An Investigation into the Migratory Behavior, Habitat Use and Genetic Composition of Fluvial and Resident Bull Trout (*Salvelinus confluentus*) in the Yakima River Basin

Final Report

by

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ABSTRACT

Uncertainty regarding the distribution, migratory patterns, and habitat preferences of some populations of adult and sub-adult bull trout (*Salvelinus confluentus*) in the Yakima Basin constrains effective management for this species. Adfluvial populations have been studied extensively, but information is lacking on fluvial and resident forms of bull trout. This radio telemetry study was initiated in 2003 to increase our knowledge of Yakima Basin fluvial and resident bull trout populations.

Fish movement patterns were intensively monitored from September 2003 through December 2006. A total of 96 fluvial bull trout were captured. Seventy-one of these were radio-tagged and tissue samples taken for DNA analysis. Sixty-two bull trout were radio-tagged in the Naches drainage and seven in the smaller, adjacent Ahtanum Creek drainage. Only two fish were captured and tagged from the upper Yakima drainage. These latter two were chance encounters, as few bull trout are found in the upper Yakima River mainstem or tributaries outside of the Bureau of Reclamation storage reservoirs. Of the 62 bull trout tagged in the Naches drainage, 29 were captured from various holding pools in the mainstem Naches River, 16 from the Tieton River below Rimrock Reservoir (Tieton Dam), seven from Rattlesnake Creek, three from the Bumping River, two from the American River and five from Union Creek (American River tributary). In the Ahtanum Creek drainage, four were from the N. Fork and three from the Middle Fork Ahtanum Creek.

Surgical implantation training was conducted on 32 hatchery rainbow trout before tagging bull trout. Rainbow trout were held as a “control group” for nine months at the WDFW Naches Hatchery. Although no mortalities occurred with the control group, we observed some shed tags, unabsorbed sutures, suture injury and keloidal extrusion of tags. With tagged bull trout, we found evidence of only six shed tags that we could directly attribute to our surgeries. However, we did find additional tags during the project, some of which appeared to be associated with natural (i.e., spawning) and/or predator induced mortalities that occurred months or years after initial tagging.

We used information derived from DNA tissue analysis to confirm population/stream assignments for radio-tagged fish. In both the Ahtanum and the Naches drainages, bull trout stayed true to their natal spawning areas. Site fidelity was extraordinarily high, near 100% on radio-tracked fish. Genetic analysis revealed that bull trout in the Tieton River stilling pool below the dam at Rimrock Reservoir were from various populations. Some were from adfluvial populations above the dam that were entrained out of the reservoir. Since there were no fish passage facilities, they could not move back upstream to natal spawning grounds. Other bull trout in the dam stilling pool were from various Naches Basin fluvial populations, likely moving into the pool to feed on the abundant forage (entrained kokanee salmon).

Adult bull trout in the Naches River spent lengthy periods of time in their over-wintering habitat, generally moving very little after settling in for the winter (November thru March). The prime locations consisted of a series of large pools in the mid to upper Naches River from the Wapatox Diversion Dam (RM 17.1) upstream to Pool #6 (R.M. 40.5). Fluvial bull trout from several tributary populations over-wintered in these pools, which included adults from Rattlesnake Creek, American River/Union Creek and Crow Creek. Pool selection seemed to be driven by velocity and surface opacity, especially where other forms of cover were absent, but where prey was readily available. Velocity preferences in these holding areas consistently ranged from 1.4 –

1.9 feet per second (fps). Adult bull trout were found in these same pools or moving slowly upstream between them throughout the spring (April, May). By early to mid-summer (June, July) the fish were moving into their natal tributary streams, where they continued to move slowly upstream to the spawning grounds. Conversely, resident bull trout found in the Ahtanum Creek drainage stayed year-round in their respective natal streams. Spawning occurs in the month of September in both drainages.

Although adult bull trout often migrated into their natal tributary streams well before the actual spawning period, the time spent on the actual spawning grounds was relatively short, usually only 2-3 weeks, compared to the overwintering (5-6 months) and foraging/migration (5 months) periods. Habitat preference was also different. Spawning habitat consisted of gravel, small cobble and sand substrate found in smaller, higher gradient stream reaches. Also, spawning areas typically contained more woody debris. Spawning bull trout often preferred areas where cover was abundant and vegetation draped over the water or lay completely across the channel. Although redds were often in open exposed areas of the stream; adults were usually close to some form of concealment cover. Access to woody debris (log jams), large boulders, undercut banks, shoreline vegetative cover, deep pools, as well as substrate composition, water flow and temperature all played a crucial role in the selection of spawning areas. Water depth on spawning grounds was much shallower than the water depths associated with foraging, migration and over-wintering (FMO) pool-glide habitat. Bull trout were often observed in shallow water riffles from just a few inches deep to pool tail outs that were two feet deep.

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INTRODUCTION

In June, 1998, the U.S. Fish and Wildlife Service (USFWS) listed bull trout (***Salvelinus confluentus)*** in the Columbia Basin as "threatened" under the Endangered Species Act of 1973 (USFWS, 1998). The ESA listing stemmed from several factors that led to marked declines in bull trout abundance. Among these was loss or degradation of habitat, barriers to movement (thermal or physical), population fragmentation, overfishing, and competition/predation with exotic species. The ESA listing resulted in an increased focus to protect and monitor bull trout populations and their habitats in the Yakima basin. This required cooperation from various local, state, federal, and tribal managers. A recovery unit team for the Yakima basin was established and a draft recovery plan was drafted by the USFWS (2002), including a chapter for the Yakima basin "core area". The draft plan summarized population status and identified limiting factors. The plan also identified knowledge gaps regarding bull trout biology and their habitats that required additional research.

The Washington Department of Fish and Wildlife (WDFW) started monitoring activities (i.e., spawning redd counts) and conservative management strategies (i.e., harvest restrictions, spawning area fishing closures) for Yakima basin bull trout populations in the mid-to-late 1980's. Some genetics baseline work had been accomplished by Reiss (2003) and adfluvial spawning and habitat studies were completed by James (2002). However, considerable uncertainty remained regarding the distribution, migratory patterns, and habitat preferences of fluvial and resident bull trout populations and whether all known spawning areas had been identified. WDFW, with funding assistance from the USFWS, initiated the bull trout radio telemetry study in the fall of 2003 to expand our knowledge of "fluvial" (river-dwelling) and "resident" (small stream-dwelling) bull trout.

Radio-tracking and genetics analysis identified the need to expand the study to include movement patterns of bull trout above and below the U.S. Bureau of Reclamation (USBR) storage dams. This lead to collecting DNA tissue samples from "adfluvial" (lake-dwelling) bull trout to compare with the downstream fluvial and resident life history types. The genetics analysis conducted by Small et.al. (2009) was particularly valuable, as it shed light on the origin of all of our radio-tagged bull trout, as well as the origin of bull trout that had been discharged from Rimrock Reservoir. During the course of this study, fish movement patterns were intensively monitored from September 2003 through December 2006. A total of 96 fluvial bull trout were captured. Seventy-one of these were radio-tagged and tissue samples taken for DNA analysis. Sixty-two bull trout were radio-tagged in the Naches River drainage and seven in the smaller Ahtanum Creek drainage. Only two fish were captured and tagged from the upper Yakima River.

STUDY PURPOSE AND OBJECTIVES

Project Goal

"Evaluate the migratory patterns of adult and sub-adult resident and fluvial bull trout and identify habitat preferences in the Yakima Basin. Evaluate connectivity, locate spawning and wintering areas, identify migratory patterns and habitat preferences using radio-telemetry, archival tags, snorkel surveys, spawning surveys habitat surveys, and other available data."

Primary Objectives

1) Document timing and patterns of migration and spawning activity for adult bull trout.
   a) Locate fish during the spawning period and document upstream and downstream limits of spawning grounds.
   b) Document late fall/winter (pre- and post-spawn) movement patterns.
   c) Document 24-hour movement patterns of some tagged fish.
   d) Document overwinter habitats.
   e) Evaluate temperature ranges and how movements and spawning relate to temperature and stream flows. Use archival tags, in-stream thermographs (data loggers), spot temperature readings and FLIR (Forward Looking Infra-Red), and TIR (Thermal Infra-Red) flight data to collect temperature information.
   f) Obtain biometric measurements of captured bull trout to track and document fish condition and growth rates post-tagging.
2) Evaluate habitats used by tagged and untagged bull trout.
   a) Conduct snorkel surveys to determine habitat use of radio-tagged and untagged bull trout.
   b) Determine primary habitat types (e.g. pool or riffle), secondary habitat types (e.g. scour, pocket, or edge pool), and cover type (woody debris, depth, overhead vegetation, etc.), and identify temperatures and/or stream flows that bull trout are using. In addition, use existing stream survey and water quality data, if available, to evaluate habitat parameters.

Secondary Objectives

3) Develop recommendations and procedures for future bull trout radio-telemetry and archival tag studies.
   a) Identify how techniques used in the Yakima Basin radio-telemetry study can help fulfill Washington State's "Forests and Fish Law" (1999) objectives (WDNR, 2005).
   b) Identify how these techniques fulfill the USFWS long-term monitoring plan for recovery of the species.
4) Collect tissue samples from all bull trout encountered for DNA genetic analysis, fin rays for aging and perform analyses of the samples.
   a) Collect tissue samples and fin rays using the latest non-lethal tissue sampling protocols developed for bull trout. Fin rays will be clipped close to the body, labeled, and stored in tissue sample envelopes. Duplicate DNA tissue samples (paper punch hole-size) will be labeled, stored in vials filled with 100% ethanol, and assigned to a comprehensive data sheet that compiles information on all bull trout captures.
   b) Obtain analysis of tissue samples and fin rays to conduct genetic analysis for local population identification and age tagged fish. Coordinate with USFWS to determine techniques to be used for analysis of these samples. Use tissue samples from WDFW and other entities to develop a comprehensive basin-wide genetic map.

STUDY AREA

The Yakima River flows 214 miles from Keechelus Lake in the Cascade Mountains to the Columbia River near Richland. The basin covers approximately 6,100 square miles. Major tributaries include Kachess, Cle Elum, Teanaway and Naches Rivers to the north and Ahtanum, Toppenish and Satus Creeks to the south. There are five major irrigation storage reservoirs in

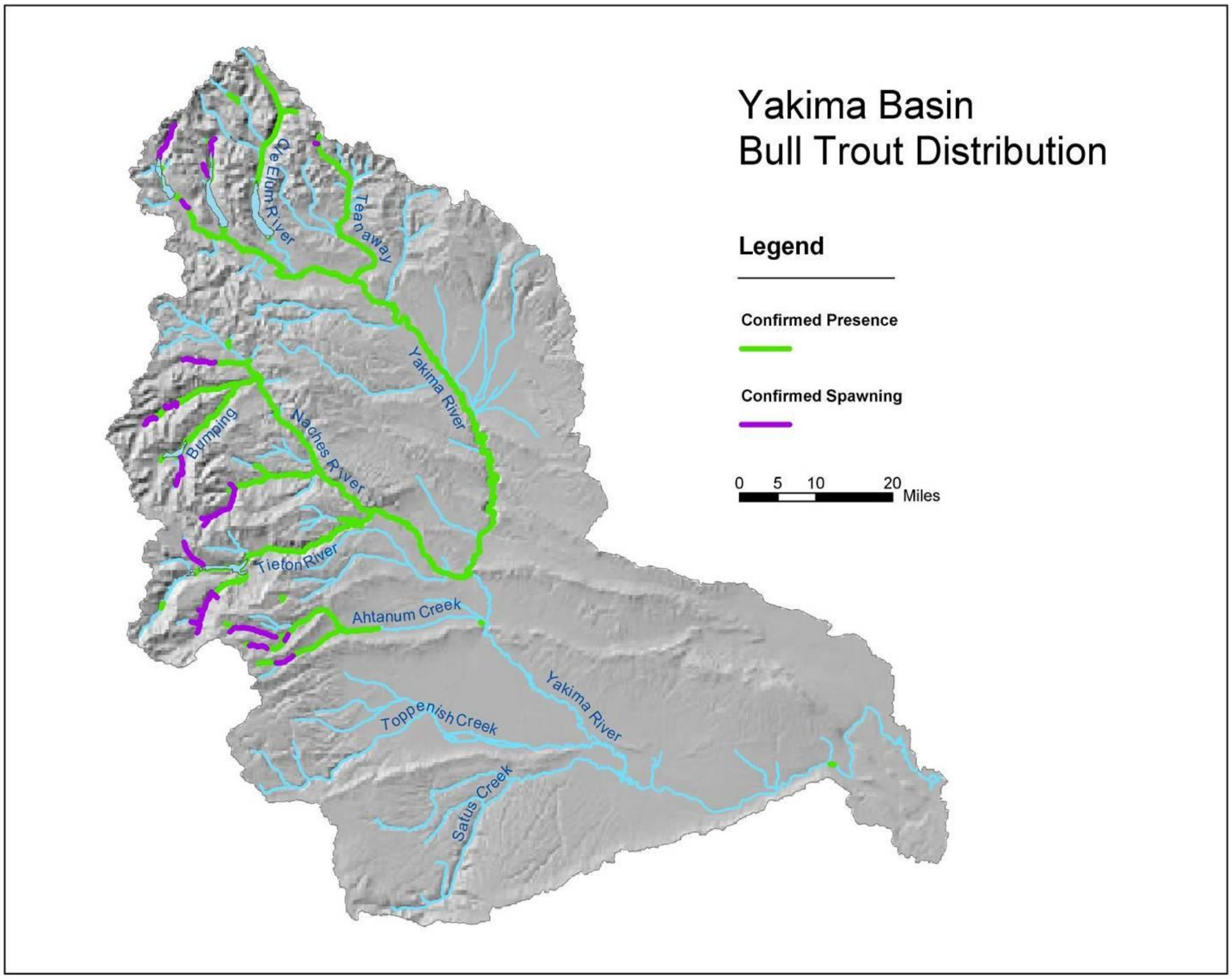

Figure 1. Yakima River basin bull trout distribution and spawning areas.

the headwater areas of the basin, including Keechelus, Kachess and Cle Elum in the upper Yakima basin and Bumping and Rimrock in the Naches drainage. Annual discharge from the Yakima basin averages approximately 2.9 million acre-feet of water, of which 2.4 million acre-feet are diverted for irrigation use.

Bull trout distribution primarily occurs in the upper portion of the basin from the City of Yakima to the headwaters in the Cascade Mountains. Figure 1 shows the known distribution and spawning areas. There are isolated, adfluvial populations in four of the storage reservoirs (excluding Cle Elum Reservoir) and fluvial/resident populations below the reservoir dams. Since bull trout are far more abundant in the Naches arm of the drainage, this study primarily focused on fluvial and resident bull trout in the Naches and in the nearby Ahtanum drainage (see Figure 2). The Naches River is the largest Yakima River tributary, extending 45 river miles northwest from the confluence at Yakima, WA. Major tributaries include the Tieton River, Rattlesnake Creek, Little Naches River, Bumping River, and American River. Rimrock Reservoir is located on the Tieton River and Bumping Reservoir on the Bumping River. Neither storage dam has fish passage facilities. The Ahtanum Creek drainage is an independent tributary to the Yakima River at Union Gap, WA.

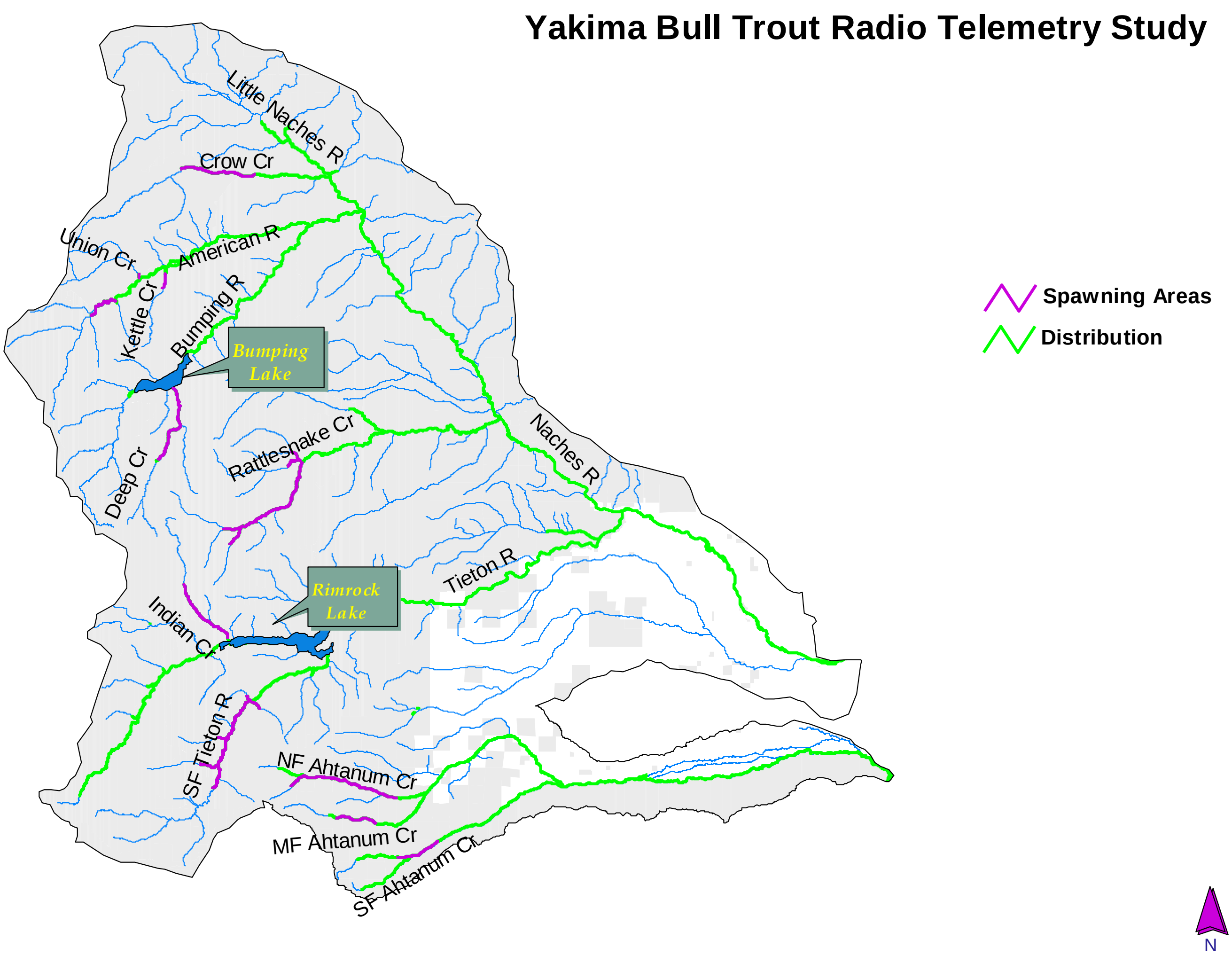

Figure 2. Study area in the Naches and Ahtanum drainages showing bull trout distribution and spawning areas.

METHODS

Fish Capture

Bull trout were captured for radio-tagging with sport fishing gear (hook-and-line) and traps. Hook-and-line capture was used in larger holding pools where traps were not practical. We were able to travel to holding pools to capture bull trout because the tag implant surgical equipment was portable. All the fish tagged in the mainstem Naches, American and Bumping Rivers were captured by hook-and-line. Various artificial lures were used including spinners, spoons and plugs. All lures were equipped with one, single-point barbless hook to reduce injury. Hooked fish were played and landed quickly to reduce exhaustion and stress. Fish were landed in a knotless net to minimize de-scaling, kept in the water during hook removal, and transferred to 10-inch diameter perforated PVC submerged holding tube. The fish were held in the river for a short time prior to surgery. All these methods were employed to reduce stress during tag implantation and improve post-release survival.

During periods when fish were migrating into smaller tributary streams or when it was necessary to capture post-spawned bull trout, stationary weir traps were used. This was particularly useful in the Ahtanum Creek drainage where the small size of the stream and the low density of bull trout made it impractical to use hook-and-line gear. We used both “V” style and “N” style pipe and panel weirs with live box traps. The “V” style weir was used to trap post-spawned bull trout that could be intercepted on their way out of the spawning area. This type weir was used in Union, Crow and Rattlesnake Creeks (Figures 3-5). The “N” style weir was used in certain areas to allow fish unrestricted movement upstream, but to trap downstream migrants. This weir configuration was used in lower Crow Creek to allow spring chinook and bull trout unrestricted movement upstream to spawn, but trapping post-spawned bull trout migrating downstream. The “N” style panel weir trap was also used in the upper Ahtanum drainage to trap resident bull trout migrating in both directions (Figure 6). The pipe weir frame consisted of steel tripods that supported two lengths of angle iron attached horizontally, one above the other. The angle iron supports were drilled with 1” diameter holes on 1.5” centers to accept vertical pipes (pickets) with 0.5” clear spacing. One-inch O.D. pipes were installed vertically in the weir frame to block fish passage. Smaller wood frame panel weirs were constructed with pipe or steel mesh. Migrating fish were directed into a large PVC pipe, which ended in a capture box. The inside of the PVC tube leading to the trap entrance was painted black to reduce avoidance behavior by the fish.

All traps were checked once or twice daily. Captured fish were inspected to see if they had spawned and to assess their overall condition. Those fish deemed suitable for radio-tagging were held in a large live box until surgery. Surgery usually occurred within 12 hours of capture. Tissue samples for DNA analysis were taken from all captured bull trout. Samples were placed in vials of 100% ethanol for preservation.

Radio-Tag Implants: Materials & Surgical Procedure

Radio-tags for this study were obtained from Lotek Engineering. Specifications are listed in Table 1. Initially, three sizes of tags were purchased: the MCFT-3A which had an air weight of 16 grams (g) and a minimum life of 685 days at a five second burst rate, the MCFT-3FM with an air weight of 10 g and a life of 504 days at a five second burst rate, and the MCFT-3EM with an

Figure 3. Union Creek "V" style panel weir and live box trap.

Figure 4. Rattlesnake Creek pipe weir and live box trap.

Figure 5. Crow Creek "V" style panel weir with live box trap.

Figure 6. N. F. Ahtanum Creek "N" style weir with upstream & downstream box traps.

Table 1. Lotek radio-tag specifications used in the study.

TAG	WEIGHT	DIMENSIONS	LIFE	BURST RATE
MCFT-3A	16 grams	16 x 59 mm	685 days	5 seconds
MCFT-3FM	10 grams	11 x 59 mm	504 days	5 seconds
MCFT-3FM	10 grams	11 x 59 mm	567 days	6 seconds
MCFT-3FM	10 grams	11 x 59 mm	579 days	7 seconds
MCFT-3EM	8.9 grams	11 x 49 mm	444 days	8 seconds
NTC-6-2	4.5 grams	9.1 x 30 mm	268 days	8 seconds

air weight of 8.9 g and a life of 444 days at a burst rate of eight seconds. The burst rate refers to the time interval (seconds) between signals emitted by the tag. For a given tag size, increasing the burst rate increases the battery life of the tag. As the study progressed, smaller tags with longer battery life were needed, so a set of MCFT-3FM tags with a six second burst rate (567 day life), MCFT-3FM tags with a seven second burst rate (579 day life), and "nano" tags (NTC-6-2) that weighed 4.5 g with an eight second burst rate (268 day life) were purchased. The nano tags were necessary for smaller, resident bull trout encountered in the Ahtanum population. Different burst rates also allowed us to stagger the coding sequence and facilitate quicker acquisition of individual codes when multiple tagged fish were encountered in close proximity to each other (e.g., many fish in one pool). For all tag and fish sizes, the "two percent rule" was followed, meaning radio-tag weight was kept below 2% of the total body weight to avoid affecting the fish's metabolic functions and swimming ability (Wigglesworth, P. 2003 per. Com.). Figure 7 shows the four sizes of tags used in the surgical implants.

Prior to field deployment to capture and radio-tag adult bull trout, we practiced our surgical procedure by implanting tags into 32 hatchery-reared rainbow trout. This proved to be a very beneficial confidence booster, because we could hold and monitor recovery of the hatchery trout prior to performing the procedure on ESA "threatened" bull trout. This control group of rainbow trout was held at the WDFW Naches Hatchery for nearly nine months (Sept. 2003 to May 2004) for evaluation. This included monitoring the fish for surgical recovery, incision healing, mortality, shed tags and disease problems. Tag implant/surgery training was conducted by Judy Neibauer (USFWS) and followed standard procedures developed by the USFWS. After training on a few dozen rainbow trout, we began capturing bull trout for radio-tag implantation during the fall 2003 spawning season. Since the project got started late in the year, we took advantage of our ability to locate, trap and tag post-spawned bull trout during September and October.

A portable surgical kit was used for radio-tag implantation (Figure 8). The kit fit in a backpack and consisted of a tray with radio-tags, radio receiver, surgical tools, anesthetic/antiseptic solutions, scale/tape measure, DNA sample vials, a perforated PVC holding/recovery tube, and a V-shaped fish surgery trough made from very smooth ABS plastic to prevent abrasions to the fish. The trough was mounted on top of a three gallon bucket, which served as both a stand for the trough and a mixing container for the "knockout" (K.O.) and anesthetic (A) solutions. After mixing, the K.O. solution was transferred to a collapsible K.O. container constructed from a whitewater raft center float tube (blue in Fig. 8).

Figure 7. Four sizes of radio-tags used in bull trout surgical implants. Also shown is the steel catheter needle and copper "stinger" used in guiding the antenna lead through the fish's body cavity.

We carried a pre-mixed stock solution of MS-222 (10 g Tricaine Methanesulfonate per 100 ml water) for mixing the K.O. and anesthetic solutions. A 12 ml dose of the "10/100 stock" was mixed with 15 liters of water to make the K.O. solution. Likewise, 3 ml of the stock solution was mixed with 7.5 liters of water to make the dilute anesthetic solution for use during the surgery. The knockout and anesthetic solutions were then added to the K.O. tub and the anesthesia bucket prior to surgery. New solutions were mixed after performing two or three fish surgeries. Both solutions were buffered with sodium bicarbonate at 10 g $NaHCO_3$ per 100 ml to match the acidity of the stream. Additional containers and trays held saline (antiseptic) and "Nolvason" (surgical scrub) solutions. Nolvason was used to clean hands and tools prior and during the surgical procedure (30 ml Nolvason per liter distilled water). A tablespoon of table salt was also mixed in a shallow surgical tray to keep the surgical tools clean. The tools were first cleaned and sterilized in the Nolvason, then moved to the saline tray just before the surgical procedure. The saline solution cleaned the Nolvason solution off the tools to prevent transfer to the fish's body cavity where it could be harmful.

Figure 8. Portable surgical kit for implanting radio-tags in captured bull trout.

Fish to be implanted with radio-tags were kept in flow-through holding/recovery tubes made from 10” PVC pipe with one-inch holes drilled through the sides to allow in-and-out water flow. The holes in the tube were smoothed so that no sharp edges were present. The ends of the holding tubes had threaded caps to secure the fish and make sure that none were lost prior to tagging. A rope was threaded through both ends of the tube so that it could be tethered from the riverbank.

Only fish that appeared to be in good health and condition were selected to be radio-tagged. Initially, selected fish were immersed in the K.O. solution until anesthetized (typically 10-12 minutes). It was then measured (fork and total length) and weighed. The fish was weighed in a knotless bag with an electronic scale. Approximately one square centimeter of fin tissue was taken and placed in an individually marked vial of 100% ethanol for future DNA analysis.

The fish was considered completely anesthetized after it made several rapid gulps followed by a much shallower rhythmic opercula movement. Knockout time for individual fish varied depending on fish size, water and air temperature, and water quality (i.e., pH and turbidity). The fish was removed from the K.O. solution and placed on its back (i.e. ventral surface up) on the surgical “V” trough. The dilute anesthetic solution was then administered to the fish’s gills via a plastic turkey baster. Both opercula were opened and wetted to maintain gill integrity (wetness). The incision area was disinfected with jelled Betadine topical antiseptic and then wiped clean and dried with cotton swabs. Using a curved #12 stainless steel scalpel, a 2-4 cm incision (depending on fish and tag size) was made on the mid-line of the ventral surface, anterior of the ventral fins (pelvic girdle) and approximately ¼ - ½ of the distance between the ventral fins and the pectoral fins. The skin was pinched gently between the surgeon's thumb and forefinger and scored with the blade. Several cutting passes were made until the abdominal wall was breached. Once the outer skin and scales were cut, 1x2 tooth tissue forceps were used to pull the skin up and away from the internal organs to minimize risk of organ puncture and ensuing peritonitis. The incision was made slightly larger than the tag to allow it to pass through the abdominal wall without tearing, yet leave a small opening for closure. The fish was visually assessed through this incision to determine its sex.

During surgeries early in the study, the surgeon's finger was inserted into the incision to guide the hollow catheter needle for the radio-tag antenna insertion, but this was too invasive and had greater potential for puncturing internal organs, especially on smaller "resident" fish (10-15 inches total length). We soon devised a copper tube we dubbed "the stinger" to guide the catheter needle rather than the surgeon's finger. The stinger was curved to match the curved needle that was inserted into it for threading the radio transmitter antenna through the abdominal wall of the fish. The stinger was beveled on one end and smoothed so there were no sharp edges (see Figure 7). After the incision was made, the stinger was inserted into the incision towards the rear flank of the fish following the inside surface of the abdominal wall in the same way as the surgeon's finger was used in previous surgeries (Figure 9). The sharp catheter needle was then inserted into the stinger and pushed through the body wall of the fish from the inside, adjacent to the pelvic girdle and midway between the ventral surface and the lateral line. Then the stinger was removed from the incision and the radio-tag antenna lead was threaded through the catheter to the outside of the fish. The catheter was then pulled out through the body wall of the fish and off of the antenna lead. This allowed the tag to be inserted thru the incision and seated in the body cavity by gently pulling on the antenna lead from outside the fish. The copper "stinger" tube worked so well that it was used in all subsequent surgeries for large and small fish. This new procedural modification allowed for smaller incisions, speeded up recoveries and allowed the radio-tag body to be placed further back inside the fish's body cavity away from the incision site, which also helped to reduce the tag-shedding problem.

After the radio-tag was seated in the fish's body cavity, two to four independent sutures were placed evenly along the incision (Figure 10). Suture knots were done with a 3-2-2 wrap, where the suture material was wrapped three times around the forceps and pulled tight, then two wraps and finally two last wraps. An FS-1 3/8 24mm surgical needle was used for suturing. Tools and suture material were continually rinsed in saline solution. After trimming the knots of excess suture material and thoroughly drying the area with cotton swabs, "vet bond" surgical glue was applied to the suture site and dried by blowing on it. During this later step, the anesthesiologist switched to fresh water to begin reviving the fish. The fish and surgical trough was then removed from the bucket (stand) and placed in the river for a minute or two while the sutures were kept just out of the water, allowing the fish to recover while the surgical glue could finish drying. The additional time and care taken in drying the glue proved worthwhile when several fish were recaptured several weeks post-surgery and the glue was still in place. After the surgical glue dried, the fish was transferred to the recovery/holding tube where it could fully recover for another 20 minutes or more before being released into a nearby pool.

Figure 9. Bull trout radio-tag implant surgery. "Stinger" in use for facilitating catheter needle/radio-tag antennae insertion through the body cavity (note needle protruding from body above right ventral fin). Fish is on the surgical "V" trough and anesthetic solution is being applied to the gills.

Figure 10. Radio-tagged bull trout showing sutured incision and external antenna.

Archival Tags

Although archival temperature tags were acquired from Lotek Engineering, we did not use any during this study. The tags, which can record depth and temperature every hour for up to several years, are externally attached to the fish. They are approximately one inch by one-half inch by one-quarter inch thick with holes at both ends for attachment (Figure 11). Our initial goal was to attach a few archival tags to radio-tagged bull trout and then recapture the fish 1-2 years later and then download the archived information. However, since previous studies had not had much success keeping these tags externally anchored to the fish in riverine environments (Neibauer, J. 2003. per. com.), we did not use them in this study. We did use the archival tags in a later study that involved monitoring adfluvial bull trout movements in Bumping Reservoir (Mizell and Anderson, 2008). In that study, archival tags were surgically implanted inside the fish's body cavity with the radio tag. The archival tag was simply attached by sliding it onto the radio tag antenna (thru the holes) and then binding it together. Fish were recaptured a year later, when they returned to spawn and the tag surgically removed to download the data.

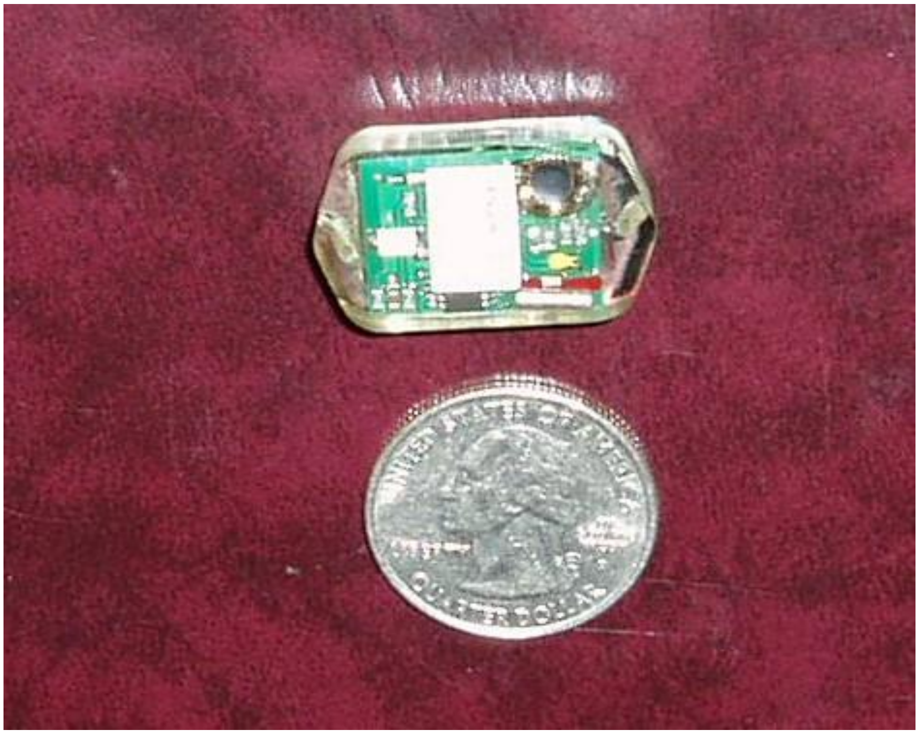

Figure 11. Archival temperature tag (photo courtesy of Judy Neibauer)

Radio-Tracking

Tagged fish were radio-tracked by fixed station and mobile receiver/antennae units. Mobile tracking was primarily conducted weekly by using a truck-mounted and backpack receiver unit (Figure 12). Backpack forays were often required to locate tagged fish at a holding pool or river mouth. Mobile tracking was occasionally supplemented with aerial (fixed-wing aircraft) surveys, especially during periods of widespread fish distribution and/or intense migration periods. Air tracking was accomplished with two different fixed wing aircraft, a Maule M7 at an air speed of 80-100mph, or a Super Cub PA18 (Figure 13) at 80mph. Both aircraft had tracking antennas ("H" style) mounted under the wings at a 20-degree angle. During our surveys, the right side "H" antenna was used exclusively, allowing the tracker to see the physical area in conjunction with obtaining the GPS coordinates. Prior to all mobile tracking and fixed station data downloads, the receiver unit batteries were charged and the unit checked against a test transmitter to make sure the receiver was functioning properly.

Five Lotek SRX receivers were strategically placed at fixed station monitoring sites in the study area. Fixed stations were located at the mouth of the Tieton River (confluence with Naches River), mouth of Rattlesnake Creek (confluence with Naches River), the junction of the Bumping/Little Naches Rivers, the American River, and at the confluence of the North and Middle Fork Ahtanum Creeks (Figure 14). Receiver units were provided by the USFWS, the USBR and WDFW. Two types of fixed receivers were used, the W-7 and the W-31. The main difference was that the W-31 could use different gain levels for different channels, which was especially useful at multi-antenna fixed station sites. Both receiver styles were multi-port, DSP compatible, and capable of monitoring a 4 MHz bandwidth with a programmable range of 148-152 MHz. The units were programmed to monitor tags at various burst rates used in the study (i.e., burst rates varied between 5-8 seconds). Because four fixed stations were located in areas without commercial AC power, we had to supply our own power. These stations were powered by twin 60-watt Toshiba solar panels connected to a solar gauge/charger/converter system with deep cycle DC marine battery backup. The American River station utilized a nearby AC power source from a WDFW-owned cabin. This station was backed up with a deep cycle DC marine battery-converter system to ensure continuous operation in the event of an AC power failure. Each fixed station receiver, including its power charger, converter and battery system was housed in a watertight, camouflaged steel equipment box that was chained or bolted to the base of a large tree. Three-element Yagi antennas were used, either foldable for mobile operation (back-pack) or rigid pole-mounted antennas on trees (fixed station sites). Three antennas were mounted at each fixed station site and oriented in such a way as to monitor fish movement up or downstream. Data was downloaded at least once a week from fixed station receiver units directly onto a battery operated laptop computer (Figure 15). Each site was frequently tested during data downloads to ensure that the stations were detecting and recording signals emitted by the radio-tags.

We coordinated our radio-telemetry monitoring with other agencies (e.g., Yakama Nation and USBR) conducting steelhead and salmon radio-tracking projects. This was especially useful for extending our coverage of tagged bull trout movements into lower river areas where we did not have fixed station sites. The most useful of these stations was located in the lower Naches River at Cowiche Diversion Dam (RM 3.6). Although some bull trout over-wintered in the lower Naches River, only a few were radio-tracked beyond this point into the Yakima River.

A rigid, pole-mounted Yagi antennae mounted on a 4WD truck (Figure 12) was used for monitoring fish movement between fixed stations. During mobile tracking, the GPS coordinates of tagged fish were recorded along with a description of the physical habitat. Coordinates were later converted to a river mile location. By using fixed station and mobile (foot/backpack, truck & air) radio-tracking information, we were able to generate an in-depth understanding of each individual fish's movement patterns and timing.

Figure 12. Mobil radio-tracking along the Bumping River with truck-mounted three element Yagi antenna.

Figure 13. Flight tracking crew with Super Cub.

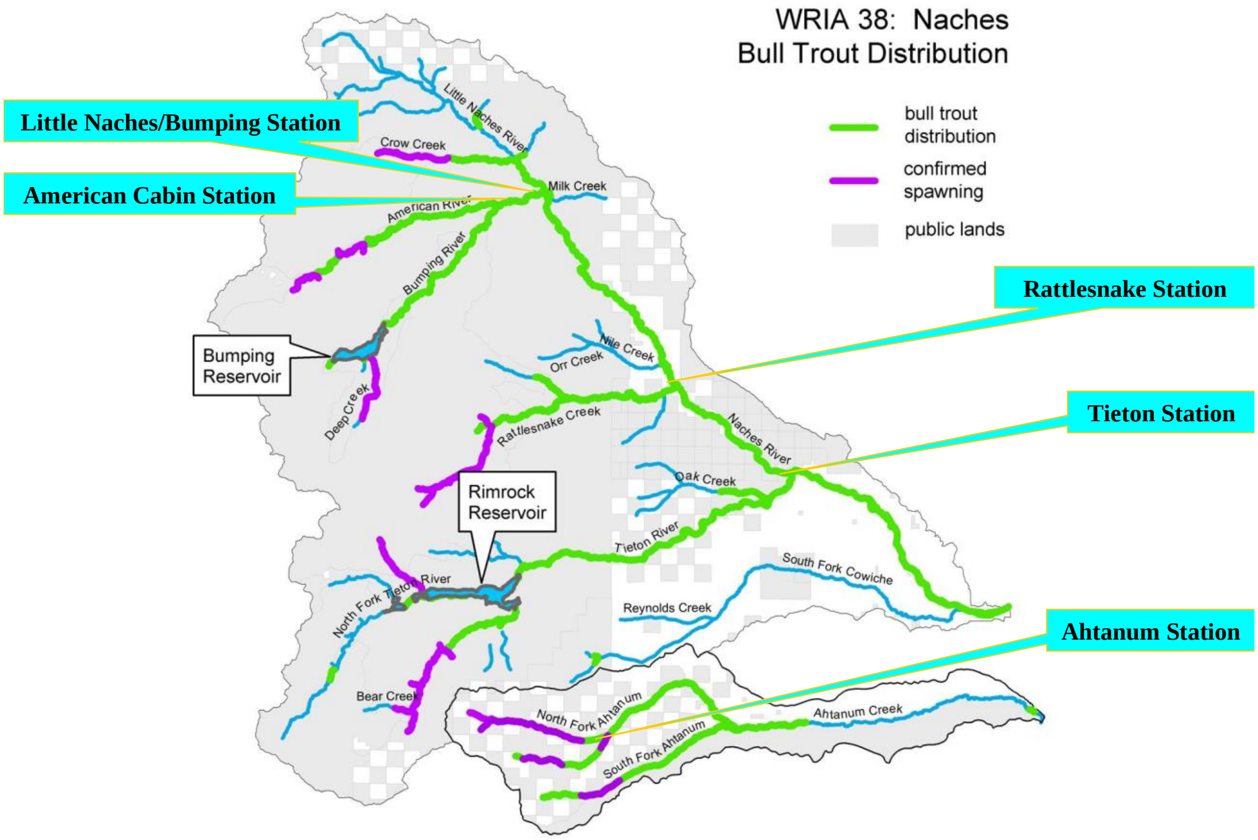

Figure 14. Radio-telemetry stations in the Naches River basin.


Figure 15. Downloading Tieton/Naches station, Tieton/Naches solar panel.

Snorkel Surveys

Snorkel surveys were occasionally conducted to pinpoint fish location, after determining general location by radio-tracking, especially if a tagged fish held position for a long period time (e.g., several weeks) without moving. These surveys were useful for verifying the status of tagged fish (alive or dead) and to retrieve a shed tag. When possible, we would retrieve radio-tags, unless they were buried in a logjam or in river gravels. Surveys were not always practical or safe, especially during periods of high flow and/or turbid conditions. Snorkel surveys were also conducted to locate bull trout for hook-and-line capture, habitat surveys and general presence/absence. Presence/absence surveys were usually conducted at night. Two or three surveyors would move upstream, in parallel where possible, covering the center and the banks, enumerating all fish encountered and estimating their size. If only one surveyor could move in a reach at a time, the second surveyor would move up the same reach 10 minutes later. Data was recorded onto wrist slates and transposed onto paper copy or immediately called to a bank side observer and record keeper.

Spawning Surveys

Bull trout spawning ground (redd count) survey procedures were adopted from Shepard and Graham (1983) and are consistent with those outlined by Brown (1992). Surveys were conducted in established index areas for each population, which allows for year-to-year comparisons and assessing long-term trends. Two or more preliminary surveys were conducted starting in late August to early September in the Naches/Ahtanum drainages and in late September in the upper Yakima subbasin (Keechelus and Kachess Lake areas). A final survey was conducted after most adults left the spawning area. Preliminary surveys provide trend information for the brood year, which is useful in case the final survey is cancelled or rendered ineffective due to inclement weather and/or high turbulent stream flow. Also, preliminary surveys are important for tracking the spawning progression, especially in those areas with a protracted spawning period (i.e., some redds at the start of the season may look old and even indistinguishable by the third survey). Hence, the value of tracking and marking redds throughout the spawning period. Spawn timing varies among some populations in the basin. Generally, final pass surveys are conducted in the Naches/Ahtanum drainage by late September to early October and in the upper Yakima by late October to early November.

Spawning surveys consist of enumerating “definite”, “probable” and “possible” redds, along with numbers of adult bull trout observed. The following redd identification criteria are used for every redd survey:

(1) “Definite”: No doubt about it. The area is definitely cleaned and a pit (excavated pocket) and tail spill are recognizable. Adult bull trout may still be attending the site. Not normally in an area scoured by stream hydraulics.

(2) “Probable”: An area cleaned that may possibly be due to stream hydraulics, but a pit and tail spill are recognizable, <u>or</u> an area that does not appear clean, but has a definite pit and tail spill (an “old” redd).

(3) “Possible”: A cleaned area of about the right size and appearance from a distance, but which does not have a definite pit or tail spill. This could be caused by stream hydraulics, by the tentative digging of spawners (false or test dig), or by wading anglers, etc.

For final reports and trend analysis, only definite and probable redds are included. Occasionally, large (up to 5 m x 10 m) multiple redds are encountered in the field where surveyors may find it difficult to determine the exact number of individual redds at the site. In such instances, each identifiable pit or pocket is counted as a separate redd. In such areas, definite and probable redds will also have overlapping tails pills.

During every survey, each new redd is flagged with the date, redd type, number of fish observed and the surveyor(s) initials. Bright fluorescent-colored surveyor’s flagging tape is usually used for this purpose. A foot long strip of flagging is tied to a nearby overhanging bush, tree limb, etc. All information is recorded in the surveyor’s field notebook and transferred to the biologist or manager responsible for summarizing the redd count data. This is done in a consistent survey format that includes the surveyors name, stream name, section, date, water temperature, start and end time, number of new & old (definite, probable & possible) redds, number of adult, sub-adult and juvenile bull trout observed and any other pertinent information the surveyor may observe during the survey (e.g. carcasses, genetic sample, water clarity, conditions, etc.).

At the end of every spawning season, the current year’s data is summarized and added to the annual summary table that includes redd count data for all previous years. The annual summary table is then distributed to various federal, state, tribal and local resource management authorities. Hard copies of all surveys for each year are stored at the WDFW Regional Office in Yakima. The data is copied and stored electronically as well.

Habitat Surveys

A primary objective was to document over-winter habitat, but we also conducted habitat surveys in other areas where bull trout spent long periods of time. This included evaluating temperature and stream flow as it relates to influencing fish movement patterns. Foot surveys along stream banks and snorkel surveys were used to verify primary habitat types (e.g., pool or riffle), secondary habitat types (e.g., scour pocket, edge pool) and cover types (e.g., woody debris, overhanging vegetation, rock/boulder formations, substrate composition, undercut banks, water depth and surface turbulence) and to identify temperature and/or stream flows that bull trout were using. We did not specifically measure spawning and over-wintering habitat to the degree of some studies (Nelson et al. 2004), but instead concentrated on characterizing the types of habitat that bull trout frequented. We used and incorporated existing stream survey and water quality data as much as possible (e.g., USFS stream habitat surveys, USBR flow data, and Washington Dept. of Ecology’s stream temperature data) (USDA-USFS 1992 – 2000; USBR 2005; WDOE, 2005). Available tools included our use of archival temperature tags (see previous section on Archival Tags), in-stream thermographs (data loggers), and Ecology’s FLIR (Forward Looking Infra-Red), and TIR (Thermal Infra-Red) flight data to collect temperature information. A standardized form was used to record habitat data. We recorded in-stream woody debris, substrate composition/size, and wetted stream reach according to the definitions in Table 2.

Table 2. Definitions used in recording in-stream woody debris, substrate composition and wetted reach.

Woody Debris Small – average diameter of 6” or less for its wetted width. Medium – average diameter of 6-12” for its wetted width. Large – average diameter greater than 12” for its wetted width.
Substrate Size Sand = 1-6 mm, Gravel = 7 mm - 5cm, Cobble = 5.1 cm - 40 cm, Boulder = 40.1cm and larger, Bedrock = solid rock bottom.
Wetted reach Cascade – a series of small waterfalls over rocks. Riffle – a section of thin, choppy water over sand, gravel or cobble. Pool – a deep pool, with a slow water input at the head (as defined by Webster, a deep place in a river or stream. We used the term “pool” for fish holding spots that were deep but open. Additional pool types are: Cutbank Pool – a pool formed by the erosion of an unstable bank (usually at the outside of a meander). Flowing Pool – a deep pool or hole usually with a fast water input at the head, and a turbulent surface. Glide Pool – a long, shallow pool with fairly laminar flow and a fairly consistent, uniform bottom. Impoundment Pool – a manmade pool for water accumulation or storage. Tail Out – a fast shallow riffle at the end of a pool or hole.

RESULTS

Radio-Tagged Bull Trout

A total of 96 fluvial bull trout were captured during the project and 71 were radio-tagged from September 2003 thru November 2005. Table 3 summarizes the number of fish captured and tagged at each location in the Naches and Ahtanum drainages. Sixty-two bull trout were radio-tagged in the Naches drainage and seven in the Ahtanum drainage. Only two fish were captured and tagged at locations outside of the Naches/Ahtanum area, one at the Roza Dam fish trap on the upper Yakima River and the other from the pool at the base of Kachess Dam on the Kachess River (upper Yakima drainage). These latter two fish were chance encounters, as few bull trout are found in the upper Yakima River mainstem or tributaries outside of the large reservoirs. Of the 62 bull trout radio-tagged in the Naches drainage, 29 were captured in various holding pools in the mainstem Naches River, 16 in the Tieton River below Rimrock Reservoir (Tieton Dam), seven in Rattlesnake Creek, three in the Bumping River, two in the American River and five in Union Creek (American River tributary). In the Ahtanum Creek drainage, four were caught in the North Fork and three in the Middle Fork.

Detailed information on radio-tagged fish including identification number (tag code), sex, length, weight, surgery (capture) location and the date of surgery is listed in **Appendix 1 - Summary of Radio-Tagged Bull Trout**. Generally, adult-sized fish in good condition were tagged, although a few of the smaller fish in the Naches drainage may have been sub-adults. The total length (TL) of the 29 fish (three males, four females, 22 unknown) tagged from the Naches River ranged from 350 to 650 mm (mean TL = 455 mm) and their weight ranged from 0.7 to 4.65 lbs (mean = 2.09 lbs). The TL of the 16 fish (four males, 11 females, one unknown) tagged from the Tieton River ranged from 370 to 570 mm (mean TL = 458 mm) and their weight ranged from 1.25 to 4.3 lbs (mean = 2.3 lbs). The TL of the seven fish (three males, four females) tagged from Rattlesnake Creek ranged from 480 to 600 mm (mean TL = 509 mm) and their weight ranged from 1.75 to 3.1 lbs (mean = 2.2 lbs). The TL of the three fish (all unknown sex) from the

Table 3. A summary of bull trout captured and radio-tagged in the Naches & Ahtanum drainages, 2003-2005.

Capture / Radio Tag Location (River Mile)	Total Number Captured	Total Number Radio-Tagged
Naches drainage		
Naches River - various pools (RM 27-43.5)	18	18
Naches River - pool below Wapatox Dam (RM 17)	13	11
Tieton River - pool below Tieton Dam (RM 21.2)	15	15
Tieton River - mainstem (RM 7)	1	1
Rattlesnake Creek - weir trap (RM 7.9)	14	7
Bumping River - pools below dam (RM 17)	5	3
Bumping River mainstem (RM 0.7)	1	0
American River - pool below Union Cr. (RM 11)	2	2
Union Creek - weir trap (RM 0.1)	5	5
Crow Creek - weir trap (RM 0.2)	1	0
Total	**75**	**62**
Ahtanum drainage		
N.F. Ahtanum Creek - weir trap (RM (17.8)	6	4
M.F. Ahtanum Creek – weir trap (RM 3)	13	3
Total	**19**	**7**
Upper Yakima River drainage		
* Yakima River - Roza Dam fish trap (RM 128)	1	1
* Kachess River – pool below dam (RM 1)	1	1
Total	**2**	**2**
Grand Total	**96**	**71**
*Captured outside of the Naches & Ahtanum drainage.		

Bumping River ranged from 395 to 435 mm (mean TL = 420 mm) and their weight ranged from 1.05 to 1.75 lbs (mean = 1.47 lbs). The TL of the two fish (both males) from the American River ranged from 490 to 575 mm (mean TL = 532 mm) and their weight ranged from 4.1 to 5.3 lbs (mean = 4.7 lbs). The TL of the five fish (four males, one female) from Union Creek ranged from 446 to 570 mm (mean = 514 mm) and their weight ranged from 1.75 to 3.5 lbs. (mean = 2.7 lbs). The TL of the seven fish (all unknown sex) from Ahtanum Creek ranged from 295 to 360 mm (mean TL = 325 mm) and their weight ranged from 0.6 to 0.8 lbs (mean = 0.72 lbs). Clearly, resident-type bull trout in the Ahtanum drainage were much smaller than migratory fluvial fish found in the Naches River tributaries.

Although, the incidence of shed tags in this study appeared to be low, it was difficult to determine if a recovered tag was shed, due to complications involving surgery, predation, natural mortality or a combination of factors. Due to the more extreme and variable conditions that tagged bull trout are subjected to after being released back into a stream environment, it seems likely that there would be a greater proportion of shed tags and a higher mortality factor for tagged bull trout in the wild than tagged rainbow trout in a hatchery. Certainly, post-spawned bull trout that were tagged during the project were in a weaker physical condition and hence more susceptible to stress, predation, etc. Although we found evidence of only six shed tags that we could directly attribute to our surgeries, we did find additional tags during the project, some of which appeared to be associated with natural (spawning) and/or predator induced mortalities that occurred months or year(s) after initial tagging (see **Appendix 2 – Daily Fish Tracking Radio Telemetry Data).** The six fish/tags that we attributed to surgical mortality were all from post-spawned fish that we had tagged and released early in the project. The tags and/or carcasses were found soon after tagging. Most of the radio-tagged bull trout, regardless of whether they were tagged as post-spawned fish or not, survived for tracking throughout a good portion of the project.

Radio-Tagged Hatchery Rainbow Trout -- Control Group

Before implanting radio-tags into bull trout we practiced surgical procedures by implanting tags into 32 hatchery-reared rainbow trout that were similar in body size to stream resident-type bull trout (TL 250-300 mm). This “control group” of rainbow trout was held at the WDFW Naches Hatchery for nine months (Sept 2003 to May 2004) for observation. The fish were monitored for surgical recovery, incision healing, mortality, shed tags and disease problems. Necropsies were performed on a few fish to assess the degree of healing around the incision area and to assess the fish’s general condition.

Although two fish shed their tags, there were no mortalities in the control group. Shed tags are not uncommon and have been observed by other researchers (Gilles et. al. 2004; Summerfelt and Mosier 1984; Chisholm and Hubert 1985; Marty and Summerfelt 1986; Baras and Westerloppe 1999; Jepsen et. al. 2002; Bridger and Booth 2003). The incision on one fish that shed its tag was healed, but all the other fish had an abrasion at one of the sutures where the tag was eventually expelled. The suture, although loose, was still present and appeared to have created a hole in the tissue where the loose suture was rubbing. Otherwise, both fish appeared to be in good health. Although the sutures are made of vicryl and are designed to be absorbed, they can persist for long periods of time in cold-water environments where the absorption time is slower. Although physiological changes and healing appear to be most significant during the first six weeks after surgery, shedding has been observed as late as seven months (Martinelli, et al. 1998; Jepsen et. al. 2002; Wagner et. al. 1999).

There were no disease problems noted in any of the “control group” of fish. Of the several necropsies that were conducted, we observed “keloidal encapsulation” of the tag (i.e., a tag totally encapsulated in tissue). Figure 16 shows a radio-tagged hatchery rainbow trout with a sutured incision. The incision is healing, but the suture material has produced some abrasion in the skin and body wall. As the abrasion continues, it causes a hole to enlarge in the body wall and potentially allows the tag to be shed from the fish’s body cavity (see Figure 17). Figure 18 shows a control fish with an unhealed scar from a recently shed tag. Although shed tags occurred in two of our control fish, it was not the norm. In most fish the incision healed within a few weeks and the suture material fell away without causing major damage. Figure 19 shows a radio-tagged fish with a healed incision where the scar is barely noticeable. The fish was completely healed within six weeks and appeared to be in excellent condition. The knowledge gained by practicing our tagging methods on hatchery rainbow trout and by monitoring those fish over time in the hatchery gave us confidence that are methods were sound and applicable for implanting radio tags into bull trout.

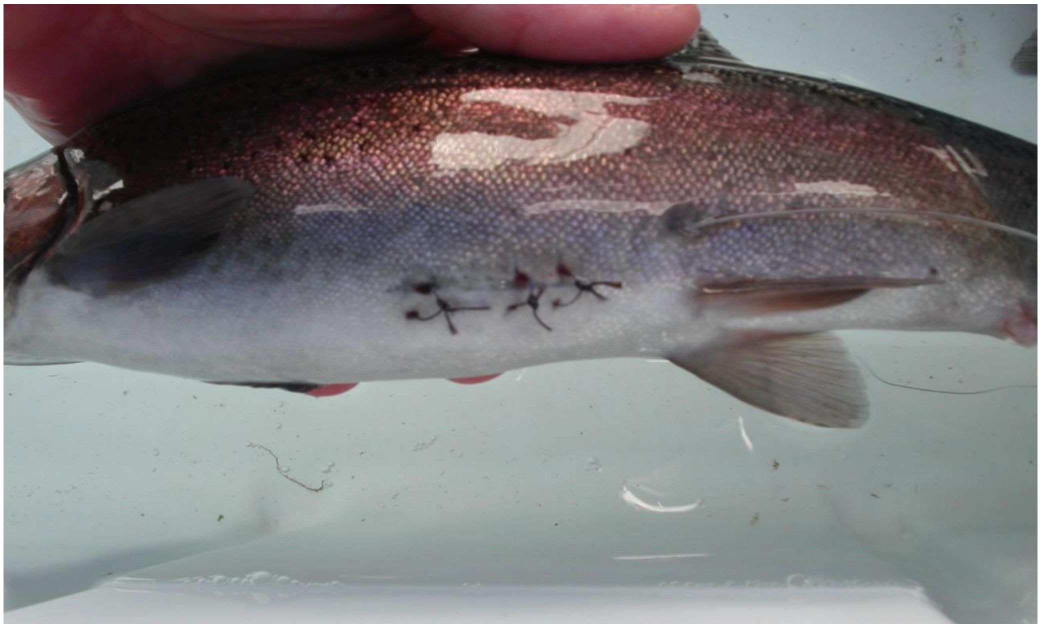

Figure 16. Radio-tagged rainbow trout from control group showing sutured incision area. Note antenna lead projecting from side of fish above ventral fins.

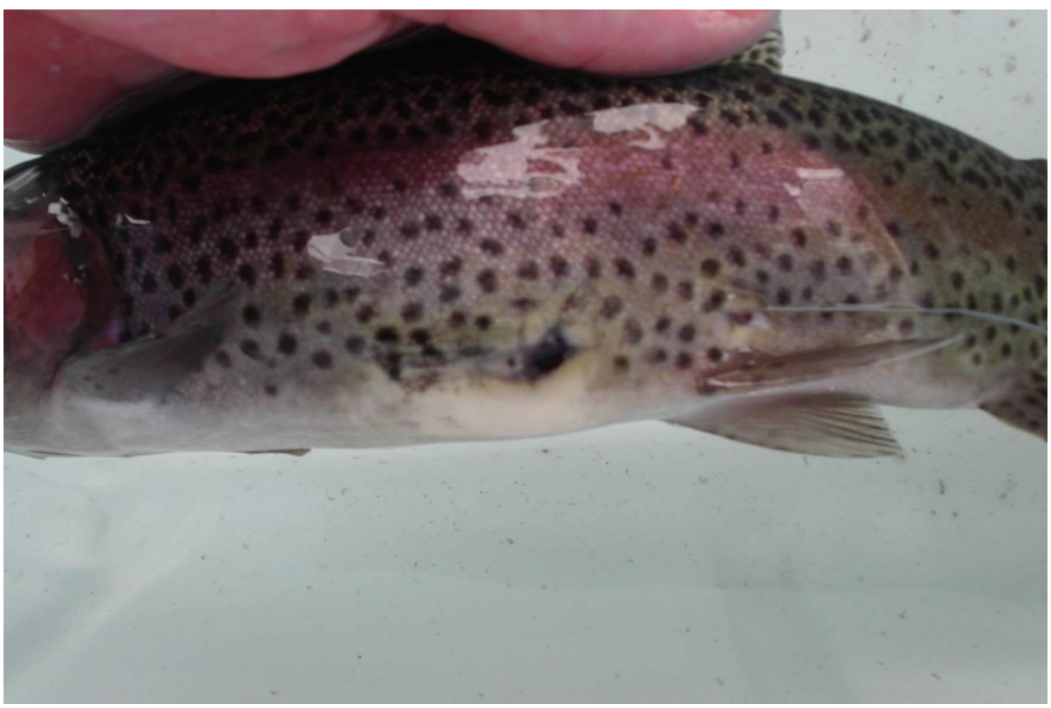

Figure 17. Rainbow trout from control group with tag beginning to extrude through suture hole created by abrasion of the sutures at the incision. Sutures have fallen away.

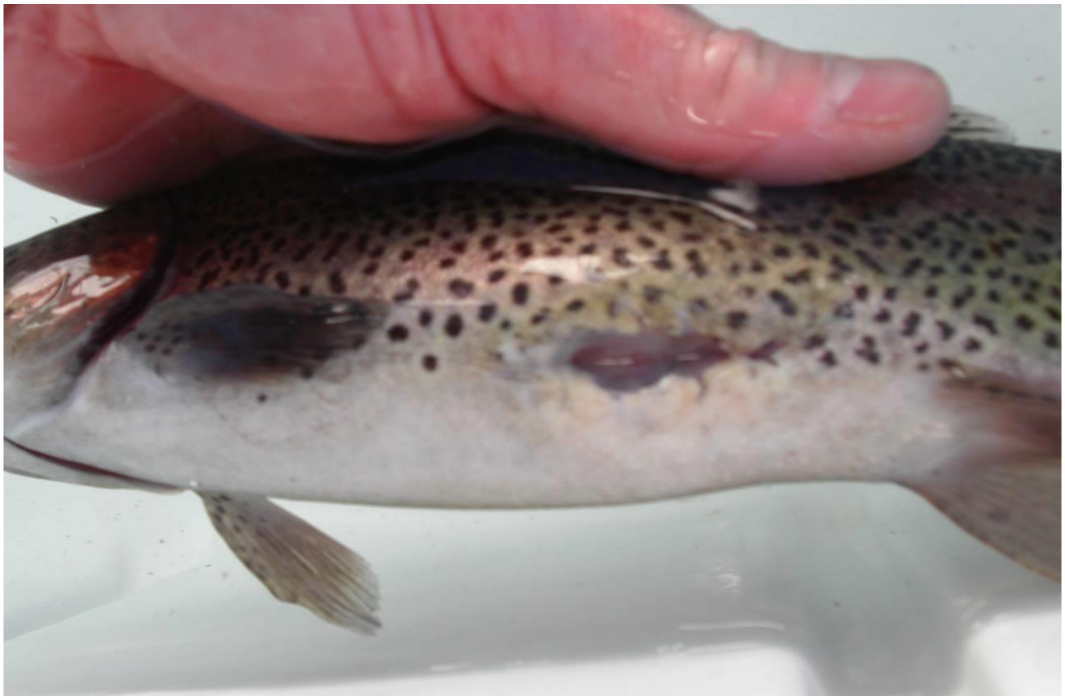

Figure 18. Rainbow trout from the control group with an unhealed scar from a recently shed tag. Fish was in good condition other than this healing wound.

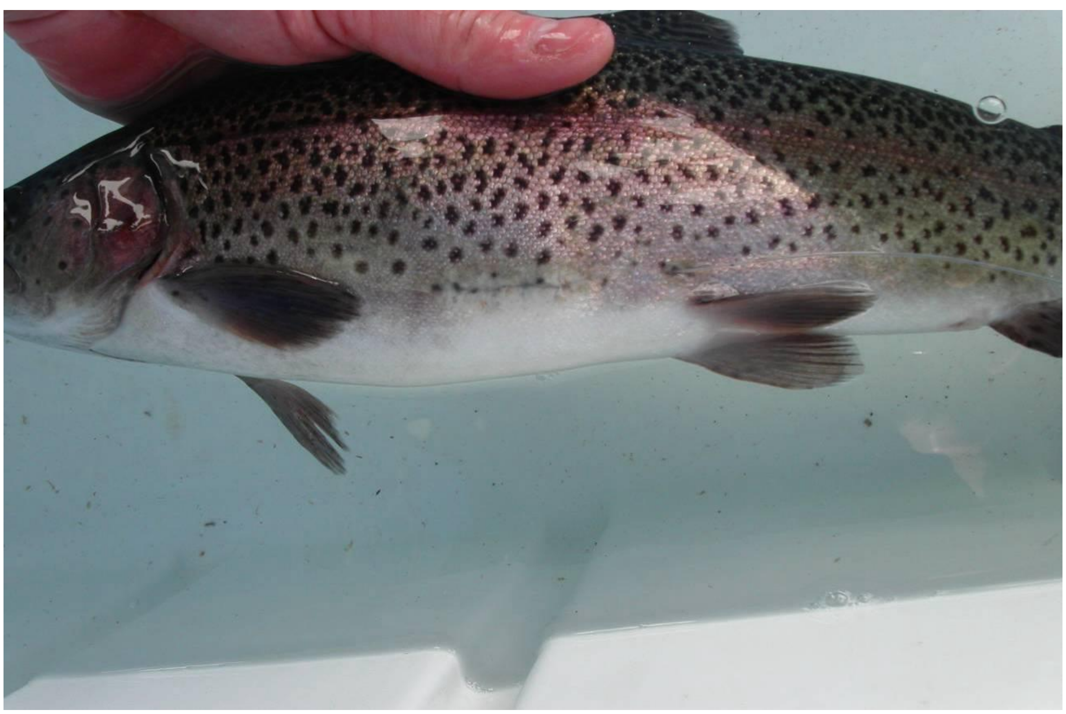

Figure 19. Radio-tagged rainbow trout from the control group with completely healed scar. Note the antenna lead projecting from the side of the fish above the ventral fins.

Fish Movement Patterns

Naches & Ahtanum Creek Drainages

This section addresses one of our primary objectives---to document the timing and spatial extent of migration and spawning activity of adult, fluvial and resident bull trout. We focused on determining the pre- and post-spawn movement patterns and the location of the spawning and over-wintering areas. We also evaluated bull trout movement and spawning as it relates to temperature and stream flow. Additional information on 24-hour movement patterns and fish growth is presented near the end of this section.

After initial tagging and release, most bull trout moved downstream for a distance of a few hundred yards to several miles, in a "pool-to-pool" type of movement behavior. Some fish would hold in an area for a period of a few weeks to a few months. This holding period was likely related to several factors including trauma associated with the surgery and subsequent healing, seasonal movement patterns, high flows, etc. Other studies have reported similar downstream movement and holding behavior (Mendel et. al., 2003). It is believed that radio-tagging does not adversely affect the fish's movement patterns (Koed and Thorstad, 2001) or gonadal development (Martin et. al. 1995). However, it does seem plausible that the combined side effects of deep anesthesia and surgery require a recovery and reorientation period that may vary for each fish. It also seems likely that there is more stress associated with tagging post-spawned bull trout, as opposed to fish tagged well before or well after the spawning period. We documented six mortalities early in the project that were probably the result of post-spawn/surgical stress. Most of the tagged, post-spawned bull trout eventually moved downstream to holding pools in the Naches River prior to the onset of winter.

Fish movement patterns were intensively monitored from September 2003 through December 2006 (see **Appendix 2 – Daily Fish Tracking Radio Telemetry Data).** Monitoring began with the capture and tagging of post-spawned bull trout from weir traps in Rattlesnake and Union Creeks during September 2003. Efforts were made to trap bull trout near the mouth of Crow Creek in the Little Naches drainage, but were unsuccessful despite several months of trap operation. This was likely due to the low abundance of bull trout in Crow Creek, as well as potential early pre-spawn and late post-spawn migration, which make it difficult to trap fish at the mouth. The more remote nature of Crow Creek also complicates collection efforts compared to other Naches River tributaries.

After initial efforts at trapping/tagging post-spawned bull trout from the smaller spawning tributaries (i.e., Union, Rattlesnake and Crow Creeks), we shifted to capturing fish using hook-and-line in the large, deep pools of the mainstem Naches River and in the larger tributary streams (e.g. Tieton R.). We continued to capture and tag bull trout in this manner throughout 2004 and 2005 in the Naches, Tieton, Bumping, and American Rivers and in the Ahtanum Creek drainage (see Table 3). Weir traps were also used to capture bull trout in the Ahtanum drainage. Radio-tracking commenced immediately after fish were tagged and released. Most tracking was conducted using mobile units (vehicle and foot), but aerial flight surveys were also conducted periodically.

Fixed station receiver monitoring sites were established in late 2003 and early 2004 to help keep track of tagged bull trout in mainstem and tributary streams (see Figure 14 and Methods - Radio Tracking). Records of fish tracked at fixed station receiver stations in 2004-2005 are listed in

Appendix 3 - Diel Movement of Bull Trout at Fixed Stations. The station recorded the fish's code number, and the date/time it passed. Fixed stations helped focus mobile tracking efforts more efficiently and provided information on diel movement patterns. As shown in the fixed station data in Appendix 3, most bull trout movement occurred during the low light periods of dawn, dusk and at night. We also verified low light/night movement patterns during mobile tracking. The term "multi-day" in the fixed station table (Appendix 3) was used when fish held in front of the station for an extended period of time. A more extensive radio-tracking record that includes both mobile and fixed station data for each fish is found in **Appendix 2 – Daily Fish Tracking Radio Telemetry Data.**

The Tieton, Rattlesnake and Bumping telemetry stations (Figure 14) were important for recording bull trout movement into or out of tributary streams and for recording the movement of tagged fish up and down the mainstem Naches River. The stations recorded early spring/ summer upstream movement of foraging and pre-spawn bull trout as well as recording downstream movement of over-wintering fish into the mainstem Naches River. The American River telemetry station, which was located the furthest upstream (i.e. highest in the basin), was important for recording the movement of adults to/from the spawning grounds in that river system. It reflects the timing for the American River, Union Creek and Kettle Creek spawning group. The 2005 American R. fixed station data was not recorded in full due to a power outage at the cabin where the telemetry station was located, but fish were tracked by mobile units (vehicle/foot) once a week, providing a clear picture of timing and movement. Pre-spawner movement at the American River station was fairly quick past the station, with no fish holding near the station for multiple days like other fixed stations. This may be because the station was located 0.4 miles upstream of the confluence with the Bumping River in an area with poor holding habitat (i.e., absence of deep pools). Other fixed stations were located at or very close to tributary confluences where fish were more likely to hold before migrating upstream. Generally, we noted upstream movement of pre-spawn fish in the lower to mid reaches of the Naches River beginning in late May to early July and downstream movement of post-spawners from October through December. Post-spawned fish settled into their over-winter locations in the mid to lower Naches River by December. We noted very little activity at the Ahtanum fixed station, which was located at the confluence of the Middle and North Forks. This was probably a result of both the low number of fish that were tagged in the Ahtanum drainage (only 7 fish), as well as the resident nature of the population.

We produced GIS-based ArcView maps of the drainage that showed monthly fish locations for each population or group of fish that were tagged from a particular stream (see **Appendix 4a-e – Maps with Monthly Population Track Locations for each Population, 2003-2005**). Tagged fish were also portrayed in two composite maps (2004 and 2005), which showed fish locations during the spawning period (Figure 20) and during the over-wintering period (Figure 21) in the Naches and Ahtanum drainages. The over-wintering area essentially comprised the entire mainstem Naches River, which serves as the primary **f**oraging, **m**igration and **o**verwintering (**FMO**) habitat for bull trout populations in the Naches drainage. Foraging and migration habitat extends upstream into the terminal spawning areas (tributary streams) as well. Figure 20 shows the spawning index areas (magenta color) in the Naches and Ahtanum drainages and the locations of 39 radio-tagged bull trout during the September spawning period in 2004 and 2005. Radio-tagged fish that were originally tagged in a spawning tributary in September 2003 (e.g., Union Creek, Rattlesnake Creek) or tagged in mainstem Naches River FMO habitat during the winter, and then subsequently tracked back to a spawning tributary in September of the following year, were given a unique color code for that population or stream. For example, blue and green represented the American River/Union Creek population; red was for the Rattlesnake population; purple was the Tieton River group; yellow and tan represented the Ahtanum population (North Fork & Middle Fork, respectively). Likewise, Figure 21 shows the locations of 34 radio-tagged bull trout during the over-wintering period (November–March) of 2004 and 2005, also color-coded by population or stream.

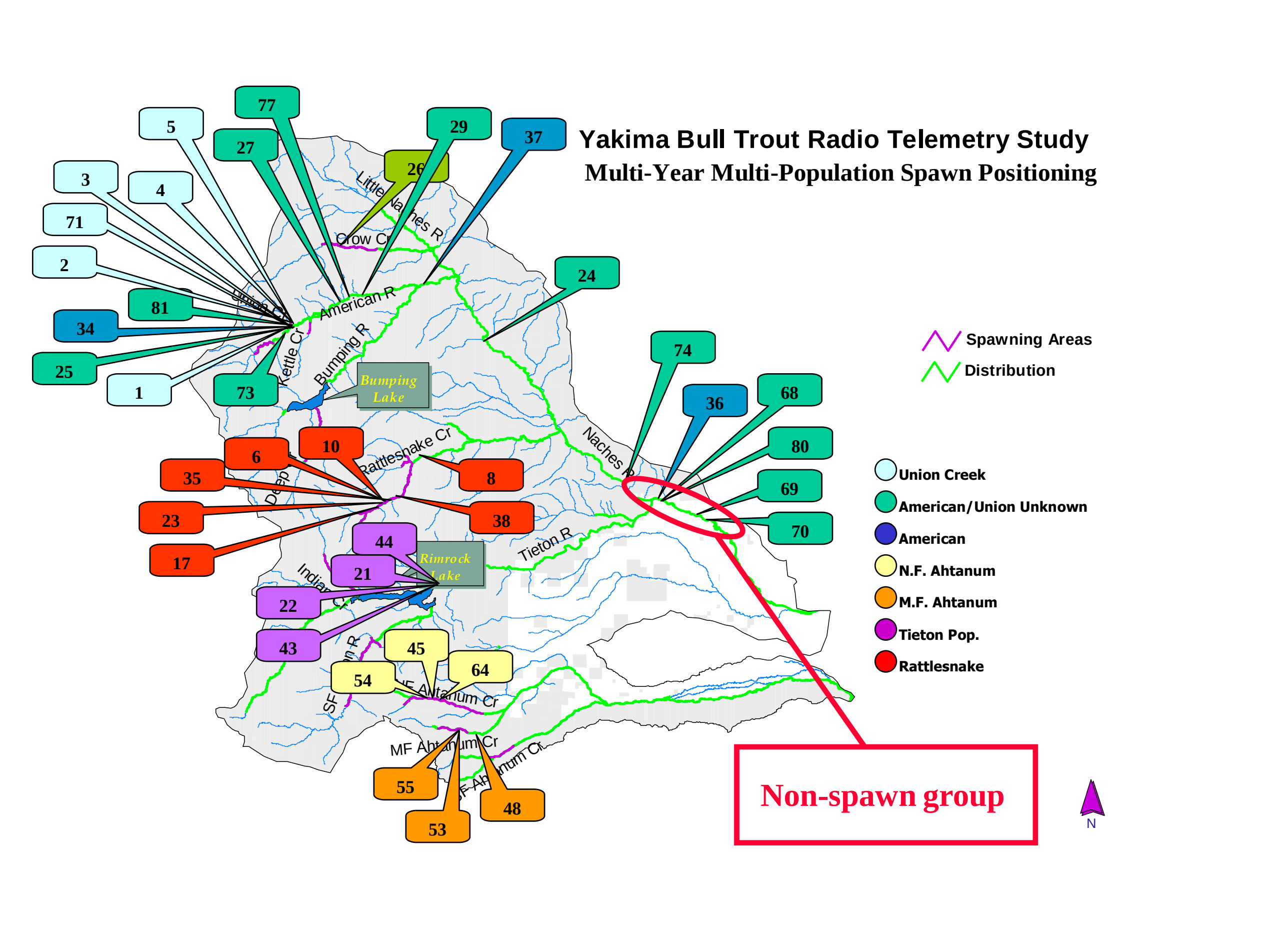

Figure 20. Locations of radio-tagged bull trout during the September spawning period in 2004 and 2005 in the Naches and Ahtanum drainages.

We used information derived from DNA tissue analysis to confirm population /stream assignments for radio-tagged fish (see **Appendix 7 – Genetics Sample Locations and Population Assignments; also noted in Appendix 2 – Daily Fish Tracking Radio Telemetry Data.** A detailed analysis of the genetics for bull trout populations in the Yakima basin can be found in the following reports: Hawkins and Von Bargen 2006, 2007; Small et. al. 2009. In both the Ahtanum and the Naches drainages, bull trout stayed true to their natal spawning areas. We did not observe any straying between populations or streams with the exception of a couple of adfluvial fish transported from the Tieton pool to the Naches River (will be discussed below). The four fish (fish #'s 21, 22, 43, and 44) that were initially radio-tagged in the Tieton River below the dam at Rimrock Reservoir stayed in the area near the dam. They did not spawn in the Tieton or migrate to an area outside the Tieton to spawn. Genetic analysis confirmed these fish

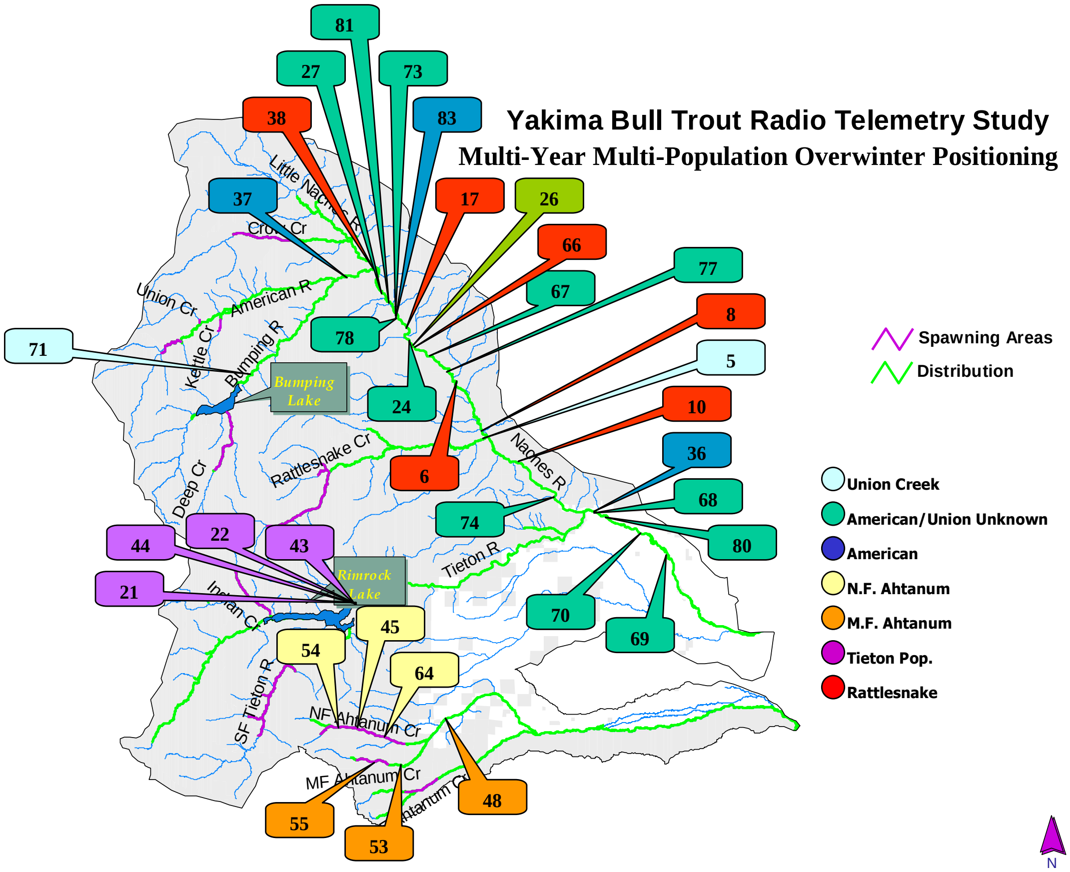

Figure 21. Locations of radio-tagged bull trout during the over-wintering period (Nov. – Mar.) in 2004 and 2005 in the Naches and Ahtanum drainages.

originated from adfluvial populations above the dam (3 from Indian Creek and 1 from S.F. Tieton River) and were obviously entrained past the dam and into the Tieton River during irrigation water releases. Since there are no fish passage facilities, these tagged fish could not return to the reservoir and remained in the large stilling pool at the base of Tieton Dam.

Another, larger group of bull trout (12 adults) were captured and radio-tagged from this pool in November 2005 (see Mizell and Anderson, 2008). They were transported downstream and released into the Naches River below the Wapatox Irrigation Diversion. Genetic analysis of these fish revealed a mixed population, with seven of them being from above the reservoir (Indian 4, N.F. Tieton 2, S.F. Tieton 1) and five were from Naches fluvial populations (Rattlesnake 3, American/Union 2). As expected, movement patterns for the transported group were a bit different than the four fish that were previously tagged and released in the Tieton Dam stilling pool. Of the transported fish; one of the adults was genetically assigned to the N.F. Tieton (Fish #110), but migrated to upper Rattlesnake Creek during the spawning period, while another fish genetically assigned to Indian Creek (Fish # 121), migrated to the upper American River during the spawning period. Whether these two adfluvial fish actually spawned with fluvial fish from a different population is unknown. However, the fact that these two fish made the journey to other spawning grounds is noteworthy. One of the transported adfluvial fish did migrate back to the Tieton Dam stilling pool for a period of time (Fish #119) and was genetically assigned to the S.F Tieton River population. Only one of the five fluvial fish that we transported migrated back to its natal stream during the spawning period (Fish #114 to the American River). The other eight fish stayed in the Naches River near the Wapatox Diversion or moved a short distance upstream or downstream. Within 8-10 months we had collected five of the radio-tags from these fish on the river bed. Whether the tags were naturally shed or the fish died from stress associated with the tag implant or other mortality factors is unknown. Additional details about the movements of these 12 Tieton Dam stilling pool fish were provided in an earlier report (Mizell and Anderson, 2008).

A more detailed discussion of individual population movement patterns are listed below. Refer to Figures 20 and 21 and for additional information see **Appendix 4a-e. Maps with Monthly Population Track Locations for each Population, 2003-2005**.

American River/Union Creek

The Union Creek portable weir-trap was operated to capture post-spawned bull trout from September 10-22, 2003. It was removed after surveys indicated that no more adult bull trout were observed in the spawning area. Five fish were captured and tagged; four males and one female. No other fish were caught at this trap. Two of the five were tracked back to the spawning grounds in subsequent years. Two others were mortalities or shed their radio-tags shortly after tagging and a fifth stayed in the Naches River and did not spawn. Genetic analysis of all five indicated they were all from the same American/Union Creek spawning population. During 2004 and 2005 there were 29 additional bull trout captured and tagged by winter angling in the mainstem Naches River. Genetic analysis revealed that 21 of these were from the American/Union Creek population group, seven were from the Rattlesnake group and one was from Crow Creek. Four of these were subsequently tracked back to Union Creek (out of a total of nine tagged fish from Union Creek) and three to the American River. DNA analysis revealed these fish originated from the American River system. Most of these fish were tracked back to the American River system to spawn, while a few did not spawn, but stayed in the mainstem Naches River. As is the case with other bull trout populations, adults do not spawn every year, but may exhibit alternate year spawning.

The American, Union, Kettle (A/U/K) group leaves the middle Naches River FMO habitat a little sooner (late May – early June) than the Rattlesnake group of fish, but moves slower upstream. After the A/U/K group moves upstream into the Bumping River (June and July) and the American River (July to early August), waiting time in pools becomes shorter. By mid to late August they are in their primary staging pools below Union and Kettle Creeks. Although we did not tag any fish from Kettle Creek, we observed a few bull trout holding in the American River below Kettle Cr. prior to the spawning period. The A/U/K group of pre-spawners leaves the holding (staging) pools in the American River as a fairly cohesive group in late August to enter the spawning grounds. Primary spawning occurs in early to mid-September.

Not all tagged fish from the A/U/K population spawned every year. Non-spawners that did not make the upstream spawning migration into the American River remained in the larger mainstem Naches River. James (2002) found that the percentage of fish that spawn on an annual basis in two other Yakima basin (Rimrock Lake) populations varied from 61.5% (S.F. Tieton River) to

77% (Indian Creek). The percentage of annual repeat spawners in Trestle Creek (tributary to Lake Pend Oreille, ID.) varied from 83 to 93% (Downs et.al. 2006). Both annual and alternate-year spawning occurs in other systems as well (Fraley and Shepard 1989, Pratt 1992), but studies quantifying the relative proportions are limited. Regardless of spawning frequency, by mid-September, most spawning in the American system is complete and post spawners move quickly downstream to larger pools in mainstem river areas of the American, Bumping and Naches rivers. They will continue to drop further downstream into the large pools of the Naches River as more severe winter conditions set in. A detailed month-to-month depiction of the movement for the A/U/K population group is provided in Appendix 4b and the daily radio tracking information for each fish is given in Appendix 2.

As shown in Figure 20, a large group of radio-tagged fish spawned in the upper American River/Union Creek area (blue & green tag #'s), which is a known spawning area. However, six tagged fish identified from the A/U/K population did not spawn in one or both years (fish #'s 36, 68, 69, 70, 74, 80), circled in red (Figure 20). These non-spawners stayed in the mid to lower Naches River. Four additional A/U/K fish (fish #'s 27, 29, 37, 77) were tracked into the American River approximately five-plus miles downstream of the known spawning area. A survey of the area did not show any spawning activity. It is quite possible that these fish moved further upstream, spawned with the others and left before we could record their presence on the spawning grounds. As spawning in the American River / Union Creek area occurs very quickly (7-14 days), fish could be easily missed. Fish #24, which was recorded in the Lost Creek Village area on the upper Naches River well below the spawning area, was likely a shed tag or mortality as we did not record any further movement from this tag number.

The American/Union/Kettle population generally over-winters from late October through March, becoming more active with the higher stream flows that occur during April and May. The Union/American fish also show a progressive outward movement from their over-wintering area, but unlike the Rattlesnake fish this movement is mostly upstream. They arrive at a medium sized pool below the confluence of the American River and Union Creek in late August, where a large portion of the population congregates to wait for spawning to begin. The Union Creek fish move into Union Creek as a fairly cohesive group in early September, while the American River spawners exhibit a more staggered upward movement into their spawning area. The Union Creek fish spawn quickly with the majority of the spawners moving out within 10 days to two weeks, and most spawning is finished by mid-September. The American River fish spawn in a much more spread out area and slowly migrate back downstream to their over-wintering areas.

Rattlesnake Creek

The Rattlesnake Creek portable weir-trap was setup to capture post-spawned bull trout from September 18 to October 28, 2003. The trap was located in the upper portion of the drainage above the N.F. Rattlesnake Creek, but well below the spawning area. The trap was removed when high water threatened its integrity. Seven bull trout were tagged at this trap, three males and four females. Seven more bull trout were captured and released, but not tagged due to their small size or poor condition. From 2004-05 there were seven more bull trout captured and tagged by angling in the mainstem Naches River that were subsequently tracked back to Rattlesnake Creek (six in 2004 and one in 2005) for a total of fourteen tagged fish from the Rattlesnake population.

The Rattlesnake population moves into the creek in late June and July, and is on or just below the spawning ground by mid-August, where they hold until September when they move onto the spawning ground (see red tag #'s, Figure 20). The Rattlesnake population tends to stay in the lower mainstem Naches River longer than the American/Union/Kettle (A/U/K) group, as they do not have as far to migrate before entering their natal tributary. Although we did not record any non-spawners in the Rattlesnake population, there were fewer tagged fish in this group compared to the American/Union population.

The Rattlesnake population over-winters in a comingled group consisting of the Rattlesnake, American River, and Union Creek fish (see Figure 21). The Rattlesnake population reaches their over-wintering area by the end of October and stays there until mid-April. During the over wintering period, the Rattlesnake fish tend to stay within a very short distance of their chosen habitat. They exhibited both nocturnal and daylight forage movements during close tracking and snorkel observation. The fish begin to move in and out of their over-winter territory to a greater extent by April and May, similar to other bull trout in the mainstem Naches River. This increased movement and activity coincides with increased flows from the melting snow pack.

The population moves from the Naches River into Rattlesnake Creek at the end of June (pre-spawn movement). Some fish will arrive near the spawning grounds by late July, but the bulk of the population arrives at or just below the spawning ground by mid-August, where they hold until spawning in early to mid-September (see Figure 20). Spawning generally lasts about 2 weeks after which they move slowly back downstream. By the end of October they are beginning to settle into their over-wintering areas (Figure 21). There have been several fish from this population that have not spawned consistently. Although alternate year spawning is common, some fish may not spawn for a couple of years. Monthly movement patterns for the Rattlesnake population is shown in Appendix 4a and daily radio tracking information for each fish is given in Appendix 2.

Tieton River

Two bull trout were captured and tagged by hook-and-line angling in the large stilling pool below Tieton Dam (Rimrock Reservoir) on October 29, 2003. Two more bull trout were caught and tagged during a May 10-11, 2004 survey. One fish was caught from the pool and one in the mainstem Tieton River. Additionally, twelve adult bull trout were captured and tagged from the Tieton Dam stilling pool on November 13-14, 2005 during a fish salvage effort that occurred prior to the installation of hydroelectric turbines in the dam. In total, 37 bull trout were salvaged and 12 were radio-tagged. All 37 fish were transported downstream and released into the Naches River below the Wapatox Irrigation Diversion (see earlier discussion, page 36; also see Mizell and Anderson, 2008).

The original four bull trout that were tagged in the Tieton River below Tieton Dam were monitored over the course of a couple years (purple tag #'s in Figure 20 and 21). With the exception of a few short and brief forays out of the pool into the mainstem Tieton River, none of these fish moved much throughout the study period (see Appendix 4e). As previously noted (page 35), genetic analysis confirmed these fish originated from adfluvial populations above the dam (3 from Indian Creek and 1 from S.F. Tieton River) and were obviously entrained through the dam outlet and into the Tieton River during irrigation water releases. As the fish could not migrate back upstream into the reservoir, they remained in the deep stilling pool which provides ideal foraging habitat for sub-adult and adult bull trout because thousands of small kokanee are entrained out of the reservoir each year. The quality of the habitat and abundant forage prey explains why the state record bull trout (22.5 lbs.) was caught by an angler in the Tieton Dam stilling pool in April 1961. Two of these tagged bull trout were captured during the fish salvage. Additional discussion about their size and growth will be provided later in the report (see section on condition and growth, fish tag #'s 21 and 22).

Crow Creek

A weir trap was placed in lower Crow Creek (a tributary of the Little Naches River) to capture bull trout from September 10 to October 28, 2003 and again during the same time period in 2004. Only one juvenile bull trout (25 cm) was caught. A DNA tissue sample was taken and the fish was released. The trap was removed both years due to high water and debris problems during the fall period. A hook-and-line angling and snorkel survey was conducted on July 20-21, 2005 in a remote area of upper Crow Creek in an effort to capture and tag adult bull trout. Although forty-two bull trout were observed, most were juvenile fish (90-150 mm) and too small to radio-tag. Three bull trout over 300 mm were observed, but could not be captured by hook-and-line or by snorkel and net.

One fish encountered, tagged and released in the Naches River in January 2004 was later found on the spawning ground in Crow Creek in September 2004 (Fish #26 (green tag), Fig. 20 and Fig. 21, see Appendix 4c). This fish was also genetically assigned to the Crow Creek population. Thus, there is some proof of movement from the Naches River to Crow Creek. Unfortunately, the adult population in Crow Creek appears to be quite small and we could not capture and tag any additional fish from this population.

Ahtanum Creek

Project focus shifted from the Naches basin to the Ahtanum Creek drainage in the late summer of 2004 with a goal of radio-tagging 15 fish, five from each fork (i.e., North, Middle & South Forks). As most adult spawners in the Ahtanum basin weigh less than 0.5 lbs., they required smaller tags (Lotek micro tags, NTC-6-2).

The first tagged fish from the N.F. Ahtanum (# 45) was captured by hook-and-line at Snow Cabin Campground on May 18, 2004. The fish subsequently disappeared, but was recaptured in a weir trap on July 19, 2004 in the same area. The original radio tag had failed, so we surgically removed and replaced it with a new tag and released the fish. The old surgery scar was clean and healed although there was some pitting where two of the sutures were still in the tissue. The scar tissue was tough and leathery and the tag was encapsulated in the tissue of the fish. As it became too difficult and time consuming to capture fish by hook-and-line, we set weir traps to capture and tag six more fish, three on the Middle Fork and three on the North Fork. No fish were captured in the South Fork Ahtanum. Tissue samples for DNA analysis were taken from 10 more bull trout that were captured in the Middle Fork and two more from the North Fork. In all, there were 19 bull trout captured in the Ahtanum drainage; 13 on the North Fork and six on the Middle Fork. Only one fish (#48) moved downstream past the Ahtanum Creek fixed telemetry station site at the junction of the N.F. and M.F on the night of October 9, 2004.

All the Ahtanum basin fish were smaller "resident" fish which do not migrate the longer distances typical of the larger river "fluvial" life history. The Ahtanum radio-tagged fish mostly stayed near their natal spawning areas year-round, although one fish tagged in the M. F. moved downstream below the confluence with the N. F. during the winter (see Fig. 20 and Fig. 21, tan & brown tag #'s). During spawning surveys in the Ahtanum basin in the fall of 2004, a larger 17-18" (1.75-2 lbs.) bull trout was observed with a smaller 11" male bull trout in Shellneck Cr. approximately 50 feet above the Shellneck Creek /N.F. Ahtanum confluence. This fish was larger than any bull trout observed in the Ahtanum basin during any previous spawner surveys. We believe this fish may have been one of the larger fluvial fish from the Naches system that moved into the Ahtanum basin. Improvement in stream flows in the lower Ahtanum Cr. during the summer has occurred and this may have allowed this potential stray to migrate onto the Ahtanum spawning grounds.

Radio-tagged fish in both the Middle and North Forks began to move out of the spawning area in November, but movement was minor compared to other fish in the basin. Fish # 48 from the Middle Fork moved to an area just below the North/Middle Fork confluence where it stayed for about two months, never moving more than about 300 yards. It finally moved about 2 miles further downstream in February 2005. It remained in the new location until early to mid-April at which time a heavy rain, high flow event triggered upstream movement. This fish was the only tagged fish to ever move below the North/Middle Fork confluence. Two of the tagged fish, one from each fork moved down to the lower end of their respective spawning areas, but moved no further downstream. Two tags lost battery power in early June 2005, with the remaining four turning off at the end of June 2005. Additional efforts to capture and tag more bull trout, particularly in the S.F. Ahtanum, were unsuccessful because of very low abundance of adult spawners. The fixed tracking station was subsequently pulled on July 12th, 2005. A month-by-month movement history for all tagged fish can be found in Appendix 4d.

Upper Yakima River

Only two bull trout were captured and radio-tagged in the upper Yakima River drainage outside of the Naches basin. One fish was captured and tagged at the fish ladder trap at Roza Dam in May 2004 and the other fish was caught by hook-and-line from the large stilling pool below Kachess Dam on February 1, 2005. Despite repeated attempts to capture additional fish by angling in the upper Yakima River, no bull trout were encountered. There appears to be few bull trout in the upper Yakima system relative to the size of the drainage, hence we decided to concentrate our efforts on capturing and tagging bull trout in the Naches and Ahtanum drainages.

The tagged fish (Fish #46) from Roza Dam was not found during mobile (ground based and aerial) tracking efforts despite repeated attempts to locate the fish. It is possible an angler caught the fish and/or the tag malfunctioned. The area does experience heavy fishing pressure and tags do occasionally fail. DNA tissue analysis revealed that the fish originated from the Tieton group of fish (i.e., genetically assigned to Indian Creek). This fish had been entrained through Tieton Dam and then moved downstream in the Tieton and Naches Rivers and then moved up the Yakima River where it was captured in the trap at Roza Dam.

The Kachess R. fish (Fish #75) was a gravid female with a large egg skein still intact. This fish was genetically assigned to the Gold Creek spawning population that resides in Keechelus Reservoir. It was entrained through Keechelus Dam, moved downstream into Easton Lake and then migrated upstream in the lower Kachess R. to the stilling pool at the base of Kachess Dam where we captured and tagged it. We did not record any subsequent movement of this fish and believe it may have shed the tag or died. The tag was never recovered.

Fish Movement Patterns during 24- Hour Monitoring Period

The movement patterns of five adult bull trout were monitored over a 24-hour period on April 5th and 6th, 2006. This was conducted to determine the primary movement or activity period (e.g., night vs. day, etc.). Table 4 shows where and when these fish were originally tagged, their assigned population, and the location where they were "reacquired" for 24-hour tracking purposes. All five were captured, tagged and located in the Naches River.

Fish #81 was originally tagged below the Wapatox Diversion Dam (RM 17) on 4/19/05 and was reacquired for 24-hour monitoring at the Lost Creek Bridge (RM 38.7) on 4/5/06. This fish had been previously tracked to the American River/Union Creek spawning area and was genetically assigned to that population.

Fish #78 was originally tagged at the USFS Chinook Pass Work Center Pool (RM 36) on 4/19/05 and was reacquired for 24-hour monitoring at the same location on 4/5/06. This fish had also been previously tracked to the American River/Union Creek spawning area and was genetically assigned to that population.

Fish #82 was originally tagged below Wapatox Diversion Dam (RM 17) on 4/19/05 and was reacquired for 24-hour monitoring at the USFS Chinook Pass Work Center Pool (RM 36) on 4/5/06. Radio-tracking and genetic stock identification assigned this fish to the Rattlesnake Creek population.

Fish #67 was originally tagged at the Jefferson Pool (RM 37.5) on 12/9/04 and was reacquired for 24-hour monitoring at the Red Bridge Pool (RM 24) on 4/5/06. Radio-tracking and genetic stock identification assigned this fish to the American River/Union Creek population.

Fish#73 was originally tagged at the Pine Cliffs Pool (RM 35.7) on 12/9/04 and was reacquired for 24-hour monitoring at the same location on 4/5/06. Radio-tracking and genetic stock identification assigned this fish to the American River/Union Creek population.

Table 4. Tagged bull trout monitored for 24-hour period.

Fish #	Originally Tagged	Reacquired 24 hours	Population
81	Wapatox Diversion Dam on 4/19/05	Lost Creek Bridge	American/Union
78	Work Center Pool on 4/19/05	Work Center Pool	American/Union
82	Wapatox Diversion Dam on 4/19/05	Work Center Pool	Rattlesnake
67	Jefferson Pool on 12/9/04	Red Bridge Pool	American/Union
73	Pine Cliffs Pool on 1/13/05	Pine Cliffs Pool	American/Union

Twenty-four hour monitoring began on 4/5/06 at 0600 and was completed on 4/6/06 at 0600. Hourly tracking was accomplished by using mobile Lotek receivers, handheld Yagi antennas and Garmin GPS units (see Methods Section). We also found it useful to note fish locations in the field by hanging distinctively colored ribbons on the bank next to the fish. This facilitated acquisition time during hourly passes and allowed us to more efficiently keep track of individual fish, especially if they did not move very far between tracks. We used the "signal strength" meter on the Lotek receiver unit and manipulated the gain to provide tracking resolution down to a few feet. GPS resolution was generally within 15 feet.

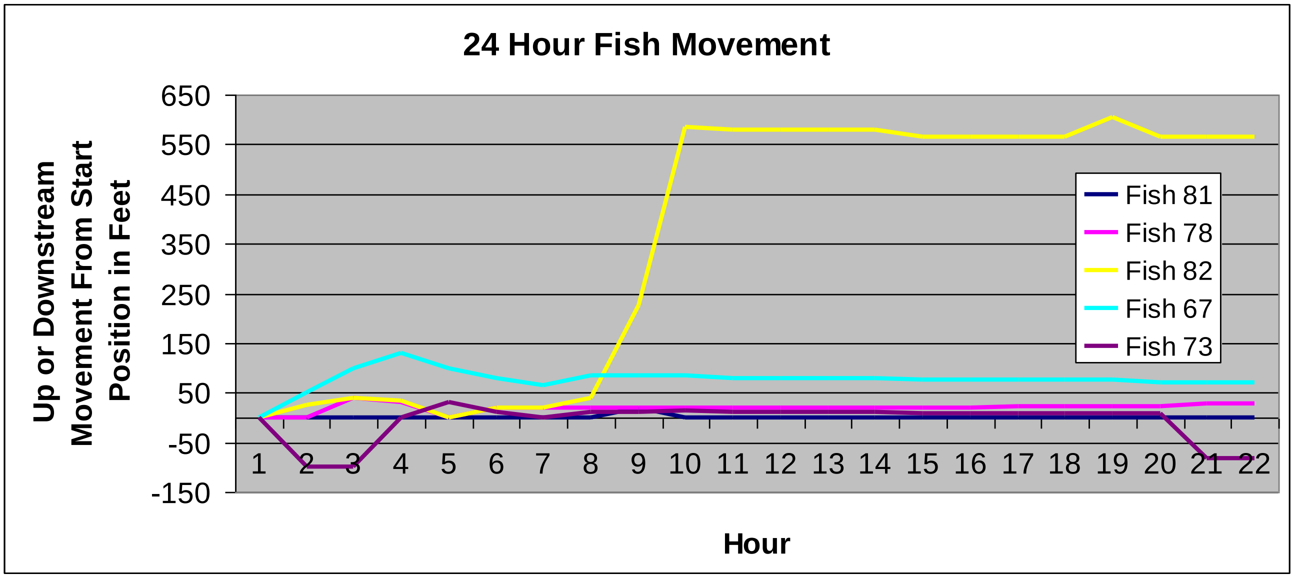

Figure 22. Distance of fish movement during 24-hour radio tracking session.

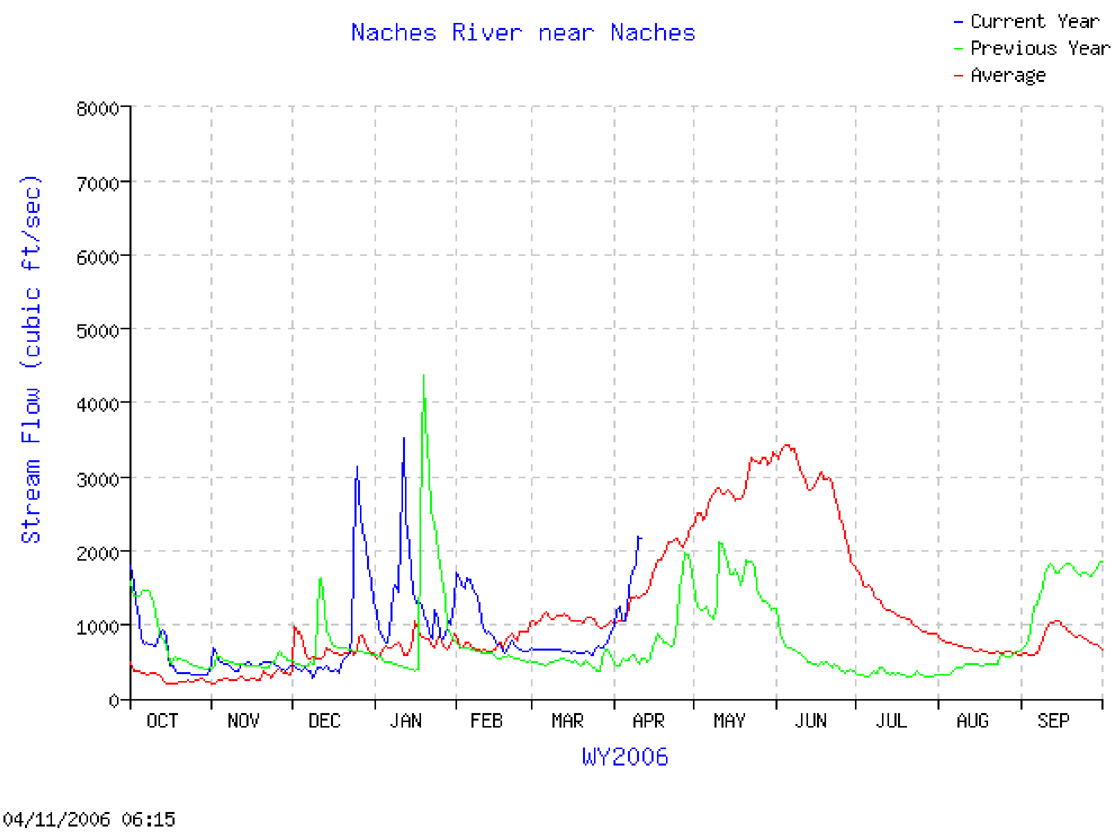

Figure 23. Naches River flows at the town of Naches (red = 10 year avg., green = 2005, blue = 2006 up to 24-hour radio-tracking session in early April).

With the exception of one fish (#82), the other four tagged fish exhibited short movements (generally less than 50 feet) up and downstream (Figure 22). Fish #82 made an upstream movement of over 550 feet in 2 hours starting at 1400 hours on 4/5/06. Fish #82 was from the Rattlesnake population, the other four were from the American/Union population. Ironically, even during normal tracking sessions, we noted that other fish from the Rattlesnake population seemed to exhibit a more frenetic movement pattern than fish from the American/Union Creek population. Tagged fish from the American/Union population seemed more lethargic in their movements. Also notable is that Fish #82 was upstream of Rattlesnake Creek, it's natal stream, by seven miles, whereas the four American/Union fish were downstream of their natal stream approximately 6 to 9 miles.

During our regular tracking sessions, we found other radio-tagged fish from both populations occupying similar reaches of the Naches River in close proximity to each other. Generally, early April is the period when increasing flows begin in the Naches River. As Figure 23 shows, Naches R. flow measured 21 miles downstream of our 24-hour monitoring site was beginning to increase during this time period, and we noted a slight increase in flow between 1050-1150 hours in the area where we were monitoring the five bull trout. However, it seems unlikely that this slight increase would have triggered the movement of one fish (#82) and not the others. We conclude that it is difficult to discern major movement patterns during short duration (i.e., 24 hour) monitoring periods and it is more realistic to look at longer blocks of time (days or weeks) for depicting variables that trigger major fish movements, especially before, during and after peak flow events.

General Condition and Growth of Recaptured Radio-Tagged Bull Trout

There were few opportunities to assess the condition or growth of bull trout after initial tagging and release, however we did recapture a few during hook-and-line surveys in the winter of 2004 and during a fish salvage operation below Tieton Dam in the fall of 2005. Since most fish were recaptured within 30 days of initial tagging, we could not make an assessment of growth within that short time frame. However, we were able to document the general physical condition of some of our tagged fish shortly after release.

Fish #24 (Figure 24) was recaptured on Feb 24, 2004 on a spinner in the Upper Jefferson Pool on the upper Naches River. This fish was originally tagged on January 22, 2004 near the same location. It was caught at the tail out of the pool along with a slightly larger bull trout, both of which hit the lure on the first cast to a specific area. Fish #24's aggressiveness and the location within the pool suggest both fish were actively feeding. The fish appeared to be in good condition with no signs of infection or parasites. All four stitches were still tight and were not pitting / eroding or cutting out of the abdominal wall as was the case with some of our rainbow trout in the control (training) group held at the Naches Hatchery. We attribute this to several factors: the bull trout's tougher skin, the fish's natural setting instead of a concrete raceway and the surgeons' growing experience. While on the line, the fish fought for over a minute with no signs that the antenna lead was hampering it in any way. The antenna lead could be seen from 5-7 yards away, thus the fish was quickly recognized as a tagged bull trout. There was no noticeable size difference in the fish between the initial capture and the recapture date 32 days later. The fish (female) weighed 2.85 lbs and was 485 mm in total length.

Figure 24. Fish # 24 recaptured 32 days after initial radio-tag implant.

Figure 25. Fish # 34 recaptured 21 days after initial radio-tag implant.

Fish #28 was recaptured on March 3, 2004 fifty yards below the Wapatox Diversion Dam on the Naches River. This fish was originally tagged near the same location on February 4, 2004. The fish was caught on a spoon. It fought vigorously for several minutes. Upon inspection the incision was healing well, although a slight “pucker” was evident between two of the sutures. The stitches were tight and there was no evidence of abrading or pitting. The fish appeared to be in very good to excellent overall health. There was no noticeable size difference in the fish between the initial capture and the recapture date 27 days later. The fish (unknown sex) weighed 2.65 lbs and was 480 mm in total length.

On March 17, 2004 Fish # 34 (Figure 25) was recaptured at the upper Jefferson Pool where it was originally captured and tagged on February 24, 2004. The surgical incision on this fish looked good and appeared to be healing well. The fish fought vigorously and was in the active feeding zone at the pool tail out. The vet bond applied to the surgical incision/stitches was still present 21 days after the initial surgery. Like the other fish recaptured within 30 days of its initial capture and surgical tag implant, there was no noticeable difference in the fish’s original size. The fish (sex unknown) weighed 2.5 lbs. and was 500 mm in total length.

Fish #36 (Figure 26) was originally caught on March 3, 2004 and was recaptured on March 15, 2004 in the same area below Wapatox Diversion Dam. There was no noticeable change in the fish’s size between the time it was originally captured and its recapture date. The fish (female) weighed 2.45 lbs. and was 470 mm in total length. Notice the similar scarring and bruising as the other fish in Figures 24 and 25. This surgical bruising was observed in all recaptured fish during this 30-day period, but all were active and fought vigorously when hooked. Most of the recaptured fish were caught during the late winter period of February March 2004 because we were primarily focused on capturing and tagging fish in winter holding pools.

Two additional radio-tagged bull trout were recaptured during a fish salvage operation in the pool at the base of Tieton Dam in mid-November 2005. The pool was drawn down to facilitate the installation of a hydroelectric generator in the dam. During the salvage operation, a total of 37 adult bull trout were salvaged along with thousands of small (4-9 inch) kokanee and rainbow trout. Two of the 37 bull trout had been radio-tagged two years previously. Although both radio tags were inoperable at the time of the recaptures, we were able to determine, through the process of elimination the tag numbers for both fish since there were only a total of four fish that were tagged in the Tieton Dam stilling pool. Neither fish had been tracked outside of the pool during the previous two years. The tag in fish #22 had turned off two months earlier due to a dead battery and the antennae lead in this fish had created a series of calloused abrasions along the fish’s side, mostly at the hole for the antenna lead (Figure 27); otherwise the fish was in very good condition. The abrasions were healed and did not appear to affect the fish.

The other fish (#21) also appeared to be in very good condition. A photo of this fish at initial tagging (Oct. 2003) is shown in Figure 28 and at recapture two years later (Nov. 2005) in Figure 29. This fish had shed its tag, but still retained some of its surgical tag scars. Although the tag was gone and we could not confirm the fish’s movement patterns between the time it had shed the tag and its recapture; we believe this fish had not left the area below the dam since it was originally tagged. Fish # 21 weighed 1.75 lbs. and Fish # 22 weighed 2.0 lbs. at the time of their original capture. Two years later they weighed 6 pounds each; an average growth rate of over 2 pounds per year. We attributed this rapid growth to the abundant forage fish in the pool, most of which were entrained from Rimrock Reservoir. The thousands of kokanee and rainbow trout that were salvaged from the pool is evidence that food is certainly abundant enough to grow

Figure 26. Fish # 36 recaptured 12 days after initial radio-tag implant.

Figure 27. Tag antenna abrasion on fish #22, from Tieton Dam stilling pool.

Figure 28. Fish #21 (1.75 lbs) captured from the Tieton pool, 10/29/03.

Figure 29. Fish #21 (6.1 lbs) recaptured from the Tieton Pool, 11/14/05.

these fish to a large size (e.g. state record bull trout, 22.5 lbs. caught in 1961), but reproductively they appear to be isolated, as they cannot move upstream to their natal spawning tributaries because Tieton Dam lacks upstream fish passage facilities. The abundant food supply and perhaps the instinct to stay near their natal waters (i.e., Rimrock Reservoir) reduced the urge to migrate elsewhere.

Bull Trout Habitat -- Naches River & Ahtanum Creek Drainages

This section addresses our second primary objective; to evaluate the habitats used by tagged and untagged bull trout. After radio-tracking tagged fish to various stream reaches, we focused on determining the general habitat types (see methods for definitions), stream flows and temperatures in those areas where bull trout spent lengthy periods of time (e.g., overwintering pools). We conducted snorkel surveys in primary holding areas to verify bull trout use by both tagged and untagged fish. Where possible we used existing stream survey and water quality data (e.g., USFS stream habitat surveys, USBR flow data, and Washington Dept. of Ecology's stream temperature data) to show the types of habitat and environmental conditions where we found bull trout (see Methods – Habitat Surveys, page 27.)

Bull trout were found using a variety of habitats in the Naches and Ahtanum drainages. We divided this habitat into three primary areas. The first was over-wintering habitat, which consisted of a series of large pools in the mainstem Naches River. Fluvial bull trout from several tributary populations over-wintered in these pools, which included adults from Rattlesnake Creek, American River, and Crow Creek. We also found bull trout that were entrained out of Rimrock Reservoir that over-wintered in the large pool at the base of Tieton Dam (Tieton River). We also found adult bull trout in two large pools at the base of Bumping Dam. The resident bull trout found in the Ahtanum Creek drainage (i.e., mainstem, N., M., & S. Forks) stayed year-round in their respective natal streams.

The second major habitat type was transitional (pre-spawn) habitat. Generally, these were shorter duration holding areas (smaller pools, runs) located between spawning and wintering habitat. Most transitional habitat was upstream of the overwintering areas, usually in tributary streams, but downstream of the spawning grounds. Over-wintering areas in the upper Naches River, near the confluence of the Bumping and American Rivers was also used as a transitional area, especially for adult bull trout migrating from lower river pools. Together, the over-wintering and transitional areas that we describe in the following sections comprise the bull trout foraging, migration and over-wintering (FMO) habitat. Also included in this section are water temperature data for the Naches R. and water velocity measurements in some bull trout holding pools.

The third major habitat type was spawning habitat. Adult bull trout occupied spawning areas the least amount of time (roughly 2-3 weeks or less) compared to the other two habitat types. Although adults may spend little time on the spawning grounds, the eggs and developing embryos stay in the gravel for approximately six months after being deposited. Juvenile bull trout will continue to rear in the area before gradually moving downstream to rear.

Over-Wintering (Pool) Habitat in the Naches River

Adult bull trout spent lengthy periods of time in their over-wintering habitat, generally moving very little after "settling-in" for the winter. This over-winter period ranged from November thru March. However, adult bull trout were often found in these same pools or moving between pools throughout the spring/summer period as well. The prime locations consisted of a series of large pools in the mid to upper Naches River from the Wapatox Irrigation Diversion (RM 17.1) upstream to pool #6 (R.M. 40.5) (see Table 5 below & Appendix 7 for most pool locations listed with GPS coordinates). Some adult bull trout were found during the winter in the lower Naches and lower Bumping Rivers, but most over-wintered in the mid to upper Naches R. Highways 12 and 410 run parallel to the Naches R. and there are a number of spur roads/bridges that cross the river. Land ownership is a mix of federal, state, county and private, with much of the upper Naches watershed dominated by U.S. Forest Service lands. There is good riparian cover along much of the Naches R., but there are also many developed areas with rip-rapped banks along bridge and highway abutments. Many of the over-wintering pools were created by channel down-cutting adjacent to basalt cliffs and bedrock out-croppings. Below the intersection of State Route 410 and U.S. Hwy.12, the cliffs move away from the river channel and are replaced by a larger, wider floodplain with increased development in the form of orchards, pastures, and private residences. In this lower section, the river skirts the Town of Naches and runs along the north-west edge of the City of Yakima to where it joins with the Yakima River near Selah Gap. Several major irrigation diversions exist in the lower reach.

Table 5. Major over-wintering pools in the Naches River.

Pools From Upstream to Downstream	**River Mile**
Over-winter Pool# 6	40.5
Upper Jefferson Pool	39.5
Lower Jefferson Pool	39.0
Chinook Pass Work Center Pool	36.0
Pine Cliffs Pool	35.2
Upper "S" Curve Pool	34.5
Upper Nile Bridge Pool	29.0
Rattlesnake Confluence Pool	27.8
Blue Nile Church Pool	26.5
Lower Nile Bridge Pool	24.0
Over-winter Pool# 4	22.2
Cougar Canyon Pool	21.7
Wapatox Diversion Pool	17.1

Generally, most over-wintering pools varied between 1-3 meters deep, and contained a mix of cobble, large boulders and/or basalt shelves that provided cover either directly or by creating surface opacity through flow deflection. Bull trout seemed to prefer certain sections of pools as well. We analyzed factors influencing pool choice by directly observing bull trout in pools (snorkel surveys) and we measured flows across the pools in areas where we observed bull trout holding. Adults often used depth and turbulence (i.e. surface opacity) as the main source of cover, especially in areas with a lack of other nearby cover (log jams, large boulders, undercut banks, etc.).

Substrate composition in the over-wintering pools varied quite a bit from pool to pool, but most contained a high percentage of cobbles, with a mix of gravel and sand (Figure 30). Boulders were also present, but were not a dominant feature and there was very little bedrock. A more detailed description of each pool is discussed in the following section beginning with the most upstream pool and working downstream.

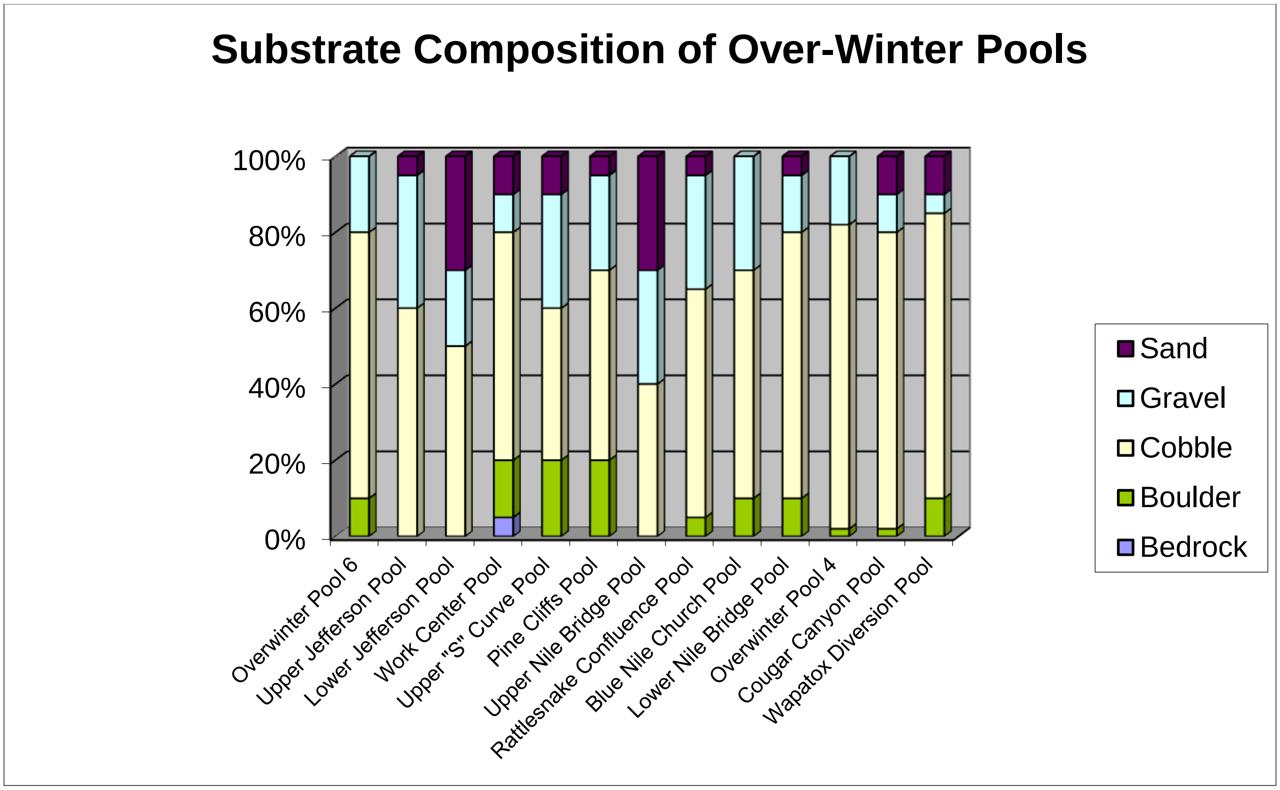

Figure 30. Substrate composition of bull trout over-winter pools in the Naches River.

<u>Over-winter Pool #6</u> -- Naches R.M. 40.5 (see Figure 31)

This over-winter pool was located in the most upstream reach of the Naches River. Although there were a few additional over-winter/transition pools in the Bumping and American Rivers above this point, Pool #6 was a prime over-wintering pool. It was located between Lost Creek Village and Cliffdell on an outside bend. The pool is located next to a nearly vertical hillside on the left bank (with Highway 410 approximately 70 feet above) and the right bank (on the inside of the curve) was covered with residential lawns to the edge of the river. There were a few large conifers, small hardwood saplings and shrubs along the bank that provided some cover/shade. The reach was estimated to be 90% flowing pool and 10% tail out. The substrate was estimated to be 10% boulder, 70% cobble, and 20% gravel.

<u>Upper Jefferson Pool</u> -- Naches R.M. 39.5 (see Figure 31)

The Upper Jefferson Pool was located 100 yards past a left bend in the river near a steep right bank/hillside. A dirt access road leading to a few residences (homes) and small retreat camp was

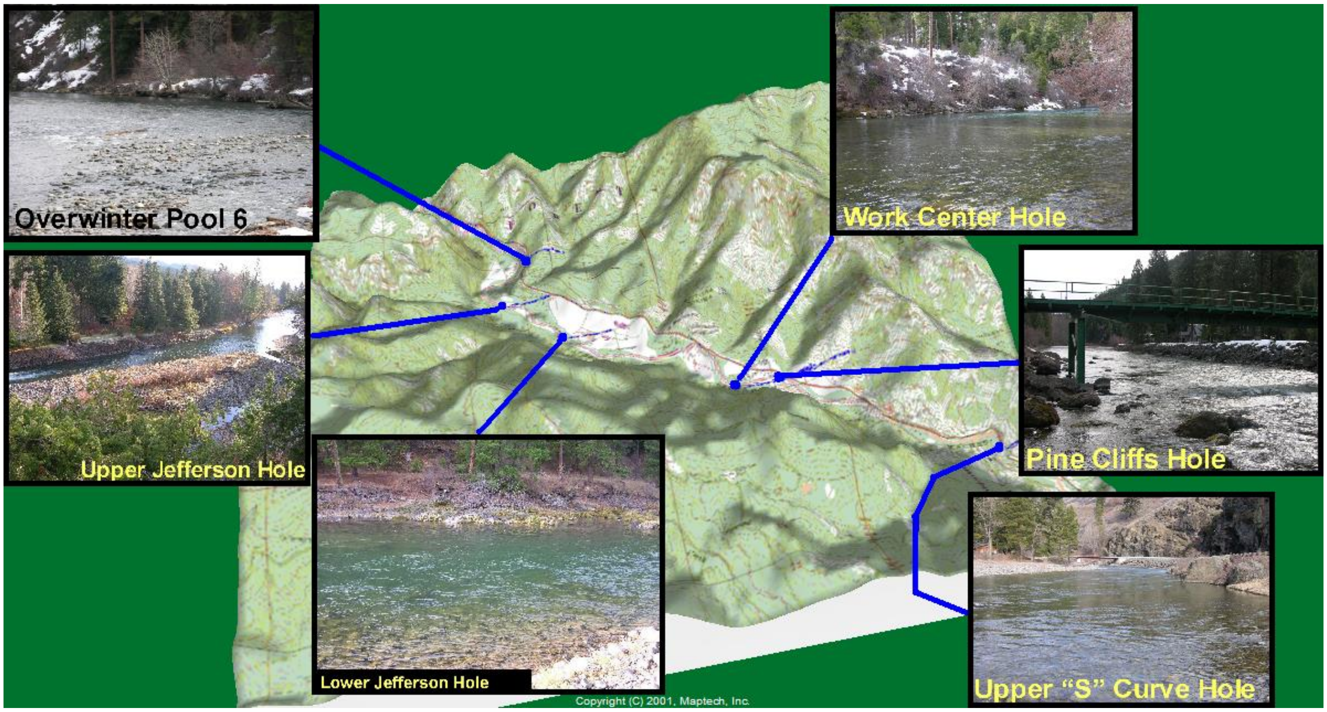

Figure 31. Upper Naches River over-wintering pools located between River Mile (RM) 34.5 to 40.5.

nestled between the river and the steep hillside. There was a large gravel/cobble bar on the right bank at the upper end of the pool with a smaller gravel bar on the right bank a little further downstream. A side channel was also located in this area. The side channel mostly dries up in the summer. The left bank had rip-rap and concrete to protect the houses above it. The right bank was covered with large conifers and shrubs, the left bank had several large conifers interspersed with a few residential buildings, manicured lawns, and a few small shrubs. The reach was estimated to be 4% cascade, 58% flowing pool and 38% tail out. The substrate was estimated to be 60% cobble, 35% gravel, and 5% sand. Three bull trout were caught and radio-tagged at this location. It was a popular holding area for bulls during over-wintering and pre-spawn movement.

<u>Lower Jefferson Pool</u> -- Naches R.M. 39 (see Figure 31)

The Lower Jefferson Pool was located on a straight run, and was created by a basalt shelf under the river. Basalt outcroppings on the right bank helped to create higher velocity inflow that keeps the pool deep and clear of woody debris. The dirt road described in the Upper Jefferson Pool section ends here. There are steep hillsides off on the right bank, with a shallower left bank composed of cobble. Large to medium sized conifers and a few shrubs occupy the right bank with vegetation on the left bank composed mostly of grass, shrubs and a few large conifers. The reach was estimated to be 5% cascade, 60% flowing pool, and 35% tail out. The substrate was estimated to be 50% cobble, 20% gravel, and 30% sand. We caught and radio-tagged three bull trout in this location. Like the upper pool, this lower pool was a popular holding area for over-wintering and pre-spawn fish.

Work Center Pool -- Naches R.M. 36 (see Figure 31)

The [USFS Chinook Pass] Work Center Pool was located on a straight run, 75 yards past a left bend in the river. It was created by a large basalt outcrop that deflected the river flow to cut a deep pool on the right side of the river. There was a gravel road cut through USFS property that lead to a USBR gauging station at the lower end of the pool. The basalt outcrop was located on the right bank with a small pocket of boulders and cobble in a depression on the bank approximately two thirds of the way through the pool. The basalt bank was undercut in many areas. The left bank/bed of the river was imbedded with a cobble/gravel mix, with water depth staying relatively shallow until it neared the right bank where it quickly dropped into the pool. The reach was estimated to be 50% flowing pool, 20% glide, and 30% tail out. The substrate was estimated to be 5% bedrock, 15% boulder, 60% cobble, 10% gravel, and 10% sand. There was one bull trout caught and radio-tagged in this pool and several bulls were tracked to this pool during the over-wintering and pre-spawn movement period.

Pine Cliffs Pool -- Naches R.M. 35.2 (see Figure 31)

The Pine Cliffs Pool was oriented on a straight section of the river just after a long cascade littered with small to medium sized boulders and large cobble. A residential area occupied the right bank. Highway 410 closely paralleled the river on the left bank for the length of the pool. There was a bridge at the upper end of the pool that provided shade relief at certain times of the day. The right bank was armored with rip-rap for a height of eight feet, designed to afford some protection for residences. The left bank was a mixture of imbedded cobble and small to medium boulders with pockets of gravel and sand interspersed. The reach was estimated to be 30% flowing pool, 20% glide and 50% tail out. The substrate was estimated to be 20% boulder, 50% cobble, 25% gravel and 5% sand. Boulders were mostly in the upper section of the pool and provided cover.

Upper "S" Curve Pool -- Naches R.M. 34.5 (see Figure 31)

The Upper "S" Curve Pool was created by a small cliff wall on the left bank followed by a larger cliff wall on the right bank forcing the river to make two abrupt turns, first to the right and then to the left. The right turn created a long deep pool. There was a (private) red colored iron and wood bridge at the upper end of the pool. The bridge also provided access to a pool located on the right bank, on the inside of the first turn. The right bank/bed of the river was a mixture of cobble and gravel and was very flat. The left bank was steep and armored by several medium to large boulders and contained large rip-rap bordering the bank along Highway 410. The reach was estimated to be 5% cascade (at the head of the pool), 55% flowing pool, and 40% tail out. The substrate was estimated to be 20% boulder, 40% cobble, 30% gravel, and 10% sand.

Upper Nile Bridge Pool -- Naches R.M. 29 (see Figure 32)

The Upper Nile Bridge pool was on a straight section of the Naches River just above the upper Nile Road Bridge. A steep hillside on the right bank has deflected flow to the left slightly to scour out a pool. Most of the available shade is provided by the bridge. The right bank is rip-rapped under the bridge but then transitions to a wide gravel/cobble bar for the length of the pool and tail out. The right bank is slightly undercut beneath the bridge. The left bank is a wide gravel/cobble bar that transitions into a silted back water two thirds of the way downstream.

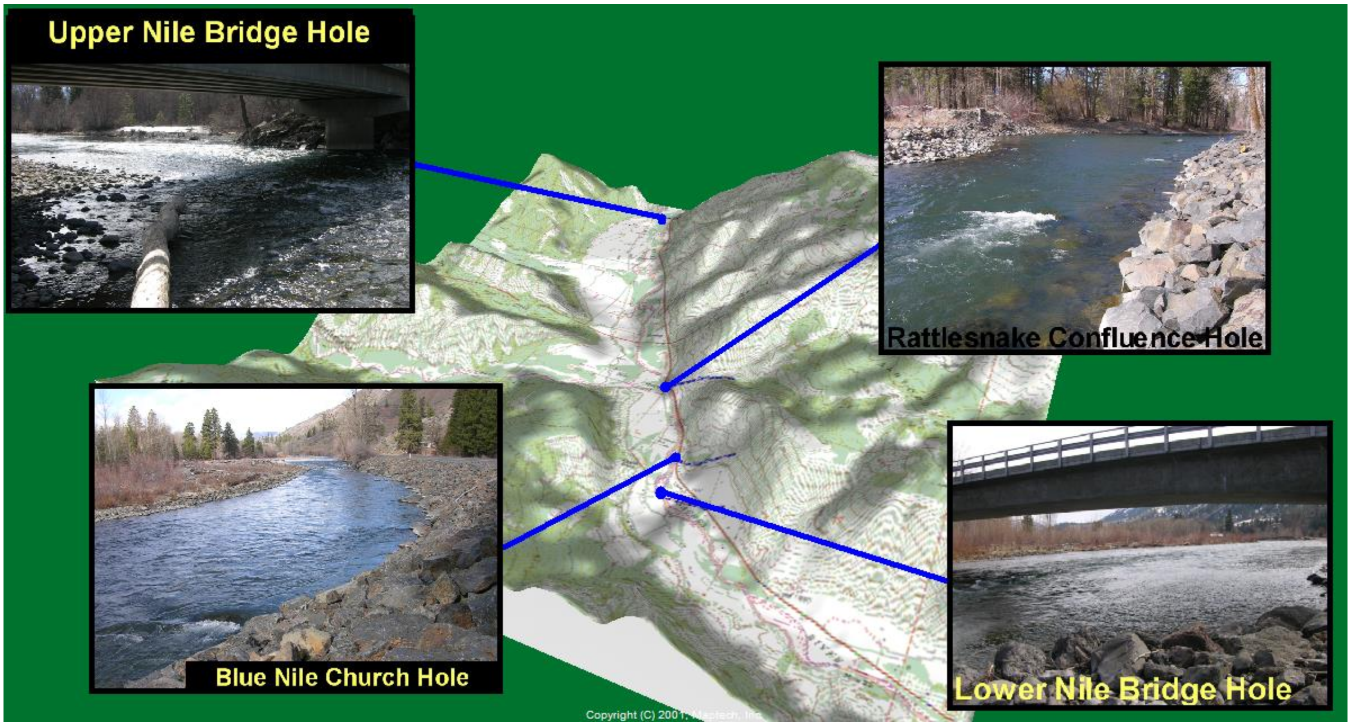

Figure 32. Upper Naches River over-wintering pools in the Nile/Rattlesnake Creek area located between River Mile (RM) 29 to 24.

Near the pool there is one hardwood tree on the right bank and a few shrubs. The left bank has several small hardwoods downstream of the silted backwater. The reach was estimated to be 60% flowing pool and 40% tail out. The substrate was estimated to be 40% cobble, 30% gravel and 30% sand.

<u>Rattlesnake Confluence Pool</u> -- Naches R.M. 27.8 (see Figure 32)

The pool near the mouth of Rattlesnake Creek begins 50 yards above its confluence with the Naches River. The pool encompasses the area of the Rattlesnake confluence and ends in a long glide and tail out. The right bank has a large amount of embedded and loose cobble deposited during the flood of 1995-96. There is one residence near the upper end of the pool, but it is about 80 yards from the river bank. The right bank is comprised of the braided wet and dry channels of Rattlesnake Cr. as it enters the Naches River. The left bank consists entirely of rip-rap to armor Highway 410 which is within 30 to 60 feet of the pool the entire length. Riparian vegetation is sparse, although the right bank has several hardwoods clumped at the upper end of the pool, and a few small conifers nearby. The left bank has a few hardwoods that are presently being worked on by gnawed by beavers and may fall soon. The reach was estimated to be 20% cascade, 50% flowing pool, and 30% glide. The substrate was estimated to be 5% boulder, 60% cobble, 30% gravel and 5% sand.

<u>Blue Nile Church Pool</u> -- Naches R.M. 26.5 (see Figure 32)

The Blue Nile Church pool is on a slightly right meandering section of the Naches River. The right bank consists of a large, loose cobble bar with a secondary flood channel cutting in before the pool and re-entering the Naches River 80 yards below the pool's tail out. The left bank is completely armored with rip-rap to protect Highway 410 which runs 25 feet from the river for the length of the pool. A blue-colored church that serves the local Nile Valley area is located off the highway and next to the pool, hence the name Blue Nile Church Pool. The church was flooded in the winter of 1995-96. There is a small stand of shrubs on the right bank, but they are some distance from the pool. The left bank is completely devoid of any vegetation for the length of the pool. There is no shade provided by the vegetation and the pool is in full sun nearly the entire day, year round. The reach was estimated to be 60% flowing pool, 20% glide and 20% tail out. The substrate was estimated to be 10% boulder, 60% cobble, and 30% gravel. There was one bull trout caught and radio-tagged at this pool. It was tracked and genetically identified as belonging to the Rattlesnake Creek population.

Lower Nile Bridge Pool -- Naches R.M. 24 (see Figure 32)

The Lower Nile Bridge pool was oriented along a slightly left bending section of the Naches River. The right bank was armored by rip-rap above the bridge, part of which had been arranged as a spur jutting out into the river in front of the bridge footing to protect it. Below this spur was a sand and gravel bar with some cobble interspersed in it. The gravel bar became more cobble substrate in the downstream direction. Sand and gravel was deposited behind the spur at the upper end during high flow events. A small gravel/cobble bar occupied the left bank and river bed that ran the length of the pool. The only shade or physical cover was provided by the bridge. There was no riparian vegetation present save a few small shrubs and weeds. The reach was estimated to be 5% cascade at the head, 65% flowing pool, and 30% tail out. The substrate was estimated to be 10% boulder (loose rip-rap), 70% cobble, 15% gravel and 5% sand. There were two bull trout caught and radio-tagged from this pool. They were tracked back to and genetically assigned to the Rattlesnake Creek population.

Over-winter Pool #4 -- Naches R.M. 22.2 (see Figure 33)

Overwinter Pool #4 is in the middle of a large straight run with a large basalt cliff on the right side of the river that provides shade during much of the day. There is a large boulder in the center of the pool that also provides cover and breaks up/distributes river flow in a manner that perpetuates the dynamics of the pool. The left bank and river bed is a mixture of cobble with some rip-rap armored sections along the bank where Highway 410 runs parallel with the river. Riparian vegetation is nearly nonexistent on the right bank due to the large basalt cliff. The left bank vegetation consists of a fair amount of bushes, shrubs and hardwoods, but they do not produce much stream cover. The reach was estimated to be 70% flowing pool and 30% tail out. The substrate was estimated to be 2% boulder, 80% cobble, and 18% gravel.

Cougar Canyon Pool -- Naches R.M. 21.7 (see Figure 33)

The pool at Cougar Canyon was created via a large basalt outcrop on the right bank and flow from Cougar Canyon. The area has a large reverse pool and a long flowing pool. The right bank and river bed is a mixture of cobble, gravel and sand, transitioning to the basalt outcrop. The left bank is mostly cobble and gravel, with some sand. The left bank gravel/cobble bar is littered with woody debris from higher water. There is a small waterfall from Cougar Canyon that drops over the basalt outcropping into the pool. The right bank has a few scattered shrubs, bushes and grasses with a few hardwood trees nearby. The left bank has scattered shrubs and bushes on the gravel/cobble bar, and several good sized hardwood trees above the active channel. The reach was estimated to be 70% flowing pool, and 30% tail out. The substrate was estimated to be 2% boulder, 78% cobble, 10% gravel and 10% sand.

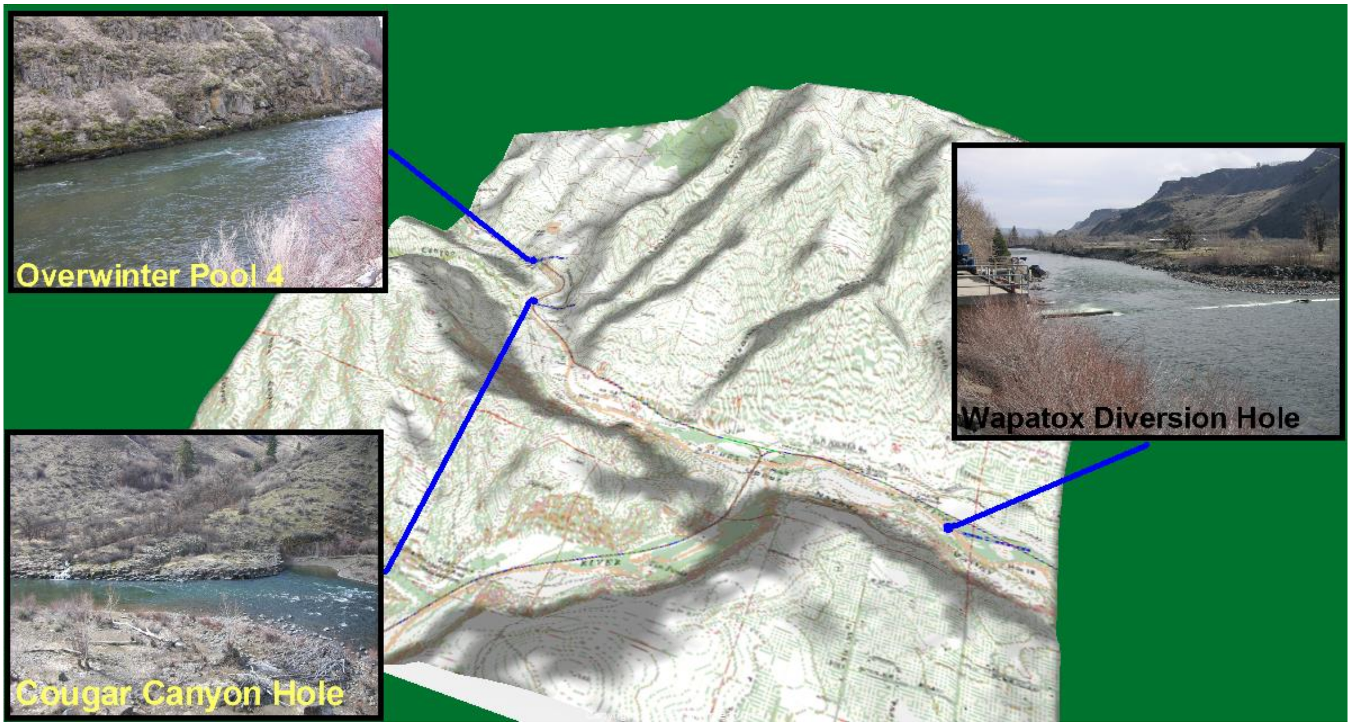

Figure 33. Upper Naches River over-wintering pools near the Tieton River, Naches River Mile (RM) 22 to 17.

Wapatox Diversion Pool -- Naches R.M. 17.1 (see Figure 33)

The Wapatox Diversion pool, downstream of the Tieton River confluence, is unique in that it is the only fully manmade pool on the mainstem Naches River. The Wapatox Pool is created by an irrigation diversion dam. There is a deep pool at the base of the dam with a long, deep, flowing channel that extends for several hundred yards. It also has the highest bull trout use based on hook-and-line captures during the study. We caught 13 adult bull trout in this pool and radio-tagged 11 fish, with several more that were hooked and lost. The right bank is an unstable mix of cobble, gravel and sand, with a rather steep drop to the bank. The left bank consists of small to medium boulders, and cobble, interspersed with gravel and sand. Riparian vegetation is sparse on both banks. There is a small stand of shrubs and grass on the right bank near the dam. The left bank is nearly devoid of any vegetation near the water, but has a thick stand of shrubs and hardwoods near Highway 12 which runs parallel and within 100 feet of the river. The Wapatox Diversion Pool also serves as a thermal refuge for bull trout (see later section on Water Temperatures). This reach was estimated to be 60% flowing pool and 40% glide. The substrate was estimated to be 10% boulder, 75% cobble, 5% gravel, and 10% sand.

Transitional Habitat Pools in the Upper Naches, American & Bumping Rivers

We identified some primary transitional habitat reaches in the upper Naches, American and Bumping Rivers. Transitional habitat was shorter duration holding areas (smaller pools, runs) located between spawning and wintering habitat. The primary area extended from below the Union Creek spawning grounds in the upper American River (RM 11.5) downstream to the Bumping R., a 3.5 mile section of the lower Bumping River, and then further downstream to the Whistling Jack’s Pool on the upper Naches River at river mile 39.9 (see Table 6). A few pools like Whistling Jack's Pool and Overwinter Pool #6 (RM 40.5) overlapped between the over-winter and transitional zones. Transition pools like Whistling Jacks were used more for short duration stays during upstream migration to the spawning areas versus the longer duration holding period associated with over-wintering. There tended to be more activity through the transition pools during the peak upstream migration period of summer and early fall (July to October). During this time, bull trout migrated upstream to staging pools below the spawning grounds. Spawning occurred in early September followed by post-spawn movement of bull trout back downstream to the wintering areas during late September and October.

The transition zone is in an area where several upper basin rivers converge to form the Naches River. The American River flows into the Bumping River at RM 3.5, and the Little Naches and Bumping Rivers join to form the Naches River at RM 44.6 (see map in Study Area section). The American River is designated as a wild and scenic river, with some higher gradient sections and large log jams. It has excellent riparian cover of conifers mixed with some deciduous trees, shrubs and interspersed with grassy meadows and wetland areas. Landownership is primarily U.S. Forest Service (USFS). There are a number of campgrounds in the area and along the river banks. It is a popular recreational area from late spring to early fall.

Similar to over-winter pools, transition pools varied quite a bit in size and depth (1-3 meters) and also contained a good mix of sand, gravel, cobble, boulders and bedrock material. However, the upper river transition pools were smaller and contained more gravel/sand mixtures (Figure 34) than the cobble dominated substrates found in the overwintering pools (see Figure 30). Woody debris and riparian cover were also more prevalent in these upper transition areas. A more detailed description of primary transition pools beginning from the most upstream pool and working downstream is outlined below. It is not intended to be an all-inclusive list, but it does contain a number of primary pools where we radio-tracked bull trout.

<u>Union Creek Pre-Spawn Pool #1</u> -- American R.M. 11.5 (Figure 35)

The Union Creek Pre-Spawn Pool #1 was located in the American River below the confluence of Union Creek at a basalt outcrop. A medium sized, fairly deep pool has been scoured just below the Union Creek confluence. The right bank is composed of the basalt formation, while the left bank and river channel is composed of a cobble, gravel, sand mix. There is a large imbedded log sticking into the pool at the confluence. The right bank riparian zone is made up of a stand of conifers perched on top of the basalt formation. The left bank has a large stand of medium to large conifers a short distance from the watered channel. The reach was estimated to be 80% flowing pool and 20% tail out. The substrate was estimated to be 10% bedrock, 10% cobble, 20% gravel, and 60% sand.

<u>Union Creek Pre-Spawn Pool #2</u> -- American R.M. 11.4 (Figure 35)

The Union Creek Pre-Spawn Pool #2 was located on a bend in the American River and is created by a basalt outcrop on the right bank. The right basalt bank was undercut and some imbedded logs were beginning to be exposed. The left bank consisted of a gravel bar that transitioned into an imbedded log that was anchored by a cabin owner on the hill above the river. Union Creek Pools #1 & 2 are primary staging pools for the Union Creek bull trout spawning population. Pool 2 is relatively shallow (3 ft) compared to pool 1 (5 ft). There is a stand of conifers nearly to

Table 6. Major transition pools in the Naches, lower Bumping and American Rivers.

Pools From Upstream to Downstream	River Mile
Union Creek Pre-Spawn Pool 1	American 11.5
Union Creek Pre-Spawn Pool 2	American 11.4
Transition Pool 16 (American conf. with Bumping)	American 0.0
Icicle Pool	Bumping 2.2
Upper Bridge Hole	Bumping 1.3
Transition Pool 10	Bumping 0.3
Transition Pool 11 (Sawmill 3)	Naches 43.3
Transition Pool 12 (Sawmill 2)	Naches 43.1
Transition Pool 13 (Sawmill 1)	Naches 43.0
Jim Cummins Pool	Naches 42.9
Boulder Cave Pool	Naches 42.3
Transition Pool 5	Naches 41.1
Whistling Jack's Pool	Naches 39.9

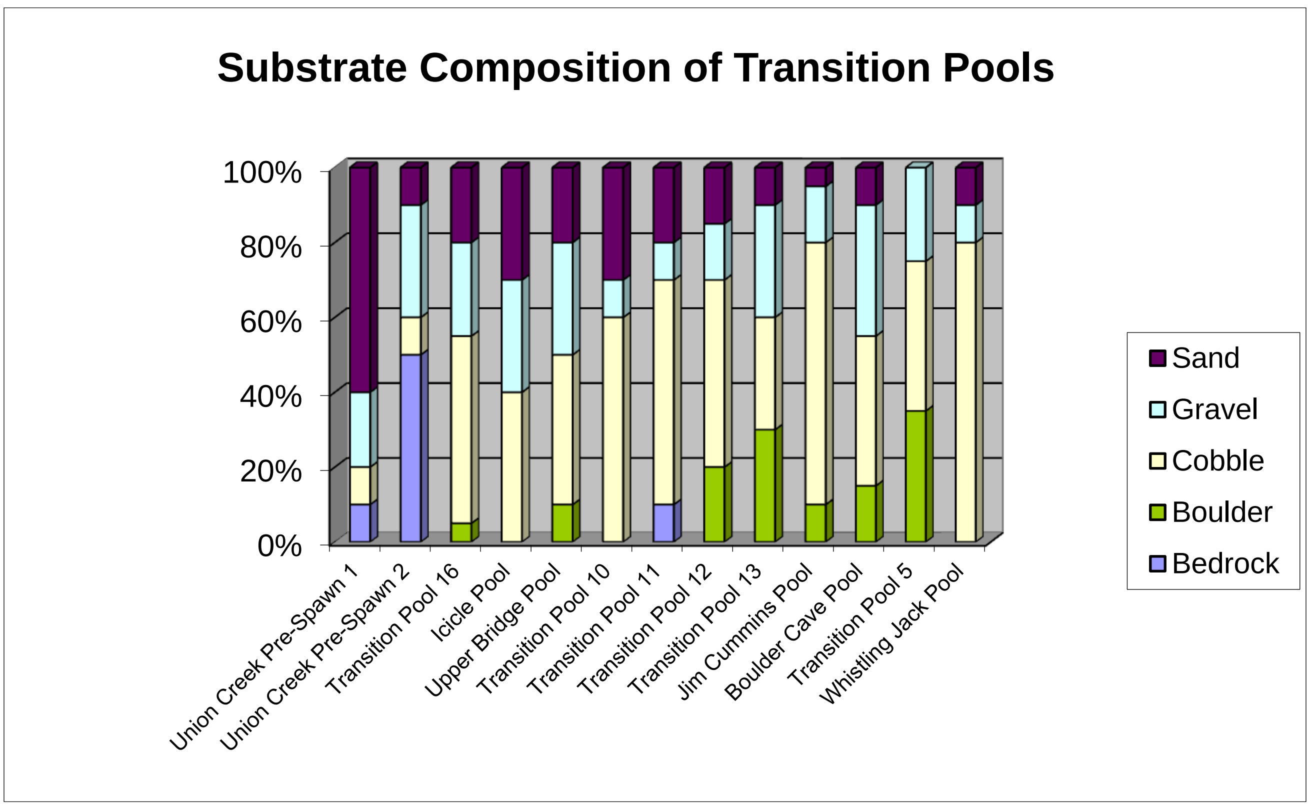

Figure 34. Substrate composition of bull trout transition pools in the Naches, lower Bumping and American Rivers.

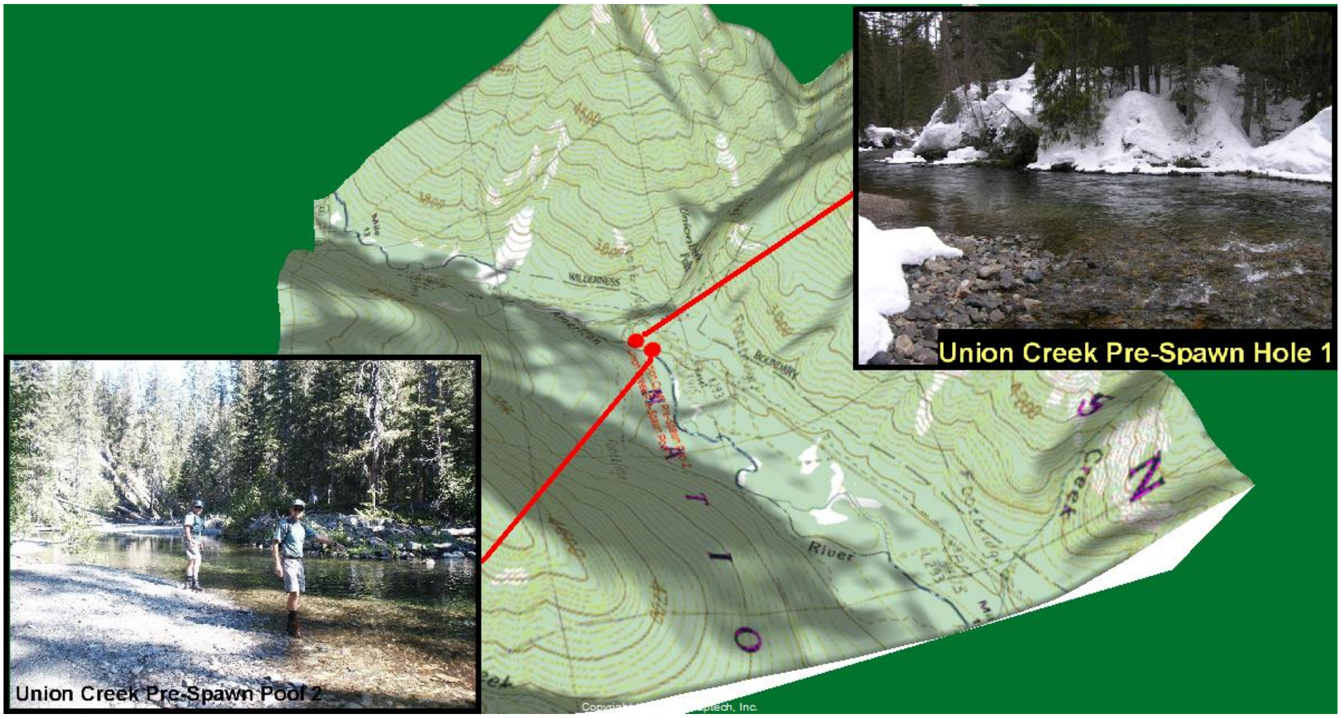

Figure 35. Union Creek transition (pre-spawn) pools #1 & #2 on the American River (RM 11.5 & 11.4).

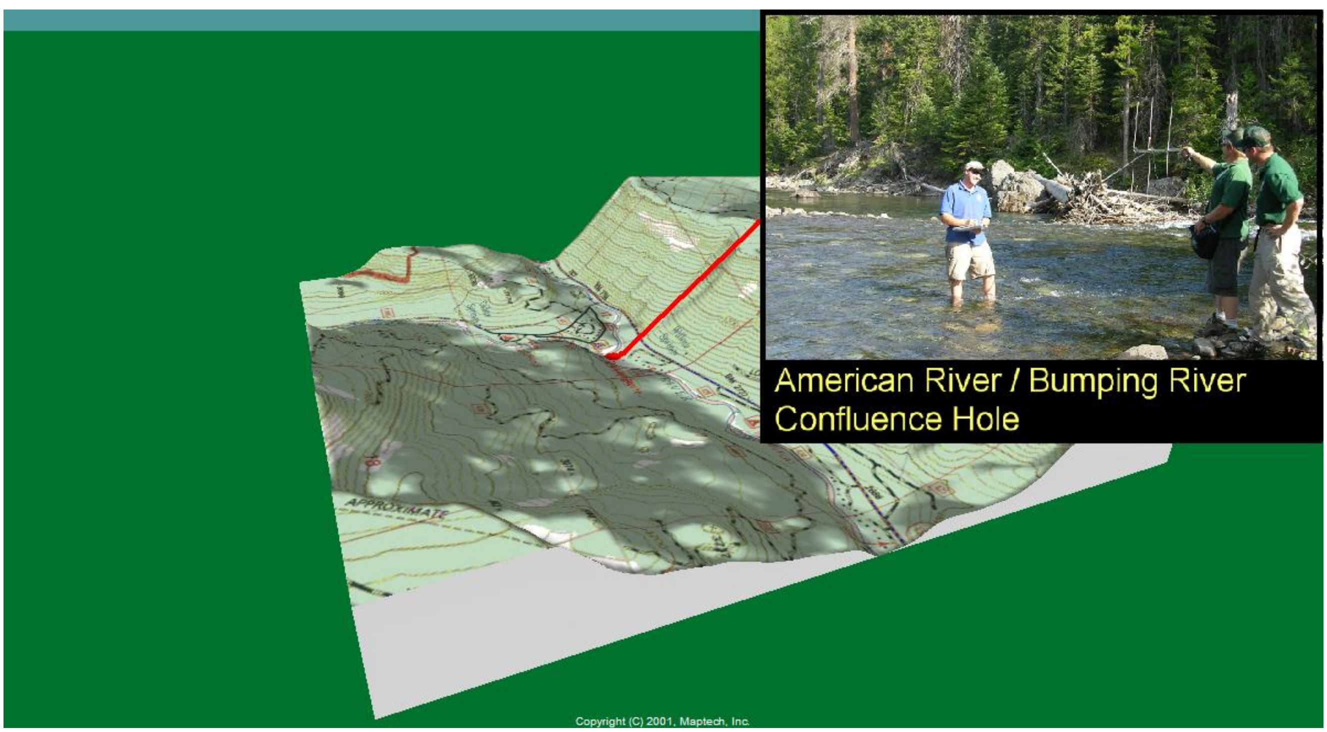

Figure 36. Transition Pool #16, American River (RM 0.0) confluence with Bumping River (RM 3.5).

the right bank edge of the pool and a mix of small shrubs, hardwoods, and medium to large conifers on the left bank. The reach was estimated to be 80% flowing pool, and 20% tail out. The substrate was estimated to be 50% bedrock, 10% cobble, 30% gravel, and 10% sand. Pools 1 & 2 were some of the most important transition (staging) pools for adult bull trout during August right before they move the short distance upstream to spawn in early September. Up to 40 adult bull trout were observed in the Union Creek pre-spawn pools at one time.

Transition Pool #16 (American River confluence with Bumping River) -- American R.M. 0.0, Bumping R.M. 3.5 (Figure 36)

Transition Pool #16 was a large pool formed at the confluence of the American River (R.M 0.0) with the Bumping River (R.M 3.5). This pool has the distinction of having the only large woody debris of any of the holding or transitional pools measured on the American, Bumping and Naches Rivers. There were several large boulders and a woody debris log jam at the head end of the pool. A basalt cliff occupied the right bank (Bumping River) with the riparian being a mixture of shrubs and small to medium conifers along the steep hillside. It provided minimal shade during the summer except during the morning and evening. The point between the Bumping and American Rivers is mostly gravel and small cobble and has several medium and large shrubs. The left bank (American River) is a cobble and gravel beach, with a wide un-vegetated zone until small conifers lead into a good dense forest of medium and large conifers. The reach was estimated to be 85% flowing pool, and 15% tail out. The substrate was estimated to be 5% boulder, 50% cobble, 25% gravel, and 20% sand. A number of bull trout were tracked to this pool, but none were caught or tagged here.

Icicle Pool -- Bumping R.M. 2.2 (Figure 37)

The Icicle Pool was located on a slightly left turning stretch of the river. The right bank was a tall overhanging basalt shelf. This shelf was concave and promoted considerable scour keeping the pool deep. The left bank was composed primarily of gravel and cobble. Highway 410 runs parallel and very close to the river at this point. The highway is cut into the steep hillside next to the river channel. The right bank vegetation consists of several small overhanging shrubs with some small to medium conifers near the edge as well. The left bank vegetation consists of thick shrubs and a few small to medium hardwoods and conifers. The reach was classified as 80% flowing pool and 20% tail out. The substrate was estimated to be 40% cobble, 30% gravel, and 30% sand. Pool use by radio-tracked fish varied from one day to one week during the upstream pre-spawn movement period.

Upper Bridge Pool -- Bumping R.M. 1.3 (Figure 37)

The Upper Bridge Pool was created by a basalt outcrop on the right bank. A concrete bridge abutment for F.S. Road #1701 was built into the outcrop. The entire right bank was basalt except for a small pocket beach of sand and gravel below the bridge. The left bank was a gravel and cobble mix that gently sloped up to a primitive campsite. There was sparse vegetation on the right bank; most of it was setback from the shoreline and was below the bridge. The vegetation on the left bank consisted of a few small shrubs. Most of the understory had been stripped, leaving a stand of large conifers. The reach was estimated to be 75% flowing pool, and 25% tail out. The substrate was estimated to be 10% boulder, 40% cobble, 30% gravel and 20% sand. Many fish were observed passing through or holding in this pool (observed from the bridge

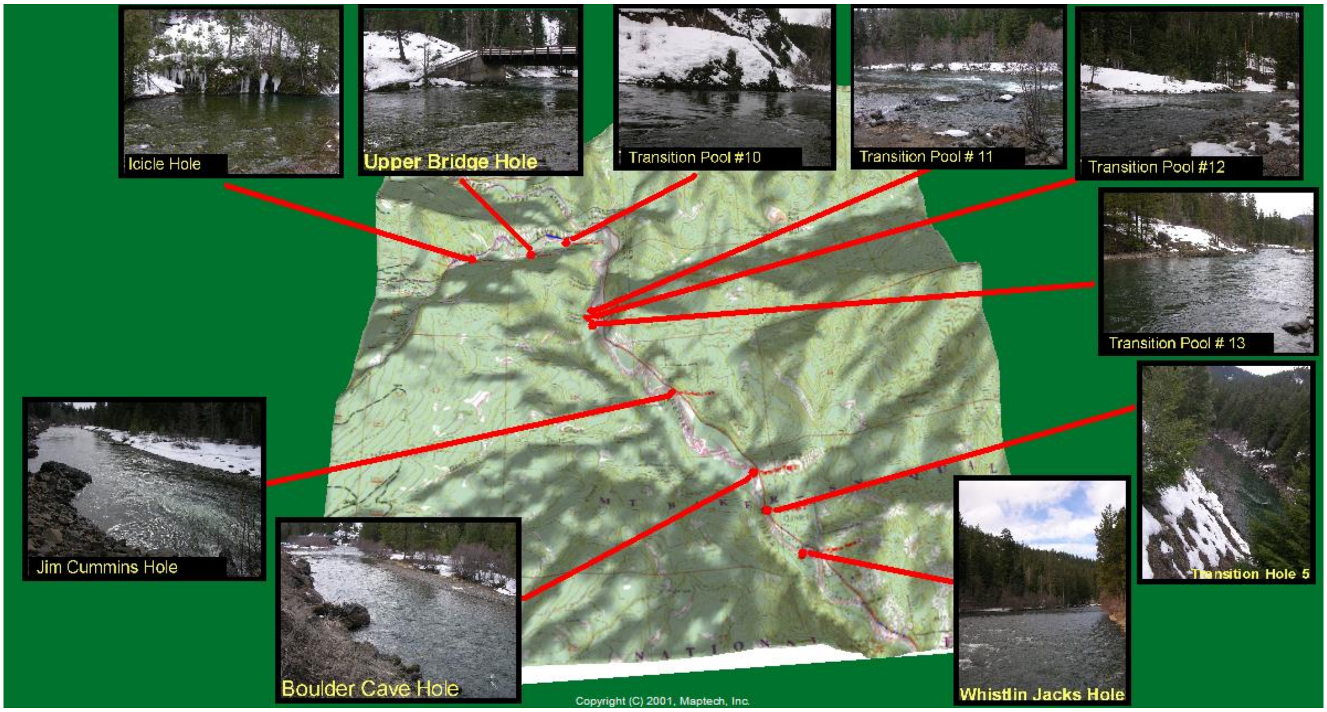

Figure 37. Bull trout transition pools (pre- and post-spawn staging pools) in the lower Bumping River from RM 2.2 to 0.3 and Naches River from RM 43.3 to 39.9.

above) from July through August (pre-spawn) and again in late September to early December (post-spawn).

Transition Pool #10 -- Bumping R.M. 0.3 (Figure 37)

Transition Pool #10 was formed where the Bumping River is deflected to the left by a large basalt outcrop, above which is a dirt road cut into a higher cliff. The main pool is over six feet deep, with a smaller pool above the outcrop. The right bank contains the large basalt outcrop for the entire length of the main pool. The left bank is composed of gravel and cobble with a short steep cut bank. The bank near the small pool has a grass lined shoreline bordered by a thick stand of bushes and shrubs. The lower right bank is rocky and nearly devoid of any vegetation. The left bank is not heavily vegetated either with only a few small bushes. The reach was estimated to be 50% flowing pool, 40% pool, and 10% tail out. The substrate was estimated to be 60% cobble, 10% gravel, and 30% sand (all the sand was in the small pool). Several radio-tagged fish were tracked to this pool and large numbers of untagged bull trout were also observed especially during August and September.

Transition Pool #11 -- Naches R.M. 43.3 (Figure 37)

Transition Pool #11 was formed as the Naches River crosses over a low basalt (bedrock) shelf. The pool is fast and not very wide, with several boulders on the left side of the river. The right bank is consists of cobble and is wide and low. The left bank consists of cobble and exposed basalt shelf. There is a low amount of near shore vegetative cover. The right bank has several large bushes near the water line and the left bank has several large conifers and a few small shrubs. The reach was estimated to be 90% flowing pool, and 10% tail out. The substrate was estimated to be 10% bedrock, 60% cobble, 10% gravel, and 20% sand.

Transition Pool #12 -- Naches R.M. 43.1 (Figure 37)

Transition Pool #12 was a long, straight run with a large basalt shelf at the right bank for the entire length of the pool. The pool was six to eight feet deep along the shelf. The left shoreline area was shallow and the river bed and bank consisted of cobble and small boulders. There was little vegetation on the rocky basalt shelf. A few grass clumps and small bushes. The left bank has a few shrubs setback from the shoreline and some medium to large conifers. The reach was estimated to be 90% flowing pool, and 10% tail out. The substrate was estimated to be 20% boulder, 50% cobble, 15% gravel, and 15% sand. There was one fish caught and tagged at this pool which was tracked and genetically assigned to the American/Union bull trout population.

Transition Pool #13 -- Naches R.M. 43.0 (Figure 37)

Transition Pool #13 was formed where Milk Creek enters the Naches River on the left bank, directly across from a basalt outcrop on the right bank. The right bank was composed of a solid basalt formation, with several outcrops and indentions along its length. There were pockets of cobble and gravel in these indentations. The left bank was composed of small boulders, cobble and a small amount of gravel. Right bank vegetation was sparse in the basalt layer although several small and medium conifers were growing there. The left bank was covered with many shrubs above the wetted channel and medium to large conifers beyond that. The reach was estimated to be 40% flowing pool, 30% glide and 30% tail out. The substrate was estimated to be 30% boulder, 30% cobble, 30% gravel and 10% sand.

Jim Cummins Pool -- Naches R.M. 42.9 (Figure 37)

The Jim Cummins Pool was the longest pool in the study (over 300 yards) created by a large basalt boulder and rip-rap bank on the left side. High velocity input from right to left at the head of the pool created a long deep channel on the left bank. The right bank was a cobble flat covered with a few sparse bushes near the bank and a number of small to medium conifers above that.   The left bank was armored with rip rap for the length of the pool to protect Highway 410 which bordered the river channel (30 ft from river). The reach was estimated to be 40% flowing pool, 20% glide, and 40% tail out. The substrate was estimated to be 10% boulder, 70% cobble, 15% gravel and 5% sand. There was one fish caught and tagged here. It was tracked and genetically assigned to the Rattlesnake bull trout population.

Boulder Cave Pool -- Naches R.M. 42.3 (Figure 37)

The Boulder Cave Pool was a long flowing pool. The right bank had a wide cobble bar with some gravel. The left bank was a steeper dirt, boulder and rip-rap incline with Highway 410 perched above. Right bank vegetation consisted of a few shrubs. The left bank had minimal grass and shrub cover. The reach was estimated to be 90% flowing pool, and 10% tail out. The substrate was estimated to be 15% boulder, 40% cobble, 35% gravel, and 10% sand. One fish was caught and tagged here. It was tracked and genetically assigned to the American River bull trout population.

<u>Transition Pool #5</u> -- Naches R.M. 41.1 (Figure 37)

Transitional pool #5 was located just above the small community of Cliffdell. It was a long deep section of river with steep banks on both sides. Highway 410 ran along the left bank approximately 150 feet above the gorge and a dirt access road ran along the right bank for about the same distance. The pool had several boulders in it that had rolled down from above. The steep right bank consisted of boulders and conifers with shrubs interspersed throughout. The left bank was steep basalt and dirt bank with small to medium conifers interspersed in it. The trees provided minimal cover, but the steep banks provided shade during morning and evening hours. The reach was estimated to be 90% flowing pool and 10% tail out. The substrate was estimated to be 35% boulder, 40% cobble and 25% gravel. No fish were caught here, but bull trout were tracked to the pool.

<u>Whistling Jack's Pool</u> -- Naches R.M. 39.9 (Figure 37)

Whistling Jack's Pool in Cliffdell was the lowest of the transitional pools and overlapped with the over-wintering pools. Most pools above this point were considered primarily transitional pools, although some like Over-winter Pool #6 were used as a transition pool for bull trout migrating upstream from lower river reaches. Most pools below this point were considered primarily over-winter pools, although adult bulls used over-winter areas throughout the spring and early summer as well. Transition areas were generally in higher gradient reaches than over-wintering pools. The Whistling Jack's pool was the second longest (250 yards) pool in the study. It was a fairly shallow glide with an extended tail out. The right bank was embedded cobble and sand, undercut in places. The left bank was a mixture of cobble and rip-rap with some large conifers along the shore. Rip rap had been placed to protect the residential lawns/homes along this bank. The right bank riparian zone had a dense stand of shrubs and brush, with medium to large conifers further back from the channel. The reach was estimated to be 80% glide, 20% tail out. The substrate was estimated to be 80% cobble, 10% gravel, 10% sand. No bull trout were caught here, although they were often observed in this pool on their upstream migration during mid to late summer.

Pools below Irrigation Storage Dams

We also captured and radio-tagged bull trout from pools below large irrigation storage dams. Bull trout in these pools tended to spend most of their time below the dam, seldom venturing outside of the pool. We hypothesize that most were entrained out of the reservoir and stayed in the same pool because they could not move back upstream over to their natal population. With abundant forage present, the bull trout grew fast and tended to stay put. Since bull trout were much more abundant in the Naches drainage than in the upper Yakima, most of our attention was focused on the pool habitat below the dams at Bumping Reservoir and Rimrock Reservoir (Tieton Dam). We had little success capturing and tagging bull trout from upper Yakima River basin pools, so did not spend much time analyzing habitat conditions in those areas. Upper Yakima basin pools included those below the storage dams on Keechelus, Kachess, and Cle Elum reservoirs. Easton Dam and Roza Dam are irrigation diversion dams with fish ladders. The USBR storage dams do not have fish ladders and have effectively isolated bull trout populations in the Yakima basin. A short description of each pool where we caught and radio-tagged bull trout is presented below.

Pools below Bumping Dam

These two pools were located below the Bumping Lake Dam. The Bumping River continues downstream to the junction with the Little Naches River to form the origin of the Naches River. The upper pool lies just below Bumping Dam and is fed via a concrete sluiceway conveying the flow released from Bumping Dam. This pool is deep (estimated at 12 feet). Bull trout, cutthroat, rainbow, brook trout, mountain whitefish and spring chinook salmon have been caught and seen via snorkel reconnaissance surveys in the pools. One bull trout was caught and radio-tagged here, and one hybrid brook/bull trout was captured and tissues taken for genetic analysis. The lower pool is just a short distance downstream below the dam's overflow spillway. This is also a deep pool with abundant woody debris throughout the riverbed and shoreline area. Three bull trout were caught and two were radio-tagged in this pool (a total of 3 bull trout tagged from both pools). The substrate is a mix of gravel and cobble with some finer sand. Spring chinook, and to a lesser extent steelhead, spawn in the lower Bumping River. Bull trout redds have not been observed.

Pool below Tieton Dam

This is a large, deep pool located below the dam on Rimrock Reservoir (Tieton Dam). It is lined with boulders and medium to large rip-rap to armor it from high velocity flow that was routinely discharged from the lake prior to installation of the hydroelectric project in 2005-06. Water is often turbid and visibility is severely limited. Three bull trout were initially caught and radio-tagged from this pool early in the study in 2003, another was caught and tagged in the Tieton River further downstream. Two years later we tagged another 12 bull trout during a fish salvage operation at the pool. These fish were physically transported and released downstream in the Naches River in the Wapatox Pool (Mizell and Anderson, 2008). The Tieton River is primarily managed for irrigation flow deliveries and is not conducive to spawning for salmon, steelhead or bull trout. High velocity flows have scoured the river bed and disrupted potential spawning opportunity for most species of fish, particularly late summer and fall spawning species like bull trout and salmon.

Pool below Kachess Dam

The pool below Kachess Dam (Kachess River) in the upper Yakima arm of the drainage is similar in design to the pool below Bumping Dam in that it has a long concrete sluiceway that spills water from Kachess Lake to the pool. The pool is much shallower than the stilling pools at other storage dams. There is an undercut concrete and bedrock shelf at the upper end of the pool that provides cover. A gravid female was caught, and radio-tagged in early 2005. This fish did not leave the pool to spawn in another location.

Thermal Conditions -- Refugia in the lower Naches River

We obtained thermal (aerial FLIR) imagery for the Tieton and Naches Rivers from the Washington Department of Ecology (WDOE). Of particular interest was the temperature profile of both rivers before and after they joined. The Wapatox Diversion pool, a major holding area for bull trout, was just a short distance downstream from the confluence. This pool is a major spring, summer foraging and over-winter area for adult bull trout. Thermal imagery taken on August 14, 2004, shows the much colder water of the Tieton River (58.5 F/14.7 C) entering the Naches River (66 F/18.8 C) (Figure 38). Colder water of the Tieton R. at first displaced and then mixed with the warmer Naches R. flow. Some of the warmer Naches flow is diverted into the Wapatox Diversion canal (see Fig 38, center of photo). Further downstream, water temperatures in the Naches R. had dropped by 3.5 C to 15.3 C, creating a "thermal refugia" for bull trout. We found both tagged and untagged bull trout occupying this area during the summer of each year (not all bull trout leave the area to migrate upstream to spawn every year). Indeed, we radio-tracked and hook-and-line sampled the pool below the diversion dam and caught most bull trout from the cooler, Tieton R. side (i.e. right bank). These cooler waters enter the Tieton River from glacial and spring fed systems that enter Rimrock Reservoir. Subsequently, cooler water is released from the reservoir hypoliminion through the outlet works at the base of the dam, 196 feet below the surface at full pool elevation. This cooling effect extends through September as the Tieton River flow is increased to meet downstream irrigation needs during the fall "Flip-flop" operation.

A thermal overview of the Naches River, which also includes several miles of the upper Bumping River (Figure 39), shows the thermal cooling effect in the lower Naches River from the Tieton River inflow. In the summer, temperatures in the mainstem Naches R. above the Tieton R. confluence can reach into the mid 70's F (23C), while temperatures in the tributaries are in the low to mid 50's F (10C) and mid-to-upper 40's on the spawning grounds. Most migratory adult bull trout were either in the cooler tributary spawning streams or in the cooler Wapatox "thermal refugia" at this time. A temperature data logger was placed in the upper Naches River (Upper Jefferson Pool) in November 2003 and left in place until January 2005 to record temperatures for a full year (Figure 40). In June 2004, the temperature begins to rise into the 60's F (16C), and by August is approaching 70 F (21C). Many adult bull trout had already moved into the cooler tributary (spawning) streams by late June to early July, thus avoiding any temperature induced stress in the mainstem Naches River.

Velocity Preferences in the Naches River

Individual tagged bull trout were tracked to their holding areas during the spring, summer and fall and various habitat parameters were measured. After each tagged fish was located using the telemetry gear it was visually located by snorkeling. The substrate, riparian cover, flow and other parameters were measured. Formation of ice and very low temperatures made it difficult to accurately gauge velocities in the winter months. We noticed early in the habitat portion of the study that tagged and untagged bull trout were almost always found holding in medium to large pools with no overhanging cover, although shrubs and large trees were on nearby banks (e.g., Jefferson Pools in the Naches River). The Jefferson pools have many basalt overhangs and back eddies that bull trout seemed to prefer. Our radio-tagged bull trout were often found with other untagged bull trout. This could vary from one to 40 bull trout in a holding pool and we also observed other species as well, including rainbow trout (steelhead and resident rainbow) chinook, mountain whitefish, and cutthroat trout. Usually the largest bull trout would be at the head of the pool and the smaller fish in the rear, reflecting a dominance pattern likely based on the best access to prey. Bull trout also seemed to prefer certain sections of pools, often holding in a linear fashion where the surface tended to be choppy and surface turbulence (opacity) was the primary source of cover. We coined the phrase "velocity tube" after it was found that bull trout preferred stream velocities of 1.4 to 1.9 feet per second (fps). Protocols were immediately developed to accurately measure this phenomenon. A rope was marked at one foot increments

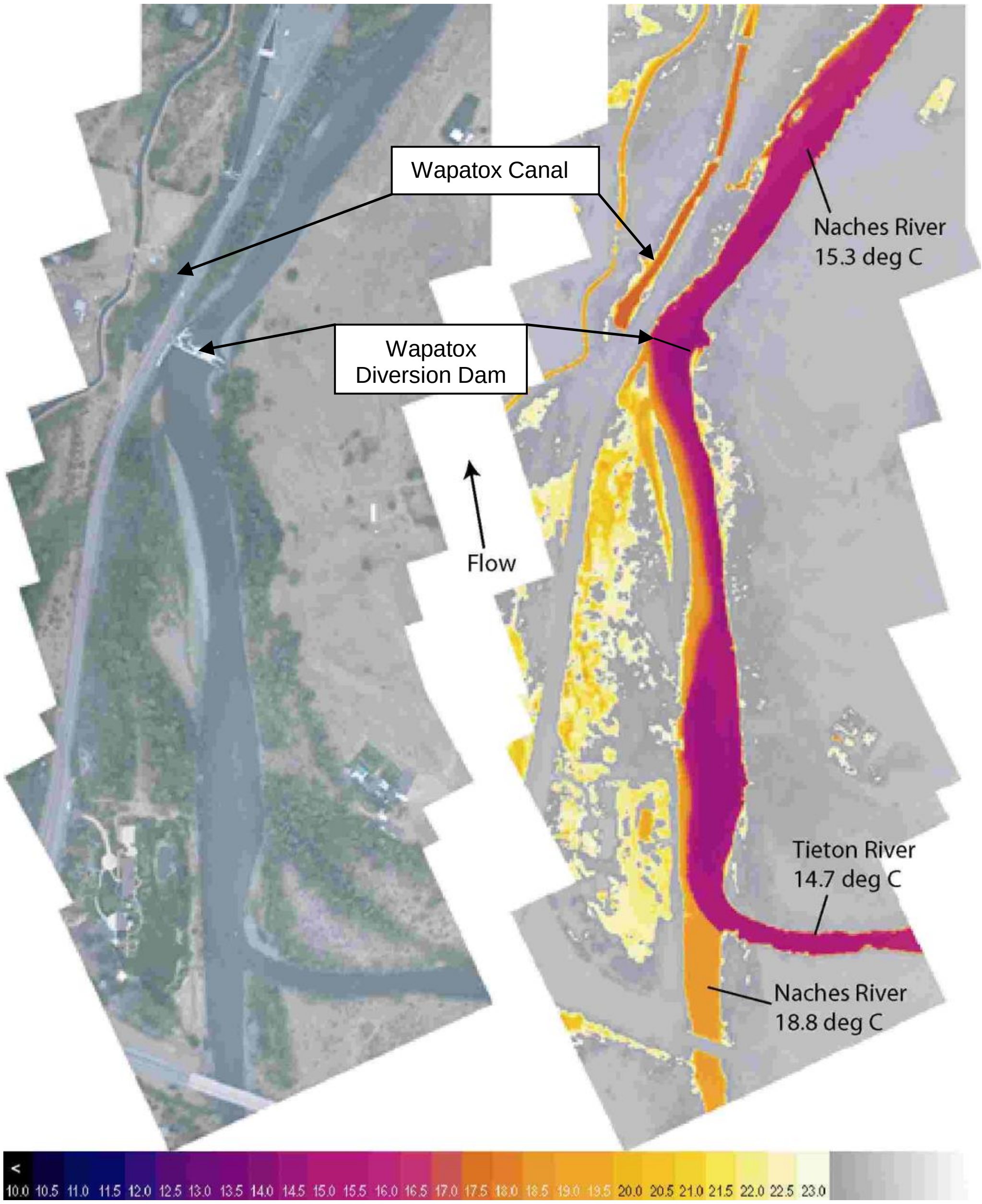

Figure 38. Aerial photograph with thermal (FLIR) image of the Tieton and Naches Rivers, August 14, 2004. Note the colder Tieton River water (reprinted with permission from WDOE).

(Figure 41) and then stretched across the pool where we observed bull trout holding. A raft was attached to the rope by a carabiner and moved slowly across the river at designated intervals to record velocity. We used a Marsh-McBirney Model 2000 velocity meter and measured water velocity at one foot intervals across the stream and at one foot depth intervals from the surface to the bottom. The raft was oriented away from the flow head of the meter for accurate measurements (**see Appendix 5a-b – Jefferson Pools Habitat Velocity Profile**). These cross sectional measurements, when coupled with radio-tracked fish and visual observations of bull trout in the stream allowed us to get an accurate representation of velocity preferences.

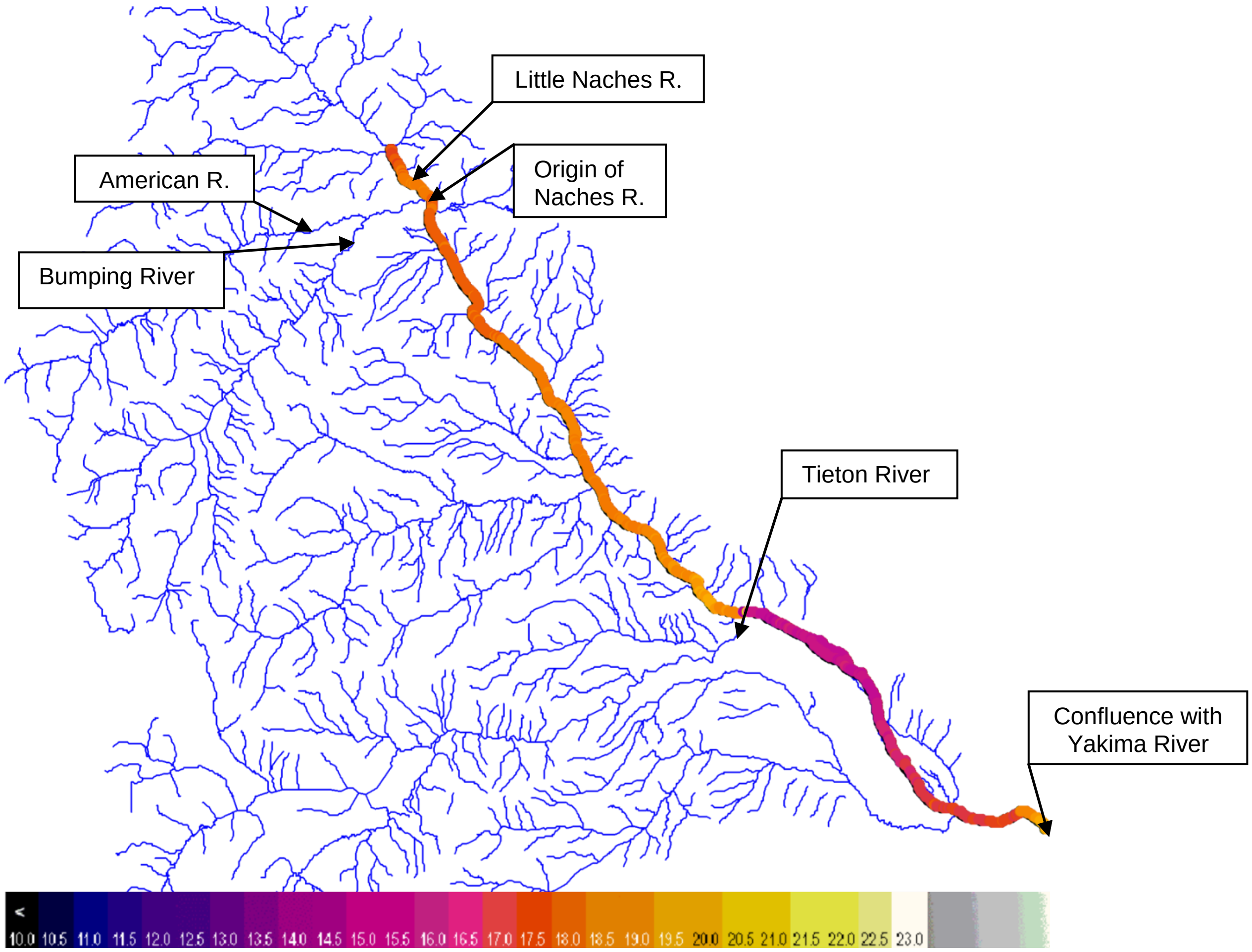

Figure 39. Thermal imaging (FLIR) overlay of the Naches River on August 14, 2004 (reprinted with permission from WDOE).

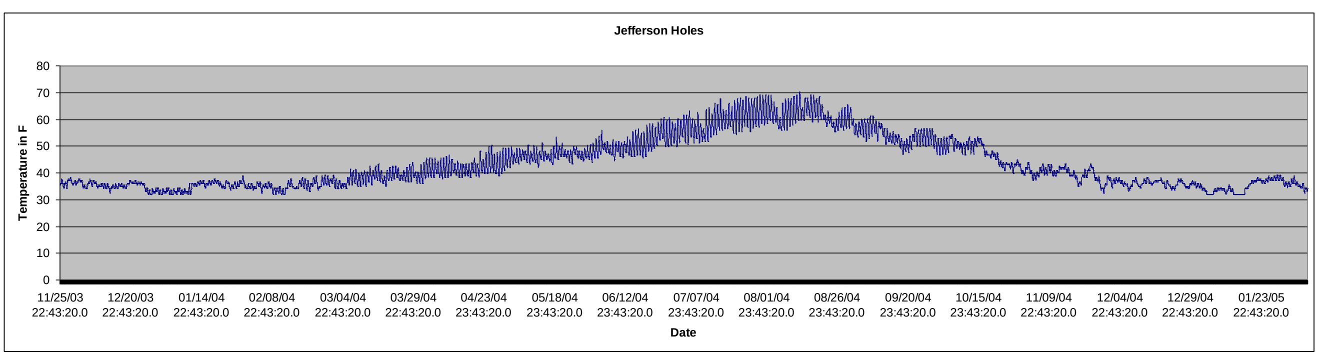

Figure 40. Temperatures in the Upper Jefferson Pool from November 2003 to January 2005.

Figure 41. Naches River velocity measurements in a bull trout holding pool.

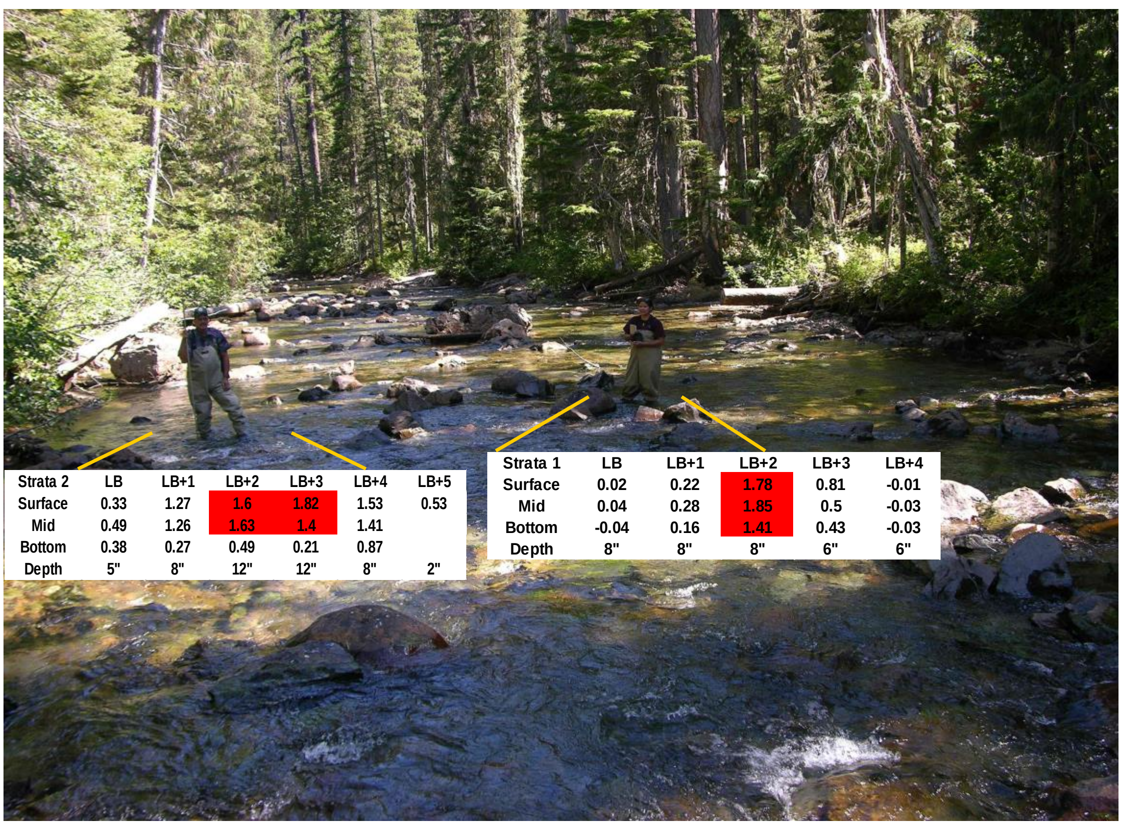

Figure 42. American River velocity measurements in a bull trout holding area.

We noticed that bull trout usually oriented themselves to one side of a much faster column of water at or near the head end of the pool with flow velocities in the 1.4 to -1.9 fps range. The surface opacity in these areas also provided some form of concealment for predation avoidance and/or foraging. Maintaining position near a fast water chute allowed bull trout to capture disoriented prey, which we observed while snorkeling on numerous occasions. Although we observed bull trout in close proximity to each other, and to other species holding in or near the same areas, we observed no aggressive behavior. The fish were so unperturbed during some habitat/velocity surveys that at times we had to physically move the fish with the end of the flow meter to get accurate readings. The raft with several people above the group of fish did not spook them either. The flow preference was so high that the fish would not leave the preferred velocity without prompting and would often move back into the same spot before the second measurement was done (approximately one minute for two measurements). We conducted these velocity measurements in the smaller tributary streams of the Ahtanum drainage as well.

Figure 42 shows a section of the American River where we conducted velocity measurements in a bull trout holding area below the spawning grounds. Bull trout were observed holding in small pools where the two biologists are standing (via radio-tracking and snorkel survey). Velocities through the pools where the fish were holding are noted in red in the table inset (velocity range 1.4 to 1.85). The two pools were shallow, yet two-pound fish were not visible due to surface turbulence. The velocity preference was apparent even in shallow areas.

Habitat, Temperature and Velocity Preferences in the Ahtanum Creek Drainage

Bull trout in the Ahtanum Creek drainage which includes the North, Middle, and South Forks are chronically low in abundance. Hence, we did not capture and tag as many fish as in the Naches basin. We also had to be more selective of the adults we tagged since they were small fish and we needed to meet a minimum weight criteria of about 0.5 lbs. for the tag sizes that we had (see methods). Our tagged fish averaged about 0.75 lbs. Since we only tagged a total of seven bull trout in the Ahtanum drainage, we maximized opportunities to collect as much data about their movements and habitats as possible. Although resident-type bull trout in the Ahtanum drainage stay in their natal streams year-round, there is some seasonal movement of fish up and downstream, but on a much smaller scale than the distances traversed by fluvial-type bull trout in the Naches drainage. There were many good holding pools dispersed throughout the Ahtanum basin and we found fish well dispersed from the upper spawning grounds downstream to the tributary junctions.

We found adult bull trout over-wintering in small pools several miles below the spawning grounds. Velocity measurements were taken in several of the pools where we tracked our tagged fish. Flow velocities were very similar to that of the larger fluvial forms in the Naches River. We found preferred velocities for over-wintering fish in the N.F. Ahtanum ranged from 1.6 to 1.8 fps. Table 7 shows the velocity measurements for three of our tagged fish (Fish #45, #48, #54). Fish #45 was tracked to its over-wintering area on the N. Fork and flow velocities were measured at 1.7 fps at a one foot depth. Fish #48 over-wintered in a pool on the lower N. Fork and was the only fish that was tracked below the confluence of the North and Middle Forks. It was found holding at the tail out of the pool in 22 inches of water, with a flow velocity of 1.7-1.8 fps (Figure 43). Likewise, Fish #54 was tracked to its over-wintering area on the N. Fork and was found in an area with water depth of approximately 9 inches and a velocity range of 1.6-1.8 fps adjacent to a faster current.

Table 7. Flow velocities measured for three tagged bull trout in their respective over-wintering locations in the N.F. Ahtanum.

Fish#45 velocity preference

	Depths from left bank to right at one foot intervals							
Width	1 foot	2 foot	3 foot	4 foot	5 foot	6 foot	7 foot	8 foot
Depth	9"	8"	9"	17"	17"	9"	7"	6"
Flow	2	2.2	2.3	2.5	1.6	2.2	1.6	1.4

fish holding in zone at 1.7 fps

Fish #48 velocity preference

	Depths from left bank to right at one foot intervals							
Width	1 foot	2 foot	3 foot	4 foot	5 foot	6 foot	7 foot	8 foot
Depth	8"	12"	21"	23"	25"	19"	12"	6"
Velocity	1.2	1.6	1.8	1.7	1.6	1.3	1.2	0.8

Fish holding

Fish #54 velocity preference.

	Depths from left bank to right at one foot intervals							
Width	1 foot	2 foot	3 foot	4 foot	5 foot	6 foot	7 foot	8 foot
Depth	8"	12"	10"	8"	6"			
Flow	2.2	2.5	1.8	1.6	1.2			

Fish holding

Data loggers in the upper Ahtanum basin showed a large yearly fluctuation in temperatures from 28 F (-2 C) in the winter to a summer peak of 61 F (16.1 C) at the N. Fork/M. Fork confluence (Figures 44-46). [Note: the 67 F (19.5 C) summer peak at the N. Fork/Shellneck Cr. confluence in Figure 44 is not accurate as this logger was in a portion of the channel influenced by dewatering; peak summer temperature at the confluence is actually in the low 50’s F, see Figure 46]. Average summer temperatures ranged in the low to mid 50’s F (11 C) in the N.F. Ahtanum. Lowest winter temperatures were recorded at 28F (-2 C) near the N. Fork/Shellneck confluence (spawning grounds) during January and February. Some data loggers became completely encased in ice during the winter period. Nearly the entire creek at the higher elevations near the N. Fork/Shellneck Cr. confluence was frozen solid, providing no habitat for resident Ahtanum bull trout. It is likely that low winter flows coupled with frozen stream beds severely affect bull trout redds/eggs in this area. Average June-August temperature near the Shellneck Cr. confluence (spawning grounds) was 51 F; average temp during the mid-September spawning period was 45 F (7 C), although just prior to spawning, a dip was recorded to 38.5 F (3.5 C) on Sept. 15, 2004. Winter temperatures averaged 34 F (1 C) on the N. Fork spawning grounds. Adults tracked in the winter were found several miles below the spawning area where water temperature was slightly warmer.

Figure 43. Over-winter holding pool for Fish #48 in the N.F. Ahtanum Cr.

The N.F/M.F. Ahtanum confluence area (FMO habitat) was slightly warmer than the upper N.F./Shellneck confluence (spawning habitat). The average summer temperature was 54 F (12 C) from June through August, although cooler temperatures prevailed until mid June, where a 10 degree F (4 C) jump was recorded (Figure 45). High temps in this zone reached 61 degrees F (16 C), and the low was 44 degrees F (7 C) in early June. We tracked one fish several miles below the confluence where summer temperatures were warmer. All others were tracked to areas higher (cooler) in the system. Radio-telemetry showed fish were most active between early July and mid-August. Midnight temperatures during this period ranged from 44 F (7 C) on July 9, 2004 in areas near the spawning grounds to 58 F (14.5 C) on August 15, 2004 near the N. F./ M. F. confluence (see Figure 46). This increased activity appeared to be related to fish moving closer to the spawning grounds.

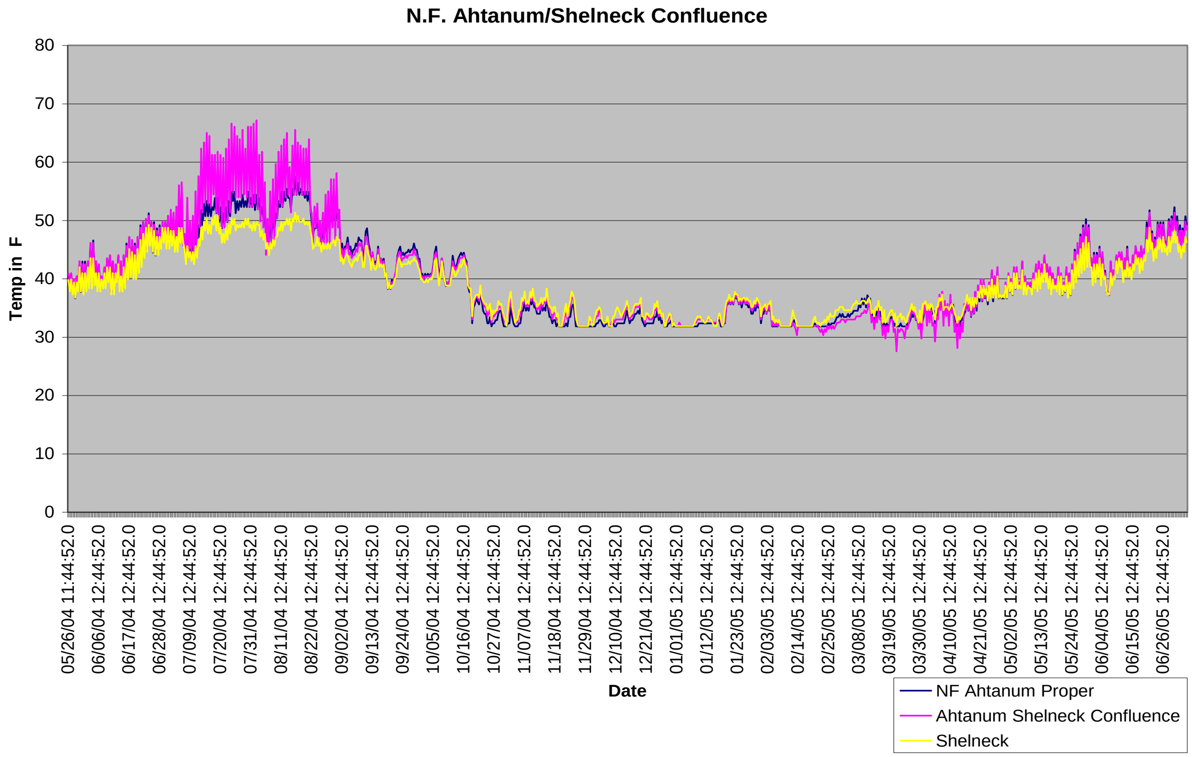

Figure 44. N.F. Ahtanum/Shellneck Creek temperatures, April 2004 to May 2005.

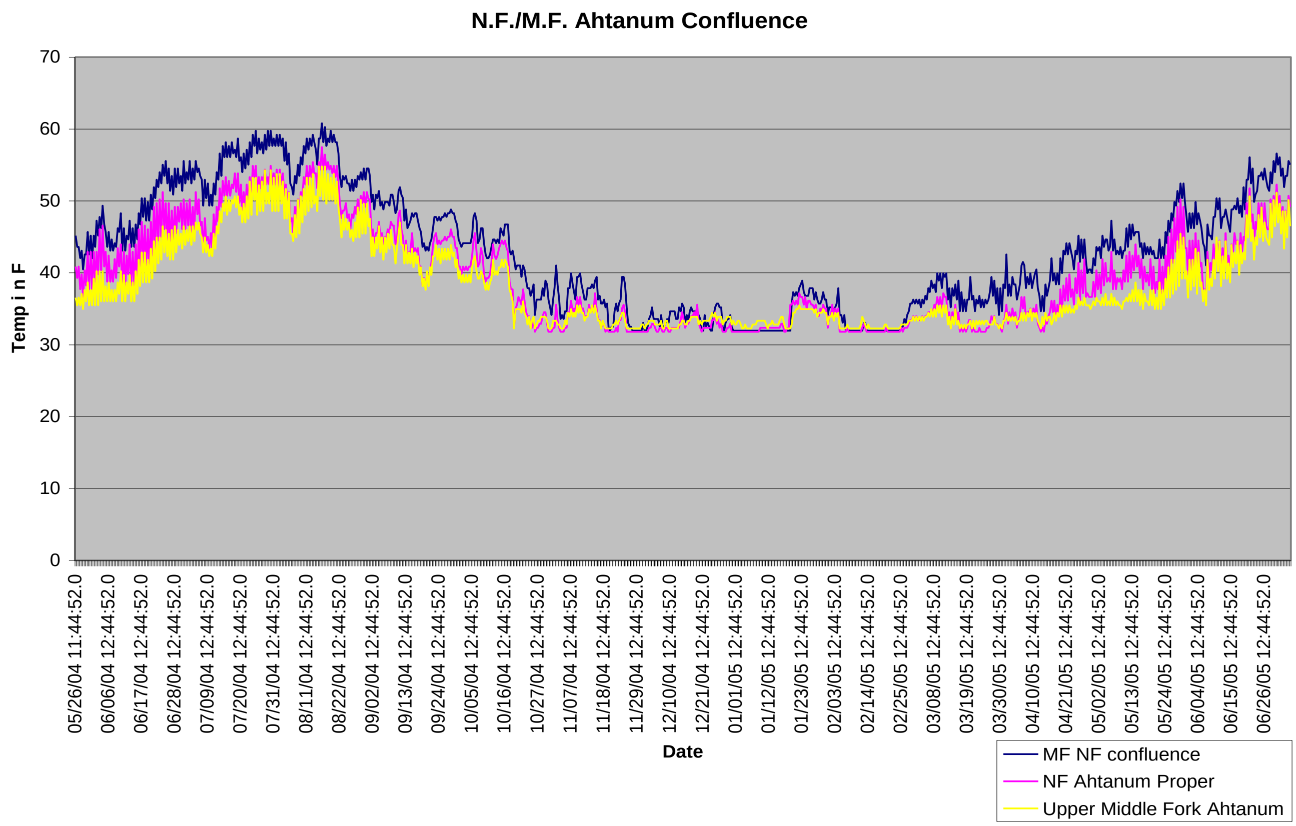

Figure 45. N.F./M.F. Ahtanum Cr. Confluence temperatures, May 2004 to June 2005.

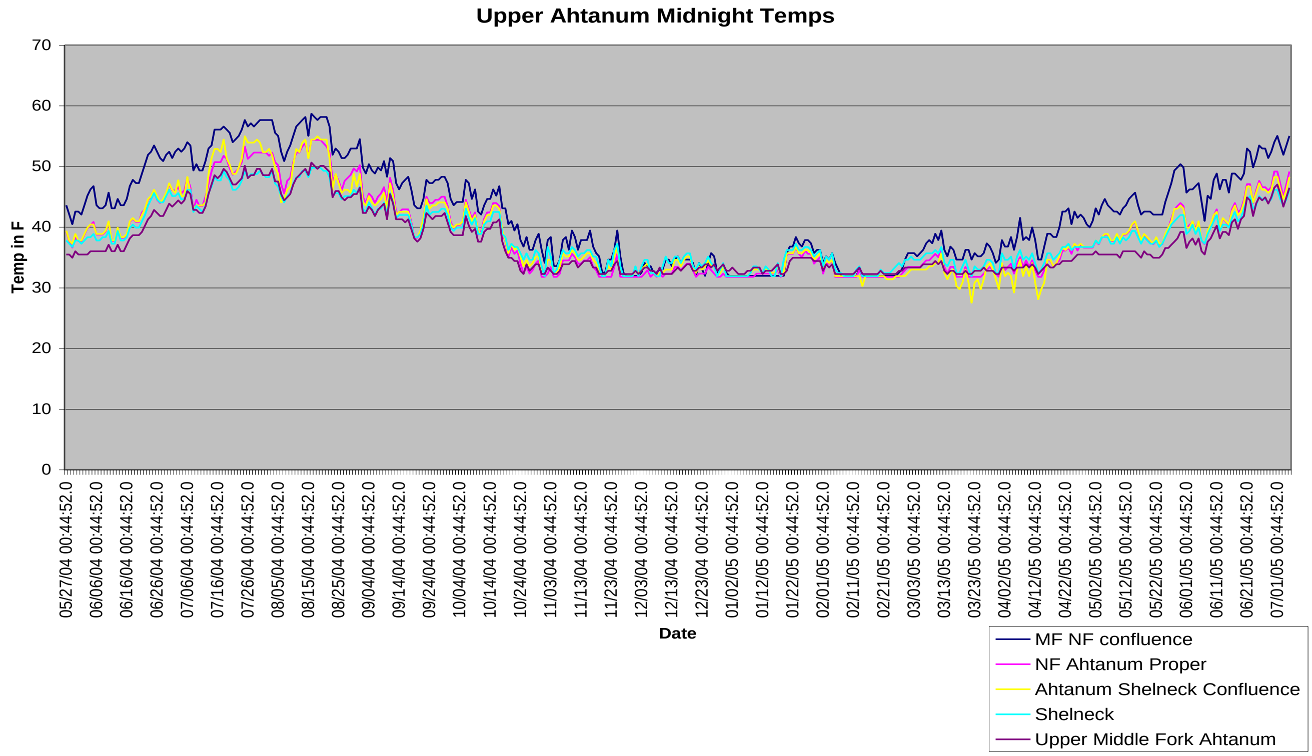

Figure 46. Upper Ahtanum Creek midnight temperatures May 2004 to July 2005.

Ahtanum Recreational Dams

During radio-tracking we encountered seventeen "recreational" dams on the North and Middle Forks Ahtanum Creek after the Memorial Day weekend in 2005 (Figure 47). Ten of these dams were impassable for bull trout. Some were two to three feet wide and one to two feet high. We breached these dams whenever possible, but it was a difficult and time consuming process for two people with hand tools as some dams were built with large material using all-terrain vehicles and winches. This is a significant problem for bull trout movement in the Ahtanum drainage.

Spawning Habitat in Tributary Streams

Although adult bull trout often migrated into their natal tributary streams well before the actual spawning period, the time spent on the actual spawning grounds was relatively short (i.e. 2-3 weeks) compared to the overwintering (i.e. 5-6 months) and foraging/migration (i.e. 5 months) periods. The habitat was also different. Generally, it consisted of smaller substrate material, with more gravel, small cobble and sand in smaller, higher gradient stream reaches than what we observed in typical FMO habitat. Also, spawning areas typically contained more woody debris. Spawning bull trout often preferred areas where cover was abundant and vegetation draped over the water or lay completely across the channel. Although redds were often in open exposed areas of the stream, adults were usually close to some form of concealment cover. Access to woody debris (log jams), large boulders, undercut banks, shoreline vegetative cover, deep pools, as well as substrate composition, water flow and temperature all play a crucial role in the selection of spawning areas. The water depth on spawning grounds was much shallower than the water depths associated with FMO habitat. Bull trout were often observed in shallow riffles a few inches deep to pool tail outs that were two feet deep.

Figure 47. Recreational dam below the N.F./M.F. Ahtanum Cr. confluence.

The following is a description of each of the major spawning tributaries where we radio-tracked bull trout. Adults were tracked from their lower river mainstem FMO habitat into the upper spawning tributaries where the bull trout continued to move slowly upstream to the actual spawning grounds.

American River including Union and Kettle Creeks

The American River is a tributary to the Bumping River, which enters the Bumping River at R.M. 3.5 on the left bank. It is approximately 24.5 miles long and has a watershed in excess of 50,000 acres. The American River is classed as a scenic, wild river. It is one of the few unregulated drainages in the Yakima Basin. The Forest Service performed Hankin-Reeves habitat surveys on or near the American R. bull trout spawning grounds (USDA Forest Service, 1992, 1998, 2001). We used some of their survey information in conjunction with WDFW field data to describe habitat for this report.

River sections we surveyed included from Hells Crossing Bridge at Hwy 410 (Elev. 3,120 ft.) to Union Creek, and from Lodgepole Campground to Morse Creek (Elev. 3,590 ft.). USFS completed H-R surveys in 1992 and again in 2001 and found that the American River averaged from 4-6 pools per mile (using ≥ 36 inches as the threshold pool depth). Woody debris was fair, averaging 164 to 302 small pieces of wood per mile, 84 to153 medium pieces of wood per mile, and 14 to 35 pieces of large wood per mile. Log jam complexes accounted for 79% to 91% of the wood, respectively. The sections where bull trout spawning occurs have an average gradient of 1.3%. Measured substrate averaged from 7% to 18% sand per section, 52% to 55% gravel per section, 28% cobble per section, 2% to 4% boulders per section and 1% to 6% bedrock per section. These measurements are consistent with our visual observations. The riparian zone consists of conifers, hardwoods, shrubs and grasses. There are several side channels with beaver dams on the upper reaches, including one large complex covering several acres.

The American River bull trout spawning population is relatively small averaging 4-5 redds per year and is approximately 14% of the annual redd count in the American/Union/Kettle spawning complex. Redds found during spawner surveys were scattered throughout the index area with no real pattern to placement. Redds were generally large and oriented out in the open channel although an occasional redd was found in a braided channel. Substrate was predominately large gravel and small cobble suitable for large fluvial spawning adults (avg. fork length 510 mm) (Figure 48). Average fork length for Union Creek bull trout was 489 mm.

Figure 48. Bull trout spawning on typical substrate in the American River above Union Creek.

Union Creek, a bull trout spawning tributary to the American River, joins the American River at Elev. 3,500 feet approximately 9.5 miles east of Chinook Pass (Figure 49). Union Creek enters the American River at RM 11.5. There are two impassable waterfalls less than 0.5 mile from the mouth of Union Creek, which limits the accessible spawning area. The upper waterfall is approximately 70 feet high and the lower is 18 feet high. The lower waterfall is a log jam that has been backfilled by gravel and rocks creating a second falls (see Figure 50). The majority of bull trout in the American River drainage, which includes the mainstem American River, Union and Kettle Creeks, spawn in Union Creek.

Figure 49. Overview of Union Creek and American River confluence along Hwy 410 (trail in yellow).

Union Creek is a medium to high gradient stream, comprised of large cobble and boulders near the waterfall, interspersed with pockets of gravel and cobble. The substrate becomes a mix of smaller cobble and gravel downstream. The riparian vegetation is thick in places, and is comprised of a mix of conifer, hardwoods, and thick understory shrubs. Additional shade is provided below the waterfalls by steep stream banks to vertical cliffs. Hwy 410 crosses Union Creek and there is a large USFS paved parking lot with access to hiking trails in the area. A hiking trail parallels the creek. A few private cabins are located along the east end of the creek.

Adult spawners that enter Union Creek typically stage below the Union Creek confluence in two deep pools in the American River. One pool is at the confluence while the second is 400 yards downstream (see Figure 35 and Figure 51). Both American and Union Creek spawners comingle in the two "staging pools" until the majority of the fish move into Union Creek to spawn. This pool has received illegal fishing pressure in the past. The river in this area is closed to fishing from July 16 to September 15 each year by permanent regulation to protect staging and spawning bull trout. Spawning takes place from the last week in August to the third week of September. Spawning sites in Union Creek consisted of pea sized gravel to small cobble, interspersed among larger boulders, or under overhanging brush or logs. Redds have even been located under the hiking trail bridge that crosses the creek. Habitat choice during spawning seems to be driven to a large degree by direct physical cover over the spawning site or accessible cover nearby to hide under. Acceptable spawning sites are at a premium due to the small area and relative number of fish spawning. Several redds have been found near the base of the lower falls in small pockets of gravel among the large boulders.

A data logger was placed below Union Creek Falls in June 2005 to record temperatures before, during and after spawning. Temperatures fluctuated from the mid 40's F (5 C) to lower 50's F (11 C) from late June through mid-August (Figure 52). By late August temperatures were in the mid to lower 40's (6 C) (spawning period) and stayed in the lower 40's to the upper 30's (4 C) through October. Union Creek has a stable temperature regime compared to many other small streams in the basin.

Figure 50. The barrier water falls on Union Creek.

Figure 51. Staging pool on American River below Union Cr. (Union Pre-Spawn Pool #2).

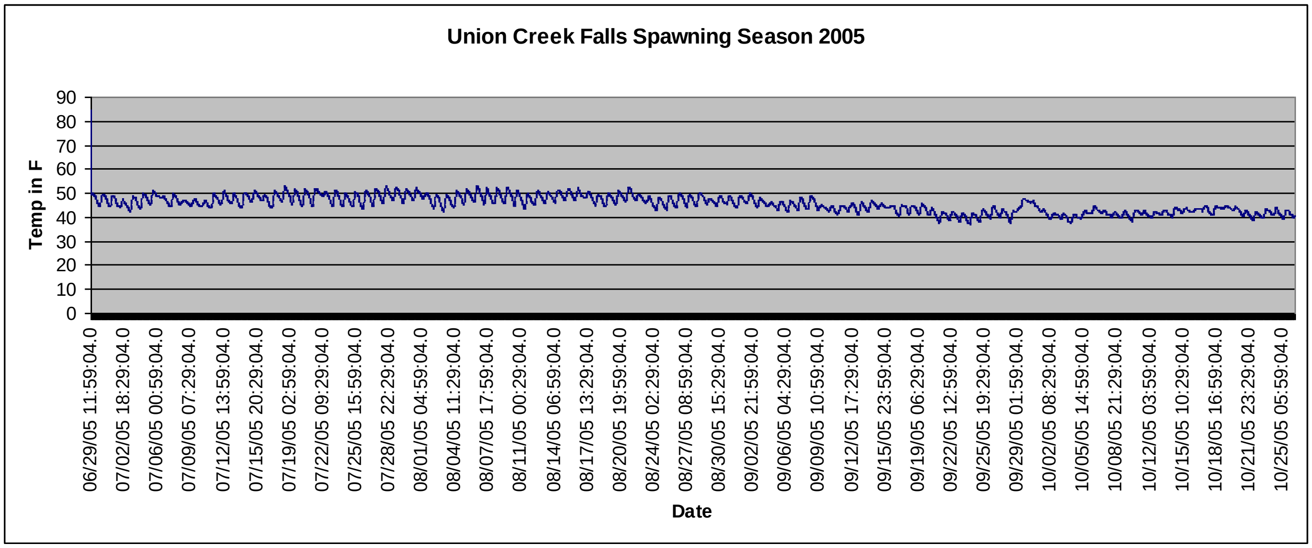

Figure 52. Union Creek temperature profile for June through October 2005.

Kettle Creek enters the American River on the right bank directly across from the upper section of the USFS Pleasant Valley Campground (RM 9.7) (Figure 53). The creek contains a large amount of woody debris and thick forest canopy that shades the creek throughout much of the day. There were several small braided sections on the creek with some meandering through the trees creating undercut root sections and undercut banks. Some of these braided sections have created new short step falls where they re-enter creek. The index area ends in a steep gradient canyon with a series of cascade waterfalls, approximately 0.75 miles from the mouth.

Spawning in Kettle Creek takes place on small pea gravel to medium sized gravel that is interspersed throughout the length of the creek. These gravel patches or pockets are scattered among larger cobble and imbedded woody debris. The creek has a moderate gradient until the area near the canyon, where the gradient becomes steeper. The creek is surrounded by a fairly thick over story canopy consisting of mostly coniferous trees, while there are some large shrubs along the edges of the creek. The Kettle Creek trail crosses Kettle Creek approximately 0.25 miles above the mouth. Kettle Creek water temperatures from late August through early October (2001-2005) averaged 45 F (7.7 C) with a high of 49 F (10 C) and a low of 42 F (5.5 C). The creek has an annual redd count of 3 to 5 redds.

Figure 53. Overview of Kettle Creek and American River confluence along Hwy 410. Kettle Creek trail in yellow.

Rattlesnake Creek

Rattlesnake Creek flows approximately 28 miles from its source in the Cascade Range into the Naches River at river mile 27.8, near the community of Nile. The headwaters originate near the 4,000 foot elevation and the average gradient can vary from 2% to 6%. The creek drains an area of approximately 134 square miles and is tightly confined for over half its length in a steep walled canyon. The canyon walls can reach from 100 to over 1000 feet high and in some areas lie adjacent to the bank of the creek (Figure 54). The steep canyon walls provide shade during most of the day, while the few wider areas have a mix of Engelmann spruce, cedar and alder, as well as a variety of understory species. The bull trout spawning area extends from RM 19 to RM 21.

The Forest Service conducted Hankin-Reeves habitat surveys in 1996 on or near the spawning index areas of the middle to upper reaches of Rattlesnake Cr (USDA Forest Service, 1996). We used their data in conjunction with our field surveys and temperature data to describe habitat in Rattlesnake Creek. These surveys found that instream wood and riparian cover is scarce in much of Rattlesnake Cr., especially in the canyon areas. Cover and woody debris become more common in the upper reaches in the bull trout spawning index upstream of the N.F. Rattlesnake Cr. confluence. There are also more braided channels in the upper reaches. Substrate consisted of more cobbles and boulders in the lower reaches with a higher percentage of gravel toward the headwaters. A greater mixture of gravel, woody debris, riparian cover and cooler spring-fed water in the upper reach is the preferred spawning habitat for bull trout. The USFS surveys indicate there were 12.6 pools per mile in Rattlesnake Creek. These pools serve as excellent holding or resting areas for adult bull trout on their upstream spawning migration (Figure 55).

Figure 54. Mid to upper Rattlesnake Creek habitat with steep canyon walls.

Figure 55. Typical Rattlesnake Creek holding pool.

Water temperatures measured during August 1996 by USFS survey crews in upper Rattlesnake Cr. averaged 47° F. WDFW annual spawning surveys indicate a similar temperature profile, but cooling into the lower to mid-40's F. by mid-September. Temperatures in lower Rattlesnake Cr. can easily be 10° F. warmer than the upper Rattlesnake during September (mid to upper 50's F). Water temperatures in the lower reach are at their peak during late July-August. Radio-tracking data indicates that bull trout move upstream before this temperature peak occurs. Unfortunately, we did not obtain daily temperature information from loggers that were placed in the upper and lower sections of Rattlesnake Creek due to a freshet that destroyed one and another that was de-watered.

Regardless, temperature readings during spot surveys and radio-tracking provided useful information. One of our temperature probes was successfully retrieved from the Naches River near the Rattlesnake/Naches confluence (Figure 56). Water temperatures in this section of the river can reach 70° F. during August.

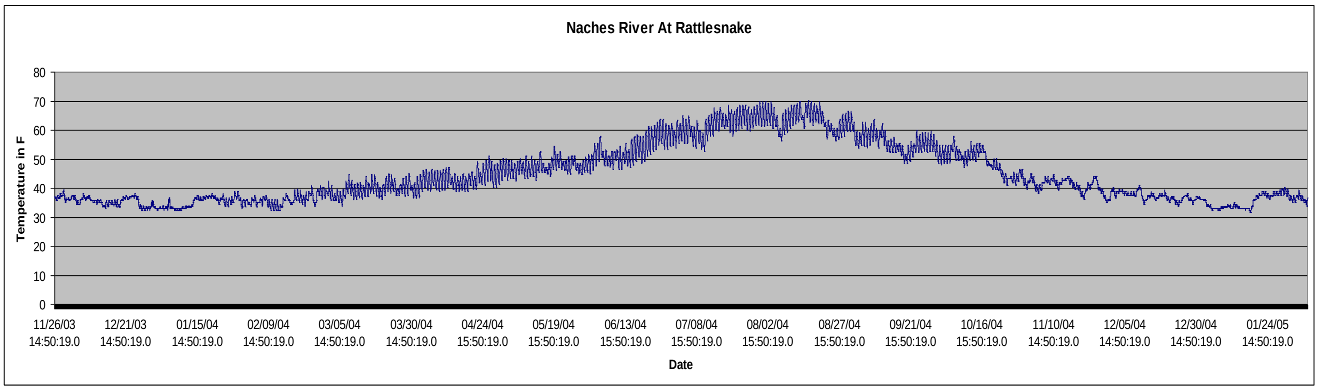

Figure 56. Naches river temperatures above the Rattlesnake Cr./Naches River confluence.

Crow Creek

Crow Creek is a right bank tributary of the Little Naches River at RM 3.2. The headwaters of Crow Creek are in the Norse Peak Wilderness Area. There is a heavily used USFS campground near the confluence of Crow Creek and the Little Naches River. The lower section of Crow Creek runs through a steep valley, with vertical cliffs over 200 feet high in some places. The upper section of Crow Creek, including the spawning area, is wider with a moderate gradient (3%), (USDA Forest Service, 2000).

The USFS survey in 2000 included portions of the bull trout spawning index area. Surveys included a lower section of Crow Creek from creek mile (CM) 3.7 to 5.4, and an upper section from CM 5.4 to 8.7. The upper section contained the bull trout spawning area. It had an average of 25 pools per mile (Figure 57). Sections of the upper area are littered with huge boulders that trap woody debris and gravels, and create deep pools (Figure 58). There is a landslide area that has bare rock, sand and clay, below exposed limestone cliffs near the lower end of the spawning index area (Figure 59). All of the redds that have been observed in Crow Creek have been above this slide area, indicating the area below the slide may be less desired for spawning due to sediment input.

Figure 57. Typical upper Crow Creek habitat pool.

Figure 58. Crow Creek spawning area with boulders and typical woody debris.

The dominant understory is alder and thick shrubs, with the over story being spruce and cedar with lesser concentrations of hemlock and lodgepole pine. The USFS survey in 2000 found slightly over 78 pieces of medium and large woody debris in the upper survey reach (CM 5.4-8.7). Water temperatures in the upper reach ranged from 42^o F (5.5^o C) to 52^o F (11^o C), with an average of 46.4^o F (8^o C). WDFW temperature readings during September spawning surveys (2002-05) ranged from 42^o F (6^o C) to 46^o F (7.8^o C) with an average of 44.8^o F (7^o C). WDFW temperature data loggers placed in upper and lower Crow Creek were also lost during the freshet in 2005.

The spawning area has diverse habitats, from cobble-filled channels to areas with 12 to 18 foot diameter and larger boulders, to slow areas with beaver dams, and cascading high gradient falls. The USFS found an average upper reach (CM 5.4 to CM 8.7) substrate to be 42.7% gravel, 39.4% cobble, 11.8% boulder, and the remaining 6.1 % sand and bedrock.

Figure 59. Slide/bedrock area below Crow Creek spawning index area.

Habitat Below Storage Dams –Tieton River & Bumping River

Tieton River

The Tieton River below Rimrock Dam undergoes a yearly "flip-flop" flow operation in September (flows ramp up in late August), so that water can be used for downstream irrigation needs. "Flip-flop", which increases the release of water from Rimrock Reservoir, flushes gravel downriver and has led to an imbedded cobble/boulder substrate. The river stays cool because of the cold water being released from the bottom of the lake, but otherwise it does not create a very hospitable environment for fish in the Tieton River. Peak flows are very high, fast and turbid; essentially flushing gravel, wood and aquatic insect production from the Tieton R. into the lower Naches R.

Bull trout, kokanee salmon, rainbow trout and other species are entrained and discharged into the stilling pool at the base of the dam. At times fish must pass through the hydroelectric turbines that were installed in 2006, depending on the total flow being released by the U.S. Bureau of Reclamation. Neither the dam outlet nor the hydroelectric project is equipped with fish screens to prevent entrainment. Other than a large, deep rearing pool for entrained fish, a forage base of kokanee for bull trout to eat, and a link with the Naches River downstream, the Tieton R. does not provide much habitat benefit for bull trout or any other fish species under current water management practices.

Bumping River

The Bumping River below Bumping Dam is home to bull trout, brook trout, cutthroat trout, whitefish and spawning chinook salmon. The river has a good mix of substrate, from small boulders to gravel, sand and fine sediment. Several angling trips were made to the 10.5 mile reach from the dam to the American/Bumping confluence to capture bull trout for tagging. The two deep pools below the dam and spillway were the only locations where bull trout were caught. This was similar to the bull trout utilization below Tieton Dam, except that habitat conditions in the Bumping River are more favorable for fish because the USBR-regulated flow regime is not as extreme.

Temperature data loggers showed that peak temperatures in the upper and lower reaches of the river are nearly 70^o F (22^o C) in early August, creating a thermal barrier to bull trout movement during the migratory period (Figures 60 and 61). A total of five bull trout were caught in the two pools below the dam and three were tagged. Although we did not capture and tag many bull trout, the habitat in the Bumping River is quite good. There is a large amount of quality gravel, woody debris, forest canopy and riparian cover.

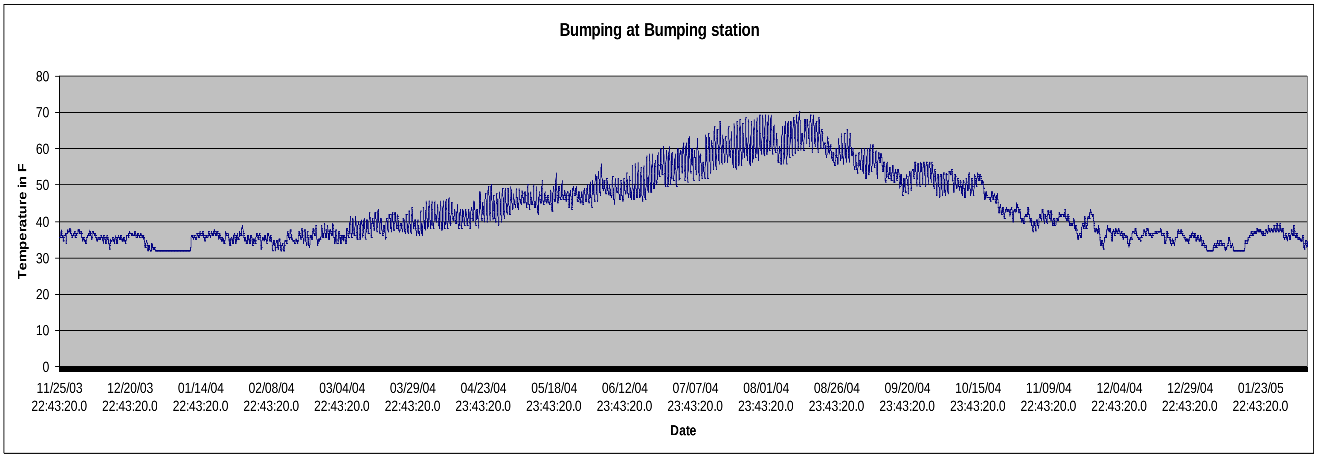

Figure 60. Bumping River temperatures at Bumping River station Nov 2003 to Jan 2005.

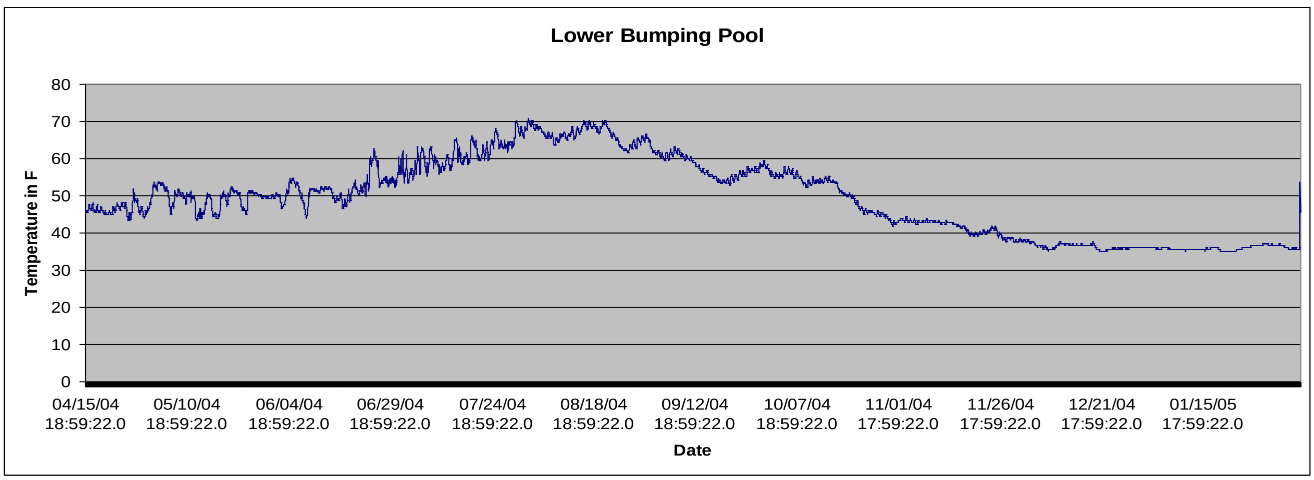

Figure 61. Bumping Dam spill pool temperatures from mid-April 2004 to mid-Jan 2005.

Spawning Surveys

This final report version was updated with bull trout spawning data through 2015. A summary for all years from 1984 to 2015 is listed in **Appendix 6 – Bull Trout Redd Summary** with trend data in Figure 62 (below). There is also an updated **Spawning Distribution Map in Appendix 8.** In 2015, the spawning survey total redd count in the basin was only 342 redds. This is down significantly from 2014 (426 redds) and substantially lower than the previous 20-year average (1995 – 2014) of 580 redds. Peak counts in the basin occurred in 2000 (704 redds) and 2008 – 2012 (range 687 – 795 redds). Most of this increase can be attributed to three adfluvial populations; Indian, S.F. Tieton and Deep. When one of these populations' crashes it greatly affects the overall basin redd count. This happened in 2000 – 2004 in Indian Creek (e.g., 226 redds in 2000 to 50 redds in 2004) and again in 2012 – 2015 (e.g. 174 redds in 2012 to 10 redds in 2013). Deep Creek also experiences these large swings in redd counts (see Appendix 6). This is caused by a combination of factors including drought, low flows, low reservoir levels creating passage barriers for adult migration or high turbid flows that scour redds and flush juveniles from natal rearing areas. Either way, recruitment in subsequent years can be severely affected. The S.F. Tieton River is more stable and absorbs these impacts better and has the healthiest population in the basin. The last few years have been particularly tough on bull trout in the basin, beginning with September storm cells and heavy rains in 2013 that generated high flows that flushed spawning areas and increased sediment bedload / turbidity levels and severe drought conditions in the summer and fall of 2015 which created low stream flows that hampered upstream migration of adults into spawning areas. Recent (December 2015) rain on snow events in the mountains has also triggered historic high flow events in area streams. These high flows scoured stream beds and delivered sediment onto bull trout redds and will likely reduce bull trout recruitment in the future.

Figure 63 graphically shows that approximately 80% of the redds in the basin are in the Rimrock and Bumping drainages. These adfluvial populations are represented by the South and North Fork Tieton River and Indian Creek (Rimrock Lake) and Deep Creek (trib. to Bumping Lake). The other adfluvial populations in the upper Yakima are very weak; they include Gold Creek, Box Canyon Creek, and the Kachess River. The fluvial populations in the Naches include the American River, Rattlesnake Creek & Crow Creek. Crow Creek is severely depressed and although not healthy, the American and Rattlesnake populations are relatively stable (at low levels). The resident Ahtanum population continues to be chronically low and depressed and is near extirpation. Bull trout are already considered to be functionally extirpated in the Teanaway, Cle Elum and Waptus Rivers.

Details of the spawning survey results for each population in the Yakima core area is outlined in the following sections. The total length of the stream index area is noted in parenthesis next to the population (stream) name. Results are generally organized by drainage, starting with lower end tributaries and working upstream with resident and fluvial populations grouped first, upper basin adfluvial populations grouped second.

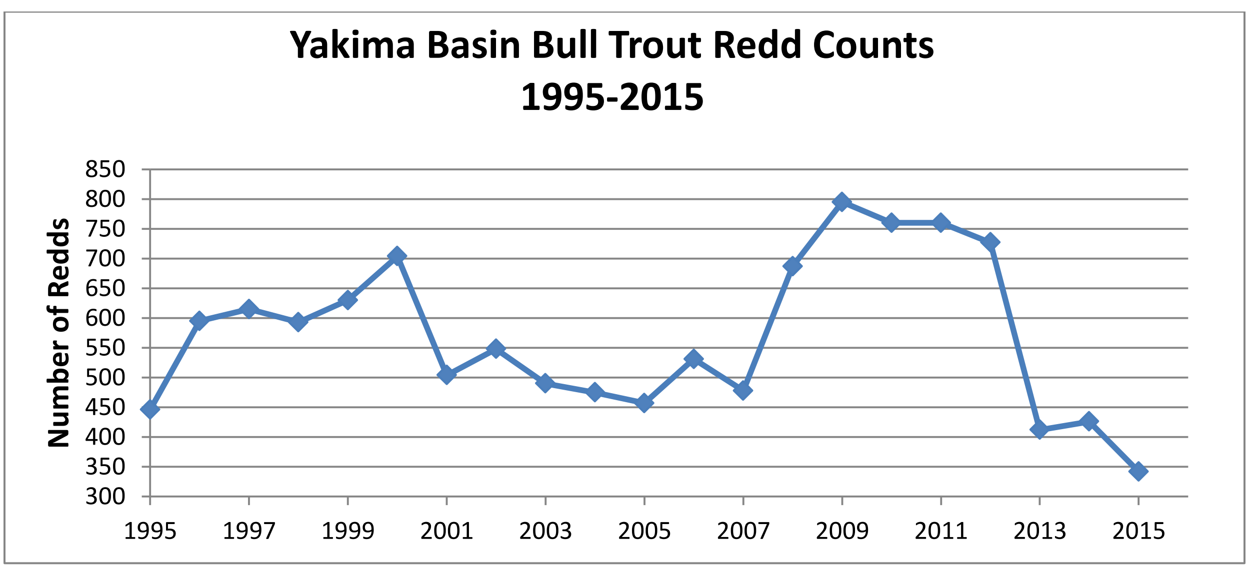

Figure 62. Bull trout redd counts in the Yakima basin.

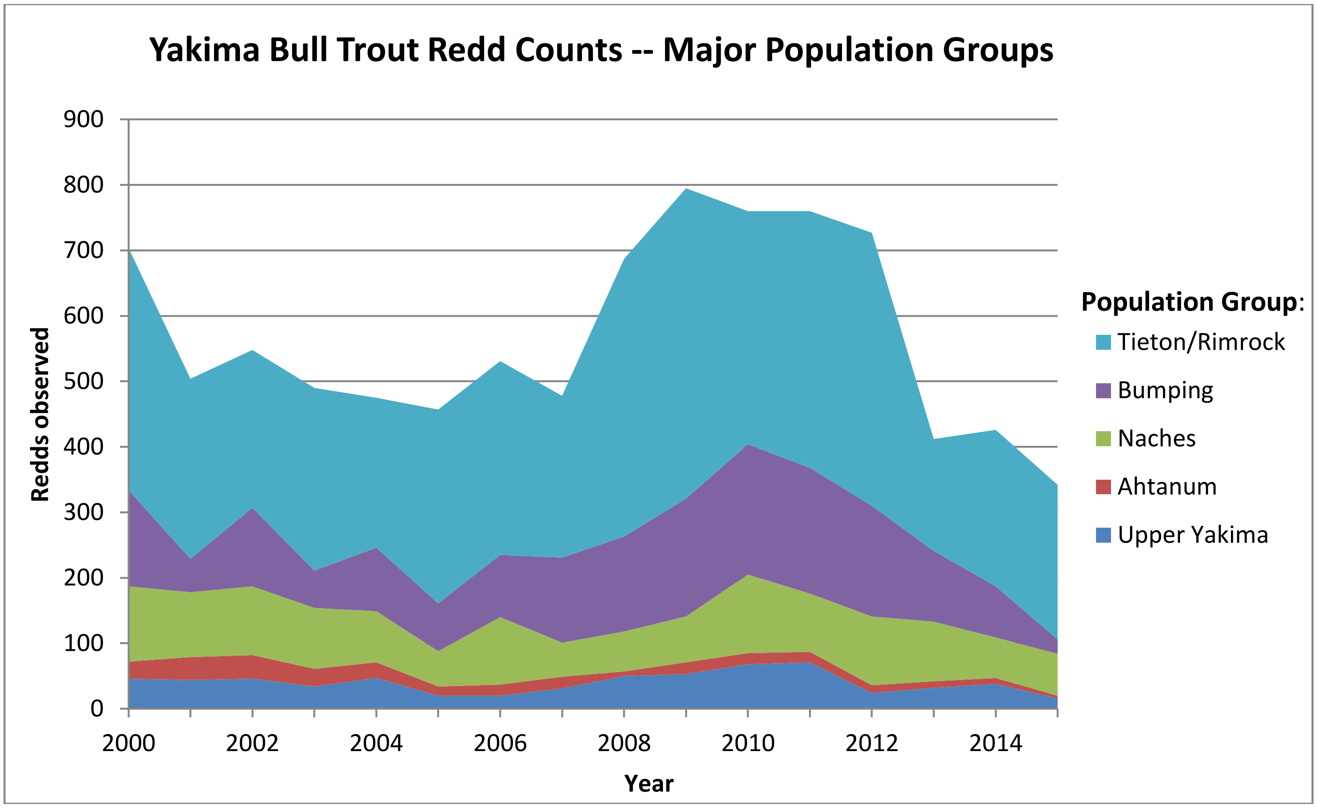

Figure 63. Bull Trout redd count trend data for major population groups.

Ahtanum Creek Drainage – 1 resident population

North, South & Middle Fork Ahtanum Creek (index area surveyed was 7.1 river miles)
In 2015, a total of four redds were found in the Ahtanum drainage; all were in the M. Fork, none in the S. or N. Forks (see summary table in Appendix 6). The total count for the Ahtanum drainage remains very depressed and continues to spiral downward since the record high counts of 35-36 redds in 2001-2002 (Figure 64). In 2013 the N. Fork had a considerable amount of channel alteration, sediment & gravel movement caused by large rain events during the spawning period which probably impacted this population. Although conditions were much better in 2014 the population remains in critically low abundance. Low flow and warm water conditions during the summer drought of 2015 also contributed to the low count and absence of spawning activity in the S. and N. Forks.

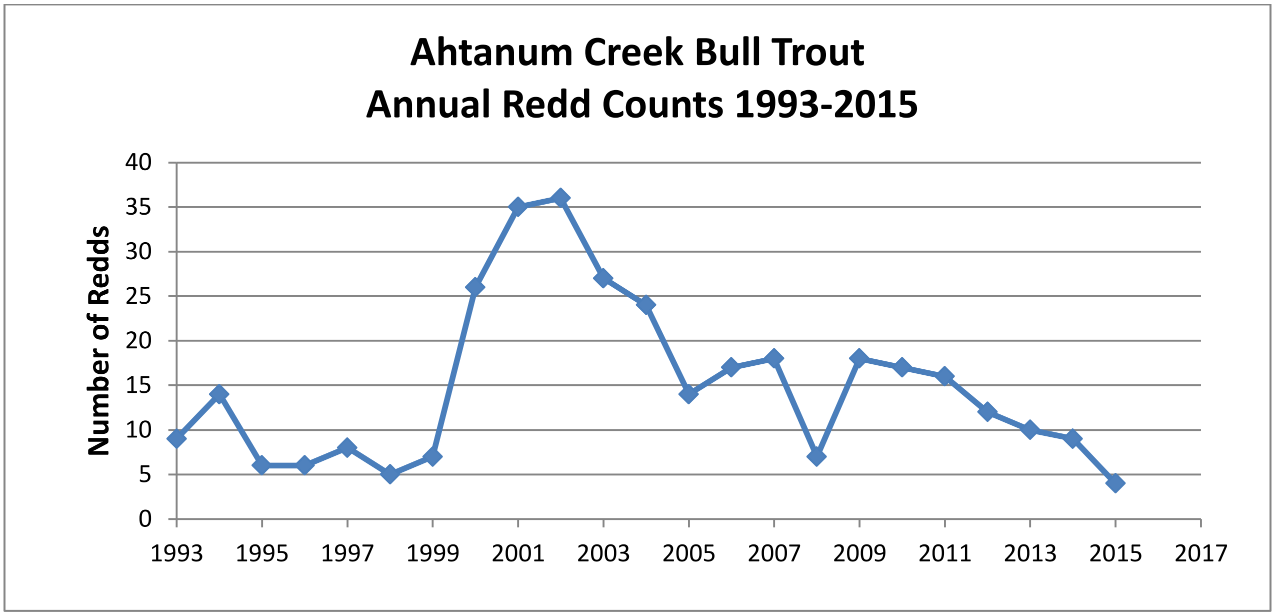

Figure 64. Bull trout redd counts in Ahtanum Creek.

Naches River Drainage including Rimrock & Bumping Reservoirs – 3 fluvial, 4 adfluvial populations

Rattlesnake Creek (index area surveyed was 7.7 river miles; fluvial population)
A total of 28 redds were counted in 2015 in the Rattlesnake drainage, which includes Little Wildcat and Shell Creeks. This is a little better than last year's count (23 redds in 2014) but down considerably from the peak counts of 2002 (69 redds) and 2010 (64 redds) (Figure 65). The lower count appears to be in part due to a large debris jam preventing upstream migration of adults into the upper spawning area as well as the low flows created by this summer's drought conditions.

American River (index area surveyed was 4.3 river miles; fluvial population)
The redd count in the American River drainage, which includes Union and Kettle Creeks, dropped to 31 redds in 2015; a bit lower than the 37 redds in 2014. Peak redd counts occurred in 2006 (55 redds), 2012 and 2013 (54 redds in each year) (Figure 66). The American River population, like the Rattlesnake has experienced considerable variation in redds the past 20 years and continues to exist in a moderately depressed state.

Crow Creek (index area surveyed was 2.5 river miles; fluvial population)
Only 5 redds were counted in Crow Creek in 2015. Redd counts in Crow have been chronically low for the past 15 years (Figure 67). The highest recorded counts were in 1999 and 2000 (19 and 26 redds, respectively). The lowest recorded count occurred in 2008 and 2014 (2 redds).

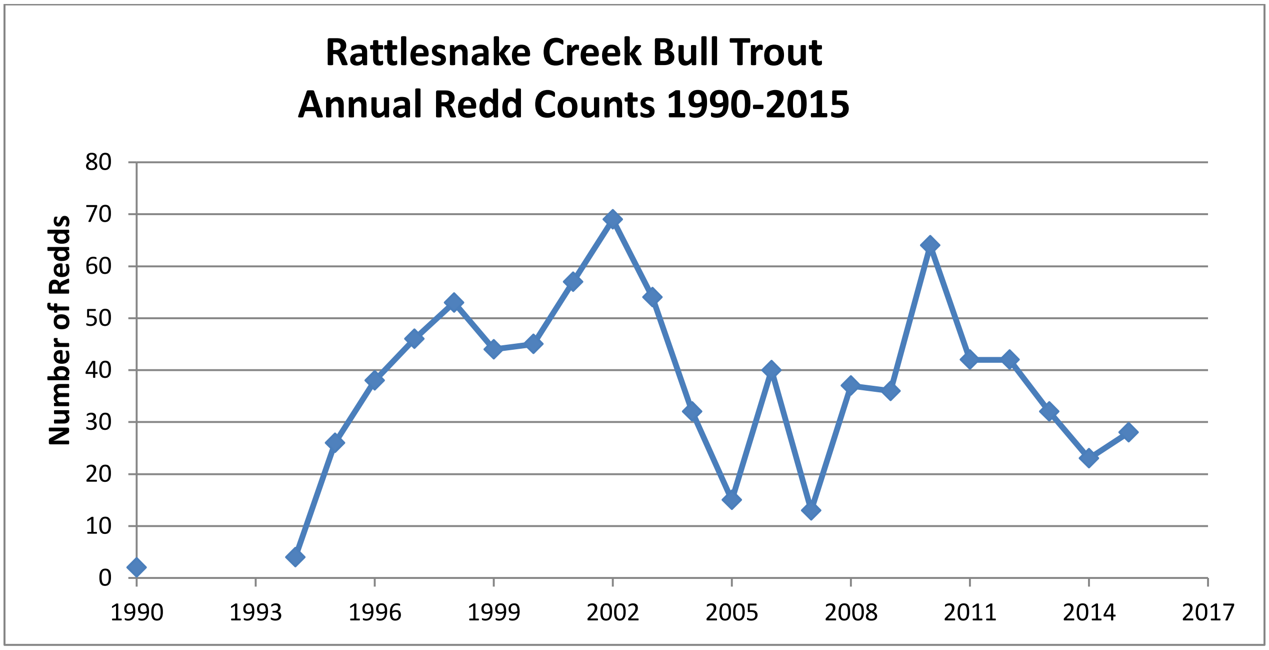

Figure 65. Bull trout redd counts in Rattlesnake Creek.

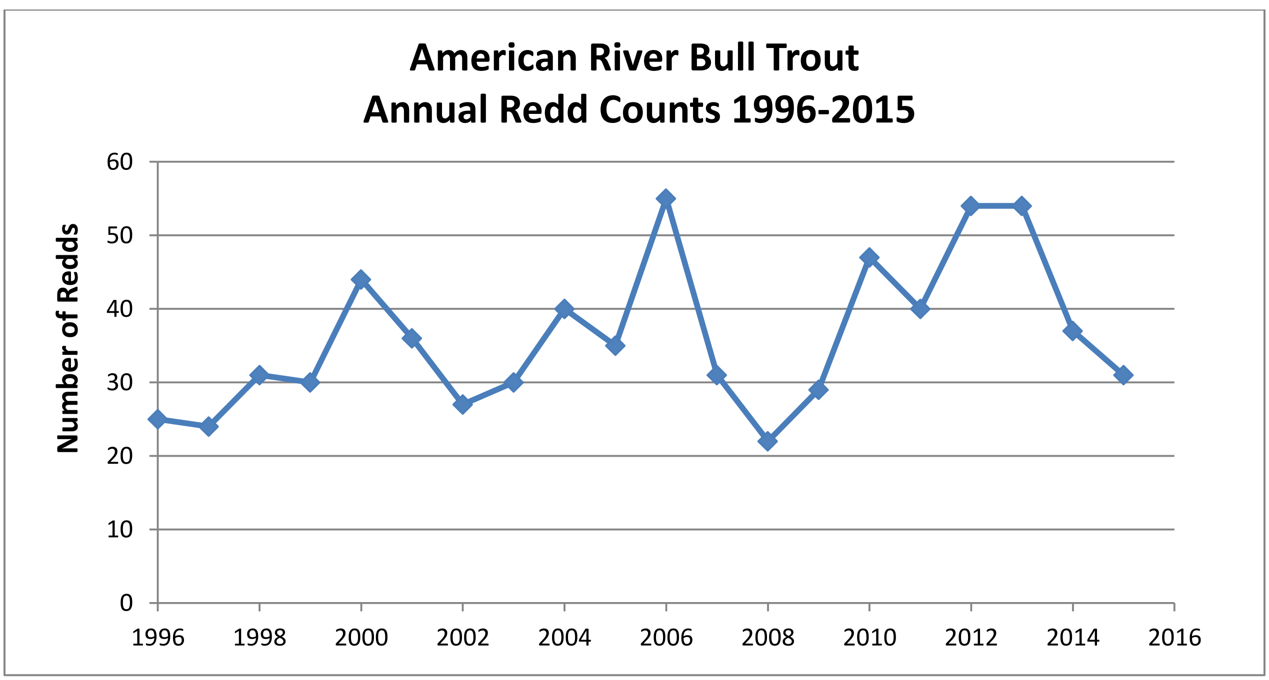

Figure 66. Bull trout redd counts in the American River.

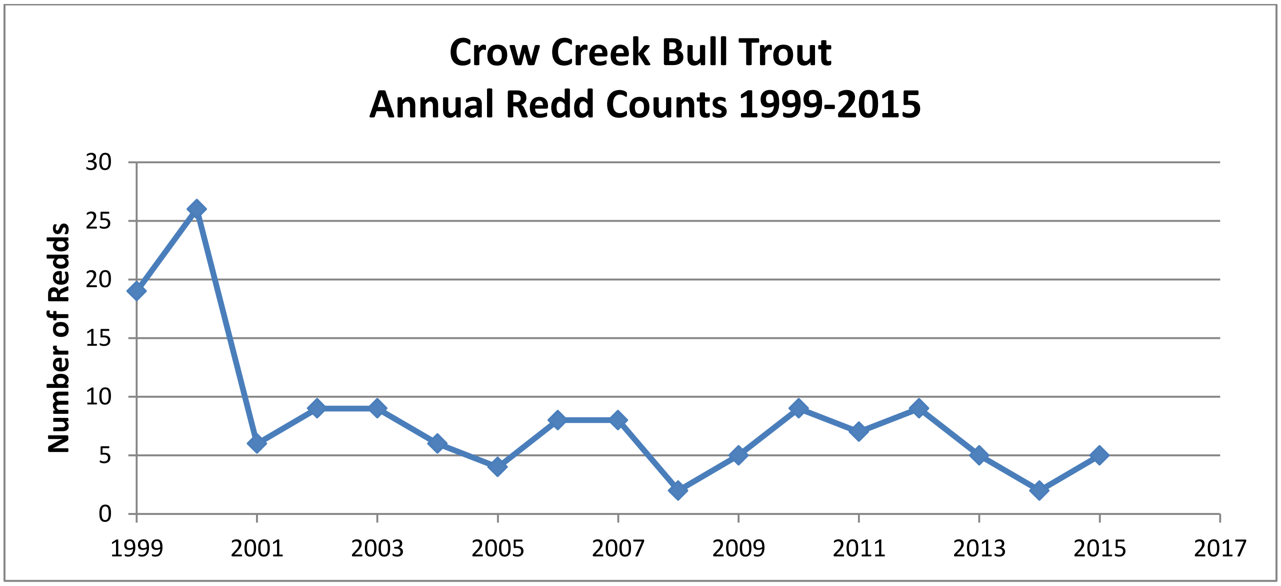

Figure 67. Bull trout redd counts in Crow Creek.

Rimrock Reservoir – 3 adfluvial populations

S.F. Tieton River (index area surveyed was 6.4 river miles; adfluvial population)
There were 160 redds counted in the S. F. Tieton index area (including Bear Creek) in 2015. There were an additional 10 redds counted outside of the standard index (176 total redds). Although the redd counts in the S. Fork were down a bit this year, it remains the most consistently stable and healthy population in the basin averaging nearly 190 redds for the past 20 years (1996-2015) (Figure 68). This larger river tends to have more stable flows with good spawning habitat.

Indian Creek (index area surveyed was 4.3 river miles; adfluvial population)
The total count in Indian Creek includes several spring tributaries. In 2015 we only counted 49 redds, but this was a substantial improvement over the last 2 years (10 redds in 2013 & 28 redds in 2014). During the 2013 spawning period massive sediment and debris flows in the spawning area altered the stream bed and channel composition and wiped out redds that were deposited early in the season. These changes to channel morphology and composition appeared to discourage spawning activity in 2014, but improved in 2015 even with the low flow drought conditions. The more stable spring flows in Indian Creek likely contributed to the better spawning activity. The population has had major winter flood damage in the past that has affected recruitment with major fluctuations of 226 redds in 2000 to 10 redds in 2013 (Figure 69). Hopefully, the population can rebound from low levels these past few years.

N.F. Tieton River (index area surveyed was 2.3 river miles; adfluvial population)
The redd count in the N.F. Tieton River which includes an unnamed tributary (unofficially called Hellbender Creek) was 27 redds in 2015 (Figure 70). Thirteen redds were in Hellbender Creek and fourteen redds in the N. F. Tieton. High, turbid flows often preclude getting a complete count in the main stem of the N.F. Tieton, but conditions were favorable this year and a complete count was made. A detailed study by the USFWS on timing and movement patterns for adult bull trout has been ongoing the past few years (Thomas, J. 2015. pers. com.). WDFW has been assisting the USFWS with this effort. A final detailed study report should be available in 2016.

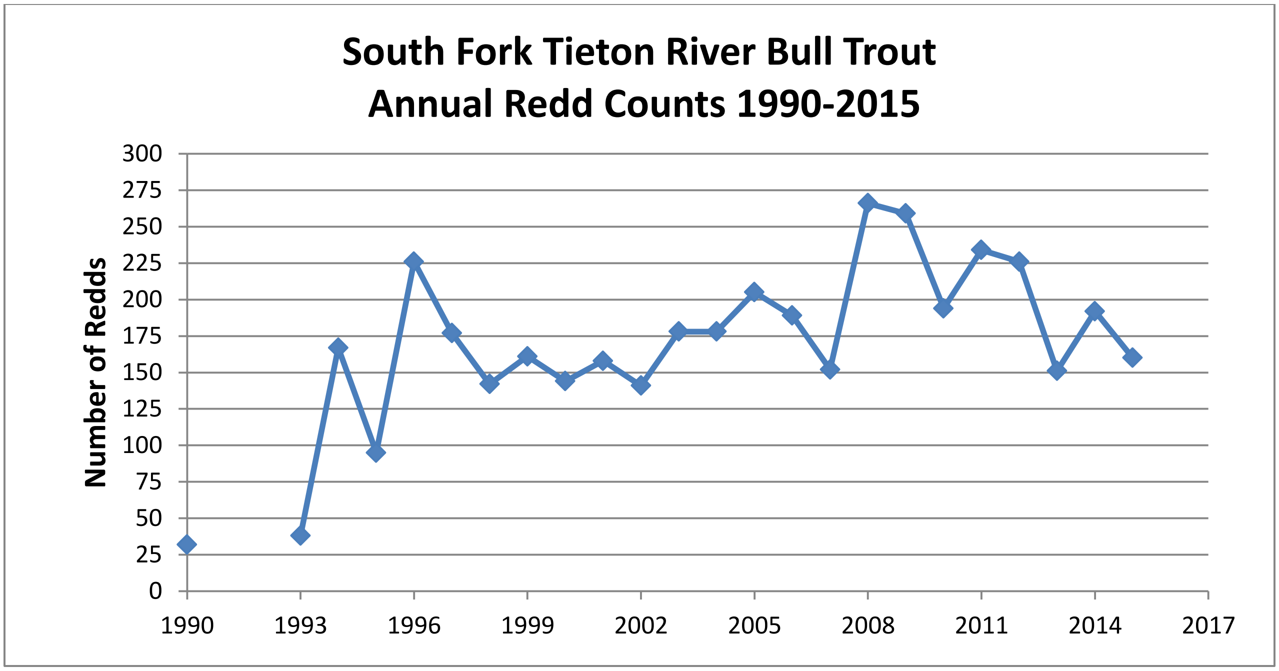

Figure 68. Bull trout redd counts in the South Fork Tieton River.

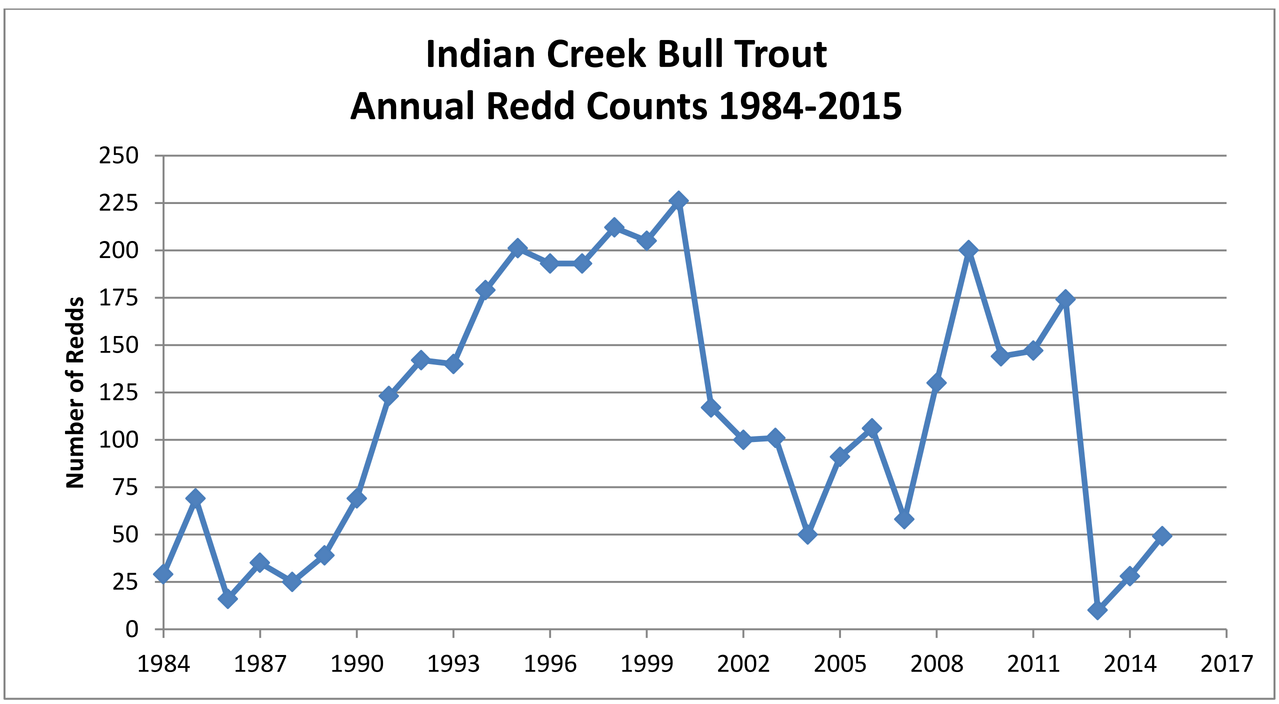

Figure 69. Bull trout redd counts in Indian Creek.

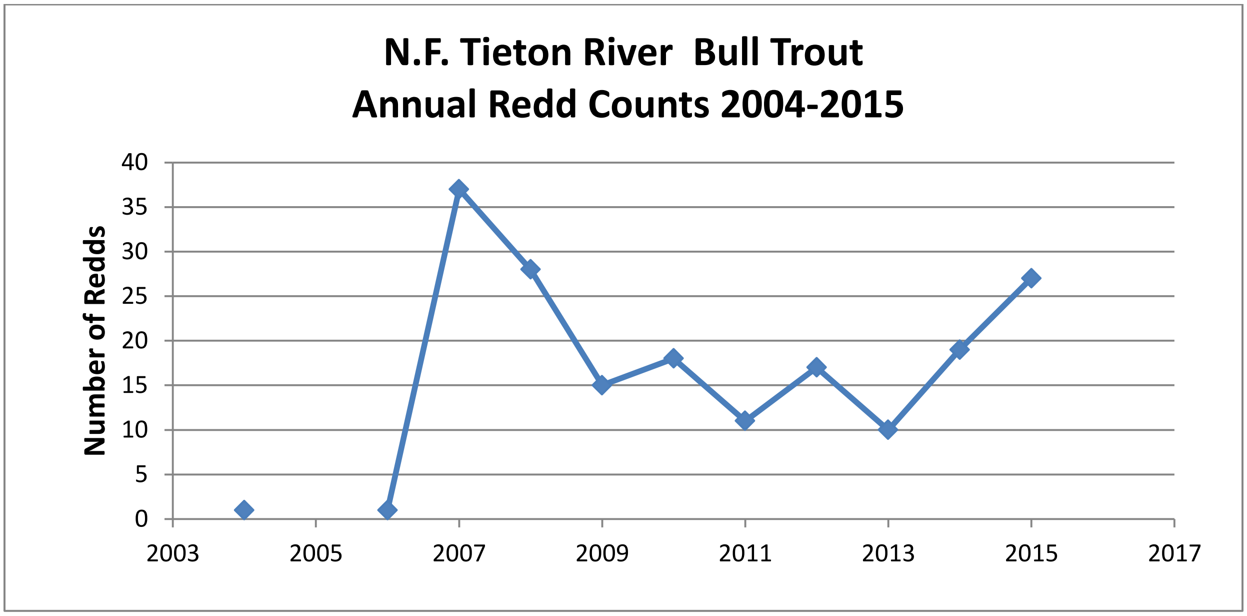

Figure 70. Bull trout redd counts in the North Fork Tieton River.

<u>Bumping Reservoir – 1 adfluvial population</u>

Deep Creek (index area surveyed was 5.75 river miles; adfluvial population)
In 2015 there were only 22 redds observed in Deep Creek. This is the lowest count in 21 years (i.e., 12 redds in 1994). Although there have been some comparatively high redd counts over the years, especially from 2007 – 2012 (range 130-199 redds), there have been some large annual fluctuations (Figure 71). This appears to be influenced by low and dispersed stream flows across the dry reservoir bed of Bumping Lake, as it is drafted lower in the late summer and by dewatered sections of the creek in the mid to upper reaches. Both conditions create adverse passage for bull trout and elevate the mortality rate for adults, sub adults and juveniles.

Upper Bumping River (index area surveyed was 0.5 river miles; not distinct from Deep Ck.)
Recent genetics analysis (Small, M. 2011, pers. comm.) has revealed that bull trout in the upper Bumping River are not a distinct population, but the same as Deep Creek bull trout. In 2014 a snorkel / redd count survey was conducted in the upper and lower Bumping River. Only one small redd was observed in the upper Bumping; it was unknown whether bull or brook trout redd. No redds were observed in the lower Bumping River. In 2009 there were only two redds and none in 2010, 2011 or 2012 (Figure 72). There were no redd counts conducted in the Bumping River in 2015. Water temperatures during the peak spawning period are consistently warmer in the upper Bumping River (mid 50's F) compared to temperatures in nearby Deep Creek (mid 40's F) and thus the upper Bumping is not a favored spawning area for bull trout.

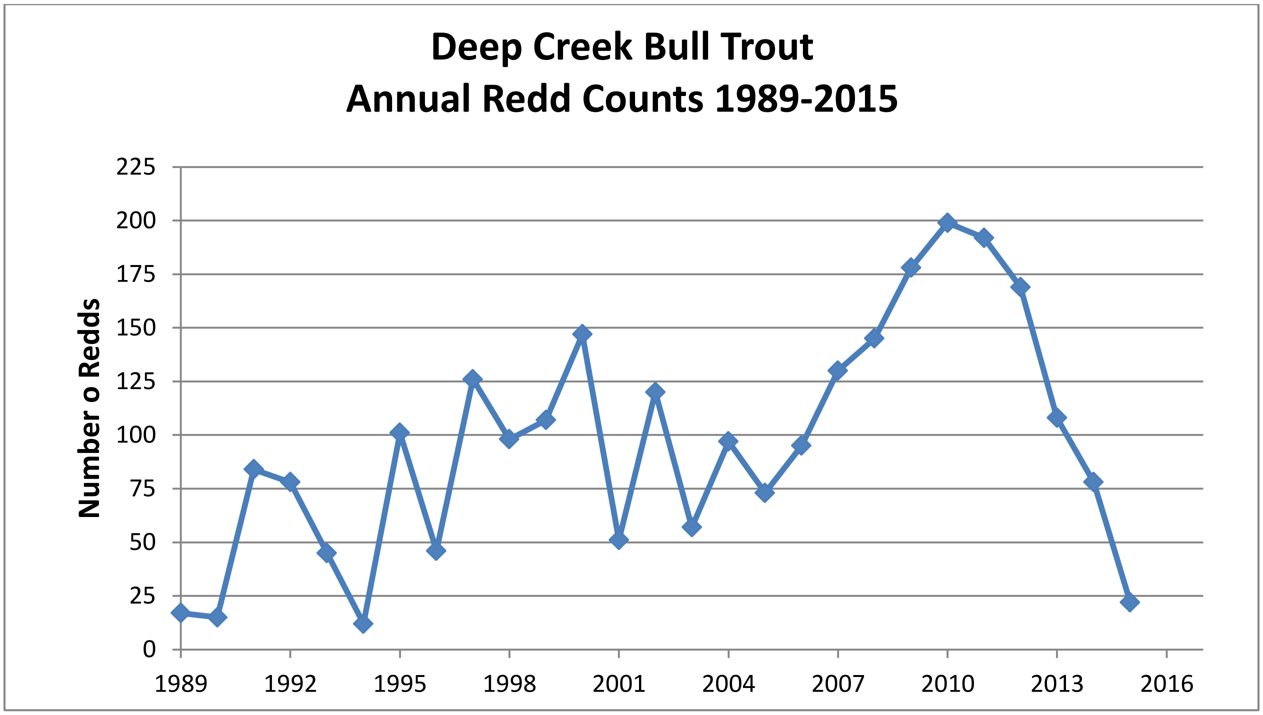

Figure 71. Bull trout redd counts in Deep Creek.

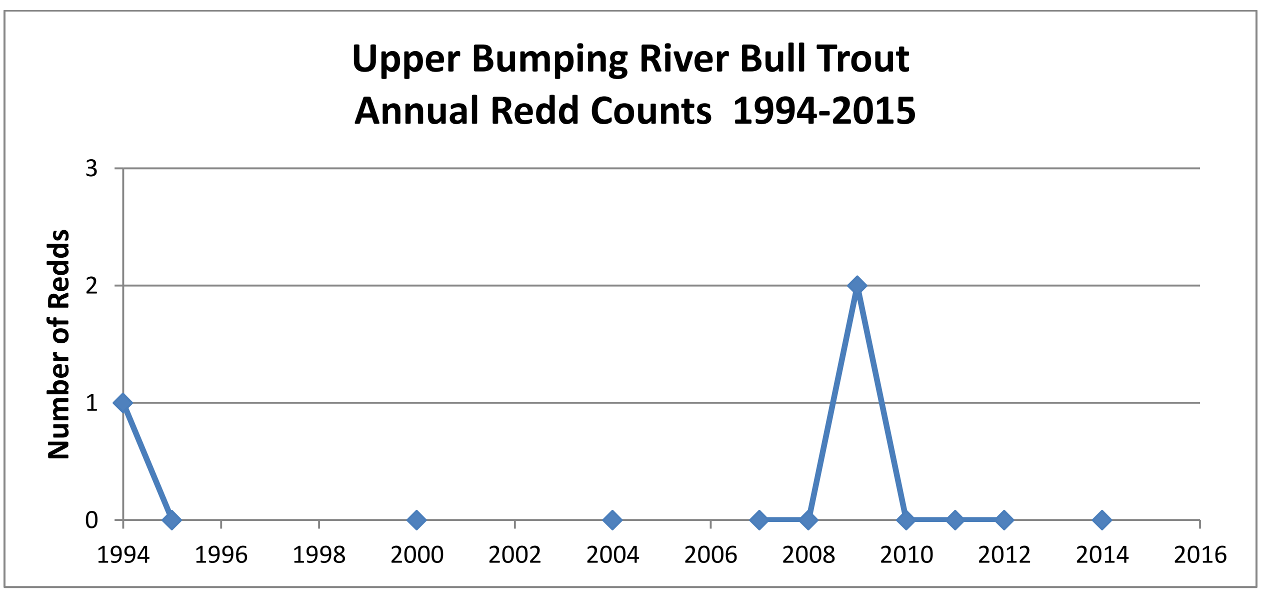

Figure 72. Bull trout redd counts in the Upper Bumping River.

Upper Yakima Drainage -- Yakima mainstem, N.F. Teanaway R., Kachess, Keechelus, & Cle Elum Res., Waptus Lk., – 1 fluvial, 1 resident/fluv., 3 adfluvial populations, 2 unknown

Yakima River – Keechelus-to-Easton Reach (spot check survey in the 11 mile index area; fluvial – unknown status) Surveys conducted in this reach have confirmed a few bull trout redds over the years despite the warmer water temperatures (typically in the low 50’s F). There have only been eight redds counted in this reach in six years of surveys dating back to year 2000 (Figure 73). There have been no surveys conducted since 2011. Although the total survey reach is about 11 miles long, most surveys have centered on the Crystal Springs and Cabin Creek areas where most redds have been found. We hypothesize that bull trout that spawn in this reach are adfluvial fish that have been entrained with irrigation flow releases from Keechelus Dam. Since there is no fish ladder at the dam to allow them to migrate back upstream to their natal spawning grounds (Gold Creek), they are forced to spawn in the reach below the dam and assume a fluvial life history strategy. The population does not appear to be expanding or increasing from this low level of spawning activity. It has not been confirmed as a distinct population segment.

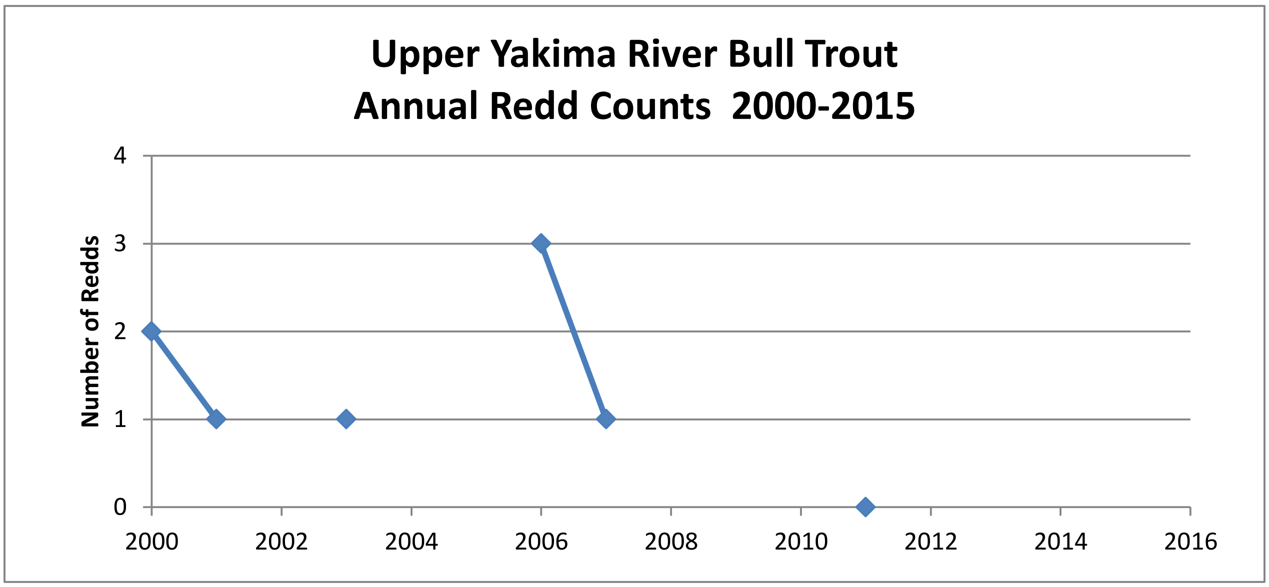

Figure 73. Bull trout redd counts in the Upper Yakima River.

N.F. Teanaway River (index area surveyed was 2.5 river miles; fluvial/resident population) The N.F. Teanaway River index also includes a one mile section of DeRoux Creek. Although enough genetic samples have been collected to confirm the presence of a distinct bull trout population, few redds have ever been observed. Only five redds have been found in the past ten years; two in 2005, one in 2006, one in 2009 and one in 2013 (Figure 74). There was no survey conducted in 2015. During the mid-1990’s, snorkel surveys confirmed the presence of a few larger, fluvial bull trout (approx. 16+ inches), presumably migrating from the main stem Teanaway R. or Yakima R., and a few smaller resident forms as well. However, snorkel surveys conducted in recent years have not confirmed any bull trout; juveniles or adults. The population appears to be functionally extirpated.

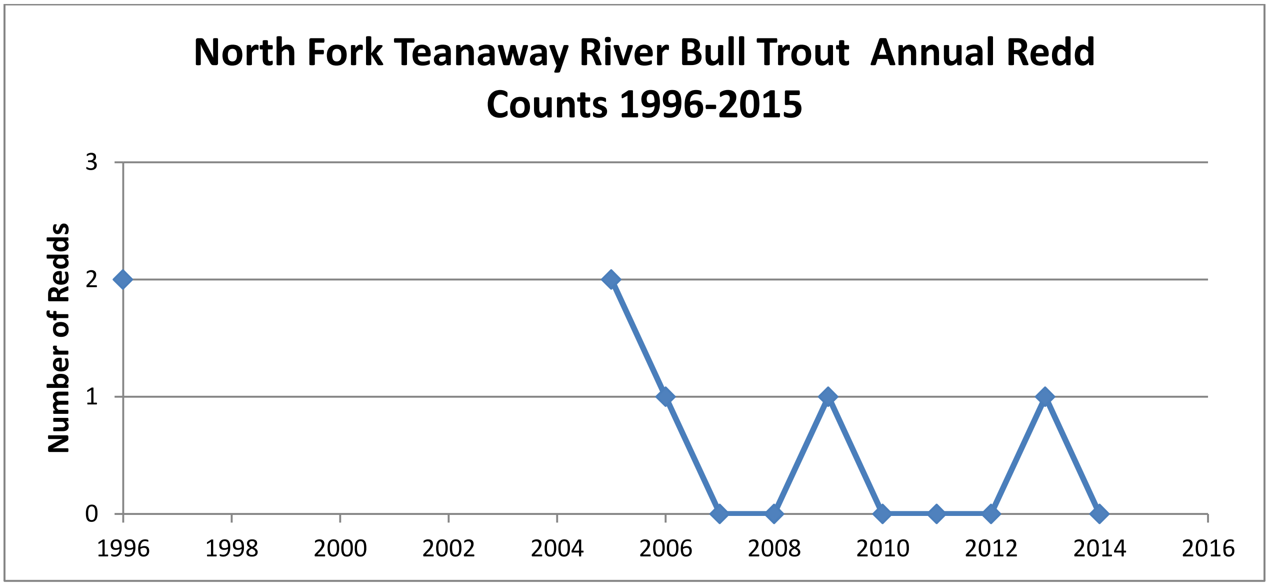

Figure 74. Bull trout redd counts in the N.F. Teanaway River.

<u>Kachess Reservoir – 2 adfluvial populations</u>

Box Canyon Creek (index area surveyed was 1.6 river miles; adfluvial population)
The last four years have seen a downturn in the redd counts in Box Canyon Creek with only nine in 2012, six in 2013, ten in 2014 and eight in 2015. The highest counts occurred during the 2009 – 2011 time periods with 21, 30 and 31 redds respectively (Figure 75). This year, due to low stream flows caused by severe drought conditions, passage was very poor to non-existent on the reservoir bed. For that reason, a temporary plastic (visqueen) passage flume was installed on the lake bed to consolidate water in the channel and provide passage for adults migrating from the lake. This effort appeared to be successful as bull trout and redds were observed shortly after the flume was installed. However, the population remains at critically depressed levels.

Kachess River (index area surveyed was 0.8 river miles; adfluvial population)
Redd counts in the upper Kachess River vary considerably; with annual spikes in redd counts that range from 0 to 33 (Figure 76). In 2011 we had a record count of 33 redds, up from 15 redds in 2010, but was back down again in 2012 (8 redds), 2013 (13 redds) and 2014 (9 redds). There were only five redds in 2015, but high flows due to rains and melting snow precluded a final pass/redd count. The Kachess River has the latest spawn timing of all the Yakima bull trout populations---late October to late November. As the lower ½ mile of the Kachess River is usually dry in the late summer and early fall, bull trout cannot migrate into the river until the fall freshet rains increase flow and reconnect the river to Kachess Reservoir. Like Box Canyon, the Kachess River is a critically depressed population.

<u>Keechelus Reservoir – 1 adfluvial population</u>

Gold Creek (index area surveyed was 6.8 river miles; adfluvial population)
There was a severe drop in redd counts in 2011 and 2012 to only seven redds each year. It was up a bit in 2013 (12 redds), and 2014 (19 redds), but the population remains in a severely depressed state (Figure 77). Only three redds were observed in 2015, but high turbid flows from

fall rains precluded a final pass/redd count. The creek was severely affected earlier in the summer due to the drought, with large stretches drying up. This created and extended the period of time that bull trout could not migrate to the upper spawning reach and likely contributed to heavy juvenile and sub adult mortality rates. Past gravel pit mining with subsequent pond development, logging, cabin construction and other recreation activities in the Gold Creek floodplain continues to negatively impact this population.

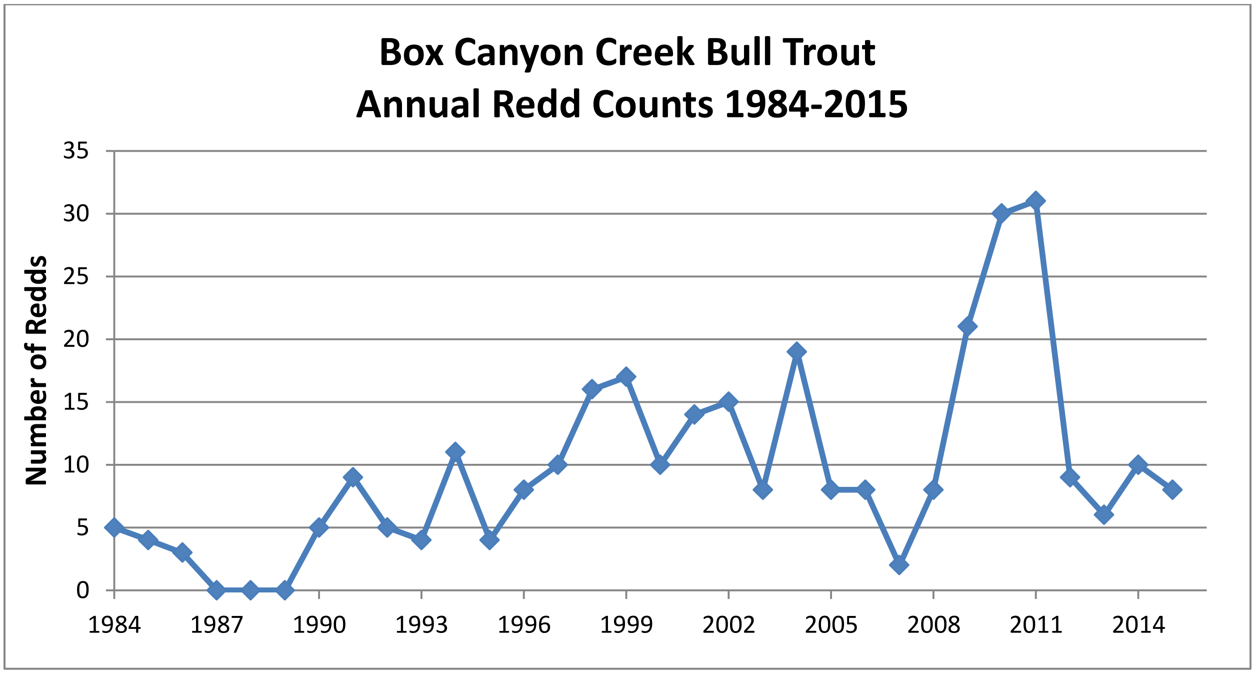

Figure 75. Bull trout redd counts in Box Canyon Creek.

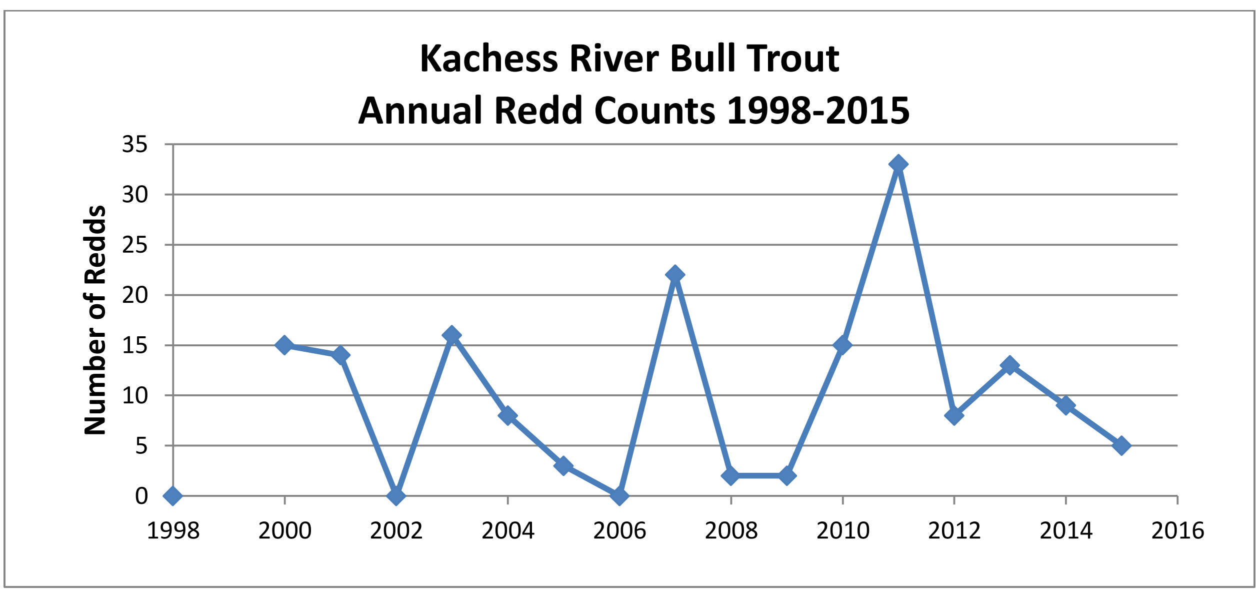

Figure 76. Bull trout redd counts in the Kachess River.

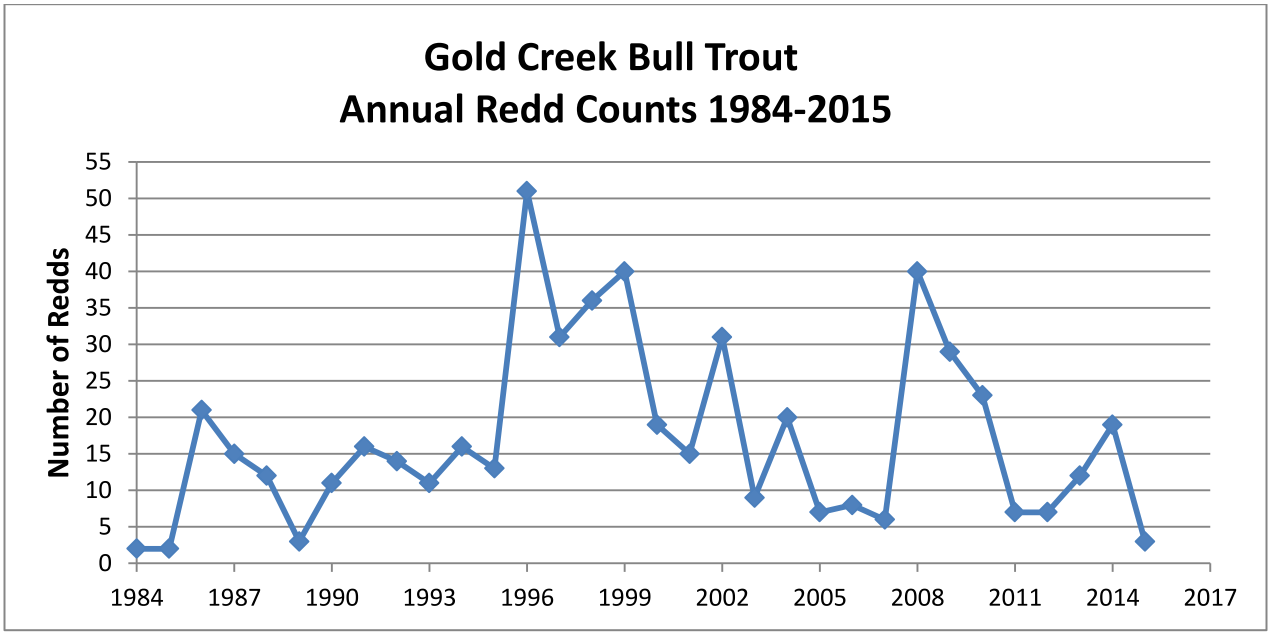

Figure 77. Bull trout redd counts in Gold Creek.

<u>Cle Elum Reservoir & Waptus Lake (no established index areas; adfluvial populations – unknown status)</u>

There were no surveys conducted in the Cle Elum / Waptus Lake area in 2015. Repeated attempts to locate bull trout and their spawning areas in the drainage have been unsuccessful. Actual bull trout observations in the drainage have been very infrequent. There are many eastern brook trout in the drainage, as well as lake trout and brown trout. We believe the prevalence of these non-native species have pushed bull trout to extirpation in the drainage. We recently monitored a lake trout fishing derby in Cle Elum Resrvoir for a few years with the hopes of encountering a bull trout, but to no avail. We have also assisted Yakama Nation staff with removing adult mackinaw from the spawning grounds on Cle Elum by gill netting, but have not encountered any bull trout. It is probable that bull trout are extirpated from Cle Elum Reservoir as there have been no confirmed observations for at least two decades and only anecdotal (unconfirmed) information about their presence prior to that. It may still be possible that a remnant population exists in the more remote Waptus Lake area. WDFW staff captured a sub-adult and an adult hybrid bull-brook trout in Waptus Lake in the mid-1990's, but there were no genetic samples taken. Additional investigations in the Waptus drainage are needed with a focus on collecting genetic samples.

<u>Additional Exploratory Surveys</u>

In 2009 we conducted additional "exploratory" redd surveys in areas that had not previously been surveyed for bull trout spawning activity. The focus was primarily on areas where we received recent observation reports, mostly by other fishery workers, of bull trout in the stream. Most reports were of a sub-adult or juveniles captured while electro fishing. We also surveyed a section of upper Crow Cr. above a suspected barrier falls to confirm whether it was still serving as a barrier to bull trout migration. Surveys were conducted during the peak bull trout spawning period in the following Naches tributaries: N.F. Little Naches River, Quartz Creek, N.F. Quartz Creek, Nile Creek and upper Crow Creek. There were no redds or spawning bull trout encountered in any of these "exploratory" stream surveys. Although most contained good spawning habitat, they appeared to be too warm for bull trout spawning (most were in the low to mid 50's F). Upper Crow Creek was the exception, but the barrier falls appears to completely block bull trout passage. Although we did not encounter any spawning bull trout during our initial exploratory survey in Nile Creek, it will require some additional survey work in the future. There was no bull trout radio tracked into Nile Creek or the Little Naches tributaries except for one bull trout tracked into Crow Creek in 2004. Exploratory surveys also occurred in 2014 in the upper Bumping River and in 2015 in lower Crow Creek and the lower S.F. Tieton River. These surveys served as a "check-up" on potential expansion of the populations and to confirm that current spawning index areas are accurately portrayed. No spawning activity or redds were observed in these expanded exploratory surveys.

Snorkel Surveys

Occasional spot checks were made using snorkel gear to verify the status of radio-tagged bull trout or to retrieve a radio-tag. We did not keep a consistent record of these spot checks, but we did conduct periodic snorkel surveys to document presence of other species, juvenile bull trout, etc. These surveys are summarized below.

We conducted a snorkel survey during the day on July 7, 2004 in the American River near Pleasant Valley Campground. The survey reach was 400 meters long. We observed five bull trout ranging from 10 to 50 cm in total length, as well as 73 cutthroat trout ranging from 5 to 30 cm, five rainbow trout from 10 to 20 cm and 11 chinook salmon fry. Another reach of the American River was surveyed at night further upstream near the mouth of Union Creek. We observed fifteen bull trout ranging from 10 to 50 cm in total length, fourteen brook trout ranging from 10 to 30 cm, three cutthroat trout from 5 to 30 cm and an estimated 250 chinook salmon fry.

Another survey was conducted on August 25, 2004 in the American River near Hells Crossing Campground. Survey reach was approximately 400 meters. This survey was conducted during the day and then repeated at night. During daylight we observed five brook trout ranging from 10 to 20 cm in total length and eight cutthroat trout from 5 to 20 cm and at night we observed three brook trout from 10 to 20 cm and twelve cutthroat trout 10 to 30 cm. No bull trout were observed.

A day survey was conducted on Union Creek on August 25, 2004. We observed 54 spring chinook fry rearing from the mouth of Union Creek upstream to the trail footbridge. Juvenile chinook produced in the American R. move into Union Creek to rear (off-channel rearing); spring chinook do not spawn in Union Creek. Upstream from the footbridge to the barrier falls we did not observe any fish. Total survey length was approximately 0.4 miles. We were surprised not to see any bull trout considering this is a bull trout spawning index area, but during the day juvenile bull trout may have moved into the American R. or were in concealment cover. There were adult bull trout holding in the American R. below the mouth of Union Creek at the time of the survey.

Day and night snorkel surveys were conducted on the Middle Fork Ahtanum Creek on October 10, 2004. During the day we observed seven bull trout ranging from 20 to 30 cm total length, and five cutthroat trout from 10 to 20 cm. The night survey yielded five bull trout from 20 to 30 cm long, five cutthroat trout from 10 to 20 cm long and two rainbow trout from 30 to 40 cm long. Survey reach length was about 400 meters.

We conducted a two-day survey on Crow Creek on July 20-21, 2005. This survey was a combined hook-and-line/snorkel trip. One snorkeler surveyed while a second crew member fished the water where the snorkeler verified presence of bull trout. During the daytime survey we observed 38 bull trout from 5 to 40 cm in total length and 29 cutthroat trout from 5 to 30 cm. The following day a second survey was made and we observed four bull trout from 10 to 40 cm, twelve cutthroats from 10 to 30 cm and one rainbow trout at 20 cm long. The first survey was conducted higher in the drainage near the spawning index area, while the second survey was conducted more than a mile downstream for the index area.

Genetic Analysis

All bull trout encountered in this project were sampled for DNA analysis. Population genetic assignments were made as a result of that analysis and are shown in **Appendix 7 – Genetics Sample Locations and Population Assignments**. Confirmation of the genetic origin for each radio-tracked fish is also listed in the daily radio tracking data (Appendix 2). Genetic details are summarized in the latest report by Small et. al. (2009). This was the last phase in a process that looked at a wide range of samples collected in the Yakima basin. Results from that analysis confirmed population assignments for our radio-tracked bull trout. A combined total of 108 bull trout samples were collected during this and the reservoir portion of the radio-telemetry study (see Mizell and Anderson, 2008). Only one of our samples, collected from the upper Bumping River pool, was confirmed as a bull/brook trout hybrid. The fish was a smaller sub-adult and was not tagged. In total, 932 genetic samples have been analyzed to help define the bull trout populations in the Yakima basin (Reiss, 2003; Hawkins and Von Bargen, 2006; 2007; Small et al, 2009).

Gentic analysis identified 12 distinct bull trout populations in the Yakima basin (Small et. al., 2009). Although there are three more areas where bull trout are known to occur, they have not been analyzed due to insufficient data. Most adult bull trout in the Yakima basin migrate from large USBR reservoirs to smaller tributary streams to spawn (adfluvial life history) or they migrate from the mainstem Naches River to smaller spawning tributaries (fluvial). A couple populations do not migrate the long distances, but instead spend most of their time (all life stages) in the same stream (resident life history). Currently, there are three fluvial populations: American River, Crow Creek, and Rattlesnake Creek; two resident populations: Ahtanum Creek and N.F. Teanaway River and seven adfluvial populations: Gold Creek, Box Canyon Creek, Kachess River, Deep Creek, Indian Creek, N.F. Tieton River and the S.F. Tieton River. Although a few redds have been observed in the upper Bumping River (above Bumping Lake) and in the mainstem Yakima River below Keechelus Dam (Keechelus Lake), there is insufficient data to confirm whether these are distinct bull trout populations. Likewise, only a few bull trout have been reported from the Cle Elum/Waptus Lake drainage and no bull trout redds have been confirmed there.

DISCUSSION

Movement Patterns of Bull Trout in the Naches River Drainage

The Naches basin fluvial bull trout populations include fish from the American River, Rattlesnake Creek, and Crow Creek. The American R. population group also includes the two small tributary streams, Union and Kettle Creeks. Although we only tagged one adult from Crow Creek, since it exhibited similar overwintering and spawn timing, we assume it had similar movement patterns as the other two populations. Bull trout from all three of these distinct population groups primarily overwinter in a series of pools in the mainstem Naches River, but we also found some overwintering in the pool below Tieton Dam (Tieton River) and a few in the pool below Bumping Dam (Bumping River). Adult bull trout spent lengthy periods of time in their overwintering habitat, moving very little after settling in for the winter. The prime over-winter locations consisted of a series of large pools in the mid to upper Naches River from the Wapatox Irrigation Diversion (RM 17.1) upstream to an area near Cliffdell (R.M. 40). The over-winter period generally ranged from November thru March.

Adults become much more active in April and May, moving and foraging throughout much of the river, including the lower Naches R. below the Tieton R. confluence. By mid to late June they are moving upstream to their natal tributaries (i.e., Rattlesnake Creek, American Rivers); in July they are slowly moving upstream to their spawning grounds. This increased activity pattern by bull trout appears to be strongly influenced by both temperature and flow. As the graph in Figure 23 shows, the flows in the Naches River start their upward trend in April and are peaking by late May to early June. Bull trout are quite active at this time. As flow begins to recede in late June/early July, water temperature also increases. By August, when Naches R. temperatures are near their warmest of the year, bull trout have already reached the staging areas below their spawning grounds, essentially in a holding pattern until the temperatures drop slightly in September and they move onto the grounds to spawn. Not all adults spawn every year. Some skip a spawning cycle and stay in the mainstem Naches R. It is not known what percentage of the population does this.

Although both populations shared many of the same over-wintering pools, their respective travel distances to the natal spawning grounds were different. Most Rattlesnake Cr. fish traveled 17-30 miles from their overwintering/foraging area in the Naches R. to the spawning grounds in the upper Rattlesnake Creek. Most American/Union/Kettle (A/U/K) fish traveled 20-43 miles to their spawning grounds in the upper American River. The upstream movement of the American River and Rattlesnake Creek bull trout populations coincides with spring chinook spawning. Chinook salmon spawn in the upper reaches of the American River in late July and August. As bull trout pass through the area they will feed on loose chinook eggs. Tagged and untagged bull trout have been observed feeding on eggs of spawning spring chinook. Their behavior is interesting to observe. Bull trout seemed to take turns acting as an aggressor so the chinook would chase them, while other bull trout would dart in to steal loose, drifting eggs.

Bull trout move upstream to their staging pools below the spawning grounds by mid to late August where they hold until spawning in early September. The spawn timing for all three populations can vary from 10 to 21 days. The A/U/K group tends to be on the spawning grounds for only about 10 to 14 days. Temperatures are typically in the 44^{o} to 47^{o} F. range. After spawning the A/U/K group exhibits a stop-and-go post-spawn downstream movement pattern. This slow downstream migration pattern allows post-spawned fish to rest, forage and recover. By late October to early November they are back in their overwintering locations in the Naches River.

Although the Rattlesnake Cr. population may travel only 1 to 10 miles in the Naches R. on their way to the spawning grounds, they travel a substantial distance in Rattlesnake Cr. (16 to 20 miles) to get to the spawning grounds. The Rattlesnake Cr. spawning area is remote and gets less angling pressure than the American R. population group. Most of the Rattlesnake Cr. population will arrive below the spawning grounds by late July where they hold until early September. After spawning, they move rather quickly back to the mainstem Naches R. to their overwintering pools compared to American R. fish.

Not all bull trout overwinter in the mainstem Naches River. Some were found in the large pools below the irrigation storage dams (i.e., Tieton Dam and Bumping Dam). We found evidence, through genetic analysis (Small et.al. 2009), that some of these fish originated from populations above the dam and some from below. Those from above were obviously entrained out of the reservoirs and since there were no fish passage facilities, they could not move back to their natal streams. Four adults tagged early in the study, all from populations above the reservoir, never left the Tieton Dam stilling pool. Other bull trout, such as fluvial fish that move into the Tieton pool from the Naches River, do so presumably to feed on the abundant kokanee entrained out of the reservoir.

In November 2005, we assisted with salvaging 37 bull trout from the Tieton Dam stilling pool before hydropower installation occurred at the dam (Ackerman, 2005). Twelve of the captured adults were radio-tagged and transported 22 miles downstream and released into the Naches River below the Wapatox Diversion Dam. Genetic analysis of the radio-tagged fish revealed mixed populations, with seven fish originating from above Rimrock Reservoir (Indian Cr. 4, N.F. Tieton 2, S.F. Tieton 1) and five from below the reservoir (Rattlesnake 3, American/Union 2). Analysis of all the salvaged bull trout in the pool indicated 70% were from the Rimrock basin (40% Indian, 26% S.F. Tieton, and 4% N.F. Tieton) and 30% from below or outside the basin (15% American/Union and 15% Rattlesnake Creek) (Small et.al. 2009).

As expected, movement patterns for the transported (radio tagged) group were different than the four fish that were previously tagged and released in the Tieton Dam stilling pool. One of the tagged and transported adults was genetically assigned to the N.F. Tieton R., but it migrated to the upper Rattlesnake Cr. during the spawning period. Another tagged fish genetically assigned to the Indian Cr. population migrated to the upper American River during the spawning period. Whether these two adfluvial fish actually spawned with fluvial fish from a different population is unknown. One of the transported adfluvial fish from Rimrock Lake that was genetically assigned to the S.F. Tieton R. population did migrate back to the Tieton Dam stilling pool.

Only one of the five fluvial fish that we tagged and transported migrated back to its natal stream, the American River. The other four fish stayed in the Naches River near the Wapatox Diversion or moved a bit up or down stream. Within 8-10 months we had collected five radio tags from the 12 tagged fish. Whether the tags were naturally shed or the fish died from stress associated with the tag implant or other mortality factors is unknown. Additional details about the movements of these Tieton Dam stilling pool radio-tagged fish were provided in an earlier report (Mizell and Anderson, 2008). The tracking data suggests that most entrained bull trout tend to stay in the pool, but if transported to another area, a few may integrate themselves with other populations and migrate/spawn with those populations.

Bull Trout Habitat in the Naches Basin

We noticed early during habitat assessment that tagged and untagged bull trout were almost always found holding in medium to large pools. Many of these pools did not have other forms of overhanging cover. Pool selection seemed to be driven by velocity and water surface opacity (i.e. lack of clarity/transparency) preference, especially where other forms of cover were absent, but where prey was readily available. Velocity preferences for sub-adult and adult bull trout in these holding areas consistently ranged from 1.4 – 1.9 cfs. Many pools in the mid to upper Naches River contained basalt overhangs and back eddies that bull trout preferred. On most occasions tagged bull trout were not alone, but would be in the company of untagged fish. We observed as many as 40 bull trout in a pool and other species as well, including steelhead, adult chinook salmon, mountain whitefish, rainbow trout, and cutthroat trout. Usually we observed the largest bull trout at the upstream end of the holding area and the smaller fish in the pool tail out, suggesting behavioral dominance played a role in selecting preferred holding locations. However, we did not observe aggressive behavior among bull trout in these groups to confirm size-related dominance. Similar observations have been observed by Boag 1987; Allan 1980; and Watson and Hillman 1997. We observed fish holding only in certain sections of the pool, in a linear orientation with the current, where the surface tended to be turbulent and surface opacity was usually the only source of cover. Adults often used pool depth and surface turbulence as the main source of cover during over-wintering.

Although adult bull trout often migrated into their natal tributary streams well before the actual spawning period, the time spent on the actual spawning grounds was relatively short (e.g. 2-3 weeks) compared to the overwintering (e.g. 5-6 months) and foraging/migration (e.g. 4-5 months) periods. A staging period of a week to a month or more could occur as adults arrived near the spawning grounds. Staging typically occurred in large runs or pools below the spawning area. Adult bull trout were quite vulnerable to angling at these times. In high use and/or high visibility areas like the American River, the WDFW has closed the river to fishing during these times to protect staging/spawning bull trout and salmon.

In spawning areas the habitat is quite different. Generally, it consisted of smaller substrate material, with much more gravel, small cobble and sand. Although there could be some steeper gradient sections leading up to the spawning area, the spawning zone itself was usually low to moderate gradient. Spawning areas typically contained more woody debris that provided escape cover. Spawning bull trout often preferred areas where cover was abundant and vegetation draped over the water or lay completely across the channel. Although redds were often in open exposed areas of the stream, adults were usually close to some form of concealment (i.e. escape) cover. The water depth on spawning grounds was much shallower than the water depths associated with FMO habitat. Bull trout were often observed in shallow water riffles from just a few inches deep to pool tail outs that were two feet deep. Water temperatures typically ranged between 44^{o} to 47^{o} F range. Access to woody debris (log jams), large boulders, undercut banks, shoreline vegetative cover, deep pools, as well as substrate composition, water flow and temperature all played a crucial role in the selection of spawning areas.

Irrigation storage dams in the Yakima basin have dramatically changed the habitat and fish populations, both upstream and downstream. Dams have split and isolated bull trout populations that formerly were formerly able to intermix. Both radio-telemetry and genetic analysis supports the hypothesis that fish, once entrained through the dams, are effectively removed from the gene pool because spawning site fidelity is so high. Currently, there is no mechanism or plan to address the issue of bull trout entrainment through the USBR storage dams. Adfluvial population recovery, particularly for the Keechelus and Kachess Reservoir populations, would benefit from an effort to determine the extent of the entrainment problem. If significant, then providing the means to capture entrained bull trout and return them to their natal area (e.g., capture and transport) would be justified.

We conducted many hook-and-line and snorkel surveys in the American River. Although a beautiful river, it is a sterile environment with a low abundance of fish life. We observed low numbers of most species, including cutthroat, rainbow, bull trout and spring chinook fry. Most cutthroat trout were less than 20 cm total length. The American R. appears to be a very nutrient deficient system. Without greater biomass of chinook salmon carcasses to increase the marine-derived nutrient base, it is difficult to imagine how the system can support very many juvenile or adult fish. In headwater, nutrient-poor areas, continued recovery of bull trout populations will also depend on the recovery of salmon and steelhead populations.

<u>Movement Patterns of Bull Trout in the Ahtanum Creek Basin</u>

The Ahtanum Creek basin has a chronically low bull trout abundance as evidenced by the small number of redds and the very few fish caught in traps. This sub-basin is also semi-isolated because of thermal and physical (i.e. low flow) barriers. Fish that were tracked in the N.F. and M.F. Ahtanum stayed in their natal tributaries, moving downstream only far enough to avoid the ice formation that occurs in the upper reaches. Out of seven tagged adults, only one was tracked below the M.F./N.F. confluence. We did not capture any bull trout in the S. Fork. The average size of spawning adults ranged from 10-14 inches total length, although fish as small as 8-9 inches have been observed actively spawning. The tagged fish in both the N.F. and the M.F. generally moved downstream less than 2 miles. The one exception was a tagged fish from the North Fork that moved below the N.F./M.F confluence about 1.5 miles.

Resident-type adult bull trout (10-14 inches) were captured by WDFW in mainstem Ahtanum Creek at the Bachelor-Hatton [irrigation] Diversion (CM 18.9) near the Ahtanum Mission in April 1994 (Easterbrooks, J. 1994. Pers. Com.). The Yakama Nation also captured a “smolting” (silvery) juvenile bull trout in a screw trap at Fulbright Park near the mouth of Ahtanum Creek. It was caught in February 2003 along with a group of steelhead smolts. In July 2004, we observed a large bull trout in a pool near the Wapato Irrigation Project (WIP) Upper [irrigation] Diversion (CM 19.5) during a hook-and-line survey, but it was not captured. Presumably, this was a fluvial fish that moved into the Ahtanum drainage from the Yakima R. We also observed coho fry in the same area a week later while beach seining. These fry were recently planted in the Ahtanum by Yakama Nation fisheries staff as part of the coho reintroduction efforts. In September 2004, we observed a large male bull trout (approximately 24 inches) spawning with a 12-inch female on the upper spawning grounds in the N.F. Ahtanum. We assume this was a fluvial (or displaced/entrained adfluvial) fish from another population that migrated upstream from the Yakima River. Unfortunately, we were unable to capture and collect a tissue sample to allow genetic stock identification. WDFW has not observed another large fish like this in the Ahtanum basin since 2004. For decades, a long reach of Ahtanum Creek (5.5 miles minimum) was totally dewatered downstream of the Upper WIP Diversion from mid-July to mid-October. This has been a major factor causing isolation of the Ahtanum population from other populations. However, beginning in 2001, a reduction in the Upper WIP Diversion flow has allowed for a minimum continuous creek flow of 10 cfs at the American Fruit Rd. bridge (CM 14.0), which is the downstream end of the "losing" reach (i.e. loss of surface flow to the hyporheic zone). Ahtanum Cr. gains surface flow from the hyporheic zone from this location downstream, hence a migration corridor has been restored allowing for potential reconnection of Ahtanum Cr. bull trout with other populations.

Bull Trout Habitat in the Ahtanum Creek Drainage

Habitat in the upper Ahtanum basin spawning areas had good riparian cover, spawning gravel and log jams/woody debris. In some areas log sills have formed that create natural waterfalls that may be blocking upstream passage of small resident fish. This is particularly acute in the area near the mouth of Shellneck Creek where the road closely parallels the creek and impinges on the natural flow and movement of bed load material. There is also a considerable amount of logging occurring in the drainage that may be influencing flows and temperature profiles in the watershed. The highest summer temperatures (60 F) were recorded at the N.F./M. F. confluence (foraging/migration corridor) and the lowest winter temperatures were recorded at the N.F/ Shellneck Cr. confluence (spawning grounds).

A huge concern in the Ahtanum drainage is the proliferation of "recreational" dams. During radio-tracking we encountered 17 "rec dams" on the North and Middle Forks after the 2005 Memorial Day weekend. Ten of these dams were impassable for bull trout. Some were two to three feet wide and one to two feet high. We breached dams whenever possible, but it was a difficult, time-consuming process for two people with hand tools because some dams were built with large material using winch-equipped, all-terrain vehicles. These dams are often built near campgrounds that are below or adjacent to spawning areas. There needs to be an increased awareness and focus by land and resource managers on eliminating recreational barrier dams and educating the public. Although there have been some positive changes and improvements to stream flows and irrigation diversion screening, there needs to be a continued vigilance in improving habitat conditions related to fish passage at rock barrier dams.

Night vs. Day Movement, Fixed and Mobile Operations

Data from fixed station and mobile tracking indicated bull trout in the Naches drainage moved more often and greater distances at night than during the day. Over 90% of all movement past the fixed stations was recorded during dusk-to-dawn hours. Although fixed stations were very useful in determining when tagged fish passed a particular site, most of our tracking data was obtained via mobile operations. Although "down time", particularly during adverse weather conditions, periodically affected fixed station tracking, we had good success with the stations. Fixed stations gave us valuable information on general areas where fish were located so that we could more efficiently utilize mobile operations to refine exact locations of radio-tagged fish.

Fish Populations – Genetic Identification, Spawning Areas & Redd Counts

Although this study did not identify any additional or unknown spawning areas, it did provide a better understanding of the timing associated with migration of bull trout to and from the spawning areas. Although we attempted to capture and tag fluvial bull trout in the upper Yakima basin, it became evident that there were so few fish that it was going to require a huge effort with very little benefit. Therefore, we concentrated most efforts in the Naches and Ahtanum basins.

By working cooperatively with other federal, tribal and local agencies, we have continued to monitor existing bull trout populations and even expanded into additional stream reaches that had not been surveyed previously. In 2009, the Yakima subbasin had a record year for bull trout spawning with an index area total count of 795 redds. By adding an additional 30 redds that were counted in the S.F. Tieton River outside of the standard index area, we had a grand total of 825 redds. The previous high index count was 704 redds in 2000.

Genetic analysis identified 12 distinct bull trout populations in the Yakima River basin (Small et. al., 2009). Currently, there are three fluvial populations: American River, Crow Creek, and Rattlesnake Creek; two resident populations: Ahtanum Creek and N.F. Teanaway River and seven adfluvial populations: Gold Creek, Box Canyon Creek, Kachess River, Deep Creek, Indian Creek, N.F. Tieton River and the S.F. Tieton River. Although there are three more areas where bull trout are known to occur, they have not been genetically analyzed due to very low abundance and insufficient data. These three areas are in the upper Bumping River (above Bumping Lake), the mainstem Yakima River below Keechelus Dam (Keechelus Lake) and the Upper Cle Elum R./Waptus Lake drainage.

Radio-Tag Surgeries -- Rainbow Trout (Control Group) & Bull Trout

We found it both practical and useful to use a control (test) group of hatchery rainbow trout to practice our radio-tag implant surgery techniques. Holding the control group for a period of nine months bolstered our confidence in tagging bull trout. We also learned some valuable information from the test group of rainbow trout. Although no mortalities occurred with the 32 control fish, we observed a few shed radio-tags through the keloidal extrusion of tags. We also observed unabsorbed sutures and suture injuries, yet all of the fish survived. However, the same surgical procedures used on bull trout in the wild may have varying results depending on when and what condition the bull trout are in when tagged. For example, bull trout captured near or after spawning do not recover well. There are more mortalities and shed tags. The vigorous spawning activity and the subsequent weakened condition of post-spawners do not provide for adequate recovery from the surgical technique and is definitely not recommended. Although we only found evidence of six shed tags that we could directly attribute to our surgeries, we did find additional shed tags during the project. Some appeared to be associated with natural and/or predator-induced mortalities that occurred months or years after initial tagging.

During this project, we developed a small, beveled metal tube (aka the “stinger”) that facilitated tag implantation during surgeries, which was especially useful on smaller fish. The “stinger” tube worked so well that it was used in all subsequent surgeries, for both large and small fish. This new procedural refinement allowed us to keep incisions smaller and keep fingers out of the incision, while still allowing the radio-tag to be seated further back in the fish’s body cavity away from the incision site. The “stinger” also reduced or eliminated the potential to puncture internal organs. Consequently, fish recovered from the surgery faster and helped to reduce the tag shedding problem. The instrument and process is outlined in detail in the methods section. We recommend the use of this instrument in future surgeries.

We also learned that it is worth the extra time and effort to thoroughly dry the incision area before applying the vet bond. This was accomplished by drying the incision area with cotton swabs and then lightly blowing across the incision for up to one minute. Otherwise, the vet bond does not stick very well. We noticed a vet bond “sheen” on the water in the recovery tank if the vet bond failed to adhere to the skin of the fish. This could be detrimental to the recovery of the fish if taken in through the gills during respiration.

Additional Observations, Conclusions and Recommendations

1. Migratory corridors are critically important to maintaining the integrity of bull trout populations. This is particularly important between adult over-winter, foraging and spawning areas. The deep pools in rivers (e.g., Naches River) are commonly used as over-wintering habitat. Adults will move outside of these areas to forage, especially during the spring as water temperature and flows increase.
2. Adult bull trout in the Naches River spent lengthy periods of time in their over-wintering habitat, generally moving very little after settling in for the winter (November thru March). The prime locations consisted of a series of large pools in the mid-to-upper Naches River from the Wapatox Irrigation Diversion (RM 17.1), upstream to pool #6 (RM 40.5). Fluvial bull trout from several tributary populations over-wintered in these pools, which included adults from Rattlesnake Creek, American River/Union Creek and Crow Creek.
3. Pool selection seemed to be driven by velocity and surface opacity; especially where other forms of cover were absent, but where prey was readily available. Velocity preferences in these holding areas consistently ranged from 1.4 – 1.9 cfs. Later, adult bulls were found in these same pools or moving slowly upstream between them throughout the spring (April, May) in preparation for migration to spawning areas.
4. In the Naches drainage, adults are very active thru the spring and summer as they continue to forage. Foraging activity continues as they slowly move toward the spawning areas. By early to mid-summer (June, July) the fish were moving into their natal tributary streams, where they continued to move slowly upstream to their spawning grounds.
5. Resident bull trout found in the Ahtanum Creek drainage (NF, MF and SF) stayed year-round in their respective natal streams. Spawning occurs in the month of September in the Naches and Ahtanum drainages.
6. In fluvial environments like the Naches River, bull trout movement also coincides with the upstream movement of spring chinook salmon. Bull trout are piscivorous, but also opportunistic, feeding on drifting salmon eggs during the chinook spawning period in August-September.
7. By mid-to-late summer, adult bull trout move upstream to their respective spawning areas, often holding for a period of time below the spawning areas before engaging in active spawning. During this pre-spawn staging period and during spawning the adults are highly susceptible to harassment, angling, and poaching. They often congregate at the mouth of a tributary stream. Adults may hold in these areas for up to a month or more. During the bull trout spawning season, most streams are at their lowest flows and water clarity can be excellent. The adults are often highly visible in these environments during this period. WDFW has closed fishing in high recreational use/high visibility areas like the American River and Union Creek to protect spawning bull trout and chinook salmon.
8. Although adult bull trout often migrated into their natal tributary streams well before the actual spawning period, the time spent on the actual spawning grounds was relatively short (e.g. 2-3 weeks) compared to the overwintering (e.g. 5-6 months) and foraging/migration (e.g. 5 months) periods. The adults spend much less time leaving the

spawning grounds than they did arriving. Post-spawners usually move quickly back to the deeper water environments of the Naches River.

9. Spawning habitat consisted of smaller substrate material, with much more gravel, small cobble and sand in small stream reaches in the upper tributaries than what we observed for foraging, migration and overwintering (FMO) habitat. Also, spawning areas typically contained more woody debris. Spawning bull trout often preferred areas where cover was abundant and vegetation draped over the water or lay completely across the channel. Access to woody debris (log jams), large boulders, undercut banks, shoreline vegetative cover, deep pools, as well as substrate composition, water flow and temperature all played a crucial role in the selection of spawning areas. The water depth on spawning grounds was much shallower than the water depths associated with FMO habitat. Bull trout were often observed in shallow water riffles from just a few inches deep to pool tail outs that were two feet deep. Water temperatures typically ranged from 43^{o} to 47^{o} F in spawning areas.
10. Index area redd counts have continued to be one of the best indicators of bull trout population status, abundance, and trends in the Yakima River subbasin. The record index count of 795 redds (825 redds including 30 observed downstream of the SF Tieton index area) occurred in 2009. Index redd count totals in excess of 700 were also observed in 2010 – 2012. In 2013 and 2014, redd count totals plummeted by about 300 redds into the low 400's, largely driven by poor visibility on key surveys in the SF Tieton R. and a near total collapse of the Indian Cr. adfluvial population associated with flood damage and mud slides in the spawning areas.
11. We used DNA tissue analysis to confirm population/stream assignments for radio-tagged fish. In both the Ahtanum and the Naches drainages, tagged bull trout exhibited high fidelity (near 100%) in returning to their natal spawning areas. Genetic analysis revealed that bull trout entrained into the Tieton Dam stilling pool were from various populations. Some were from adfluvial populations above the dam (SF, NF Tieton and Indian Cr.) and some were from Naches R. fluvial populations. Naches fish likely moved into the pool to feed on the abundant forage (entrained kokanee).
12. Genetic analysis identified 12 distinct bull trout populations in the Yakima River basin (Small et. al., 2009). Currently, there are three fluvial populations: American River, Crow Creek, and Rattlesnake Creek; two resident populations: Ahtanum Creek and N.F. Teanaway River and seven adfluvial populations: Gold Creek, Box Canyon Creek, Kachess River, Deep Creek, Indian Creek, N.F. Tieton River and the S.F. Tieton River. Although there are three more areas where bull trout are known to occur, they have not been genetically analyzed due to very low abundance and insufficient data. These three areas are in the upper Bumping River (above Bumping Lake), the mainstem Yakima River below Keechelus Dam (Keechelus Lake) and the Cle Elum/Waptus Lake drainage.
13. It is important to consider all of the migration characteristics and habitats that bull trout use to effectively manage them to recovery. These are migratory fish that require a diverse, connected environment with a good supply of spawning, wintering foraging and refuge habitats. Bull trout populations in drainages with less isolation between resident, fluvial, and adfluvial life history forms, such as the Wenatchee basin, fare much better than populations that are fragmented by extensive irrigation infrastructure like the 12 populations in the Yakima basin.
14. Large irrigation storage dams with no fish passage facilities are huge impediments to bull trout population connectivity. Migration corridors and passage needs to be provided at the dams to re-establish the connectivity between fluvial and adfluvial bull trout life history forms. Passage would also benefit anadromous fish and further benefit bull trout

and resident fish populations by restoring annual inputs of ocean-derived nutrients from salmon carcasses. Hence, long-term recovery of bull trout will also be dependent on salmon and steelhead recovery in the Yakima basin.

15. Recreational dams, particularly in the Ahtanum Cr. basin, are a chronic problem for bull trout passage. Most were located near DNR-managed campgrounds. Since 2011, the Bull Trout Task Force, has conducted periodic surveys during the summer/fall in known "recreation dam" problem areas to locate and remove migration barriers.
16. Bull trout entrained through Tieton Dam cannot migrate back into Rimrock Reservoir because there are no fish ladders. Essentially these fish are lost to the adfluvial population. Most do not move downstream or integrate themselves with other bull trout populations on their own. There is no bull trout spawning habitat in the Tieton River for these fish to complete their life cycle. However, when captured and transported to another location with bull trout from another population, they may integrate themselves into that population. If passage facilities cannot be provided at Tieton Dam and if screening or some other device to prevent entrainment cannot be achieved, then entrained bull trout should be captured and released back into the reservoir. These fish may also potentially be used as a donor stock to supplement other critical adfluvial or fluvial populations in the Yakima basin.

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