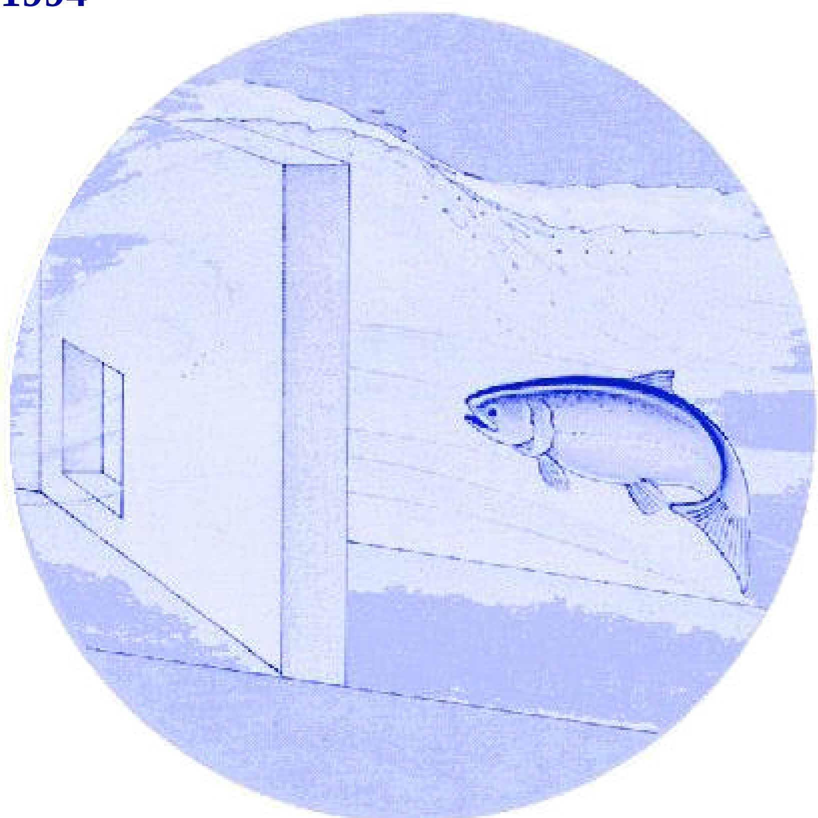
Fisheries Evaluation of the Dryden Fish Screening Facility

Annual Report
1994



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A FISHERIES EVALUATION OF THE DRYDEN FISH SCREENING FACILITY

ANNUAL REPORT 1994

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Preface

The Bonneville Power Administration (BPA) is funding the construction and evaluation of fish passage and fish protection facilities in the Wenatchee River Basin, Washington. The Dryden Fish Screening Facility was selected for passage improvements under the Columbia River Fish and Wildlife Program section 7.1D, subsection 7.10D.1 (NPPC 1994). The program provides offsite enhancement to compensate for fish and wildlife losses caused by hydroelectric development throughout the Columbia River Basin, and addresses natural propagation of salmon to help mitigate the impact of water diversions in the Wenatchee River Basin. Under the program, the BPA would fund the planning, design, construction, and evaluation of improvements to the fish screens and bypass facilities. Maintenance and operation of the facility would be provided by the Chelan County PUD. The National Marine Fisheries Service was responsible for establishing written criteria for operation of the Dryden Fish Screening Facility.

Evaluations were conducted to test the effectiveness of the screening facility for intercepting and returning salmonids unharmed to the Wenatchee River. Studies were conducted in which fish were released upstream of or within the screening facility and captured in the fish bypass that transfers them back to the river. Sections of this report include study area description, methods used to evaluate the effectiveness of screens, screen test results, a discussion, and recommendations.

This study emphasized the collection and evaluation of salmonids. Test fish were spring chinook salmon (*Oncorhynchus tshawytscha*) smolts, (*O. mykiss*) subyearlings and (*O. mykiss*) fry. Evaluations were conducted during typical seasonal canal flows at the facility.

Acknowledgments

The success of this project required the involvement and cooperation of many people. Jodi Stroklund of the Bonneville Power Administration was the project manager. Steve Hays and Gary Rice from Chelan County Public Utility District (PUD) assisted in operating the facility to meet our research needs. Dan Davies of the Leavenworth National Fish Hatchery U.S. Fish and Wildlife Service (USFWS) and Steve Robards Washington Department of Fish and Wildlife (WDFW) of the Chelan Hatchery helped with the procurement and holding of test fish. Brain Cates from the Mid-Columbia River Fishery Resource Office helped in gaming approvai for using spring chinook salmon in our tests. Larry Basham of the Fish Passage Center approved branding marks. Rod Wooden and John Kerwin from the WDFW assisted in fish acquisition. Dick Whitney of the Mid Columbia Coordinating Committee reviewed our work plan and study objectives.

We wish to thank Pacific Northwest Laboratory (PNL) staff Bill Mavros, Gregg Martenson, Trevor VanArsdale, and Associated Washington State University students Mark Tennier, and Judy Williams for their valuable assistance in conducting the evaluation. The manuscript was reviewed by Launa Morasch, Dale Becker and Dennis Dauble.

Abstract

Fisheries staff at the Pacific Northwest Laboratory (PNL)[a] evaluated the effectiveness of the Dryden Fish Screening Facility in the Wenatchee Reclamation District Canal near Dryden in north central Washington State. In situ tests were conducted by releasing groups of hatchery reared salmonids of different ages and sizes. Descaling tests showed that spring chinook salmon smolts *(Oncorhynchus tshawytscha)* (110 to 165 mm) were not injured'or descaled as they passed through the canal forebay. Smolts were not delayed as they migrated in the canal. Most fish released at the canal headworks exited the screening facility in less than 4 hours, with over 99% of the test fish captured in the fish bypass in less than 24 hours. Steelhead (*Oncorhynchus mykiss*) subyearlings (65 to 125 mm) were not injured or descaled as they traveled through the bypass flume and fish return pipe. The average time for steelhead subyearlings to travel through the bypass structure was 70 seconds.

Screen integrity tests showed that small. rainbow trout (*Oncorhynchus mykiss*) *fry (23 to 27 mm)* were able to pass through the 3.175 mm (0.125 in.) profile bar screen openings and were entrained in the irrigation canal. Based on sampling efficiency estimates, about 38% of the rainbow trout fry were lost to the irrigation canal within 48 hours of release. Some fry remained in the forebay and did not migrate during our tests. Wild chinook fry (36 to 42 mm) were also entrained. An estimated 34% of emergent wild chinook salmon fry passed through the profile bar screens and were entrained in the Canal.

Flow measurements taken at the Dryden Screens indicated that approach velocity was at or slightly exceeded the design criteria of 0.4 ft/sec. Low velocities through the first two screen panels indicated that vertical louvers installed behind each screen panel to balance flow were not totally effective.

(a) The Pacific Northwest Laboratory is operated by the Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

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Introduction

The Wenatchee River **subbasin** (Figure **1),** located in northcentral Washington, drains approximately 1,327 sq miles on the eastern side of the Cascade Mountains and enters the Columbia River at River Mile **(RM)** 468.4. The Wenatchee River is managed for spring chinook and summer chinook salmon, sockeye salmon, and steelhead. The watershed provides excellent habitat for spawning, rearing, and production of salmonids. Current programs being implemented to increase **salmonid** stocks include, supplementation, screening diversion and pump intake improvements, **instream** flow protection, and agency cooperation **(WDF** 1990).

Several species and races of salmonids reproduce in the Wenatchee River system. Summer chinook salmon ***(Oncorhynchus tshawytscha)*** spawn in the **mainstem** Wenatchee River and its tributaries. Sockeye salmon (0. ***nerka)*** spawn in and migrate from Lake Wenatchee each spring. Steelhead (0. ***mykiss),*** resident rainbow trout (0. ***mykiss),*** and bull trout ***(Salvelinus confluentsis) also*** utilize the basin **(Wydoski** 1979).

The Wenatchee River is one of the last remaining drainages in the mid-Columbia that supports wild runs of spring chinook salmon. Returns of wild adult spring chinook salmon to the Wenatchee river averaged 4,200 from 1977-1986 **(WDF** 1990). Hatchery returns averaged 3,500 salmon over the same period. Wild and hatchery adult spring chinook salmon enter the Wenatchee river from April through June. Spawning occurs in August and juvenile outmigration occurs from May-June. Adults enter the river in from late May to early June.

Summer chinook salmon adults enter the middle and upper portions of the basin during summer and early **fall.** Run size averaged 7,800 adults from 1977-1986 **(WDF** 1990). Emergent fry (average length of 41 mm) appear from mid- February through mid-April. Outmigration of subyearlings (95 mm) generally occurs from April through June.

Sockeye salmon are presently managed as a wild stock although they were supplemented by hatchery releases to Lake Wenatchee from 1941-1969. Run **size** averaged 31,000 fish from 1977-1986. Adults migrate into the Wenatchee River from July through September. Juveniles migrate from Lake Wenatchee from mid-April through June.

Adult returns of wild summer steelhead to the Wenatchee River averaged 374 during 1977-1987. Hatchery returns averaged 3,050 fish over the same period. Very little data is available on **life** history and population characteristics. Steelhead generally enter the river from mid-July through October. Fry emergence starts in June and continues through the summer. The **subbasin** plan calls for an minimum spawning escapement of 4,700 wild and 7,500 hatchery fish **(WDF** 1990).

In addition to native salmonids, many hatchery-released salmonids migrate down the Wenatchee River. The Leavenworth National Fish Hatchery releases about 1.5 million spring chinook salmon annually in mid-April. A volitional release of about 50,000 summer chinook salmon from the Chiwawa River begins in early April. About 300,000 hatchery-reared steelhead are also released upstream of **Dryden** Dam.

The Dryden Fish Screening Facility was selected as one site to enhance salmon and steelhead runs in the middle Columbia River Basin under a regional Conservation and Electric Power Plan. Under the plan the BPA, with assistance from Technical Work Groups and the Fish Screening Oversight Committee, is funding construction of fish passage and protection facilities at irrigation withdrawals in the Wenatchee River Basin. The Northwest Power Planning Council administers the Plan and is responsible for developing a program to protect and enhance.fish and wildlife populations, and to mitigate adverse effects from development, operation, and management of fish protection facilities.

PNL was contracted by the BPA to evaluate the effectiveness of the Dryden Screens in returning fish that had entered the canal back to the river unharmed. Planning for the evaluations began in January of 1994. The evaluations were conducted during April, May, and August of 1994. All requests for test fish were cleared through the Washington Department of Fish and Wildlife and the Mid-Columbia Fishery Resource Office. (USFWS). The work plan was presented to the Mid-Columbia Coordinating Committee in March of 1994.

This report also includes two appendices. Appendix A contains a copy of the Washington State Fish Protection Screen Criteria. Appendix B describes the operating criteria used to set screen submergence and bypass flow at the Dryden Screens.

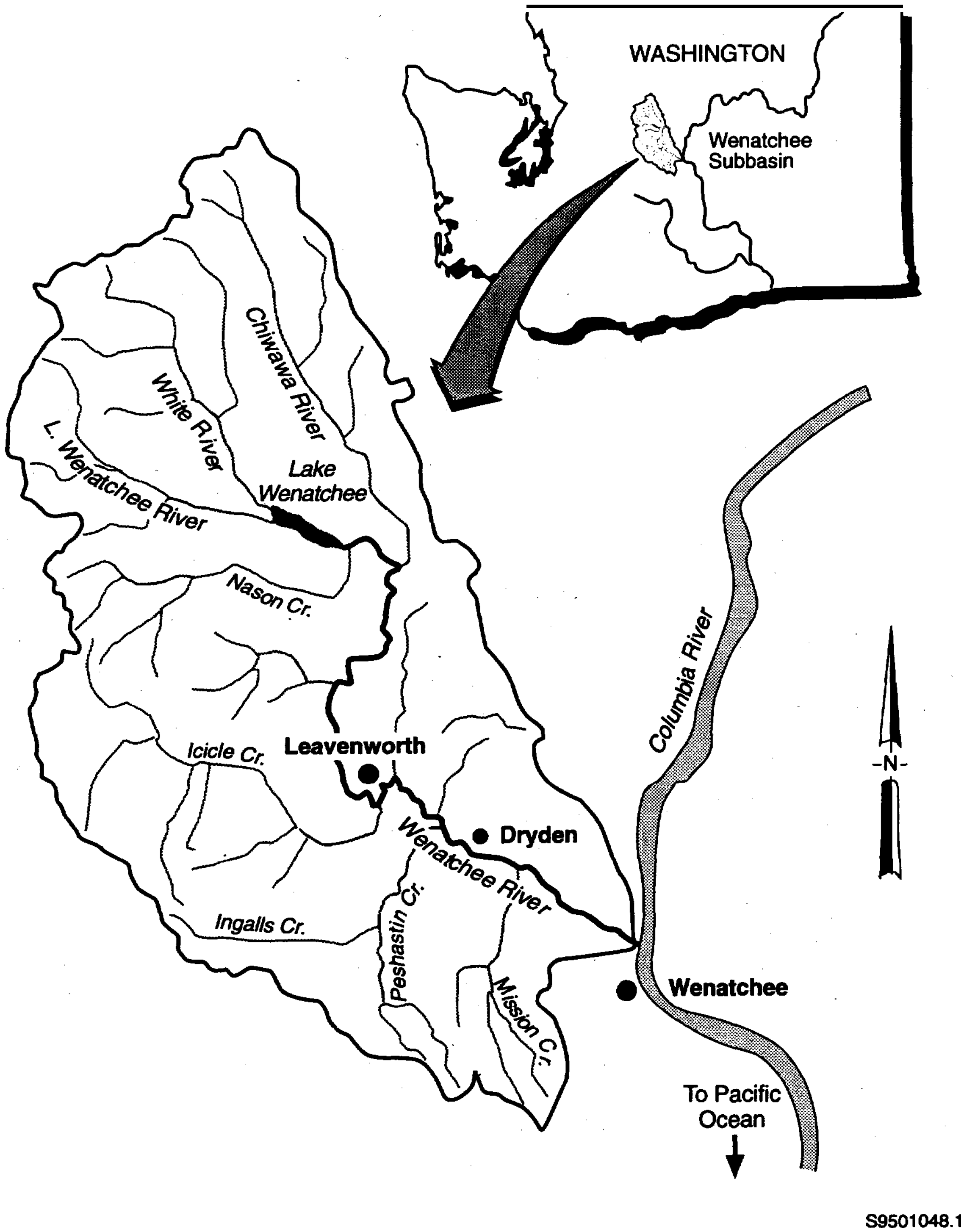

Figure 1. Map of the **Wenatchee** River **Subbasin** Including Major Tributaries

Description of Study Area

Dryden Facilities

The Wenatchee Reclamation District Canal begins at Dryden Dam on the left bank of the Wenatchee River river mile 16.1 (River KM 25.9). The Dryden Fish Screening Facility (Dryden Screens) is located about 500 ft downstream of the Dryden Dam (Figures 2 and 3). The screening facility, completed in the spring of 1993, replaced an old rotary drum screening facility. The canal was originally built to carry 1,500 cubic ft per second (cfs) of water which was used for both irrigation and power generation. However, power generation has ceased and the canal is now used for irrigation and to provide water for fish rearing ponds.

The new screening facility is designed for a maximum flow of 230 cfs. It consists of seven fixed plate vertical profile bar panels installed at a 15" angle to canal flow. The openings in the profile bar are 3.17 mm (0.125 in.) wide. Each panel is 13 ft wide with a submergence of 6.4 ft at maximum canal level, for a total submerged screening area of 582 ft^2. Using the Washington State screening requirement approach velocity of 0.4 ft per second (Appendix A), and assuming even distribution of water through all areas of the seven panels, the facility should effectively screen 233 cfs of water. Canal flow is regulated by a manual headgate structure about 500 ft upstream of the screens. Withdrawal from the canal is estimated by headgate opening and by reading a staff gage in the screen forebay. To ensure balanced flow among the screen panels, adjustable vertical louvers (for porosity control) are installed behind each screen. The screening surface is cleaned with an electric power-driven nylon brush that travels along the face of the screens at regular intervals.

Fish bypass flow of 20 cfs is achieved by adjusting a 36 in. wide weir gate mounted on top of a 4 foot high ramp in the entrance to the bypass slot. Flow through the bypass is maintained by adjusting the bypass weir gate relative to the canal water surface (Appendix B). A fisheries evaluation area 4 ft wide by 16 ft long is built into the fish bypass slot. The fish return has three major components: 1) a 32-in. diameter fish return pipe leads from the fish bypass slot to the head of an open baffled-flume bypass, 2). an open flume designed to dissipate energy resulting from the head difference between the canal and river elevation, and 3) a second 32-in. diameter pipe connected to the end of the flume terminating in the Wenatchee River. This pipe also has a vent to purge entrained air to prevent surging and "burping" in the line (CH_2M Hill 1992).

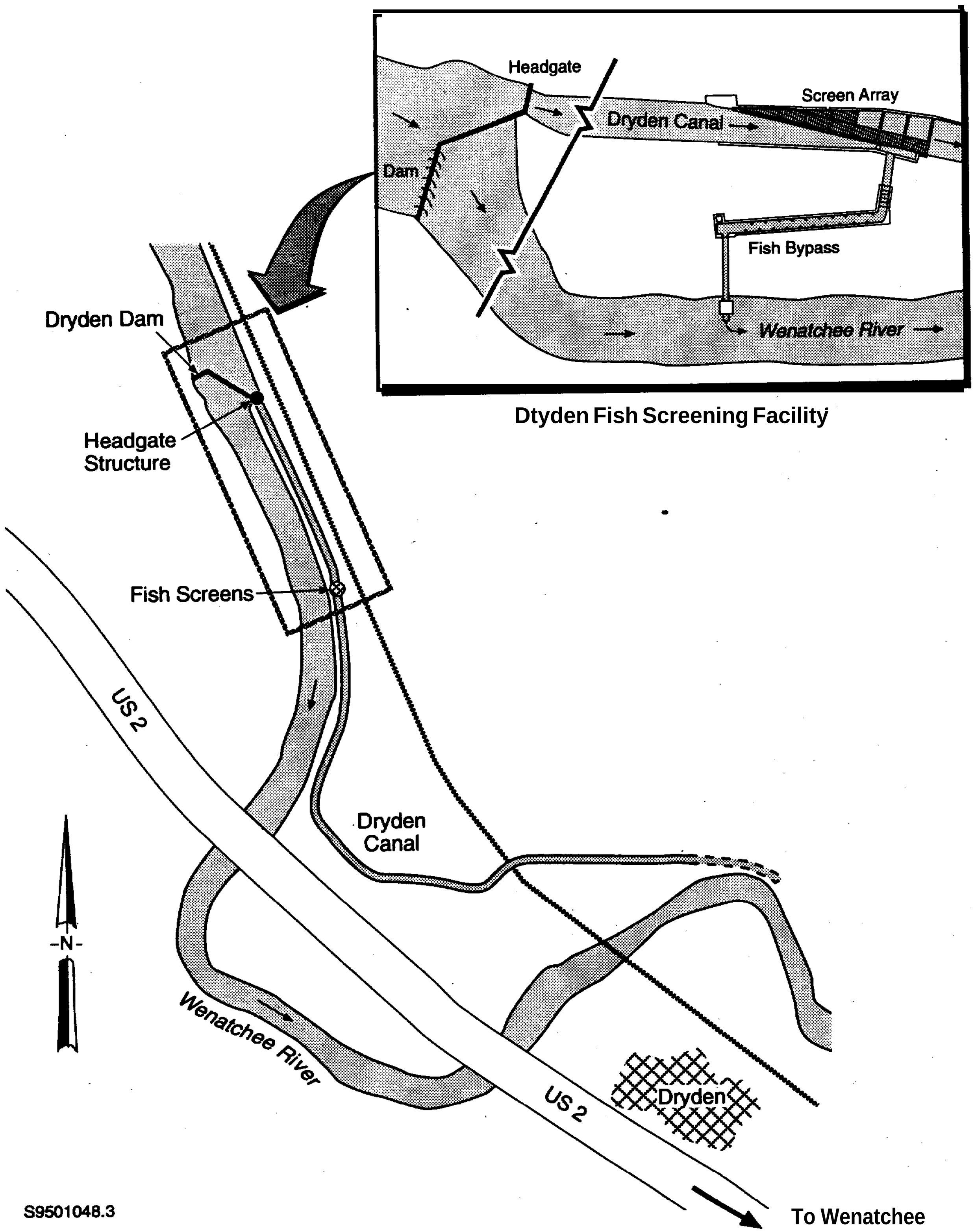

Figure 2. Location of **Dryden** Dam and the **Dryden** Fish Screening Facility

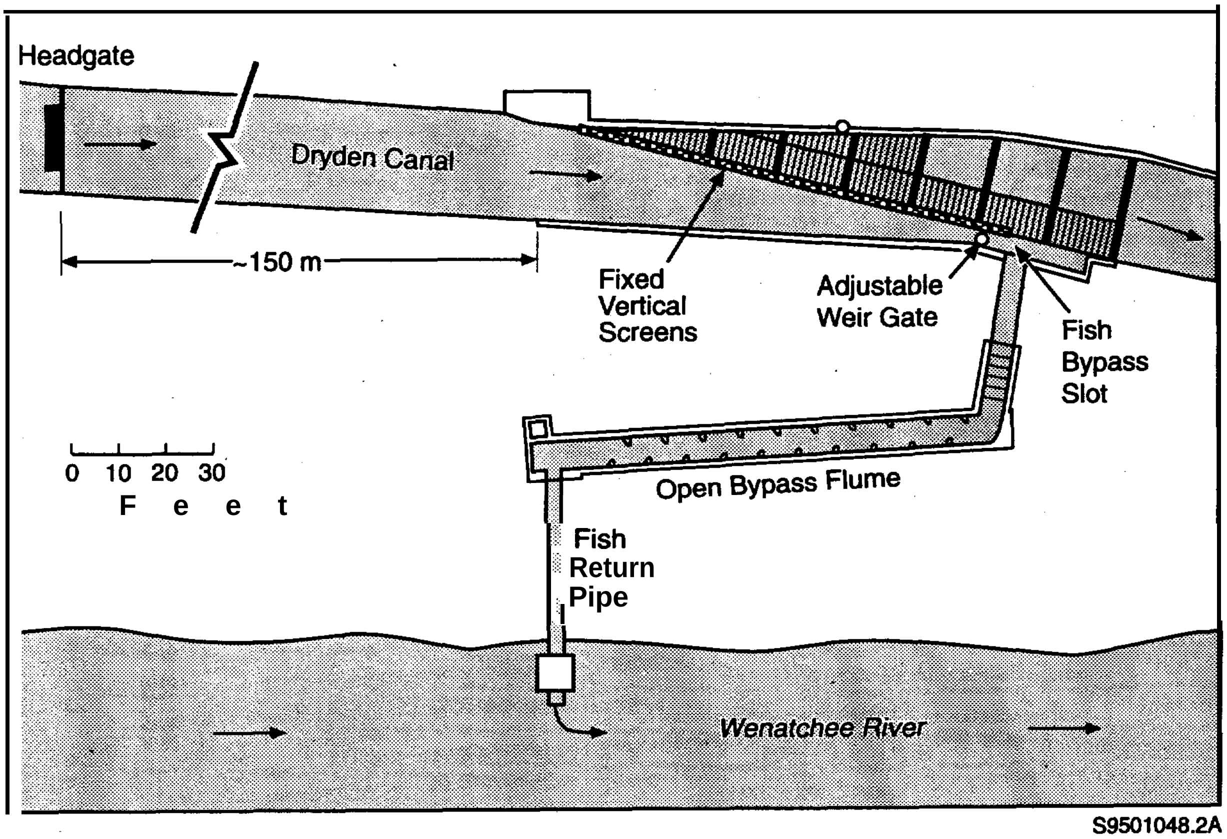

Figure 3. Flow Control Structure and Fish Bypass System in the **Dryden** Fish Screening Facility

Methods

Test Fish

Fish species selected for tests were approved by the Mid-Columbia Coordinating Committee, a group comprised of biologists from various agencies including the United States Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the Washington Department of Fish and Wildlife (WDFW), Native American tribes, and private utilities. Selection was based on the potential impact of the Dryden Screens on resident and anadromous salmonids during the rearing and outmigration periods. Therefore, selection depended on the species, races, and life stages of salmonids present in the Wenatchee River drainage upstream of Dryden Dam. Taking all these variables into consideration the committee approved the following test fish. Spring chinook salmon smolts from the Leavenworth Hatchery, operated by the USFWS were used for descaling evaluation at the screens. Young-of-the-year steelhead from the Chelan Hatchery, operated by WDFW were used in descaling evaluation of the fish bypass structure. Rainbow trout fry ~ 25 mm in fork length (FL) from the Chelan Hatchery were used in screen integrity tests.

Spring Chinook Salmon

Spring chinook salmon smolts were progeny of Leavenworth Hatchery stocks returning to the Icicle Creek near Leavenworth, Washington. Fish were branded at the hatchery on April 8, and transported to the Dryden screens on April 10 and 11. The fish weighed about 18 fish/lb and ranged from 1 10-165 mm FL when released.

Steelhead

Juvenile steelhead at the Chelan Hatchery came from stocks scheduled to be planted in the Wenatchee River in the spring of 1995. The fish weighed about 40 fish/lb when released in our test. Fish were in relatively good condition with minimal scale loss. Fork length ranged from 75-120 mm.

Rainbow Trout

Rainbow trout fry also came from the Chelan Hatchery. The evaluation work plan called for 4,000 -5,000 fish, but because of a weighing error at the hatchery only about 2,500 fry were transported. The fry averaged about 25 mm in FL. The fry were transported to the Dryden site and held 24 hours before the start of testing. Test fish were marked with Bismark Brown Y dye (0.14g dye/3.78 L water) for 1 hour. Based on previous tests at our laboratory, it was determined that dyed fish could be identified up to 48 hrs after release. Since only one color of dye was available, only one release group was possible. No native (wild) emergent trout/steelhead were present in the canal during our tests.

Sampling Equipment

Fish were captured in the fish bypass slot, at the terminus of the bypass pipe, and in a fyke net mounted in the canal behind the screens, depending on the objectives of each test. A modified inclined plane was used to collect fish in the bypass slot. A fyke net was deployed in the canal to collect fish behind the screens during the screen integrity test, and a portable electrofisher and dipnets were used to collect fish in the river during the fish bypass test. Temporary fish-holding facilities were set up at the site to minimize handling stress during our evaluation and to acclimate and hold fish.

Inclined Plane

An inclined plane trap was used to capture fish as they entered the fish bypass. The trap measured 7 ft long and 3.3 ft wide. .A live box 1.3 ft long by 3.3 ft wide, 26 gal volume was attached at the end of the inclined plane (Figure 4). The entrance of the trap was designed to rest on the lip of the existing weir gate, which allowed the trap to be deployed without affecting the bypass flow. Any gaps between the entrance of the trap and the adjustable weir were filled with foam. Splash guards along the sides of the inclined plane prevented fish loss. The inclined plane had an aluminum frame covered by a perforated stainless steel sheet with 0.125 in. diameter holes. The trap was positioned over the bypass chamber and lowered into position using two 1/2 ton hand winches suspended from a wooden support frame. The trap was positioned prior to fish releases and remained in place until tests were terminated.

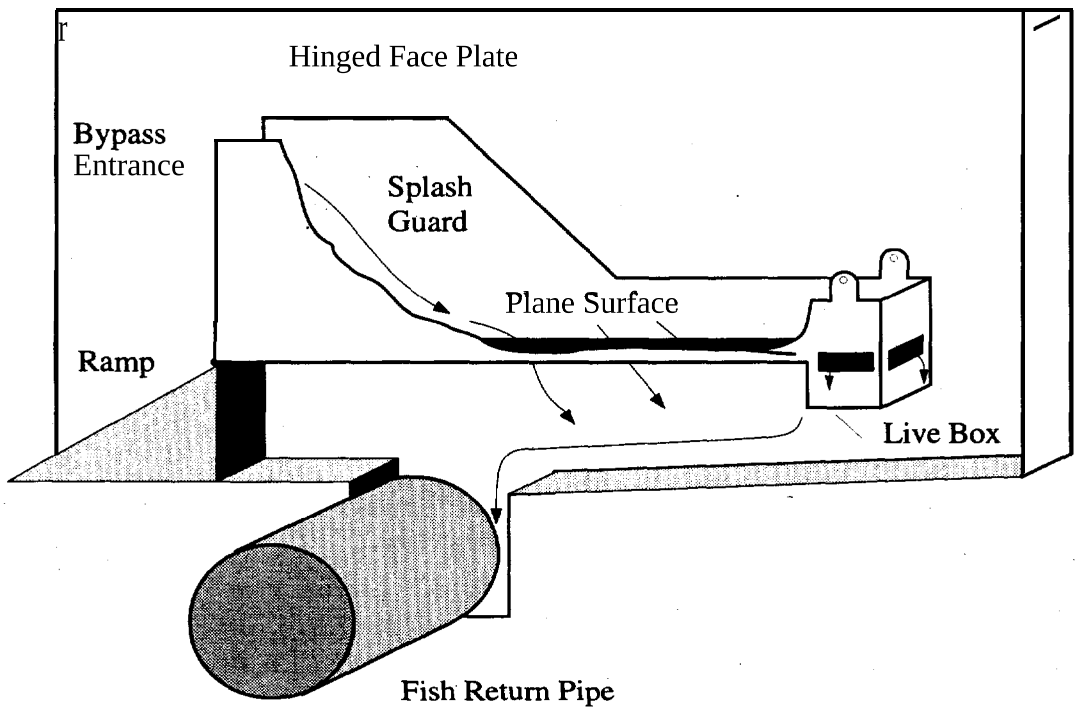

Figure 4. Inclined Plane Trap Used at the Dryden Fish Screening Facility, Spring 1994

Fish were netted and placed in a holding trough as they appeared in the live box. The inclined plane surface was cleaned as necessary to prevent buildup of debris that could otherwise affect bypass flow or cause injuries to fish.

Fyke Net

A 4.3 ft wide by 8 ft tall fyke net with 1/8 in. knotless mesh netting was used to capture fish passing through the vertical screen panels. The net mouth was fastened to a 1 in. steel angle iron frame. The net was 20 ft long and tapered to a 2 ft square cod end. The square cod end was tied shut. The net was retrieved by ropes tied to the lower comers of the frame. The fyke net was positioned immediately downstream of the screening structure in the center portion of the canal. Retrieval took about ten minutes and was performed during slack migration periods. The net was emptied, cleaned, and repositioned as quickly as possible.

Electrofishing

A Smith. Root Model 12 backpack electrofisher was used to stun fish as they exited the fish bypass pipe during the bypass descaling evaluation. The unit was programmed to generate a pulsed DC current to minimize fish injury. Probes were placed immediately downstream of the bypass terminus. Stunned fish were dip netted from the river using long handled dip nets with 1/8 in. mesh netting. Swift current and large boulders at the terminus of the fish return pipe made it impractical to use a fyke or seine net to capture test fish.

Water Velocity Measurements

A Marsh/McBirney Model 5 11, bidirectional current meter was used ‘to measure approach and sweep velocities near the face of the vertical fixed-plate screens. Approach and sweep velocities were displayed and measured simultaneously. Measurements were taken at 0.2, 0.5, and 0.8 of the depth at locations that were 1, 4.7, 8.3, and 12 ft (transects 1-4) from the upstream edge of each screen panel (Figure 5). A total of twelve measurements were taken for each of the seven screen panels. Due to electromagnetic interference in front of the screen panels, approach and sweep velocities were taken about 6 inches behind the screen panels. Sweep velocity in front of the screens was estimated by floating an orange in the forebay and timing its movement from the head end of the forebay to the fish return. The orange was dropped into the forebay so that it drifted close to the screens, near the center of the forebay, or near the wall opposite the screens.

Underwater Camera

An underwater video system was used to monitor fish movement and behavior in front of the screens. The system consisted of a high-sensitivity remote camera (Sony, model HVM-352) with a 70” wide angle lens connected by 66 ft of quadraxial cable to an 8-mm camcorder (Sony, model CCD-FX710 Handycam Hi-8) housed in a weatherproof case. The case was fitted with external weatherproof controls, a 4-in. black and white monitor, and internal battery power supply for the system.

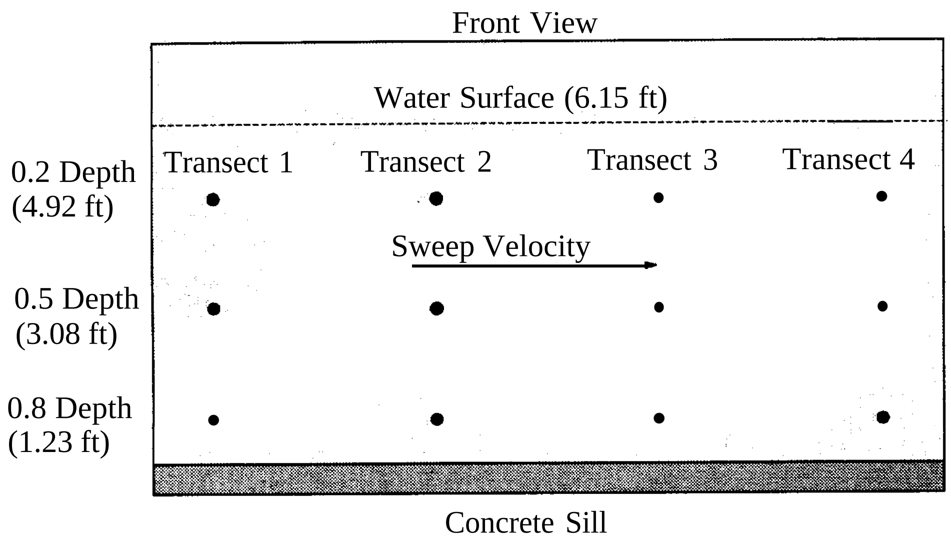

Figure 5. Sampling Locations for Velocity Measurements at the Face of **Vertical** Screens at the **Dryden** Fish Screening Facility

Holding Facilities

Test fish were transported to the site and placed in a temporary holding trough to acclimate. The fiberglass trough measured 16 **ft** long x 2.5 **ft** wide by 2 ft deep, and **450-gal** volume. An additional **140-gal** trough was used to temporarily hold and sort fish after they were removed from the inclined plane trap. A **30-gpm** pump was used to supply canal water to the troughs. Two 20 gal plastic containers were used to hold fish collected during **the bypass** injury test. The weighted containers had **1/8-in.** perforations and were placed in the river near the bypass terminus. -A 16 **ft** construction trailer with fluorescent lighting was transported to the site to provide consistent lighting conditions for evaluating descaling and injuries during 24-hr screen descaling and integrity tests, and to provide a **safe** work environment during inclement weather.

Descaling Evaluation System

The evaluation system developed by the U.S. Army Corps of **Engineers (Basham** et al. 1982) was used to quantify the condition of test release and control group fish. Evaluation criteria included modifications adopted in 1985 (Neitzel et al. 1985). Baseline descaling was determined by randomly sampling groups of test fish **before** their release. Descaling was evaluated in each of ten areas of a fish, five on each side. When $\geq$ 40% or more scale loss was observed in any two areas on one side of a fish, the fish was classified as descaled (significant scale loss).

Stock Identification

Spring chinook salmon smolts from the Leavenworth Hatchery were cold-branded with liquid nitrogen to differentiate the test fish from native stocks. The fish were branded on April 8 at the Leavenworth NFH. Chinook salmon were branded with a horizontal mark "—" above the lateral line on either the left or right anterior region. Branding marks were approved by the NMFS, and were distinguishable from all other brands used in the Columbia River basin. Rainbow trout fry were marked with Bismark Brown Y dye. The dye imparts an orange color visible on the fins, belly, and head of fry for up to 48 hrs. Fry were placed in a water and dye solution of 0.14g dye to 3.78 L water (37 ppm solution) for approximately 2 hours. Dyed fish were held for. 2 hours in a holding trough . supplied with canal water to recover before release. Steelhead subyearlings used in the bypass descaling test were already adipose-fin-clipped and did not receive any additional marks for the evaluation.

Fish Transport and Release

Test fish were transported from the hatcheries to the Dryden Screens-in a insulated fish tank (125-gal volume) supplied with oxygen. Transit times ranged from fifteen minutes from Leavenworth Hatchery to about two hours from the Chelan Hatchery. Loading densities did not exceed 120 g of fish/L. Water temperature was monitored during transport and did not change more than 1 . C from the rearing temperature at the hatcheries. All test fish were transferred immediately upon arrival to the holding trough at the Dryden Screens. No losses (mortalities) occurred during transport.

Test Procedures

Fish were released and recaptured to evaluate individual components of the screening facility. Two descaling tests and one screen integrity test were conducted. The primary descaling test involved releasing groups of marked fish at the headworks of the screening facility then recapturing them as they entered the fish bypass. The objectives of this test were to determine the percentage of fish descaled, the number of fish killed (both immediately and after two days), and the transit times. The bypass descaling test involved releasing test fish at the entrance to the fish bypass pipe and recapturing them as they exited the terminus of the bypass pipe. The objectives of the test were to evaluate bypass components that may adversely affect the condition of fish passing the fish return structure and to determine transit times. Screen integrity tests were conducted to determine if test fish were entrained in the irrigation canal. The objectives of the integrity test were to evaluate the effectiveness of the profile bar screen in protecting small fish and to develop a hypothesis about the fate of noncollected fish. In addition to collecting test fish, native chinook and sockeye salmon, rainbow trout/steelhead, and other fish species were also collected, monitored, and evaluated as they appeared on the inclined plane.

Screen Descaling Test

Branded spring chinook salmon were released near the headworks of the Dryden Screens and recaptured as they appeared on the inclined plane in the fish return. Testing occurred over a 3day period, April 11-13, 1994. Canal flow during this period remained constant at ~ 225 cfs with a 20 cfs (20 in. weir crest) bypass flow. Wenatchee River flow upstream of Dryden Dam was near 3,300 cfs and stable over the testing period.

Bypass Descaling Test

The bypass pipe descaling test was originally scheduled for late March or early April (before river flows increased), but approval from the Mid-Columbia River Fishery Resource Office did not occur until mid April. Sampling the bypassed fish at the pipe terminus was not feasible or safe at high river flows with conventional sampling gear, therefore, sampling was delayed until river flows decreased to safe conditions for electrofishing. The bypass injury test was conducted on August 17, 1994 when river flows at Dryden Dam were about 650 cfs. Bypass flow was set at 20 cfs as specified in the operating criteria. A total of 500 steelhead subyearlings were released in small groups (10-50) at the adjustable weir and recaptured when the fish exited the pipe terminus.

Screen Integrity Test

The screen integrity test was conducted on May 2-5, 1994. Canal flow was -225 cfs. Wenatchee River flows averaged 5,200 cfs during the testing period. Bypass flow was set at 20 cfs. Due to the design of the facility, sampling the entire cross section behind the screens was not possible. Therefore, a fyke net which sampled about 22% of the total cross-sectional area was positioned downstream of the screens. Water depth in the canal was 6.1 ft and canal width was 19.8 ft wide. Prior to the beginning of the test, two groups of 50 fish were released in the net mouth to determine net capture efficiency. Following this test, 1,500 dyed fish were released above the screens and 827 undyed fish were released uniformly behind the screens. Captures of undyed fish were used to calculate capture efficiency of fyke net, and numbers of dyed fish captured behind the screens (in the net) were used to determine percent entrained.

Fish Release Locations

Test fish were released at different locations at the facility depending on the test objectives. Screen descaling test fish (spring chinook salmon) were released immediately downstream of headgate structure about 500 ft upstream of the screens. Test fish could not swim upstream due to the design of the headgate structure and hydraulic conditions. Screen integrity test fish (rainbow trout fry) were released just upstream of the screening forebay on the screen side of the canal. Bypass pipe test fish (steelhead subyearlings) were released into the bypass flow as it plunged over the adjustable weir gate located in the fish bypass slot.

Release Controls

A subsample of 136 branded spring chinook salmon were retained as controls and examined to monitor the baseline condition of released fish. Control fish were not used in descaling tests. The first 100 test fish captured on the plane were held for ~ 48 hours to monitor for post-test mortality. One hundred steelhead subyearlings were used as controls to determine baseline descaling during the bypass pipe descaling test. Control fish were not used as part of the test releases and were released in the fish return structure after testing.

Fish Capture and Evaluation

Screen Descaling Test

Two groups of test fish (878 total) were released downstream of headgate structure. The first release occurred at 1010 hours on April 11 and the second at 1815 hours. The inclined plane trap was fished continuously for the duration of the test. All fish caught on the inclined plane were netted and placed in a temporary holding trough. Descaling evaluation was continuous but data was broken down into half-hour intervals through the test period. Fish were anesthetized in tricane methane sulfonate (MS-222), examined to determine extent of descaling, and returned to holding trough. After the fish recovered from the anesthetic, they were returned to the fish return pipe. (One hundred fish were retained for up to 48 hours to monitor for past-test mortality). An underwater camera was also deployed and recorded fish behavior as they migrated in front of the vertical plate screens near the entrance to the fish bypass.

Bypass Descaling Test

Test fish were released at the overflow of the fish weir gate and recaptured at the pipe terminus to estimate travel time through the bypass flume/pipe. No native steelhead smolts were captured during the test. Fish were released in small groups (10-50) to increase the probability of capture. Fish were stunned with a backpack electrofisher at a small pool downstream of the pipe. The recovered fish were captured using dip nets and placed in 20 gal perforated containers in river water. Recovered fish were then transferred to 5 gal pails, anesthetized, and examined for scale loss and other injuries. After examination, fish were held in a trough to recover from stress then released into the river when testing was completed. Incidental catches of wild steelhead/rainbow trout, wild chinook salmon, sculpins, whitefish, dace, and suckers were released into the river when captured.

Screen Integrity Test

Because of the test objective, fish were not examined for scale loss or injury but to monitor if they could pass through and/or around the screens. Test fish (released in front of screens) were dyed with Bismark Brown Y dye to distinguish from other native fish and efficiency control fish. A fyke net in the canal was used to capture a subsample of fish appearing behind the screens. A total of 1,500 dyed fish and 827 undyed fish were released at 1200 hours on May 3, 1994. Over the next 36 hours, the fyke net was fished continuously except for retrievals at 4-6 hour intervals. During the net retrieval (~ 10 minutes) the fyke net was cleaned and the contents were emptied into a trough and examined. In addition to the fyke net, the inclined plane trap was deployed in the fish bypass chamber and sampled every half hour to monitor the number of fry successfully bypassed. All fish captured on the plane were anesthetized and examined to determine whether they were dyed or undyed. All test rainbow trout fry were sacrificed after collection. All other fish captures on the inclined plane were returned to the fish return pipe after recovery from the anesthetic.

Statistical Analysis

The percent of fish killed or descaled and the length of time for fish to move from their release point to the point of capture was determined. Capture efficiencies of the fyke net used during screen integrity tests were estimated from the number of control fish captured. Capture efficiencies were used to estimate the effectiveness of the screen in preventing fish from passing from the screen forebay and into the canal downstream of the screens.

Descaling and Mortality Estimates

Estimates of the percentage of fish descaled or killed depended on the number of test fish caught. Descaled fish were considered dead for the analyses. The lower and upper confidence limits (LCI and UCI, respectively of a 95% confidence interval) were estimated as

$$LCI = \frac{B}{B+(n-B+1)F}$$

and

$$UCI = 1 - \frac{n-B}{n-B[n-(n-B)+1]F}$$

where

- **B** = the number of dead or descaled fish
- **n** = the number of fish caught
- **F** = ratio of the estimates for the mean sample variance and the individual sample variance

The estimates were calculated from Mainland's Tables (Mainland et al. 1956).

The estimate assumed each fish behaved independently (i.e., fish within a test did not behave more similarly than fish between tests, and there were no interactions among fish within a test). Although some interaction was expected among fish, the analytical methods required this assumption.

Screen Efficiency Estimates

One screen integrity test was conducted at the Dryden Screens. An overall screen efficiency estimate was computed based on fish captures or noncaptures at two sampling locations.

Entrainment estimates were determined by the number of test fish released in front of screens and caught in the fyke net. Three quantities were computed to estimate screen efficiency: inclined plane efficiency (EFF_{ip}), net capture efficiency (EFF_{nc}), and net retention efficiency (EFF_{nr}). Inclined plane efficiency **(EFFip)** was assumed to be equal to 1. Net capture efficiency was determined **from** the number of fish caught from releases behind the screens. Net retention was calculated by releases into the net mouth and determining the number actually caught.

Of the total number of fish released in front of screens **(N),** some fish were not accounted for **after** the efficiencies **(EFF_{nc} and EFF_{nr})** were considered. It must be noted that N was not an actual accounting of all fish caught in different locations (inclined plane and fyke net) but an estimate based on the actual numbers, adjusted by efficiencies for net losses and human error.

The entrainment determinations are defined as

$$C = \left[\frac{Xnet}{Effnc \times EFFnr}\right] \quad \text{and} \quad E = 100\left[\frac{C}{Xip + C}\right]$$

where

C	=	the estimated number of fish that passed through the screens .
Xnet	=	the number of fish released in front of screens and caught in net
EFFnc	=	the percent of fish captured in net from fish released behind screens
EFFnr	=	the percent of fish released in net mouth retained in the net
E	=	the estimated percent of fish entrained in canal
Xip	=	the number of fish caught in the inclined plane

Results

Fish released upstream of the facility and fish that passed through the bypass/flume were not descaled or killed. H-ever, based on the tests conducted with rainbow trout **fry,** the facility was not completely effective at preventing small salmonids from entering the irrigation canal.

Screen Descaling Test

Of the 878 fish released below the headworks,. 871 (99.2%) were captured on the inclined plane as they exited the fish bypass. Only one test fish was significantly descaled (Table 1). Fish moved quickly down the canal and into the bypass chamber where they were collected on the inclined plane. Over 80 **%** of both groups of test fish released were accounted for in the **first** 4 hours. All but 0.8 **%** of the test fish were accounted for by 2400 hours on April 11 (Figure 6). There was no significant difference in descaling rates between the test fish and the baseline control group. In addition, **100** test fish held for 48 hours showed no delayed mortality.

Observations made with the underwater camera showed most test fish stayed well away from the screen face and did not come in contact with the profile bar screen. Out of several hundred fish observed, the only contact between fish and screened surface involved a single emaciated fish that was too weak to avoid mild intermittent impingement. Of the 871 test fish examined, 6 fish were noted as “emaciated” on the data sheets, and all were partially descaled, although descaling probably occurred when the fish were at the Leavenworth Hatchery and not at the screening site..

Table 1. Descaling Condition of Smolt Sized Salmonids ***(Oncorhynchus spp.)*** Caught on the Inclined Plane at the' **Dryden** Fish Screening Facility, April 1994

Species or Group	Number Examined	Number Descaled	Percent **Descaled**	95 **% Confidence** Interval
Spring Chinook Baseline Control	136	0	0.0	O-2.6
Spring Chinook Test Fish	871	1	0.1	0.003 -0.702
Other Chinook	222	0	0.0	o-1.64
Steelhead/ Rainbow Trout	14	0	0.0	0 - 23.16
Sockeye	338	4	1.2	0.33 - 3.14

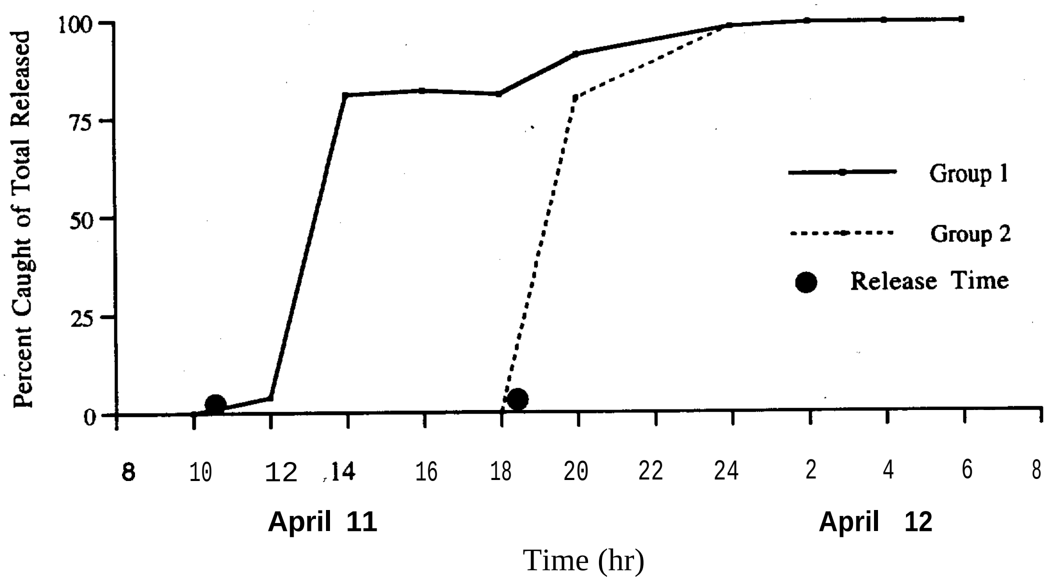

Figure 6. **Time** to Capture of Spring Chinook Salmon ***(Oncorhynchus tshawytscha)*** **Smolts** During Screen Descaling Tests at the **Dryden** Fish Screening Facility, April 1994

Wild chinook salmon were also captured during the screen descaling teat. A total of 545 wild chinook fry (< 50 mm) were collected on the inclined plane trap over the three day test period. These fish ranged in size from 28 to 49 mm FL and migrated predominately at night (Figures 7 and 8). Other salmonids collected during the test included 222 wild chinook salmon smolts, 14 wild **steelhead/** rainbow trout, and 338 wild sockeye salmon smolts. Of the 338 sockeye salmon smolts collected, **four** were classified as descaled. Sockeye fork length ranged from 76 to 120 mm FL (Figure 9). Most sockeye were also caught at night (Figure 10). Of the 222 chinook salmon smolts collected, none were descaled. Chinook salmon smolts moved predominately at night (Figure 11) and averaged 91 mm in FL. No descaling was observed on the wild steelhead and rainbow trout caught on the inclined plane.

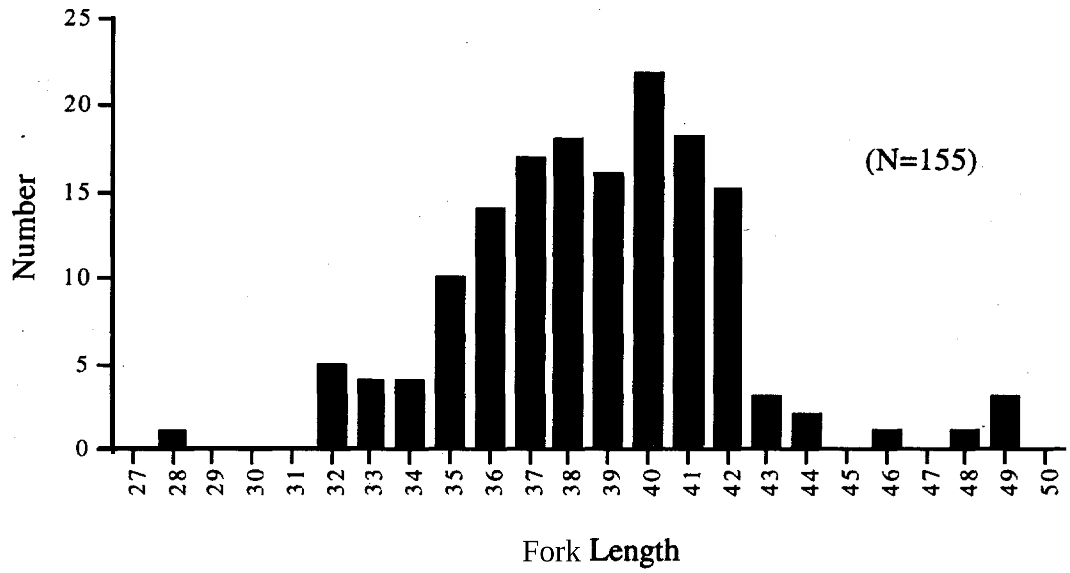

Figure 7. Fork Length (mm) of Chinook Salmon (***Oncorhynchus tshawytscha***) Fry Caught During Screen Descaling Tests at the **Dryden** Fish Screening Facility, April 1994

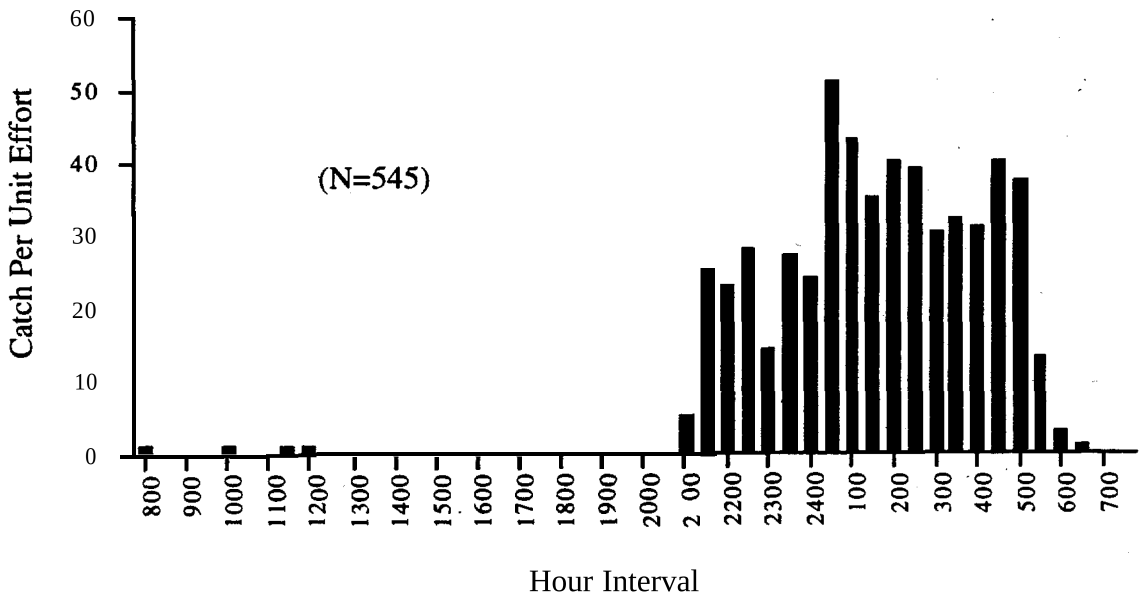

Figure 8. Hourly Captures of Chinook Salmon (***Oncorhynchus tshawytscha***) Fry Caught During Screen Descaling Tests at the **Dryden** Fish Screening Facility, April 1994

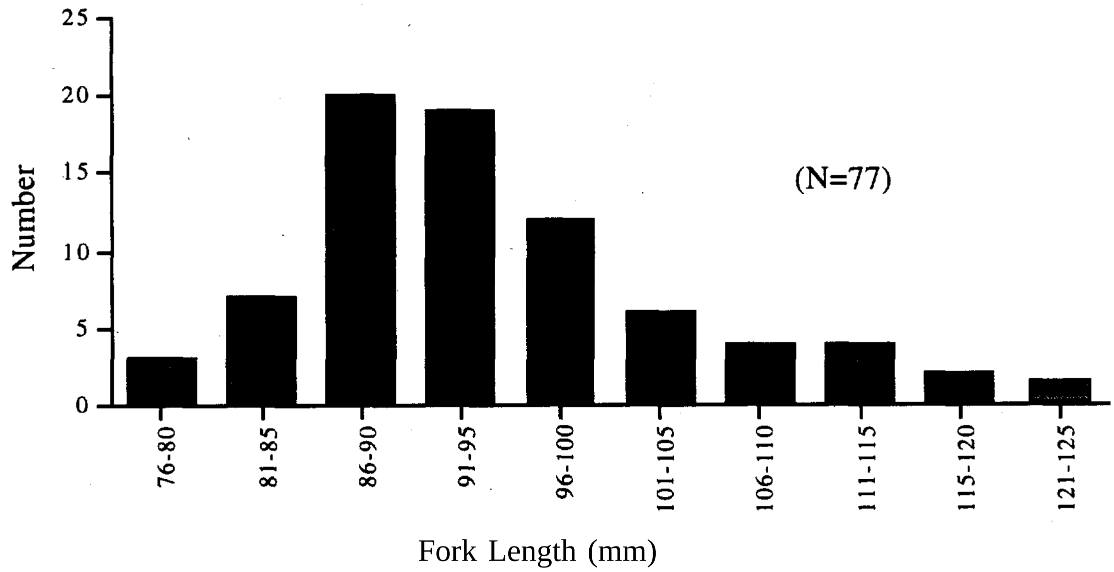

Figure 9. Fork Length (mm) of Sockeye Salmon ***(Oncorhynchus nerka)*** Smolts Collected During Screen De-scaling Tests at the **Dryden** Fish Screening Facility, April 1994

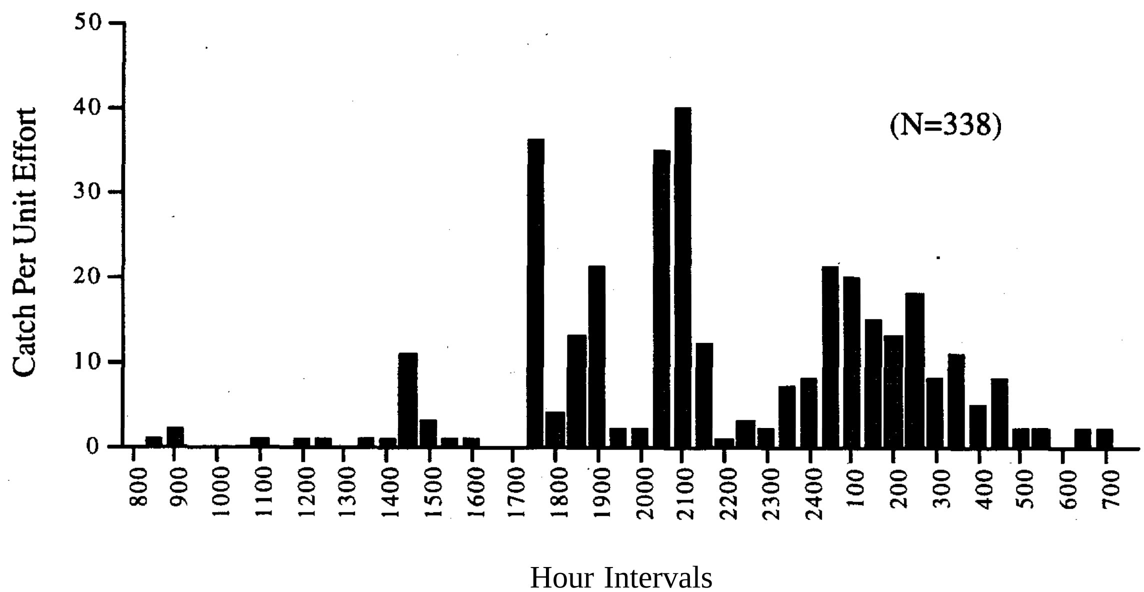

Figure 10. Hourly Captures of Sockeye Salmon ***(Oncorhynchus nerka)*** **Smolts** Collected During Screen Descaling Tests at the **Dryden** Fish Screening Facility, April 1994

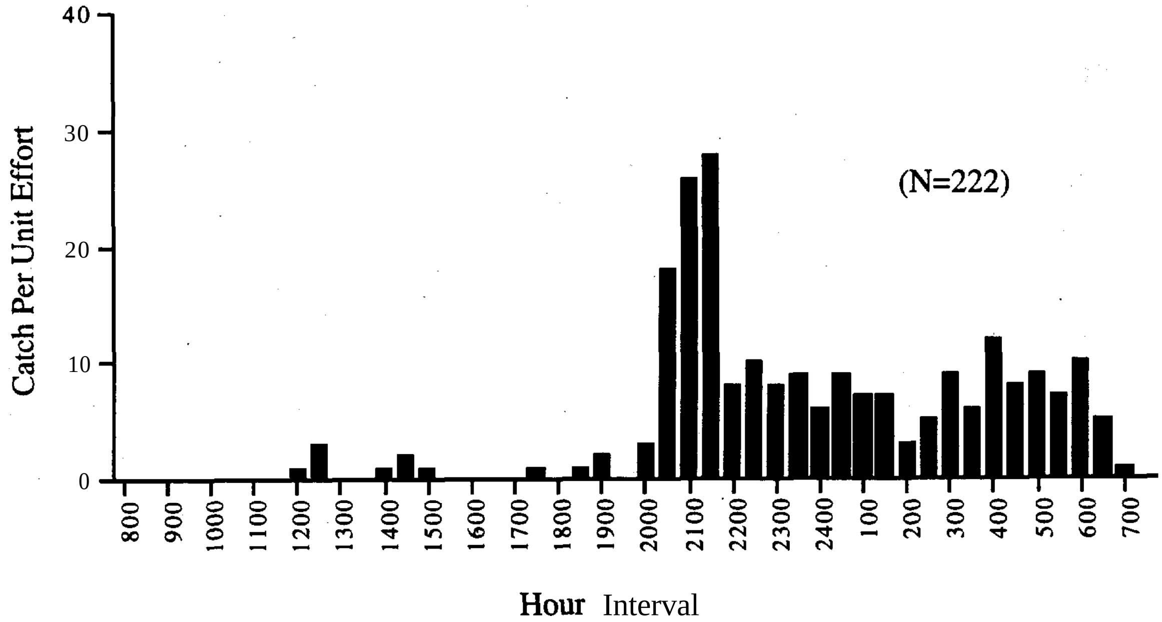

Figure 11. Hourly Captures of Chinook Salmon ***(Oncorhynchus tshuwytscha)*** **Smolts** Caught During Screen Descaling Tests at the **Dryden** Fish Screening Facility, April 1994

Bypass Descaling Test

Five hundred steelhead subyearlings (test fish) were released in groups of 10 to 50 fish at the bypass flow control weir and recaptured after they migrated through the fish return flume/pipe and exited the bypass pipe terminus. A total of 139 test fish were captured at the pipe terminus with a backpack electrofisher and dip nets. The average travel time from release to capture was 70 seconds. Bypass flow was set at approximately 20 **cfs.** Capture efficiency of **these** fish ranged from 17 to 38% (Table 2). Sixes of 100 randomly selected steelhead ranged from 66 to 128 mm in FL (Figure 12). Eleven test fish captured at the terminus died as result of electroshocking. These fish contacted the anode and had visible hemorrhaged tissue. The sampling area was characterized by large to medium sized boulders, a small pool about 3 **ft** deep, and a shallow near shore area. The number of fish collected during the later releases increased, probably because some test fish held in the pipe or some fish from previous releases may have stayed near the sampling area for an extended period of time.

Table 2. Capture Data for Steelhead (***Oncorhynchus mykiss***) Subyearlings Released at Adjustable Weir and Collected by Electrofisher During Bypass Descaling Test at the **Dryden** Fish Screening Facility, August 1994

	Number of Fish			Gear Mortality	Percent Capture Efficiency
	Released	**Captured**	**Descaled**		
	10	2	0	0	20
	30	8	0	1	27
	30	6	0	1	20
	30	7	0	1	23
	30	9	0	1	30
	30	6	0	1	20
	30	6	0	0	20
	30	10	0	2	33
	30	5	0	1	17
	50	17	0	0	34
	50	15	0	2	30
	50	19	0	1	38
	50	14	0	0	28
	50	15	0	0	30
Total	500	139	0	11	**28**[a]

a) Average percent capture **efficiency.**

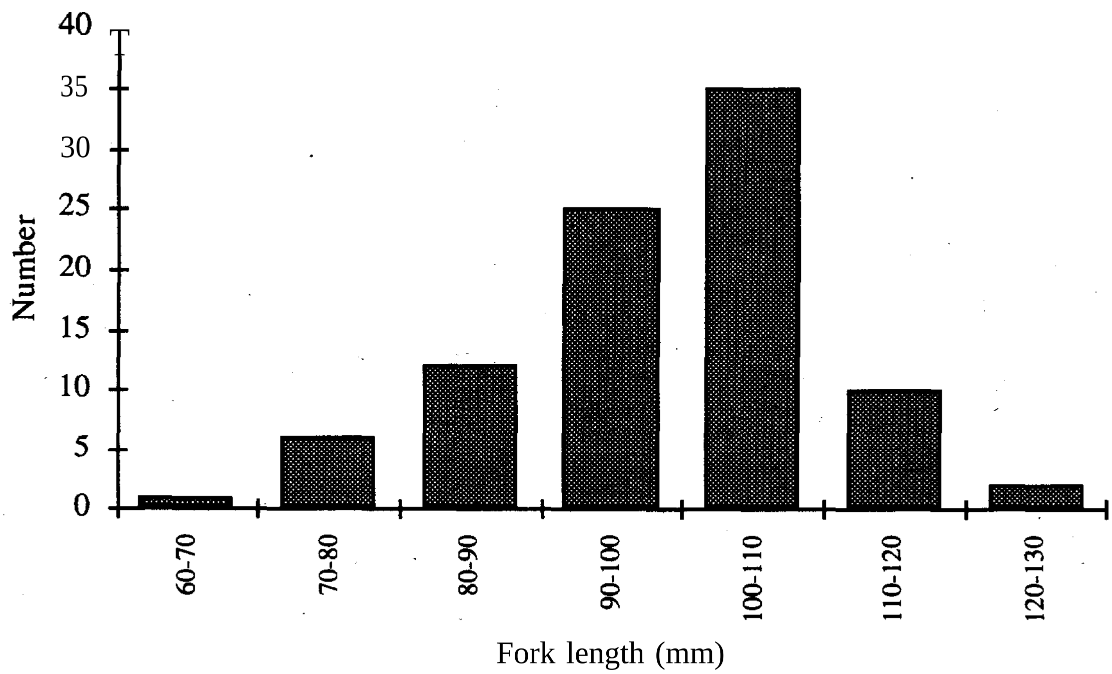

Figure 12. Size Distribution of Steelhead (***Oncorhynchus mykiss***) Subyearlings Used in Bypass Descaling Test at the **Dryden** Fish Screening Facility, August 1994

Screen Integrity Test

On the morning of May 3, 1,500 dyed rainbow trout fry (teat fish) were released upstream of the screen **forebay.** Downstream movement was monitored at **half-hour** intervals as test fish appeared on the inclined plane in the bypass slot. The movement rate for rainbow trout (Figure 13) indicated fry exited from the **forebay** at their own volition and were not flushed into the bypass slot. The test was terminated at 2330 hours on May 4. Of the total test fish released, 516 (34%) were recovered on the inclined plane and 63 (4.2%) in the fyke net behind the screens. The net was fished **for** l-hour periods **for** each **50** fish release group. The **fyke** net fished 26.8 **ft²** (4.4 **ft** x 6.1 **ft** water depth) of the canal or about 22.2% of the cross-sectional area. Average net efficiency was estimated at 91% based on the recovery rates **for** two 50 fish groups released into the net mouth. Of the 827 undyed fish released behind the screens, 175 (21.2%) were recovered in the fyke net and two were caught on the inclined plane (Table 3). A net capture efficiency of 19.3% (0.212 x 0.91) was estimated for rainbow trout **fry.** Using this efficiency value, it was estimated that 38.7% of the rainbow trout fry were entrained in the canal (Table 4). These values were calculated using the **formula** presented in the statistical analysis section.

Other species captured in **the** fyke net behind the screens included 5 **dace (*Rhinichthys spp.*),** 2 whitefish **(*Prosopium spp.*)** and 10 wild chinook **fry (Table** 5). Wild chinook salmon fry caught in the fyke net ranged from 36 to 42 mm in FL while salmon **fry** caught on the inclined plane ranged from 27 to 49 mm in FL (Figure 14). Head width of rainbow trout fry (test fish) **recovered** ranged from 3.11 to 3.58 mm. Head width measured on the 10 wild chinook salmon fry captured in the fyke net ranged from 4.26 to 4.34 mm. A total of 68 **wild** chinook fry were captured on the inclined plane during the integrity test. Using the entrainment **formula,** an estimated 34% of the salmon fry were entrained in the canal. **Wild** chinook **salmon** fry caught on the inclined plane ranged in age from alvins with yolk sacs to more advanced fry (Figure 15). A large proportion of the wild chinook salmon fry were in various stages of yolk sac absorption. All captured wild chinook salmon fry were returned unharmed **to** the fish bypass.

Water Velocity Measurements

The combination of water velocity across the **face** of the screens and screen construction materials (stainless steel) created a sufficient electromagnetic **field** to **interfere** with velocity measurements taken with the bidirectional electromagnetic current meter. By placing the current meter probe behind the screen panels, stable readings were **obtained** and water velocity through the screen (approach velocity) was recorded. Sweep velocity behind the screens was also recorded, but these **readings** only showed the vector angle of the flow through the screens and were not related to sweeping velocity in front of the screen panels. Velocity measurements were taken when the screen@ facility's cleaning brush was either stationary and between cleaning cycles or was at least two screen panels away from the measurement point.

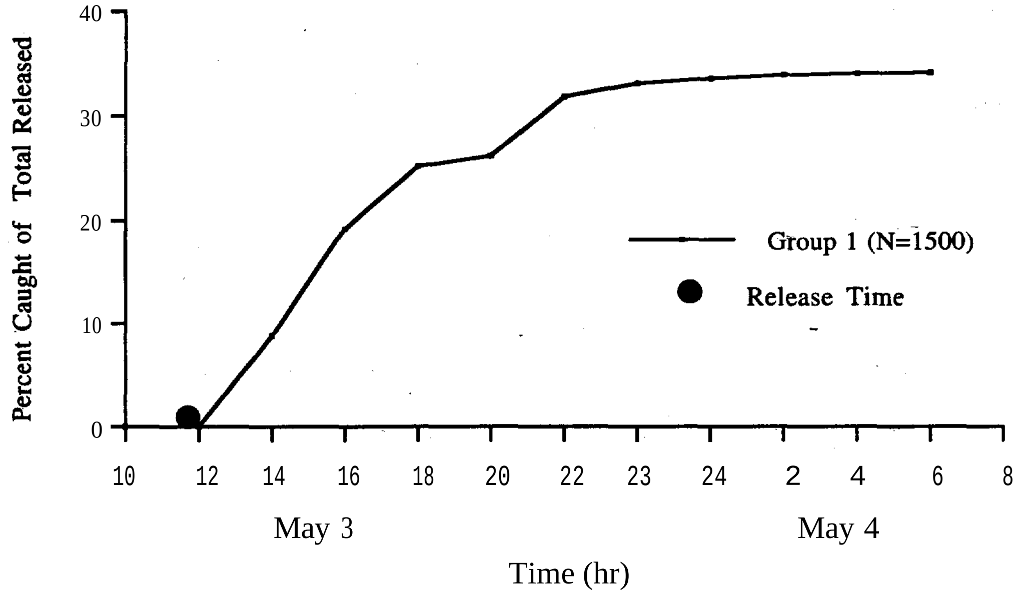

Figure 13. 'lime to Capture Rainbow Trout (***Oncorhynchus mykiss***) Fry During Integrity Test at the **Dryden** Fish Screening Facility, May 1994

Table 3. Capture Data for Rainbow Trout (***Oncorhynchus mykiss***) Fry Caught During Integrity Test at the **Dryden** Fish Screening Facility, May 1994

		Number of Fish Captured		Percent of Fish Collected	
Release Site	Released	in Fyke Net	on Plane	in Net	on Plane
In Front of Screens	1500	63	516	4.2	34.4
Behind Screens	827	175	2	21.2	0.2
Mouth of Fyke Net	50 50	46 45	0 0	92.0 90.0	

Table 4. Entrainment Estimates of Rainbow Trout (***Oncorhynchus mykiss***) Fry Released in Front of Screens During Integrity Test at the **Dryden** Fish Screening Facility, May 1994

	Number of fish Captured			
Time Interval	on Plane	in Net	Estimated Number Entrained in Canal	Estimated Percent Entrained
1200 - 1500	239	21	109	31.3
1500 - 1900	144	6	31	17.7
1900 - 2400	114	28	145	55.9
2400 - 0600	13	6	31	70.4
0600 - 1200	3	1	5	62.5
1200 - 1730	1	1	5	83.3
1730 - 2400	2	0	0	0.0
Total	516	63	326	38.7

Table 5. Length and Width Data on Fish Species Captured in Fyke Net During Integrity Test at the **Dryden** Fish Screening Facility, May 1994

Fish Species	Number	Fish **Length**[(a)] **Range (mm)**	Head Width **Range (mm)**
Rainbow **Trout** Fry	63	23 - 27	3.11 - 3.58
Wild Chinook Fry	10	36 - 42	4.26 - 4.34
Dace (*Rhinichthys*)	5	**21** - 31	not measured
Whitefish **(*Prosopium*)**	2	26 - 28	not measured

a) Many fish recovered from the net were crushed and mutilated by debris accumulation. Measurements were taken from representative fish in good condition.

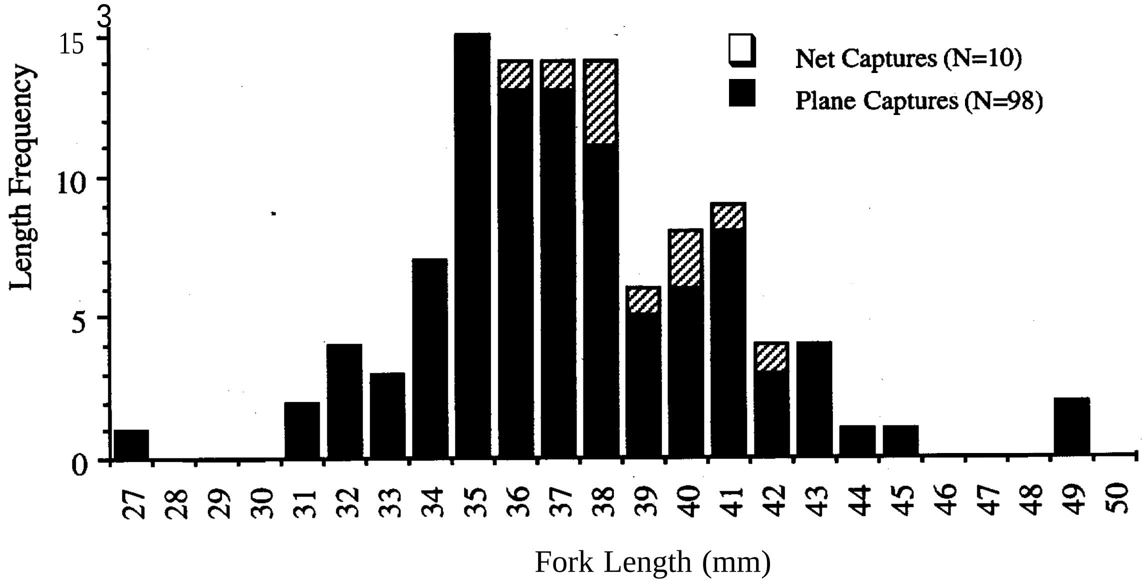

Figure 14. Fork Lengths of Wild Chinook Salmon ***(Oncorhynchus tshawytscha)*** Fry Caught During Integrity **Test** at the **Dryden** Fish Screening Facility, May 1994

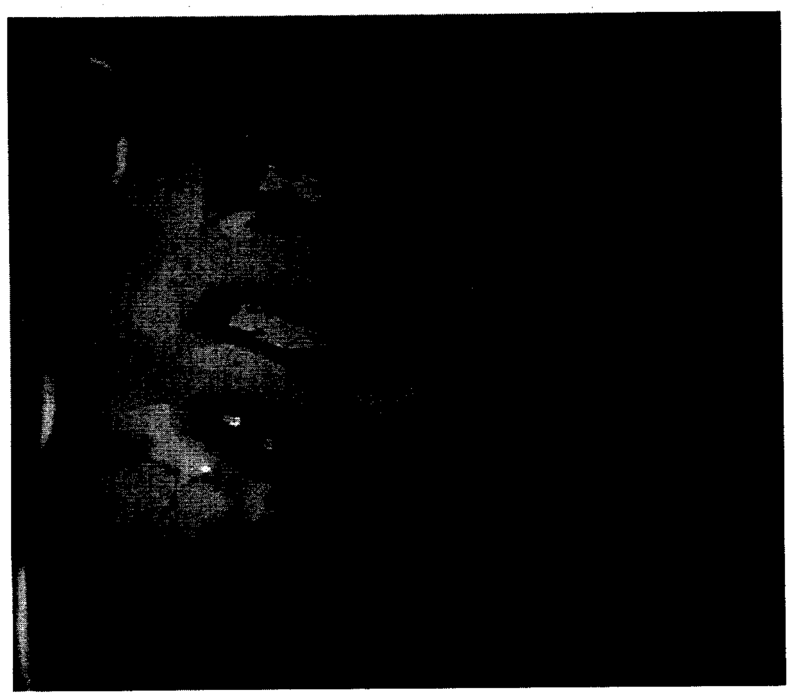

Figure 15. Picture of Wild Chinook Salmon ***(Oncorhynchus tshawytscha)*** Fry **Caught** on the Inclined Plane During Integrity Test at the **Dryden** Fish Screening **Facility,** May 1994

Velocity measurements through the screen panels is summarized in Table 6. **Very** little water passed through screen panel 1, and velocity through screen panel 2 was less than velocity through screen panels 3-7. Adjustable vertical louvers (13 behind each screen panel) were in the full "open" position behind screen panels 1, 2, and the upstream half of screen panel 3. The louvers were completely closed on the downstream half of screen panel 3 and on screen panels 4-7 (Figure 16).

The approach velocity was usually higher at the upstream and downstream edges than in the middle of many screen panels. The I-beams to which the screen panels were **fastened** may have **affected** flow through the screens. However, since the measurements were taken behind the screens, this aberration in approach velocity may not exist in front of the screens. Approach velocity was also slightly higher at 0.8 of the depth and lower at 0.2 of the depth.

Surface sweep velocity based on drift rates of an orange were estimated at 2.1 **ft/sec.** The orange traveled 91 **ft** (length of 7 screen panels) in 43 seconds. In some drifts, the orange contacted the screens and slowed down **as** it rolled along the screen facetowards the fish bypass. Drift rates were measured only during those periods when the orange was not in contact with the screens. There was very little variation in drift rates in relation to the point of release or the drift path in the **forebay.**

Table 6. Approach Water Velocity Measurements **(ft/sec)** Behind Profile Bar Screen Panels at the **Dryden** Fish Screening Facility, April 12, 1994

Screen Panel Number	Transect Number	0.2 Depth	0.5 Depth	0.8 Depth
1	1	0.2	0.2	0.2
1	2	0.0	0.1	0.0
1	3	0.1	0.2	0.2
1	4	0.2	0.3	0.4
2	1	0.3	0.3	0.5
2	2	0.3	0.3	0.5
2	3	0.3	0.3	0.3
2	4	0.4	0.4	0.4
3	1	0.5	0.5	0.5
3	2	0.7	0.6	0.6
3	3	0.4	0.5	0.4
3	4	0.4	0.5	0.4
4	1	0.4	0.7	0.6
4	2	0.4	0.4	0.5
4	3	0.4	0.5	0.4
4	4	0.4	0.3	0.6
5	1	0.4	0.6	0.6
5	2	0.2	0.4	0.4
5	3	0.4	0.5	0.7
5	4	0.4	0.4	0.6
6	1	0.5	0.7	0.7
6	2	0.4	0.5	0.4
6	3	0.4	0.6	0.5
6	4	**0.5**	0.4	0.6
7.	1	0.5	0.8	0.6
7	2	0.3	0.5	0.6
7	3	0.3	0.5	0.7
7	4	0.6	0.4	0.8
	Average	0.37	0.44	0.49

Overal Average Approach Velocity: 0.43 **ft/sec**

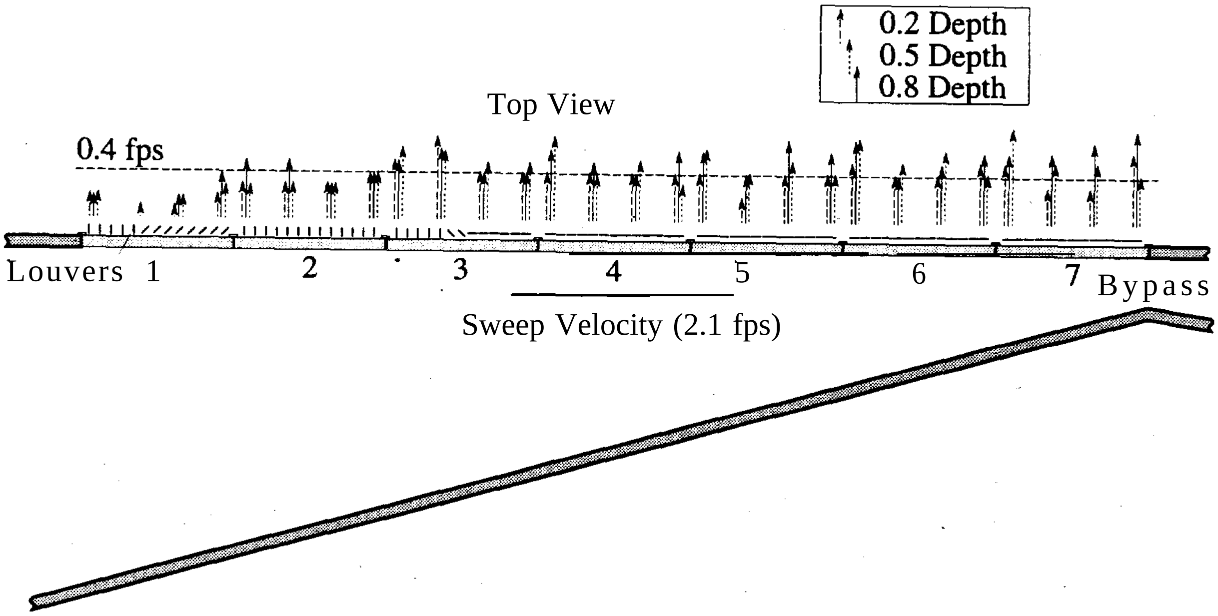

Figure 16. Water Velocity Profiles Through and Across the Screen Face of the Profile Screen Panels at the **Dryden** Fish Screening Facility, Measured on April 12, 1994

Discussion

The use of capture-and-release tests with fish as a tool for conducting fish screen evaluations is becoming increasingly difficult due to changes in fish management decisions regarding planting/release strategies, impacts to native stocks, genetic concerns, and other legislated restrictions such as protective measures mandated by the Endangered Species Act. These decisions **affect** how and when research with fish is conducted as well as what stocks will be used. Often, the stocks needed to address **site-**specific issues are not approved for use or are not available.

Also in past fisheries evaluations at rotary drum fish screening facilities **(Neitzel** 1986, 1988, **1990.),** fish are not descaled or injured as they move through the screen **forebay** at the **Dryden** Screens. Underwater video recordings provide further evidence that fish are not descaled or injured **as** they move through the screens **forebay.**

Wild sockeye salmon smolts captured during the evaluation at the **Dryden** Screens were probably the best indicator species for monitoring descaling and/or injury. The condition of sockeye salmon smolts **before** they entered the canal system was unknown, but a high percentage of these fish were not descaled to any degree as they migrated in front of the screen and into the fish bypass, despite the fact that their scales were very deciduous. Occasionally loose scales in the live box, on the dip nets, and in holding buckets were observed during the evaluation, indicating that some of the descaling and partial descaling observed was attributable to the sampling equipment. The inclined plane was continuously monitored and fish were removed and evaluated as quickly as practical in order to minimize potential gear effects.

Released spring chinook salmon smolts moved downstream rapidly. The first test fish appeared in the live box of the inclined plane trap only 20 minutes after their release below the canal headgate. Most fish released in the morning exited the bypass by mid-afternoon on a bright, sunny day. Although vegetation along the canal bank provided good cover that was used by wild chinook salmon fry, smolt teat fish showed no inclination to remain in the canal. The simplistic design and structure of the vertical fixed plate screen (vertical walls within the **forebay** with no structures to provide shade or protection from above) does not promote holding by either smolts or predator fish species, but leads to rapid passage. However, subsequent screen integrity teats with rainbow trout fry showed that small fish could maintain their position in the **forebay** for several days.

Screen integrity, or the ability of the screening facility to prevent fish from getting through, over, or around the barrier screens, is a major concern at the **Dryden** Screens. Mesh size requirements have been altered several times in the last decade to improve the effectiveness of fish **screens** in preventing entrainment of **salmonid** fry. Rotary drum fish screens built in the Yakima Basin from 1985 through 1990 were constructed of stainless steel woven wire mesh screens with a 3.175 mm (0.125 in.) opening (12 gage wire, 4 meshes per in.). Head measurements of chinook salmon fry caught behind the screens confirmed that it was possible **for** small chinook salmon fry to pass through the mesh openings **(Neitzel** et al. 1990).

Laboratory testing by Bates and Fuller (1992) with different screening materials (woven wire mesh, perforated plate, and profile bar) **confirmed** that 3.175 mm (0.125 in.) opening were too large to provide complete protection against entrainment for chinook salmon fry, the largest of **salmonid** fry. Tests showed that 3.1% (n= 114) of 34 mm chinook salmon fry were able to pass through bar screen when the approach velocity was 0.4 **ft/sec.** Bates (1988) reported that 30 of 100 rainbow trout fry (23 mm FL) passed through a 3.175 mm (0.125 in.) profile bar. Other studies have shown that 2.38 mm (0.094 in.) profile bar would exclude chinook salmon fry greater than 30 mm in length **(Kano** 1982).

The head widths of chinook salmon fry that were recovered behind the screens were greater than the bar spacing on the profile bar at the **Dryden** Screens. By anesthetizing the fish and attempting to force them through a caliper set at 0.125 in. chinook salmon fry could not pass through the opening head-first. However, by turning the fry around and simulating a tail-first approach to the screens, the fry could pass through a 3.175 mm (0.125 in.) gap. The soft tissues of the body easily fit through the gap until the fry's operculas came in contact with the caliper blades. At this point, the fish could pass through the screen if it rotated slightly to allow the operculas to pass through the long dimension of the slots. Since salmonids frequently migrate facing upstream while passively drifting downstream (as noted with **smolts** with underwater video), it is possible that many fry approach the screen tail-first. Bates and Fuller (1992) found chinook salmon fry blocked by their head and opercles in their studies with a 3.175 mm (0.125 in.) profile bar.

Most of the fry recovered in the **fyke** net were dead from high impingement velocities and debris in the net. Therefore, it was not possible to detect an injury caused by a fry becoming "gilled" in the profile bar. Impinged fry may be forced through as the screen as the cleaning brush passes, and fry may be more vulnerable to entrainment through profile bar if approach velocities exceed criteria or if sweep velocities are low. If smaller spacing profile bar screen was installed at the site, additional modifications would probably be necessary such as a more effective cleaning brush, more frequent cleaning, and increased maintenance.

When the **Dryden** Screens were constructed in 1993, the profile bar screen installed met existing criteria required by the WDFW (Appendix A). The criteria was developed to create optimal conditions for passage from the screen diversion back to the river. Based on recent studies, a new screening criteria was adopted by the WDFW in January of 1995 that required a maximum opening of 1.75 mm (0.069 in.) **for** the profile bar to protect emergent **salmonid** fry (Appendix A).

Although summer chinook salmon fry may be the primary species of concern in the Wenatchee River, consideration must also be given to other **salmonid** fry such as steelhead, resident rainbow trout, and bull trout that would benefit from new screening criteria. The question of whether or not to attempt to provide 100% protection for these species needs to be addressed by the various fisheries agencies.

The bypass weir gate was found out of adjustment several times during visits to the site. Low bypass flows can contribute to migration delays. High bypass flows can cause excessive turbulence in the bypass flume. Fish may also get washed into and trapped inside the flume **baffles.** The bypass weir crest gate is supposed to be maintained at a level 20 in. below the **forebay** elevation. Although there is a **staff** gage to measure the canal surface elevation in the **forebay,** there is no staff gage or operator aid with which to set the adjustable weir. A simple way to accurately set the weir crest would be **to** construct a "paper" table correlating the height of the weir gate (as measured by the length of weir gate shaft exposed above the collar) to canal surface elevation.

The screen-cleaning brush appeared effective in keeping the screens clean during the descaling evaluation in mid-April. However, the Wenatchee River was very clear during the week of the tests. The cleaning brush was being operated with a 15-minute time delay between cleaning cycles. In the week following the evaluation, an attempt was made to monitor the movement of spring chinook salmon released from the Leavenworth Fish Hatchery by means of underwater video. The river was very muddy (≤ 1 foot visibility), and efforts to monitor fish movement were unsuccessful. However, with the aid of artificial lighting, we were able to monitor the effectiveness of the cleaning brush with a high debris load in the water. Large sections of some screen panels were totally plugged with pine needles and leaves. The brush was ineffective at removing the debris even though it was in continuous operation. From the surface, the brush appeared to be performing relatively well, although a head loss across the screens (several inches) indicated otherwise.

Results of the bypass pipe test indicated that the bypass/flume structure provided safe passage to steelhead subyearlings as none of the fish captured were descaled. As mentioned earlier, it would have been preferable to conduct the bypass descaling test in March or April, but recovery of fish at the bypass pipe terminus. was not possible at high river flows. Descaling from sampling nets has been observed in high flow conditions (Neitzel et al. 1986, 1988, 1990). It may have been possible to fish a true inclined plane trap or a screw trap just downstream of the terminus of the fish return pipe. However, the purchase of this equipment for one test could not be justified. A water diffusing trap (similar to the inclined plane used at the entrance to the bypass) could possibly be fished at the lower end of the open flume, but fish collection at this point would only evaluate 2/3 of the fish bypass. Therefore, evaluation of the bypass descaling on subyearling steelhead was postponed until river flows decreased in August.

Entrainment of air in the lower section of the fish return pipe occurred during low river stages. The anti-surging vent seemed to be effective at eliminating most of the air trapped in the pipe during high river flows, as little boiling near the pipe terminus was observed. However, at lower flows that occurred when conducting the bypass descaling test, trapped air forced water to splash about five ft upwards from the top of the bypass pipe. This event occurred at regular intervals every few minutes.

A large log wedged in the entrance to the fish bypass almost prevented the bypass descaling test. The log was subsequently removed by reducing the bypass flow. Similar problems were experienced with large woody debris during previous tests in April and May. Floating objects that are thrown or drift into the canal could damage the cleaning brush mechanism or cause injury to fish if the objects become lodged in the fish bypass.

In general river conditions did not impact the ability to conduct the tests except that high flows in the spring eliminated the possibility of recovery sampling at the fish return pipe terminus. Spring rainfall increased the debris loading in the river, and debris buildup on the plane was extensive as the brush mechanism reached the downstream end of the screen panel. However, the screen prevented most debris from entering the canal, which allowed fishing the fyke net for a longer periods between retrievals during the screen integrity tests.

Approach velocity measurements showed velocities exceeding the 0.4 ft/sec recommended screening criteria at the downstream screen sections, despite the louvers being in the fully closed position. The lowest approach velocities occurred at the two upstream panels. The installation of wider louvers behind the downstream screens (panels 4-7) may be needed to produce uniform flow through all screen sections and prevent velocities from exceeding approach velocity criteria when the canal is full.

Many predacious birds (herons, kingfishers, and mergansers) were observed in and along the Wenatchee River and also in the canal. Bird bites on young fish are distinctive, but none'were observed on smolt-sized salmonids examined during the evaluations. The birds did not seem to prefer the canal over the adjacent section of the river for feeding. The rapid movement of chinook salmon smolts during our descaling evaluation showed that fish were not delayed by the screening facility, therefore, there was no increased exposure to predation at the facility. Salmonid fry are vulnerable to predation by both predatory birds and fish. No predatory fish were captured on the inclined plane during the evaluations. Furthermore, no large fish were observed in the screen forebay during descaling evaluation, despite having extremely-good visibility ($\geq$ 6 ft). In addition, the vertical fixed plate screen design does not create structures or hydraulic conditions (overhanging structures, structures that create dead spots, or eddies) that predators prefer.

Recommendations

Bypass Flow

Efforts should be made to ensure that bypass flow is always set at 20 cfs at the Dryden Screens. Flow regulation could be achieved by using automated headgate valves. It may be necessary to add a check structure to ensure proper forebay elevation. Automated head gates would also prevent overtopping of screen panels if the cleaning brush system failed. If manual headgates valves are used, bypass flow regulation could be improved if a staff gage was added to the bypass weir gate and a table was added to the operating criteria showing the correct valve setting baaed on canal forebay surface elevation. Regardless of how flow regulation is achieved, it is important to stress the need for maintaining a 20 cfs flow through the fish bypass. A surface water elevation gage should also be added behind the screens so that head differential can be monitored easily.

Profile Bar Opening

Based on the screen integrity tests and previous laboratory studies by other researchers, a 3.175 mm (0.125 in.) profile bar screen is too coarse to protect chinook salmon fry or early life stages of other smaller salmonid and resident fish species. The newest screening criteria adopted by the WDFW calls for 1.75 mm (0.069 in.) profile bar for protecting salmon and steelhead fry (Appendix A). Therefore, the replacement the existing 3.175 mm (0.125 in.) profile bar at Dryden Screens with profile bar with 1.75 mm or smaller openings is recommended

Inspection and Cleaning

Annual inspection of the headgate structure, screen surface, seals, cleaning bush, and bypass pipe/flume is highly recommended. The bypass system, including primary pipe, open baffle flume, and secondary pipe should be inspected before the canal is filled with water. Partial blockages from sticks or other debris in the bypass pipe could occur without causing descaling or injuries to fish. However, over time small blockages could grow and cause injury or migration delays. Screen operators should be trained to look for signs of blockage and check for “normal” flow in the bypass as part of their daily screen inspection. It is also advisable to periodically clean the bypass pipe by passing a device (slightly smaller than the diameter of the pipe) through the pipe to detect and dislodge debris in the pipe. The success of fish enhancement and restoration programs within the Columbia Basin will depend on screening facilities that do not delay, injure, or entrain salmonid fry or smolts during rearing or migration.

Operating Criteria

The electric brush mechanism could operate at 15-minute intervals when water is clear, but should operate continuously when debris is in the water. Regular inspection (daily) after storm events and manual removal of debris when there is a buildup is recommended.

The headgates and bypass trash rack should be inspected at regular intervals to minimize flow constraints by debris, especially when there is a lot of floating debris in the river. Large debris must be removed and not allowed to enter the canal, where it could potentially damage the profile bar panels or brush assembly, or become lodged in the fish bypass. In addition, large debris should be removed from along the canal upstream of the screening facility to prevent it from being thrown into the canal.

To be completely effective the Dryden Screens operating criteria should be updated to cover all possible flow scenarios, and the screens should be operated according to those criteria (Appendix B).

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Appendix A

Washington State Screening Criteria for Water Diversions

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STATE OP WASHINGTON
DEPARTMENTS OF FISHERIES AND WILDLIFE.

SCREENING REQUIREMENTS FOR WATER DIVERSIONS

Washington State Laws (RCW 77.16.220; RCW 75.20.040, RCW 75.20.061) require all diversions from waters of the state to be screened to protect fish.

These laws and the following design criteria-are essential for the protection of fish at surface water diversions. Fish drawn into hydropower, irrigation, water supply, and other diversions are usually lost from the fish resources of the state of Washington.

The following criteria are based on the philosophy of physically excluding fish from being entrained in water diverted without becoming impinged on the diversion screen.

Additional criteria may be required for unique situations, large facilities or intakes within marine waters.

I. Screen Location and Orientation

a. Fish screens in rivers and streams shall be constructed within the flowing stream at the point of diversion and parallei to the stream flow. The screen face shall be continuous with the adjacent bankline. A smooth transition between the screen and bankline shall be provided to prevent eddies in front, upstream and downstream of the screen.

Where it can be thoroughly demonstrated that flow characteristics'or site conditions make construction or operation of fish screens at the diversion entrance impractical, the screens may be installed in the canal downstream of the 'diversion.

b. Diversion intakes in lakes and reservoirs shall be located offshore in deep water to minimize the exposure of juvenile fish to the screen. Salmon and trout fry generally inhabit shallow water areas near shore.

Revised 3/15/93

c. <u>Screens constructed in canals and ditches</u> shall be located as close as practical to the diversion. They shall be oriented so the angle between the face of the screen and the approaching flow is no more than 45°. All screens constructed downstream of the diversion shall be provided with an efficient bypass system.

II. Approach Velocity

The approach velocity is defined as the component of the local water velocity vector <u>perpendicular</u> to the face of the screen. Juvenile fish must be able to swim at a speed equal or greater than the approach velocity for an extended length of time-to avoid impingement on the screen. The following approach velocity criteria are <u>maximum</u> velocities that shall not be exceeded anywhere on the face of the screen.

A maximum approach velocity of 0.4 feet per second is allowed. This approach velocity criterion is based upon the swimming stamina of small fish under low temperature conditions. It is recognized that there may locations at which design for these conditions may not be warranted. Unless conclusive data from studies acceptable to Washington Departments of Fisheries and Wildlife indicate otherwise, it is assumed that these extreme conditions exist at some time of the year at all screen sites.

The approach velocity is calculated based on the-gross screen area not the net open area of the screen mesh.

The intake structure and/or fish screen shall be designed to assure that the diverted flow is uniformly distributed through the screen so the maximum approach velocity is not exceeded.'

III. Minimum Screen Area

The minimum required screen area is determined by dividing the maximum diverted flow by the maximum allowable approach velocity. To find the screen area in square feet, divide the diverted flow in cubic feet per second (450 gpm = 1.0 cubic foot per second) by the.approach velocity 0.4 feet per second):

$$\text{Minimum Screen Area} = \frac{\text{Diverted Flow (cubic feet/second)}}{\text{Approach Velocity (feet per second)}}$$

The minimum required screen area must be submerged during lowest stream flows and may not include any area that is blocked by screen guides or structural members.

Revised 3/15/93

Diversions less than or equal to 180 gallons/minute (0.4 cfs) require a minimum submerged screen area of 1.0 square foot, which is the smallest practical screening device.

IV. Sweeping Velocity

The sweeping velocity is defined as the component of the water velocity vector <u>parallel</u> to and **immediately** upstream of the screen surface. The sweeping velocity shall **equal** or exceed the maximum allowable approach velocity. The sweeping velocity requirement is satisfied by a combination of proper orientation of the screen relative to the approaching flow and adequate bypass flow.

Adjacent screen bay piers or walls shall be flush with screen surfaces so the sweeping velocity is not impeded.

V. Screen Mesh Size, Shape, and Type of Material

Screen openings may be round, square, rectangular, or any combination thereof, provided structural integrity and cleaning operations are not impaired.

The following table shows the maximum screen openings allowable (in the narrow dimension for rectangular slots or mesh) within the screen structure, **including** the screen mesh, guides, and seals;

[illegible]	Woven Wire Mesh	Profile Bar	Perforated Plate
Chinook Salmon Steelhead Trout	0.125 inch (5-14 or 4½-12 mesh	0.125 inch	0.125 inch
Coho and chum Salmon	0.125 inch (5-14 or-4½-12 mesh	0.080 inch (2.0 mm)	
Pink and Sockeye Salmon	0.087 inch (6-14 mesh)		

The allowable woven wire mesh openings is the greatest open space distance between mesh wires. Example allowable mesh specifications are provided above for each mesh opening; there are other standard allowable openings available. The mesh specification gives the number of mesh openings per lineal inch followed by the gauge of the wires. For example, 5-14 mesh has five mesh openings per inch of screen. It is constructed with 6, 14-gauge (0.080 inch diameter) wires per inch.

The profile bar openings are the maximum allowable space between bars. The allowable perforated plate'openings are the diameter of circular perforations. Perforated slots **are** treated as profile bars.

Screens may be constructed of any durable material; woven, welded, or perforated. The screen material must be resistant to corrosion and ultraviolet damage.

For longevity and durability, minimum wire diameter for woven mesh shall be 0.060 inch (18 gauge) on fixed panel screens, where they are not subjected to impact of debris. Minimum wire diameter for woven mesh shall be 0.080 inch (14 gauge) for rotary drum screens, traveling belt screens, and in areas where there **is** a potential for damage from floating debris or cleaning operations.

VI. Bypass

All screens constructed downstream of the diversion shall be provided with an efficient bypass system to rapidly collect,. juvenile fish and safely transport them back to the river. The downstream end of the screen shall terminate at the entrance to the **bypass** system.

It is the water diversion **owner's** responsibility to obtain necessary water rights to operate the fish bypass; failure to do so may be considered failure to meet **state** screening law requirements.

VII. Cleaning

Fish screens shall be cleaned **as** frequently as necessary to prevent obstruction of flow and violation of the approach velocity criterion. Automatic cleaning devices will be required on large screen facilities.

Additional detailed information is available explaining the background and justification of these criteria **and showing** standard details of flow distributors, **acceptable** bypass designs and screen areas required **for various** flows.

For further information, **contact** the Washington Department of Fisheries or Washington Department of Wildlife.

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Revised 3/15/93

New Screening Reauirements For Water Diversions Adopted bv the Washington Department of Fish and Wildlife 1/23/95.

The screen mesh criteria listed below is based on the assumption that steelhead and/or resident trout fry are ubiquitous in the state of Washington and will be present at all diversion sites.

Current criteria for screen opening at water diversions (revised 1/23/95)

Woven Wire Mesh	Profile Bar	Perforated Plate
0.087 inch (6- 14 mesh)	1.75 mm (0.069 inch)	0.094 inch (3132 inch)

Appendix B

Operating Criteria for the Dryden Fish Screening Facility

OPERATING CRITERIA FOR THE DRYDEN FISH SCREENING FACILITY

This appendix contains the operating criteria for the **Dryden** facility evaluated in -1994. The criteria was developed by hydrologists for the National Marine Fisheries Service. The intent of the criteria is to provide the information necessary so that maintenance personnel can set and adjust can and bypass flows to a achieve optimal fish passage conditions.

The operating criteria for the **Dryden** Fish Screening Facility is presented below and a drawing showing the components of the facility is on page B.3.

4/7/94
S. Rainey **-** NMFS

Dryden Screen **&** Bypass
Operating Criteria
May **13, 1993**

Routine Maintenance:

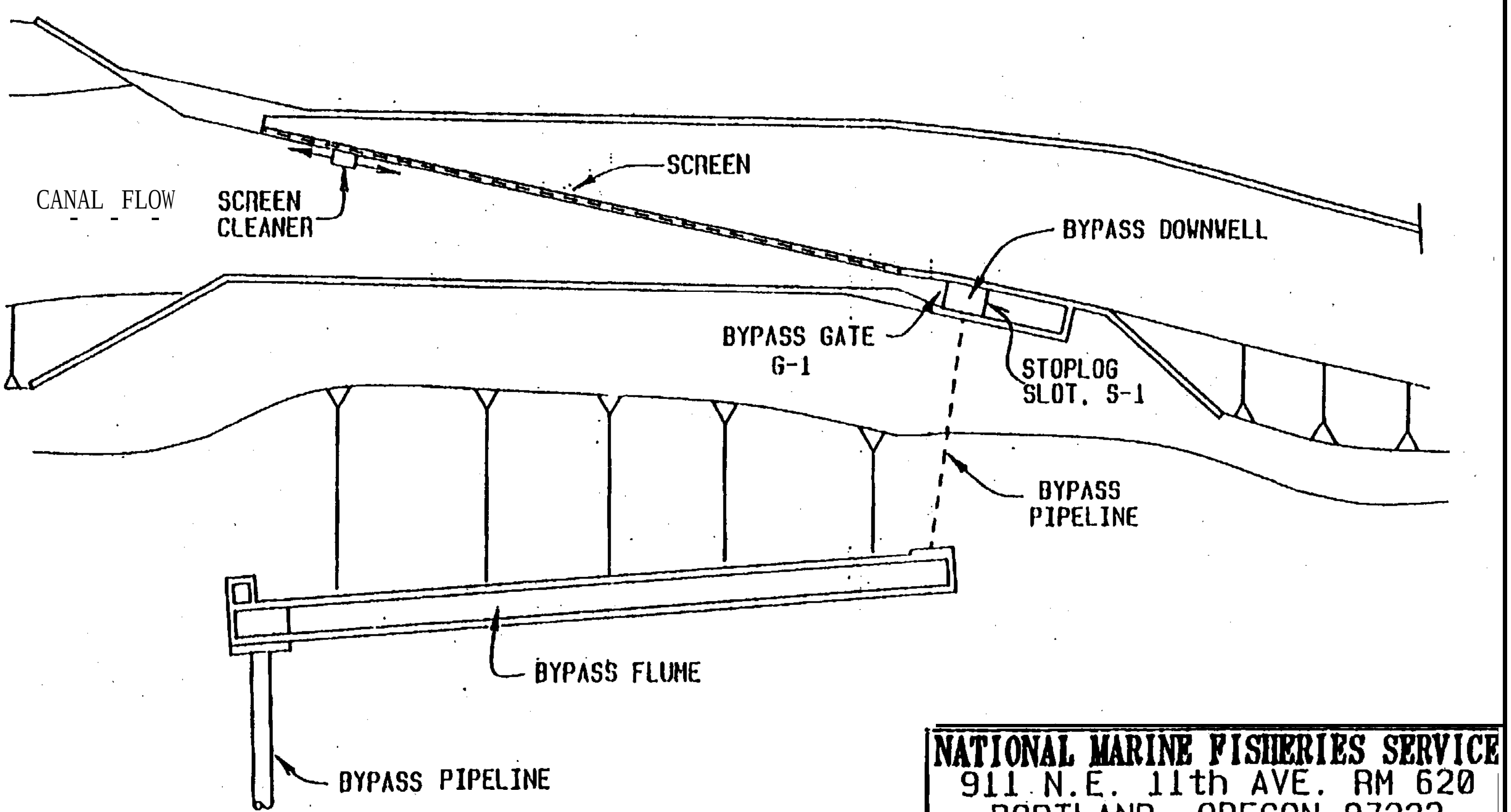
Check headworks trash rack (not shown). Remove debris when observed, or when head differential across trash rack exceeds 0.3 ft.

Check to ensure screen cleaner is functioning and debris accumulations on the screen face are not evident. Cleaner bristles should be in contact with the screen along the entire brush length. The screen cleaner should be operating continuously during most periods of the irrigation season, in order to effectively minimize debris build-up. Screen head differential should not exceed 0.1 **ft** (Otherwise, screen velocities are excessive for **fish** protection).

Check the bypass **downwell** for signs of debris at the bypass pipe entrance. Check bypass flume for course debris (i.e., long sticks) which may be detained by flume baffles. Check bypass pipeline entrance at downstream end of flume for signs of course debris.

Bypass Operation:

Bypass gate G-l is to be operated with a 20" weir crest submergence (relative to the canal water surface) during all diversion periods.



NATIONAL MARINE FISHERIES SERVICE
911 N.E. 11th AVE. RM 620
PORTLAND, OREGON 97232

DRYDEN SCREENS
AND BYPASS

DRN BY: G.A.H.	DATE: 04/27/93	FILE NO. CANSP	RE
APP. BY:	SCALE: 1" = 1"		