Evaluating the Effectiveness of Artificially-Introduced Instream Woody Debris for Restoring Coho Salmon *(Oncorhynchus kisutch)* Habitat in Patterson Creek

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Abstract

Patterson Creek, a tributary to the Scott River in northern California, has been identified as a high priority stream for endangered coho salmon spawning and rearing habitat rehabilitation efforts. In October 2018, the Scott River Watershed Council introduced instream woody debris structures to Patterson Creek in order to enhance the suitability of streambed substrates for coho Salmon spawning and pools for juvenile rearing habitat. This research was conducted to determine whether artificially-introduced log jam structures in Patterson Creek are impacting coho habitat parameters, particularly spawning gravel suitability and juvenile rearing habitat quality. The study resulted in the creation of a thorough stream habitat profile for Patterson Creek, including quantification of current discharge, water temperature, streambed substrate composition, pool frequency and quality, and vegetative coverage with the intention of establishing a protocol for monitoring the continued effects of the instream woody debris structures on coho salmon habitat in the creek. Qualitative descriptors of stream habitat were also documented, including stream channel type, habitat unit classification, log jam descriptive inventory, photo point establishment, and fish presence documentation. Recommendations are provided for future data collection in Patterson Creek as well as in similar restoration project implementations.

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Introduction

The Scott River watershed supports the largest population of native coho salmon *(Oncorhynchus kisutch)* in the Klamath River basin tributary system, despite widespread degradation of habitat quality (Cramer Fish Sciences et al. 2010). Nearly two hundred years of anthropogenic influence on this 813 square mile northern California watershed has resulted in the impairment of channel morphology and habitat quality, which poses a threat to coho populations (Cramer Fish Sciences et al. 2010; NOAA 2014). The Southern Oregon/Northern California Coast Environmentally Significant Unit (ESU) to which the Scott River's coho belong has maintained a threatened listing under both the Federal and California Endangered Species Act since 1997 (Cramer Fish Sciences et al. 2010; Williams et al. 2006). Concern regarding fisheries habitat and water quality has prompted extensive efforts to restore the Scott River's riparian function with the intention of maintaining coho viability (SRWC & Siskiyou RDC 2014).

Recovery strategies for the watershed have identified several coho habitat parameters that the Scott River's tributaries currently do not meet adequately. These include suitable flow velocity, slow water refugia in pools, frequency of floodplain inundation, sediment sorting, and instream coverage structures for adult migration, spawning redd construction, and juvenile rearing (Cramer Fish Sciences et al. 2010; NOAA 2014; SRWC 2018). Certain tributaries of the Scott River were determined to have higher enhancement potentials based on their capability to meet coho habitat criteria, and of these tributaries, Patterson Creek was ranked as the fifth best candidate for restoration (Cramer Fish Sciences et al. 2010). In 2018, the local Scott River Watershed Council (SRWC) introduced instream woody debris structures into Patterson Creek's riparian zone with the intention of re-establishing natural stream processes and improving a multitude of coho habitat parameters (SRWC 2018). Monitoring and quantifying the effectiveness of instream woody debris as a coho salmon habitat restoration method in Patterson Creek is crucial for understanding the ecological and hydrological role that the woody debris plays. It is also essential information to support similar restoration projects in the Scott River Watershed and in other salmon habitats.

As in countless watersheds throughout the west, the current Scott River Valley condition does not reflect its historic quality. Before European settlement, the Scott River riparian zone was characterized by fire-tolerant conifers and abundant willows with grassy prairies sprawling along the river's mainstem, and the basin was home to a thriving beaver population whose damming activity crucially influenced stream conditions (SRWC & Siskiyou RDC 2014). The introduction of fur trappers into the Scott River ecosystem in the 1830s created a severe imbalance in predator-prey interactions that resulted in nearly complete eradication of beavers by the 1850s (Cramer Fish Sciences et al. 2010; SRWC & Siskiyou RDC 2014). This was the first significant anthropogenic impact on watershed quality and coho habitat. It was followed shortly afterward by the Scott Bar gold rush, which initiated decades of mining activity in the watershed that notably altered substrate composition (Cramer Fish Sciences et al. 2010; NOAA 2014; SRWC & Siskiyou RDC 2014). Modern impacts on channel morphology and hydraulic function include agricultural activity, cattle ranching, waterway dams and diversions, logging, and infrastructure building (Cramer Fish Sciences et al. 2010; NOAA 2014).

These anthropogenic forces have resulted in the simplification, degradation, and fragmentation of coho salmon migrating, spawning and rearing habitats in the Scott River basin. Channel confinement and lack of floodplain connectivity, coupled with the increasing prevalence of drought conditions, threatens the ability of migrating coho to reach spawning tributaries (Cramer Fish Sciences et al. 2010; NOAA 2014; SRWC & Siskiyou RDC 2014). A severe drought in 2014 caused premature disconnection of almost all Scott River tributaries; this event unfortunately coincided with the biggest run of coho salmon in recent history and was followed by a mass coho salmon rescue and relocation effort that affected the fishes' ability to locate spawning tributaries when they returned the following winter (Bull et al. 2015; Curtis et al. 2014). Dredging from past mining endeavors directly affects the current proportion of suitably-sized streambed gravels for redd construction, and elevated levels of interstitial fine sediments from anthropogenic sources interferes with egg incubation and fry emergence (Cramer Fish Sciences et al. 2010; Kondolf 2000). The removal of beavers from the watershed negatively impacts the quality and frequency of woody debris-formed scour pools, instream complexities, and vegetative temperature buffers that are essential components of juvenile rearing habitats (NOAA 2014). According to Clean Water Act standards in section 303(d), the Scott River watershed has been listed as impaired in relation to sediment since 1992 and impaired in relation to temperature since 1998 (Cramer Fish Sciences et al. 2010). This myriad of stressors is disproportionately affecting the survival success of juvenile coho, and therefore the juvenile life stage has been identified as the current limiting freshwater life stage for the viability of the Scott

River coho salmon population (NOAA 2014).

The Scott River coho comprise a functionally independent population within the Interior Klamath River diversity stratum, meaning they historically persisted mostly in isolation and their population dynamics are not substantially impacted by interactions with individuals from other populations (NOAA 2014). It is estimated that the Scott River needs to support at least 242 spawning adults each year to avoid deterioration of the Functionally Independent population, and 6,500 spawning adults annually to maintain the Interior Klamath River stratum and Southern Oregon/Northern California Coast (SONCC) ESU viability (NOAA 2014). Spawning densities are not consistently meeting these requirements at present, and the Scott River population has a moderate risk of extinction as determined by the National Marine Fisheries Service (NOAA 2014).

There is a lack of numerical data regarding coho salmon abundance before the mid-20th century, and even modern spawning surveys for California coho are limited in their extent and accuracy (Cramer Fish Sciences et al. 2010; NOAA 2014). Despite these limitations, population estimates for the Scott River watershed have been extrapolated based on surveys. The California Department of Water Resources estimated an adult population of 2,000 individuals in the Scott River in the early 1960s, and surveys recorded a slight increase to 2,731 adult coho in 2013 (NOAA 2014). It is important to note the cyclic nature of coho abundance when considering these estimates. Coho in the SONCC ESU typically exhibit a three-year life cycle, and Scott River populations of adult spawners meeting or exceeding 1,000 individuals are observed every third brood year with numbers between 60 to 355 in the other two brood years (NOAA 2014; Williams et al. 2006). While these population densities may be adequate to maintain the viability of the Scott River Functionally Independent stratum, they do not meet the identified parameters for maintaining stratum or ESU viability even during maximum brood years. Ensuring the availability of suitable spawning habitats as well as the survival of juvenile coho salmon in rearing habitats is essential for supplementing this existing population.

Spawning adults, redds, and juvenile coho have historically been observed with variable density throughout the study area in Patterson Creek. In the Scott River system, spawning typically occurs between November 1st and January 15th with embryos incubating from November 1st through April 15th and all fry emerging by May 15th (Cramer Fish Sciences et al. 2010). Patterson Creek is one of the first tributaries in which spawning is observed within the

Scott River watershed (Quigley 2004). 232 live coho were observed in Patterson Creek during the 2004-2005 spawning season, and although no redds were documented in the creek during the 2012-2013 season, 27 redds were documented within the study reach during the 2008-2009 spawning season (Quigley 2004; Yokel 2013).

Suitable coho habitat is a result of the channel geomorphology, which is largely influenced by flow regimes, sediment composition, and riparian vegetation (Kondolf 2000). Woody debris in riparian systems is comprised of fallen trees or branches that directly alter all these aspects of channel morphology and influence instream habitat quality. The Scott River and its tributaries lack adequate instream large woody debris according to what scientific literature suggests is necessary for coho salmon, which is likely a consequence of anthropogenic influence in the basin (Cramer Fish Sciences et al. 2010). Logging as well as high intensity wildfires in the watershed have diminished the potential introduction of woody debris into waterways and decreased the size and strength of logs available for recruitment (Cramer Fish Sciences et al. 2010; SRWC 2018). Due to the significant influence of woody debris presence on a multitude of riparian quality characteristics, installation of insteam debris structures has become the most common method of salmonid spawning habitat rehabilitation (Cramer Fish Sciences et al. 2010). Coupled with its relative ease of implementation and mimicry of natural processes, artificial introduction of instream debris structures is an appealing restoration strategy to consider in coho habitats.

The presence of large woody debris (LWD) directly contributes to suitable channel morphology and instream protective coverage for juvenile coho rearing habitat. Stream obstructions such as LWD cause flow convergence and turbulent velocity variation that scours the channel bed, resulting in the formation of scour pools (Flosi et al. 1998; Montgomery et al. 1995). Scour around LWD has been identified as a critical and even a dominant pool-forming mechanism in numerous study reaches (Beechie & Sibley 1997; Cramer Fish Sciences et al. 2010; Kondolf 2000; Montgomery et al. 1995). Increasing the density of LWD in a stream has additionally been correlated to increases in pool frequency (Beechie & Sibley 1997; Cramer Fish Sciences et al. 2010; Montgomery et al. 1995). Pools are essential slow water refugia for juvenile coho, and LWD obstructions create pools of satisfactory frequency and protective cover for coho fry rearing as well as spawning (Buffington et al. 2004; Giannico 2000). Cover associated with LWD effectively reduces the risk of predation for coho fry (Cramer Fish Sciences et al. 2010;

Giannico 2000; Kondolf 2000). Positive correlations between instream cover and coho abundance have been observed (Buffington et al. 2004; Giannico 2000; McMahon & Hartman 1989), and coho have been found to particularly prefer pools with debris cover during the summer months, possibly due to their temperature-buffering ability (Giannico 2000). However, ideal LWD pool habitats consist of a low to medium density of underwater debris that does not negatively interfere with foraging ability by decreasing visibility and maneuverability of fry (Giannico 2000).

In addition to providing quality fry rearing habitat pools, instream woody debris augments the retention of sediment and effectively sorts suitable spawning gravels (Beechie & Sibley 1997; Cramer Fish Sciences et al. 2010; Giannico 2000; Kondolf 2000). Streamflow accelerates as it moves around LWD and exhibits an increased ability to carry sediments; as it passes the debris, velocity decreases and sediments are deposited (Cramer Fish Sciences et al. 2010). Debris structures thus slow the downstream migration of sediments as well as concentrate suitable spawning gravel in association with the structures. This study will assess whether this association is evident in Patterson Creek. The Scott River Watershed Council refers to artificially-introduced instream woody debris structures as log jams, and this terminology will be used throughout the remainder of this paper.

This research assesses the effectiveness of introducing instream woody debris as a restoration strategy for coho habitat in Patterson Creek through direct observation, data collection, and literary research. Additionally, this research will determine the extent to which instream woody debris contributes to Patterson Creek's coho rearing habitat quality through consideration of pool frequency and quality, slow velocity refugia, and protective cover. This study particularly emphasizes substrate composition as an indicator of woody debris influence, and statistical analyses will be conducted to evaluate spawning gravel quality in relation to debris structures.

This study design addresses the expressed stream profile documentation needs of the Scott River Watershed Council in addition to the influence of large woody debris on stream morphology and coho habitat parameters. Collaboration with the SRWC produced five data collection components; these included stream flow, water temperature, streambed substrate composition, pool frequency and quality, and vegetative coverage instream as well as in the riparian zone. These components were identified for their usefulness in creating a thorough profile of Patterson Creek's current coho habitat quality as well as their value as quantitative descriptors of large woody debris influence on stream morphology. This study seeks to provide data regarding morphological characteristics that may be referenced in the future to compare stream conditions before and after woody debris implementation. The research methodology developed in this study sets a precedent for future data collection in Patterson Creek that will document the long-term effects of large woody debris on coho habitat quality.

Research Design and Methodology

Out of all of the Scott River's tributaries, Patterson Creek was ranked fifth overall for its coho habitat enhancement potential (Cramer Fish Sciences et al. 2010). Restoration efforts in each of the top-ranked tributaries have been tailored to the specific existing habitat conditions and targeted restoration goals of each stream. In the upper and middle reaches of Patterson Creek where the study area spanned, existing habitat has been documented as sufficient for supporting coho salmon populations in regard to temperature range, presence of potentially inundated off-channel features, and riparian vegetative coverage (NOAA 2014; Quigley 2004; SRWC 2018). A primary limiting factor to coho survival success in Patterson Creek is disconnection from the mainstem Scott River during spawning season due to lack of flow between precipitation events (Quigley 2004; Yokel 2013). Its disconnectivity has typically been observed through late November and occurs consistently every year (SRWC & Siskiyou RDC 2014; SRWC 2018; Yokel 2013). Since precipitation is an uncontrollable factor in Patterson Creek's restoration efforts, emphasis should be given to managing water retention capability, floodplain connectivity, and suitable habitat accessibility.

The Scott River Watershed Council concluded that introducing log jams would be the most effective strategy for improving coho habitat conditions in Patterson Creek. During the first two weeks of October in 2018, the SRWC dropped 35 conifers and hardwoods 10-30" in diameter from the creek's riparian zone and positioned them across its main channel (SRWC 2018). The SRWC expressed that their specific intentions for introducing woody debris were to partition flow, create slow water refugia and scour pools, increase frequency of floodplain inundation, sort gravel, and retain more wood elements in the creek (SRWC 2018). They intended to carry out two more phases of log jam implementation in the creek, one of which was initiated on September 30, 2019 after the majority of fieldwork had been completed. The third phase currently awaits funding.

This research is relevantly designed to address restoration priorities as identified by the SRWC and scientific literature. No data collection was conducted prior to phase 1 implementation with the specific locations of log jams in mind. The only available data regarding sediment composition, which is a primary focus in the analysis of the influence log jams have on habitat parameters, was collected in previous studies which did not document the exact locations of sediment collection (Cramer Fish Sciences et al. 2010; Quigley 2004). Specificity in the spatial relationship between sediment data and log jams is crucial to determining whether the structures alter spawning gravel quality; this study seeks to fill this gap in data and create a more thorough sediment profile for Patterson Creek that focuses attention on log jam locations. In addition, this research will characterize the flow and temperature regimes of the creek, describe all of its habitat types for the first time on record, and descriptively inventory the existing phase 1 log jams. Installing flow gauges to monitor tributary connectivity was recommended in the *Scott River Spawning Gravel Evaluation and Enhancement Plan* (Cramer Fish Sciences et al. 2010)*,* and this study will compile baseflow data throughout the months in which Patterson Creek is most susceptible to inadequate flows. The Riparian Planning Committee recommended conducting a geomorphic survey and analysis of Patterson Creek (SRWC & Siskiyou RDC 2014), which this research will initiate. The Recovery Strategy for California coho salmon emphasizes a detailed assessment of spawning gravels in the Scott River watershed (NOAA 2014), and this assessment methodology in Patterson Creek will set a precedent for future surveys throughout the basin.

GPS Data Collection

GPS data collection was an imperative part of improving the spatial understanding of the applied restoration as it relates to the surveyed area. Using a Garmin GPSMAP 64st, geospatial data was collected and recorded throughout the entire project, providing context and spatial reference to other methodological procedures. This included GPS coordinate use in transect identification, temperature and discharge monitoring stations, location of applied log jams, substrate inventories, photo points, and wood sourcing for future phases of implementation.

Establishment of Transects

In early July 2019, eight transect locations throughout the surveyed area were established.

In order to accurately represent the varying conditions of Patterson Creek throughout the treated and untreated reaches, one transect was set up just before phase one, two within phase one, two within phase two, and three within phase three (Appendix A). Each transect was installed above bankfull using two steel rebar, tape measure, stadia rod, and a self-leveling rotary laser system kit to ensure equal elevation of the rebar placement on river right and river left.

Temperature and Discharge Monitoring

Two flow monitoring stations were established at the top and bottom of the surveyed reach with stream depth staff gauge and HOBO water level flow loggers at each station (Appendix A). Three temperature data loggers were also placed at the bottom of each project phase and all loggers were set to take measurements every fifteen minutes. To improve the accuracy of this flow data, discharge was also manually measured using a SonTek Flow Tracker: Handheld ADV. These manual flow measurements were conducted at flow station one in July, August, September, and November. Manual measurements at flow station two occurred only in July due to a lack of water presence in subsequent months. When manually measuring flow, a tape measure was run across the stream from river left rebar to river right rebar, one foot cells were established, and 30 second measurements of flow were taken halfway between each cell across the entirety of the active stream channel to determine total discharge in cubic feet per second.

Streambed Substrate Composition Assessment

Streambed substrate composition data was collected at each established transect and at seven additional sites (Figure 1). These locations were selected to accurately represent varying conditions of Patterson Creek in the untreated reaches and control area, as well as represent streambed substrate composition in locations of newly introduced log jam structures. Data was collected in accordance with Wolman Pebble Count methodology adapted through use of a Wildco Gravelometer. With this method, substrate was categorized based on the largest slot with specified diameter through which an individual pebble could not pass, 100 pebbles were collected, and counts of each substrate size class between 2mm-180mm were recorded (Cramer Fish Sciences et al. 2010).

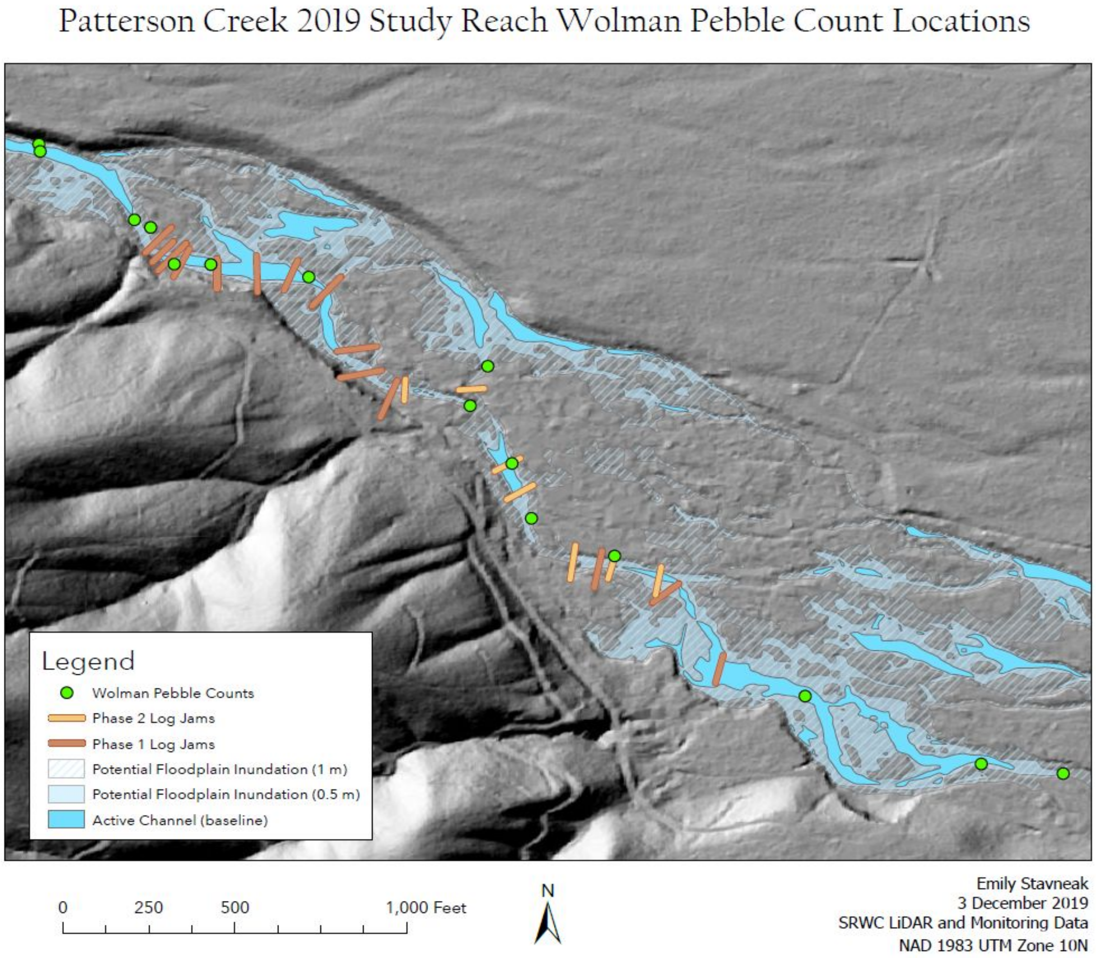


Figure 1: Locations of Wolman Pebble Counts conducted on Patterson Creek.

Stream Channel Typing and Habitat Classification

Stream channel typing and habitat classification were carried out in accordance with the methods outlined in *California salmonid stream habitat restoration manual, 4th ed. California Department of Fish and Game: Part III Habitat Inventory Methods*. This standardized methodology determines stream channel classification based off of the system developed by D. L. Rosgen in 1994 and determines habitat typing using a variation of a system originally introduced by Bisson et al. in 1982 (Flosi, et al. 1998).

Stream classification methodology was carried out in two locations of Patterson Creek; one in phase one at transect #1 and one in phase two at transect #5. Assessment of transect depths, dominant substrate, entrenchment value, width/depth ratio, and water surface slope was conducted at each location. Resulting values of these determinants were then applied to the "Key to Classification of Streams” and a stream type (A1-DA6) was applied (Flosi et al. 1998). For examples of field forms used to determine channel type, see Appendix B.

In habitat classification data collection, habitat units were described using four levels of habitat classification. Division of habitat units was determined on the basis that homogeneous hydrologic features were measured to be equal or greater in length than the wetted channel width (Flosi et al. 1998). Each habitat unit was described using rapid assessment protocol of physical features of the active stream, shelter rating, substrate composition, bank composition, and vegetation in order to then apply appropriate habitat type descriptions (1.1-9.1) as outlined in the *California Salmonid Stream Habitat Restoration Manual*, and taken originally from the *Pacific Southwest Region Habitat Typing Field Guide* published by the USDA-USFS. For examples of field forms used to classify habitat units, see Appendix C.

Log Jam Inventory

Log jam data inventory forms were created and completed to qualitatively and quantitatively describe log jam structures identified throughout the surveyed area. Fourteen log jams were identified throughout phases one and two of the project. At each log jam, the survey team recorded length, width, and height measurements of each structure, noted GPS coordinate location, identified LWD plate numbers of intentionally placed logs, described log jam functional characteristics in relation to stream morphology, and created sketches of each structure. For examples of log jam inventory forms, see Appendix D.

Photo Point Procedure

In order to supplement quantitative data collection with visual examples of Patterson Creek’s habitat conditions, a photo point procedure was developed. The replication of these photo points is ensured through thorough numerical delineation, GPS coordinate collection, and written description of each photo point location. Photo points were taken systematically in the middle of the main channel streambed at nose height facing north, northeast, east, southeast, south, southwest, west, and northwest. A total of twenty formal photo points were created throughout the entirety of the surveyed area. Additionally, previous photos of log jams taken shortly after the implementation of phase one were replicated to document changes in log jam structure or stream morphology. For examples of photo points, see Appendix E.

Fish Presence Documentation

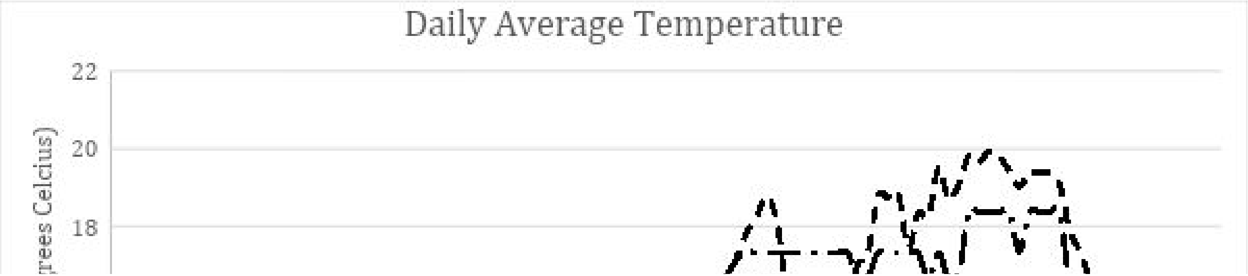
Given the small number of sites where juvenile fish were observed during routine data collection, a formal survey of the entirety of the study reach was deemed unnecessary. Instead, snorkel dives were conducted only at sites where fish presence had been observed. Photo and video evidence of fish presence was collected using a GoPro camera placed underwater within log jam #1 and just before log jam #5 where fish were consistently present. The camera was installed below water level and left unmonitored for twenty minutes.

Study Results

Temperature and Discharge Monitoring

Temperature data was evaluated, and daily average temperatures were determined for each of the four temperature recording locations. Graphing this data confirmed that temperatures within Patterson Creek are typically within the desirable range for coho salmon viability (Figure 2). This is likely due to the adequate vegetative coverage throughout much of this study reach. However, this is contingent upon water levels maintaining an appropriate depth to buffer the effects of insolation on water temperatures. Discharge consistency in Patterson Creek is one of this tributary's limiting factors in supporting coho salmon populations. It becomes disconnected from the mainstem Scott River during summer months and may not reconnect until late winter. Stream discharge at the upstream end of the study reach was recorded and graphed (Figure 3). Discharge drops dramatically between July and September from an already low level of 1 cfs to 0.1 cfs. Notably, this low discharge may have been a result of the placement of the monitoring station. Further data collection is recommended to assess discharge in Patterson Creek.

A rating curve for the approximation of flow based on temperature was created in accordance with USGS protocol from collected temperature and discharge data (Appendix F). The accuracy of this rating curve is limited due to the few months during which this study took place. Future data collection should seek to produce a more accurate rating curve for Patterson Creek.



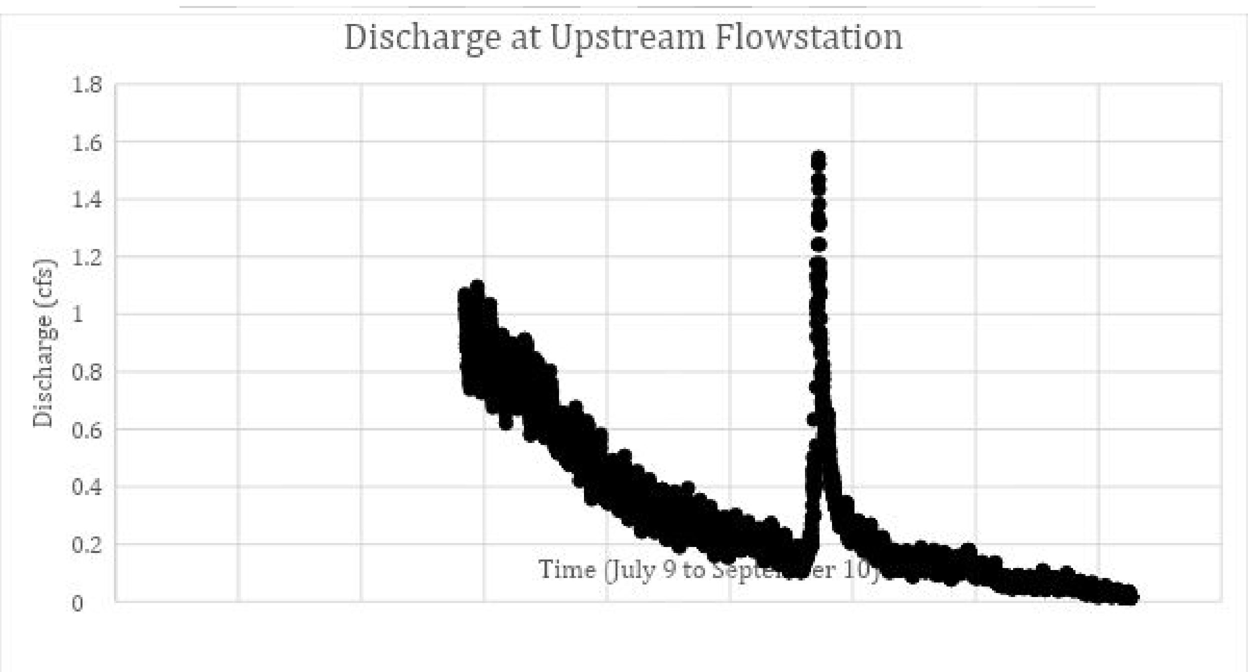


Figure 3: Stream discharge recorded at the upstream flow monitoring station on Patterson Creek from July 9 to September 10, 2019.

Streambed Substrate Composition Assessment

In assessing streambed substrate composition data, cumulative frequency curves were created for each data collection site (Appendix G). Additionally, calculations were made to determine D16, D50, and D84 values for each substrate sample (Appendix H).

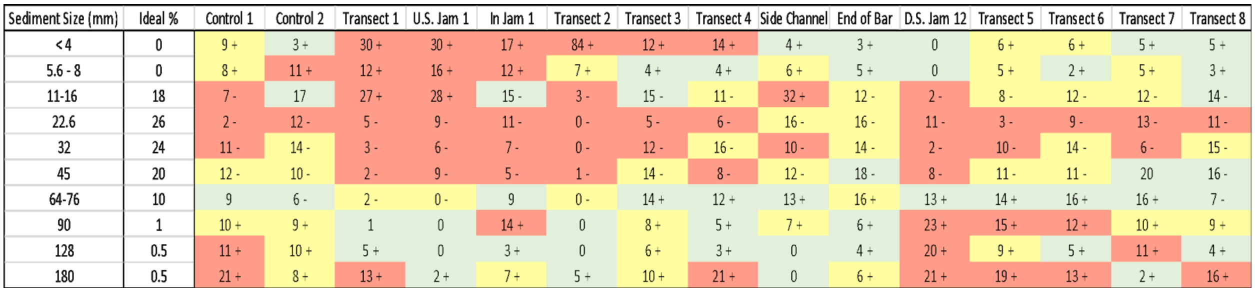
Statistical analysis of streambed substrate composition was conducted on four distinct locations of streambed substrate collection. These locations are Control 1 and Control 2, located just below Flow Station 1, and collections taken within Log Jam #1, at the top of the treated reach, and at Transect 3, just beyond the treated reach. These tests were conducted through utilization of a z-statistic with the null hypothesis that artificially-introduced instream woody-debris has no effect on the composition of streambed substrate (Appendix I). A statistically significant difference between the Control 1 sample substrates and the two substrate samples within the treated reach was observed ($p = 5.66\ E^{-5}$, $p = 0.0127$), resulting in a rejection of the null hypothesis in both instances. In testing of the Control 2 sample compared to the two within the treated reach, no statistical significance was determined between samples ($p = 0.2161$, $p = 0.6648$), resulting in acceptance of the null hypothesis. These results were inconsistent in determining whether log jam presence affects sediment size.

In addition to these tests, a chi-square test of association was applied to assess if overall substrate composition varied between the treated and control substrate samples (Appendix J). This analysis found no statistically significant difference in the relative proportion of salmon-suitable substrate between the treated area of the project and the control reach ($p = 0.9709$, $X^2 = 0.0013$). Given these results, with inconsistencies in findings within each statistical test, it is inconclusive whether or not implementation of instream woody debris has impacted streambed substrate composition in Patterson Creek.

The inconsistency in data analysis results is likely due to a lack of data collection and assessment. The baseflow timeframe during which substrate was collected may have impacted sediment sizes, and the time elapsed between implementation and data collection may not have been long enough to cause significant changes in substrate composition. Future data collection regarding substrate composition, especially in proximity to logjams, is recommended.

Another method for assessing substrate composition in the creek, specifically whether sediments were too small or too large at a particular site to be conducive to coho spawning habitat, was the creation of a sediment profile table (Table 1). Data from the *Scott River Spawning Gravel Evaluation and Enhancement Plan* (Cramer et al. 2010) indicated desirable percentage proportions of each sediment size class based on the average female coho spawner size in the Scott River, which determines what size sediments are moveable in the construction of a redd. Collected sediment data for Patterson Creek was then compared to these ideal percentage proportions. If a sediment size class proportion is within 5% of the ideal proportion, it is given a green cell in Table 1. If it is within 10% of the ideal, the cell is shown in yellow, and if it is greater than 10% different from the ideal, the cell is shown in red.

Table 1: Comparison of collected substrate samples in Patterson Creek to an ideal substrate composition profile for the Scott River Watershed as determined by Cramer et al. 2010.



Sediment Size (mm)	Ideal %	Control 1	Control 2	Transect 1	U.S. Jam 1	In Jam 1	Transect 2	Transect 3	Transect 4	Side Channel	End of Bar	D.S. Jam 12	Transect 5	Transect 6	Transect 7	Transect 8
< 4	0	9 +	3 +	30 +	30 +	17 +	84 +	12 +	14 +	4 +	3 +	0	6 +	6 +	5 +	5 +
5.6 - 8	0	8 +	11 +	12 +	16 +	12 +	7 +	4 +	4 +	6 +	5 +	0	5 +	2 +	5 +	3 +
11-16	18	7 -	17	27 +	28 +	15 -	3 -	15 -	11 -	32 +	12 -	2 -	8 -	12 -	12 -	14 -
22.6	26	2 -	12 -	5 -	9 -	11 -	0 -	5 -	6 -	16 -	16 -	11 -	3 -	9 -	13 -	11 -
32	24	11 -	14 -	3 -	6 -	7 -	0 -	12 -	16 -	10 -	14 -	2 -	10 -	14 -	6 -	15 -
45	20	12 -	10 -	2 -	9 -	5 -	1 -	14 -	8 -	12 -	18 -	8 -	11 -	11 -	20	16 -
64-76	10	9	6 -	2 -	0 -	9	0 -	14 +	12 +	13 +	16 +	13 +	14 +	16 +	16 +	7 -
90	1	10 +	9 +	1	0	14 +	0	8 +	5 +	7 +	6 +	23 +	15 +	12 +	10 +	9 +
128	0.5	11 +	10 +	5 +	0	3 +	0	6 +	3 +	0	4 +	20 +	9 +	5 +	11 +	4 +
180	0.5	21 +	8 +	13 +	2 +	7 +	5 +	10 +	21 +	0	6 +	21 +	19 +	13 +	2 +	16 +

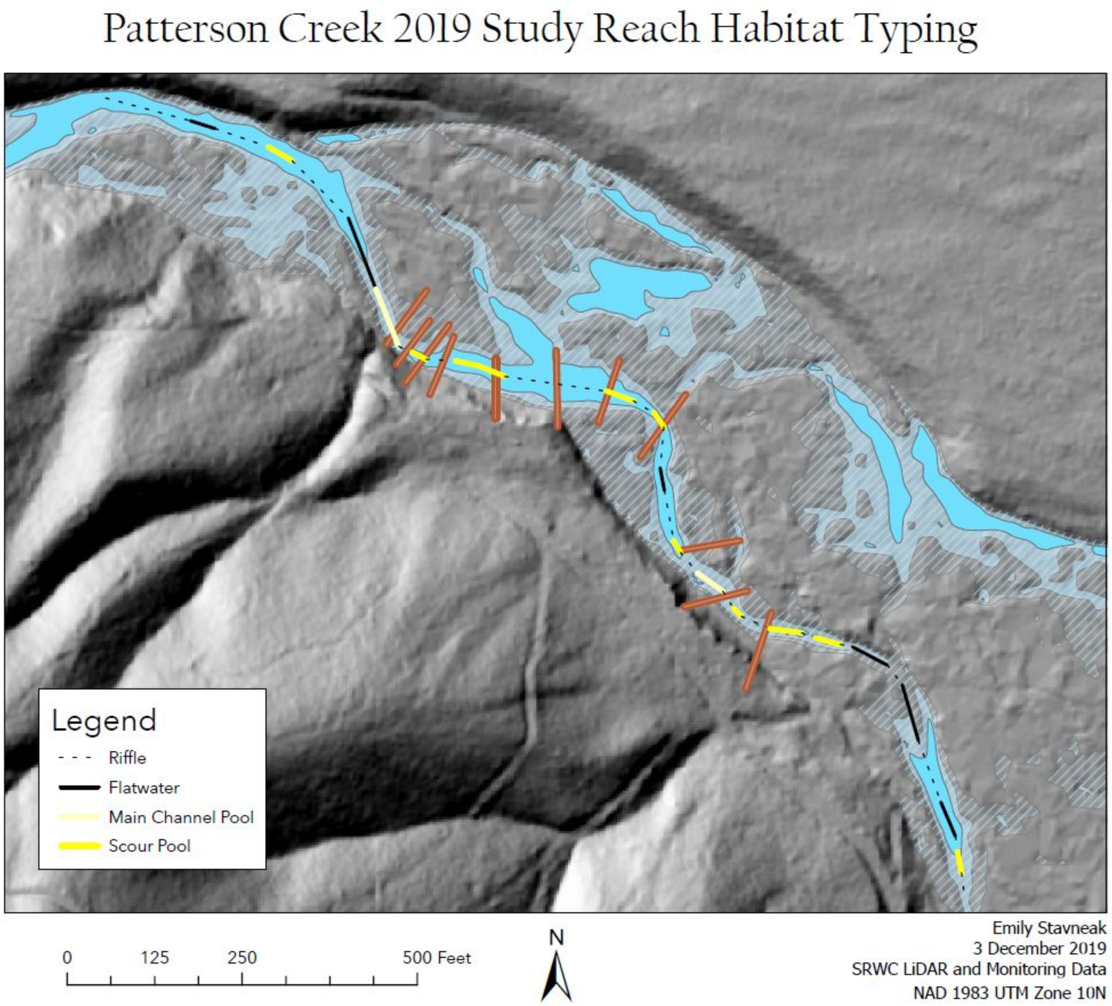
This assessment concluded that there is a substantial difference in small sediment sizes throughout the upstream portion of the Patterson Creek study reach, and throughout the entire reach, essential sediments between 11mm-45mm are not currently close to an ideal proportion. Additionally, + and – symbols next to the number in each cell indicate whether that percentage is higher (+) or lower (-) than the ideal proportion. Upstream sections tend to have a disproportionately high amount of fine sediment, while downstream sections have a disproportionately high amount of large cobbles and boulders. This assessment method is valuable in understanding what improvements to sediment composition are needed in Patterson Creek, and its replication in future research is encouraged.

Stream Channel Typing and Habitat Classification

Stream channel typing procedure identified Patterson Creek as a B3 type stream (Appendix B). This stream type is a moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools (Flosi et al. 1998). It has a stable plan and profile, stable banks, and a cobble-dominated channel. The *California Salmonid Stream Habitat Restoration Manual* recommends this stream type as being excellent for plunge weirs, boulder clusters and bank placed boulders, single and opposing wing-deflectors, and log structures to improve fish habitat

(Flosi et al. 1998)

After classifying habitat units throughout a sizable portion of the creek, a map was created to visually assess whether there was a spatial association between log jam structures and desirable pool habitat types for juvenile coho rearing (Figure 4). Evaluation of this map suggests that there is some degree of association between log jams and pools. This method of determining habitat unit types in the field and mapping them in accordance with log jam placement is extremely valuable in exploring the relationship between these structures. It is recommended that habitat classification be conducted before the implementation of restoration techniques that directly affect stream morphology in order to determine associated changes in stream habitat.



Patterson Creek 2019 Study Reach Habitat Typing

Emily Stavneak
3 December 2019
SRWC LiDAR and Monitoring Data
NAD 1983 UTM Zone 10N

Figure 4: Habitat unit types in association with log jam structures Patterson Creek.

Fish Presence Documentation

While the majority of fish observed in snorkel dives and video footage were determined to be steelhead trout, one video confirmed positive identification of juvenile coho salmon in a pool habitat associated with the log jam #1 complex (Figure 5). Identification was based on the width of spaces between parr marks being wider than marks themselves, a strongly forked tail, and a lack of spots on dorsal fin and tail (Quigley 2004). Confirmation was approved by Erich Yokel, a member of the SRWC who mentored this research. Observing juvenile coho utilizing log jam associated habitats was an additional assurance that these structures are preferential rearing habitats in actuality rather than only in theory.

Figure 5: Juvenile coho salmon observed in log jam 1 complex.

Conclusion

This study produced a thorough descriptive profile of current coho salmon habitat conditions within Patterson Creek that may be referenced and replicated in the future in order to monitor the effects of log jam structures on habitat parameters. Since no thorough habitat data was collected on Patterson Creek before the SRWC implemented log jam structures in 2018, acquiring quantitative and qualitative information about the creek's conditions was necessary to document changes in stream habitat as the project continues to affect the stream. Preliminary assessment of statistically significant differences between habitat conditions associated with log jams was conducted, with emphasis placed on substrate composition alteration, yet further data collection is necessary to add robustness to these results. While there is a surplus of literature citing the effectiveness of woody debris in sorting sediment sizes, there is a. notable lack of case study examples of this process. The research conducted on Patterson Creek could set a precedent among restoration projects of this nature to thoroughly monitor streambed substrates in relation to log jam implementation. Additionally, habitat classification maps created as part of this study may be recreated in the future as phases two and three of Patterson Creek's restoration plan are implemented. The benefits of this research extend beyond its immediate results and are especially poignant in the application of these methodologies for data collection, documentation of current conditions, and recommendations for future data collection on this creek.

Bibliography

Beechie, T. J., & Sibley, T. H. (1997). Relationships between Channel Characteristics, Woody Debris, and Fish Habitat in Northwestern Washington Streams. *Transactions of the American Fisheries Society*, *126*(2), 217–229. https://doi.org/10.1577/1548-8659(1997)126<0217:rbccwd>2.3.co;2

Buffington, J. M., Montgomery, D. R., & Greenberg, H. M. (2004). Basin-scale availability of salmonid spawning gravel as influenced by channel type and hydraulic roughness in mountain catchments. *Canadian Journal of Fisheries and Aquatic Sciences*, *61*(11), 2085–2096. https://doi.org/10.1139/F04-141

Bull, J., Flickinger, D., Preston Harris, Lindsay Magranet, Bobbie Miller, & Sommarstrom, S. (2015). *Cooperative Report of the Scott River Coho Salmon Rescue and Relocation Effort : 2014 Drought Emergency. California Department of Fish & Wildlife Report*. https://doi.org/10.1080/02691728.2017.1317865

Cramer Fish Sciences, Philip Williams & Associates, & Siskiyou Resource Conservation District. (2010). *Scott River Spawning Gravel Evaluation and Enhancement Plan*. Retrieved from papers3://publication/uuid/9A321108-D5C6-43F5-8127-01FF050ACCF3

Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey, R., & Collins, B. (1998). *California salmonid stream habitat restoration manual, 4th ed. California Department of Fish and Game.* Retrieved from http://www.dfg.ca.gov/fish/resources/habitatmanual.asp

Giannico, G. R. (2000). Habitat selection by juvenile coho salmon in response to food and woody debris manipulations in suburban and rural stream sections. *Canadian Journal of Fisheries and Aquatic Sciences*, *57*(9), 1804–1813. https://doi.org/10.1139/f00-132

Kondolf, G. M. (2000). Some suggested guidelines for geomorphic aspects of anadromous salmonid habitat restoration proposals. *Restoration Ecology*, Vol. 8, pp. 48–56. https://doi.org/10.1046/j.1526-100X.2000.80007.x

McMahon, T. E., & Hartman, G. F. (1989). Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (Oncorhynchus kisutch). *Canadian Journal of Fisheries and Aquatic Sciences*, *46*(9), 1551–1557. https://doi.org/10.1139/f89-197

Montgomery, D. R., Buffington, J. M., Smith, R. D., Schmidt, K. M., & Pess, G. (1995). Pool Spacing in Forest Channels. *Water Resources Research*, *31*(4), 1097–1105.

NOAA. (2014). Chapter 36: Scott River Population. *Final SONCC Coho Recovery Plan.* Retrieved from https://archive.fisheries.noaa.gov/wcr/publications/recovery_planning/salmon_steelhead/domains/southern_oregon_northern_california/SONCC%20Final%20Sept%202014/sonccfinal_ch36_scottriver.pdf

Quigley, D. (2004). *Scott River Watershed Adult Coho Spawning Ground Surveys*.

Scott River Watershed Council, & Siskiyou RCD. (2014). *Scott River Watershed Restoration Strategy & Schedule*.

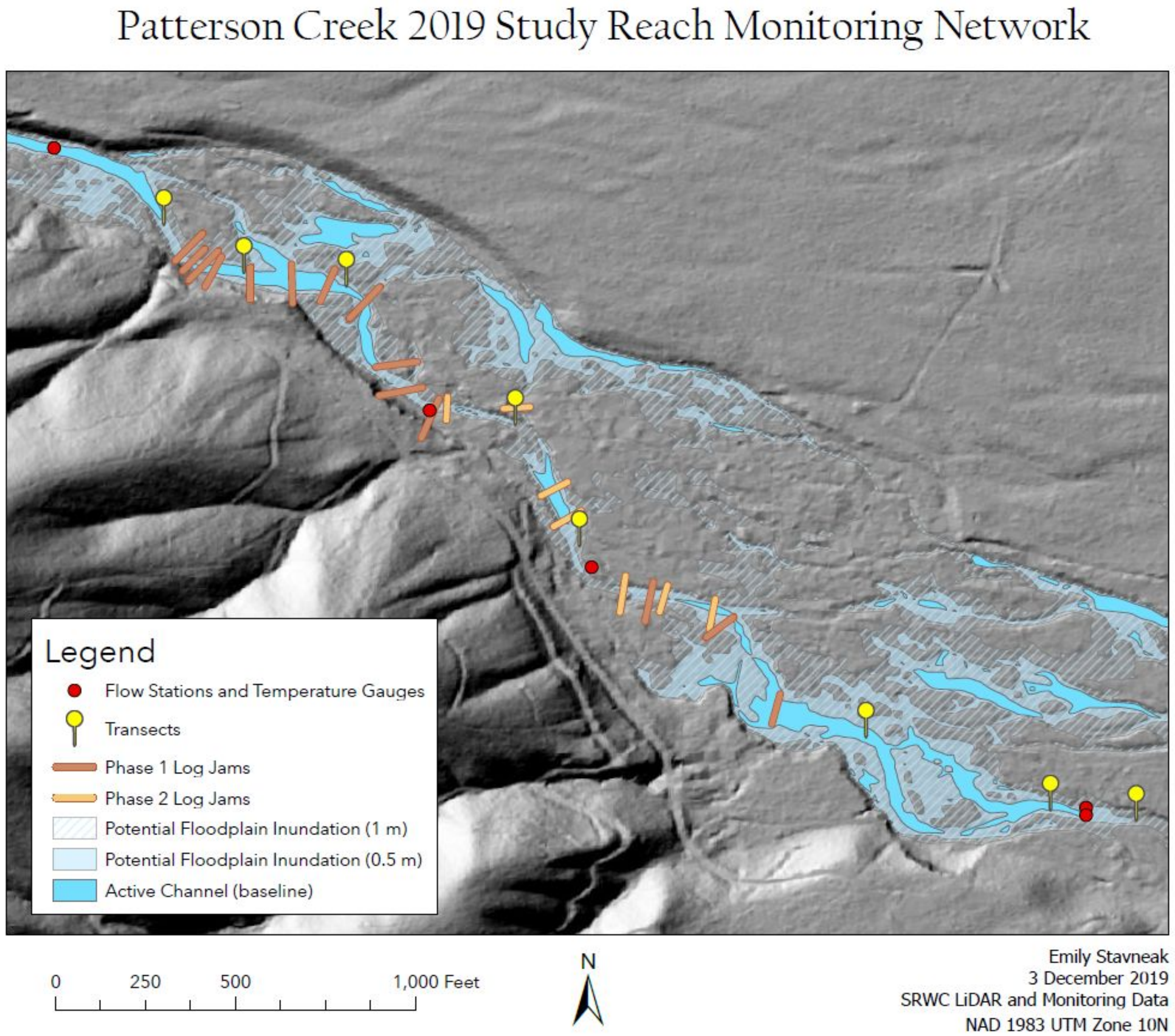
Scott River Watershed Council. (2018). *Patterson Creek Accelerated Wood Recruitment Project*.

Williams, T. H., Bjorkstedt, E. P., Duffy, W. G., Mccain, M., Rode, M., & Szerlong, R. G. (2006). *Historical population structure of Coho Salmon in Southern Oregon/Northern California coasts evolutionary significant unit*.

Yokel, D., & Siskiyou Resource Conservation District. (2013). *Scott River Adult Coho Spawning Ground Surveys 2012-2013 Season*.

Appendix A

Map of the monitoring network established on Patterson Creek including the locations of transects, flow monitoring stations, and temperature gauges.

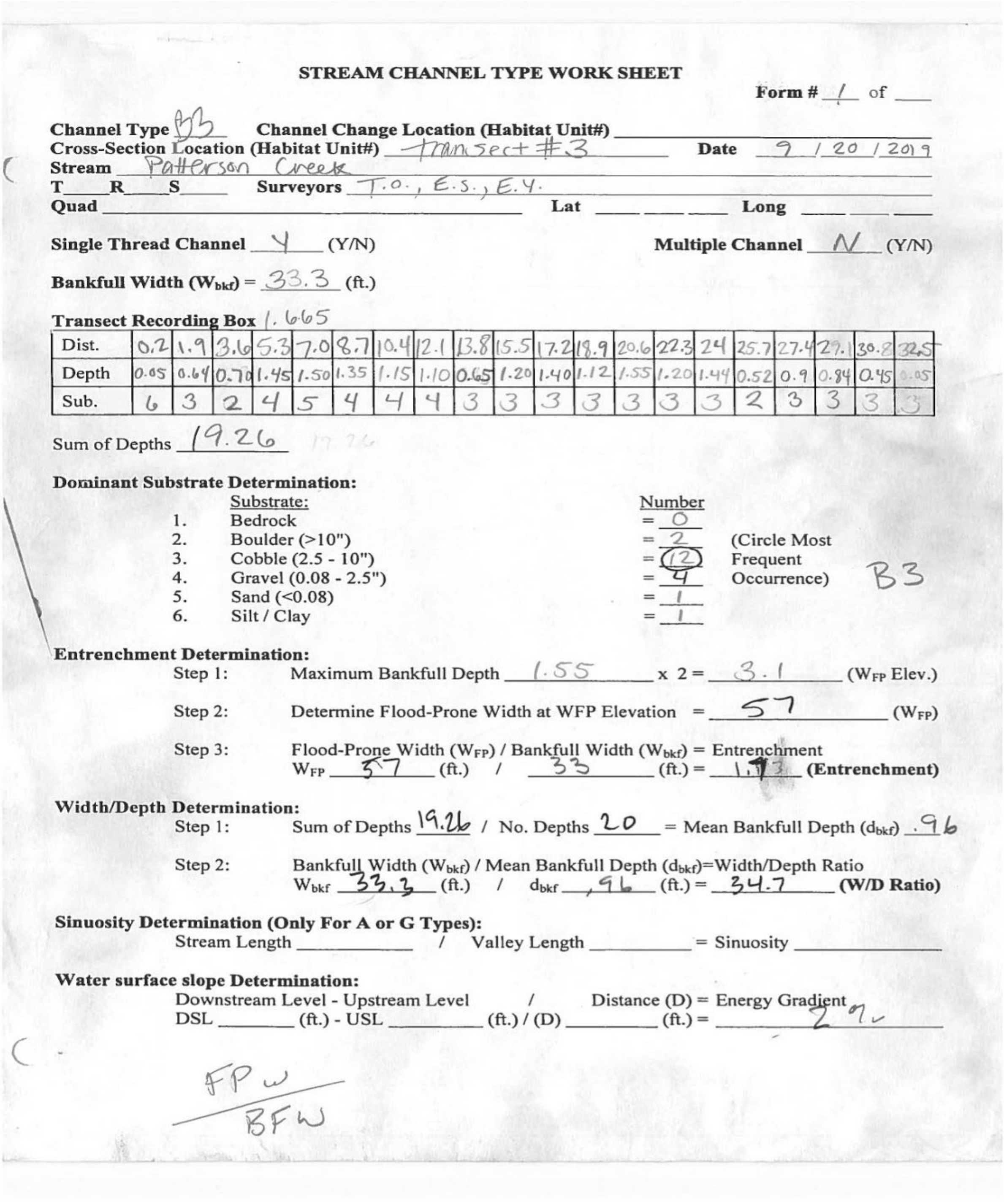


Patterson Creek 2019 Study Reach Monitoring Network

Emily Stavneak
3 December 2019
SRWC LiDAR and Monitoring Data
NAD 1983 UTM Zone 10N

Appendix B

Form used to determine stream channel type.



STREAM CHANNEL TYPE WORK SHEET

Form # 1 **of** ____

Channel Type B3 **Channel Change Location (Habitat Unit#)** ____
Cross-Section Location (Habitat Unit#) Transect #3 **Date** 9 / 20 / 2019
Stream Patterson Creek
T___ **R**___ **S**___ **Surveyors** T.O., E.S., E.Y.
Quad ____ **Lat** ____ **Long** ____

Single Thread Channel Y (Y/N) **Multiple Channel** N (Y/N)

Bankfull Width (W_{bkf}) = 33.3 (ft.)

Transect Recording Box 1.665

Dist.	0.2	1.9	3.6	5.3	7.0	8.7	10.4	12.1	13.8	15.5	17.2	18.9	20.6	22.3	24	25.7	27.4	29.1	30.8	32.5
Depth	0.05	0.64	0.70	1.45	1.50	1.35	1.15	1.10	0.65	1.20	1.40	1.12	1.55	1.20	1.44	0.52	0.9	0.84	0.45	0.05
Sub.	6	3	2	4	5	4	4	4	3	3	3	3	3	3	3	2	3	3	3	3

Sum of Depths 19.26 19.26

Dominant Substrate Determination:

	Substrate:	Number
1.	Bedrock	= 0
2.	Boulder (>10")	= 2
3.	Cobble (2.5 - 10")	= [✓ 12]
4.	Gravel (0.08 - 2.5")	= 4
5.	Sand (<0.08)	= 1
6.	Silt / Clay	= 1

(Circle Most Frequent Occurrence)

B3

Entrenchment Determination:

Step 1: Maximum Bankfull Depth 1.55 x 2 = 3.1 (W_{FP} Elev.)

Step 2: Determine Flood-Prone Width at WFP Elevation = 57 (W_{FP})

Step 3: Flood-Prone Width (W_{FP}) / Bankfull Width (W_{bkf}) = Entrenchment
W_{FP} 57 (ft.) / 33 (ft.) = 1.73 **(Entrenchment)**

Width/Depth Determination:

Step 1: Sum of Depths 19.26 / No. Depths 20 = Mean Bankfull Depth (d_{bkf}) .96

Step 2: Bankfull Width (W_{bkf}) / Mean Bankfull Depth (d_{bkf})=Width/Depth Ratio
W_{bkf} 33.3 (ft.) / d_{bkf} .96 (ft.) = 34.7 **(W/D Ratio)**

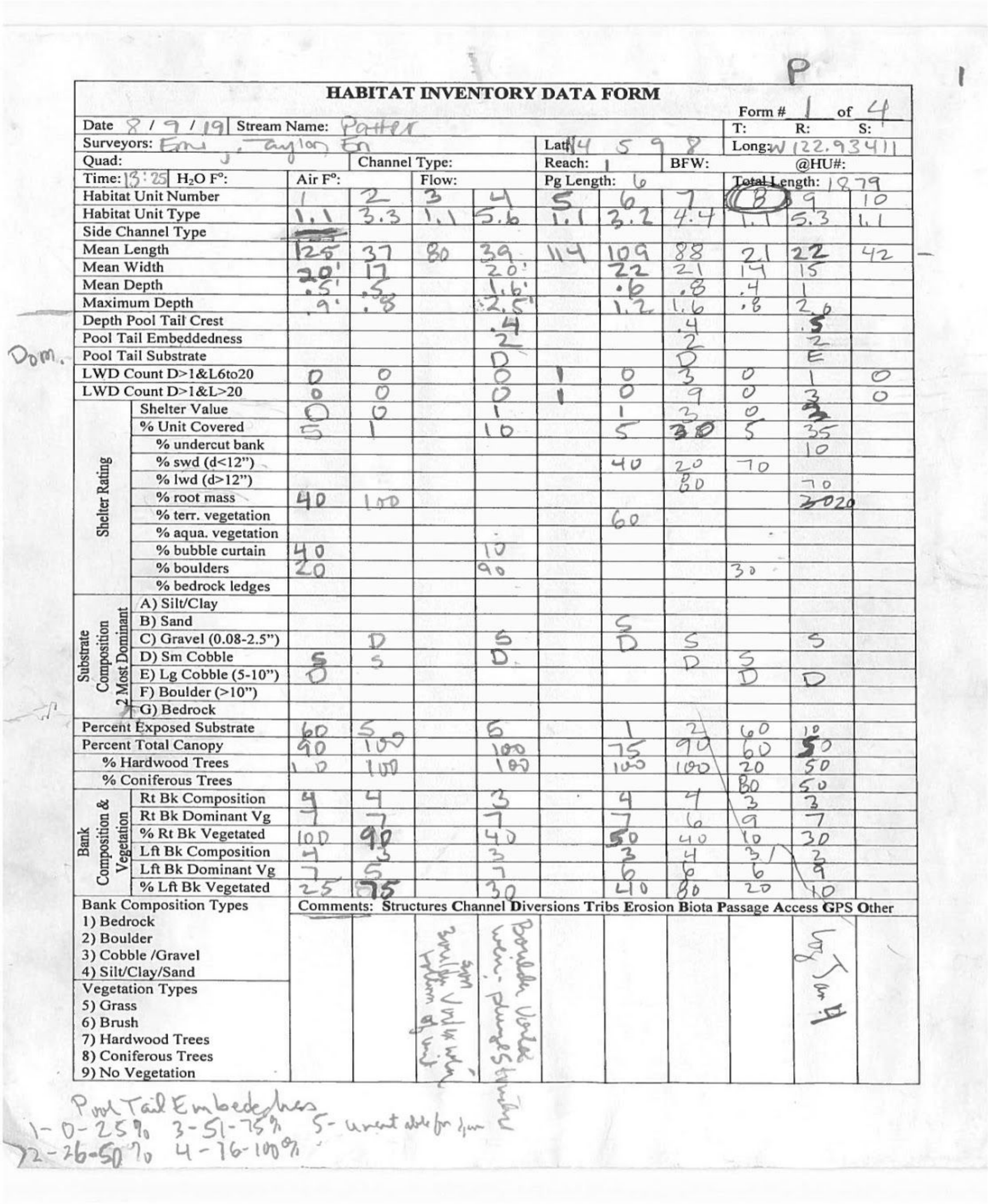
Sinuosity Determination (Only For A or G Types):
Stream Length ____ / Valley Length ____ = Sinuosity ____

Water surface slope Determination:
Downstream Level - Upstream Level / Distance (D) = Energy Gradient
DSL ____ (ft.) - USL ____ (ft.) / (D) ____ (ft.) = 2%

$\frac{\text{FPw}}{\text{BFW}}$

Appendix C

Forms used to classify habitat types, from upstream to downstream.



P 1

HABITAT INVENTORY DATA FORM

Form # 1 of 4

Date 8 / 9 / 19 Stream Name: Potter
T: R: S:
Surveyors: Emi, Taylor, Em
Lat: 4 5 9 8
Long: W 122.93411
Quad:
Channel Type:
Reach: 1
BFW:
@HU#:
Time: 13:25 H₂O F°:
Air F°:
Flow:
Pg Length: 6
Total Length: 1879

Habitat Unit Number	1	2	3	4	5	6	7	8	9	10
Habitat Unit Type	1.1	3.3	1.1	5.6	1.1	3.2	4.4	1.1	5.3	1.1
Side Channel Type										
Mean Length	125	37	80	39	114	109	88	21	22	42
Mean Width	20'	17		20'		22	21	14	15	
Mean Depth	.5'	.5		1.6'		.6	.8	.4	1	
Maximum Depth	.9'	.8		2.5'		1.2	1.6	.8	2.6	
Depth Pool Tail Crest				.4			.4		.5	
Pool Tail Embeddedness				2			2		2	
Dom. Pool Tail Substrate				D			D		E	
LWD Count D>1&L6to20	0	0		0	1	0	3	0	1	0
LWD Count D>1&L>20	0	0		0	1	0	9	0	3	0
Shelter Rating: Shelter Value	0	0		1		1	3	0	3	
% Unit Covered	5	1		10		5	30	5	35	
% undercut bank									10	
% swd (d<12")						40	20	70		
% lwd (d>12")							80		70	
% root mass	40	100							~~30~~20	
% terr. vegetation						60				
% aqua. vegetation										
% bubble curtain	40			10						
% boulders	20			90				30		
% bedrock ledges										
Substrate Composition 2 Most Dominant: A) Silt/Clay										
B) Sand						S				
C) Gravel (0.08-2.5")		D		S		D	S		S	
D) Sm Cobble	S	S		D			D	S		
E) Lg Cobble (5-10")	D							D	D	
F) Boulder (>10")										
G) Bedrock										
Percent Exposed Substrate	60	5		5		1	2	60	10	
Percent Total Canopy	90	100		100		75	90	60	50	
% Hardwood Trees	100	100		100		100	100	20	50	
% Coniferous Trees								80	50	
Bank Composition & Vegetation: Rt Bk Composition	4	4		3		4	4	3	3	
Rt Bk Dominant Vg	7	7		7		7	6	9	7	
% Rt Bk Vegetated	100	90		40		50	40	10	30	
Lft Bk Composition	4	3		3		3	4	3	3	
Lft Bk Dominant Vg	7	5		7		6	6	6	9	
% Lft Bk Vegetated	25	75		30		40	80	20	10	

Comments: Structures Channel Diversions Tribs Erosion Biota Passage Access GPS Other

		3pm boulder vortex w/in bottom of unit	Boulder Vortex w/in; plunge structure					Log Jam 4	

Bank Composition Types
1) Bedrock
2) Boulder
3) Cobble /Gravel
4) Silt/Clay/Sand

Vegetation Types
5) Grass
6) Brush
7) Hardwood Trees
8) Coniferous Trees
9) No Vegetation

Pool Tail Embeddedness
1- 0-25% 3- 51-75% 5- unsuitable for spawn
2- 26-50% 4- 76-100%

HABITAT INVENTORY DATA FORM

9/10/19

Form # 2 of 4

Date 8/9/19 | Stream Name: Patterson | T: | R: | S:

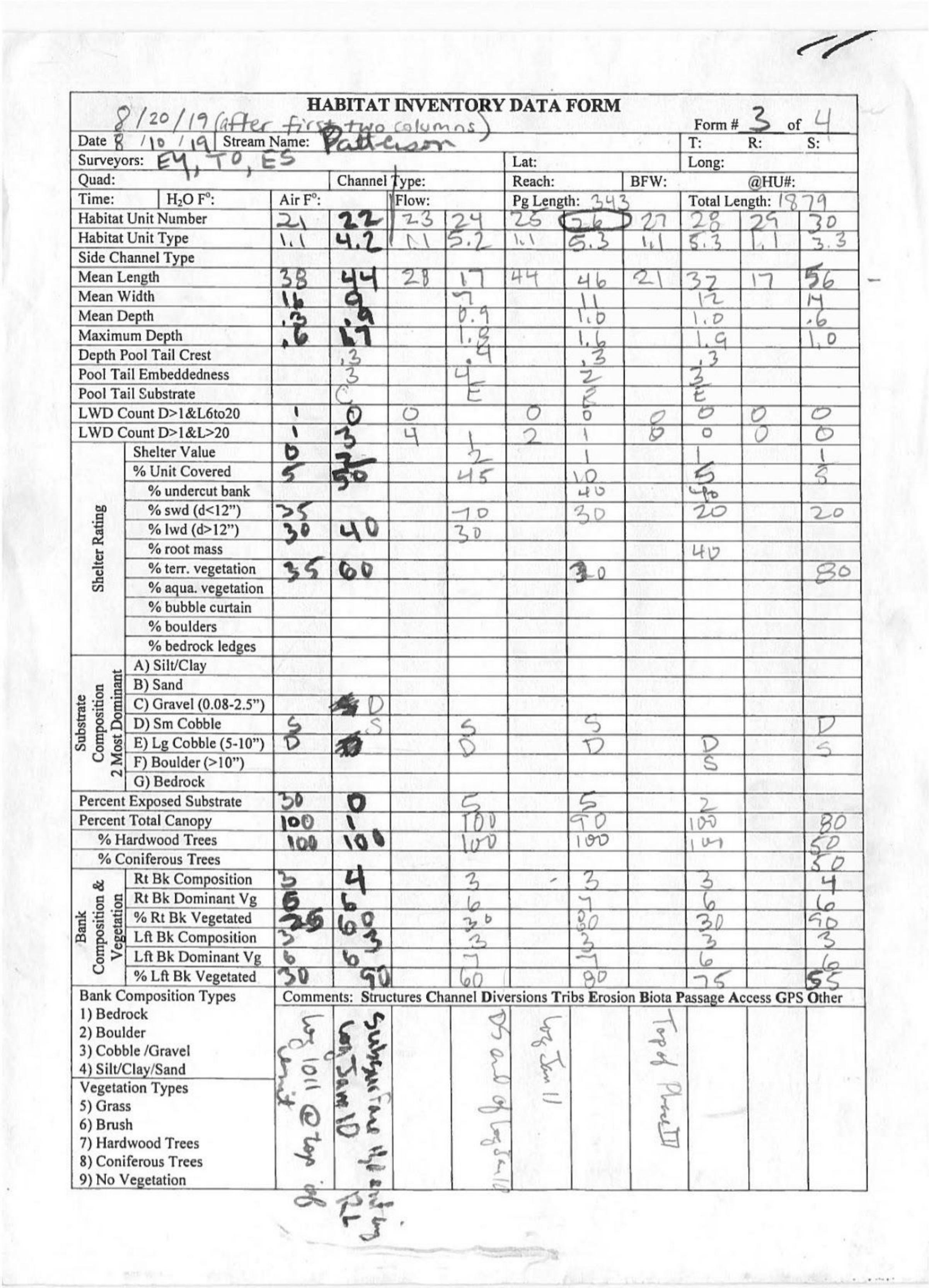
Surveyors: | Lat: | Long:

Quad: | Channel Type: | Reach: | BFW: | @HU#:

Time: | H₂O F°: | Air F°: | Flow: | Pg Length: 5 4 | Total Length: 1879

	Habitat Unit Number	11	12	13	14	15	16	17	18	19	20
	Habitat Unit Type	5.2	5.6	1.1	5.2	1.1	5.2	1.1	3.3	1.1	5.2
	Side Channel Type										
	Mean Length	34	40	147	41	33	25	59	33	73	19
	Mean Width	18	16	12	25		11		4		10
	Mean Depth	1.0'	1.2	.3	.7		1.1		.7		.9
	Maximum Depth	1.6	2.0	.9	2.3		1.7		1.2		1.6
	Depth Pool Tail Crest	.2	.4		.5		.5				.5
	Pool Tail Embeddedness	2	2		2		2				2
	Pool Tail Substrate	3	D		D		E				D
	LWD Count D>1&L6to20	0	0	0	1	0	0	0	0	0	~~3~~0
	LWD Count D>1&L>20	0	7	4	1	2	1	0	0	0	3
Shelter Rating	Shelter Value	1	3	1	1		2		1		1
	% Unit Covered	10	80		10		65		10		15
	% undercut bank								40		
	% swd (d<12")	100%	50	40	40		40				90
	% lwd (d>12")		50	60	60		20				
	% root mass								40		
	% terr. vegetation						40		20		
	% aqua. vegetation										
	% bubble curtain										10
	% boulders										
	% bedrock ledges										
Substrate Composition 2 Most Dominant	A) Silt/Clay										
	B) Sand	D	D								
	C) Gravel (0.08-2.5")	S									
	D) Sm Cobble			D	D		D	~~8~~	S	~~D~~	D
	E) Lg Cobble (5-10")		S	S	S		S	~~D~~	D	~~4~~	S
	F) Boulder (>10")										
	G) Bedrock										
	Percent Exposed Substrate	0	5	30	5		3		8		
	Percent Total Canopy	100	50	100	80	~~60~~	60		100		80
	% Hardwood Trees	100	100	100	100	~~100~~	100		100		100
	% Coniferous Trees										
Bank Composition & Vegetation	Rt Bk Composition	3	3	4	3		3		3		4
	Rt Bk Dominant Vg	7	6	6	6		6		7		6
	% Rt Bk Vegetated	70	60	70	75		100		85		95
	Lft Bk Composition	4	4	3	3		3		3		3
	Lft Bk Dominant Vg	7	7	7	6		9		7		6
	% Lft Bk Vegetated	50	70	90	85		0		10		70

Bank Composition Types 1) Bedrock 2) Boulder 3) Cobble /Gravel 4) Silt/Clay/Sand Vegetation Types 5) Grass 6) Brush 7) Hardwood Trees 8) Coniferous Trees 9) No Vegetation	Comments: Structures Channel Diversions Tribs Erosion Biota Passage Access GPS Other 45 Log Jam 5	Log Jam 5	Log 6 - Jam 7	Log 1024 - Jam 7						Log 9 Jam



HABITAT INVENTORY DATA FORM

8/20/19 (after first two columns)

Form # 3 of 4

Date 8 /10 /19 Stream Name: Patterson

T: R: S:

Surveyors: EY, TO, ES

Lat:

Long:

Quad:

Channel Type:

Reach:

BFW:

@HU#:

Time:

H₂O F°:

Air F°:

Flow:

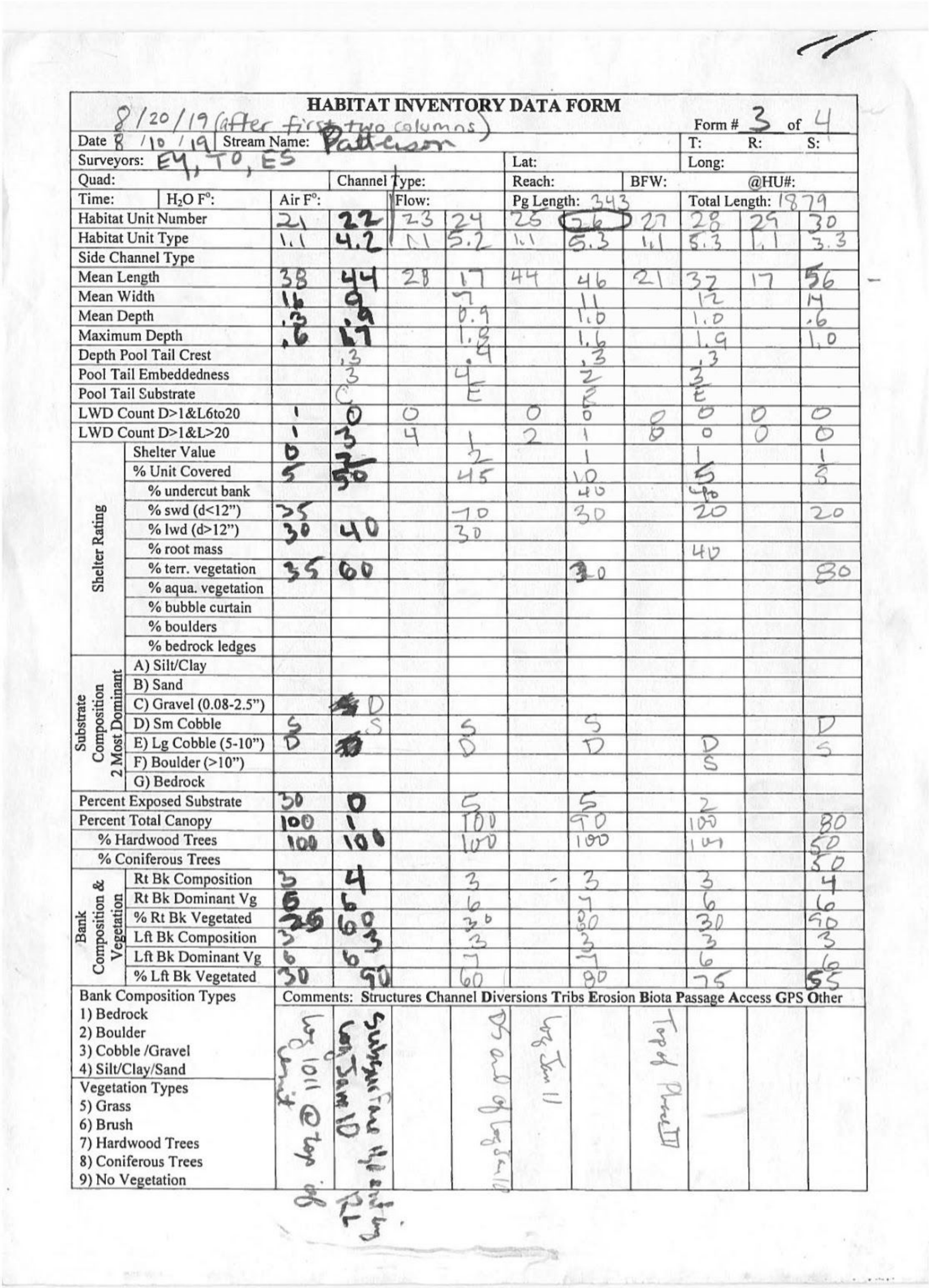
Pg Length: 343

Total Length: 1879

Habitat Unit Number		21	22	23	24	25	26	27	28	29	30
Habitat Unit Type		1.1	4.2	1.1	5.2	1.1	5.3	1.1	5.3	1.1	3.3
Side Channel Type											
Mean Length		38	44	28	17	44	46	21	32	17	56
Mean Width		16	9		7		11		12		14
Mean Depth		.3	.9		0.9		1.0		1.0		.6
Maximum Depth		.6	1.7		1.8		1.6		1.9		1.0
Depth Pool Tail Crest			.3		.4		.3		.3		
Pool Tail Embeddedness			3		4		2		3		
Pool Tail Substrate			C		E		E		E		
LWD Count D>1&L6to20		1	0	0		0	0	0	0	0	0
LWD Count D>1&L>20		1	3	4	1	2	1	0	0	0	0
Shelter Rating	Shelter Value	0	2		2		1		1		1
	% Unit Covered	5	50		45		10		5		5
	% undercut bank						40		40		
	% swd (d<12")	35			70		30		20		20
	% lwd (d>12")	30	40		30						
	% root mass								40		
	% terr. vegetation	35	60				30				80
	% aqua. vegetation										
	% bubble curtain										
	% boulders										
	% bedrock ledges										
Substrate Composition 2 Most Dominant	A) Silt/Clay										
	B) Sand										
	C) Gravel (0.08-2.5")		D								
	D) Sm Cobble	S	S		S		S				D
	E) Lg Cobble (5-10")	D			D		D		D		S
	F) Boulder (>10")								S		
	G) Bedrock										
Percent Exposed Substrate		30	0		5		5		2		
Percent Total Canopy		100	1		100		90		100		80
% Hardwood Trees		100	100		100		100		100		50
% Coniferous Trees											50
Bank Composition & Vegetation	Rt Bk Composition	3	4		3	-	3		3		4
	Rt Bk Dominant Vg	6	6		6		7		6		6
	% Rt Bk Vegetated	25	60		30		80		30		90
	Lft Bk Composition	3	3		3		3		3		3
	Lft Bk Dominant Vg	6	6		7		7		6		6
	% Lft Bk Vegetated	30	90		60		80		75		55
Comments: Structures Channel Diversions Tribs Erosion Biota Passage Access GPS Other		log 1011 @ top of unit	log Jam 10 Subsurface flow thru entire log RL		DS end of log Jam 10	log Jam 11		Top of Phase II			

Bank Composition Types
1) Bedrock
2) Boulder
3) Cobble /Gravel
4) Silt/Clay/Sand

Vegetation Types
5) Grass
6) Brush
7) Hardwood Trees
8) Coniferous Trees
9) No Vegetation



HABITAT INVENTORY DATA FORM

8/20/19 (after first two columns)

Form # 3 of 4

Date 8 /10 /19 Stream Name: Patterson

T: R: S:

Surveyors: EY, TO, ES

Lat:

Long:

Quad:

Channel Type:

Reach:

BFW:

@HU#:

Time:

H₂O F°:

Air F°:

Flow:

Pg Length: 343

Total Length: 1879

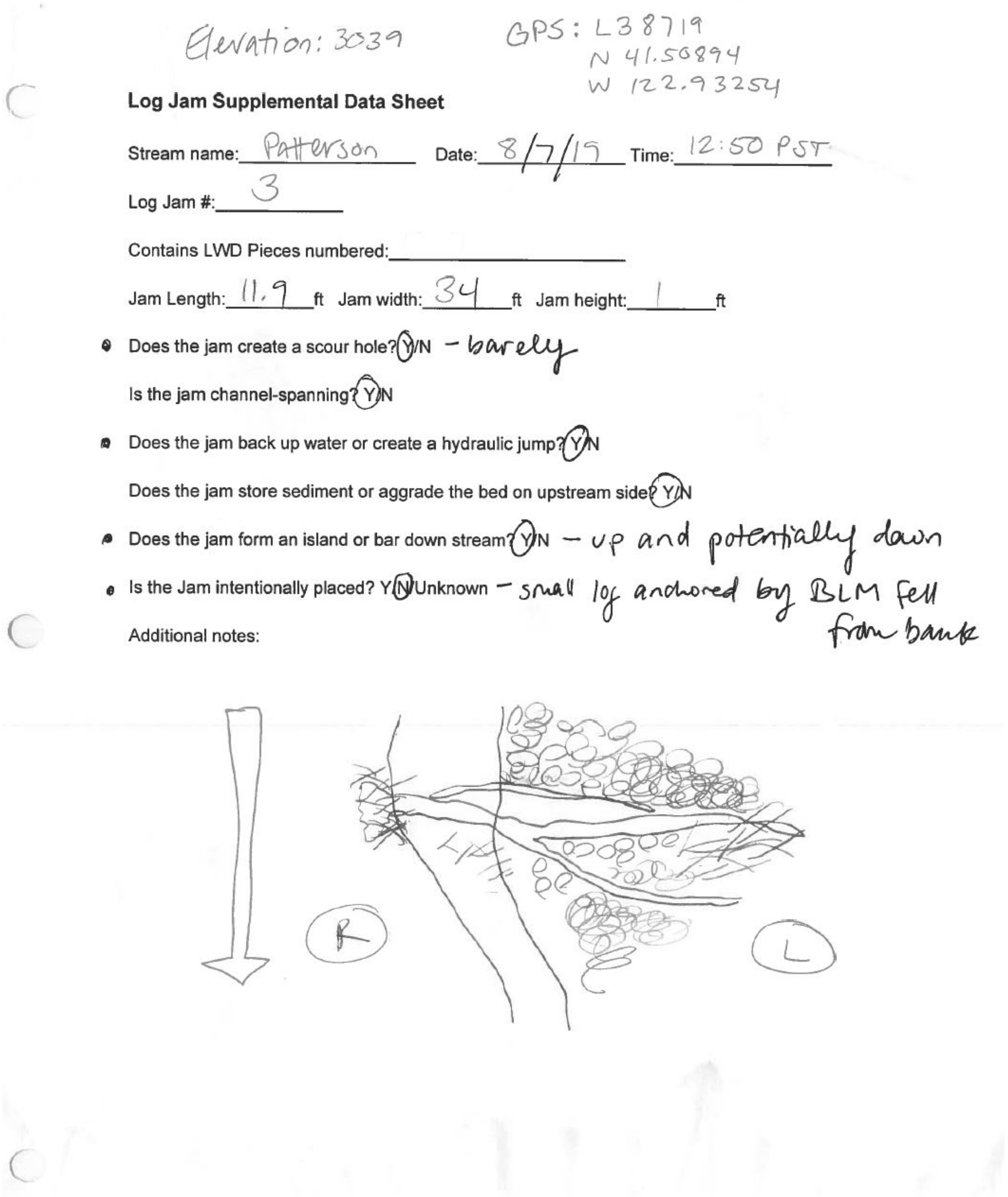
Habitat Unit Number		21	22	23	24	25	26	27	28	29	30
Habitat Unit Type		1.1	4.2	1.1	5.2	1.1	5.3	1.1	5.3	1.1	3.3
Side Channel Type											
Mean Length		38	44	28	17	44	46	21	37	17	56
Mean Width		16	9		7		11		12		14
Mean Depth		.3	.9		0.9		1.0		1.0		.6
Maximum Depth		.6	1.7		1.8		1.6		1.9		1.0
Depth Pool Tail Crest			.3		.4		.3		.3		
Pool Tail Embeddedness			3		4		2		3		
Pool Tail Substrate			C		E		E		E		
LWD Count D>1&L6to20		1	0	0		0	0	0	0	0	0
LWD Count D>1&L>20		1	3	4	1	2	1	8	0	0	0
Shelter Rating	Shelter Value	0	2		2		1		1		1
	% Unit Covered	5	50		45		10		5		5
	% undercut bank						40		40		
	% swd (d<12")	35			70		30		20		20
	% lwd (d>12")	30	40		30						
	% root mass								40		
	% terr. vegetation	35	60				30				80
	% aqua. vegetation										
	% bubble curtain										
	% boulders										
	% bedrock ledges										
Substrate Composition 2 Most Dominant	A) Silt/Clay										
	B) Sand										
	C) Gravel (0.08-2.5")		D								
	D) Sm Cobble	S	S		S		S				D
	E) Lg Cobble (5-10")	D			D		D		D		S
	F) Boulder (>10")								S		
	G) Bedrock										
Percent Exposed Substrate		30	0		5		5		2		
Percent Total Canopy		100	1		100		90		100		80
% Hardwood Trees		100	100		100		100		100		50
% Coniferous Trees											50
Bank Composition & Vegetation	Rt Bk Composition	3	4		3		3		3		4
	Rt Bk Dominant Vg	6	6		6		7		6		6
	% Rt Bk Vegetated	25	60		30		80		30		90
	Lft Bk Composition	3	3		3		3		3		3
	Lft Bk Dominant Vg	6	6		7		7		6		6
	% Lft Bk Vegetated	30	90		60		80		75		55
Comments: Structures Channel Diversions Tribs Erosion Biota Passage Access GPS Other		log 1011 @ top of unit	Subsurface flow @ end by RL log Jam 10		DS end of log Jam 10	log Jam 11		Top of Phase III			

Bank Composition Types
1) Bedrock
2) Boulder
3) Cobble /Gravel
4) Silt/Clay/Sand

Vegetation Types
5) Grass
6) Brush
7) Hardwood Trees
8) Coniferous Trees
9) No Vegetation

Appendix D

Example form used to describe log jam structures.



Elevation: 3039

GPS: L38719
N 41.50894
W 122.93254

Log Jam Supplemental Data Sheet

Stream name: Patterson Date: 8/7/19 Time: 12:50 PST

Log Jam #: 3

Contains LWD Pieces numbered: ____

Jam Length: 11.9 ft Jam width: 34 ft Jam height: 1 ft

- Does the jam create a scour hole? [✓ Y]/N - barely

Is the jam channel-spanning? [✓ Y]/N

- Does the jam back up water or create a hydraulic jump? [✓ Y]/N

Does the jam store sediment or aggrade the bed on upstream side? [✓ Y]/N

- Does the jam form an island or bar down stream? [✓ Y]/N - up and potentially down

- Is the Jam intentionally placed? Y/[✓ N]/Unknown - small log anchored by BLM fell from bank

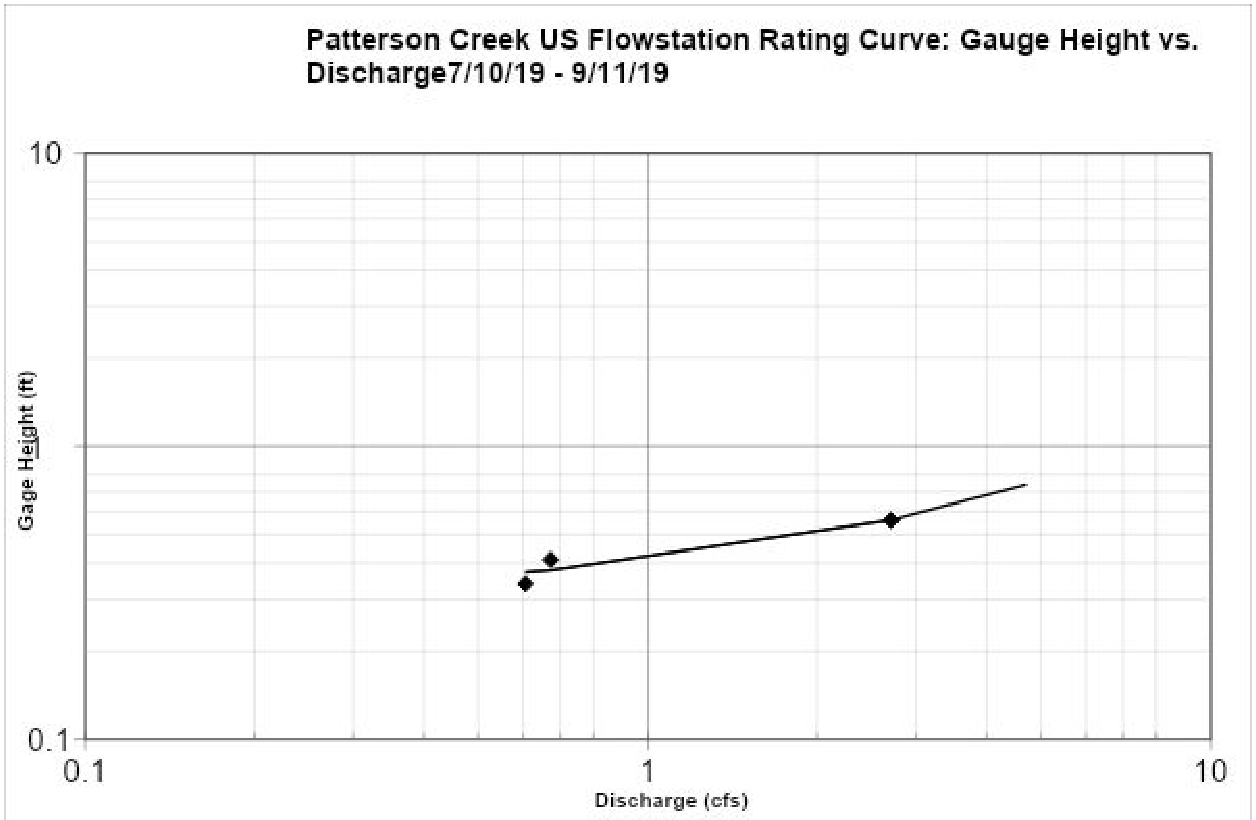
Additional notes:

Appendix E

Photo point series near log jam 1, ordered as follows from left to right and down the page: north, northeast, east, southeast, south, southwest, west, northwest.

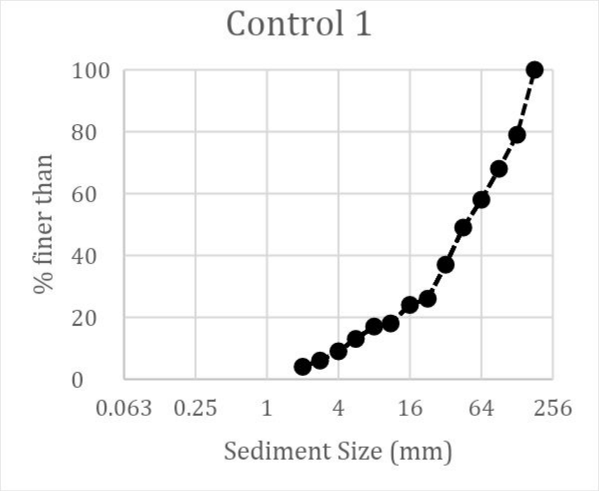
Appendix F

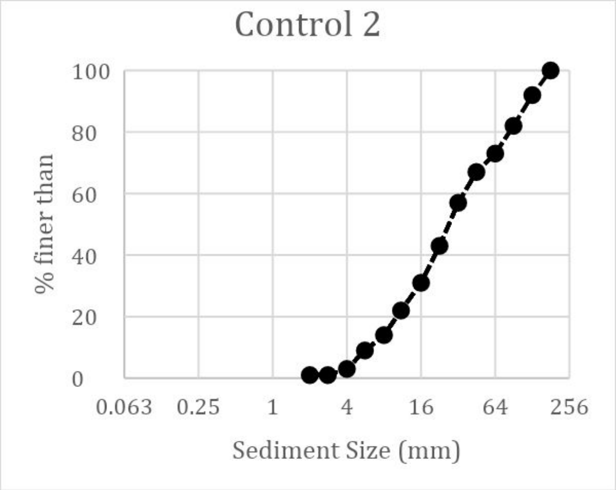
Rating curve for Patterson Creek based on collected discharge and temperature data from July 9 to September 10, 2019.

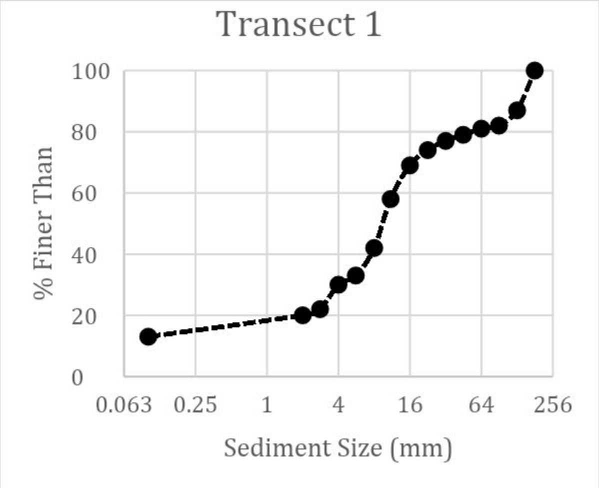


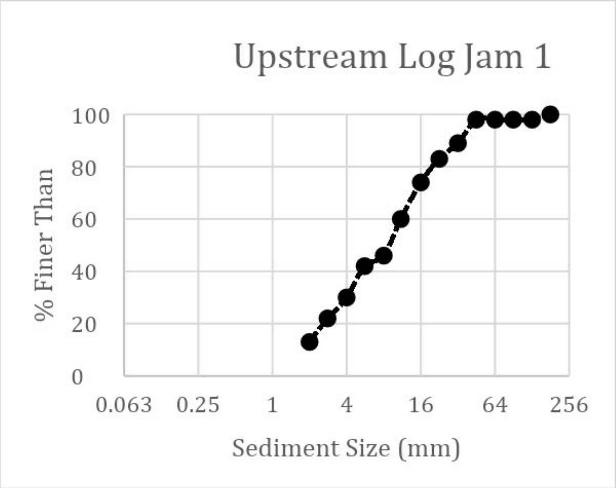
Appendix G

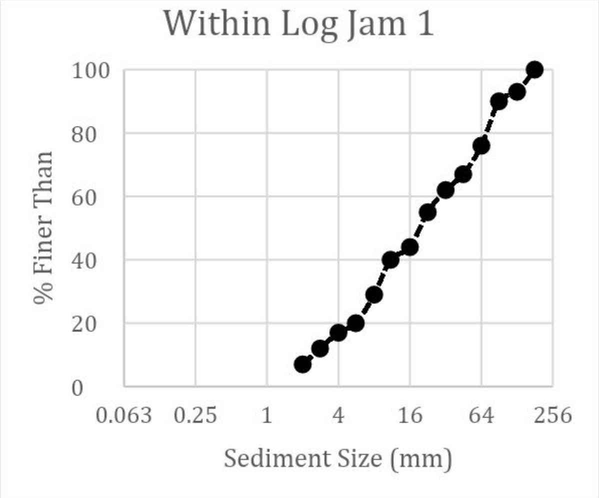
Cumulative frequency curves for each of the 15 Wolman Pebble Counts conducted throughout Patterson Creek, organized from upstream to downstream.

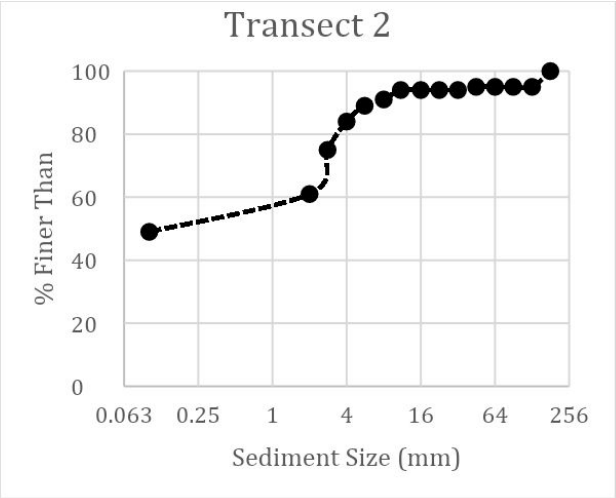

Control 1

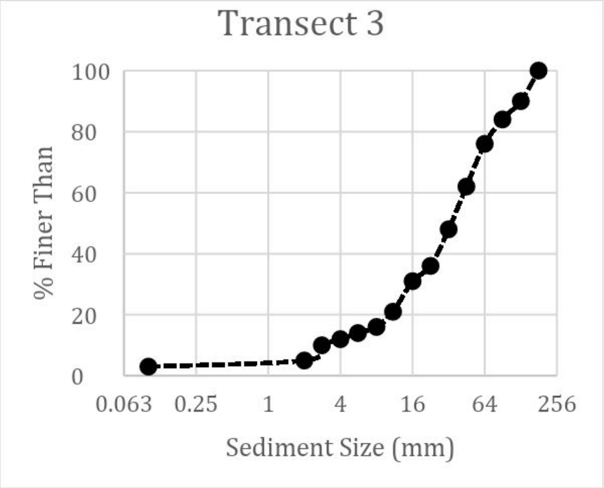

Control 2

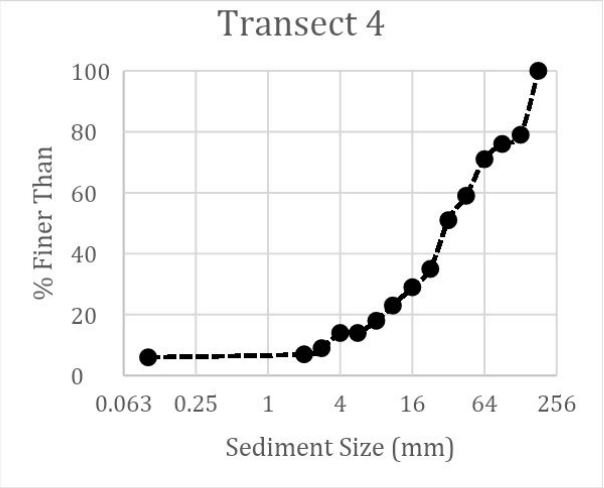

Transect 1

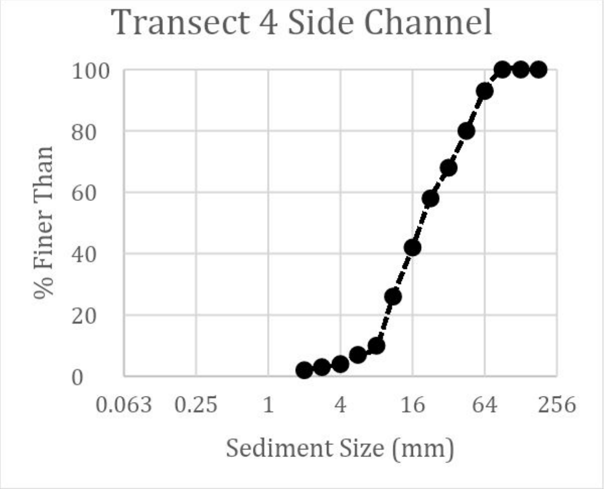

Upstream Log Jam 1

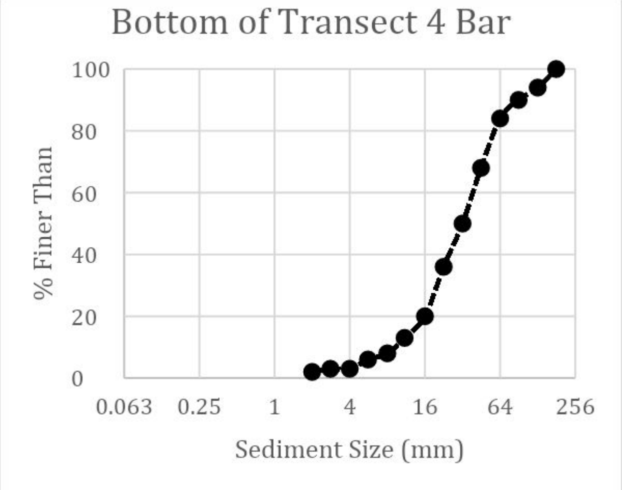

Within Log Jam 1

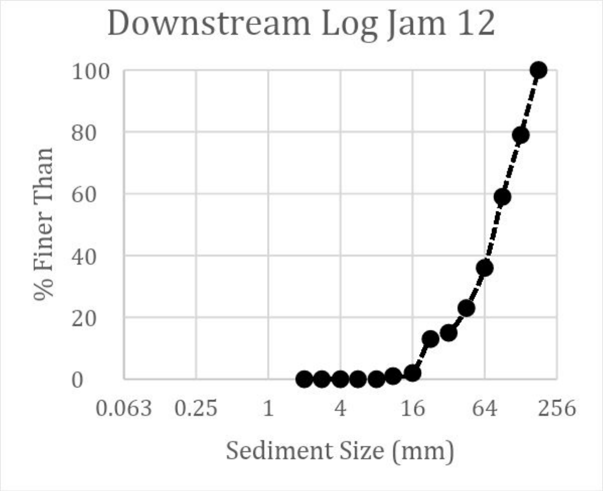

Transect 2

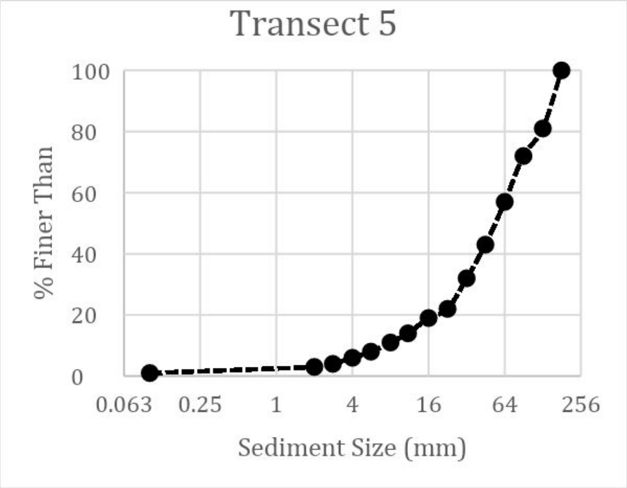

Transect 3
100
80
60
40
20
0
% Finer Than
0.063
0.25
1
4
16
64
256
Sediment Size (mm)

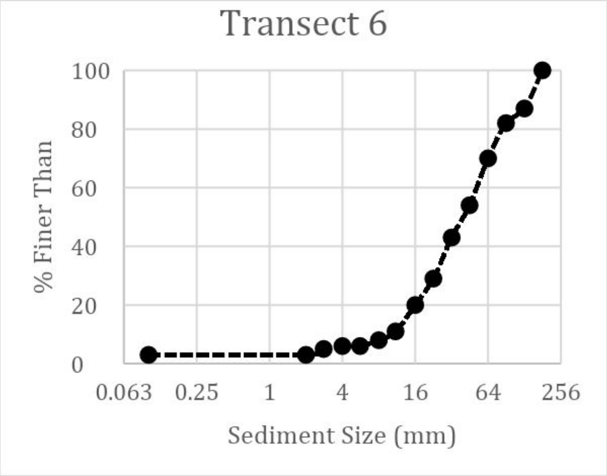

Transect 4
100
80
60
40
20
0
% Finer Than
0.063
0.25
1
4
16
64
256
Sediment Size (mm)

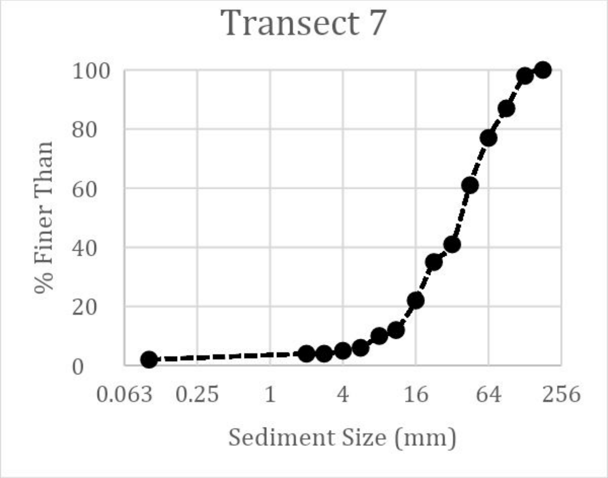

Transect 4 Side Channel
100
80
60
40
20
0
% Finer Than
0.063
0.25
1
4
16
64
256
Sediment Size (mm)

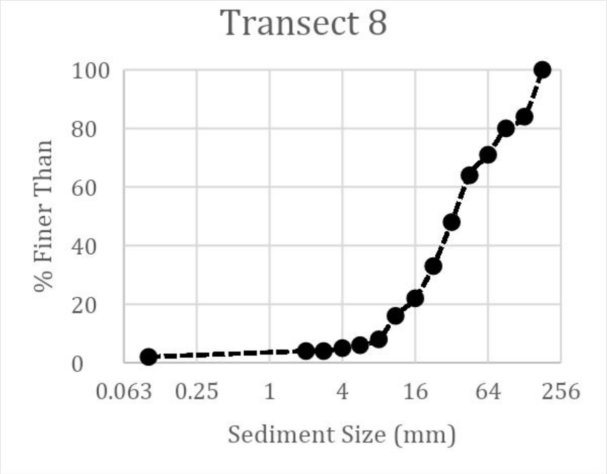

Bottom of Transect 4 Bar
100
80
60
40
20
0
% Finer Than
0.063
0.25
1
4
16
64
256
Sediment Size (mm)


Downstream Log Jam 12
% Finer Than
100
80
60
40
20
0
0.063
0.25
1
4
16
64
256
Sediment Size (mm)


Transect 5
% Finer Than
100
80
60
40
20
0
0.063
0.25
1
4
16
64
256
Sediment Size (mm)


Transect 6
% Finer Than
100
80
60
40
20
0
0.063
0.25
1
4
16
64
256
Sediment Size (mm)


Transect 7
% Finer Than
100
80
60
40
20
0
0.063
0.25
1
4
16
64
256
Sediment Size (mm)


Transect 8
100
80
60
40
20
0
% Finer Than
0.063
0.25
1
4
16
64
256
Sediment Size (mm)

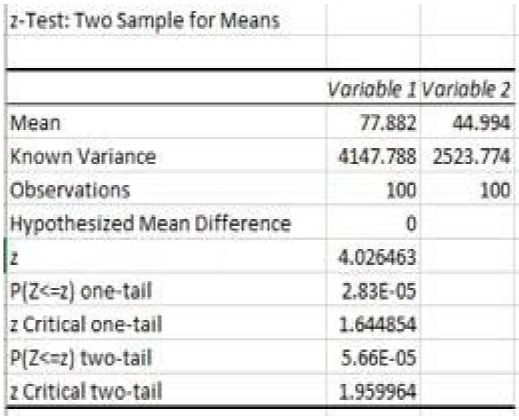
Appendix H

Calculated D16, D50, and D84 sizes for each Wolman Pebble Count location. These values indicate the substrate diameter size that 16% of samples, 50% of samples, and 84% of samples fall under.

	Control 1	Control 2	Transect 1	U.S. Jam 1	In Jam 1	Transect 2	Transect 3	Transect 4	Side Channel	End of Bar	D.S. Jam 12	Transect 5	Transect 6	Transect 7	Transect 8
D16	7.4	8.8	0.91	2.2	3.8	---	8	6.8	9.1	13.1	33.6	13.0	13.8	13.0	11.0
D50	47.1	27.3	9.5	8.8	19.6	0.6	33.9	31.4	19.3	32.0	79.8	54.5	40.3	37.9	33.6
D84	140.3	97.6	105.2	24.2	78.9	4.0	90.0	140.4	50.8	64.0	140.4	136.2	105.2	82.2	128.0

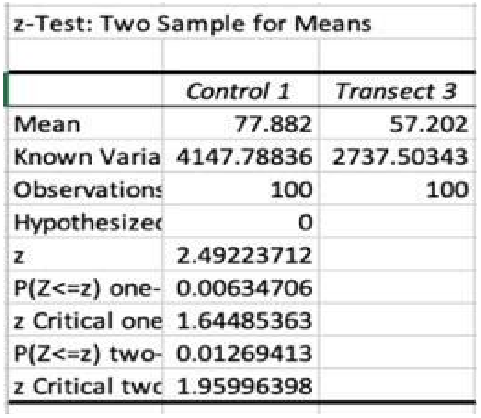
Appendix I

Results from z-tests conducted on substrate samples.



z-Test: Two Sample for Means

	Variable 1	Variable 2
Mean	77.882	44.994
Known Variance	4147.788	2523.774
Observations	100	100
Hypothesized Mean Difference	0	
z	4.026463	
P(Z<=z) one-tail	2.83E-05	
z Critical one-tail	1.644854	
P(Z<=z) two-tail	5.66E-05	
z Critical two-tail	1.959964	

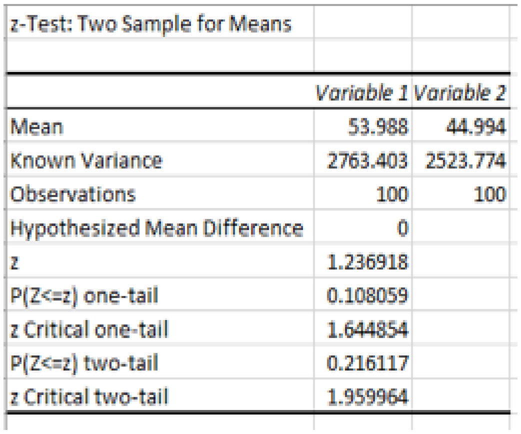


z-Test: Two Sample for Means

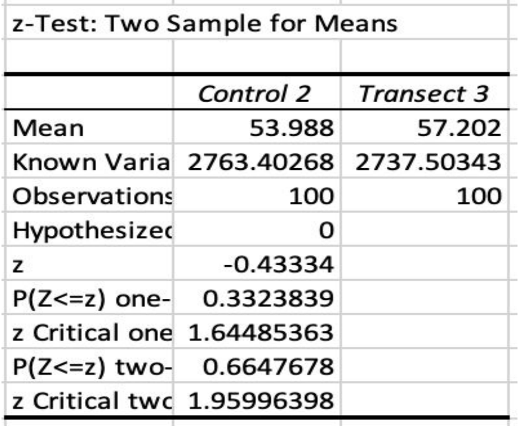
	Control 1	Transect 3
Mean	77.882	57.202
Known Varia	4147.78836	2737.50343
Observations	100	100
Hypothesizec	0	
z	2.49223712	
P(Z<=z) one-	0.00634706	
z Critical one	1.64485363	
P(Z<=z) two-	0.01269413	
z Critical twc	1.95996398	

Control 1 vs Within Log Jam 1

Control 1 vs Transect 3



z-Test: Two Sample for Means		
	Variable 1	*Variable 2*
Mean	53.988	44.994
Known Variance	2763.403	2523.774
Observations	100	100
Hypothesized Mean Difference	0	
z	1.236918	
P(Z<=z) one-tail	0.108059	
z Critical one-tail	1.644854	
P(Z<=z) two-tail	0.216117	
z Critical two-tail	1.959964	



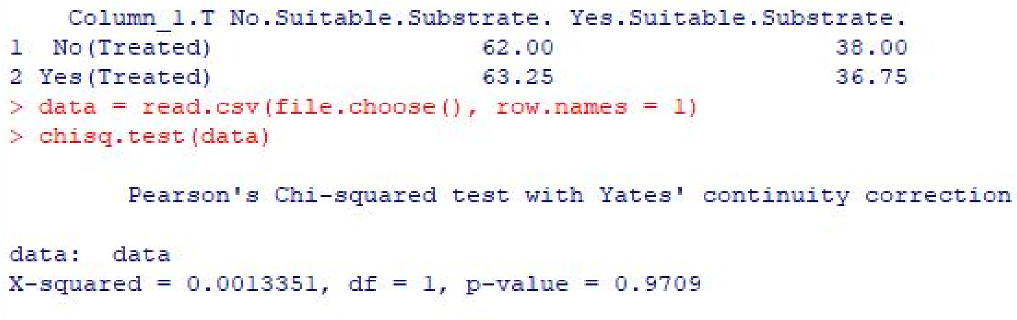
z-Test: Two Sample for Means		
	Control 2	*Transect 3*
Mean	53.988	57.202
Known Varia	2763.40268	2737.50343
Observations	100	100
Hypothesizec	0	
z	-0.43334	
P(Z<=z) one-	0.3323839	
z Critical one	1.64485363	
P(Z<=z) two-	0.6647678	
z Critical twc	1.95996398	

Control 2 vs Within Log Jam 1

Control 2 vs Transect 3

Appendix J

Chi-squared test of association, conducted using R, comparing percentages of suitable substrate in the control region and percentages of suitable substrate in the treated reach and beyond



```
    Column_1.T No.Suitable.Substrate. Yes.Suitable.Substrate.
1  No(Treated)                  62.00                   38.00
2 Yes(Treated)                  63.25                   36.75
> data = read.csv(file.choose(), row.names = 1)
> chisq.test(data)

        Pearson's Chi-squared test with Yates' continuity correction

data:  data
X-squared = 0.0013351, df = 1, p-value = 0.9709
```