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# A FISHERIES EVALUATION OF THE RICHLAND AND WAPATO CANAL FISH SCREENING FACILITIES

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# A FISHERIES EVALUATION OF THE RICHLAND AND WAPATO CANAL FISH SCREENING FACILITIES, SPRING 1987

Annual Report

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# PREFACE

The Bonneville Power Administration (BPA) is funding the construction and evaluation of fish passage and fish protection facilities at 20 irrigation and hydroelectric diversions in the Yakima River Basin, Washington. Construction implements Section 904 (d) of the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (NPPC 1984). The program provides off-site enhancement to compensate for fish and wildlife losses caused by hydro-electric development throughout the Columbia River Basin and addresses natural propagation of salmon to help mitigate the impact of irrigation in the Yakima River Basin.

The Richland and Wapato Canal Fish Screening Facilities (Richland Screens and Wapato Screens) are two of the protective facilities funded by BPA. This report evaluates the effectiveness of the Richland and Wapato Screens in intercepting and returning juvenile salmonids unharmed to the Yakima River. Studies were conducted in which fish were released upstream of or within the screen facilities and captured in the diversion that transfers them back to the river. Results indicated that the screens safely diverted fish from the canals.

The study emphasized salmonids: Test fish were steelhead smolts *(Salmo gairdneri)*; spring chinook salmon smolts *(Oncorhynchus tshawytscha)*: and fall chinook salmon fry. Evaluations were made under both low and high canal flows at the Wapato Screens. Tests at Richland Canal were conducted during typical spring flows in the diversion.

# ACKNOWLEDGMENTS

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The manuscript was reviewed by Susan A. Kreml, C. Dale Becker, and Robert H. Gray. Dale Becker, Dennis D. Dauble, R. William Hanf. Theodore M. Poston, and Jody R. Cearlock assisted with the field tests.

## ABSTRACT

We evaluated the effectiveness of new fish screening facilities at the Richland and Wapato Canals in south-central Washington State. The screen integrity tests at the Richland Screens indicated that 100% of fall chinook salmon fry *(Oncorhynchus tshawytscha)* released in front of the screens were prevented from entering the canal behind the screens. Our estimate is based on a 61% catch efficiency for control fish planted behind the screens. At the Wapato Canal, we estimated that between 3% and 4% of the test fish were either impinged on the screen surface and passed over the screens or passed through faulty screen seals. Our estimate is based on a greater than 90% capture of control fish released in front of the screens.

At the Wapato Screens, we estimated that 0.8% of steelhead smolts *(Salmo gairdneri)* and 1.4% of spring chinook salmon smolts released during low canal flow tests were descaled. During full canal flow tests, 1.6% of the steelhead and 3.1% of the spring chinook salmon released were descaled. The fish return pipe at the Wapato Canal was tested; the estimate of descaled test fish was not different from the estimate of descaled control fish.

The time required for fish to exit from the Wapato Screen forebay varied with species and with canal flow. During low canal flows, 43.2% of steelhead and 61.6% of spring chinook salmon smolts released at the trash racks were captured in the fish return within 96 hr. During full canal flows, 91.6% of the steelhead released during the day were captured in the fish return, with 50% caught in 12 hr, and 90.7% of the fish released at night were captured, with 50% caught in 0.5 hr. For spring chinook salmon, 97.0% of day-released fish were captured in the fish return with 50% caught in 2 hr and 95% captured in 13.5 hr: 95.5% of night-released fish were captured, with 50% caught in less than 0.5 hr and 95% caught in 1.5 hr.

Methods used in 1987 were first used at Sunnyside in 1985 and again at Richland and Toppenish/Satus in 1986 (Neitzel et al. 1985, 1986). The methods and 1985-1986 results have been reviewed by the Washington State Department of Fisheries, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Northwest Power Planning Council, and the Yakima Indian Nation.

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# INTRODUCTION

The Yakima River Basin has historically supported significant runs of salmonids. During the late 1800s, between 500,000 and 600.000 adult salmon *(Oncorhynchus* spp.) and steelhead *(Salmo gairdneri)* returned to the Yakima River and its tributaries (Bureau of Reclamation 1984). Runs of salmon included several races: spring, summer, and fall chinook salmon *(0. tshawytscha)*, coho salmon *(0. kisutch)*, sockeye salmon *(0. nerka)*. and steelhead.

Some of the runs are now extinct or near extinction. 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 improvements in efforts to manage and enhance salmonid runs in the Yakima River increased the total spawning escapement to 8000 adults in 1986 (Fast et al. 1986).

Runs of salmonid to the Yakima River Basin are the result of many factors. Spawning and rearing habitat has reduced as a result of the waste removal at diversion dams. Stream flows have been inadequate for fish because of irrigation withdrawals. Ineffective fish passage facilities for adults and juveniles at diversion dams caused high mortality during migration. Additionally, many Yakima River fish were killed while passing hydroelectric dams on the mainstem Columbia River.

The Pacific Northwest Electric Power Planning and Conservation Act (Public Law 96-501) 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 charged with 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 for enhancement of salmon and steelhead runs. 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 20 existing irrigation and hydroelectric diversions in the Yakima River Basin (Figure 1). BPA is also providing funds to the Yakima Indian Nation to increase production of spring chinook salmon in the Yakima River Basin.

The Richland and Wapato Canal Fish Screening Facilities (Richland and Wapato Screens) are part of the passage and protection facilities being constructed by BPA and BR. Construction of the Richland and Wapato Screens was completed in spring 1986 and winter 1987. respectively. BPA asked the Pacific Northwest Laboratory (PNL) to evaluate the effectiveness of these diversion facilities in returning to the river fish that had entered the Richland and Wapato Canals.

This report covers work by PNL fisheries staff at the Richland and Wapato Screens in 1987. It describes each screen facility. methods used to evaluate the effectiveness of the screens, and test results. Our findings are discussed and compared with results from previous tests at the Sunnyside Screens (Neitzel et al. 1985) and at the Richland and Toppenish/Satus Screens (Neitzel et al. 1986). The report includes three appendices. Appendix A is a description of the work plan prepared to guide the evaluations and associate specific

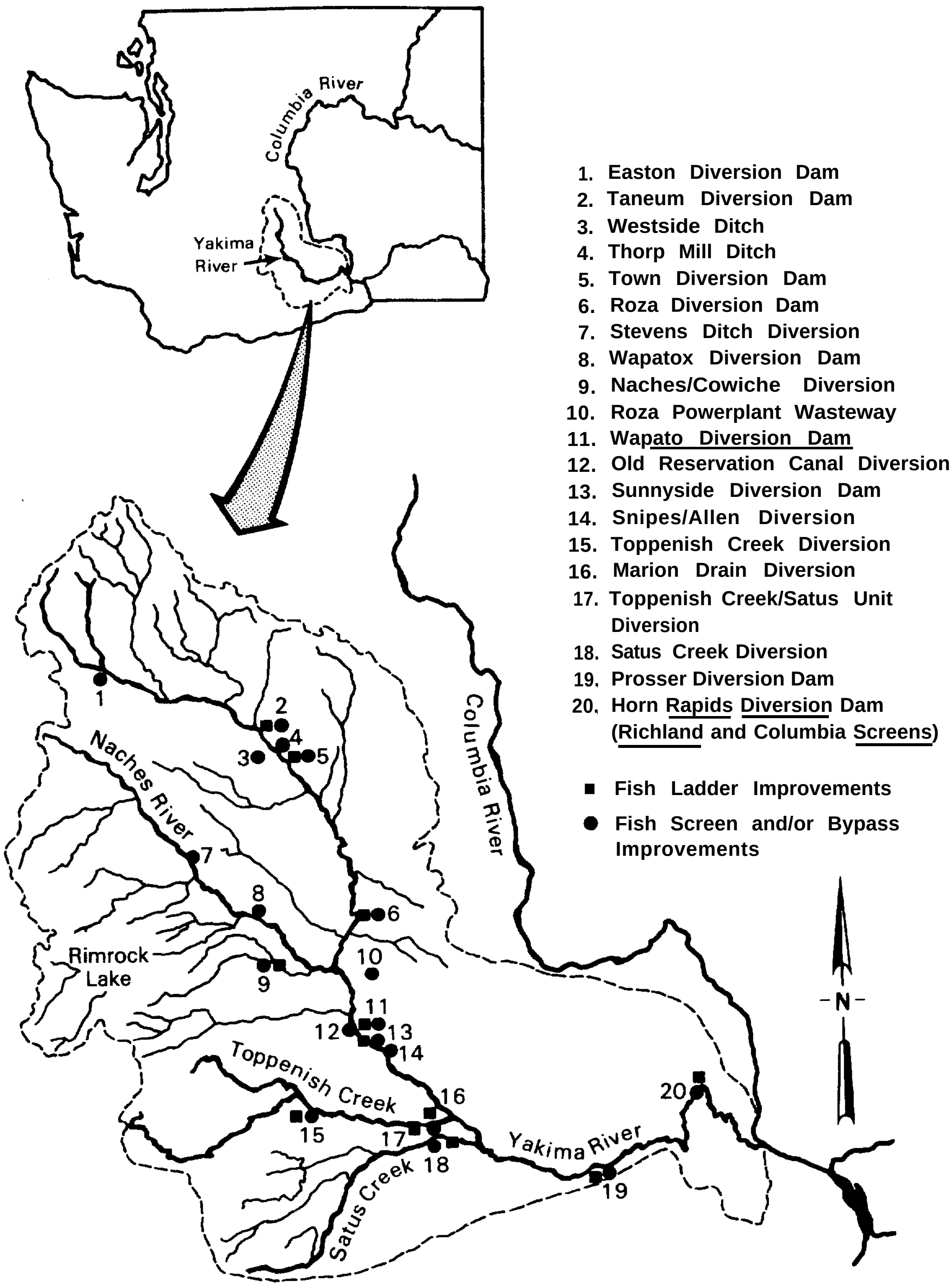


FIGURE 1. **Yakima River Basin Including Locations of the Richland and Wapato Canal Fish Screening Facilities and Other Fish Protection and Passage Facilities**

objectives with the methods used during the evaluations. Appendix B lists tables of the data collected at the Sunnyside Screens in 1985, the Richland and Toppenish/Satus Screens in 1986, and the Richland and Wapato Screens in 1987. Appendix C describes the operating criteria used to set flows at the screening facilities.

## DESCRIPTION OF THE STUDY AREAS

During 1987. studies were conducted at the Richland and Wapato screening facilities. At both facilities, the study areas included the canal from the trash rack to the screening facility, the fish bypass system within the screening facility, the terminus of the fish bypass system, and the canal downstream of the screening facility. Our description of the study area includes the range of conditions under which the sites are operated. Specific conditions tested during the evaluations are reported in the Results and Discussion sections.

### THE RICHLAND CANAL

The head gate of the Richland Canal is located at the Horn Rapids Diversion Dam on the Yakima River (Figure 2) at river kilometer (km) 29 [river mile (RM) 191. The carrying capacity of the Richland Canal is about 2.5 $m^3$/sec [90 cubic feet per second (cfs)]. Canal flow behind the screens is maintained at 0.8 to 1.4 $m^3$/sec (30 to 50 cfs) during the irrigation season (April to October) and at about 0.6 $m^3$/sec (20 cfs) during the rest of the year.

Canal flow is regulated at the canal head gates about 1 km upstream of the Richland Screens. The screening facility diverts fish that have entered the canal and directs them back to the Yakima River. Trash racks placed in the canal upstream of the screening facility (Figures 2 and 3) "filter" out large debris that could damage the screens or interfere with flow control through the screen facility.

A wastewater channel is immediately upstream of the trash racks. The channel runs perpendicular to the canal and discharges into the Yakima River. Excess water spills into the wastewater channel when the canal flow exceeds the combined flows through the screens and fish return pipe. Wastewater flow can be regulated to help keep debris from accumulating on the trash racks, but its primary function is to prevent flooding of the screening facility during the winter when ice forms at the screens.

The screening facility houses four rotary drum screens (Figure 3) with axes parallel to the length of the structure. Each screen is about 3 m (10 ft) wide and 1.7 m (5.5 ft) in diameter. Screen mesh openings are 3.18 mm (l/8 in.). Water depth at the screens varies with canal flow. However, the average depth across the face of the screens is about 1.7 m. The screens are mounted on top of a 0.5-m curb on the forebay floor, so that the water surface is normally about 0.5 m below the crest of the screens.

The fish bypass is located in the flow control structure at the downstream end of the screening facility (Figure 3). Water and fish diverted past the front of the screens pass through the fish bypass slot and out the fish return pipe. Flow through the fish return is adjusted to about 0.7 m3/sec (25 cfs) by stoplogging "Slot C" as described in the operating criteria (Appendix C).

The rotary screens are installed at an angle of $26^0$ to canal flow. This orientation is designed to provide a sweeping-velocity-to-approach-velocity ratio equal to or exceeding 2:l (Easterbrooks 1984). The maximum allowable

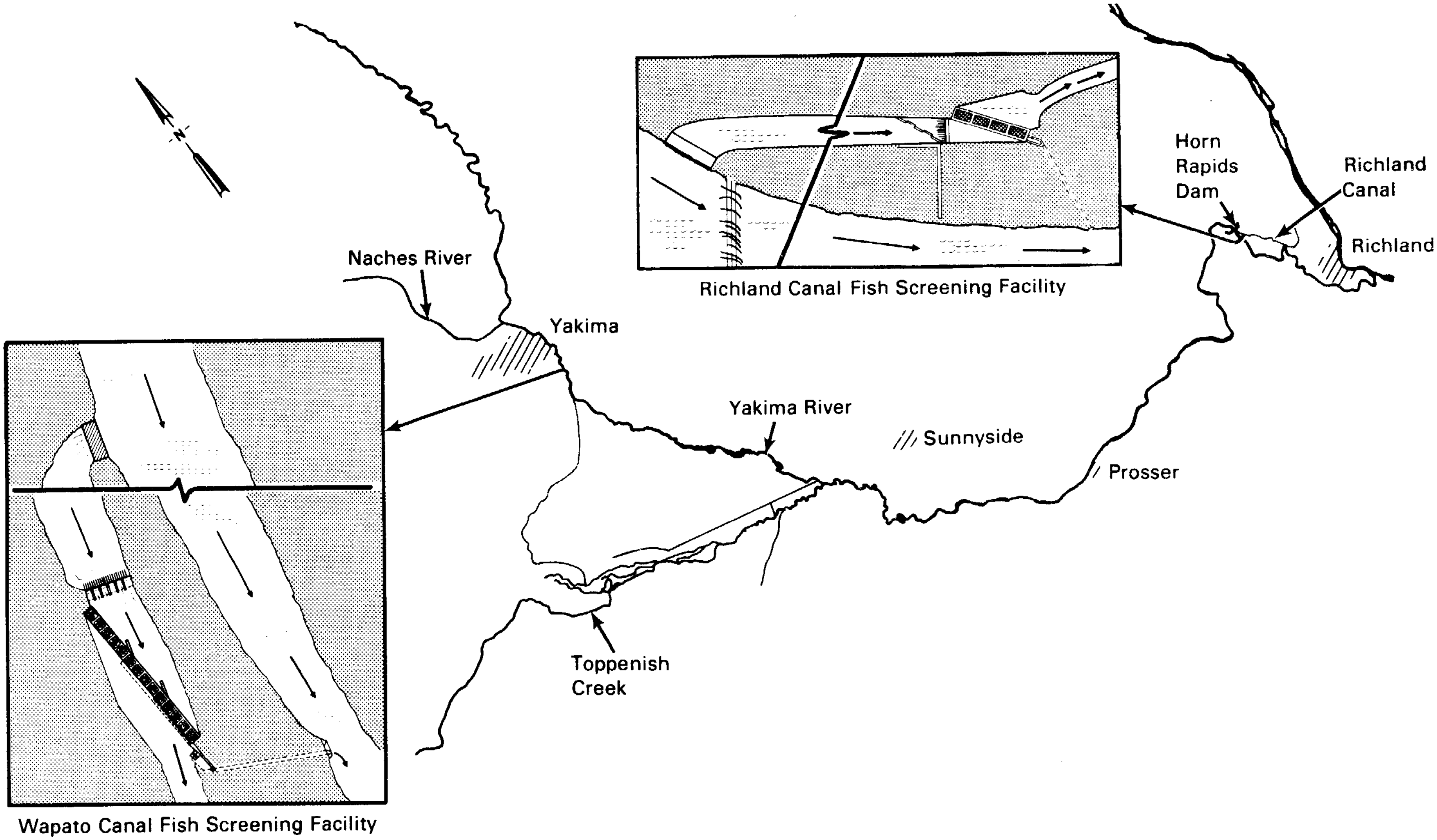


FIGURE 2. Yakima River Basin Showing Location of the Richland Canal Fish Screening Facility and the Wapato Canal Fish Screening Facility

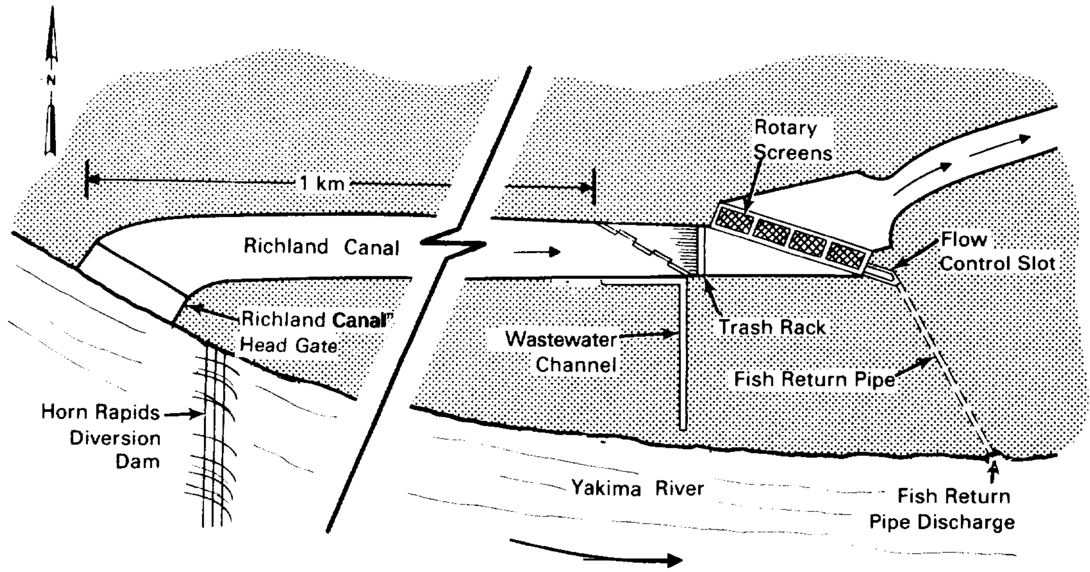


FIGURE 3. Flow Control Structure and Fish Bypass System in the Richland Canal Fish Screening Facility

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.

## THE WAPATO CANAL

The Wapato Diversion (Figure 4) is located at river km 172 (RM 106.7) on the Yakima River. The diversion directs water from the Yakima River into the Wapato Canal. Canal operation begins in early March and continues through the irrigation season, usually until mid-October. Canal capacity is about 57 $m^3$/sec (2000 cfs).

The Wapato Canal Fish Screening Facility (Wapato Screens) is located about 1 km downstream of the head gates of the Wapato Canal. The screening facility (Figures 2 and 4) diverts fish entering the canal and directs them back to the Yakima River.

The trash racks from the old screening facility, which was located immediately upstream of the new Wapato Screens. are used to "filter" out debris entering the canal. The racks prevent large logs or tree branches from damaging the screens or interfering with flow through the screening facility. The screening facility houses 15 rotary drum screens (Figure 4) with axes parallel to the length of the structure. Each screen is about 7.3 m (24 ft) wide and 4.6 m (15 ft) in diameter. Water depth at the screens varies with canal flow: however, the depth across the face of the screens at full canal level is normally about 3.7 m (12 ft).

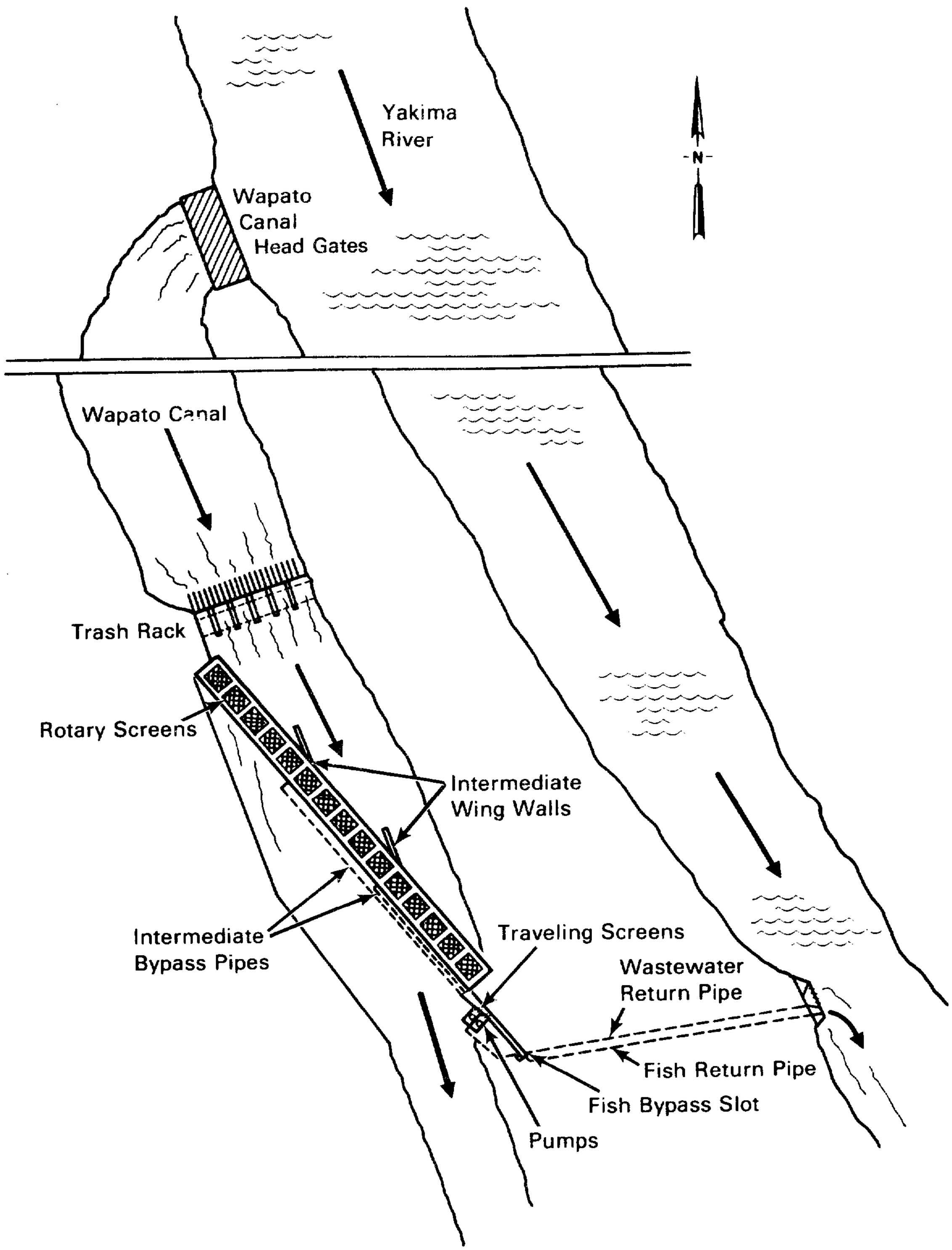


FIGURE 4. Flow Control Structure and Fish Bypass System in the Wapato Canal Fish Screening Facility

The flow control structure and the separation chamber (Figure 4) are located at the downstream end of the screen facility. Two fish bypass pipes and the terminal bypass, each with a flow of about 1.4 $m^3/sec$ (50 cfs), feed into the separation chamber. During normal operation, about 4.2 $m^3/sec$ (150 cfs) of water enter the separation chamber. About 0.9 $m^3/sec$ (30 cfs) of water, and all fish that are diverted in front of the screens, pass through the flow control structure and out the fish return pipe. Two bypass water return pumps, each with a pumping capacity of 1.4 $m^3/sec$ (50 cfs). are located behind traveling screens near the terminus of the separation chamber. The traveling screens are equipped with screen washers to prevent fish and debris from being entrained in the pumpback system.

The pumpback system is not used during normal operation. Adequate flows are maintained in the fish bypass by discharging 3.4 $m^3/sec$ (120 cfs) of water back to the Yakima River over adjustable weirs in the pump basin. When the pumps are operating, flow over the weirs is reduced. Thus, bypass flows are achieved by adjusting weirs in each fish bypass (Gates 1, 2. and 3). the fish return (Gate 4), and the two weirs behind the pump intakes (Gates 5 and 6). as described in operating criteria (Appendix C).

The rotary drum screens are installed in the canal at an angle of 26° to the canal flow. This orientation is designed, as at Richland and other screening facilities, to direct fish toward the fish return pipe and back to the river.

# METHODS

Two types of tests were conducted in 1987: descaling tests and screen integrity tests. In descaling studies at the Wapato Screens, fish were released upstream of the screen facility and captured at the terminus of the fish bypass slot or released at the head of the fish return pipe and captured at the terminus of the pipe. Some test fish were held for post-test observation. Native and hatchery-released salmonids entering the diversion canal were also monitored during release/capture tests. In screen integrity studies at the Richland and Wapato Canals. fish were released both in front of and behind the screens. and were captured as they appeared in the primary fish return or in the canal behind the screens.

## TEST FISH

The species of fish selected for tests at the Wapato and Richland Screens were recommended by fisheries biologists from the Washington State Department of Fisheries (WDF), U.S. Fish and Wildlife Service (USFWS), and the Yakima Indian Nation. The species were selected on the basis of the potential impact of an irrigation diversion on specific salmonid populations likely to encounter each screening facility during the rearing and outmigration period. Therefore, the selection was dependent on the species, race, and size of salmonids occurring in the Yakima River upstream of each diversion.

Steelhead and spring chinook salmon are produced in the Yakima River and its tributaries above the Wapato Diversion. Additionally, coho salmon are currently being introduced into the upper Yakima River to build up the run. Fall chinook salmon, which now spawn only downstream of the Wapato Diversion, may utilize upriver areas as the population builds. All these species and races are found upstream of the Richland Screens. Spring chinook salmon and steelhead smolts were selected to evaluate descaling at the Wapato Screens so that results could be compared to previous evaluations at the Sunnyside. Richland. and Toppenish/Satus Screens.

Fall chinook salmon fry (<60 mm) were selected for screen integrity tests at both the Richland and Wapato Screens. Integrity tests were designed to address two questions: 1) are fish impinged on the rotary screen? and 2) are the screens effective in preventing small salmonids from entering the irrigation canal behind the screens?

### Steelhead

Yearling steelhead were obtained from the Chelan County Public Utility District. The Wells strain steelhead were hatched, reared, and adipose finclipped at the Chelan Hatchery in Chelan, Washington. They weighed about 24 fish/kg (11 fish/lb) when transferred to PNL on February 20, 1987. The fish were reared outdoors at 12°C in a mixture of Columbia River and well water until they weighed 15 to 22 fish/kg (6 to 9 fish/lb) and measured 15 to 23 cm (6 to 9 in) [fork length (FL)]. Fish were acclimated to temperatures at each test site at least 1 week before release.

### Spring Chinook Salmon

Yearling spring chinook salmon were obtained from the USFWS Leavenworth National Hatchery in Leavenworth, Washington. The fish were adipose fin-clipped and coded wire-tagged (#63-41-58). The salmon weighed about 46 fish/kg (21 fish/lb) when transferred to PNL on March 10, 1986. The fish were rearea outdoors at 7° to 13°C in Columbia River water until smolting occurred. Fish were acclimated to temperatures at the test site at least 1 week before release by mixing river water and well water. They weighed 25 to 33 fish/kg (11 to 15 fish/lb) and measured 12 to 16 cm (4.5 to 6.5 in.) FL when released.

### Fall Chinook Salmon

Fall chinook salmon fry were obtained from the Washington State Department of Fisheries Priest Rapids Hatchery near Mattawa, Washington. The swimup fry were 1500 fish/kg (680 fish/lb) when transferred to PNL on February 10 1987. The fry were held indoors in chilled well water (10° to 11°C) and acclimated to test temperatures at least 1 week before release. The fry weighed 400 fish/kg (180 fish/lb) and measured 50 to 60 mm (2 to 2.5 in.) FL when released.

## SAMPLING EQUIPMENT

Fish were captured within the screening facility, at the terminus of the primary fish return pipe, and in the canal behind the screens, based on the objectives of each test. Inclined planes were custom-built to fit the structures at the Richland and Wapato Screens, and a trap was built to collect fish at the terminus of the Wapato Screen fish return pipe. Fyke nets and an electroshocker were used to collect fish behind the screens. Temporary fish-holding facilities were installed at each test site.

### Inclined Plane

Fish were captured by placing an inclined plane in the fish return between the last rotary drum screen and the head of the fish return pipe. The inclined plane used at the Richland Canal (Figure 5) was 2.5 m (8 ft) long and 0.76 m (2.5 ft.) wide. Adjustable wings 2.5 m (8 ft) long and 0.15 m (0.5 ft) wide were fastened to the sides of the inclined plane to compensate for irregularities in the walls of the concrete bypass structure. A live box CO.37 m (1.5 ft) long by 0.75 m (2.5 ft) wide, 45 1 (12 gal) volume] was fastened at the end of the inclined plane. The inclined plane had an aluminum frame covered with a perforated aluminum sheet [0.32-cm- (1/8-in.-) diameter holes, staggered centers. 40% open]. Flow was directed over the plane surface by inserting dam boards in the upstream stoplog slot (Slot A) in the fish bypass slot. The height of the dam boards relative to the water depth determined the water volume through the fish bypass.

The inclined plane used at the Wapato Screens (Figure 6) was built to capture fish in the primary fish return downstream of Gate 4 at the terminus of the fish return slot. The plane was 1.5 m (5 ft) wide and 2.13 m (7 ft) long. The surface of the plane was covered with a perforated aluminum sheet [0.32-cm (1/8-in.) holes, 40% open]. A live box CO.3 m (1 ft) long by 0.61 m (2 ft) wide; 0.46 m (1.5 ft) deep] with a volume of 85 1 (22 gal) was attached to the end of the plane. Aluminum walls CO.6 m (2 ft) high] were welded to the edges

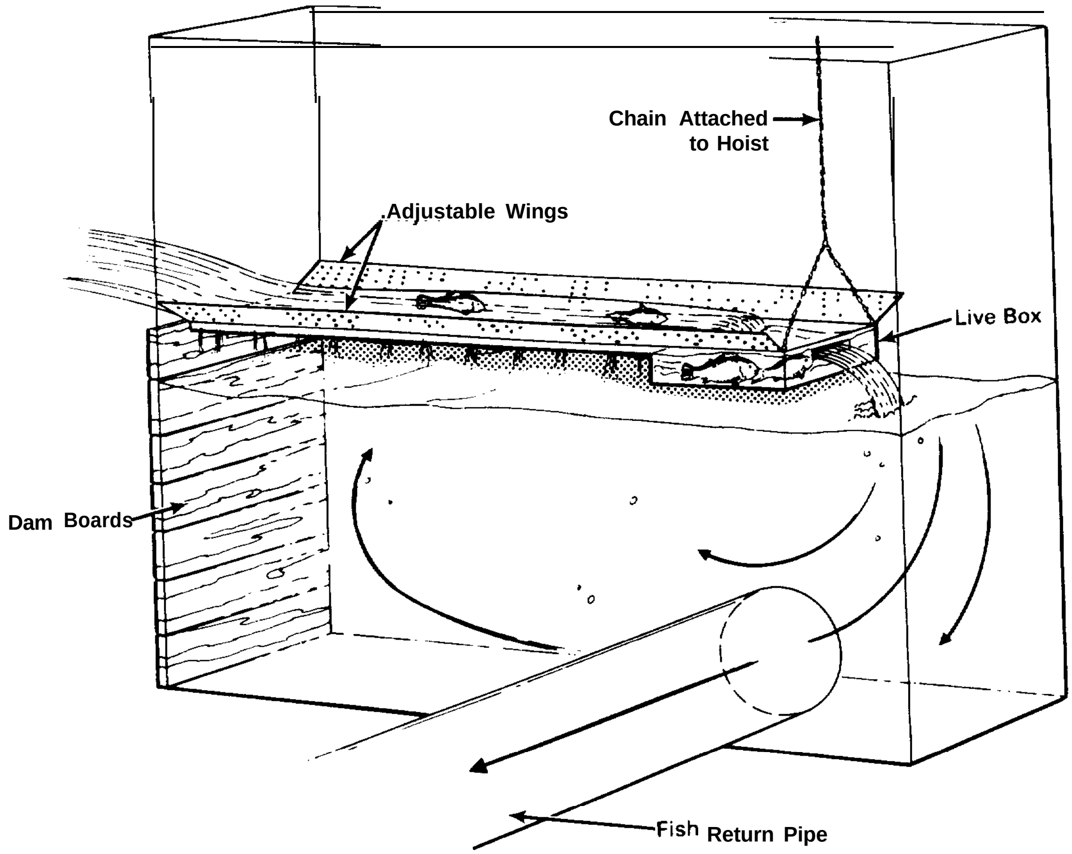


FIGURE 5. Inclined Plane Used at the Richland Canal Fish Screening Facility, Spring 1987

of the plane, and the corners of the plane surface were elevated 0.3 m (1 ft) to help guide the fish toward the live box. The volume of water entering the plane was controlled by stoplogging at Gate 4. Bureau of Reclamation personnel set Gate 4 to the specifications outlined in the operating criteria (Appendix C) before each test.

The inclined planes were lowered into position with hand hoists. The planes were brushed periodically to prevent clogging of the perforated surface with vegetation and debris. Any clogging restricted the ability of the plane to filter water and separate fish from the bypass water.

Fvke Nets

Fyke nets were used to capture fish at both the Richland and Wapato Canals in screen integrity tests. At Richland Canal. a fyke net was set in the canal about 75 m (250 ft) downstream of the screening facility (Figure 7). A fence made of plastic mesh [6.4-mm (1/4-in.) opening] was installed at an angle in the canal to guide fish to the mouth of the fyke net. The top of the fence extended above the water, and the bottom was sealed with mud. The fyke net was 6.0 m (20 ft.) long, with a net mouth 1 m (3 ft) square that tapered to a 0.25-m- (0.9-ft-) square cod end. A zipper was installed at the cod end for removal of fish.

FIGURE 6. Inclined Plane Used at the Wapato Canal Fish Screening Facility, Spring 1987

Six fyke nets were used in the Wapato Canal screen integrity tests. The nets were fished immediately downstream of three selected screens during each test. Two nets, each 3.65 m (12 ft) square, were lowered down the stoplog slots behind a screen (Figure 8). The tops of the nets were above the waterline, and the bottoms of the nets settled into the mud on the canal floor. The nets tapered from a 3.65-m- (12-ft-) square mouth down to a 1.22-m (4-ft) square over a distance of 6.1 m (20 ft). The 1.22-m- (4-ft-) square sock extended back another 6.1 m (20 ft) to make the total length of the net 12.2 m (40 ft). A zipper was installed near the end of the sock to facilitate fish removal.

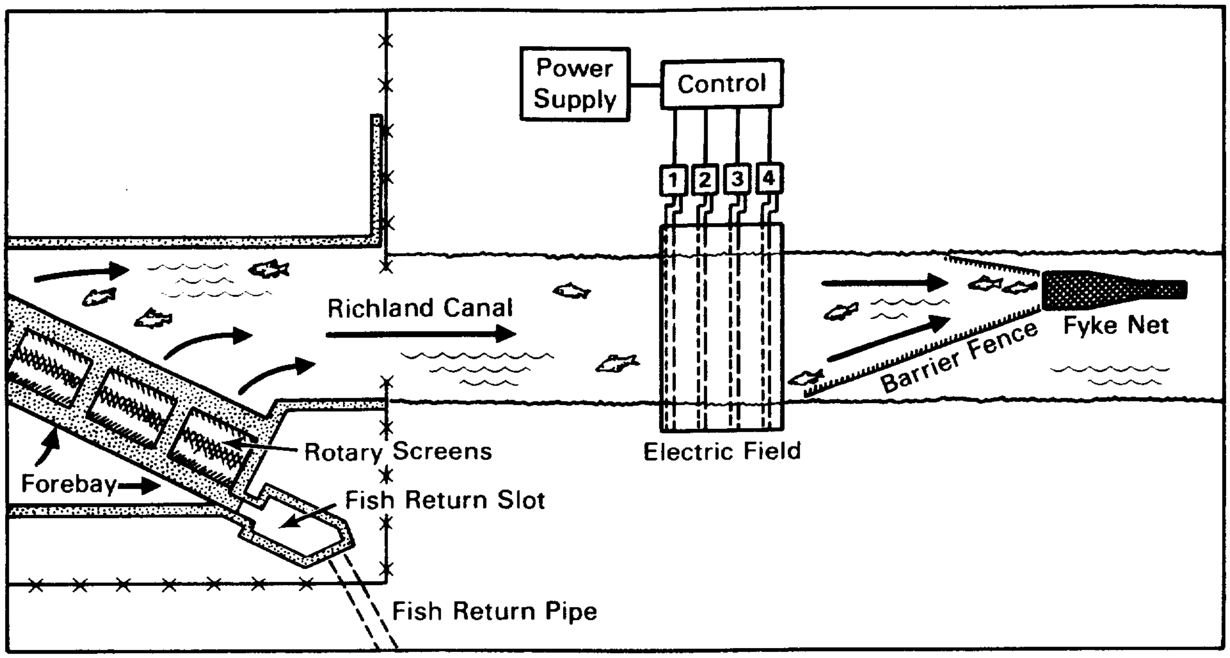


FIGURE 7. Fyke Net and Barriers Used During Screen Integrity Tests at the Richland Canal Fish Screening Facility, Spring 1987

Electrofishing Gear

An electroshocker (Smith-Root Model Type VI Electrofisher) was used to collect fish in the Richland Canal behind the rotary screens. Electrofishing supplemented fyke net catch data in tests in which fish were released in the canal behind the drum screens. An electrical barrier (Smith-Root Model JFFB-JB-6) was installed in the Richland Canal about 50 m (160 ft) downstream from the screening facility, just upstream of the fence and fyke net recovery system (Figure 7). The barrier was used to stun or kill fish in order to increase fyke net efficiency.

Holding Facilities

Temporary facilities were installed to hold fish during descaling evaluation and to retain some fish for 96 hr after capture. Four metal troughs [1.5 m (5 ft) long by 0.3 m (1 ft) wide, 0.2 m (0.7 ft) deep, and 90 l (25 gal) in volume] were installed at the Richland Canal, and three fiberglass troughs [3 m (10 ft) long by 0.56 m (1.8 ft) wide, 0.25 m (0.8 ft) deep, and 540 l (140 gal) in volume] and two fiberglass circular tanks [1.22 m (4 ft) in diameter by 0.6 m (2 ft) deep] were installed at the Wapato Screens. All tanks were supplied with canal water pumped from behind the screens. A temporary building [3.1 m (10 ft) wide by 4.3 m (14 ft) long] with an aluminum roof and translucent plastic sides was installed at the Wapato site. The building was equipped with fluorescent lighting so that fish captured during both the day and night could be evaluated for descaling under similar light conditions.

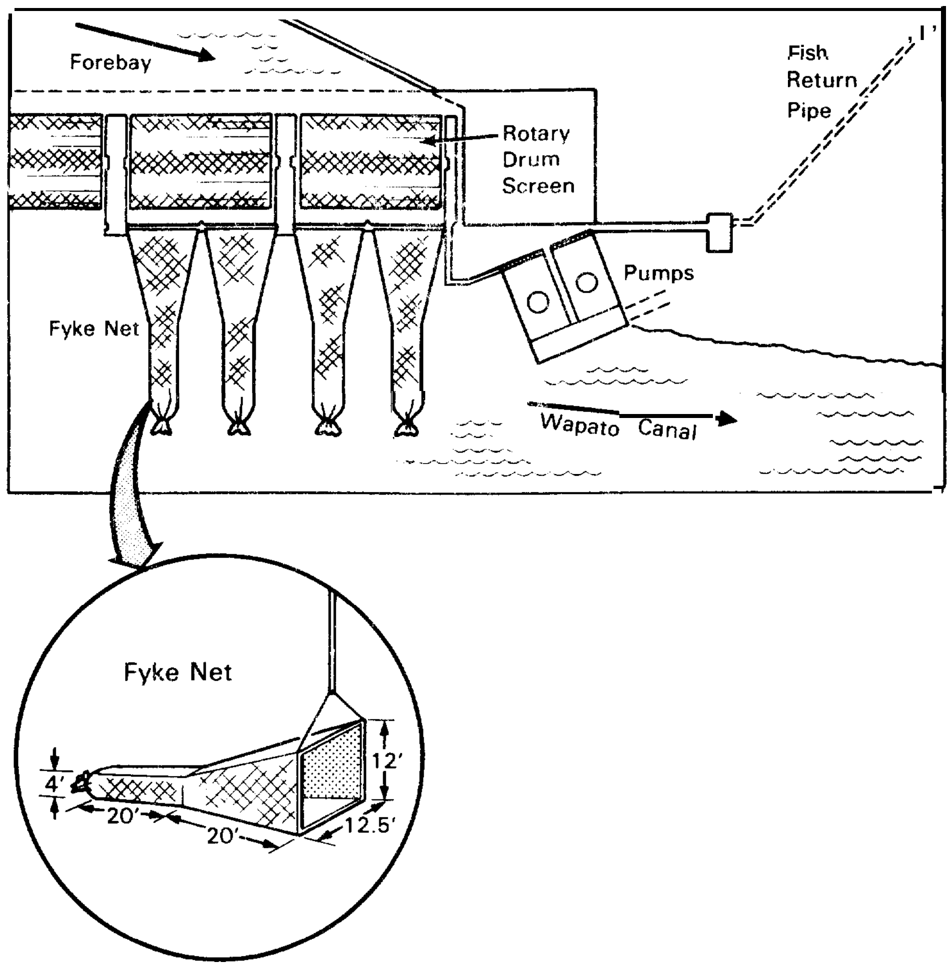


FIGURE 8. Fyke Nets Used in Screen Integrity Tests at the Wapato Canal Fish Screening Facility. Spring 1987

## DESCALING EVALUATION

The evaluation system developed by the U.S. Army Corps of Engineers (Basham et al. 1982) was used to monitor the condition of fish at both sites Evaluation criteria included modifications established in 1985 (Neitzel et al. 1985). Baseline descaling condition was determined by randomly sampling groups of test fish before their release. Descaling was evaluated in each of 10 areas, 5 on each side of the fish. When 40% or more scale loss was observed in any 2 areas on one side of a fish. the fish was classified as descaled.

## TEST PROCEDURE

Descaling evaluations at the Wapato Screens were made by introducing branded groups of steelhead and spring chinook salmon at the trash rack and capturing the fish when they appeared on the inclined plane in the primary fish return (Phase IIa, Appendix A). Tests were conducted in March under low canal flow conditions, and again in May under full canal flow conditions (Phase III Appendix A). Fish were also released at the head and captured at the end of the fish return pipe in tests to evaluate effects of passage through the pipe (Phase IIb, Appendix A). Native fish populations were monitored during all our sampling periods (Phase IVa, Appendix A). Screen integrity tests were conducted at both the Richland and Wapato Screens by releasing branded groups of fall chinook salmon in front of and behind the rotary screens (Phase IVb, Appendix A). Fish were collected as they appeared either on the inclined plane in the fish return or in fyke nets placed in the canal behind the screens.

Test Stock Identification

Steelhead, spring chinook salmon, and fall chinook salmon were cold branded to identify specific test groups. Fish were marked in one of three locations: right anterior, left anterior, or right dorsal. The brands were applied at least 1 week before release. The brands used in our studies were approved by the National Marine Fisheries Service (NMFS) and were distinguishable from all other brands used in the Columbia River Basin. All releases were reported to the Fish Passage Center in Portland, Oregon, and entered into their computer files. Thus, U.S. Army Corps of Engineers biologists could identify our test fish as they arrived at dams on the lower Columbia River.

Fish Transport and Release

Test fish were transported at acclimation temperature in an insulated tank [400 l (125 gal) in volume] supplied with oxygen. Transit times from PNL to the Richland and Wapato Screens were 0.3 hr and 1.3 hr, respectively. Loading densities did not exceed 120 g of fish/l. Water temperature in the transporter changed less than 1°C during transit. Test fish were either netted from the transporter and placed in holding tanks at the facility for acclimation, or were netted into buckets for direct release to the canal. There were no losses attributable to transporting stress.

Fish Release Locations

Test fish for descaling evaluation were released uniformly across the canal downstream of the trash rack in Phase IIa tests at the Wapato Screens. In Phase IIb tests at Wapato, fish were released in the fish return structure at Gate 4, where the water plunged into the head of the fish return pipe. Fall chinook salmon used in Phase IV tests at the Richland were released in two locations: just upstream of the first rotary screen near the structure wall, and uniformly across the downstream side of the rotary screens. In Phase IVb tests at the Wapato Screens, fall chinook salmon were released in four locations: next to the concrete piers of the screen structure just upstream of the screens to be tested, in the fish bypass below each set of screens being tested, and in the mouth and cod end of the fyke nets.

Release Controls

The condition of test fish at the time of release (baseline condition) was estimated by sampling each group of test fish before release. Baseline condition evaluations were conducted inside the temporary building under artificial light. The day and night crew evaluators scored the baseline condition together in order to standardize the descaling evaluation. For Phase IIa tests, 100 to 200 fish were sampled for baseline condition, and 400 to 940 fish were released into the canal.

## Fish Capture and Evaluation

Fish captured during Phase IIa tests were dip netted from the live box of the inclined plane and placed in a holding tank before evaluation. Evaluations were made at half-hour intervals. The fish were anesthetized in MS-222, examined to determine the extent of scale loss, and returned to a holding tank. Up to 10% of the test fish were held for 96 hr to monitor delayed mortality. After fish recovered from the anesthetic, they were released in the fish return pipe, which carried them to the Yakima River.

Fish were captured on a plane positioned at the end of the fish return pipe in Phase IIb tests. Fish were dipnetted from the plane quickly to reduce damage caused by heavy turbulence in the live box. The fish were anesthetized with MS-222, examined, held in a bucket to recover, and released into the river.

Fish captured in Phase IVb tests were not evaluated for descaling. The purpose of Phase IVb tests was to determine the effectiveness of screening facilities in preventing fish from entering the canal behind the screens, and to monitor the rate at which fish moved through the fish bypass. Fish were identified by brand group and enumerated 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.

In tests at the Richland Canal the inclined plane was fished for up to 41 hr after the fish were released; however, the fyke net in the canal was fished for up to 93 hr after fish releases. Groups of fish were released both in front of and behind the screens at three different times; early afternoon late afternoon, and evening. The electric barrier was used only during and immediately after the first fish release and was not used thereafter The fyke net was monitored at 2-hr intervals during the first 48 hr. four times on the third day, and once on the last day. Additionally, an electroshocker was used to collect fish immediately behind the screens on the second and third days.

## STATISTICAL ANALYSIS

The 15 rotary drum screens at the Wapato facility are divided into three sections of five screens each by design of the system and placement of the intermediate wing walls and bypass pipes. Screen efficiency estimates and confidence intervals were therefore computed for each of these sections in addition to an overall estimate and confidence interval The method for computation was the same in all four estimates (three sections and overall), and will be described in general. Screens 1 through 5 are referred to as Section 1, 6 through 10 as Section 2. and 11 through 15 as Section 3.

Four tests were performed at Wapato Canal with respect to screen efficiency estimation. The first test involved all three screen sections, specifically screens 5. 10, and 15: the second test, Section 3, screens 13 14, and 15; the third test, Section 1, screens 3. 4. and 5; and the fourth, Section 2 screens 8, 9, and 10. Although the method for estimation for each section and overall was the same, the input data were different in each case For Section 1 estimates,
For Sections 2 and 3, the relevant screen data from test 1 were used in addition to the test for that specific section. For the overall estimate, all data were used.

Three quantities must be computed to estimate screen efficiency. These are inclined plane efficiency ($EFF_{ip}$), net capture efficiency ($EFF_{nc}$), and net retention efficiency ($EFF_{nr}$). Given these, the formula for computation of screen efficiency ($EFF_{sc}$) is

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

where $X_{net}$ equals the number of fish released upstream of the screens and caught in the nets, and N is defined as follows. The N value is calculated differently for Section 1 than for Sections 2, 3, and overall. For Section 1, N is equal to the total fish released into that section, or 2195 (723 from test 1 and 1472 from test 3). For Sections 2, 3, and the overall estimate, the following formula was used:

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

where $X_{ip}$ equals the number of fish released upstream of the screens and caught in the inclined plane. N is representative of the total number of fish released into the section being estimated. For Sections 2, 3, and overall, after the efficiencies ($EFF_{ip}$, $EFF_{nc}$, and $EFF_{nr}$) have been considered, some fish are still not accounted for. To avoid making assumptions about what might have happened to these, an effective N has been computed that is smaller than the actual number released. For Section 2, N is 2159, although 2226 actually were released. For Section 3, N is 2127; the actual number released was 2193. Overall, N is 6562; 6614 were released. It must be noted that N is 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 se must now be defined. The input data for each section are as were explained, combining across relevant tests. The general forms are

$$EFF_{ip} = \frac{n_{ip}}{N_{ip}} \qquad EFF_{nc} = \frac{n_{nc}}{N_{nc}} \qquad EFF_{nr} = \frac{n_{nr}}{N_{nr}}$$

where $n_{ip}$ is the number of fish released in the bypass and caught in the inclined plane for the section being estimated, $N_{ip}$ is the number released in the bypass, $n_{nc}$ is the number released in the net mouth and caught in the net, $N_{nc}$ is the number released in the net mouth, $n_{nr}$ is the number that remained in the net cod end, and $N_{nr}$ is the number originally placed in the net cod end.

In Section 1, for example, $n_{ip}$ is equal to 187. This is calculated from 99 from test 1 (screen 5) and 88 from test 3. $N_{ip}$ is equal to 200 because 100 fish were released into the bypass in each case (100 at screen 5 in test 1 and 100 for all three screens together in test 3). Therefore, $EFF_{ip}$ is equal to 0.935 or 187 ÷ 200. For Section 1, $n_{nc}$ is equal to 54 (test 1) + 78 (test 3) = 132; $N_{nc}$ is equal to 400 (100 from test 1 and 300 from test 3), an $EFF_{nc}$ of 132 ÷ 400 or 0.33; $n_{nr}$ is equal to 58 (test 1) + 79 (test 3) = 137; $N_{nr}$ is equal to 250 (100 from test 1 and 150 from test 3); and therefore $EFF_{nr}$ is equal to 137 ÷ 250 or 0.55. Efficiencies for Section 2 and 3 and the overall efficiencies are computed in the same manner. For overall efficiencies, it should be noted that individual section efficiencies are not simply averaged; rather, the efficiency is computed by combining all data. Averaging the separate sections would assume equal numbers were released in each test and weight them as such. By computing the overall estimates from all data lumped as one test, the varying N values are incorporated and differences in test size are compensated.

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

$$P\left[ EFF_{sc} - 1.96\sqrt{var\ (EFF_{sc})} \le true\ [EFF_{sc}] \le EFF_{sc} + 1.96\ \sqrt{var\ (EFF_{sc})} \right] = .95$$

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

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

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 have been neglected. The assumption is made that $EFF_{ip}$, $EFF_{ncr}$, and $X_{net}$ are independent of each other, which is reasonable in this case.

The variances of $EFF_{ip}$ and $EFF_{ncr}$ 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. In the case of $EFF_{ncr}$, the variances were computed individually for $EFF_{nc}$ and $EFF_{nr}$ and propagated through. The variable $X_{net}$, the number of fish caught in the nets that were released upstream of the screens, is distributed binomial ($N, EFF_{sc}$), making its variance equal to $N[EFF_{sc}\ (1-EFF_{sc})]$.

## RESULTS

Fish that passed through the fish bypass facilities at the Wapato and Richland Screens were not descaled or killed. Fish were not "flushed" from the screen forebays. but appear to move out of their own volition. The angled rotary drum screen design at the Richland and Wapato screens was effective at keeping fish from entering the canal behind the screens. Data are presented as they relate to the objectives of each phase outlined in the work plan. A detailed summary of the catch data and estimates for percent of test fish that were descaled or killed are presented in Appendix B.

### PHASE I TESTS

Phase I tests are designed to evaluate components within the fish diversion system other than the rotary drum screens. The fish bypass system at the Wapato Screens was similar in design to the bypass system at the Sunnyside Screens. Because no component of the Sunnyside Screens appeared to cause descaling or mortality (Neitzel et al. 1985). no Phase I tests were conducted at the Wapato Screens.

### PHASE II TESTS

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). Phase IIa and IIb tests were completed at the Richland Screens in 1986 (Neitzel et al. 1986) and were not conducted this year. At the Wapato Screens. we initiated our evaluations with Phase IIa testing. We released fish at the trash racks and captured them before they entered the fish return pipe. In addition to fish descaling and mortality data, we determined how long released fish remained upstream of or within the Wapato Screens. We also conducted Phase IIb tests at the Wapato Screens to test the potential effects of passage through the fish return pipe.

#### Phase IIa

Tests at the Wapato Screens were conducted in March during low canal flow and in May during full canal flow. A total of 1775 marked fish were released in the low canal flow tests conducted early in the irrigation season at flows typical of those during canal startup. A total of 1754 marked fish were released in tests during full canal flow to evaluate fish passage conditions during peak salmonid migration in the Yakima River.

Marked steelhead were released behind the trash racks on three occasions: during low canal flow tests in March, and in the morning and just before dark during high canal flow tests in May. Canal flow was about 500 cfs during March and about 2000 cfs during May. Of the 835 steelhead planted during low canal flow tests, 361 (43.2%) were captured on the inclined plane in the fish return during the next 96 hr. Based on the number of descaled fish that were captured, we estimated that 0.8% of the steelhead were descaled. No mortalities were observed among 55 steelhead held for 96 hr of observation. Of 440 steelhead released in the morning during full canal flow tests, 403 (91.6%) were caught in the following 36 hr. Based on the number of captured fish that were descaled. we estimated that about 1.8% were descaled or dead. Of the 440 steelhead released just before dark in the full canal flow tests, 399 were captured during the following 24 hr. and we estimated 1.5% were descaled or dead (Table 1). Overall, the loss from descaling was 1.4%. well within the 95% confidence interval for the condition controls (Appendix B).

Marked spring chinook salmon were also released during low canal flow, and in the morning and just before dark during high canal flow. Of 940 fish released during low canal flow, 579 (61.6%) were captured on the inclined plane in the following 96 hr. and 1.4% were descaled or dead. No mortalities were observed among 88 salmon held for 96 hr observation. Of 470 salmon released in the morning during full canal flow tests, 456 were captured in the following 36 hr. and 0.4% were descaled. Of 404 salmon released just before dark during full canal flow, 386 were captured during the next 24 hr. and 6.2% were descaled or dead (Table 2). Overall, the loss resulting from descaling was 2.4%. within the 95% confidence interval for the condition controls (Appendix B).

The downstream movement of steelhead and spring chinook salmon released for descaling evaluations was monitored each half-hour as the fish appeared on our sampling plane in the fish return. The rate and percentage of recovery for steelhead (Figure 9) and spring chinook salmon (Figure 10) indicate that salmonid smolts are not flushed from the Wapato Screens forebay; rather, they move through the screen forebay of their own volition. Movement rate varied depending on factors such as canal flow, smolting condition, and species-dependent behavior. Movement rates were slower during low canal flow than during high canal flow. Spring chinook salmon vacated the screen forebay more rapidly than steelhead (Table 3), resulting in a slightly higher capture in our tests.

### Phase IIb

Because test fish were more easily captured at the flow control structure, the potential effect of passage through the fish return pipe was evaluated separately. Since this was a test of a specific component of the fish return system, test results are presented with Phase IIb. Tests involving the fish return pipe at the Richland Screens were reported previously (Neitzel et al. 1986). Tests were conducted only at the Wapato Screens during 1987.

Nearly all test fish survived passage through the fish return pipe at the Wapato Screens. Of 150 spring chinook salmon released in the fish return at the head of the fish return pipe, 135 were netted from the trap at the end of the fish return pipe and 8 (5.9%) were descaled (Table 4). The observed descaling probably resulted when smolts were not recovered immediately after being trapped. This test will be repeated in 1988 to ensure that no fish are being descaled in the return pipe. A new trap will be designed to prevent delayed recovery from the trap. Of 110 steelhead released, 65 were captured and 1 (1.5%) was descaled.

## PHASE III TESTS

Descaling evaluations (Phase IIa) were conducted at the Wapato Screens when the surface elevation of the canal was at 283.8 m (931.0 ft) and 284.9 m (934.6 ft). These canal levels corresponded to canal flows of 29.5 and 48.1 $m^3$/sec (1040 and 1700 cfs), respectively. The results of the descaling tests and movement data are presented in the Phase IIa section of this report Canal level did not affect descaling rate among our test fish (Tables 1 and 2); however, movement of fish from the forebay was much slower during low canal flow conditions (Figures 9 and 10: Table 3).

TABLE 1. Descaling and Mortality Data from Release and Capture Tests with Steelhead Smolts (*Salmo gairdneri*) at the Wapato Canal Fish Screening Facility, Spring 1987

| TEST GROUP | CANAL FLOW (cfs) | RELEASE TIME (hr) | NUMBER | | | | PERCENT | | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|---|---|---|---|
| | | | RELEASED | CAPTURED | DESCALED | DEAD | CAPTURED | DESCALED | |
| 1 | 1040 | NA | 280 | 120 | 1 | 0 | 43 | 0.8 | 0.02-4.56 |
| 2 | 1040 | NA | 278 | 127 | 2 | 0 | 46 | 1.6 | 0.19-5.57 |
| 3 | 1040 | NA | 277 | 114 | 0 | 0 | 41 | 0.0 | 0-3.18 |
| TOTAL | | | 835 | 361 | 3 | 0 | 43 | 0.8 | 0.17-2.41 |
| 1 | 1700 | 0800 | 145 | 134 | 2 | 1 | 92 | 2.2 | 0.46-6.40 |
| 2 | 1700 | 0800 | 148 | 138 | 0 | 2 | 93 | 1.5 | 0.17-5.14 |
| 3 | 1700 | 0800 | 147 | 126 | 0 | 2 | 86 | 1.6 | 0.19-5.62 |
| TOTAL | | | 440 | 398 | 2 | 5 | 90 | 1.8 | 0.71-3.59 |
| 1 | 1700 | 1900 | 142 | 125 | 2 | 0 | 88 | 1.4 | 0.19-5.66 |
| 2 | 1700 | 1900 | 144 | 131 | 1 | 0 | 91 | 0.8 | 0.02-4.18 |
| 3 | 1700 | 1900 | 154 | 143 | 2 | 1 | 93 | 2.1 | 0.43-6.01 |
| TOTAL | | | 440 | 399 | 5 | 1 | 91 | 1.5 | 0.55-3.24 |
| GRAND TOTAL | | | 1715 | 1158 | 10 | 6 | 68 | 1.4 | 0.79-2.24 |

TABLE 2. Descaling and Mortality Data from Release and Capture Tests with Spring Chinook Salmon Smolts (*Oncorhynchus tshawytscha*) at the Wapato Canal Fish Screening Facility, Spring 1987

| TEST GROUP | CANAL FLOW (cfs) | RELEASE TIME (hr) | NUMBER RELEASED | NUMBER CAPTURED | NUMBER DESCALED | NUMBER DEAD | PERCENT CAPTURED | PERCENT DESCALED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1040 | NA | 306 | 191 | 2 | 0 | 62 | 1.0 | 0.13-3.73 |
| 2 | 1040 | NA | 321 | 192 | 5 | 0 | 60 | 2.6 | 0.85-5.97 |
| 3 | 1040 | NA | 313 | 196 | 1 | 0 | 63 | 0.5 | 0.01-2.81 |
| TOTAL | | | 940 | 579 | 8 | 0 | 62 | 1.4 | 0.06-2.70 |
| 1 | 1700 | 0800 | 155 | 151 | 0 | 0 | 97 | 0.0 | 0.00-2.41 |
| 2 | 1700 | 0800 | 155 | 147 | 0 | 0 | 95 | 0.0 | 0.00-2.48 |
| 3 | 1700 | 0800 | 160 | 158 | 2 | 0 | 99 | 1.3 | 0.15-4.50 |
| TOTAL | | | 470 | 456 | 2 | 0 | 97 | 0.4 | 0.05-1.58 |
| 1 | 1700 | 1900 | 142 | 133 | 5 | 5 | 94 | 7.5 | 3.66-13.39 |
| 2 | 1700 | 1900 | 126 | 122 | 3 | 4 | 97 | 5.7 | 2.34-11.46 |
| 3 | 1700 | 1900 | 136 | 131 | 3 | 4 | 96 | 5.3 | 2.18-10.70 |
| TOTAL | | | 404 | 386 | 11 | 13 | 96 | 6.2 | 4.02-9.11 |
| GRAND TOTAL | | | 1814 | 1421 | 21 | 13 | 78 | 2.4 | 1.66-3.33 |

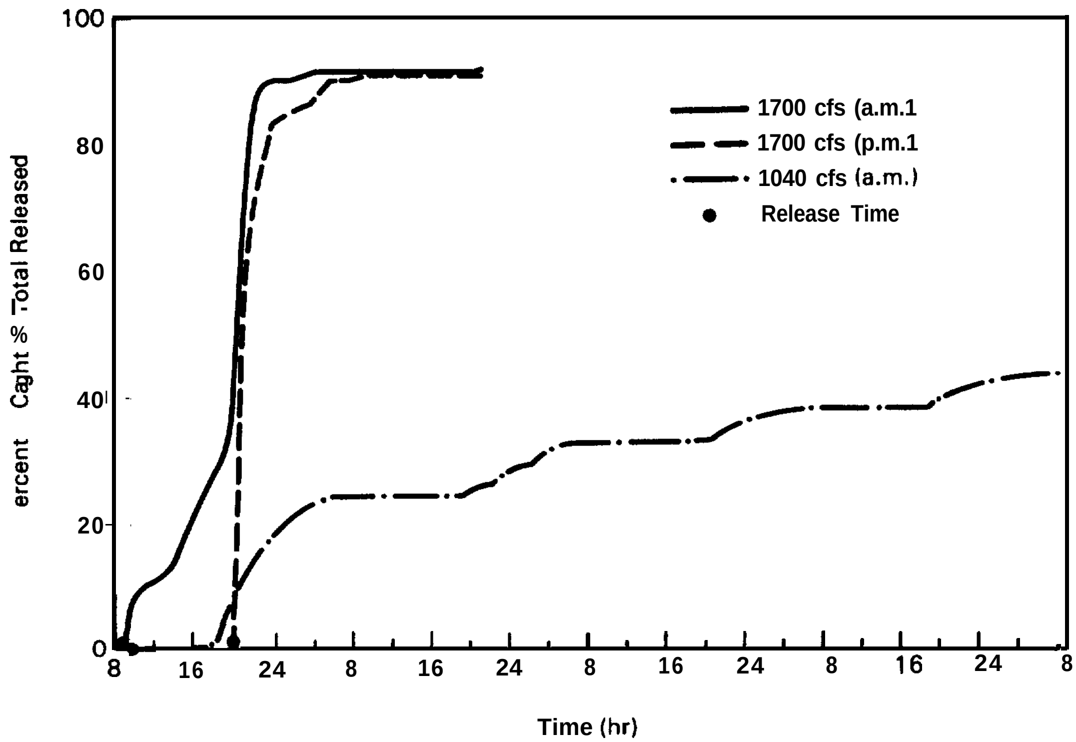


FIGURE 9. Movement of Steelhead Smolts *(Salmo gairdneri)* Based on the Capture of Test Fish at the Wapato Canal Fish Screening Facility, Spring 1987

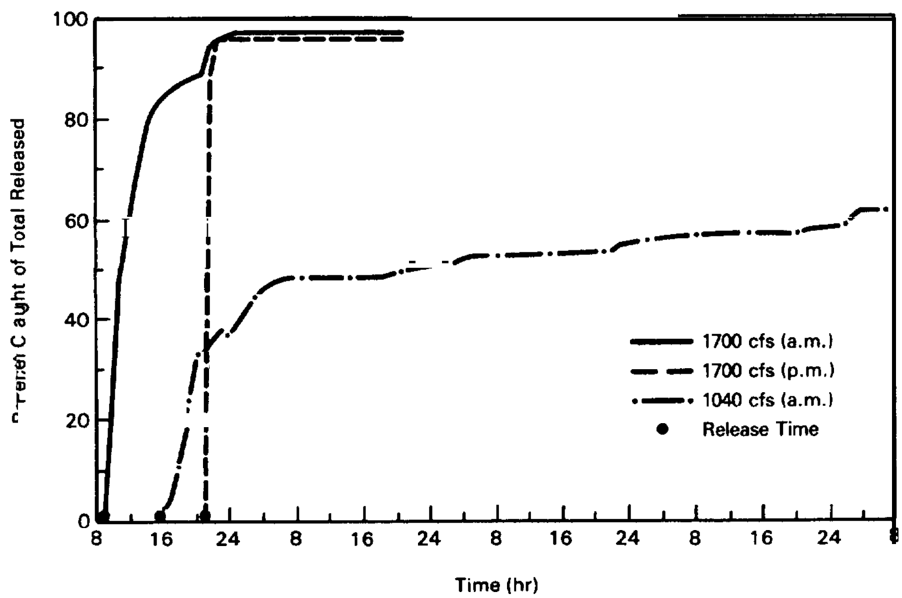


FIGURE 10. Movement of Spring Chinook Salmon Smolts *(Oncorhynchus tshawytscha)* Based on the Capture of Test Fish at the Wapato Canal Fish Screening Facility, Spring 1987

TABLE 3. Estimated Time (hr) to Catch 50% and 95% of Test Fish Released at the Wapato Canal Fish Screening Facility, Spring 1987

| SPECIES | CANAL FLOW (cfs) | RELEASE TIME | NUMBER RELEASED | TIME TO CATCH 50% | TIME TO CATCH 95% | NUMBER CAUGHT | TIME TO CATCH 50% | TIME 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 4. Descaling and Mortality Data for Spring Chinook Salmon (*Oncorhynchus tshawytscha*) and Steelhead (*Salmo gairdneri*) Smolts After Passage Through the Fish Return Pipe at the Wapato Canal Fish Screening Facility, Spring 1987

| SPECIES | NUMBER RELEASED | NUMBER CAPTURED | NUMBER DESCALED | PERCENT CAPTURED | PERCENT DESCALED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|---|
| Spring Chinook | 150 | 135 | 8 | 90 | 5.9 | 2.59-11.34 |
| Steelhead | 100 | 65 | 1 | 65 | 1.5 | 0.00-5.52 |

## PHASE IV TESTS

The inclined plane was used during release and capture tests to note the presence of predatory fish and the occurrence and condition of native and hatchery-released salmonids. Also, the drum screens were monitored to determine if fish were impinged.

Fall chinook salmon fingerlings were released upstream and downstream of the Richland and Wapato Screens to test for possible passage through, around, or over the rotary drum screens.

### Phase IVa, Richland Canal

Phase IVa tests were conducted in 1986 at the Richland Canal (Neitzel et al. 1986). Salmonids were not impinged on the angled rotary drum screens. The occurrence of predators and condition of upriver salmonid stocks were monitored (Neitzel et al. 1986). Our Phase IV efforts this year concentrated on screen integrity (Phase IVb). Consequently, the inclined plane was only fished for about 41 hr, and few upriver salmonids were captured and evaluated (Table 5).

TABLE 5. Descaling and Mortality Data for Upriver Salmonids Captured During Phase IV Tests at the Richland Canal Fish Screening Facility, Spring 1987

| SPECIES | NUMBER CAUGHT | NUMBER DESCALED | PERCENT DESCALED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|
| Steelhead | 11 | 0 | 0.0 | 0-28.49 |
| Spring Chinook | 28 | 0 | 0.0 | 0-12.34 |
| Fall Chinook | 44 | --(a) | --(a) | --(a) |

(a) Not evaluated for descaling.

A total of 3021 fall chinook salmon fry were released in front of the screens and 3021 behind the screens to evaluate the effectiveness of angled rotary drum screens in preventing fish from entering the irrigation canal behind the screens. During 41 hr after release, 1396 fish (46.2%) of the fish planted in front of the screens were captured in the fish return structure. During the 94-hr period after the release, none of the fish released in front of the screens (0%) and 1845 (61.1%) of the fish released behind the screens were captured by fyke net (1743 fish) or electrofishing (101 fish) in the canal behind the screens (Table 6). No fish released behind the screens were captured on the inclined plane in the fish return. Fall chinook salmon fry (52.1 mm FL) were not flushed from the Richland Screens forebay. Most fish were captured on the inclined plane either immediately after their release or after sunset on the first night (Figure 11). Because of the sharp decrease in catch rate, the inclined plane was removed after the second night.

Phase IVa. Wapato Canal

Few predacious fish (largemouth bass, *Micropterus salmoides*; smallmouth bass, *M. dolomieui*; northern squawfish, *Ptychocheilus oregonensis*) were caught in the fish return during our tests. Limited predacious feeding activity was observed in the canal during our tests; the gut of one smallmouth bass (25 cm FL) contained two of our branded fall chinook salmon fry. Seagulls (*Larus* spp.) were not common at the site. Forage fish, mostly redside shiners (*Richardsonius balteatus*), chiselmouth (*Acrocheilus alutaceus*), and sucker (*Catostomus* spp.) were the most common forage fish caught at the Wapato Screens. However, four species of juvenile salmonids were observed: chinook salmon, coho salmon, sockeye salmon,[a] and steelhead. Descaling was observed among all upriver salmonid stocks (Table 7). Most of the descaled and dead fish were observed during the peak migration period at night and were probably the result of overcrowding in holding tanks during our evaluation. The condition of hatchery-released steelhead was consistently poor, however. Wild chinook salmon fry (35 to 50 mm FL) were caught routinely throughout our sampling, indicating that fry were emerging from mid-March through May. Peak movement of 0-age chinook salmon occurred at night.

Phase IVb. Wapato Canal

A total of 9314 fall chinook salmon fry were released in screen integrity tests at the Wapato Screens (Table 8). Fish were released in front of the screens, in the intermediate and terminal fish bypasses, and in the mouth and cod end of fyke nets positioned behind the screens.

Of 600 fish planted in the intermediate and terminal bypasses, 571 were captured in the fish return, indicating a catch efficiency of about 95% (Table 9), assuming there were no losses to predation or passage through the traveling screens in the separation chamber. Catch efficiency of the fyke nets varied from 33% to 93%. The net retention efficiency ranged from 55% to 97%.

Of 6614 fish planted in front of the screens, 6011 (about 91%) were caught in the fish return, and 111 (1.7%) were caught in the fyke nets behind the

(a) The sockeye salmon observed at the Wapato Screens were probably kokanee from Rimrock Lake.

TABLE 6. Capture Data for Fall Chinook Salmon Fry (*Oncorhynchus tshawytscha*) Released in Screen Integrity Tests 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 |

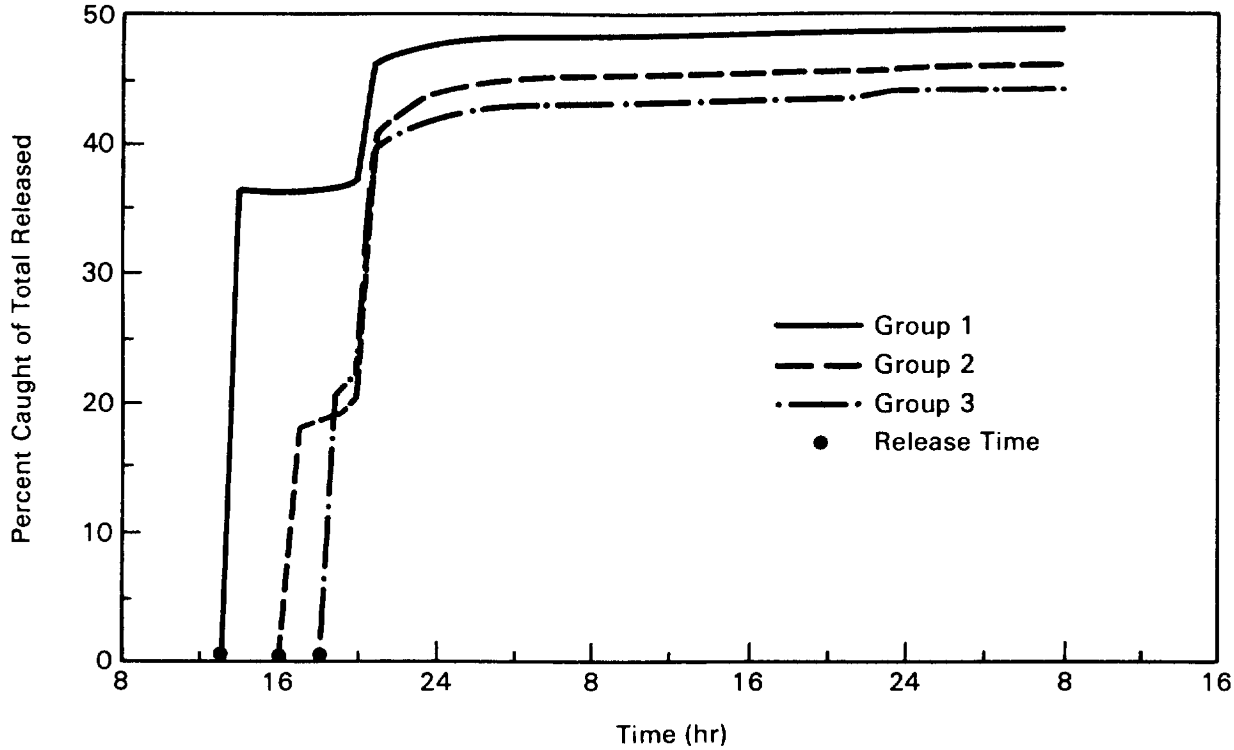


FIGURE 11. Movement of Fall Chinook Salmon Fry (*Oncorhynchus tshawytscha*) Based on the Capture of Test Fish in the Bypass During Screen Integrity Tests at the Richland Canal Fish Screening Facility, Spring 1987

screens. Given the catch efficiency estimates for the plane and the fyke nets, we can account for almost all (94% to 100%) of the fry released in front of the screens.

Fall chinook salmon fry released in the fish bypasses were flushed rapidly through the separation chamber and into the fish return slot. However, some fry released in front of the screens were able to avoid being flushed through the fish bypass immediately (Table 10).

**TABLE 7.** Descaling and Mortality Data for Upriver Salmonids Captured During Tests at the Wapato Canal Fish Screening Facility, Spring 1987

| SPECIES | ORIGIN | NUMBER CAUGHT | NUMBER DESCALED | NUMBER DEAD | PERCENT DESCALED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|---|
| Steelhead | Wild | 147 | 6 | 0 | 4.1 | 1.51-8.67 |
| Steelhead | Hatchery | 51 | 11 | 0 | 21.6 | 11.29-35.32 |
| Coho Salmon | Hatchery | 34 | 4 | 0 | 11.8 | 3.3-27.45 |
| Chinook Salmon | Wild | 181 | 36 | 15 | 28.2 | 23.57-37.01 |
| Chinook Salmon | Hatchery | 70 | 10 | 8 | 25.7 | 16.01-37.56 |
| Chinook Salmon | --(a) | 146 | 3 | 0 | 2.1 | 0.42-5.89 |
| Chinook Salmon | --(b) | 397 | 49 | 23 | 18.1 | 15.48-23.36 |
| Sockeye Salmon | Wild | 1 | 0 | 0 | 0.0 | -- |

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

**TABLE 8.** Capture Data for Fall Chinook Salmon Fry *(Oncorhynchus tshawytscha)* Released During Screen Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1987

| TEST GROUP | SCREEN NUMBER[a] | NUMBER OF CONTROL FISH: RELEASED FYKE NET | CAPTURED COD END | RELEASED FYKE NET | CAPTURED MOUTH | RELEASED BYPASS | CAPTURED BYPASS | NUMBER OF TEST FISH: RELEASED | CAPTURED IN: PLANE | FYKE NET | 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] | II | II | -- | -- | 39 | 38 |
| 3 | 3 | 50 | 24 | 100 | 22 | 100 | 88 | 1472 | 1311 | 3 | 0 |
| | 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 | g[d] | 50 | 48 | 100 | 5 | -- | -- | -- | -- | 0 | 0 |
| 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 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 9. Capture Efficiency for Inclined Plane and Nets and the Retention Efficiency for Fyke Nets Used During Screen Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1987

| SCREEN SECTION[a] | CAPTURE PROBABILITY ESTIMATE FOR | | | SCREEN EFFICENCY | 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 seperation chamber (NUMBER 15).

TABLE 10. Estimated Time (hr) to Capture 50% and 95% of Fall Chinook Salmon Fry *(Oncorhynchus tshawytscha)* Released in Screen Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1987

| TEST GROUP | RELEASE SITE | NUMBER RELEASED | NUMBER CAUGHT | PERCENT CAUGHT | TIME TO CATCH 50% | TIME 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.

## DISCUSSION

Fish screening facilities in the Yakima Basin are designed to direct fish that have been diverted from the river and 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: 1) evaluate the conditions or circumstances that affect fish survival as the fish pass through the screening facility: 2) determine if a screening facility provides conditions under which diverted fish may become more susceptible to predation: 3) evaluate whether fish are delayed at or upstream of the screening facilities; and 4) determine if fish pass through, around, or over rotary drum screens and become trapped in the irrigation canal.

Operating conditions at each facility vary, resulting in different conditions for bypassed or diverted fish. The work plan includes tests to determine the potential for adverse conditions resulting from changes in operating conditions.

### FISH SURVIVAL AT SCREENING FACILITIES

Based on release/capture tests at four 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, and Toppenish/Satus Screens, the descaling rate for test fish at the Wapato Screens falls within the confidence limits for control fish.

Improvements in our methods were effective at standardizing the scoring of fish during descaling evaluations at the Wapato Screens. The extent of injury or descaling is determined by comparing the condition of fish released upstream of the screening facility and captured as they return to the river (test fish) to the general condition of the test group before release (baseline condition control fish). However, lighting, background color of the fish, and differences in personal interpretation can affect the accuracy of the evaluation. In last year's evaluation at the Toppenish/Satus Screens (Neitzel et al. 1986), the day shift evaluator scored all the baseline-condition control fish and fish that moved out during the day under natural daylight conditions, while the night shift scored the fish that moved out at night under artificial light. This resulted in a higher scoring for test fish moving out at night than for the baseline-condition controls. At the Wapato Screens. the scoring of baseline condition by both descaling evaluators, along with the use of artificial lighting, helped reduce variation in the evaluation.

Collection of fish with an inclined plane in the fish return slot provides the best opportunity to evaluate descaling as well as providing a means of comparing results among different screening facilities. Collection of fish at the end of the fish return pipe as the sole source of data collection is not desirable because of fluctuating river levels, turbulence, the lack of adequate structures in which to mount sampling equipment, and the lack of utilities necessary to safely hold fish.

## POTENTIAL FOR PREDATION AT THE WAPATO SCREENING

On the basis of the samples we have collected loss to predation does not appear to be a problem at the screening facilities. The facilities could affect the predator/prey relationship if the screens concentrate prey or increase the exposure of prey to predators because of stress, injury, or delay in migration. At Wapato, we caught a few predators and found our test fish in the gut of one that we examined. This is consistent with previous observations at the Sunnyside. Richland, and Toppenish/Satus Screens (Neitzel et al. 1985. 1986).

Few predacious fish were caught at any of the screening facilities during our tests, and feeding activity was not apparent in the screen forebays. In addition, the high recovery rate of fall chinook salmon fry released in fish bypasses during Phase IV tests at the Wapato Screens indicates that predators do not concentrate in the separation chamber of the fish return system. Predacious birds were not observed at the Wapato Screens.

## POTENTIAL FOR FISH DELAY AT SCREENING FACILITIES

One of the basic objectives of the redesign and construction of new screens is to provide a facility that safely and rapidly returns fish from the diversion canal to the river (Easterbrooks 1984). The evaluation of the screens that PNL has tested to date depends on how this objective is defined. Fish are not "flushed" from the screen forebay back to the river, although the screening facilities do not impede voluntary movement and migration. Fish that enter the diversion system are rapidly flushed to the fish return pipe. Fish released into the bypass at the Wapato Screens during screen efficiency tests were flushed to the fish return pipe (see section entitled Phase IVb. Wapato Canal, p. 28).

Involuntary movement ("flushing") of the fish could occur in the screen forebay if the water velocity exceeded the swim speed of the fish and the canal was void of eddies and resting areas. None of the screening facilities we have tested have successfully flushed fish out of the screen forebay.

Many factors can influence movement rate within a river or screening facility (e.g., fish species, smolting stage, fish size, water flow and velocity, and time of day). Fish movement at the Wapato Screens was much slower during low canal flow than during full canal flow. However, few of the steelhead and spring chinook salmon we released during low canal flow tests showed characteristic signs of smolting. Despite other differences, such as fish size and canal flow, we believe that conducting the tests before smolting was the major factor affecting the movement rate of fish released into the forebay.

The movement patterns at the Wapato Screens were consistent with our previous observations at other screening facilities: Salmon were captured sooner and at a higher rate than steelhead, and major movement occurred at night.

## POTENTIAL EFFECTS OF CHANGING SCREEN OPERATION

Operating conditions at a screening facility are important when evaluating the relevance of fisheries evaluation data. Screen efficiency may vary with flow water temperature, amount of debris in the water. other conditions that affect the screens, and the condition of fish that enter the screening facility. Normal operating conditions must be clearly defined at each screening facility in order to properly evaluate screen effectiveness.

Wapato Screens

The operating criteria for the Wapato Screens (Appendix C) describes weir heights and surface elevations required for optimum fish passage through the bypass under a wide range of canal flows. However, the criteria do not adequately address flow needs during canal startup or low canal level. Weir height adjustment at Gates 1 through 4 is made by adding stoplogs above a 1.2-m- (4-ft-) high approach ramp. With the bottom of the canal at an elevation of 281.3 m (923.0 ft). the minimum crest elevation at Gates 1 through 4 is 282.5 m (927.0 ft): this occurs with no stoplogs added over the ramp. Therefore, according to the graph provided in the operating criteria (Appendix C). the minimum canal level in which flow specifications can be met is 284.3 m (932.8 ft).

During our March tests, the canal surface elevation was 283.8 m (931.0 ft). Weir heights were set properly in the fish bypasses (Gates 1. 2, and 3). but flow over Gate 4 would have been inadequate if Gates 5 and 6 (in the pump basin) were set to specifications. In order to achieve adequate flow through Gate 4 (fish return slot), flows through Gates 5 and 6 were less than required in the criteria. The overall effect of the gate settings was a reduced flow and velocity through the entire fish bypass system. Water velocity in the the approach to Gates 1 through 3 and in the fish return slot was about 0.5 m/sec (1.5 fps).

During our tests in May, the canal surface elevation level was 284.7 m (934.2 ft). All weir heights were set to specifications: however, there was some confusion concerning the criteria to achieve the proper flows. Staff gauges are needed at Gates 1 through 4 in order to properly stoplog each bypass. A staff gauge is also needed in the fish separation chamber (in front of the traveling screens) to measure the 1.1-m (3.5-ft) differential in water level called for in the criteria.

Richland Screens.

The operating criteria for the Richland Canal (Appendix C) call for a forebay surface elevation of 126.1 m (413.61 ft). with minimum and maximum elevations of 126.0 and 126.1 m (413.28 and 413.61 ft), respectively. With Slot "C" stoplogged to an elevation of 412.0 ft. adequate bypass flows are achieved throughout the range of canal surface elevations. Adjustments to the canal surface elevation are made by opening or closing the head gates, or by stoplogging at the old screen structure in the canal downstream of the screening facility.

At 126.1 m (413.61 ft). the forebay elevation is lower than the overflow lip of the wastewater channel. Therefore, under normal operating conditions, no water should be spilled out the wastewater channel, except when stoplogs are pulled during trash rack cleaning operations. Screen integrity tests at the Richland Canal were conducted when the canal surface elevation was 126.0 m (413.28 ft), or the minimum level outlined in the criteria. Stoplogs were added at the old screen site to achieve this level.

Poor canal maintenance affects the operation of the Richland Screens. Canal flows and elevations were affected by an accumulation of tumbleweeds at two locations: at the footbridge above the old screen site, and at the trash racks. An obstruction in the canal downstream of the screening facility could cause the canal to back up. resulting in high canal elevations at the screening facility and spill at the wastewater channel. Blockage at the trash racks can cause low canal level, affecting bypass flow and fish passage. Both obstructions were removed before we conducted our screen integrity tests.

## FISH PASSAGE THROUGH OR OVER ROTARY DRUM SCREENS

Most fish that move through the forebay of a screen facility will pass near the screens. The screen openings (3.18 mm, 1/8 in.) are small enough to exclude most fish. The sweeping/approach velocity ratio as designed into the facilities helps guide fish away from the screens and into the bypass. Tests were designed and accomplished at the Richland and Wapato Screens to determine if any fish might be impinged by or passed through the screens.

### Wapato Screens

At Wapato, test fish passed through the seals on the screen drums and over the screens as the screens rotated. The rubber seals on the leading (upstream) edge of the rotary screens are effective at preventing fish passage, but the seals on the downstream edge of the drum screens were lifted away from the screen surface by the water currents associated with the sweeping velocity (the upper seals were held down flat by the same force). The effectiveness of bottom seals was not directly evaluated by these tests. The capture of two chinook salmon smolts behind the screens during our screen integrity tests suggests that the gap at some seals may be large. Not all of the downstream seals were faulty, indicating that replacement of worn seals might be all that is necessary to alleviate the problem. However, a new seal design, such as an overlapping flap that would prevent the seal from lifting, might be required to eliminate the problem. Discussions with Bureau of Reclamation personnel have indicated that the "music note" type of seal used at the Chandler Fish Screening Facility is more effective than the seals used at Wapato.

Impingement and passage over the screens appeared to be associated with small pieces of driftwood or other debris that accumulate at the water surface on the screen face. Entrainment is worst in front of the screens nearest each fish bypass where impingement velocities appear to be greatest. The fall chinook salmon fry we released hid behind the debris where sweeping velocity was disrupted. The fish became passive as a result of fatigue, and eventually became impinged and rode up the near-vertical face of the screens and over the top. When the fish reached the water surface behind the screens, they washed free and swam away, apparently unharmed. Impingement was rare on screens that were free of driftwood and debris. Whether this was because of the lack of disruption to the sweep velocity or because of a balanced sweep-to-approach-velocity ratio is not known.

Impingement of fish on the front of the screens could possibly be reduced in three ways: 1) by balancing the flows among the screens more accurately: 2) by stoplogging at the surface behind the screens to reduce approach velocity at the water surface in front of the screens: or 3) by installing a skimmer in front of the screens to prevent floating debris from accumulating on the face of the screens.

Balancing flows among the screens would require intensive flow measurement and stoplogging at each screen. Stoplogging requirements might vary with canal level, requiring that the measurements be made several times during the irrigation season. Stoplogging at the surface behind the screens, if effective at reducing approach velocity at the surface in front of the screens, would be a much less tedious solution. A skimmer in front of the screens might be more expensive to install, but would probably require less maintenance and adjustment. The need for these or other improvements is contingent on the importance placed on the losses attributable to impingement and entrainment.

Richland Screens.

The Richland Screens prevent fish from entering the canal downstream of the screening facility when the canal is operated within the specifications outlined in the operating criteria. No fish released in front of the screens were captured in the canal behind the screens. However, we suggest periodic inspection of the screen seals and the wooden sill under the screens.

## SUMMARY

Release and capture tests and other monitoring studies have been conducted at four diversion screen facilities in the Yakima Basin: the Sunnyside Screens (Neitzel et al. 1985). the Richland and Toppenish/Satus Screens (Neitzel et al. 1986). and the Wapato Screens. The objective of our evaluations is to determine whether or not fish that have entered a irrigation canal are safely diverted back to the river. The objective is met by determining if: 1) fish that pass through the diversion are killed, injured, or eaten by predators: 2) fish migration is delayed at the screen structure: and 3) fish are prevented from passing through or over the screens. These objectives are addressed in the various phases of the work plan.

### PHASE I

Phase I tests were conducted at the Sunnyside Screens with 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 were conducted at the Richland or Toppenish/Satus 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 fish passage facility differed significantly from components at the Sunnyside Screens, which were proven safe for fish passage.

### PHASE II

Phase IIa tests have been completed at all four 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, and Wapato Screens, fish were released only at the trash racks. Captured fish were not killed or injured. Tests at the Sunnyside Screens were conducted with chinook salmon and steelhead smolts, and tests at the Richland, ToppenishlSatus. and Wapato Screens were conducted with chinook salmon fry or fingerlings as well as chinook salmon and steelhead smolts.

Phase IIb tests were conducted at the Sunnyside, Richland. and Wapato 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 and Wapato Screens, the f!sh return pipe was evaluated. Fish successfully passed through each of the components without injury or delay.

### PHASE III

Phase III tests have been conducted at the Richland and Wapato 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 Wapato 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 conditions. Opportunities to conduct tests under different

canal flows have been limited because of delays in construction and startup at the Sunnyside, Richland, and Toppenish/Satus Screens. The Sunnyside and Toppenish/Satus Screens were evaluated only under full canal flow conditions and the Richland Screens only under minimum flow conditions.

## PHASE IV

Native fish were collected during all bypass tests. The gut contents of predacious fish were examined. Predacious bird activity was monitored in the vicinity of each of the screening facility. The screening facilities do not cause an increase in predation. Rotary drum screens were examined during bypass tests to determine if any fish were impinged on or passed over the screens. Successful screen integrity tests have been completed at the Richland and Wapato Screens. The Richland Screens are effective at preventing fish from entering the irrigation canal; however, some fish passed over the screens and through faulty screen seals at the Wapato Screens. Screen integrity tests initiated at the Sunnyside and Toppenish/Satus Screens were unsuccessful.

# RECOMMENDATIONS

Fisheries evaluations have been conducted at four diversion screen facilities: the Sunnyside. Richland, Toppenish/Satus, and Wapato 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 are not descaled or killed as they are diverted by the screening facilities: however, descaling tests should be conducted at future diversion sites to assess potential site-specific problems. Emphasis should be placed on correlating descaling to canal operations (Phase III). The periods when canal operating conditions are of greatest concern are 1) during canal startup. and 2) during peak migration of native salmonid stocks in the vicinity of each screening facility.

We have not observed increased predation on juvenile salmonids in or near screen facilities that could be attributed to the screens. Predacious fish do not appear to concentrate within the screening facilities. We plan to conduct canal surveys in Fall 1987 when canals are dewatered for the winter. Unless these surveys indicate otherwise, predation concerns should be assigned a lower priority in future evaluations.

Fish are not involuntarily delayed at or within the screening facilities when bypass flows are set according to the operating criteria. Salmonids that have not completed smolt transformation may reside in screen facility forebays when canal flows are low or flow criteria are not achievable. At the Wapato Canal, bypass flows can be less than design criteria specifications when the canal surface elevation is less than 284.3 m (932.8 ft). In 1987, the surface elevation in the Wapato Screens forebay was less than 284.3 m (932.8) ft from March through April. Efforts should be made to minimize abnormal flow events at each screening facility by incorporating fish bypass flow into canal startup operations.

Tests to evaluate screen integrity should continue to have high priority. Screen integrity tests we completed at the Richland and Wapato Screens indicated that the effectiveness of screens in preventing fish from entering the irrigation canal can vary. The Richland Screens were very effective at preventing fish from entering the canal, primarily because of low approach velocities in the screen forebay. However, at the Wapato Screens, poor seals were responsible for some fish loss. Annual inspection and replacement of faulty seals might alleviate the problem, but a new screen seal design may be necessary. Screen seals at the Sunnyside Screens are similar to those at the Wapato Screens and might also require improvement. Screen integrity tests with 0-age chinook salmon should be conducted at the Sunnyside Screens.

Chinook salmon fry passed over the rotary screens at the Wapato facility. Water flows did not appear to be uniform through all of the screens, resulting in a higher approach velocity at some screens. Passage over the screens appeared to be related to the presence of driftwood or other floating matter at the water surface in front of screens with high water flow. Stoplog adjustments behind the screens to achieve uniform flow might eliminate the problem: however, modifications in front of the screen, such as the addition of a skimmer or spray system, might also be necessary. Screen integrity problems must be addressed immediately because of plans by the Yakima Indian Nation to rear 250,000 fall chinook in the Wapato Screens forebay in the spring of 1988.

The operating criteria for each screening facility must rewritten to cover the entire range of potential flow conditions each canal. The criteria must be written to correspond with measurement facilities at the screens. For example, some of the staff gauges needed to adjust bypass at the Wapato Screens are not installed. Additionally, the operating criteria were written to address full canal flow conditions but are vague or lacking in information on operations during canal startup or during low canal flow.

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# APPENDIX A

## WORK PLAN

# APPENDIX A

## WORK PLAN

The work plan for all BPA-funded screen evaluations includes four phases. Phase 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 necessary 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 percent 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 an estimate of the proportion of the released fish that are killed or descaled. we will 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 will use a similar criterion for developing a sample duration. Samples are collected continuously. if possible, during the first 24 to 48 hr after release. If a higher catch total is required after 48 hr. collection will be made to the period of highest probable catch for the next 48 hr.

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 percent of fish that are killed or descaled during passage through the fish bypass system on 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.

PHASE IIa

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 bypass) 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 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 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) 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 IIb.

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 assumed 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) 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 will continue 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.

Phase IVb

Phase IVb monitoring is conducted to examine 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, AND WAPATO CANAL FISH SCREENING FACILITIES

## APPENDIX B

## RELEASE AND CAPTURE DATA FROM SUNNYSIDE, RICHLAND, TOPPENISH/SATUS, AND WAPATO CANAL FISH SCREENING FACILITIES

This appendix contains data collected during the evaluations of Sunnyside (Neitzel et al. 1985). Richland, and Toppenish/Satus (Neitzel et al. 1986) and Wapato Canal Fish Screening Facilities. Data presented in the Results sections are sometimes combined (i.e., individual trials within a test series were combined for a single estimate). In this appendix we are trying to present the data from each of the individual trials that were conducted. Descaled fish were considered dead for the estimates presented here, as they were in the Results sections of each of the annual reports. Dead and descaled fish were combined to evaluate screen performance.

Data from the Sunnyside Screens (Neitzel et al. 1985) indicate that fish are safely diverted from the canal to the river. Data are presented in Tables B.l through 8.7. The data in Tables B.l and 8.2 represent evaluation of the inclined plane and fyke net. Both samplers collected fish without killing or descaling the fish. Data in Tables 8.3 and 8.4 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 B.5 and B.6 are the results of the screening facility evaluations. Descaling data from upriver hatchery and native fish are presented in Table 8.7.

Data from the Richland Screens (Neitzel et al. 1986) evaluation indicate that fish are safely diverted from the canal to the river. Data from the 1986 evaluation are presented in Tables B.8 through B-15 and from the 1987 evaluation in Tables B.25 and B.29. Data in Tables B.8 and B.9 are from the evaluation 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 B.10 and B.1l are evaluations of the condition of the test fish before their release in the canal. Fish were in good condition before release. Data in Tables 8.12 and B-13 are the results of screening facility evaluations. Data in Table B.14 are the estimated times for test fish to move through the Richland Screen Facility. Descaling data from upriver hatchery and native fish are presented in Table B.15 (1986 data) and Table 8.25 (1987 data). The screen integrity data collected at Richland Canal in 1987 are presented in Table B.29.

Data from the Toppenish/Satus Screens evaluation indicate that fish are safely diverted from the canal to the river. Data are presented in Tables B.16 through B.19. Data in Table 8.16 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 8.17 are the results of screening facility evaluations. Data in Table B.18 are the estimated times for test fish to move through the Toppenish/Satus Screen Facility. Descaling data from upriver hatchery-released and native fish are presented in Table B.19.

Data from the Wapato Screens evaluation indicate that fish are safely diverted from the canal to the river. The evaluation of the potential for screen passage at Wapato indicates that some fish do pass through and over the screens: the estimated number based on tests with fall chinook salmon fry is less than 4%. Data from the tests at the Wapato Screens are presented in Tables B.20 through 8.24. B.26 through B-28. and B.30 through B.32. Data in Tables 8.20 and 8.30 are from the evaluations of the inclined plane and nets used to capture fish at the Wapato Screens. The plane and nets safely collected fish. Data in Table 8.21 and 8.22 are evaluations of the condition of the test fish before release in the canal. Fish were in good condition before release. Data in Tables 8.23 and 8.24 are the results of the screening facility evaluations. Table 8.26 presents the descaling data collected from upriver native and hatchery salmonids captured during the evaluation tests. Table 8.27 presents data from a test of the fish return pipe at the Wapato Screens. Table 8.28 gives data used to estimate the migration time through the screen facility for test fish. Table B.31 gives the data from the screen integrity tests at the Wapato Screens. Data in Table 8.32 are the estimated times for test fish to move through the Wapato Screen Facility.

**TABLE B.1.** **Percentage of Coho Salmon Smolts *(Oncorhnychus kisutch)* Descaled or Killed During Tests of the Inclined Plane at 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 | 0 | 0 | O-41.0 |
| 2 | 10 | 9 | 0 | 0 | 0-33.6 |
| 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 | O-37.0 |
| 7 | 10 | 10 | 0 | 0 | O-30.8 |
| 8 | 10 | 10 | 0 | 0 | o-4.8 |
| TOTAL | 80 | 74 | 0 | 0 | O-04.8 |

**TABLE B.2.** **Percentage of Steelhead *(Salmo gairdneri)* and Chinook Salmon *(Oncorhynchus tshawytscha)* Smolts Descaled or Killed During Tests of the Fyke Net at 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 | 0 | O-36.0 |
| Steelhead 2 | 50 | 28 | 0 | 0 | O-12.3 |
| Steelhead 3 | 2 | 21 | 0 | 0 | 0-16.1 |
| TOTAL | 155 | 57 | 0 | 0 | 0-6.3 |
| Chinook Salmon 1 | 50 | 21 | 0 | 0 | 0-16.1 |

**TABLE B.3.** Percentage of Steelhead Smolts *(Salmo gairdneri)* Descaled Before Being Used in Tests at 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 Smolts *(Oncorhynchus tshawytscha)* Descaled Before Being Used in Tests at 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 | 0-9.7 |
| Intermediate Bypass | 20 | 0 | 0 | 0-16.8 |
| Terminal Bypass | 20 | 0 | 0 | 0-16.8 |
| Trash Rack | 20 | 0 | 0 | 0-16.8 |
| Canal Head Gates | 32 | 0 | 0 | 0-9.7 |

TABLE B.5. Percentage of Steelhead Smolts (*Salmo gairdneri*) Descaled or Killed in Each Test at Sunnyside Canal Fish Screening Facility, Spring 1985

| RELEASE SITE | TEST REP. | NUMBER OF FISH RELEASED | CAPTURED | DESCALED OR KILLED | PERCENT DESCALED OR KILLED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|---|
| Primary Fish Return Pipe | 1 | 50 | 8 | 0 | 0 | 0-36.8 |
| | 2 | 50 | 16 | 0 | 0 | 0-20.6 |
| | 3 | 72 | 6 | 0 | 0 | 0-45.9 |
| Intermediate Bypass | 1 | 275 | 139 | 0 | 0 | 0-2.6 |
| Terminal Bypass | 1 | 200 | 112 | 0 | 0 | 0-3.2 |
| Trash Rack | 1 | 500 | 126 | 0 | 0 | 0-2.9 |
| Canal Head Gates | 1 | 500 | 100 | 0 | 0 | 0-3.6 |

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

| RELEASE SITE | TEST REP. | NUMBER OF FISH RELEASED | CAPTURED | DESCALED OR KILLED | PERCENT DESCALED OR KILLED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|---|
| Primary Fish Return Pipe | 1 | 100 | 83 | 0 | 0 | 0-4.4 |
| | 2 | 100 | 64 | 2 | 3.1 | 0.4-10.8 |
| | 3 | 100 | 75 | 0 | 0 | 0-4.8 |
| | 4 | 100 | 60 | 1 | 1.7 | 0-8.9 |
| | 5 | 100 | 89 | 0 | 0 | 0-4.1 |
| Inter-mediate Bypass | 1 | 100 | 82 | 2 | 2.4 | O-3-8.5 |
| | 2 | 100 | 95 | 0 | 0 | 0-3.8 |
| | 3 | 100 | 99 | 0 | 0 | 0-03.7 |
| | 4 | 100 | 95 | 2 | 2.1 | 0.3-7.4 |
| | 5 | 100 | 97 | 0 | 0 | o-3.7 |
| Terminal Bypass | 1 | 100 | 98 | 2 | 2 | 0.3-7.2 |
| | 2 | 100 | 96 | 1 | 1 | o-5.7 |
| | 3 | 100 | 98 | 0 | 0 | o-3.7 |
| | 4 | 100 | 98 | 3 | 3.1 | 0.6-8.7 |
| | 5 | 92 | 86 | 1 | 1.2 | 0-6.3 |
| 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 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 | O-2-14.7 |

TABLE B.8. Percentage of Chinook Salmon Smolts *(Oncorhynchus tshawytscha)* Descaled or Killed During Tests of the Inclined Plane at Richland Canal Fish Screening Facility, Spring 1986

| SPECIES | TEST REP. | NUMBER OF FISH | | | PERCENT DESCALED OR KILLED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|---|
| | | RELEASED | CAPTURED | DESCALED OR KILLED | | |
| Spring | 1 | 25 | 21 | 0 | 0 | O-16.1 |
| | Control | | 19 | 0 | 0 | o-17.7 |
| Fall | 1 | 25 | 16 | 0 | 0 | O-20.6 |
| | Control | | 20 | 0 | 0 | O-16.8 |
| | 2 | 500 | 156 | 0 | 0 | O-2.3 |

TABLE B.9. Percentage of Chinook Salmon Smolts *(Oncorhynchus tshawytscha)* Descaled or Killed During Tests of the Fyke Net at Richland Canal Fish Screening Facility, Spring 1986

| TEST REPLICATE | NUMBER OF FISH | | | PERCENT DESCALED OR KILLED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|
| | RELEASED | CAPTURED | DESCALED OR KILLED | | |
| 1-L[(a)] | 50 | 26 | 0 | 0 | 0-13.2 |
| L-control | 50 | 50 | 0 | 0 | o-7.1 |
| 1-H[(b)] | 90 | 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.10. Percentage of Steelhead Smolts *(Salmo gairdneri)* Descaled Before Being Used in Tests at Richland Canal Fish Screening Facility, Spring 1986

| TEST REPLICATE | NUMBER OF FISH | | | PERCENT DESCALED OR KILLED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|
| | RELEASED | CAPTURED | DESCALED OR KILLED | | |
| 1 | 100 | 100 | 0 | 0 | 0-3.6 |
| 2 | 100 | 100 | 0 | 0 | 0-3.6 |
| 3 | 101 | 101 | 1 | 1 | 0-5.4 |
| TOTAL | 301 | 301 | 1 | 0.3 | 0-1.8 |

TABLE B.11. Percentage of Chinook Salmon Smolts (*Oncorhynchus tshawytscha*) Descaled Before Being Used in Tests at 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 | 0-3.6 |
| 3 | 102 | 102 | 0 | 0 | 0-3.6 |
| TOTAL | 302 | 302 | 0 | 0 | 0-1.2 |

TABLE B.12. Descaling and Mortality Data from Release and Capture Tests with Steelhead Smolts (*Salmo gairdneri*) at 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 | 200 | 129 | 1 | 0.8 | 0.2-4.2 |
| 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.13. Descaling and Mortality Data from Release and Capture Tests with Spring Chinook Salmon Smolts *(Oncorhynchus tshawytscha)* at 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 | NUMBER OF FISH 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 | 4 | 0 | 0-12.0 |
| TOTAL | | | | 270 | 124 | 3 | 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. fyke net.
(b) E.S. electroshocker.

**TABLE B.14. Estimated Time (hr) to Catch 50% and 95% of Test Fish Captured at Richland Canal Fish Screening Facility, Spring 1986**

| SPECIES | TIME TO CATCH | | | NUMBER OF FISH | | PERCENT |
|---|---|---|---|---|---|---|
| | GROUP | 50% | 90% | RELEASED | CAPTURED | 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.15. Scale Loss for Hatchery-Released and Native Fish Captured During Tests at Richland Canal Fish Screening Facility, Spring 1986**

| SPECIES | NUMBER OF FISH | | PERCENT | 95% |
|---|---|---|---|---|
| | CAPTURED | DESCALED OR KILLED | DESCALED OR KILLED | CONFIDENCE INTERVAL |
| Chinook Salmon[a] | 17 | 3 | 4.7 | 1.0-11.0 |
| Coho Salmon | 51 | 3 | 17.7 | 3.8-48.0 |
| Steelhead | | | 5.9 | 1.3-18.9 |

(a) Primarily spring chinook salmon 010 cm FL). but includes some fall chinook salmon (<10 cm FL).

TABLE B.16. Percentage of Steelhead Smolts *(Salmo gairdneri)* Descaled Before Being Used in Tests at Toppenish/Satus Canal Fish Screening Facility, Spring 1986

| TEST REPLICATE | NUMBER OF FISH RELEASED | CAPTURED | DESCALED OR KILLED | PERCENT DESCALED OR KILLED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|
| 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 | 22-32.9 |
| TOTAL | 311 | 311 | 82 | 26.4 | 22.0-32.9 |

TABLE B-17. Descaling and Mortality Data from Release and Capture Tests with Steelhead Smolts *(Salmo gairdneri)* at Toppenish/Satus Canal Fish Screening Facility, Spring 1986

| TEST REPLICATE | NUMBER OF FISH RELEASED | CAPTURED | DESCALED OR KILLED | PERCENT DESCALED OR KILLED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|
| 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.18. Estimated Time (hr) to Catch 50% and 95% of Test Fish Captured at Toppenish/Satus Canal Fish Screening Facility, Spring 1986

| SPECIES | GROUP | TIME TO CATCH 50% | TIME TO CATCH 95% | NUMBER OF FISH RELEASED | NUMBER OF FISH CAPTURED | PERCENT CAPTURED |
|---|---|---|---|---|---|---|
| Steelhead | 1 | 12.5 | 41 | 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.19. Scale Loss for Hatchery-Released and Native Fish Captured During Tests at 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 | 0.0-16.8 |
| 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.20. **Percentage of Spring Chinook Salmon *(Oncorhynchos tshawytscha)* and Steelhead *(Salmo gairdneri)* Smolts Descaled or Killed During Tests of the Inclined Plane at Wapato Canal Fish Screening Facility, Spring 1987**

| SPECIES | NUMBER OF FISH RELEASED | CAPTURED | DESCALED | PERCENT DESCALED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|
| **Steelhead** | 10 | 9 | 0 | 0 | O-33.6 |
| **Steelhead** | 10 | 9 | 0 | 0 | o-33.6 |
| **TOTAL** | 20 | 18 | 0 | 0 | o-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.21. Percentage of Steelhead Smolts *(Salmo gairdneri)* That Were Descaled Before Being Used in Tests at Wapato 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-5.52 |
| 2 | 800 | 67 | 1 | 1.5 | 0.04-8.04 |
| 3 | 800 | 68 | 0 | 0 | O-5.28 |
| TOTAL | | 200 | 1 | 0.5 | 0.01-2.76 |
| 1 | 2000 | 35 | 0 | 0 | 0-10.00 |
| 2 | 2000 | 32 | 0 | 0 | 0-10.89 |
| 3 | 2000 | 33 | 0 | 0 | 0-10.58 |
| TOTAL | | 100 | 0 | 0 | O-3.62 |
| 1 | 2000 | 38 | 0 | 0 | 0-9.25 |
| 2 | 2000 | 36 | 0 | 0 | 0-9.74 |
| 3 | 2000 | 26 | 0 | 0 | 0-13.23 |
| TOTAL | | 100 | Q | 0 | 0-3.67 |
| GRAND TOTAL | | 400 | 1 | 0.25 | 0.01-1.39 |

**TABLE B.22** Percentage of Spring Chinook Salmon Smolts *(Oncorhynchus tshawytscha)* That Were Descaled Before Being Used in Tests at Wapato Canal Fish Screening Facilities, Spring 1987

| TEST REPLICATE | CANAL FLOW (cfs) | NUMBER OF FISH | | PERCENT DESCALED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|
| | | EXAMINED | DESCALED | | |
| 1 | 800 | 74 | 0 | 0 | 0-4.86 |
| 2 | 800 | 59 | 0 | 0 | 0-6.06 |
| 3 | 800 | 67 | 0 | 0 | 0-5.36 |
| TOTAL | | 200 | 0 | 0 | 0-1.83 |
| 1 | 2000 | 35 | 0 | 0 | 0-10.00 |
| 2 | 2000 | 35 | 0 | 0 | 0-10.00 |
| 3 | 2000 | 30 | 0 | 0 | 0-11.57 |
| TOTAL | | 100 | 0 | 0 | 0-3.62 |
| 1 | 2000 | 33 | 0 | 0 | 0-10.58 |
| 2 | 2000 | 28 | 0 | 0 | 0-12.34 |
| 3 | 2000 | 39 | 0 | 0 | 0-9.03 |
| TOTAL | | 100 | 0 | 0 | 0-3.62 |
| GRAND TOTAL | | 400 | 0 | 0 | 0-0.92 |

TABLE B.23. Percentage of Steelhead Smolts *(Salmo gairdneri)* Descaled or Killed in Each Test at Wapato Canal Fish Screening Facility, Spring 1987

| TEST GROUP | CANAL FLOW (cfs) | RELEASE TIME (hr) | NUMBER RELEASED | NUMBER CAPTURED | NUMBER DESCALED | NUMBER DEAD | PERCENT DESCALED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|---|---|---|
| 1 | 800 | NA | 280 | 120 | 1 | 0 | 0.8 | 0.02-4.56 |
| 2 | 800 | NA | 278 | 127 | 2 | 0 | 1.6 | 0.19-5.57 |
| 3 | 800 | NA | 277 | 114 | 4 | 0 | 0.0 | 0-3.18 |
| TOTAL | | | 835 | 361 | 3 | 0 | 0.8 | 0.17-2.41 |
| 1 | 2000 | 0800 | 145 | 134 | 2 | 1 | 2.2 | 0.46-6.40 |
| 2 | | | 148 | 138 | 0 | 2 | 1.5 | 0.17-5.14 |
| 3 | 2000 | 0800 | 147 | 126 | 0 | 2 | 1.6 | 0.19-5.62 |
| TOTAL | | | 440 | 398 | 2 | 5 | 1.8 | 0.71-3.59 |
| 1 | | | | | | | | |
| 2 | 2000 | 1900 | 142 | 125 | 2 | 0 | 1.4 | 0.19-5.66 |
| | 2000 | 1900 | 144 | 131 | 1 | 0 | 0.8 | 0.02-4.18 |
| 3 | 2000 | 1900 | 154 | 143 | 2 | 1 | 2.1 | 0.43-6.01 |
| TOTAL | | | 440 | 399 | 5 | 1 | 1.5 | 0.55-3.24 |
| GRAND TOTAL | | | 1715 | 1158 | 10 | 4 | 1.4 | 0.79-2.24 |

TABLE B.24. Percentage of Spring Chinook Salmon Smolts (*Oncorhynchus tshawytscha*) Descaled or Killed in Each Test at Wapato Canal Fish Screening Facility, Spring 1987

| TEST GROUP | CANAL FLOW (cfs) | RELEASE TIME (hr) | NUMBER | | | | PERCENT DESCALED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|---|---|---|
| | | | RELEASED | CAPTURED | DESCALED | DEAD | | |
| 1 | 800 | NA | 306 | 191 | 2 | 0 | 1.0 | 0.13-3.73 |
| 2 | 800 | NA | 321 | 192 | 5 | 0 | 2.6 | 0.85-5.97 |
| 3 | 800 | NA | 313 | 196 | 1 | 0 | 0.5 | 0.01-2.81 |
| TOTAL | | | 940 | 579 | 8 | 0 | 1.4 | 0.06-2.70 |
| 1 | 2000 | 0800 | 155 | 151 | 0 | 0 | 0.0 | 0.00-2.41 |
| 2 | 2000 | 0800 | 155 | 147 | 0 | 0 | 0.0 | 0.00-2.48 |
| 3 | 2000 | 0800 | 160 | 158 | 2 | 0 | 1.3 | 0.15-4.50 |
| TOTAL | | | 470 | 456 | 2 | 0 | 0.4 | 0.05-1.58 |
| 1 | 2000 | 1900 | 142 | 133 | 5 | 5 | 7.5 | 3.66-13.39 |
| 2 | 2000 | 1900 | 126 | 122 | 3 | 4 | 5.7 | 2.34-11.46 |
| 3 | 2000 | 1900 | 136 | 131 | 3 | 4 | 5.3 | 2.18-10.70 |
| TOTAL | | | 404 | 386 | 11 | 13 | 6.2 | 4.02-9.11 |
| GRAND TOTAL | | | 1814 | 1421 | 21 | 13 | 2.4 | 1.66-3.33 |

TABLE B.25 Scale Loss for Hatchery-Released and Native Salmonids During Tests at Richland Canal Fish Screening Facility, Spring 1987

| SPECIES | NUMBER CAUGHT | NUMBER DESCALED | PERCENT DESCALED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|
| Steelhead | 11 | 0 | 0.0 | 0-28.49 |
| Spring Chinook | 28 | 0 | 0.0 | 0-12.34 |
| Fall Chinook | 44 | --(a) | --(a) | --(a) |

(a) Not evaluated for descaling.

**TABLE B.26.** Scale Loss for Hatchery-Released and Native Salmonids Captured During Tests at Wapato Canal Fish Screening Facility, Spring 1987

| SPECIES | ORIGIN | NUMBER CAUGHT | NUMBER DESCALED | NUMBER DEAD | PERCENT DESCALED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|---|
| Steelhead | Wild | 147 | 6 | 0 | 4.1 | 1.51-8.67 |
| Steelhead | Hatchery | 51 | 11 | 0 | 21.6 | 11.29-35.32 |
| Coho Salmon | Hatchery | 34 | 4 | 0 | 11.8 | 3.3-27.45 |
| Chinook Salmon | Wild | 181 | 36 | 15 | 28.2 | 23.57-37.01 |
| Chinook Salmon | Hatchery | 70 | 10 | 8 | 25.7 | 16.01-37.56 |
| Chinook Salmon | --(a) | 146 | 3 | 0 | 2.1 | 0.42-5.89 |
| Chinook Salmon | --(b) | 397 | 49 | 23 | 18.1 | 15.48-23.36 |
| Sockeye Salmon | Wild | 1 | 0 | 0 | 0.0 | -- |

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

TABLE B.27. Percentage of Test Fish Descaled or Killed During Pipe Tests at 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 | 2.59-11.34 |
| Steelhead | 100 | 65 | 1 | 1.5 | 0.00-5.52 |

TABLE B-28. Estimated Time (hr) to Capture 50% and 95% of the Test Fish Released at Wapato Canal Fish Screening Facility, Spring 1987

| SPECIES | CANAL FLOW (cfs) | RELEASE TIME | NUMBER RELEASED | TIME TO CATCH 50% | TIME TO CATCH 95% | NUMBER CAUGHT | TIME TO CATCH 50% | TIME 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.29. Capture Data for Fall Chinook Salmon Fry (*Oncorhynchus tshawytscha*) Released at 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.30. Capture Efficiencies of the Inclined Plane and Nets and Retention Efficiency of the Fyke Nets Used in Screen Integrity Tests at Wapato Canal Fish Screening Facility, Spring 1987

| SCREEN(a) SECTION | CAPTURE PROBABILITY ESTIMATE FOR INCLINED PLANE | NET CAPTURE | NET RETENTION | SCREEN EFFICIENCY | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|---|
| 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 |

(a1 The screens are numbered from the upstream screen (NUMBER 1) to the downstream screen nearest the separation chamber (NUMBER 15).

TABLE B.31. Capture Data for Fall Chinook Salmon Fry *(Oncorhynchus tshawytscha)* Released During Screen Integrity Tests at Wapato Fish Screening Facility, Spring, 1987

| | | NUMBER OF CONTROL FISH | | | | | | NUMBER OF TEST FISH CAPTURED IN | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TEST GROUP | SCREEN NUMBER[a] | RELEASED FYKE NET | CAPTURED COD END | RELEASED FYKE NET | CAPTURED MOUTH | RELEASED BYPASS | CAPTURED BYPASS | RELEASED | PLANE | FYKE NET | 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 | 0 |
| 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.32.** Estimated Time (hr) to Capture 50% and 95% of Fall Chinook Salmon Fry *(Oncorhynchus tshawytscha)* Released in Screen Integrity Tests at Wapato Canal Fish Screening Facility, Spring 1987

| TEST GROUP | RELEASE SITE | NUMBER RELEASED | NUMBER CAUGHT | PERCENT CAUGHT | TIME TO CATCH 50% | TIME TO CATCH 95% |
|---|---|---|---|---|---|---|
| 1 | Upstream Bypass | 100 | 99 | 99.0 | <0.25[a] | <0.25 |
| 3 | Upstream | 100 | 88[b] | 88.0 | <0.5.0 | 1.00 |
| 1 | Screen 5[c] | 723 | 695 | 96.1 | <0.25 | 1.25 |
| 3 | Screen 3 | 1472 | 1311 | 89.1 | 0.5.0 | 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.

# APPENDIX C

## OPERATING CRITERIA FOR THE FISH SCREENING FACILITIES AT SUNNYSIDE. RICHLAND. TOPPENISH/SATUS. AND WAPATO CANALS

# APPENDIX C

## OPERATING CRITERIA FOR THE FISH SCREENING FACILITIES AT SUNNYSIDE. RICHLAND. TOPPENISH/SATUS. AND WAPATO CANALS

Appendix C contains the operating criteria for each of the fish screens that we have evaluated to date. The criteria were developed by hydrologists from 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 to achieve optimum fish passage conditions at each screening facility.

The operating criteria for the Sunnyside Screens are on pages C.2-C.11. Text describing different operating modes are on pages C.2-C.5. A diagram of the Sunnyside Screens is on page C.6. Detailed graphs for setting each of the five weirs at the Sunnyside Screens are on pages C.7-C.11.

The operating criteria for Richland Screens are on page C.12. The criteria describe alternate methods to adjust the canal surface elevation to achieve proper bypass flows. A diagram of the Richland Screens is included.

The operating criteria for the Toppenish/Satus Screens are on page C.13, and a graph describing weir adjustment is on page C.14. A letter from Dale R. Evan (NOAA) to Robert Tuck (YIN) addressing questions about a proposed operating criteria from the Bureau of Reclamation is included on pages C.15-C.16. The operating criteria for the fish ladder and fish bypass suggested by the BR are on pages C.17-C.19.

The operating criteria for the Wapato Screens are on pages C.20-C.23. Text describing the operating criteria appears on pages C.20-C.21. and a diagram of the Wapato Screens is on page C.22. A graph summarizing weir crest height adjustment based on canal surface elevation is on page C.23.

R. Pearce - NMFS
February 11, 1987

Operating Criteria for Sunnyside Canal Fish Screens
Bypass System, Trashrack and Screen Structure
Stoplogs and Pump Bay Baffles

I. Fish Screen Bypass System:

operation of the fish bypass system requires the adjustment of four bypass overflow weir gates located at points in the bypass system. These weir gates control the quantity of bypass flows and the water surface elevations within the system for good fish passage. The layout of the facility is shown on attached Figure 1.

The operation of the fish bypass requires that 50 cubic feet per second (cfs) enter the pumpback structure through both the intermediate fish bypass pipe and the terminal bypass (100 cfs total). The fish water return pumps, when both are operating, remove 80 cfs from the structure and return it to the Sunnyside Canal downstream of the screen facility. The remaining 20 cfs is returned to the river via the primary fish return pipe at the extreme southeast end of the pumpback structure. The bypass system should be operated in the pumpback mode (both pumps operating) whenever river flows past Sunnyside Dam are less than 500 cfs to avoid attracting upstream migrating adult fish into the river outlets of the primary and auxiliary fish return pipes.

In lieu of two pump operation, the required cfs bypass flow is provided by proper adjustment of the weir gates. In the case where the pumps are not operating, approximately 50 cfs should exit the structure by each of the primary and auxiliary fish return pipes, returning the total 100 cfs to the river. In the case where only one pump is operating, 40 cfs is pumped back to the canal with approximately 30 cfs being returned to the river by the fish return pipe and auxiliary fish return pipe each making a total of 60 cfs to the river.

To provide these specified bypass flows, the overflow weir gates should be adjusted as follows. The weir gates and gages are numbered and located as shown on the attached Figure 1.

For Two - Pump Operation:

1. Fish return weir gate No. 3 set at el. 891.0 (full open) with yoke at 5.5 ft. below deck.

2. Intermediate bypass control weir gate No. 1 at el. 892.0 (full open), with yoke at 6.0 ft. below deck.

3. Terminal bypass weir gate No. 2 set at el. 892.0 (full open), with yoke 4.5 ft. below deck.

For No Pumps Operating or One Pump Operation:

1. Open all four gates full open

   Fish return weir gate No. 3 set at el. 891.0 with yoke 5.5 ft. below deck.

   Intermediate bypass control weir gate No. 1 set at el. 892.0, with yoke at 6.0 ft. below deck.

   Terminal bypass control weir gate No. 2 set at el. 892.0 with yoke at 4.5 it. below deck.

   Aux fish return weir gate No. 4 set at el. 892.25 with yoke at 4.25 ft. below deck.

Care must be taken to avoid operation of either pump when canal [illegible] is not enough to assure that at least 20 cfs is ~~until the flow through the bypass system is sufficient to assure that at least 20 cfs will continue to be~~ discharged over weir gate No. 3 through the fish return pipe back to the river. To maintain this minimum return flow at all times requires the weir gate No.3 be lowered completely and the water surface in the pumpback structure at gage No. ~~4 be at~~ elevation 893.1 or higher. The pump low-water shutoff switches for both pumps must be set at elevations above 893.1.

Attached figures 2 through 5 provide information on weir gate flows for various gage water surface elevations and weir gate settings, and Figure 6 provides pump discharges for various gage No. 4 water surface elevations. These figures are the basis for the weir gate operations specified above. They can be used to more precisely define flow quantities through the bypass system.

Generally, the weir gate settings specified above will provide the desired bypass system flows during periods when the canal water surface is near the maximum elevation of 896.5. During periods when the canal water surface is significantly lower ( below 896.0) the bypass flows will fall somewhat short of design values, but biological evaluation of the facility has indicated they will be adequate.

The fabricated metal adjustable-width slot assemblies initially provided for the bypass slots are not to be used.

II. Trashrack Stoplogs:

Wood and steel stoplogs have been provided immediately downstream of the trashracks to alter the naturally unbalanced flow in the canal to obtain a relatively uniform distribution of flow across the full width of the drum screen forebay. This uniform flow is fundamental to obtaining acceptable fish guidance conditions in front of the drum screens. The initial placement of logs was determined by hydraulic model studies and has an eight-foot height of logs in the right (south) bay and a seven-foot height of logs in the center bay. The left (north) bay has no logs placed in it. The placement of the logs should not be changed.

III. Screen Structure Stoplogs:

The screen structure stoplogs are located in pier slots immediately downstream of the drum screens. They are wood and steel, to be placed in such a configuration as to prevent floatation. Their purpose is to baffle flow to provide for a uniform velocity distribution through the screen drums.

The stoplog placement has been adjusted based on field observations and velocity measurements to obtain the best flow distribution possible. This placement noted below should be maintained in the future.

Note that "on blocks" means that two concrete blocks are placed beneath the bottom-most log to create a 8-inch ± gap between the concrete slab and the bottom log.

| Screen bay No. | Steel logs/timber loss/ Blocks |
|---|---|
| 1 (upstream-most bay) | Totally closed w/logs |
| 2 | None |
| 3 | None |
| 4 | None |
| 5 | None |
| 6 | None |
| 7 | None |
| 8 | 2 steel/3 timber/on blocks |
| 9 | None |

| | |
|---|---|
| 10 | 3 steel/5 timber/on blocks |
| 11 | 1 steel/2 timber/on blocks |
| 12 | 1 steel/2 timber/on blocks |
| 13 | 2 steel/3 timber/on blocks |
| 14 | 2 steel/3 timber/on blocks |
| 15 | None |
| 16 | None |
| 17 (downstream-most bay) | None |

IV. Pump Bay Baffles:

Directly behind the belt screens in the pumpback structure are structural steel frames with adjustable horizontal baffles. The baffles regulate the distribution of velocity top to bottom to meet current screening criteria. No future adjustment of the baffles is anticipated. Extra baffles have been provided and are stored on the site. The two frames are different and vary in width by l/2-inch to meet "as-build" concrete dimensions.

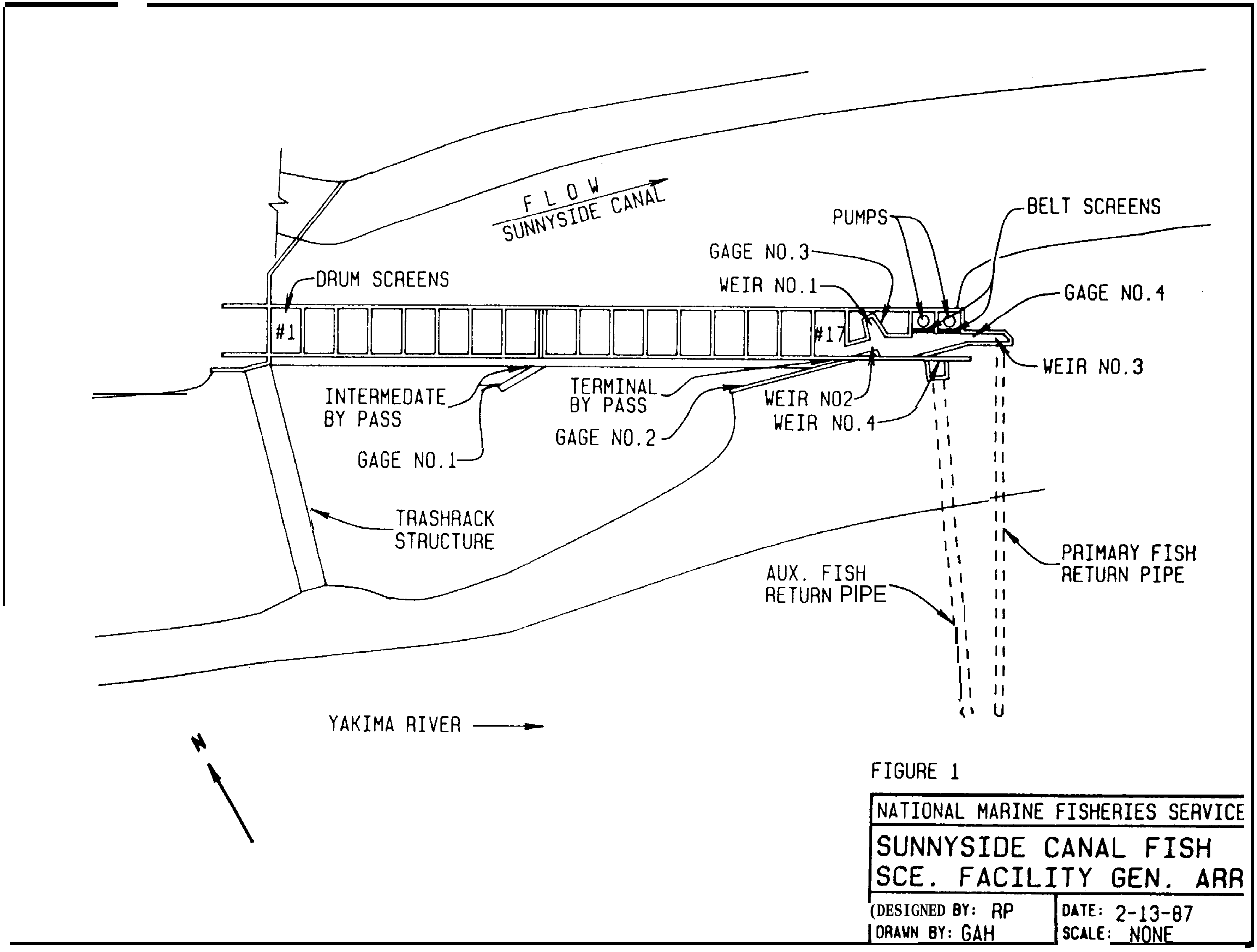

FLOW
SUNNYSIDE CANAL
DRUM SCREENS
#1
#17
PUMPS
BELT SCREENS
GAGE NO.3
WEIR NO.1
GAGE NO.4
WEIR NO.3
INTERMEDATE
BY PASS
TERMINAL
BY PASS
WEIR NO2
WEIR NO.4
GAGE NO.2
GAGE NO.1
TRASHRACK
STRUCTURE
PRIMARY FISH
RETURN PIPE
AUX. FISH
RETURN PIPE
YAKIMA RIVER
N
NATIONAL MARINE FISHERIES SERVICE
SUNNYSIDE CANAL FISH
SCE. FACILITY GEN. ARR
DESIGNED BY: RP
DATE: 2-13-87
DRAWN BY: GAH
SCALE: NONE

FIGURE 1

K·E 10 X 10 TO THE INCH · 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 0706

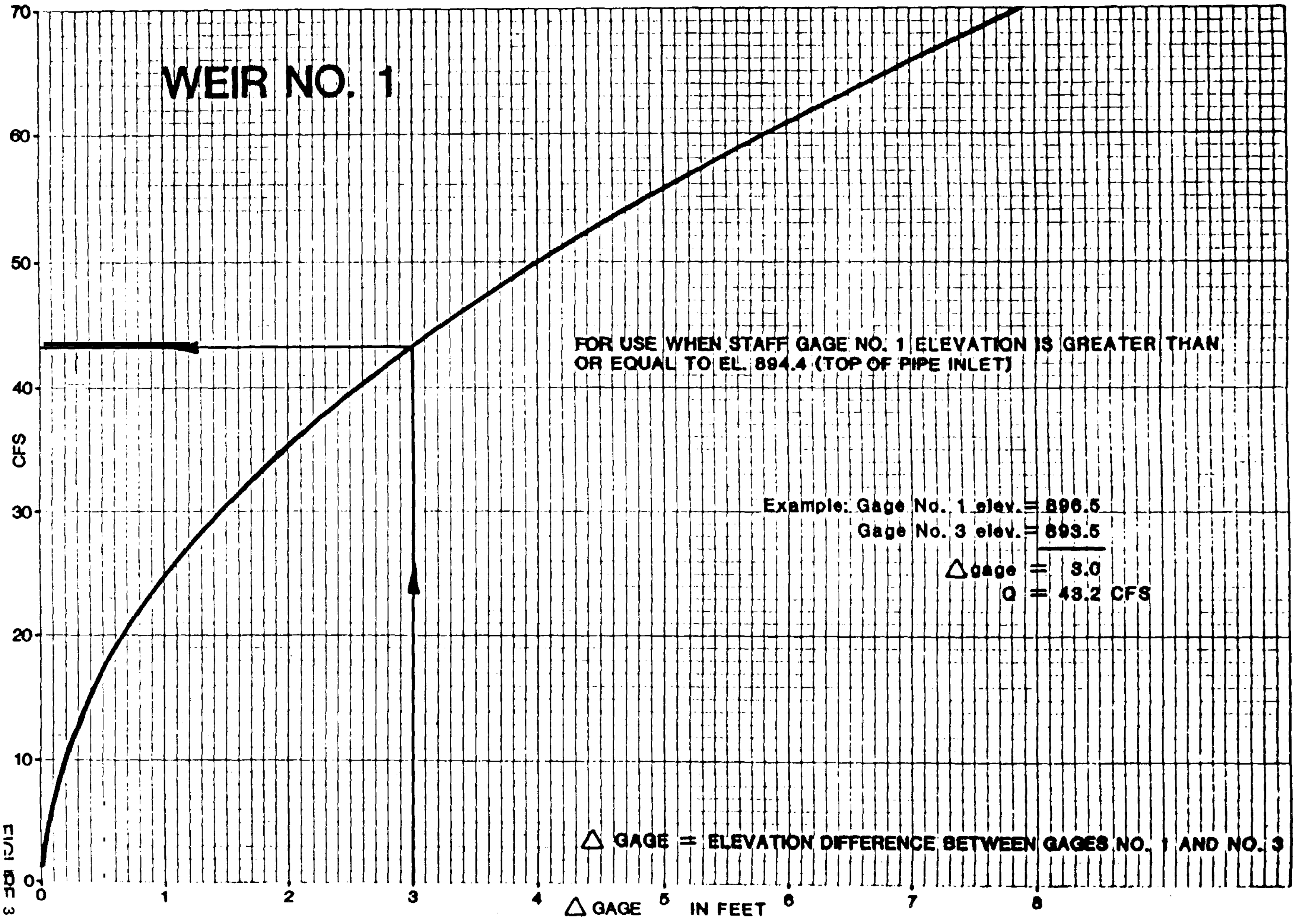
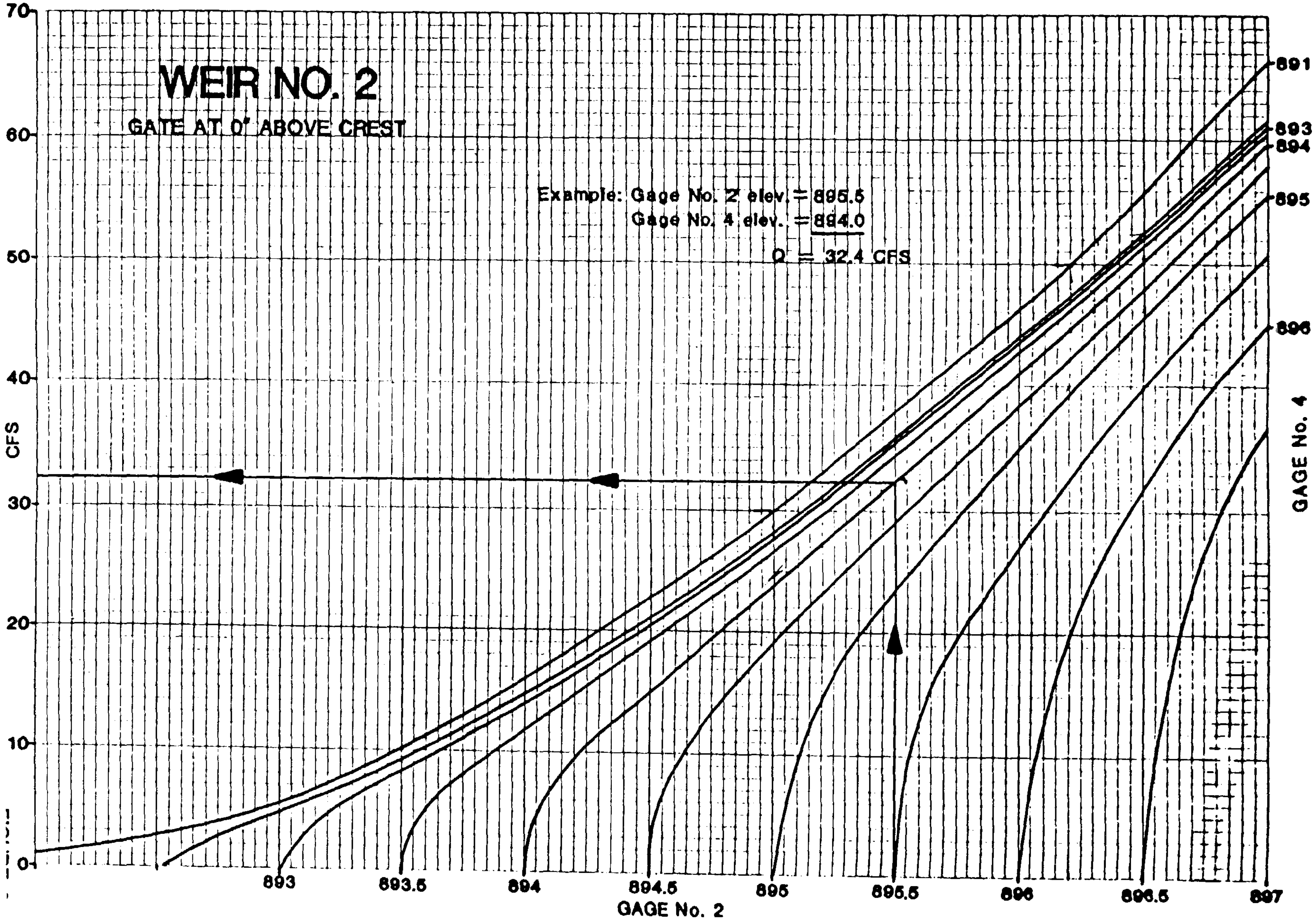
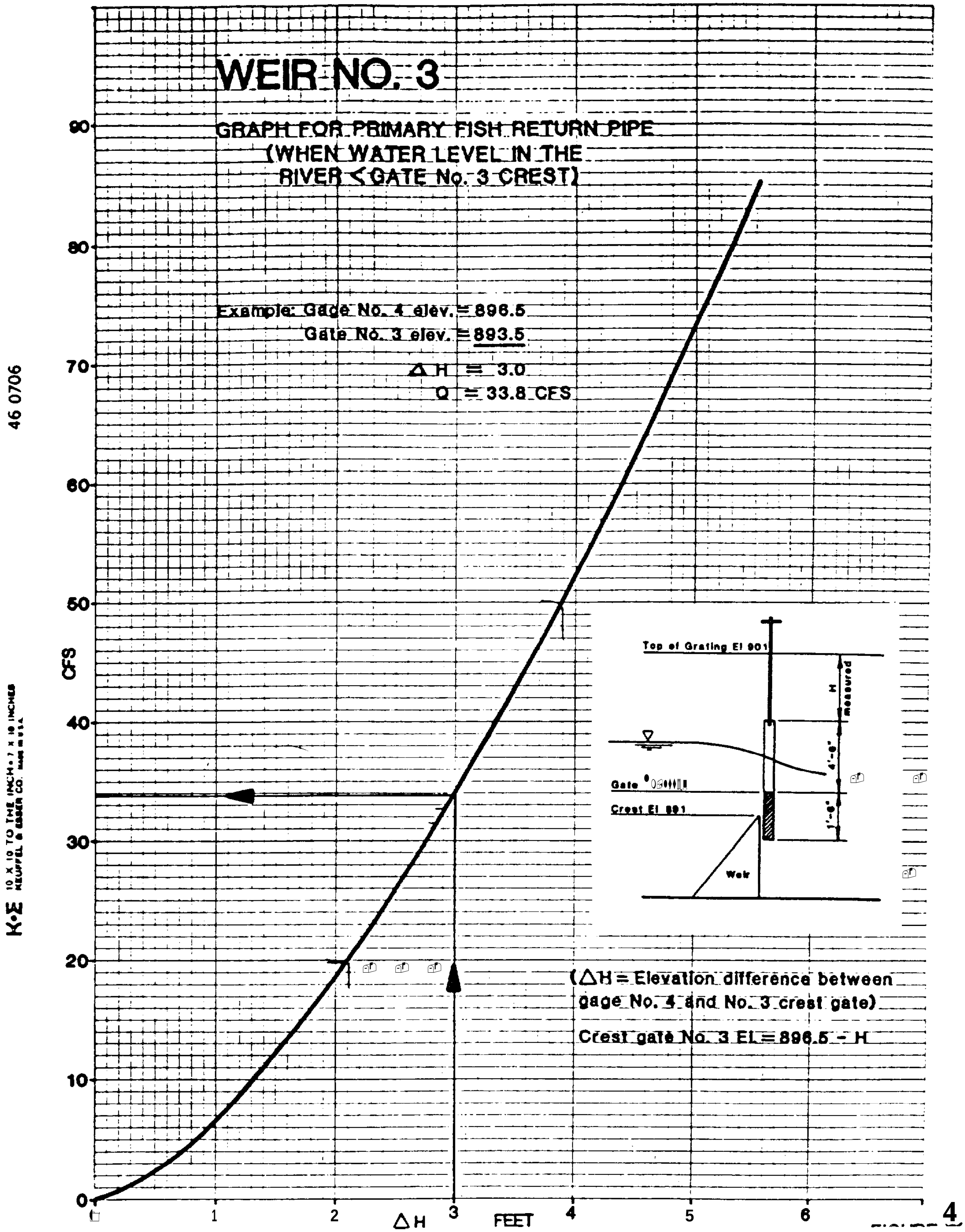



FIGURE 3

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 0705




C.8



WEIR NO. 3
GRAPH FOR PRIMARY FISH RETURN PIPE
(WHEN WATER LEVEL IN THE RIVER < GATE No. 3 CREST)
Example: Gage No. 4 elev. = 896.5
Gate No. 3 elev. = 893.5
ΔH = 3.0
Q = 33.8 CFS
Top of Grating El 901
H measured
4'-6"
1'-6"
Gate
Crest El 891
Weir
(ΔH = Elevation difference between gage No. 4 and No. 3 crest gate)
Crest gate No. 3 EL = 896.5 - H
CFS
ΔH FEET
0
10
20
30
40
50
60
70
80
90
1
2
3
4
5
6
4
46 0706
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

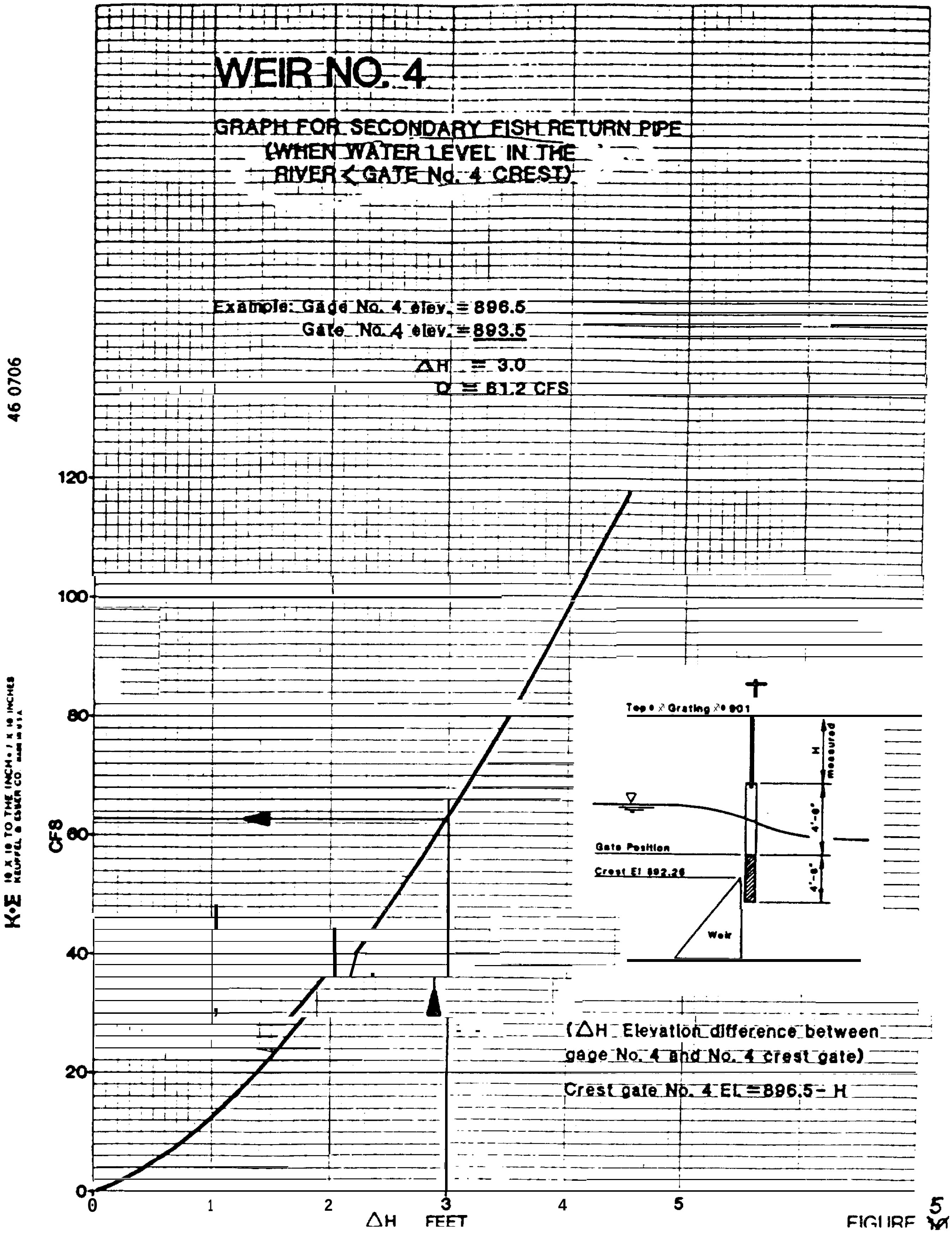
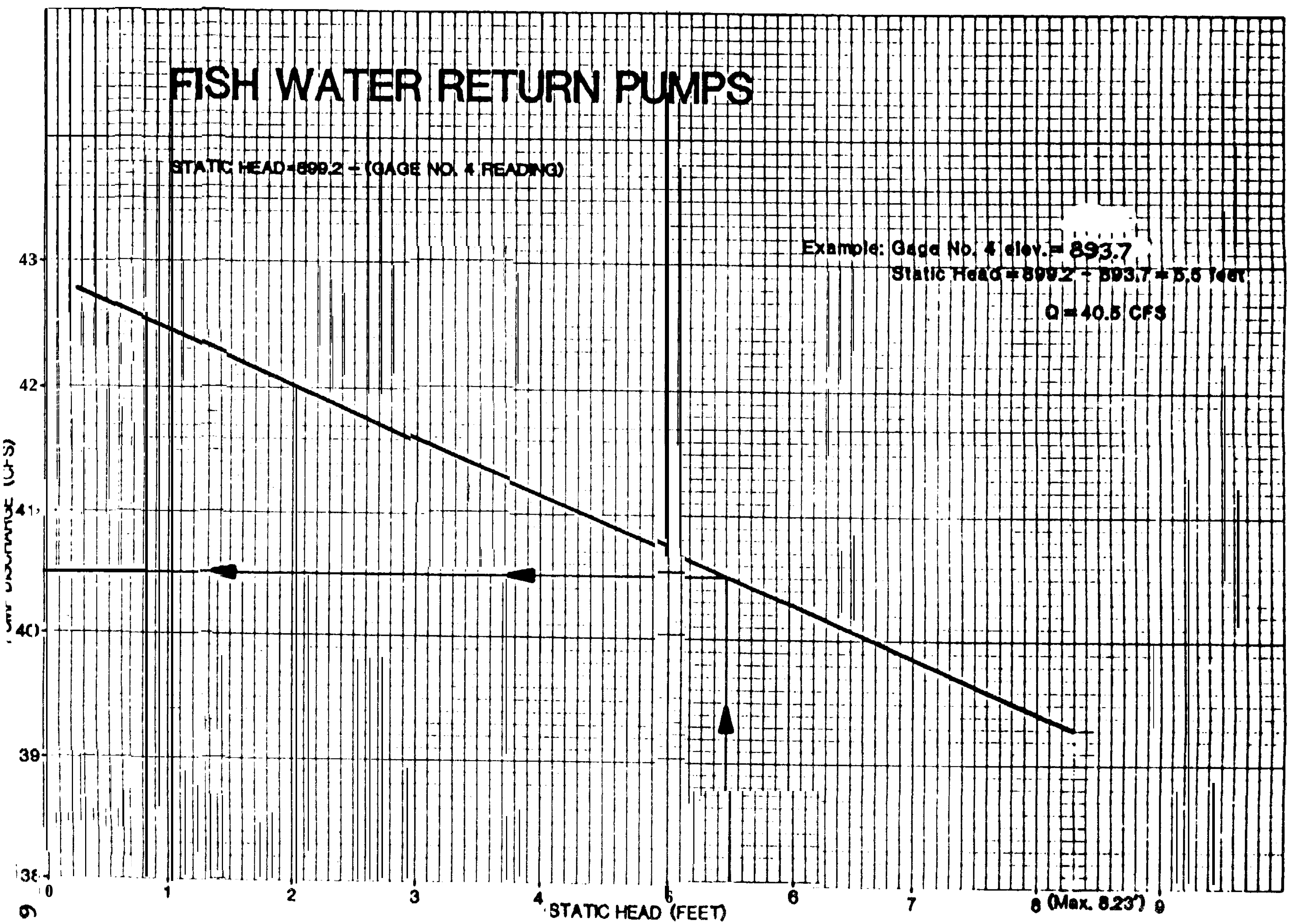
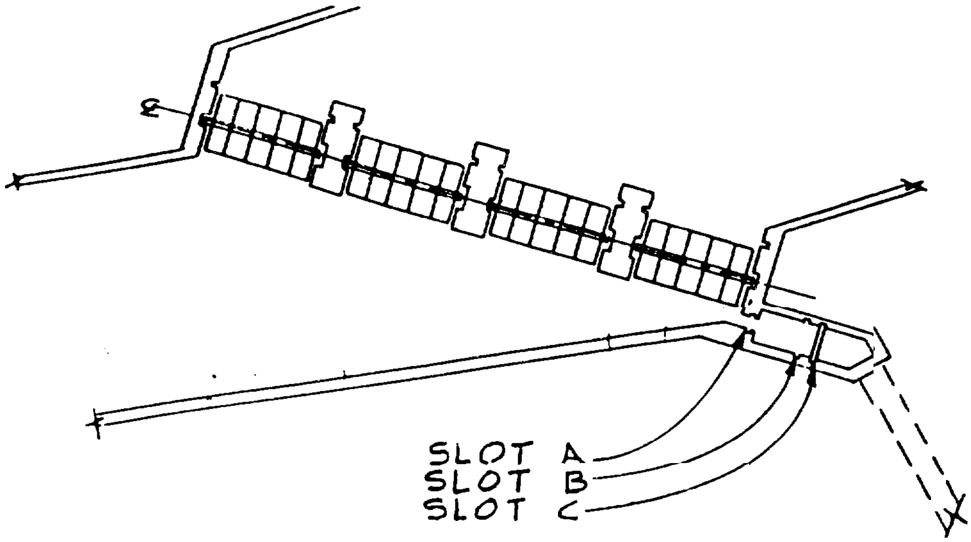

WEIR NO. 4
GRAPH FOR SECONDARY FISH RETURN PIPE
(WHEN WATER LEVEL IN THE RIVER < GATE No. 4 CREST)
Example: Gage No. 4 elev. = 896.5
Gate No. 4 elev. = 893.5
ΔH = 3.0
Q = 61.2 CFS
CFS
0
20
40
60
80
100
120
0
1
2
3
4
5
ΔH FEET
Top of Grating El 901
H measured
4'-6"
4'-6"
Gate Position
Crest El 892.26
Weir
(ΔH Elevation difference between gage No. 4 and No. 4 crest gate)
Crest gate No. 4 EL = 896.5 - H
46 0706
K•E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

FIGURE 5


FISH WATER RETURN PUMPS
STATIC HEAD=899.2 - (GAGE NO. 4 READING)
Example: Gage No. 4 elev.= 893.7
Static Head = 899.2 - 893.7 = 5.5 feet
Q = 40.5 CFS
43
42
41
40
39
38
0
1
2
3
4
5
6
7
8
9
STATIC HEAD (FEET)
(Max. 8.23')

OPERATING CRITERIA
Richland Screens
(NMFS-S/28/87)




Set check structure (downstream of screen structure) to provide canal water surface of E1.413.75. The canal water surface should not exceed E1.413.85, nor should it be lower than E1.413.4.

slot (A) is to be empty, slot (B) is to be empty. Place stoplogs in slot (C), with top stoplog 1.5' below water surface elevation.

Design Bypass Q=25 cfs

Notes:

1. The 12" wide, full depth slot is not to be used at the bypass entrance.

2. If the canal water surface falls below E1.413.4, either add stoplogs to the downstream water surface control structure (old screen structure), or increase the head gate opening, or both. Under no circumstances should the bypass entrance flows be reduced to increase canal flows. This should not be necessary, especially if the canal is properly maintained.

3. Minimize flow through the overflow facilities, upstream of the new and old screen locations, except for temporary flushing of debris.

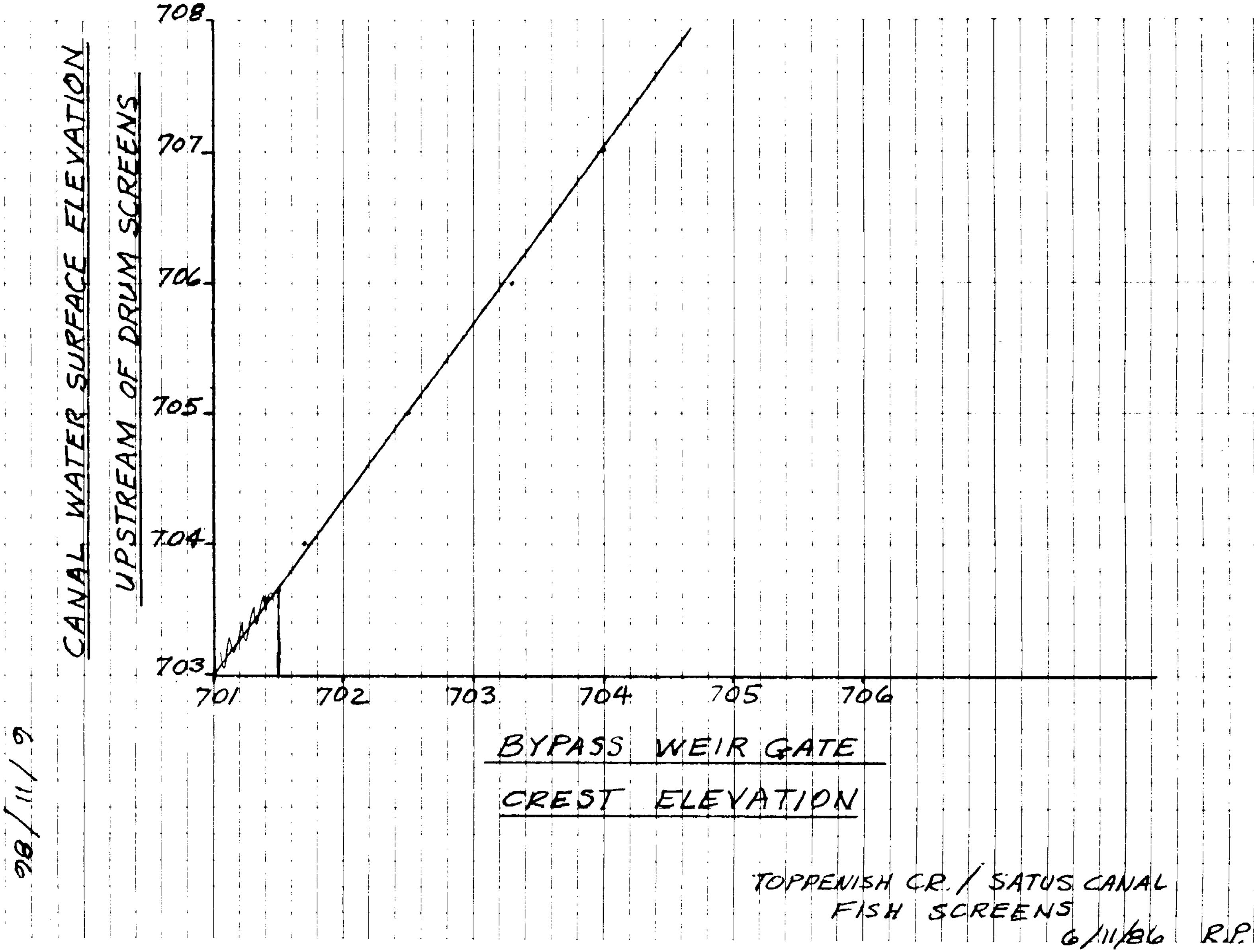
DRAFT
(NMFS CRITERIA)

June 13, 1986 F/NWR5

Subject: Operating Criteria for TO PPENISH CREEK/SATUS CANAL [redacted] Fish Screens
Bypass System

Operation of the bypass system requires the adjustment of the 2-foot wide bypass overflow gate located in the fish bypass channel at the south end of the screen structure. This weir gate controls the quantity of flow through the bypass as required for good fish passage.

The weir gate is to be adjusted based on the canal water surface elevation measured immediately upstream of the drum screens. The crest of the gate is to be set at the appropriate elevation as shown on the attached curve. For example when the canal water surface upstream of the drum screens is at elevation 706.0, the weir gate crest should be set at elevation 703.~~3~~2.


CANAL WATER SURFACE ELEVATION
UPSTREAM OF DRUM SCREENS
708
707
706
705
704
703
701
702
703
704
705
706
BYPASS WEIR GATE
CREST ELEVATION
TOPPENISH CR. / SATUS CANAL
FISH SCREENS
6/11/86 R.P.
6/11/86

X Tracie's cy

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

ENVIRONMENTAL & TECHNICAL SERVICES DIVISION
847 NE 19th AVENUE, SUITE 350
PORTLAND OREGON 97232-2279
(503) 230-5400

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— BROWN
— CEBALLOS
KOSKI
PEARCE
RAINEY
— ROSS
— VREELAND
— CROSBY
— STRICKER
X FILE

July 25, 1986 F/NWR5-335

Mr. Robert Tuck, Fisheries Biologist
Yakima Indian Nation
P.O. Box 151
Toppenish, Washington 98948

Dear Mr. Tuck:

We have reviewed the Bureau of Reclamation (BR) operational criteria for the Toppenish-Satus fish facilities provided by your letter of June 15, 1986 to Bob Pearce. The following comments are provided for your consideration in evaluating the adequacy of the criteria.

1. The criteria states that"the fish ladder is only capable of operating (with some minor adjustments for head changes) with gates either opened or closed". We don't know to what minor adjustments they are referring. No adjustment of flow was provided for in the design. The exit (upstream) gate should be full open for any ladder operation. Partial closure of that gate can reduce ladder flow by only an estimated 3 to 4 cfs at the most, and then would create an undesirable restriction for fish passage. A throttled gate condition would be exacerbated by the presence of the trashrack immediately upstream, especially when debris is present on the rack.

2. We don't know if the stated ladder flow range of 23 to 37 cfs was measured by the BR, but it appears close to our calculated values.

3. The criteria states that "the screen bypass has an adjustable gate with an outflow of about 48 cfs or about 51 cfs under uncontrolled conditions". Actually, the bypass flow is not to be operated as uncontrolled. It is to be controlled by operation of the overlow weir gate in the bypass to maintain the desired 2.0 fps velocity at the upstream end of the 2-foot wide bypass channel. Desired bypass flow therefore varies from 40 cfs at maximum canal water surface elevation 708.0 to 24 cfs at elevation 704.0.

   Attached is a copy of draft operating criteria for the bypass system which we prepared and sent to BR's Yakima Project office in June. This draft defines bypass weir gate

FILE COPY

operation necessary to maintain the 2.0 fps bypass channel velocity, based on calculated weir flows.

4. Reducing the bypass flow below the design value can be expected to reduce the juvenile passage efficiency of the facility. If flow is reduced significantly, juveniles can be expected to delay longer and to be subjected to increased potential for injury and predation. Quantifying the impact of reduced flow on passage efficiency would be difficult even with an extensive biological evaluation. It is our feeling that a reduction in flow of 25 percent or even less could very significantly impact passage.

5. Based on providing a maximum of 40 cfs through the bypass, the combined total flow of bypass and ladder during high water levels in both the diversion dam forebay and the canal would be 77 cfs rather than the stated 85 cfs. For lower water levels at either location the total flow would be reduced. We do not know what these water levels are at the time when low flows require fish facility flow curtailment, but they may be low enough that full operation does not require 77 cfs.

6. We agree with your previous suggestion that attention should be given to refining the irrigation project operation downstream of the screens to minimize the frequency and severity of those occasions when fish facility flow curtailment will be necessary.

7. Information on the migration periods for juveniles and adults of various species at this site is very limited. Setting priorities at this time for ladder versus screen bypass operation during periods of flow curtailment on the basis of anticipated migration periods can only be considered a first cut at establishing effective criteria.

Sincerely,

Dale R. Evans
Division Chief

Enclosure

cc: Ray Nelson, USBR Yakima Project Office
Ken Bates, WDF
Gary Malm, USFWS Yakima

Tuck;ROP:pt:jmr
7/24/86

United States Department of the Interior

**BUREAU OF RECLAMATION**
YAKIMA PROJECT OFFICE
1917 MARSH ROAD
P.O. BOX 1749
YAKIMA, WASHINGTON 98907-1749

IN REPLY REFER TO: 720
500.4-

July 11, 1986

Wapato Irrigation Project
Attn: Lou Hilderbrand
P. O. Box 220
Wapato, WA 98951

Dear Lou:

Please find enclosed a copy of the USBR operational criteria for the Toppenish-Satus fish faciiities.

The Yakima Project fish facilities will operate according to this criteria. We would appreciate receiving your comments pertaining to this matter at your earliest convenience.

Sincerely yours,

Ray Nelson
Project Superintendent

cc: Regional Director, Boise, Idaho, Attn: 201, Jim Mumford

bcc: [redacted]SOAC Member

Operating Criteria

Toppenish-Satus Fish Facilities

## I. Overview

The Satus Feeder Canal flow (see the attached sketch) originates at the confluence of Toppenish Creek and Marion Drain on Wapato Irrigation Project. A reservoir pool is formed at this confluence and a controlled spill is made into the final leg of Toppenish Creek before it enters the Yakima River System. The Satus Feeder Canal thence flows to Satus II pumping plant and provides irrigation water to a portion of the Wapato Irrigation Project.

A fish screening facility with bypass into Toppenish Creek has recently been constructed and is in operation on the Satus Canal. A fish ladder joins Toppenish Creek and the reservoir pool.

Prior to construction of the fish passage facilities, controlled flows from Marion drain and Toppenish Creek flows minus spill into the downstream leg of the Toppenish Creek were diverted to Satus Feeder Canal. Adjustments to spill flow necessary to maintain proper levels in the Feeder canal were completed as needed.

## II. Operations

until the following migration season. — What is the normal operation of the spillway gate during non-irrigation season? It should be opened to maximum extent possible when not required for flow diversion

Daily observations of pool level and flows into the Satus Canal will be made by USBR Fish Facilities O&M personnel during periods of low flow and adjustments will be made to the fish facilities as necessary. Measures to prevent depletion of flow to the Satus II pumping facilities will be performed in the following manner depending on the status of fish migration for a particular period of the year.

As the flow over the Toppenish Creek spillway drops below about 10 $ft^3/s$, or total flow in Toppenish is less than 95 $ft^3/s$: I can't agree with this figure. See comments above

I. February to Mid-April-Target Species: Adult Steelhead

Question re: there flow given to canal during non-irrigation season — Feb-March

Step 1- Incrementally close the screen bypass to zero flow as flows for diversion to Satus Feeder Canal become reduced,

Step 2- Close the fish ladder gate.

II. Mid-April to Aug 30-Target Species: Juvenile Chinook, Salmon and Steelhead

Step 1- Close the fish ladder gate.

Revised 6/29/87

## Operating Criteria
## Wapato Canal Fish Screens Bypass System

Operation of the bypass system requires the adjustment of four 2-foot wide bypass overflow weir gates (these are temporarily stoplogs at the present time) located in the fish bypass channels and two 5-foot wide excess water overflow weir gates located behind the pumps in the pumpback structure. These weir gates (or temporary stoplogs) control the quantity of bypass flows and the water surface elevations within the system for good fish passage.

Weir gates (or stoplogs) should be adjusted as follows. Weir gate locations are shown on the attached sketch.

Normal Operation (no pumpback):

1. Adjust crest of weir gates #l, #2, and #3 (or top of temporary stoplogs) to appropriate elevation depending on canal w.s. (water surface) elevation from attached graph. Example: canal w.s. in front of drum screens is at elevation 934.0; set crest of weir gates (stoplogs) to elevation 930.7

2. Adjust crest of weir gate #4 (or top of temporary stoplogs) To appropriate elevation depending on canal w.s. elevation as shown on attached graph. Example: canal w.s. elevation 934.0; set crest of #4 weir gate (or top of stoploq) at elevation 928.0.

3. Adjust weir gates #5 & #6 "equally" until w.s. elevation in front of traveling screens is 3.5' lower than canal w.s. elevation in front of drum screens. Example: canal w.s. elevation 934.0: adjust weir gates #5 & #6 equally until w.s. elevation is front of traveling screens is 930.5.

Operation with Pumpback:

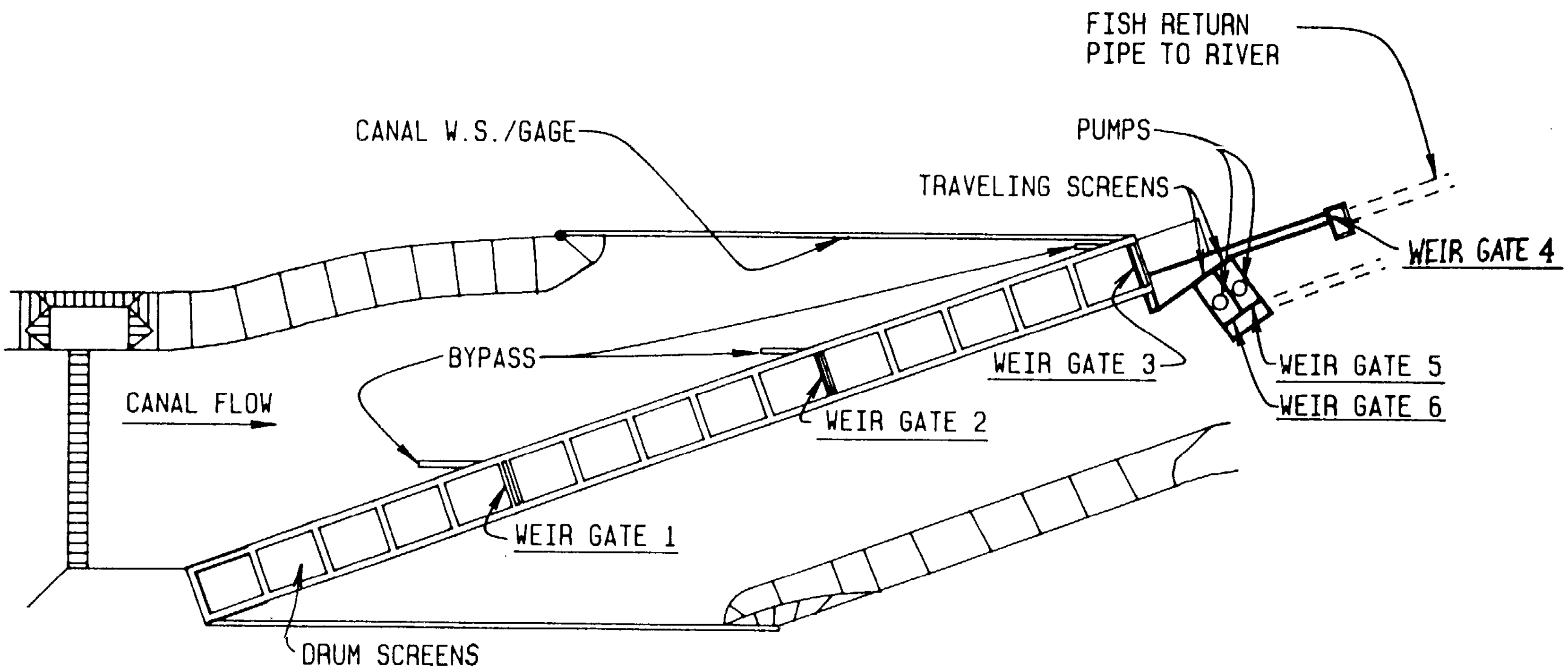
1. Set weir gates #l, #2, #3 & #4 same as for Normal Operation (No Pumpback).

2. With either one or both pumps in operation adjust both weir gates #5 & #6 to maintain the traveling screen w.s. 3.5' lower than canal w.s. elevation. Divide flow through both traveling screens equally.

3. If the difference between the canal w.s. and the traveling screen w.s. is greater than 3.5', even with

both weir gates #5 & #6 closed, then lower gates #l, #2 & #3 equally to obtain 3.5' difference. Note: This is very important since for certain conditions pumps may have enough capacity to pull the water level in the pumpback structure down two low, drying up the bypass flow over weir gate No. 4 and resulting in major fish damage.

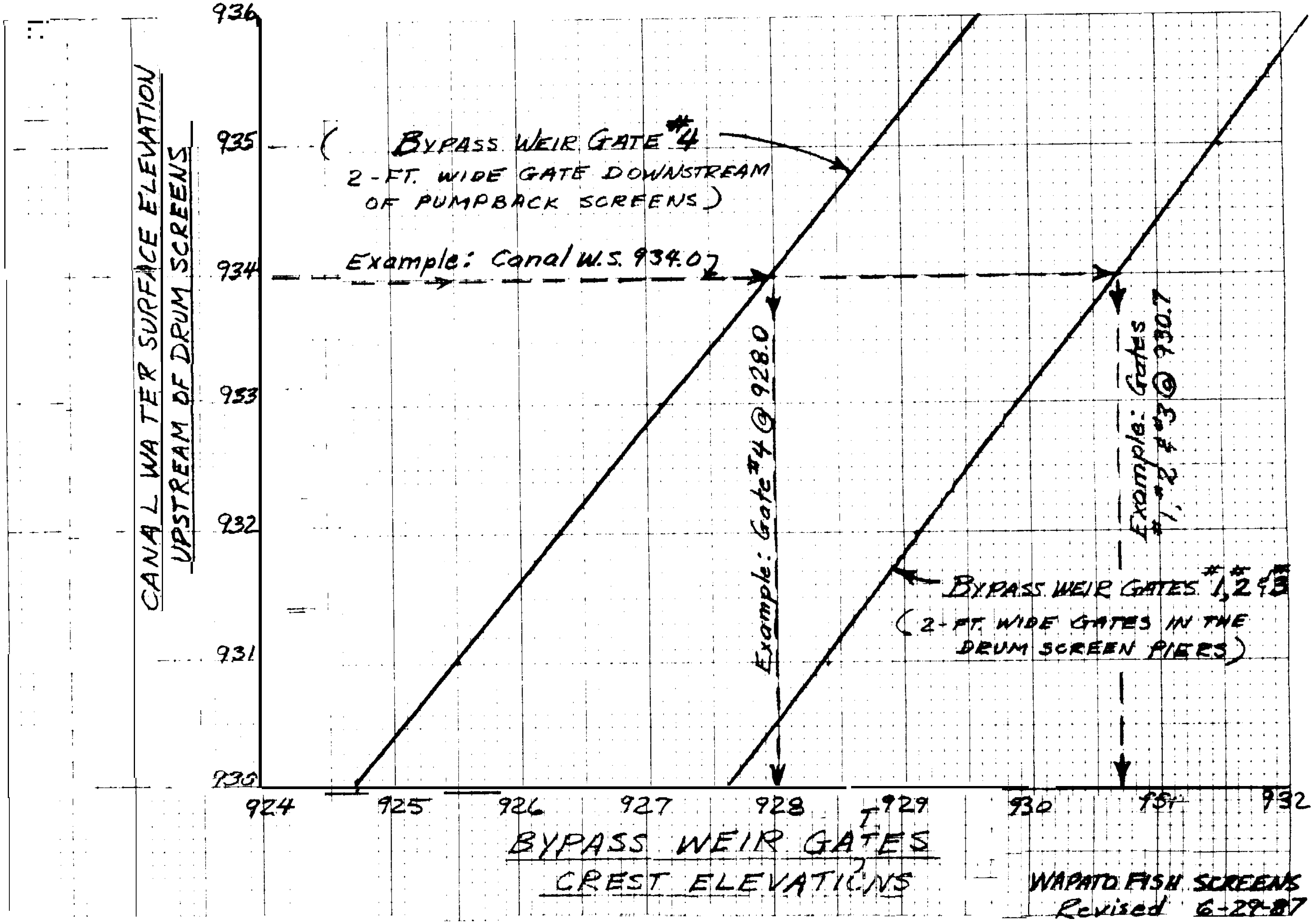
C.22




# WAPATO CANAL FISH SCREEN FACILITY PLAN

| NATIONAL MARINE FISHERIES SERVICE | |
|---|---|
| **WAPATO CANAL FISH SCREEN FACILITY** | |
| DESIGNED BY: R.P.<br>DRAWN BY: 6.A.H. | DATE: 2 - 30 - 87<br>SCALE : |

CAD FILE: WAPCAFSF


CANAL WATER SURFACE ELEVATION
UPSTREAM OF DRUM SCREENS
936
935
934
933
932
931
930
BYPASS WEIR GATE #4
(2-FT. WIDE GATE DOWNSTREAM OF PUMPBACK SCREENS)
Example: Canal W.S. 934.0
Example: Gate #4 @ 928.0
Example: Gates #1, #2 & #3 @ 930.7
BYPASS WEIR GATES #1, 2 & 3
(2-FT. WIDE GATES IN THE DRUM SCREEN PIERS)
924
925
926
927
928
929
930
931
932
BYPASS WEIR GATES
CREST ELEVATIONS
WAPATO FISH SCREENS
Revised 6-29-87

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