Asotin Creek Intensively Monitored Watershed:

2017 Progress Memo, December 31, 2017

Charley Creek treatment section 2017

Prepared for:

Recreation and Conservation Office

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SUMMARY

Background

The Asotin Creek Intensively Monitored Watershed (IMW) was implemented in 2008. The focal species are natural reproducing summer steelhead. Based on previous habitat assessments and preliminary IMW monitoring it was decided that riparian function and instream habitat complexity were impaired. The restoration proposed was fencing, native plant revegetation, and weed control to enhance riparian function in the **long-term**, and the addition of large woody debris (LWD) in the **short-term** to increase habitat diversity and promote a more dynamic channel (e.g., increase sediment sorting, pool frequency, and floodplain connection). We implemented the IMW using a staircase experimental design where restoration actions were implemented in different years starting in 2012 and ending in 2016 in three different streams. Each stream is divided into three 4 km long sections and one or more sections has been restored in each stream with the remaining sections acting as controls. We completed the restoration actions in 2016 and have built 654 large woody debris structures at an average density of 4.7 structures per 100 m in the treatment sections (~39% of the study area has been restored and 61% remains as controls). We are using extensive habitat sampling and fish PIT tagging and resighting to estimate habitat changes and changes juvenile steelhead abundance, growth, survival, movement, production, and productivity in each experimental section.

Analyses Approaches

We continue to develop and refine tools/models to help us analyze the data we have including:

- The Staircase statistical model which allows us to more accurately assess responses to restoration because it can differentiate variance components (year, stream, section, response) and interactions. We have completed the development of model and can update the model each year to accommodate the changing year after treatment component of the staircase design. We have analyzed the juvenile steelhead abundance data with the model and will be using the model to analyze other fish and habitat responses
- Geomorphic unit delineation tool (GUT) which allows us to use the topographic data to look at fine scale changes in geomorphic unit assemblages; We have run the GUT tool on all sites for three years of data and will be running the remaining sites to complete all sites from 2011-2017.
- The Barker model for calculating true survival, site fidelity, and probability of captures. We have now completed and run for all sites, seasons, and years from 2008-2016. We will update the survival estimates and analyze them with the staircase model (see above) when we have our age data analyzed for 2017 fish captures.
- We have developed a Bayesian based model for aging all of our fish using a subsample of known ages and acquired from scale samples and fish lengths. We use the age model to estimate the age of tagged fish that were not aged with scales so that we can determine the brood year of migrants and calculate smolts per spawners as well as assess treatment responses by age class.
- Net rate of energy intake model has been run for North Fork and South Fork sites for three periods: 1 year pre-restoration, 1 year post-restoration, and 2016. We have since updated the NREI model based on field validation and are currently running the model on all topographic data in all streams from 2011-2017.
- We have begun to summarize productivity of treatment and control sites pre and post restoration by estimating the number of migrants (smolts) by age class and then back-calculating the brood year they came from using PIT tag detections at the interrogation sites at the mouths of each IMW study stream. We used the same interrogation sites and redd surveys to estimate the number of female steelhead entering each tributary and spawning in each treatment and control section.

Trends

Habitat

- We continue to see habitat responses that are in line with many of original hypotheses.
- The frequency of wood in the treatments is staying high relative to the control sections.
- The frequency of pools and bars has increased in treatment areas compared to control areas.
- Other habitat characteristics such as width or thalweg variability have not responded as strongly.
- The rate of habitat change is more dramatic in the North Fork compared, minor but consistent in the South Fork, and less consistent and significant in Charley Creek. This fits our understanding to the dominant reach types in these three streams: the North Fork is a wandering Gravel bed stream with higher stream power and more natural capacity for adjustment. The South Fork and Charley are more confined planeform and bedrock controlled systems with a lower capacity for adjustment.
- We have produced geomorphic unit analyses that confirm coarse scale data such CHaMP habitat data and or rapid habitat surveys. The delineation of geomorphic units is a consistent unbiased manner will allow us to better understand what factors are driving the fish response.

Fish

- We have observed positive trends in fish abundance and are beginning to see difference in the fish response by stream. Like the habitat changes, the fish response in the North Fork appears to be greater than the other two streams despite being treated last (i.e., we are observing a Year 3 response in North Fork, Year 4 in Charley, and Year 5 in South Fork).
- We will be analyzing growth and survival data using the staircase model from 2008-2017 in the coming months
- Smolts/spawner data summaries have been completed for 2010-2015 and we are working on updating smolts/spawner estimates for 2016 and 2017.

General

- We have implemented a robust design, completed a large restoration treatment, maintained a high quality data stream for both habitat and fish for 10 years, developed a series of geomorphically and empirically based set of tools to summarize raw data, and developed a staircase statistical model to analyze these data and separate multiple sources of variance from the true treatment response.
- We are now in the phase of the project where we need to complete enough years of post-treatment monitoring to complete the smolts/spawner table (by annually back-calculating the brood year of smolts and continuing to monitor adult escapement), develop models that can explain what factors are driving the responses we see (i.e., causal mechanisms), and assessing if the responses are consistent, persistent, and how they vary between stream types.

ACKNOWLEDGMENTS

The Asotin Intensively Monitored Watershed (IMW) is a collaborative multi-agency initiative sponsored by the Snake River Salmon Recovery Board (SRSRB). The SRSRB provides oversight and technical review of all the Asotin Creek IMW activities through support from the Regional Technical Team (RTT) and National Oceanic and Atmospheric Administration (NOAA) staff. The majority of the IMW takes place on Washington Department of Fish and Wildlife (WDFW) and US Forest Service (USFS) land, and both agencies have supported the development and implementation of the project. Funding for the primary research components of the IMW are from the NOAA Pacific Coastal Salmon Recovery Fund (PCSRF). Funding for the restoration activities comes from PCSRF through the State of Washington's Salmon Recovery Funding Board (SRFB), BPA, Conservation Commission, USFS, and WDFW. We are particularly grateful for support we receive from Ethan Crawford of WDFW in the form of field staff and data on fish-in fish-out from the Clarkston office to assist the IMW project, and Bonneville Power Administration (BPA) which supports WDFW's efforts to collect fish in-fish out data in Asotin Creek. Bob Dice, the manager of the Clarkston Wildlife Office, has also provided the IMW with accommodation, transportation, and access since the start of the project. We also wish to thank the Koch and Thornton families for graciously providing us access to private property along Charley Creek to conduct monitoring and restoration. Brad Johnson, Palouse Conservation District has also been an indispensable part of the IMW team working with the local landowners and agencies to help secure land access, operating permits, and local support and sponsorships for the IMW. The Asotin County Public Utility Department has provided us with office space and storage for field gear. Del Groat (now retired) of the USFS has provided generous donations of time and large wood for the restoration treatments and Billy Bowles, also with USFS, has helped with safety training for field crews. Bruce Heiner, WDFW Habitat Engineer and Barry Sutherland, USDA Natural Resources Conservation Service (NRCS) Fluvial Geomorphologist provided comments on the earlier versions of the restoration plan. The following groups have provided direct support to the IMW in either goods or services and we wish to thank them for their help with this important fisheries conservation project: Avista Power, Clearwater Power, Collier Electric, Inland Metals Electric, TDS Telecom, WDFW, and USFS.

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Figure 18. Results from the staircase model analysis comparing change in juvenile steelhead abundance in the treatments compared to the controls before and after restoration. Estimates are the percent change in juvenile steelhead abundance (fish/100m) within each study stream in the Asotin Creek IMW: 2008-2017. Confidence intervals are 90% ($\alpha = 0.1$). The estimates were derived using the Impact 0/1 response contrasts because there is not strong evidence for choosing any specific response. All estimates of a response were positive and ranged from 3.8% (Charley Creek, $p = 0.19$), 61.7% (North Fork, $p = 0.002$), and (South Fork, $p = 0.19$). 3

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Table 1. Summary of the type and count of large woody debris (LWD) structure built in each stream by year constructed. PALS = post-assisted log structure, Seeding = unsecured LWD placed in channel, Key LWD = LWD too large to move by hand (e.g., > 10 m long and > 0.4 m diameter). 10

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1 BACKGROUND

In 2008, Asotin Creek was chosen as a location to implement an Intensively Monitored Watersheds (IMW) project in southeast Washington (Figure 1). We are implementing the IMW experiment within an adaptive management framework and have revised aspects of the experimental design, restoration plan, and monitoring based on the iterative evaluation process of adaptive management (Bouwes et al. 2016). An experimental study design has been developed and refined for the Asotin Creek IMW that includes treatment and control sections within the Asotin Creek tributaries of Charley Creek, North Fork Asotin Creek (North Fork), and South Fork Asotin Creek (South Fork; hereafter referred to together as "study creeks"). The study creeks generally exhibit homogenized and degraded habitats, with poor riparian function and low frequencies of large woody debris and pool habitat which is thought to be limiting salmonid production (SRSRB 2011). A detailed Restoration Plan was developed that proposed ***riparian enhancement and large woody debris additions as restoration treatments in the Asotin Creek IMW*** (Wheaton et al. 2012).

The Asotin Creek IMW is funded from NOAA's Pacific Coastal Salmon Recovery Fund (PCSRF) and the Pacific States Marine Fisheries Commission (PSMFC). The NOAA funds are used to fund the ongoing fish and habitat monitoring and data collection and analysis. These funds are administered via the Governors Salmon Recovery Office. A separate project funded by the Bonneville Power Administration (BPA) and implemented by the WDFW provides fish-in, fish-out monitoring for the Asotin watershed (Crawford et al. 2016). Funding for the restoration actions has primarily come from Pacific Coast Salmon Recovery Fund (PCSRF) through the State of Washington's Salmon Recovery Funding Board (SRFB) and donations of wood from US Forest Service, accommodation and equipment from WDFW and SRSRB. Eco Logical Research Inc. is the primary contractor that manages the Asotin Creek IMW and implements the restoration. The intent of this progress memo is to give a brief update of i) status of the IMW (what has been done), ii) data trends and advances in analysis, and iii) challenges and further analyses in 2018.

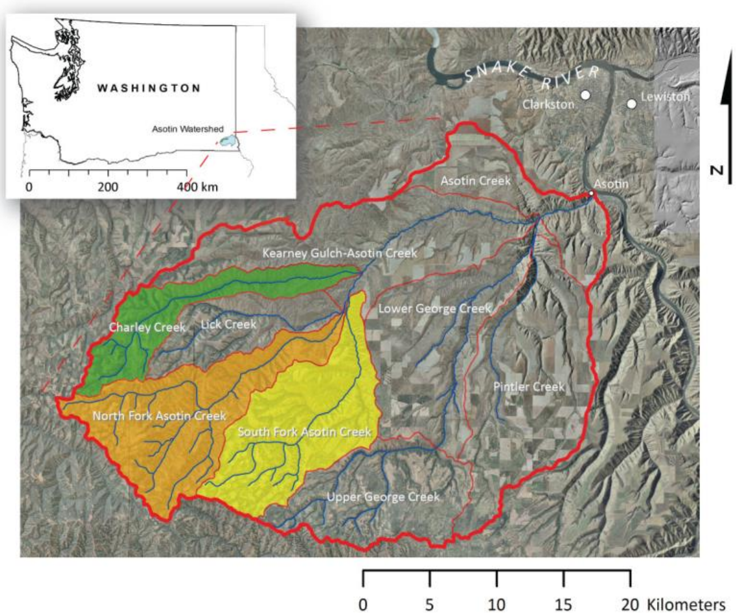


Figure 1. Location of Asotin Creek within Washington and the Asotin Creek Intensively Monitored Watershed study creek watersheds (i.e., three colored watersheds) within Asotin Creek.

2 ASOTIN IMW STATUS

We began the Asotin IMW in 2008 and it has been running for ten years (Figure 2). We secured funding to install the majority of the monitoring infrastructure (e.g., PIT tag arrays, water height gages, and temperature probes) in 2009. The Asotin IMW also relies on the intensive monitoring of fish-in fish-out conducted by WDFW to provide detailed information on age, condition, size, migration timing, and spawning distribution of steelhead in the Asotin watershed (Crawford et al. 2016). A total of four PIT tag interrogation sites, a smolt trap, and adult weir provide valuable data to the IMW for assessing restoration effectiveness (Appendix A**Error! Reference source not found.**). We have completed the restoration for the IMW treating a total of 14 km (~ 39% of the study area) with high densities of large woody debris structures averaging ~ 4.7 structures per 100 m. We implemented the IMW using a staircase experimental design where restoration actions were implemented in different years starting in 2012 and ending in 2016 in three different streams. Each stream is divided into three 4 km long sections and one or more sections has been restored in each stream with the remaining sections acting as controls (Appendix A). See Bennett et al. (2015) for details on activities from 2008-2015.

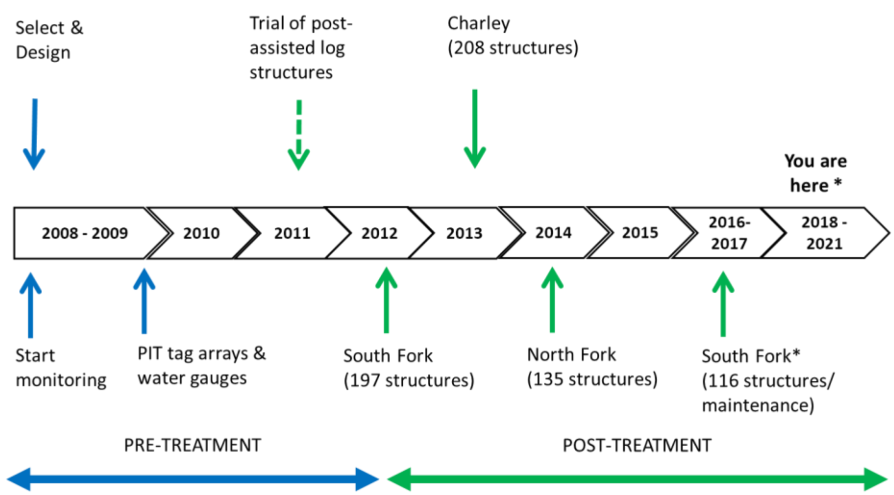


Figure 2. Timeline of Asotin Creek IMW design, monitoring, and restoration implementation. The initial restoration design of 12 km of wood treatments was completed from 2012-2014. Another restoration treatment to extend South Fork was implemented in 2016 along with adding more wood to existing structures to enhance their function in 2016 and 2017. Monitoring of habitat and fish is expected to continue to at least 2021.

3 RESTORATION ACTIONS

We built 197 structures in the South Fork, 208 in the Charley Creek, and 135 in North Fork treatment sections from 2012-2014 (Table 1). The total number of pieces of LWD added to each treatment section was 1500 pieces in the South Fork (structures built in 2012 and 2016), 497 pieces in Charley Creek, and 568 pieces in North Fork. The majority of structures built were deflector PALS in all streams. In 2016 we added another 116 LWD structures to the upper 2 km of South Fork Section 1. The total length of stream restored with LWD is 14 km which equates to 38.9% of the IMW study area (i.e., 14/36 km). On average the LWD structures are approximately 21 m apart or 4.7 LWD structures/ 100 m. In addition to the installation of LWD structures we conducted a round of maintenance in 2016 where we added LWD the existing treatments built between 2012-2014. Approximately 600 pieces of LWD were added to the existing treatments focusing on structures that where less effective at promoting hydraulic and/or geomorphic change. Figure 3 shows an example of a stream reach before treatment and after treatment and Figure 4 shows examples of the common structure types we built.

Table 1. Summary of the type and count of large woody debris (LWD) structure built in each stream by year constructed. PALS = post-assisted log structure, Seeding = unsecured LWD placed in channel, Key LWD = LWD too large to move by hand (e.g., > 10 m long and > 0.4 m diameter).

Type	South Fork (2012)	Charley (2013)	North Fork (2014)	South Fork (2016)	Total
Bank attached PALS	115	129	75	67	386
Mid Channel PALS	17	38	31	17	103
Debris Jam PALS	2	10	15	18	45
Seeding	50	30	14	14	108
Key LWD	12	0	0	0	12
Total	**196**	**207**	**135**	**116**	**654**

Figure 3. Example of treatment section before restoration (left) and after restoration (right) in South Fork Section 1. Treatment took place in summer of 2016.

Figure 4. Example of the three most common post-assisted log structure (PALS) built in the new treatment section of the South Fork Asotin Creek in summer of 2016. Top left = series of Bank-attached PALS, top right = Mid-channel PALS, and bottom picture = Debris Jam PALS.

3.1 Ongoing maintenance

In 2017, with remaining funds, we added more wood to the sections of the IMW project that had been previously treated in order to maintain high levels of large woody debris (LWD) in treatment sites compared to control sites (Figure 5). We also acquired a permit from WDFW to fell live trees along each treatment section to increase wood densities (Figure 6). We added approximatley 400 pieces of LWD to both North Fork and South Fork Asotin Creek and 200 pieces of LWD to Chalrey Creek. Monitoring funded by the IMW shows that the exisitng and new restoration structures are producing positive habitat responses. The structures are forcing floodplain connection, creating pools, backwaters, sediment deposition, gravel bars, and recruiting trees as the channel increases in sinuousity (Figure 7-10).

Figure 5. Example of felling a tree and adding large woody debris to an existing structure in North Fork Asotin Creek treatment section 1 to maintain high large woody debris density.

Figure 6. Example of felling a tree on an existing structure in North Fork Asotin Creek treatment section 1 to maintain high large woody debris density.

a) b)

Figure 7. a) Debris jam built in 2016 and viewed in summer of 2017. Note large dam pool upstream. b) Upstream of debris jam large sediment deposit covered with cottonwood seeds.

Figure 8. Example of post-assisted log structure built in 2016 in South Fork section 1 creating a large gravel and cobble bar downstream of the structure.

Figure 9. Example of trees that have been recruited into the stream by the strategic design of a post-assisted log structure.

4 MONITORING, DATA MANAGEMENT, AND TRENDS

4.1 Stream Discharge and Water Temperature

Prior to the start of the IMW in 2008 there were several years of low peak stream discharge and high temperatures (Figure 10). Water temperatures were cooler at the start of the IMW which is correlated with higher peak flows observed from 2008 through to 2012. However, since we began restoration in 2012, peak flows have decreased and average 7-day maximum temperatures have increased. Consistent low peak flows since the start of restoration in 2012 are suspected of limiting the effectiveness of the LWD structures to cause large changes to the channel and floodplain connection. Thankfully we observed the third largest peak flow in 17 years in the spring of 2017 and for the first time since restoration saw some extensive overbank flow, side-channel reconnection, and substantial sediment movement and sorting (Figure 11).

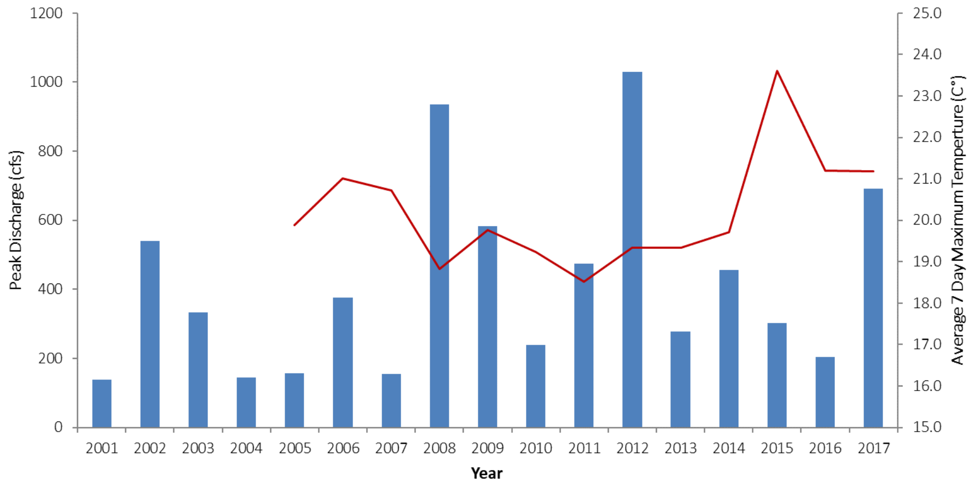


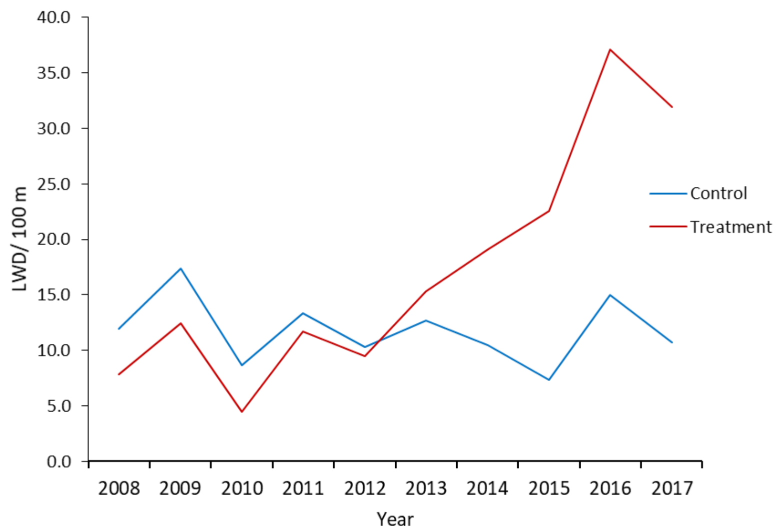
Figure 10. Asotin Creek mainstem a) average discharge (blue bars) and summer temperature (July and August – red line) by year and b) peak discharge and 7-day max summer temperature by year. Peak flows measured at USGS gauge 13334450 and water temperature measured at WDOE gauge 35D100.

Figure 11. South Fork Asotin Creek treatment section 1 in the spring of 2017 overflowing the banks and reconnecting with the floodplain. We had not observed overbank flow in the South Fork since the IMW started in 2008. Note the high-density of large woody debris that is causing the response.

4.2 Habitat Trends

The restoration actions have increased the amount of LWD (≥ 0.1 m diameter and ≥ 1.0 m long) in the treatment sections relative to the control sections by almost 200% (mean LWD/100 m in control = 10.7 and in treatment =

31.9; Figure 12). The changes in habitat since the addition of LWD have generally been positive. For example, our habitat surveys are showing the frequency of pools has increased 38% in treatment sections relative to control sections (mean pools/100 m in control = 2.4 and in treatment = 3.4; Figure 13Figure 13). We have begun to analyze the topographic data we collect as part of the Columbia Habitat Monitoring Protocol (CHaMP) using the geomorphic delineation tool which uses algorithms to identify topographic features and geomorphic units. For example, concavities in the streambed are characteristic of pools whereas convexities in the topography are characteristic of sediment deposits (i.e., bars). We are now seeing increases in the area of pools in the topography which match our visual observations of habitat units, and also increases in bars and transitional areas (i.e., units that are not a specific geomorphic type; Figure 14 - 16). These data may help us better describe what is commonly been described as "habitat diversity" but has previously been difficult to measure. Other habitat metrics have not yet responded to the restoration. For example, the variability in the thalweg and residual pool depths are either not increasing as expected or are increasing in both treatment and control areas.



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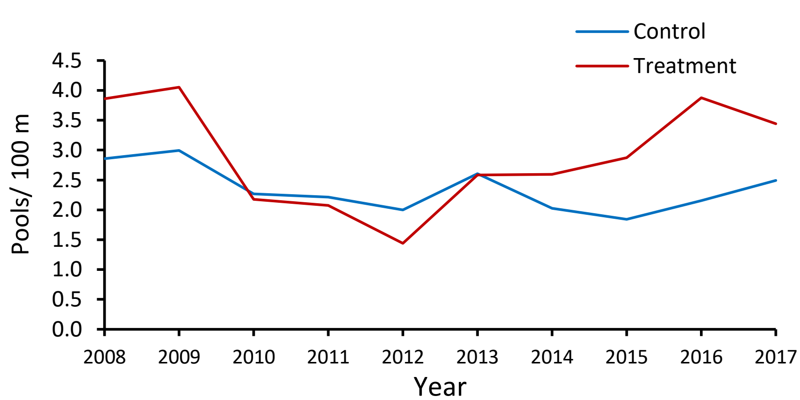

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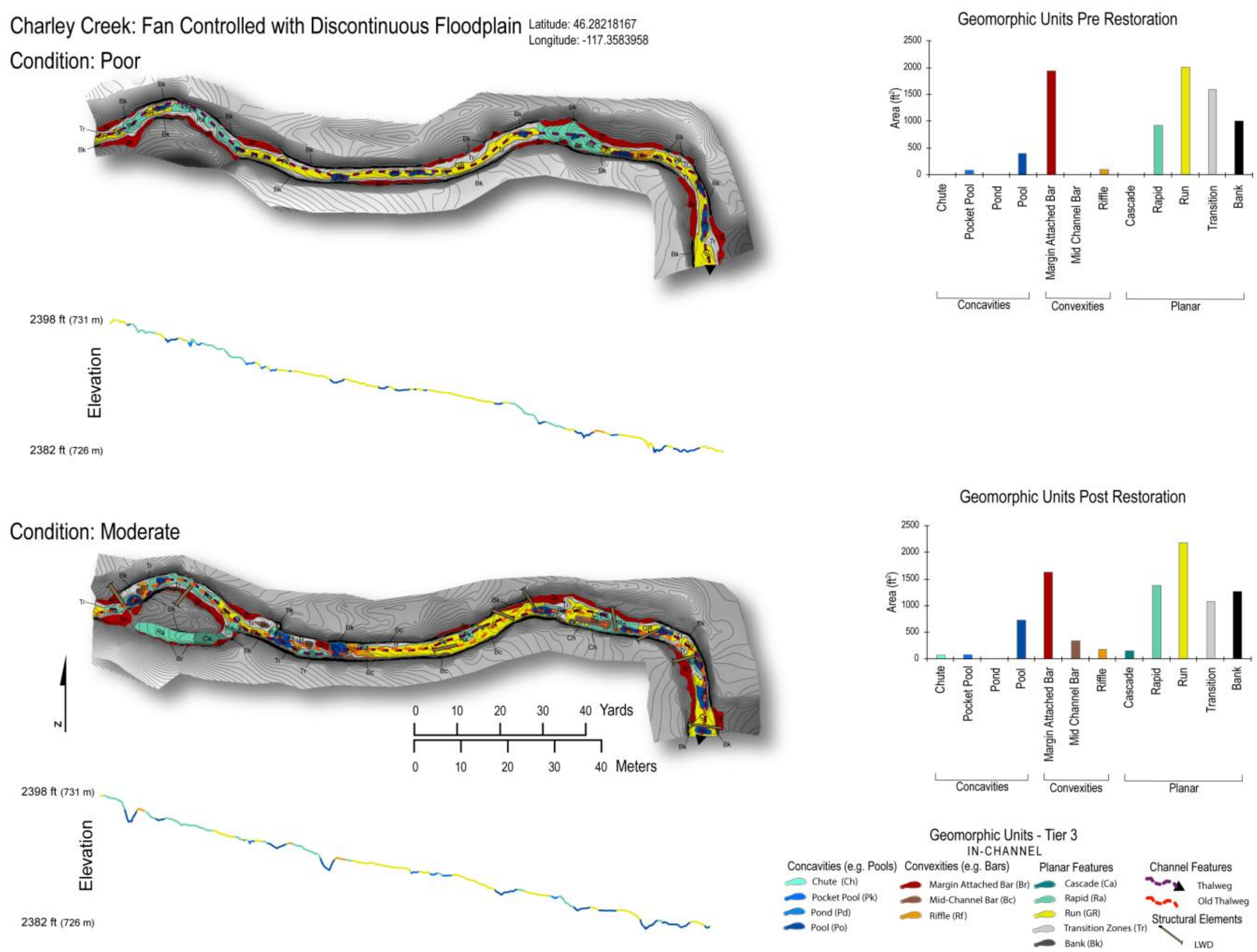
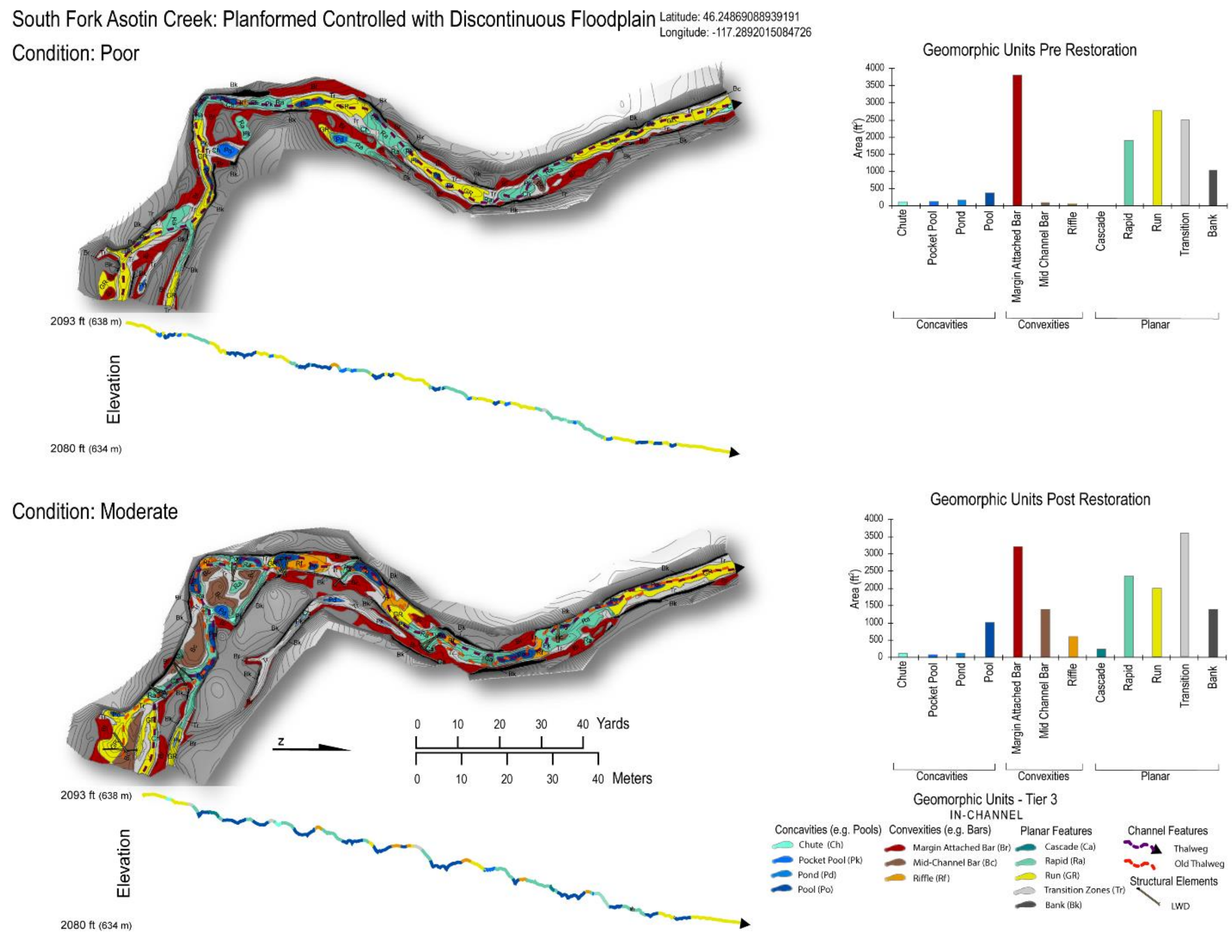


Figure 14. Geomorphic unit delineation of Columbia Habitat Monitoring Protocol (CHaMP) topographic data for a Charley Creek treatment site before restoration (top panel) and after restoration (bottom panel). Graphs show area of geomorphic units organized by concavities (i.e., pools), convexities (i.e., bars), and planar topographic features (i.e., runs, rapids, etc.). Geomorphic units are delineated by the geomorphic unit tool (GUT) developed by Joe Wheaton and the Ecohydraulics Laboratory at Utah State University (http://www.joewheaton.org). Area of pools and bars has increased since restoration.



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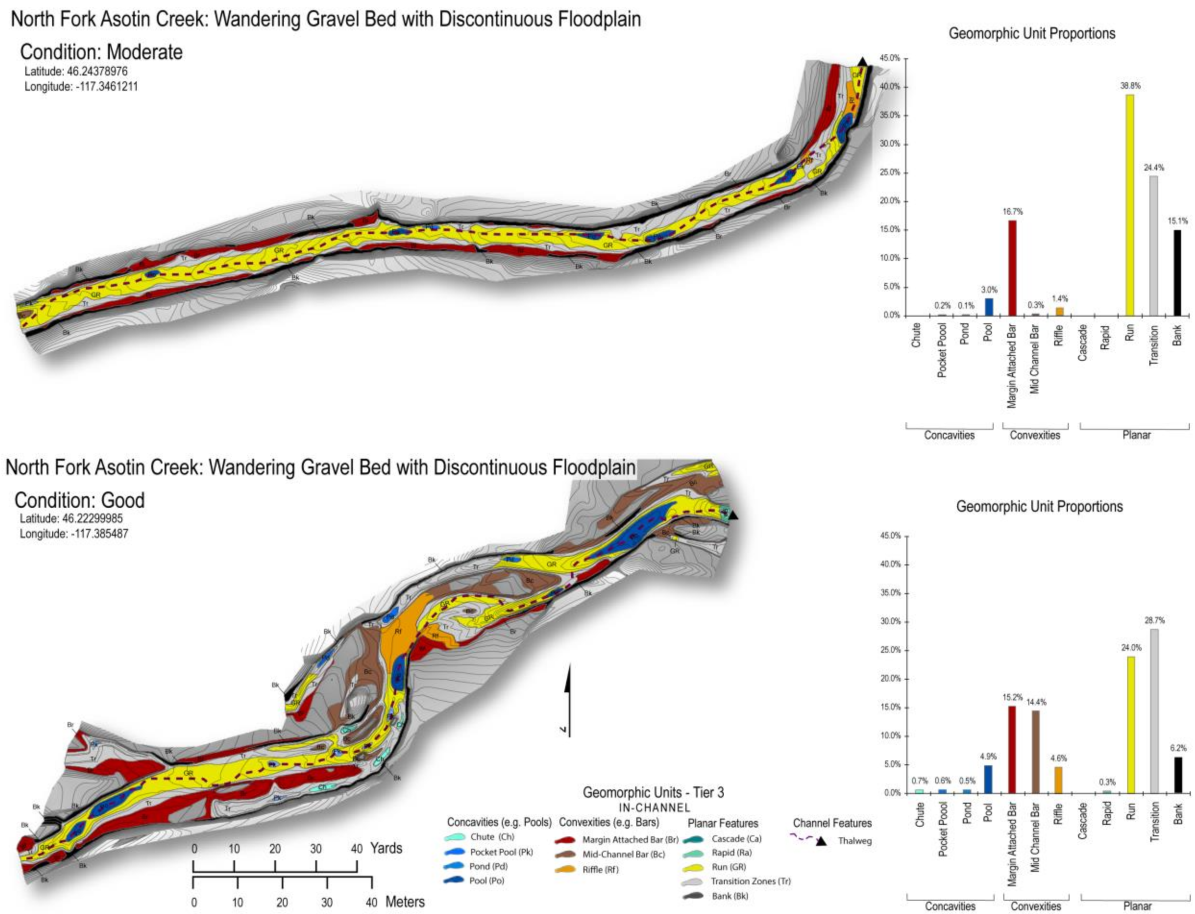

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4.3 Fish Capture

Since 2008 we have tagged 40,536 juvenile steelhead > 70 mm in the three study creeks of the IMW (Table 2). We capture relatively few bull trout and Chinook and have only tagged 39 bull trout and 169 Chinook since the start of IMW. WDFW has tagged 39,405 juvenile steelhead at the smolt trap and from hook and line sampling on the mainstem Asotin Creek (see Crawford et al. 2015). The majority of the juvenile steelhead we capture and tag are age 1 (~ 60%) and very few fish are age 3 or older (< 10%).

Table 2. Summary of the number of juvenile steelhead (> 70 mm) PIT tagged in Asotin Creek from 2005 to 2017 at the smolt trap on the Asotin mainstem by WDFW and in the IMW study creeks by Eco Logical Research Inc.

Stream	2005	2006	2007	2008	2009	2010	2011	2012	2013*	2014*	2015*	2016*	2017	Total
Asotin (WDFW)	2,462	1,552	1,895	1,862	946	2,605	4,002	4,679	3,944	5,607	2,334	4,339	3,178	**39,405**
Charley	-	-	-	424	1296	1,955	1,283	1,136	1,246	1,180	1,048	1,086	1,205	11,859
North Fork	-	-	-	372	470	1,397	906	931	1,797	1,549	2,035	2,244	1,792	13,493
South Fork	-	-	-	549	737	1,862	1,275	1,499	1,939	1,848	1,892	1,782	1,801	15,184
IMW subtotal	-	-	-	1,345	2,503	5,214	3,464	3,566	4,982	4,577	4,975	5,112	4,798	**40,536**
Total	**2,462**	**1,552**	**1,895**	**3,207**	**3,449**	**7,819**	**7,466**	**8,245**	**8,926**	**10,184**	**7,309**	**9,451**	**7,976**	**79,941**

4.4 Fish Abundance

Recapture rates during mark-recapture surveys have been high throughout the tagging efforts averaging approximately 30% in Charley Creek and South Fork Creek and 20% in North Fork. The density of juvenile steelhead is very similar across all three study creeks and generally tracks across years. When comparing the density of fish, the South Fork tends to have the highest densities of juvenile steelhead and the North Fork tends to have the lowest. However, when comparing the frequency of fish, the North Fork tends to have the highest frequency and the Charley Creek has the lowest. We have chosen to use fish/100 m as the primary metric for assessing fish response because our restoration actions may increase the area of stream per linear length of stream and therefore, changes in the total number of fish per length may be a more appropriate measure than density.

We analyzed the juvenile steelhead abundance data using the staircase model to look at the restoration response (Figure 17 and 18). When we assessed the overall response across all streams we found 23 - 47% increase in juvenile abundance in treatments compared to controls (Figure 17). The response varied depending on what type of response we looked for. We did not know where the response would be high in the first year and then fade away, ramp up over time, or any other combination of possible responses. Therefore, we looked for reasonable alternative response types. Specifically we tested for a traditional BACI response which is just a yes/no response pre versus post restoration (Impact 0/1). We also looked to see if the first or second year had the biggest response (Year 1 or Year 2), or if the response ramped up over time. So far there appears to be no dominate response type but Year 2 stands out from the other response types (though not statistically different from the other responses).

This could be due to the dominance of age 1 and 2 fish in the system which could secure responses to be more pronounced every 2 years, or be due to structures taking two years to be more effective at causing geomorphic change, or a combination of these factors.

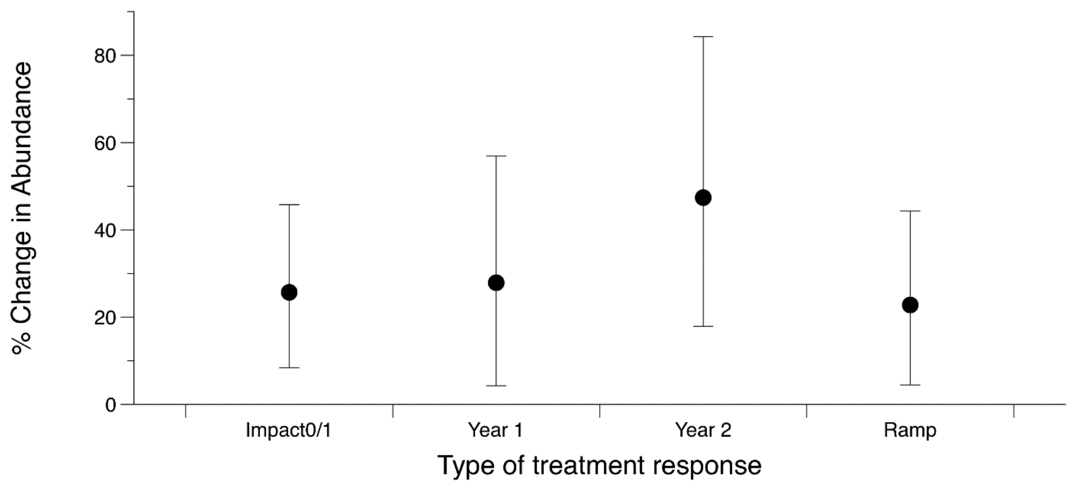

Figure 17. Results from the staircase model analysis comparing change in juvenile steelhead abundance in the treatments compared to the controls before and after restoration. Estimates are the percent change in juvenile steelhead abundance (fish/100m) across all three study streams combined in the Asotin Creek IMW: 2008-2017. Confidence intervals are 90% (α = 0.1). The different estimates are for analysis looking for different treatment responses (we did not presume what the response would look like): Impact0/1 is equal to a traditional BACI where mean of pre-restoration abundance is compared to mean post-restoration. Year 1 is a response that is expected to be greatest in year 1 after restoration. Year 2 is a response expected to be the greatest in year 2 after restoration. Ramp is a response that increases incrementally after restoration (i.e., expected response is smaller in year 1 compared to year 2, and smaller in year 2 compared to year 3).

We also used the staircase model to look at responses of the individual streams (Figure 18). There is a positive trend in abundance in treatment areas compared to control areas in all the streams. However, like the habitat changes, the fish response in the North Fork appears to be greater than the other two streams despite being treated last (i.e., we are observing a Year 3 response in North Fork, Year 4 in Charley, and Year 5 in South Fork). This would tend to suggest that it is geomorphic change that is causing the change in abundance and not other factors such as cover or refugia from high flows since there are similar densities of LWD structures in each stream. The

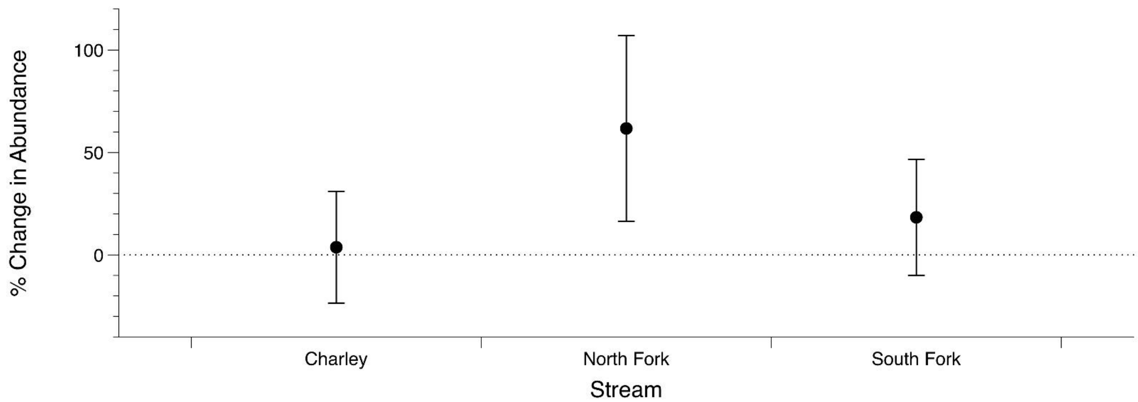

Figure 18. Results from the staircase model analysis comparing change in juvenile steelhead abundance in the treatments compared to the controls before and after restoration. Estimates are the percent change in juvenile steelhead abundance (fish/100m) within each study stream in the Asotin Creek IMW: 2008-2017. Confidence intervals are 90% (α = 0.1). The estimates were derived using the Impact 0/1 response contrasts because there is not strong evidence for choosing any specific response. All estimates of a response were positive and ranged from 3.8% (Charley Creek, p = 0.19), 61.7% (North Fork, p = 0.002), and (South Fork, p = 0.19).

4.5 Growth, Movement, and Survival

We continue to collect data and calculate growth by age class and site within each stream. We also assess fish movement, and seasonal survival. We will use the staircase model now we have fully developed it to analyze these important population parameters.

4.6 Productivity and Smolts/Spawner

We have developed a novel method to assess the productivity of the study area and treatment and control sections by estimating the migrants leaving the study area and the adult escape using the PIT tagging efforts of juvenile steelhead in the IMW study area and the tagging of adult returning and captured at the WDFW weir in the lower Asotin Creek. Future reports will describe this method in detail but briefly we used the following approach:

Migrants (Smolts)

- We estimate the total population of juveniles each year using our mark-recapture estimates at four fish sites in each stream (Figure 19).
- We calculate a tagged to untagged ratio by using the known number of fish we tagged each year divided by the population estimate for each stream and year
- We summarize the fish detections at each PIT tag array at the mouth of the three study streams by tag site, age, and year they left the tributary and expand these counts by the array efficiency (Figure 20)
- Assume the survival rate for marked and unmarked fish is the same
- Expand the tag detections by the tagged to untagged ratio
- We calculate the age of all tagged juveniles using a Bayesian model that uses a subsample of ages determined by scale analysis and known lengths to estimate the probability a fish of X length is a particular age.
- We can then attribute the attribute a proportion of total migrants estimated to have left into the appropriate brood year based on their age at the time they migrated (Figure 21).

- These analyses can be done at the stream level and at the treatment and control section (the ultimate goal; Figure 22)

Adult escapement

- We perform a similar approach to estimate the adult escapement except we focus on females because they wander between tributaries less and drive productivity (i.e., more egg limited than sperm limited)
- WDFW estimates a total population of male and females entering Asotin Creek each year and they PIT tag all fish they capture at the weir that are not already tagged
- We can count the number of females entering each study stream using the PIT tag arrays and expand by the antenna efficiency and tagged to untagged ratio from WDFW population estimates

We have built the databases to perform all these calculations and produced initial estimates of population estimates, adult escapement, and migrants by stream and treatment and control section from 2010-2015. These data will provide a wealth of information about these streams, naturally reproducing summer steelhead populations, and the effectiveness of large woody debris stream restoration.

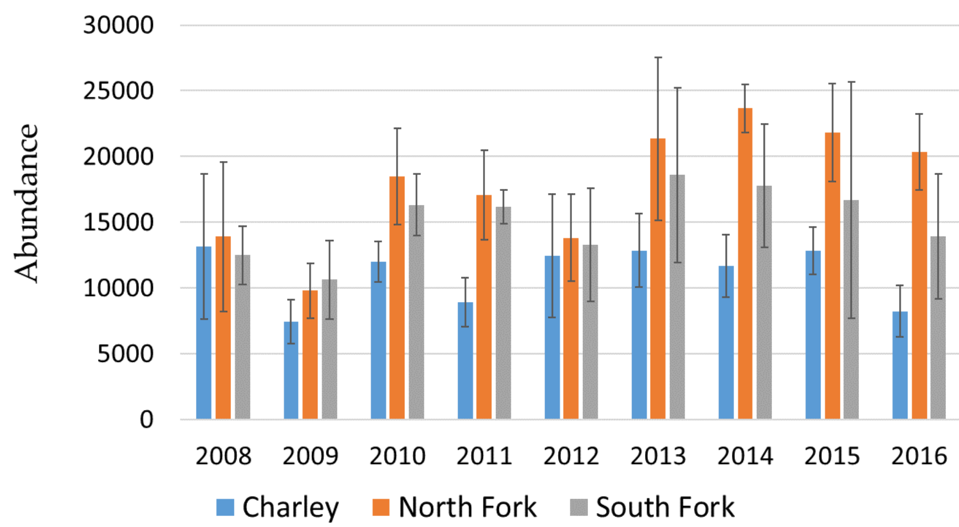

Figure 19. Estimate of the total population of juvenile steelhead in each IMW study stream

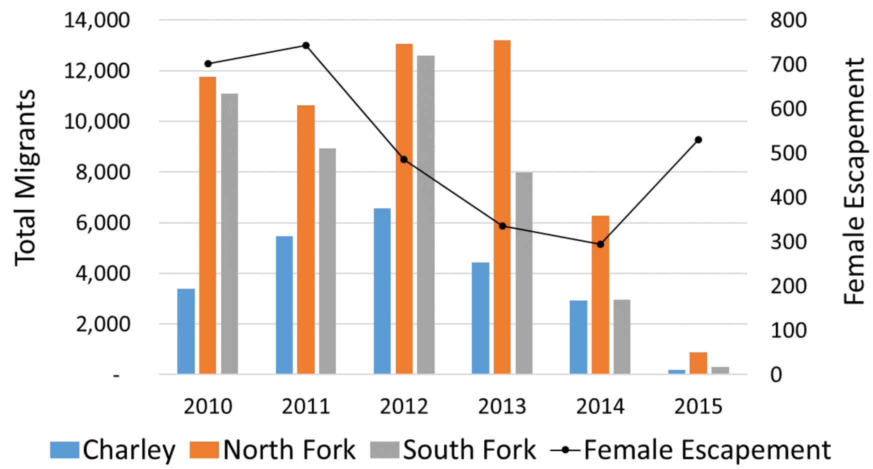

Figure 20. Total migrants leaving each study stream by brood year and female escapement. The brood years 2014-2015 are not complete counts of all migrants but will be completed in future summaries.

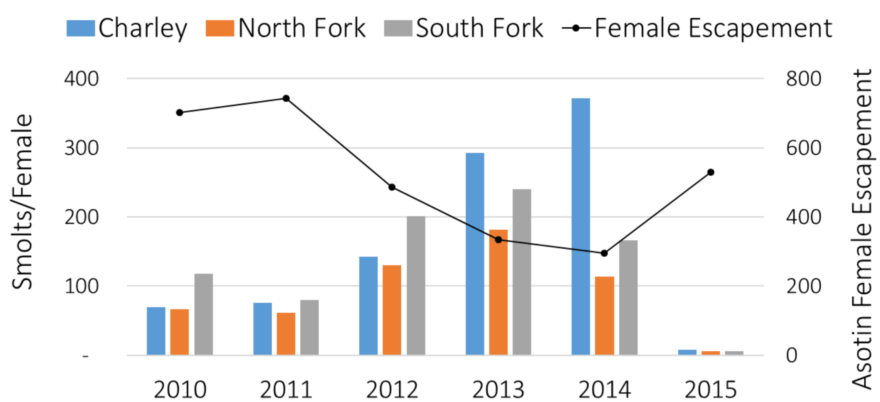

Figure 21. Smolts per female and total female escapement for Asotin Creek IMW study streams: 2010 -2015. Strong density dependence is evident from 2010 – 2014. Brood years 2014 and 2015 are not complete counts of all migrants but will be completed in future summaries.

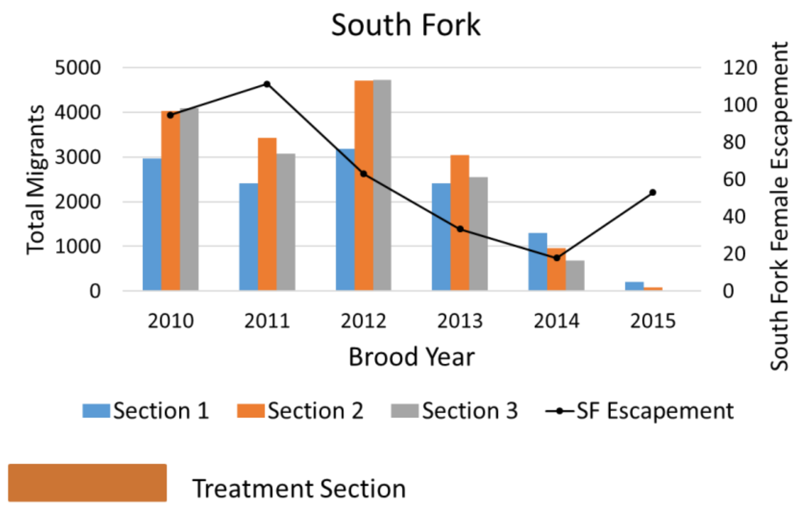

Figure 22. Migrants per treatment and control section and the total female escapement in South Fork Asotin Creek: 2010 -2015. Brood years 2014 and 2015 are not complete counts of all migrants but will be completed in future summaries.

5 CHALLENGES

We have suit of tools and models to assess the restoration actions – and analysis will be the focus of our efforts in 2018. Although we have made progress on developing tools and analyses methods, data management, and data preparation continue to hinder our analysis efforts. It takes a considerable amount of time to collect the monitoring data and updating model outputs every year takes time – it would require a considerable effort to automate these efforts. However, we plan to reduce our habitat sampling efforts in 2018 and dedicate more of that time to data preparation and data analysis. We will maintain the same level of effort for fish sampling because it is critical to complete our productivity analysis.

6 FUTURE ANALYSES

Below is a summary of the tasks for 2018:

- Estimate total number of smolts emigrating from IMW study creeks and Asotin Creek by brood year
- Estimate the distribution adult steelhead in the IMW study creeks by year and section
- Calculate smolts per spawner for IMW study creeks
- Recalculate survival by age class using refined Barker model approach (only need to calculate 2017 survival)
- Complete running NREI for all sites and years
- Analyze CHaMP data and incorporate into analyses
- Develop models to explain variability in population parameters
- Publish experimental design using hierarchical-staircase approach (this is 95% complete)
- Publish life history of juvenile steelhead in Asotin Creek

7 APPENDIX A. MONITORING DESIGN AND EXPERIMENTAL DESIGN

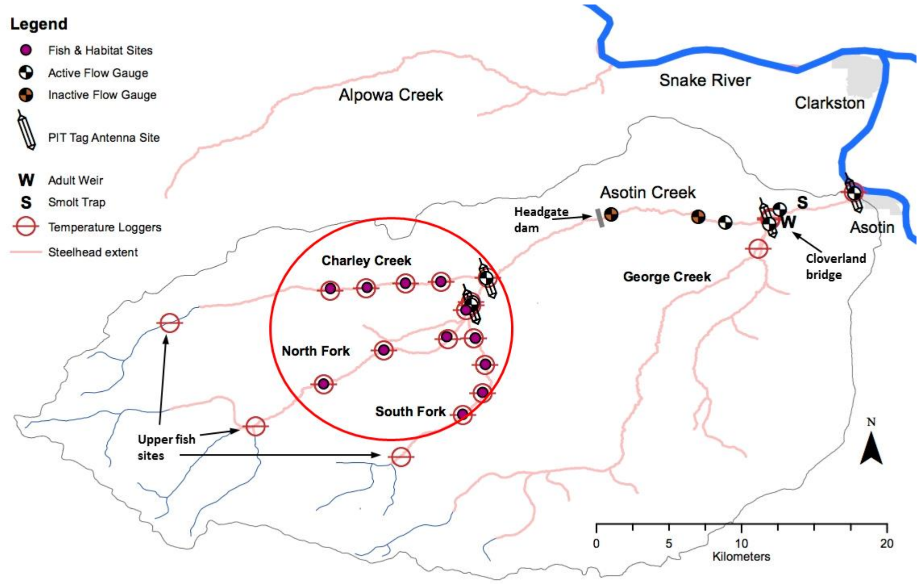

Figure 23. Monitoring infrastructure including fish and habitat sites in Charley Creek, North Fork, and South Fork Creek, temperature and discharge gauges, PIT tag antenna arrays, and the WDFW adult weir and smolt trap for fish-in fish-out monitoring.

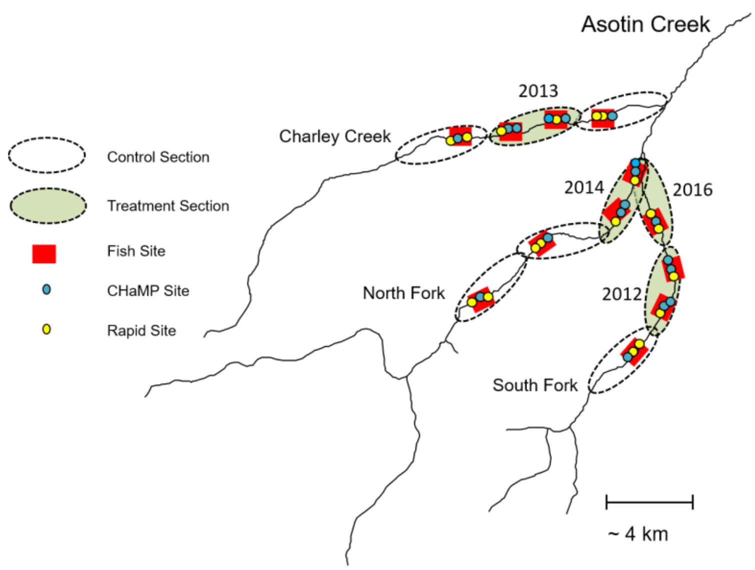

Figure 24. Experimental design of Asotin Creek Intensively Monitored Watershed. Each study stream has three 4 km long sections. One section in each stream has been restored using post-assisted log structures (shaded green): South Fork (2012), Charley Creek (2013), and North Fork (2014). Section 1 of South Fork (lower section) was restored in 2016. All other sections not colored will be controls throughout the project. Fish sites and habitat survey sites are nested within each section. CHaMP = Columbia Habitat Monitoring Protocol, Rapid = custom rapid habitat survey.

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