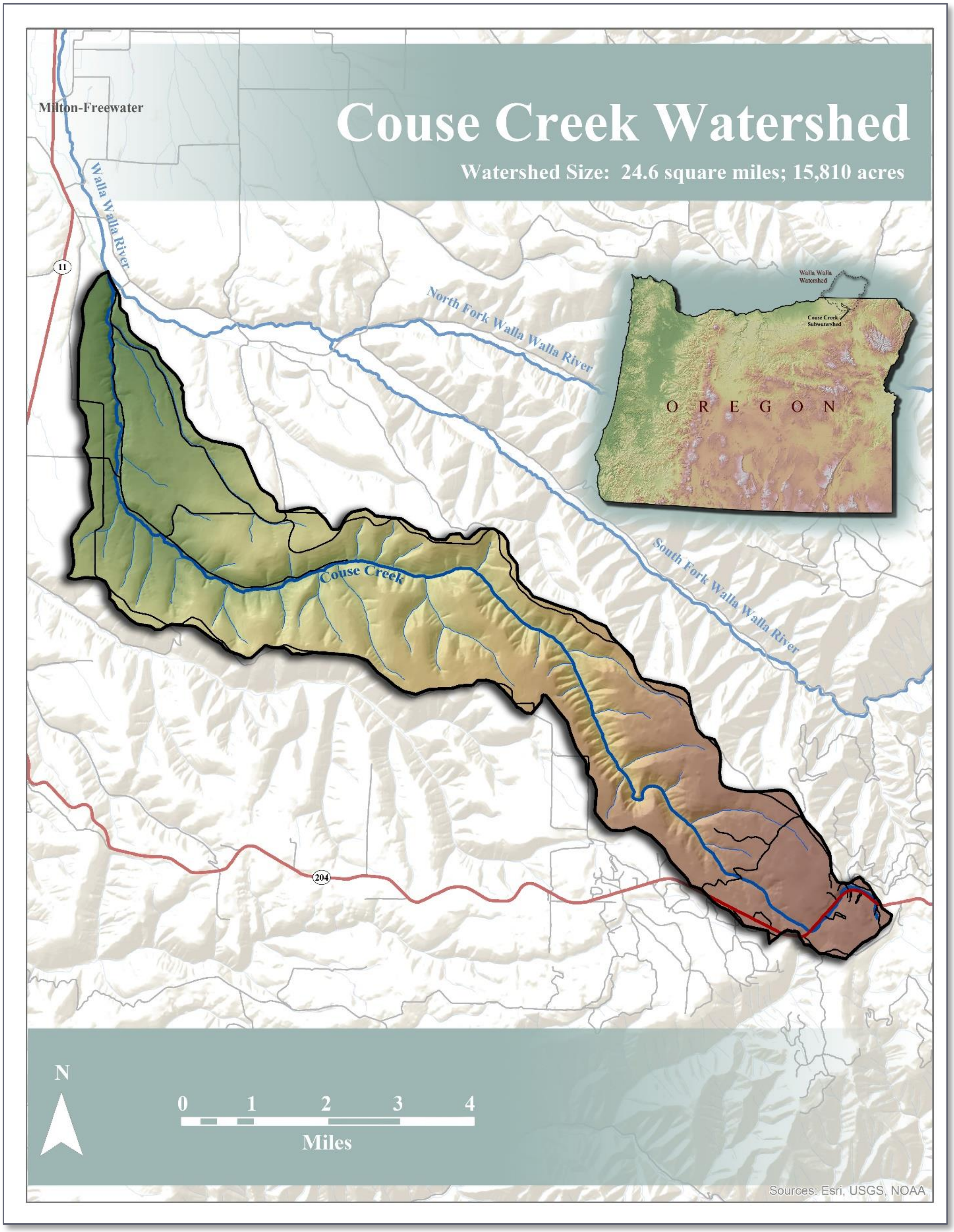


Figure 1. Couse Creek Watershed

SECTION II: WATERSHED DESCRIPTION

Couse Creek originates in the Blue Mountains at about 4,300 feet above sea level and flows northwest down the narrow canyon between Lincton Mountain to the north and Basket Mountain to the south. Downstream, the valley broadens, hillslopes become less steep, and the creek turns west for about three miles before heading north and emptying into the Walla Walla River upstream from Milton-Freewater, Oregon. The Couse Creek Watershed drains an area of 15,810 acres (approx. 25 square miles) and includes 28.5 river miles of Couse Creek and its seasonal tributaries. Daily average flow ranges annually from 0 to 450 cfs, with the vast majority of flow volume occurring from December to June.

Land Use and Vegetation

With the exception of two small parcels near the mouth that belong to the City of Milton-Freewater, Couse Creek flows exclusively through private property. The upper watershed is dominated by evergreen forest and used mostly for recreation and timber production. The grassland and shrubland in the middle of the watershed are utilized for cattle grazing. The lower elevations are used for dryland wheat production with rural residences scattered along the stream corridor (Figure 2).

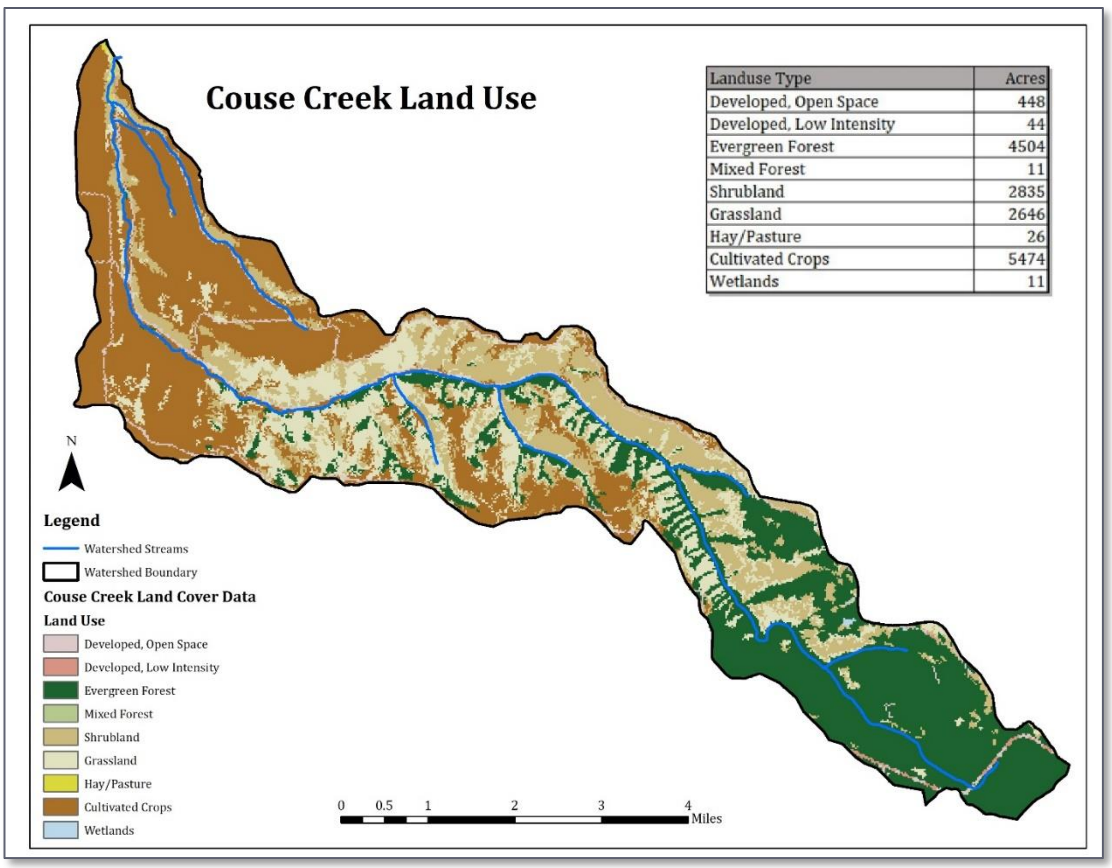


Figure 2. Land cover in the Couse Creek Watershed

The historical, pre-settlement distribution and condition of vegetation in the Couse Creek watershed is not documented. In 1879, a plat survey of portions of Couse Creek mentions the presence of alder and yew underbrush with a heavy timber (fir, tamarack, spruce, hemlock) overstory. In the mountainous areas of the Walla Walla basin in 1940-41, approximately 28% of the wild land zone (forest and grasslands) had a severely depleted vegetative cover, 24% had a moderately depleted vegetative cover, and the remaining 48% had slight or no depletion in cover density (USDA, 1950, Appendix I, p. 18).

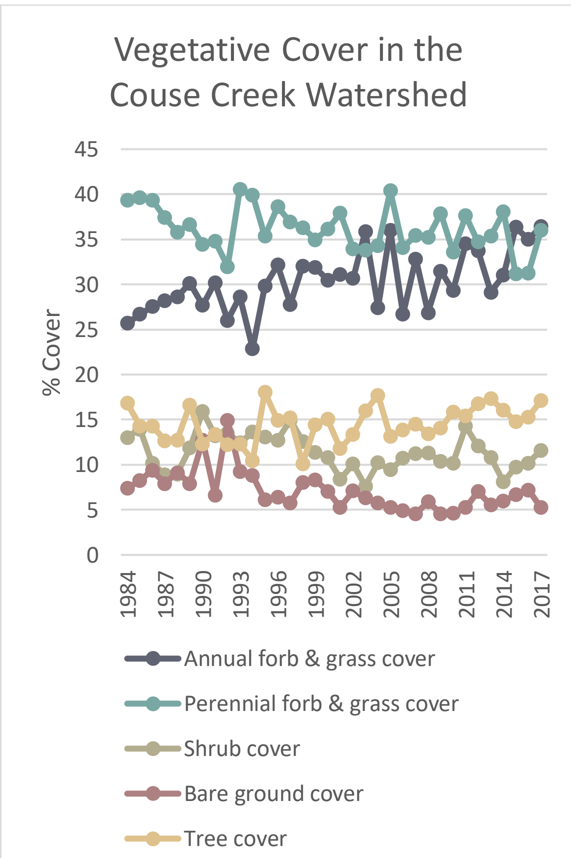


Figure 3. Vegetation cover trends in the Couse Creek Watershed

The watershed is dominated by perennial forbs and grasses (36%), with substantial annual forbs and grasses (30%), and smaller areas of trees (14%), shrubs (11%), and bare ground (7%) (Jones et al, 2018). Changes in cover types have been relatively small from 1984 to 2017, however it does appear that annual cover is increasing as perennial form cover slowly decreases (Figure 3). A continuation of this trend has implications for reduced hillslope infiltration rates and increased sediment delivery to Couse Creek.

The historical conditions assumed for fish recovery efforts documented in the *Walla Walla Subbasin Plan* were as follows:

"The Couse Creek drainage itself would have featured thick riparian growth of shrubs, cottonwoods, with some mixed conifers growing more prevalent in mid elevations. After several miles this would have quickly given way to primarily conifer growth, which would have been thick on north facing slopes and more woodland/grasslands on south facing slopes. The riparian areas would have been heavily wooded giving the stream a steady input of LWD and adding to its complexity and pool ratios (which would have been high)." (p. 17, Appendix C, Walla Walla Subbasin Aquatic Assessment, Walla Walla Subbasin Plan, 2004).

A 2002 study of riparian vegetation along Couse Creek found that conditions were better than many streams within the Walla Walla River Basin (Mackey). The author noted that buffer widths in the lower reaches of the watershed were narrower than descriptions of the ecoregion but nonetheless supported dense hardwood stands.

Geology

Much of the lower half of Couse Creek is located over a narrow strip of quaternary surficial deposits (the orange alluvium shown in Figure 4 below). The remainder of the watershed is underlain by Columbia River basalt flows, primarily the N2 Grande Ronde Basalt formation. The lower reaches of Couse Creek flow along two fault lines, and two others are located near the headwaters (DOGAMI, 2020).

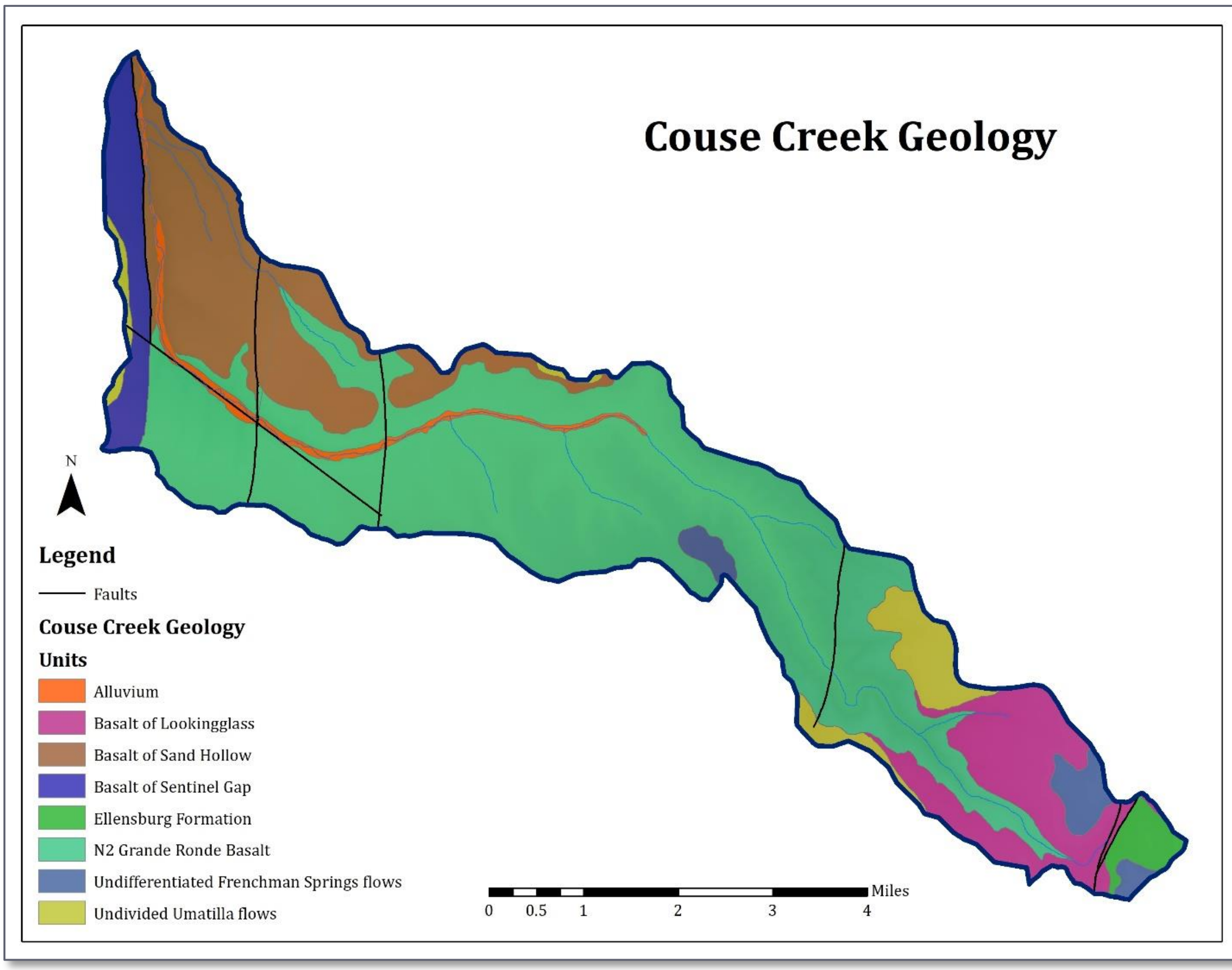


Figure 4. Geologic formations in the Couse Creek Watershed. Seven faults documented within the drainage area are shown with black lines. Data obtained from DOGAMI's Oregon Geologic Data Compilation, release 6 (https://www.oregongeology.org/pubs/dds/p-OGDC-6.htm).

Soils

Soil types within the Couse Creek watershed vary with elevation, geology, and topography.

Lower stream

- Onyx silt loam: high available water storage in profile, rare flooding, silty alluvium, floodplains, depth to water table > 80”, silt loam 0-60”
- Xerofluvents (126A): low available water storage in profile, floodplains, somewhat poorly drained, frequent flooding, cobbly loam/very cobbly loam/extremely gravelly sandy loam/extremely gravelly sand, depth to water table 12-36”
- Veazie silt loam (109A): moderate available water storage in profile, rare flooding, floodplains, depth to water table 48-72”, gravelly/cobbly loam or sand 18-60”

Middle-upper stream (RMs 10-16.5)

- Wrentham-Rock outcrop complex, 35-70% slopes
- Gwin-Rock outcrop complex, 40-70% slopes
- Umatilla-Kahler-Gwin association, 35-70% slopes

Near headwaters

- Tolo silt loam, 3-15% slope: high available water storage in profile, no flooding, depth to water table >80”, well drained, 1-61” silt loam
- Limberjim-Syrupcreek complex, 0-15% slope, moderate available water storage in profile mountain slopes/plateaus, parent material volcanic ash over colluvium and residuum, depth to water table >80”, well drained, no flooding, silt or clay loams 1-42”, 42-52” bedrock

In *Report of Survey Walla Walla River Watershed Washington and Oregon* (USDA, 1950), infiltration rates in the mountain zone were compared in different predominant cover types (virgin forest, excellent bunchgrass, annual brome grass, poor bunchgrass, good bunchgrass, excellent bunchgrass). The rates ranged from 0.5 to 4.8 inches per hour (Table 1). In contrast, in the same report watershed infiltration rates derived from an analysis of storm and flood events in the Walla Walla River at Milton ranged from 0.08 to 1.46 inches per hour.

Table 1. Infiltration rates in mountainous zone

Soil Type	Predominating Cover					
	Virgin Forest	Excellent bunch grass	Annual brome grass	Poor bunch grass	Good bunch grass	Excellent bunch grass
	Infiltration rate (in/hr)					
Holmer loam	4.542	--	--	--	2.480	--
Couse stony loam	0.850	--	--	--	--	--
Couse loam and silt	2.699	2.699	--	1.340	1.470	--
Underwood stony loam	0.850	0.850	--	0.522	--	--
Underwood loam	--	2.805	--	--	--	--
Waha stony loam	0.850	0.850	--	0.522	0.571	0.850
Waha loam	2.805	2.805	--	1.452	1.589	--
Waha silt loam	4.760	4.760	1.600	--	2.606	--
Palouse silt loam	4.760	4.760	--	2.376	2.606	--
Alluvium	4.760	--	--	--	--	--

Note: Underlined figures are infiltration rates during final 30 minutes of wet runs as determined by Type FA infiltrometer. Other rates were interpolated. Source: USDA 1950, Appendix IV, Table 6.

Climate

Climate conditions in the Couse Creek Watershed vary primarily with elevation. The upper watershed is located in the Marine-Influenced Zone ecoregion of the Blue Mountains, which intercepts marine weather systems moving up through the Columbia River Gorge. The middle and lower watershed are identified as Umatilla Plateau and Deep Loess Foothills portions of the Columbia Plateau ecoregion (Thorson, 2003).

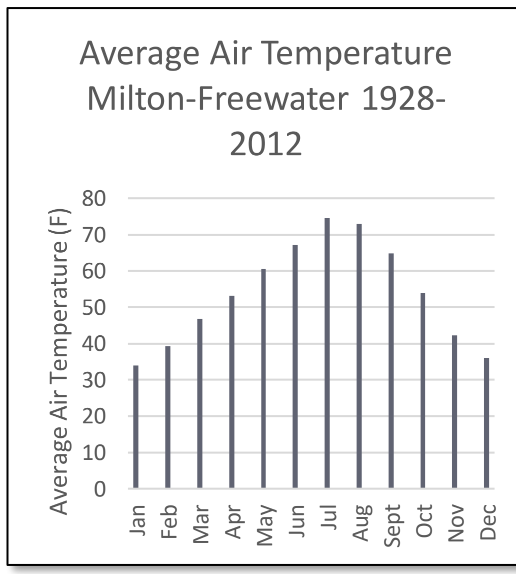


Figure 5. Monthly average air temperatures in Milton-Freewater from 1928 to 2012. Data from the Western Regional Climate Center (www.wrcc.dri.edu).

Monthly average air temperatures for Milton-Freewater are shown in Figure 5 (www.wrcc.dri.edu). A modeled dataset shows annual precipitation in the watershed ranging from 18 inches in the lowlands to over 40 inches at the headwaters (Figure 6). Average annual snowfall ranges from 11 inches in the lower watershed to 65 inches in the Blue Mountains.

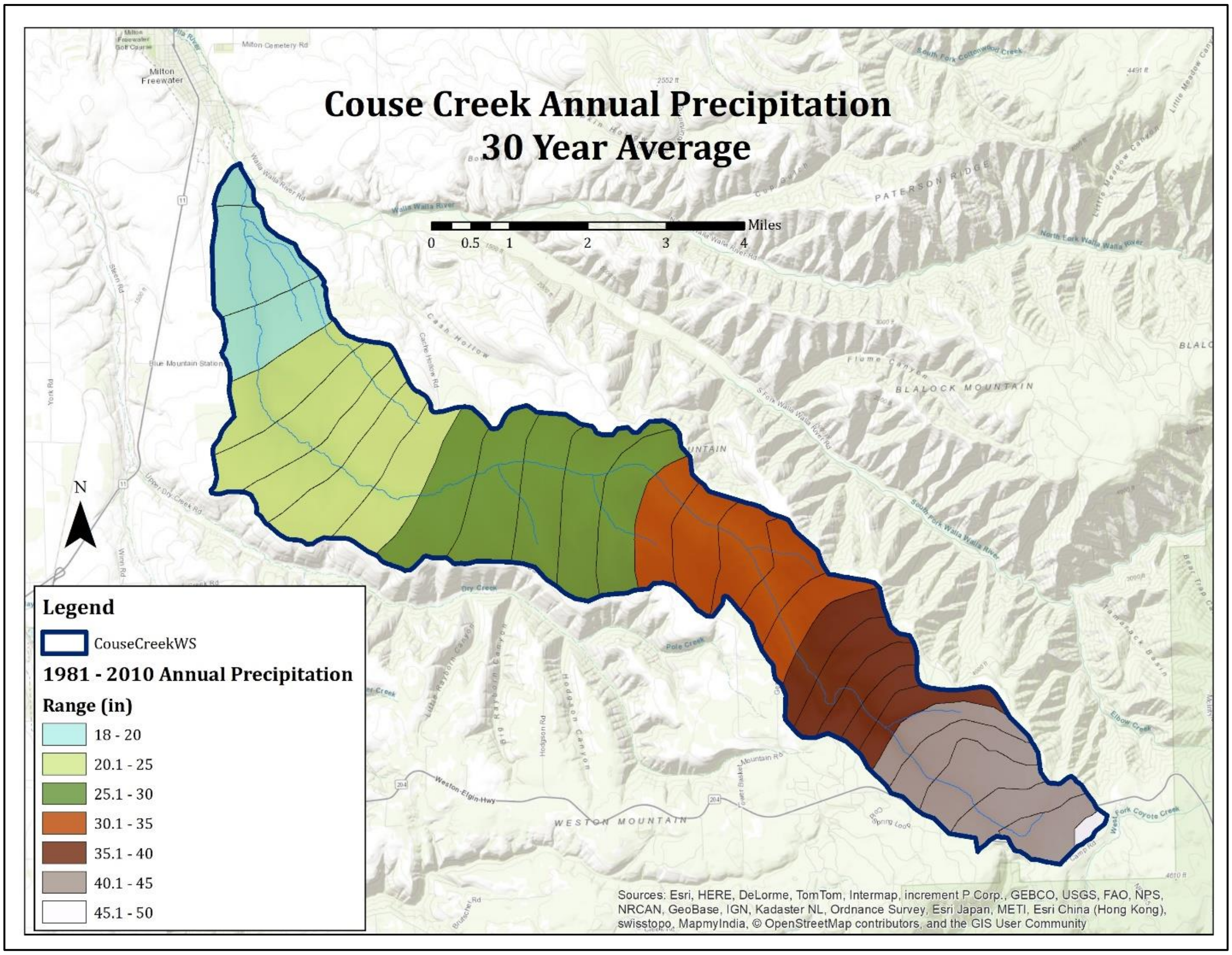
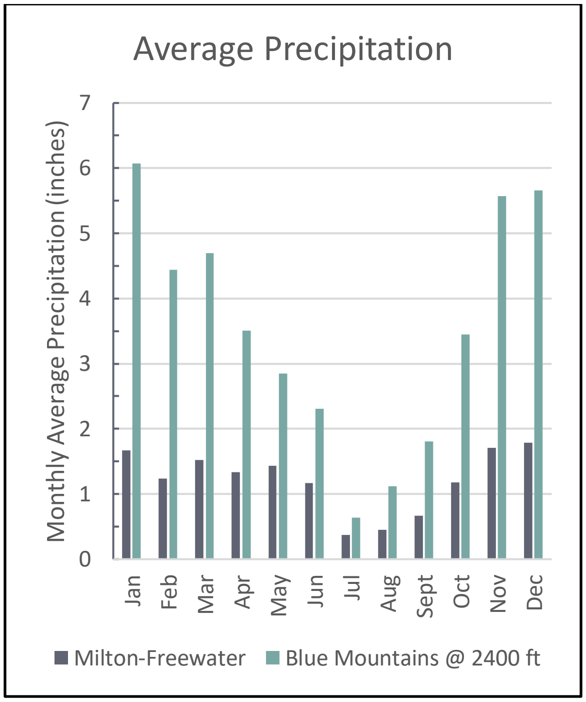


Figure 6. Map showing the range of annual precipitation within the Couse Creek watershed.

Monthly average precipitation and snowfall in Milton-Freewater (1928-2012) and at a mid-elevation Blue Mountains weather station (1948-2000) are shown in Figure 7.

Climate change models predict a shift in the type and timing of precipitation for the Blue Mountains (Clifton et al, 2017). Predicted increases in air temperature in the mid-elevations of the Blue Mountains, the location of Couse Creek's headwaters, are modeled to impact local hydrology, impacting the timing and duration of peak flows and potentially extend periods of no flow. It is likely that this shift is already occurring, but the lack of long term snowfall data in the region makes it challenging to document the change.



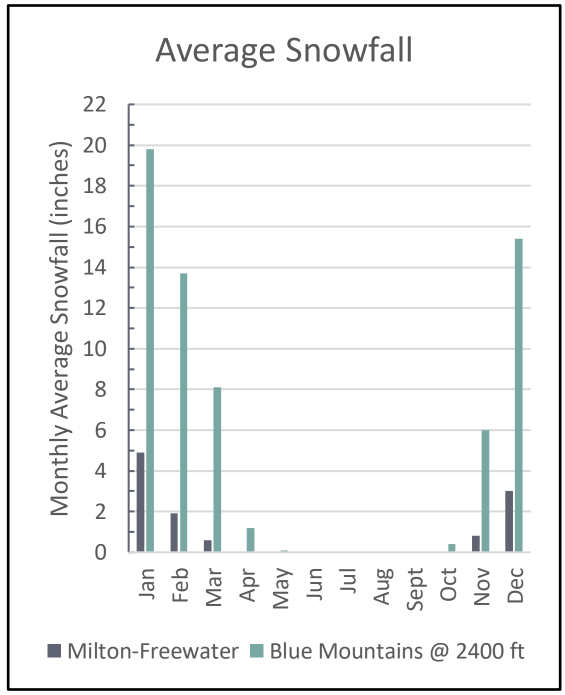


Figure 7. Monthly average precipitation (left) and snowfall (right) measured in Milton-Freewater (1928-2012) and at a mid-elevation Blue Mountains weather station (1948-2000). Data obtained from www.wrcc.dri.edu.

Geomorphology

Couse Creek is a 3rd order stream that emerges from the Blue Mountains, an upraised portion of basaltic plateau. Like the Walla Walla River and its branches, Couse Creek is a "consequent stream," directed in its course by the original surface slope of the land (Russell, 1897, p.22).

The results of a 1997 stream survey conducted by ODFW suggest the following: A small moderate gradient headwater channel at an elevation of about 4200 feet becomes a cascading stream as it drops into a steep V-shaped valley. The stream is naturally constrained by hillslopes and terraces as the gradient lessens to a moderately steep valley that gradually widens, giving way to a broad, heavily flood-impacted valley. In the lower part of the watershed the channel is mostly constrained by alternating terraces and hillslopes and has a low-moderate gradient. Overall 22% of stream channel is constrained by high terraces, 38% is unconstrained, and 40% is constrained by hillslope. Except for the headwater reach, the substrate is dominated by gravel. The primary habitat type is riffle, with less than 10% of area being pool habitat (Lovatt, 1997).

A pebble count and shear stress analysis of the Couse Creek channel at the entrance to the Konen Rock Products quarry were conducted to support the design of a replacement culvert to improve fish passage (AP&A, 2011). The pebble count determined the bed material present above the bedrock had a D80 of 4 inches, meaning 80% of the particles counted had a diameter of 4 inches or less. In a test pit dug next to the stream, the depth of substrate above bedrock was 1 to 2 feet. The shear stress analysis concluded that "due to the confined nature of the channel and lack of floodplain connectivity, the steep slope and high flows have the ability to move a 48-inch rock during the 100-year event and a 24-inch rock during the 2-year event (based on the SCS method)" (p. 2). The plan to reconstruct portions of the channel as part of the culvert replacement called for placing "well graded stream simulation material with a D80 of 24 inches" (p. 3) to increase channel stability and break up the stream flow, provide in-channel habitat, yet allow migration of the material during high-flow events.

Additional data obtained included: channel slope was approximately 3.55 percent, the OHW depth was about 2.5 feet and the channel width at the OHW was about 16 feet. The calculated depth of water for a 2-year event was 2.5-3 feet and for a 100-year event was 5.5 feet.

Portions of the channel are incised (Figure 8). A few banks have been artificially armored to prevent erosion and subsequent damage to structures or working lands. In some locations, flows are ephemeral during summer months with pocket water sections providing habitat in some reaches.

Figure 8. Barn next to Couse Creek in the early 1900s (left). Same barn in June 2017; Couse Creek located behind children. Cut bank just past Couse Creek indicates amount of channel incision (right).

Hydrology

Couse Creek hydrology is typical of a transient snow (mixed rain and snow) watershed. The flow regime includes prolonged periods of low flows reliant on groundwater sources and higher pulse flows occurring during the rainy season and during spring snowmelt. An early flow measurement conducted by the United States Geological Survey (USGS) documented 10 second-feet (an older term which means the same as the modern term cubic feet per second) on March 23, 1906 (USGS, 1915, p. 810).

A record of flows is also available from 1964-1978 collected by the Oregon Water Resources Department (OWRD). Their monitoring site was located at the present-day Blue Mountain Station Road (Figure 9). Daily average flow data from water years 1965 to 1978 are shown in Figure 10 and illustrate extended periods of low (and sometimes zero) flows along with seasonal pulses and peak ranging from 150-550 cfs.

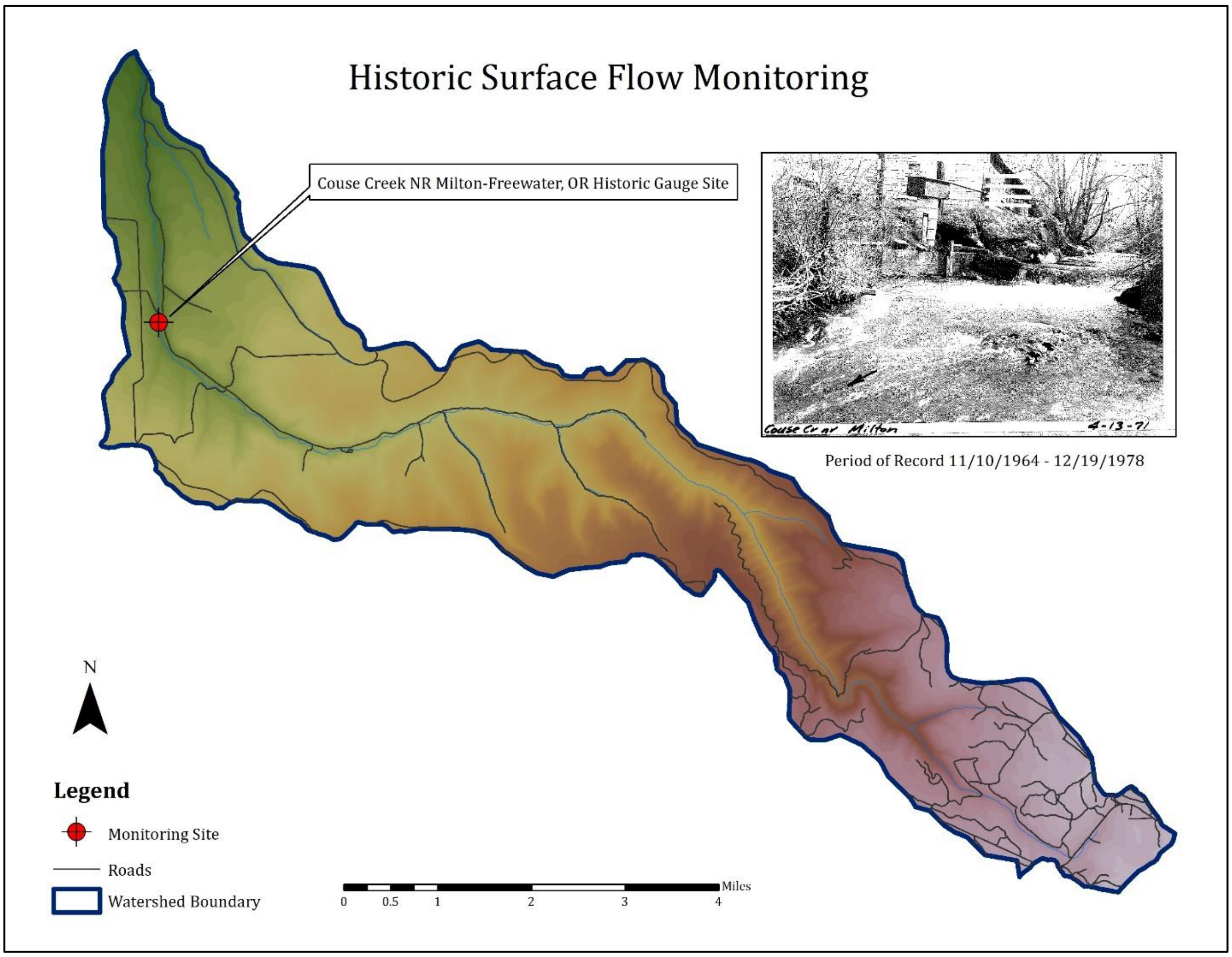
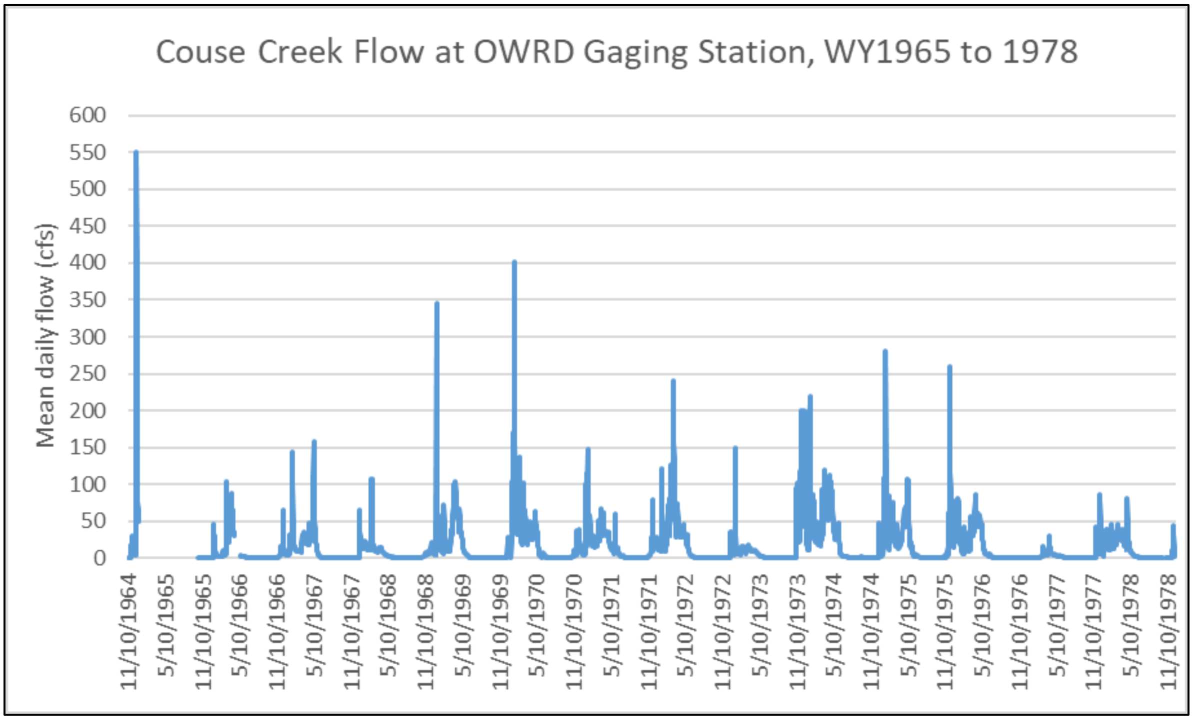


Figure 9. Location of OWRD historical Couse Creek flow monitoring station at Blue Mountain Station Rd.



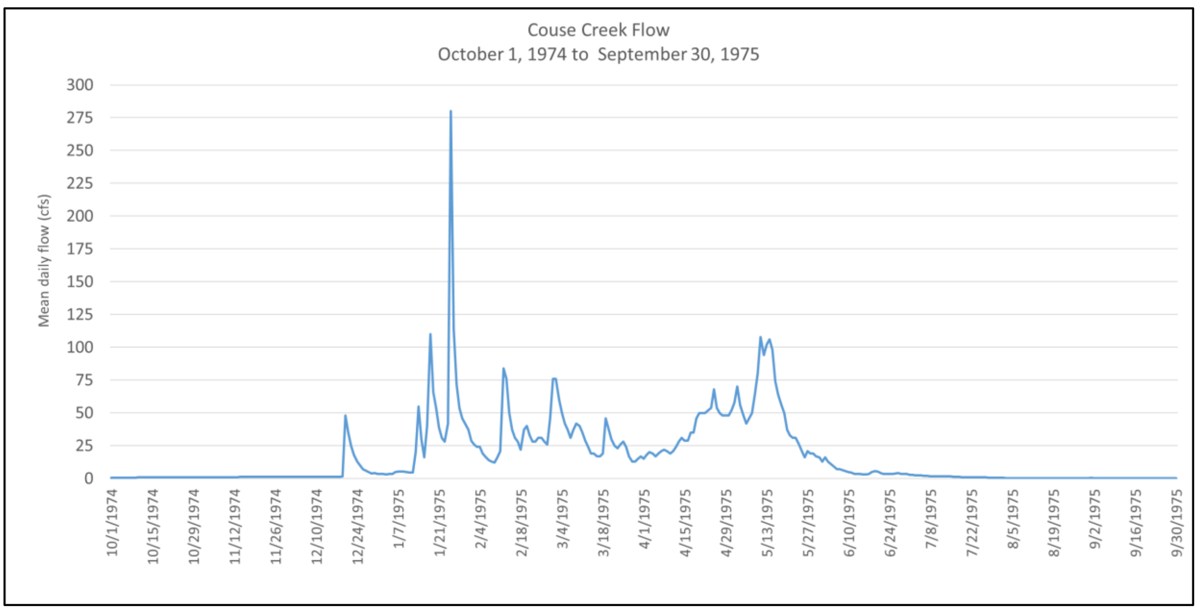


Figure 10. Historical flows documented by OWRD from Water Years 1965 to 1978 (top). The hydrograph of a typical Couse Creek water year during the historical monitoring period (bottom).

Groundwater

Very little documentation is available related to groundwater in the Couse Creek watershed. Based on the mapped extent of recent alluvium (Figure 4, data from DOGAMI), an alluvial aquifer is likely very limited in extent and volume.

The basalt aquifer under the Couse Creek drainage has not been characterized in detail. For the Columbia River basalt underlying the Walla Walla Basin, including the Couse Creek drainage, Newcomb (1965) describes how permeable zones between basalt flows are the principal water-bearing portions of the basalt; the discharge of groundwater from the basalt usually occurs along the lines of contact between the flows. Aquifers occur as separate tabular zones due to fractures, discontinuities, stratigraphic traps, and variable permeability and transmissivity characteristics. Static water levels in wells relatively close to each other can vary widely due to the fragmented nature of the aquifer. Newcomb also describes:

"Above the Couse Creek fault the groundwater in the shallow layers of the basalt is confined and flows from the few wells that have been drilled into the basalt, but the deeper aquifers may have water at levels low enough to be in agreement with normal ground-water slope to the water in the basalt farther west. The natural static water level in the basalt was 100 feet below river level in the southern part of Milton, 70 feet in the northern part of Milton, and 40 feet in the northern part of Freewater." (p. 33)

OWRD has measured groundwater elevations at UMAT 5267, near the mouth of Couse Creek since 1992. Water levels were variable from 1992 to 2006 from 26.7 to 35 feet below ground surface (bgs), rose in 2007 and 2009 to a maximum of 23 feet, and decreased in 2019 to the late 1990's levels (Figure 11). At this location, basalt is present beginning at 21 feet below ground surface.

Longer-term data for the City of Milton-Freewater's well UMAT 4010/4005 (just east of the mouth of Couse Creek), as reported on OWRD's groundwater info webpage (accessed 8/20/2019) indicate a declining groundwater table (Figure 12).

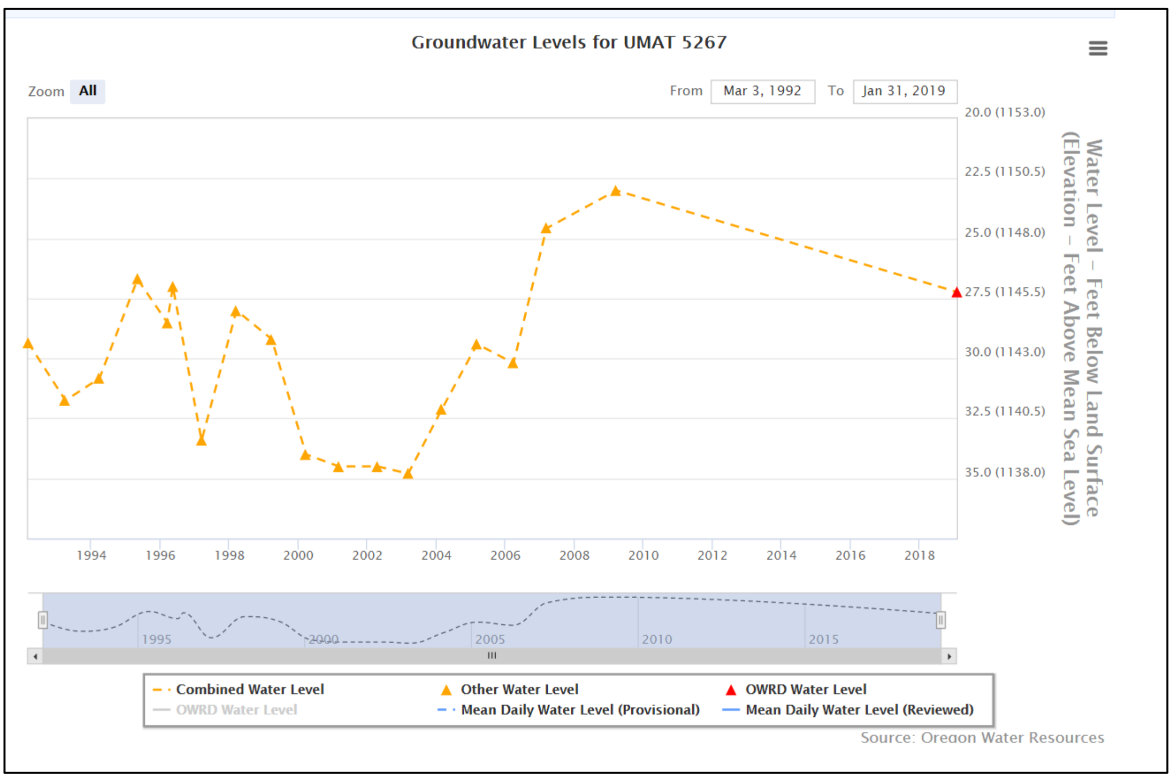


Figure 11. Groundwater levels in UMAT 5267, drilled into the basalt aquifer near the mouth of Couse Creek.

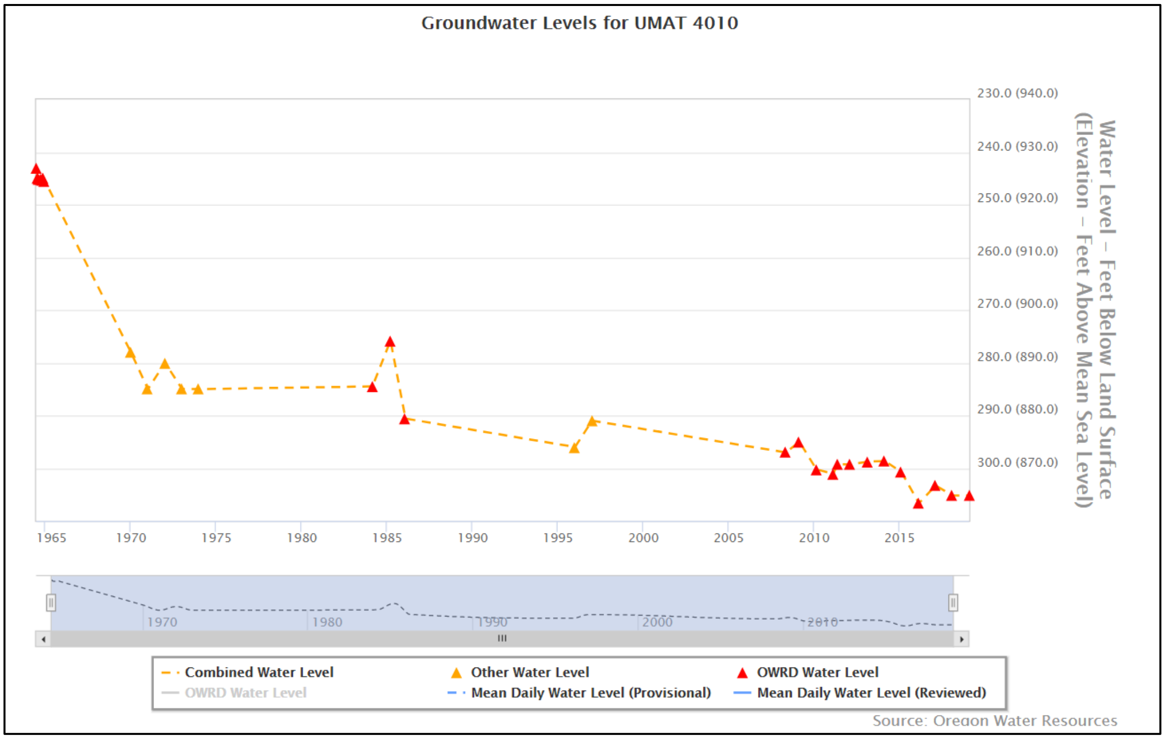


Figure 12. Groundwater levels in UMAT 4010, drilled into the basalt aquifer east of the mouth of Couse Creek.

Fish and Wildlife

Couse Creek includes approximately 14.2 miles of steelhead access and habitat and was identified in the Walla Walla Subbasin Plan as being in important area for steelhead production within the Walla Walla Basin (NWPCC, 2004, p. 40, 63). Historical accounts from watershed residents describe abundant salmon in the watershed as well. One verbal history from the early 1900s includes use of a horse-drawn hay rake to pull salmon onto the streambank. The Shumway family, who has owned land in the Couse Creek drainage area for over a century, has shared accounts of a strong salmon run in the late 1800s as well but noted that "now we have very few, if any" (Couse Creek Watershed Residents et al., 1996, Section 2). The reason(s) for the decline are unknown, but another long-term farming family documented 10 years starting in 1985 "that we have not had enough winter moisture to make side draws and spring runs to produce water for late summer survival…The area where I live almost always had enough water to last through the summer in previous years" (Section 2).

Local sportsmen working with ODFW for a few years in the late 1980s spawned wild steelhead from Couse Creek and Yellowhawk Creek. "Eggs were incubated streamside and fry volitionally released back into Couse Creek" (James and Scheeler, 2001, p. 72, 75, 106).

Major habitat constraints as identified in the 1990 Walla Walla Subbasin Plan for Salmon and Steelhead Production include severe sedimentation problems due to land management and bank cutting, low flow during summer, and high summer water temperature (CTUIR, 1990, Table 11). The 2004 Subbasin Plan documents the following general habitat characterization: poor flow, temperature, passage condition, channel conditions, instream habitat diversity, and riparian condition; comments – logging, grazing, low flows and rural development (NWPCC, 2004).

Two bull trout were documented in Couse Creek in 1999 as well as many redband/steelhead. Historically, an irrigation push-up dam as well as water pipe protection infrastructure at the mouth obstructed passage during portions of the year, but the final remedy was completed in 2019 through a collaboration of WWBWC, Bonneville Power Administration (BPA) and the Oregon Watershed Enhancement Board (OWEB).

Current steelhead production in the Walla Walla basin is concentrated in the North and South Fork Walla Walla River, Couse Creek, Mill Creek and Dry Creek (ODFW, 2010, p. B-147). In the years when steelhead redds were surveyed in Couse Creek, 2002-2007, the number of redds in Couse Creek exceeded the number of redds in the surveyed portions of Mill Creek and the Walla Walla River in five out of six years (Table 2, based on data from *WW Natural Production M&E* 2006, p. 41). Redd locations documented during 2004 and 2005 spawning surveys are shown on Figure 13. More recent data are not available because 'Due to variability in redd counts between and within years the CTUIR discontinued steelhead redd surveys in 2008…'" (Mahoney *et al.*, 2011, p. 46).

Stream Survey Results 1997, ODFW

(Lovatt, 1997)

- 22% of channel constrained by high terraces, 38% unconstrained, and 40% is constrained by hillslope
- 96% had desirable percentages of shade
- 71% of surveyed stream length had less than 10% pool habitat
- Substrate composition was good with 38-73% gravel
- Greater than 30% of streambanks were actively eroding in 65% of surveyed length
- The most LWD was in two reaches with a high number of riparian conifers
- Numerous tributary failures and landslides were present where Couse Ck turns south upstream of the east-west portion.
- "A potential fish barrier, consisting of a bedrock step 1.8 meters height in Reach 16, unit 570." (p. 2). "One four inch trout was seen above the barrier at unit 582 in Reach 16." (p. 5).

Table 2. Numbers of steelhead redds, 2002-2007

Year	Couse Creek			Mill Creek + Walla Walla River			Total Number of Redds
	Number of redds	KM Surveyed	Redds per KM*	Number of redds	KM Surveyed	Redds per KM*	
2002	49	15.9	3.1	31	13.1	0.4	80
2003	48	15.9	3.0	25	13.1	0.5	73
2004	93	15.9	5.8	16	13.1	0.8	109
2005	17	15.9	1.1	141	43.7	0.3	158
2006	8	15.9	0.5	4	10.9	2.7	12
2007	45	15.9	2.8	28	13.1	0.5	73

*These values were not included in the report; they were calculated based on the data presented in the report for number of redds and number of kilometers surveyed.

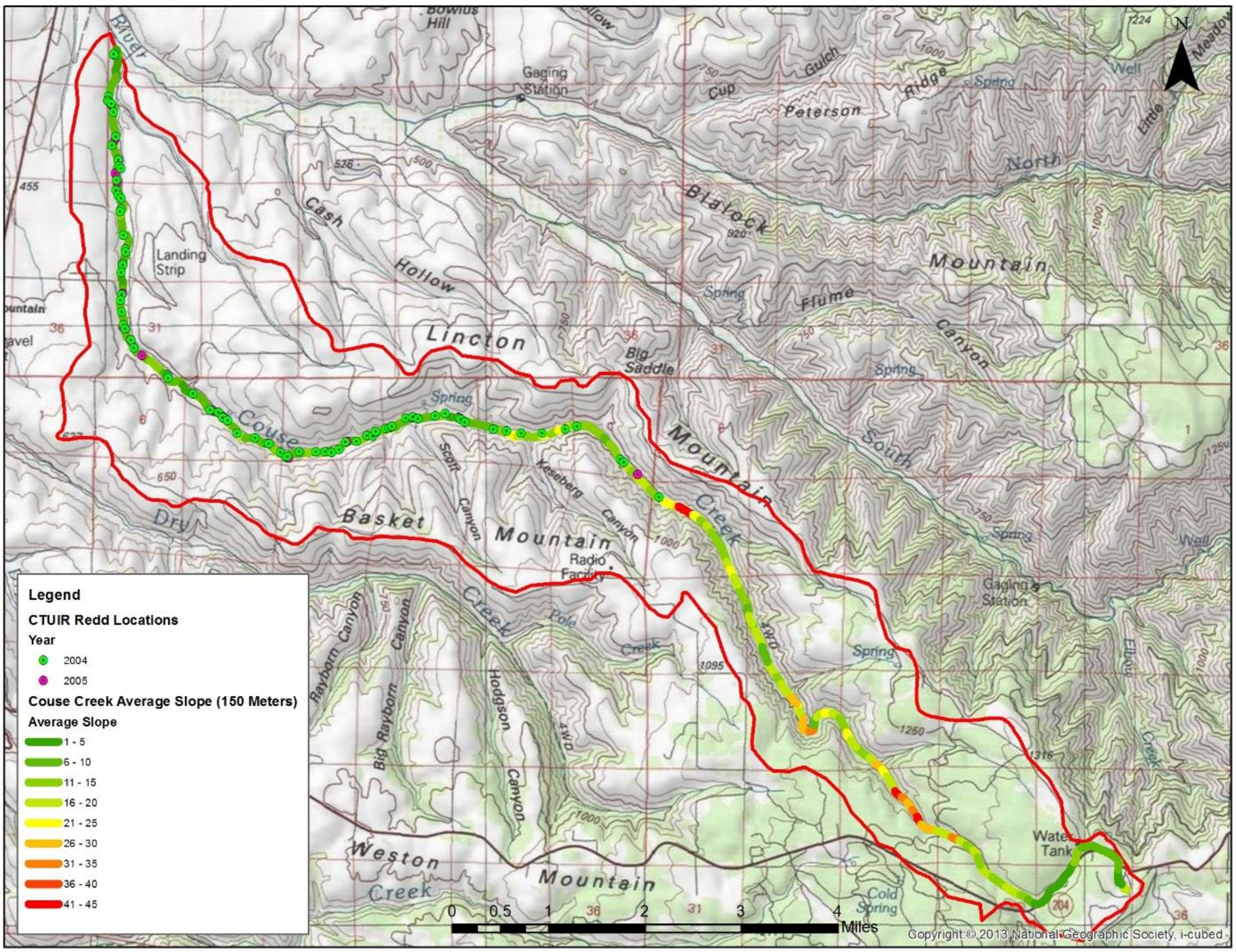


Figure 13. Location of steelhead redds in Couse Creek during 2004 and 2005 CTUIR surveys

HISTORICAL ACCOUNTS

Local residents shared the following accounts of life in the Couse Creek watershed:

Shumway barn during flood on Couse Creek.

- In the lower creek, they experienced much more successful fishing in the 1970s than now.
- Downstream of the rock quarry they have had year-round summer flow (described as a slight trickle) maybe 6 times in the last 37 years.
- A hand-dug well near the creek didn't go dry but used to get cloudy during high flow events. If they thought the creek would rise, they would pump water and store it beforehand. In the spring the creek was moving so fast their mother wouldn't let them play in it but by mid-August the water was low and stagnant with algae. The creek seems to be narrower than years ago. In spring 2017 a debris dam formed; steelhead were able to get past the dam but struggled to get up the tiny braided channels/rivulets in the gravel/cobble deposited upstream of the dam.
- High flows last year (2017) filled their basement with water. The bank has eroded by over 5 feet (laterally) over the 18 years they've lived here. Two years ago is when all that gravel moved down the creek. Years ago gravel came into the creek from a mined area that eroded into the creek but that gravel already moved downstream.
- The fields near the creek at Kinnear Road used to grow alfalfa and were sub-irrigated (indicating shallow groundwater). A private well was probably intentionally located in a spot at the base of a gully. The level in the well drops but doesn't go dry. According to the landowner's father, the creek has always gone dry in this section.
- The 1964 flood deposited much rock and took all the black soil that was in the meadows…for a mile at the end of the road (Watershed Residents et al., 1996, Section 2).

SECTION III: ASSESSMENT APPROACH

Purpose

The 2020 Couse Creek Watershed Assessment and Action Plan provides the framework to protect and restore ecological function within the Couse Creek watershed for the benefit of native fish and wildlife while maintaining sustainable agricultural practices. The purpose of the action plan is to 1) identify naturally functioning areas for protection and 2) document impairments and opportunities to enhance and restore watershed processes.

Assessment Methods

To document current conditions and evaluate ecological function, we assessed the following components of the watershed:

- Hydrology – to evaluate water quantity and seasonal trends
- Water Temperature – to compare current conditions to biologically-based temperature criteria
- Geology – to evaluate the potential of aquifer storage as a flow improvement tool
- Geomorphology and fish habitat – to evaluate floodplain connectivity, pool formation, bedform diversity, riparian condition and large woody debris (LWD) transport and storage
- Hillslope conditions – to characterize sediment load and sources

To assess hydrology we collected water level data, created rating curve, and produced flow data from the same location as the historical OWRD flow gage at RM 3.2. We also produced flow data at RM 1.1, for comparison. Daily average flows were calculated and were compared to the historical record from the 1960s and 70s. Data were collected and analyzed according to WWBWC's flow monitoring procedures (Appendix A).

To assess water temperature we deployed thermistors at nine locations from the mouth to the headwaters and logged 15-minute temperature values during the summers of 2018 and 2019. We visited the sites for periodic field checks and followed the protocols described in Appendix A.

For the geology assessment we reviewed available well logs and soil data from the Couse Creek watershed to make an initial determination about the suitability of aquifer storage as a tool for flow enhancement.

To assess geomorphological function and fish habitat we used the ODFW stream habitat survey method, found in Appendix B (Moore et al. 2017). The survey includes measurements of valley form and channel form, identification of habitat unit types, substrate composition, shade and riparian conditions, and number and size of large woody debris. The ODFW methods do not include pebble counts, so we utilized the Wolman method for pebble counts (Appendix C).

To inventory roads and assess their condition, we used the Soil and Water Assessment Tool (SWAT) developed by the United States Department of Agriculture (USDA) and Texas A & M University to model hillslope erosion (Appendix D). Additional assessment of road conditions were performed using the Watershed Erosion Prediction Project model (WEPP). Model documentation is found in Appendix E. Field surveys were conducted to verify road conditions.

Community Involvement

The Couse Creek watershed is almost exclusively privately owned. Several farming families have lived and worked in the watershed for multiple generations and have a long history with strong attachments to the area. We invited all residents to participate in the assessment development and planning process.

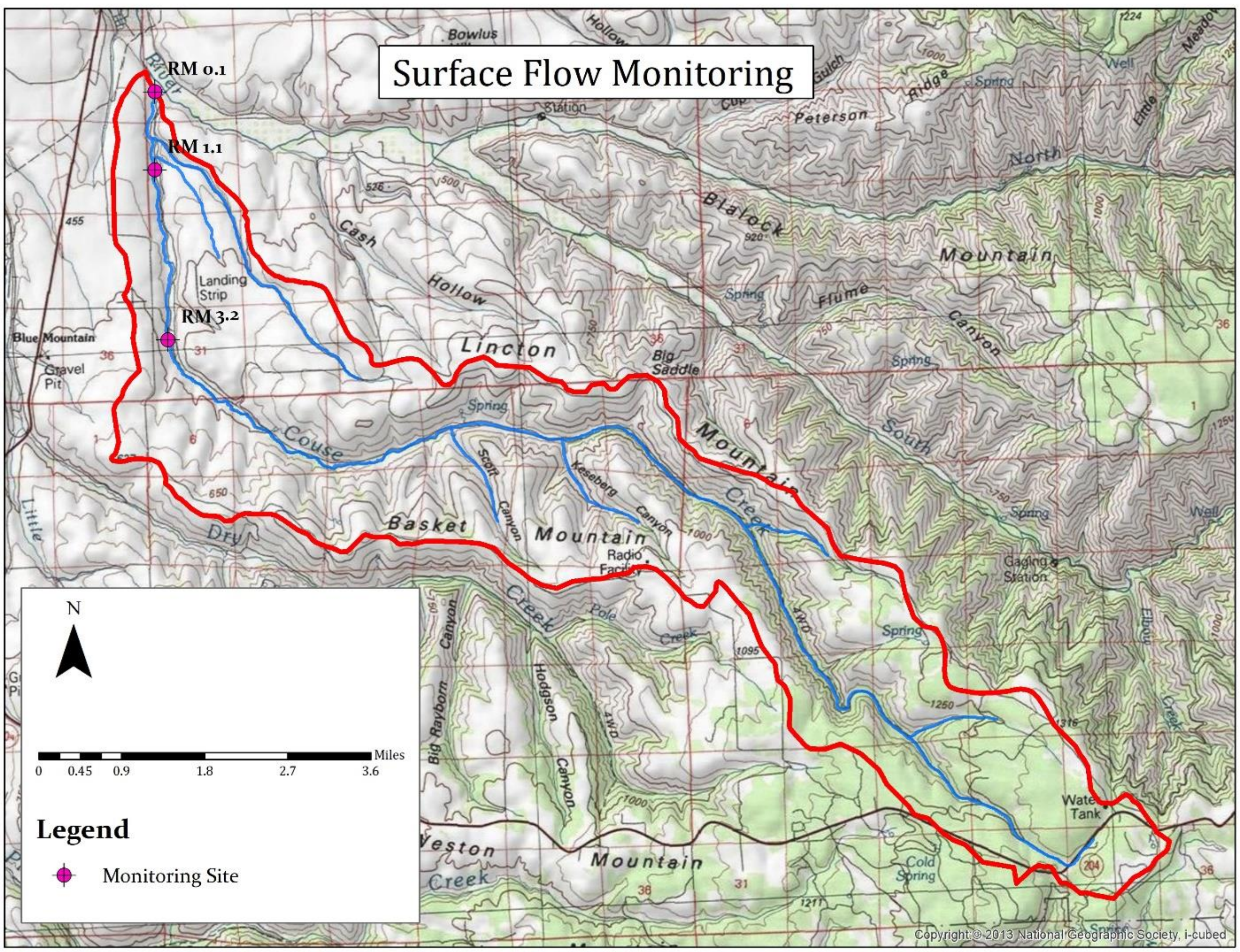
- Letters were sent to 200 watershed residents introducing the assessment effort and inviting them to share knowledge of current and historic conditions and ideas for improvement. The letter is available in Appendix F.
- A community meeting was held in April 2018 (~15 people in attendance) to discuss the assessment and request input.
- Phone calls and/or property visits were made to all streamside landowners to request permission for stream survey access and invite input.
- Landowner interviews were conducted.
- Dozens of property owners granted permission for WWBWC staff to walk up the creek through their land to conduct survey activities.
- Landowners at two locations agreed to the installation of streamflow monitoring equipment on their property, like the setup shown below at RM 1.1.
- Landowners at seven additional locations granted permission for summertime water temperature monitoring on their property.

SECTION IV: ASSESSMENT RESULTS AND DISCUSSION

Hydrology

Flows in Couse Creek are dominated by prolonged periods of high flow pulses and low flows, suggesting a mixed rain and snow driven hydrology supplemented by groundwater inputs during the summer and fall. Flow data obtained during the 2018-2019 assessment project were collected at RM1.1 and RM 3.2 (Figure 14).

Figure 14. Map below showing Couse Creek flow monitoring locations at RM 1.1 and Blue Mountain Station Road (RM 3.2). Photo (right) showing water level monitoring equipment (equipment box, conduit, pressure transducer (circled)) installed at RM 3.2.



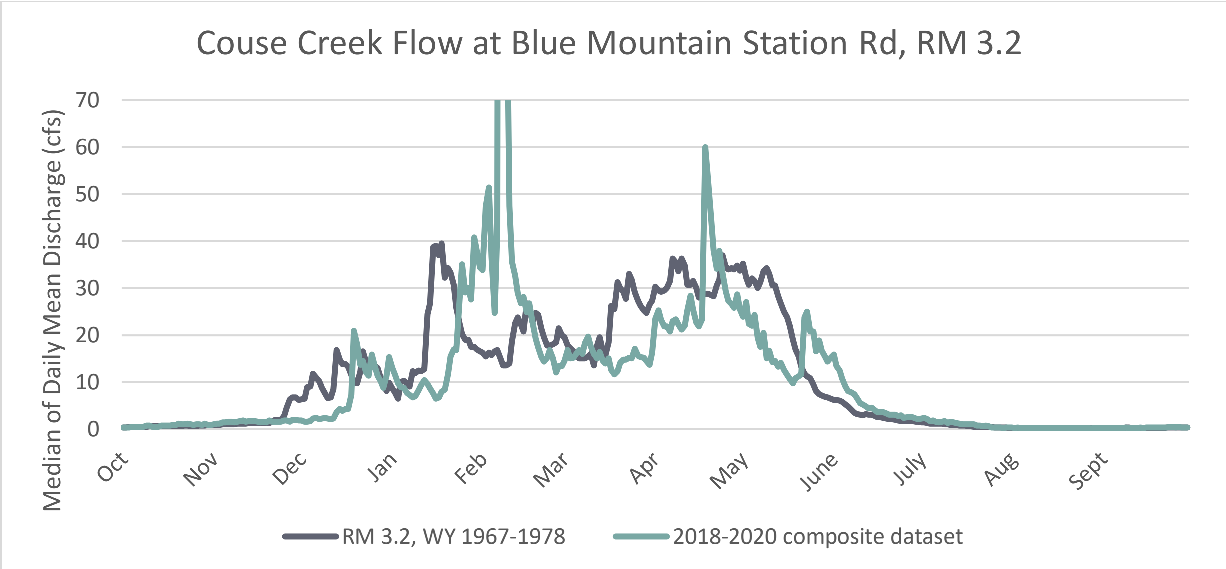


Figure 15. Hydrograph showing Couse Creek flows from historical data collected by OWRD and a composite dataset from 2018-2020 collected at the same location.

Discharge data from Couse Creek at Blue Mountain Station Rd (RM 3.2) were compared with OWRD's historical data from the same location. A hydrograph showing daily mean flows from the historical data set is found in Section II: Watershed Description, Figure 10. To compare historic and current conditions we produced a composite dataset for the 2018-2020 monitoring period because a complete year-long dataset was not available for that location due to equipment failure. The composite data set was created using the median of available daily average flow data collected at that site from 2018-2020.

The assessment data generally follow the flow data from the 1960s-70 (Figure 15). Low flows, typically 0-5 cfs, occur from July-November. Higher pulse flows and flood events occur from December-June. One notable difference is the timing of the fall flow increase, which occurs 2-3 weeks earlier in the historical data. Whether this difference is due to long term climate trends or unusually low fall precipitation during the recent monitoring period is unknown.

Flow rates and volumes for the current data set are somewhat skewed due to the impact of the unusually high flow events in February and, to a lesser degree, in April of 2020. Figure 15 is scaled to more clearly compare the lower flows due to the limited usefulness of the February peak for general trend comparison.

To compare the recent flow data with the historical dataset, the following characteristics of the hydrograph were evaluated:

- Average flows
- Magnitude of peak flows
- Duration of no flows
- Annual flow volume
- Runoff timing

Annual average precipitation in Milton-Freewater, OR during the assessment period was compared to the annual average during the historical monitoring period to provide some context about climate influence on flow data results.

Peak Flows

The magnitude of peak flows during the recent period was 443 cfs, notably higher than the range of values observed from 1967 to 1978, which was 26-309 cfs. The recent value was, however, influenced by the February 2020 100-year flood event in the Walla Walla valley (Table 3). The WY 2019 peak of 280 cfs at RM 1.1 is likely a more representative value for typical current conditions and does fall within the range of the historical peaks, but is higher than the historical median of 162.5 cfs.

Table 3. Maximum daily average flow by year

Water Year	Max Daily Average Flow (cfs)	Date of Peak
1967	145	5/14/67
1968	105	2/21/68
1969	309	1/6/69
1970	302	1/24/70
1971	134	1/20/71
1972	204	3/15/72
1973	100	1/17/73
1974	180	12/8/73
1975	197	1/26/75
1976	213	12/8/75
1977	26	4/9/77
1978	82	12/15/77
Median	162.5	
Mean	166.4	
Composite 2018-2020 @ RM 3.2	443	2/7/2020
2019 @ RM 1.1	280	4/13/2019

2018-2020 Flow

Figure 16 compares the flows at RM 1.1 and RM 3.2. The hydrograph for the two sites is very similar, with the notable difference being the February 2020 peak, which should be considered an estimated value due to the lack of high flow calibration measurements at the RM 3.2 monitoring location.

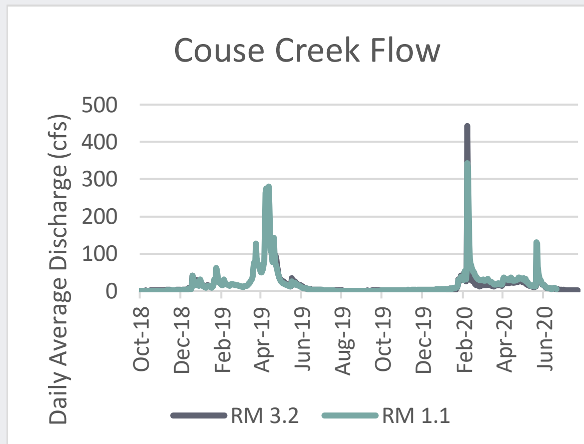
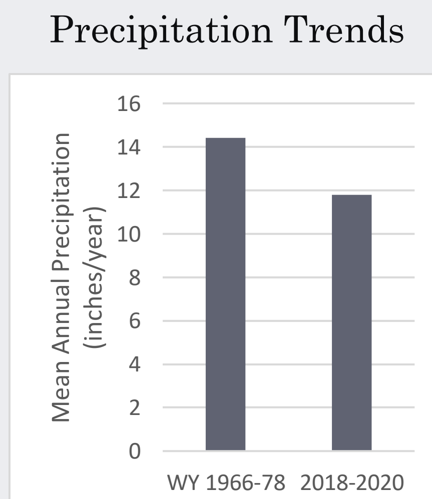


Figure 16. (Above) Daily average discharge at RM 1.1 and RM 3.2 during 2018-2020. (Below) Annual precipitation in Milton-Freewater during the historical and recent monitoring periods.



Precipitation Trends

During the 1966-1978 flow monitoring period average annual precipitation in Milton-Freewater was 14.4 inches. The long term average (1928-2012) is 14.5 inches/year. During the 2018-2020 water years, average precipitation at the same location was 11.8 inches. Precipitation records from the Milton-Freewater monitoring site are used because it has the longest available precipitation record in the region. Couse Creek hydrology is strongly influenced by precipitation in the mid elevations of the Blue Mountains, which typically receives over 4 times as much precipitation as falls in the valley.

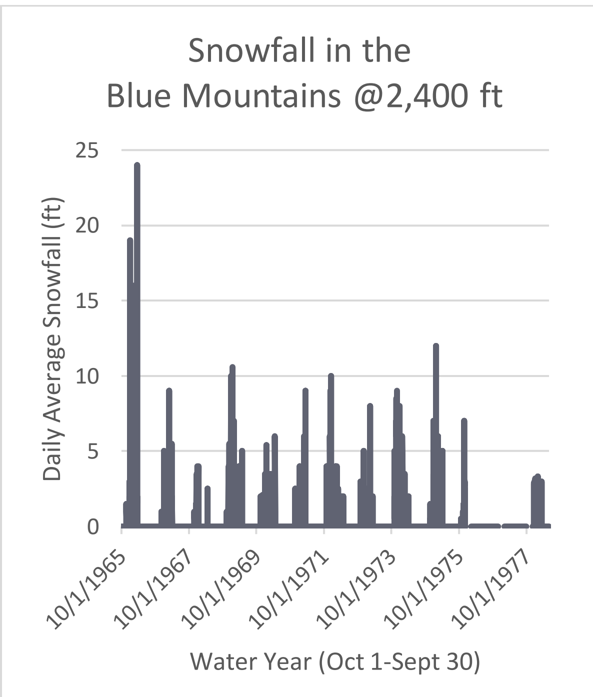


Figure 17. Snowfall in the foothills of the Blue Mountains (45.99,-118.0511) during the water years of the historical flow monitoring dataset.

Snowfall records for the Blue Mountains during the water years of the historical flow monitoring period are shown in Figure 17. The available dataset does not extend to the 2018-2020 monitoring period.

Annual Flow Volume

To obtain yearly total volume, each day's average flow in cfs is multiplied by 1.983 to convert to acre-feet per day. Within the historical dataset, the mean annual flow was 14.7 cfs. The total flow volume varied widely with a low of 1,662 AF in WY 1977 and a high of 24,767 AF in WY 1974. From the composite data set collected at Blue Mountain Station Road from 2018-2020, we calculated an annual flow volume of 8,620 AF (Figure 18). Although the current flow volume falls within the range of historic volumes, it is less than the 1967-78 average annual flow volume of 11,270 AF/year. Annual precipitation during the recent period was notably lower than the annual historical average.

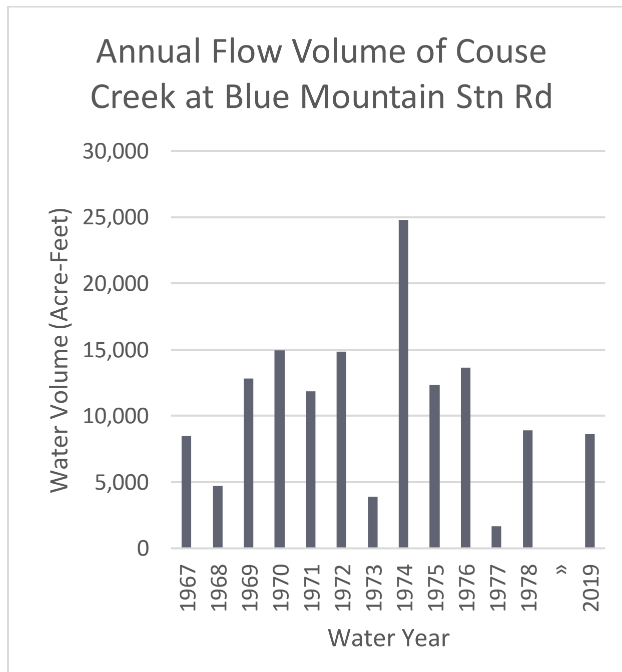


Figure 18. Annual flow volume at Blue Mountain Station Rd gage from 1966-1977 and during the recent watershed assessment. The 2019 value represents a composite dataset calculated from median of daily mean flow values produced during 2018-2020.

To evaluate trends in runoff timing, we compared the date at which 50% of the total annual volume passed the Blue Mountain Station Road gage from year to year during the historic and current monitoring periods. Results are shown in Table 4. Typically this 50% point occurred in February and March, with a median date of March 3. Water Year 1977 was an outlier, with the 50% point occurring on April 8. The 50% point for the current dataset (shown in Table 4 as water year 2019) occurred on February 22, just over a week earlier than the historic median date of March 3. It should be noted, however, that the current annual flow volume and date of 50% volume are influenced by the 100 year flood event in February 2020. Under more typical February flow conditions, the annual flow volume is closer to 7,000 AF and the 50% point would occur in late March.

Table 4. Annual flow volumes, dates of 50% annual flow volume, and days of zero flow at RM 3.2 during the historical and current monitoring periods

Water Year	Annual Flow Volume (Acre-Feet)	Date of 50% Flow Volume	Days of Zero Flow
1967	8,492	March 30	69
1968	4,720	February 22	99
1969	12,822	March 28	48
1970	14,919	February 20	0
1971	11,875	March 4	0
1972	14,821	March 16	0
1973	3,888	February 19	68
1974	24,767	February 15	2
1975	12,343	March 21	0
1976	13,657	March 2	0
1977	1,662	April 8	33
1978	8,912	February 27	0
Median	12,109	March 3	1
Mean	11,073	March 8	24.6
2019	8,620	February 22	0*
2018			42*

Flow Targets and Exceedances

The following minimum instream flow recommendations for Couse Creek are listed on OWRD's Water Availability Analysis Webpage (Figure 19). Flow targets are not met except for occasional periods between January and April.

- 5 cfs Jul, Aug, and Oct
- 2 cfs Sept
- 10 cfs Nov and Jun
- 25 cfs Dec-Apr
- 55 cfs May

Minimum instream flow recommendations at the Couse Creek mouth made by CTUIR Office of Fisheries and ODFW in 1988 call for 5 cfs from July-Sept, 10 cfs on the shoulder months of June and November, and 25 cfs through the winter.

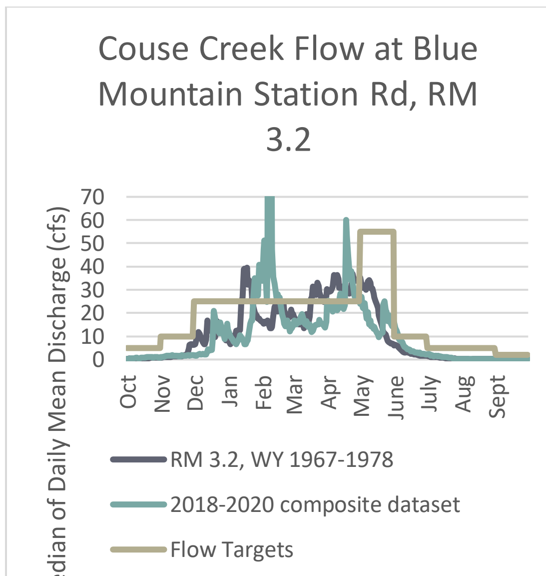


Figure 19. Daily mean discharge in Couse Creek at RM 3.2 graphed with the minimum instream flow targets listed on OWRD's Water Availability Analysis Webpage.

Exceedance data were calculated for the historical and current data sets and can be found in Appendix G. Due to the relatively short period of available data, the exceedance outputs are likely skewed by anomalous water years, limiting their usefulness as a tool for trend analysis.

Groundwater Inputs and Upper Watershed Flows

Water temperature monitoring data, manual flow measurements, conductivity measurements, and observations during the instream fish habitat survey suggest that groundwater inputs play a significant role in Couse Creek hydrology, particularly during the low flow season (Figure 20).

Figure 20. Groundwater flowing into Couse Creek in Reach 5; taken July 16, 2019 at the "elbow".

Seasonal variability of specific conductance measurements taken in Couse Creek at RM 1.1 illustrate the importance of groundwater inputs during periods of low flows (Figure 21).

Year-round flow was documented in reaches 3-6, and several springs were observed during the stream survey in June and July (Figure 20 shows one example). Several manual flow measurements were conducted during the summers of 2018 and 2019 to evaluate longitudinal trends. Table 5 shows a summary of results.

Table 5. Summary of manual flow measurements

	Measured Flow (cfs)		
Location	5/30/18	4/18/19	7/16-17/19
RM 7.9	0.15	60.3	0
RM 10.3	1.84	41.5	.45
RM 12.4	1.61	17.2	.26
RM 13.8	1.16	17.7	.06
RM 17.9	.41	-	.03 (est.)

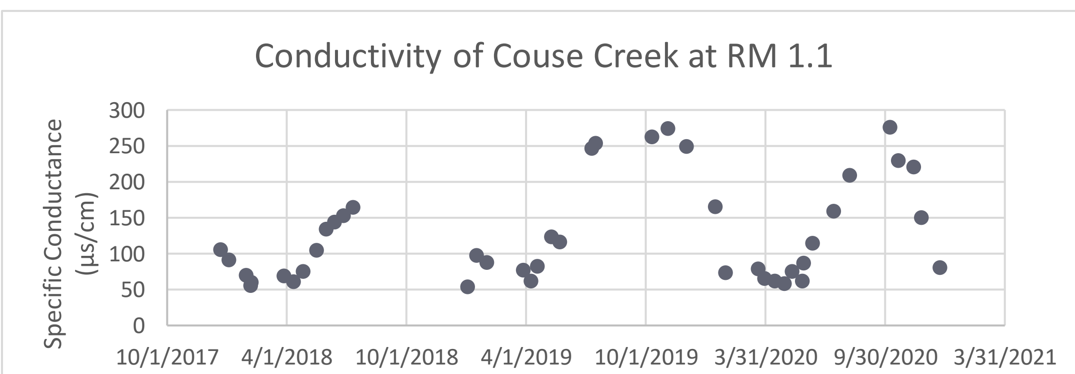


Figure 21. Specific conductance of Couse Creek at RM 1.1 shows distinct seasonal variation suggesting importance of groundwater contributions during low flow periods.

Water Temperature

High water temperatures limiting the use of the watershed for steelhead and salmon have been documented in Couse Creek. To assess current conditions we collected discrete measurements during stream surveys according to the ODFW methods and, in addition, we deployed nine water temperature sensors at RMs 0.1, 1.1, 3.2, 4.4, 7.9, 10.3, 12.4, 13.8, and 17.9 (Figure 22). The dataloggers recorded temperature values every 15 minutes during the summers of 2018 and 2019. Figure 23 shows examples of water temperature sensors deployed in Couse Creek.

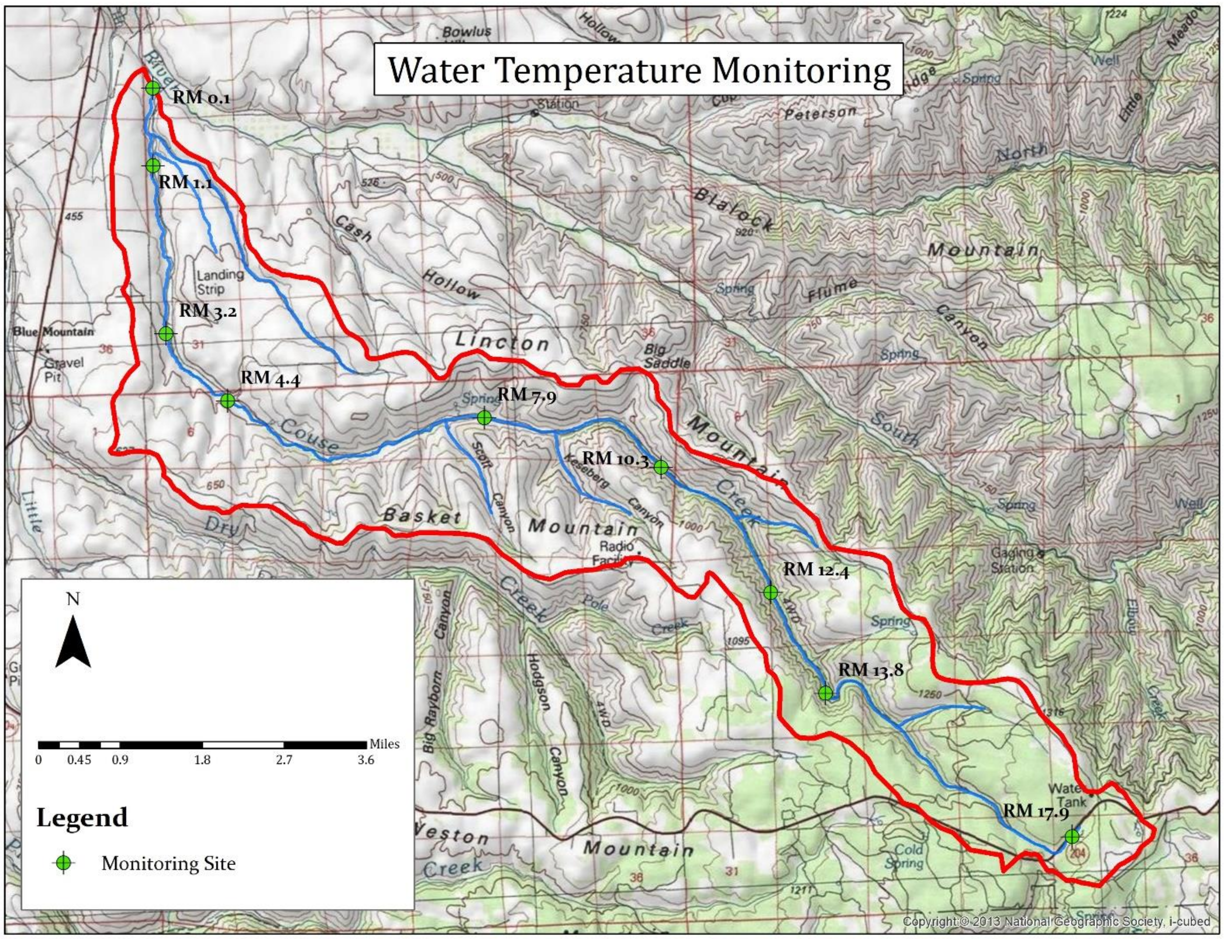


Figure 22. Map showing the 9 locations on Couse Creek where we recorded 15-minute water temperature data during the summers of 2018 and 2019.

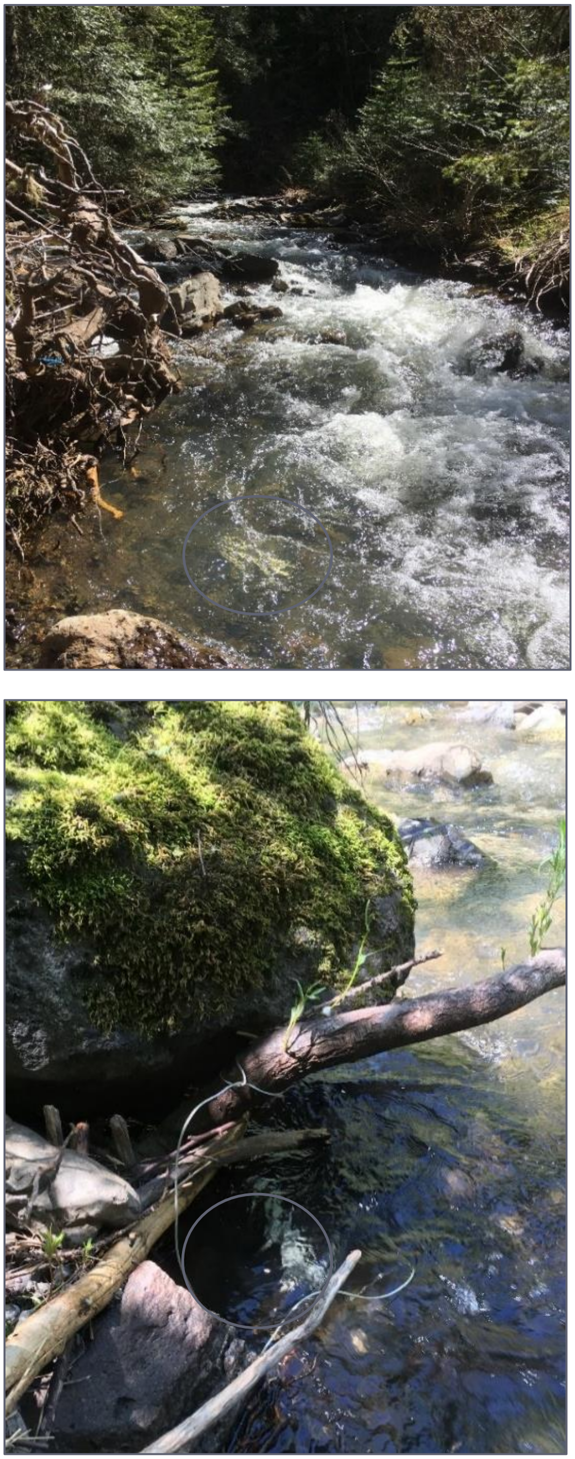


Figure 23. Water temperature sensors deployed at RM 13.8 (top) and RM 12.4 (bottom). White circles indicate sensor location. Sensors were anchored to nearby roots or branches with cable and housed in pvc tubes for protection and to block solar radiation.

For each dataset we calculated the 7-day moving average of daily maximum temperatures (7-DAD Max) to enable comparisons along the length of the stream and comparison with the following biologically based temperature thresholds assigned to Couse Creek (ODEQ, 2005, p. 1-8).

- Core cold water habitat in waters draining to the Walla Walla River: 16°C (60.8°F) applicable year-round except when superseded by cooler criteria
- Salmon and steelhead spawning use: 13°C (55.4°F) applicable January 1 to May 15

Longitudinally, temperatures generally increased with decreasing elevations. Figure 24 shows the maximum summertime temperatures of the four upper watershed monitoring sites. These sites had year-round flow in 2018, and water temperatures were cooler higher in the watershed. At RM 12.4 in Reach 4 the 7-day moving average of maximum temperatures exceeded the cold water habitat criterion of 16 °C for 54% of the summer (June, July, and August) with a peak of 19.3 °C on July 29, 2018. At RM 13.8, maximum temperatures exceeded the standard during 67% of the summer, with a peak of 20.5 °C on July 30, 2018.

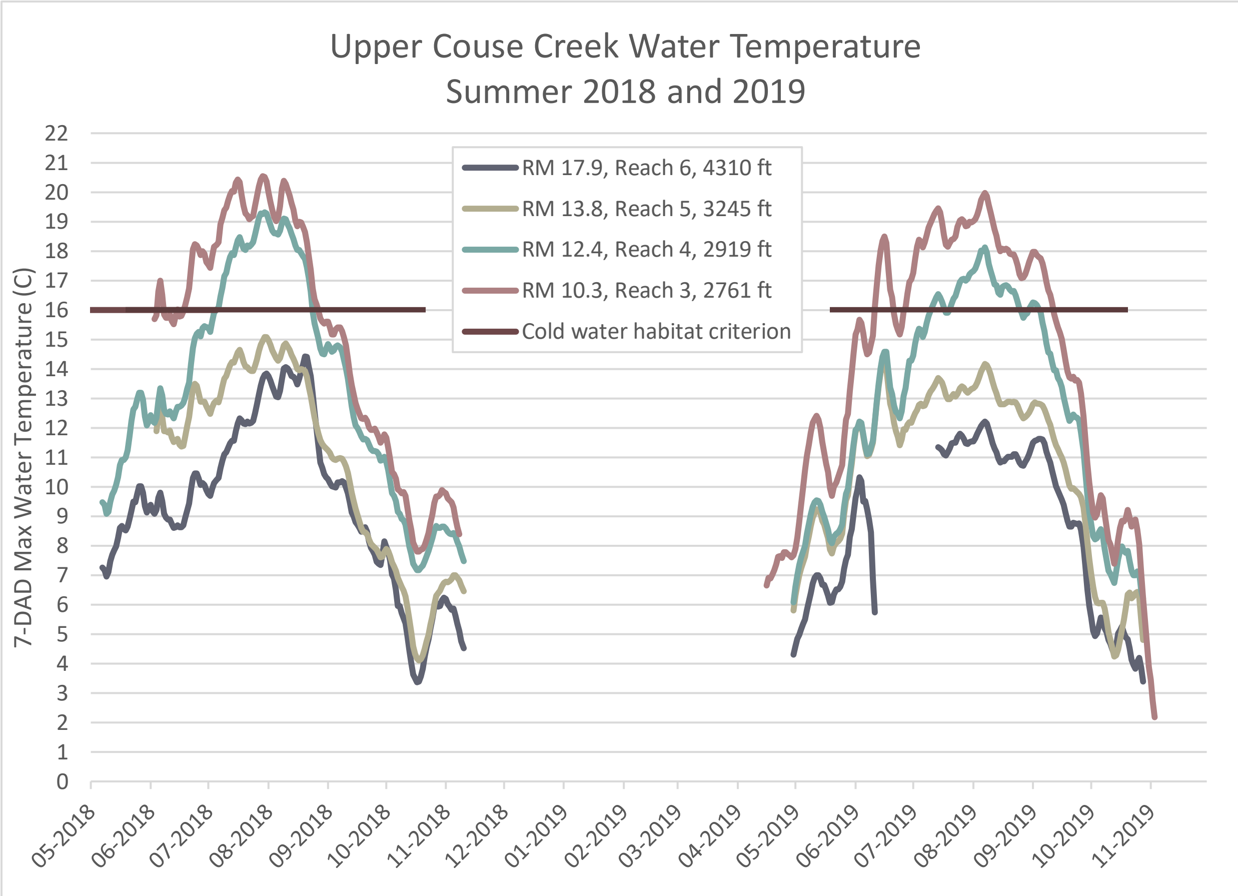


Figure 24. Seven-day moving average of maximum summertime temperatures of the four upper watershed monitoring sites plotted with ODEQ's cold water habitat criterion. The legend shows the reach number and elevation of each site. These sites had year-round flow in 2018-2019. The June-July 2019 data gap in the RM 17.9 signal near the Couse Creek headwaters was due to the logger not being submerged.

In the lower half of the watershed (reaches 1 and 2), Couse Creek went dry at most temperature monitoring sites for a portion of the summers of 2018 and 2019.

- Couse Creek mouth (RM 0.1): Went dry on June 11, 2018 but stayed wet into July in 2019
- RM 1.1: Dry for 145 days in 2018 (June 4 –Oct 27) and 42 days in 2019 (July 28-Sept 8)
- RM 3.2: Dry for 42 days in 2018 (July 29-Sept 9) and wet throughout the 2019 summer
- RM 4.4: Dry for >145 days in 2018 (June 14-after Nov 6 logger retrieval) and >118 days in 2019 (July 5-after Oct 31 site visit)
- RM 7.9: Dry for > 156 days in 2018 (June 3-after Nov 6 logger retrieval) and >144 days in 2019 (June 9-after 10/31 site visit)

In OWRD's 1960s-70s data set from Couse Creek at Blue Mountain Station Road (RM 3.2), the number of days of zero flow ranged from 0-99 with an average of 25 days, very similar to the 2018-2019 average of 24 days.

As we might expect, water temperatures at these seasonally dry sites met the 16 °C cold water habitat criterion only rarely during the summer months. However, temperatures are within an acceptable range during the period of summer steelhead migration (November-May, with peak migration occurring in March/April). Figure 25 shows maximum temperatures at RM 1.1 during steelhead migration. From January-May 15, the 13 °C criterion for salmon and steelhead spawning use applies here and is met except for 9 days in May when maximum temperatures rise to 14.0 °C. Adults may find suitable conditions to move upstream and spawn, but those that migrate back downstream may experience the low flows and high temperatures of June-July.

Juveniles spending multiple years in the watershed before migrating downstream may find cool water refuges in areas of year-round spring-fed flow located in reaches 4, 5, and 6. Due to limited access on private property, the extent of high quality habitat and year round flow in these upper reaches is undocumented.

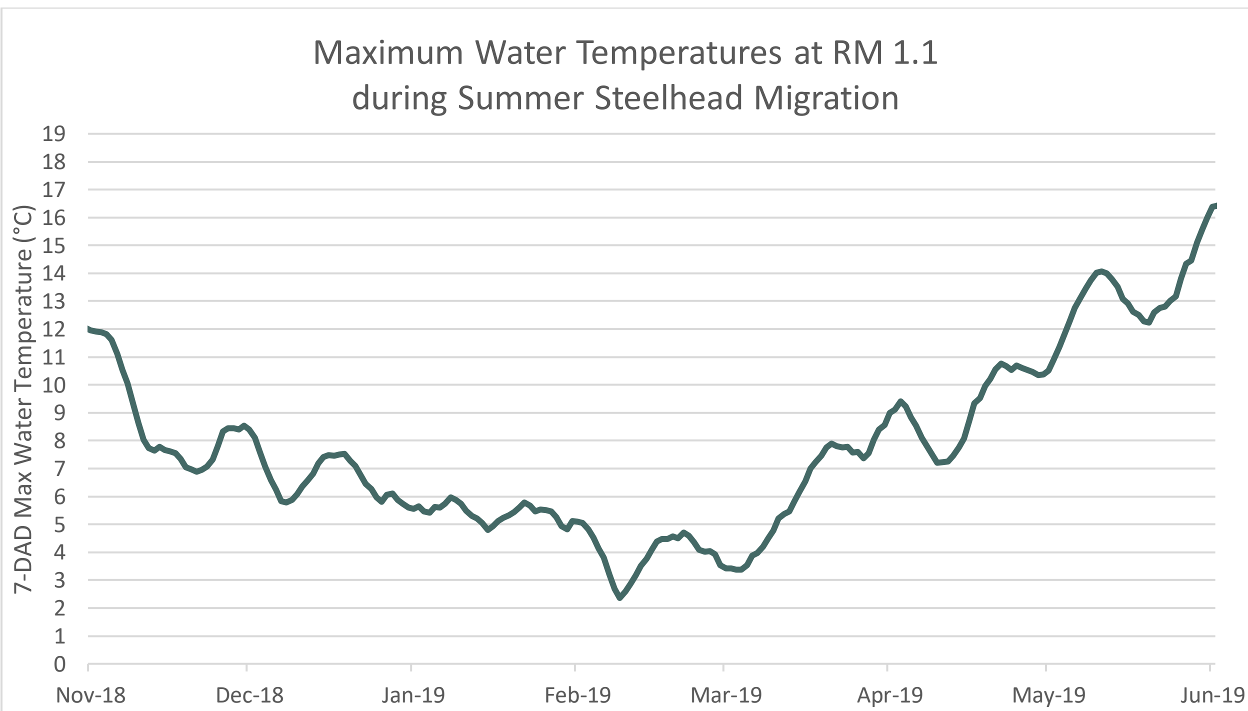


Figure 25. The 7-day moving average of maximum water temperatures at RM 1.1 during summer steelhead migration.

Watershed Geology

Well logs were reviewed to assess the possibility of aquifer storage as a flow improvement tool for Couse Creek. Out of 20 well logs reviewed, only two had at least 20 feet of coarse sediments (gravels, boulders) above the basalt. Of these two well logs, one had no water bearing zones (a dry hole) and one was located on a steep hillslope.

Because there were so few wells logs within or near the floodplain, soil characteristics were also considered, even though NRCS data includes only the top 5 feet of the soil profile. Most of the soil types in the Couse Creek valley had too finely grained soils, steep slopes, or insufficient water storage capacity to be appropriate for aquifer storage. Only one soil series, Veazie silt loam, appeared potentially suitable for alluvial storage. The deposit of Veazie silt loam is approximately 1.1 miles long, 106 acres in extent, roughly from the Konen rock quarry to Kinnear Road.

Based on the paucity of deep alluvial sediments in the watershed, a more effective flow improvement tool may be to supplement the natural recharge of basalt aquifer to increase spring performance. The primary source of water in Couse Creek during summer low flows is not precipitation but groundwater entering the stream as above-ground springs or below-ground hyporheic flow. Because of the limited depth and width of alluvial floodplain sediments, it seems safe to assume the primary source of groundwater is from the basalt aquifer, not the shallow alluvial aquifer.

In *Storage of Ground Water Behind Subsurface Dams in the Columbia River Basalt Washington, Oregon, and Idaho* (Newcomb, 1961), the author suggests increasing low summer flows in streams by taking advantage of natural groundwater reservoirs which sometimes occur behind faults such as occurs in the South Fork of the Walla Walla River. DOGAMI's geologic map identifies fault lines in the Couse Creek drainage which may be similar in nature to the South Fork faults and thus potentially geologically suitable for artificial recharge into the basalt aquifer, with the goal of increasing spring flows. The usefulness of such an approach for Couse Creek would require a more detailed geologic investigation.

Geomorphology and Fish Habitat

To evaluate floodplain connectivity, pool formation, bedform diversity, riparian condition and large woody debris (LWD) transport and storage WWBWC conducted a stream survey of Couse Creek using the ODFW methods. The survey includes measurements of valley form and channel form, identification of habitat unit types, substrate composition, shade and riparian conditions, and number and size of large woody debris.

Couse Creek is, by nature, a transport stream, moving eroded sediments from the Blue Mountains to the Walla Walla River. The steep, narrow valley of Couse Creek's upper watershed creates a naturally constrained channel morphology. As the valley floor broadens, the middle reaches are characterized by wide, unconstrained floodplains. The creek's lower reach continues through broad valleys with an average gradient of 1-2%, is moderately incised, and flows between constraining terraces and hillslopes. Figure 26 provides an overview of watershed gradient, and includes Couse Creek and its seasonal tributaries. Drainage density is 1.16 miles of channel per square mile.

The headwaters of Couse Creek emerge below the summit of the Blue Mountains near the intersection of Highway 204 and Lincton Mountain Road. The creek runs southwesterly along Highway 204, crosses under the highway through a culvert, then drops into a NW-oriented shallow valley which rapidly becomes steeper and deeper. Along the crest, flow is minimal, substrate is composed almost entirely of fines, the channel is shallow, and riparian vegetation is primarily grasses.

The stream descends at a 3-8% slope through its conifer-dominated valley in a northwesterly direction. In the upper portion of the "elbow", a basalt-bounded large meander in the channel, flow abruptly and substantially increased just downstream of a basalt cliff on the right bank which contributed spring flow to the stream. Continuing downstream, past the lower end of the "elbow" was a 700-ft dry section. Substrates were predominantly cobble with numerous boulders.

Roughly 1 mile downstream of the "elbow," impacts from past flooding were apparent in sediment (gravel, cobble) plugs in the channel, unsorted substrates, and cut banks above the active channel height. Numerous gullies on the steep hillslopes indicate historical erosion. Most of the gullies are vegetated.

As Couse Creek turns west, the valley widens, hillslopes become less steep, gullies are fewer and are present primarily on the north-facing slopes. Vegetation cover was dominantly grass, shrubs, and, in riparian areas, deciduous trees. The stream was dry for much of the surveyed portion of the westward-oriented section in late June 2018. The channel had been heavily impacted by past flood(s), with extensive deposition of gravels and cobble over wide areas (much wider the modern-day stream) and poorly defined or nonexistent banks. While vegetation had re-established in some of the flood-impacted areas, many other areas were bare.

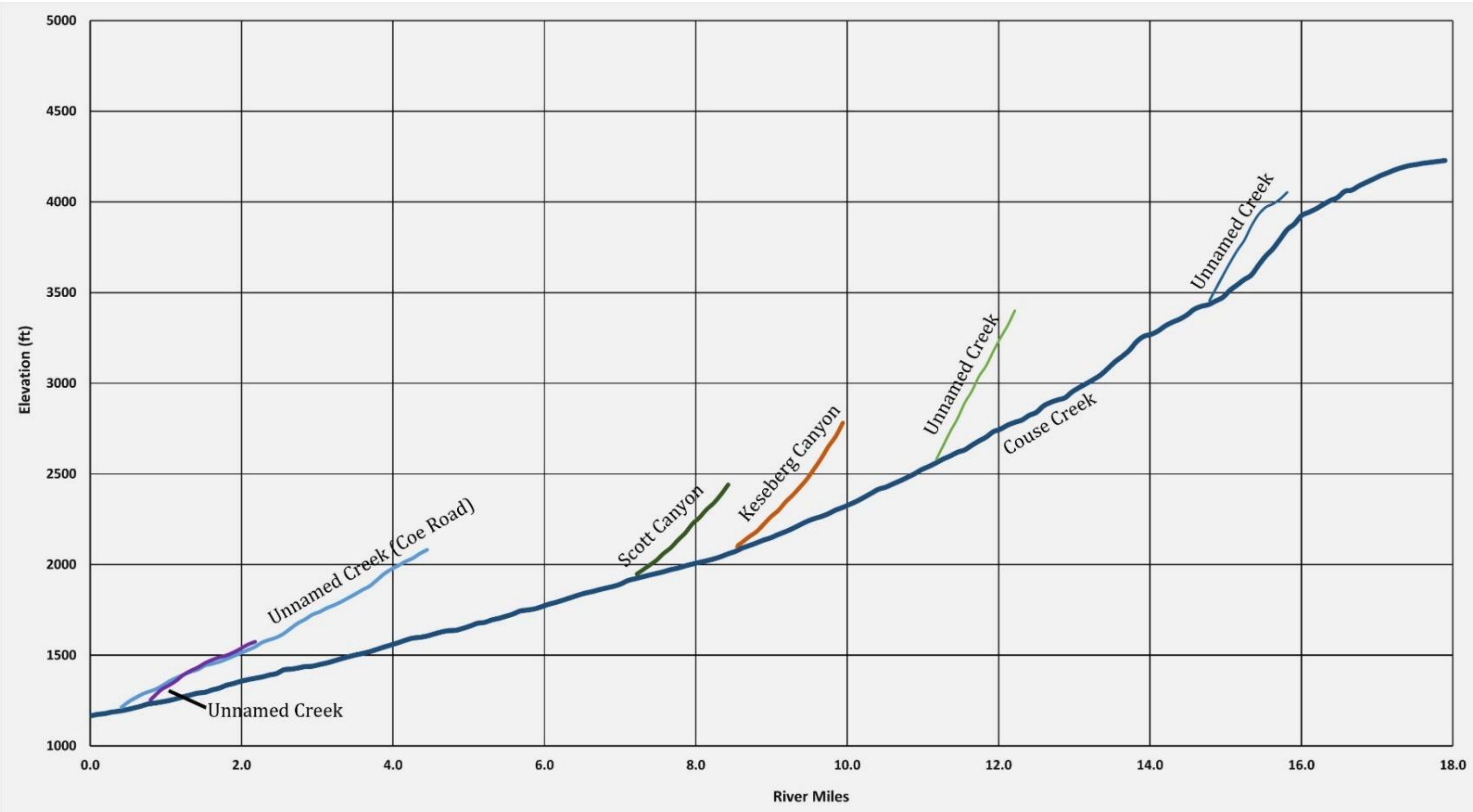


Figure 26. Stream elevation and gradient of Couse Creek and its tributaries.

As the stream turns north, water emerges from the gravel deposits. Flow increased near the bend to the north due to contributions from a tributary on the right bank, which appeared to have almost as much flow as in the Couse Creek at the time of the survey. The channel in this reach was typically narrower and deeper than the rest of the stream, with steep hillslopes (sometimes exposed basalt) or dense vegetation (blackberries, etc.) along its banks. The channel was incised in places, which enabled the formation of several log jams that had accumulated gravels behind the jams, raising the stream bed elevation by a few feet. Land use adjacent to the lowest portion of the stream is primarily rural residential. Couse Creek enters the Walla Walla River under a closed canopy formed by deciduous trees.

“RIVERS ARE THE GUTTERS DOWN WHICH FLOW THE RUIN OF CONTINENTS” LUNA LEOPOLD, 1964

Reach Descriptions

WWBWC surveyed 51% of the Couse Creek’s 18 mile length. Six reaches were identified based on valley width, gradient, vegetation cover, impacts from past floods on channel shape, location and spacing of tributaries and aspect (Figure 27). See Appendix G for discussion of reach numbering in the stream survey database.

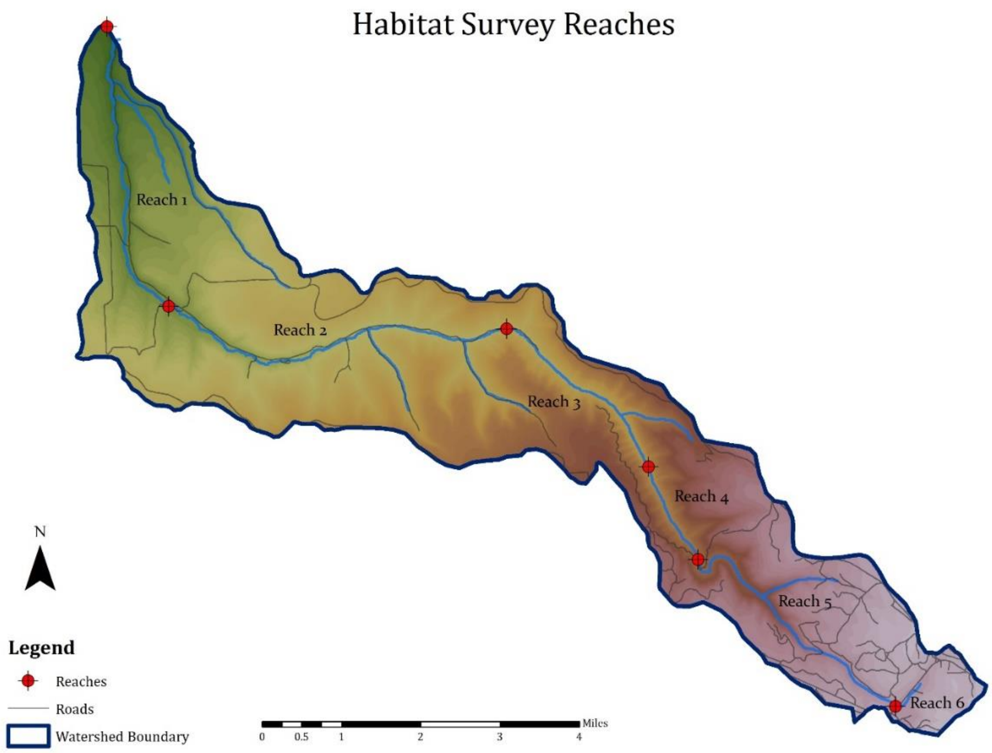


Figure 27. Six habitat survey reaches of Couse Creek identified based on valley width, gradient, vegetation cover, impacts from past floods on channel shape, location, spacing of tributaries, and aspect.

Reach 1

Reach 1 began at the confluence with the Walla Walla River and continued upstream for 3.1 miles (4982 m). Typical conditions in Reach 1 include a single channel bordered by a wall of vegetation or a steep hillslope (sometimes exposed basalt), giving the surveyors the impression of walking through a long narrow tunnel with occasional glimpse of open sky. The channel was constrained by terraces within a wide valley. Land use is primarily rural residential and farm land yet few homes or barns were visible from the stream corridor due to dense vegetation and steep hillslopes.

Reach 1 conditions

Many debris jams were observed, and most instream woody debris was too small to qualify according to the survey methods. The numerous cut banks were usually vertical, not undercut. Near the end of the reach, at unit 105, the canopy disappeared. A large spring or tributary inflow entered the stream from the right bank at the end of the reach. Out of 28 recorded debris jams, 22 occurred in Reach 1. Very few benthic invertebrates were initially observed when picking up rocks for the substrate characterization but numbers increased farther up the reach.

Photos Top: Cut bank example

Middle: Unit 2 looking upstream at the logjam (left) and looking downstream from above the jam (right)

Bottom: Unit 57 looking upstream at the jam (left) and sediment accumulated upstream of the jam (right)

Reach 2

The unsurveyed lower portion of Reach 2 has nearly continuous riparian cover based on aerial images and is partially fed by year-round groundwater inputs near RM 7 (landowner communication).

The surveyed portion of Reach 2 was mostly dry with an open canopy, wide valley, and lacking a defined channel. This reach showed evidence of extensive flood impacts, having large areas of unordered deposition of gravel/cobble and mostly shallow banks (images below). In October 2019 water was observed going subsurface above Keseberg Canyon, near the upstream end of Reach 2. Data collected by a temperature sensor deployed in the upper half mile of Reach 2 during the summers of 2018 and 2019 show the presence of year-round flow. Maximum water temperature reached 20°C, which exceeds the criteria for Couse Creek described in the Walla Walla Subbasin TMDL but falls within the 22°C threshold for steelhead described in the Mid-Columbia Steelhead Viability Assessments (ODFW, 2010, Appendix B).

Landowners remember the area being dramatically changed during the high flow events of 1964 and 1996. One account includes the scouring of "all the black soil in the meadows" and deposition of "much rock" during the 1964 event.

The four images above illustrate the extensive gravel and cobble deposits in the middle portion of Reach 2.

Reach 3

Only 15% of this reach was surveyed, so conditions are mostly unknown. In the surveyed portion, however, canopy cover increased, the channel narrowed and had shallow sloping banks. The stream was mostly shaded due to dense riparian vegetation. Substrate contained an increasing proportion of larger sized material and was somewhat embedded, in contrast to the highly disordered substrate in Reach 2. The gradient increased and several pool-like units were observed that were not classified as pools due to the velocity of water moving through them. Several juveniles and one 8" fish were observed in these pool-like habitats.

The four images above were taken in Reach 3.

Reach 4

The lower 25% of Reach 4 was surveyed and observations suggest a transition to a montane environment. Couse Creek flows through a narrow valley with steep hillslopes, a steeper channel gradient, larger substrate, and varying canopy closure but often only a narrow opening was present. The riparian area was dominated by fir trees instead of deciduous. A crayfish was observed but not as many juvenile fish were apparent compared to Reach 3. Water temperature monitoring data from this reach indicated the continuous presence of water during the summer of 2018 and intermittent dry periods during summer 2019.

These images show the conditions present in Reach 4.

Reach 5

We surveyed about 30% of the lower portion of Reach 5, which is largely owned by a timber company. Observations include decreased flow, increased substrate size compared to Reach 4, narrow opening of canopy, and generally the floodprone width equaled the valley width. Flow in Reach 5 included both dry and flowing units. The change in flow was dramatic near the lower end of the reach, where a proportionally large quantity of water entered the channel from spring water emerging from a basalt cliff near the middle of the “elbow.” Upstream of the basalt cliff the stream flow decreased and the stream was dry for a section before flowing again on the surface in a series of riffles and pools. Maximum pool depth varied from 0.2-0.5 meters. Three 5 inch fish were observed. Water temperature data collected by a sensor deployed at the “elbow” showed continuous presence of water throughout the summers of 2018 and 2019. Throughout the monitoring period, temperatures at this location met the Core Cold Water Habitat and Spawning Use criteria for salmon and steelhead.




These photos illustrate Reach 5 conditions: Low flows, dry units, and a basalt wall with flowing springwater inputs to Couse Creek.

Reach 6

Reach 6 is a low-gradient headwater reach east of the Hwy 204 crossing. Distinctly different than Reaches 4 and 5, Reach 6 has a poorly defined channel in a broad valley, mostly herbaceous and brushy deciduous riparian vegetation, and substrate of almost exclusively fine sediment. Land use is primarily recreational with seasonal cabins. The survey documented invertebrates observed but no fish in this reach. The survey ended at a dry unit with a small amount of puddled water upstream of the end point. Couse Creek headwaters likely emerge from multiple diffuse groundwater inputs. Water temperature data from from Reach 6 indicate the presence of water throughout the summer of 2018 and intermittent dry spells during summer 2019.

These photos show Reach 6 conditions: Low-gradient meadows, multiple culvert crossings, intermittently dry

Results

The total length surveyed was 14,321 m. The average unit width was 3.0 m (9.8 ft). The average depth of primary channels was 0.23 m (0.8 ft). The average substrate was composed of 12% silt/organic matter, 7% sand, 49% gravel, 24% cobble, 3% boulder, and 4% bedrock. Within the surveyed portions, the areal extents of types of habitat were 47% dry, 43% riffle, 4% pools, and 6% other. No cascades or beaver pools were observed. The average and maximum pool depths were 0.54m and 1.4 m, respectively. The average residual pool depth was 0.45 m. The average overall gradient was 3.1%.

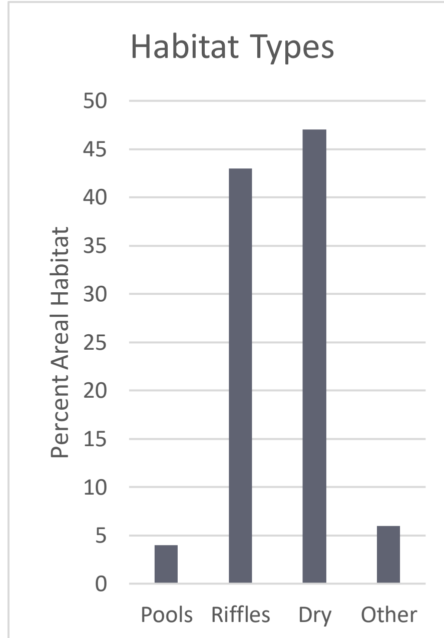


Table 6 summarizes the results of the survey, by reach, for key fish habitat attributes. Findings are shown alongside applicable ODFW benchmarks documented in a 2001 publication *A Guide to Interpreting Stream Survey Reports*.

Table 6. Fish habitat attribute data

Attribute	ODFW Benchmarks		Reach						
	Undesirable	Desirable	Avg all units	1	2	3	4	5	6
Pools									
Pool area (%)	<10	>35	4	9	2	4	4	2	1
Pool frequency (# channel widths between pools)	>20	5-8	135	19	22	17	17	40	695
Avg residual pool depth (m)	<0.2*	>0.5*	0.45	0.6	0.4	0.3	0.35	0.25	n/a
Complex pools/km**	< 1.0	>2.5	0.6						
Riffles									
Width:depth	>30	<10	20	10	35	23	11	23	6
% Area Gravel	<15	≥35	49	52	59	37	45	38	2
% Area silt-sand-organics	>15	<8	20	15	14	17	9	12	95
	>25 if gradient <1.5%	<12 if gradient <1.5%	17	16	15	24	9	12	96
Shade (%)	<50	>60	71	79	52	95	74	82	64
Large woody debris (LWD)									
Pieces/100 m	<10	>20	2.9	0.3	0.8	0.8	4.4	2.5	5.5
Volume/100 m	<20	>30	1.8	0	0.5	1.8	2.6	2.0	3.1
Key pieces/100 m***	<1	>3	0	0	0	0.2	0	0	0
Riparian Conifers									
Number >20" dbh/1000 ft	<150	>300	82						
Number >35" dbh/1000 ft	<75	>200	7						

*ODFW habitat benchmark specifically for small streams (<7 m width)

** Complex pool contains ≥3 LWD pieces

***Key pieces = >60cm diameter and ≥10m long

Pool and Riffle Habitat

Results indicate impaired geomorphic function related to pool formation and bed form diversity. Overall pool area is quite low compared to desirable values. Residual pool depth is closer to the benchmark, but pool complexity and frequency are not adequate for productive habitat. Twenty-seven percent of units were pools, but pools accounted for only 4% of areal habitat.

The average pool depth was 1.8 ft (0.54 m), meeting ODFW recommendations, and the average pool tail crest was 0.3 ft. The survey identified 36 pools with depths greater than 1.8 ft (0.5 m), 29 of which were in Reach 1 and 7 in Reach 2. Many pocket pools were observed but not recorded as pools, so the amount of pool habitat is under-represented. Backwater pools, alcoves, dammed and beaver pools provide refuge during high flows. Only two pools were categorized as dammed pools. The deepest pool, 4.6 ft, a plunge pool (unit 13), was immediately downgradient of a large culvert. No beaver dams were noted. No units were recorded as backwater pools or alcoves, although the comment section mentioned four backwater. More pool-like habitat was present, however, than recorded because some units had slower velocities, deeper water and resting places but not strictly meet the survey criteria for pools (slope=0 with calm, slow water throughout).

The presence of cobbles and boulders in pools is important for winter rearing habitat. Boulders also create pocket pools. The substrate in pools was 57% gravels, 20% cobble, and 16% fines (silt/organic/sand). Out of 69 pools, 14 had boulders; of the pools with boulders the average number of boulders was four.

Riffles, rapids, and glides accounted for 36% of areal habitat. The average riffle depth was 0.45 ft. The average wetted width was 9.8 ft (3 m). Widths generally became narrower with increasing elevation, generally decreasing from an average of 10 ft in Reach 1 to 3 ft in Reach 6, with the exception of Reach 2, which had the highest average width of 14 ft. As described in ODFW's guidance (Foster et al, 2001), "deep, narrow stream channels tend to provide better fish habitat than shallow wide channels" (p. 8). Out of 26 measured transects, 9 (35%) had width-to-depth ratios meeting ODFW's recommended ratio of less than 10. Five of these were in Reach 1. Units within Reach 2 had the three highest width-to-depth ratios (65, 61, and 55) where the "active" channel was often difficult to determine due to impacts from past flood(s). In these cases, an established channel was not yet apparent within the flood deposits, and the width of the only discernable "channel" was often the width of the gravel/cobble.

High proportions of silt and sand in streambed material may indicate poor spawning habitat in a stream. Riffle substrate in Couse Creek was composed primarily of gravel (49%) and cobble (28%). The proportion of fines in riffle substrate was 19%, a value strongly affected by the silty Reach 6 conditions. Without Reach 6, the average percent fines in riffles was 13%, a moderately desirable habitat value according to the ODFW benchmark. The average number of boulders in riffles/rapids/glide was nine.

Shade, Riparian Habitat, and Large Woody Debris

Average percent channel shade (indicated by the angle to the top of the riparian vegetation or the top of the hillslope) was 64%. ODFW's guidelines are > 60% for small (<12 m wide) streams in the NE portion of Oregon. Fifty-eight of 253 units had < 50% shade (undesirable), accounting for 30% of the surveyed length. The 1997 ODFW survey found that 96% of the surveyed units had a desirable amount of shade; however, they did not survey Reach 2, which contained a substantial flood-impacted section with limited riparian recovery. Excluding Reach 2, in 2018 six units comprising 3% of the surveyed length had undesirable amount of shade.

Within the units where detailed data on the riparian area was obtained, the average canopy closure (percent shade) was 73% in the 10 meter zone closest to the stream, 46% in the 10-20 meter zone, and 27% in the 20-30 meter zone.

Riparian areas were present on hillslopes (43%), floodplains (20%), high terraces (15%), low terraces (11%), and next to roads (2%). The predominant riparian vegetation transitioned from mixed deciduous to conifers as elevation increased. Based on eight riparian transects extrapolated to 1,000 ft along the stream, the average numbers of types of trees per 1,000 ft were: 276 hardwoods, 523 conifers, 82 conifers > 20" dbh, and 7 conifers > 35" dbh. An average of 24% of the riparian trees were large, > 11.8 in (30 cm), providing a source of recruitment for in-stream large woody debris, however, the number of large riparian trees was less than the ODFW guideline of more than 300 conifers > 20" dbh per 1,000 ft.

The survey found less large woody debris instream than recommended by ODFW. More wood is present in the stream than was recorded because it was too small to meet the criteria. The woody debris present in the stream was, however, frequently effective in forming dams which blocked the movement of sediment (gravels, cobbles) but did not form dammed pools. Out of 14 log jams, at least six jams had accumulated deep sediment behind the jam. The accumulated sediment was not measured during the surveys but based on the photographs and surveyed unit measurements, typical dimensions of the deposits upstream of the dams were 3 to 6 feet deep, 15 to 25 feet wide, and from 40-100+ feet long.

Undercut banks provide cover and low-velocity areas for fish and are an indication of stream banks effectively stabilized by vegetation because it is likely that without vegetation, the bank would erode away. Undercut banks were present throughout the surveyed units but were most frequent in Reach 1 (Figure 28). Out of 253 units, 36 units (14%) contained undercut banks meeting the survey criteria. Out of the 36 units with undercut banks, 47% were in Reach 1.

Figure 28. Example of undercut bank.

Valley Form

Most reaches had a broad valley floor with a wide and active floodplain. In Reach 1, however, the channel was largely constrained, primarily by terraces. The valley was narrow in Reach 5. The small floodplains and shallow soils limit the amount of floodwater stored in the floodplains, reducing the amount of cool water returning to the stream during dry summer months, increasing the importance of springs emerging from the basaltic hillslopes in this reach.

The valley width index, which is the valley width divided by the active channel width, varied from 1.7 in Reach 5 to 27 at the confluence with the Walla Walla River, with an overall average of 6.9. Average VWIs by reach are shown in Table 7. A larger VWI reflects the potential for the stream channel to migrate if no human obstacles prevent it and if the channel is not deeply incised. A valley is considered narrow by ODFW if the VWI < 2.5. Narrow valleys only occurred in reaches 4 and 5, in the upper elevations.

Table 7. Valley and channel characteristics by reach

Reach	Average VWI	Average Entrenchment ratio	Average # Habitat Units/100 m
1	9.2	2.0	2.1
2	5.6	4.7	1.5
3	3.9	3.5	2.3
4	2.45	2.7	1.5
5	2.9	2.1	1.4
6	11.8	2.4	1.5

Floodplain Interaction

The entrenchment ratio, the floodprone width divided by the active channel width, indicated most measured units were not entrenched. This suggests the stream is able to interact with its floodplain over much of its length. Only two units were entrenched according to Rosgen (2004) (entrenchment ratio ≤ 1.4): one in Reach 1 and one in Reach 6. However, floodprone width was measured in relatively few units; more measurements could easily result in a different understanding of this characteristic. Visibly, the deeply incised banks typical of many units in Reach 1 suggest limited interaction with the floodplain. Observations during the February 2020 high flow event also indicate entrenched conditions. During what was likely a 100-year flood, water overtopped the streambanks in very few places within Reach 1. However, the presence of perennial summer flow observed at RM 1.1 during the summer of 2020 may suggest that some degree of floodplain activation and storage did occur. Landowners at this location note that they have seen a similarly small trickle of year round summer flow maybe 6 times in the last 37 years.

Benefits of floodplain interaction include productive riparian zones, improved streambank stability, increased habitat complexity, and bank storage for slow release during lower flows.

Figure 29. Reach 1 incised channel with tall cut bank.

The average entrenchment ratio we measured in the lower portion of Reach 2 in the vicinity of Kinnear Road was 2.7, the same value reported by Volkman in a 2009 progress report of CTUIR habitat projects.

The ODFW survey method no longer includes an estimate of percentage of actively eroding streambanks (Figure 30). The survey does allow the option of indicating presence or absence of actively eroding banks but WWBWC chose not to record the presence/absence information because of the highly judgmental nature of this metric. In the 1997 ODFW survey the percentage of actively eroding banks was high, exceeding 30% in 65% of the surveyed length. In the 2018 survey, at several locations banks were bare above the height of the active channel (Figure 30, right). Of the units surveyed, only 3 were observed to have artificially reinforced banks to prevent bank erosion.

Figure 30. Active erosion of a cut bank in Reach 2.

Channel Characteristics

Except for portions of Reach 2, Couse Creek was primarily a single-channel system. The average number of habitat units per 100 m varied from 1.4 to 2.3 with Reaches 1 and 3 having the highest values, indicating more variety and complexity.

The extent of off-channel habitat available during high winter flows is indicated by the length and area of secondary channels. Out of the 52,773 m^2 surveyed, only 1,369 m^2 was recorded in secondary channels (3%). Most of the side channels were in Reaches 2 and 3 and most were dry at the time of the survey.

Dry units comprised 23% of the survey length; 69% of the dry units were in Reach 2. In ODFW's 1997 survey, none of the units in the primary channel were dry -- only three secondary channels and one tributary were dry. In 1997, the dry units were located in ODFW's Reach 14 (roughly halfway up our Reach 3) and Reach 16 (the elbow). In a July 31, 2000 survey of RM 7—8.2 (approximately the upper third of Reach 2, Units 141-173), CTUIR reported 100% dry units (CTUIR, 2003). Our survey of this section occurred on June 22, 2018 and documented 85% as dry units.

Figure 31. Example of a dry unit in Reach 2.

Pebble Count Data

Pebble counts were conducted to quantify the particle size distribution of streambed material. Based on pebble count data, the size of most sediments (84% of each pebble count) was 4.2-6.1 inches (108-154 mm) in Reach 1, 2.2-2.6 inches (57-67 mm) in Reach 2, 3.1-6.6 inches (78-167 mm) in Reach 3, 7.1-9.2 inches (180-233 mm) in Reach 4, 8.1 inches (205 mm) in Reach 5, and 0.1 inch (2 mm) in Reach 6 (Table 8). The pebble counts found the following proportions of sand (< 2mm): Reach 1=6.9 and 10%, Reach 2=7.8 and 12.3%, Reach 3=9.0 and 10.6%, Reach 4=6.2 and 14.05%, and Reach 5=12.7%. No pebble counts were performed in Reach 6 but would have likely resulted in >90% < 2 mm based on the consistent nature of the channel bed (fine sediment).

D16 ranged from 7 to 20 mm while the median sediment size (D50) ranged from 30 to 78 mm. Couse Creek has coarser sediment than the reference reaches included in Kershner et al. (2004), which reported mean D16=9.3 mm and D50=29.7 mm.

A pebble count completed by CTUIR in 2009 at RM 4.4 (CTUIR, 2009) found the following size distribution:

D16=20 mm, D50=42 mm, D85=73 mm

That location correlates most closely with our Reach 1, Upper Third pebble count site. Comparing the results suggest that the majority of substrate (D84) is coarser than in 2009.

Table 8. Summary of particle size distribution of Couse Creek substrate.

Location	D16 (mm)	D50 (mm)	D84 (mm)
Reach 1, Lower Third	16	78	154
Reach 1, Upper Third	20	55	108
Reach 2, Lower Third	11	30	57
Reach 2, Upper Third	10	35	67
Reach 3, Lower Third	7.5	34	78
Reach 3, Upper Third	16	68	167
Reach 4, Lower Third	20	68	180
Reach 4, Upper Third	7	78	233
Reach 5, Lower Third	9	56	205
Reach 6, Upper Third	100% < 2 mm		

Fish and Fish Passage

The most dramatic influence on fish presence and movement within Couse Creek is the ephemeral nature of large portions of the stream. Of the surveyed sections, 47% was dry. The dry and puddled units create numerous complete passage barriers primarily in the lower half of the watershed annually from approximately June to November.

Thermal barriers are another consideration for aquatic species in Couse Creek. Water temperature results suggest that during peak migration for summer steelhead, conditions consistently meet the salmon and steelhead spawning threshold of 13°C even in the lower portion of the watershed except in mid-late May. Summer water temperature criteria are not met except in the upper portion of the drainage area.

The longitudinal connectivity of Couse Creek was also evaluated by documenting step habitat units and instream structures. The survey identified 11 step units: 6 steps over boulders, 2 steps over cobble bars, 2 steps over bedrock, and 1 step over a structure (Table 9).

None were considered to be passage barriers by the surveyors but further analysis of the structural step determined it to be at least a seasonal barrier (Figure 32). Although not a barrier to migrating adult steelhead, it creates a significant barrier to young of the year through age 3+ salmonids attempting to migrate upstream to more favorable conditions.

Figure 32. Unit 96, Step over Structure

None of the four culvert crossings were considered as barriers or steps (Figure 33, for example). ODFW's 1997 survey identified a possible barrier of a boulder step in the "elbow" and, although the 2018 survey did document two boulder steps in the same area, neither were identified as potential barriers (Figure 34).

Table 9. Step units

Step #	Location	Type	Height (ft)	Length (ft)	Water Depth Downstream of Step (ft)
1	R1, Unit 2	Boulder	5 (total rise, smaller multiple steps of < 1 ft)	11 (total)	0.5
2	R1, Unit 5	Bedrock	2.5	Not recorded	2.5
3	R1, Unit 20	Cobble bar	Not recorded		1.95
4	R1, Unit 66	Boulder	Not recorded		0.5
5	R1, Unit 96	Structure	2.35	1.2	2.0
6	R2, Unit 119	Bedrock	0.5	1.0	2.96
7	R2, Unit 123	Boulder	Step was dry		2.2
8	R3, Unit 188	Cobble bar	0.95	0.3	0.4
9	R3, Unit 195	Boulder	0.5	0.8	0.8
10	R4, unit 220	Boulder	2.0	2.5	1.52
11	R5, Unit 224	Boulder	1.7	1.3	0.4

Figure 33. Culvert with no step, Unit 15, under a private road crossing.

Figure 34. Steps near the possible barrier documented in the 1997 ODFW survey. Unit 220, Step over boulders (top). Unit 224, Step over boulders and bedrock (bottom).

Fish Presence

The purpose of the stream survey was to assess stream characteristics, rather than survey for the presence or absence of fish, however fish were observed and documented in all reaches except Reach 6. A few photographs illustrate the fish seen (Figures 35 and 36).

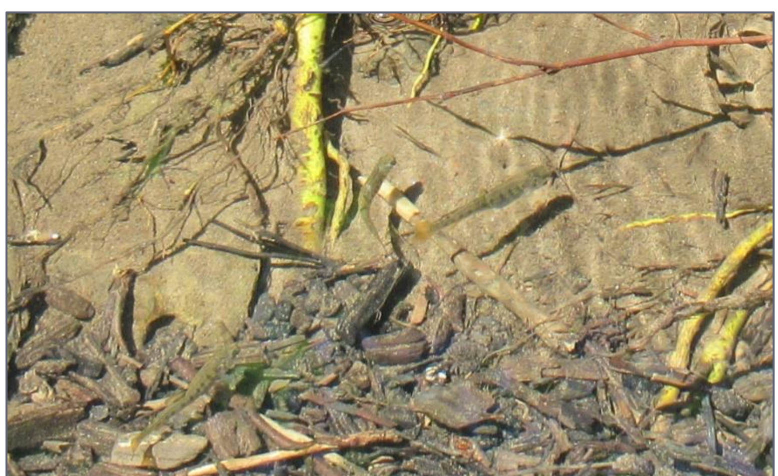
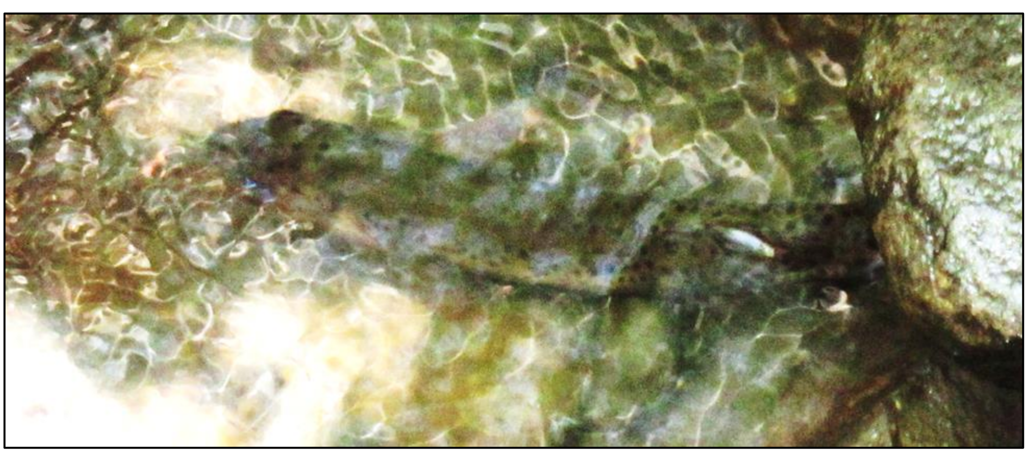


Figure 35. Juvenile fish in Reach 2, unit 168 (pool).

Figure 36. (left) Juvenile fish in Reach 2, unit 187 (riffle). (Middle) Trout in Reach 3, unit 202 (riffle). (Bottom) Close-up of middle photograph with increased brightness and contrast.



Hillslope Conditions

The yield of sediment from a drainage basin is a complex process responding to all the variations that exist in precipitation, soils, vegetation, runoff, and land use (Langbein and Schumm, 1958). The estimated hillslope sediment erosion varies within the Couse Creek watershed. The upper watershed subbasins consist of low to moderate slopes with an overstory dominated by Ponderosa pine, Douglas fir, Grand fir, Western Larch, and pockets of Engelmann spruce located in the drainage bottoms in the riparian corridor. The average annual total sediment loading to stream channels within the watershed is the lowest in the upper one third of the watershed.

Hillslope percentages increase midway downstream in the watershed with an overstory that consists of Ponderosa pine and Douglas fir timber stringers in the ephemeral stream drainages. Areas with less than 10% slope are dominated by a combination of single story and multistory Ponderosa pine and Douglas fir.

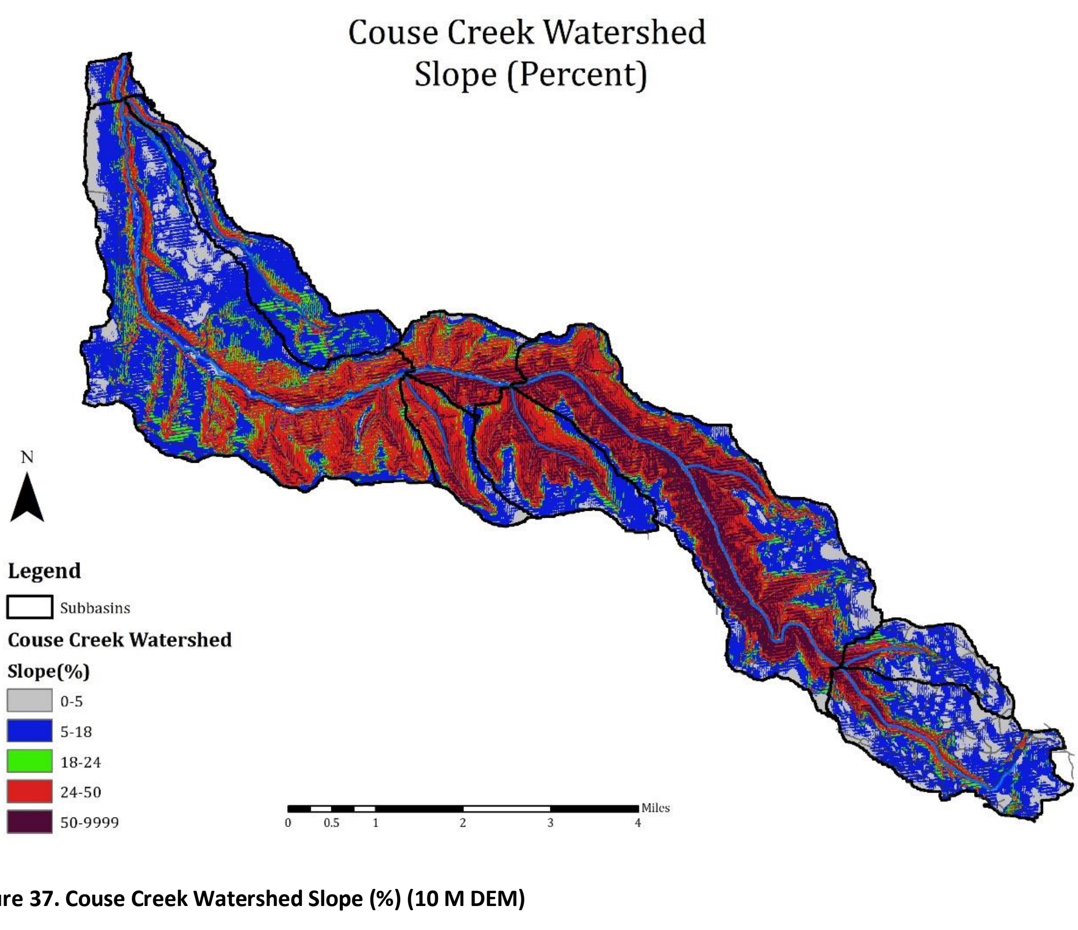


Figure 37. Couse Creek Watershed Slope (%) (10 M DEM)

Hillslopes with greater than 20% slope are dominated by annual and perennial grasses and woody shrubs. Star thistle can also be found dominating areas within the middle one third of the open hillslopes in the watershed. The average annual total sediment loading to stream channels within the watershed is the highest in the middle third of the watershed.

In the lower one third of the watershed the hydrologic conditions are noticeably different than the upper watershed. Drier conditions and ephemeral stream channels combine with lower topographic relief resulting in lower annual sediment load being delivered Couse Creek.

Table 10. Average Annual Sediment Yield

Average Annual Sediment Yield	
Subbasin	Lbs./Acre/Yr.
1	7278
2	457
3	3662
4	11143
5	10918
6	2814
7	4790
8	300
9	0

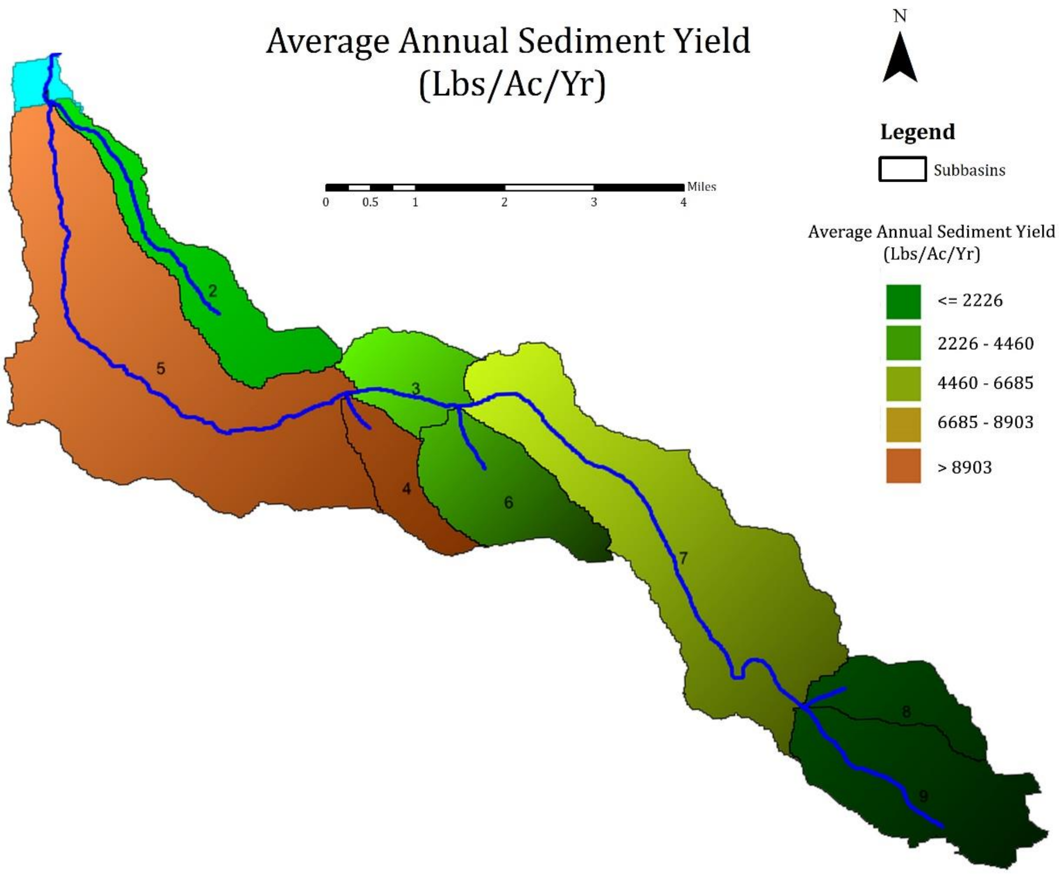


Figure 38. Average Annual Sediment Yield

There are 68 miles of roads in the watershed ranging from a paved state highway (Hwy 204) to native surface farm roads. From the existing road network sediment has the potential to be transported into the watershed stream network. Using the Water Erosion Prediction Project (**WEPP**:Road) model, the amount of sediment being transported into the stream network was quantified. Of the total watershed road network a relatively small proportion contributes the vast majority of the sediment to streams. The modeled Subbasin 4 not only has a high potential for sediment transport from the existing farm roads, but also contributes a high amount of annual sediment to Couse Creek (SWAT Model). The 68 miles of watershed roads has the potential to annually contribute 26,052 lbs of sediment into the watershed streams.

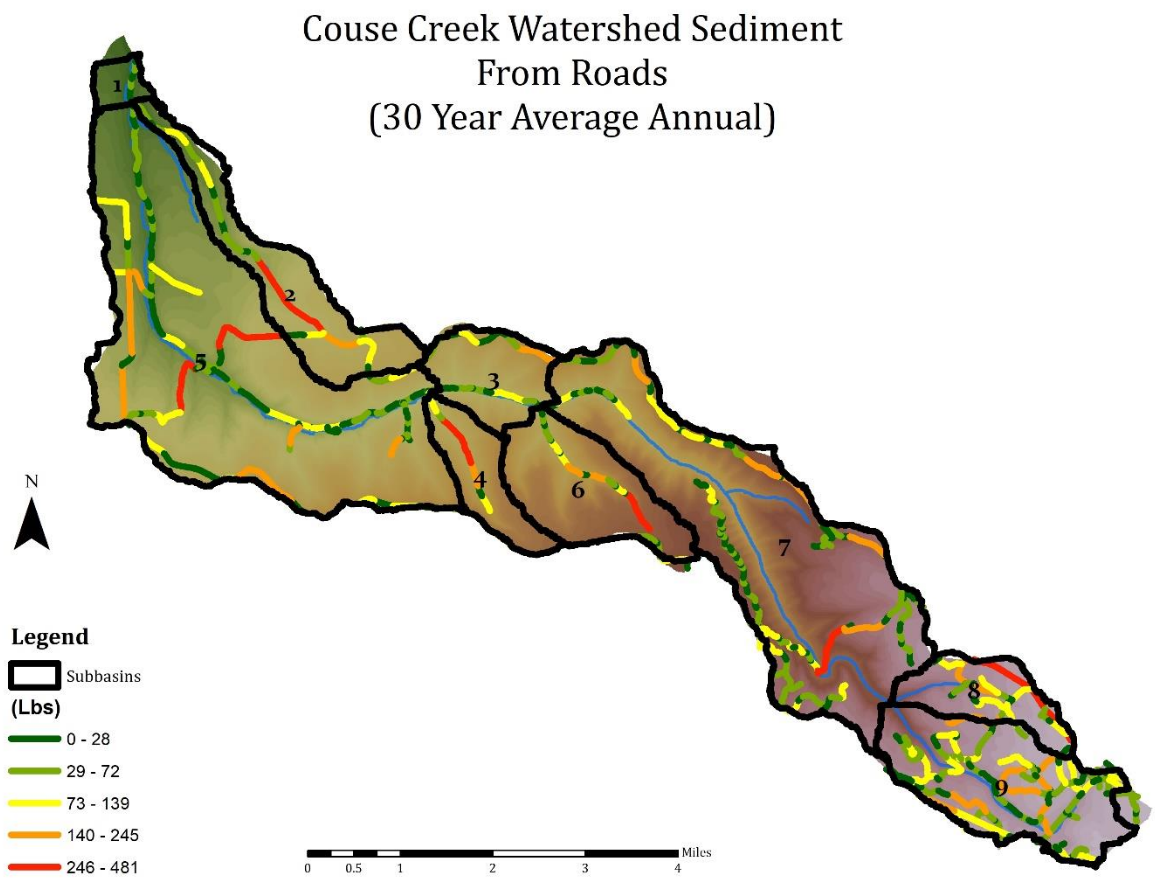


Figure 39. Sediment from roadways (30 Yr. Average Annual)

SECTION V: CONCLUSIONS

A summary of assessment findings are outlined below. The purpose of this assessment was to identify naturally functioning areas for protection and to document impairments and opportunities to restore watershed processes. Recommendations for enhancement activities follow in Section VI: Action Plan.

Hydrology

Couse Creek flows do not meet the targets described by OWRD, CTUIR, and ODFW, which include 5 cfs of summertime flow at the mouth. Flow patterns during the 2020 assessment were similar to those documented by OWRD in the 1960s and ’70s. It is unknown whether all portions of the creek historically flowed year round, but the accounts of one watershed resident describes at least a localized decrease in flow in the mid -1980s. The mechanism of decline is undocumented but assessment results indicate that the hydrology of the watershed is impacted by 1) seasonal weather patterns, 2) mid-elevation snowfall in the Blue Mountains, and 3) spring production. Hydrologic processes including infiltration, runoff and streamflow retention in the watershed have likely been modified by land use impacts on geomorphology. In addition, climate change impacts are probable. More data are needed to understand the hydrologic effects of changes in precipitation quantity, timing, and type in the upper watershed. However, the predicted shift to more rain and less snow would increase runoff and reduce recharge to the basalt aquifer, likely resulting in reduced spring performance and lower summertime flows in the stream.

Water Temperature

Temperature criteria for Couse Creek are met during much of steelhead migration season. During the summer months when young of the year through age 3+ salmonids are attempting to migrate upstream to more favorable conditions, however, much of Couse Creek is temperature impaired, likely due to low and intermittent flows in much of the watershed. Couse Creek is well shaded for much of its length, with a notable exception being the upper part of Reach 2, which has had limited riparian re-growth following the high flow events in 1964 and 1996

Geology

Based on limited available well logs, the assessment determined that the small quantity of alluvium in Couse Creek likely does not lend itself to shallow aquifer storage as a tool for flow enhancement. Storage in the basalt aquifer could be an option but would require further investigation.

Geomorphology and Fish Habitat

Stream survey results show that, of the surveyed portions, about one third of Couse Creek is unconstrained, accessing its floodplain while flowing through broad valleys. Hillslopes and terraces limit floodplain connectivity for much of the channel, and portions of Reach 1 are deeply incised.

Results suggest that geomorphic processes governing pool formation and bed diversity are impaired. Pools comprise a very small portion of instream habitat, although more pool-like habitat is present than was documented because it did not meet the survey criteria. Habitat complexity is limited overall. Riffles are the dominant unit type and have moderately desirable width to depth ratios. Few side channels were documented. Substrate composition is dominantly gravel and cobble with moderately desirable proportions of fines.

Couse Creek's riparian area provides shade for much of the stream with the exception of the heavily flood-impacted middle reach. Buffer widths are limited by agricultural production in some reaches. Riparian trees are smaller than ODFWs metrics for desirable conditions, and numbers and volume of LWD are low. There is more wood in the channel than documented however, because it did not meet the size criteria for the survey. Numerous log jams and accumulated sediments are present in Reach 1.

Hillslope Conditions and Sediment

Gravel, dirt, and native surface roads, particularly where they cross drainages, are contributing sediment to the watershed stream network. NRCS data shows cover types trending toward less perennials and more annuals. WWBWC observed hillslopes dominated by annual bromes and invasive species.

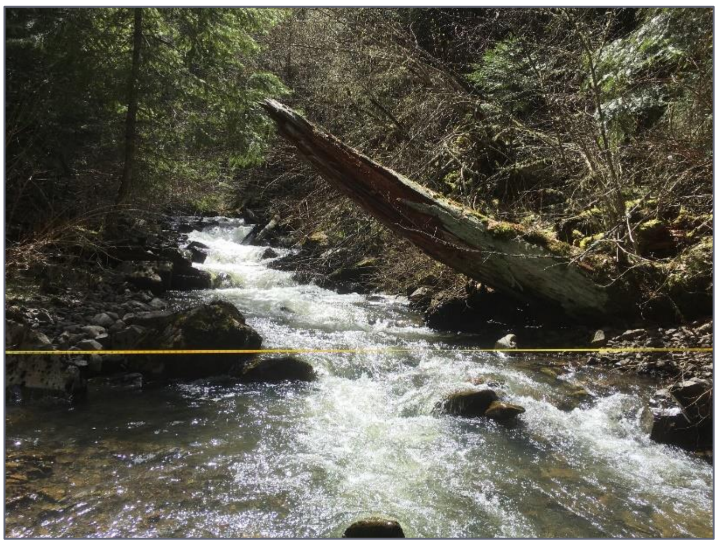
One landowner describes two foot boulders coming down onto the road and water flooding his house from a nearby gully, suggesting active erosion conditions in at least some of the hillslope drainage areas.

SECTION VI: ACTION PLAN

Based on assessment results, 7 goals were developed to enhance natural watershed processes. Under each goal, recommended actions are described below.

Goal 1: Protect functioning habitat

Actions:
- Protect high quality instream steelhead habitat in Reaches 4 and 5 (Figure 40)
- Conduct inventory of spring sources and condition
- Explore potential for conservation easements in riparian areas



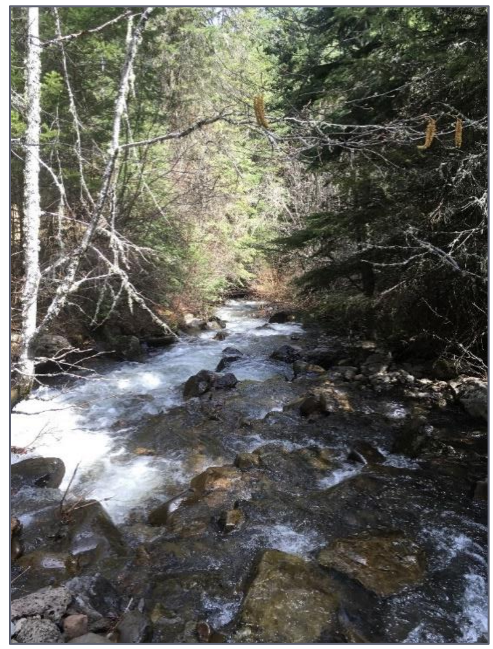


Figure 40. Photos taken in Reach 5 illustrating excellent habitat quality features to be protected.

Goal 2: Improve riparian conditions

Actions:
- Conduct community outreach and volunteer or cooperative riparian planting program
- Expand functional riparian zones where possible
- Install livestock exclusion fencing and off channel watering where needed
- Construct armored fords or install culverts at crossings
- Ongoing implementation of the Forest Practices Act by Oregon Department of Forestry (ODF). In ODEQ's temperature TMDL, the ODF is listed as having jurisdiction over conifer and mixed forest on non-federally owned land within the Couse Creek drainage (ODEQ, 2005, p. 2-6).

Project Example: In the flood-impacted portion of Reach 2, evaluate capacity to speed riparian recovery by studying groundwater depths and further investigating the hydrology of that reach.

Goal 3: Improve water retention and flows

Actions:

- Coordinate with water acquisition entities to provide information to residents about water right leases, transfers etc.
- Follow up with OWRD on expired water right transfers/leases
- Evaluate opportunities to enhance basalt groundwater recharge and increase spring performance
- Develop forest plans with upper watershed landowners to address stand health and fire resilience and to treat priority roads (identified by WEPP model outputs) to reduce runoff and erosion (Goal 4 addresses one of the priority roads). These actions are likely to result in water retention onsite and reduce runoff and erosion downstream

Project Example: Landowners at RM 12. 4 are willing to consider an upland storage pond on an intermittent tributary to Couse Creek.

Goal 4: Improve water quality by reducing water temperature and sediment inputs

Actions:

- Improve riparian cover where needed – primarily Reach 2, portions of Reach 4
- Improve flows, floodplain connection, and hyporheic function
- Improve conditions on Blue Mountain Station Road and others identified by WEPP:Road model outputs as high sediment contributors
- Conduct outreach to forest landowners about sustainable harvest and private forest management protocols
- Manage invasive weeds and seed native perennials on hillslopes specifically in the steeper slope mid-watershed

Goal 5: Enhance aquatic habitat quality and connectivity

Actions:

- Increase instream habitat complexity
- Increase quantity of off-channel habitat
- Improve floodplain connectivity
- Improve hyporheic function
- Improve longitudinal connectivity by removing barriers

Project Examples: 1) Floodplain reconnection, habitat complexity, and off-channel habitat project at the Shumway property (~RM 2). 2) Channel reconfiguration at Kinnear Road, continuing from previous restoration efforts at the site, which are described in Appendix I (Shumway Project). 3) Install beaver dam analogs to improve floodplain connectivity at RM

1.1 and RM 4.4. 4) Barrier removal project currently underway at Blue Mountain Station Road, scheduled for completion in 2022.

Goal 6: Monitor and evaluate outcomes
Actions:
- Conduct continuous flow and water temperature monitoring at RM 1.1
- Develop a conductivity monitoring plan to further evaluate groundwater contributions to summertime flows
- Monitor turbidity
- Study hyporheic flow patterns, status and potential role in flow and water temperature enhancement
- Track status of native fish populations, resume redd surveys
- Track and evaluate project implementation and effectiveness
- Develop adaptive management plans

Goal 7: Community Engagement
Actions:
- Continue to invite community involvement and voluntary stewardship
- Develop strategic monitoring plans to track outcomes of enhancement actions
- Invite local school groups to participate in monitoring and restoration activities

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APPENDIX A: WWBWC FLOW AND TEMPERATURE MONITORING METHODS

WWBWC FLOW MONITORING PROCEDURES

Updated September 2018

Summary

The WWBWC flow monitoring program seeks to accurately measure stage height, conduct accurate instantaneous streamflow measurements and create reliable rating curves based on established methods to produce high quality discharge data for the rivers and streams we monitor. At near real-time telemetered sites, data are collected every 15 minutes and transmitted hourly to be automatically stored in our AQUARIUS database and reported online at www.wwbwc.org. At stand-alone sites, data are collected every 15 minutes, downloaded quarterly, added to our AQUARIUS database and reported online.

The procedures described below are based primarily on USGS methods and modified as local conditions require.

References

These procedures are based on and modified from the following reference documents:

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Field Procedures

Time

Pacific Standard Time (PST) is used year round.

Equipment to take from the office

- Flow Meter: FlowTracker ADV (wading) or Price AA current meter (bridge mmt)
- Four foot top set wading rod
- AquaCalc computer (bridge mmt)
- Bridge Board and Sounding Reel (bridge mmt)
- Columbus sounding weight (bridge mmt)
- Tape Down Measuring Tape with engineer's scale (with weight attached)
- Laser Level
- Stadia Rod
- NIST Thermometer
- YSI-30 Temperature and Conductivity Meter
- 100-200 Ft Measuring Tape with engineer's scale (feet, 10ths, 100ths)
- Chest or Hip Waders
- Laptop Computer
- Cables for connecting to data loggers
- Memory card to download data
- Pen or Pencil
- Data sheets
- Station Keys

Station Equipment

WWBWC flow gauges use a combination of submersible pressure transducers, data loggers and telemetry equipment to collect and transmit stage data.

Our real-time monitoring sites utilize some combination of the following types of equipment:

- CS451 - Campbell Scientific submersible, vented sensor to measure water level and water temperature. Collects and sends data to a data logger in an on-site weather-proof enclosure.
- Campbell Scientific data logger, one of several different models depending on site conditions and sensor used.
- CRS451 – Campbell Scientific submersible, vented, recordable sensor to measure water level and water temperature. Collects and logs data, can connect directly to radio.
- RF450 or RF451 – Campbell Scientific 900 MHz, 1 Watt Spread Spectrum radio
- CS470 – Ott Compact Bubble Water Level Sensor. Collects gauge height data
- WaterLog H-355 bubbler and gas purge system. Collects gauge height data
- WaterLog H-350 XL pressure transducer and data logger
- Campbell Scientific 107 temperature probe
- WaterLog H-377 temperature probe

- WaterLog H-222 GOES transmitter. Sends data through NOAA's Geostationary Operational Environmental Satellite (GOES) system.
- Solar panel, charge controller, and 12 volt battery to power sensors, data logger and radio

Our stand-alone monitoring sites utilize the following recordable pressure transducers that are downloaded quarterly using communication cables and a field laptop.

- Solinst Levelogger pressure transducer with water temperature sensor
- In-Situ LevelTroll 300 pressure transducer with water temperature sensor
- In-Situ LevelTroll 500, vented pressure transducer with water temperature sensor

Measuring Stage

Each flow monitoring site has an established primary gauge used as the reference gauge for continuous stage (water level) measurement. An arbitrary local gauge datum (zero point of the primary gauge) is established as a convenient working reference for each site. WWBWC uses bubblers and submerged pressure transducers to collect continuous stage data, which are then offset to align with reference gauge height measurements. Auxiliary gauge locations are established to serve as a check of the primary gauge (to make sure it has not moved) and to provide comparison for quality control. At many sites, the primary gauge is a staff gauge installed in the stream channel. Auxiliary gauges include tape down measurement locations and reference points (typically bolts in large boulders or other stable objects) on the streambank. At sites where conditions do not permit a permanent staff gauge, primary gauge height measurements are taken using differential level survey to determine vertical distance from the water surface to an established reference point with known elevation. The elevations (based on NAVD 88) of primary and auxiliary gauge locations are established by GPS survey. For ease of rating curve development, we establish an arbitrary local elevation (below the estimated elevation of zero flow) to serve as the zero point of our gauge height measurements at each site.

Procedure for Staff Gauge Measurements

1. Read the water level on the staff gauge to the nearest 0.01 ft. If the water level is fluctuating during the reading, take the average water level and note the range of fluctuation (1.25 ±0.04 where 1.25 is the average water level and 0.04 is the range above or below the average).
2. If water level fluctuations are excessive, you can get a more accurate reading by creating a temporary stilling well (using a 5-gallon bucket with the bottom cut out) around the staff gauge.
3. Take the necessary time to obtain an accurate staff gauge reading – both the water level and uncertainty.
4. Record the date, time and water level value on the data sheet.

Procedure for Tape-Down Stage Measurement

Measuring tape-down stage involves lowering a weighted measuring tape from a reference point to the water surface. Often the reference point is a metal washer attached to a bridge railing.

1. Locate the reference point.
2. Lower the weighted tape down to the water surface. The weight should only just touch the water surface creating a small "V" shape on the water surface.
3. Read the tape at the edge of the reference point and record to the nearest 0.01. Include uncertainty caused by wave action or wind.
4. Because the weight is attached to the end of the measuring tape, record the added length of the weight and any attachment hardware as a correction factor for the tape-down value.

Procedure for Laser Level Stage Measurement

Running levels at gauge stations is an important part of accurate stage measurement and the subsequent production of reliable streamflow values. Differential leveling is the process of measuring the vertical distance between a point of known elevation and point of unknown elevation. A differential level survey is used 1) to measure gauge height in the absence of a staff gauge and 2) to allow a check on the primary gauge (either staff gauge or primary reference point) and all auxiliary gauge locations (ie: tape down reference point). Levels are run at gauge stations whenever differences in gauge readings are unresolved, if stations are damaged or according to a pre-determined frequency. At new monitoring sites, levels to check the stability of staff gauge and and/or other reference points should be run at least once a year. Once stability is confirmed, levels will be run every 2-3 years. Our use of the laser level and stadia rod used will meet the precision standard of 0.001 feet and accuracy standard of <0.010 feet difference between measured and actual vertical distances.

1. Before using a laser level (LL) to measure stage height, you must confirm that the primary reference point has not moved. Record elevation differences between the primary reference point and 1-2 secondary reference points established nearby. Compare measured and previously established values to confirm that the primary reference point is stable.
2. Using the self-leveling laser and a stadia rod, measure the elevation difference between the primary reference point and the water surface. If a permanent staff gauge exists, place the stadia rod in the channel as close to it as possible. Record the LL and also the water level (including level of uncertainty) on the stadia rod.
3. Complete the calculations on the Stream Gage Logger Notes datasheet to compute the LL stage.

Continuous Stage Measurement

Water level sensors are installed at a fixed instream location and programmed to log stage measurements every 15 minutes. Two types of stage measuring devices are used. An electronic submersible pressure transducer measures water column pressure and converts it to a digital value with a measurement accuracy of ±0.03 ft[1]. The other type of device we currently use is an out-of-stream pressure transducer (bubbler) that measures the pressure needed to emit a bubble from the end of a pneumatic orifice line anchored at a fixed location instream. The pressure is directly proportional to the water column height above the bubble chamber. Pressure is converted to a digital value and stored in a data logger with an accuracy of 0.01 ft (WaterLog bubbler) or 0.02 ft (OTT bubbler).

Procedures for Station Visit (without Discharge Measurement)

Telemetered flow monitoring stations are visited every other week to take stage and water temperature measurements and perform any site needed maintenance. These visits do not include a discharge measurement.

1. Measure primary gauge height (see above for procedure)
2. Measure auxiliary gauge readings (see above for procedure)

[1] Measurement accuracy of the submersible pressure transducers currently in use does not meet the USGS accuracy standard of 0.01 ft. As funding allows, we will work to replace them with transducers meeting the accuracy standard.

3. Measure water temperature with NIST-certified thermometer
4. Measure air temperature with NIST-certified thermometer (if applicable)
5. Connect to or read display on the data logger and record the following:
    a. Data Logger clock time – double check with GPS time
    b. Water temperature
    c. Air temperature (if applicable)
    d. Battery volts
6. Once every 6 weeks, download data from the data logger and note the time on the data sheet
7. For bubbler systems:
    a. Purge the pressure sensor
    b. Record battery minimum and maximum.
    c. Reset Stats screen.
    d. Delete the .New file after download
8. Note any problems, maintenance issues or other information at the bottom of the data sheet.
9. Replace desiccant as needed
10. Close and secure the gauge station

Measuring Discharge

Discharge measurements are conducted to capture the widest possible range of flows at each monitoring site in order to develop a reliable rating curve. Once the curve has been established, discharge measurements are made to verify the rating curve approximately every 6 weeks at telemetered monitoring sites and quarterly at stand-alone flow sites (or more frequently as site conditions require). As high flow events modify channel geometry by depositing or eroding bed material, measurements are used to verify and update rating curves with the objective of accurately predicting discharge across the full range of flow for each site.

WWBWC currently uses two methods for measuring stream discharge: 1) wading cross-sectional measurement using a rod-mounted ADV and 2) cross-sectional measurement from a bridge using a Price AA current meter. In each case, we divide the cross section into segments, determine the depth and water velocity of each and use the USGS mid-section method to calculate flow.

Duplicate Discharge Measurements

For quality control, a duplicate discharge measurement will be taken each month at a randomly selected flow monitoring site. Duplicate measurements are intended to assess the precision of discharge measurements and document variability inherent in the measurement procedure. The cross section and meter used for the first measurement will also be used for the duplicate, but depth and velocity measurements should be taken at different vertical locations. Verticals for the duplicate should be offset by some distance ie: 0.5 or 1 ft from the vertical locations of the first measurement. The relative percent difference (RPD) for the two measurements will be calculated using the equation below. To meet our quality objectives the RPD of duplicate measurements should be within 5%.

$$RPD = \left[\frac{|\ R1 - R2\ |}{R1 + R2}\right] x200$$

Where R1=Result for the first measurement
R2=Result for the second measurement.

Procedure for Wading Measurements

1. Select an appropriate location to perform a discharge measurement (refer to Rantz, 1982 for full details). Often some or many of the below criteria cannot be met. The best available cross section location should be chosen. A good cross section will typically have the following characteristics:
    a. relatively straight channel with defined, parallel edges, and uniform shape
    b. free of vegetative growth and large cobbles or boulders
    c. free of eddies, slack water and turbulence
    d. depths greater than 0.5 feet
    e. evenly distributed velocities greater than 0.5 feet per second
    f. close to the gauging station

2. Stretch a measuring tape across the channel where the measurement will be taken. The tape should be perpendicular to as much of the flow as possible to reduce oblique flow angles.
3. Determine the width of the wetted channel and divide the width into 25-30 segments (verticals). The width should be divided such that each cell has approximately 5% of the total flow and no more than 10%. Segments should be shorter where flow is more concentrated or the bottom is irregular. The width of any segment should not be less than three tenths of a foot (0.3 feet).
4. Perform the FlowTracker QC test (BeamCheck) to verify system performance. If any warnings result, try moving the sensor to a different location and perform the test again. If warnings persist, the instrument cannot be used for discharge measurement until it is further evaluated.
5. Start at either the right or left edge of water (REW or LEW). Record tape distance for edge of water.
6. Set wading rod at location for the first measurement. The rod is graduated in tenths of a foot. Depth should be estimated and recorded to the nearest 0.01 feet.
7. If depth is less than 1.5 feet use the one point method of measuring velocity at 0.6 of the depth.
8. If depth is equal to or greater than 1.5 feet use the two point method of measuring at both 0.2 and 0.8 of the depth and average the velocities.
9. In cases where there is no logarithmic relationship to the velocities in the water column (this is when the 0.2 velocity is less than the 0.8 velocity or the 0.2 velocity is more than twice the 0.8 velocity) the three point method should be used. The three point method measures at 0.2, 0.6 and 0.8. The 0.2 and 0.8 velocities should be averaged and then that result should be averaged with the 0.6 velocity. This weights the 0.6 velocity at 50% and the 0.2 and 0.8 each at 25%. (Based on 0.8 and 0.2 velocities, the FlowTracker ADV will prompt the user to measure 0.6 velocity as necessary and will also perform the calculation described above.)
10. The meter should be set to average velocity data over 40 seconds in order to capture variations in water velocity over time at each vertical measurement point.
11. Repeat steps 5-10 for each of the subsequent verticals until you reach the opposite edge of water.
12. Sometimes, water flow direction is oblique to the FlowTracker sensor. As it conducts its automatic QA test prior to each velocity measurement, it will produce a warning for high flow angle. Keep the sensor oriented perpendicular to the flow and continue with the velocity measurement. The FlowTracker will conduct an internal calculation to correct the resulting velocity value according to the flow angle at which it was measured.
13. The FlowTracker calculates discharge using the mid-section method in which each section extends halfway between measurement locations. The flow through each section is calculated by multiplying the average velocity by the cross-sectional area of the section. See references for a complete description of discharge calculations.
14. The FlowTracker evaluates several quality control parameters for each velocity measurement and produces warnings when thresholds are exceeded. (Quality Control thresholds are established according to USGS standards.) Whenever warnings are produced, move the probe location slightly and redo the velocity measurement. Under certain measurement conditions, QC warnings cannot be remedied. The FlowTracker tracks QC parameters for each velocity measurement and calculates an overall uncertainty value for the cross section.

15. Grade the measurement on a scale from excellent to poor based the FlowTracker's uncertainty calculation as well as measurement conditions (streambed smoothness, velocity conditions, equipment performance). Grades will be used to determine the tolerance for adjustment of the rating curve for that site. Observations that can influence the rating of a measurement include (but are not limited to): channel characteristics, proximity to bridges or other structures, number and degree of oblique flow angles, condition of equipment, weather, water level bounce and velocity pile up on wading rod. Use the FlowTracker uncertainty values as follows to inform a professional judgment of grade:
    a. ≤2.5% uncertainty = Excellent
    b. 2.5-5% uncertainty = Very Good
    c. 5-10% uncertainty = Good
    d. 10-20% uncertainty = Fair
    e. >20% uncertainty = Poor

Procedure for Discharge Measurement from a Bridge

This section describes procedural changes specific to bridge discharge measurements. Follow the procedure for wading discharge measurements above with the following changes:

1. Perform a spin test on the Price AA current meter each day before leaving the office. Spin time must exceed 2:00 minutes to indicate acceptable performance of the meter. If not, the meter cannot be used for measurement.
2. The choice of cross section locations is obviously limited when measuring from a bridge.
3. Use a bridge board, sounding reel and sounding weight instead of a wading rod. Depths should be measured to the nearest 0.1 feet.
4. For accurate depth measurement under swift and deep conditions, perform dry and wetline angle corrections according to USGS guidelines.
5. Increase measurements near bridge piers.
6. Use the one point method on depths less than 2.5 feet and the two point method on depths equal to or greater than 2.5 feet.
7. Sometimes, water flow direction is all oblique to the bridge. In these cases multiply the raw average velocity of the measurement by the cosine of the angle between current direction and the cross section. Use the data sheet to measure the angle coefficient and then apply a correction to the velocity (see figure below). Align the point of origin on the measuring tape. Rotate the data sheet until the opposite long edge is parallel to the direction of flow (the same direction the meter is pointed). The angle coefficient is read where the measuring tape intersects the data sheet. Multiply the velocity measurement by the angle coefficient to calculate the perpendicular velocity. The AquaCalc flow computer will perform the calculation to correct for flow angle when an angle's cosine (angle coefficient) is entered.

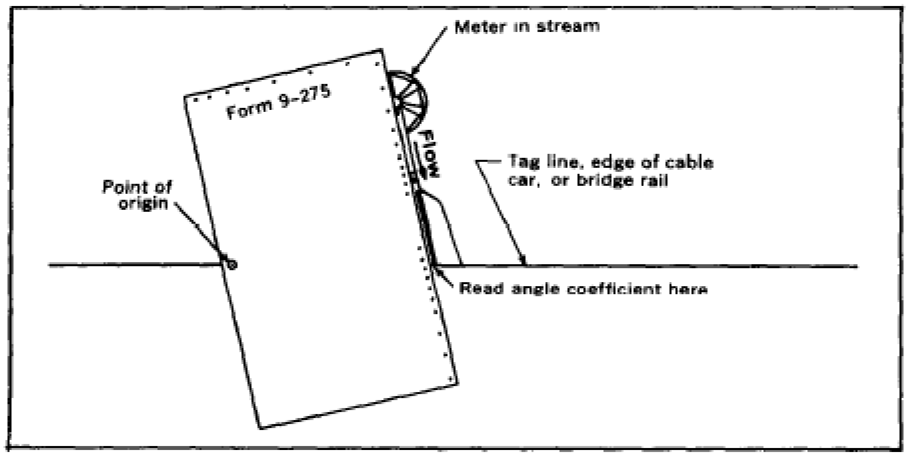


Figure taken from Rantz, 1982.

8. The AquaCalc calculates discharge using the mid-section method in which each section extends halfway between measurement locations. The flow through each section is calculated by multiplying the average velocity by the cross-sectional area of the section. See references for a complete description of discharge calculations.
9. Discharge measurements from a bridge using the Price AA and Aquacalc should be graded based on site conditions and professional judgement of velocity data quality. Grades will be used to determine the tolerance for adjustment of the rating curve for that site.
10. After returning to the office, conduct the daily maintenance of Price AA current meter.

Calculating Streamflow Using Gauge Height and Rating Curve

To obtain a continuous streamflow record, 15-minutes gauge height data are applied to a stage-discharge equation (rating curve). For each site, we use the AQUARIUS rating tool to develop a mathematical relationship between gauge height and instantaneous flow. Measured stage and discharge values are plotted to logarithmic scales and a scale offset (the effective gauge height of zero flow) is defined, producing a linear relationship between stage (the independent variable) and discharge (the dependent variable). In most cases, the rating curve will have multiple segments, each with their own scale offset, to describe the stage-discharge relationship during various flow conditions (low flow, within bank, overbank flow).

We work to conduct discharge measurements and record corresponding gauge height values across the full range of flow for each site. If the rating curve does not cover the full range of flows, the curve can be extended to twice the highest and ½ of the lowest discharge measurement. Any extension beyond those limits will serve only to estimate flow, and the data will be graded as estimated values.

Shifting

Stream channels change due to natural or man-made influences. Shifts are gauge-height adjustments that account for temporary changes to rating curves. When site conditions change temporarily due to scouring or material deposition or to seasonal vegetative growth, the rating curve can be shifted for a specified time period. All shift records are maintained in the AQUARUIS database.

Annual Data Review and Station Summary

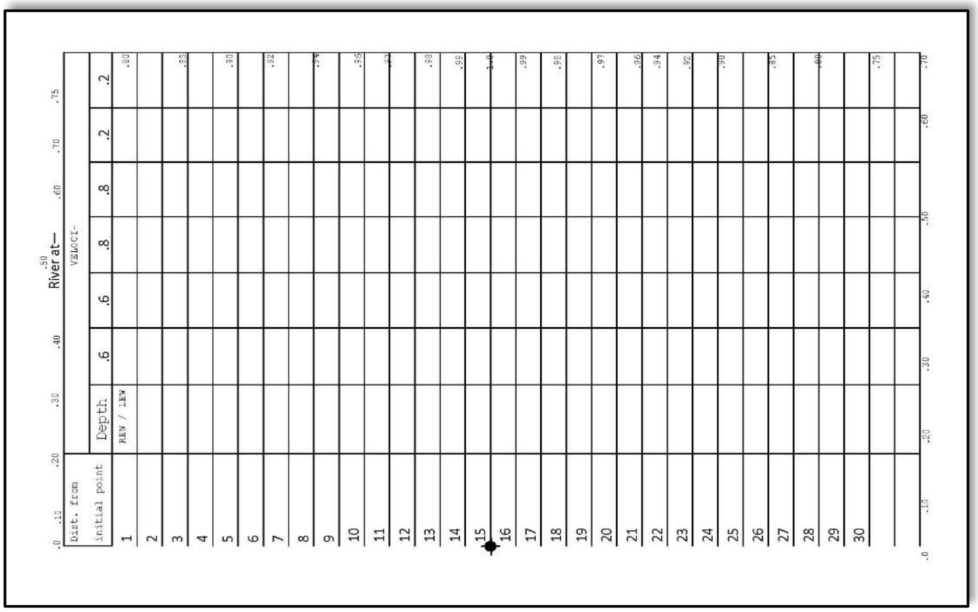
At the close of each water year, we will conduct a thorough review of data, assign grades and approve the record. A narrative description of conditions and results will be produced for each site summarizing measurement activities and quality controls.

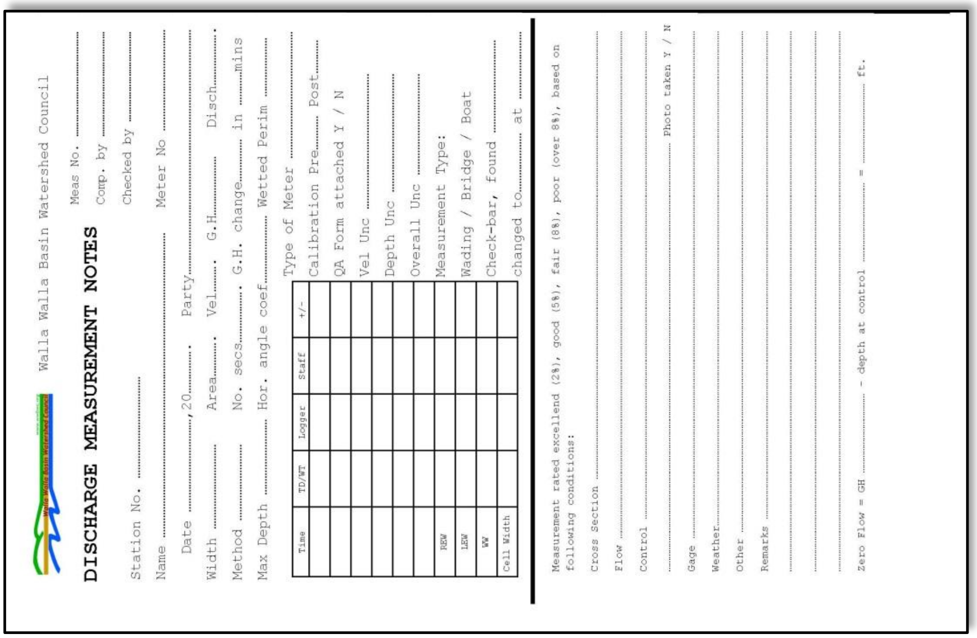
Data Management Procedures

An unaltered electronic copy of the original stage data will be downloaded directly from the datalogger to provide data in case of telemetry transmission gaps and for data auditing. Corrections will be made on a working copy of the stage data according to the following procedure:

- Plot the continuous stage data with field measurements for visual verification and quality control. Apply any offsets and/or make corrections for sensor drift or other anomalous values. The AQUARIUS software maintains a record of all corrections and the user who applied them.
- Visually verify calculated discharge values, plotted with discharge measurements.
- View the current rating curve and any applied shifts to determine how well the new discharge measurement aligns with the predicted flow value.

Discharge Notes Data Sheet





Walla Walla Basin Watershed Council

DISCHARGE MEASUREMENT NOTES

Meas No. ....
Comp. by ....
Checked by ....
Station No. ....
Name .... Meter No ....
Date ...., 20........ . Party..................
Width .... Area........ . Vel........ . G.H.......... Disch.......... .
Method .... No. secs.......... . G.H. change.......... in ....mins
Max Depth .... Hor. angle coef.......... Wetted Perim ....

Time	TD/WT	Logger	Staff	+/-
REW				
LEW				
WW				
Cell Width				

Type of Meter ....
Calibration Pre........ Post........
QA Form attached Y / N
Vel Unc ....
Depth Unc ....
Overall Unc ....
Measurement Type:
Wading / Bridge / Boat
Check-bar, found ....
changed to.......... at ....

Measurement rated excellend (2%), good (5%), fair (8%), poor (over 8%), based on following conditions:

Cross Section ....
Flow ....
Control ....
.... Photo taken Y / N
Gage ....
Weather..................
Other ....
Remarks ....

Zero Flow = GH .... - depth at control .... = ... ft.

Gaging Station Log Data Sheet

Walla Walla Basin Watershed Council

Gaging Station Log

Station Name: ______________________________ Station Number ________________ Water Year __________

Party												
Date												
Time												
PGI												
SGI												
AUX												
LOGGER												
H20 TEMP.												
THERMISTOR												
AIR TEMP.												
THERMISTOR												
BATT. V												
REPLACED (Y / N)												
DOWNLOADED (Y / N)												
PURGE (Y / N)												
SYNCED (Y / N)												
SYSTEM RESETS												
BATT. V (MIN/MAX)												
RESET STAT SCREENS (Y / N)												
MEASUREMENT (Y / N)												
MGH												
MEASURED Q												
PROFESSIONAL RATING												
METHOD												
LOCATION												
MAX DEPTH												
MAX VELOCITY												
PZF												
CONTROL (LOCATION, CONDITION, ETC.)												

Stream Gage Notes Data Sheet

Batt V .... Min .... Max ....

Reset Stats Y / N Batt Replaced Y / N

GOES Time OK Y / N

Data Downloaded Y / N .NEW File Erased Y / N

Desiccant Condition .... Changed Y / N

CSG checked Y / N

HWM .... ft on stick + Ref Elev .... ft

= HWM Elev .... ft. Cleaned Y / N

Added Cork Y / N

Remarks:............

Walla Walla Basin Watershed Council

WWBWC Stream Gage Logger Notes

Station name ....

Station # .... Party ....

DATE					
TIME (PST)					
LOGGER					
STAFF GAGE					
WIRE WEIGHT					
CHECK BAR					
TAPE DOWN					
CORR. FACTOR					
CORRECTED TD					
TD RP ELEVATION					
CORRECTED TD					
= WS ELEV @ TD					
LASER: LASER ROD READING					
- WATER SURFACE, ROD READING					
= DIFFERENTIAL, LASER TO WATER SURFACE					
LASER BEAM ELEVATION					
DIFFERENTIAL					
= STAGE					
WATER TEMP				ELEVATION	READING
THERMISTER			LL RP1		
AIR TEMP			LL RP2		
THERMISTER			LL RP3		

WWBWC Water Temperature Monitoring procedures

Updated September 2018

Summary

This procedure is for continuous water temperature monitoring in rivers and streams using data loggers. The procedure describes the equipment needed, calibration checks, deployment, field accuracy checks (site visits) and recovery.

This procedure is modified from the following references:

Water Quality Monitoring – Technical Guide Book, 2001. Oregon Watershed Enhancement Board.

ODEQ, 2009. Water Monitoring and Assessment Mode of Operations Manual. Watersheds Quality Monitoring Field Sampling Standard Operating Procedure – Laboratory and Environmental Assessment Division. Version 3.2

U.S. Geological Survey, 2006. National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chapter 6, available online at https://water.usgs.gov/owq/FieldManual/Chapter6/6.1_ver2.pdf.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; available online at http://pubs.water.usgs.gov/tm1d3.

Ward, W., 2018. Standard Operating Procedures for Continuous Temperature Monitoring of Freshwater Rivers and Streams, Version 2.1. WA Dept of Ecology. SOP Number EAP080. https://fortress.wa.gov/ecy/publications/documents/1803205.pdf

Equipment

- Data Logger (Onset U-22, Solinst Levelogger, In Situ Leveltroll 300 or other)
- Laptop/Computer set to Pacific Standard Time
- Computer interface cable for data logger
- NIST-certified field thermometer
- 1 medium sized cooler
- Ice
- Temperature Accuracy file (MS Excel workbook)
- 1 ½" PVC Pipe, grey (to reduce temperature variations due to solar radiation)
- 1/16" aviation cable or 16 gauge speaker wire
- Wire cutters
- Stainless steel u-bolts
- Needle nose pliers or other tool to tighten u-bolts
- Forestry Flagging/Surveyors Tape
- GPS unit
- Camera
- Waders
- Field Notebook
- First Aid Kit

Note: All field measurements and datalogger clocks should use Pacific Standard Time (PST) year-round.

Calibration Checks

1. For 20°C calibration test, pour room temperature water into the cooler. Adjust temperature in the cooler with ice, cold water or hot water to the desired 20°C. If ice is used make sure it is completely melted. Close lid.
2. Insert the NIST-certified field thermometer sensor into the cooler. Pull it through enough so that when the lid is closed, the sensor will be suspended midway (or slightly lower) in the water bath.
3. Use the computer and manufacturer's software to start the temperature data loggers and set them to record data (°C) every 1-minute.
4. Place temperature data loggers directly into the water bath.
5. Allow water bath to stabilize (for 15-30 minutes) before recording NIST thermometer temperatures (°C). After stabilization, record temperatures from the NIST thermometer every minute for ten minutes. More readings may be necessary if there is suspicion the water bath temperature changed or was not stabilized.
6. Download data from the temperature data loggers and audit thermometer results with time of record on an audit form. Water temperatures should not vary more than ± 0.5°C between the NIST thermometer and the data logger's temperature. Units not passing this accuracy test should be re-tested and will not be used if the ± 0.5°C accuracy standard is not met.
7. Repeat accuracy test for cold water bath at 5°C.
8. For telemetered sensors that are deployed year-round, a single point ambient temperature water bath calibration test is conducted annually, typically during the summer months.

Deployment

1. Start temperature data logger either prior to going to the field or in the field with a laptop. Data loggers should be set to record data in Celsius (°C) every 15 minutes. Data loggers should be set to start collecting data at the quarter hour.
2. Secure data logger inside of the 1 ½" PVC pipe using the aviation cable, ensuring that the entire length of the logger is covered by the PVC.
3. Secure data logger at the site using the aviation cable. Often the cable can be secured to trees, logs, large rocks or other stable structures. Make sure that the logger is in a well-mixed portion of the river to ensure accurate readings. Ideal deployment locations are typically at the upstream outside edge or downstream inside edge of the river bends or in the middle of riffles of low flow and wadeable streams. Also, place the data logger to ensure that it will stay submerged in the water as river flows drop.
4. Place NIST-certified thermometer in the water directly next to the temperature data logger.
5. Allow field thermometer to stabilize for at least one minute and then record the temperature reading.

6. The representativeness of the temperature logger deployment location should be verified by measuring several points in and near the vicinity of the logger and the temperature of the well-mixed part of the stream. If the stream can be easily waded, then a simple cross sectional temperature survey could also be done. Review the survey results, calculating the average temperature, and consider another deployment location, if necessary, to help ensure that the logger will record representative results.
7. Record in the field notebook the following:
    a. Time of deployment
    b. Date the data logger will run out of memory for logging data
    c. Record site name and data logger serial number
    d. Stream temperature using the NIST-certified field thermometer
    e. Cross sectional temperature survey results and calculation of average value
    f. GPS coordinates
    g. Write a short description and create a sketch of the site including approximate distances from structures (bridges, log jams, etc.)
8. Take pictures of site for future reference and recovery.

Field Accuracy Checks (Site visits)

During a typical season of water temperature monitoring (June-November), two field accuracy checks will be conducted using the following procedure. At telemetered monitoring sites, field checks are conducted every other week.

1. Determine if the data logger is still adequately placed in the river (see deployment procedure for details) to record water temperatures.
2. Place NIST-certified thermometer in the water directly next to the temperature data logger.
3. Allow field thermometer to stabilize for at least one minute and then record the temperature reading.
4. If the stream may be easily waded, consider doing a cross-sectional survey of the stream temperature. The survey results may help determine if the stream-temperature logger measured representative temperatures and show any cross-sectional temperature differences.

Recovery

1. Locate temperature data logger
2. Place NIST-certified thermometer in the water directly next to the temperature data logger.
3. Allow field thermometer to stabilize for at least one minute and then record the temperature reading.
4. If the stream may be easily waded, consider doing a cross-sectional survey of the stream temperature. The survey results may help determine if the stream-temperature logger measured representative temperatures and show any cross-sectional temperature differences.
5. Record time of data logger recovery and note any site conditions that may have affected data accuracy or reliability.

6. Return to the office and download the data. Data loggers should be stopped after data download to prevent unnecessary battery use.
7. Compare the logged water temperature values to the field thermometer measurements. Data accuracy should be ± 0.5°C.
8. Conduct the post-deployment accuracy check in the room temperature and cold water baths.

DATA MANAGEMENT

1. Enter field measurements into the AQUARIUS database, recording to the tenths place
2. Load continuous temperature data into the database and visually verify values by plotting with field measurements.
3. Apply data corrections as needed:
    a. Delete any air temperature values logged when the sensor was not submerged.
    b. If logged data differ from field measurements by more than 0.2°C, correct for fouling, calibration drift and cross-section variability.
    c. Correct for logger bias according to results of calibration checks: If the mean absolute value of the temperature difference for a logger in each water bath, compared against the NIST-certified thermometer, is equal to or less than the manufacturer stated accuracy (i.e. usually ±0.2°C for a water-temperature logger or ±0.4°C for an air temperature logger), then a second check should be performed. If a second calibration check result confirms a consistent bias above the stated accuracy, then the raw data should be adjusted by the mean difference of the pre- and post-calibration check results to correct for the logger bias.
    d. The AQUARIUS software documents all corrections and the user who applied them. If the recorded values differ from the corrected values by more than 2.0°C, the data cannot be used or reported.
4. Grade the data from excellent to unusable based on the completeness of the dataset, comparison of logger data and field checks, equipment maintenance and performance, the corrections applied, instrument calibration information and other pertinent factors. Use the table below as a starting point for the accuracy rating.

	Magnitude of corrections applied for fouling and/or calibration drift
Excellent	≤ ±0.2 °C
Good	±0.2-0.5 °C
Fair	±0.5-0.8 °C
Poor	≥ ±0.8 °C
Unusable	> ±2.0 °C

5. Use AQUARIUS report tools to calculate desired statistics and publish "provisional" data online.
6. Conduct annual data review and publish "approved" data online.

APPENDIX B: ODFW AQUATIC INVENTORY PROJECT METHODS

WWBWC followed methods in *Aquatic Inventories Project, Methods for Stream Habitat and Snorkel Surveys*, 2017, Conservation and Recovery Program, Oregon Department of Fish and Wildlife. The complete methods document can be found at the link below. Project specifics are noted in the list that follows.

http://wwbwc.org/images/Projects/Assessments/CouseCreek2020/AquaticInventoriesProjectMethodsStreamHabitatSurveys_2017.pdf

- WWBWC conducted a "Basin (Census) Habitat Survey," described in Appendix 2 of the methods.
- Did not conduct snorkel surveys, electroshocking, or amphibian/mussel/crayfish surveys.
- Established preliminary reach breaks before the survey based on available data; revised reach breaks based on survey results.
- Measured length of all units (except first few were estimated).
- Entered data on field sheets, not electronic tablets.
- Intended to conduct 2 pebble counts in representative riffles in each reach at roughly 1/3 and 2/3 of the reach length (but missed upper third of R5 and lower third of R6).

APPENDIX C: USFS WOLMAN PEBBLE COUNT METHOD

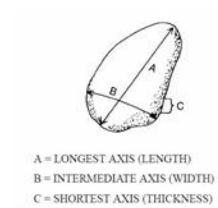
Wolman Pebble Count

Various publications describe the Wolman Pebble Count procedure. This technique requires the observer to measure sizes of random particles using a gravelometer. Particles smaller than 2 mm are placed in a category of <2mm. A step-toe procedure is frequently used to randomly select particles for quantification.

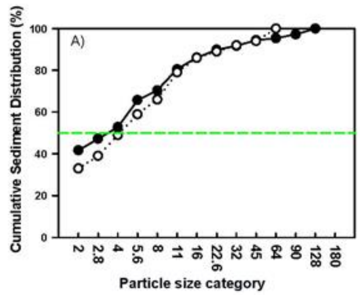
Size Class	Size Range (mm)
Sand	<2
Very Fine Gravel	2-4
Fine Gravel	4-6
Fine Gravel	6-8
Medium Gravel	8-11
Medium Gravel	11-16
Coarse Gravel	16-22
Coarse Gravel	22-32
Very Coarse Gravel	32-45
Very Coarse Gravel	45-64
Small Cobble	64-90
Medium Cobble	90-128
Large Cobble	128-180
Very Large Cobble	180-256
Small Boulder	256-512
Medium Boulder	512-1024
Large Boulder	1024-2048
Very Large Boulder	2048-4096

Wolman Pebble Count Procedure

1. Select a reach for sediment particle size distribution quantification. For stream characterization, sample pools and riffles at the same proportion the occur in the stream reach.
2. Start transect at a randomly selected point (throw a pebble) along the edge of stream. Take one step into the water perpendicular to flow and, while averting your eyes, pick up the first pebble touching your index finger next to your big toe.
3. Measure the b-axis by determining which hole the pebble fits through in the gravelometer and record in data book. For embedded pebbles or those that are too large to move, measure the shortest axis visible.
4. Take another step across the stream and repeat the previous steps until you reach the opposite side. Establish a new transect and begin the process over again. If your stream reach is relatively narrow (<2 m), you can modify the method by walking upstream in a zig-zag pattern instead of perpendicular to flow. In general, you will need to collect 100 measurements in order to accurately quantify pebble distributions.



5. After data is collected, plot data by size class (log_2 scale) and frequency to determine distributions. For example the D_{50} is the particle size that 50% of the samples are equal to or smaller than.



APPENDIX D: SOIL AND WATER ASSESSMENT TOOL (SWAT)

Watershed Sediment Modeling

Hillslope

Watershed sediment yield models were used to estimate the potential sediment delivery from hillslopes to the streams. The ArcGIS version of the Soil and Water Assessment Tool (ArcSWAT, v. 2012.10.18) was used to model hillslope erosion. Other inputs to the model included the elevation, slope and soils data.

Data Sources

The input data to the model was; a 10 meter Digital elevation model (10 m DEM), watershed model delineated in ArcSWAT watershed delineator plugin, vegetation cover and land use data was obtained from the USDA/NRCS - National Geospatial Center of Excellence (2011 National Land Cover Dataset (NLCD).

The soil data was obtained from the Soil Survey Geographic Database (gSSURGO_OR) database.

Weather data stations located inside or near the basin which were used for the climate data simulation. A precipitation dataset was obtained for the period 1970 to 2010 from the Global Weather TAMU website (https://globalweather.tamu.edu). The inbuilt time series weather data for the period 1970 to 2010 was used as the weather data generator for the simulation period.

Modeling Parameters

- A total number of 9 sub-basins were defined from the whole basin
- 183 HRUs were also defined with a threshold of 10% landuse, 10% soil and 5% slope classes.
- The SWAT model was executed on a monthly basis from 1970 to 2010 with a warm-up period of 3 years.

Data Summary

Hillslope sediment yield within a subbasin was summarized by one metric:

1. Average annual sediment yield within the subbasin. This is a standard output summary from SWAT (output.std) of watershed average loading to streams, and does not include any channel routing. These are the weighted sums of HRU loadings.

APPENDIX E: WATERSHED EROSION PREDICTION PROJECT MODEL (WEPP:ROAD)

Potential sediment delivery from primary and secondary roads was estimated with the road version of the Watershed Erosion Prediction Project model (WEPP:road). Road characteristics were developed from field surveys and elevation data in the GIS database. The WEPP:road is an interface of the Water Erosion Prediction Project (WEPP) soil erosion model developed by the Rocky Mountain Research Station in 1999 (http://forest.moscowfsl.wsu.edu/fswepp/docs/wepproaddoc.html). The procedure to calculate road runoff follows the WEPP:road Batch input screen provided by Washington State University (http://forest.moscowfsl.wsu.edu/cgibin/fswepp/wr/wepproadbat.pl). The WEPP:road analysis required a desktop and field study. The study plan was designed to collect the data necessary for the following model input parameters:

- Design (insloped bladed, insloped vegetated, outsloped rutted, outsloped unrutted)
- Road surface (native, gravel, paved)
- Traffic level (high, low, none)
- Road gradient (%)
- Road length (ft)
- Road width (ft)
- Fill gradient (%)
- Fill length (ft)
- Buffer gradient (%)
- Buffer length (ft)
- Rock fragment (%)

Road Data

In ArcGIS, roads were selected that are likely to influence sediment yield in the Couse Creek watershed using the Streets feature class provided by Umatilla County. We use the NHD Flowline stream segments created in ArcHydro. Road segments were segmented at each stream crossing. The selected roads were exported into a new ArcGIS feature. The horizontal distance between successive stream crossings represents the road segment length. The roads shapefile was exported in a .kml Google Earth file in order to collect filed data using a Windows tablet.

During July - August 2018, field data were collected from 68 miles of road throughout the Couse Creek watershed. Road characteristics were observed and measured at multiple observation points along each road segment. Where road conditions changed appreciably within a predefined road segment, the road segment was split into two or more distinct segments.

Road data were post-processed in ArcGIS. Buffer widths and gradients were measured from a mid-point of the road segment to the nearest stream. Streams that were not parallel to the road segment required estimation for appropriate buffer dimensions. Stream buffers were digitized from the edge of road to nearest stream. Lengths were automatically generated in ArcMap. Gradients to the stream were manually calculated using elevation data (10 M DEM). Buffer results were added to the shapefile. Road segment gradients were manually calculated in ArcMap. Traffic levels were interpreted from field observations and historic aerial photography using Google Earth Pro.

Road Sediment Modeling

Spatial data for the road characteristics were delineated into subbasin boundaries. The data were organized into WEPP:road input tables, with each defined road segment containing data for the model input parameters. These data were used as inputs to the online WEPP:road model at http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/wr/wepproadbat.pl. The model run was for 30 years of simulated climate, based on data from nearby weather stations.

APPENDIX F: LANDOWNER OUTREACH LETTER

www.wwbwc.org
Walla Walla Basin Watershed Council
541-938-2170 or 7086 P.O.Box 68, Milton-Freewater, OR 97862

Dear Landowner,

The Walla Walla Basin Watershed Council (WWBWC), a nonprofit organization in Milton-Freewater, was recently awarded grant funding to conduct a watershed assessment in the Couse Creek Drainage. The WWBWC has been working with landowners in the area for over twenty years doing a diversity of projects largely aimed at improving water resources and environmental conditions, while also providing benefits to landowners. We are contacting you because the county's tax lot map indicates that you own land within the boundaries of the watershed and we would greatly appreciate willing participants to allow the WWBWC to conduct a comprehensive assessment of the Couse Creek Watershed.

The WWBWC applied for grant funding to conduct the assessment for a diversity of reasons including better understanding the hydrology, geomorphology, and habitat conditions as well as identifying potential projects that could improve conditions. A major focus of many of WWBWC projects is identifying ways to retain more water in a system, with the intent of improving water supplies in times of scarcity. Identification of potential projects will rely on each landowner's willingness and needs but may include identification of potential projects to improve bank stability, reduce erosion, or provide off-channel watering for livestock.

Our grant funding allows us to collect data to assess current conditions and we will review whatever existing data we can find to indicate past conditions. Your personal knowledge of how conditions have changed over time is invaluable and will help us to understand changes in more depth than any available records can provide. Even if you don't have the time or interest in sharing your knowledge, our hope is that you will allow us access to Couse Creek on your property so we can collect data on conditions in the creek.

The Walla Walla Basin Watershed Council is a non-regulatory entity, governed by a volunteer local board of directors whose primary focus is to protect and restore water resources to create healthy habitats and provide sustainable access to water for the basin's citizens and landowners. The Council's collaborative relationship with local landowners has been the cornerstone of our success to date. We hope that you will consider facilitating our work on this current Couse Creek project.

We will have a meeting on April 25, 2018 at 7:00 PM at the Milton-Freewater Public Library Albee room (8 SW 8th Ave), to explain our preliminary approach to assessing conditions, listen to your input on what needs to be included in the assessment, and find out who may be interested in helping with the assessment. If you are interested but cannot attend the meeting, please call the WWBWC office at 541-938-2170 or e-mail graham.banks@wwbwc.org and we can discuss it with you individually. For questions on the assessment e-mail marie.cobb@wwbwc.org.

Cordially,

Graham Banks
Education Outreach Coordinator
Walla Walla Basin Watershed Council

Enclosures: WWBWC Projects Tour invite and WWBWC Pamphlet

APPENDIX G: FLOW EXCEEDANCES

Table G11. Flow exceedances in Couse Creek at RM 3.2 derived from OWRD data from November 1965 to September 1978. Quantiles should be interpreted as follows: 10% quantile=90% exceedance, 25% quantile=75% exceedance, etc. Bi-Month: 1 = Jan 1-15. 1.5=Jan 16-31, 2=Feb 1-14, 2.5=Feb 15-28, etc.

BiMonth	MeanDischarge.Min	MeanDischarge.Median	MeanDischarge.Max	MeanDischarge.Mean	MeanDischarge.Quantile.10%	MeanDischarge.Quantile.25%	MeanDischarge.Quantile.50%	MeanDischarge.Quantile.75%	MeanDischarge.Quantile.90%	MeanDischarge.Var	MeanDischarge.N
1	0.2	12	309	22.66	1.22	5	12	28.25	46.7	1310.35	195
1.5	0.4	22	302.5	41.55	3.04	11	22	51.5	108.75	2366.74	208
2	1.3	14	84	20.01	2.94	8.125	14	27.75	42.7	286.88	195
2.5	1.3	19.5	135.5	27.23	3.845	11.5	19.5	32.5	62.55	608.91	172
3	1.95	16.5	204	26.63	7.57	9.975	16.5	34	59.6	771.63	195
3.5	3.6	27.5	170.5	34.79	8.675	17.375	27.5	40.625	64.3	852.46	208
4	4.85	32	98.5	38.16	10.7	19	32	54.75	79.3	621.94	195
4.5	4.85	31.5	110	33.57	7.35	14.13611	31.5	48	61.8	486.43	195
5	3	29	145	31.84	4.52	7.7	29	44.5	67	748.32	195
5.5	2	9.125	86	14.56	2.4	3.4	9.125	20.375	33	225.42	208
6	1.1	3.25	52	6.62	1.5	1.95	3.25	6.7	14.5	75.61	195
6.5	0.55	1.6	13	2.42	0.8	0.95	1.6	3.35	5.21	4.44	195
7	0	1.05	4.75	1.17	0.32	0.55	1.05	1.6	2.1	0.69	195
7.5	0	0.45	2.75	0.59	0	0.1	0.45	1	1.2	0.27	208
8	0	0.2	0.85	0.23	0	0	0.2	0.475	0.6	0.06	195
8.5	0	0.2	0.6	0.19	0	0	0.2	0.3	0.5	0.04	208
9	0	0.2	0.9	0.22	0	0	0.2	0.35	0.6	0.05	195
9.5	0	0.3	2.45	0.33	0	0.1	0.3	0.4	0.5	0.15	195
10	0	0.4	1.65	0.46	0.1	0.3	0.4	0.7	0.8	0.08	181
10.5	0	0.7	2.2	0.66	0.1	0.4	0.7	0.8125	1.1	0.14	192
11	0.2	1	78	3.21	0.5	0.6	1	1.6	2.84	106.47	194
11.5	0.6	1.5	98.5	7.52	0.8	1.025	1.5	6.175	23.3	203.83	195
12	0.65	7.1	213	20.37	1	1.125	7.1	22.75	55.9	1112.23	195
12.5	0.8	10.225	170	19.61	1	1.9125	10.225	22.625	45.3	829.43	208

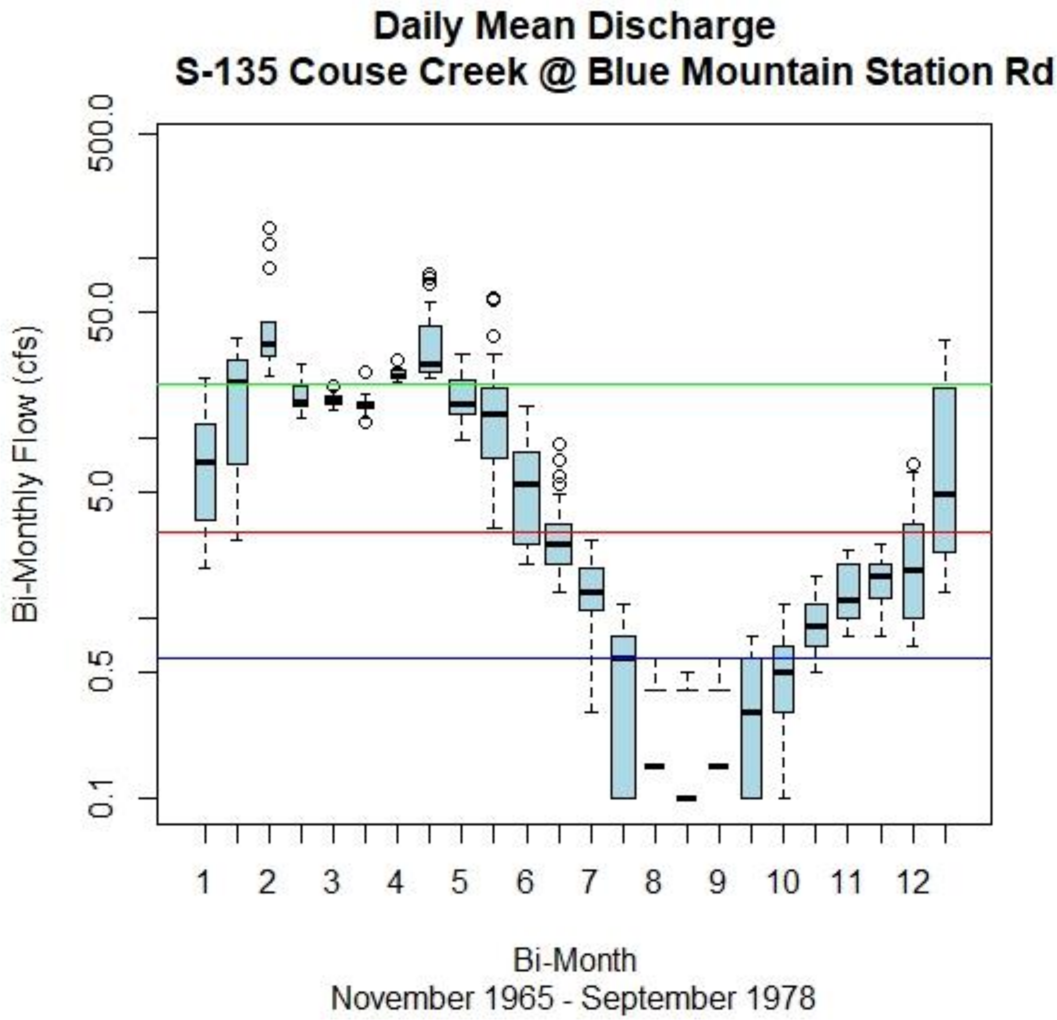


Figure G41. Boxplot of daily mean discharge in Couse Creek at RM 3.2 derived from OWRD data from November 1965 to September 1978.

Table G12. Flow exceedances in Couse Creek at RM 3.2 derived from WWBWC data from April 2018 to July 2020. Quantiles should be interpreted as follows: 10% quantile=90% exceedance, 25% quantile=75% exceedance, etc. Bi-Month: 1 = Jan 1-15. 1.5=Jan 16-31, 2=Feb 1-14, 2.5=Feb 15-28, etc.

BiMonth	Mean Discharge.Min	Mean Discharge.Median	Mean Discharge.Max	Mean Discharge.Mean	Mean Discharge.Quantile. 10%	Mean Discharge.Quantile. 25%	Mean Discharge.Quantile. 50%	Mean Discharge.Quantile. 75%	Mean Discharge.Quantile. 90%	Mean Discharge.Var	Mean Discharge.N
1	1.9	7.35	21.7	8.36	3	3.575	7.35	11.925	14.24	28.28	30
1.5	2.7	20.35	36.5	18.12	3.52	7.4	20.35	27.025	34.04	136.18	28
2	22.3	33.4	149	50.45	26.34	28.95	33.4	43.95	109.06	1470.42	15
2.5	12.9	15.75	25.9	17.5	14.03	15	15.75	18.975	23.73	16.29	14
3	14.5	16.5	19.7	16.59	15.26	15.6	16.5	17.2	18.26	1.89	15
3.5	12.3	15.55	23.1	15.63	13.1	14.675	15.55	15.95	17.1	5.84	16
4	20.7	22.4	27.3	22.83	21.24	21.7	22.4	23.75	24.72	3.16	15
4.5	21.5	26.05	82.9	36.27	22.95	23.375	26.05	40.725	71.95	370.78	36
5	9.8	15.6	29.2	17.31	12.5	13.8	15.6	21	23.36	21.6	45
5.5	3.2	13.55	60.4	15.73	4.47	7.85	13.55	18.9	26.82	144.03	48
6	2	5.5	15	6.18	2.34	2.6	5.5	8.3	11.42	13.28	45
6.5	1.4	2.6	9.3	2.97	1.64	2	2.6	3.3	4.86	2.6	45
7	0.3	1.4	2.7	1.46	0.64	1.1	1.4	1.9	2.2	0.33	45
7.5	0	0.6	1.2	0.51	0	0.1	0.6	0.8	1.02	0.17	39
8	0	0.15	0.6	0.22	0	0	0.15	0.4	0.5	0.05	30
8.5	0	0.1	0.5	0.19	0	0	0.1	0.4	0.4	0.04	32
9	0	0.15	0.6	0.2	0	0	0.15	0.4	0.41	0.04	30
9.5	0	0.3	0.8	0.35	0	0.1	0.3	0.6	0.7	0.08	30
10	0.1	0.5	1.2	0.51	0.1	0.3	0.5	0.7	0.9	0.09	30
10.5	0.5	0.9	1.7	0.95	0.6	0.7	0.9	1.2	1.29	0.09	32
11	0.8	1.25	2.4	1.48	0.8	1	1.25	2	2.31	0.34	30
11.5	0.8	1.7	2.6	1.65	1	1.3	1.7	1.975	2.41	0.27	30
12	0.7	1.85	7.1	2.35	0.9	1	1.85	3.3	3.6	2.86	30
12.5	1.4	4.95	35.1	10.97	1.81	2.3	4.95	18.9	25.45	105.56	32

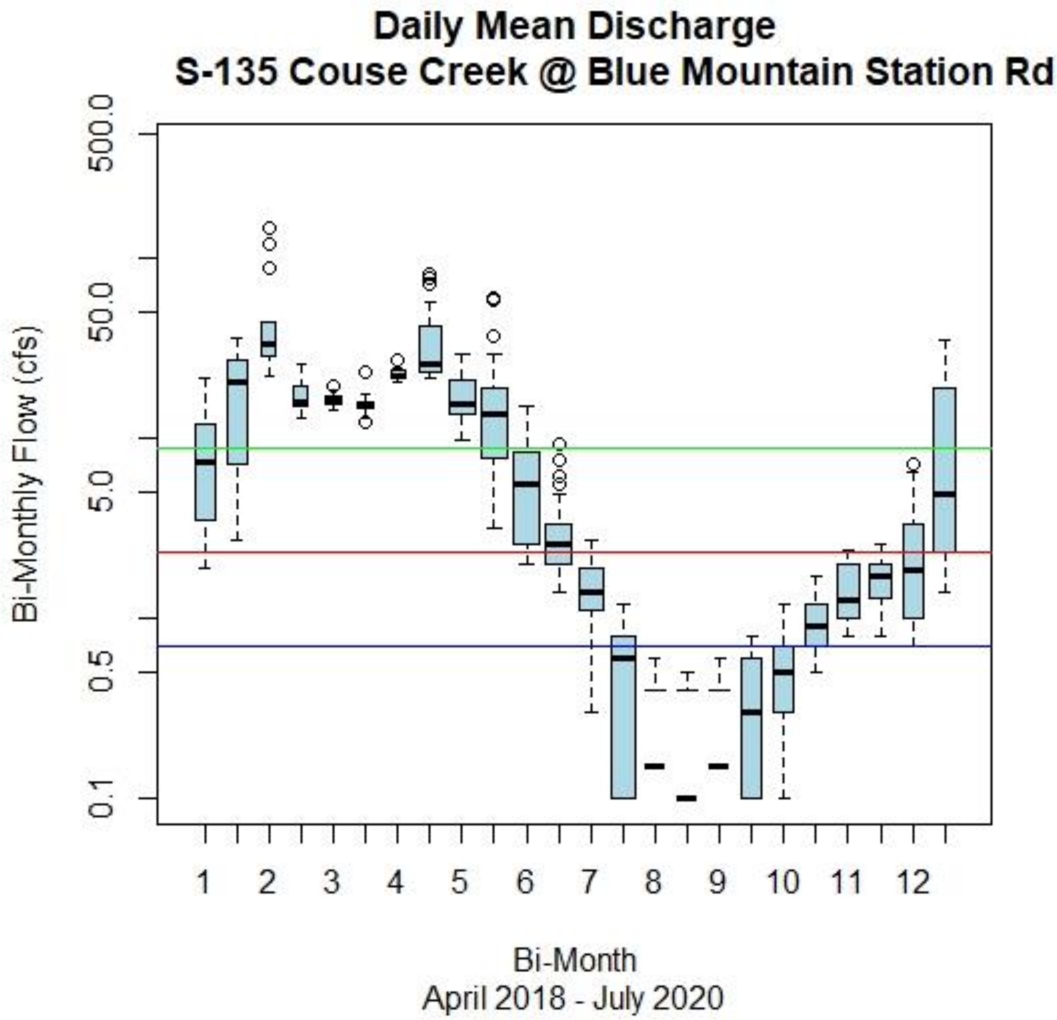


Figure G42. Boxplot of daily mean discharge in Couse Creek at RM 3.2 derived from WWBWC data from November April 2018 to July 2020.

R scripts used to generate the data above can be found at the links below:

http://www.wwbwc.org/images/Projects/Assessments/CouseCreek2020/S135_1965-1978.R

http://www.wwbwc.org/images/Projects/Assessments/CouseCreek2020/S135_2018-2020.R

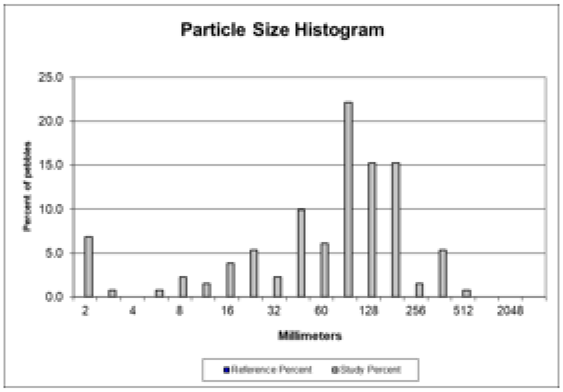
APPENDIX H: REACH NUMBERING AND PEBBLE COUNT DATA

The database created to store the stream survey data uses the ODFW template, which contains standardized analyses and graphing outputs. In the database, unsurveyed portions of the stream are assigned reach numbers. So the database lists 14 reaches. The following discussion aggregates the surveyed reaches into the six reaches that represent significant changes in the characteristics of the stream. (Maybe this info and table can be in an appendix since it is only of interest to users digging into the raw survey data).

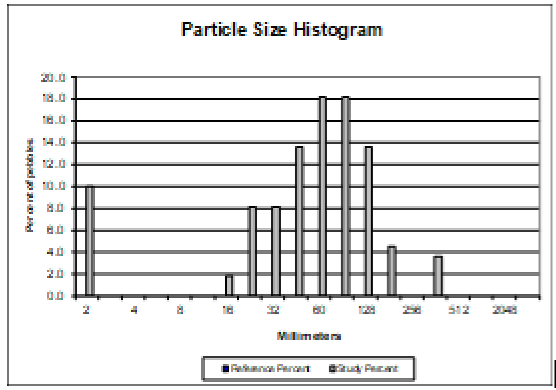
Aggregated reach number	Database reach number
1	1
	2 (unsurveyed)
	3
	4 (unsurveyed)
	5
2	6
	7 (unsurveyed)
	8
3	9
	10 (unsurveyed)
4	11
	12 (unsurveyed)
5	13
	14 (unsurveyed)
6	15

Pebble Count Data

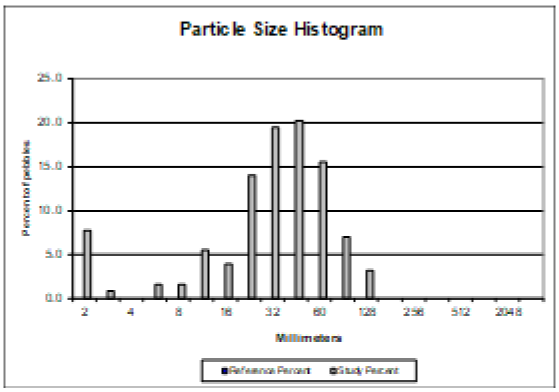
Size finer than (mm)	Cumulative Percent							
	R1, lower third	R1, upper third	R2, lower third	R2, upper third	R3, lower third	R4, lower third	R5, lower third	R6, upper third
2	6.9	10.0	7.8	12.3	9.0	10.6	14.0	100
4	7.6	10.0	8.5	13.0	11.5	11.4	14.0	100
5.7	8.4	10.0	10.1	13.0	12.2	11.4	15.0	100
8	10.7	10.0	11.6	13.7	17.3	12.2	17.0	100
11.3	12.2	10.0	17.1	17.8	22.4	13.8	17.0	100
16	16.0	11.8	20.9	25.3	30.8	16.3	19.0	100
22.6	21.4	20.0	34.9	33.6	39.1	19.5	22.0	100
32	23.7	28.2	54.3	47.3	48.7	25.2	25.0	100
45	33.6	41.8	74.4	60.3	59.6	35.0	32.0	100
60	39.7	60.0	89.9	82.9	75.6	48.0	43.0	100
90	61.8	78.2	96.9	93.2	92.9	65.9	57.0	100
128	77.1	91.8	100.0	98.6	98.7	78.9	71.0	100
180	92.4	96.4	100.0	99.3	99.4	86.2	74.0	100
256	93.9	96.4	100.0	100.0	100.0	94.3	89.0	100
362	99.2	100.0	100.0	100.0	100.0	98.4	94.0	100
512	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100
1024	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100
2048	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100
4096	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100



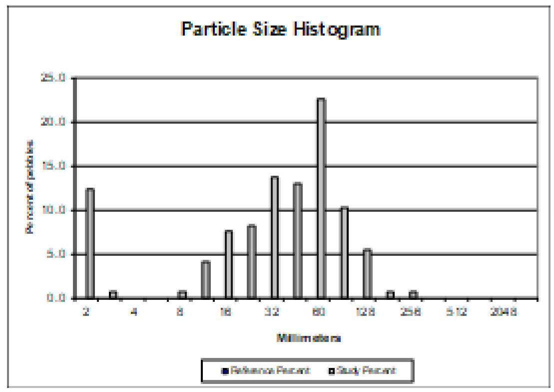
Reach 1, Lower Third of Reach



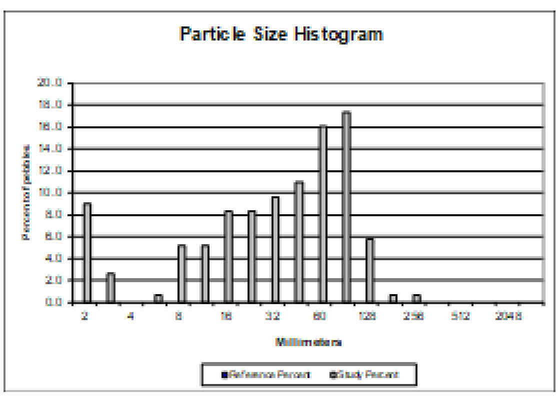
Reach 1, Upper Third of Reach



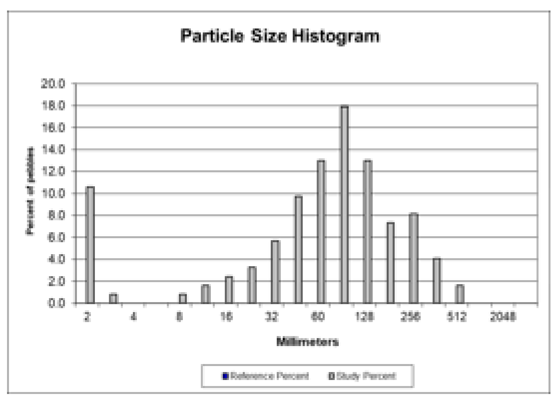
Reach 2, Lower Third of Reach



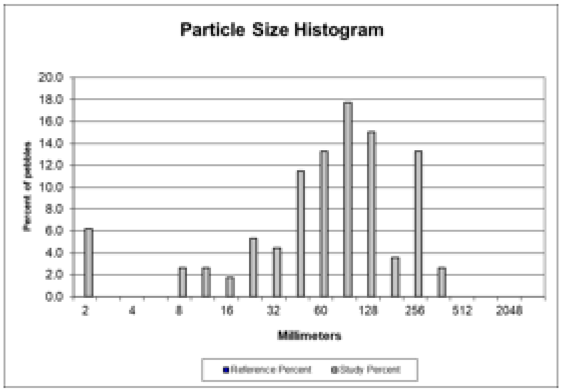
Reach 2, Upper Third of Reach



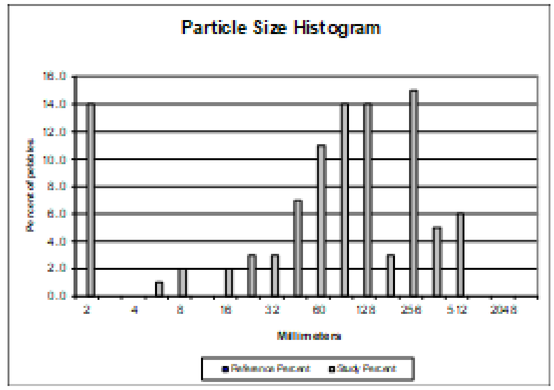
Reach 3, Lower Third of Reach



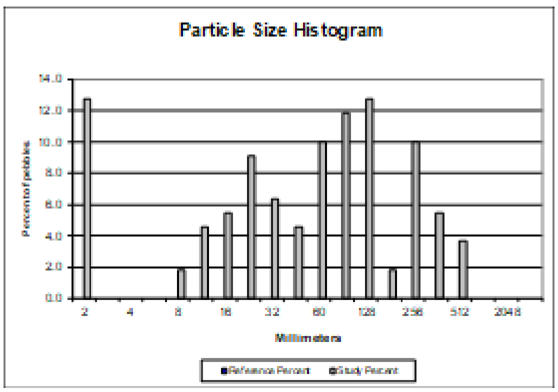
Reach 3, Upper Third of Reach



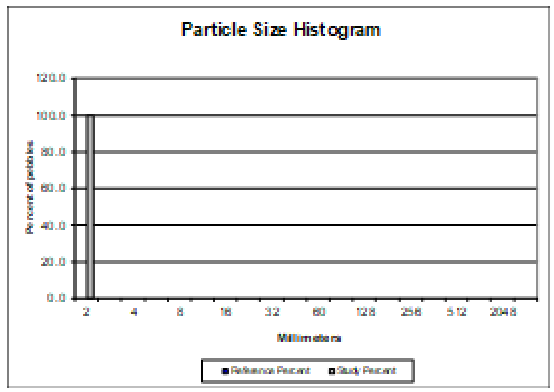
Reach 4, Lower Third of Reach



Reach 4, Upper Third of Reach



Reach 5, Lower Third of Reach



Reach 6, Upper Third of Reach

APPENDIX I: PREVIOUS ENHANCEMENT PROJECTS

Documentation of Previous Projects

CTUIR, ODFW, WDF, and WDW, 1990, *Columbia Basin System Planning Salmon and Steelhead Production Plan*

- Instream and riparian habitat enhancement projects: Couse Creek RM 0 to 8: 4 miles of work, $141,600, ODFW. Footnote: most of these projects are in the NPPC Fish & Wildlife Program but no implementation plans have been developed at this time. (Table 18).

ODFW, 2010, *Conservation and Recovery Plan for Oregon Steelhead Populations in the Middle Columbia River Steelhead Distinct Population Segment*, p. C-30 thru C-33:

- OWEB project 1127, WWBWC 1997, $17,540: Instream habitat enhancement (3 anchored log structures, 4 deflectors), riparian planting & 0.4 m fencing, upland weed control; 10 ac treated.
- OWEB project 20050612, Umatilla SWCD 2004, $10,553: upland vegetation management 29 ac
- OWEB project 991048, Oregon Water Trust, 1997, $21,318: instream water rights transfers/leases
- No project #: Oregon Water Trust $39,125 + OWEB $36,780, 1998, instream lease of water (pump inactive)
- No project #: CTUIR, 2000, no dollar amount listed, upland restoration and riparian fence, 1.2 miles
- No project #: CTUIR, 1997, no dollar amount listed, riparian fence, 1.3 miles

James and Scheeler [CTUIR], 2001, *Draft Walla Walla Subbasin Summary*, Prepared for the Northwest Power Planning Council, p.109, 111, 118

- Couse Creek riparian enhancement, BPA project # 9604600, CTUIR, 1996-1998
- Couse Creek/Shumway riparian and instream restoration, 1996-2001, ODFW, NRCS, WWBWC, CTUIR
- Oregon Water Trust, 1998, 10-year lease providing over 2 cfs in a critical steelhead spawning and rearing habitat area

WWBWC, 2017. OWEB and BPA funded fish passage barrier removal and riparian planting at the mouth of Couse Creek.

WWBWC, 2019. BPA funded designs for fish passage barrier removal at Blue Mountain Station Road. Construction is scheduled for 2022, pending funding approval.

Project Notes and Descriptions

Volkman and Sexton [CTUIR], 2003, *Walla Walla River Basin Fish Habitat Enhancement Project*, *Annual Report 2000-2001*, Project No. 1996-04601 (BPA Report DEO/BP-00006414-1).

- Shumway project. Approx RM 7. 10-year conservation easement signed in 1996 between the landowner, WWBWC, and ODFW. Project approx. 0.5 mi length, elevation 1600 ft. Predominant land-use is farming and livestock pasture. Past ag practices severely impacted site; lead to disappearance of virtually all native riparian plant species and resulting high incidence of bank failure. Limited salmon production due to low or non-existent flows during summer but also affected by high stream temperatures, bank and channel instability, and lack of channel diversity, poor pool frequency, and poor riparian cover.

  1997 four straight rock barbs installed by CTUIR and ODFW to reduce bank erosion. Cottonwood tree log revetments constructed, several thousand native willow cuttings placed between barbs to provide additional bank protection and instream habitat. Rock barbs effectively reduced bank erosion but contributed minimal instream habitat. Barbs were overbuilt due to poorly designed instream hydraulic plan. Barbs shifted flow away from the bank and riparian vegetation, which decreased channel length and reduced benefits of the structure, especially shading and undercut banks. Additional work planned for 2001. Survival of root stock plantings has been poor in general because of competition from non-native species. No future plans for bare-root plants. ≥70% survival of willow cuttings. Confident willow has reestablished itself over much of the plant-free shoreline. Native plants were hand-watered during Aug & Sept 2000. Spot spraying and hand-pulling weeds also in 2000.

- Hasso project. Approx RM 7. Landowner signed a 15-year conservation easement with CTUIR in Dec. 1999. CREP participant. Restoration area: 1.2 miles of stream and entire floodplain. Yellow starthistle predominates much of nearby uplands and riparian corridor. Shallow soils, ephemeral flow, abrupt changes in valley width and subsequent substrate deposition. So focused on livestock exclusion and riparian planting.

  Livestock exclusion fence constructed Feb. 2000. Volunteer plants immediately began sprouting throughout the project area. Thousands of willow cuttings installed (trenching, stinging) in Oct 2000. Fence and water gap maintenance conducted by project technicians. Includes list of monitoring survey results (Table 3).

Volkman and Sexton [CTUIR], 2003, *Walla Walla River Basin Fish Habitat Enhancement Project, Annual Report, 2001-2002*, Project No. 1996-04601 (BPA Report DOE/BP-00006414-2).

- [regarding Shumway project] "By the spring of 1999, the reintroduced willows had established themselves. The barbs, although very effective at reducing erosion, had forced the stream channel away from the shoreline. This unfortunately eliminated all of the benefits we had hoped to maintain along the stream bank including shade, pool formation, cover, etc. We now realize that the barbs were over-designed. A less aggressive design may have allowed us to protect the bank while still maintaining the shoreline diversity. We will continue to monitor these changes and provide any new data in future reports."

Volkman, Jed [CTUIR], 2005, *Walla Walla River Basin Fish Habitat Enhancement Project, 2002-2003 Annual Report*, Project No. 199604601 (BPA Report DOE/BP-00006414-3).

- Banks (Shumway) project. RM 3. 10-year conservation easement signed in 1996 between landowner, WWBWC and ODFW. 0.5 stream miles, elevation 1600 ft. same problem description as Shumway. 15-year conservation easement signed in May 2001 for an additional 0.5 miles of Couse Creek and 32 acres upland habitat. Weed control and native grass plantings. Fall 2003 most of the field had an established stand of native grasses.

- Hasso project. By summer 2003 approx 40% of willows were growing, plus dozens of young cottonwood trees, hawthorne, rose and various species also beginning to grow.