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A FISHERIES EVALUATION OF THE WESTSIDE DITCH AND TOWN CANAL FISH SCREENING FACILITIES SPRING 1990

Annual Report 1990

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A FISHERIES EVALUATION OF THE WESTSIDE DITCH AND TOWN CANAL FISH SCREENING FACILITIES SPRING 1990

Annual Report

BY

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U.S. Department of Energy
Bonneville Power Administration

Project No. 85-62
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November 1990

PREFACE

The Bonneville Power Administration, the United States Bureau of Reclamation. and the Washington State Department of Ecology are funding the construction of fish passage and protection facilities at irrigation and hydroelectric diversions in the Yakima River Basin, Washington State. This construction implements Sections 904(d) and 803(b) of the Northwest Power Planning Council's 1984 and 1987 Columbia River Basin Fish and Wildlife Programs.(a) The programs provide offsite enhancement to compensate for fish and wildlife losses caused by hydroelectric development throughout the Columbia River Basin. and they address natural propagation of salmon to help mitigate the impact of irrigation withdrawals in the Yakima River Basin.

The Westside Ditch and Town Canal fish screening facilities are two juvenile screening facilities in the Yakima River Basin. This report evaluates the effectiveness of these screens in intercepting and returning juvenile salmonids unharmed to the Yakima River, from which the water was diverted. We conducted studies in which representative fish were released upstream of or within the screening facilities and captured in the bypass that returns them to the river. Results indicated that the screens safely diverted fish from the canals and returned them to the river.

Our study emphasized the collection and evaluation of salmonids. Test fish were steelhead *Oncorhynchus mykiss* smolts and rainbow trout 0. *mykiss* fry. Evaluations were conducted during typical spring flows at each facility.

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ta) Northwest Power Planning Couoncil (NPPC). **1984.** Columbia River Basin Fish and Wildlife Proaram. Northwest Power Planning Council, Portland, Oregon.

Northwest Power Planning Council (NPPC). **1987.** Columbia River Basin Fish and Wildlife Program . Northwest Power Planning Council. Portland. Oregon.

ACKNOWLEDGMENTS

The involvement and cooperation of many people during these studies were greatly appreciated. Thomas J. Clune. Bonneville Power Administration. was the Project Manager. Charles R. Keller and Edward J. Spigler. Bureau of Reclamation. and their operations and maintenance staffs provided critical support and assistance during site preparation. James L. Cumins and James E. Lee, Washington Department of Wildlife. helped us procure test fish. Jeanne C. Simpson helped with the statistical analysis. Robert W. Hanf and Dennis D. Dauble helped conduct the field tests. The manuscript was reviewed by Regina E. Lundgren and C. Dale Becker.

ABSTRACT

The Pacific Northwest Laboratory (PNL)[a] evaluated the effectiveness of new fish screening facilities in the Yestside Ditch and Town Canal, near Ellensburg, in south-central Washington State. At the Town Canal, we estimated that 0.3% of steelhead *Oncorhynchus mykiss* smolts released during tests were significantly descaled. The time required for 50% of the fish in the two steelhead test groups to exit from the Town Screens forebay ranged from 12 h to >85 h.

Integrity tests at the Town Screens indicated that none of the rainbow trout fry released in front of the rotary drum screens passed through the screens. although 8.5% of the native zero-age chinook salmon fry diverted from the river into the screening facility were lost through the screens. At the Uestside Screens. 16.8% of native zero-age chinook salmon fry passed through the screens. Most of the chinook salmon lost through the screens were small, <36 mm long.

The methods used in 1990 were first used at the Sunnyside Screens in 1985. These methods were used again in subsequent years in tests at the Richland. Toppenish/Satus, Wapato. and Toppenish Creek screens. The methods used from 1985 through 1989 have been reviewed by the Uashington State Department of Fisheries, U.S. Fish and Wildlife Service. National Marine Fisheries Service. Northwest Power Planning Council, and Yakima Indian Nation.

(a) The Pacific Northwest Laboratory is operated by the Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RL0 1830.

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INTRODUCTION

The Yakima River Basin has supported significant runs of anadromous salmonids over recorded history. During the late 1800s. 500.000 to 600.000 adult salmon and steelhead *Oncorhynchus* spp. returned to the Yakima River and its tributaries (Bureau of Reclamation 1984). Runs of salmon included chinook salmon *0. tshawytscha* (spring. summer. and fall races). coho salmon *0. kisutch.* sockeye salmon *0. nerka* and steelhead *0. mykiss.*

Some runs (races) are now extinct. and those remaining are severely depleted. Spawning escapement averaged about 2000 salmonids in the early 1980s (Bureau of Reclamation 1984). There is no sockeye run in the Yakima River Basin today, and only 37 coho salmon passed the Prosser Diversion Dam in 1983 (Hollowed 1984). Recent efforts to manage and enhance salmonid runs in the Yakima River have increased the total spawning escapement to between 5000 and 10.000 adults in the mid-1980s (Fast et al. 1986).

Smaller returns of adult salmonids to the Yakima River Basin result from a combination of many factors. Reduced in-stream flow downstream from irrigation diversion dams has limited spawning and rearing habitat. Ineffective fish passage facilities for adults and juveniles at diversion dams have caused high mortality during migration. Additionally, many Yakima River fish are killed while passing hydroelectric dams on the mainstem Columbia River.

The Pacific Northwest Electric Power Planning and Conservation Act was passed to enable preparation and implementation of a regional Conservation and Electric Power Plan. 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 hydroelectric facilities.

The Yakima River Basin was selected as one site to enhance salmon and steelhead runs in the middle Columbia River. Under the Plan. the Bonneville Power Administration (BPA) and the Bureau of Reclamation (BR) are funding the construction of fish passage and protection facilities at irrigation and hydroelectric diversions in the Yakima River Basin (Figure 1). BPA also provides funds to the Yakima Indian Nation (YIN) to enhance natural production of spring chinook salmon in the Yakima River Basin.

The Westside Ditch and Town Canal fish screening facilities (Westside Screens and Town Screens, respectively) are two of the passage and protection facilities in the Yakima River Basin that were recently upgraded by BPA and BR. Construction of these fish diversions was completed in **1989.** BPA asked the Pacific Northwest Laboratory (PNL) to evaluate the effectiveness of the screening facilities in returning fish that had entered the canals back to the river unharmed.

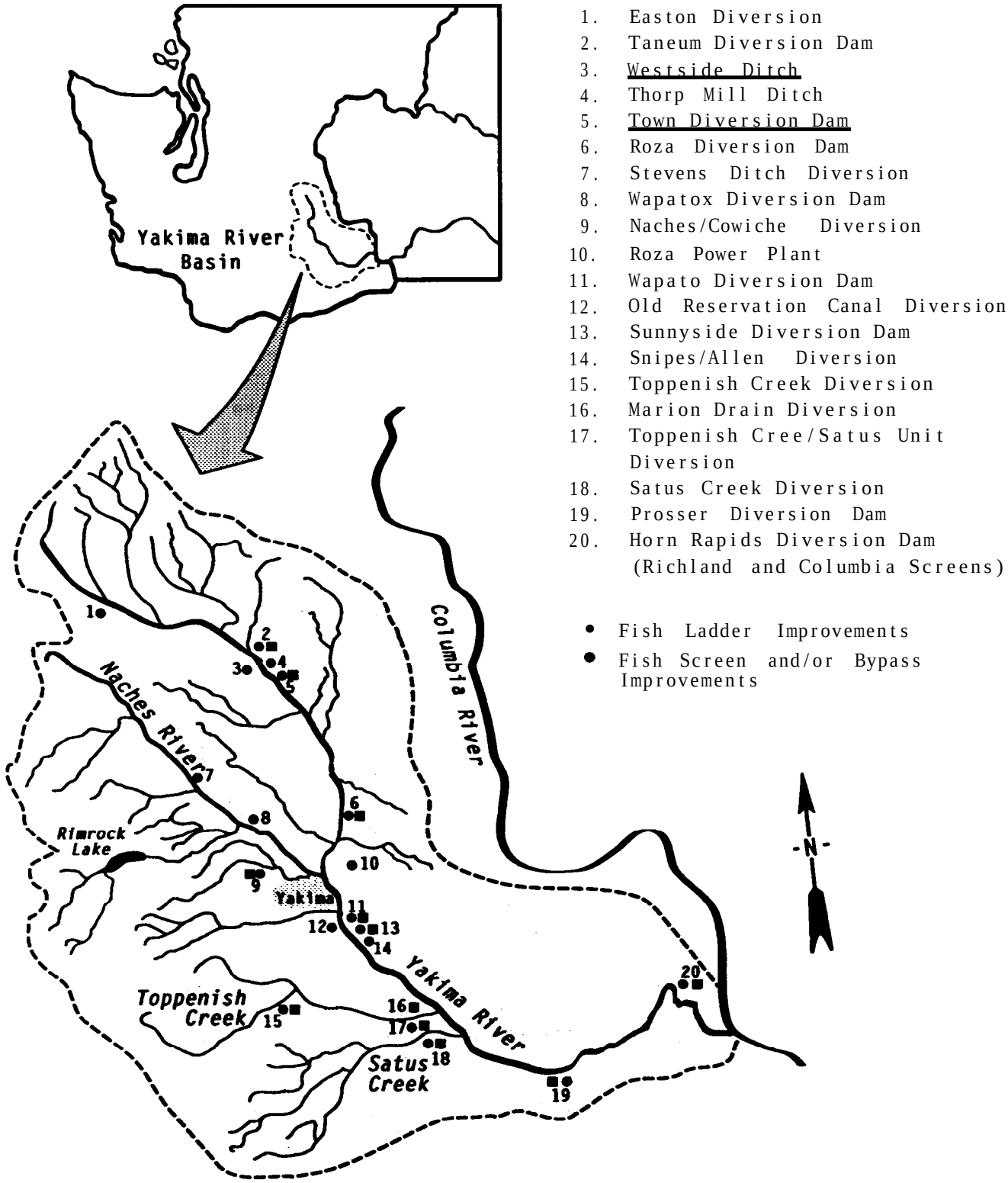

FIGURE 1. Overview of the Yakima River Basin, Including Locations of the Westside Ditch and Town Canal Fish Screening Facilities and Other Fish Protection and Passage Facilities

This report covers work performed by scientists from PNL at the Westside and Town screens in 1990. It describes each facility, methods used to evaluate the effectiveness of the screens, and test results. The findings are discussed and compared with results from previous tests at the Sunnyside Screens (Neitzel et al. 1985): the Richland and Toppenish/Satus screens (Neitzel et al. 1986): the Richland and Wapato screens (Neitzel et al. 1988): the Toppenish Creek. Wapato. and Sunnyside screens (Neitzel et al. 1990a): and the Wapato and Westside screens (Neitzel et al. 1990b).

The report also includes three appendixes. Appendix A is the work plan used to develop our evaluation and associate specific objectives with the methods used during our evaluations. Appendix B contains a collation of data from our studies at the Sunnyside Screens in 1985: the Richland and Toppenish/Satus screens in 1986; the Richland and Wapato screens in 1987: the Wapato. Sunnyside. and Toppenish Creek screens in 1988: the Westside and Wapato screens in 1989; and the Westside and Town screens in 1990. Appendix C contains the operating criteria for the Westside and Town screens.

DESCRIPTION OF THE STUDY AREAS

During 1990. studies were conducted at the Town and Westside screens. The study area for the Town Screens extended from the canal head gates to the area immediately downstream of the screens. The study area for the Westside Screens was limited to the forebay and the area behind the screens. Specific information on test conditions during the evaluations is in the Results and Discussion sections.

TOWN CANAL

The Town Diversion Dam and Canal are located on the left bank of the Yakima River at river km 259.5 [river mile (R) 161.31. about 11 km (7 mi) northwest of Ellensburg. Washington. Water is diverted from the Yakima River into the Town Canal. The carrying capacity of the canal is about 7 m^3/sec (250 cfs). Canal flow varies from 2.8 to 7.0 m^3/sec (100 to 250 cfs) and is regulated by four head gates about 75 m upstream of the Town Screens. The screening facility (Figures 2 and 3) diverts fish drawn into the canal and directs them back to the Yakima River. Trash racks, located between the head gates and screen array, "filter" out large debris that could damage the screens or interfere with flow control through the screening facility.

The screening facility (Figure 3) houses ten rotary drum screens with axes parallel to the length of the structure. Each screen is about 3.7 m (12 ft) long and 1.7 m (5.5 ft) in diameter. Screen mesh openings are 3.2 mm (l/8 in.). Water depth in the forebay is maintained at about 1.3 m (4.2 ft). The fish bypass is located in the flow control structure at the downstream end of the screening facility. Water and fish diverted past the front of the screens pass through the fish bypass and out the fish return pipe. Flow through the fish bypass is 0.6 m^3/sec (20 cfs).

The drum screens are installed at a 26^o angle to canal flow. This angle provides a sweeping-velocity-to-approach-velocity ratio equal to or exceeding 2:l (Easterbrooks 1984). The maximum allowable approach velocity is 0.15 m/set (0.5 fps). Screen orientation and flow velocity differential help direct fish to the fish return pipe and back to the river.

WESTSIDE DITCH

A detailed description of the Westside Screens is presented in Neitzel et al. (1990b). Briefly. the Westside Ditch is located on the right bank of the Yakima River at river km 267.4 (RM 166.2) near Thorpe, Washington. Water is diverted from the Yakima River into the Westside Ditch (Figure 4). The carrying capacity of the canal is about 2.8 m^3/sec (100 cfs). Canal flow varies from 0.6 to 2.8 m^3/sec (20 to 100 cfs) and is

regulated at head gates located about 0.5 km upstream of the Westside Screens. The screening facility houses four rotary drum screens with axes parallel to the length of the structure. Each screen is about 3.7 m (12 ft) long and 1.8 m (6 ft) in diameter. Water depth in the forebay is maintained at about 1.6 m (5 ft). Flow through the fish bypass is 0.6 m^3/sec (20 cfs). A waste water channel along the forebay's wall opposite the drum screens prevents flooding and canal bank erosion.

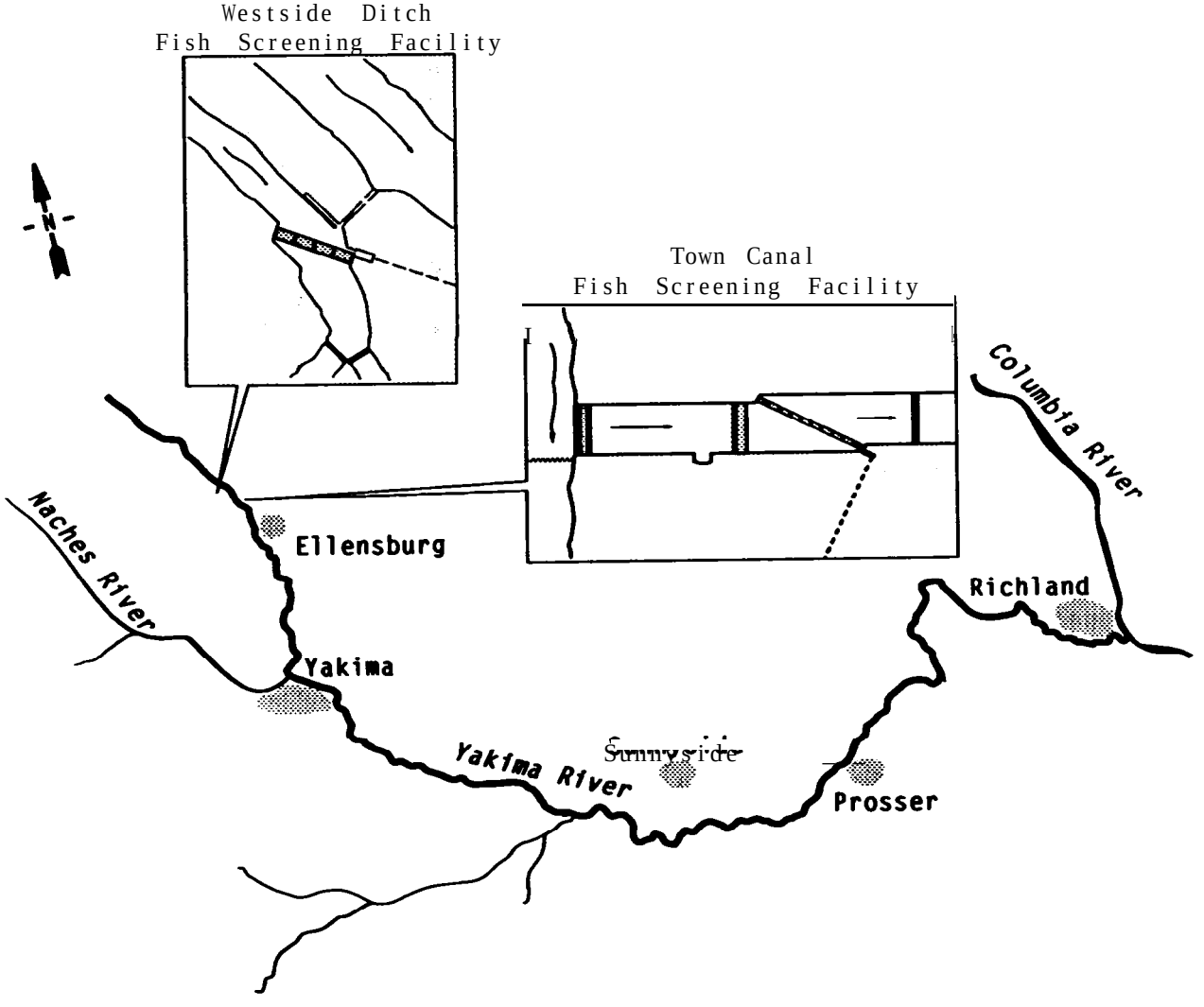

FIGURE 2. Specific Location of the Town Canal and the Westside Ditch Fish Screening Facilities

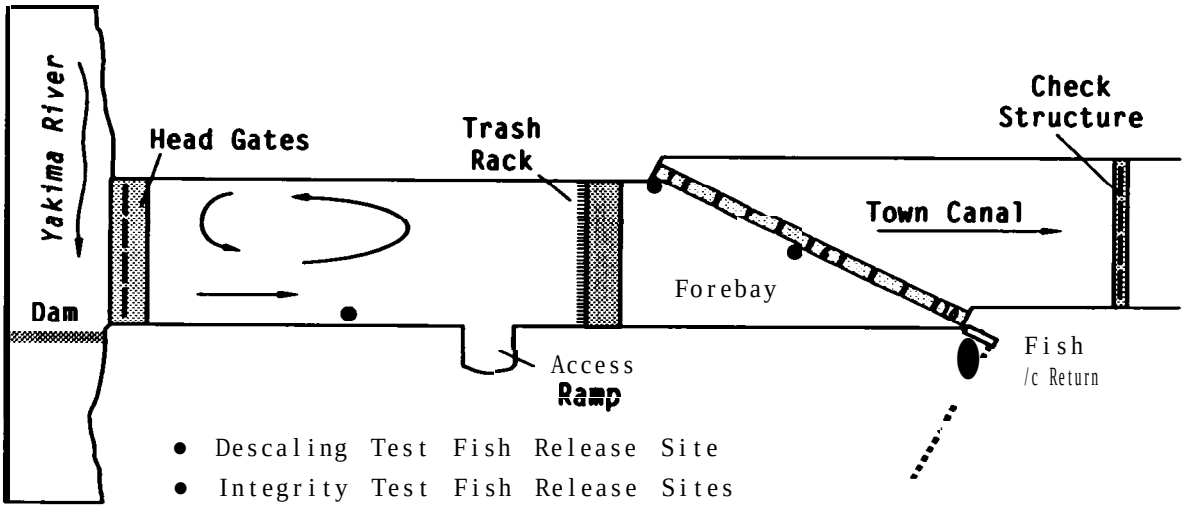

FIGURE 3. Flow Control Structure and Fish Bypass System in the Town Canal Fish Screening Facility

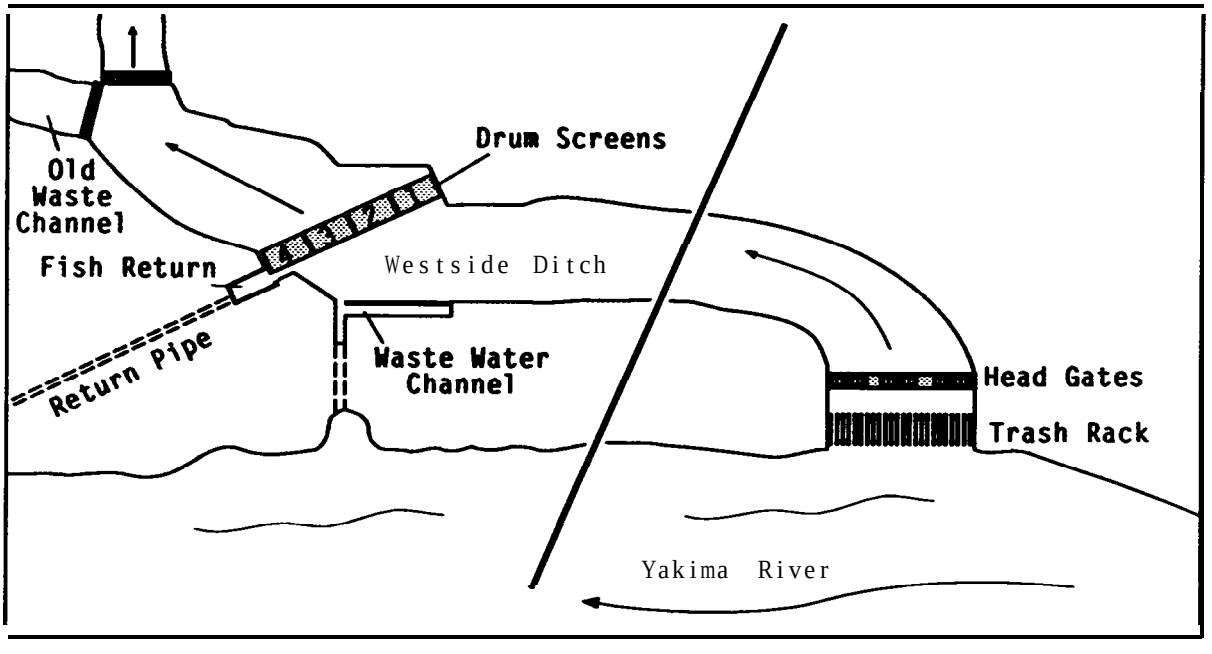

FIGURE 4. Flow Control Structure and Fish Bypass System in the Westside Ditch Fish Screening Facility

METHODS

Two types of tests were conducted at the Uestside and Town screens in 1990: descaling (Phase II) tests and screen integrity (Phase IV) tests. In descaling tests. fish were released in the canal upstream of the screening facility and captured as they entered the fish bypass. Some test fish were held for post-test observation. In screen integrity tests, fish were released in front of and/or behind the screens and were captured as they appeared in the fish bypass or in fyke nets mounted behind drum screens.

TEST FISH

The fish species selected for tests were recommended by fisheries biologists from the Washington State Department of Fisheries, the U.S. Fish and Wildlife Service, and the YIN. Selection was based on the potential impact of an irrigation diversion on specific salmonid populations likely to encounter each screening facility during their rearing and outmigration periods. Therefore. the selection depended on the species. race, and size of salmonids that utilize the Yakina River drainage upstream of each diversion.

Resident rainbow trout *0. mykiss* steelhead. and spring chinook salmon use the upper reaches of the Yakima River. Steelhead smolts were used for descaling tests at the Town Screens because spring chinook salmon of Yakima River origin were not available. Rainbow trout fry (<60 mm) were used in screen integrity tests at the Uestside and Town screens.

Steelhead

Juvenile steelhead were obtained from the Yakima Trout Hatchery in Yakima. Washington. operated by the Washington Department of Wildlife. The fish were progeny of native steelhead captured from the Yakima River at the Chandler Adult Fish Trap at Prosser. Washington. operated by the YIN. The fish were transported to PNL in November 1989 and were held through the winter in ambient Columbia River water or well water. Fish were branded and acclimated to temperatures expected at the Town Screens at least 1 week before release. The fish weighed about 17 fish/kg (7.5 fish/lb) when released in our tests.

Rainbow Trout

Rainbow trout fry used in screen integrity tests at the Uestside and Town screens came from PNL brood stock spawned in December 1989. Eggs were hatched in vertical flow incubators supplied with 10°C well water. Fry were transferred to troughs and reared at 10°C until testing commenced. Rainbow trout fry used in tests at the Uestside Screens were not branded and averaged about 45 mm fork length (FL). Rainbow trout used at the Town Screens ranged from 50 to 60 mm and were branded at least one week before release.

SAMPLING EQUIPMENT

Fish were captured within the screening facility and/or in the canal behind the screens. based on the objectives of each test. Inclined planes were custom-built for the fish bypass structure at each site. Fyke nets were mounted in stoplog slots behind the rotary drum screens to collect fish at the Uestside and Town screens. Temporary fish-holding facilities were installed at each site to acclimate and hold fish.

Inclined Planes

Fish were captured on an inclined plane as they entered the fish bypass. The inclined plane used at the Town Screens was 3.7 m (12.Oft) long and 0.6 m (2 ft) wide (Figure 5). The front face of the plane was hinged so that the slope of the plane could be changed to control the flow of water entering the fish live box. Solid walls, tapering from 0.9 m (3 ft) at the entrance to 0.41 m (1.3 ft) at the live box, acted as splash guards to reduce fish loss from the plane. The live box [O.38 m (1.3 ft) long by 0.6 ❑ (2 ft) wide, 75-L (20-gal) volume] was attached to the end of the plane. The plane had an aluminum frame covered by a perforated aluminum sheet [0.32-cm- (l/8-in.-) diameter holes, staggered centers, 40% open]. Dam boards in the upstream stoplog slot of the fish bypass directed flow over the plane surface. The height of the dam boards relative to the water depth determined the volume of water entering the fish bypass.

The inclined plane used at the Uestside Screens was 2.1 m (7.0 ft) long and 1.0 m (3.3 ft) wide. A live box [O.38 m (1.3 ft) long by 1.0 m (3.3 ft) wide, 100-L (26-gal) volume] was attached to the end of the inclined plane. The plane is described in greater detail in Neitzel et al. (1990b).

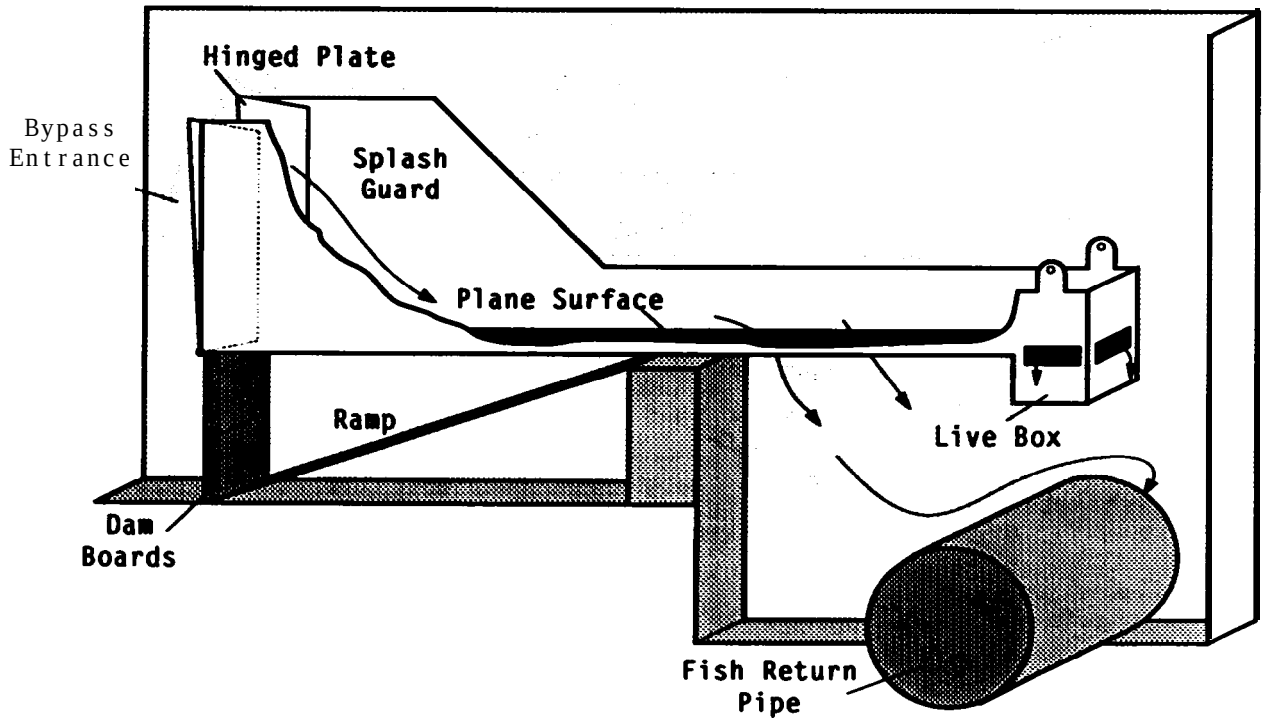

FIGURE 2. Inclined Plane Used at the Town Canal Fish Screening Facility, Spring 1990

Fyke Nets

Fyke nets were used behind each of the four drum screens in screen integrity tests at the Westside Screens. The net mouths were 3.7 m (12 ft) wide and 1.8 ■ (6 ft) deep. The tops of the nets were above the water surface, and the bottoms of the nets settled into the mud on the canal floor. The net mouth tapered to the 0.91-m- (3-ft-) square cod net (the trap end) over a length of 4.6 m (15 ft). The two sides of the net had different lengths so that the net would hang parallel to canal flow without billowing on one side (Figure 6). The cod net was 1.8 m (6 ft) long, resulting in an overall net length of 6.4 ❑ (21 ft). The end of the cod net was tied shut. These four nets and a fifth net of similar design were also used for screen integrity tests at the Town Screens. The nets were fished around the clock during integrity tests except for a l- to 4-h interval at the end of each test. when the nets were removed for fish retrieval and net cleaning.

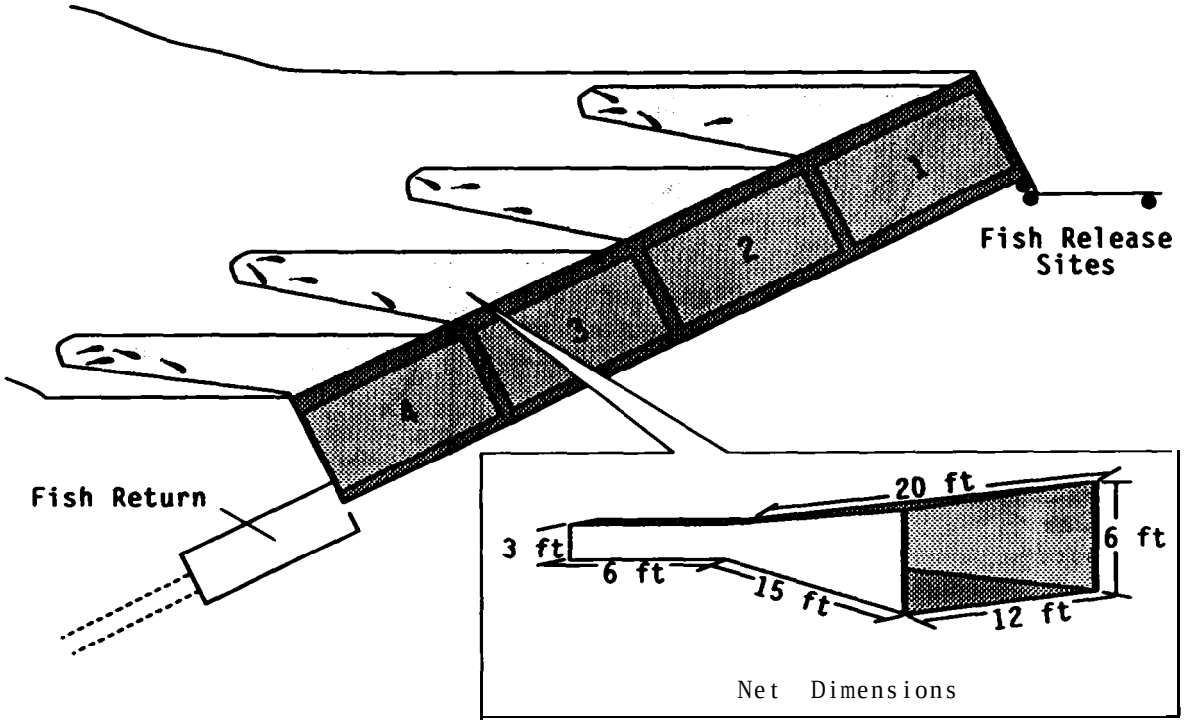

FIGURE 6. Fyke Nets Used in Integrity Tests at the Town Canal and Westside Ditch Fish Screening Facilities, Spring 1990

HOLDING FACILITIES

Temporary facilities were installed to hold and handle fish during our tests. A mobile laboratory containing three troughs [3 m (10 ft) long by 0.6 m (1.8 ft) wide by 0.3 m (0.8 ft) deep, and 540-L (140-gal) volume] was used at each site. Two circular tanks [1.22 m (4 ft) in diameter by 0.6 m (2 ft) deep] were also used at the Town Screens to retain fish for 96 h after capture. All tanks were supplied with canal water. The laboratory was equipped with fluorescent lighting so that descaling of fish captured during both day and night could be evaluated under similar light conditions.

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 fish at each site. 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 10 areas of a fish. 5 on each side. When 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).

TEST PROCEDURE

Descaling at the Town Screens was evaluated by releasing branded groups of steelhead upstream of the screening facility and capturing the fish when they appeared on the inclined plane in the fish return (Phase IIa, Appendix A). Tests were performed during the first week in May. Canal flows were maintained at 3.4 to 4.3 m^3/sec (120 to 150 cfs) during the tests. Native salmonid populations were monitored during tests at the Town Screens (Phase IVa. Appendix A). Integrity tests were conducted at the Town Screens by releasing branded groups of rainbow trout in front of and behind the screens. and at the Yestside Screens by releasing rainbow trout behind the screens. Native chinook salmon fry were monitored in integrity tests at both sites (Phase IVb. Appendix A). Fish were collected as they appeared on the inclined plane in the fish bypass or in fyke nets mounted behind the screens.

Test Stock Identification

Test fish were cold-branded with liquid nitrogen to identify specific test groups. Steelhead were marked on either the right or the left anterior region. Branding occurred at least one week before release. The brands. approved by the National Marine Fisheries Service (NHFS). were distinguishable from all other brands used to mark fish in the Columbia River Basin. Rainbow trout fry used for integrity tests at the Town Screens were marked in either the right or the left anterior region: however. fry used at the Yestside Screens were not marked.

Fish Transport and Release

Test fish were transported to the screen sites in an insulated tank C400-L (125-gal) volume] supplied with oxygen. Transit times from PNL to the Town and Westside screens were 2.5 h. Loading densities did not exceed 120 g of fish/L. Water temperature changed less than 1°C from the acclimation temperature (-8°C) during transit. Test fish were netted from the transporter and placed in holding tanks for acclimation before release at the Town Screens. and fish at the Yestside Screens were held in floating pens in the canal behind the screens. No losses resulted from fish transport.

Fish Release Locations

Test fish for evaluating descaling at the Town Screens were released from the south bank of the canal about 30 m upstream of the trash racks. Rainbow trout used in screen integrity tests at the Town Screens were released just upstream of the first screen and next to the structure wall,

or just upstream of the sixth screen. depending on where the fyke nets were positioned (Figure 3). Control groups were released uniformly across the mouth of the fyke nets positioned on the downstream side of the screens and at the entrance of the fish bypass to test gear efficiency and effect.

Release Controls

For descaling tests at the Town Screens. we examined 150 steelhead smolts to determine baseline condition (condition at time of release) by sampling each group of test fish before release. Fish used for baseline evaluation were not used in a test. An additional 93 smolts released in the fish return were examined to measure descaling caused by the inclined plane. All descaling evaluations were conducted in the mobile laboratory under artificial light.

Fish Capture and Evaluation

Two groups of steelhead (699 fish total) were released in front of the screens. Fish captured during Phase IIa tests at the Town Screens were netted from the live box of the inclined plane and placed in a holding tank before evaluation. Evaluations were made at half-hour intervals at night and hourly during the day. The fish were anesthetized in tricaine methane sulfonate (W-222). examined to determine the extent of scale loss. and returned to another holding tank. After fish recovered from the anesthetic, they were released into the fish return pipe. About 100 steelhead smolts were held for 96 h to detect any delayed mortality.

Fish captured in Phase IVb tests were not evaluated for descaling. The purpose of Phase IVb tests was to determine if the screens prevented fish from passing through and entering the canal behind them and to monitor the rate at which fish moved through the fish bypass. At the Town Screens. fish were counted and identified by brand group as they appeared on the inclined plane in the fish return. The brands identified when and where the fish were released within the screening facility. At the blestside Screens. our Phase IVb evaluation was based on the recovery of native chinook salmon fry: therefore. no branded fish were released in front of the screens.

The inclined plane was fished continuously during our tests at the Town and Westside screens. Fish groups for Phase IVb tests were released in front of and behind the screens during the day. usually at mid-morning. Control groups were released at the entrance of the fish bypass during each test to estimate capture efficiency. Fyke nets were fished continuously for about 20 h after the release of test fish. then removed for a 2- to 4-h period to retrieve fish and clean the nets. The nets were then repositioned before the next test started.

STATISTICAL ANALYSIS

We estimated the percentage of fish killed or descaled and the length of time for 50% of the test fish to move from their release point to the inclined plane. We estimated capture efficiencies of the inclined plane and the fyke nets used during screen integrity tests from the number of control fish captured. Capture efficiencies were used to estimate the efficiency of the screen in preventing fish from passing from the screen forebay to the canal downstream of the screens.

Descaling and Mortality

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 intervals (LCI and UCI. respectively) were estimated as

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

and

$$UC1 = 1 - \frac{n-B}{n-B[n-(n-B)+1]F}$$

where B equaled the number of dead or descaled fish, n the number of fish caught. and F a 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)

We combined data fron replicate tests to obtain a mean estimate. 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. All tests were conducted in the same manner to reduce nonindependent behavior of fish.

Screen Efficiency Estimates

Three tests with four groups of fish were conducted at the Uestside Screens. Screen efficiency estimates were computed for each test in addition to an overall estimate. Fyke nets were mounted behind each screen in all tests.

Two quantities were computed to estimate screen efficiency: inclined plane efficiency (EFF_{ip}) and net capture efficiency (EFF_{nc}). Net retention was assumed to be equal to net efficiency at the Uestside Screens. Thus, net retention (EFF_{nr}) equaled 1. Given this, the formula for computing screen efficiency (EFF_{sc}) was

$$EFF_{sc} = 1 - \frac{X_{net}}{EFF_{nc}N}$$

where Xnet equaled the number of fish released upstream of the screens and caught in the nets. and N was defined as

$$N = \frac{X_{net}}{EFF_{nc}} + \frac{X_{ip}}{EFF_{ip}}$$

where X_{ip} equaled the number of fish released upstream of the screens and caught in the inclined plane. N represented the total number of fish released in a test. For some estimates and the overall estimate, some fish were not accounted for after the efficiencies (EFF_{jp} and EFF_{nc}) were considered. To avoid making assumptions about what might have happened to these fish, an effective N was computed that was smaller than the actual number of fish released. It must be noted that N was not an actual accounting of all fish caught in different locations (inclined plane, fyke nets. bypass). but an estimate based on the actual numbers, adjusted by efficiencies for net losses and human error.

The efficiencies per set were defined. The input data for each section were as previously explained, combining across relevant tests. The general forms were

$$EFF_{ip} = \frac{n_{ip}}{N_{ip}} \quad \text{and} \quad EFF_{nc} = \frac{n_{nc}}{N_{nc}}$$

where

- n_{ip} - the number of fish released in the bypass or the entrance to the fish return slot and caught in the inclined plane for the section being estimated
- N_{ip} - the number released in the bypass
- n_{nc} - the number released in the net mouth and caught in the net
- N_{nc} - the number released in the net mouth.

For determining the overall efficiency, it should be noted that individual test efficiencies were not simply averaged: rather, the efficiency was computed by combining all data. Averaging the separate tests would assume equal numbers were released in each test and would weight them as such. By computing the overall estimates from all data lumped as one test. the varying N values were incorporated and differences in test size were compensated.

The confidence intervals were computed using the standard normal approximation method (Mood et al. 1974). For a 95% confidence interval

$$P\left[EFF_{sc} - 1.96\sqrt{var(EFF_{sc})} \leq \text{true } [EFF_{sc}] \leq EFF_{sc} + 1.96\sqrt{var(EFF_{sc})}\right] = 0.95$$

Here EFFsc indicated our estimate while true [EFFsc] indicated the true or actual value of the screen efficiency. EFFsc was a binomial proportion. and the form for its variance was EFFsc $(1-EFF_{sc})/N$. However, because we used efficiencies $(EFF_{ip}, EFF_{nc}, EFF_{nr})$ in the computation of EFFsc with their own inherent errors. these errors must be propagated and incorporated into the variance of EFF_{sc}. If EFF_{ncr} was defined to be the combined catch and retain efficiency $(EFF_{nc} \times EFF_{nr})$, then the variance of EFFsc was

$$var[EFF_{sc}] = \left(\frac{\partial EFF_{sc}}{\partial EFF_{ip}}\right)^2 var[EFF_{ip}] + \left(\frac{\partial EFF_{sc}}{\partial X_{net}}\right)^2 var[X_{net}]$$

where all variables are as previously defined. This formula is the first term of a Taylor's series expansion (Holman 1971). Second-order and higher-order effects were neglected. The assumption was made that EFF_{ip} and Xnet were independent of each other. which was reasonable in this case.

The variances of EFF_{ip} and EFF_{nc} were computed by assuming them to be binomial proportions and using the appropriate N for the section in the $EFF(1-EFF)/N$ formula as stated previously. The variable Xnet. the number of fish caught in the nets that were released upstream of the screens. was a distributed binomial (N, EFF_{sc}), making its variance equal to $N[EFF_{sc}(1-EFF_{sc})]$.

RESULTS

Fish that passed through the fish bypass system at the Town Screens were not descaled or killed. Fish were not "flushed" from the screen forebay. but moved out of their own volition. The angled rotary drum screen design prevented test fish from passing to the canal behind the screens at the Town Screens: however. some native chinook salmon fry were able to pass through. over. or around the screens. Chinook salmon fry were caught behind the screens at the Uestside Screens despite repairs made to the side seals before we performed our tests. Data are presented as they relate to the objectives of each phase outlined in the work plan (Appendix A). All phases of our work plan were considered when we evaluated the Uestside Screens in 1989 (Neitzel et al. 1990b): only Phase IVb tests were repeated at the Uestside Screens in 1990.

PHASE I

Phase I tests were designed to evaluate components within the fish diversion system other than the rotary drum screens. The fish bypass system at the Town Screens contained no structures other than the drum screens; therefore, no Phase I tests were conducted there.

PHASE II

Phase II tests evaluated either the entire fish bypass system from the trash racks through the fish return pipe (Phase IIa) or specific components of the fish return system (Phase IIb). Ye initiated our evaluations with Phase IIa testing at the Town Screens. Ye released fish upstream of the screening facility and captured them at the entrance to the fish bypass. In addition to obtaining fish descaling and mortality data, we determined how long released fish remained upstream of or within the Town Screens.

Phase IIa

Tests at the Town Screens were performed in early May 1990. Ye released two groups of branded steelhead upstream of the screen forebay. One group of 350 fish was released in the morning, and the other group of 349 fish was released in the evening. Of the morning release. 214 steelhead (61.1%) were captured on the inclined plane in the fish bypass during the next 96 h. Of the evening release. 127 steelhead (36.43) were caught in the following 85 h. Of 341 steelhead examined for descaling. only one fish (0.3%) was descaled (Table 1). The descaling rate of 1.8% for steelhead was well within the 95% confidence intervals for the condition controls (Appendix B). None of the 93 steelhead held to determine possible delayed mortality died in 96 h.

TABLE 1. Descaling and Mortality Data from Release and Capture Tests with Steelhead *Oncorhynchus mykiss* Smolts at the Town Canal Fish Screening Facility, Spring 1990

Species	Group	Number				Percent		95% Confidence Interval
		Released	Captured	Descaled	Dead	Captured	Descaled	
Steelhead	1	350	214	1	0	61.1	0.5	0 - 3
Steelhead	2	350	127	0	0	36.3	0.0	0 - 3
	Total	700	341	1	0	48.7	0.3	0 - 2
Sockeye		-	14	0	0	-	0.0	0 - 21
Rainbow	(Native)	-	21	0	D	-	0.0	0 - 17

The downstream movement of steelhead released for descaling evaluations was monitored as the fish appeared on the sampling plane in the fish bypass. The movement rate for steelhead (Figure 7, Table 2) indicated that salmonid snolts were not flushed from the forebay at the Town Screens: rather. they moved through the forebay of their own volition.

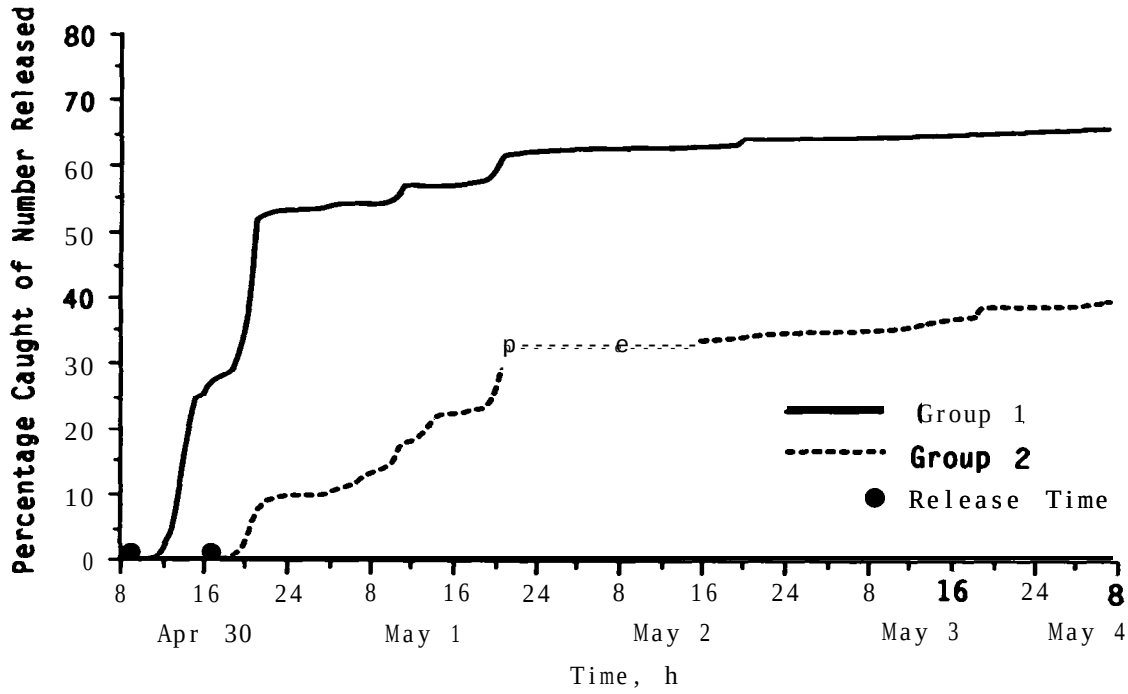

FIGURE. Movement of Steelhead *Oncorhynchus mykiss* Snolts Based on the Capture of Test Fish at the Town Canal Fish Screening Facility. Spring 1990

TABLE 2. Estimated Time to Capture 50% of Steelhead *Oncorhynchus mykiss* Smolts Released in Descaling Tests at the Town Canal Fish Screening Facility. Spring 1990

	Number		Percent	Time To Catch
Group	Released	Caught	Caught	50%. h
1	350	214	61.1	**12.0**
2	349	127	36.4	**(a)**

(a) 50% of test fish were not caught after 85 h.

Phase IIb

Phase IIb tests evaluated specific components of the fish bypass system. However. the fish return at the Town Screens is a basic bypass system: it does not use intermediate bypass pipes. a separation chamber. a pumpback system. or traveling screens. The bypass pipe is void of sharp bends or changes in elevation. Therefore, no Phase IIb tests were conducted at the Town Screens.

PHASE III

Our tests at the Town Screens were performed about one week after startup of the canal in the spring. Irrigation demand usually increases later in the summer, but a canal flow of 3.7 m^3/set (130 cfs) is normal for May. Because of a fixed irrigation demand during our tests. no Phase III tests could be conducted at the Town Screens. nor were they considered necessary.

PHASE IV

The goal of Phase IV tests was to evaluate predation and determine whether screening facilities allow fish to enter the canal behind the screens. Predatory fish populations and the abundance and condition of native salmonids were monitored at the Town Screens as fish were captured on the inclined plane during release and capture tests. The drum screens were also monitored to determine if fish were impinged. Rainbow trout fry were released at the Town Screens to test for passage through, around. or over the screens. Native chinook salmon fry populations were monitored at the Uestside Screens.

Phase IVa

Few native juvenile salmonids were captured during tests at the Town Screens: however, chinook salmon fry (32 to 60 mm FL) were common. None of the 21 juvenile rainbow trout/steelhead or 14 hatchery-reared sockeye salmon smolts we caught were descaled. Few of the rainbow trout had developed typical smolt characteristics. One northern squawfish *Ptychocheilus oregonensis* (22.5 cm) and one yellow perch *Perca flavescens* were caught on the inclined plane and examined: no fish were found in their stomachs. Other species captured were sculpin *Cottus* spp.. red-sided shiner *Richardsonius balteatus.* whitefish *Prosopium williamsoni.* dace *Rhinichthys* spp., and suckers *Catostomas* spp. We saw no activity by predacious birds at the Town Screens.

Phase IVb

Phase IVb tests were conducted at both the Uestside and the Town screens. At the Uestside Screens. the passage of native chinook salmon fry was monitored. At the Town Screens. we monitored the passage of rainbow trout fry that we released as well as native chinook salmon fry.

Uestside Screens

No test fish were released in front of the screens in Phase IVb tests at the Uestside Screens.
monitored by comparing the number of fry captured in the fish bypass to the number caught in fyke nets behind the drum screens. We released control groups of rainbow trout fry in the mouth of the fyke nets and in the fish return during each test to evaluate capture efficiency.

Of the 1200 rainbow trout planted in the fyke nets during 3 days of testing, 474 (39.5%) were recovered from the fyke nets (Table 3). Three hundred rainbow trout were released near the entrance to the inclined plane

of nets ranged from 24.5% to 57.3% among the three tests. and the capture rate varied from 32% to 58% behind individual screens during the tests. In

fry recovered in the bypass. The 19 fish represent 13.4% of the total number of fish captured. resulting in a passage efficiency of 83.2% for the Uestside Screens (Table 4).

Chinook salmon fry captured in the nets behind the drum screens represented the lower end of the size range of fish captured in the fish bypass (Figure 8). The average length of fish caught behind the screens was (± 2.2) mm (N = 19 fish). while the average length of fish caught in the bypass was 39.8 (± 5.2) mm (N = 164 fish).

To compare the size of the chinook salmon with the mesh size of the screens, we took head-depth measurements on all salmon fry caught behind the screens and on 52 fry captured in the fish bypass (Figure 9). Head depths averaged 4.95 mm (range 4.37 to 6.35 mm) for fish caught behind the screens and 5.88 mm (range 4.37 to 9.0 mm) for fish caught in the bypass. About 150 fish captured on the plane were held in a basket (made of the mesh material used to construct the screens) for up to 24 h. Only one fish escaped through the mesh.

TABLE 3. Capture Data for Rainbow Trout *Oncorhynchus mykiss* and Chinook Salmon *Oncorhynchus tshawytscha* Fry Caught During Integrity Tests at the Westside Ditch Fish Screening Facility, Spring 1990

		Number of Control Fish		Chinook Salmon Captured	
	Screen	Released	Captured	Fyke Net	Plane
Test 1	1	100	54	0	71
	2	100	58	2	-
	3	100	47	4	-
	4	100	70	1	-
	Total	400	229	7	71
Test 2	1	100	24	0	88
	2	100	30	4	-
	3	100	30	3	-
	4	100	63	1	-
	Total	400	147	8	88
Test 3	1	100	22	2	77
	2	100	16	1	-
	3	100	20	1	-
	4	100	40	0	-
	Total	400	100	4	77
	Total Screen 1	300	100	2	
	Total Screen 2	300	104	7	
	Total Screen 3	300	97	8	
	Total Screen 4	300	173	2	
	Total	1200	474	19	236

TABLE 4. Capture Efficiency of the Inclined Plane and Fyke Nets Used During Integrity Tests at the Westside Ditch Fish Screening Facility, Spring 1990

	Capture Probability Estimate		Screen	95% Confidence
Test	Inclined Plane	Fyke Net	Efficiency	Interval
1	1.000	0.573	0.853	0.97-0.74
2	1.000	0.368	0.802	0.96-0.64
3	1.000	0.245	0.825	1.00-0.57
Total	1.000	0.395	0.832	0.92-0.74

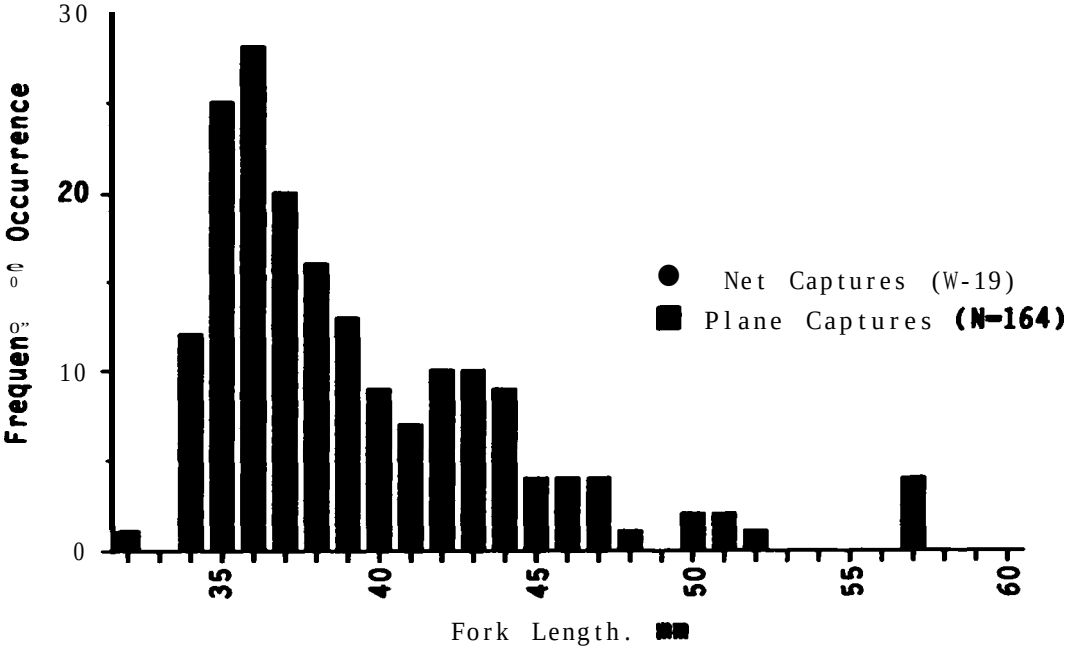

FIGURE 8. Length Measurements (FL) for Chinook Salmon Oncorhynchus tshawytscha Fry Caught in Fyke Nets and in the Fish Bypass During Integrity Tests at the Westside Ditch Fish Screening Facility. Spring 1990

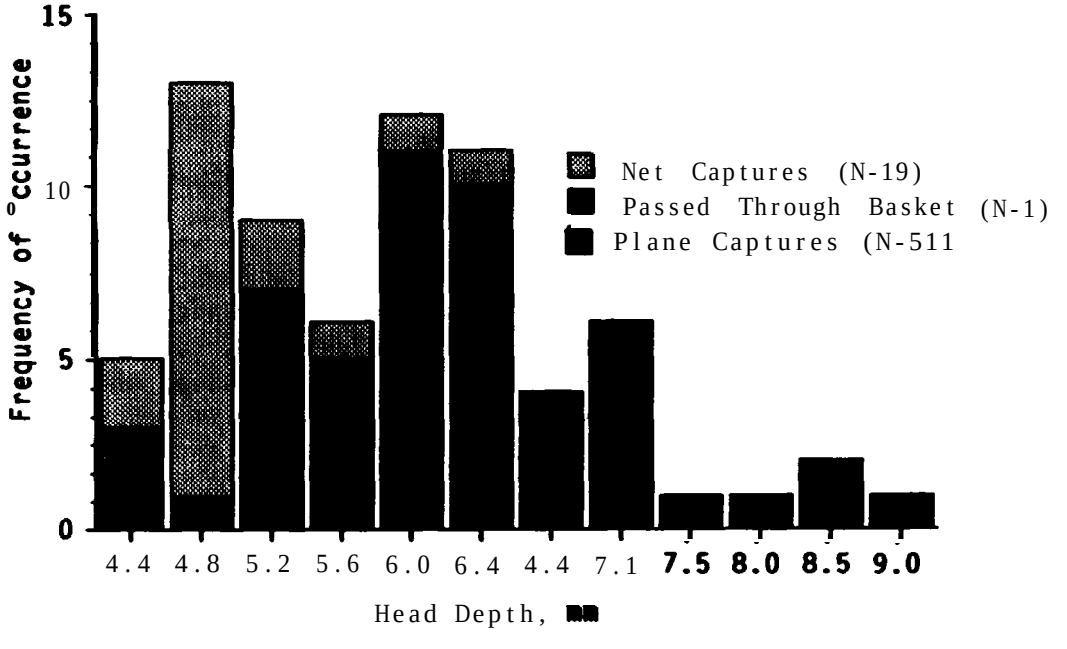

FIGURE 9. Head-Depth Measurements (mm) or Chinook Salmon Oncorhynchus tshawytscha Fry Captured During Integrity Tests at the Yestside Ditch Fish Screening Facility. Spring 1990

Town Screens

A total of 4024 rainbow trout fry (55 mm FL) were released in front of the screens, and 2000 fry were released in the fyke nets behind the screens to evaluate screen effectiveness in preventing fish from entering the canal (screen integrity). Of the 4024 fish released in front of the screens, we recovered 1209 fish (30.0%) in the fish return and none (0.0%) in the fyke nets (Table 5). Of the 2000 branded rainbow trout fry released behind the drum screens, we recovered 1017 fish (50.9%) in the. fyke nets.

We did not recover about 70% of the rainbow trout fry released in front of the screens. The fry were not flushed from the forebay of the Town Screens. Most of the fry held in the forebay: however. the steelhead we released for descaling tests may have eaten some of the trout fry. The recovery rate on the inclined plane decreased markedly for fish groups released near screen 1 compared to fish groups released near screen 6. In the days following releases near screen 1. we observed many of the fry holding in an eddy at the base of the access ramp along the south wall of the canal just upstream of the trash racks. Fish from each of the four test groups were still being caught in the fish bypass when our tests terminated, although catches of each group decreased daily. Movement was slow during the day and increased at sunset (Figure 10).

In addition to our control fish, we caught a total of 15 chinook salmon fry in fyke nets behind the screens in 4 days. compared to 311 fry caught in the fish bypass (Table 6). The capture rate for chinook salmon fry in fyke nets varied. In replicate tests of screens 6 through 10. no fry were captured in the fyke nets during the first test, and four fry were captured in the second test. In replicate tests of screens 1 through 5. 10 fry were caught in the first test and only one in the second test. Most of the chinook salmon fry moved through the fish bypass at night.

Based on the number of fish caught on the inclined plane and our estimates of sampling efficiency (Table 7). none of the rainbow trout released in front of the drum screens passed over. around, or through the drum screens. The 15 fall chinook salmon fry captured in the fyke nets represented 4.6% of the total number of fry captured during our tests. Based on our capture efficiencies with rainbow trout fry. we estimate that 8.5% **(±5.5)** of the chinook salmon fry entering the Town Canal passed over. around. or through the drum screens.

Chinook salmon fry recovered from the fyke nets were small when compared to fry caught in the fish bypass (Figure 11). averaging 35.7 mm (range of 32 to 37 mm). while fish captured in the bypass averaged 42.1 mm (range of 33 to 58 mm). Comparison of the head depths of chinook salmon fry caught during the first two tests at the Town Screens to those of fry caught in the fish bypass at the Town Screens, or to fry caught in nets at the Westside Screens, showed that only the smaller fish with the smallest heads passed through. over. or around the screens (Figure 12).

TABLE 5. Capture Data for Rainbow Trout *Oncorhynchus mykiss* Fry Released During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990

Test Group	Screen Number	Number of Control Fish				Number of Test Fish			
		Released	Captured	Released	Captured		Captured In		
		Fyke Net		Plane		Released	Plane	Fyke Net	Other
1	6-10	500	13	100	100	1006	479	0	0
2	6-10	500	352	-	-	1007	474	0	4
3	1-5	500	373	100	95	1005	190	0	10
4	1-5	500	279	100	100	1006	66	0	1
Total		2000	1017	300	295	4024	1209	0	15

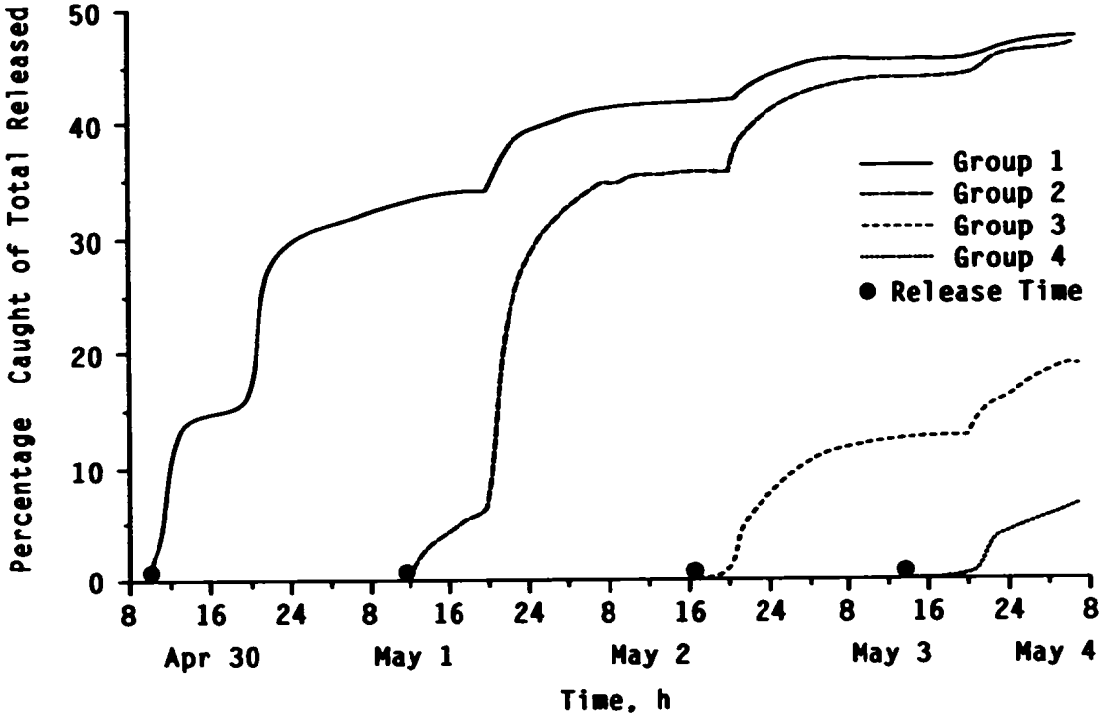

FIGURE 10. Movement of Rainbow Trout *Oncorhynchus mykiss* Fry Based on the Capture of Test Fish in the Bypass During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990

TABLE 6. Capture Data for Chinook Salmon *Oncorhynchus tshawytscha* Fry Caught During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990

Test	Screens Tested	Captured In	
		Fyke Nets	Plane
1	6-10	0	85
2	6-10	4	125
	Total	4	210
3	1-5	10	69
4	1-5	1	32
	Total	11	101
	Four-Test Total	15	311

TABLE 7. Capture Efficiency of the Inclined Plane and Fyke Nets Used During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990

Test	Screens	Capture Probability Estimate		Screen Efficiency	95% Confidence Interval
		Inclined Plane	Fyke Net		
1	6-10	1.000	0.026	1.000	1.00-1.00
2	6-10	0.950[a]	0.704	0.949	1.00-0.89
3	1-5	0.950	0.746	0.844	0.93-0.76
4	1-5	1.000	0.558	0.947	1.00-0.82
Total		0.983	0.509	0.915	0.97-0.86

(a) No plane control fish were released in Test 2; we assumed a 95% capture efficiency.

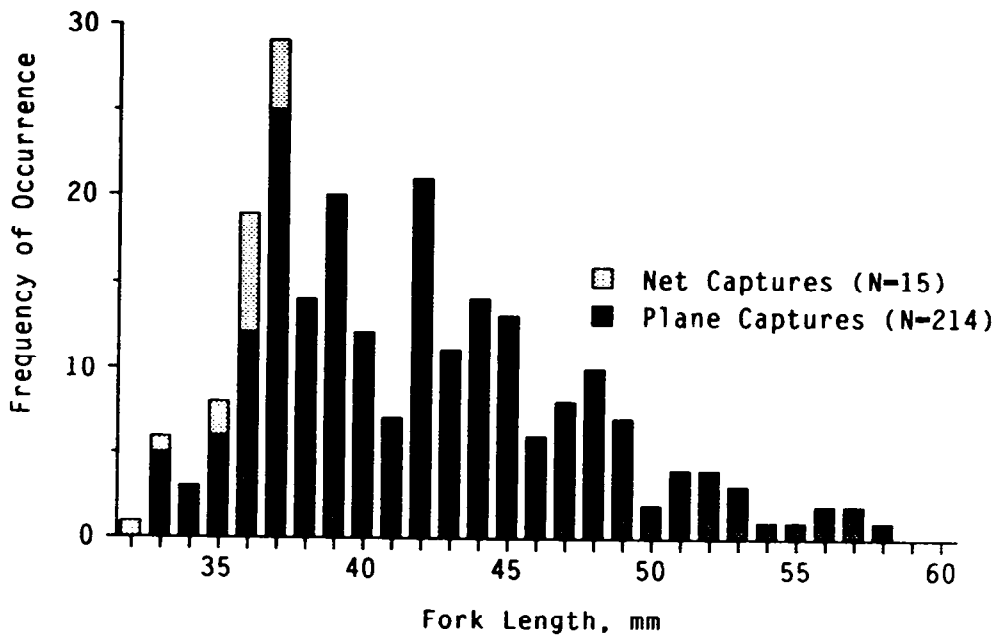

FIGURE 11. Size Distribution of Chinook Salmon *Oncorhynchus tshawytscha* Fry Captured During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990

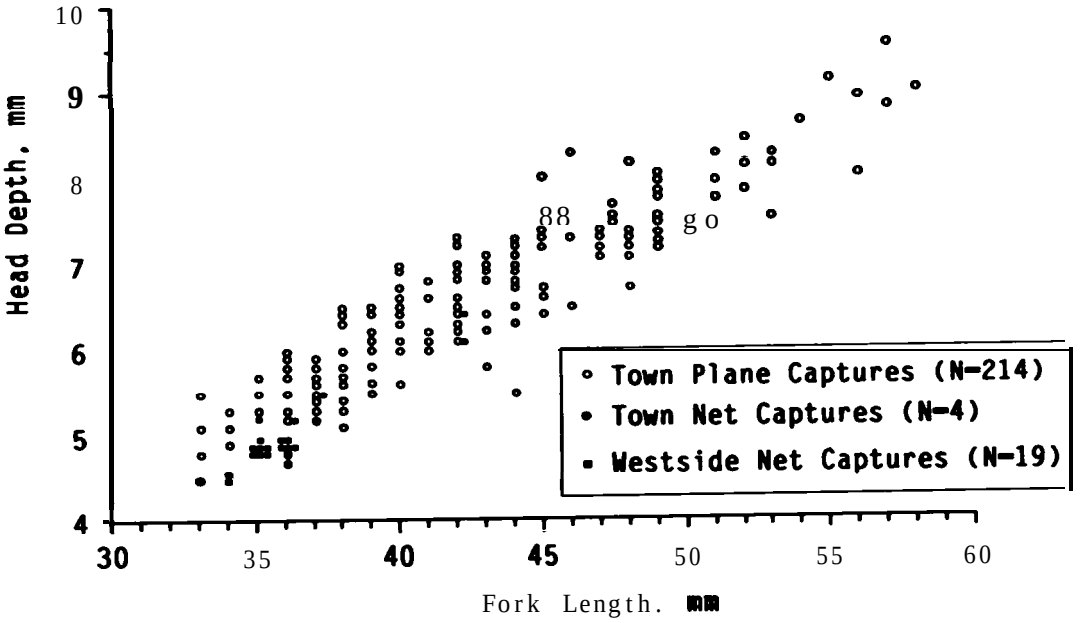

FIGURE 12. The Relationship Between Head Depth and Fork Length for Chinook Salmon *Oncorhynchus tshawytscha* Fry Captured During Integrity Tests at the Yestside Ditch and Town Canal Fish Screening Facilities. Spring 1990

DISCUSSION

Fish screening facilities in the Yakima Basin were designed to direct fish diverted from the river into irrigation canals back to the river without killing or injuring them or delaying their migration. The work plan for this study was designed to determine if the diverted fish can be safely and expeditiously returned to the river. Tests following the work plan were conducted to determine 1) the conditions or circumstances that affect fish survival as fish pass through the screening facility: 2) if a screening facility provides conditions under which diverted fish may become more susceptible to predation: 3) whether fish are delayed at or upstream of the screening facilities: and 4) if fish pass through. around. or over rotary drum screens and become trapped in the irrigation canal.

FISH SURVIVAL AT SCREENING FACILITIES

Based on release and capture tests at seven screening facilities, fish are not descaled or killed during passage in front of the rotary drum screens or through the fish bypass systems. As in previous descaling evaluations at the Sunnyside. Richland, Toppenish/Satus. Toppenish Creek. Wapato. and Westside screens. the descaling rate for test fish at the Town Screens is within the confidence limits for control fish.

POTENTIAL FOR PREDATION AT SCREENING FACILITIES

On the basis of the samples we have collected, loss to predation does not appear to be a problem at screening facilities when only native species are involved. However. hatchery-released salmonids that take up temporary residence in a screen forebay nay increase predation pressure at screen sites. Screening facilities could affect the predator/prey relationship if the screens concentrate predators or prey. or increase the exposure of prey to predators because of stress. injury, or delay in migration.

Westside Screens

No predation was observed at the Yestside Screens. Few fish other than zero-age chinook salmon were captured. The Westside Screens had been in operation for only about a week before our tests. and the few smolt-size salmonids we caught during 3 days of monitoring indicate that actively migrating saolts do not take up temporary residence in the screen forebay. or they had already migrated from the reach of the Yakina River upstream of the Westside Screens.

Town Screens

No predation was observed at the Town Screens. Few salmonid smolts were caught during 4 days of continuous sampling. indicating that actively

migrating salmonid smolts do not congregate in the screen forebay. However, about 50% of the steelhead we released for descaling evaluations were not captured in the fish bypass. Ye observed that smolt-sized salmonids. presumably our test fish. held and actively fed in a large eddy along the north wall of the canal between the head gates and the trash rack.

During our tests. most of the water was entering the canal through the two motor-operated head gates next to the south wall. The manually operated head gates closer to the north wall were closed. The operating criteria for the Town Canal (Appendix C) call for equal flow through all head gates to avoid creating the eddy.

POTENTIAL FOR FISH DELAY AT SCREENING FACILITIES

One of the basic objectives of redesigning and constructing new screening facilities is to provide a fish bypass that is easily found by fish and is safe for fish passage (Easterbrooks 1984). Although fish are not "flushed" from the screen forebay back to the river, the screening facilities do not impede voluntary movement and migration under normal operating conditions. Conversely, inadequate bypass flows resulting from improper operation, inoperable components in the bypass system, low canal flows or forebay elevations, or blockages in the fish return pipe can impair the movement of fish through the fish bypass system and contribute to delays in migration.

Flow through the fish return pipe at the Yestside Screens appeared to be normal the week before we initiated our tests, although the water level in the fish bypass was somewhat high in conjunction with high river levels. an expected condition described in the operating criteria (Appendix C). Before the 1989 tests we conducted (Neitzel et al. 1990b). the head of the fish return pipe was plugged with debris that either washed into the fish return slot when the canal was filled or was not removed before startup. The restricted bypass flow could have caused a migration delay. We observed several small emaciated chinook salmon fry in the fish bypass before the blockage was removed. No chinook fry were observed in the fish bypass this year. and fewer chinook salmon fry were caught during our tests this year than in 1989. The smaller catch rate may be related to natural variability in the population or emergence timing. but may also reflect improved efficiency when the fish bypass is unobstructed.

Bypass flow was inadequate at the Town Screens before our tests started because the surface elevation of the water in the screen forebay was low. The concrete sills of the check structure downstream of the screens were too short to build an adequate head level during low canal flows. Ye raised the forebay elevation by partially closing the flow control gates at the check station and increasing canal flow slightly at the head gates before we started our tests. Hydrologists from the NMFS visited the site during our tests and are aware of the problem.

FISH PASSAGE THROUGH OR OVER ROTARY DRUM SCREENS

The sweeping-velocity-to-approach-velocity ratio designed into the facilities helps guide fish into the fish bypass. and screen mesh openings (3.2 mm. l/8 in.) were small enough to prevent most salmonid fry from passing through the drum screens. Tests were completed at the Uestside and Town screens to determine if any fish might be impinged by or pass over. around. or through the drum screens.

Although fewer fish were caught in fyke nets behind the drum screens at the Uestside Screens than during our 1989 tests. the proportion of fish that passed through. over. or around the drum screens remains high when compared to the number of fry caught in the fish bypass. Modifications to the end seals of the drum screens did not dramatically decrease fish loss through the drum screens. Chinook salmon fry were caught behind all four of the drum screens. Screens 1 and 4 were more efficient at preventing fish passage this year. whereas only screen 1 prevented passage in 1989. No rollover was observed: therefore. fish caught in the nets presumably passed around or through the drum screens.

The screen integrity tests at the Uestside and Town screens showed that the few chinook salmon fry captured behind the screens were small in size compared to the general population of chinook salmon fry captured in the fish bypasses. Additionally. the head depth of fish caught behind the screens appeared to be smaller in relation to their fork length compared to fry caught in the bypasses. although measurement data for fish behind the screens were limited.

The 3.2-mm (l/8-in.) screen mesh used in the construction of the drum screens at the Town and Uestside screens and most other screening facilities is believed to be small enough to prevent salmonid fry from passing through the mesh. Fisher (1978) concluded that chinook salmon fry 32 to 40 mm in length could not pass through a 4.0-mm (5/32-in.) screen opening: however. his tests were conducted with perforated plate. Rather than with the coarse woven wire mesh used to construct drum screens in the Yakima Basin. The diagonal measurement (hypotenuse) of a square mesh with 3.2-mm (l/8-in.) sides is 4.5 mm. Many of the smaller chinook salmon fry had head-depth measurements $\leq$ 4.5 mm. Additionally. the tissues in the heads of salmonids are flexible, so some salmonids could conceivably pass through the mesh. Although only one salmon fry (32 mm FL, head depth of 4.4 mm) passed through a basket constructed from the l/8-in. screen mesh in static water conditions. we conclude that if spawning occurs near a screen site, some emergent chinook salmon fry, as well as fry of other species. can pass through drum screens constructed from 3.2-mm mesh.

SUMMARY

Release and capture tests and other monitoring studies have been conducted at seven diversion screen facilities in the Yakima Basin: the Sunnyside Screens (Neitzel et al. 1985). the Richland and Toppenish/Satus screens (Neitzel et al. 1986). the Uapato Screens (Neitzel et al. 1988). the Toppenish Creek Screens (Neitzel et al. 1990a). the Westside Screens (Neitzel et al. 1990b). and the Town Screens. The objective of our evaluations was to determine whether fish that have entered a irrigation canal are safely diverted back to the river. The objective was met by determining if 1) fish that pass through the diversion were killed, injured, or eaten by predators: 2) fish migration was delayed at the screen structure: and 3) fish were prevented from passing through or over the screens. These questions are addressed in the various phases of the work plan.

PHASE I

Phase I tests conducted at the Sunnyside Screens in 1985 used chinook salmon and steelhead smolts. The test data indicated that fish safely pass through all components of the fish bypass system. No Phase I tests have been conducted at the Richland. Toppenish/Satus. Toppenish Creek. Westside. or Town screens, because the fish bypass systems did not incorporate intermediate and terminal bypasses, traveling screens, or fish water pumpback systems in their designs. No Phase I tests were conducted at the Wapato Screens, because none of the components of the facility differed significantly from components at the Sunnyside Screens. which were proven safe for fish passage.

PHASE II

Phase IIa tests evaluate either the entire fish bypass system from the trash racks through the fish return pipe (Phase IIa) or specific components of the fish return system (Phase IIb). Phase IIa tests have been completed at all seven screening facilities. At the Sunnyside Screens. fish were released at either the trash racks or the head gates. Fish captured after moving through the screen forebay and diversion system were not injured or killed. At the Richland, Toppenish/Satus. Uapato. and Toppenish Creek screens. fish were released only at the trash racks. Fish were released midway between the trash racks and the head gates at the Town Screens and in the canal upstream of the screens at the Uestside Screens. The condition of test fish did not differ from the controls. Tests at the Sunnyside. Uapato. Richland. and Uestside screens were conducted with chinook salmon and steelhead smolts. Tests at the Toppenish/Satus. Toppenish Creek, and Town screens were conducted with steelhead smolts only.

Phase IIb tests have been conducted at the Sunnyside. Richland. Toppenish Creek. and Uapato screens. At Sunnyside. tests were conducted to evaluate the intermediate bypass system. the terminal bypass system, the secondary separation chamber, and the primary fish return pipe. At the Richland. Toppenish Creek, and Uapato screens, the fish return pipe was evaluated. Fish successfully passed through each of the components without significant injury or delay.

PHASE III

Phase III tests have been conducted at the Richland. Toppenish Creek. and Uapato screens. Pipe tests were conducted under two bypass flows at the Richland Screens. Fish were not injured or killed at either bypass flow. Evaluations at the Toppenish Creek and Yapato screens were conducted during low and full canal flow conditions. Fish were not injured or killed in either test: however, movement rate was slower during low canal flow. Opportunities to conduct tests under different canal flows were limited because of delays in construction and startup at the Sunnyside. Richland. and Toppenish/Satus screens. The Sunnyside, Toppenish/Satus. and Yestside screens were evaluated only at full canal flow conditions and the Richland Screens only at minimum flow conditions. The Town Screens were evaluated under flow conditions occurring during normal irrigation demand in early May.

PHASE IV

Ye collected native fish during all bypass tests and examined the gut contents of predacious fish. Increased predation does not occur at screening facilities. except where hatchery-released salmonid smolts sometimes congregate in the screen forebay and prey on salmonid fry. Activity by predacious birds has been monitored at each screening facility. Predatory birds do not congregate at most of the facilities: however. at the Richland Screens. sea gulls preyed on fish released during the day as they exited the fish return pipe.

We examined drum screens during our tests to determine if any fish were impinged on or passed over the screens. Successful screen integrity tests were completed at the Richland. Toppenish Creek, Sunnyside. Uapato. Westside. and Town screens. The Richland Screens are effective at preventing fish from entering the irrigation canal: however, some fish passed over or through the screens or through faulty screen seals at the Toppenish Creek, Sunnyside. Uapato. Yestside. and Town screens. Screen integrity tests initiated at the Toppenish/Satus Screens were unsuccessful because we did not have nets to capture fish downstream of the drum screens.

RECOMMENDATIONS

Fisheries evaluations have been conducted at seven diversion screen facilities: the Sunnyside. Richland, Toppenish/Satus, Wapato. Toppenish Creek. Uestside. and Town screens. Data were collected to address five areas of concern: fish survival. predation. migration delays. screen passage. and effects of operating conditions. The results of tests addressing each concern were integrated to evaluate the effectiveness of the screens.

The data indicate that fish were not descaled or killed as they were diverted by the screening facilities. Descaling tests should be given a low priority in future evaluations unless there are changes in facility design or site-specific concerns.

Canal operating level did not appear to affect the injury rate for fish. Operating criteria should be evaluated to ensure that maximum bypass efficiency is achieved through the operating range at each screening facility. The periods when canal operating conditions were of greatest concern at each screening facility were during 11 canal startup and 2) peak migration of native salnonid stocks.

Increased predation did not appear to occur at screening facilities except when hatchery-released salmonids were present in the screen forebay and preyed on smaller salmonids. The potential impact of predation on fish diverted through screening facilities can be assessed only if the predation rate for fish passing through a screening facility is compared to predation rates in the river.

Fish were not "flushed" from the screen forebays; however, fish successfully passed through the fish bypass of their own volition. The potential impact of migration delay at screening facilities can be assessed only when migration timing through the facilities is compared to migration timing in the river.

Tests to evaluate screen integrity should retain high priority. The screen integrity tests we completed at the Toppenish Creek. Sunnyside, Wapato. Yestside, and Town screens indicate that screen seals play a vital role in preventing fish from entering the irrigation canal. Annual inspection and replacement of screen seals might reduce losses. and a new seal design may be necessary if the present loss rate is not acceptable.

Concerns over screen mesh size and early-season operations must be addressed at screening facilities downstream of major spawning areas in the Yakina River Basin to minimize loss of emergent salmonids. The 3.2-mm (l/8-in.) screen mesh may be too coarse to provide protection to smaller salmonid fry. As fish runs are introduced and enhanced in the tributaries

and mainstem of the Yakima River, the protection of emergent salmonid fry will likely become a more widespread concern.

Optimal flow for fish passage through bypass systems is contingent on proper maintenance of flow through head gates. flow control gates. fish return pipes. and other bypass structures. Operating criteria were established to maximize bypass efficiency and to protect fish that move through the system. It is imperative that the operating criteria are met at each facility, especially when major fish movements are occurring at the diversions. Operating criteria should cover all operating conditions for each facility. Facility structures (such as water elevation markers) must be installed at all facilities so that site maintenance personnel can make the adjustments specified in the operating criteria to provide optimal fish passage conditions.

The fish bypass system at each screening facility should be thoroughly checked and calibrated at the beginning of each irrigation season. Operating criteria should stress that flow through the fish bypass is very important in achieving effective fish return to the river.

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APPENDIX A

WORK PLAN

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WORK PLAN

The work plan for all BPA funded screen evaluations includes four phases. Phases I through III are mark/release studies to determine changes in fish condition and transit time through the screen facilities. Phase IV is a monitoring study to determine presence of predators near the screen facilities. passage through the diversions into the canals, and arrival times at the screen facilities for migrating populations of fish.

The work plan addresses a generic facility (i.e., head gates, trash rack, screens. fish-water-pumpback system, separation chamber, and fish return pipe). Some of the facility components may be different or not used at a given facility: however. the four-phase concept will be applied as much as possible. Additionally, it is not always possible to implement all phases at all sites. The most important data needed to evaluate a specific screen site are determined by the fisheries management agencies in the Yakima Basin. This decision then determines the phase of the work plan to be implemented first at a site.

PHASE I

Phase I tests are conducted to determine the condition of fish after passage through the fish diversion components of the screen facility. Phase I is accomplished by releasing branded fish at the entry to the fish bypass system. Released fish are collected near the terminus of the fish return pipe. The percentage of descaling. the number of fish killed (both immediately and after 4 days). and the rates and extent of injuries are recorded.

Several collection systems are considered, including a net at the terminus of the primary fish return pipe and a modified inclined plane or net near the terminus of the diversion system. The collection system is chosen after a site-specific evaluation of the screen facility. Collection systems are tested to determine their effectiveness and to make sure collected fish are not being injured or stressed by the system. These tests are conducted by releasing fish in and near the collection system. Efficiency and handling tests are conducted throughout the evaluation tests.

Collection of released fish begins immediately on release. Collection duration and interval varies with the site and the test objective. Where the primary objective is to estimate the proportion of the released fish that are killed or descaled, we fish until we get a 95% confidence interval estimate that is acceptable. When we are estimating the travel time through a component of the screen facility. we use a similar criterion for

developing a sample duration. Samples are collected continuously, if possible, during the first 24 to 48 h after release. If a higher catch total is required after 48 h, collection will be made to the period of highest probable catch for the next 48 h.

A hypothesis as to the fate of the noncollected fish for each release will be developed on the basis of the catch efficiency data that we collect during the control tests. the duration of the sample effort, and data from replicate tests when available.

Expected results from Phase I data include 1) the percentage of fish that are killed or descaled during passage through the fish bypass system in the screen diversion. 2) the change in condition for the fish that survive passage through the bypass. 3) a hypothesis as to the fate of the noncollected fish. 4) the potential effects of sampling equipment, and 5) the handling effects of the mark. release. and capture techniques.

PHASE II

Phase II tests are conducted to determine the condition of fish after passage from upstream of the trash racks through the bypass system (Phase IIa) or after passage through individual fish passage components of the screen facility (Phase IIb). The choice of which test to use depends on whether or not fish are killed or injured during Phase I. If there are no mortalities or injuries after passage through the bypass system during Phase I, Phase IIa follows Phase I. If there are mortalities or injuries during Phase I. Phase IIb follows Phase I.

P h a s e .

If no effect is observed in Phase I. the condition of fish that pass through the screen facility (from upstream of the trash racks through the bypass1 is determined. The species tested is the same as used in Phase I. if possible.

Fish are released at the trash rack. Fish are collected at the terminus of the fish return pipe. The percent descaling. the number killed (immediately and after 4 days). and the rates and extent of injuries are noted. Releases are made in and near the collection system to determine collection efficiency and handling effects.

Study objectives addressed are 1) the condition of fish that enter the headworks of the canal and are subsequently returned to the river through the primary fish return pipe and 2) transit time from the trash racks to the river discharge.

Expected results from these data include 1) the change in condition for fish that pass through the entire fish diversion and are returned to the

river. 2) a hypothesis as to the fate of noncollected fish, 3) the transit time for fish through the facility. and 4) collection efficiency and handling effects.

Phase II&.

If an effect is observed in Phase I. the condition of fish that pass through individual components of the fish bypass system. including the intermediate bypass pipe. the secondary separation chamber. the traveling screens, and the primary fish return pipe. will be determined. The species tested are the same as used in Phase I. if possible. The number released are determined by using the same criteria used in Phase I.

Fish are released in individual components of the bypass system. The fish are collected at the terminus of the component or at the terminus of the primary fish return pipe, depending on the data needed and the possibility of sampling within the component.

Study objectives addressed are condition of fish at the discharge. condition of fish through the bypass and secondary separation chamber. transit time across the facility, and transit time through the secondary separation chamber.

Expected results from these data include identification of 1) a hypothesis as to the fate of noncollected fish, 2) the bypass components that adversely affect the condition of fish passing through the fish screen facility, and 3) possible changes to the screen facility to reduce identified effects.

PHASE III

Phase III tests are conducted to determine screen operating conditions and canal flow changes that may affect the efficiency of the screens. The test design. test organisms. and most study objectives are the same as those in Phases I and IIa. Study objectives addressed are operational conditions that maximize screen efficiency, effectiveness of the screens over a range of flows, and factors that affect fish transit time through the facilities.

Expected results from these data include 1) determination of any change in the effectiveness of the facility over a range of canal flows, and 2) examination of factors that may change the transit time through the facility.

PHASE IV

Phase IV monitoring is conducted to determine if piscivorous predators are present near the screen facility and if fish can pass through or over the screen facility into the canal.

Phase IV has two parts: both are monitoring studies. Phase IVa is designed to examine presence and temporal distribution of predators near the screens. and Phase IVb is designed to examine rates of impingement on the screens.

Phase IVa

Phase IVa includes use of an inclined plane, fyke nets, beach seines, or electroshocker to monitor presence and temporal distribution of natural fish populations in the area of the facility. Proposed locations for monitoring are downstream of the headworks. in the canal downstream of the facility. and in the river downstream of the discharge.

The collection equipment are used at predesignated times. Sample duration is determined by consultation with BPA and Yakima Basin fisheries agencies and the priority of the Phase IV work. Phase IVa monitoring at the inclined plane continues during every mark/release test. The presence and quantity of any predators are noted.

Study objectives addressed are the presence of fish populations near the facility and fish passage through the facility.

Expected results from these data include 1) a qualitative determination of the fish predator populations in the area of the facility, 2) an evaluation of effectiveness of the screens in keeping fish from entering the canal downstream of the screens. and 3) the arrival time at the screen facility for salmonid populations.

P h a s e .

Phase IVb monitoring examines the rotating screens and the vertical traveling screens.

If necessary. Phase IVb objectives may be met with a task other than monitoring. For example. marked fish may have to be released in front of the screens, and subsequent monitoring behind the screens will indicate whether or not fish are able enter the canal through or over the screens.

The study objective is to address the rates of impingement on the rotating and traveling screens.

Expected results from these data include 1) the rate of impingement on the rotating screens. 2) the rate of impingement on the traveling screens. and 3) the operational conditions that result in increased impingement.

This task will not be necessary if impingement does not occur during operation of the facility. This is evaluated during Phase I and II.

APPENDIX B

RELEASE AND CAPTURE DATA FROM SUNNYSIDE, RICHLAND TOPPENISH/SATUS, WAPATO TOPPENISH CREEK, WESTSIDE DITCH, AND TOWN CANAL FISH SCREENING FACILITIES

APPENDIX B

RELEASE AND CAPTURE DATA FROM SUNNYSIDE RICHLAND. TOPPENISH/SATUS WAPATO TOPPENISH CREEK. WE$TSIDE DITCH. AND TOWN CANAL FISH SCREENING FACILITIES

This appendix contains data collected during 1985 through 1989 at Sunnyside (Neitzel et al. 1985. 1990a). Richland (Neitzel et al. 1986. 1988) Toppenish/Satus (Neitzel et al. 1986). Yapato (Neitzel et al. 1988: 1990a. 1990b). Toppenish Creek (Neitzel et al. 1990a). and Westside Ditch (Neitzel et al. 1990b) fish screening facilities. Additionally, the data collected during 1990 at Yestside and Town screens are presented. Data presented in the Results section are sometimes combined (i.e., individual trials within a test series were combined for a single estimate). In this appendix, we present the data from each of the individual trials that were conducted. Descaled fish were considered as dead for the estimates presented here. as they were in the Results sections of each of the annual reports. Dead and descaled fish were also combined to evaluate screen performance.

Data from the Sunnyside Screens are presented in Tables B-1 through B-11. Data from the 1985 evaluation (Neitzel et al. 1985) are presented in Tables B.1 through B.7. Fish are safely diverted from the canal to the river. The data in Tables B.1 and B.2 are evaluations of the inclined plane and fyke net. Both samplers collected fish without killing or descaling the fish. Data in Tables B.3 and B.4 are evaluations of the condition of test fish before release in the canal or screen facility. Test fish were in good condition before their release. Data in Tables 8.5 and 8.6 are the results of the screening facility evaluations. Descaling data from upriver hatchery-released and native fish are presented in Table 8.7.

Data from the 1988 evaluation (Neitzel et al. 1990a) are presented in Tables B.8 through B-11. Data in Table 8.8 are the estimated times for test fish to move through the Sunnyside Screens during integrity tests. The integrity tests, presented in Tables B.9 through B.11 indicate that less than 2% of test fish pass through or over the screens.

Data from the Richland Screens evaluations (Neitzel et al. 1986. 1988) indicate that fish are safely diverted from the canal to the river. Data from the 1986 evaluation (Neitzel et al. 1986) are presented in Tables B.12 through B.19. Data in Tables B.12 and B.13 are the evaluations of the inclined plane and the fyke net. The inclined plane safely collected fish. The fyke net descaled too many fish to be used as an effective collection device at the terminus of the Richland Canal fish return pipe during flows of 0.6 m^3/sec (20 cfs). Therefore, we used an electroshocker to collect fish during the evaluation of the fish return pipe. Data in Tables 8.14 and B.15 are evaluations of the condition of the test fish before their release into the canal. Fish were in good condition before release. Data

in Tables B.16 and B.17 are the results of screening facility evaluations. Data in Table B.18 are the estimated times for test fish to move through the Richland Screens. Descaling data from upriver hatchery and native fish are presented in Table B.19.

Data from the 1987 tests (Neitzel et al. 1988) are presented in Tables B.20 and B.21. Table B.20 presents descaling data for hatchery-released and native salmonids. Table B.21 summarizes the screen integrity data. No test fish passed through the Richland Screens.

Data from the Toppenish/Satus Screens evaluation (Neitzel et al. 1986) indicate that fish are safely diverted from the canal to the river. Data are presented in Tables B.22 through B.25. Data in Table B.22 are evaluations of the condition of the test fish before release in the canal. The fish were in marginal condition before testing. The water temperature at the canal during testing was near 20°C: therefore. we acclimated the test fish to near 20°C. The scales were loose on the test fish. and many of them became descaled during acclimation and transport: however. the test data are useful. The condition of the test fish as a population was not degraded by passage through the screen diversion. This conclusion is based on the change of condition between test and control populations. Data in Table B.23 are the results of screening facility evaluations. Data in Table B.24 are the estimated times for test fish to move through the Toppenish/Satus Screens. Descaling data from upriver hatchery-released and native fish are presented in Table B.25.

Data from the Yapato Screens evaluation (Neitzel et al. 1988. 1990a. 1990b) are presented in Tables B.26 through B.41. Tests performed in 1987 (Neitzel et al. 1988). presented in Tables B.26 through B.36 indicate that fish are safely diverted from the canal to the river. The evaluation of the potential for screen passage at Wapato indicates that few fish pass through and over the screens: the estimated number based on tests with fall chinook salmon fry is less than 2%. Data in Table B.26 are from the evaluation of the inclined plane used to capture fish at the Yapato Screens. Data in Table B.27 and B.28 are evaluations of the condition of the test fish before release in the canal. Fish were in good condition before release. Data in Tables B.29 and B.30 are the results of the screening facility evaluations. Table B.31 presents the descaling data collected from upriver native and hatchery-released salmonids captured during the evaluation tests. Table B.32 presents data from a test of the fish return pipe at the Yapato Screens. Table B.33 estimates the migration time through the screening facility for test fish. Tables B.34 through B.36 summarize screen integrity tests. Table B.34 estimates the capture efficiencies of our sampling devices.

Data from screen integrity tests performed in 1988 (Neitzel et al. 199Da) are presented in Tables B.37 through B.40. The results of pipe tests performed in 1989 (Neitzel et al. 1990b) are presented in Table B.41.

Data from the Toppenish Creek Screens (Neitzel et al. 1990a) indicate that fish are safely diverted from the canal to the river. Data are presented in Tables B.42 through B.49. The data in Tables B.42 and B.49 represent evaluation of the inclined plane. The plane collected fish without killing or descaling the fish. Data in Table B.43 are evaluations of the condition of test fish before release in the canal or screening facility. Test fish were in good condition before their release. The data for the descaling evaluations are in Tables B.44 and B.47. Data in Tables B.45 and B.46 are the estimated times for test fish to move through the Toppenish Creek Screens. Data in Table B.48 are the results of the screen integrity evaluations. The screen integrity tests indicate that less than 1% of test fish pass through or over the screens.

Data from Yestside Screens (Neitzel et al. 1990b) indicate that fish are not descaled at the screen facility. Zero-age chinook salmon can pass through. over. or around the screens. Data are presented in Tables B.50 through B.56. The data for the descaling evaluations are in Table B.50 Data in Table B.51 are the estimated times for test fish to move through Uestside Ditch. Data in Tables B.52 through B.54 are the results of the screen integrity evaluation in 1989. and Tables B.55 and B.56 are the results of the screen integrity evaluation in 1990.

Data from Town Screens indicate that fish are not descaled at the screen facility. Zero-age chinook salmon can pass through. over, or around the screens. Data are presented in Tables B.57 through B.60. The data for the descaling evaluations are in Table B.57. Data in Table B.58 are the estimated times for test fish to move through Town Screens. Data in Tables B.59 and B.60 are the results of the screen integrity evaluation.

TABLE B.1 Percentage of Coho Salmon *Oncorhynchus kisutch* Smolts Descaled or Killed During Tests of the Inclined Plane at the Sunnyside Canal Fish Screening Facility. Spring 1985

Test Replicate	Number of Fish Placed on Plane	Captured	Descaled or Killed	Percent Descaled or Killed	95% Confidence Interval
1	10	7	D	D	O-41.0
2	10	9	0	0	D-33.6
3	10	10	0	0	O-30.8
4	10	10	0	0	O-30.8
5	10	10	0	0	O-30.8
6	10	8	0	0	D-37.0
7	10	10	0	D	O-30.8
8	10	10	0	0	D-30.8
Total	80	74	0	0	O-4.8

TABLE B.2 Percentage of Steelhead *Oncorhynchus mykiss* and Chinook Salmon *0. tshawytscha* Smolt Descaled or Killed During Tests of the Fyke Net at the Sunnyside Canal Fish Screening Facility. Spring 1985

Species & Test Replicate	Number of Fish Placed on Plane	Captured	Descaled or Killed	Percent Descaled or Killed	95% Confidence Interval
Steelhead 1	50	8	0	D	O-36.0
Steelhead 2	50	28	0	0	O-12.3
Steelhead 3	55	21	0	0	O-16.1
Total	155	57	0	0	O-6.3
Chinook Salmon 1	50	21	0	0	D-16.1

TABLE B.3 Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled Before Being Used in Tests at the Sunnyside Canal Fish Screening Facility, Spring 1985

Test Site	Number of Fish Evaluated	Number of Fish Descaled	Percent Descaled	95% Confidence Interval
Intermediate Bypass	24	0	0	0-14.3
Terminal Bypass	13	0	0	0-24.7
Trash Rack	19	0	0	0-17.7
Canal Head Gates	20	0	0	0-16.8

TABLE B.4 Percentage of Chinook Salmon *Oncorhynchus tshawytscha* Smolts Descaled Before Being Used in Tests at the Sunnyside Canal Fish Screening Facility. Spring 1985

Test Site	Number of Fish Evaluated	Number of Fish Descaled	Percent Descaled	95% Confidence Interval
Primary Fish Return Pipe	36	0	0	o-9.7
Intermediate Bypass	20	0	0	O-16.8
Terminal Bypass	20	0	0	O-16.8
Trash Rack	20	0	0	O-16.8
Canal Head Gates	32	D	0	o-9.7

TABLE B.5 Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled or Killed in Each Test at the Sunnyside Canal Fish Screening Facility. Spring 1985

Release Site	Test Replicate	Number of Fish Released	Number of Fish Captured	Number of Fish Descaled Or Killed	Percent Descaled Or Killed	95% Confidence Interval
Primary Fish Return Pipe	1	50	8	0	0	D-36.8
	2	50	16	0	0	O-20.6
	3	72	6	0	D	0-45.9
Intermediate Bypass	1	275	139	0	0	O-2.6
Terminal Bypass	1	200	112	0	0	O-3.2
Trash Rack	1	500	126	0	0	0-2.9
Canal Head Gates	1	500	100	0	0	O-3.6

TABLE B.6. Percentage of Chinook Salmon *Oncorhynchus tshawytscha* Smolts Descaled or Killed in Each Test at the Sunnyside Canal Fish Screening Facility. Spring 1985

Release Site	Test Replicate	Number of Fish			Percent Descaled Or Killed	95% Confidence Interval
		Released	Captured	Descaled Or Killed		
Primary Fish Return Pipe	1	100	83	0	0	0.0-4.4
	2	100	64	2	3.1	0.4-10.8
	3	100	75	0	0	0.0-4.8
	4	100	60	1	1.7	0.0-8.9
	5	100	89	D	D	0-0-4.1
Intermediate Bypass	1	100	82	2	2.4	0.3-8.5
	2	100	95	D	0	0.0-3.8
	3	100	99	0	D	0.0-3.7
	4	100	95	2	2.1	0.3-7.4
	5	100	97	D	D	0.0-3.7
Terminal Bypass	1	100	98	2	2	0.3-7.2
	2	100	96	1	1	0.0-5.7
	3	100	98	0	0	0.0-3.7
	4	100	98	3	3.1	D-6-8.7
	5	92	86	1	1.2	D-O-6.3
Trash Rack	1	1000	856	20	2.3	1.4-3.6
Canal Head Gates	1	1000	729	6	0.8	0.2-1.6
	2	1000	725	21	2.9	2.0-4.7

TABLE B.7 Scale Loss for Hatchery-Released and Native Fish Captured During Tests at the Sunnyside Canal Fish Screening Facility, Spring 1985

Species	Number of Fish Captured	Number of Fish Descaled Or Killed	Percent Descaled Or Killed	95% Confidence Interval
Chinook Salmon	214	9	4.2	2.0-7.7
Steelhead	36	1	2.8	0.2-14.7

TABLE B.8 Estimated Time to Capture 50% of Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released in Integrity Tests at the Sunnyside Canal Fish Screening Facility, Spring 1988

Test Group	Number Released	Number Caught	Percent Caught	Time (h) to Catch 50%
1	1045	746	71.4	1.0
2	1047	791	75.5	1.0
3	1047	891	85.1	<0.5
4	1047	845	80.7	<0.5

TABLE B.9. Capture Data for Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released During Integrity Tests at the Sunnyside Canal Fish Screening Facility, Spring 1988

Test Group	Screen Number	Number of Control Fish				Number of Test Fish			
		Released	Captured	Released	Captured		Captured In		
		Fyke Net		Plane		Released	Plane	Fyke Net	Other
1	5	100	98	100	75	1045	746	9	0
1	6	100	95	-	-	-	-	1	0
1	7	100	88	-	-	-	-	18	3
1	8	100	82	-	-		-	3	0
2	5	100	93	100	80	1047	791	2	0
2	6	100	94	-	-	-	-	0	0
2	7	100	95	-	-	-	-	6	0
2	8	100	73	-	-		-	3	0
3	13	100	62	100	75	1047	891	2	4
3	14	100	60	-	-	-	-	0	0
3	15	100	78	-	-	-	-	3	0
3	16	100	75	-	-	-	-	7	5
4	14	100	76	100	87	1047	845	0	0
4	15	100	81	-	-	-	-	0	0
4	16	100	83	-	-	-	-	1	0
4	17	99	77	-	-	-	-	5	0
Total		1599	1310	400	317	4186	3273	60	12

TABLE B.10 Capture Efficiency of the Inclined Plane and Fyke Nets Used During Integrity Tests at the Sunnyside Canal Fish Screening Facility. Spring 1986

Screen Section(a)	Probability Estimate			95% Confidence Interval
	Plane Capture	Net Capture	Screen Efficiency	
3-8 (Test 1)	0.750	0.908	0.967	0.96-0.98
3-8 (Test 2)	0.800	0.888	0.988	0.98-1.00
3-8	0.775	0.898	0.977	0.97-0-98
9-17 (Test 3)	0.750	0.688	0.986	0.98-1.00
9-17 (Test 4)	0.870	0.794	0.992	0.99-1.00
9-17	0.810	0.741	0.989	0.98-0.99
3-17	0.793	0.819	0.983	0.98-0.99

(a) The screens are numbered from the upstream screen (Number 1) to the downstream screen nearest the separation chamber (Number 17). Screens 1 and 2 are permanently out of service.

TABLE B.11 Capture Data from Fyke Nets Behind Selected Screens at the Sunnyside Canal Fish Screening Facility After the Release of Fall Chinook Salmon *Oncorhynchus tshawytscha* Fingerlings from the Yapato Screens Forebay. Spring 1988

Screen Number	Net(a)	Fyke Net Captures	
		YIN Fish	Other Salmonids(b)
7	A	2	2
7	B	0	0
8	A	26	2
8	B	157	5
Total		185	9

(a) Net A is the top net. Net B is the bottom net.
(b) Includes smolt-sized and zero-age salmonids.

TABLE B.12 Percentage of Chinook Salmon *Oncorhynchus tshawytscha* Smolts Descaled or Killed During Tests of the Inclined Plane at the Richland Canal Fish Screening Facility, Spring 1986

Species	Test Replicate	Number of Fish Released	Captured	Descaled Or Killed	Percent Descaled Or Killed	95% Confidence Interval
Spring	1	25	21	0	0	0-16.1
	Control		19	0	0	0-17.7
Fall	1	25	16	0	0	0-20.6
	Control		20	0	0	0-16.8
	2	500	156	0	0	0- 2.3

TABLE B.13 Percentage of Chinook Salmon *Oncorhynchus tshawytscha* Smolts Descaled or Killed During Tests of the Fyke Net at the Richland Canal Fish Screening Facility, Spring 1986

Test Replicate	Number of Fish Released	Captured	Descaled Or Killed	Percent Descaled Or Killed	95% Confidence Interval
l-L[(a)]	50	26	0	0	0.0-13-2
L-control	50	50	0	D	0.0- 7.1
l-H[(b)]	9 0	75	14	18.7	10.6-29.3
H-control	50	42	17	40.5	25.6-56.7

(a) The L designation indicates tests at 0.6 m^3/sec flow through the fish return pipe.
(b) The H designation indicates tests at 1.6 m^3/sec flow through the fish return pipe.

TABLE B.14. Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled Before Being Used in Tests at the Richland Canal Fish Screening Facility, Spring 1986

Test Replicate	Number of Fish Released	Captured	Descaled Or Killed	Percent Descaled Or Killed	95% Confidence Interval
1	100	100	0	0	0-3.6
2	100	100	0	0	O-3.6
3	101	101	1	1	0-5.4
Total	301	301	1	0.3	O-l.8

TABLE B.14 Percentage of Chinook Salmon *Oncorhynchus tshswytscha* Smolts Descaled Before Being Used in Tests at the Richland Canal Fish Screening Facility, Spring 1986

Test Replicate	Number of Fish Released	Captured	Descaled Or Killed	Percent Descaled Or Killed	95% Confidence Interval
1	100	100	D	0	O-3.6
2	100	100	0	0	O-3.6
	102	102	0	0	0-3.6
Total	302	302	0	0	o-1.2

TABLE B.15 Descaling and Mortality Data from Release and Capture Tests with Steelhead *Oncorhynchus mykiss* Smolts at the Richland Canal Fish Screening Facility. Spring 1986

Test Replicate	Number of Fish Released	Captured	Descaled Or Killed	Percent Descal ed Or Killed	95% Confidence Interval
1	200	129	1	0.8	0.2-4-Z
2	200	132	2	1.5	0.2-5.4
3	200	102	1	1.1	0.3-2.8
Total	600	363	4	1.1	0.3-2-8

TABLE B.17 Descaling and Mortality Data from Release and Capture Tests with Spring Chinook Salmon *Oncorhynchus tshawytscha* Smolts at the Richland Canal Fish Screening Facility, Spring 1986

Test Site	Capture Method	Flow (m^3/sec)	Flow (cfs)	Number of Fish Released	Number of Fish Captured	Descaled Or Killed	Percent Descaled Or Killed	95% Confidence Interval
Pipe	Fyke[a]	0.3	10	90	58	2	3.5	0.4 -11.9
Pipe	Fyke	0.3	10	90	37	1	2.7	0.1 -14.2
Pipe	Fyke	0.3	10	90	29	0	0.0	0.0 -12.0
TOTAL				**270**	**124**		**2.4**	**0.5 - 6.9**
Pipe	Fyke	0.6	10	90	75	14	18.7	10.6 -29.3
Pipe	E.S.[b]	0.3	10	110	107	2	1.9	0.2 - 6.6
Pipe	E.S.	0.6	10	210	106	0	0.0	0.0 - 3.4
Trash Rack				200	186	2	1.1	0.1 - 3.8
Trash Rack				200	189	2	1.1	0.1 - 3.8
Total				600	560	4	0.7	0.2 - 1.8

(a) Fyke net.
(b) Electroshocker.

TABLE B.18 Estimated Time to Catch 50% and 95% of Test Fish Captured at the Richland Canal Fish Screening Facility. Spring 1986

Species	Group	Time (h) to Catch 50%	Time (h) to Catch 90%	Number of Fish Released	Number of Fish Captured	Percent Captured
Steelhead	1	18.0	52.5	200	129	64.5
Steelhead	2	21.0	48.0	200	134	67.0
Steelhead	3	29.0	54.5	200	102	51.0
Spring Chinook	1	0.5	6.5	200	186	93.0
Spring Chinook	2	1.0	5.0	200	188	94.0
Spring Chinook	3	1.0	3.5	200	185	92.5
Fall Chinook	1	9.5	34.5	1000	638	63.8
Fall Chinook	2	8.5	32.0	1150	682	59.3
Fall Chinook	3	7.0	31.0	1150	809	70.3

TABLE B.19 Scale Loss for Hatchery-Released and Native Fish Captured During Tests at the Richland Canal Fish Screening Facility, Spring 1986

Species	Number of Fish Captured	Number of Fish Descaled Or Killed	Percent Descaled Or Killed	95% Confidence Interval
Chinook Salmon[a]	64	3	4.7	1.0-11.0
Coho Salmon	17	3	17.7	3.8-48-O
Steelhead	51	3	5.9	1.3-18.9

(a) Primarily spring chinook salmon (>10 cm FL) but including some fall chinook salmon (<10 cm FL).

TABLE B.20 Scale Loss for Hatchery-Released and Native Salmonids Captured During Tests at the Richland Canal Fish Screening Facility, Spring 1987

Species	Number Caught	Number Descaled	Percent Descaled	95% Confidence Interval
Steelhead	11	D	0.0	O-28.5
Spring Chinook	28	0	0.0	O-12.3
Fall Chinook	44	--(a)	--(a)	--(a)

(a) Not evaluated for descaling.

TABLE B.21 Capture Data for Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released at the Richland Canal Fish Screening Facility, Spring 1987

Test Group	Number Released	Release Site	Hours Sampled	Sampling Method			% Captured in	
				Plane	Fyke Net	Shocker	Bypass	Canal
1	1008	Front	42.2	490	0	0	48.6	0
2	1004	Front	39.8	462	0	0	46.0	0
3	1009	Front	37.8	444	0	0	44.0	0
Total	3021			1396	0	0	46.2	0
4	1001	Behind	93.7	0	584	17	0	60.0
5	1010	Behind	91.2	0	550	39	0	58.3
6	1010	Behind	89.2	0	609	45	0	64.8
Total	**3021**			**0**	**1743**	**101**	**0**	**61.0**

TABLE B.22 Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled Before Being Used in Tests at the Toppenish/Satus Canal Fish Screening Facility, Spring 1986

Test Replicate	Number of Fish			Percent Descaled Or Killed	95% Confidence Interval
	Released	Captured	Descaled Or Killed		
1	103	103	37	35.9	26.7-46.0
2	103	103	29	28.2	19.7-37.9
3	105	105	16	15.2	22.0-32.9
Total	311	311	82	26.4	22-0-32.9

TABLE B.23 Descaling and Mortality Data from Release and Capture Tests with Steelhead *Oncorhynchus mykiss* Smolts at the Toppenish/Satus Canal Fish Screening Facility. Spring 1986

Test Replicate	Number of Fish			Percent Descaled Or Killed	95% Confidence Interval
	Released	Captured	Descaled Or Killed		
1	520	462	120	26.0	23.1-31.3
2	520	463	102	22.0	19.4-27.1
3	520	463	40	8.6	6.2-11.6
Total	1560	1388	262	18.9	17.4-21.6

Table B.24 Estimated Time to Catch 50% and 95% of Test Fish Captured at the Toppenish/Satus Canal Fish Screening Facility. Spring 1986

Species	Group	Time (h) to Catch 50%	Time (h) to Catch 95%	Number of Fish Released	Number of Fish Captured	Percent Captured
Steelhead	1	12.5	41.0	520	462	88.8
Steelhead	2	12	46.5	520	464	89.2
Steelhead	3	10	42.5	520	463	89.0
Spring Chinook	1	0.5	1.5	360	356	98.9
Spring Chinook	2	0.5	1.5	335	329	98.2
Spring Chinook	3	0.5	1.5	335	314	93.7
Fall Chinook	1	0.5	0.5	1000	728	72.8
Fall Chinook	2	0.5	0.5	1000	702	70.2
Fall Chinook	3	0.5	0.5	460	330	71.7

TABLE B.25 Scale Loss for Hatchery-Released and Native Fish Captured During Tests at the Toppenish/Satus Canal Fish Screening Facility. Spring 1986

Species	Number of Fish Captured	Number of Fish Descaled Or Killed	Percent Descaled Or Killed	95% Confidence Interval
Steelhead (l-age)	20	0	0	O-O-16.8
Steelhead (O-age)	69	0	0	0.0-05.2
Coho Salmon (l-age)	29	0	0	0.0-12.0
Chinook Salmon	25	1	4	0.1-20.4

TABLE B.26 Percentage of Spring Chinook Salmon *Oncorhynchus tshawytscha* and Steelhead *Oncorhynchus mykiss* Smolts Descaled or Killed During Tests of the Inclined Plane at the Yapato Canal Fish Screening Facility. Spring 1987

Species	Number of Fish Released	Number of Fish Captured	Descaled	Percent Descaled	95% Confidence Interval
Steelhead	10	9	0	0	0-33.6
Steelhead	10	9	0	0	0-33.6
Total	20	18	0	0	0-17.7
Spring Chinook	10	10	0	0	0-30.8
Spring Chinook	10	10	0	0	0-30.8
Total	20	20	0	0	0-16.8

TABLE B.27 Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled Before Being Used in Tests at the Yapato Canal Fish Screening Facility, Spring 1987

Test Replicate	Canal Flow (cfs)	Number of Fish Examined	Number of Fish Descaled	Percent Descaled	95% Confidence Interval
1	800	65	0	0	o-o-5.5
2	800	67	1	1.5	0.0-8.0
3	800	68	0	D	O-D-5.3
Total		**200**		**0.5**	**0.0-2.8**
1	2000	35	0	0	0.0-10.0
2	2000	32	0	0	0.0-10.9
3	2000	33	0	0	O-O-10.6
Total		100	0	0	0.0-3.6
1	2000	38	0	0	0.0-9.3
2	2000	36	0	0	0.0-9.7
3	2000	26	D	0	0.0-13.2
Total		**100**	**0**	**0**	**0.0-3.6**
Total		400	1	0.3	0.0-l-4

Table B.28 Percentage of Spring Chinook Salmon *Oncorhynchus tshawytscha* Smolts Descaled Before Being Used in Tests at the Yapato Canal Fish Screening Facility. Spring 1987

Test Replicate	Canal Flow (cfs)	Number of Fish Examined	Number of Fish Descaled	Percent Descaled	95% Confidence Interval
1	800	74	0	0	D-4.86
2	800	59	0	0	D-6.06
3	800	67	0	0	O-5.36
Total		200	0	0	D-l.83
1	2000	35	0	0	**0-10.00**
2	2000	35	D	0	O-10.00
3	2000	30	D	D	o-11.57
Total		100	0	0	D- 3.62
1	2000	33	0	0	O-10.58
2	2000	28	0	0	O-12.34
3	2000	39	0	0	o- 9.03
Total		**100**	**0**	**0**	**0- 3.62**
Total		400	0	0	O-D.92

TABLE B.29 Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled or Killed in Each Test at the Wapato Canal Fish Screening Facility, Spring 1987

Test Group	Canal Flow (cfs)	Release Time (h)	Number				Percent Descaled	95% Confidence Interval
			Released	Captured	Descaled	Dead		
1	800	NA	280	120	1	0	0.8	0.0-4.6
2	800	NA	278	127	2	0	1.6	0.2-5.6
3	800	NA	277	114	0	0	0.0	0.0-3.2
Total			835	361	3	0	0.8	0.2-2.4
1	2000	0800	145	134	2	1	2.2	0.5-6.4
2	2000	0800	148	138	0	2	1.5	0.2-5.1
3	2000	0800	147	126	0	2	1.6	0.2-5.6
Total			**440**	**398**			**1.8**	**0.7-3.6**
1	2000	1900	142	125	2	0	1.4	0.2-5.7
2	2000	1900	144	131	1	0	0.8	0.0-4.2
3	2000	1900	154	143	2	1	2.1	0.4-6.0
Total			**440**	**399**	**5**		**1.5**	**0.6-3.2**
Total			1715	1158	10	6	1.4	0.8-2.2

TABLE B.30 Percentage of Spring Chinook Salmon *Oncorhynchus tshawytscha* Smolts Descaled or Killed in Each Test at the Wapato Canal Fish Screening Facility, Spring 1987

Test Group	Canal Flow (cfs)	Release Time (h)	Number				Percent Descaled	95% Confidence Interval
			Released	Captured	Descaled	Dead		
1	800	NA	306	191	2	0	1.0	0.1-3.7
2	800	NA	321	192	5	0	2.6	0.9-6.0
3	800	NA	313	196	1	0	0.5	0.0-2.8
Total			**940**	**579**	**8**	**0**	**1.4**	**0.1-2.7**
1	2000	0800	155	151	0	0	0.0	0.0-2.4
2	2000	0800	155	147	0	0	0.0	0.0-2.5
3	2000	0800	160	158	2	0	1.3	0.2-4.5
Total			**470**	**456**		**0**	**0.4**	**0.1-1.6**
1	2000	1900	142	133	5	5	7.5	3.7-13.4
2	2000	1900	126	122	3	4	5.7	2.3-11.5
3	2000	1900	136	131	3	4	5.3	2.2-10.7
Total			**404**	**386**	**11**	**13**	**6.2**	**4.0-9.1**
Total			**1814**	**1421**	**21**	**13**	**2.4**	**1.7-3.3**

TABLE B.31 Scale Loss for Hatchery-Released and Native Salmonids Captured During Tests at the Wapato Canal Fish Screening Facility, Spring 1987

Species	Origin	Number			Percent Descaled	95% Confidence Interval
		Caught	Descaled	Dead		
Steelhead	Wild	147	6	0	4.1	1.5-8.7
Steelhead	Hatchery	51	11	D	21.6	11.3-35.3
Coho Salmon	Hatchery	34	4	0	11.8	3.3-27.5
Chinook Salmon	Wild	181	36	15	28.2	23.6-37.01
Chinook Salmon	Hatchery	70	10	8	25.7	16.0-37.6
Chinook Salmon	--(a)	146	3	0	2.1	0.4-5.9
Chinook Salmon	--(b)	397	49	23	18.1	15.5-23.4
Sockeye Salmon	Wild	1	0	0	0.0	--

(a) Chinook salmon collected during the 800-cfs flow at Wapato Screens.
(b) Totals for all one-age chinook salmon collected at Wapato Screens during 1987.

TABLE B.32 Percentage of Test Fish Descaled or Killed During Pipe Tests at the Wapato Canal Fish Screening Facility, Spring 1987

Species	Number Released	Number Captured	Number Descaled	Percent Descaled	95% Confidence Interval
Spring Chinook	150	135	8	5.9	2.6-11.3
Steelhead	100	65	1	1.5	0.0-5.5

TABLE B.33 Estimated Time to Capture 50% and 95% of the Test Fish Released at the Wapato Canal Fish Screening Facility, Spring 1987

Species	Canal Flow (cfs)	Release Time	Number Released	Time (h) To Catch 50%	Time (h) To Catch 95%	Number Caught	Time (h) To Catch 50%	Time (h) To Catch 95%
Steelhead	1040	0800	835	--(a)	--(b)	361	17.5	85.0
Steelhead	1700	0800	440	11.5	--(b)	403	11.5	12.5
Steelhead	1700	1900	440	0.5	--(b)	399	0.5	4.0
Spring Chinook	1040	0800	940	37.5	--(b)	579	10.5	86.0
Spring Chinook	1700	0800	470	2.0	11.0	456	2.0	11.0
Spring Chinook	1700	1900	404	<0.5	1.5	404	<0.5	0.5

(a) Less than 50% of the released fish captured.
(b) Less than 95% of the released fish captured.

TABLE B.34 Capture Efficiencies of the Inclined Plane and Nets and Retention Efficiency of the Fyke Nets Used in Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1987

Screen[a] Section	Capture Probability Estinate For			Screen Efficiency	95% Confidence Interval
	Inclined Plane	Net Capture	Net Retention		
1-5	0.94	0.33	0.55	0.972	0.96-0.99
6-10	0.98	0.45	0.72	0.996	0.99-1.00
11-15	0.95	0.93	0.97	0.950	0.94-0.96
1-15	0.95	0.57	0.78	0.962	0.96-0.97

(a) The screens are numbered from the upstream screen (Number 1) to the downstream screen nearest the separation chamber (Number 15).

TABLE B.35 Capture Data for Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released During Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1987

Test Group	Screen Number[a]	Number of Control Fish						Number of Test Fish			
		Released Fyke Net	Captured Cod End	Released Fyke Net	Captured Mouth	Bypass Released	Bypass Captured	Released	Captured In Plane	Captured In Fyke Net	Captured In Other
1	5	100	58	100	54	100	99	723	695	2	0
1	10	100	56	100	39	100	98	724	700	1	0
1	15	100	73	100	61	100	96	723	631	26[b]	0
2	13	100	97	100	92	100	93	1470	1278	6	0
2	14	100	97	100	98	--	--	--	--	14	1
2	15	100	119[c]	100	121[c]	--	--	--	--	39	38
3	3	50	24	100	22	100	88	1472	1311	3	0
3	4	50	21	100	23	--	--	--	--	0	0
3	5	50	34	100	33	--	--	--	--	6	0
4	8	50	35	100	58	100	97	1502	1396	0	0
4	9[d]	50	48	100	5	--	--	--	--	0	D
4	10	50	40	100	76	--	--	--	--	2	0
Total		900	702	1200	682	600	571	6614	6011	99[e]	39

(a) The screens were numbered from upstream (Number 1) to downstream (Number 15).
(b) Eleven (11) test fish from Test 1 were caught in the net during Test 2.
(c) Screen 15 was tested on two consecutive tests. Fish must have escaped from the net and been held inside the drum screen between tests.
(d) Screen 9 was not turning and was almost totally plugged. Fyke net was flaccid behind the screen.
(e) A total of 110 fish, if the 11 test fish released in Test 1 and caught in Test 2 are included.

TABLE B.36 Estimated Time to Capture 50% and 95% of Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released in Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1987

Test Group	Release Site	Number Released	Number Caught	Percent Caught	Time (h) To Catch 50%	Time (h) To Catch 95%
1	Upstream Bypass	100	99	99.0	<0.25[a]	<0.25
3	Upstream	100	88[b]	88.0	<0.50	1.00
1	Screen 5[c]	723	695	96.1	<0.25	1.25
3	Screen 3	1472	1311	89.1	0.50	6.00
1	Middle Bypass	100	98	98.0	<0.25	<0.25
4	Middle Bypass	100	97	97.0	<0.50	1.00
1	Screen 10	724	700	96.7	<0.25	0.75
4	Screen 8	1502	1396	92.9	<0.50	2.00
1	Downstream Bypass	100	96	96.0	<0.25	0.50
2	Downstream Bypass	100	93	93.0	<0.50	<0.50
1	Screen 15	723	631[d]	87.3	<0.50	5.00
2	Screen 13	1470	1278[d]	86.9	<0.50	1.50

(a) During Test 1, the plane was checked 10 min after release, and then on the half-hour. During Tests 2 through 4, the plane was checked only on the half-hour.
(b) An additional 5 fish were lost at the plane during collection.
(c) Screens were numbered from upstream (Number 1) to downstream (Number 15).
(d) Many fish were "lost" to passage over the top of screens.

TABLE B.37 Estimated Time to Capture 50% of Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released in Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1988

Test Group	Screens	Number Released	Number Captured	Percent Captured	Time (h) To Capture 50%
1	5	1044	775	74.2	6.5
1	10	1041	816	78.4	7.0
1	15	1042	535	51.3	7.5
2	13-15	1041	620	59.6	4.5
3	3-5	1028	675	65.7	0.5
4	15	1039	959	92.3	1.0

TABLE B.38. Capture Data for Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released During Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1988

Test Group	Screen Number	Number of Control Fish						Number of Test Fish			
		Released Fyke Net	Captured Cod End	Released Fyke Net Mouth	Captured	Released Plane	Captured	Released	Captured In Plane	Captured In Fyke Net	Captured In Other
1	5	50	35	100	68	100	85	1044	775	5	0
1	10	50	45	100	95	100	77	1041	816	2	0
1	15	50	39	100	87	100	71	1042	535	24	1
2	13	50	44	100	90	100	76	1041	620	2	0
2	14	50	46	100	90	-	-	-	-	0	0
2	15	50	49	100	97	-	-	-	-	4	41
3	3	50	47	100	78	100	76	1028	675	0	0
3	4	50	42	100	84	-	-	-	-	0	0
3	5	50	46	100	87	-	-	-	-	1	0
4	15	50	44	100	95	100	96	1039	959	5	1
Total		500	437	900	871	600	481	6235	4380	43	43

TABLE B.39 Capture Efficiency of the Inclined Plane and Nets and Retention Efficiency for Fyke Nets Used During Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1988

Screen Section(a)	Probability Estimate			Screen Efficiency	95% Confidence Interval
	Plane Capture	Net Capture	Net Retention		
1-5	0.805	0.793	0.850	0.995	0.99-1.00
6-10	0.770	0.950	0.900	0.998	0.99-1.00
11-15	0.810	0.918	0.888	0.984	0.98-0.99
15	0.960	0.950	0.880	0.994	0.99-1.00
1-15	0.802	0.968	0.874	0.991	0.99-1.00

(a) The screens are numbered from the upstream screen (Number 1) to the downstream screen nearest the separation chamber (Number 15).

TABLE B.40. Capture Data from Fyke Nets Behind Selected Screens at the Wapato Canal Fish Screening Facility After the Release of Fall Chinook Salmon *Oncorhynchus tshawytscha* From Net Pens in the Wapato Screen Forebay. Spring 1988

Screen	Net(a)	Fyke Net Captures	
		YIN Fish	Other Salmonids
13	A	(b)	(b)
13	B	1	0
14	A	1	0
14	B	3	1
15	A	37	2
15	**B**	**148**	
Total		190	4

(a) Net A mounted in the upstream half of the screen: Net B mounted in the downstream half of the screen bay.
(b) Cod end of net not secure: net contents lost.

TABLE B.41 Percentage of Spring Chinook Salmon *Oncorhynchus tshawytscha* Smolts Descaled in Pipe Tests at the Wapato Canal Fish Screening Facility. Spring 1989

Group	Number of Fish			Percent Descaled	95% Confidence Interval
	Released	Captured	Descaled		
1	50	(a)			
2	50	(a)	-	-	-
3	50	(a)			
Total	150	152(b)	0	0.00	- 0-2

(a) Groups of 50 fish were released at the head of the fish return pipe at 3- to 6-min intervals. Sampling at the end of the pipe was continuous: therefore. we were not able to determine capture or descaling rates for individual release groups.

(b) Two native chinook salmon were apparently captured that were indistinguishable from our test fish.

TABLE B.42. Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled or Killed in Tests of the Inclined Plane at the Toppenish Creek Canal Fish Screening Facility. Spring 1988

Test Replicate	Number of Fish			Percent Descaled	95% Confidence Interval
	Released	Captured	Descaled		
1	10	10	0	0.00	0-31
2	10	10	0	0.00	0-31
3	10	10	0	0.00	0-31
4	10	10	0	0.00	0-31
5	10	10	0	0.00	0-31
6	10	10	0	0.00	0-31
7	10	9	0	0.00	0-34
8	10	10	0	0.00	0-31
9	10	10	0	0.00	0-31
10	10	10	0	0.00	0-31
Total	100	99	0	0.00	0-4

TABLE B.43 Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled Before Being Used in Tests at the Toppenish Creek Canal Fish Screening Facility. Spring 1988

Test Replicate	Number of Fish		Percent Descaled	95% Confidence Interval
	Examined	Descaled		
1	70	0	0.00	0-5
2	70	0	0.00	0-5
3	70	0	0.00	0-5
Total	210	0	0.00	0-2

TABLE B.44 Descaling and Mortality Data from Release and Capture Tests with Steelhead *Oncorhynchus mykiss* Smolts at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

Canal Flow (cfs)	Number				Percent		95% Confidence Interval
	Released	Captured	Descaled	Dead	Captured	Descaled	
20	250	144	0	0	57.6	0.00	0-2
50	255	199	10	0	78.0	0.50	0-3
50	250	196	0	0	78.4	0.00	0-2
Total	755	539	1	0	71.4	0.19	0-1
Wild Fish		462	1	0		0.22	0-1

TABLE B.45 Estimated Time to Capture 50% of Steelhead *Oncorhynchus mykiss* Smolts Released in Descaling Tests at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

Canal Flow (cfs)	Number		Percent Captured	Time (h) to Capture 50%
	Released	Captured		
20	250	144	57.61[a]	39.0
50	255	199	78.0	16.0
50	250	196	78.4	14.0

(a) Inclined plane was removed for 2 h when canal flow was changed from 20 cfs to 50 cfs. Some fish from Test Group 1 may have moved out of the screen forebay during this period, which may have contributed to the lower percent caught for Test Group 1.

TABLE B.46 Estimated Time to Capture 50% of Rainbow Trout *Oncorhynchus mykiss* Fry Released in Integrity Tests at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

Test Group	Number Released	Number Captured	Percent Captured	Time (h) to Capture 50%
1	1024	868	84.8	4.0
2	1024	724	70.7	9.0
3	1025	781	76.2	4.0

TABLE B.47 Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled in Pipe Tests at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

Test Group	Number of Fish Released	Number of Fish Captured	Number of Fish Descaled	Percent Descaled	95% Confidence Interval
1	10	(a)	0	-	-
2	10		0	-	-
3	10		0	-	-
4	10		0	-	-
5	10		0	-	-
6	10		0	-	-
7	10		0	-	-
8	10		0	-	-
9	10		0	-	-
10	10		0	-	-
11	10		0	-	-
12	10		0	-	-
13	10		0		
Total	130	106	0	0.0	0-3

(a) Groups of 10 fish were released at the head of the fish return pipe every 3 to 6 min. We were not able to determine capture or descaling rates for individual release groups, because sampling at the end of the pipe was continuous.

TABLE B.48 Capture Data for Rainbow Trout *Oncorhynchus mykiss* Fry Released During Integrity Tests at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

Test Group	Screen Number	Number of Control Fish				Number of Test Fish			
		Released	Captured	Released	Captured		Captured In		
		Fyke Net		Plane		Released	Plane	Fyke Net	Other
1	1	100	36	100	100	1024	868	1	2
1	2	100	66	-	-	-	-	0	-
1	3	100	39	-	-	-	-	0	-
2	1	100	63	100	96	1024	724	1	0
2	2	100	54	-	-	-	-	0	-
2	3	100	58	-	-	-	-	3	-
3	1	100	80	100	100	1025	781	0	4
3	2	100	75	-	-	-	-	0	-
3	3	100	51	-	-	-	-	6	-
Total		900	522	300	296	3073	2373	11	6

TABLE B.49 Capture Efficiency of the Inclined Plane and Fyke Nets Used During Integrity Tests at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

Screen	Capture Probability Estimate		Screen Efficiency	95% Confidence Interval
	Inclined Plane	Fyke Net		
1	0.987	0.597	0.999	1.00-1.00
2	0.987	0.650	1.000	1.00-1.00
3	0.987	0.493	0.992	l-00-1.00
(a)	0.966	0.580	9.84	0.95-0.98
All Screens	0.987	0.580	0.991	0.99-1.00

(a) During the tests, 37 control fish placed in the fyke nets were caught on the inclined plane. Assuming the 37 fish were test fish that passed from the forebay to the area behind the screens. we calculated a "worst case" screen efficiency of 0.97 **(±0.015).**

TABLE B.50 Descaling and Mortality Data from Release and Capture Tests with Steelhead *Oncorhynchus mykiss* and Sprlng Chinook Salmon *0. tshawytscha* Smolts at the Westside Ditch Fish Screening Facility, Spring 1989

		Number				Percent		95% Confidence
Species	Group	Released	Captured	Descaled	Dead	Captured	Descaled	Interval
Steelhead	1	375	304	3	0	81.1	1.0	0-3
Steelhead	2	375	321	8	0	85.6	2.5	1-5
	Total	750	625	11	D	83.3	1.8	1-3
Chinook	1	375	371	0	0	98.9	0.0	1-0
Chinook	2	380	379	2	0	99.7	0.5	2-0
	Total	755	750	2	0	99.3	0.3	1-0
Rainbow	(Native)	-	16	0	0	-	0.00	0-21

TABLE B.51 Estimated Time to Capture 50% of Steelhead *Oncorhynchus mykiss* and Spring Chinook Salmon *0. tshswyacha* Smolts Released in Descaling Tests at the Yestside Ditch Fish Screening Facility, Spring 1989

Species	Group	Number Released	Number Captured	Percent Captured	Time (h) To Capture 50%
Steelhead	1	375	304	81.1	12.5
Steelhead	2	375	321	85.6	28.1
Chinook	1	375	371	98.9	3.3
Chinook	2	380	379	99.7	7.8

TABLE B.52. Capture Data for Rainbow Trout *Oncorhynchus mykiss* Fry Released During Screen Integrity Tests at the Westside Ditch Fish Screening Facility, Spring 1989

Test Group	Screen Number	Number of Control Fish				Number of Test Fish			
		Released	Captured	Released	Captured		Captured In		
		Fyke Net		Plane		Released	Plane	Fyke Net	Other
1	1-4	400	316	100	100	1047	140	6	5
2	1-4	800	448	100	99	1049	199	10	0
3	1-4	800	473	300	300	1047	169	6	6
Total		2000	1237	500	499	3143	508	22	11

TABLE B.53 Capture Data for Chinook Salmon *Oncorhynchus tshawytscha* Fry Caught During Integrity Tests at the Westside Ditch Fish Screening Facility, Spring 1989

		Catches	
	Screen	Fyke Net	Plane
Test 1	1	2	227
	2	9	
	3	14	
	4	9	
Total		34	227
Test 2	1	4	217
	2	14	
	3	16	
	4	16	
Total		50	217
Test 3	1	5	206
	2	8	
	3	23	
	4	13	
Total		49	206
Total Net 1		11	
Total Net 2		31	
Total Net 3		53	
Total Net 4		38	
Total		133	650

TABLE B.54. Capture Efficiency of the Inclined Plane and Fyke Nets Used During Integrity Tests at the Westside Ditch Fish Screening Facility. Spring 1989

Test	Capture Probability Estiamte		Screen Efficiency	95% Confidence Interval
	Inclined Plane	Fyke Net		
Rainbow Trout				
1	1.000	0.790	0.949	0.91-0.99
2	0.990	0.560	0.918	0.86-0-98
3	1.000	0.591	0.943	0.89-1.00
Total	0.998	0.619	0.935	0.90-0.97
Chinook Salmon				
1	1.000	0.790	0.841	0.79-0.89
2	0.990	0.560	0.711	0.65-0.78
3	1.000	0.591	0.713	0.65-0.78
Total	0.998	0.619	0.752	0-72-0.79

TABLE B.55. Capture Data for Rainbow Trout *Oncorhynchus mykiss* and Chinook Salmon *Oncorhynchus tshawytscha* Fry Caught During Integrity Tests at the Yestside Ditch Fish Screening Facility. Spring 1990

		Number of Control Fish		Chinook Salmon Captured	
	Screen	Released	Captured	Fyke Net	Plane
Test 1	1	100	54	0	71
	2	100	58	2	
	3	100	47	4	
	4	100	70	1	
	Total	400	229	7	71
Test 2	1	100	24	0	88
	2	100	30	4	
	3	100	30	3	
	4	100	63	1	
	Total	400	147	8	88
Test 3	1	100	22	2	77
	2	100	16	1	
	3	100	20	1	
	4	100	40	0	
	Total	400	100	4	77
Total	Screen 1	300	100	2	
Total	Screen 2	300	104	7	
Total	Screen 3	300	97	8	
Total	Screen 4	300	173	2	
Total		1200	474	19	236

TABLE B.56 Capture Efficiency of the Inclined Plane and Fyke Nets Used During Integrity Tests at the Yestside Ditch Fish Screening Facility. Spring 1990

	Capture Probability Estimate			95% Confidence
Test	Inclined Plane	Fyke Net	Screen Efficiency	Interval
1	1.000	0.573	0.853	0.97-0.74
2	1.000	0.368	0.802	0.96-0.64
3	1.000	0.245	0.825	1.00-0.57
Total	1.000	0.395	0.832	0.92-0.74

TABLE B.57. Descaling and Mortality Data from Release and Capture Tests with Steelhead *Oncorhynchus mykiss* Smolts at the Town Canal Fish Screening Facility, Spring 1990

Species	Group	Number				Percent		95% Confidence
		Released	Captured	Descaled	Dead	Captured	Descaled	Interval
Steelhead	1	350	214	1	0	61.1	0.5	0 - 3
Steelhead	2	350	127	0	0	36.3	0.0	0 - 3
	Total	700	341	1	0	48.7	0.3	0 - 2
Sockeye		-	14	0	0	-	0.0	0 - 21
Rainbow	(Native)	-	21	0	0	-	0.0	0 - 17

TABLE B.58. Estimated Time to Capture 50% of Steelhead *Oncorhynchus mykiss* Smolts Released in Descaling Tests at the Town Canal Fish Screening Facility. Spring 1990

Group	Number Released	Number Caught	Percent Caught	Time (h) To Catch 50%
1	350	214	61.1	12.0 (a)
2	349	127	36.4	

(a) 50% of test fish were not caught after 85 h.

TABLE B.58 Capture Data for Chinook Salmon *Oncorhynchus tshawytscha* Fry Caught During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990

Test	Screens Tested	Captured In Fyke Nets	Captured In Plane
1	6-10	0	85
2	6-10	4	125
	Total	4	210
3	1-5	10	69
4	1-5	1	32
	Total	11	101
	Four-Test Total	15	311

TABLE B.60. Capture Data for Rainbow Trout *Oncorhynchus mykiss* Fry Released During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990

Test Group	Screen Number	Number of Control Fish				Number of Test Fish			
		Released	Captured	Released	Captured		Captured In		
		Fyke Net		Plane		Released	Plane	Fyke Net	Other
1	6-10	500	13	100	100	1006	479	0	0
2	6-10	500	352	-	-	1007	474	0	4
3	1-5	500	373	100	95	1005	190	0	10
4	1-5	500	279	100	100	1006	66	0	1
Total		2000	1017	300	295	4024	1209	0	15

APPENDIX C

OPERATING CRITERIA FOR THE WESTSIDE DITCH AND TOWN CANAL FISH SCREENING FACILITIES

APPENDIX C

OPERATING CRITERIA FOR THE WESTSIDE DITCH AND TOWN CANAL FISH SCREENING FACILITIES

Appendix C contains the operating criteria for the two facilities we evaluated in 1990. The criteria were 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 fish bypass flows at each screening facility to achieve optimal fish passage conditions.

The operating criteria for the Yestside Screens are presented on pages C.2 and C.3 Text describing proper operation is on page C.2. and a drawing of the Yestside Screens showing the main components of the facility is on page C.3.

The operating criteria for the Town Screens are presented on pages C.4 and C.5. Text describing proper operation is on page C.4. and a drawing of the Town Screens showing the main components of the facility is on page C-5.

2/6/89

R. Pearce-NMFS

Operating Criteria for Yestside Canal
Fish Screens Bypass System

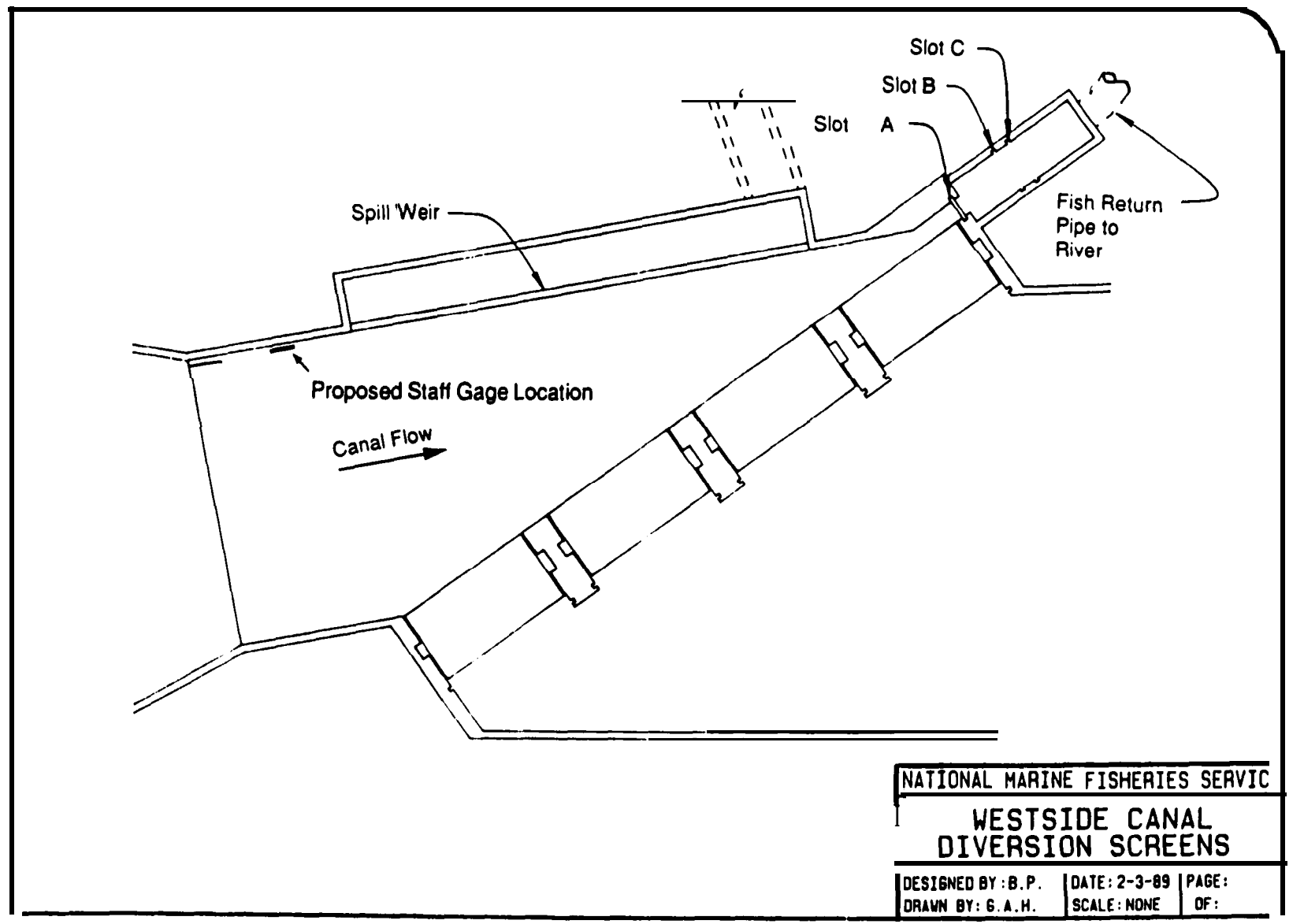
Operating of the bypass system requires adjustment of the stoplogs in slot A in the 18-inch wide fish bypass located at the downstream end of the screen drums. The stoplogs are to form an overflow weir. The top (or crest) elevation of the logs controls the quantity of flow through the bypass as required for good fish passage. Slots B and C have no stoplogs installed.

The top (or crest) elevation of the bypass stoplogs shall be set 2.0 to 2.25 feet lower than the canal water surface elevation in front of the drum screens. This setting will provide the normal required bypass flow of 15 cfs.

The canal water surface elevation in front of the drum screens should be maintained within a normal range of 1681.0 to 1681.6. For reference. the spill weir upstream of the drums which returns excess canal flow back to the river has a crest elevation of 1682.3.

The attached drawing shows a plan view of the facility with stoplog slot locations noted.

Note: When flood flows occur in the Yakima River the high river water level at the bypass outlet may result in reduction of the bypass flow below the desired 15 cfs.


Slot C
Slot B
Slot A
Spill Weir
Fish Return Pipe to River
Proposed Staff Gage Location
Canal Flow
NATIONAL MARINE FISHERIES SERVIC
WESTSIDE CANAL DIVERSION SCREENS
DESIGNED BY: B.P.
DRAWN BY: G.A.H.
DATE: 2-3-89
SCALE: NONE
PAGE:
OF:

TOWN DIVERSION DAM FISH SCREENS

OPERATING CRITERIA

(NMFS 2/14/90)

Normal Operation (forebay elevation less than 1616.0):

1. Set head gates and check structure gates to maintain canal water surface at el. 1614.5. Canal water surface should not exceed or fall below elevations 1614.3 and 1615.4 (70% to 90% screen submergence).

2. Set head gates in a manner that reduces eddying upstream of trashracks and allows uniform flow through the trashrack.

3. Rake trashrack. keep head differential across trashrack less than 0.2 feet.

4. Keep sluiceway SW-l closed between June 1st and the end of irrigation, except as required to sluice sediment buildup at the headgates. Replace stoplogs within 24 hours of their removal from slots.

5. Maintain weir gate G-l crest at 1.5 ft. below canal water surface.

High Flow Operation (forebay elevation greater than 1616.0):

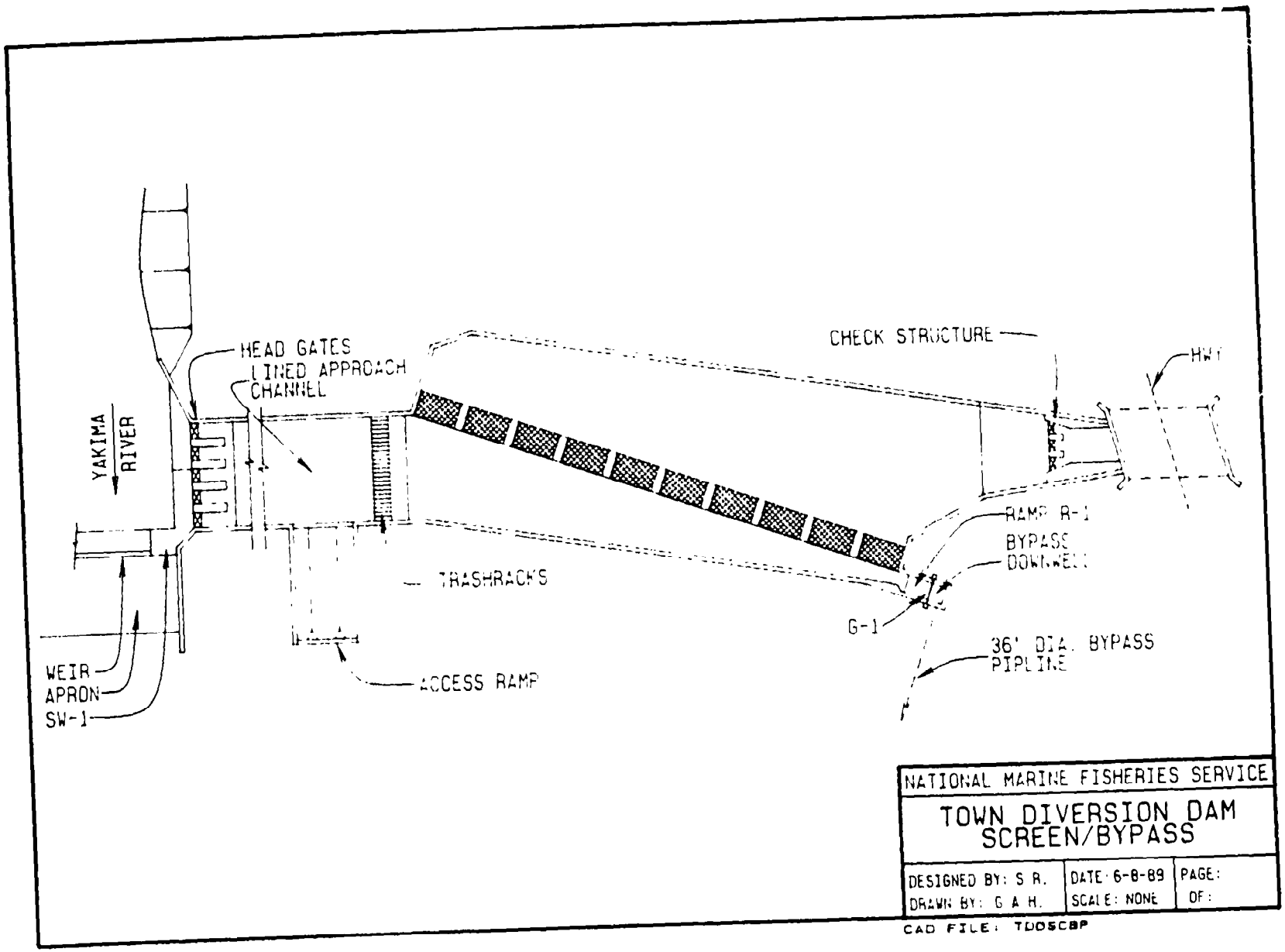
1. Set head gates and check structure gates to maintain canal water surface at 1615.0-1615.4.

Items #2. #3. and #4 are operated the same as for Normal Operation (above).

5. Lower weir gate G-l crest to its lowest position.

Dewatering Canal

When the canal is to be dewatered. remove ramp R-l. then remove orifice plugs below gate G-l to allow juvenile fish to escape from upstream of screens. This should be done only after notifying Washington Dept. of Fisheries, which may want to be present.


HEAD GATES
LINED APPROACH CHANNEL
CHECK STRUCTURE
HWY
YAKIMA RIVER
RAMP R-1
BYPASS DOWNWELL
TRASHRACKS
G-1
36' DIA. BYPASS PIPLINE
ACCESS RAMP
WEIR APRON
SW-1
NATIONAL MARINE FISHERIES SERVICE
TOWN DIVERSION DAM SCREEN/BYPASS
DESIGNED BY: S R.
DRAWN BY: G A H.
DATE: 6-8-89
SCALE: NONE
PAGE:
OF:
CAD FILE: TDDSCBP