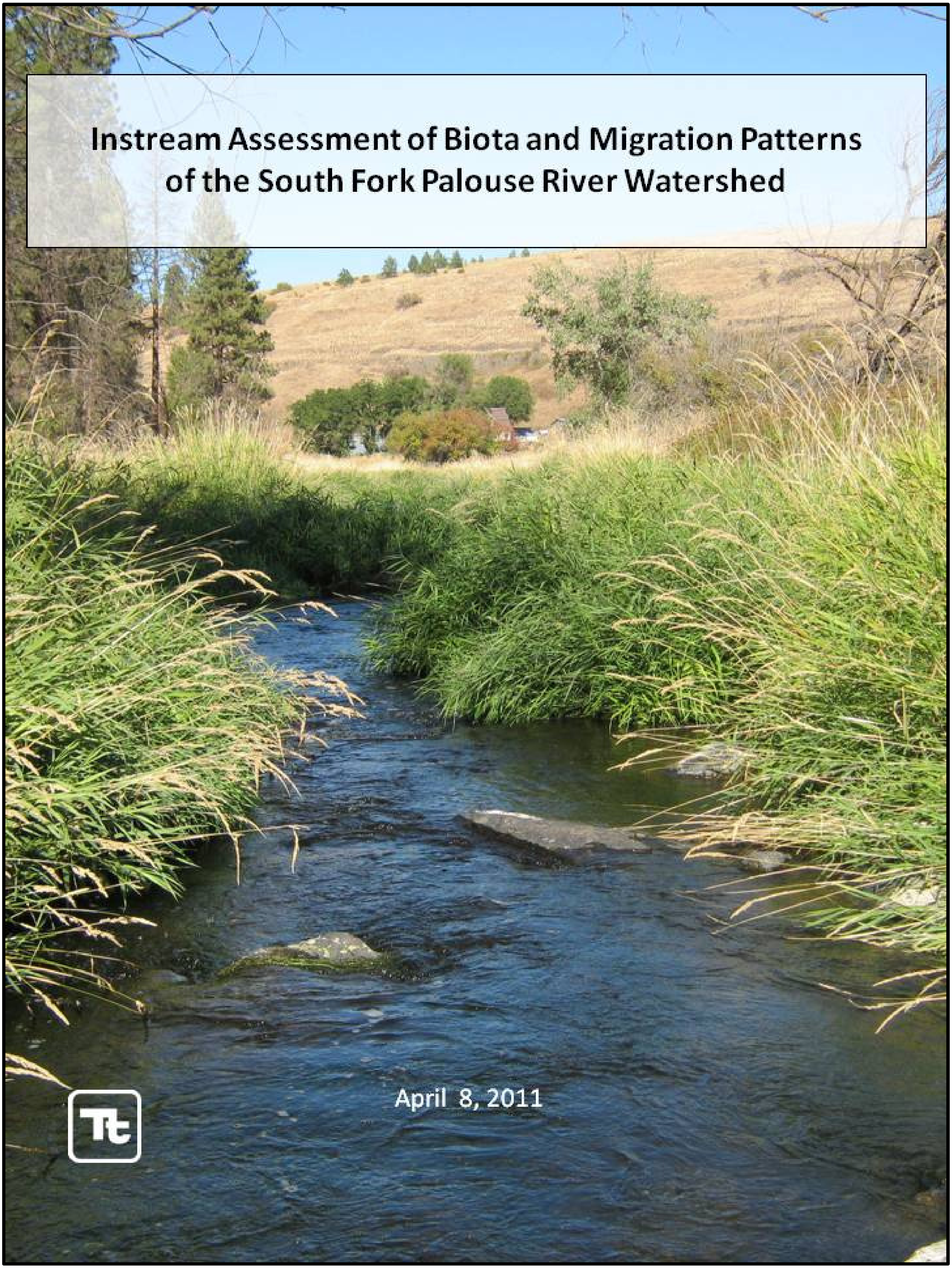
# Instream Assessment of Biota and Migration Patterns of the South Fork Palouse River Watershed



April 8, 2011

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# 1.0 INTRODUCTION

## 1.1 Project Setting

The Palouse region in Washington State occupies a large portion of the southeastern landscape. This region is characterized by asymmetric, steep and rolling hills with a deep tawny silt layer with underlying basalt and weathered basalt. Initial and extensive investigation of the unique topography and soil (Loess) origin of this region dates back to Russell (1897). Further investigation by Ringe (1968) compiled past research and proposed origins of the loess soil that comprises the "Palouse Hills" as well as a drainage basin analysis.

Drainage patterns (mainstem and tributaries of the Palouse River) are influenced by convergence of several characteristics:

- Topography
- Soils
- Underlying geology
- Climate patterns, and
- Groundwater-Surface water interaction.

The drainage pattern and hydrologic characteristics of stream surface flow are discussed in detail by Russell (1897) with several key points important for determining expectations for water quantity. The occurrence of perennial flow and intermittent flowing streams are explained by factors consistently associated with stream flow type. Those streams incised into bedrock channels are perennial streams whereas those incised into loess are associated with intermittent flow during portions of the year. Records indicate that surface flow had decreased in the Palouse River (at Hooper) by approximately 15 percent when comparing observations from 1898 and 1958 in February, during the same high flow months (USGS 1921; USGS 1962). Currently, high flows at this site have shifted consistently to March and were 35 percent lower during the water year 2010 more than 50 years later. Either climatic patterns have changed in the 52 year time period and/or water consumption had changed that accounts for some of the stream channel dewatering.

The landscape in the South Fork Palouse drainage was dominated by fescue/bunchgrass circa 1900 (Quigley and Arbelbide 1997) and has since been replaced by cropland, hay, and pasture with some forbs/annual grass mix (Daubenmire 1942, 1970, 1975). These changes from an uncultivated landscape to a setting that is now heavily cultivated has raised concerns about cumulative impact to sensitive surface water resources.

Development of the area by European settlers began after 1870 and consisted of a growing agricultural economy based primarily in fruit crops. The fruit crops were rapidly replaced over the next 20 years and dominated by wheat crops, yielding higher monetary returns than the first agricultural crops that were planted in the region. The native bunchgrasses were cleared rapidly and replaced by cultivated, non- native wheat crops that occupied at least half of

Whitman County by 1990. The native bunchgrass prairie existed as isolated tracts by 1990 in areas less favorable for farming throughout the Palouse region (Black et al. 2002). Less than 1% of all farming is currently irrigated as soil conditions and timing of precipitation promotes dryland farming (USGS 1975).

## 1.2 Regulatory Issues and Water Quality Studies

Recent Total Maximum Daily Load (TMDL) water quality studies addressed bacteriological impairments throughout the South Fork Palouse River drainage (Carroll and Snouwaert 2009). These impairments may originate from a variety of sources that indirectly and directly influence characteristics of the stream channel and riparian area. These influences include: livestock grazing, wildlife (especially ubiquitous populations), land use practice changes, and Wastewater Treatment Plants (e.g., Moscow, Pullman, and Albion). Although bacteriological contamination may not directly affect sensitive fish species, the occurrence of high concentration of this indicator reveals land use activities that alter stream channel characteristics and refugia important for survival of aquatic life (Mathieu and Carroll 2006).

Other water quality impairments identified in segments of the South Fork Palouse River are: ammonia (Pelletier 1993, 1995), dissolved oxygen and pH (Carroll and Mathieu 2006), and temperature (Bilhimer et al. 2006). The 1998 §303 (d) list for Idaho focuses on impacts related to flow alteration, habitat alteration, nutrients, sediment, and temperature. State of Idaho listings of reasons for water quality impairment are observed in the State of Washington portion of the drainage. Each of these water quality parameters that have exceeded water quality criteria in segments of this drainage directly affect life stages of sensitive fish species, particularly salmonids and char. EPA and the State of Washington considered water quality requirements for salmonids, char, other aquatic organisms, and the requirements for survival of various life stages in developing the current criteria for these parameters (Ecology 2006).

Earlier water quality studies informed on the type of pollutants and severity of contamination at locations throughout the Palouse River watershed (Clark 2003; Henderson 2005). Among the water quality parameters previously mentioned as primary pollutants, sediments, phosphorus, and bacteriological contamination were the most prevalent. The longevity of human activity (beginning in the late 1800's) in the basin has altered landscape vegetation characteristics that have compounded pollution problems through de-stabilization of soil integrity, introduction of large quantities of nutrients into soils, that eventually erode to nearby stream channels (Figure 1-1). The effects on stream water quality are observed in several

**Figure 1-1.** Eroding banks along the lower South Fork Palouse River (Site SFPR-098891).

reports where eutrophication of aquatic ecosystems has affected dissolved oxygen concentrations and then pH conditions (Figure 1-2). There is some question, however, about the role riparian vegetation may have played historically and if the greater contribution to temperature mediation in streams of this basin during the warm months may have been migration of groundwater to streams and surface water exchange to groundwater in select reaches.

**Figure 1-2.** Signs of eutrophication along the lower South Fork Palouse River (Site SFPR-098891).

Groundwater influence on surface water streams can be significant during low flow portions of the year. The development of population centers like Pullman, WA has depleted groundwater levels and has permanently affected the presence of artesian wells that were well-known in the area. Groundwater recharge does not occur rapidly enough through surface water streams, lakes, or precipitation in order to replace as rapidly as withdrawal from select areas (USGS 1975). Nearly every town and farmstead uses springs or wells as a source for drinking water and limited irrigation.

## 1.3 Purpose for the Literature Review

A thorough literature review that examines historic information describing biological communities, changes to physical habitat, and available information describing water quality conditions for pre-European, 1975 to current, and current conditions was conducted. This review will provide information that will help determine the natural conditions of the system, and how the system has changed over time. The biological descriptions may provide the greatest evidence for historic conditions derived from autecological characteristics of biological communities and tolerance to environmental gradients.

## 1.4 Objectives of the Effort

The objectives of this project focus on generating answers to the following questions:

**Question 1:** What were the historic aquatic-life uses in the waterbody?

- What fish, amphibian, and invertebrate species were historically resident in the watershed?
- What other notable historic biological information is available pertaining to aquatic life in the waterbody?

**Question 2:** What are the current aquatic-life uses in the waterbody?

- What fish, amphibian, and invertebrate species currently reside in

the watershed?
- When are the fish, amphibian, and invertebrate species present?
- Do the fish have migration patterns and do they utilize thermal (or other) refugia in the watershed? Where are these refugia located and when are they utilized?

**Question 3:** What are aquatic life uses that would most likely occur within a range of estimated natural conditions in the waterbody (Ecology will provide a description for the range of estimated natural conditions), both currently and historically?
- What aquatic habitats could have occurred within the range of estimated natural conditions?
- What is a reasonable estimation of the biota assemblage that could be found in this system if the water quality and habitat were improved to within the range of estimated natural conditions?
- What are the effects of non-native riparian vegetation on the current aquatic community (i.e. reed canary grass compared to native riparian vegetation)?

A description of the environmental conditions during 3 important periods related to the above questions was developed by summarizing information gathered from existing knowledge and generating data describing current conditions. The time periods are:

- Pre-European conditions (Question 1; habitat and biotic conditions prior to arrival of original settlers).
- Current conditions (Question 2; field data from this study and more recent surveys),
- Trends from 1975-Current (Question 3; a reflection of environmental change over a 35 year period).

These 3 periods along a timeline, beginning with Pre-European settlement, were compared in order to determine (1) the extent of change in biotic communities that may have directly and indirectly been influenced by the arrival of Europeans, and (2) the effects of the development of the regional economy on aquatic resources.

# 2.0 METHODS

## 2.1 Literature Review and Professional Interviews

### *2.1.1 Strategy for initiating the review*

The literature survey was completed using multiple approaches that could yield primary literature necessary to adequately address the objectives in this study. Three main sources for information were used to locate literature eventually used in constructing this document:

- Web-based survey (Google©),
- Library search (Eastern Washington University, Washington State University, and University of Idaho), and
- Professional Interviews (by telephone, in-person, or by email exchange).

The web based survey and library search methods were more consistent in approach and expected results. Search words and intensity of literature discovery were uniform between the two methods. The professional interviews differed among the respondents and this was due to the type of information each had to offer and the level of experience within the organization.

### *2.1.2 Literature Survey*

Literature surveys were extracted from both the web-based search and from the library search. Literature was collected in electronic form, where available, and stored in sub-folders that reflected themes for environmental information:

- Benthic Macroinvertebrates (BMI)
- Dams
- Entomology
- Fisheries
- Land Use
- Literature from the Palouse Bibliography
- Periphyton
- Physical Habitat
- Remote Imagery
- TMDL Regulatory
- Use Attainability Analysis (UAA)
- Vegetation
- Water Quality
- Water Quantity
- Water Supply Bulletins
- Watersheds
- Wetlands

General categories that were related to any of these environmental themes were also used as key search terminology in locating available technical literature.

### *2.1.3 Database review*

Information from existing databases like Ecology's EIM (Environmental Information Management) system was reviewed for relevant data. EIM is a clearinghouse of environmental data stored and annotated by Ecology and offers access via a web link:

http://www.ecy.wa.gov/eim/

Additional databases were reviewed for useful information through the Natural Resources Information Portal:

http://www.swim.wa.gov/

Information was reviewed for references to reports and/or literature relevant to objectives of this study. Reports generated by the Washington Department of Ecology related to the Palouse River drainage and surrounding region were located through on-line access to publications by the Water Quality Program and the Environmental Assessment Program. The Idaho Department of Health and Welfare-Division of Environmental Quality as well as the Nez Perce Tribe generated useful documents that described bases of information used to develop regulatory tools.

### *2.1.4 Personal communications*

Several staff from academic institutions and tribes were contacted for information generated in the Palouse River drainage. Detailed information regarding these contacts is found in Appendix A: Professional Contacts List. Relatively little information was contributed from these conversations and through attempts to contact environmental professionals listed in the table.

Fishery Biologists from the Coeur d'Alene and Nez Perce Tribes stated that very little focus had been placed on resource management in the Palouse River drainage. The Nez Perce contact was able to locate a single document that reported on recent water quality conditions from several reaches in the State of Idaho. Results of this study identified primary pollution problems as: sediment, phosphorus, and bacteriological contamination (Clark 2003). The eroding soils both instream and from along banks carries high concentrations of adsorbed phosphorus from agricultural applications. The movement of the soils (with associated phosphorus) occurs with precipitation or rain-on-snow runoff and erosion of river banks during high flows. The phosphorus aggregates in increasing quantities as adhered to soils and influences trophic condition in nearby streams.

### *2.1.5 Compilation of the information and results*

Organization of the summary of results section was organized into three time periods as described in the objectives of this literature survey. The time periods in which available and relevant literature was organized further partitioned these summaries as: physical habitat, water quality, and biological conditions. The time periods were intended to reflect typical periods during which significant changes occurred in land use, economic development, or availability of data from scientific investigations. The following were time periods in which these results were categorized:

- Pre-European
- Trends from 1975 to Current
- Current Conditions

Several types of environmental information were useful in examining how changes in one or more conditions during a time period might have influenced biological potential (and migratory patterns) throughout the South Fork Palouse River drainage. A summary of information from the literature survey was used in the Final Technical Report. Differences in physical, chemical, or biological conditions were identified by comparing data among the three time periods. Any differences were further examined for impact on biological communities and limitations to migration within the drainage (e.g., water quality factors or physical habitat availability). Scientific references were included in these summaries as well as additional references not cited, but evaluated for utility in this project.

### *2.1.6 Data presentation*

Data summaries are presented as text, tabular, and graphical form in the Results section. Any tables or graphs that appear in this report are copied and included from the original source (cited) to preserve integrity of information content. Available data from historic studies as well as from summer 2010 field work are organized by the three time periods previously described and compared in order to identify what and where ecosystem changes have occurred in the drainage. These differences are categorized as physical habitat changes, water quality impairments, or biological impairments when current conditions differ from historical.

## 2.2 Current Instream Biological Characterization

The focus for most of the characterization of fish assemblages and other aquatic life, water quality, and habitat was in Washington State; with a small portion of the watershed located in Idaho. Figure 2-1 is an overall view of the drainage identifying major tributaries that confluence with the South Fork Palouse River.

Stream types were stratified by bottom substrate type (soft and hard substrate) as these features can be limiting to spawning success of several fish species known to occur in the South Fork Palouse River. EPA's General Randomized Tessellation Stratified (GRTS) design was used to select candidate sites in the Washington and Idaho portions of the watershed. A subset of 20 sites was used for field surveys of fish, benthic invertebrates, habitat, and water quality parameters relevant to the TMDL process. Because of the GRTS design, a target number of 30 sites is considered adequate to represent the various features of the river basin for an assessment (Olsen et al. 2009), but this assumption was altered in order to accommodate for sampling of multiple biological assemblages. In this study, 20 sites were used to represent fish population characteristics and 10 overlapping sites represented both fish and benthic invertebrate populations. The reduced number of sites from the minimum was still considered a valid random sample based on a reduced drainage network and likelihood that a measurable portion of stream channels are dry during the summer in the South Fork Palouse River

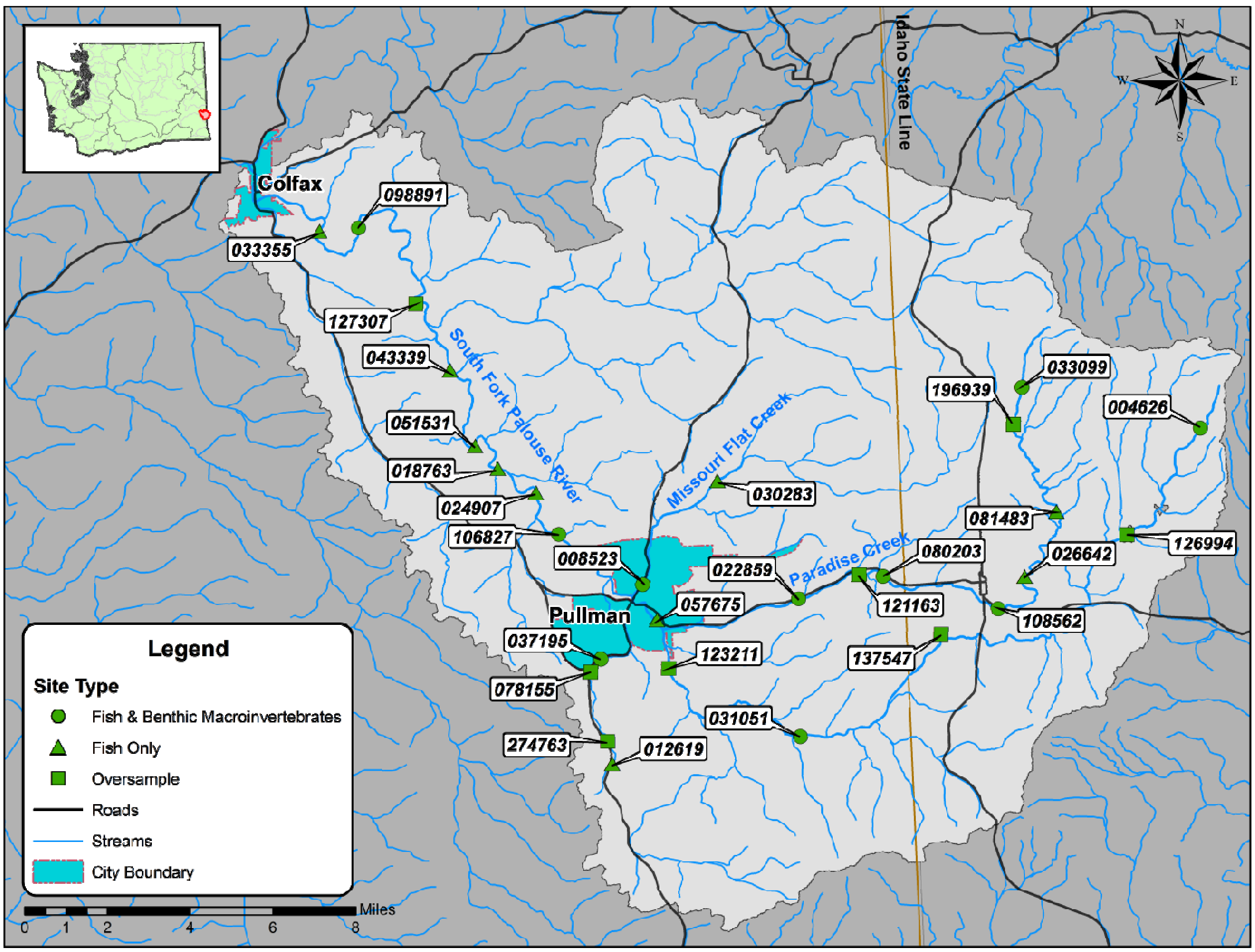


**Figure 2-1.** Map of the study area and proposed sampling sites in the South Fork Palouse River watershed**.**

drainage. The final survey design addressed factors that affect fish populations, and provided a basis for assessing the instream biota of the system.

Site selection focused on four streams and creeks of the South Fork Palouse River watershed: South Fork Palouse River, Paradise Creek, Missouri Flat Creek, and Dry Fork Creek. These tributaries and mainstem regions of the South Fork Palouse River watershed are known to remain wetted along the entire study area or, in the case of tributaries, at the lower portion of the creek prior to confluence with mainstem South Fork Palouse River. A representation of the primary sites and oversample sites (i.e., replacement sites for unsampleable primary sites) is reported in Figure 2-1.

To address the central issue of sustaining a viable fish assemblage and other aquatic life within the South Fork Palouse River and which also is attentive to WA Ecology's aquatic life use designation, the survey focused on the current status of the fish community, benthic macroinvertebrate community (at select locations), physical habitat condition, and conventional water quality conditions. Based on an analysis of historical data, trends in the viability of the fish assemblage can be ascertained from a direct comparison (past versus present assemblages), estimates of food availability and environmental conditions (as assessed from benthic macroinvertebrate collections) from historical and current data, and descriptions of existing refugia from physical habitat assessments.

Twenty (20) sample sites in the Washington and Idaho portions of the South Fork Palouse River watershed were chosen using EPA's GRTS method to evaluate water quality, habitat and fish and benthic macroinvertebrate communities relevant to the TMDL process. Field data collections followed Washington State Department of Ecology's guidance for site verification and layout, *in situ* water quality, substrate characterization, and fish community composition (Washington Department of Ecology 2009 [draft]). Benthic macroinvertebrate assessments followed Hayslip (2007) biological collection protocols that have been adopted by PNAMP (Pacific Northwest Ambient Monitoring Partnership). An additional evaluation of habitat quality was accomplished using EPA's Rapid Bioassessment Protocols (RBP) developed by Barbour et al. (1999).

<u>Site Verification and Layout</u>

Sample reaches are defined as 20 times mean bankfull width, using a minimum reach length of 150 meters and a maximum of 2000 meters. Thus, sites with a mean bankfull width of less than 8 meters are extended to 150 meters and those greater than 100 meters are limited to 2000 meters.

<u>Water Quality</u>

Water quality parameters, including temperature, dissolved oxygen, pH and conductivity were measured using a YSI or Hydrolab multimeter probe. Data were collected twice, at the start and end of sampling at the site, in the vicinity of the mid-point of the sampling reach.

<u>Substrate Characterization</u>

Substrate was characterized at each of 10 equidistant transects along the length of the sampling reach. Particle size class, based on the intermediate axis length, was recorded at 11 equally-spaced stations along each transect. Other morphological features, including wetted width, bankfull width, wet depth, bankfull depth, and substrate embeddedness were also evaluated.

Fish Community Composition

Fish community sampling was conducted using a single-pass electrofishing estimate. All habitats were sampled over the stream reach. Specimens were enumerated and identified to species, categorized by life stage (juvenile or adult), and measured to determine the minimum/maximum length (total length - mm) by species. Most fish were returned back to the stream following processing; however, some individuals (≤ 3 individuals per species) were retained to verify taxonomic identification or to be used as reference specimens.

Benthic Macroinvertebrates

Benthic macroinvertebrate communities were characterized using existing information beginning with collections from the past 20 years. More recent community composition was characterized with benthic macroinvertebrate collections at 10 randomly selected sites (collected simultaneously at 10 of the 20 fish population sites) and compared against data that had been collected from the early 1990s in order to determine trends in condition of this community.

Physical Habitat

The RBP habitat evaluation is visually-based and consists of scoring a continuum of conditions for each parameter into one of four categories represented as optimal, suboptimal, marginal, and poor. Included is a 20-point scale for each parameter with 0 being the poorest and 20 the optimal. Habitat quality was scored by visually assessing (i.e., scoring) parameters along stream reach. The total possible score for physical habitat is 200. Riparian conditions were assessed using both a rapid, visual scoring survey as well as a quantitative estimate of canopy cover following methods detailed in Washington Department of Ecology (2009 [Draft]). Canopy cover contributes food energy to the benthic macroinvertebrate community and provides temperature regulation on a localized scale during the warmer months in the southeast region of Washington State. The type and presence of canopy cover, in part, has a strong influence on benthic communities. Well-developed riparian areas, with extensive canopy cover serve to regulate temperature, promoting more diverse assemblages comprised of species intolerant to high or fluctuating water temperatures.

# 3.0 RESULTS

The following sections present ecological characterizations of the South Fork Palouse River watershed over three time periods: pre-European, 1975 to current, and current conditions. Points of contact for historical information (pre-European through current) and the resulting technical memorandum of the literature review are presented in appendices A and B of this report. Biological data collected as part of the current study are also provided as appendices C and D .

## 3.1 Pre-European

### *3.1.1 Physical habitat and Landscape Characteristics*

Historically, fall chinook (*Oncorhynchus tshawytscha*) spawning in the Washington portion of the Snake River was concentrated near the mouths of the Palouse and Clearwater Rivers (Fulton 1968, cited in Dauble 2000). This portion of the Palouse River flows through a deep canyon cut through the Columbia River Basalts during the torrential Spokane Floods. Prior to these floods, the Palouse River flowed down the now abandoned Washtucna Coulee, joined Esquatzel Coulee at Connell, and then joined the Columbia River near Pasco. The floods spilled over the south wall of the historic Palouse River valley and headed for the Snake River where the waters poured over the lip of the Snake River Canyon. This was likely the original location of Palouse Falls. Successive flood flows produced immense whirlpools that tore large blocks of basalt from the face of the falls, causing the falls to erode upstream about six miles to its current location. The Palouse Falls at approximately 185 feet is a complete barrier to anadromous and non-anadromous fish passage. Anadromous fish and bull trout are not present in the headwaters of the Palouse River within Washington (Kuttel 2002).

In the nineteenth century, perennial caespitose grasses, often associated with forbs and low shrubs, dominated uplands, but parts of the landscape where surface water accumulated in winter and spring developed distinctive vegetation. Dense stands of common camas (*Camassia quamash*), an important food plant for the region's native people, were the most obvious feature of this association (Weddell date unknown).

Weddell (date unknown) states that it is interesting to note that reed canarygrass (*Phalaris arundinacea*), which now forms virtually monolithic stands in stream channels and floodplains throughout the Palouse Prairie, was not collected in the study area prior to 1917 and is not listed by Piper and Beattie as occurring in the Palouse Region prior to 1901. This plant occurred in some parts of the West prior to white settlement, but the highly invasive form that now dominates streams and streamside environments in the Intermountain West may be descended from a non-native cultivar or a hybrid between a cultivar and a native form (Merigliano and Lesica 1998). The earliest Latah or Whitman County specimen in the Stillinger or Ownbey herbaria was collected by R. Daubenmire in 1938 in a "muddy roadside ditch" 5 miles north of Moscow (WSU Ownbey Herbarium Spec. No. 261001).

### *3.1.2 Water quality*

There are no known records that measured water quality conditions in the South Fork Palouse River drainage during the pre-European time period. The markers that inform on surface water conditions are the precipitation records for the Palouse Region and the dryland crop cultivation favorable in this area. The precipitation period during the year is held as moisture in the loess soil and stored for a prolonged period into the early summer. The augmentation of surface flow during the warming season may have been delivery of surface soil moisture to the stream channel. The pre-European water temperature conditions may have been slightly cooler further into the summer season, but not by an appreciable amount.

### *3.1.3 Biological Conditions*

The Palouse Falls, at approximately 185 feet, is a complete barrier to anadromous and non-anadromous fish passage. Anadromous fish and bull trout are not present in the headwaters of the Palouse River within Washington (Kuttel 2002).

According to fishery documents, the Palouse River was, at least historically not used by spawning salmon (Fulton 1968). Parkhurst (1950) did not survey the Palouse River during his fisheries study and historic overview of Snake River Basin anadromous fishes. He noted that a high falls (Palouse Falls) located about 10 km above the mouth “renders the stream inaccessible to migratory fish”. Ethnographic records show that salmon fishing was extremely productive at the confluence of the Palouse and Snake Rivers (Ray 1975; Butler 2004). Lewis and Clark and later explorers describe a very large village at the mouth of the Palouse River. Ross Cox, who spent time in the village around 1812, noted that in early August, people there were engaged in catching and drying salmon in large numbers (Ray 1975). Historic documents also show fishing camps and villages along the Palouse River itself (Ray 1975). Ray refers to two such locales in particular: *A’patap*, which was located at the foot of the Palouse Falls, and *Claxo’pa*, about four miles above the mouth. Unfortunately, the documents do not indicate whether the Native American fishery along the Palouse River targeted resident freshwater fish or anadromous salmon and trout (Butler 2004).

The falls have been a barrier to migratory salmonids at least since the late Pleistocene and Holocene periods, thus it is clear that the Palouse River itself was not a passageway for fish migrating to headwater areas to spawn. It is possible of course that the Palouse River channel below the falls was used by salmon for spawning and thus a fishery might have developed to target such fishes. Pre-dam records for fish distribution lead to the conclusion that the Palouse River never supported large salmonid populations (Butler 2004).

The historic fish assemblage in the Palouse River Subbasin prior to European settlement consisted primarily of anadromous and resident salmonids, cyprinids, and catastomids in the lower Palouse River below Palouse Falls, and a diverse assemblage of fish species, primarily composed of cyprinids and catastomids above the falls (Cook 2001). The anadromous salmonid fish species noted included Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O.*

*mykiss*) (Parkhurst 1950). Although there is a general understanding of what species now exist in the sub-basin, there is a lack of knowledge on what native fish species existed within the subbasin, prior to European immigrant settlement in the area, which are no longer present (Cook 2001).

Wertz (1993) quotes a longtime resident as stating that Paradise Creek supported a cutthroat trout population up until the 1890's (Doke and Hashmi 1994).

## 3.2 1975 to Current

### *3.2.1 Physical habitat and Landscape Characteristics*

The Palouse River originates in the mountains of western Idaho and flows 262 km, through forest, dryland farming (non-irrigated), and barren rangelands before discharging to the Snake River; it drains 8500 $km^2$. Dryland farming, mainly wheat, constitutes 75% of land use in the Palouse River Basin, with grazing and urban development in localized areas.

A notable physical feature in the drainage is Palouse Falls, a vertical rise of approximately 185 feet, and is a complete barrier to anadromous and non-anadromous fish passage. Anadromous fish and bull trout are not present in the headwaters of the Palouse River within Washington (Kuttel 2002) and there is no record of use by salmon and/or trout in the lower 10 km (6 miles) of the river (downstream of the falls) (Fulton 1970).

The Palouse River and its tributaries flow freely to the Snake River with no major man-made impoundments (USDA 1978). There are a few minor impoundments for irrigation purposes, mostly located on small tributaries. There have been major efforts historically to straighten and keep stream channels clear of vegetation to assist with drainage of the surrounding landscape and to control flooding on tributaries of the Palouse River. In some cases dikes have been installed along streams to reduce flooding, these have disconnected the streams from the riparian and upland zones. Tiling has been used to improve the drainage of wetter areas to open the ground for agricultural purposes; the tiling normally directed to the closest stream. Farm practices and the removal of wetlands have dramatically reduced the upland water storage capacity of the Palouse Basin (Servheen et al. 2002). Forest grounds in Idaho have been historically clear-cut reducing water storage potential. Also, an increase in the amount of impervious surfaces from expansion of urban areas has had a noticeable effect on aquatic resources. The Palouse River, as it flows through Colfax, Washington, is contained in a concrete aqueduct. These factors have contributed to a 'spiky' hydrologic curve, and several tributary streams becoming intermittent in the summer months. Occurrence of precipitation events results in rapid movement of water through the small feeder streams that drain to the mainstem Snake River (Cook 2001).

The gradient reflected by land use changes from headwater to mouth establishes a unique opportunity for examining biological response in aquatic ecosystems as related to a longitudinal nutrient gradient. In addition, nutrient input is also influenced by source water and location of discharge into the South Fork Palouse River (e.g., Paradise Creek). The periphyton community, for example, has been a good indicator in aquatic settings for differentiating nutrient sources in stream flow from sewage treatment effluent and excessively high nutrient loading from Moscow, Idaho, and Pullman, Washington (Greene et al. 1994; Munn et al. 2002).

The South Fork and its main tributaries in Idaho (Crumarine Creek, Gnat Creek and Howard Creek) originate from springs within the forested terrain of Moscow Mountain. The South Fork Palouse River experiences low flows during the late summer and early fall months and high flows in the spring and early summer months. Drained wetlands and flood plains in the Palouse have resulted in changes to channel sinuosity and diversity. Wetland and floodplain areas typically serves as recharge sources for surface water in streams during low flow months of the year so the absence of these recharge zones results in more severe drought conditions in select reaches. Without these water storage areas, peak flows are higher and for a shorter period of time, creating in-stream channel erosion, flooding, and deeply incised channels (IDEQ 2007).

Erosion is occurring along most stream banks of the Idaho portion of the South Fork Palouse River that are adjacent to cropland and pastureland fields. Livestock activity often promotes stream bank deterioration, as well as the removal of vegetation and the disturbance of woody vegetation and rhizomatous herbaceous species in the riparian zone is evidence of this effect in select reaches. Declining root mass density promotes bank soil instability and sloughing resulting in contribution of significant amounts of sediment into the SFPR drainage. Currently, several reaches of the stream have been channelized or lack woody vegetation where cropland fields were established. Herbicide spray and tillage operations, as well as grazing activities, are intentional, preventive measures for re-establishment of woody plant species in the riparian zone. Many small intermittent streams have been converted to drainage ditches, and the riparian vegetation removed during alteration. Tillage often occurs up to the edge of the ditch or property, leaving limited or no buffer between the waterway and the cropland. Elevated water temperatures in the summer and increased nutrient and sediment loads can adversely affect aquatic habitat (HDR 2007). While there are some remnant areas; much of the historically diverse and multi-layered, complex vegetation structure in stream reaches is missing (ISCC 2009).

The alteration of the landscape in the South Fork Palouse River drainage is reflected as changes in flow patterns and water quality conditions. Changes in flow patterns include increased peak flows in winter and spring storm events, and lower sustained summer base flows. The increase in peak flows is partly caused by loss of storage within the riparian zone, leading to a reduction in infiltration, which in turn, lowers the sustained summer base flows. The flow pattern changes have materialized as significant flood events that have been documented in the City of Pullman. The most recent severe flood occurred in 1996, triggered by heavy rainfall on snow that covered frozen ground. Lower summer base flows also contribute to warmer water temperatures. During low flow summer periods, there is no sustained summer base flow in the South Fork. Downstream from Pullman, the instream summer flow in the South Fork is mainly composed of City of Moscow and City of Pullman wastewater discharges (HDR 2007).

Table 3-1 below was taken from IDHW-DEQ 1994 and summarizes habitat scores for various stations on Paradise Creek (all stations in Table 3-1 are located in the State of Idaho). Schwarz Creek is a reference site used by Rabe (1993) for comparison with those on the mainstem of Paradise Creek. The qualitative habitat quality for a stream segment is rated as excellent (101-125), good (67-100), fair (33-66), or poor (0-32). Schwartz Creek was the reference stream in the study, (Rabe et al. 1993).

**Table 3-1.** Habitat assessment scores of Paradise Creek, October 1992 and February 1993.

| | Mt. View | | White &Troy | | 6th & Deakin | | | Blw. WWTP | | Schwartz | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Oct** | **Feb** | **Oct** | **Feb** | **Oct** | **Feb** | **Oct**[1] | **Oct** | **Feb** | **Oct `91** | **Feb `92** |
| Bottom substrate | 3 | 2 | 3 | 3 | 6 | 4 | 2 | 10 | 3 | 15 | 16 |
| Embeddedness | 2 | 2 | 2 | 2 | 7 | 4 | 2 | 12 | 6 | 11 | 14 |
| Channel shape | 2 | 2 | 5 | 5 | 2 | 2 | 2 | 12 | 12 | 13 | 13 |
| Riffle/bend ratio | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 4 | 4 | 11 | 11 |
| Channel alteration | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 5 | 5 | 15 | 15 |
| Lower bank stability | 3 | 3 | 5 | 5 | 5 | 5 | 4 | 6 | 6 | 8 | 8 |
| Bank vegetation protection | 4 | 4 | 6 | 6 | 6 | 6 | 6 | 8 | 8 | 10 | 10 |
| Canopy cover | 2 | 0 | 7 | 5 | 7 | 5 | 7 | 6 | 4 | 8 | 6 |
| Width of riparian | 3 | 0 | 4 | 2 | 4 | 2 | 4 | 8 | 3 | 8 | 8 |
| **TOTAL SCORE** | 22 | 16 | 35 | 31 | 41 | 32 | 30 | 69 | 49 | 99 | 101 |

[1] **October 1993**

### *3.2.2 Water quality*

The South Fork Palouse River and several of its tributaries (Paradise Creek, Missouri Flat Creek and Dry Fork Creek) are listed as impaired by fecal coliform bacteria on the Clean Water Act's 303(d) list of impaired water bodies (Carroll et al. 2009). The streams in this watershed are required to have a geometric mean of less than 100 colony forming units/100 milliliters (cfu/mL) and not more than 10% of the samples used to calculate the geometric mean can exceed 200 cfu/100mL.

The South Fork Palouse River is listed on the 303(d) list of impaired waterbodies for high in-stream temperatures (Table 3-2) (Bilhimer et al. 2006). As a consequence, Thermal Infra Red (TIR) true color imagery was collected in late July 2005 to characterize general patterns in surface water temperature throughout the South Fork Palouse River drainage (Figure 3-1).

Radiant water temperatures in the South Fork Palouse River ranged from 17.7°C just downstream of the Paradise Creek confluence to a survey maximum of 26.4°C at river mile 3.3 upstream of the town of Colfax). The TIR survey began at the river mouth and continued upstream to near the headwaters (mile 43.4). However, upstream of river mile 33.2, the South Fork did not have enough visible surface water to obtain accurate temperature samples (Watershed Sciences, Inc. 2006).

**Table 3-2.** 2005 monthly summary for ambient monitoring stations.

| Station ID | July (°C) | | | | August (°C) | | | |
|---|---|---|---|---|---|---|---|---|
| | Avg. DMax | Stdev | Max 7DADMax | Date of 7DADMax | Avg. DMax | Stdev | Max 7DADMax | Date of 7DADMax |
| 34C100 (Paradise Cr) | 21.31 | 0.74 | 21.67 | 7/30/2005 | 20.64 | 0.95 | 21.33 | 8/1/2005 |
| 34B110 (SFPR at Pullman) | 20.03 | 0.67 | 20.39 | 7/15/2005 | 17.83 | 1.64 | 20.1 | 8/1/2005 |
| 34B130 (SFPR blw Sunshine) | 21.57 | 1.13 | 22.51 | 7/4/2005 | 17.62 | 1.59 | 20.57 | 8/1/2005 |

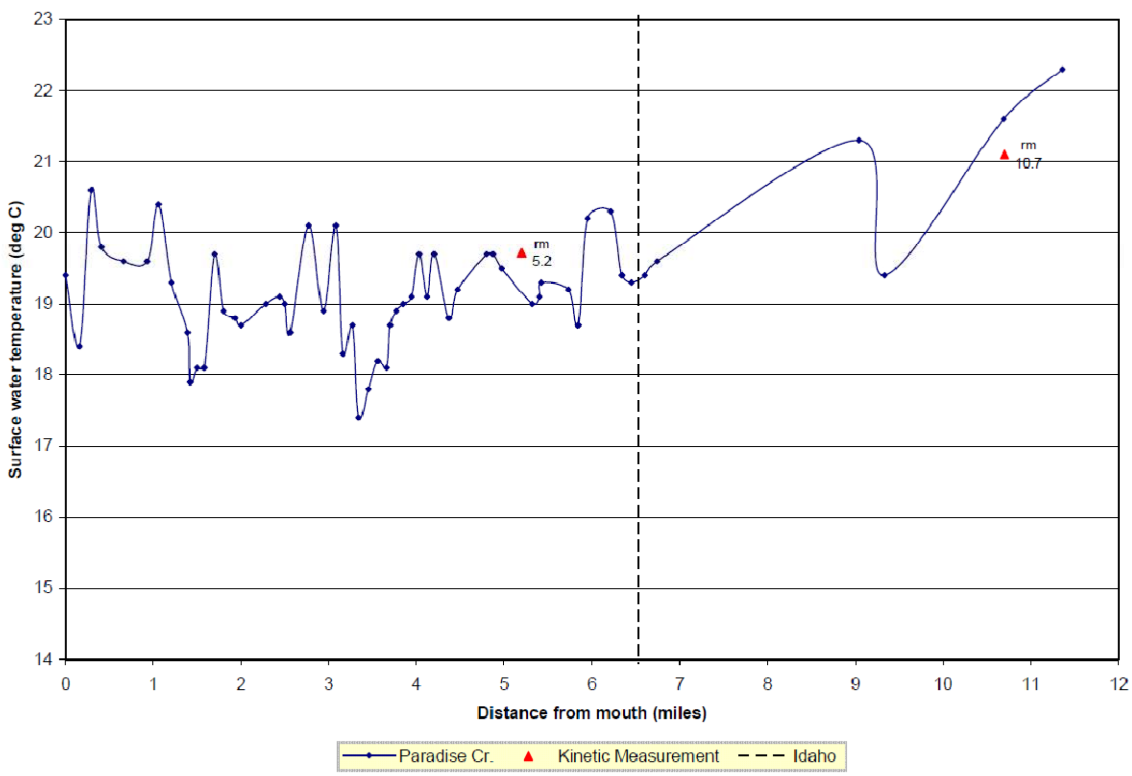


**Figure 3-1.** Radiant water temperatures plotted versus river mile (from N. Fork Palouse) for the South Fork Palouse River.

Radiant water temperatures in Paradise Creek ranged from 17.4°C to 22.3°C (Figure 3-2). The longitudinal profile shows considerable variability between radiant temperature samples. The wetted channel width was relatively small (1 to 5 meters) throughout the entire extent with some reaches having no visible surface water. Radiant temperatures were sampled where surface water was clearly visible and wetted widths were at least 1.5 meters.

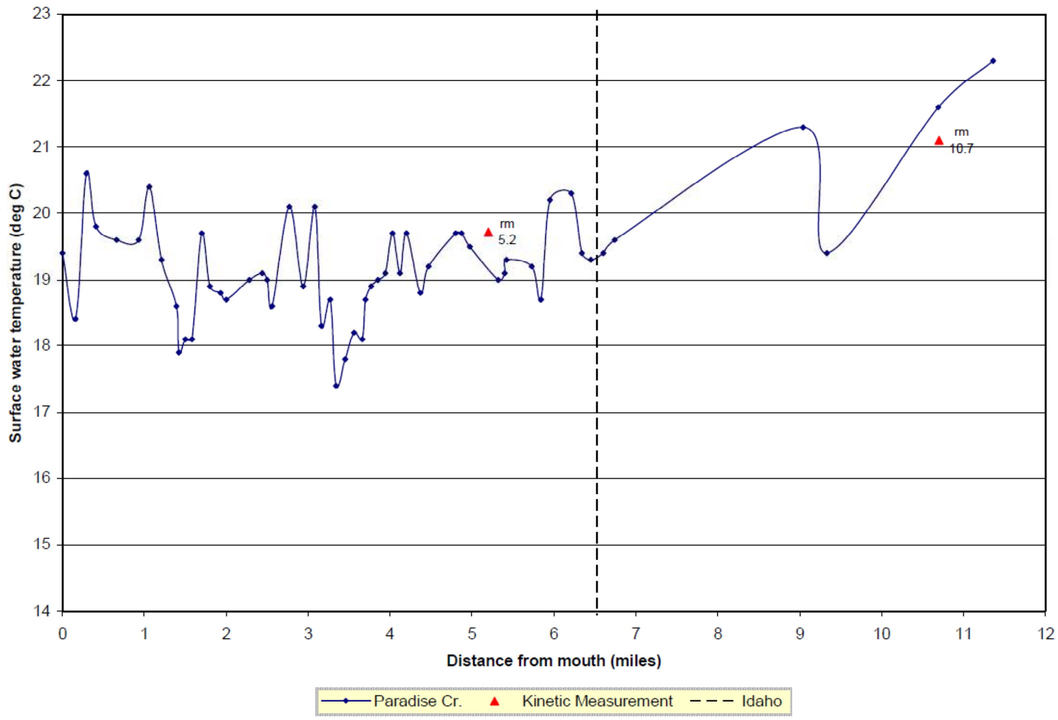


**Figure 3-2.** Radiant water temperatures plotted versus river mile for Paradise Creek.

The South Fork Palouse River has been listed by the state of Washington under Section 303(d) of the Clean Water Act for non-attainment of Washington State dissolved oxygen (DO) and pH criteria. The listings are based on sampling done by the Washington State Department of Ecology in 1987, 1991, and 1994-2001. An additional 303(d) listing within the South Fork Palouse River watershed for ammonia can be found in Carroll et al.( 2006). Pelletier (1993) showed that the fraction of POTW effluent in the SFPR during critical flow is high. Moscow POTW and Pullman POTW are estimated to comprise the majority of the river flow during July–November for a typical year (Figure 3-3).

In 1980, Idaho's Department of Health and Welfare, Division of Environmental Quality (DEQ) listed Paradise Creek as protected for agricultural water supply and secondary contact recreation designated beneficial uses in the Idaho Water Quality Standards. In October 1993, DEQ staff conducted a Use Attainability Assessment (UAA) for Paradise Creek. The purpose of the UAA was to evaluate the appropriateness of the current designated uses and to determine whether the creek should be protected for any additional uses. It was determined through the UAA that if the water and habitat quality is improved, Paradise Creek would be capable of supporting salmonid spawning and cold water biota. This designation applies to the portion of the creek flowing through Idaho; however above Mountain View Park the creek is intermittent and these uses would apply only when water is present. Secondary contact recreation and agricultural water supply were confirmed as appropriate designated beneficial uses (IDHW-DEQ 1994).

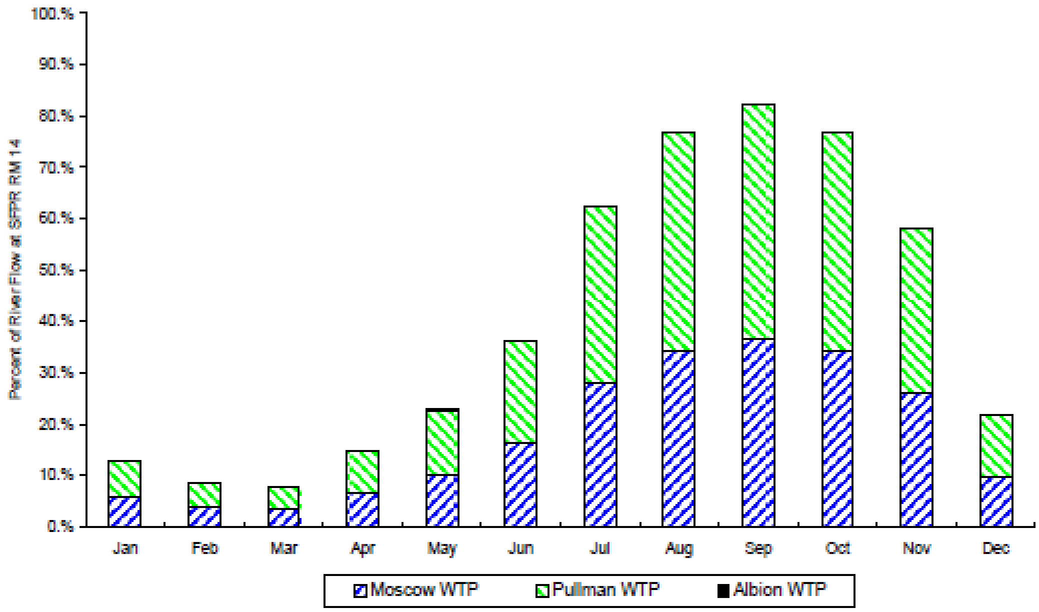


**Figure 3-3.** Estimated monthly fraction of POTW effluent in the South Fork Palouse River median flow year. Adapted from Pelletier (1993).

In 1979, DEQ identified the South Fork of the Palouse River and Paradise Creek as having severe pollution problems due to erosion on dryland farming ground (IDHW-DEQ 1981). A water quality survey was conducted and determined the concentration of sediment and associated pollutants depends on the timing and magnitude of runoff. During high flows the concentration of suspended sediment ranged 1,000-3,000 mg/l, fecal coliform numbers increased downstream and exceeded Idaho water quality standards for secondary contact recreation. Paradise Creek had an overall water quality rating of 99 on a scale of 0-100, with zero being pristine waters and 100 being highly degraded. The survey also concluded that with respect to water quality, most of the surveyed agricultural areas within the Palouse drainage would be considered critical. Due to the severe impacts that agriculture has on Paradise Creek, the Latah Soil and Water Conservation District conducted a planning project to implement best management practices (BMPs) in the Paradise Creek watershed through the Idaho Agricultural Water Quality Program. The District submitted a grant application for implementation in 1981 and 1986, it was rejected both years. (Latah SWCD 1981, 1986) (IDHW-DEQ 1994).

Idaho DEQ designated Mountain View Park as the point where Paradise Creek becomes a perennial stream. Historically, this area was a wetland and water is almost always present during the low flow periods. Upstream from this point the creek is intermittent except during spring runoff. Paradise Creek is located along the western edge of Mountain View Park. In this section the creek is channelized, has little canopy cover, and the bottom substrate is highly embedded. For these reasons this site is generally considered as a poor habitat for fish. The water quality is capable of supporting cold water biota; water temperatures are below 20°C and only once was the dissolved oxygen level measured to be below the minimum requirement (6 mg/L) for cold water biota as defined in the Idaho Water Quality Standards (IDHW-DEQ 1994). Table 3-3 below also from IDHW-DEQ (1994).

**Table 3-3.** Mountain View Park water quality data (Source: Washington Water Research Center)

| Parameter | Winter Values Nov. – April (n=8) | Summer Values May –Oct. (n=6) |
|---|---|---|
| Temperature (°C) | 0 – 5.5 | 6.9 – 16.0 |
| pH | 6.8 – 7.7 | 6.9 – 7.6 |
| Dissolved Oxygen (mg/L) | 7.0 – 13.2 | 3.9 – 11.8 |
| Conductivity | 127 – 218 | 37 – 385 |
| Alkalinity (mg/L as $CaCO_3$) | 27 – 187 | 40 – 203 |
| Suspended Solids (mg/L) | 0.8 – 286.7 | 4.5 – 112.7 |
| Total Nitrogen (mg/L) | 2.27 – 13.87 | 1.37 – 3.24 |
| $NH_3$ (mg/L) | 0.02 – 0.09 | <0.01 – 0.04 |
| $NO_3$ (mg/L) | 0.75 – 12.45 | 1.21 – 2.71 |
| $NO_2$ (mg/L) | <0.01 – 0.05 | 0.03 – 0.04 |
| Total Phosphorus (µg/L) | 75 – 388 | 61 – 350 |
| Fecal Coliforms (CFU/100 ml) | <4 – 152 | 4 – 433 |
| Fecal Strep (CFU/100 ml) | 10 - >6000 | 42 – 1400 |
| Flow (CFS) | 0.05 – 27.49 | 0.03 – 28.76 |

Tables 3-4 and 3-5 below are also from IDHW-DEQ (1994) and summarize water quality information from other stations on Paradise Creek.

**Table 3-4.** White Avenue and Troy Highway water quality data (Source: Washington Water Research Center).

| Parameter | Winter Values Nov. – April (n=8) | Summer Values May –Oct. (n=6) |
|---|---|---|
| Temperature (°C) | 0 – 5.2 | 6.9 – 18.0 |
| pH | 6.8 – 7.6 | 7.2 – 8.6 |
| Dissolved Oxygen (mg/L) | 3.2 – 12.8 | 2.6 – 13.0 |
| Conductivity | 166 – 772 | 153 – 459 |
| Alkalinity (mg/L as $CaCO_3$) | 32 – 189 | 50 – 169 |
| Suspended Solids (mg/L) | 4.0 – 28.6 | 2.5 – 56.7 |
| Total Nitrogen (mg/L) | 0.76 – 13.25 | 0.64 – 3.24 |
| $NH_3$ (mg/L) | <0.01 – 0.11 | 0.02 – 0.06 |
| $NO_3$ (mg/L) | 2.73 – 11.46 | 0.23 – 2.47 |
| $NO_2$ (mg/L) | <0.01 – 0.04 | 0.01 – 0.04 |
| Total Phosphorus (µg/L) | 18 – 312 | 100 – 396 |
| Fecal Coliforms (CFU/100 ml) | 6 - >967 | 8 – 600 |
| Fecal Strep (CFU/100 ml) | 20 – 310 | 80 - >780 |
| Flow (CFS) | 0.06 – 24.96 | 0.03 – 26.48 |

**Table 3-5.** Sixth Street and Deakin water quality data (Source: Washington Water Research Center).

| Parameter | Winter Values Nov. – April (n=9) | Summer Values May –Oct. (n=6) |
|---|---|---|
| Temperature (°C) | 0 – 7.6 | 6.9 – 13.5 |
| pH | 6.8 – 7.7 | 6.9 – 7.8 |
| Dissolved Oxygen (mg/L) | 5.7 – 12.8 | 5.6 – 11.6 |
| Conductivity | 165 – 536 | 171 – 751 |
| Alkalinity (mg/L as $CaCO_3$) | 37 – 201 | 52 – 225 |
| Suspended Solids (mg/L) | 6.0 – 265 | 3.6 – 203.2 |
| Total Nitrogen (mg/L) | 2.12 – 12.21 | 1.7 – 13.02 |
| $NH_3$ (mg/L) | 0.08 – 2.04 | 0.08 – 4.84 |
| $NO_3$ (mg/L) | 1.41 – 11.46 | 0.72 – 4.94 |
| $NO_2$ (mg/L) | <0.01 – 0.34 | 0.03 – 0.31 |
| Total Phosphorus (µg/L) | 39 – 775 | 225 – 1060 |
| Fecal Coliforms (CFU/100 ml) | 12 – 290 | 144 - >2000 |
| Fecal Strep (CFU/100 ml) | 61 – 420 | 128 – 2500 |
| Flow (CFS) | 0.11 – 24.33 | 0.07 – 20.09 |

Under normal conditions, the Moscow WWTP discharges approximately two million gallons of effluent a day into Paradise Creek. During low flow periods, the flow in the creek increases at least ten fold as a result of this discharge. This water is generally warmer than the creek with an average yearly temperature of 14.3°C (SWWRC 1994). Paradise Creek below the WWTP has higher concentrations of suspended solids, ammonia, nitrate, and total phosphorus due to the discharge (SWWRC 1994; IDHW-DEQ 1994)(Table 3-6).

**Table 3-6.** ID/WA Border water quality data (Source: Washington Water Research Center).

| Parameter | Winter Values Nov. – April (n=9) | Summer Values May –Oct. (n=6) |
|---|---|---|
| Temperature (°C) | 4.7 – 14.8 | 9.5 – 17.3 |
| pH | 6.6 – 7.7 | 7.1 – 7.6 |
| Dissolved Oxygen (mg/L) | 0.9 – 12.0 | 1.9 – 10.3 |
| Conductivity | 255 – 993 | 277 – 750 |
| Alkalinity (mg/L as $CaCO_3$) | 60 – 176 | 93 – 183 |
| Suspended Solids (mg/L) | 7.8 – 736 | 4.0 – 35.1 |
| Total Nitrogen (mg/L) | 7.56 – 29.49 | 13.6 – 21.9 |
| $NH_3$ (mg/L) | 1.00 – 7.60 | 1.33 – 3.10 |
| $NO_3$ (mg/L) | 4.23 – 12.20 | 3.10 – 10.95 |
| $NO_2$ (mg/L) | <0.01 – 1.00 | 0.10 – 0.80 |
| Total Phosphorus (µg/L) | 780 – 7250 | 1060 – 4200 |
| Fecal Coliforms (CFU/100 ml) | 11 - >630 | 84 – 310 |
| Fecal Strep (CFU/100 ml) | 7 – 2000 | 28 – 866 |
| Flow (CFS) | 4.7 – 41.61 | 3.02 – 22.18 |

In summer 2006, the Washington State Department of Ecology initiated several TMDL-based field studies to assess current stream temperatures and water quality conditions along the Palouse River, South Fork Palouse River, and Paradise Creek. The study, Surface-water/Groundwater Interactions and Near-stream Groundwater Quality along the Palouse

River, South Fork Palouse River, and Paradise Creek, was part of that effort, and was undertaken to characterize the thermal and water quality influences that groundwater imparts to these rivers along gaining reaches. Results from that study showed that measurable concentrations of dissolved orthophosphate (0.018 to 0.171 mg/L) and dissolved total phosphorus (0.073 to 0.875 mg/L) were found at all sampled piezometer sites. Measurable concentrations of dissolved nitrate+nitrite-N and ammonia were found at roughly half of the sampled piezometers at concentrations ranging from 0.013 to 10.1 mg/L and 0.03 to 0.549 mg/, respectively. The average estimated unit-area-mass loading to the river from discharging groundwater varied by parameter and location. The loading ranged from 0.03 to 107 mg/d/$m^2$ of streambed for dissolved total phosphorus, and 0.01 to 3,119 mg/d/$m^2$ for dissolved nitrate+nitrite-N. These load values are considered upper bound estimates since they do not account for biological or chemical reactions that may potentially reduce nutrient concentrations in discharging groundwater as it passes through the final few feet of the streambed (Ecology 2009).

The water temperature of the Palouse River at Hooper during October 1967-September 1971 ranged from a low of 0°C (32°F) in December to a high of 30°C (86°F) in July. The quantity of suspended sediment transported by streams in the basin, owning to the rapid erosion of the loess soils covering much of the basin, is greater than that of most other basins in the State. The average annual sediment yield during July 1961-June 1965 ranged from 5 tons/$mi^2$ from Cow Creek at Hooper to 2,100 tons/$mi^2$ from Rebel Flat Creek at Winona, and the average annual suspended-sediment discharge of the Palouse River at its mouth during the same period was 1.50 million tons (Nassar and Walters 1975).

The Palouse River and its tributaries are currently listed on the states (Washington and Idaho) 303(d) list for metals, pesticides, fecal coliform, dissolved oxygen, pH, ammonia-N, sediment, nutrients, temperature, and flow. The most common pollutants affecting the Palouse River and its tributaries are temperature, dissolved oxygen, pH, and fecal coliform. The South Fork of the Palouse River has been rated as having the worst water quality in Washington based on WDOE's water quality ambient monitoring data collected in Pullman (Cook 2001). In Idaho, the Palouse River tributaries of Deep Creek, Flannigan Creek, West Fork Rock Creek, Gold Creek, Hatter Creek, Big Creek, and the South Fork Palouse River are listed as water quality limited for bacteria, flow alteration, habitat alterations, nutrients, sediment and temperature. Cow Creek (Idaho) is listed for habitat alterations, nutrients and temperature. Paradise Creek is the only Idaho stream in the drainage where a Total Maximum Daily Load (TMDL) Implementation Plan has been developed (Cook 2001). A TMDL Implementation Plan for Agriculture is currently under development for the South Fork Palouse River in Idaho to address listings for sediment, nutrients, temperature, and bacterial contamination (IDHW-DEQ 2009).

Based on total annual load estimates, the Moscow WWTP was the largest source of phosphorus and nitrogen to Paradise Creek. The Moscow WWTP was also the major source of ammonia observed at the Busch site (IDHW-DEQ 1994) in WA (located at the border between Idaho and Washington) and, therefore, contributes to WA state ammonia and dissolved oxygen standards not being met at this site. Ag fields were a major source of suspended solids to Paradise Creek during peak flows in late winter and early spring when precipitation, runoff and erosion were greatest. Additional non-point sources of pollution include livestock and animal research facilities (Idaho), forestry, mining, construction, recreation, failing septic systems and toxic sites (Idaho). Dissolved oxygen concentrations were generally lowest in the summer and fall of 1993. Poor water quality is not the only problem facing Paradise Creek. The stream bank and habitat surrounding Paradise Creek have also experienced major damage. The removal of riparian vegetation, alternation of the stream channel and construction along the stream bank have resulted in unstable stream bank conditions which increase erosion and damage the habitat of aquatic organisms including macroinvertebrates and fish. Removal of riparian vegetation is also greatly responsible for the elevated water temperatures observed in Paradise Creek and the SFPR in the summer (Doke and Hashmi 1994).

### *3.2.3 Biological conditions*

An earlier study establishing a link between water quality conditions and biological response can be found in a preliminary survey of fish parasites in the Palouse Area (Griffith 1953). The majority of creeks and streams used as collection localities drain into the Palouse River, which then empties into the Snake River. The small streams sampled, including the Palouse River, resemble those in the South Fork Palouse River drainage and all had high turbidity levels. The low water clarity was considered to have an impact on number of fish species that would be present (Griffith 1953).

The lowest portion of the Palouse River drainage is host to summer steelhead, bull trout, fall chinook, and smallmouth bass are all known to be present in the lower six miles (Mendel et al. 2003; Mendel et al. 2004). Fall Chinook use this reach of the Palouse River for spawning and rearing as well. However, Palouse Falls presents a 185 foot vertical barrier to anadromous and non-anadromous fish passage. Anadromous fish and bull trout are not present in the headwaters of the Palouse River within Washington (Kuttel 2002).

Brook stickleback is established in the upper 36 km of Rock Creek, Spokane, Washington. Rock Creek is a tributary of the Palouse River which drains into the Snake River. Collection prior to 1999 yielded no brook stickleback in this drainage, leading researchers to believe that the species was recently introduced. Rock Creek resembles portions of the South Fork Palouse River drainage in habitat availability and water quality characteristics. For this reason identification of this fish species as a recent arrival in the drainage indicates the frequency of occurrence of non-native species. This is the fifth record of occurrence for the brook stickleback west of the continental divide in the United States since 1995 and the first occurrence in Washington. Brook Stickleback was previously collected in the Swan/Flathead River Drainage, Montana, Green River Drainage, Utah, the Elk River Drainage in Colorado, and the Klamath River Drainage, California (Scholz et al. 2003).

A comparison of fish species found above and below Palouse falls from 1968 through 1975 described no significant or identifiable differences. Species composition below Palouse Falls was composed of eight native species and three exotics (as mentioned in the two previous paragraphs). Upstream of Palouse Falls fish collections contained eleven native species and nine exotics. These fish species are potentially able to colonize and survive in the South Fork Palouse River further upstream based on the connectivity within the drainage. The major differences in species composition above and below Palouse Falls appeared to be the absence of Paiute sculpin (*Cottus beldingii*). Paiute sculpin is the most abundant cottid in the lower Clearwater River and tributaries near the mouth of the Clearwater and presumably also the lower Snake River. The exclusion of *C. beldingii* and *C. bairdi* (mottled sculpin) of the *hubbsi* form from above the falls would seem to indicate that the Palouse River and its tributaries were subjected to multiple invasions of cottid species and forms from centers of endemism (Maughan et al. 1980). Three species, northern pikeminnow (*Ptychocheilus oregonensis*), western dace or speckled dace (*Rhinichthys osculus*), and Palouse finescale sucker (*Catostomus catostomus*) were collected from South Fork Palouse River stations in two studies (Griffith 1953; Maughan et al. 1980). Griffith (1953) reported the additional species: speckled dace and Palouse finescale sucker and confirmed the presence of northern pikeminnow.

Peripheral studies of fisheries condition informed on identity of fish species present in various reaches throughout the Palouse River drainage. For example, Griffith (1953) surveyed the parasites of fishes found in the Palouse Area of southeastern Washington from the fall of 1948 through the spring of 1950. Fish were collected from lakes, ponds, and streams in 15 different localities. A total of 181 specimens representing seven families and 17 species were examined. Table 3-7 indicates locations surveyed number of fish species collected, and rates of infection. A total of 21 Palouse fine-scale suckers were examined and 18 were infected. Palouse fine-scale sucker were taken from two areas: the South Fork of the Palouse River and Missouri Flat Creek. Columbia large-scale sucker, 27 examined, 26 infected, was also collected from the South Fork Palouse River and the North Fork Palouse River. Western Dace-9 examined, 5 infected. These minnows were the most abundant fish in the small creeks and streams of the Palouse area. Dace were collected from Robinson Lake, South Fork of the Palouse River, North Fork of the Palouse River, and Paradise Creek. One largemouth bass fingerling from the North Fork of the Palouse River had six copepods attached externally (Griffith 1953). These observations lend some insight into the type of stream or waterbody setting where each of the named species were resident. Although the incidence of parasites on fish species can be useful for determining residence time and habitat in which they are acquired by individual fish, the identification of fish species and autecological characteristics was useful for understanding constraints for survival or migratory behavior.

Several warmwater species of fish have been identified for endemism to the South Fork Palouse River drainage. The first documented occurrence of a salmonid native to the Palouse was an isolated population of Yellowstone cutthroat trout, as Palouse Falls was an effective barrier to redband trout migration. Behnke (2002) contends the evolutionary history of the Yellowstone cutthroat trout is associated with the Snake River drainage. Following appearance of Shoshone Falls, ID more than 60,000 years ago, the Yellowstone cutthroat was likely replaced below this point by invading rainbow trout throughout this lower end of the Snake River drainage and tributaries. More recently, Behnke (2002) described the possible introduction of Westslope cutthroat trout in isolated populations resulting from repeated failures of the ice dam from

Lake Missoula more than 12,000 years ago. Currently no native salmonid species and no anadromous fish exist in the drainage. Idaho State Water Quality Standards do not distinguish between native and non-native salmonids for the designation and protection of the salmonid spawning beneficial use (IDEQ 2007).

**Table 3-7.** Rates of infection for the various streams and lakes.

| Localities | Number of Fish Species | Number of Specimens Examined | Number of Infected | Per Cent Infected | Number with Cestodes | Number with Trematodes | Number with Nematodes | Number with Acanthocephala |
|---|---|---|---|---|---|---|---|---|
| Asotin Creek | 1 | 2 | 2 | 100.0 | -- | -- | 2 | -- |
| Davis Lake | 7 | 32 | 18 | 56.3 | 2 | 1 | 7 | 16 |
| Missouri Flat Creek | 1 | 19 | 17 | 89.5 | 1 | 5 | -- | 12 |
| Palouse River, North Fork | 2 | 2 | 1 | 50.0 | -- | -- | -- | -- |
| Palouse River, South Fork | 3 | 9 | 6 | 66.7 | -- | -- | -- | 2 |
| Paradise Creek | 1 | 3 | 3 | 100.0 | -- | -- | -- | -- |
| Robinson Lake, Idaho | 4 | 14 | -- | 0.0 | -- | -- | -- | -- |
| Rock Creek | 3 | 5 | 2 | 40.0 | -- | 1 | 1 | 1 |
| Samish Lake | 1 | 3 | 3 | 100.0 | 3 | 1 | 3 | -- |
| Snake River, Clarkston | 2 | 6 | 5 | 83.5 | -- | 5 | 4 | 4 |
| Snake River, Davis Bar | 4 | 4 | 4 | 100.0 | 2 | -- | 3 | 1 |
| Snake River, Wawawaii | 1 | 10 | 10 | 100.0 | 4 | -- | 10 | -- |
| Sprague Pothole | 5 | 30 | 4 | 13.3 | 4 | -- | -- | -- |
| Union Flat Creek | 1 | 6 | 5 | 83.3 | 1 | -- | -- | 3 |
| Williams Lake | 7 | 36 | 15 | 41.7 | 13 | 10 | 1 | -- |

The following native fish may be found in the South Fork Palouse River:

- Longnose dace
- Speckled dace
- Redside Shiner
- Largescale sucker
- Bridgelip sucker

The following species have been introduced in the watershed:

- Brook trout
- Brown Trout
- Rainbow trout
- Northern pikeminnow

Other biological groups useful as indicators to presence of stressors were benthic algae sampled in the South Fork Palouse River and Paradise Creek as part of Munn et al. (2002) study for response to environmental gradients in agriculturally dominated landscapes. Pattern of results showed that Blue-green algae dominated the forested sites, composing 85% to 95% of the relative abundance, with the remainder consisting of small percentages of diatoms, green, and red algae. In contrast, diatoms tended to dominate the urban and range sites, with blue-greens far less dominant. The range sites were somewhat unique in that the red alga *Audouinella violacea* composed 35% of the community at the upstream range site, which was fed by shallow groundwater; however, this red alga decreased to only 5% at the downstream range site. Sites in the dryland and irrigated agricultural areas contained various combinations of blue-greens and diatoms, with the relative abundance of either varying substantially from site to site. Both the South Fork Palouse River and Paradise Creek were considered to be in the urban landscape because approximately 95% of instream flows comes from wastewater treatment discharge (Munn et al. 2002). Distinct biological patterns emerged in each of the stream settings: forested sites, dryland/irrigated agricultural areas, and urban landscape. The significance for appearance of each pattern relates to the food source (e.g., surface water quality) and physical habitat used for colonization.

Dr. Fred Rabe et al. (1993) have monitored the benthic macroinvertebrate communities of Paradise Creek since 1991. The data used in the UAA study (IDHW-DEQ 1994) was collected in October 1992 and February, April, June 1993. Samples were collected along the entire length of Paradise Creek and portions of the South Fork of the Palouse River, but only those stations which correspond with the UAA stations are presented below in Table 3-8. Schwartz Creek was used as a reference site.

In most of the samples collected for the UAA study (IDHW-DEQ 1994), Chironomidae (midges) was the dominant insect group in Paradise Creek and are therefore ecologically important because of their high densities and diversity. Total midge abundance in excess of 30% probably indicates depressed habitat/water quality (Wisseman 1993). In contrast, midge populations in samples from Schwartz Creek were well below 30% of the total abundance. Other dominant insects included Odonata, the dragonflies and damselflies. In the October samples, high numbers of damselflies were found at White and Troy and Sixth and Dealcin. Damselflies are extremely tolerant of impaired water conditions and sediment, their ability to climb onto the reed canary grass enables them to partially avoid the water (Rabe et al. 1993). Oligochaeta (aquatic earthworms) had the highest density of the non-insects at the three lower sites. In October, over a thousand individuals per square meter were recorded below the WWTP, this is common below sewage effluent. Other non-insect dominants were Gastropoda (snails) and Hirudinea (leeches).

Results from fish shocking in Paradise Creek UAA study (IDHW-DEQ, 1994) are in Table 3-9.

Fish resources within the Palouse River sub-basin are limited by long standing in-stream, riparian, and up-land habitat conditions, which have contributed to degraded water quality, extreme seasonal fluctuations in water quantity, and subsequent degraded in-stream habitat conditions. The existing fish community in the lower Palouse River (below Palouse Falls) consists of the salmonid species noted previously, as well as native resident species including largescale sucker (*Catostomus macrocheilus*), redside shiner (*Richardsonius balteatus*), northern pikeminnow (*Ptychocheilus oregonensis*), and chiselmouth (*Acrocheilus alutaceus*). Recent fish survey work conducted by WDFW below the Palouse Falls have confirmed the presence of sub-adult bull trout (*Salvelinus confluentus*), rainbow trout / juvenile steelhead, tench (*Tinca tinca*), bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), northern pikeminnow, chiselmouth, redside shiner, and dace spp. (Cook 2001).

**Table 3-8.** Macroinvertebrate results in Paradise Creek.

| | Month | Total abundance | Species richness | EPT-taxa richness | Hilsenhoff Biotic Index | Percent dominant taxa |
|---|---|---|---|---|---|---|
| Mt. View Park | Oct | 213 | 31 | 2 | 7 | 15 |
| | Feb | 219 | 16 | 2 | 4.2 | 41 |
| | Apr | 398 | 31 | 3 | 6.7 | 24 |
| | Jun | 380 | 38 | 4 | 7.4 | 18 |
| White & Troy | Oct | 645 | 28 | 0 | 7.6 | 32 |
| | Feb | 133 | 19 | 1 | 7.9 | 19 |
| | Apr | 131 | 24 | 0 | 7.8 | 27 |
| | Jun | 195 | 26 | 2 | 8.2 | 21 |
| 6th & Deakin | Oct | 847 | 23 | 0 | 8.9 | 35 |
| | Feb | 77 | 14 | 0 | 8 | 41 |
| | Apr | 200 | 23 | 0 | 8.1 | 16 |
| | Jun | 194 | 14 | 0 | 8.4 | 19 |
| Below WWTP | Oct | 1412 | 5 | 0 | 9 | 73 |
| | Feb | 478 | 7 | 0 | 9 | 87 |
| | Apr | 427 | 6 | 0 | 9 | 80 |
| | Jun | 803 | 12 | 0 | 8.7 | 50 |
| Schwartz | Oct | 146 | 36 | 21 | 3.2 | 7 |
| | Feb | -- | 34 | 20 | -- | -- |
| | Apr | -- | 29 | 18 | -- | -- |
| | Jun | 56 | 33 | 18 | 4.5 | -- |

**Table 3-9.** Electrofishing results in Paradise Creek.

| Species | Number | Size | Location |
|---|---|---|---|
| Speckled dace (*Rhinichthys osculus)* | >50 | 1-3" | Mountain View Park[1], White & Troy Hwy., Guy Wicks Field |
| Bridgelip sucker (*Catostomus columbianus)* | 11 | 3-6" | White Avenue & Troy Highway |
| Longnose sucker (*Catostomus catostomus)* | 1 | 6" | White Avenue & Troy Highway |

1 Shocking recovery estimated at 20% due to large amounts of duckweed on water surface.

2

Historic stocks of native species that continue to inhabit the Palouse River above the falls include chiselmouth, northern pikeminnow, largescale sucker (*Catostomus macrocheilus*), redside shiner, speckled dace (*Rhinichthys osculus*), and cottid species. Thirty-seven fish species have been documented within the Palouse River sub-basin. No ESA listed species have been documented as occurring above the Palouse Falls. A synoptic list of fish species for the Palouse River sub-basin is listed in the Table 3-10 below (Cook 2001).

Stream habitat usage by resident salmonids is dictated by the extremely few locations within the Palouse River sub-basin where agriculture, grazing, road building, and logging practices have not significantly altered habitat conditions such that salmonids can survive. There are a small number of tributaries to the Palouse River, which exhibit isolated reaches of relatively intact natural habitats and which contain self-sustaining wild populations of salmonids. There is speculation on distribution and abundance of salmonids in the tributaries to the Palouse River, but there have been no efforts to conduct genetic analysis on these populations. The relationship of these disjunct populations to redband rainbow trout and any hybridization with hatchery-reared fish is currently unknown (Cook 2001). Rainbow trout from several origins have been introduced throughout the Palouse Sub-basin. WDFW has regularly stocked rainbow trout in Chapman Lake, Rock Lake, Williams Lake, Hog Canyon Lake, Fish Trap Lake, Sprague Lake and other smaller water bodies within the sub-basin.

Appearance of salmonids in the Palouse River and South Fork Palouse River drainages can be accounted for by past stocking programs. The first stocking of rainbow trout occurred in 1950 in the Palouse River, Idaho. The size of rainbow trout stocked has been "catchable" (8-12 inches), to provide an immediate return to the creel. There is evidence that natural reproduction is occurring, as they have been recently sampled in streams where stocking never occurred, or is no longer occurring. Re-distribution of rainbow trout from known points of stocking has been opportunistic and, in some cases, has resulted in successful perpetuation of a hatchery fish stock. The stock of rainbow planting has varied over the years depending on egg availability (Cook 2001).

Paradise Creek has reportedly supported several species of trout over the past century. A recent Beneficial Use Attainability Study included a quote that stated brook trout have a current, sustaining population in upper Paradise Creek and tributaries in the Palouse Mountain Range (Wertz 1993). There have also been reports that rainbow trout caught at a fish derby from Reaney Park swimming pool in Pullman could be re-introduced into locations along nearby South Fork Palouse River. Pullman Park and Recreation employees have stated that some children release the trout caught at the fish derby into the nearby river with potential to migrate as far as Paradise Creek. If rainbow trout do migrate as far as Paradise Creek, they likely return to the SFPR seeking habitat characterized by deeper, cooler waters with a higher dissolved oxygen concentration (Doke and Hashmi 1994).

**Table 3-10.** Fish species present in the Palouse Sub-basin, Washington (Cook 2001).

| Species | Origin | Status |
|---|---|---|
| Bull trout (*Salvelinus confluentus*) * | N | U |
| Steelhead trout */ Rainbow trout (*Oncorhynchus mykiss*) | N | O/U |
| Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) | N | O/U |
| Fall Chinook salmon (*Oncorhynchus tshawytscha) ** | N | O/S |
| Mountain whitefish (*Prosopium williamsoni)* | N | O/U |
| Brook trout (*Salvelinus fontinalis)* | N | O/U |
| Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) | E | O/U |
| Brown trout (*Salmo trutta*) | E | O/U |
| Northern pikeminnow (*Ptychocheilus oregonensis)** | N | C/S |
| Speckled dace (*Rhinichthys osculus)** | N | C/U |
| Longnose dace (*Rhinichthys cataractae*)* | N | O/U |
| Redside shiner (*Richardsonius balteatus*)* | N | C/U |
| Chiselmouth (*Acrocheilus alutaceus*)* | N | O/U |
| Peamouth (*Mylocheilus caurinus*) | N | O/U |
| Largescale sucker (*Catostomus macrocheilus*) | N | O/U |
| Longnose sucker (*Catostomus catostomus)* | N | O/U |
| Bridgelip sucker (*Catostomus columbianus*) | N | C/S |
| Mountain sucker (*Catostomus platyrhynchus*) | N | O/U |
| Tench (*Tinca tinca*) | E | O/U |
| Walleye (*Sander vitreus*) | E | O/S |
| Largemouth bass (*Micropterus salmoides*)* | E | O/S |
| Brown bullhead (*Ictalurus nebulosus*)* | E | O/U |
| Yellow bullhead (*Ictalurus natalis*) | E | O/U |
| Smallmouth bass (*Micropterus dolomieu*)* | E | O/S |
| Slimy sculpin (*Cottus cognatus*) | N | O/D |
| Mottled sculpin (*Cottus bairdi*)* | N | O/U |
| Brook stickleback (*Culaea inconstans*) | E | O/I |
| Paiute sculpin (*Cottus beldingii*)* (cottid species identification / location(s) in question) | N | C/U |
| Torrent sculpin (*Cottus rhotheus*) | N | O/U |
| Goldfish (*Carassius auratus*) | E | O/U |
| Yellow perch (*Perca flavescens*)* | E | O/U |
| Carp (*Cyprinus carpio*)* | E | C/U |
| Bluegill (*Lepomis macrochirus*)* | E | O/U |
| Crappie (*Pomoxis spp.*)* | E | O/S |
| Channel catfish (*Ictalurus punctatus*) | E | O/S |
| Grass pickerel (*Esox americanus vermiculatus*) | E | O/U |
| Pumpkinseed (*Lepomis gibbosus*) | E | O/U |

*E=Exotic, N=Native, A=Abundant, C=Common, O=Occasional, U=Unknown, S=Stable, I=Increasing, D=Decreasing, * only denotes presence below Palouse Falls*

## 3.3 Current Instream Biological Characterization

Field data collections were made from September 22 through September 30, 2010. A total of 28 sites were visited, yielding nineteen of the proposed twenty sampling sites (Figure 3-4). Of the sites deemed unsampleable, five were dry reaches, three had undetermined landowners, and one was an active access denial. The twentieth sampling site, located on Dry Fork Creek, was abandoned after reconnaissance found that the primary and oversample sites, as well as all other accessible reaches, were dry. In order to maintain the target of ten benthic samples, the collection designated for the Dry Fork Creek site (SFPR-037195) was transferred to site SFPR-123211 on the South Fork Palouse River.

The following sections detail the results of the sampling effort. In most instances the data are presented by the four main stream systems comprising the South Fork Palouse River drainage; South Fork Palouse River (SFPR), Missouri Flat Creek (MFC), Paradise Creek (PC) and Dry Fork Creek (DFC). Site-specific results are beyond the scope of the current study; however, data summaries are provided for each site in Appendix C.

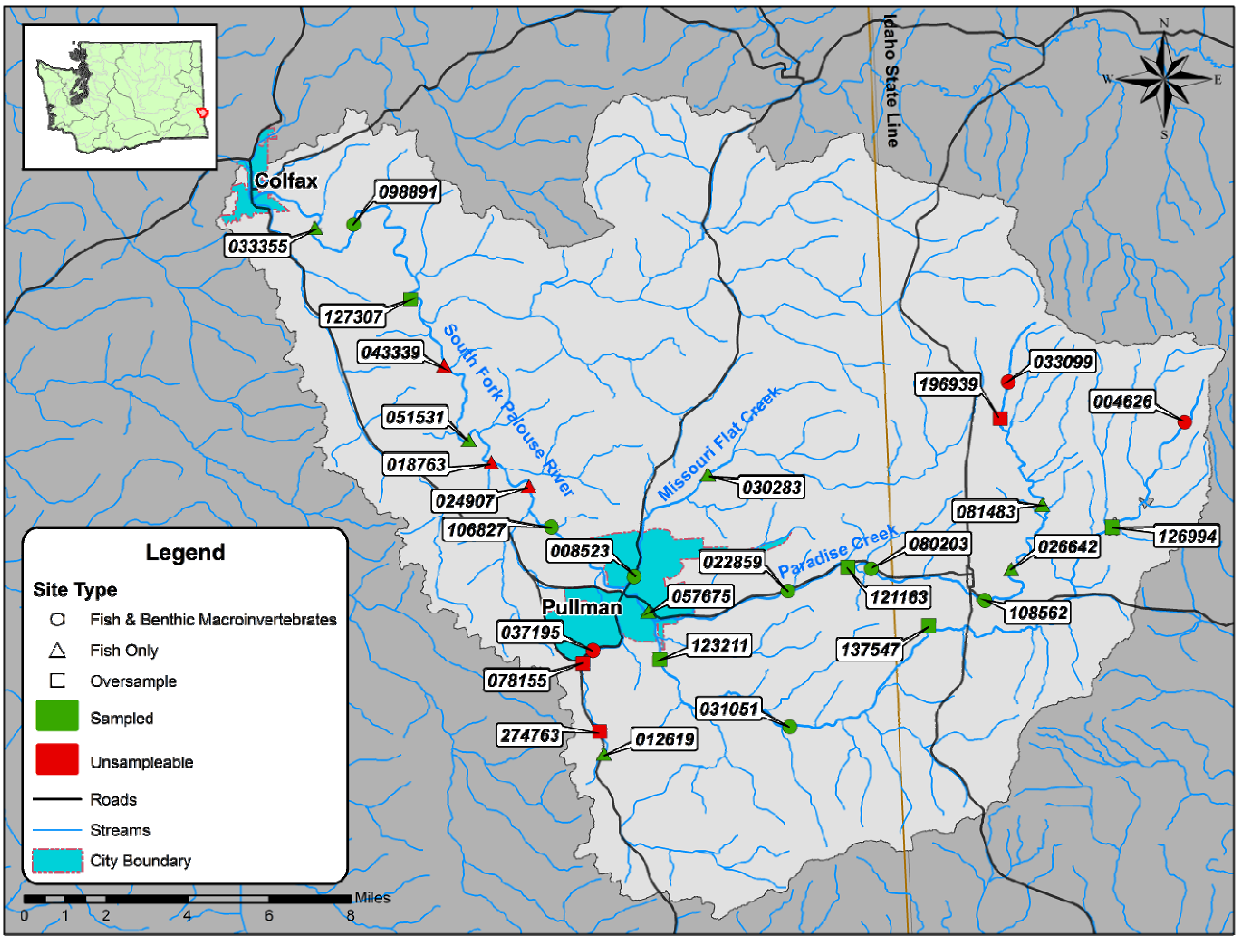


**Figure 3-4.** Map indicating the status of sampling sites in the South Fork Palouse River watershed.

### *3.3.1 Physical habitat*

An RBP habitat assessment was completed at each sampling site. Overall, physical habitat conditions rated higher in the larger streams, with mean sites scores of 100 and 106 in the South Fork Palouse River and Paradise Creek, respectively, compared to Missouri Flat Creek (65) and Dry Fork Creek (40) (max. – 200 points). Most metrics scored in the “fair” and “suboptimal” ranges and indicated the highest degree of degradation in pool variability, channel sinuosity, bank stability, bank vegetative protection and riparian cover (Table 3-11). Channel flow status and channel alteration were among the highest scoring metrics (suboptimal, mean: 13.2 and 12.5 respectively) at all sites.

**Table 3-11.** Rapid Bioassessment Protocol (RBP) Habitat Scores at study sites in the South Fork Palouse River watershed. Data are presented in ascending order, from downstream to upstream.

| | Station Number | Epifaunal Substrate | Pool Substrate | Pool Variability | Sediment Deposition | Channel Flow | Channel Alteration | Channel Sinuosity | Bank Stability L | Bank Stability R | Vegetative Protection L | Vegetative Protection R | Riparian Habitat L | Riparian Habitat R | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SFPR | SPFR-033355 | 16 | 16 | 13 | 18 | 18 | 20 | 9 | 7 | 6 | 1 | 1 | 7 | 9 | 141 |
| SFPR | SPFR-098891 | 11 | 15 | 11 | 7 | 13 | 10 | 6 | 7 | 4 | 1 | 1 | 3 | 2 | 91 |
| SFPR | SPFR-127307 | 14 | 18 | 11 | 12 | 20 | 19 | 9 | 5 | 6 | 1 | 1 | 1 | 8 | 125 |
| SFPR | SPFR-051531 | 13 | 12 | 12 | 13 | 16 | 17 | 8 | 6 | 8 | 2 | 2 | 3 | 3 | 115 |
| SFPR | SPFR-106827 | 18 | 17 | 12 | 8 | 8 | 10 | 6 | 4 | 3 | 2 | 3 | 3 | 4 | 98 |
| SFPR | SPFR-057675 | 12 | 13 | 11 | 8 | 16 | 12 | 7 | 3 | 3 | 2 | 2 | 4 | 3 | 96 |
| SFPR | SPFR-123211 | 13 | 8 | 11 | 11 | 12 | 13 | 9 | 3 | 3 | 1 | 1 | 7 | 4 | 96 |
| SFPR | SPFR-031051 | 13 | 11 | 11 | 19 | 18 | 14 | 10 | 7 | 7 | 1 | 1 | 5 | 5 | 122 |
| SFPR | SPFR-137547 | 7 | 8 | 12 | 7 | 8 | 14 | 11 | 6 | 4 | 3 | 3 | 2 | 2 | 87 |
| SFPR | SPFR-126994 | 16 | 15 | 17 | 17 | 14 | 16 | 14 | 5 | 5 | 1 | 1 | 2 | 2 | 125 |
| MFC | SPFR-008523 | 16 | 12 | 13 | 7 | 13 | 5 | 2 | 3 | 3 | 1 | 1 | 1 | 1 | 78 |
| MFC | SPFR-030283 | 1 | 2 | 2 | 3 | 2 | 13 | 13 | 2 | 2 | 1 | 1 | 4 | 6 | 52 |
| PC | SPFR-022859 | 12 | 13 | 11 | 18 | 18 | 11 | 8 | 7 | 7 | 2 | 2 | 4 | 6 | 119 |
| PC | SPFR-121163 | 6 | 11 | 11 | 18 | 19 | 11 | 9 | 4 | 5 | 2 | 2 | 1 | 6 | 105 |
| PC | SPFR-080203 | 14 | 11 | 13 | 15 | 14 | 14 | 8 | 3 | 4 | 1 | 1 | 5 | 3 | 106 |
| PC | SPFR-108562 | 8 | 11 | 11 | 18 | 15 | 13 | 10 | 7 | 7 | 8 | 8 | 2 | 3 | 121 |
| PC | SPFR-026642 | 9 | 8 | 11 | 18 | 20 | 13 | 6 | 8 | 8 | 9 | 9 | 2 | 2 | 123 |
| PC | SPFR-081483 | 6 | 7 | 4 | 4 | 5 | 12 | 8 | 7 | 7 | 1 | 1 | 1 | 1 | 64 |
| DFC | SPFR-012619 | 2 | 1 | 1 | 13 | 2 | 1 | 0 | 8 | 8 | 1 | 1 | 1 | 1 | 40 |

*Abbreviations of tributaries are as follows: SFPR - South Fork Palouse River (mainstem); MFC - Missouri Flat Creek; PC - Paradise Creek; DFC - Dry Fork Creek.*

Instream habitat features, including epifaunal substrate, pool substrate, pool variability and sediment deposition, were generally lacking in Missouri Flat Creek and Dry Fork Creek. These systems maintain very low water levels and flow was often minimal or, in some cases, absent. South Fork Palouse River and Paradise Creek sites were mainly limited by reduced sinuosity and degraded bank and riparian habitat. Most of the sites in these streams were adjacent to paved roads, railroads, and agricultural fields; thus, many were laterally constrained by these features and maintain minimal riparian habitat.

Substrate characterizations were completed using a modified Wolman pebble count. Fines were the dominant substrate in Missouri Flat Creek, Paradise Creek and Dry Fork Creek (Table 3-12). The South Fork Palouse River was largely comprised of gravel (approximately 45 percent) and fines (23 percent). These results support those of the habitat assessment in showing a lack of instream habitat and, particularly, cover in the form of larger substrate (e.g., cobble and boulder). Particles comprising these size classes were generally lacking, comprising 15 percent or less of available substrate. Exceptions to this are sites in the lower reaches of the South Fork Palouse River (near Colfax), where cobble/boulder associations make up more the 25 percent of the samples.

**Table 3-12.** Substrate characterizations based on modified Wolman pebble counts at study sites in the South Fork Palouse River watershed. Data are presented in ascending order, from downstream to upstream.

| | Site No. | Percent Fines | Percent Sand | Percent Gravel | Percent Cobble | Percent Boulder | Percent Bedrock/Hardpan |
|---|---|---|---|---|---|---|---|
| SFPR | SPFR-033355 | 0 | 9 | 26 | 12 | 53 | 0 |
| | SPFR-098891 | 5 | 0 | 73 | 11 | 5 | 6 |
| | SPFR-127307 | 17 | 0 | 51 | 10 | 11 | 0 |
| | SPFR-051531 | 18 | 0 | 54 | 15 | 2 | 0 |
| | SPFR-106827 | 8 | 0 | 49 | 37 | 6 | 0 |
| | SPFR-057675 | 34 | 0 | 35 | 19 | 11 | 10 |
| | SPFR-123211 | 39 | 0 | 29 | 24 | 8 | 0 |
| | SPFR-031051 | 41 | 1 | 45 | 6 | 3 | 4 |
| | SPFR-137547 | 33 | 13 | 28 | 8 | 4 | 0 |
| | SPFR-126994 | 34 | 7 | 57 | 2 | 0 | 0 |
| MFC | SPFR-008523 | 32 | 0 | 36 | 14 | 18 | 0 |
| | SPFR-030283 | 62 | 3 | 14 | 8 | 3 | 10 |
| PC | SPFR-022859 | 13 | 9 | 51 | 4 | 23 | 0 |
| | SPFR-121163 | 42 | 2 | 35 | 4 | 1 | 16 |
| | SPFR-080203 | 22 | 2 | 32 | 0 | 0 | 44 |
| | SPFR-108562 | 47 | 4 | 43 | 6 | 0 | 0 |
| | SPFR-026642 | 71 | 3 | 4 | 1 | 1 | 20 |
| | SPFR-081483 | 90 | 0 | 0 | 0 | 0 | 10 |
| DFC | SPFR-012619 | 100 | 0 | 0 | 0 | 0 | 0 |

Densiometer readings were taken at the mid-channel and stream bank locations at the downstream, mid-point and upstream portions of the sampling reach. Due to the abundance of reed canary grass, separate measurements were made including its presence. Riparian areas, as mentioned previously, were limited and lacked any significant woody vegetation. As a result, shading was generally low, averaging just 17 percent across all sites and ranging from a low of 0 percent at several locations to approximately 68 percent at Paradise Creek (Table 3-13). Estimates including reed canary grass averaged approximately 36 percent, including 100 percent shading at a single site on the South Fork Palouse River. Shading was typically reduced in the lower portions of the South Fork Palouse River and Paradise Creek watersheds, where greater mean wetted width decreased the proportion of stream exposed to shading. This observation is more pronounced in the estimates that include reed canary grass.

**Table 3-13**. Percent shading estimates with and without reed canary grass (RCG) at study sites in the South Fork Palouse watershed. Data are presented in ascending order, from downstream to upstream.

| | Station Number | Percent Shading Without RCG | Percent Shading With RCG |
|---|---|---|---|
| SFPR | SPFR-033355 | 0.0 | 0.00 |
| | SPFR-098891 | 1.6 | 5.6 |
| | SPFR-127307 | 9.8 | 13.01 |
| | SPFR-051531 | 5.9 | 34.0 |
| | SPFR-106827 | 4.6 | 9.2 |
| | SPFR-057675 | 55.9 | 72.6 |
| | SPFR-123211 | 11.1 | 46.1 |
| | SPFR-031051 | 11.1 | 19.9 |
| | SPFR-137547 | 49.4 | 49.4 |
| | SPFR-126994 | 0.0 | 100.0 |
| MFC | SPFR-008523 | 14.4 | 26.1 |
| | SPFR-030283 | 7.8 | 74.5 |
| PC | SPFR-022859 | 11.8 | 28.8 |
| | SPFR-121163 | 4.3 | 18.3 |
| | SPFR-080203 | 67.7 | 82.7 |
| | SPFR-108562 | 43.8 | 43.8 |
| | SPFR-026642 | 24.8 | 39.2 |
| | SPFR-081483 | 0.0 | 25.5 |
| DFC | SPFR-012619 | 0.0 | 0.0 |

* *Indicates differences in values rather than percent increase.*

### 3.3.2 Water quality

Water quality parameters are presented as Table 3-14. Three of the four streams, South Fork Palouse River, Missouri Flat Creek and Paradise Creek, show similar values of pH and conductivity. However, mean temperatures are 3°C to 4°C higher in the South Fork Palouse River and Paradise Creek, likely due to the high proportion of effluent discharging from wastewater treatment plants on those systems. More significantly, low dissolved oxygen levels

**Table 3-14.** Water quality data collected at the start and end of biological sampling at each site in the South Fork Palouse River watershed. Data are presented in ascending order, from downstream to upstream.

| | Station Number | Date | Time (approximate) | Temperature (°C) | pH | DO (mg/l) | Conductivity (µs/cm) |
|---|---|---|---|---|---|---|---|
| SFPR | SPFR-033355* | 09/22/2010 | 9:20 | 12.67 | 8.05 | 9.98 | 560.8 |
| | SPFR-098891 | 09/28/2010 | 8:55 | 15.33 | 7.97 | 8.5 | 563.9 |
| | SPFR-098891 | 09/28/2010 | 11:30 | 16.7 | 8.21 | 11.76 | 556.4 |
| | SPFR-127307 | 09/28/2010 | 14:00 | 17.72 | 7.74 | 11.22 | 611.5 |
| | SPFR-127307 | 09/28/2010 | 15:45 | 18.24 | 8.03 | 12.22 | 603.8 |
| | SPFR-051531 | 09/29/2010 | 8:30 | 15.5 | 7.64 | 6.27 | 643.2 |
| | SPFR-051531 | 09/29/2010 | 10:55 | 16.32 | 7.76 | 8.18 | 647.4 |
| | SPFR-106827 | 09/29/2010 | 12:40 | 18.42 | 8.05 | 12.78 | 677.6 |
| | SPFR-106827 | 09/29/2010 | 16:05 | 19.44 | 8.39 | 14.5 | 666.5 |
| | SPFR-057675 | 09/30/2010 | 7:50 | 12.57 | 7.76 | 7.93 | 669 |
| | SPFR-057675 | 09/30/2010 | 10:10 | 12.83 | 7.85 | 8.74 | 687.9 |
| | SPFR-123211 | 09/30/2010 | 11:20 | 13.25 | 7.6 | 7.79 | 371.5 |
| | SPFR-123211 | 09/30/2010 | 14:05 | 15.9 | 7.75 | 10.38 | 366.2 |
| | SPFR-031051 | 09/25/2010 | 10:05 | 11.62 | 7 | 6.49 | 308.6 |
| | SPFR-031051 | 09/25/2010 | 12:30 | 13.41 | 6.96 | 6.48 | 292.3 |
| | SPFR-137547 | 09/25/2010 | 15:30 | 14.63 | 6.72 | 8.05 | 323.5 |
| | SPFR-137547 | 09/25/2010 | 17:45 | 13.43 | 6.75 | 7.17 | 323.8 |
| | SPFR-126994 | 09/26/2010 | 15:45 | 11.56 | 6.23 | 8.73 | 71.6 |
| | SPFR-126994 | 09/26/2010 | 18:15 | 11.57 | 6.36 | 8.15 | 72.2 |
| MFC | SPFR-008523 | 09/26/2010 | 11:55 | 13.3 | 7.32 | 6.93 | 464.3 |
| | SPFR-008523 | 09/26/2010 | 14:20 | 14.08 | 7.34 | 7.57 | 490.4 |
| | SPFR-030283 | 09/26/2010 | 9:15 | 9.1 | 7.08 | 2.55 | 399 |
| | SPFR-030283 | 09/26/2010 | 10:45 | 8.43 | 7.18 | 2.02 | 381.1 |
| PC | SPFR-022859 | 09/24/2010 | 8:00 | 13.82 | 7.26 | 7.1 | 431.2 |
| | SPFR-022859 | 09/24/2010 | 11:45 | 14.24 | 7.11 | 8.12 | 370 |
| | SPFR-121163 | 09/24/2010 | 12:55 | 14.31 | 7.07 | 8.33 | 405.9 |
| | SPFR-121163 | 09/24/2010 | 15:30 | 15.36 | 7.07 | 8.36 | 501 |
| | SPFR-080203 | 09/27/2010 | 12:50 | 18.04 | 7.35 | 7.61 | 718.8 |
| | SPFR-080203 | 09/27/2010 | 16:50 | 18.76 | 7.28 | 7.02 | 742.7 |
| | SPFR-108562* | 09/23/2010 | 8:55 | 11.62 | 6.97 | 1.65 | 401.7 |
| | SPFR-026642* | 09/23/2010 | 14:15 | 12.68 | 6.91 | 5.61 | 231.3 |
| | SPFR-081483 | 09/27/2010 | 9:00 | 14.55 | 6.77 | 0.67 | 294.2 |
| | SPFR-081483 | 09/27/2010 | 9:45 | 14.93 | 6.73 | 0.91 | 303.3 |
| DFC | SPFR-012619 | 09/25/2010 | 8:20 | 10.57 | 6.62 | 5.88 | 256.8 |
| | SPFR-012619 | 09/25/2010 | 8:50 | 10.7 | 6.71 | 5.78 | 250.9 |

* Only one measure of water quality recorded (collected at the start of biological sampling)

were evident in Missouri Flat Creek, Paradise Creek, and Dry Fork Creek, ranging from 4.8 to 5.8 mg/L. The sites on Missouri Flat Creek and Dry Fork Creek were largely comprised of pools interspersed within dry sections that made up approximately 30 percent to 40 percent of the reach. The low dissolved oxygen values, coupled with colder water temperature and low conductivity suggest that these reaches may be spring fed. Though not below the 4.0 mg/L standard generally applied to aquatic life uses, these sites may fall below that criterion seasonally.

### *3.3.3 Biological conditions*

Nearly 5,100 fish representing nine species were collected during fish community sampling, 4,200 of which were from the South Fork Palouse River (mean: 384 fish/site) (Table 3-15). Diversity was low but typical of the region, with nine species collected in the South Fork Palouse River and five species collected in both Missouri Flat Creek and Paradise Creek. No fish were collected at the site on Dry Fork Creek. Species unique to the South Fork Palouse River include chiselmouth (*Acrocheilus alutaceus*), fathead minnow (*Pimephales promelas*), pumpkinseed (*Lepomis gibbosus*) and rainbow trout (*Oncorhynchus mykiss*). All the species captured are considered tolerant or intermediately tolerant of non-specific stressors; no intolerant species were encountered.

Throughout the study area, speckled dace (*Rhinichthys osculus*) were the most abundant species; however, redside shiner (*Richardsonius balteatus*) were numerically dominant in the South Fork Palouse River. Mean catch per unit effort (CPUE), expressed as the number fish captured per 1000 seconds of electrofishing per site, yielded similar results with the highest values for speckled dace and redside shiner. However, chiselmouth and bridgelip sucker (*Catostomus columbianus*) showed good recruitment to the gear with values of 20 and 17 fish per 1000 seconds of effort, respectively.

Minimum and maximum lengths (total length (mm)) were recorded for each species. Specimens collected in the South Fork Palouse River were generally larger than their cohorts collected in the other streams (Table 3-15). Similarly, mean aggregate biomass measures were more than four times higher (3,587 g/site) than those in Missouri Flat Creek (414 g/site) and Paradise Creek (820 g/site).

Benthic macroinvertebrate samples were collected from ten sites; five in the South Fork Palouse River, one in Missouri Flat Creek and four in Paradise Creek. No samples were collected in Dry Fork Creek. Metrics describing taxa richness, relative abundance and community structure are provided as Appendix D and are summarized below.

With exception to two sites (SFPR-022859 and SFPR-080203) in Paradise Creek, taxa richness was greater than 29 per site. Taxa of the order Diptera were dominant in five of six samples from the South Fork Palouse River; Ephemeroptera taxa were most abundant in the remaining samples. In Paradise Creek, Diptera and Oligochaeta taxa comprised 53 percent of the samples at sites SFPR-108562 and SFPR-080203, respectively. Coleoptera were the dominant taxa at sites SFPR-022859 and SFPR-121163 (80 percent and 51 percent, respectively). Oligochaeta taxa comprised 54 percent of the sample at Missouri Flat Creek.

The presence of EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa are generally an indicator of good water quality conditions. These organisms are largely absent from the samples, except from a single site on the South Fork Palouse River (SFPR-098891) and Paradise Creek (SFPR-121163) where they comprise 34 percent and 19 percent of the samples, respectively. Conversely, tolerant taxa are in high relative abundance, ranging from 12 – 31 percent in the South Fork Palouse, 21 – 41 percent in Paradise Creek, and 24 percent in Missouri Flat Creek. Hilsenhoff Biotic Index scores provide further confirmation of degraded conditions and are presented in Table 3-16. Only two sites received a “good” rating, the remainder range from “fair” to “very poor”.

**Table 3-15.** Fish community data at study sites in the South Fork Palouse watershed, 2010.

| | Species | Number | Relative Abundance (%) | Min. Length (mm) | Max. Length (mm) | CPUE Fish/1000 sec |
|---|---|---|---|---|---|---|
| SFPR | Bridgelip Sucker | 334 | 7.9 | 98 | 170 | 17.3 |
| | Chiselmouth | 304 | 7.2 | 111 | 155 | 19.8 |
| | Fathead Minnow | 3 | 0.1 | 77 | 77 | 1.1 |
| | Largescale Sucker | 258 | 6.1 | 121 | 176 | 11.4 |
| | Northern Pikeminnow | 263 | 6.2 | 94 | 211 | 11.0 |
| | Pumpkinseed | 1 | 0.0 | 92 | | 0.4 |
| | Rainbow Trout | 4 | 0.1 | 83 | 182 | 2.7 |
| | Redside Shiner | 1572 | 37.2 | 55 | 126 | 64.8 |
| | Speckled Dace | 1490 | 35.2 | 51 | 81 | 53.5 |
| | **Total/number per site** | **4229/384.5** | | | | |
| MFC | Bridgelip Sucker | 1 | 1.1 | 74 | | 0.8 |
| | Largescale Sucker | 2 | 2.1 | 132 | 173 | 1.5 |
| | Northern Pikeminnow | 31 | 33.0 | 91 | 216 | 23.6 |
| | Redside Shiner | 21 | 22.3 | 58 | 96 | 16.0 |
| | Speckled Dace | 39 | 41.5 | 39 | 81 | 16.1 |
| | **Total/number per site** | **94/47.0** | | | | |
| PC | Bridgelip Sucker | 121 | 16.1 | 79 | 146 | 17.0 |
| | Largescale Sucker | 24 | 3.2 | 99 | 165 | 4.5 |
| | Northern Pikeminnow | 6 | 0.8 | 155 | 215 | 1.5 |
| | Redside Shiner | 201 | 26.7 | 61 | 113 | 31.5 |
| | Speckled Dace | 400 | 53.2 | 45 | 75 | 50.0 |
| | **Total/number per site** | **752/125.3** | | | | |
| DFC | No fish | | | | | |

**Table 3-16.** Hilsenhoff Biotic Index scores and narrative values at study sites in the South Fork Palouse watershed, 2010.

| | Site No. | Score | Narrative Rating |
|---|---|---|---|
| SFPR | SPFR-098891 | 5.23 | Good |
| | SPFR-106827 | 6.65 | Fairly Poor |
| | SPFR-057675 | 6.28 | Fair |
| | SPFR-123211 | 7.15 | Fairly Poor |
| | SPFR-031051 | 6.81 | Fairly Poor |
| MFC | SPFR-008523 | 7.3 | Fairly Poor |
| PC | SPFR-022859 | 4.96 | Good |
| | SPFR-121163 | 5.63 | Fair |
| | SPFR-080203 | 7.48 | Fairly Poor |
| | SPFR-108562 | 8.87 | Very Poor |

# 4.0 DISCUSSION

## 4.1 Comparisons of Historic and Current Conditions

Obvious barriers to migration of fish species that may have been the primary influence in establishing distinct biological communities are: Palouse Falls (current and past locations), and changes to stream flow patterns following settlement of the region. In-stream habitat may have been limiting (as modified by stream flow patterns) in some locations to successful completion of life stages for species of fish. Salmonid fish species are thought to be limited to that portion of the Palouse drainage below Palouse Falls and not resident in the upper Palouse River drainage.

A statement made by a long-time resident and recorded by Doke and Hashmi (1994) indicates that cutthroat trout (likely an isolated population of Yellowstone cutthroat trout) may have been resident in the upper portion of the South Fork Palouse River drainage (Paradise Creek) prior to European settlement The presence of this species may indicate that the greater portion of this tributary may have provided suitable physical habitat and water quality conditions for perpetuating a cutthroat trout population prior to the development of a thriving agricultural industry. Loss of elevation head in the groundwater table may have diminished aquatic habitat area and limited once useable stream reaches in Paradise Creek.

There are no additional reports from historic literature that indicate presence of other salmonid species. The physical barrier presented by Palouse Falls had limited the potential for salmonid distribution into the watershed and a shift to resident forms. Some of the oldest records of fish species in the area were noted by Lupher (1936) and Scheid (1937) when a cyprinid fossilized skeleton was found in the Latah formation along the lower end of the Clearwater, Idaho river drainage. This fossilized skeleton was most closely related to an Asian cyprinid and may indicate that abundance of cyprinids currently found in the surrounding drainages (e.g., South Fork Palouse River) is endemic.

The few observations of rainbow trout in the South Fork Palouse River are likely the result of State or private stocking efforts. Any occurrences outside the initial stocking locations (e.g., Paradise Creek) can be attributed to fish movements related to seeking preferred temperature and dissolved oxygen conditions. Current evidence suggests that the greatest movement of this introduced species is between Paradise Creek, in the vicinity Reaney Park, and the South Fork Palouse River just above Pullman. It is unknown if these fish persist through warm summer conditions and, if so, whether they are naturally reproducing.

Comparison of fish species collected in 2010 with those reported as endemic from the Palouse River drainage (Cook 2001) indicates that at least one-third have been introduced into the South Fork Palouse mainstem (comparison of results between Table 3-10 and Table 3-15). All species collected in 2010 from Missouri Flat Creek and Paradise Creek were considered native to this drainage. Dry Fork Creek could not be sampled as the stream channel was de-watered at the end of the summer index period and the randomized site selection sample design required the site be retained and characterized in current condition. Historic literature confirms that many of the original species endemic to this drainage still exist and that it is possible that those not observed in this study (from the Cook 2001 comprehensive fish species list) may have been displaced by exotic (introduced) species.

Benthic macroinvertebrate (BMI) communities are used as both indicators of general stream condition as well as for consideration as a food base for other aquatic life. One of the indicators for describing condition of the BMI community is the Hilsenhoff Biotic Index that reflects intensity and effect of nutrient enrichment at a stream site. The best BMI community conditions were at the lowest sampling site in the South Fork Palouse River with the most impaired condition measured below the Pullman WWTP (Site SPFR-106827). The BMI indicator used to determine biological condition was the Hilsenhoff Index; known to evaluate eutrophic impacts by favoring less sensitive species. The presence of dense algal growth on larger substrate materials below the WWTP was an indication of eutrophication with a reduction in hard-bottomed substrate living surface that supported the higher quality BMI community ate the lowest sampling site. The dense algal community below the WWTP increased dissolved oxygen concentrations by a measureable amount (Table 3-14) during peak photosynthetic activity during the day and may have prohibited colonization by the pollution-intolerant BMI species. The BMI community at the next site on South Fork Palouse River and above the WWTP was in better condition (Table 3-16; Fair). Differences in habitable substrates by sensitive BMI species influence the type and condition of a community. Nutrient enrichment in the South Fork Palouse River has as great an effect on the benthic macroinvertebrate community as de-watering of the stream channel; both result in inhabitation of pollution-tolerant species, with BMI community abundance directly related to fluctuation in flows.

Paradise Creek BMI communities responded differently below the Moscow WWTP (Site SFPR-022859) outfall where substrates that dominated were moderately-sized and water temperature among the lowest observations made during the recent 2010 study. Similar results were obtained in the 2010 BMI assessment as were reported by Rabe et al. 1993. The benthic macroinvertebrate community condition improves as the distance from the Moscow WWTP increases. Based on this confirmation it appears that a comparison between biological conditions from the 1975-current and data collected during summer 2010, factors affecting the biological community have not changed.

## 4.2 Limiting Factors

A number of physical and chemical factors have been investigated in the South Fork Palouse River drainage and tributaries for effects on aquatic life. Concerns with water quality during the latter part of the 1975-current time period examined in this study have been focused on ammonia, dissolved oxygen, pH, and temperature conditions (Pelletier 1993; Carroll and Mathieu 2006; Bilhimer, Carroll, and Sinclair 2006). These parameters have been characterized primarily during the most stressful time of year (mid-summer) and present widespread challenges to fish migration in some populations. Particularly common in streams within this region, are temperature and dissolved oxygen barriers that can isolate populations of sensitive fish species and prohibit migration through reaches of the drainage where these barriers establish during the summer season.

Augmentation of flow in stream channels benefits conditions by improving availability of water and mediating temperatures for aquatic life. Increases to stream channel flow in Paradise Creek and below the Wastewater Treatment Plant (WWTP) in Pullman result in increases in food base (e.g., algae) and in useable habitat (Munn et al. 2002). Benthic macroinvertebrate (BMI) data showed declining community abundances at sites further downstream from the Pullman WWTP and an increase in number of pollution-sensitive species. The species list generated from below the WWTP are known to be tolerant of low dissolved oxygen concentrations and so the early morning dissolved oxygen concentrations that dip below 2 mg/L had no effect, but did support a greater number of filter-feeding BMI.

Conditions in the stream today are first explained by a step-wise progression of impacts beginning with the type of historic development of the region. Agricultural activity (e.g., beginning with fruit growing and then transitioning to cultivated wheat crops) initially required irrigation and as the human population of the area grew, groundwater became an important source for drinking water. The loss of flow in streams had first begun when water withdrawal was focused on crop irrigation and then continued when demand for growing settlements increased. An additional consideration is that growing settlements (now cities) have introduced new groups of stressors to stream channels in the South Fork Palouse River drainage. Various types of pollutants related to urban activity and commercial agriculture operations are associated with toxics like some of the more common metals (lead, zinc, cadmium, chromium, copper, mercury, arsenic, et al. in trace quantities) as well as pesticides associated with urban/sub-urban development and agricultural crops.

It was inevitable that alteration of the groundwater table in various quantities throughout this drainage would limit surface water flow in select portions of this drainage. Those stream segments incised into bedrock channels are perennial streams whereas those incised into loess are associated with intermittent flow during portions of the year Russell (1897). Localized de-watering of the groundwater table results in either drying of a channel segment or very low stream flow, depending on composition of the stream bottom.

## 4.3 Conclusions

There has been an overall loss of native fish species in all portions of this drainage. Currently, the South Fork Palouse River drainage from the confluence of the Palouse River and to the Idaho border is designated spawning/rearing habitat (Ecology 2006). This designated use is a goal for maintaining successful re-generation of salmonid populations where emergence occurs outside the summer season (September 16 through June 14). Current fisheries conditions in the South Fork Palouse drainage are dominated primarily by warmwater species. The few salmonids identified from the summer 2010 surveys indicate that available habitat favors the warmwater species. Cook (2001) notes that prior to European settlement in the region, a diverse assemblage of fish species existed above Palouse Falls and were dominated by cyprinids and catastomids. This observation suggests that salmonids have only made opportunistic appearances above the natural barrier (Palouse Falls) through large-scale catastrophic events. Designated aquatic life uses now in effect will encourage survival of re-stocked salmonids, but efforts may not be synchronized with the appearance and subsequent disappearance of salmonid fisheries introduced through natural catastrophic events prior to European settlement. Protection of existing salmonid refugia has limited opportunities caused by large-scale changes in the landscape promoting disjunct aquatic habitat corridors and that limit ability for migration. Disappearance of several warmwater species reported in Cook (2001) indicate that changes to habitat and water quality conditions in the South Fork Palouse River drainage may have an effect on endemic warmwater species. These changes are evident in other biological communities like the BMI that show a strong response to increased nutrients, for example, from obvious sources like multiple wastewater treatment plants.

Three factors that have changed since European settlement are flow availability, augmentation of flow, and changes in flow pattern. Flow availability in any segment of stream channels of this drainage is the primary driver for water quality issues. During settlement of this region groundwater withdrawals may have decreased the perennial flows in the streams. However, augmentation of the flows through discharges from the WWTPs may have returned the in-stream flow to levels comparable to historic conditions.

These factors affect the location and timing of aquatic habitat and refugia, water quality, erosion processes and rates, and species community makeup and distributions. The changes in water quality conditions are primarily a result of nutrient introduction and the corresponding biological response, and changes to stream channel properties.

The historical information located for use in this study indicated that the South Fork Palouse River drainage is typical of semi-arid streams in the Northwestern portion of the United States. This stream type experiences a wide range of temperature conditions that are dependent on seasonal climatic effects. Changes to flow patterns affect water temperature and these flow and temperature patterns are important to native species. As seasonal water temperature patterns change in portions of the drainage, the range for native species begins to shrink. This change in range is based on the need for specific optimum physicochemical requirements and the environmental tolerance of the life cycle stage for each species.

Currently the growth of human activities, in both urban and rural areas, has compounded challenges to the biological communities. The most stressed biological conditions in the South Fork Palouse River mainstem and tributaries like Paradise Creek are located in the urban stream settings. Historically, biological alterations would have been directly related to effects from low flow conditions during the summer months.

There are existing refugia in the drainage that can be protected and characteristics used to guide restoration of similar channel segments. The expansion of contiguous stream segments with suitable habitat and flow patterns would present the best opportunity for preservation of the current number of native species identified throughout the drainage.

The disturbance history of a stream prevents restoration to an original condition, but comparison with the original condition can be used as a guide for making decisions on the type of management practice that should be implemented and the order in which each should be implemented.

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# APPENDIX A. PROFESSIONAL CONTACT LIST

| Professional Contact | Response |
|---|---|
| 1. Allan T. Scholz (Eastern Washington University) Fisheries Professor (509-359-6397) ascholz@ewu.edu | No response following repeated effort to contact. |
| 2. Bruce Z. Lang (Eastern Washington University) Professor Emeritus (509-828-3204) blang@aimcomm.com | No response following effort to contact. |
| 3. Mark Grandstaff (WDFW; Regional habitat Biologist) (509-527-4141) Mark.Grandstaff@dfw.wa.gov | Left a voicemail message October 19th, 2010 and requested available knowledge and sources of information for the SF Palouse R (and nearby aquatic resource areas) fisheries, aquatic habitat, and water quality. |
| 4. Angelo Vitelli (Fisheries Program Manager-Coeur d'Alene Tribe) 208-686-6307 (CDA Tribe does not have any information pertaining to the SF Palouse or surrounding drainages) | Spoke with Mr. Vitelli on October 19th, 2010 regarding work completed in and around the SF Palouse R drainage. The Coeur d'Alene Tribe has not conducted any work in this drainage and suggested Tt tries with the Nez Perce Tribe. |
| 5. Jay Hesse (Director of Biological Services-Nez Perce Tribe) 208-843-7145 Ext. 1 jayh@nexperce.org<br><br>**Prepared by:**<br>Ken Clark<br>Water Quality Analyst<br>Idaho Association of Soil Conservation Districts<br>Moscow, Idaho 83843<br>September 2003<br>Technical Results Summary KPC-PR-02<br>**Tributaries of the Palouse River Monitoring Report 2002**<br><br>A Water Quality Sampling Project for the 303 (d) listed Tributaries of the Palouse River | Left a message October 19th, 2010 and requested available knowledge and sources of information for the SF Palouse R (and nearby aquatic resource areas) fisheries, aquatic habitat, and water quality.<br>Returned call on Thursday October 21st, 2010 and advised that one report was generated that assessed water quality and habitat characteristics at select locations in the South Fork Palouse River drainage. The following was the note Ken Clark of the Nez Perce Tribe provided Mr. Hesse:<br><br>I conducted a water quality monitoring project on the SF Palouse river back in 2002. I'll attach the report for you. In a nutshell, there was a tremendous problem with excessive nutrients in the South Fork, as well as habitat alteration, due to channelization of the stream. Episodic spikes in sediment loads were seen during spring runoff and heavy precipitation events, as one would expect in a sand/silt dominated system like the SF Palouse.<br>"The beneficial uses for the SF Palouse River are: Cold Water Aquatic Life, Salmonid Spawning and Secondary Contact Recreation. So, water temperatures are never to exceed 22 °C as a daily maximum, or 19 °C as a daily |

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| | average, according to the CWAL designation. Brook trout were the salmonid species identified in the South Fork by the IDEQ, and the more restrictive salmonid spawning criteria of 9°C as a daily average and 13°C as a daily maximum apply from September 15th to July 1st. I know IDEQ has done some BURP surveys in that stream, and they would have shocked fish as part of their surveys. Cindy Barrett, in Lewiston, would be a good person to contact for that data. I'm not really sure how your stream designations are organized, but if there is a cool water vs. cold water designation debate going on, I would probably lean towards the cold water designation." |

# APPENDIX B. TECHNICAL MEMORANDUM: APPROACH AND FINDINGS OF THE LITERATURE REVIEW

# TECHNICAL MEMORANDUM:
# APPROACH AND FINDINGS OF THE LITERATURE REVIEW

## INTRODUCTION

### a. Project setting

The Palouse region in Washington State occupies a large portion of the southeastern landscape. This region is characterized by asymmetric, steep and rolling hills with a deep tawny silt layer with underlying basalt and weathered basalt. Initial and extensive investigation of the unique topography and soil (Loess) origin of this region dates back to Russell (1897). Further investigation by Ring (1968) compiled past research and proposed origins of the loess soil that comprises the "Palouse Hills" as well as a drainage basin analysis.

Drainage patterns (mainstem and tributaries of the Palouse River) are influenced by convergence of several characteristics:

- Topography
- Soils
- Underlying geology
- Climate patterns, and
- Groundwater-Surface water interaction.

The drainage pattern and hydrologic characteristics of stream surface flow are discussed in detail by Russell (1987) with several key points important for determining expectations for water quantity. The occurrence of perennial flow and intermittent flowing streams are explained by factors consistently associated with stream flow type. Those streams incised into bedrock channels are perennial streams whereas those incised into loess are associated with intermittent flow during portions of the year. Records indicate that surface flow had decreased in the Palouse River (at Hooper) by approximately 25 percent when comparing observations from 1898 and 1954 during the same high flow months (USGS 1921; USGS 1962). Either climatic patterns have changed in the 40 year time period and/or water consumption had changed that accounts for some of the stream channel dewatering.

Development of the area by European settlers began after 1870 and consisted of a growing agricultural economy based primarily in fruit crops. The fruit crops were rapidly replaced over the next 20 years and dominated by wheat crops, yielding higher monetary returns than the first agricultural crops that were planted in the region. The native bunchgrasses were cleared rapidly and replaced by cultivated, non-native wheat crops that occupied at least half of Whitman County by 1990. The native bunchgrass prairie existed as isolated tracts by 1990 in areas less favorable for farming throughout the Palouse region (Black *et al.* 2002). Less than 1% of all farming is currently irrigated as soil conditions and timing of precipitation promotes dryland farming (USGS 1975).

**b. Regulatory issues and water quality studies**

Recent TMDL (Total Maximum Daily Load) water quality studies addressed bacteriological impairments throughout the South Fork Palouse River drainage (Ecology 2009). These impairments may originate from a variety of sources that indirectly and directly influence characteristics of the stream channel and riparian area. These influences include: livestock grazing, wildlife (especially ubiquitous populations), land use practice changes, and Wastewater Treatment Plants (e.g., Moscow, Pullman, and Albion). Although bacteriological contamination may not directly affect sensitive fish species, the occurrence of high concentration of this indicator reveals land use activities that alter stream channel characteristics and refugia important for survival of aquatic life.

Other water quality impairments identified in segments of the South Fork Palouse River are: ammonia (Pelletier 1993), dissolved oxygen and pH (Carroll and Mathieu 2006), and temperature (Bilhimer, Carroll, and Sinclair 2006). Each of these water quality parameters that have exceeded water quality criteria in segments of this drainage directly affect life stages of sensitive fish species, particularly salmonids and char. The basis for the water quality criteria considered water quality requirements for salmonid and char species and requirements for survival of life stages in developing current criteria for these parameters (Ecology 2006). Water quality requirements for fish species were considered the most rigorous and, therefore, protective of all forms of aquatic life that are considered under WAC 173-201A (Water Quality Standards for the State of Washington).

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Earlier water quality studies informed on the type of pollutants and severity of contamination at locations throughout the Palouse River watershed (Clark 2003). Among the water quality parameters previously mentioned as primary pollutants, sediments, phosphorus, and bacteriological contamination were the most prevalent. The longevity of human activity (beginning in the late 1800's) in the basin has altered landscape vegetation characteristics that have compounded pollution problems through de-stabilization of soil integrity, introduction of large quantities of nutrients into soils, that eventually erode to nearby stream channels (Figure 1). The effects on stream water quality are observed in several reports where eutrophication of aquatic ecosystems has affected dissolved oxygen concentrations and then pH conditions (Figure 2). There is some question, however, about the role riparian vegetation may have played historically and if the greater contribution to temperature mediation in streams of this basin during the warm months may have been migration of groundwater to streams and surface water exchange to groundwater in select reaches. The 1998 §303 (d) list for Idaho focuses on impacts related to flow alteration, habitat alteration, nutrients, sediment, and temperature. State of Idaho listings of reasons for water quality impairment are observed in the State of Washington portion of the drainage.

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r (Site SFPR-

The landscape in the South Fork Palouse drainage was dominated by fescue/bunchgrass circa 1900 (Quigley and Arbelbide 1997) and has since been replaced by cropland, hay, and pasture with some forbs/annual grass mix. These changes from an uncultivated landscape to a setting that is now heavily cultivated has raised concerns about cumulative impact to sensitive surface water resources.

Groundwater contribution to surface water streams is particularly significant during low flow portions of the year. The development of population centers like Pullman, WA has depleted groundwater levels and has permanently affected the presence of artesian wells that were well-known in the area. Groundwater recharge does not occur rapidly enough through surface water streams, lakes, or precipitation in order to replace as rapidly as withdrawal from select areas (USGS 1975). Nearly every town and farmstead uses springs or wells as a source for drinking water and limited irrigation. The location, timing during the year, and volume of groundwater used influences the surface water available in parts of the South Fork Palouse River drainage.

### c. Purpose for the Literature Review

Currently, results from TMDL modeling demonstrate degraded water quality conditions in the South Fork Palouse River drainage with sources related to riparian and instream habitat degradation as well as heavily used groundwater resources. Water Quality criteria for the State of Washington (WAC 173-201A) declares the South Fork Palouse River and tributaries a salmonid spawning and rearing aquatic resource. This designation establishes a 7 day average daily maximum of 17.5 $^{o}$C. A thorough literature review had been conducted in order to determine if present expectations (as defined in WAC 173-201A) are achievable based on historic information describing biological communities, changes to physical habitat, and available information describing water quality conditions. The biological descriptions may provide the greatest evidence for historic conditions derived from autecological characteristics of biological communities and tolerance to environmental gradients.

### d. Objectives of the effort

The objectives of this project focus on generating answers to the following questions:

**Question 1:** What were the historic aquatic-life uses in the waterbody:

- What fish, amphibian, and invertebrate species were historically resident in the watershed?
- What other notable historic biological information is available pertaining to aquatic life in the waterbody?

**Question 2:** What are the current aquatic-life uses in the waterbody:

- What fish, amphibian, and invertebrate species currently reside in the watershed?
- When are the fish, amphibian, and invertebrate species present?
- Do the fish have migration patterns and do they utilize thermal (or other) refugia in the watershed? Where are these refugia located and when are they utilized?

**Question 3:** What are aquatic life uses that would most likely occur within a range of estimated natural conditions in the waterbody (Ecology will provide a description for the range of estimated natural conditions, both currently and historically):

- What aquatic habitats could have occurred within the range of estimated natural conditions?
- What is a reasonable estimation of the biota assemblage that could be found in this system if the water quality and habitat were improved to within the range of estimated natural conditions?
- What are the effects of non-native riparian vegetation on the current aquatic community (i.e. reed canary grass compared to native riparian vegetation)?

Summarization of information gathered from existing knowledge and by generating data describing current conditions attempted to describe environmental conditions during 3 important periods related to the above questions and are as follows:

- Pre-European conditions (Question 1; habitat and biotic conditions prior to arrival of original settlers).
- Current conditions (Question 2; field data from this study and more recent surveys),
- Trends from 1975-Current (Question 3; a reflection of environmental change over a 35 year period).

These 3 periods along a timeline, beginning with Pre-European settlement, were compared in order to determine the extent of change in biotic communities that may have directly and indirectly been influenced by arrival of Europeans and effects on aquatic resources from the development of the regional economy.

## METHODS

### b. Strategy for initiating the review

The literature survey was completed using multiple approaches that could yield primary literature necessary to adequately address the objectives in this study. Three main sources for information were used to locate literature eventually used in constructing this document:

- Web-based survey (Google©),
- Library search (Eastern Washington University, Washington State University, and University of Idaho), and
- Professional Interviews (by telephone, in-person, or by email exchange).

The web based survey and library search were methods that were more consistent in approach and expected results. Search words and intensity of literature discovery were uniform between the two methods. The professional interviews differed among the respondents and this was due to the type of information each had to offer and the level of experience within the organization.

### c. Literature Survey

Literature surveys were extracted from both the web-based search and from the library search. Literature was collected in electronic form, where available, and stored in sub-folders that reflected themes for environmental information:

- Benthic Macroinvertebrates (BMI)
- Dams
- Entomology
- Fisheries
- Land Use
- Literature from the Palouse Bibliography
- Periphyton
- Physical Habitat
- Remote Imagery
- TMDL Regulatory
- Use Attainability Analysis (UAA)
- Vegetation
- Water Quality
- Water Quantity
- Water Supply Bulletins
- Watersheds
- Wetlands

General categories that were related to any of these environmental themes were also used as key search terminology in locating available technical literature.

**d. Database review**

Information from existing databases like Ecology's EIM (Environmental Information Management) system was reviewed for relevant data. EIM is a clearinghouse of environmental data stored and annotated by Ecology and offers access via a web link:
http://www.ecy.wa.gov/eim/

Additional databases were reviewed for useful information through the Natural Resources Information Portal:
http://www.swim.wa.gov/

Information was reviewed for references to reports and/or literature relevant to objectives of this study. Reports generated by the Washington Department of Ecology related to the Palouse River drainage and surrounding region were located through on-line access to publications by the Water Quality Program and the Environmental Assessment Program. The Idaho Department of Health and Welfare-Division of Environmental Quality as well as the Nez Perce Tribe generated useful documents that described bases of information used to develop regulatory tools.

**e. Personal Communications**

Several staff from academic institutions and tribes were contacted for information generated in the Palouse River drainage. Detailed information regarding these contacts is found in Appendix A: Professional Contacts List. Relatively little information was contributed from these conversations and through attempts to contact environmental professionals listed in the table.

Fishery Biologists from the Coeur d'Alene and Nez Perce Tribes stated that very little focus had been placed on resource management in the Palouse River drainage. The Nez Perce contact was able to locate a single document that reported on recent water quality conditions from several reaches in the State of Idaho. Results of this study identified primary pollution problems as: sediment, phosphorus, and bacteriological contamination (Clark 2003). The eroding soils both instream and from along banks carries high concentrations of adsorbed phosphorus from agricultural applications. The movement of the soils (with associated phosphorus) occurs with precipitation or rain-on-snow runoff and erosion of river banks during high flows. The phosphorus aggregates in increasing quantities as adhered to soils and influences trophic condition in nearby streams.

**f. Compilation of the information and results**

Organization of the summary of results section was partitioned by three time periods as described in the objectives of this literature survey. The time periods in which available and relevant literature was organized further partitioned these summaries as: physical habitat, water quality, and biological conditions. The time periods were intended to reflect typical periods during which significant changes occurred in land use, economic development, or availability of data from scientific investigations. The following were time periods in which these results were categorized:

- Pre-European
- Trends from 1975 to Current
- Current Conditions

Several types of environmental information were useful in examining how changes in one or more conditions during a time period might have influenced biological potential (and migratory patterns) throughout the South Fork Palouse River drainage. Summaries of information that informed on physical, chemical, and biological gradients were prepared for transfer to the Final Technical Report and interpretation of limitations (e.g., water quality factors or physical habitat availability) to biological uses in select reaches of the South Fork Palouse River drainage. Scientific references were included in these summaries as well as additional references not cited, but evaluated for utility in this project.

**g. Data Presentation**

Data summaries were presented as text and in tabular or graphical form. Any tables or graphs that appear in this report were copied and included from the original source (cited) to preserve integrity of the information content. In some cases, narrative provides conclusion for the observations made from individual studies. All of this information is considered for inclusion in the Final Technical Report and reveals the fullest extent of information currently available. Some of the summaries are literature compilations themselves and report on the work of many more scientific studies.

## SUMMARY OF RESULTS

### a. Pre-European

*Physical Habitat*

Historically, fall chinook (*Oncorhynchus tshawytscha*) spawning in the Washington portion of the Snake River was concentrated near the mouths of the Palouse and Clearwater Rivers (Fulton 1968, cited in Dauble 2000). This portion of the Palouse River flows through a deep canyon cut through the Columbia River Basalts during the torrential Spokane Floods. Prior to these floods, the Palouse River flowed down the now abandoned Washtucna Coulee, joined Esquatzel Coulee at Connell, and then joined the Columbia River near Pasco. The floods spilled over the south wall of the historic Palouse River valley and headed for the Snake River where the waters poured over the lip of the Snake River Canyon. This was likely the original location of Palouse Falls. Successive flood flows produced immense whirlpools that tore large blocks of basalt from the face of the falls, causing the falls to erode upstream about six miles to its current location. The Palouse Falls at approximately 185 feet is a complete barrier to anadromous and non-anadromous fish passage. Anadromous fish and bull trout are not present in the headwaters of the Palouse River within Washington (Kuttel 2002).

In the nineteenth century, perennial caespitose grasses, often associated with forbs and low shrubs, dominated uplands, but parts of the landscape where surface water accumulated in winter and spring developed distinctive vegetation. Dense stands of common camas (Camassia quamash), an important food plant for the region's native people, were the most obvious feature of this association (Weddell unknown).

Weddell (date unknown) states that it is interesting to note that reed canarygrass (Phalaris arundinacea), which now forms virtually monolithic stands in stream channels and floodplains throughout the Palouse Prairie, was not collected in the study area prior to 1917 and is not listed by Piper and Beattie as occurring in the Palouse Region prior to 1901. This plant occurred in some parts of the West prior to white settlement, but the highly invasive form that now dominates streams and streamside environments in the Intermountain West may be descended from a non-native cultivar or a hybrid between a cultivar and a native form (Merigliano and Lesica 1998). The earliest Latah or Whitman County specimen in the Stillinger or Ownbey herbaria was collected by R. Daubenmire in 1938 in a "muddy roadside ditch" 5 mi north of Moscow (WSU Ownbey Herbarium Spec. No. 261001).

*Water Quality*

No information available.

*Biological Conditions*

The Palouse Falls, at approximately 185 feet, is a complete barrier to anadromous and non-anadromous fish passage. Anadromous fish and bull trout are not present in the headwaters of the Palouse River within Washington (Kuttel 2002).

According to fishery documents, the Palouse River was, at least historically not used by spawning salmon (Fulton 1968). Parkhurst (1950) did not survey the Palouse River during his fisheries study and historic overview of Snake River Basin anadromous fishes. He noted that a high falls (Palouse Falls) located about 10 km above the mouth "renders the stream inaccessible to migratory fish". Ethnographic records show that salmon fishing was extremely productive at the confluence of the Palouse and Snake Rivers (Ray 1975, reference from Butler 2004). Lewis and Clark and later explorers describe a very large village at the mouth of the Palouse River. Ross Cox, who spent time in the village around 1812, noted that in early August, people there were engaged in catching and drying salmon in large numbers (Ray 1975, reference form Butler 2004). Historic documents also show fishing camps and villages along the Palouse River itself (Ray 1975). Ray refers to two such locales in particular: *A'patap*, which was located at the foot of the Palouse Falls, and *Claxo'pa*, about four miles above the mouth. Unfortunately, the documents do not indicate whether the Native American fishery along the Palouse River targeted resident freshwater fish or anadromous salmon and trout (Butler 2004).

The falls have been a barrier to migratory salmonids at least since the late Pleistocene and Holocene periods, thus it is clear that the Palouse River itself was not a passageway for fish migrating to headwater areas to spawn. It is possible of course that the Palouse River channel below the falls was used by salmon for spawning and thus a fishery might have developed to target such fishes. Pre-dam records for fish distribution lead to the conclusion that the Palouse River never supported large salmonid populations (Butler 2004).

The historic fish assemblage in the Palouse River Subbasin prior to European settlement consisted primarily of anadromous and resident salmonids, cyprinids, and catastomids in the lower Palouse River below Palouse Falls, and a diverse assemblage of fish species, primarily composed of cyprinids and catastomids above the falls (Cook 2001). The anadromous salmonid fish species noted included Chinook salmon Oncorhynchus tshawytscha and steelhead O. mykiss (Parkhurst 1950). Although there is a general understanding of what species now exist in the sub-basin, there is a lack of knowledge on what native fish species existed within the subbasin, prior to European immigrant settlement in the area, which are no longer present (Cook 2001).

Wertz (1993) quotes a longtime resident as stating that Paradise Creek supported a cutthroat trout population up until the 1890's (Doke & Hashmi 1994).

### b. 1975 to Current

*Physical Habitat*

The Palouse Falls at approximately 185 feet is a complete barrier to anadromous and non-anadromous fish passage. Anadromous fish and bull trout are not present in the headwaters of the Palouse River within Washington (Kuttel 2002).

Palouse Falls blocks all fish. There is no record of use by salmon and/or trout in the lower 10 km of the river (downstream of the falls) (Fulton 1970).

The South Fork and its main tributaries in Idaho (Crumarine Creek, Gnat Creek and Howard Creek) originate from springs within the forested terrain of Moscow Mountain. The South Fork Palouse River experiences low flows during the late summer and early fall months and high flows in the spring and early summer months. Most of the wetlands and flood plains in the Palouse have been drained or eliminated by modern land use, urbanization, and transportation infrastructure affecting channel sinuosity and diversity. These areas retained water during high flow periods and released water during the lower flow periods. Without these water storage areas, peak flows are higher and for a shorter period of time, creating instream channel erosion, flooding, and deeply incised channels (IDEQ 2007).

The Palouse River originates in the mountains of western Idaho and flows 262 km, through forest, dryland farming (non-irrigated), and barren rangelands before discharging to the Snake River; it drains 8500 $km^2$. Dryland farming, mainly wheat, constitutes 75% of land use in the Palouse River Basin, although grazing and urbanization affect water quality in localized areas. The South Fork of the Palouse River region is commonly considered a dryland farming (81-91%) area with low runoff into streams, but a high percentage of the stream flow is composed of sewage treatment effluent with excessively high nutrient loading from Moscow, Idaho, and Pullman, Washington (Greene et al 1994; Munn et al 2002).

Erosion is occurring along most stream banks of the Idaho portion of the South Fork Palouse River that are adjacent to cropland and pastureland fields because of the lack of woody vegetation and rhizomatus herbaceous species. Livestock activity often promotes stream bank deterioration, as well as the removal of vegetation. This lack of root mass allows for bank sloughing which contributes significant amounts of sediment into SFPR drainages. Many portions of the stream have been channelized or have had woody vegetation removed when cropland fields were established. Herbicide spray and tillage operations, as well as grazing activities, have prevented the reestablishment of woody species. While there are some remnant areas; much of the historically diverse and multi-layered vegetation along the stream is missing (ISCC 2009).

Table 1 below was taken from IDHW-DEQ 1994 and summarizes habitat scores for various stations on Paradise Creek. The qualitative habitat quality for a stream segment is rated as excellent (101-125), good (67-100), fair (33-66), or poor (0-32). Schwartz Creek was the reference stream in the study, Rabe et al 1993.

**Table 1.** Habitat Assessment Scores of Paradise Creek October 1992 and February 1993

| | Mt. View | | White&Troy | | 6th & Deakin | | | Blw. WWTP | | Schwartz | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Oct | Feb | Oct | Feb | Oct | Feb | Oct[1] | Oct | Feb | Oct'91 | Feb'92 |
| Bottom substrate | 3 | 2 | 3 | 3 | 6 | 4 | 2 | 10 | 3 | 15 | 16 |
| Embeddedness | 2 | 2 | 2 | 2 | 7 | 4 | 2 | 12 | 6 | 11 | 14 |
| Channel shape | 2 | 2 | 5 | 5 | 2 | 2 | 2 | 12 | 12 | 13 | 13 |
| Riffle/bend ratio | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 4 | 4 | 11 | 11 |
| Channel alteration | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 5 | 5 | 15 | 15 |
| Lower bank stability | 3 | 3 | 5 | 5 | 5 | 5 | 4 | 6 | 6 | 8 | 8 |
| Bank vegetation protection | 4 | 4 | 6 | 6 | 6 | 6 | 6 | 8 | 8 | 10 | 10 |
| Canopy cover | 2 | 0 | 7 | 5 | 7 | 5 | 7 | 6 | 4 | 8 | 6 |
| Width of riparian | 3 | 0 | 4 | 2 | 4 | 2 | 4 | 8 | 3 | 8 | 8 |
| TOTAL SCORE | 22 | 16 | 35 | 31 | 41 | 32 | 30 | 69 | 49 | 99 | 101 |

[1] October 1993

The Palouse River and its tributaries flow freely to the Snake River with no major man made impoundments (USDA 1978). There are a few minor impoundments for irrigation purposes, mostly located on small tributaries. There have been major efforts historically to straighten and keep stream channels clear of vegetation to assist with drainage and control flooding on the tributaries of the Palouse River. In some cases dikes have been installed along streams to reduce flooding, these have disconnected the streams from the riparian and upland zones. Tiling has been used to improve the drainage of wetter areas to open the ground for agricultural purposes; the tiling normally is outletted directly into a stream. Livestock grazing has altered stream channel stability. Farm practices and the removal of wetlands have dramatically reduced the upland water storage capacity of the Palouse Basin. Forest grounds in Idaho have been historically clear-cut reducing water storage potential. Also there has been an increase in the amount of impervious surfaces (primarily urban areas). The Palouse River as it flows through Colfax, Washington, is contained in a concrete aqueduct. These factors have contributed to a 'spiky' hydrologic curve, and several tributary streams becoming intermittent in the summer months. When there is a precipitation event the waters tend to enter the streams quickly and drain to the Snake River quickly (Cook 2001).

Most of the South Fork's subbasin riparian areas have been altered by land use, and the remaining riparian habitat is limited and of poor quality. Many small intermittent streams have been converted to drainage ditches, and the riparian vegetation removed. Tillage often occurs up to the edge of the ditch or property, leaving a limited buffer between the waterway and the cropland. Elevated water temperatures in the summer and increased nutrient and sediment loads can adversely affect aquatic habitat (HDR 2007).

The alteration of the landscape in the basin is reflected in changes in flow patterns and water quality. Changes in flow patterns include increased peak flows in winter and spring storm events, and lower sustained summer base flows. The increase in peak flows is partly caused by loss of storage within the riparian zone, leading to a reduction in infiltration, which in turn, lowers the sustained summer base flows. Several significant flood events have been documented in the City of Pullman. The most recent severe flood occurred in 1996, triggered by heavy rainfall on snow on frozen ground. During low flow summer periods, there is no sustained summer base flow in the South Fork. Downstream from Pullman, the instream summer flow in the South Fork is mainly composed of City of Moscow and City of Pullman wastewater discharges (HDR 2007).

*Water Quality*

The majority of the creeks and streams, used as collection localities in Griffith's preliminary survey of fish parasites in the Palouse Area (1953), drain into the Palouse River which then empties into the Snake River. The small streams sampled, as well as the Palouse River, have a high turbidity. This may account for the restricted number of fish species (Griffith 1953).

In 2005, the Washington Department of Ecology and the City of Moscow, ID contracted with Watershed Sciences to provide TIR and true color digital imagery on Paradise Creek, and the North and South Forks Palouse River. The data were collected in support of an ongoing temperature TMDL analysis in the basin. The data were acquired on July 30 and 31, 2005 during the mid-afternoon hours (1:00 to 4:00 PM). Results for the South Fork Palouse River are shown in Figure 3 below (Watershed Sciences, Inc. 2006).

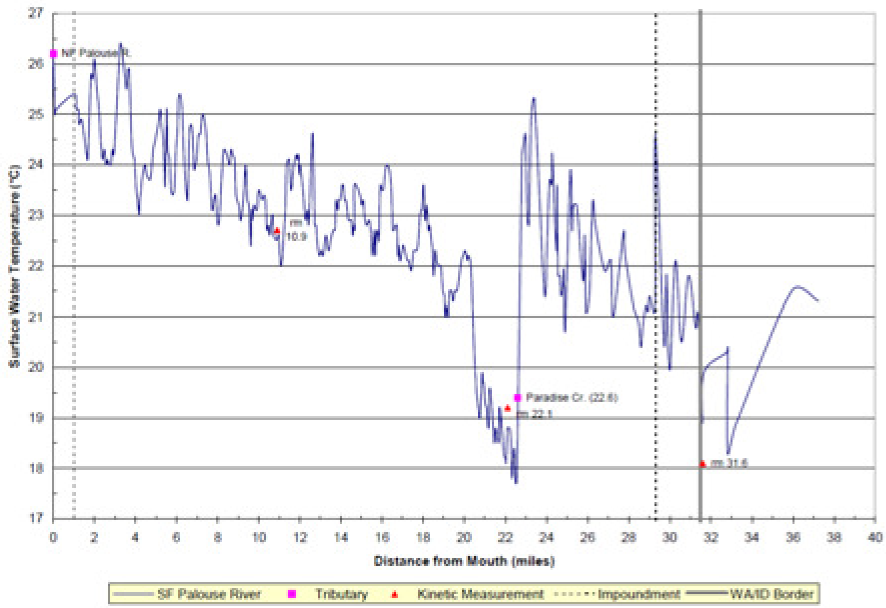


**Figure 3.** Radiant water temperatures were plotted versus river mile for the South Fork Palouse River. River miles were calculated upstream from the confluence of the North Fork Palouse River.

Radiant water temperatures in the South Fork ranged from 17.7°C just downstream of the Paradise Creek confluence to a survey maximum of 26.4°C at river mile 3.3 upstream of the town of Colfax). The TIR survey began at the river mouth and continued upstream to near the headwaters (mile 43.4). However, upstream of river mile 33.2, the South Fork did not have enough visible surface water to obtain accurate temperature samples (Watershed Sciences, Inc. 2006).

Between river mile 33.2 and Paradise Creek, stream temperatures exhibited a general warming trend increasing from ~18.3°C (mile 33.2) to a local maximum of 25.3°C (mile 23.4). Within this general trend, radiant water temperatures exhibited a high degree of spatial variability with rapid, local changes in radiant temperatures. A high degree of local thermal variability is often a characteristic of comparatively warm streams under low flow conditions. In these cases, relatively small sub-surface discharges can have a dramatic influence on bulk water temperatures. The rapid increase in stream temperature at river mile 29.3 suggests some thermal stratification immediately upstream of a small impoundment observed at that location (Watershed Sciences, Inc. 2006).

Between the Paradise Creek confluence and the mouth, radiant water temperatures in the South Fork exhibited considerable local variability within an overall downstream warming trend (Figure 4). A notable increase in longitudinal heating was observed between river miles 20.8 and 20.0 with radiant water temperatures increasing by ~3.3°C. Inspection of the imagery revealed that this increase occurs downstream of the Pullman waste water treatment plant and that the channel is exposed through this reach (as it is through much of its length). However, no direct mass transfer (i.e. surface or warm water returns) into the river was detected through this reach (Watershed Sciences, Inc. 2006).

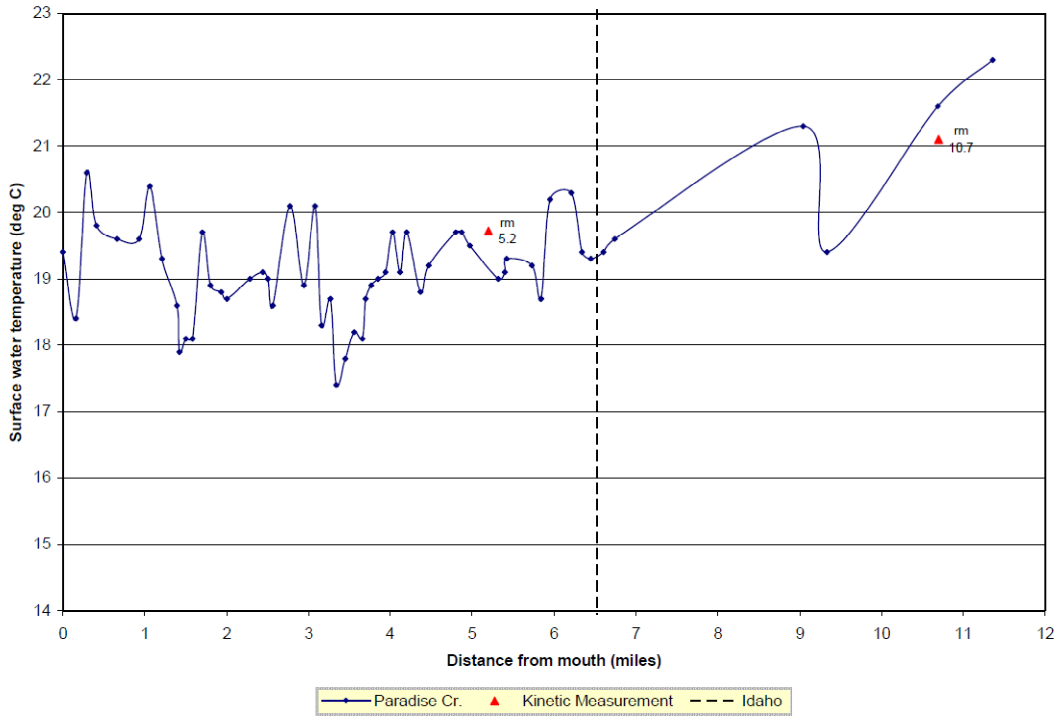


Figure 4. Radiant water temperatures were plotted versus river mile for Paradise Creek.

Radiant water temperatures in Paradise Creek ranged from 17.4°C to 22.3°C. The longitudinal profile shows considerable variability between radiant temperature samples. The wetted channel width was relatively small (1 to 5 meters) throughout the entire extent with some reaches having no visible surface water. Radiant temperatures were sampled where surface water was clearly visible and wetted widths were at least 1.5 meters. This resulted in intermittent sampling throughout the surveyed extent. Although the TIR survey covered 18.6 miles, radiant temperature sampling was only possible over the lower 11.4 miles with only 6 images sampled over the Idaho State Line (mile 6.5) (Watershed Sciences, Inc. 2006).

The South Fork Palouse River and several of its tributaries (Paradise Creek, Missouri Flat Creek and Dry Fork Creek) are listed as impaired by fecal coliform bacteria on the Clean Water Act's 303(d) list of impaired water bodies. The streams in this watershed are required to have a geometric mean of less than 100 colony forming units/100 milliliters (cfu/mL) and not more than 10% of the samples used to calculate the geometric mean can exceed 200 cfu/100mL.

The South Fork Palouse River (Table 2) is on the 303(d) list of impaired waterbodies for high instream temperatures (Bilhimer et al 2006).

Table 2. 2005 Monthly Summary for Ambient Monitoring Stations.

| Station ID | July (°C) | | | | August (°C) | | | |
|---|---|---|---|---|---|---|---|---|
| | Avg. DMax | Stdev | Max 7DADMax | Date of 7DADMax | Avg. DMax | Stdev | Max 7DADMax | Date of 7DADMax |
| 34C100 (Paradise Cr) | 21.31 | 0.74 | 21.67 | 7/30/2005 | 20.64 | 0.95 | 21.33 | 8/1/2005 |
| 34B110 (SFPR at Pullman) | 20.03 | 0.67 | 20.39 | 7/15/2005 | 17.83 | 1.64 | 20.1 | 8/1/2005 |
| 34B130 (SFPR blw Sunshine) | 21.57 | 1.13 | 22.51 | 7/4/2005 | 17.62 | 1.59 | 20.57 | 8/1/2005 |

The South Fork Palouse River has been listed by the state of Washington under Section 303(d) of the Clean Water Act for non-attainment of Washington State dissolved oxygen (DO) and pH criteria. The listings are based on sampling done by the Washington State Department of Ecology in 1987, 1991, and 1994-2001. An additional 303(d) listing was identified within the South Fork Palouse River watershed for ammonia (Carroll et al 2006). Pelletier (1993) showed that the fraction of POTW effluent in the SFPR during critical flow is high. Moscow POTW and Pullman POTW are estimated to comprise the majority of the river flow during July–November for a typical year (Figure 5).

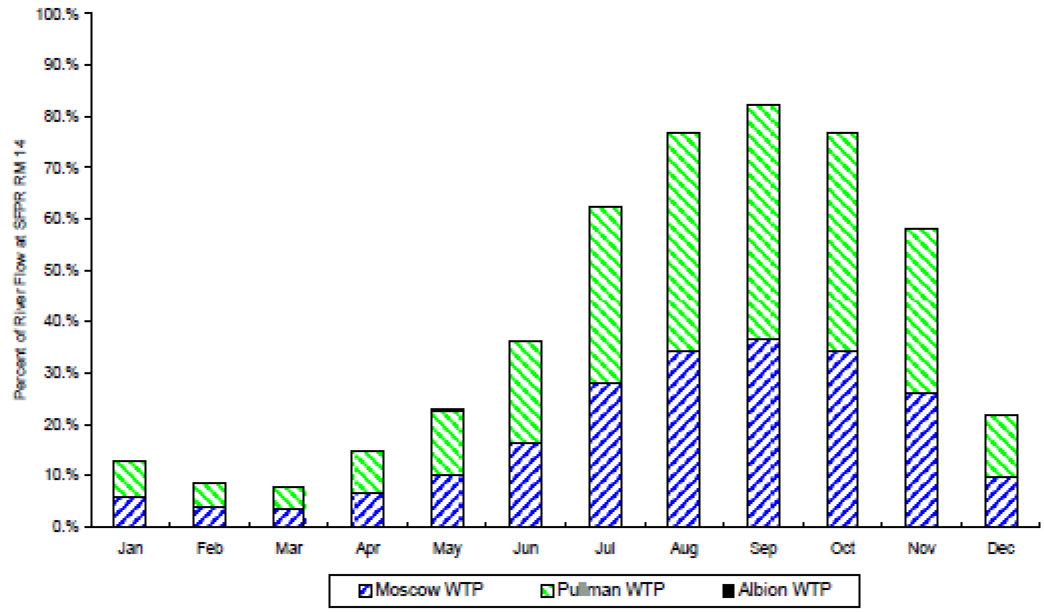


Figure 5. Estimated monthly fraction of POTW effluent in the South Fork Palouse River for a median flow year. Adapted from Pelletier (1993).

In 1980, Idaho's Department of Health and Welfare, Division of Environmental Quality (DEQ) listed Paradise Creek as protected for agricultural water supply and secondary contact recreation designated beneficial uses in the Idaho Water Quality Standards. In October 1993, DEQ staff conducted a Use Attainability Assessment (UAA) for Paradise Creek. The purpose of the UAA was to evaluate the appropriateness of the current designated uses and to determine whether the creek should be protected for any additional uses. It was determined through the UAA that if the water and habitat quality is improved, Paradise Creek would be capable of supporting salmonid spawning and cold water biota. This designation applies to the portion of the creek flowing through Idaho; however above Mountain View Park the creek is intermittent and these uses would apply only when water is present. Secondary contact recreation and agricultural water supply were confirmed as appropriate designated beneficial uses (IDHW-DEQ 1994).

In 1979, DEQ identified the South Fork of the Palouse River and Paradise Creek as having severe pollution problems due to erosion on dryland farming ground (IDHW-DEQ 1981). A water quality survey was performed which determined that the concentration of sediment and associated pollutants depends on the timing and magnitude of runoff. During high flows the concentration of suspended sediment ranged 1,000-3,000 mg/l, fecal coliform numbers increased downstream and exceeded Idaho water quality standards for secondary contact recreation. Paradise Creek had an overall water quality rating of 99 on a scale of 0-100, with zero being pristine waters and 100 being highly degraded. The survey also concluded that with respect to water quality, most of the surveyed agricultural areas within the Palouse drainage would be considered critical. Due to the severe impacts that agriculture has on Paradise Creek, the Latah Soil and Water Conservation District conducted a planning project to implement best management practices (BMPs) in the Paradise Creek watershed through the Idaho Agricultural Water Quality Program. The District submitted a grant application for implementation in 1981 and 1986, it was rejected both years. (Latah SWCD 1981, 1986) (IDHW-DEQ 1994).

Idaho DEQ designated Mountain View Park as the point where Paradise Creek becomes a perennial stream. Historically, this area was a wetland and water is almost always present during the low flow periods. Upstream from this point the creek is intermittent except during spring runoff. Paradise Creek is located along the western edge of Mountain View Park. In this section the creek is channelized, has little canopy cover, and the bottom substrate is highly embedded. For these reasons this site is generally considered as a poor habitat for fish. The water quality is capable of supporting cold water biota; water temperatures are below 20°C and only once was the dissolved oxygen level measured to be below the minimum requirement (6 mg/L) for cold water biota as defined in t he Idaho Water Quality Standards (IDHW-DEQ 1994). Table 3 below also from IDHW-DEQ 1994.

Table 3. Mountain View Park Water Quality Data[1].

| Parameter | Winter Values[2] | Summer Values[3] |
|---|---|---|
| Temperature (°C) | 0 - 5.5 | 6.9 - 16.0 |
| pH | 6.8 - 7.7 | 6.9 - 7.6 |
| Dissolved Oxygen (mg/L) | 7.0 - 13.2 | 3.9 - 11.8 |
| Conductivity | 127 - 218 | 37 - 385 |
| Alkalinity (mg/L as $CaCO_3$) | 27 - 187 | 40 - 203 |
| Suspended Solids (mg/L) | 0.8 - 286.7 | 4.5 - 112.7 |
| Total Nitrogen (mg/L) | 2.27 - 13.87 | 1.37 - 3.24 |
| $NH_3$ (mg/L) | 0.02 - 0.09 | < 0.01 - 0.04 |
| $NO_3$ (mg/L) | 0.75 - 12.45 | 1.21 - 2.71 |
| $NO_2$ (mg/L) | <0.01 - 0.05 | 0.03 - 0.04 |
| Total Phosphorus (µg/L) | 75 - 388 | 61 - 350 |
| Fecal Coliforms (CFU/100 ml) | <4 - 152 | 4 - 433 |
| Fecal Strep (CFU/100 ml) | 10 - >6000 | 42 - 1400 |
| Flow (CFS) | 0.05 - 27.49 | 0.03 - 28.76 |

[1] Collected by the Washington Water Research Center
[2]November-April, 8 samples
[3]May-October, 6 samples

Tables 4 and 5 below are also from IDHW-DEQ 1994 and summarize water quality information from other stations on Paradise Creek.

Table 4. White Ave. & Troy Highway Water Quality Data[1]

| Parameter | Winter Values[2] | Summer Values[3] |
|---|---|---|
| Temperature (°C) | 0 - 5.2 | 6.9 - 18.0 |
| pH | 6.8 - 7.6 | 7.2 - 8.6 |
| Dissolved Oxygen (mg/L) | 3.2 - 12.8 | 2.6 - 13.0 |
| Conductivity | 166 - 772 | 153 - 459 |
| Alkalinity (mg/L as $CaCO_3$) | 32 - 189 | 50 - 169 |
| Suspended Solids (mg/L) | 4.0 - 28.6 | 2.5 - 56.7 |
| Total Nitrogen (mg/L) | 0.76 - 13.25 | 0.64 - 3.24 |
| $NH_3$ (mg/L) | <0.01 - 0.11 | 0.02 - 0.06 |
| $NO_3$ (mg/L) | 2.73 - 11.46 | 0.23 - 2.47 |
| $NO_2$ (mg/L) | <0.01 - 0.04 | 0.01 - 0.04 |
| Total Phosphorus (µg/L) | 18 - 312 | 100 - 396 |
| Fecal Coliforms (CFU/100 ml) | 6 - >967 | 8 - 600 |
| Fecal Strep (CFU/100 ml) | 20 - 310 | 80 - >780 |
| Flow (CFS) | 0.06 - 24.96 | 0.03 - 26.48 |

[1] Collected by the Washington Water Research Center
[2] November-April, 8 samples
[3] May-October, 6 samples

Table 5. Sixth St. & Deakin Water Quality Data[1]

| Parameter | Winter Values[2] | Summer Values[3] |
|---|---|---|
| Temperature (°C) | 0 - 7.6 | 6.9 - 13.5 |
| pH | 6.8 - 7.7 | 6.9 - 7.8 |
| Dissolved Oxygen (mg/L) | 5.7 - 12.8 | 5.6 - 11.6 |
| Conductivity | 165 - 536 | 171 - 751 |
| Alkalinity (mg/L as $CaCO_3$) | 37 - 201 | 52 - 225 |
| Suspended Solids (mg/L) | 6.0 - 265 | 3.6 - 203.2 |
| Total Nitrogen (mg/L) | 2.12 - 12.21 | 1.7 - 13.02 |
| $NH_3$ (mg/L) | 0.08 - 2.04 | 0.08 - 4.84 |
| $NO_3$ (mg/L) | 1.41 - 11.46 | 0.72 - 4.94 |
| $NO_2$ (mg/L) | <0.01 - 0.34 | 0.03 - 0.31 |
| Total Phosphorus (µg/L) | 39 - 775 | 225 - 1060 |
| Fecal Coliforms (CFU/100 ml) | 12 - 290 | 144 - >2000 |
| Fecal Strep (CFU/100 ml) | 61 - 420 | 128 - 2500 |
| Flow (CFS) | 0.11 - 24.33 | 0.07 - 20.09 |

[1] Collected by the Washington Water Research Center
[2]November-April, 9 samples
[3]May-October, 6 samples

Under normal conditions, the Moscow WWTP discharges approximately two million gallons of effluent a day into Paradise Creek. During low flow periods, the flow in the creek increases at least ten fold as a result of this discharge. This water is generally warmer then the creek with an average yearly temperature of 14.3°C (SWWRC 1994). Paradise Creek below the WWTP has higher concentrations of suspended solids, ammonia, nitrate, and total phosphorus due to the discharge (SWWRC 1994) (IDHW-DEQ 1994).

Table 6. ID/WA Border Water Quality Data[1]

| Parameter | Winter Values[2] | Summer Values[3] |
|---|---|---|
| Temperature (°C) | 4.7 - 14.8 | 9.5 - 17.3 |
| pH | 6.6 - 7.7 | 7.1 - 7.6 |
| Dissolved Oxygen (mg/L) | 0.9 - 12.0 | 1.9 - 10.3 |
| Conductivity | 255 - 993 | 277 - 750 |
| Alkalinity (mg/L as $CaCO_3$) | 60 - 176 | 93 - 183 |
| Suspended Solids (mg/L) | 7.8 - 736 | 4.0 - 35.1 |
| Total Nitrogen (mg/L) | 7.56 - 29.49 | 13.6 - 21.9 |
| $NH_3$ (mg/L) | 1.00 - 7.60 | 1.33 - 3.10 |
| $NO_3$ (mg/L) | 4.23 - 12.20 | 3.10 - 10.95 |
| $NO_2$ (mg/L) | < 0.01 - 1.00 | 0.10 - 0.80 |
| Total Phosphorus (µg/L) | 780 - 7250 | 1060 - 4200 |
| Fecal Coliforms (CFU/100 ml) | 11 - > 630 | 84 - 310 |
| Fecal Strep (CFU/100 ml) | 7 - 2000 | 28 - 866 |
| Flow (CFS) | 4.7 - 41.61 | 3.02 - 22.18 |

[1] Collected by the Washington Water Research Center
[2]November-April, 9 samples
[3]May-October, 6 samples

In summer 2006, the Washington State Department of Ecology initiated several TMDL-based field studies to assess current stream temperatures and water quality conditions along the Palouse River, South Fork Palouse River, and Paradise Creek. The study, Surface-water/Groundwater Interactions and Near-stream Groundwater Quality along the Palouse River, South Fork Palouse River, and Paradise Creek, was part of that effort, and was undertaken to characterize the thermal and water quality influences that groundwater imparts to these rivers along gaining reaches. Results from that study showed that measurable concentrations of dissolved orthophosphate (0.018 to 0.171 mg/L) and dissolved total phosphorus (0.073 to 0.875 mg/L) were found at all sampled piezometer sites. Measurable concentrations of dissolved nitrate+nitrite-N and ammonia were found at roughly half of the sampled piezometers at concentrations ranging from 0.013 to 10.1 mg/L and 0.03 to 0.549 mg/, respectively. The average estimated unit-area-mass loading to the river from discharging groundwater varied by parameter and location. The loading ranged from 0.03 to 107 $mg/d/m^2$ of streambed for dissolved total phosphorus, and 0.01 to 3,119 $mg/d/m^2$ for dissolved nitrate+nitrite-N. These load values are considered upper bound estimates since they do not account for biological or chemical reactions that may potentially reduce nutrient concentrations in discharging groundwater as it passes through the final few feet of the streambed (Ecology 2009).

Analyses of samples collected from streams in the Palouse River Basin showed the water to be chemically suitable for most common uses. The water temperature of the Palouse River at Hooper during October 1967-September 1971 ranged from a low of 0°C (32°F) in December to a high of 30°C (86°F) in July. The quantity of suspended sediment transported by streams in the basin, owning to the rapid erosion of the loess soils covering much of the basin, is greater than that of most other basins in the State. The average annual sediment yield during July 1961-June 1965 ranged from 5 $tons/mi^2$ from Cow Creek at Hooper to 2,100 $tons/mi^2$ from Rebel Flat Creek at Winona, and the average annual suspended-sediment discharge of the Palouse River at its mouth during the same period was 1.50 million tons (Nassar and Walters 1975).

The Palouse River and its tributaries are currently listed on the states (Washington & Idaho) 303(d) list for metals, pesticides, fecal coliform, dissolved oxygen, pH, ammonia-N, sediment, nutrients, temperature, and flow. The most common pollutants affecting the Palouse River and its tributaries are temperature, dissolved oxygen, pH, and fecal coliform. The South Fork of the Palouse River has been rated as having the worst water quality in Washington based on WDOE's water quality ambient monitoring data collected in Pullman (Cook 2001). In Idaho, the Palouse River tributaries of Deep Creek, Flannigan Creek, West Fork Rock Creek, Gold Creek, Hatter Creek, Big Creek, and the South Fork Palouse River are listed as water quality limited for bacteria, flow alteration, habitat alterations, nutrients, sediment and temperature. Cow Creek in Idaho is listed for habitat alterations, nutrients and temperature. Paradise Creek is the only Idaho stream in the drainage where a Total Maximum Daily Load (TMDL) Implementation Plan has been developed (Cook 2001).

Based on total annual load estimates, the Moscow WWTP was the largest source of phosphorus and nitrogen to Paradise Creek. The Moscow WWTP was also the major source of ammonia observed at the Busch site in WA and therefore contributes to WA state ammonia and dissolve oxygen standards not being met at this site. Ag fields were a major source of suspended solids to Paradise Creek during peak flows in late winter and early spring when precipitation, runoff and erosion were greatest. Additional non-point sources of pollution include livestock and animal research facilities, forestry, mining, construction, recreation, failing septic systems and toxic sites. Dissolved oxygen concentrations were generally lowest in the summer and fall of 1993. Poor water quality is not the only problem facing Paradise Creek. The streambanks and habitat surrounding Paradise Creek have also experienced major damage. The removal of riparian vegetation, alternation of the stream channel and construction along the stream bank have resulted in unstable stream bank conditions which increase erosion and damage the habitat of aquatic organisms including macroinvertebrates and fish. Removal of riparian vegetation is also greatly responsible for the elevated water temperatures observed in Paradise Creek and the SFPR in the summer (Doke & Hashmi 1994).

*Biological Conditions*

Summer steelhead, bull trout, fall chinook, and smallmouth bass are all known to be present in the lower six miles of the Palouse River. Fall chinook use this reach of the Palouse River for spawning and rearing as well. However, the Palouse Falls at approximately 185 feet is a complete barrier to anadromous and non-anadromous fish passage. Anadromous fish and bull trout are not present in the headwaters of the Palouse River within Washington (Kuttel 2002).

Brook stickleback is established in the upper 36 km of Rock Creek, Spokane, Washington. Rock Creek is a tributary of the Palouse River which drains into the Snake River. Collection prior to 1999 yielded no brook stickleback in this drainage, leading researchers to believe that the species was recently introduced. This is the fifth record of occurrence west of the continental divide in the United States since 1995 and the first occurrence in Washington. Brook Stickleback were previously collected in the Swan/Flathead River Drainage, Montana, Green River Drainage, Utah, the Elk River Drainage in Colorado, and the Klamath River Drainage, California (Scholtz et al. 2003).

Fish species found above and below Palouse falls from 1968 through 1975 did not differ greatly. Species composition below Palouse Falls was composed of eight native species and three exotics. Upstream of Palouse Falls fish collections contained eleven native species and nine exotics. The major differences in species composition above and below Palouse Falls appeared to be the absence of *C.beldingi* above the falls. *C.beldingi* is the most abundant cottid in the lower Clearwater River and tributaries near the mouth of the Clearwater and presumably also the lower Snake River. The exclusion of *C.beldingi* and *C. bairdi* of the *hubbsi* form from above the falls would seem to indicate that the Palouse River and its tributaries were subjected to multiple invasions of cottid species and forms from centers of endemism (Maughan et al 1980). One species, *Ptychocheilus oregonensis*, was collected at the South Fork Palouse River station (#11) in 1976 (Maughan et al 1980).

Griffith (1953) surveyed the parasites of fishes found in the Palouse Area of southeastern Washington from the fall of 1948 through the spring of 1950. Fish were collected from lakes, ponds, and streams in 15 different localities. A total of 181 specimens representing seven families and 17 species were examined. Table 7 indicates locations surveyed no. of fish species collected, and rates of infection.

Table 7. Rates of Infection for the various streams and lakes.

| Localities | Number of Fish Species | Number Specimens Examined | Number Infected | Per Cent Infected | Number with Cestodes | Number with Trematodes | Number with Nematodes | Number with Acanthocephala | Number with Copepods | Number with Multiple Infections |
|---|---|---|---|---|---|---|---|---|---|---|
| Asotin Creek | 1 | 2 | 2 | 100.0 | .... | .... | 2 | .... | .... | .... |
| Davis Lake | 7 | 32 | 18 | 56.3 | 2 | 1 | 7 | 16 | .... | 7 |
| Missouri Flat Creek | 1 | 19 | 17 | 89.5 | 1 | 5 | .... | 12 | 7 | 7 |
| Palouse River, North Fork | 2 | 2 | 1 | 50.0 | .... | .... | .... | .... | 1 | .... |
| Palouse River, South Fork | 3 | 9 | 6 | 66.7 | .... | .... | .... | 2 | 5 | 1 |
| Paradise Creek | 1 | 3 | 3 | 100.0 | .... | .... | .... | .... | 3 | .... |
| Robinson Lake, Idaho | 4 | 14 | .... | 0.0 | .... | .... | .... | .... | .... | .... |
| Rock Creek | 3 | 5 | 2 | 40.0 | .... | 1 | 1 | 1 | .... | 1 |
| Samish Lake | 1 | 3 | 3 | 100.0 | 3 | 1 | 3 | .... | .... | 3 |
| Snake River, Clarkston | 2 | 6 | 5 | 83.5 | .... | 5 | 4 | 4 | .... | 5 |
| Snake River, Davis Bar | 4 | 4 | 4 | 100.0 | 2 | .... | 3 | 1 | 1 | 2 |
| Snake River, Wawawaii | 1 | 10 | 10 | 100.0 | 4 | .... | 10 | .... | .... | 4 |
| Sprague Pothole | 5 | 30 | 4 | 13.3 | 4 | .... | .... | .... | .... | .... |
| Union Flat Creek | 1 | 6 | 5 | 83.3 | 1 | .... | .... | 3 | 4 | 3 |
| Williams Lake | 7 | 36 | 15 | 41.7 | 13 | 10 | 1 | .... | 3 | 12 |

Palouse Fine-Scale Sucker-21 examined; 18 infected. Palouse fine-scale sucker were taken from two areas: the South Fork of the Palouse River and Missouri Flat Creek. Columbia large-scale sucker, 27 examined, 26 infected, was also collected from the South Fork Palouse River and the North Fork Palouse River. Western Dace-9 examined, 5 infected. These minnows were the most abundant fish in the small creeks and streams of the Palouse area. Dace were collected from Robinson Lake (may have been filled and converted to a County Park), South Fork of the Palouse River, North Fork of the Palouse River, and Paradise Creek. One largemouth bass fingerling from the North Fork of the Palouse River had six copepods attached externally (Griffith 1953).

The only salmonid native to the Palouse was an isolated population of Yellowstone cutthroat trout, as Palouse Falls was an effective barrier to redband trout migration. Currently no native salmonid species and no anadromous fish exist in the drainage. Idaho State Water Quality Standards do not distinguish between native and non-native salmonids for the designation and protection of the salmonid spawning beneficial use (IDEQ 2007).

The following native fish may be found in the South Fork Palouse River:

- Longnose dace
- Speckled dace
- Redside Shiner
- Largescale sucker
- Bridgelip sucker

The following species have been introduced in the watershed:

- Brook trout
- Brown Trout
- Rainbow trout
- Northern pike minnow

Benthic algae was sampled in the South Fork Palouse River and Paradise Creek as part of Munn et al. (2002) study on the response of benthic algae to environmental gradients in agriculturally dominated landscapes. Results show that Blue-green algae dominated the forested sites, composing 85 to 95% of the relative abundance, with the remainder consisting of small percentages of diatoms, green, and red algae. In contrast, diatoms tended to dominate the urban and range sites, with blue-greens far less dominant. The range sites were somewhat unique in that the red alga *Audoui-nella violacea* composed 35% of the community at the upstream range site, which was fed by shallow groundwater; however, this red alga decreased to only 5% at the downstream range site. Sites in the dryland and irrigated agricultural areas contained various combinations of blue-greens and diatoms, with the relative abundance of either varying substantially from site to site. Both the South Fork Palouse River and Paradise Creek were considered to be in the urban landscape because approximately 95% of instream flows comes from wastewater treatment discharge (Munn et al 2002).

Dr. Fred Rabe et al. (1993) have monitored the macroinvertebrate communities of Paradise Creek since 1991. The data used in the UAA study (IDHW-DEQ 1994) was collected in October 1992 and February, April, June 1993. Samples were collected along the entire length of Paradise Creek and portions of the South Fork of the Palouse River, but only those stations which correlate with the UAA stations are presented below in Table 8. Schwartz Creek was used as a reference site.

In most of the samples collected for the UAA study (IDHW-DEQ 1994), Chironomidae (midges) was the dominant insect group in Paradise Creek and are therefore ecologically important because of their high densities and diversity. Total midge abundance in excess of 30% probably indicates depressed habitat/water quality (Wisseman 1993). In contrast, midge populations in samples from Schwartz Creek were well below 30% of the total abundance. Other dominant insects included Odonata, the dragonflies and damselflies. In the October samples, high numbers of damselflies were found at White & Troy and Sixth & Dealcin. Damselflies are extremely tolerant of impaired water conditions and sediment, their ability to climb onto the reed canary grass enables them to partially avoid the water (Rabe et al. 1993). Oligochaeta (aquatic earthworms) had the highest density of the non-insects at the three lower sites. In October, over a thousand individuals per square meter were recorded below the WWTP, this is common below sewage effluent. Other non-insect dominants were Gastropoda (snails) and Hirudinea (leeches).

Table 8. Macroinvertebrate Results in Paradise Creek

| | Mt. View Park | | | | White & Troy | | | | 6th & Deakin | | | | Below WWTP | | | | Schwartz | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metric Evaluated | Oct | Feb | Apr | Jun | Oct | Feb | Apr | Jun | Oct | Feb | Apr | Jun | Oct | Feb | Apr | Jun | Oct | Feb | Apr | Jun |
| Total Abundance | 213 | 219 | 398 | 380 | 645 | 133 | 131 | 195 | 847 | 77 | 200 | 194 | 1412 | 478 | 427 | 803 | 146 | - | - | 56 |
| Species Richness | 31 | 16 | 31 | 38 | 28 | 19 | 24 | 26 | 23 | 14 | 23 | 14 | 5 | 7 | 6 | 12 | 36 | 34 | 29 | 33 |
| EPT-Taxa Richn | 2 | 2 | 3 | 4 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 20 | 18 | 18 |
| Hilsenhoff B.I. | 7.0 | 4.2 | 6.7 | 7.4 | 7.6 | 7.9 | 7.8 | 8.2 | 8.9 | 8.0 | 8.1 | 8.4 | 9.0 | 9.0 | 9.0 | 8.7 | 3.2 | - | - | 4.5 |
| %Dominant Taxa | 15 | 41 | 24 | 18 | 32 | 19 | 27 | 21 | 35 | 41 | 16 | 19 | 73 | 87 | 80 | 50 | 7 | - | - | - |

Results from fish shocking in Paradise Creek UAA study (IDHW-DEQ 1994) are in Table 9.

Table 9. Electrofishing Results in Paradise Creek

| Species | Amount | Size | Location |
|---|---|---|---|
| Speckled dace (*Rhinichthys osculus*) | > 50 | 1-3" | Mountain View Park[1], White & Troy Hwy., Guy Wicks Field |
| Bridgelip sucker (*Catostomus columbianus*) | 11 | 3-6" | White Avenue & Troy Highway |
| Longnose sucker (*Catostomus catostomus*) | 1 | 6" | White Avenue & Troy Highway |

[1]Shocking recovery estimated at 20% due to large amounts of duckweed on water surface

Fish resources within the Palouse River sub-basin are limited by long standing in-stream, riparian, and up-land habitat conditions, which have contributed to degraded water quality, extreme seasonal fluctuations in water quantity, and subsequent degraded in-stream habitat conditions. The existing fish community in the lower Palouse River (below Palouse Falls) consists of the salmonid species noted previously, as well as native resident species including largescale sucker *Catostomus macrocheilus*, redside shiner *Richardsonius balteatus*, northern pikeminnow *Ptychocheilus oregonensis*, and chiselmouth *Acrocheilus alutaceus*. Recent fish survey work conducted by WDFW below the Palouse Falls have confirmed the presence of sub-adult bull trout *Salvelinus confluentus*, rainbow trout / juvenile steelhead, tench *Tinca tinca*, bluegill *Lepomis macrochirus*, yellow perch *Perca flavescens*, northern pikeminnow, chiselmouth, redside shiner, and dace spp. (Cook 2001).

Historic stocks of native species that continue to inhabit the Palouse River above the falls include chiselmouth, northern pikeminnow, largescale sucker *Catostomus macrocheilus*, redside shiner, speckled dace *Rhinichthys osculus*, and cottid species. Thirty-seven fish species have been documented within the Palouse River sub-basin. No ESA listed species have been documented as occurring above the Palouse Falls. A synoptic list of fish species for the Palouse River sub-basin is listed in Table 10 below (Cook 2001).

Table 10. Fish species present in the Palouse Subbasin, Washington. (Cook, 2001)

| Species | Origin | Status |
|---|---|---|
| Bull trout (*Salvelinus confluentus*) * | N | U |
| Steelhead trout */ Rainbow trout (*Oncorhynchus mykiss*) | N | O/U |
| Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) | N | O/U |
| Fall Chinook salmon (*Oncorhynchus tshawytscha) **  | N | O/S |
| Mountain whitefish (*Prosopium williamsoni)* | N | O/U |
| Brook trout (*Salvelinus fontinalis)* | N | O/U |
| Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) | E | O/U |
| Brown trout (*Salmo trutta*) | E | O/U |
| Northern pikeminnow (*Ptychocheilus oregonensis)** | N | C/S |
| Speckled dace (*Rhinichthys osculus)** | N | C/U |
| Longnose dace (*Rhinichthys cataractae*)* | N | O/U |
| Redside shiner (*Richardsonius balteatus*)* | N | C/U |
| Chiselmouth (*Acrocheilus alutaceus*)* | N | O/U |
| Peamouth (*Mylocheilus caurinus*) | N | O/U |
| Largescale sucker (*Catostomus macrocheilus*) | N | O/U |
| Longnose sucker (*Catostomus catostomus)* | N | O/U |
| Bridgelip sucker (*Catostomus columbianus*) | N | C/S |
| Mountain sucker (*Catostomus platyrhynchus*) | N | O/U |
| Tench (*Tinca tinca*) | E | O/U |
| Walleye (*Sander vitreum*) | E | O/S |
| Largemouth bass (*Micropterus salmoides*)* | E | O/S |
| Brown bullhead (*Ictalurus nebulosus*)* | E | O/U |
| Yellow bullhead (*Ictalurus natalis*) | E | O/U |

| | | |
|---|---|---|
| Smallmouth bass (*Micropterus dolomieu*)* | E | O/S |
| Slimy sculpin (*Cottus cognatus*) | N | O/D |
| Mottled sculpin (*Cottus bairdi*)* | N | O/U |
| Brook stickleback (*Culaea inconstans*) | E | O/I |
| Piute sculpin (*Cottus beldingii*)* (cottid species identification / location(s) in question) | N | C/U |
| Torrent sculpin (*Cottus rhotheus*) | N | O/U |
| Goldfish (*Carassius auratus*) | E | O/U |
| Yellow perch (*Perca flavescens*)* | E | O/U |
| Carp (*Cyprinus carpio*)* | E | C/U |
| Bluegill (*Lepomis macrochirus*)* | E | O/U |
| Crappie (*Pomoxis spp.*)* | E | O/S |
| Channel catfish (*Ictalurus punctatus*) | E | O/S |
| Grass pickerel (*Esox americanus vermiculatus*) | E | O/U |
| Pumpkinseed (*Lepomis gibbosus*) | E | O/U |

***E=Exotic, N=Native, A=Abundant, C=Common, O=Occasional, U=Unknown, S=Stable, I=Increasing, D=Decreasing, * denotes presence below Palouse Falls***

Population densities of rainbow trout in the sub-basin are primarily related to stocking of trout made by past and present fish management agencies in bodies of water such as Chapman Lake, Rock Lake, Sprague Lake, other lowland lakes within the Cow Creek and Rock Creek drainage(s), and Union Flat Creek. Limited natural trout spawning is known to occur in portions of Rock Creek. Rainbow trout are also known to naturally reproduce in portions of Union Flat Creek (Cook 2001).

Stream habitat usage by resident salmonids is dictated by the extremely few locations within the Palouse River sub-basin where agriculture, grazing, road building, and logging practices have not significantly altered habitat conditions such that salmonids can survive. There are a small number of tributaries to the Palouse River, which exhibit isolated reaches of relatively intact natural habitats and which contain self-sustaining wild populations of salmonids. The distribution and relative abundance of resident salmonids, including possibly native redband rainbow trout, within the watershed is generally unknown. Rainbow trout from several origins have been introduced throughout the Palouse Sub-basin. WDFW has regularly stocked rainbow trout in to Chapman Lake, Rock Lake, Williams Lake, Hog Canyon Lake, Fish Trap Lake, Sprague Lake and other smaller water bodies within the sub-basin. No genetic analysis of resident rainbow trout has been conducted to determine the possible remnant presence of redband rainbow trout (Cook 2001).

The first stocking of rainbow trout occurred in 1950 in the Palouse River, Idaho. The size of rainbow trout stocked has been "catchable" (8-12 inches), to provide an immediate return to the creel. There is evidence that natural reproduction is occurring, as they have been recently sampled in streams where stocking never occurred, or is no longer occurring (IA1). Stock of rainbow planted has varied over the years depending on egg availability (Cook 2001).

Reportedly, Paradise Creek has supported several species of trout over the past century. During a recent Beneficial Use Attainability Study, a quote was included that states brook trout are currently being supported by Paradise Creek and its tributaries in the Palouse Mountain Range (Wertz 1993). There have also been reports of rainbow trout being caught near Reaney Park in Pullman. These trout are likely released into Paradise Creek following a fish derby which takes place in Reaney Park Swimming pool each fall. Pullman Park and Recreation employees believe that some children release the trout that they have caught at the fish derby into Paradise Creek. If rainbow trout are, in fact, released to Paradise Creek, they likely migrate out of Paradise Creek to the SFPR to seek deeper, cooler waters with a higher dissolved oxygen concentration (Doke and Hashmi 1994).

**c. Current Conditions**

Field collected information from late summer 2010 (September 22 through October 1) is included in the Final Technical Report.

## NEXT STEPS

### a. Identify spatial distribution of fish species and other biological communities

Information extracted from available literature and reported in this Technical Memorandum will be transferred to appropriate sections of the Final Technical Report. Reconstruction of fish population distribution throughout the drainage is a primary component of this study and identification of factors that could reasonably explain any distributional differences between two successive time periods is the goal. This information will determine the characteristics of a biological community upon which future restoration goals will be based.

### b. Attribute changes in biological communities explained by environmental information

Comparisons of biological communities and the amount of difference between two successive time periods will be initially identified. The reason for these differences will be closely examined with available information collected in the literature survey for each time period. Significant shifts of instream conditions or in land use practices will be considered as reasons for temporal changes in biological communities. The changes in attributes between time periods may be the primary factors that limit migratory distribution of current species that are managed, in part, using water quality criteria. This determination will inform on whether the current water quality criteria appropriately represent original biological community expectations or if characteristics of the community were different from the current focus.

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# APPENDIX C. CURRENT INSTREAM BIOLOGICAL CHARACTERIZATION SAMPLING SITE SUMMARY INFORMATION

| Site: SFPR-033355 | State: Washington | Lat.: | 46.865166 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /22/2010 | Long.: | -117.332451 |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 7.4 | |
| Est. Mean Depth (m) | 0.5 | |
| Length (m) | 160 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 12.67 | |
| pH | 8.05 | |
| Dissolved Oxygen (mg/l) | 9.98 | |
| Conductivity (µs/cm) | 560.8 | |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 16 |
| Pool Substrate Charact. | 16 |
| Pool Variability | 13 |
| Sediment Deposition | 18 |
| Channel Flow Status | 18 |
| Channel Alteration | 20 |
| Channel Sinuosity | 9 |
| Bank Stability (L) | 7 |
| Bank Stability (R) | 6 |
| Vegetative Protection (L) | 1 |
| Vegetative Protection (R) | 1 |
| Riparian Vegetative Zone (L) | 7 |
| Riparian Vegetative Zone (R) | 9 |
| **Total Score** | **141** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Catostomus columbianus* | 15 | 122 | 160 |
| *Acrocheilus alutaceus* | 26 | 118 | 128 |
| *Catostomus macrocheilus* | 42 | 113 | 186 |
| *Ptychocheilus oregonensis* | 81 | 82 | 214 |
| *Richardsonius balteatus* | 275 | 60 | 113 |
| *Rhinichthys osculus* | 464 | 47 | 90 |
| **Total Number** | **903** | | |
| **Total Biomass (g)** | **5,572** | | |

**Benthic Macroinvertebrate Taxa**

NA

| Site: SFPR-033355 | State: Washington | Lat.: | 46.865166 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /22/2010 | Long.: | -117.332451 |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | NA | NA | NA |
| Center looking Left Bank | NA | NA | NA |
| Center looking Downstream | NA | NA | NA |
| Center looking Right Bank | NA | NA | NA |
| Left Bank | NA | NA | NA |
| Right Bank | NA | NA | NA |
| **Total** | NA | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 0 |
| Percent Sand | 9 |
| Percent Gravel | 26 |
| Percent Cobble | 12 |
| Percent Boulder | 53 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **100** |

| Site: SFPR-098891 | State: Washington | Lat.: | 46.865718 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /28/2010 | Long.: | -117.3125 |

| Reach Characteristics | | |
|---|---|---|
| Mean Wetted Width (m) | 9.1 | |
| Est. Mean Depth (m) | 0.8 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 15.33 | 16.7 |
| pH | 7.97 | 8.21 |
| Dissolved Oxygen (mg/l) | 8.5 | 11.76 |
| Conductivity (µs/cm) | 563.9 | 556.4 |

| Physical Habitat | |
|---|---|
| Epifaunal Substrate | 11 |
| Pool Substrate Charact. | 15 |
| Pool Variability | 11 |
| Sediment Deposition | 7 |
| Channel Flow Status | 13 |
| Channel Alteration | 10 |
| Channel Sinuosity | 6 |
| Bank Stability (L) | 7 |
| Bank Stability (R) | 4 |
| Vegetative Protection (L) | 1 |
| Vegetative Protection (R) | 1 |
| Riparian Vegetative Zone (L) | 3 |
| Riparian Vegetative Zone (R) | 2 |
| **Total Score** | **91** |

| Fish | Number | Min. (mm) | Max. (mm) |
|---|---|---|---|
| *Catostomus columbianus* | 4 | 115 | 149 |
| *Acrocheilus alutaceus* | 6 | 95 | 122 |
| *Catostomus macrocheilus* | 24 | 134 | 142 |
| *Ptychocheilus oregonensis* | 11 | 71 | 205 |
| *Richardsonius balteatus* | 259 | 64 | 115 |
| *Rhinichthys osculus* | 165 | 52 | 91 |
| **Total Number** | **469** | | |
| **Total Biomass (g)** | **2,765** | | |

| Benthic Macroinvertebrate Taxa | Number |
|---|---|
| *Baetis tricaudatus* | 1 |
| *Fallceon quilleri* | 9 |
| *Tricorythodes sp.* | 142 |
| *Argia sp.* | 21 |
| *Coenagrion/Enallagma sp.* | 20 |
| *Dubiraphia sp.* | 24 |
| *Microcylloepus sp.* | 12 |
| *Optioservus sp.* | 89 |
| *Apedilum sp.* | 3 |
| *Cricotopus bicinctus gr.* | 5 |
| *Cricotopus sp.* | 3 |
| *Dicrotendipes sp.* | 3 |
| *Polypedilum sp.* | 1 |
| *Potthastia longimana gr.* | 1 |
| *Pseudochironomus sp.* | 2 |
| *Rheotanytarsus sp.* | 2 |

| | | | |
|---|---|---|---|
| **Site: SFPR-098891** | **State: Washington** | **Lat.:** | **46.865718** |
| **Stream: South Fork Palouse River** | **Date: 09 /28/2010** | **Long.:** | **-117.3312** |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 0 |
| Center looking Left Bank | 0 | 0 | 0 |
| Center looking Downstream | 0 | 0 | 0 |
| Center looking Right Bank | 0 | 0 | 0 |
| Left Bank | 2 | 0 | 0 |
| Right Bank | 3 | 0 | 0 |
| **Total** | **5** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 5 |
| Percent Sand | 0 |
| Percent Gravel | 73 |
| Percent Cobble | 11 |
| Percent Boulder | 5 |
| Percent Bedrock/Hardpan | 6 |
| **Total** | **100** |

| **Benthic Macroinvertebrate Taxa (cont)** | **Number** |
|---|---|
| *Tanytarsus sp.* | 4 |
| *Thienemanniella sp.* | 1 |
| *Hemerodromia sp.* | 4 |
| *Simulium sp.* | 1 |
| *Helicopsyche sp.* | 6 |
| Hydroptilidae | 3 |
| *Mystacides alafimbriata* | 6 |
| *Nectopsyche sp.* | 28 |
| *Oecetis avara* | 12 |
| *Petrophila sp.* | 2 |
| *Gyraulus sp.* | 14 |
| *Physa sp.* | 1 |
| *Pisidium sp.* | 3 |
| *Erpobdella sp.* | 2 |
| Oligochaeta | 52 |
| *Hygrobates sp.* | 26 |
| *Lebertia sp.* | 11 |
| *Limnesia sp.* | 14 |
| *Mideopsis sp.* | 1 |
| *Crangonyx sp.* | 7 |
| *Prostoma sp.* | 1 |
| Turbellaria | 66 |
| **Total** | **603** |

| | | | |
|---|---|---|---|
| **Site: SFPR-127307** | **State: Washington** | **Lat.:** | **46.838252** |
| **Stream: South Fork Palouse River** | **Date: 09 /28/2010** | **Long.:** | **-117.284617** |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 7.3 | |
| Est. Mean Depth (m) | 1.1 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 17.72 | 18.24 |
| pH | 7.74 | 8.03 |
| Dissolved Oxygen (mg/l) | 11.22 | 12.22 |
| Conductivity (µs/cm) | 611.5 | 603.8 |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 14 |
| Pool Substrate Charact. | 18 |
| Pool Variability | 11 |
| Sediment Deposition | 12 |
| Channel Flow Status | 20 |
| Channel Alteration | 19 |
| Channel Sinuosity | 9 |
| Bank Stability (L) | 5 |
| Bank Stability (R) | 6 |
| Vegetative Protection (L) | 1 |
| Vegetative Protection (R) | 1 |
| Riparian Vegetative Zone (L) | 1 |
| Riparian Vegetative Zone (R) | 8 |
| **Total Score** | **125** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Acrocheilus alutaceus* | 6 | 94 | 109 |
| *Catostomus macrocheilus* | 11 | 118 | 148 |
| *Ptychocheilus oregonensis* | 1 | 70 | 0 |
| *Lepomis gibbosus* | 1 | 92 | 0 |
| *Richardsonius balteatus* | 52 | 35 | 115 |
| *Rhinichthys osculus* | 55 | 48 | 69 |
| **Total Number** | **126** | | |
| **Total Biomass (g)** | **1,028** | | |

**Benthic Macroinvertebrate Taxa**

NA

| Site: SFPR-127307 | State: Washington | Lat.: | 46.838252 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /28/2010 | Long.: | -117.284617 |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 0 | 1 | 2 |
| Center looking Left Bank | 0 | 0 | 0 |
| Center looking Downstream | 0 | 1 | 0 |
| Center looking Right Bank | 1 | 1 | 3 |
| Left Bank | 0 | 0 | 3 |
| Right Bank | 1 | 5 | 12 |
| **Total** | **30** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 17 |
| Percent Sand | 0 |
| Percent Gravel | 51 |
| Percent Cobble | 10 |
| Percent Boulder | 11 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **89** |

| | | | |
|---|---|---|---|
| **Site: SFPR-051531** | **State: Washington** | **Lat.:** | **46.787689** |
| **Stream: South Fork Palouse River** | **Date: 09 /29/2010** | **Long.:** | **-117.257404** |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 7.9 | |
| Est. Mean Depth (m) | 0.5 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 15.5 | 16.32 |
| pH | 7.64 | 7.76 |
| Dissolved Oxygen (mg/l) | 6.27 | 8.18 |
| Conductivity (µs/cm) | 643.2 | 647.4 |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 13 |
| Pool Substrate Charact. | 12 |
| Pool Variability | 12 |
| Sediment Deposition | 13 |
| Channel Flow Status | 16 |
| Channel Alteration | 17 |
| Channel Sinuosity | 8 |
| Bank Stability (L) | 6 |
| Bank Stability (R) | 8 |
| Vegetative Protection (L) | 2 |
| Vegetative Protection (R) | 2 |
| Riparian Vegetative Zone (L) | 3 |
| Riparian Vegetative Zone (R) | 3 |
| **Total Score** | **115** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Catostomus columbianus* | 12 | 139 | 207 |
| *Acrocheilus alutaceus* | 19 | 88 | 159 |
| *Catostomus macrocheilus* | 59 | 119 | 211 |
| *Ptychocheilus oregonensis* | 40 | 77 | 165 |
| *Richardsonius balteatus* | 136 | 64 | 128 |
| *Rhinichthys osculus* | 186 | 65 | 77 |
| **Total Number** | **452** | | |
| **Total Biomass (g)** | **4,341** | | |

**Benthic Macroinvertebrate Taxa**

NA

| | | | |
|---|---|---|---|
| **Site: SFPR-051531** | **State: Washington** | **Lat.:** | **46.787689** |
| **Stream: South Fork Palouse River** | **Date: 09 /29/2010** | **Long.:** | **-117.257404** |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 0 |
| Center looking Left Bank | 0 | 13 | 0 |
| Center looking Downstream | 0 | 2 | 0 |
| Center looking Right Bank | 0 | 0 | 3 |
| Left Bank | 0 | 0 | 0 |
| Right Bank | 0 | 0 | 0 |
| **Total** | **18** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 18 |
| Percent Sand | 0 |
| Percent Gravel | 54 |
| Percent Cobble | 15 |
| Percent Boulder | 2 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **89** |

| Site: SFPR-106827 | State: Washington | Lat.: | 46.75549 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /29/2010 | Long.: | -117.216619 |

| Reach Characteristics | | |
|---|---|---|
| Mean Wetted Width (m) | 7.9 | |
| Est. Mean Depth (m) | 0.7 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 18.42 | 19.44 |
| pH | 8.05 | 8.39 |
| Dissolved Oxygen (mg/l) | 12.78 | 14.5 |
| Conductivity (µs/cm) | 677.6 | 666.5 |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 18 |
| Pool Substrate Charact. | 17 |
| Pool Variability | 12 |
| Sediment Deposition | 8 |
| Channel Flow Status | 8 |
| Channel Alteration | 10 |
| Channel Sinuosity | 6 |
| Bank Stability (L) | 4 |
| Bank Stability (R) | 3 |
| Vegetative Protection (L) | 2 |
| Vegetative Protection (R) | 3 |
| Riparian Vegetative Zone (L) | 3 |
| Riparian Vegetative Zone (R) | 4 |
| **Total Score** | **98** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Catostomus columbianus* | 22 | 135 | 112 |
| *Acrocheilus alutaceus* | 244 | 113 | 206 |
| *Catostomus macrocheilus* | 3 | 166 | 190 |
| *Ptychocheilus oregonensis* | 79 | 72 | 230 |
| *Richardsonius balteatus* | 240 | 69 | 147 |
| *Rhinichthys osculus* | 197 | 52 | 91 |
| **Total Number** | **785** | | |
| **Total Biomass (g)** | **10,150** | | |

| **Benthic Macroinvertebrate Taxa** | **Number** |
|---|---|
| *Baetis tricaudatus* | 2 |
| *Caenis sp.* | 1 |
| *Tricorythodes sp.* | 3 |
| *Argia sp.* | 1 |
| *Coenagrionidae* | 54 |
| Dubiraphia sp. | 1 |
| *Optioservus sp.* | 17 |
| *Cricotopus bicinctus gr.* | 3 |
| *Cricotopus sp.* | 8 |
| *Cricotopus trifascia gr.* | 104 |
| *Dicrotendipes sp.* | 21 |
| *Orthocladius sp.* | 16 |
| *Paratanytarsus sp.* | 22 |
| *Phaenopsectra sp.* | 1 |
| *Potthastia longimana gr.* | 1 |
| *Pseudochironomus sp.* | 1 |

| Site: SFPR-106827 | State: Washington | Lat.: | 46.75549 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /29/2010 | Long.: | -117.216619 |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 0 |
| Center looking Left Bank | 0 | 0 | 3 |
| Center looking Downstream | 0 | 0 | 0 |
| Center looking Right Bank | 0 | 0 | 0 |
| Left Bank | 1 | 0 | 8 |
| Right Bank | 0 | 0 | 2 |
| **Total** | **14** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 8 |
| Percent Sand | 0 |
| Percent Gravel | 49 |
| Percent Cobble | 37 |
| Percent Boulder | 6 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **100** |

| **Benthic Macroinvertebrate Taxa (cont)** | **Number** |
|---|---|
| *Rheotanytarsus sp.* | 4 |
| *Thienemanniella sp.* | 1 |
| *Bezzia/Palpomyia sp.* | 1 |
| *Hemerodromia sp.* | 15 |
| *Simulium sp.* | 11 |
| *Hydropsyche sp.* | 1 |
| Hydroptilidae | 3 |
| *Mystacides alafimbriata* | 6 |
| Sphaeriidae | 5 |
| Oligochaeta | 20 |
| *Hygrobates sp.* | 17 |
| *Lebertia sp.* | 124 |
| *Limnesia sp.* | 1 |
| *Sperchon sp.* | 5 |
| *Crangonyx sp.* | 76 |
| Nematoda | 1 |
| *Prostoma sp.* | 1 |
| Turbellaria | 16 |
| **Total Number** | **564** |

| Site: SFPR-057675 | State: Washington | Lat.: | 46.72413 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /30/2010 | Long.: | -117.168426 |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 5.7 | |
| Est. Mean Depth (m) | 0.7 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 12.57 | 12.83 |
| pH | 7.76 | 7.85 |
| Dissolved Oxygen (mg/l) | 7.93 | 8.74 |
| Conductivity (µs/cm) | 669 | 687.9 |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 12 |
| Pool Substrate Charact. | 13 |
| Pool Variability | 11 |
| Sediment Deposition | 8 |
| Channel Flow Status | 16 |
| Channel Alteration | 12 |
| Channel Sinuosity | 7 |
| Bank Stability (L) | 3 |
| Bank Stability (R) | 3 |
| Vegetative Protection (L) | 2 |
| Vegetative Protection (R) | 2 |
| Riparian Vegetative Zone (L) | 4 |
| Riparian Vegetative Zone (R) | 3 |
| **Total Score** | **96** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Catostomus columbianus* | 45 | 80 | 192 |
| *Acrocheilus alutaceus* | 3 | 160 | 206 |
| *Catostomus macrocheilus* | 19 | 114 | 195 |
| *Ptychocheilus oregonensis* | 27 | 116 | 233 |
| *Richardsonius balteatus* | 139 | 59 | 133 |
| *Rhinichthys osculus* | 11 | 64 | 97 |
| **Total Number** | **244** | | |
| **Total Biomass (g)** | **5,216** | | |

| **Benthic Macroinvertebrate Taxa** | **Number** |
|---|---|
| *Baetis tricaudatus* | 22 |
| Coenagrionidae | 6 |
| *Dubiraphia sp.* | 8 |
| *Optioservus sp.* | 97 |
| *Chironomus sp.* | 5 |
| *Cricotopus trifascia gr.* | 1 |
| *Cryptochironomus sp.* | 19 |
| *Dicrotendipes sp.* | 38 |
| *Eukiefferiella sp.* | 1 |
| *Micropsectra sp.* | 12 |
| *Parakiefferiella sp.* | 22 |
| *Parametriocnemus sp.* | 1 |
| *Paratanytarsus sp.* | 4 |
| *Phaenopsectra sp.* | 3 |
| *Procladius sp.* | 9 |
| *Tanytarsus sp.* | 9 |

| Site: SFPR-057675 | State: Washington | Lat.: | 46.72413 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /30/2010 | Long.: | -117.168426 |

| Densiometer | Down | Mid | Up |
|---|---|---|---|
| Center looking Upstream | 14 | 17 | 3 |
| Center looking Left Bank | 3 | 17 | 0 |
| Center looking Downstream | 16 | 16 | 0 |
| Center looking Right Bank | 17 | 17 | 0 |
| Left Bank | 0 | 17 | 0 |
| Right Bank | 17 | 17 | 0 |
| **Total** | **171** | | |

| Substrate Composition | |
|---|---|
| Percent Fines | 34 |
| Percent Sand | 0 |
| Percent Gravel | 35 |
| Percent Cobble | 19 |
| Percent Boulder | 11 |
| Percent Bedrock/Hardpan | 10 |
| **Total** | **109** |

| Benthic Macroinvertebrate Taxa (cont) | Number |
|---|---|
| *Thienemannimyia gr. sp.* | 2 |
| *Bezzia/Palpomyia sp.* | 2 |
| *Hemerodromia sp.* | 6 |
| *Pericoma/Telmatoscopus sp.* | 1 |
| *Probezzia sp.* | 5 |
| *Hydropsyche sp.* | 2 |
| *Mystacides alafimbriata* | 21 |
| *Physa sp.* | 1 |
| *Pisidium sp.* | 6 |
| *Erpobdella sp.* | 1 |
| Oligochaeta | 132 |
| *Hygrobates sp.* | 1 |
| *Lebertia sp.* | 87 |
| *Sperchon sp.* | 4 |
| *Crangonyx sp.* | 13 |
| Ostracoda | 21 |
| *Prostoma sp.* | 1 |
| Turbellaria | 82 |
| **Total Number** | **645** |

| Site: SFPR-123211 | State: Washington | Lat.: | 46.706892 |
| --- | --- | --- | --- |
| Stream: South Fork Palouse River | Date: 09 /30/2010 | Long.: | -117.163538 |

| **Reach Characteristics** | | |
| --- | --- | --- |
| Mean Wetted Width (m) | 3.9 | |
| Est. Mean Depth (m) | 0.8 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 13.25 | 15.9 |
| pH | 7.6 | 7.75 |
| Dissolved Oxygen (mg/l) | 7.79 | 10.38 |
| Conductivity (µs/cm) | 371.5 | 366.2 |

| **Physical Habitat** | |
| --- | --- |
| Epifaunal Substrate | 13 |
| Pool Substrate Charact. | 8 |
| Pool Variability | 11 |
| Sediment Deposition | 11 |
| Channel Flow Status | 12 |
| Channel Alteration | 13 |
| Channel Sinuosity | 9 |
| Bank Stability (L) | 3 |
| Bank Stability (R) | 3 |
| Vegetative Protection (L) | 1 |
| Vegetative Protection (R) | 1 |
| Riparian Vegetative Zone (L) | 7 |
| Riparian Vegetative Zone (R) | 4 |
| **Total Score** | **96** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
| --- | --- | --- | --- |
| *Catostomus columbianus* | 60 | 80 | 175 |
| *Catostomus macrocheilus* | 28 | 35 | 121 |
| *Ptychocheilus oregonensis* | 18 | 119 | 201 |
| *Richardsonius balteatus* | 183 | 34 | 129 |
| *Rhinichthys osculus* | 223 | 52 | 67 |
| **Total Number** | **512** | | |
| **Total Biomass (g)** | **4,184** | | |

| **Benthic Macroinvertebrate Taxa** | **Number** |
| --- | --- |
| *Callibaetis sp.* | 1 |
| *Coenagrion/Enallagma sp.* | 20 |
| *Taeniopteryx sp.* | 2 |
| *Dubiraphia sp.* | 4 |
| *Optioservus sp.* | 18 |
| *Sialis sp.* | 1 |
| *Chironomus sp.* | 31 |
| *Cricotopus bicinctus gr.* | 2 |
| *Cricotopus sp.* | 1 |
| *Cryptochironomus sp.* | 13 |
| *Dicrotendipes sp.* | 116 |
| *Limnophyes sp.* | 1 |
| *Parakiefferiella sp.* | 12 |
| *Paratanytarsus sp.* | 4 |
| *Paratendipes sp.* | 1 |
| *Polypedilum sp.* | 1 |
| *Potthastia longimana gr.* | 3 |

| Site: SFPR-123211 | State: Washington | Lat.: | 46.706892 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /30/2010 | Long.: | -117.163538 |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 0 |
| Center looking Left Bank | 0 | 0 | 0 |
| Center looking Downstream | 0 | 0 | 0 |
| Center looking Right Bank | 17 | 0 | 0 |
| Left Bank | 0 | 0 | 0 |
| Right Bank | 17 | 0 | 0 |
| **Total** | **34** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 39 |
| Percent Sand | 0 |
| Percent Gravel | 29 |
| Percent Cobble | 24 |
| Percent Boulder | 8 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **100** |

| **Benthic Macroinvertebrate Taxa (cont)** | **Number** |
|---|---|
| *Procladius sp.* | 5 |
| *Tanytarsus sp.* | 25 |
| *Bezzia/Palpomyia sp.* | 9 |
| *Ceratopogoninae* | 6 |
| *Hemerodromia sp.* | 7 |
| *Mystacides alafimbriata* | 24 |
| *Pisidium sp.* | 16 |
| Oligochaeta | 53 |
| *Hygrobates sp.* | 4 |
| *Lebertia sp.* | 32 |
| *Sperchon sp.* | 2 |
| *Crangonyx sp.* | 3 |
| Ostracoda | 29 |
| Nematoda | 3 |
| Turbellaria | 25 |
| **Total Number** | **474** |

| Site: SFPR-031051 | State: Washington | Lat.: | 46.680996 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /25/2010 | Long.: | -117.097929 |

| Reach Characteristics | | |
|---|---|---|
| Mean Wetted Width (m) | 3.3 | |
| Est. Mean Depth (m) | 1.1 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 11.62 | 13.41 |
| pH | 7 | 6.96 |
| Dissolved Oxygen (mg/l) | 6.49 | 6.48 |
| Conductivity (µs/cm) | 308.6 | 292.3 |

| Physical Habitat | |
|---|---|
| Epifaunal Substrate | 13 |
| Pool Substrate Charact. | 11 |
| Pool Variability | 11 |
| Sediment Deposition | 19 |
| Channel Flow Status | 18 |
| Channel Alteration | 14 |
| Channel Sinuosity | 10 |
| Bank Stability (L) | 7 |
| Bank Stability (R) | 7 |
| Vegetative Protection (L) | 1 |
| Vegetative Protection (R) | 1 |
| Riparian Vegetative Zone (L) | 5 |
| Riparian Vegetative Zone (R) | 5 |
| **Total Score** | **122** |

| Fish | Number | Min. (mm) | Max. (mm) |
|---|---|---|---|
| *Catostomus columbianus* | 4 | 59 | 130 |
| *Pimephales promelas* | 1 | 82 | 0 |
| *Ptychocheilus oregonensis* | 1 | 107 | 0 |
| *Richardsonius balteatus* | 36 | 61 | 113 |
| *Rhinichthys osculus* | 14 | 45 | 89 |
| **Total Number** | **56** | | |
| **Total Biomass (g)** | **155** | | |

| Benthic Macroinvertebrate Taxa | Number |
|---|---|
| *Callibaetis sp.* | 2 |
| *Coenagrion/Enallagma sp.* | 37 |
| *Taeniopteryx sp.* | 2 |
| *Sigara sp.* | 1 |
| *Dubiraphia sp.* | 15 |
| *Optioservus sp.* | 12 |
| *Sialis sp.* | 11 |
| *Brillia sp.* | 23 |
| *Chironomus sp.* | 13 |
| *Dicrotendipes sp.* | 14 |
| *Diplocladius sp.* | 1 |
| *Paratanytarsus sp.* | 7 |
| *Phaenopsectra sp.* | 6 |
| *Polypedilum sp.* | 17 |
| *Potthastia longimana gr.* | 10 |
| *Procladius sp.* | 10 |
| *Psectrotanypus sp.* | 1 |

| Site: SFPR-031051 | State: Washington | Lat.: | 46.680996 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /25/2010 | Long.: | -117.097929 |

| Densiometer | Down | Mid | Up |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 0 |
| Center looking Left Bank | 0 | 0 | 15 |
| Center looking Downstream | 0 | 0 | 0 |
| Center looking Right Bank | 0 | 0 | 0 |
| Left Bank | 0 | 2 | 17 |
| Right Bank | 0 | 0 | 0 |
| **Total** | **34** | | |

| Substrate Composition | |
|---|---|
| Percent Fines | 41 |
| Percent Sand | 1 |
| Percent Gravel | 45 |
| Percent Cobble | 6 |
| Percent Boulder | 3 |
| Percent Bedrock/Hardpan | 4 |
| **Total** | **100** |

| Benthic Macroinvertebrate Taxa (cont) | Number |
|---|---|
| *Radotanypus sp.* | 2 |
| *Tanytarsus sp.* | 15 |
| *Thienemannimyia gr. sp.* | 7 |
| Ceratopogoninae | 3 |
| *Dixella sp.* | 1 |
| *Neoplasta sp.* | 1 |
| *Mystacides alafimbriata* | 7 |
| *Ferrissia rivularis* | 5 |
| *Gyraulus sp.* | 113 |
| *Physa sp.* | 9 |
| *Radix auricularia* | 15 |
| *Musculium sp.* | 2 |
| *Pisidium sp.* | 91 |
| Oligochaeta | 8 |
| *Lebertia sp.* | 69 |
| *Sperchon sp.* | 4 |
| *Crangonyx sp.* | 5 |
| Ostracoda | 1 |
| **Total Number** | **540** |

| | | | |
|---|---|---|---|
| **Site: SFPR-137547** | **State: Idaho** | **Lat.:** | **46.714705** |
| **Stream: South Fork Palouse River** | **Date: 09 /25/2010** | **Long.:** | **-117.024193** |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 4.3 | |
| Est. Mean Depth (m) | 0.9 | |
| Length (m) | 150 | |

| **Water Quality** | **Start** | Finish |
|---|---|---|
| Temperature (°C) | 14.63 | 13.43 |
| pH | 6.72 | 6.75 |
| Dissolved Oxygen (mg/l) | 8.05 | 7.17 |
| Conductivity (µs/cm) | 323.5 | 323.8 |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 7 |
| Pool Substrate Charact. | 8 |
| Pool Variability | 12 |
| Sediment Deposition | 7 |
| Channel Flow Status | 8 |
| Channel Alteration | 14 |
| Channel Sinuosity | 11 |
| Bank Stability (L) | 6 |
| Bank Stability (R) | 4 |
| Vegetative Protection (L) | 3 |
| Vegetative Protection (R) | 3 |
| Riparian Vegetative Zone (L) | 2 |
| Riparian Vegetative Zone (R) | 2 |
| **Total Score** | **87** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Catostomus columbianus* | 93 | 75 | 167 |
| *Catostomus macrocheilus* | 8 | 183 | 99 |
| *Richardsonius balteatus* | 96 | 34 | 91 |
| *Rhinichthys osculus* | 36 | 47 | 79 |
| **Total Number** | **233** | | |
| **Total Biomass (g)** | **1,951** | | |

**Benthic Macroinvertebrate Taxa**

NA

| | | | |
|---|---|---|---|
| **Site: SFPR-137547** | **State: Idaho** | **Lat.:** | **46.714705** |
| **Stream: South Fork Palouse River** | **Date: 09 /25/2010** | **Long.:** | **-117.024193** |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 0 | 17 | 0 |
| Center looking Left Bank | 0 | 16 | 10 |
| Center looking Downstream | 0 | 14 | 14 |
| Center looking Right Bank | 0 | 16 | 15 |
| Left Bank | 0 | 16 | 9 |
| Right Bank | 0 | 17 | 7 |
| **Total** | **151** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 33 |
| Percent Sand | 13 |
| Percent Gravel | 28 |
| Percent Cobble | 8 |
| Percent Boulder | 4 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **86** |

| Site: SFPR-126994 | State: Idaho | Lat.: | 46.746714 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /26/2010 | Long.: | -116.927215 |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 1.5 | |
| Est. Mean Depth (m) | 0.7 | |
| Length (m) | 150 | |
| | | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 11.56 | 11.57 |
| pH | 6.23 | 6.36 |
| Dissolved Oxygen (mg/l) | 8.73 | 8.15 |
| Conductivity (µs/cm) | 71.6 | 72.2 |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 16 |
| Pool Substrate Charact. | 15 |
| Pool Variability | 17 |
| Sediment Deposition | 17 |
| Channel Flow Status | 14 |
| Channel Alteration | 16 |
| Channel Sinuosity | 14 |
| Bank Stability (L) | 5 |
| Bank Stability (R) | 5 |
| Vegetative Protection (L) | 1 |
| Vegetative Protection (R) | 1 |
| Riparian Vegetative Zone (L) | 2 |
| Riparian Vegetative Zone (R) | 2 |
| **Total Score** | **125** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Pimephales promelas* | 2 | 72 | 77 |
| *Oncorhynchus mykiss* | 4 | 83 | 182 |
| *Rhinichthys osculus* | 27 | 43 | 69 |
| **Total Number** | **33** | | |
| **Total Biomass (g)** | **210** | | |

**Benthic Macroinvertebrate Taxa**

NA

| Site: SFPR-126994 | State: Idaho | Lat.: | 46.746714 |
|---|---|---|---|
| Stream: South Fork Palouse River | Date: 09 /26/2010 | Long.: | -116.927215 |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 0 |
| Center looking Left Bank | 0 | 0 | 0 |
| Center looking Downstream | 0 | 0 | 0 |
| Center looking Right Bank | 0 | 0 | 0 |
| Left Bank | 0 | 0 | 0 |
| Right Bank | 0 | 0 | 0 |
| **Total** | **0** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 34 |
| Percent Sand | 7 |
| Percent Gravel | 57 |
| Percent Cobble | 2 |
| Percent Boulder | 0 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **100** |

| Site: SFPR-008523 | State: Washington | Lat.: | 46.736617 |
|---|---|---|---|
| Stream: Missouri Flat Creek | Date: 09 /26/2010 | Long.: | -117.17504 |

| Reach Characteristics | | |
|---|---|---|
| Mean Wetted Width (m) | 1.5 | |
| Est. Mean Depth (m) | 1.2 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 13.3 | 14.08 |
| pH | 7.32 | 7.34 |
| Dissolved Oxygen (mg/l) | 6.93 | 7.57 |
| Conductivity (µs/cm) | 464.3 | 490.4 |

| Physical Habitat | |
|---|---|
| Epifaunal Substrate | 16 |
| Pool Substrate Charact. | 12 |
| Pool Variability | 13 |
| Sediment Deposition | 7 |
| Channel Flow Status | 13 |
| Channel Alteration | 5 |
| Channel Sinuosity | 2 |
| Bank Stability (L) | 3 |
| Bank Stability (R) | 3 |
| Vegetative Protection (L) | 1 |
| Vegetative Protection (R) | 1 |
| Riparian Vegetative Zone (L) | 1 |
| Riparian Vegetative Zone (R) | 1 |
| **Total Score** | **78** |

| Fish | Number | Min. (mm) | Max. (mm) |
|---|---|---|---|
| *Catostomus columbianus* | 1 | 74 | 0 |
| *Catostomus macrocheilus* | 2 | 132 | 173 |
| *Ptychocheilus oregonensis* | 31 | 91 | 216 |
| *Richardsonius balteatus* | 21 | 58 | 96 |
| *Rhinichthys osculus* | 20 | 46 | 82 |
| **Total Number** | **75** | | |
| **Total Biomass (g)** | **796** | | |

| Benthic Macroinvertebrate Taxa | Number |
|---|---|
| *Aeshna sp.* | 3 |
| Coenagrionidae | 22 |
| *Brillia sp.* | 3 |
| *Cricotopus sp.* | 1 |
| *Cryptochironomus sp.* | 1 |
| *Dicrotendipes sp.* | 4 |
| *Limnophyes sp.* | 3 |
| *Parakiefferiella sp.* | 2 |
| *Paratanytarsus sp.* | 20 |
| *Phaenopsectra sp.* | 18 |
| *Psectrocladius sp.* | 1 |
| *Tanytarsus sp.* | 17 |
| *Thienemanniella sp.* | 1 |
| *Thienemannimyia gr. sp.* | 8 |
| Ceratopogoninae | 1 |
| *Hemerodromia sp.* | 1 |
| *Neoplasta sp.* | 3 |

| Site: SFPR-008523 | State: Washington | Lat.: | 46.736617 |
|---|---|---|---|
| Stream: Missouri Flat Creek | Date: 09 /26/2010 | Long.: | -117.17504 |

| Densiometer | Down | Mid | Up |
|---|---|---|---|
| Center looking Upstream | 7 | 3 | 5 |
| Center looking Left Bank | 0 | 1 | 0 |
| Center looking Downstream | 0 | 0 | 7 |
| Center looking Right Bank | 0 | 1 | 0 |
| Left Bank | 0 | 0 | 17 |
| Right Bank | 0 | 3 | 0 |
| **Total** | **44** | | |

| Substrate Composition | |
|---|---|
| Percent Fines | 32 |
| Percent Sand | 0 |
| Percent Gravel | 36 |
| Percent Cobble | 14 |
| Percent Boulder | 18 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **100** |

| Benthic Macroinvertebrate Taxa (cont) | Number |
|---|---|
| *Tipula sp.* | 3 |
| *Cheumatopsyche sp.* | 4 |
| *Ferrissia rivularis* | 1 |
| *Gyraulus sp.* | 4 |
| *Physa sp.* | 5 |
| *Radix auricularia* | 3 |
| *Pisidium sp.* | 3 |
| *Erpobdella sp.* | 30 |
| *Helobdella stagnalis* | 25 |
| Oligochaeta | 285 |
| Acari | 2 |
| *Lebertia sp.* | 5 |
| *Sperchon sp.* | 2 |
| *Crangonyx sp.* | 16 |
| Nematoda | 1 |
| Turbellaria | 28 |
| **Total Number** | **526** |

| Site: SFPR-030283 | State: Washington | Lat.: | 46.771865 |
|---|---|---|---|
| Stream: Missouri Flat Creek | Date: 09 /26/2010 | Long.: | -117.134637 |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 0.1 | |
| Est. Mean Depth (m) | 0.3 | |
| Length (m) | 150 | |

| **Water Quality** | **Start** | Finish |
|---|---|---|
| Temperature (°C) | 9.1 | 8.43 |
| pH | 7.08 | 7.18 |
| Dissolved Oxygen (mg/l) | 2.55 | 2.02 |
| Conductivity (µs/cm) | 399 | 381.1 |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 1 |
| Pool Substrate Charact. | 2 |
| Pool Variability | 2 |
| Sediment Deposition | 3 |
| Channel Flow Status | 2 |
| Channel Alteration | 13 |
| Channel Sinuosity | 13 |
| Bank Stability (L) | 2 |
| Bank Stability (R) | 2 |
| Vegetative Protection (L) | 1 |
| Vegetative Protection (R) | 1 |
| Riparian Vegetative Zone (L) | 4 |
| Riparian Vegetative Zone (R) | 6 |
| **Total Score** | **52** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Rhinichthys osculus* | 19 | 32 | 79 |
| **Total Number** | **19** | | |
| **Total Biomass (g)** | **31** | | |

**Benthic Macroinvertebrates**

NA

| Site: SFPR-030283 | State: Washington | Lat.: | 46.771865 |
|---|---|---|---|
| Stream: Missouri Flat Creek | Date: 09 /26/2010 | Long.: | -117.134637 |

| Densiometer | Down | Mid | Up |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 0 |
| Center looking Left Bank | 0 | 0 | 0 |
| Center looking Downstream | 0 | 0 | 8 |
| Center looking Right Bank | 0 | 0 | 8 |
| Left Bank | 0 | 0 | 0 |
| Right Bank | 0 | 0 | 8 |
| **Total** | **24** | | |

| Substrate Composition | |
|---|---|
| Percent Fines | 62 |
| Percent Sand | 3 |
| Percent Gravel | 14 |
| Percent Cobble | 8 |
| Percent Boulder | 3 |
| Percent Bedrock/Hardpan | 10 |
| **Total** | **100** |

| Site: SFPR-022859 | State: Washington | Lat.: | 46.729244 |
|---|---|---|---|
| Stream: Paradise Creek | Date: 09 /24/2010 | Long.: | -117.095902 |

| Reach Characteristics | | |
|---|---|---|
| Mean Wetted Width (m) | 2.4 | |
| Est. Mean Depth (m) | 0.9 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 13.82 | 14.24 |
| pH | 7.26 | 7.11 |
| Dissolved Oxygen (mg/l) | 7.1 | 8.12 |
| Conductivity (µs/cm) | 431.2 | 370 |
| **Physical Habitat** | | |
| Epifaunal Substrate | 12 | |
| Pool Substrate Charact. | 13 | |
| Pool Variability | 11 | |
| Sediment Deposition | 18 | |
| Channel Flow Status | 18 | |
| Channel Alteration | 11 | |
| Channel Sinuosity | 8 | |
| Bank Stability (L) | 7 | |
| Bank Stability (R) | 7 | |
| Vegetative Protection (L) | 2 | |
| Vegetative Protection (R) | 2 | |
| Riparian Vegetative Zone (L) | 4 | |
| Riparian Vegetative Zone (R) | 6 | |
| **Total Score** | **119** | |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Catostomus columbianus* | 46 | 85 | 166 |
| *Catostomus macrocheilus* | 5 | 95 | 164 |
| *Ptychocheilus oregonensis* | 5 | 170 | 215 |
| *Richardsonius balteatus* | 26 | 70 | 98 |
| *Rhinichthys osculus* | 8 | 58 | 78 |
| **Total Number** | **90** | | |
| **Total Biomass (g)** | **1,199** | | |

| **Benthic Macroinvertebrate Taxa** | **Number** |
|---|---|
| *Baetis tricaudatus* | 5 |
| *Argia sp.* | 1 |
| Coenagrionidae | 7 |
| *Dubiraphia sp.* | 1 |
| *Optioservus sp.* | 496 |
| *Cryptochironomus sp.* | 1 |
| *Tanytarsus sp.* | 2 |
| *Thienemannimyia gr. sp.* | 4 |
| *Hemerodromia sp.* | 1 |
| *Lepidostoma sp.* | 2 |
| *Gyraulus sp.* | 1 |
| Lymnaeidae | 2 |
| *Pisidium sp.* | 11 |
| *Erpobdella sp.* | 1 |
| Oligochaeta | 3 |
| *Lebertia sp.* | 2 |

| Site: SFPR-022859 | State: Washington | Lat.: | 46.729244 |
|---|---|---|---|
| Stream: Paradise Creek | Date: 09 /24/2010 | Long.: | -117.095902 |

| Densiometer | Down | Mid | Up |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 13 |
| Center looking Left Bank | 0 | 0 | 0 |
| Center looking Downstream | 0 | 0 | 0 |
| Center looking Right Bank | 0 | 0 | 6 |
| Left Bank | 0 | 0 | 0 |
| Right Bank | 0 | 0 | 17 |
| **Total** | **36** | | |

| Substrate Composition | |
|---|---|
| Percent Fines | 13 |
| Percent Sand | 9 |
| Percent Gravel | 51 |
| Percent Cobble | 4 |
| Percent Boulder | 23 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **100** |

| Benthic Macroinvertebrate Taxa (cont) | Number |
|---|---|
| *Hyalella sp.* | 1 |
| Ostracoda | 1 |
| Turbellaria | 77 |
| **Total Number** | **619** |

| | | | |
|---|---|---|---|
| **Site: SFPR-121163** | **State: Washington** | **Lat.:** | **46.73677** |
| **Stream: Paradise Creek** | **Date: 09 /24/2010** | **Long.:** | **-117.06438** |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 3.4 | |
| Est. Mean Depth (m) | 0.7 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 14.31 | 15.36 |
| pH | 7.07 | 7.07 |
| Dissolved Oxygen (mg/l) | 8.33 | 8.36 |
| Conductivity (µs/cm) | 405.9 | 501 |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 6 |
| Pool Substrate Charact. | 11 |
| Pool Variability | 11 |
| Sediment Deposition | 18 |
| Channel Flow Status | 19 |
| Channel Alteration | 11 |
| Channel Sinuosity | 9 |
| Bank Stability (L) | 4 |
| Bank Stability (R) | 5 |
| Vegetative Protection (L) | 2 |
| Vegetative Protection (R) | 2 |
| Riparian Vegetative Zone (L) | 1 |
| Riparian Vegetative Zone (R) | 6 |
| **Total Score** | **105** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Catostomus columbianus* | 26 | 62 | 98 |
| *Catostomus macrocheilus* | 7 | 107 | 204 |
| *Ptychocheilus oregonensis* | 1 | 140 | 0 |
| *Richardsonius balteatus* | 3 | 71 | 98 |
| *Rhinichthys osculus* | 72 | 41 | 61 |
| **Total Number** | **109** | | |
| **Total Biomass (g)** | **675** | | |

| **Benthic Macroinvertebrate Taxa** | **Number** |
|---|---|
| *Baetis tricaudatus* | 17 |
| *Argia sp.* | 1 |
| *Coenagrion/Enallagma sp.* | 3 |
| *Optioservus sp.* | 284 |
| *Cricotopus bicinctus gr.* | 1 |
| *Cricotopus sp.* | 7 |
| *Cricotopus trifascia gr.* | 2 |
| *Dicrotendipes sp.* | 1 |
| *Parakiefferiella sp.* | 2 |
| *Paratanytarsus sp.* | 1 |
| *Potthastia longimana gr.* | 1 |
| *Tanytarsus sp.* | 4 |
| *Thienemanniella sp.* | 2 |
| *Thienemannimyia gr. sp.* | 3 |
| Ceratopogoninae | 2 |
| *Hemerodromia sp.* | 1 |
| *Simulium sp.* | 2 |

| Site: SFPR-121163 | State: Washington | Lat.: | 46.73677 |
|---|---|---|---|
| Stream: Paradise Creek | Date: 09 /24/2010 | Long.: | -117.06438 |

| Densiometer | Down | Mid | Up |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 0 |
| Center looking Left Bank | 0 | 0 | 1 |
| Center looking Downstream | 0 | 0 | 0 |
| Center looking Right Bank | 0 | 0 | 0 |
| Left Bank | 0 | 0 | 12 |
| Right Bank | 0 | 0 | 0 |
| **Total** | **13** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 42 |
| Percent Sand | 2 |
| Percent Gravel | 35 |
| Percent Cobble | 4 |
| Percent Boulder | 1 |
| Percent Bedrock/Hardpan | 16 |
| **Total** | **100** |

| Benthic Macroinvertebrate Taxa (cont) | Number |
|---|---|
| *Cheumatopsyche sp.* | 7 |
| *Hydropsyche sp.* | 77 |
| *Lepidostoma sp.* | 3 |
| *Physa sp.* | 35 |
| *Planorbella sp.* | 2 |
| *Radix auricularia* | 28 |
| *Pisidium sp.* | 3 |
| *Erpobdella sp.* | 1 |
| Oligochaeta | 68 |
| Acari | 1 |
| *Hyalella sp.* | 1 |
| Ostracoda | 1 |
| **Total Number** | **561** |

| | | | |
|---|---|---|---|
| **Site: SFPR-080203** | **State: Washington** | **Lat.:** | **46.735872** |
| **Stream: Paradise Creek** | **Date: 09 /27/2010** | **Long.:** | **-117.052307** |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 4.4 | |
| Est. Mean Depth (m) | 1 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 18.04 | 18.76 |
| pH | 7.35 | 7.28 |
| Dissolved Oxygen (mg/l) | 7.61 | 7.02 |
| Conductivity (µs/cm) | 718.8 | 742.7 |
| **Physical Habitat** | | |
| Epifaunal Substrate | 14 | |
| Pool Substrate Charact, | 11 | |
| Pool Variability | 13 | |
| Sediment Deposition | 15 | |
| Channel Flow Status | 14 | |
| Channel Alteration | 14 | |
| Channel Sinuosity | 8 | |
| Bank Stability (L) | 3 | |
| Bank Stability (R) | 4 | |
| Vegetative Protection (L) | 1 | |
| Vegetative Protection (R) | 1 | |
| Riparian Vegetative Zone (L) | 5 | |
| Riparian Vegetative Zone (R) | 3 | |
| **Total Score** | **106** | |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Catostomus columbianus* | 79 | 76 | 238 |
| *Catostomus macrocheilus* | 64 | 104 | 289 |
| *Ptychocheilus oregonensis* | 5 | 129 | 227 |
| *Richardsonius balteatus* | 156 | 69 | 171 |
| *Rhinichthys osculus* | 112 | 48 | 72 |
| **Total Number** | **416** | | |
| **Total Biomass (g)** | **3,882** | | |

| **Benthic Macroinvertebrate Taxa** | **Number** |
|---|---|
| *Aeshna sp.* | 2 |
| *Argia sp.* | 1 |
| *Coenagrionidae* | 25 |
| *Cryptochironomus sp.* | 4 |
| *Phaenopsectra sp.* | 1 |
| *Polypedilum sp.* | 1 |
| *Thienemannimyia gr. sp.* | 1 |
| *Gyraulus sp.* | 3 |
| *Physa sp.* | 13 |
| *Radix auricularia* | 18 |
| *Pisidium sp.* | 99 |
| *Erpobdella sp.* | 22 |
| Oligochaeta | 226 |
| *Lebertia sp.* | 1 |
| Ostracoda | 4 |
| Nematoda | 2 |
| Turbellaria | 1 |
| **Total** | **424** |

| | | | |
|---|---|---|---|
| **Site: SFPR-080203** | **State: Washington** | **Lat.:** | **46.735872** |
| **Stream: Paradise Creek** | **Date: 09 /27/2010** | **Long.:** | **-117.052307** |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 16 | 16 | 15 |
| Center looking Left Bank | 7 | 13 | 17 |
| Center looking Downstream | 12 | 11 | 17 |
| Center looking Right Bank | 13 | 14 | 17 |
| Left Bank | 0 | 11 | 0 |
| Right Bank | 0 | 11 | 17 |
| **Total** | **207** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 22 |
| Percent Sand | 2 |
| Percent Gravel | 32 |
| Percent Cobble | 0 |
| Percent Boulder | 0 |
| Percent Bedrock/Hardpan | 44 |
| **Total** | **100** |

| Site: SFPR-108562 | State: Idaho | Lat.: | 46.722794 |
|---|---|---|---|
| Stream: Paradise Creek | Date: 09 /23/2010 | Long.: | -116.994418 |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 4.7 | |
| Est. Mean Depth (m) | 1.1 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 11.62 | |
| pH | 6.97 | |
| Dissolved Oxygen (mg/l) | 1.65 | |
| Conductivity (µs/cm) | 401.7 | |
| **Physical Habitat** | | |
| Epifaunal Substrate | 8 | |
| Pool Substrate Charact. | 11 | |
| Pool Variability | 11 | |
| Sediment Deposition | 18 | |
| Channel Flow Status | 15 | |
| Channel Alteration | 13 | |
| Channel Sinuosity | 10 | |
| Bank Stability (L) | 7 | |
| Bank Stability (R) | 7 | |
| Vegetative Protection (L) | 8 | |
| Vegetative Protection (R) | 8 | |
| Riparian Vegetative Zone (L) | 2 | |
| Riparian Vegetative Zone (R) | 3 | |
| **Total Score** | **121** | |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Catostomus columbianus* | 31 | 92 | 171 |
| *Catostomus macrocheilus* | 12 | 96 | 126 |
| *Richardsonius balteatus* | 91 | 51 | 128 |
| *Rhinichthys osculus* | 119 | 38 | 85 |
| **Total Number** | **253** | | |
| **Total Biomass (g)** | **1,097** | | |

| **Benthic Macroinvertebrate Taxa** | **Number** |
|---|---|
| *Callibaetis sp.* | 1 |
| *Aeshna sp.* | 1 |
| Coenagrionidae | 57 |
| *Sigara sp.* | 4 |
| *Acricotopus sp.* | 2 |
| *Chironomus sp.* | 152 |
| *Cladopelma sp.* | 1 |
| *Cricotopus sp.* | 6 |
| *Cryptochironomus sp.* | 1 |
| *Dicrotendipes sp.* | 17 |
| *Endochironomus sp.* | 9 |
| *Limnophyes sp.* | 2 |
| *Micropsectra sp.* | 2 |
| *Paratanytarsus sp.* | 13 |
| *Psectrotanypus sp.* | 33 |
| *Pseudochironomus sp.* | 1 |
| *Tanytarsus sp.* | 3 |
| *Bezzia/Palpomyia sp.* | 2 |

| Site: SFPR-108562 | State: Idaho | Lat.: | 46.722794 |
|---|---|---|---|
| Stream: Paradise Creek | Date: 09 /23/2010 | Long.: | -116.994418 |

| Densiometer | Down | Mid | Up |
|---|---|---|---|
| Center looking Upstream | 16 | 0 | 1 |
| Center looking Left Bank | 17 | 0 | 12 |
| Center looking Downstream | 16 | 0 | 11 |
| Center looking Right Bank | 16 | 0 | 0 |
| Left Bank | 16 | 0 | 13 |
| Right Bank | 16 | 0 | 0 |
| **Total** | **134** | | |

| Substrate Composition | |
|---|---|
| Percent Fines | 47 |
| Percent Sand | 4 |
| Percent Gravel | 43 |
| Percent Cobble | 6 |
| Percent Boulder | 0 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **100** |

| Benthic Macroinvertebrate Taxa (cont) | Number |
|---|---|
| *Pericoma/Telmatoscopus sp.* | 2 |
| *Ptilostomis sp.* | 2 |
| *Ferrissia rivularis* | 6 |
| *Gyraulus sp.* | 15 |
| Lymnaeidae | 1 |
| Sphaeriidae | 3 |
| *Erpobdella sp.* | 2 |
| Oligochaeta | 60 |
| *Limnesia sp.* | 54 |
| *Unionicola sp.* | 2 |
| Nematoda | 5 |
| **Total Number** | **459** |

| | | | |
|---|---|---|---|
| **Site: SFPR-026642** | **State: Idaho** | **Lat.:** | **46.733622** |
| **Stream: Paradise Creek** | **Date: 09 /23/2010** | **Long.:** | **-116.980223** |

| **Reach Characteristics** | | |
|---|---|---|
| Mean Wetted Width (m) | 5.4 | |
| Est. Mean Depth (m) | 0.5 | |
| Length (m) | 150 | |

| **Water Quality** | **Start** | Finish |
|---|---|---|
| Temperature (°C) | 12.68 | |
| pH | 6.91 | |
| Dissolved Oxygen (mg/l) | 5.61 | |
| Conductivity (µs/cm) | 231.3 | |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 9 |
| Pool Substrate Charact. | 8 |
| Pool Variability | 11 |
| Sediment Deposition | 18 |
| Channel Flow Status | 20 |
| Channel Alteration | 13 |
| Channel Sinuosity | 6 |
| Bank Stability (L) | 8 |
| Bank Stability (R) | 8 |
| Vegetative Protection (L) | 9 |
| Vegetative Protection (R) | 9 |
| Riparian Vegetative Zone (L) | 2 |
| Riparian Vegetative Zone (R) | 2 |
| **Total Score** | **123** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| *Catostomus columbianus* | 18 | 76 | 148 |
| *Richardsonius balteatus* | 81 | 53 | 128 |
| *Rhinichthys osculus* | 184 | 36 | 82 |
| **Total Number** | **283** | | |
| **Total Biomass (g)** | **1,101** | | |

**Benthic Macroinvertebrate Taxa**

NA

| Site: SFPR-026642 | State: Idaho | Lat.: | 46.733622 |
|---|---|---|---|
| Stream: Paradise Creek | Date: 09 /23/2010 | Long.: | -116.980223 |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 9 | 0 | 0 |
| Center looking Left Bank | 16 | 2 | 0 |
| Center looking Downstream | 13 | 15 | 0 |
| Center looking Right Bank | 0 | 6 | 0 |
| Left Bank | 0 | 9 | 1 |
| Right Bank | 0 | 5 | 0 |
| **Total** | **76** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 71 |
| Percent Sand | 3 |
| Percent Gravel | 4 |
| Percent Cobble | 1 |
| Percent Boulder | 1 |
| Percent Bedrock/Hardpan | 20 |
| **Total** | **100** |

| Site: SFPR-081483 | State: Idaho | Lat.: | 46.756036 |
|---|---|---|---|
| Stream: Paradise Creek | Date: 09 /27/2010 | Long.: | -116.962549 |

| Reach Characteristics | | |
|---|---|---|
| Mean Wetted Width (m) | 3.5 | |
| Est. Mean Depth (m) | 0.3 | |
| Length (m) | 150 | |
| **Water Quality** | **Start** | Finish |
| Temperature (°C) | 14.55 | 14.93 |
| pH | 6.77 | 6.73 |
| Dissolved Oxygen (mg/l) | 0.67 | 0.91 |
| Conductivity (µs/cm) | 294.2 | 303.3 |
| **Physical Habitat** | | |
| Epifaunal Substrate | 6 | |
| Pool Substrate Charact. | 7 | |
| Pool Variability | 4 | |
| Sediment Deposition | 4 | |
| Channel Flow Status | 5 | |
| Channel Alteration | 12 | |
| Channel Sinuosity | 8 | |
| Bank Stability (L) | 7 | |
| Bank Stability (R) | 7 | |
| Vegetative Protection (L) | 1 | |
| Vegetative Protection (R) | 1 | |
| Riparian Vegetative Zone (L) | 1 | |
| Riparian Vegetative Zone (R) | 1 | |
| **Total Score** | **64** | |

| Fish | Number | Min. (mm) | Max. (mm) |
|---|---|---|---|
| *Rhinichthys osculus* | 17 | 54 | 70 |
| **Total Number** | **17** | | |
| **Total Biomass (g)** | **28** | | |

**Benthic Macroinvertebrate Taxa**

NA

| Site: SFPR-081483 | State: Idaho | Lat.: | 46.756036 |
|---|---|---|---|
| Stream: Paradise Creek | Date: 09 /27/2010 | Long.: | -116.962549 |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 0 |
| Center looking Left Bank | 0 | 0 | 0 |
| Center looking Downstream | 0 | 0 | 0 |
| Center looking Right Bank | 0 | 0 | 0 |
| Left Bank | 0 | 0 | 0 |
| Right Bank | 0 | 0 | 0 |
| **Total** | **0** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 90 |
| Percent Sand | 0 |
| Percent Gravel | 0 |
| Percent Cobble | 0 |
| Percent Boulder | 0 |
| Percent Bedrock/Hardpan | 10 |
| **Total** | **100** |

| | | | |
|---|---|---|---|
| **Site: SFPR-012619** | **State: Washington** | **Lat.:** | **46.674303** |
| **Stream: Dry Fork Creek** | **Date: 09 /25/2010** | **Long.:** | **-117.19442** |

| **Reach Characteristics** | |
|---|---|
| Mean Wetted Width (m) | 0.6 |
| Est. Mean Depth (m) | 0.1 |
| Length (m) | 150 |

| **Water Quality** | **Start** | Finish |
|---|---|---|
| Temperature (°C) | 10.57 | 10.7 |
| pH | 6.62 | 6.71 |
| Dissolved Oxygen (mg/l) | 5.88 | 5.78 |
| Conductivity (μs/cm) | 256.8 | 250.9 |

| **Physical Habitat** | |
|---|---|
| Epifaunal Substrate | 2 |
| Pool Substrate Charact. | 1 |
| Pool Variability | 1 |
| Sediment Deposition | 13 |
| Channel Flow Status | 2 |
| Channel Alteration | 1 |
| Channel Sinuosity | 0 |
| Bank Stability (L) | 8 |
| Bank Stability (R) | 8 |
| Vegetative Protection (L) | 1 |
| Vegetative Protection (R) | 1 |
| Riparian Vegetative Zone (L) | 1 |
| Riparian Vegetative Zone (R) | 1 |
| **Total Score** | **40** |

| **Fish** | **Number** | **Min. (mm)** | **Max. (mm)** |
|---|---|---|---|
| No Fish Collected | NA | NA | NA |
| **Total Number** | **NA** | | |
| **Total Biomass (g)** | **NA** | | |

**Benthic Macroinvertebrate Taxa**

NA

| Site: SFPR-012619 | State: Washington | Lat.: | 46.674303 |
|---|---|---|---|
| Stream: Dry Fork Creek | Date: 09 /25/2010 | Long.: | -117.19442 |

| **Densiometer** | **Down** | **Mid** | **Up** |
|---|---|---|---|
| Center looking Upstream | 0 | 0 | 0 |
| Center looking Left Bank | 0 | 0 | 0 |
| Center looking Downstream | 0 | 0 | 0 |
| Center looking Right Bank | 0 | 0 | 0 |
| Left Bank | 0 | 0 | 0 |
| Right Bank | 0 | 0 | 0 |
| **Total** | **0** | | |

| **Substrate Composition** | |
|---|---|
| Percent Fines | 100 |
| Percent Sand | 0 |
| Percent Gravel | 0 |
| Percent Cobble | 0 |
| Percent Boulder | 0 |
| Percent Bedrock/Hardpan | 0 |
| **Total** | **100** |

# APPENDIX D. BENTHIC MACROINVERTEBRATE METRIC AND BIOTIC INDEX SUMMARY

| Stream | SF Palouse River | SF Palouse River | SF Palouse River | SF Palouse River |
|---|---|---|---|---|
| **Station Number** | **SFPR-098891** | **SFPR-106827** | **SFPR-057675** | **SFPR-123211** |
| **Dominance Measures** | | | | |
| Dominant Taxon | Tricorythodes sp. | Lebertia sp. | Oligochaeta | Dicrotendipes sp. |
| Dominant Abundance | 2272 | 270.32 | 528 | 480.24 |
| 2nd Dominant Taxon | Optioservus sp. | Cricotopus trifascia gr. | Optioservus sp. | Oligochaeta |
| 2nd Dominant Abundance | 1424 | 226.72 | 388 | 219.42 |
| 3rd Dominant Taxon | Turbellaria | Crangonyx sp. | Lebertia sp. | Lebertia sp. |
| 3rd Dominant Abundance | 1056 | 165.68 | 348 | 132.48 |
| % Dominant Taxon | 23.55 | 21.99 | 20.47 | 24.47 |
| % 2 Dominant Taxa | 38.31 | 40.43 | 35.5 | 35.65 |
| % 3 Dominant Taxa | 49.25 | 53.9 | 48.99 | 42.41 |
| **Richness Measures** | | | | |
| Species Richness | 38 | 34 | 34 | 32 |
| EPT Richness | 8 | 6 | 3 | 3 |
| Ephemeroptera Richness | 3 | 3 | 1 | 1 |
| Plecoptera Richness | 0 | 0 | 0 | 1 |
| Trichoptera Richness | 5 | 3 | 2 | 1 |
| Chironomidae Richness | 10 | 11 | 13 | 13 |
| Oligochaeta Richness | 1 | 1 | 1 | 1 |
| Non-Chiro. Non-Olig. Richness | 27 | 22 | 20 | 18 |
| Rhyacophila Richness | 0 | 0 | 0 | 0 |
| **Community Composition** | | | | |
| % Ephemeroptera | 25.21 | 1.06 | 3.41 | 0.21 |
| % Plecoptera | 0 | 0 | 0 | 0.42 |
| % Trichoptera | 9.12 | 1.77 | 3.57 | 5.06 |
| % EPT | 34.33 | 2.84 | 6.98 | 5.7 |
| % Coleoptera | 20.73 | 3.19 | 16.28 | 4.64 |
| % Diptera | 4.98 | 37.06 | 21.71 | 50 |
| % Oligochaeta | 8.62 | 3.55 | 20.47 | 11.18 |
| % Baetidae | 1.66 | 0.35 | 3.41 | 0.21 |
| % Brachycentridae | 0 | 0 | 0 | 0 |
| % Chironomidae | 4.15 | 32.27 | 19.53 | 45.36 |
| % Ephemerellidae | 0 | 0 | 0 | 0 |
| % Hydropsychidae | 0 | 0.18 | 0.31 | 0 |
| % Odonata | 6.8 | 9.75 | 0.93 | 4.22 |
| % Perlidae | 0 | 0 | 0 | 0 |

| Stream | SF Palouse River | SF Palouse River | SF Palouse River | SF Palouse River |
|---|---|---|---|---|
| **Station Number** | **SFPR-098891** | **SFPR-106827** | **SFPR-057675** | **SFPR-123211** |
| **Community Composition** | | | | |
| % Perlidae | 0 | 0 | 0 | 0 |
| % Pteronarcyidae | 0 | 0 | 0 | 0 |
| % Simuliidae | 0.17 | 1.95 | 0 | 0 |
| **Functional Group Composition** | | | | |
| % Filterers | 1.66 | 3.72 | 2.64 | 8.65 |
| % Gatherers | 43.12 | 30.32 | 46.67 | 59.49 |
| % Predators | 29.19 | 41.84 | 34.73 | 26.79 |
| % Scrapers | 18.57 | 3.19 | 15.66 | 3.8 |
| % Shredders | 6.14 | 20.39 | 0.16 | 1.27 |
| % Piercer-Herbivores | 0.5 | 0.53 | 0 | 0 |
| % Unclassified | 0.83 | 0 | 0.16 | 0 |
| Filterer Richness | 4 | 4 | 3 | 2 |
| Gatherer Richness | 12 | 13 | 14 | 13 |
| Predator Richness | 10 | 11 | 12 | 12 |
| Scraper Richness | 5 | 2 | 3 | 1 |
| Shredder Richness | 4 | 3 | 1 | 4 |
| Piercer-Herbivore Richness | 1 | 1 | 0 | 0 |
| Unclassified | 2 | 0 | 1 | 0 |
| **Diversity/Evenness Measures** | | | | |
| Shannon-Weaver H' (log 10) | 1.18 | 1.11 | 1.14 | 1.19 |
| Shannon-Weaver H' (log 2) | 3.93 | 3.69 | 3.78 | 3.97 |
| Shannon-Weaver H' (log e) | 2.72 | 2.56 | 2.62 | 2.75 |
| Margalef's Richness | 4.03 | 4.64 | 4.2 | 4.09 |
| Pielou's J' | 0.75 | 0.73 | 0.74 | 0.79 |
| Simpson's Heterogeneity | 0.89 | 0.88 | 0.89 | 0.9 |
| **Biotic Indices** | | | | |
| % Indiv. w/ HBI Value | 89.05 | 73.76 | 84.5 | 90.08 |
| Hilsenhoff Biotic Index | 5.23 | 6.65 | 6.28 | 7.15 |
| % Indiv. w/ MTI Value | 67.33 | 35.82 | 50.54 | 55.7 |
| Metals Tolerance Index | 4.12 | 3.97 | 4.33 | 4.43 |
| % Indiv. w/ FSBI Value | 39.3 | 8.69 | 19.84 | 5.49 |
| Fine Sediment Biotic Index | 20 | 25 | 23 | 9 |
| FSBI - average | 0.53 | 0.74 | 0.68 | 0.28 |

| Stream | SF Palouse River | SF Palouse River | SF Palouse River | SF Palouse River |
|---|---|---|---|---|
| Station Number | SFPR-098891 | SFPR-106827 | SFPR-057675 | SFPR-123211 |
| **Biotic Indices** | | | | |
| FSBI - weighted average | 3.64 | 3.8 | 3.48 | 3.46 |
| % Indiv. w/ TPM Value | 48.76 | 27.66 | 22.33 | 10.97 |
| Temp. Pref. Metric - average | 1 | 1.12 | 1.06 | 0.47 |
| TPM - weighted average | 2.28 | 2.54 | 3.17 | 2.27 |
| | | | | |
| **Other Metrics** | | | | |
| Long-Lived Taxa Richness | 2 | 2 | 2 | 3 |
| Clinger Richness | 20 | 12 | 8 | 8 |
| % Clingers | 63.02 | 28.01 | 23.57 | 11.39 |
| Intolerant Taxa Richness | 0 | 0 | 0 | 1 |
| % Tolerant Individuals | 1.02 | 8.27 | 7.39 | 5.83 |
| % Tolerant Taxa | 15.79 | 11.76 | 29.41 | 31.25 |
| Coleoptera Richness | 3 | 2 | 2 | 2 |

| Stream | SF Palouse River | Paradise Creek | Paradise Creek | Paradise Creek |
|---|---|---|---|---|
| Station Number | SFPR-031051 | SFPR-108562 | SFPR-022859 | SFPR-121163 |
| **Dominance Measures** | | | | |
| Dominant Taxon | Gyraulus sp. | Chironomus sp. | Optioservus sp. | Optioservus sp. |
| Dominant Abundance | 226 | 228 | 1984 | 3408 |
| 2nd Dominant Taxon | Pisidium sp. | Oligochaeta | Turbellaria | Hydropsyche sp. |
| 2nd Dominant Abundance | 182 | 90 | 308 | 924 |
| 3rd Dominant Taxon | Lebertia sp. | Coenagrionidae | Pisidium sp. | Oligochaeta |
| 3rd Dominant Abundance | 138 | 85.5 | 44 | 816 |
| % Dominant Taxon | 20.93 | 33.12 | 80.13 | 50.62 |
| % 2 Dominant Taxa | 37.78 | 46.19 | 92.57 | 64.35 |
| % 3 Dominant Taxa | 50.56 | 58.61 | 94.35 | 76.47 |
| **Richness Measures** | | | | |
| Species Richness | 35 | 29 | 19 | 29 |
| EPT Richness | 3 | 2 | 2 | 4 |
| Ephemeroptera Richness | 1 | 1 | 1 | 1 |
| Plecoptera Richness | 1 | 0 | 0 | 0 |
| Trichoptera Richness | 1 | 1 | 1 | 3 |
| Chironomidae Richness | 13 | 13 | 3 | 10 |
| Oligochaeta Richness | 1 | 1 | 1 | 1 |
| Non-Chiro. Non-Olig. Richness | 21 | 15 | 15 | 18 |
| Rhyacophila Richness | 0 | 0 | 0 | 0 |
| **Community Composition** | | | | |
| % Ephemeroptera | 0.37 | 0.22 | 0.81 | 3.03 |
| % Plecoptera | 0.37 | 0 | 0 | 0 |
| % Trichoptera | 1.3 | 0.44 | 0.32 | 15.51 |
| % EPT | 2.04 | 0.65 | 1.13 | 18.54 |
| % Coleoptera | 5 | 0 | 80.29 | 50.62 |
| % Diptera | 24.26 | 53.59 | 1.29 | 5.17 |
| % Oligochaeta | 1.48 | 13.07 | 0.48 | 12.12 |
| % Baetidae | 0.37 | 0.22 | 0.81 | 3.03 |
| % Brachycentridae | 0 | 0 | 0 | 0 |
| % Chironomidae | 23.33 | 52.72 | 1.13 | 4.28 |
| % Ephemerellidae | 0 | 0 | 0 | 0 |
| % Hydropsychidae | 0 | 0 | 0 | 14.97 |
| % Odonata | 6.85 | 12.64 | 1.29 | 0.71 |

| Stream | SF Palouse River | Paradise Creek | Paradise Creek | Paradise Creek |
|---|---|---|---|---|
| **Station Number** | **SFPR-031051** | **SFPR-108562** | **SFPR-022859** | **SFPR-121163** |
| **Community Composition** | | | | |
| % Perlidae | 0 | 0 | 0 | 0 |
| % Pteronarcyidae | 0 | 0 | 0 | 0 |
| % Simuliidae | 0 | 0 | 0 | 0.36 |
| **Functional Group Composition** | | | | |
| % Filterers | 20 | 1.31 | 2.1 | 16.58 |
| % Gatherers | 15.56 | 55.12 | 1.78 | 16.76 |
| % Predators | 26.85 | 34.2 | 15.02 | 1.96 |
| % Scrapers | 26.85 | 4.79 | 80.61 | 56.86 |
| % Shredders | 7.78 | 3.27 | 0.32 | 2.32 |
| % Piercer-Herbivores | 0.19 | 0.87 | 0 | 0 |
| % Unclassified | 0 | 0.44 | 0.16 | 0.53 |
| Filterer Richness | 3 | 2 | 2 | 5 |
| Gatherer Richness | 12 | 11 | 5 | 9 |
| Predator Richness | 10 | 9 | 7 | 6 |
| Scraper Richness | 5 | 3 | 3 | 2 |
| Shredder Richness | 3 | 2 | 1 | 4 |
| Piercer-Herbivore Richness | 1 | 1 | 0 | 0 |
| Unclassified | 0 | 1 | 1 | 2 |
| **Diversity/Evenness Measures** | | | | |
| Shannon-Weaver H' (log 10) | 1.2 | 0.99 | 0.35 | 0.78 |
| Shannon-Weaver H' (log 2) | 3.99 | 3.29 | 1.17 | 2.58 |
| Shannon-Weaver H' (log e) | 2.77 | 2.28 | 0.81 | 1.79 |
| Margalef's Richness | 4.87 | 4.28 | 2.3 | 3.18 |
| Pielou's J' | 0.78 | 0.68 | 0.28 | 0.53 |
| Simpson's Heterogeneity | 0.9 | 0.84 | 0.34 | 0.7 |
| **Biotic Indices** | | | | |
| % Indiv. w/ HBI Value | 83.15 | 86.93 | 99.52 | 94.47 |
| Hilsenhoff Biotic Index | 6.81 | 8.87 | 4.96 | 5.63 |
| % Indiv. w/ MTI Value | 52.78 | 64.92 | 96.77 | 73.62 |
| Metals Tolerance Index | 3.56 | 3.78 | 4.8 | 4.99 |
| % Indiv. w/ FSBI Value | 4.26 | 0.44 | 81.1 | 69.16 |
| Fine Sediment Biotic Index | 4 | 5 | 13 | 23 |
| FSBI - average | 0.11 | 0.17 | 0.68 | 0.79 |

| Stream<br>Station Number | SF Palouse River<br>SFPR-031051 | Paradise Creek<br>SFPR-108562 | Paradise Creek<br>SFPR-022859 | Paradise Creek<br>SFPR-121163 |
|---|---|---|---|---|
| **Biotic Indices** | | | | |
| FSBI - weighted average | 2.04 | 5 | 3.02 | 3.47 |
| % Indiv. w/ TPM Value | 18.52 | 2.4 | 82.71 | 73.26 |
| Temp. Pref. Metric - average | 0.49 | 0.45 | 1.16 | 1.52 |
| TPM - weighted average | 2.78 | 4.36 | 3.01 | 2.91 |
| | | | | |
| **Other Metrics** | | | | |
| Long-Lived Taxa Richness | 5 | 3 | 2 | 2 |
| Clinger Richness | 10 | 7 | 7 | 13 |
| % Clingers | 39.63 | 9.15 | 82.07 | 83.07 |
| Intolerant Taxa Richness | 2 | 0 | 1 | 1 |
| % Tolerant Individuals | 18.93 | 22.22 | 0.53 | 1.7 |
| % Tolerant Taxa | 28.57 | 41.38 | 31.58 | 20.69 |
| Coleoptera Richness | 2 | 0 | 2 | 1 |

| Stream | Paradise Creek | Missouri Flat |
|---|---|---|
| **Station Number** | **SFPR-080203** | **SFPR-008523** |
| **Dominance Measures** | | |
| Dominant Taxon | Oligochaeta | Oligochaeta |
| Dominant Abundance | 226 | 541.5 |
| 2nd Dominant Taxon | Pisidium sp. | Erpobdella sp. |
| 2nd Dominant Abundance | 99 | 57 |
| 3rd Dominant Taxon | Coenagrionidae | Turbellaria |
| 3rd Dominant Abundance | 25 | 53.2 |
| % Dominant Taxon | 53.3 | 54.18 |
| % 2 Dominant Taxa | 76.65 | 59.89 |
| % 3 Dominant Taxa | 82.55 | 65.21 |
| | | |
| **Richness Measures** | | |
| Species Richness | 17 | 33 |
| EPT Richness | 0 | 1 |
| Ephemeroptera Richness | 0 | 0 |
| Plecoptera Richness | 0 | 0 |
| Trichoptera Richness | 0 | 1 |
| Chironomidae Richness | 4 | 12 |
| Oligochaeta Richness | 1 | 1 |
| Non-Chiro. Non-Olig. Richness | 12 | 20 |
| Rhyacophila Richness | 0 | 0 |
| | | |
| **Community Composition** | | |
| % Ephemeroptera | 0 | 0 |
| % Plecoptera | 0 | 0 |
| % Trichoptera | 0 | 0.76 |
| % EPT | 0 | 0.76 |
| % Coleoptera | 0 | 0 |
| % Diptera | 1.65 | 16.54 |
| % Oligochaeta | 53.3 | 54.18 |
| % Baetidae | 0 | 0 |
| % Brachycentridae | 0 | 0 |
| % Chironomidae | 1.65 | 15.02 |
| % Ephemerellidae | 0 | 0 |
| % Hydropsychidae | 0 | 0.76 |
| % Odonata | 6.6 | 4.75 |

| Stream | Paradise Creek | Missouri Flat |
|---|---|---|
| **Station Number** | **SFPR-080203** | **SFPR-008523** |
| **Community Composition** | | |
| % Perlidae | 0 | 0 |
| % Pteronarcyidae | 0 | 0 |
| % Simuliidae | 0 | 0 |
| | | |
| **Functional Group Composition** | | |
| % Filterers | 23.35 | 4.56 |
| % Gatherers | 54.25 | 63.12 |
| % Predators | 8.73 | 19.39 |
| % Scrapers | 4.01 | 5.32 |
| % Shredders | 0.24 | 1.33 |
| % Piercer-Herbivores | 0 | 0 |
| % Unclassified | 5.19 | 5.7 |
| Filterer Richness | 1 | 3 |
| Gatherer Richness | 2 | 8 |
| Predator Richness | 8 | 13 |
| Scraper Richness | 3 | 4 |
| Shredder Richness | 1 | 3 |
| Piercer-Herbivore Richness | 0 | 0 |
| Unclassified | 1 | 1 |
| | | |
| **Diversity/Evenness Measures** | | |
| Shannon-Weaver H' (log 10) | 0.65 | 0.87 |
| Shannon-Weaver H' (log 2) | 2.16 | 2.91 |
| Shannon-Weaver H' (log e) | 1.5 | 2.01 |
| Margalef's Richness | 2.64 | 4.63 |
| Pielou's J' | 0.53 | 0.58 |
| Simpson's Heterogeneity | 0.65 | 0.69 |
| | | |
| **Biotic Indices** | | |
| % Indiv. w/ HBI Value | 90.33 | 91.83 |
| Hilsenhoff Biotic Index | 7.48 | 7.3 |
| % Indiv. w/ MTI Value | 8.96 | 31.37 |
| Metals Tolerance Index | 3.29 | 3.53 |
| % Indiv. w/ FSBI Value | 0 | 1.52 |
| Fine Sediment Biotic Index | -99 | 10 |
| FSBI - average | -99 | 0.3 |

| Stream | Paradise Creek | Missouri Flat |
|---|---|---|
| Station Number | SFPR-080203 | SFPR-008523 |
| **Biotic Indices** | | |
| FSBI - weighted average | -99 | 2.75 |
| % Indiv. w/ TPM Value | 0.71 | 6.46 |
| Temp. Pref. Metric - average | 0.35 | 0.7 |
| TPM - weighted average | 2 | 2.47 |
| | | |
| **Other Metrics** | | |
| Long-Lived Taxa Richness | 2 | 3 |
| Clinger Richness | 5 | 8 |
| % Clingers | 8.49 | 7.03 |
| Intolerant Taxa Richness | 0 | 0 |
| % Tolerant Individuals | 70.76 | 34.43 |
| % Tolerant Taxa | 35.29 | 24.24 |
| Coleoptera Richness | 0 | 0 |

# APPENDIX E. REVIEWER COMMENT MATRIX

| Reviewer | Page | Location | Comment/Suggestion | Tt Response |
|---|---|---|---|---|
| E. Snouwaert & C.Niemi | All | General | Double-check that articles cited in the text are in the references. Will specifically point out ones noticed missing. | Completed as Requested |
| E. Snouwaert & C.Niemi | Results section | Sections 3.1 and 3.2 | I realize this is a results section so you are strictly reporting just the "results" of the review of each literature piece; however it reads awkwardly and it is redundant because of this. I think it would be better to move this information to an appendix as an annotated bibliography. Each literature piece would have a heading and then the key results you pulled from it. Then in the results section I suggest synthesizing the information more to describe the watershed without the redundancy (more like in the discussion section). If three studies stated the same thing say it once and reference each. Keep similar geographic information together. For example start by talking about the mouth and working up to the rest of the watershed but put most emphasis on the South Fork sub-basin. This would help the flow of these sections for the reader. At first read I didn't realize that each paragraph was about a different report and that's why there were so many repeats of information. I suspect other readers will have similar experiences. | Completed as Requested; redundancy removed, re-organized to begin with Palouse River discussion and transition to South Fork Palouse River drainage discussion. |
| E. Snouwaert & C.Niemi | 1-1 | 1st para | Russell and Ring not in references | Completed as Requested |
| E. Snouwaert & C.Niemi | 1-1 | 3rd para, 4th sent. | Discusses flow between 1898 and 1954 but how does that compare to now. USGS gage is still operating. | Completed as Requested |
| J. Carroll | 1-1 | Last para | Wheat crops occupied half of Whitman County by "1890"? | Completed as Requested |
| J. Carroll | 1-3 | 2nd para | Change "Groundwater contribution to surface water streams is particularly significant during low flow portions of the year..." to "Groundwater influence to surface water streams can be significant during low flow…" The groundwater contributions in the SF Palouse watershed are currently insignificant during the low flow season, but may have been significant in the past, when groundwater levels were higher. | Completed as Requested |
| J. Carroll | 1-3 | 2nd para | The last sentence is an undocumented statement and I believe the assertion that seasonal timing of water withdrawals influences surface water availability is incorrect. Probably should just delete sentence. | Completed as Requested |

| Reviewer | Page | Location | Comment/Suggestion | Tt Response |
|---|---|---|---|---|
| J. Carroll | 1-3 | Section 1.3, 1st para | TMDL water monitoring and modeling does show degraded water quality conditions during low flow conditions, and it shows that the source of pollution is almost entirely from municipal waste water discharge. It does not demonstrate that riparian or instream habitat degradation or heavily used groundwater resources are the sources of degraded water quality conditions. | Completed as Requested |
| E. Snouwaert & C.Niemi | 1-2 | Section 1.2, 1st sent. | Reference of Carroll & Snouwaert (2009) would be better than the GW-SW interaction report (that's the one listed as Ecology 2009 in the references). | Completed as Requested |
| E. Snouwaert & C.Niemi | 1-2 | Sect. 1.2, 2nd paragraph | From 3rd sentence on change to:<br>EPA and the state of Washington considered water quality requirements for salmonids,char, other aquatic organisms, and the requirements for survival of various life stages in developing the current criteria for these parameters (Ecology 2006). | Completed as Requested |
| E. Snouwaert & C.Niemi | 1-2 | 3rd paragraph | "The 1998 303(d) list for Idaho….portion of drainage." Should be moved to follow the 2nd paragraph so discussion of impairments is discussed together. | Completed as Requested |
| E. Snouwaert & C.Niemi | 1-3 | 2nd paragraph | "The landscape in the…." Paragraph should be moved to the Project Setting section. This would also result in keeping the groundwater paragraphs together and better transition. | Completed as Requested |
| E. Snouwaert & C.Niemi | 1-3 | Sec. 1.3, 3rd sent. | The temperature standard referenced is wrong. The SFPR temperature is a 7-day average daily maximum of 17.5 ˚C. | Completed as Requested |
| E. Snouwaert & C.Niemi | 1-3 | Sec. 1.3, 4th sent. | Change to and add a sentence:<br>A thorough literature review that examines historic information describing biological communities, changes to physical habitat, and available information describing water quality conditions for pre-European, 1975 to current, and current conditions was conducted. This review will provide information that will help determine the natural conditions of the system, and how the system has changed over time. The biological descriptions may provide the greatest evidence for historic conditions derived from autecological characteristics of biological communities and tolerance to environmental gradients. | Completed as Requested |
| E. Snouwaert & C.Niemi | 1-4 | Question 3 | Move final parentheses to after "condition" before "both" […waterbody (Ecology will provide a description for the range of estimated natural conditions), both currently and historically?] | Completed as Requested |
| E. Snouwaert & C.Niemi | 1-4 | Paragraph under question 3 | Change to:<br>A description of the environmental conditions during 3 important periods related to the above questions was developed by summarizing information gathered from existing knowledge and generating data describing current conditions. The time periods are : | Completed as Requested |

| Reviewer | Page | Location | Comment/Suggestion | Tt Response |
|---|---|---|---|---|
| E. Snouwaert & C.Niemi | 1-4 | Last paragraph | Change to:<br>These 3 periods along a timeline, beginning with Pre-European settlement, were compared in order to determine (1) the extent of change in biotic communities that may have directly and indirectly been influenced by arrival of Europeans and (2) the effects of the development of the regional economy on aquatic resources. | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-1 | 2nd paragraph, 1st sent. | Change to:<br>The web based survey and library search methods were more consistent in approach and expected results. | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-2 | Sec. 2.1.3 | "like Ecology's EIM" were other databases also accessed? If so what were they, where are they referenced so we can access them too? | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-2 | Sec. 2.1.5, 2nd sent. | Unclear sentence. The time periods partitioned the summaries? | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-3 | 1st para, 2nd sent. (Sec. 2.1.5) | Unclear sentence. 1) this is the technical report; 2) reads as if it's going to be transferred to the interpretation of limitations. | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-3 | Sec. 2.1.6, 1st sent. | Were presented or are presented? Where - In the results section? | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-3 | Sec. 2.1.6, 4th sent. | This is the Final Technical Report | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-3 | Section 2.2, 2nd para, last half | The 2nd half of this paragraph is confusing. It almost sounds as if 30 sites were sampled when only 20 were. Sounds as if its 20 plus 10. | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-3 | Section 2.2, 2nd para., last sentence | Change to:<br>The final survey design addressed factors that affect fish populations, and provided a basis for assessing the instream biota of the system. | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-4 | 1st para | Define/explain "oversample" | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-5 | 1st para | Ecology reference needs to be clarified. In the References that is the GW/SW interaction study (probably doesn't provide this guidance and isn't draft). | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-5 | Site Verification and layout | Assume that "not exceed 2000m" is for reaches with mean bankfull width greater than 100m. Sounds like it's also for reaches less than 8m. Clarify. | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-5 | Fish Community | All fish were returned to the stream? Thought some were kept. | Completed as Requested |
| E. Snouwaert & C.Niemi | 2-6 | Only paragraph | Ecology 2009 reference seems wrong again. See 3 comments up. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-1 | Sec. 3.1.1, 3rd para, 1st sent. | "are" should be "area" - …study area prior to 1917… | Completed as Requested |

| Reviewer | Page | Location | Comment/Suggestion | Tt Response |
|---|---|---|---|---|
| E. Snouwaert & C.Niemi | 3-1 | Sect. 3.1.2 Water Quality | We know that artesian wells occurred, groundwater was at higher levels, and there was more shade. Can we make some general statements about temperature or DO? Confer with Jim Carroll on this. Palouse Basin Aquifer Committee (PBAC) may be able to provide info about the water levels and artesian wells. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-2 | Sec. 3.1.3, 2nd paragraph | Is Ross Cox in the Ray reference in the Butler reference? | Completed as Requested |
| E. Snouwaert & C.Niemi | | Sections 3.1 and 3.2 | Refer back to Results Section comment. The Pre-European section is all focused on Palouse mainstem and then 1975 to Current jumps to mostly South Fork Palouse. I realize that this is due to the limited information about the South Fork in the pre-European literature but to the reader it seems that the change between sections is more to focus on a different area than a different time period. This section would benefit from the suggestion to move the straight literature results to an annotated bibliography and use the body portion of document to make the connection and continuity for the reader. Use the literature to describe the watershed from mouth to South Fork. State when info lacks but make speculations based on the rest of what is known. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-3 | Sec. 3.2.1, 3rd para, 4th sent. | Retained – when (during what time period in the past) did these areas retain water during high flow periods? Not clear – section is on 1975 to current but it sounds as if this was prior to that. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-3 | Sect 3.2.1, 4th para, 3rd sent. | Awkward sentence – not really clear on what it means for periphyton and why that is important. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-3 | Sec. 3.2.1, 5th para., 2nd sent. | Is this saying that livestock and removal of vegetation promote stream bank erosion or that livestock promote erosion and vegetation removal? Unclear the intended meaning. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-3 | Sec. 3.2.1, 6th para, 1st sentence | Clarify that the various stations on Paradise Creek on in Idaho. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-3 – 3-4 | Sec. 3.2.1, Paragraph 5 and 7 | • An example of why integrating the results would make this section clearer. These two paragraphs overlap and repeat a lot. Appears redundant and this would benefit from combining. Could include it in the annotated bibliography with headings to distinguish as different literature pieces.<br>• Seems this section would benefit from starting with discussion of whole basin and narrowing down to South Fork and discussing each topic such as: riparian, landuse, stream morphology, flow. Keep each topic together rather than jumping around for each publication. Hard for the reader to get a complete picture. | Completed as Requested |

| Reviewer | Page | Location | Comment/Suggestion | Tt Response |
|---|---|---|---|---|
| J. Carroll | 3-4 | Table 3-1 | It would be good to have the sites listed in the table shown on one of the maps so the reader can see where these sites are in relation to the Tetra Tech sites. | Not done. |
| J. Carroll | Figure 3-4 | Map site | The number label for the sites is too hard to read. A table should accompany the map with site descriptions. About 9 sites on this map are not referenced at all in the report. Site SFPR-057675 should be a circle and not triangle. | Not full page map due to formatting. Added background to sites labels to make more legible |
| E. Snouwaert & C.Niemi | 3-5 | Sec. 3.2.2, 1st para | Seems fish parasites should be under biology not water quality. | Completed as Requested |
| E. Snouwaert & C.Niemi | | 3.2.2 | Water Quality - For organizational purposes the WQ section might benefit from first discussing what and where there are impairments and then discussing our status with TMDLs. Don't break up by literature report but instead piece together. At the end of this section it gets a little confusing as to what is impaired and what is being addressed by a TMDL | Completed as Requested |
| J. Carroll | 3-5 to 3-6 | Section 3.2.2 | Too much emphasis on TIR study. It was a one day snap shot and showed general trends in water temperatures and probably should be left at that. There is too much discussion (regurgitation) of details from the study. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-6 | 6th paragraph, last sentence | This sentence implies that the only FC bacteria are only a problem in the Colfax concrete flood works which is not the case. There are impairments and loading throughout the system. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-7 | Lower paragraph, 3rd sentence | Confusing since temperature and FC were already discussed above. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-12 | | Specify that Cow Creek is in Idaho so as to not confuse it with the one in Washington. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-12 | 2nd paragraph, last sentence | IDEQ has developed a TMDL for the South Fork Palouse River and they are currently working on an Implementation Plan. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-12 | 3rd para., 2nd sentence | Describe where the Busch site is | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-12 | 3rd para., 4th sentence | Are the research wildlife and toxic sites in WA or ID? | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-13 | 2nd paragraph, last sentence | Sentence doesn't agree with table 3-7. One species vs. 3. | Completed as Requested |

| Reviewer | Page | Location | Comment/Suggestion | Tt Response |
|---|---|---|---|---|
| E. Snouwaert & C.Niemi | 3-14 | 2nd paragraph | Was IDEQ 2007 the only document that stated the presence of native salmonid (cutthroat)? Were there references within in it or other sources that supported this finding? When were they estimated to last be there? Where were they – throughout the watershed or a specific tributary or headwaters? | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-14 | Second set of bullets | When were they estimated to be introduced? | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-17 | 2nd & 3rd paragraphs | Stocking discussion redundant. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-17 | 3rd paragraph | This is the first mention of Redband trout. Was there no mention of the possibility of Redband in any other publication or research? | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-17 | 4th para., 3rd sent. | What does the IA1 refer to? | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-18 | 1st para | Reaney Park in Pullman is along the South Fork Palouse downstream of Paradise Creek. Do the park and rec employees actually think the children transported the fish to Paradise Creek and released them or are they more likely releasing them to the South Fork? | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-18 | Table 3-10 | Add "only" to the * to clarify those species are only found below the falls. Could just be saying they are present below the falls but also above the falls. | Completed as Requested |
| J. Carroll | 3-20 | Table 3-11 and the rest of the tables | It would be good to have a sense where these sites are while reading the tables. Include a column for River Mile for each site. Also a general description would be good (e.g., ID, WA, blw Pullman, abv Pullman, etc). The sites on Paradise Creek need to re-ordered from downstream to upstream like the rest of the water ways. | Completed as Requested |
| J. Carroll | 3-22 | First para and Table 3-13 | Please delete the "percent increase in shading due to RCG" statistic. This calculated data is misleading about how much shade is available to the stream surface. Simply state what the shade is on the banks and what it is mid-channel. Delete the sentence that makes the over-general statement that RCG offers significant shade to the streams. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-23 | Table 3-14 | Title on table wrong. Is it possible to include the approximate time of day the WQ readings were taken? | Completed as Requested |
| J. Carroll | 3-23 | Table 3-14 | Add time of day sample was measured. Ecology has 24-hour 15-minute data for these parameters collected in June and July near to at many of the Tetra Tech sites. | Completed as Requested |
| E. Snouwaert & C.Niemi | 3-24 | 1st partial paragraph | Include a description of the categories tolerant, intermediately tolerant, and intolerant. Are rainbow trout in the intermediate category? | Completed as Requested |

| Reviewer | Page | Location | Comment/Suggestion | Tt Response |
|---|---|---|---|---|
| E. Snouwaert & C.Niemi | 3-24 | 2nd para, 1st sent. | Before ; add "throughout the study area" | Completed as Requested |
| J. Carroll | 3-24 | 4th para | The way the paragraph reads, it state that "Diptera and Oligochaeta taxa comprised 53 percent of the samples at sites SFPR-022859" and later states that Coleoptera comprised 80% of the samples at SFPR-022859. That adds up to more than 100%. | Completed as Requested |
| E. Snouwaert & C.Niemi | 4-1 | 4th paragraph, 4th sentence | Unclear because Reaney Park is along SFPR about 1 mile from Paradise Creek. | Completed as Requested |
| J. Carroll | 4-1 | 2nd para, last sentence | This sentence does not make sense to me. | Completed as Requested |
| J. Carroll | 4-2 | 4th para | Make 4th para the 2nd para. It relates to the 1st para. | Completed as Requested |
| J. Carroll | 4-2 | 2nd para, mid para | The WWTP also decreases the dissolved oxygen. Early morning DO readings below the WWTP can be below 2 mg/L. | Completed as Requested |
| J. Carroll | 4-2 | 2nd para; last sentence | It is not clear what is meant by "…with abundances lower in locations that have lower flows." | Completed as Requested |
| J. Carroll | 4-3 | 3rd para; last sentence | Beginning with "The groundwater depression…." This is a far-ranging and undocumented statement that should be deleted or written to provide more detail how the assertion is made. | Completed as Requested |
| J. Carroll | 4-3 | Last para | Delete sentence with reference to timing of flow increase corresponding to University start-up. It does not add to discussion here. | Completed as Requested |
| E. Snouwaert & C.Niemi | 4-4 | Factors | Flow availability, Augmentation of Flow, and Flow Pattern Alternation all affect the items listed below it; however Water Quality Effects don't really affect the transport of nutrient-rich soil, nutrient introduction etc. Those things are factors that cause water quality effects. There seems to be a lack in parallel structure. The direction of the affect is opposite or not parallel in the last factor compared to the other factors. | Completed as Requested |
| E. Snouwaert & C.Niemi | App. B | Photo headings | None are labeled as Idaho (all say Washington) although I believe Idaho photos/sites are there. | Completed as Requested |
| E. Snouwaert & C.Niemi | App. B | Site Map | Include a site map for easy reference to where the sites are located. Could use Figure 2-1 or 3-4 but enlarge it to be a whole page so the site numbers are easy to read. | Not full page map due to formatting. Added background to sites labels to make more legible |