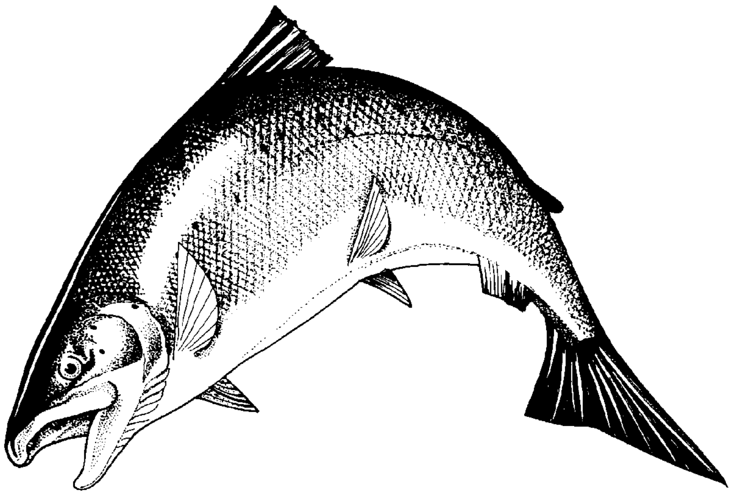
2002 Index Watershed Salmon Recovery Monitoring Report



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Executive Summary

Beginning in the early 1990s, many salmon, steelhead, and trout/char stocks were listed or are under consideration for listing under the Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS) and the U.S. Fish & Wildlife Service (USFWS). In response to these listings, federal, state, local, and tribal governments committed substantial resources to planning and implementing the recovery of depleted salmonid stocks. It is recognized that an important component of salmon recovery and key to de-listing salmonid populations is a credible monitoring and adaptive management program.

In 1999, the Washington Departments of Fish and Wildlife (WDFW) and Ecology (ECY) developed an approach for index watershed monitoring that involved measuring the production of wild downstream migrating juvenile salmon (smolts), habitat, water quality, stream flow, and macro-invertebrate assemblages in selected watersheds. Broad ranging goals included evaluating factors that influence wild salmon production, human activities and natural processes that modify those factors, and monitoring the effects of restoration activities on salmon production and the aquatic environment. To begin achievement of these goals, monitoring of all components except habitat began in 2000 and 2001 in five index watersheds: Deschutes River and Big Beef Creek in Puget Sound; Bingham Creek on the Washington Coast; and Cedar Creek and Chiwawa River in the Columbia Basin. This report describes the results of monitoring that occurred during the second year of the project; between October 2001 and September 2002. It also describes the results of first year smolt monitoring under the index watershed monitoring program.

Wild salmon freshwater production estimates were made for all five index watersheds in 2001 and 2002. In the Deschutes River, we estimated the production of 892 coho, 104 steelhead, and 23 cutthroat smolts in 2001. Wild salmonid production in 2002 was higher, with an estimated 60,000 coho, 65 steelhead, and 31 cutthroat smolts migrating from the basin. Coho estimates are preliminary in both years. In Big Beef Creek, we estimated the wild production of 21,855 coho, 1,932 steelhead, and 1,024 cutthroat in 2001 and 23,304 coho, 2,191 steelhead, and 1,589 cutthroat in 2002. In Bingham Creek, we estimated that 45,000 and 29,813 wild coho, 835 and 495 wild steelhead, and 133 and 80 wild cutthroat were produced in 2001 and 2002, respectively. Estimates for Columbia River tributaries include 24,138 and 31,909 wild coho, 3,565 and 2,225 wild steelhead, and 2,337 and 3,903 wild cutthroat produced in Cedar Creek in 2001 and 2002 respectively. In the Chiwawa River, we estimated wild spring chinook smolt production at 12,431 for the 1999 brood (spring 2001 trapping) and 37,271 for the 2000 brood (spring 2002 trapping). Neither of these estimates included the migrations of sub-yearling spring chinook that occur in the fall period prior to the smolt out-migration. Some of these fall-migrating sub-yearlings rear to smolt size downstream of the trap and contribute to the adult spring chinook escapement into the Chiwawa River.

Temperature, stream flow, water quality monitoring, and macro-invertebrate sampling occurred in all five index watersheds in 2001/02. Water quality parameters measured included turbidity, total suspended solids, fecal coliform bacteria, ammonia-N, nitrate+nitrite-N, total nitrogen, total phosphorus, and soluble reactive phosphorus (orthophosphate). Hardness and dissolved metals

(copper and zinc) were analyzed at each site for several months when sampling was initiated, but were discontinued when the concentrations were found to be low. Field measurements included dissolved oxygen, temperature, pH, and conductivity. Many of these measures were folded into a Water Quality Index (WQI). Sampling of benthic macro-invertebrates was conducted each fall.

The WQI for the Deschutes River in 2002 was relatively low, 69, due to high fecal coliform bacteria, nutrient concentrations, and suspended solids and turbidity. One low pH and one high fecal coliform sample were outside state standards for the Deschutes River. Water temperatures exceeded standards on 27 and 44 days, depending on the monitoring site. In Big Beef Creek, parameters were within standards except for two low pH readings and one high fecal coliform count. Water temperature at the outlet of Lake Symington exceeded temperature standards 73 days in 2002, reflecting the impact of the reservoir on temperature. Although not fully analyzed, temperatures at other stations are substantially lower. The WQI on Big Beef Creek was 73 in 2002, due to high total phosphorus, suspended solids, and turbidity values on two occasions. The WQI for Bingham Creek was 84 in 2002. The only problems measured on this stream were three low (<6.5) pH values. The WQI for Cedar Creek was 81 in 2002. Conditions were impaired by high fecal coliforms, low pH, and high water temperatures that exceeded standards on 64, 10, and 25 days depending on the sampling station. The only violations of water quality standards noted for the Chiwawa River were for one low pH and one high pH. Temperatures were within standards. The WQI was only 54 in 2002 due to elevated suspended solids, turbidity, and total phosphorus.

Field work conducted in 2001/02 represents the second year of monitoring under the joint WDFW/ECY Index Watershed Monitoring Program. Wild salmon production monitoring has occurred over a much longer period of time in these basins, ranging from 5 years in Cedar Creek to 25 years in Big Beef Creek. By measuring the annual production of juvenile salmon and environmental parameters across the basin, the focus of this project is at the watershed scale. This is much broader than the site scale that most restoration projects are focused. Therefore, this monitoring program evaluates changes in fish production and environmental conditions well, but is unable to evaluate the benefits from either a single project or a suite of land-use management or regulatory actions. Instead, it evaluates the cumulative effects of all restoration projects on the measured parameters given the background of human land use and natural stochastic events (e.g., storms, windthrow, etcetera). At the end of 2002, a number of SRFB-funded recovery projects have occurred in the index watersheds: 2 in the Deschutes River; 4 in Big Beef Creek; 7 in Cedar Creek; and none in Bingham Creek or the Chiwawa River. All of these projects are expected to increase or maintain salmonid production in the index watersheds.

Over the two years that index watershed monitoring has been conducted, three major project limitations were noted: 1) the project incorporates a passive approach to monitoring that fails to test specific solutions to salmon recovery in each basin; 2) funding limitations resulted in the loss of the important habitat assessment/monitoring component from the project; and 3) the lack of control and treatment streams limits the project's ability to separate change associated with salmon recovery activities from natural variability. Recommendations to address these limitations focus on transitioning the Index Watershed Monitoring program into a pilot Intensive Watershed Monitoring program, which follows designs from the Statewide Comprehensive

Monitoring Strategy and the Forest and Fish Monitoring and Design Team Report. A separate proposal will be completed in early 2003 which describes this transition in detail.

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Introduction and Background

Beginning in the early 1990s, many salmon, steelhead, and trout/char stocks were listed or are under consideration for listing under the Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS) and the U.S. Fish & Wildlife Service (USFWS). The listings have occurred statewide. In response to these listings, federal, state, local, and tribal governments have committed substantial resources to planning and implementing the recovery of depleted salmonid stocks. At the state level, planning efforts by numerous state agencies culminated in the release of the Extinction is Not an Option: A Statewide Strategy to Recover Salmon (JNRC 1999). This document outlined numerous recovery strategies to improve the survival of salmon. It also recognized that an important component of salmon recovery and key to de-listing salmonid populations is a credible monitoring and adaptive management program. As part of the monitoring component, a system of index watersheds was envisioned where comprehensive and integrated monitoring efforts would occur.

In 1999, the Washington Departments of Fish and Wildlife (WDFW) and Ecology (ECY) developed an approach for index watershed monitoring that involved measuring the production of wild downstream migrating juvenile salmon (smolts), habitat, water quality, stream flow, and macro-invertebrate assemblages in selected watersheds. Partial funding for this project was secured in the 1999/2001 biennial budget and index monitoring was initiated, sans the habitat monitoring component, in five watersheds beginning in October, 2000. These include Deschutes River in Puget Sound, Big Beef Creek in Hood Canal, Bingham Creek in the Chehalis River basin, Cedar Creek in the Lewis River basin, and Chiwawa River in the Wenatchee River basin (Figure 1). Results from water quality, flow, and macro-invertebrate monitoring during the first year are included in Summers (2001).

Beginning in July, 2001, funding for this project was provided by the Washington Salmon Recovery Funding Board (SRFB) under a contract administered by the Interagency Committee for Outdoor Recreation (IAC). This report describes the results of the first and second years of smolt monitoring activities that occurred between February 2001 and September 2002. It also describes the results of our second year (October 2001 to September 2002) of water quality/quantity, temperature, and macro-invertebrate monitoring under the index watershed monitoring program.

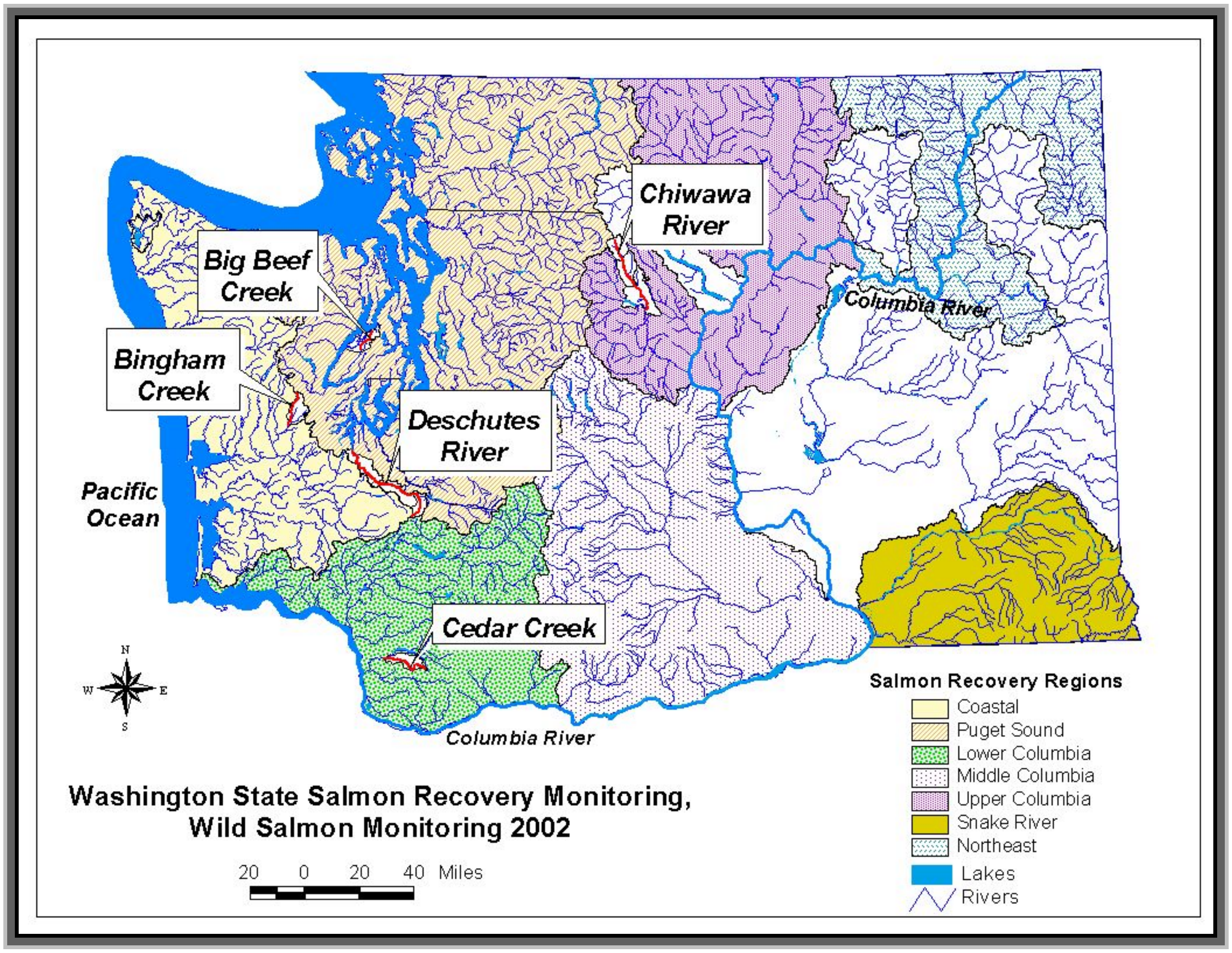

Figure 1. Location of the joint WDFW/ECY Index Watersheds monitored in 2001 and 2002.

Goals and Objectives

The goals for this project are centered on understanding the productivity of wild anadromous salmonid populations and evaluating their restoration. Three overarching goals include:

1. Determining and quantitatively evaluating the factors influencing the production and productivity of wild anadromous salmonids in the index watersheds;
2. Determining land-use activities or natural watershed processes that modify those factors; and
3. Monitoring the effects of restoration activities on wild salmonid production and on environmental factors that influence salmonid production.

Achieving these goals will require several years of assessment to evaluate inter-annual variability in the production of wild populations and in the measured variables that influence production. Achieving these goals will also require analysis to determine quantitative linkages between production/productivity levels and the measured variables. Data collected between October 2001 and September 2002 to enable achieving these long-range goals are outlined in the following objectives:

1. Measure the production of wild anadromous salmonid populations in each index watershed;

2. Measure stream temperature, water quality variables, and flows at sufficient intervals to describe their variation; and

3. Assess the benthic macro-invertebrate community to determine potential impacts to biotic communities and fish populations.

Index Watersheds

The five index watersheds discussed in this report are well distributed throughout the state (Figure 1). Two are located in the Puget Sound Region (Deschutes River and Big Beef Creek), one is within a coastal watershed (Bingham Creek), and two are located in the Columbia River basin (Cedar Creek and Chiwawa River). Of the Columbia basin watersheds, Cedar Creek is located on the westside and the Chiwawa River is located on the eastside of the Cascade Mountains. This section includes a description of each of the index watersheds, the salmonid species using them, and a description of their monitoring history.

Deschutes River

The Deschutes River originates in north central Lewis County, west of the town of Mineral near Cougar, Huckleberry and Bald Mountains. The river travels a total of 50 miles, primarily in a west-northwesterly direction through the oak prairie lands of southern Thurston County before heading in a more northerly direction through the cities of Tumwater and Olympia (Figure 2). The watershed area is 337-km^2. In Olympia, it empties into Capitol Lake and Budd Inlet in lower Puget Sound. The upstream limit of salmon distribution is Deschutes Falls, located at river kilometer 66. Tumwater Falls is located near the mouth of the river where it empties into Capitol Lake. Historically, this falls blocked access into the Deschutes River; however, a fishway constructed by WDFW in 1954 opened the river to anadromous fish.

The Deschutes River Valley is located at what was the southern terminus of the Vashon Glacier that extended into Puget Sound about 14,000 years ago. The valley was formed by the outwash of silt, sand, and gravel created by glacial processes. Much of the rainfall this area receives percolates into the porous soils and into underground aquifers. Consequently, the Deschutes River has few tributaries.

The Deschutes River supports runs of chinook and coho salmon that migrate over the fishway at Tumwater Falls. The chinook run is thought to primarily be comprised of hatchery-origin adult chinook that are released upstream to spawn naturally. The coho run, which has been in severe decline over the last ten years, is comprised of naturally-produced fish. The Deschutes River also supports runs of steelhead and cutthroat trout.

Spawning escapement into the Deschutes River has been counted annually at the fishway since its construction in 1954. In addition, the WSPE has been operating a juvenile migrant fish trap at the base of Tumwater Falls to monitor wild coho smolt production since 1977 (Figure 2). Over the last two years, an effort has been made to estimate the production of naturally produced juvenile chinook salmon as well. This effort has been hampered, however, by the large numbers of hatchery chinook that are released during the downstream migration of naturally-produced chinook. The trap must be removed during these releases to avoid capturing large numbers of hatchery fish.

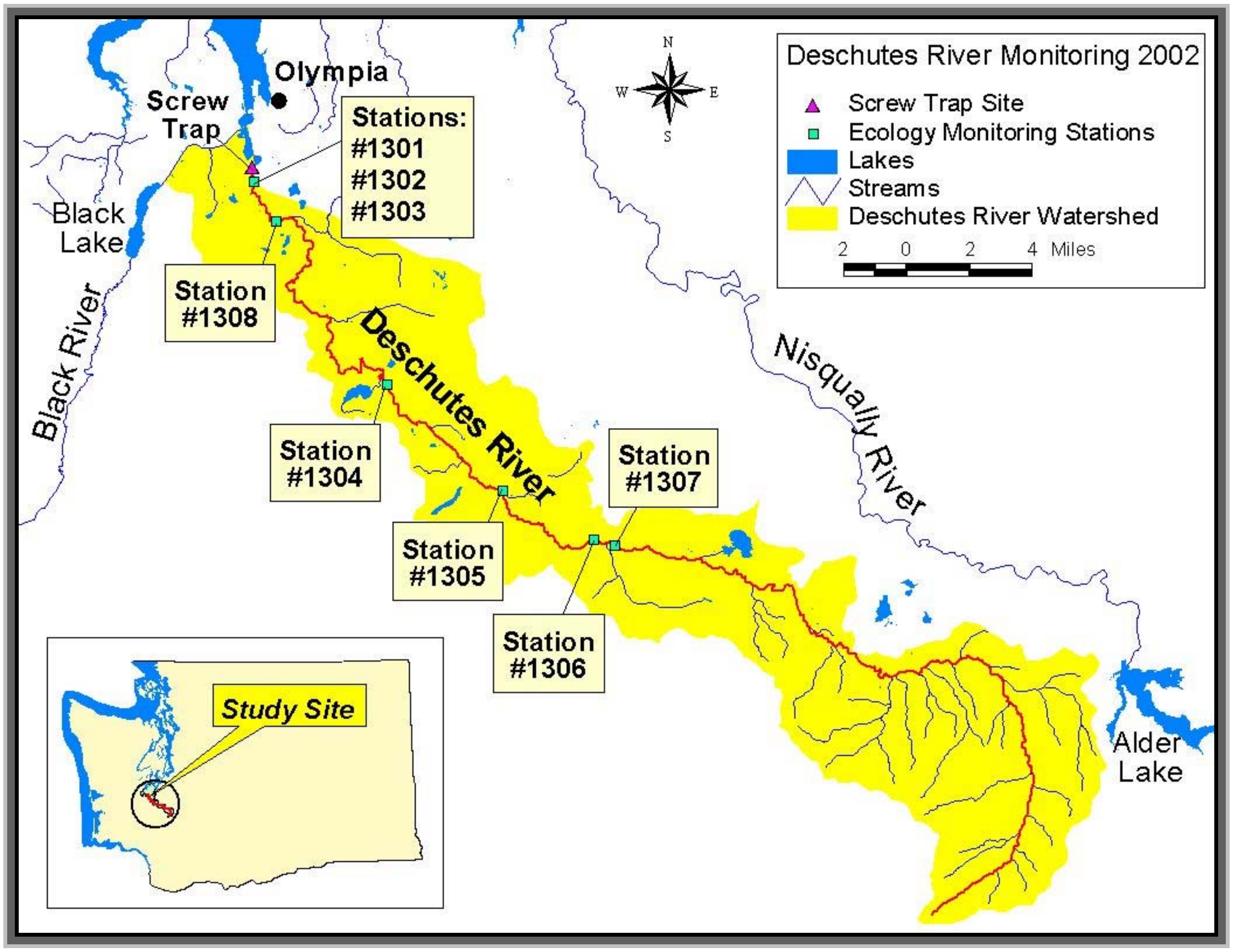

Figure 2. Map of the Deschutes River Watershed depicting the locations of the WDFW screw trap and ECY monitoring stations.

Big Beef Creek

Big Beef Creek is a tributary to eastern Hood Canal (Figure 3). It has a watershed area of 36-km^2. The stream originates at Morgan's Marsh on the Tahuya Peninsula's central plateau in Kitsap County. It travels in a northeasterly direction across the plateau and through a series of wetlands before picking up gradient and flowing into Lake Symington. Lake Symington is a shallow, man-made reservoir created as part of residential development in the area. A fishway provides access over the dam at the downstream end of the lake, primarily for coho salmon and cutthroat trout. Downstream of the lake, Big Beef Creek continues in a more northerly direction. It makes the transition from the central plateau to Hood Canal by cutting down through a steep-sided canyon. From the mouth of the canyon, the stream flows a few hundred meters through an alluvial valley bottom before reaching a 1.5-hectare embayment. At one time, the bay was open to Hood Canal; however, with the construction of the Seabeck Highway, much of the opening was closed and a causeway was created for the roadbed. The opening into the bay is currently less than 100 feet wide. This constriction has resulted in the buildup of sediment deposited in the bay. Over time, this embayment will likely continue to fill in and decrease in size.

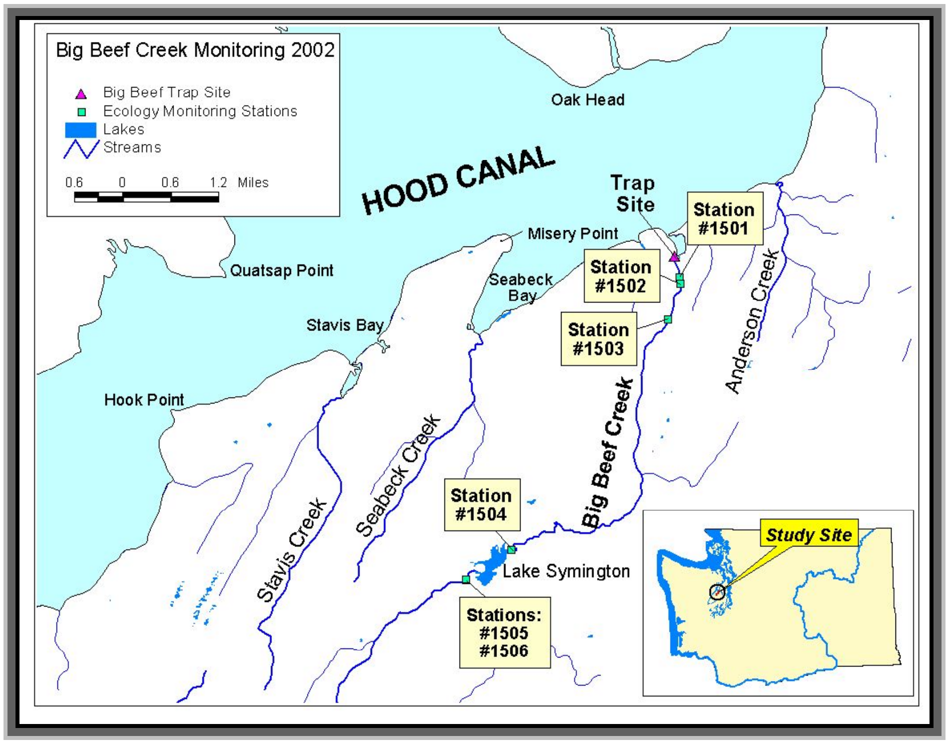

Figure 3. Map of the Big Beef Creek Watershed depicting the location of the WDFW upstream/downstream weir trap and ECY monitoring stations.

Big Beef Creek is currently used by chinook, coho, and chum salmon, and steelhead and cutthroat trout. Few chinook used Big Beef Creek historically. Chinook currently found in Big Beef Creek are the result of a hatchery program conducted at the University of Washington's Big Beef Creek Research Station. Hatchery chinook are not allowed to spawn upstream of the weir. The facility also has a summer chum program that has resulted in the reintroduction of summer chum into Big Beef Creek. Coho, fall chum, steelhead and cutthroat rearing in Big Beef Creek are the progeny of adults that spawn naturally.

The Washington Department of Fish and Wildlife has maintained a weir at the mouth of Big Beef Creek where the total escapements of chinook, coho, and chum are counted (Figure 3). Fan traps mounted on the weir between April and June of each year enable measuring the freshwater production of juvenile wild coho, steelhead, and cutthroat. The spawning migrations of steelhead and cutthroat as well as the downstream migration of juvenile chum salmon are only partially quantified since much of these migrations occur prior to fan trap installation or following adult trap removal. The weir was constructed in 1976. Adult escapement estimates began that year. Juvenile production estimates began in 1978.

Bingham Creek

Bingham Creek is a tributary of the East Fork Satsop River in the Chehalis Basin in southwest Mason County (Figure 4). The watershed area is 91-km^2. The stream originates in the southeast corner of the Olympic Mountains and flows in a southerly direction through an area of glacial outwash left at the southern terminus of the Vashon Glacier. The stream joins the East Fork

Satsop River, approximately six miles south of the town of Matlock. Bingham Creek has one major tributary, Outlet Creek. Lake Nahwatzel, a 115-hectare lake, is within the Outlet Creek watershed.

Development within the Bingham Creek watershed is light. Residential housing is confined primarily to the areas around Lake Nahwatzel and Matlock. The rest of the watershed is comprised of private timberlands or Forest Service land.

Anadromous salmonids found in Bingham Creek include coho salmon, steelhead, and cutthroat trout. WDFW's Bingham Creek Salmon Hatchery is located at the mouth of Bingham Creek. Adult hatchery coho often strayed into Bingham Creek and spawned with the naturally produced coho. In recent years, with mass marking of all hatchery coho, only unmarked coho have been allowed to spawn upstream of the weir. The steelhead and cutthroat found in Bingham Creek are solely the progeny of naturally spawning adults.

A diversion dam, located approximately ¾ mile upstream from the mouth of Bingham Creek, is used to supply water to the hatchery. WDFW's Wild Salmon Production and Evaluation Unit (WSPE) has operated an adult trap and a downstream migrant fish (fan) trap at this diversion since 1982 (Figure 4). All adult coho entering Bingham Creek are counted. Production estimates are made for coho, steelhead, and cutthroat smolts.

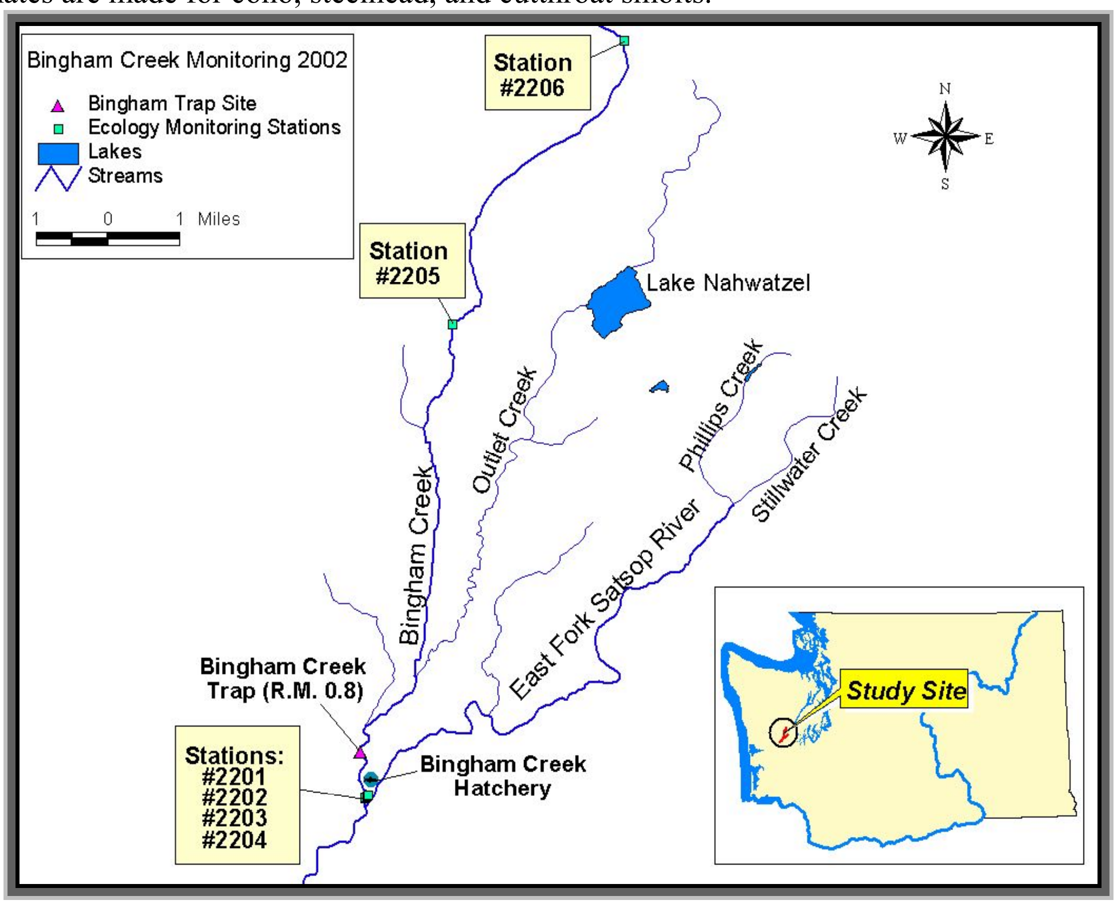

Figure 4. Map of the Bingham Creek watershed depicting the locations of the WDFW upstream/downstream weir trap and ECY monitoring stations.

Cedar Creek

Cedar Creek is a third order tributary to the Columbia River and located in Clark County, WA (Figure 5). The mouth of Cedar Creek is located across from the Lewis River Salmon Hatchery at river kilometer 25 on the Lewis River. The Cedar Creek basin is a low gradient and low elevation (11 to 570 meters) system draining approximately 144 km^2. The anadromous salmonid species identified in Cedar Creek include chinook, chum, coho, cutthroat, and steelhead. Hatchery smolt releases of steelhead, coho and spring chinook into the Lewis River strongly influence the escapement of these species in Cedar Creek. The hatchery influence on fall chinook escapement in Cedar Creek, on the other hand, is strongly influenced by hatchery strays from outside the Lewis River Basin.

Monitoring on Cedar Creek began in February 1998 with the installation of a ladder trap in the Cedar Creek fishway (RM 2.5)(Figure 5). The original intention was to monitor steelhead escapement and exclude as many hatchery steelhead from the upper watershed as possible. A rotary screw was installed a month later to measure steelhead smolt production out of the upper watershed. Since 1998, total upper watershed smolt production estimates have been produced for steelhead, coho and cutthroat trout. In addition, the potential for an index of chinook production is also being explored.

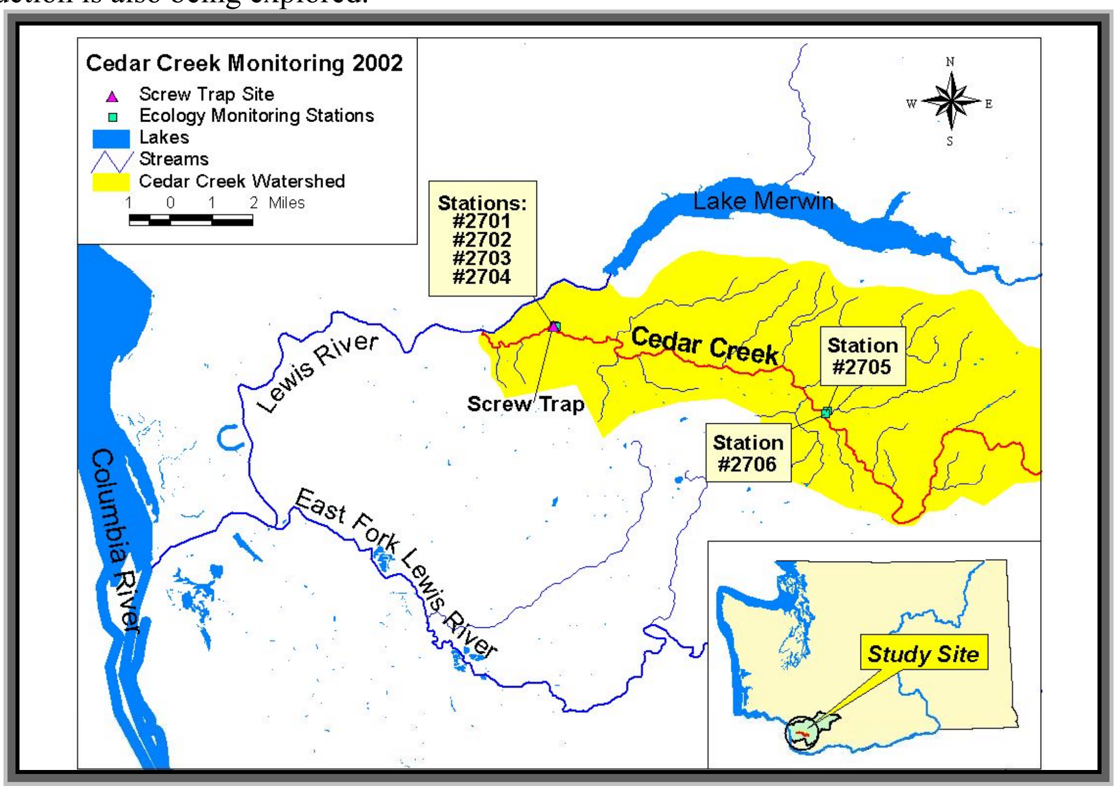

Figure 5. Map of the Cedar Creek watershed depicting the locations of the WDFW screw trap and ECY sampling stations.

Chiwawa River

The Chiwawa River is a fourth-order stream draining 570-km^2 (Mullan et al. 1992)(Figure 6). It flows primarily through the Wenatchee National Forest (96%), 32% of which is wilderness area. The headwaters are 1,676-m above sea level and the confluence with the Wenatchee River is 564-m above sea level. The river is fed by glaciers and high altitude snow fields. Fifteen percent of the lower watershed has been affected by logging, but the upper Chiwawa River has remained essentially pristine. Irrigation in the lower 6-km of river valley diverts 7% of the mean monthly flows during low flow months (Mullan et al. 1992). Historical river discharge levels at the U.S. Geological Survey (USGS) gauging station (# 4565 at river km 10.2) indicate the mean annual discharge is 13.8-m^3/s, mean low discharge is 7.5-m^3/s, and maximum recorded discharge at flood level is 158-m^3/s. The Chiwawa River has an estimated mean wetted width of 15.2-m. Estimated spawning and rearing habitat available for spring chinook salmon is 4.8-km^2 (Mullan et al. 1992).

The WDFW has operated the Chiwawa Acclimation Ponds (river km 1.5) since 1991 and has annually released hatchery spring chinook and, more recently, steelhead into the Chiwawa River. A weir located adjacent to the hatchery is operated during the summer to collect broodstock for the spring chinook program. The weir is operated intermittently, however, records are maintained on all species (i.e., steelhead, bull trout, and cutthroat) that are trapped. As part of the monitoring and evaluation plan of the hatchery program, the WDFW has operated a rotary smolt trap in the Chiwawa River since the fall of 1993 (Figure 6).

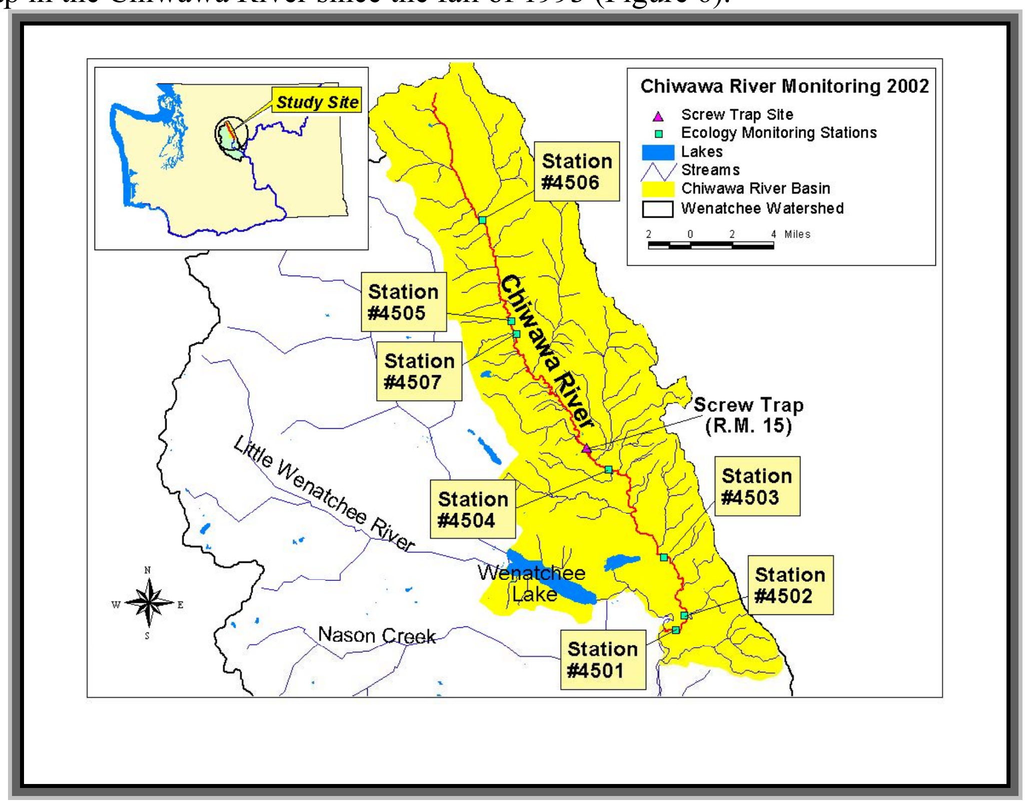

Figure 6. Map of the Chiwawa River watershed depicting the location of the WDFW screw trap and ECY monitoring statons.

Trap Design and Operation

Two trapping methods were used to capture downstream migrating salmon. At Big Beef Creek and Bingham Creek trap sites, fan traps were used to capture the juvenile fish (Seiler et al. 1981). Floating screw traps are used to capture migrants in the Deschutes River, Cedar Creek, and Chiwawa River (Busack et al. 1991).

Big Beef Creek and Bingham Creek

The fan traps consist of a series of perforated aluminum fans that screen the entire stream flow at each site. The aluminum fans (12-ft in length) screen water through a folded (four "V"-shaped troughs) 14-gauge plate floor perforated by 33 1/8-in holes per in^2. The fans are attached at the wide (7-ft) end to the permanent concrete weir at Big Beef Creek and the barrier dam at Bingham Creek. Flexible rubber gaskets seal the attachments between the fans and the stationary weir supports. Each fan is supported on the narrow (20-in) end by a ¾ ton chain hoist that allow the elevation of the fan to be adjusted to accommodate the stream flow. Fish that enter the fans are passed through into a collection system that routes them into a holding box, while the majority of the water falls through the perforated plate. Stop logs placed under the fans and in all the other bays create the head necessary for trap operation. At Big Beef Creek, three fans are used whereas seven are used at Bingham Creek.

Deschutes River, Cedar Creek, and Chiwawa River

The screw traps consisted of two tapered aluminum flights, wrapped 360 degrees around an aluminum shaft. These flights were housed inside a cone-shaped frame covered with perforated plating. An 8-foot diameter screw was used on the Deschutes and Chiwawa Rivers, whereas a 5-foot screw was used on Cedar Creek. The shaft of each trap was aligned parallel with the flow. The Deschutes River trap was lowered to the water's surface via davits and winches mounted on two 30-ft steel pontoons. The Cedar Creek and Chiwawa River traps were lowered using a single winch mounted on a semi-circular frame positioned over the trap and bolted to aluminum pontoons. At each site, the movement of water against the screw facilitated trap operation. Water current acting on the flights caused the trap to rotate, and with every 180 degrees of rotation, a flight entered the water while the other emerged. As the leading edge of a flight emerged from the water it prevented the escape of trapped fish. The fish were gently augured into a solid sided, baffled live box.

The Deschutes River trap was anchored to each bank using 3/8 inch diameter aircraft cable. A 2-ton winch was mounted on each pontoon and was used to adjust the position of the trap in the river. On the Chiwawa River, the trap was suspended using 3/8 inch diameter aircraft cable from a 1/2 inch main cable attached to large trees on either side of the river. A manual pulley system allows the trap position to be laterally adjusted across the river. A similar system was used to position the trap in Cedar Creek.

Production Estimates

Two types of juvenile wild salmon production indicators are developed from the trapping data. The preferred indicator is an estimate of total juvenile production by year class and/or brood. Production estimates enable evaluating trends in freshwater production from index watersheds for individual species over time. They can be compared between streams and correlated with habitat, environmental, and management conditions. They are also used in fishery management to forecast run sizes. The other indicator is an index of production. Where sufficient data are not available to develop a production estimate, catch of a year class and/or brood in the trap can be used as an index of production. Where the trapping effort can be standardized, the index of production can be compared between years to assess trends in freshwater production within a stream system. However, the production index is not comparable between systems since it only reflects catch per unit of effort in a given stream and not the total production.

Fan Traps

Since fan traps are designed to screen all of the water passing the trap site, all downstream migrants are captured, and if the entire migration occurs during the trapping period, then the production estimate is actually a count of all fish leaving the system. In Big Beef and Bingham Creeks, virtually all coho, steelhead, and cutthroat smolts are captured in the trap. A few coho are thought to migrate before and after the period of trap operation. Therefore, an extrapolation is made to estimate these fish. In most years, at least 95% of the migrating coho, steelhead, and cutthroat are captured in the trap. Occasionally, excessively high flows during the trapping period will briefly result in the loss of trap effectiveness. The catches missed during these periods are interpolated based on the migration timing models developed from other years' data. The resulting production estimates developed during these years have less precision since a smaller proportion of the total production would have been caught.

In Big Beef Creek, a substantial and variable portion of the total chum salmon production migrates prior to trap installation. Production indicators for chum salmon are therefore categorized as an index of production. The period of chum migration is short and primarily occurs when flow often exceed the capabilities of the trap (February-March). Since the proportion of chum salmon fry that are not trapped each year is considerable and variable, trends in production indices should only be used to evaluate gross-level changes in production.

Screw Traps

Estimating juvenile production for a year class and/or brood from screw trap catches involves two steps: 1) estimating or interpolating the catch that was missed during periods when the trap was not operated; and 2) estimating the proportion of migrants that are captured at any given point in time of trap operation (capture rate or trap efficiency).

Screw traps are generally operated 24-hours per day, seven days per week. However, conditions sometimes occur that cause trapping to be suspended. Examples include periods when debris loads/flows can damage an operating trap or cause conditions that are dangerous to the trap operators, when high recreational use of the river causes a trap to pose a danger to the public, when debris jams the screw causing trap operation to be ineffective, and during periods when very few fish are caught and trapping is intentionally suspended.

Catch is estimated during periods of suspended operation by taking into account the seasonal, diel (day vs. night), and environmentally based (e.g., flow-based) differences in the migration timing of juvenile fish. The catch estimated during suspended trapping periods added to the actual catch results in an estimate of total catch during the entire trapping period.

Trap efficiency was estimated for the Cedar Creek and Chiwawa River traps by the proportion of fin-marked or dye-marked chinook (Chiwawa River), coho (Cedar Creek), and steelhead (Cedar Creek) that were released upstream and subsequently recaptured in the trap. Cutthroat trap efficiency in Cedar Creek is assumed to be the same as that for steelhead since they are of similar size.

A different approach is used to estimate the capture rate on the Deschutes River. Coho captured in the Deschutes River trap were coded-wire tagged. When these fish return as adults, sampling at the Tumwater Falls fishway will determine the proportion that contain this tag. Assuming minimal stray rates, this proportion estimates the capture rate in the screw trap for smolts. In the meantime, an approximation of coho smolt production was estimated for the Deschutes River using a trap efficiency of 21.5% (long-term average). However, the resulting smolt production estimates are considered preliminary until the adults are sampled in the fishway approximately 18 months later.

As with the fan trap, production indices are used where data are not of sufficient quality to estimate production. Indices are being developed for chinook in the Deschutes River and Cedar Creek, and for steelhead on the Chiwawa River.

Results

Deschutes River 2001

In 2001, the Deschutes River screw trap operated from February 2 until July 17. We caught a total of 162,233 age 0+ chinook, which includes 12,001 hatchery chinook (Appendix A). Through the season, 10,044 age 0+ chinook were coded-wire tagged to evaluate the survival of the progeny of hatchery fish spawning in the wild. We also caught 28 age 1+ chinook, 114 coho fry, 1 hatchery coho smolt, and 176 wild coho smolts. One coho adult was caught during the trapping interval.

Trapping was suspended for brief intervals during the trapping period to avoid capturing large numbers of hatchery fish and when debris jammed the screw and prevented its operation. Using interpolation, we estimate an additional 16 wild coho smolts would have been captured during the suspended trapping periods. Therefore, we estimate 192 wild coho smolts would have been captured if the trap operated continuously from February 2 until July 17.

Coho smolt production in the Deschutes River is usually estimated by multiplying the number of smolts that were coded-wire tagged by the proportion of returning wild adults that contain coded-wire tags after adjusting for tag loss. However, coded-wire tagging was not done in 2001 due to the low migration of coho smolts. Therefore, using the average trap efficiency estimated from many years of work in the Deschutes system, we estimate the 2001 wild coho smolt production at 892 (Appendix A, Figure 7).

In 1999, there were 13 adult coho females that returned to the Deschutes River to spawn. An estimated 68.6 smolts per female were produced using the migration estimate of 892 smolts.

Trout were also caught during the season, including 31 trout parr. A total of 3,028 steelhead smolts (104 wild and 2,924 hatchery), and 1 wild steelhead adult was caught in 2001 (Appendix A). We also caught 23 cutthroat smolts, and 17 cutthroat adults. These catches occurred during the trapping season and have not been expanded to represent total migration.

Deschutes River 2002

The Deschutes River trap operated from February 11 to June 26. There were 41 trap outages throughout the season, totaling 620.5 hours not fished. More than half of those occurrences (26) were intervals of less than three hours. During the trapping season, we caught 183,904 age 0+ chinook, which includes 86,381 hatchery chinook. We also caught 27 age 1+ chinook, of which, 16 were hatchery. There were 16,860 coho smolts captured and 15,475 of those smolts were coded-wire tagged (Appendix A). Eleven coho fry were also caught. We estimate total wild coho smolt production at approximately 60,000 smolts (Figure 7). This preliminary estimate was derived using a higher capture rate (28%) compared to our long-term average capture rate (21%). Indicators suggested that the trap was more efficient in 2002 than in previous years. A final estimate will be developed based on the proportion of wild tagged adults that return in 2003.
In addition to salmon, 12 trout parr were caught, along with 1,640 steelhead smolts (65 wild and 1,575 hatchery) and 31 cutthroat smolts. Cutthroat adults were also caught, totaling 17 throughout the season. These catches occurred during the trapping interval, and were not expanded to represent total migration production.

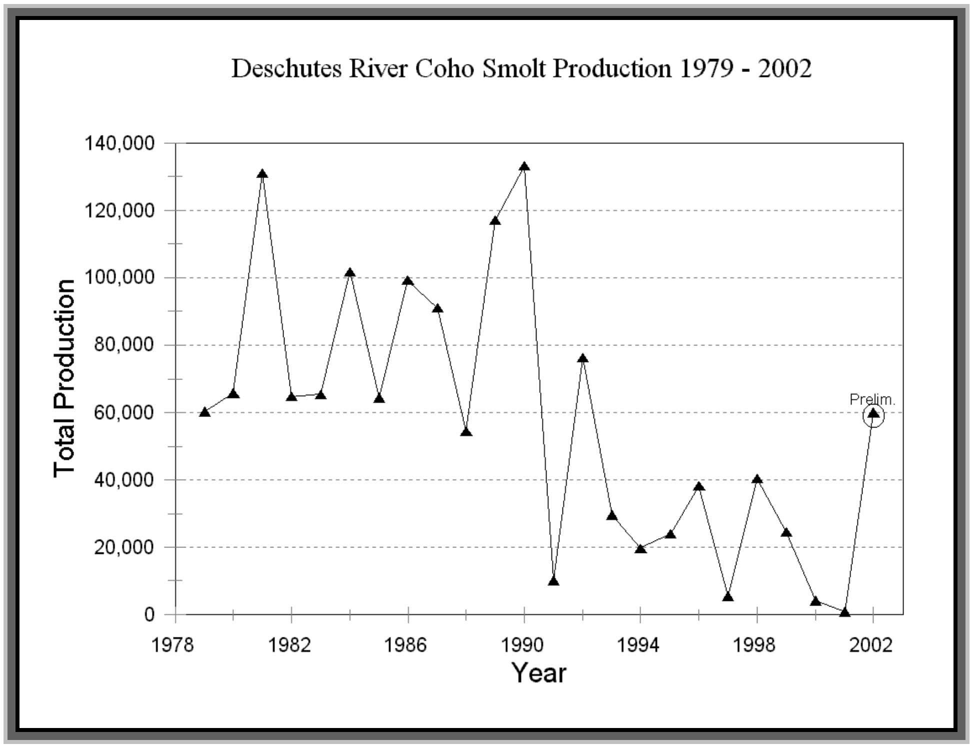

Figure 7. Deschutes River wild coho smolt production from 1979 to 2002.

Big Beef Creek 2001

The fan trap at Big Beef Creek operated from March 27 until June 11 with no trap outages occurring during the trapping interval. There was a total of 20,912 coho smolts caught during the trapping season, and 19,462 smolts were coded-wire tagged (Appendix A). Migration had begun before the trapping period started and some migrants were still moving after the last day of trapping. In order to estimate the entire migration, we extrapolated the catch assuming a migration starting date of March 1 and an ending date of June 30. This expansion increased the actual catch by an additional 460 smolts. The total estimated production in Big Beef Creek in 2001 was 21,855 coho smolts, which includes 483 wild smolts estimated to have migrated from the University of Washington FRI spawning channels and ponds (Figure 8).

In addition to coho smolts, other salmonid species caught throughout the season include 235 coho fry, 13 chinook fry, and 12,740 chum fry. The chinook fry captured are thought to be upstream migrating progeny of chinook spawning below the weir. We also caught 119 trout fry, and 1,237 trout parr. There were 1,887 steelhead smolts and 959 cutthroat smolts (Appendix A). Wild downstream migrant steelhead adults (kelts) numbered 20 (8 females and 12 males), and there were 118 cutthroat adults (69 males and 49 females). These numbers represent migration during the trapping interval, and only steelhead and cutthroat smolts were expanded to represent total production. Using migration timing to estimate total migration production, steelhead smolts were estimated at 1,932 smolts and cutthroat were estimated at 1,024 smolts (Figure 9).

In 1999, Big Beef Creek had an escapement of 278 female adult coho. Based on the production estimate of 21,855 coho smolts, the 1999 brood averaged 78.6 smolts per female.

Big Beef Creek 2002

In 2002, the trap at Big Beef Creek operated from April 4 to June 3. During the trapping interval, 22,999 coho smolts were caught (Appendix A). Of those smolts caught, 21,221 were coded-wire tagged. Using the same migration timing assumptions adopted for the 2001 migration, our preliminary estimate of coho smolt production is 23,304 (Figure 8).

We also caught 17 coho fry, 103 age 0+ chinook, and 1,514 chum fry. Other species that were caught during the season including 552 trout fry and 552 trout parr, which consisted of 273 steelhead parr and 279 cutthroat parr. We also caught 2,078 steelhead smolts and 1,394 cutthroat smolts, and using migration timing we estimated total migration production at 2,191 and 1,589 smolts, respectively (Appendix A, Figure 9).

The 2000 brood resulted in an estimated 55.6 coho smolts per female. This is estimated from the migration estimate of 23,304 and an escapement of 419 females in 2000.

The data for 2002 and the resulting estimates are preliminary.

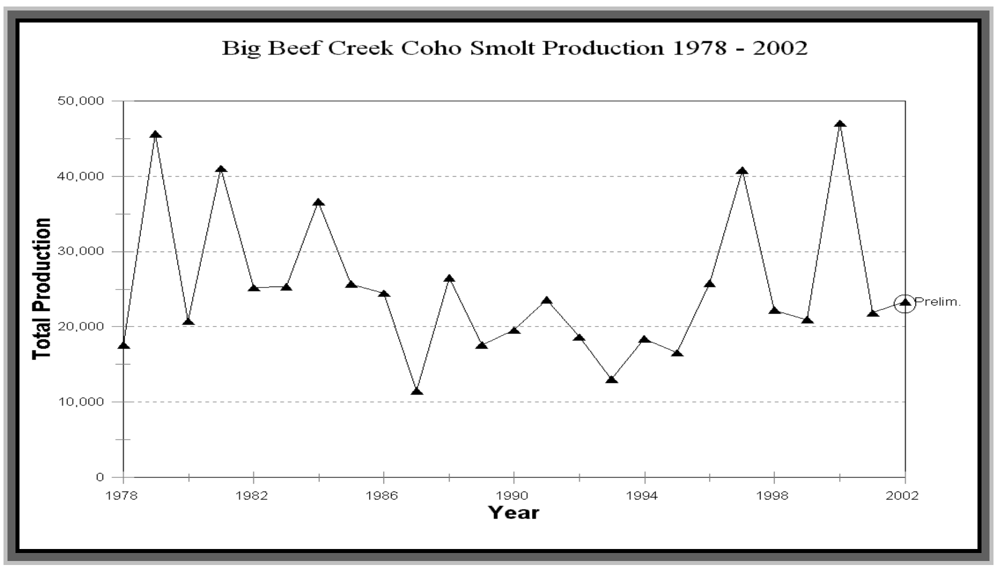

Figure 8. Big Beef Creek wild coho smolt production from 1978 to 2002.

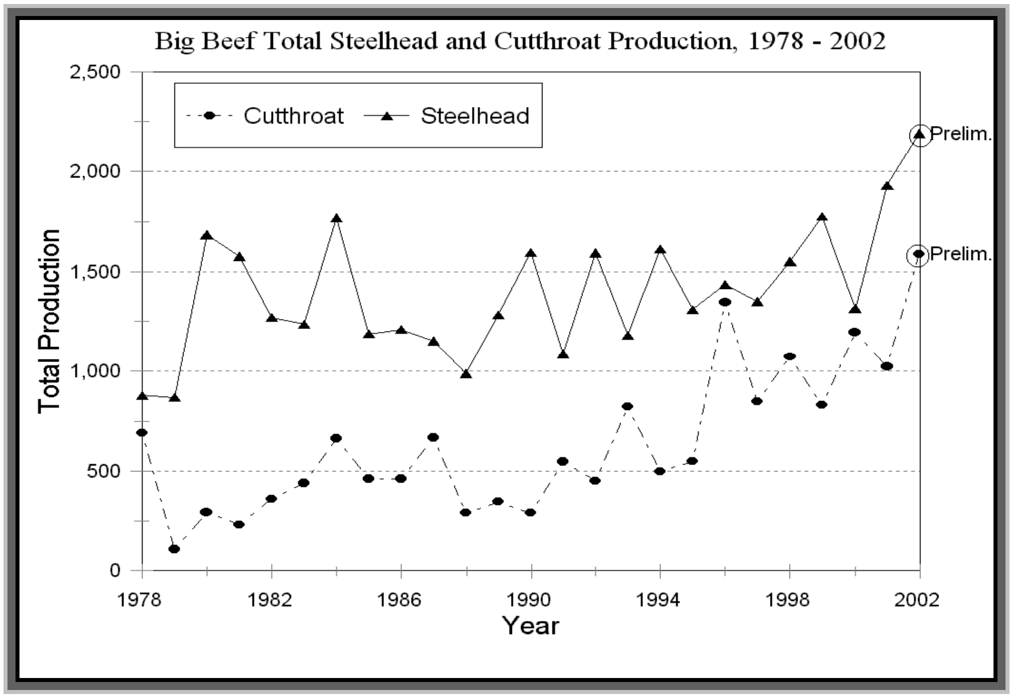

Figure 9. Big Beef Creek wild steelhead and cutthroat smolt production from 1978 to 2002.

Bingham Creek 2001

Trapping at Bingham Creek in 2001 began on March 26 and continued until June 13. We believe that during the period of operation, all downstream migrating salmonids were captured in the fan trap. During this interval, a total of 41,710 coho smolts were caught (Appendix A). Of these, a total of 41,140 were coded-wire tagged. Since some migration was believed to occur before and after the period of trap operation, total wild coho smolt production was estimated to be 45,000 (Figure 10). This estimate is preliminary. A final estimate will be developed based on the proportion of wild adults returning in 2002 that are coded-wire tagged.

Other species and year classes were also caught in the trap over the season. A total of 6,347 coho fry, 85 trout parr, 812 steelhead smolts, and 131 cutthroat smolts were captured over the trapping period (Appendix A). We also captured 101 steelhead adults (31 hatchery and 71 wild), and three cutthroat adults. These numbers represent in-season migration only. Wild steelhead and cutthroat smolt catches were expanded beyond the trapping season to estimate total production. Using migration timing, it is estimated that a total of 835 steelhead smolts and 133 cutthroat smolts migrated during 2001 (Figure 11).

In 1999, 938 female coho spawned in Bingham Creek. A production of 48 smolts per female was estimated using the migration estimate of 45,000 smolts in 2001.

Bingham Creek 2002

In 2002, the Bingham Creek trap was operated from April 5 until June 17. Due to high flows, trapping was suspended from April 13 at 0330 to April 17 at 1630. During the period of trap operation, 27,073 wild coho smolts were captured (Appendix A). We estimated that approximately 1,000 more would have been caught had the trap operated during the period when trapping was suspended. Over the season, we coded-wire tagged 21,589 coho smolts. Using migration timing, we estimate preliminary coho total production to be 29,813 smolts (Figure 10). A final estimate will be developed using the proportion of wild coded wire tagged adults that return to Big Beef Creek in 2003.

We also caught 10,672 coho fry, 23 trout parr, and 57 steelhead adults (29 wild and 28 hatchery) throughout the season. There were 466 steelhead and 75 cutthroat smolts caught, and using migration timing we estimate total production at 495 and 80 smolts, respectively (Appendix A, Figure 11).

In 2000, Bingham Creek had 668 adult female coho return upstream to spawn. This estimates a production of 44.6 smolts per female using the preliminary total coho production estimate of 29,813 smolts.

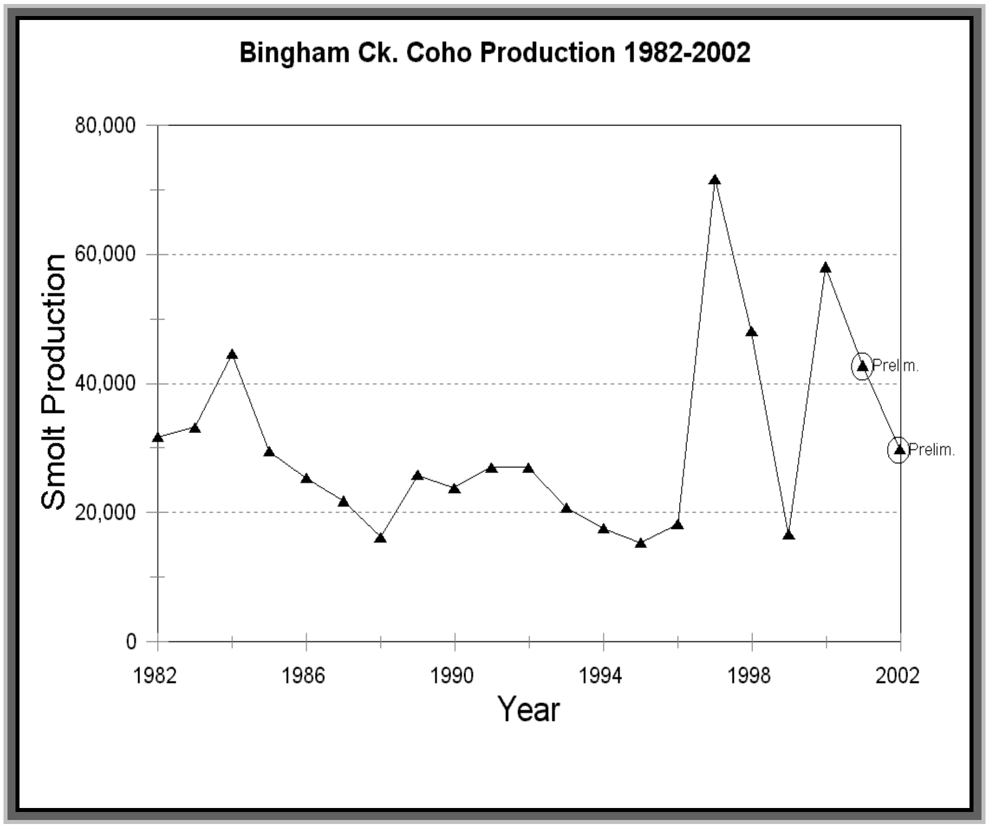

Figure 10. Bingham Creek wild coho smolt production from 1982 to 2002.

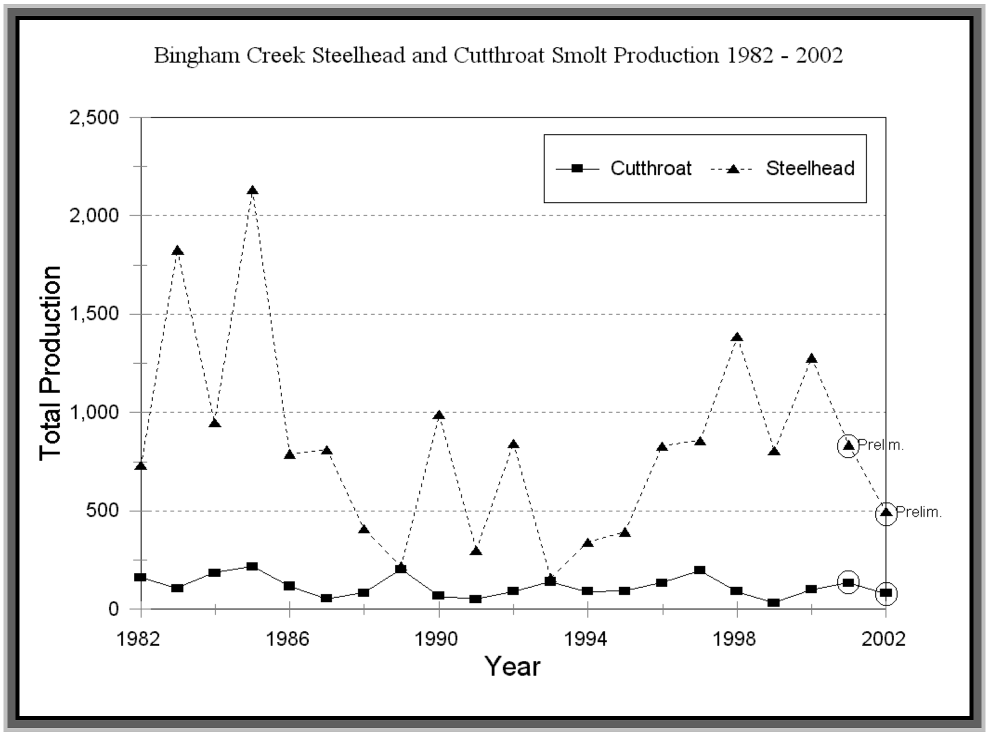

Figure 11. Bingham Creek wild steelhead and cutthroat smolt production from 1982 to 2002.

Cedar Creek 2001

A 5-foot rotary screw trap operated at river mile 2.5 in lower Cedar Creek from March 15 to June 29, 2001. During this period a total of 4,269 coho smolts, 694 steelhead smolts, and 322 cutthroat smolts were captured (Appendix A). Based on daily trap efficiency tests that were pooled by week, we estimated that Cedar Creek produced 24,138 wild coho smolts with a 95% confidence interval of 20,226 to 28,049 in 2001 (Figure 12). Production estimates and confidence intervals for wild steelhead were 3,565 smolts +/- 820, and for wild cutthroat were 2,337 smolts +/- 605. These estimates represent wild production from approximately 95% of the watershed area.

In addition to coho, steelhead and cutthroat, age 0+ chinook were also captured in the trap. Trap efficiency estimates were not made for chinook, therefore, catches are considered indices of abundance. In 2001, 544 age 0+ chinook were captured in the Cedar Creek screw trap (Appendix A).

Cedar Creek 2002

In 2002, the trap was operated from March 22-June 28, 2002. A total of 14,429 coho, 777 steelhead, and 1,138 cutthroat smolts were captured over this period (Appendix A). Based on trap efficiency tests, we estimated 31,909 coho, 2,225 steelhead, and 3,903 cutthroat smolts migrated past the gear (Figure 12). Trap placement was the same as in 2001, therefore, these estimates represent wild production from approximately 95% of the watershed area. The 2002 estimates are considered preliminary. Confidence intervals have not yet been calculated for these estimates.

As in 2001, age 0+ chinook migrants were captured in the trap. In 2002, a total of 899 chinook were captured (Appendix A).

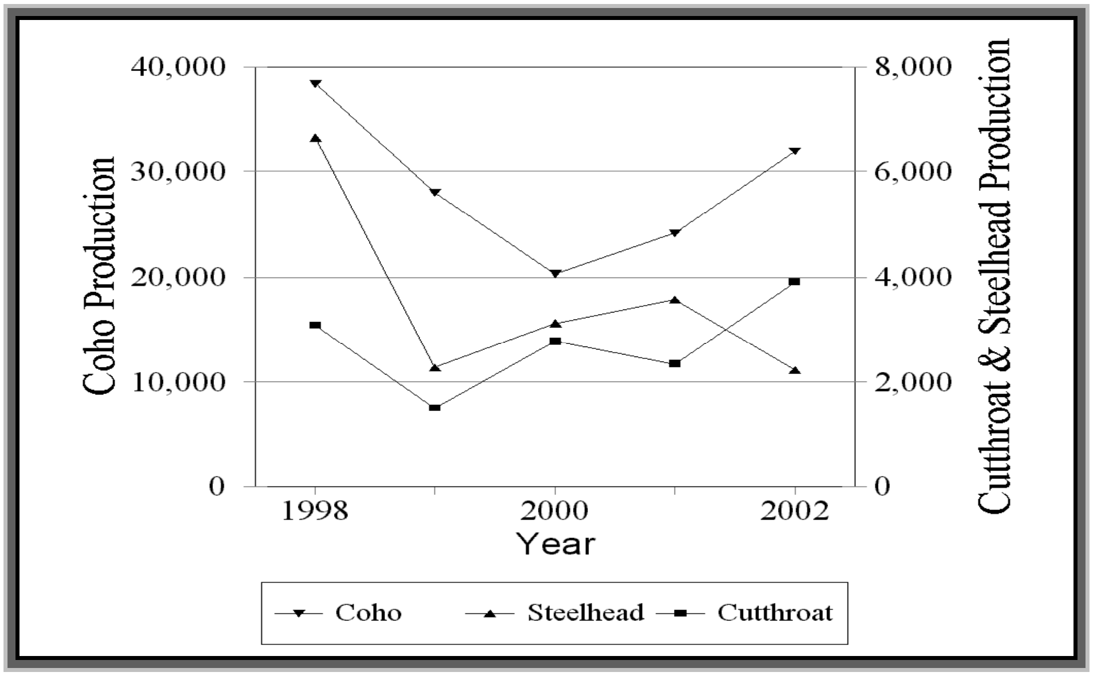

Figure 12. Cedar Creek wild coho, steelhead, and cutthroat smolt production from 1998 to 2002.

Chiwawa River 2001

The smolt trap operated from March 3 through December 13. During that time period the trap was not operated on four days due to high debris or snow. We captured 2,800 yearling spring chinook and estimated 2,931 yearling chinook would have been trapped if the trap had operated continuously (Appendix A). We conducted nine mark/recapture efficiency trials with a mean (SD) trap efficiency of 33.6 (11.2) %. In addition to the yearling chinook, we captured 5,171 sub-yearling spring chinook and estimated 5,378 sub-yearling chinook would have been captured if the trap had operated continuously. We conducted sixteen mark/recapture efficiency trials with sub-yearlings and found a mean (SD) trap efficiency of 29.8 (13.0)%.

During the sampling period the trap was operated in two positions dependent on river discharge (i.e., lower > 12 m^3/s and upper < 12 m^3/s). Daily trap efficiencies were estimated from a separate regression model for each position. The daily number of fish captured was calculated using the corresponding estimated trap efficiency to estimate a daily total emigration. Based on regression models for the lower position (r^2= 0.41, P<0.01) and upper position (r^2 = 0.63, P<0.001), we estimated (95% C.I.) that 12,431 (± 5,350) 1999 brood yearling spring chinook (Figure 13) and 19,386 (± 2,766) subyearling 2000 brood spring chinook emigrated from the Chiwawa River during the sampling period (Appendix A). Egg-to-migrant survival for the 1999 brood was estimated at 10.4%. The mean fork length of yearling and sub-yearling chinook captured was 97 mm and 82 mm, respectively.

We also captured 31 steelhead smolts and 849 steelhead parr (Appendix A). Bull trout also comprised a large proportion of incidental species captured. During the trapping period, 24 adult

(>300mm) and 253 juvenile bull trout were captured. Low numbers of fish captured prevented us from estimating the total number of steelhead and bull trout that emigrated from the Chiwawa River during the sampling period.

Chiwawa River 2002

Due to the migration timing of spring chinook in the Chiwawa River (March–December) only yearling (2000 brood) smolt production estimates were available for this report. The trap was installed and began operation on March 8. It will continue to operate, measuring the production of 2001 brood sub-yearling chinook, until snow and ice in the river force trapping to stop. During the spring migration period, the trap was not operated on 12 days due to debris and high water. During the period from March 8 through June 11 we captured 2,950 yearling smolts and estimated 3,441 smolts would have been captured if the trap was continuously operated (Appendix A). We estimated the spring smolt production (95% CI) for the 2000 brood to be 37,271 (± 13,282). Based on an estimated 588,880 eggs deposited in 2000, the egg-to-emigrant survival (sub-yearling and yearling) for the 2000 brood was 9.6% (Figure 13).

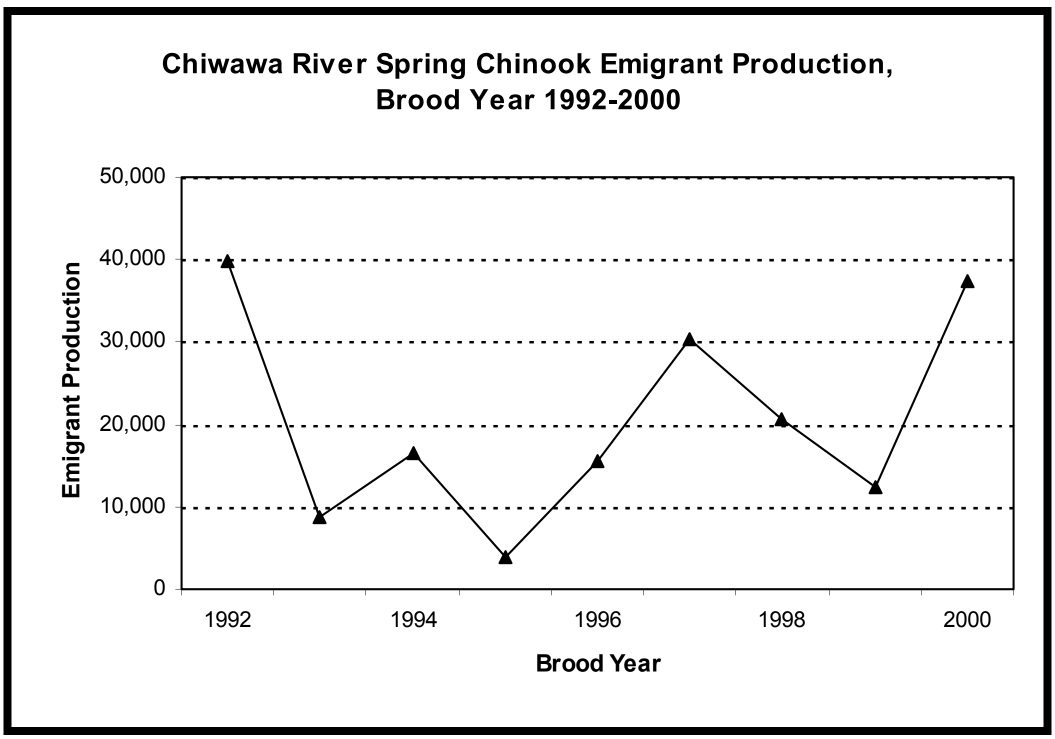

Figure 13. Chiwawa River wild spring chinook production from brood years 1992 to 2000.

Water Quality Index Monitoring

Water Quality

The methods used in this program are described in the Quality Assurance Program Plan (Summers and Serdar 2001). The monitoring components are shown in Table 1 and are described below:

Table 1. Summary of Monitoring Components

Ecology	Frequency	Number of stations per watershed
Water Quality	Monthly	1
Temperature	Continuous	2-4
Flow	Continuous	1
Benthic Macroinvertebrates	Annual Collection	1

Water quality surveys were conducted monthly from October 2000 and September 2002 at Big Beef Creek, Bingham Creek, and Cedar Creek. Monitoring began May 2001 on the Deschutes River and Chiwawa River. All samples were collected near the mouth of each stream, except for the Deschutes River where the samples were collected at river mile 21.61. Station location and description are in Appendix B. Water quality parameters determined at the Ecology-EPA Manchester Environmental Laboratory (MEL) included turbidity, total suspended solids, fecal coliform bacteria, ammonia-N, nitrate+nitrite-N, total nitrogen, total phosphorus, and soluble reactive phosphorus (orthophosphate) (MEL 2000). Hardness and dissolved metals (copper and zinc) were analyzed at each site for several months when sampling was initiated, but was discontinued when the concentrations were found to be low. Field measurements included dissolved oxygen, temperature, pH, and conductivity. Sampling protocols followed those in the Watershed Assessment Section protocols manual (Ecology 1992). Laboratory analyses, analytical methods, and the detection of precision limits for field measurements are listed in Appendix C.

Continuous Temperature Monitoring

Onset 'Tidbit' temperature data loggers were used to record hourly stream temperature, year-round at several sites per watershed. The loggers were set in 1½-inch galvanized pipe. The pipes were mounted so they were located in shaded pools at approximately ¼-½ of pool depth, in flowing water. Pre-installation calibrations were performed on all loggers using an ice bath and a calibrated thermometer. Several data loggers were lost to vandalism over the course of the study. These include: Big Beef Creek station 1503, Bingham Creek station 2206, and Chiwawa River stations 4501 and 4506 (Figures 3, 4, and 6).

Continuous Instream Flow Monitoring

Continuous flow data were collected from permanently installed gauging stations on upper Big Beef Creek, Bingham Creek, and Cedar Creek by Ecology's Stream Hydrology Unit following procedures and protocols described in Hopkins (1999). Data and procedures may be obtained at Ecology's Stream Hydrology Unit's web site at http://www.ecy.wa.gov/apps/watersheds/flows/state.asp. Currently, these data are considered provisional and so are not included in this report. Final data quality control will be completed and the data posted to the website early in 2003. Data records are complete except for February 14-March 14, 2002 on Big Beef Creek (due to battery malfunction) and for several days in March, 2002 on Bingham Creek while the station was being upgraded for automated data download.

The United States Geological Survey (USGS) also collected flow data for this program Deschutes River at Rainier station (ID# 12079000), Deschutes River at E Street Bridge station (ID# 12080010), Big Beef Creek near the mouth (ID# 12069550), and Chiwawa River near Plain station (ID# 12456500). For data and methods information, visit the USGS web site (http://wa.water.usgs.gov/). For current conditions, go to http://wa.water.usgs.gov/realtime/current.html and http://wa.water.usgs.gov/realtime/historical.html for historical data.

Benthic Macro-Invertebrates

Sampling of benthic macro-invertebrates was conducted each fall. Four composite riffle samples were collected at one site per watershed. Benthic community data from each site will be summarized by a contract laboratory. At this time, the data have not been received from the contract lab. They should be available by early 2003 and will be available by request at that time. Additional water quality sampling was conducted concurrently to help interpret results of the macro-invertebrate sampling.

The Benthic Index of Biological Integrity (B-IBI) for the Puget Sound Lowland rivers and streams was chosen to evaluate each sample due to proximity to the Puget Lowlands Ecoregion (Fore et al. 2001). The B-IBI is a composite of ten metrics that measure different aspects of macro-invertebrate community structure, including taxonomic richness and composition, the number of species tolerant and intolerant to stream degradation, habitat, reproductive strategy, feeding ecology, and population structure. Metrics are given a scoring value of 1, 3, or 5. These ten scores are summed to produce the overall B-IBI score which ranges from 10 to 50 (Table 2). Taxonomic analysis has not been completed on the current samples and will be included in a later report.

Table 2. Summary of B-IBI Scoring System		
Rating	**Score**	**Description**
Excellent	45-50	Natural stream conditions
Good	37-<45	Minimum impairment of stream conditions
Fair	27-<37	Moderate impairment of stream conditions
Poor	17-<27	Obvious impairment of stream conditions
Very Poor	10-<17	Degraded stream conditions

Data Quality

Data Quality Objectives (DQOs) for the monitoring program are described in the Salmon Recovery Index Quality Assurance Program Plan (Summers and Serdar 2001). Following is a general review of all project data.

Laboratory analysis followed data quality objectives and quality control procedures stated in the Manchester Environmental Laboratory User's Manual (MEL 2000). All metals and conventional chemistry samples met holding time requirements. Microbiology samples were analyzed within 30 hours, which is standard procedure for MEL. Because of the logistical challenges in collecting and transporting microbiology samples within the given timeframe, samples were not analyzed within the 6-hour period described in Standard Methods (APHA 1998). Overall, laboratory data quality was acceptable, with a few exceptions.

Replicate samples were collected to evaluate the overall variability of collection, processing, and analysis of samples. The coefficient of variation was calculated for each replicate sample pair and the results summarized in Table 3. Typically, the maximum CV occurred where sample mean was low. In general, repeatability of the data measurements was quite good as evidenced by the low mean and median values for most variables. Although a CV could not be calculated for either temperature or pH (because neither is measured on an absolute scale), the standard deviation of replicate analyses was always 0.1 C or less for temperature and less than 0.1 for pH.

Results

Water quality results and WQI scores for all stations are presented in Appendix D and Table 4, respectively.

Table 3. Summary of coefficient of variation (%) calculated on replicate sample pairs.					
Variable	**Minimum**	**Median**	**Mean**	**Maximum**	**N**
Dissolved O_2	0	0	0.3	1.2	10
Conductivity	0	0	4.5	43.0	11
Fecal coliform	0	24.6	24.7	48	12
Suspended solids	0	0	5.4	47.1	10
Ortho-P (ug/L)	0	1.5	3.4	14.3	10
Total P (ug/L)	0	4.4	6.2	30.5	10
Turbidity (NTU)	0	1.4	3.3	10.8	10
Ammonia-N (ug/L)	0	0	10.1	82.5	10
Nitrate-Nitrite-N (ug/L)	0	0	0.2	1.8	10
Total N (ug/L)	0.3	1.0	5.1	30.4	10

Table 4. Water Quality Index scores for 2001 and 2002.		
	Water Quality Index score by wateryear	
Basin	**2001**	**2002**
Big Beef Creek	88	73
Deschutes River	Not available	69
Bingham Creek	90	84
Cedar Creek	70	81
Chiwawa River	Not available	54

Note: WQI was not calculated for the Deschutes River and Chiwawa River because they were added midway through the water year. The WQI was modified slightly from the draft methodology used in Summers (2001). All scores presented herein are based on the revised method (Hallock 2002).

Deschutes River

All water quality parameters were within the standards, except for one low pH value and one high fecal coliform sample. Dissolved copper and zinc concentrations were also low and well within the standards. Water temperature was monitored at three sites, 1302, 1304, and 1307, and daily maximum temperature exceeded the standard on 27, 44, and 27 days, respectively (Figure 2). The WQI in 2002 was 69 (Table 4). This relatively low value was due to high fecal coliform bacteria, high nutrient concentration, and high suspended solids and turbidity. Sampling began in May 2001 (the middle of the wateryear), so that the WQI could not be calculated for wateryear 2001.

USGS monitors discharge at two sites on the Deschutes River, station 12080010 Deschutes River at E Street Bridge and station 12079000 Deschutes River near Rainier. Station information, discharge, and daily mean flow statistics can be viewed at the USGS web site.

Big Beef Creek

All parameters were within water quality standards except for two low pH values and one fecal coliform value above the Class AA standard. The stream temperature recorder near the mouth was vandalized before the summer low flow season. However, no temperature violations were noted in the monthly data near the creek mouth or at the flow station above Lake Symmington

(Figure 3). Water temperature at the outlet to Lake Symmington was above standard for 73 days in 2002, reflecting the effect of the lake itself on water temperature. Temperature data collected at the USGS flow gauge near the mouth are not yet available. The WQI in 2002 was 73 vs 88 in 2001 (Table 4). The difference was due to high total phosphorus, suspended solids, and turbidity values on two occasions in 2002 (Appendix D).

Ecology monitors discharge on Big Beef Creek above Lake Symington. The USGS maintains a flow gauge near the mouth (ID# 12069550).

Bingham Creek

No water quality standard violations were recorded in the monthly samples except for three low (<6.5) pH values. Continuous stream temperature was recorded at two sites (2202 and 2205) and daily maximum water temperature did not exceed the state Class AA standard of 16EC (Figure 4). The WQI in 2002 was 84 vs 90 in 2001 (Table 4). Low pH values, noted above, depressed the index slightly (Appendix D).

Ecology monitors discharge on Bingham Creek. A loss of data occurred in mid-March, 2002 while equipment was being upgraded, but this was quickly corrected.

Cedar Creek

Water quality conditions at Cedar Creek were impaired by high fecal coliform concentrations, low pH, and high water temperature. Continuous stream temperature recorders at three sites on Cedar Creek , 2702, 2705, and 2706, recorded temperature exceeding 18EC on 64, 10, and 25 days, respectively, indicating a severe temperature problem (Figure 5). The WQI in 2002 was 81 vs 70 in 2001 (Table 4). The WQI was depressed by several months with high fecal coliform concentrations, in addition to low pH values and high water temperature (Appendix D).

Ecology monitored discharge on Cedar Creek at Grist Mill Rd. (Station 2701)(Figure 5). The data record is complete for wateryear 2002 and will be available online in 2003.

Chiwawa River

The only monthly values exceeding water quality standards were one incidence of a low pH and one high pH value. Daily maximum water temperature at both sites 4404 and 4505 was less than 16EC (Figure 6). Dissolved copper and zinc concentrations were below the standard. The WQI in 2002 was 54 due to elevated suspended solids, turbidity, and total phosphorus (Table 4, Appendix D). Sampling began in May 2001 (the middle of the wateryear), so that the WQI could not be calculated for wateryear 2001.

USGS monitors discharge at one site, station 12456500 Chiwawa River near Plain.

Discussion

Field work conducted in 2002 represents only the second year of monitoring under the joint WDFW/ECY Index Watershed Monitoring Program. Nevertheless, juvenile salmon production has been measured in the five streams over much longer periods of time. The durations range from 5 years in Cedar Creek to 25 years in Big Beef Creek. These sites were selected, in part, because of our confidence that high quality smolt production estimates could be developed from them.

Two other considerations were used in selecting these sites for monitoring. Since a principal objective of this work is to co-evaluate wild salmonid population levels and environmental conditions, the size of the watersheds needed to be such that the monitored environmental conditions were representative of all parts of the watershed used by salmonids for spawning and rearing. Budgetary constraints placed on the environmental monitoring portion of the project necessitated that the selected watersheds be small to medium in size. Our final consideration was to distribute the index watersheds across the state. The five index watersheds represent four of the seven salmon recovery regions. Freshwater wild salmon production monitoring for three listed species (Puget Sound chinook, Upper Columbia spring chinook, and Lower Columbia steelhead) and two candidate species (Puget Sound coho and Lower Columbia coho) occurs in these streams.

Index Watershed Monitoring of SRFB Funded Projects

Changes in the freshwater production of wild salmonids are driven by a series of events. If we focus on habitat effects related to changes in land-use or from recovery projects, these events take the form of the following sequence:

- Step 1. Landscapes are altered through land-use actions (e.g., development project, road building, riparian restoration project, etc.),
- Step 2. Which alters the rate and/or condition of wood, sediment, water, energy, and nutrients that are inputted to the stream,
- Step 3. Which, in turn, alters the amount, condition, and suitability of habitat and food,
- Step 4. Which affects the size and survival of juvenile salmon populations in freshwater.

Starting with the Step 1 (land-use actions), its strongest connection is with Step 2 (change in the input of wood, sediment, water, energy, and nutrients to the stream). For example, a project to restore riparian functions to a section of stream by fencing the riparian zone, removing reed-canary grass, and planting trees, is closely tied to the future inputs of energy (increased shade), sediment (restoration of streambanks impacted by livestock), wood (LWD recruitment), and nutrients (leaf/litter fall, terrestrial invertebrate introductions, nitrogen fixing) to that section of the stream. It is less closely tied to the habitat condition that develops in the stream section (Step 3) since that condition is also affected by the basin landform and geology, the upstream inputs of wood and energy, as well as by stream size and the inputs of water that may only marginally be influenced by the project. The project is even less closely tied to the size and survival of salmon populations since the project, which is limited in its spatial scope, likely would have only a minor effect on conditions within the entire watershed and may not address the factors that are most limiting to the freshwater production of salmonids.

By monitoring the freshwater production of salmonids and environmental conditions (suitability, water quantity, and food supply), the Index Watershed Monitoring Project is focused on steps 3 and 4 of the sequence. It provides little certainty about the effectiveness of individual recovery projects. Effectiveness of projects would be better addressed by monitoring their effect on the input rates of wood, water, sediment, or other inputs to the stream. Instead, the Index Monitoring Project provides much more certainty relative to the response of salmonid populations and environmental conditions to the cumulative effects of all land-use changes, both beneficial and impacting, which occur in the basin and harvest management changes occurring on the monitored populations.

To determine the level of salmon recovery activity that has occurred in the index watersheds, the IAC's Project Information System (PRISM) was queried. After removing projects that were designed only to collect information, a total of thirteen SRFB-funded salmon recovery projects were found. Of these, two were located in the Deschutes River basin, four in Big Beef Creek, and seven in the Cedar Creek watershed. No projects were located in either the Bingham Creek or Chiwawa River basins. Index watershed monitoring would be expected to evaluate the cumulative effects of these in combination with land-use and fishery management effects, and other habitat-related actions against the backdrop of natural environmental variability.

Limitations of the Current Monitoring Approach

The WDFW-ECY Joint Index Watershed Monitoring Program represents a new approach in salmon recovery and watershed health monitoring. Over the previous two years, the program has successfully measured wild salmon production and stream flow, assessed benthic macro-invertebrate indicators of watershed health, and evaluated water quality and temperature parameters in the five index watersheds. Continuing to track these variables over time will provide for the development of trends that assess our success in salmon recovery. However, we view these first two years as a learning period from which we need to evaluate the index watershed monitoring approach.

A number of limitations from the current design are apparent. One of the principal limitations of the current monitoring design is that it uses a passive approach to monitoring. Under this approach, a suite of variables is measured in each watershed that may or may not correspond with factors that limit production or survival of juvenile salmonids. Wild salmon production has been measured in some of the index watersheds for many years. Over this period, we have often correlated changes in salmon production with environmental conditions. We believe a more fruitful design would be to focus monitoring on variables related to identified recovery objectives that are based on their importance for maintaining or increasing salmon production in each watershed.

Another limitation relates to the lack of habitat assessment and monitoring in the index watersheds. The habitat monitoring component that was originally included in the project design was excised when the appropriated funding levels were reduced from required levels in the 1999-2000 biennium state budget. The project has continued without this component since that time.

The last limitation identified pertains to our current inability to separate project-related changes in freshwater salmonid production and environmental conditions from natural variability. This is a result of monitoring single watersheds that are spatially separated. By monitoring similarly sized, adjacent watersheds, relationships are often correlated between basins over time (e.g., smolt production, temperatures, stream flow typically rise and fall together). When salmon recovery projects change a monitored variable in one watershed, we are better able to differentiate real change from natural variability using the relationships developed between basins.

Recommendations

Monitoring conducted over the first two years of the joint WDFW-ECY Index Watershed Monitoring Project has provided high quality estimates of juvenile salmon production, water quality/quantity and temperature measurements, and estimates of macro-invertebrate population structure. Continuation of the current program would enable tracking trends in these variables into the future. However, we believe addressing the design limitations described in the previous section could increase the usefulness of the project for monitoring salmon recovery. To address these limitations, we recommend that the joint WDFW-ECY Index Watershed Monitoring Program transition into a pilot Intensive Watershed Monitoring Program (IAC 2002, MDT 2002). The intensive monitoring design incorporates all of desirable attributes found in the current design such as:

- Continues wild salmon freshwater production monitoring and adult escapement monitoring, and
- Continues monitoring environmental parameters such as stream temperature and flow.

It also addresses the limitations identified in the current design. Implementing the intensive design involves restructuring the current program and bringing in additional players and resources. In order to track watershed response from recovery projects out to changes in salmon production (Steps 1 to 4), the pilot Intensive Watershed Monitoring Program would involve not only the Washington Department of Fish and Wildlife and Department of Ecology, but private landowners, lead entities, and restoration groups as well.

Specific recommendations include the following:

1. Maintain all downstream wild juvenile salmonid production monitoring projects currently funded under IAC Contract #02-1202N since they track the most fundamental goal for the restorations of watersheds (i.e., Is salmonid freshwater production/survival improving?).
2. For a subset of streams where downstream juvenile production monitoring is occurring, select one or two groups of at least two adjacent or nearly adjacent streams for intensive watershed monitoring,
3. Site selection should maintain existing basin selection criteria (i.e., good smolt production estimates, smaller size, good spatial dispersion).
4. If multiple groups of monitoring sites are funded, selection criteria should include diversification of land-use.
5. If not already available, watershed assessments should be conducted in the selected watersheds to develop specific restoration objectives tied to maintaining and/or increasing salmonid production and productivity,
6. The monitoring approach used should be consistent with the intensive monitoring recommendations described in the Statewide Comprehensive Monitoring Strategy

(IAC 2002) and the Forest and Fish Monitoring and Design Team Report (MDT 2002), and

7. Make use of a replicate design approach to factor change resulting from projects with natural system variability in the monitored variables.

These recommendations will be further developed in a proposal for funding in the 2003-04 biennium.

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Appendix A. Downstream Migrant Salmonid Catch and Production Estimates for Index Watersheds in 2001 and 2002

Appendix A. Downstream migrant catch and production estimates for Index Watersheds in 2001 and 2002.

		Catch					Migration Estimate				
		Chinook		Coho	Steelhead	Cutthroat	Chinook		Coho	Steelhead	Cutthroat
Watershed	Year	0+	1+	Smolts	Smolts	Smolts	0+	1+	Smolts	Smolts	Smolts
Deschutes River	2001	150,232	0	176	104	23	-------	-------	892	-------	-------
	2002	96,813	1	16,860	65	31	-------	-------	60,000	-------	-------
Big Beef Creek	2001	-------	-------	20,912	1,887	959	-------	-------	21,855	1,932	1,024
	2002	-------	-------	22,999	2,078	1,394	-------	-------	23,304	2,191	1,589
Bingham Creek	2001	-------	-------	41,710	812	131	-------	-------	45,000	835	133
	2002	-------	-------	27,073	466	75	-------	-------	29,813	495	80
Cedar Creek	2001	544	-------	4,269	694	322	-------	-------	24,138	3,565	2,337
	2002	899	-------	14,429	777	1,138	-------	-------	31,909	2,225	3,903
Chiwawa River	2001	5,171	2,800	-------	31	-------	19,386	12,431	-------	-------	-------
	2002	N/A[1]	2,950	-------	-------	-------	N/A[1]	37,271	-------	-------	-------

[1] 2002 age 0+ chinook catch and production estimates from the Chiwawa River were unavailable since trapping was still being conducted during the time that this report was in preparation.

Appendix B. Sampling Locations

Appendix B. Sampling Locations

I. Big Beef Creek

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Water Quality at UW Field Station SRIW 1501	AA	47.648300	122.781000	65	0.25

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Macroinvertebrate at UW Field Station SRIW 1502	AA	47.647100	122.781300	70	0.31

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at UW Field Station SRIW 1503	AA	47.640700	122.784100	80	0.75

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature below Lake Symington Spillway SRIW 1504	AA	47.598800	122.823800	350	5.25

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature above Lake Symington (Holly Rd.) SRIW 1505	AA	47.593200	122.835800	390	6.05

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Flow above Lake Symington (Holly Rd.) SRIW 1506	AA	47.593300	122.835900	390	6.05

2. Bingham Creek

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Flow at WDFW Hatchery SRIW 2201	AA	47.144600	123.400900	240	0.1

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at WDFW Hatchery SRIW 2202	AA	47.144700	123.400800	240	0.1

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Water Quality at WDFW Hatchery SRIW 2203	AA	47.145000	123.400400	240	0.16

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Macroinvertebrate at WDFW Hatchery SRIW 2204	AA	47.145200	123.400100	245	0.25

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at Shelton-Matlock Rd SRIW 2205	AA	47.236800	123.379800	345	7.4

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at Simpson Timber Rd SRIW 2206	AA	47.292900	123.332600	550	12.8

3. Cedar Creek

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Flow at Grist Mill SRIW 2701	A	45.938700	122.582100	150	2.35

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at Grist Mill (trap) SRIW 2702	A	45.938300	122.581800	160	2.42

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Water Quality at Grist Mill SRIW 2703	A	45.938300	122.581700	165	2.43

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Macroinvertebrate at Grist Mill SRIW 2704	A	45.938100	122.581500	175	2.48

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at Chelatchie Cr. SRIW 2705	A	45.911300	122.445400	390	0.08

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at Amboy SRIW 2706	A	45.910300	122.446000	390	10.77

4. Chiwawa River (new station 5/15/01)

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at WDFW Hatchery SRIW 4501	AA	47.787700	120.645900	1865	0.9

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Water Quality at Chiwawa Loop Bridge SRIW 4502	AA	47.797100	120.637600	1940	2.1

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
USGS Flow across from Goose Creek CG SRIW 4503	AA	47.837700	120.658500	2100	6.2

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at Huckleberry Ford CG SRIW 4504	AA	47.897200	120.716000	2365	12.55

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at Atkinson Flat CG SRIW 4505	AA	47.999400	120.816400	2490	24.53

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at Phelps Creek CG SRIW 4506	AA	48.068700	120.846600	2550	31.2

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Macroinvertebrate near Atkinson Flat CG SRIW 4507	AA	47.990600	120.810200	2530	23.83

5. Deschutes River (new station 5/15/01)

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Water Quality at "E" St Bridge SRIW 1301	A	47.011700	122.901800	93	0.6

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at "E" St Bridge SRIW 1302	A	47.011700	122.901900	93	0.6

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
USGS Flow at "E" St Bridge SRIW 1303	A	47.011700	122.902000	93	0.6

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at Waldrick Rd SRIW 1304	A	46.920400	122.808600	270	18.01

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Water Quality at Hwy 507 Bridge SRIW 1305	A	46.873100	122.729100	370	21.61

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
USGS Flow at Vail loop bridge SRIW 1306	A	46.852200	122.667800	380	25.91

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Temperature at Woodbrook Ln SRIW 1307	A	46.849500	122.653300	388	26.72

Station	Class	Latitude	Longitude	Elevation (ft)	River Mile
Macroinvertebrate at Pioneer Park SRIW 1308	A	46.993400	122.885700	105	2.42

Appendix C. Field and Laboratory Methods Used for Water Quality Analysis

Appendix C

The laboratory's data quality objectives and quality control procedures are documented in the Manchester Environmental Laboratory's Lab Users Manual (MEL 1994).

Table 1 Summary of laboratory methods, and lower reporting limits.

Parameters	Methods[a]	Lower reporting limit
Fecal coliform	SM18 Membrane Filter 9222D	1 cfu/100 ml
Dissolved copper (low level)	EPA 200.8	0.03 µg/l
Dissolved zinc (low level)	EPA 200.8	0.4 µg/l
Turbidity	EPA 180.1	0.1 NTU
Total N	SM 4500 NO_3-F	10 µg/L
Ammonia-N	EPA 350.1	10 µg/L
Nitrite+nitrate-N	EPA 353.2	10 µg/L
Orthophosphate	EPA 365.1	10 µg/L
Total phosphorus	EPA 365.1	10 µg/L
Total suspended solids	EPA 160.2	1 mg/L

[a] **Sources: EPA, 1993 and APHA, 1998 (SM)**

Table 2 Container type, water volume required, method of preservation, and maximum permissible holding times for water samples.

Variable	Container Type	Sample Volume (ml)	Preservation	Holding Time
Turbidity	poly	100	cool to <4°C	48 hrs
Total suspended solids	poly	1000	cool to <4°C	7 days
Total phosphorus	poly	125	adjust pH<2 w/ H_2SO_4 and cool to <4°C	28 days
Orthophosphate	brown poly	125	filter in field and cool to <4°C	48 hrs
Nitrate+Nitrite-N	poly	125	adjust pH<2 w/ H_2SO_4 and cool to <4°C	28 days
Ammonia-N	poly	125	adjust pH<2 w/ H_2SO_4 and cool to 4°C	28 days
Total N	poly	125	adjust pH<2 w/ H_2SO_4 and cool to <4°C	28 days
Fecal coliform	Autoclaved glass/ploy	250	cool < 4°C	30 hrs
Copper	Teflon	1000	filter in field, adjust pH<2 w/ HNO_3 and cool to <4°C	6 months
Zinc	Teflon	1000	filter in field, adjust pH<2 w/ HNO_3 and cool to <4°C	6 months
Hardness	poly	125	adjust pH<2 w/ HNO_3 and cool to <4°C	6 months

Table 3 Summary of field measurements, methods, and accuracy.

Variable	Method	Accuracy
Velocity	Current meter	± 0.1 f/s
Specific Conductivity	Field meter	± 5%
pH	Field meter	± 0.2 standard units
Temperature	Red liquid thermometer	± 0.2ºC
Dissolved Oxygen	Winkler Modified Azide (EPA360.20 Field Meter)	± 0.1 mg/L ± 0.2 mg/L
Stage Height	Data logger and probe	± 0.03 feet
Continuous Temperature	Underwater data logger	± 0.2ºC @ 21ºC

Appendix D. Water Quality Results from the Index Watersheds, 2000-2002

Appendix D. Water quality results from the index watersheds, 2000–2002.

Cedar Creek	DATE	Temp (C)	DO (mg/l)	pH	Cond	Fecal	TSS (mg/l)	Orthop (mg/l)	Turbidity (NTU)	Total_P (mg/l)	Ammonia (mg/l)	TPN (mg/l)	Nitrite/Nitrate (mg/l)	QA	Hardness (mg/l)	Copper (mgl)	Zinc (mg/l)
CEDAR2703	10/18/2000	11.8	10.60	7.64	13	16	2	0.009	0.8	0.024	0.01	0.434	0.311		25.6	0.34	1.7
CEDAR2703	10/18/2000	11.8	10.80	7.59	12	17	6	0.009	1.5	0.025	0.01	0.33	0.31	1	26	0.3	1.6
CEDAR2703	11/14/2000	3.7	13.00	7.03	36.0	18	1	0.006	0.6	0.028	0.01	0.547	0.509		22.3	0.24	0.5
CEDAR2703	12/12/2000	3.0	13.30	7.58	33.0	13	1	0.006	0.8	0.026	0.01	0.789	0.619		17.9	0.24	1.1
CEDAR2703	01/09/2001	5.6	12.10	6.85	31.9	29	2	0.008	1.3	0.019	0.01	0.788	0.773		17	0.26	7.01
CEDAR2703	02/13/2001	4.0	13.10	6.64	28.1	13	2	0.007	1.3	0.031	0.01	0.902	0.831		0.19	0.3	15.3
CEDAR2703	03/13/2001	7.5	12.20	6.21	35.9	5	2	0.007	1.3	0.027	0.01	0.776	0.706		16.8	0.23	0.24
CEDAR2703	03/13/2001	7.5	12.1	6.77	35.8	1	2	0.007	1.4	0.028	0.01	0.764	0.705	1	16.3	0.22	0.24
CEDAR2703	04/10/2001	7.4	11.70	7.46	47.0	17	4	0.008	2.4	0.023	0.01	0.857	0.764		14.1	0.19	0.23
CEDAR2703	05/14/2001	11.2	10.70	6.46	55.4	800	13	0.01	6.8	0.032	0.011	0.64	0.0521		16.9	0.29	0.33
CEDAR2703	06/11/2001	12.4	10.55	6.84	44.3	730	9	0.008	5.5	0.041	0.01	0.565	0.426		19.4	0.3	0.82
CEDAR2703	07/16/2001	14.4	10.25	6.34	57.6	160	2	0.01	1.7	0.023	0.01	0.452	0.35				
CEDAR2703	08/13/2001	20.1	9.10	6.5	74.5	56	3	0.011	1.7	0.03	0.01	0.399	0.296		26.9	0.35	0.37
CEDAR2703	09/10/2001	14.2	10.60	7.19	116.6	36	4	0.0101	1.5	0.026	0.01	0.358	0.297		30.7	0.28	1.3
CEDAR2703	10/08/2001	10.7	10.80	6.83	112.1	92	4	0.008	2	0.017	0.01	0.378	0.267				
CEDAR2703	11/05/2001	9.5	11.65	6.81	40.9	41	2	0.0095	1.9	0.031	0.01	0.663	0.614				
CEDAR2703	11/05/2001	9.4	11.65	6.84	40.8	20	2	0.0097	1.8	0.028	0.01	0.658	0.615	1			
CEDAR2703	12/10/2001	5.8	12.25	6.54	49.9	18	4	0.0097	3.1	0.029	0.013	1.11	1.03				
CEDAR2703	01/07/2002	9.4	11.20	6.44	29.8	350	18	0.013	10	0.048	0.012	1.02	0.875				
CEDAR2703	02/11/2002	6.1	12.50	6.86	41.5	20	3	0.0088	2	0.018	0.019	1.03	0.979				
CEDAR2703	03/13/2002	6.4	12.10	7.26	31.6	79	7	0.01	5	0.019	0.026	0.914	0.835				
CEDAR2703	04/09/2002	9.7	11.10	7.38	37.8	32	3	0.0067	2.6	0.021	0.01	0.766	0.693				
CEDAR2703	04/09/2002	9.7	11.10	7.38	37.8	60	3	0.0065	2.5	0.02	0.01	0.753	0.695	1			
CEDAR2703	05/06/2002	8.0	11.70	7.9	32.4	25	1	0.0052	1.6	0.012	0.01	0.641	0.562				
CEDAR2703	06/11/2002	13.7		6.48	56.2	50	1	0.0054	1	0.016	0.01	0.522	0.458				
CEDAR2703	07/09/2002	14.8	10.00	6.68	50.1	84	2	0.0068	1.1	0.018	0.01	0.48	0.396				
CEDAR2703	08/07/2002	14.3	10.20	6.46	70.5	59	1	0.0098	0.8	0.022	0.01	0.376	0.268				
CEDAR2703	09/09/2002	13.5	10.30	7.01	70.1	67	1	0.0092	0.7	0.02	0.010	0.299	0.248				

Appendix D. Water quality results from the index watersheds, 2000–2002 (cont'd).

Bingham Creek	DATE	Temp (C)	DO (mg/l)	pH	Cond	Fecal	TSS (mg/l)	Orthop (mg/l)	Turbidity (NTU)	Total_P (mg/l)	Ammonia_ mg/l	TPN (mg/l)	Nitrite/Nitrate (mg/l)	QA	Hardness (mg/l)	Copper (mgl)	Zinc (mg/l)
Bingh2203	10/18/2000	10.5	11.20	7.39	9	9	2	0.01	0.5	0.019	0.01	0.05	0.083		23.3	0.21	2.2
Bingh2203	11/14/2000	7.0	11.60	7.14	38.0	3	1	0.01	0.5	0.03	0.01	0.106	0.063		25.2	0.14	0.4
Bingh2203	11/14/2000	6.9	11.60	7.47	38.0	3	1	0.01	0.5	0.028	0.01	0.071	0.065	1	24.5	0.16	0.4
Bingh2203	12/12/2000	5.1	12.90	7.24	35.0	1	1	0.009	0.5	0.024	0.01	0.11	0.127		20.6	0.16	0.69
Bingh2203	01/09/2001	7.1	11.40	6.2	32.4	1	3	0.008	0.9	0.016	0.01	0.147	0.137		18.9	0.18	12.3
Bingh2203	02/13/2001	6.7	12.40	6.74	34.6	1	1	0.009	0.4	0.028	0.01	0.147	0.102		0.13	0.2	20.6
Bingh2203	03/13/2001	8.6	11.80	6.99	38.8	1	1	0.008	0.5	0.026	0.01	0.133	0.083		20.8	0.13	0.36
Bingh2203	04/10/2001	8.4	11.50	7.24	58.0	6	1	0.009	0.5	0.02	0.01	0.147	0.071		20.8	0.12	0.1
Bingh2203	04/10/2001	8.4	11.50	7.2	58.0	11	1	0.009	0.5	0.018	0.01	0.118	0.073	1	21	0.12	0.1
Bingh2203	05/15/2001	9.4	11.20	7.07	38.7	19	1	0.009	0.7	0.017	0.01	0.129	0.091		20.9	0.21	0.32
Bingh2203	06/12/2001	9.8	11.50	7.14	43.7	11	2	0.008	0.5	0.029	0.01	0.114	0.048		23.8	0.15	0.54
Bingh2203	07/17/2001	10.8	11.05	5.91	46.7	16	1	0.009	0.5	0.014	0.01	0.073	0.043				
Bingh2203	07/17/2001	10.8	11.00	6.27	46.3	17	1	0.009	0.5	0.014	0.01	0.074	0.044	1			
Bingh2203	08/14/2001	12.4	10.50	6.77	47.8	29	1	0.01	0.5	0.018	0.01	0.069	0.069		25.6	0.14	1.3
Bingh2203	09/11/2001	10.4	10.90	6.78	47.1	8	1	0.0086	0.5	0.016	0.01	0.101	0.084		25.4	0.13	1.1
Bingh2203	10/09/2001	9.2	11.80	6.74	45.0	37	1	0.0078	0.5	0.01	0.01	0.071	0.047				
Bingh2203	11/06/2001	7.4	11.70	6.88	38.6	13	3	0.0096	1.9	0.026	0.01	0.176	0.138				
Bingh2203	12/11/2001	7.1	11.60	6.58	33.7	9	1	0.0093	1.1	0.031	0.01	0.226	0.122				
Bingh2203	12/11/2001	7.1	11.60	6.5	33.6	13	2	0.0094	1.1	0.02	0.01	0.146	0.122	1			
Bingh2203	01/07/2002	8.9	10.90	6.13	25.7	25	26	0.0066	22	0.059	0.017	0.17	0.113				
Bingh2203	02/11/2002	7.8	12.00	6.84	48.4	1	1	0.0087	0.7	0.012	0.01	0.128	0.104				
Bingh2203	03/11/2002	7.6	11.40	6.55	30.0	14	7	0.0083	4.8	0.015	0.01	0.169	0.127				
Bingh2203	04/08/2002	10.0	11.30	7.69	49.7	1	1	0.0071	0.5	0.01	0.01	0.07	0.061				
Bingh2203	05/06/2002	8.8	11.10	7.81	36.2	2	1	0.006	0.5	0.01	0.01	0.086	0.053				
Bingh2203	05/06/2002	8.8	11.10	7.81	38.4	1	1	0.0063	0.5	0.01	0.01	0.09	0.053	1			
Bingh2203	06/12/2002	11.5		6.9	43.1	23	1	0.007	0.5	0.011	0.01	0.087	0.039				
Bingh2203	07/10/2002	11.8	10.50	6.44	41.3												
Bingh2203	08/06/2002	10.7	11.20	6.38	49.2												
Bingh2203	09/11/2002	10.8	10.70	6.6	48.2	17	1	0.0088	0.5	0.016	0.010	0.070	0.045				

Appendix D. Water quality results from the index watersheds, 2000–2002 (cont'd).

Big Beef Creek	DATE	Temp (C)	DO (mg/l)	pH	Cond	Fecal	TSS (mg/l)	Orthop (mg/l)	Turbidity (NTU)	Total_P (mg/l)	Ammonia (mg/l)	TPN (mg/l)	Nitrite/Nitrate (mg/l)	QA	Hardness (mg/l)	Copper (mgl)	Zinc (mg/l)
BBC1501	10/18/2000	11.5	9.60	7.48	13	10	2	0.01	1.4	0.022	0.01	0.083	0.087		37.2	0.36	2.2
BBC1501	11/14/2000	6.1	11.70	7.33	55.0	1	1	0.008	0.5	0.026	0.01	0.104	0.074		40.8	0.32	0.4
BBC1501	12/12/2000	3.2	12.80	7	40.0	2	1	0.008	0.6	0.021	0.01	0.354	0.291		28.6	0.42	1.7
BBC1501	12/12/2000	3.2	12.80	7.08	40.0	3	1	0.008	0.6	0.022	0.01	0.416	0.293	1	28.5	0.43	1.6
BBC1501	01/10/2001	5.8	11.90	6.28	32.7	12	1	0.006	1.3	0.013	0.01	0.352	0.304		21.5	0.38	1.1
BBC1501	02/14/2001	3.1	13.10	6.47	35.1	38	1	0.007	0.6	0.023	0.01	0.341	0.287		0.31	0.33	25
BBC1501	03/13/2001	9.3	11.10	7.66	44.8	1	1	0.007	0.9	0.021	0.01	0.272	0.205		25.2	0.32	0.47
BBC1501	04/11/2001	7.6	11.60	6.56	60.0	1	1	0.008	0.6	0.016	0.01	0.225	0.151		28.7	0.31	0.2
BBC1501	05/15/2001	12.8	10.10	6.76	56.8	3	2	0.008	1.4	0.018	0.01	0.168	0.086		32	0.33	0.19
BBC1501	05/15/2001	12.8	9.90	6.83	56.8	6	2	0.009	1.1	0.019	0.01	0.181	0.085	1	32	0.34	0.22
BBC1501	06/12/2001	12.9	10.30	7.31	62.3	38	2	0.01	1.5	0.028	0.01	0.219	0.094		35.3	0.35	0.25
BBC1501	07/17/2001	13.4	10.25	6.68	76.4	53	1	0.016	0.9	0.023	0.01	0.216	0.152				
BBC1501	08/14/2001	15.9	9.70	7.15	85.8	5	1	0.017	0.7	0.029	0.01	0.211	0.156		45.5	0.26	1.1
BBC1501	08/14/2001	15.9	9.70	7.18	85.9	9	1	0.017	0.7	0.027	0.01	0.201	0.155	1	45.8	0.26	0.86
BBC1501	09/11/2001	13.4	10.60	7.03	79.7	4	1	0.0145	1	0.022	0.01	0.196	0.145		44.4	0.27	2.2
BBC1501	10/09/2001	10.1	11.25	6.93	73.3	6	1	0.014	0.5	0.012	0.01	0.171	0.1				
BBC1501	11/06/2001	7.6	12.15	7.08	63.2	2	21	0.0099	0.8	0.024	0.01	0.17	0.104				
BBC1501	12/11/2001	5.6	13.20	6.64	30.6	7	2	0.0074	1.2	0.019	0.01	0.447	0.343				
BBC1501	01/09/2002		11.60	6.17	20.3	65	148	0.0059	65	0.081	0.01	0.287	0.199				
BBC1501	01/09/2002		11.80	6.17	20.3	56	135	0.0059	60	0.082	0.038	0.285	0.204	1			
BBC1501	02/06/2002	5.5	12.00	7.08	48.2	18	8	0.007	3.8	0.017	0.013	0.327	0.244				
BBC1501	03/11/2002	6.9	11.55	6.82	26.0	33	85	0.0051	33	0.062	0.01	0.374	0.242				
BBC1501	04/08/2002	10.9	10.92	7.86	57.8	1	1	0.0069	0.8	0.01	0.01	0.153	0.086				
BBC1501	05/08/2002	11.2	10.60	7.91	64.5	3	1	0.0072	0.6	0.01	0.01	0.19	0.097				
BBC1501	06/12/2002	15.0		7.47	67.5	28	2	0.0097	0.7	0.016	0.01	0.24	0.178				
BBC1501	06/12/2002	15.0		7.47	67.5	20	2	0.0095	0.8	0.016	0.01	0.243	0.178	1			
BBC1501	07/10/2002	13.7	9.95	6.63	71.8	20	1	0.0068	0.5	0.011	0.01	0.093	0.061				
BBC1501	08/06/2002	13.0	10.45	6.45	86.7	10	1	0.011	0.5	0.025	0.01	0.241	0.19				
BBC1501	09/11/2002	13.0	10.60	6.74	81.0	6	1	0.015	0.5	0.025	0.010	0.172	0.147				

Appendix D. Water quality results from the index watersheds, 2000–2002 (cont'd).

Deschutes River	DATE	Temp (C)	DO (mg/l)	pH	Cond	Fecal	TSS (mg/l)	Orthop (mg/l)	Turbidity (NTU)	Total_P (mg/l)	Ammonia (mg/l)	TPN (mg/l)	Nitrite/Nitrate (mg/l)	QA	Hardness (mg/l)	Copper (mgl)	Zinc (mg/l)
DESCH1305	05/14/2001	12.1	10.30	6.87	77.4	28	2	0.015	1.7	0.032	0.013	0.445	0.295		36.6	0.42	0.28
DESCH1305	06/11/2001	13.4	10.55	6.95	84.0	150	2	0.013	2.2	0.043	0.01	0.336	0.235		39.9	0.44	0.17
DESCH1305	06/11/2001	13.4	10.65	7.09	83.8	230	3	0.013	2.2	0.042	0.01	0.33	0.234	1	39.2	0.26	0.26
DESCH1305	07/16/2001	14.1	10.20	6.41	104.6	58	2	0.014	1.1	0.026	0.011	0.397	0.288				
DESCH1305	08/13/2001	17.8	9.50	6.39	130.1	41	2	0.016	1.1	0.038	0.02	0.508	0.383		52.6	0.42	0.4
DESCH1305	09/10/2001	14.2	10.60	7.19	116.6	21	1	0.0128	1.4	0.027	0.01	0.437	0.357				
DESCH1305	10/08/2001	10.7	10.80	6.83	112.1	21	1	0.012	0.9	0.014	0.01	0.431	0.36				
DESCH1305	10/08/2001	10.7	10.70	7.28	111.8	28	1	0.011	0.8	0.015	0.01	0.465	0.358	1			
DESCH1305	11/05/2001	8.9	11.30	7.16	63.3	17	2	0.0099	1.1	0.03	0.01	0.279	0.239		32.5	0.4	1.1
DESCH1305	12/10/2001	5.8	12.25	6.54	49.9	7	5	0.017	4.1	0.042	0.01	0.658	0.568				
DESCH1305	01/07/2002	8.4	11.30	6.54	30.1	56	316	0.013	140	0.193	0.01	0.397	0.285				
DESCH1305	02/11/2002	5.4	12.10	7.35	71.5	3	7	0.017	6.9	0.038	0.01	0.648	0.548				
DESCH1305	02/11/2002	5.4	12.00	7.38	71.5	5	7	0.017	6.9	0.034	0.013	0.651	0.548	1	25.8	0.799	1.2
DESCH1305	03/13/2002	6.1	11.60	6.44	42.2	12	41	0.018	22	0.062	0.013	0.585	0.465				
DESCH1305	04/09/2002	9.2	10.90	7.23	67.3	22	2	0.01	1.7	0.02	0.01	0.474	0.422				
DESCH1305	05/07/2002	7.8	11.80	7.82	100.8	51	3	0.0068	1.8	0.015	0.01	0.458	0.369				
DESCH1305	06/11/2002	16.0		7.08	112.2	64	2	0.0069	1.1	0.02	0.011	0.57	0.48				
DESCH1305	07/09/2002	15.8	9.95	6.7	93.7	510	4	0.011	1.8	0.027	0.015	0.588	0.499				
DESCH1305	07/09/2002	15.8	9.95	6.7	93.7	650	4	0.011	2.1	0.025	0.015	0.583	0.499	1			
DESCH1305	08/07/2002	15.5	11.00	7.65	122.0	31	1	0.0093	0.9	0.02	0.01	0.534	0.421				
DESCH1305	09/09/2002	14.8	11.00	6.83	111.6	25	1	0.013	1	0.025	0.010	0.693	0.63				

Appendix D. Water quality results from the index watersheds, 2000–2002 (cont'd).

Chiwawa River	DATE	Temp (C)	DO (mg/l)	pH	Cond	Fecal	TSS (mg/l)	Orthop (mg/l)	Turbidity (NTU)	Total_P (mg/l)	Ammonia (mg/l)	TPN (mg/l)	Nitrite/Nitrate (mg/l)	QA	Hardness (mg/l)	Copper (mgl)	Zinc (mg/l)
CHIW4502	05/16/2001	6.8	11.50	6.26	26.3	1	10	0.005	3.3	0.02	0.01	0.134	0.103		16.1	0.29	0.93
CHIW4502	06/13/2001	7.4	11.30	7.26	27.8	1	3	0.005	1	0.017	0.01	0.063	0.038		14	0.2	0.32
CHIW4502	07/18/2001	12.9	10.20	6.66	36.8	1	2	0.005	0.7	0.01	0.01	0.022	0.01				
CHIW4502	08/15/2001	17.4	9.20	6.61	43.4	3	3	0.005	1	0.01	0.01	0.033	0.01		21.7	0.23	0.88
CHIW4502	09/12/2001	13.7	9.90	6.89	47.9	1	1	0.003	0.6	0.01	0.01	0.03	0.01				
CHIW4502	09/12/2001	13.7	9.90	7.13	47.7	1	1	0.003	0.5	0.01	0.01	0.036	0.01	1			
CHIW4502	10/10/2001	4.9	11.90	6.99	40.5	1	1	0.003	0.5	0.01	0.01	0.056	0.01				
CHIW4502	11/07/2001	1.9	12.50	6.83	34.8	1	1	0.004	0.5	0.017	0.01	0.03	0.01		24.7	0.18	1.3
CHIW4502	12/12/2001	1.6	12.00	7.05	33.6	5	1	0.0037	0.5	0.016	0.01	0.042	0.019				
CHIW4502	01/08/2002	1.9	13.20	6.75	22.9	10	21	0.003	5.8	0.024	0.01	0.126	0.057				
CHIW4502	02/05/2002	1.0	13.35	8.03	62.3	1	1	0.0033	0.5	0.01	0.01	0.038	0.01				
CHIW4502	03/12/2002	0.8	13.20	7.34	33.5	2	2	0.0038	0.5	0.01	0.01	0.065	0.028				
CHIW4502	03/12/2002	0.8	13.20	7.34	33.5	3	2	0.0033	0.5	0.01	0.01	0.066	0.028	1			
CHIW4502	04/10/2002	6.8	11.50	7.36	43.6	1	4	0.003	1.3	0.01	0.01	0.0063	0.01				
CHIW4502	05/08/2002	4.6	12.20	8.33	36.7	1	3	0.003	1.2	0.01	0.01	0.086	0.037		20.2	0.23	2.5
CHIW4502	05/08/2002	4.6				1								1	20.3	0.2	2.5
CHIW4502	06/09/2002	7.2		9.32	23.2	1	16	0.0032	3.7	0.014	0.01	0.092	0.053				
CHIW4502	07/08/2002	10.2	10.75	6.49	35.4	40	32	0.003	8.1	0.026	0.01	0.052	0.023				
CHIW4502	08/05/2002	10.3	10.50	6.66	46.2	1	2	0.0049	1.3	0.011	0.01	0.049	0.012				
CHIW4502	08/05/2002	10.3	10.50	6.66	86.7	1	2	0.004	1.3	0.01	0.01	0.041	0.012	1			
CHIW4502	09/10/2002	9.6	10.50	6.89	49.2	2	1	0.004	0.7	0.01	0.010	0.025	0.010				