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A FISHERIES EVALUATION OF THE WAPATO, SUNNYSIDE, AND TOPPENISH CREEK CANAL FISH SCREENING FACILITIES

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Annual Report

By

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PREFACE

The Bonneville Power Administration, the United States Bureau of Reclamation, and the Washington State Department of Ecology are funding the construction and evaluation of fish passage and protection facilities at irrigation and hydroelectric diversions in the Yakima River Basin, Washington State. This construction implements Section 903s (d) and 803 (b) of the Northwest Power Planning Council's 1984 and 1987 Columbia River Basin Fish and Wildlife Programs.[a] The programs provide offsite enhancement to compensate for fish and wildlife losses caused by hydroelectric development throughout the Columbia River Basin and address natural propagation of salmon to help mitigate the impact of irrigation in the Yakima River Basin.

The Wapato, Sunnyside, and Toppenish Creek Screens are three of the facilities in the basin. This report evaluates the effectiveness of the screens in intercepting and returning juvenile salmonids unharmed to the river from which they were diverted. Fish were released upstream of or within the screen facilities and captured in the diversion that transfers them back to the river. The screens safely divert fish from the canals to the river. Test fish were steelhead *Oncorhynchus mykiss* smolts; spring chinook salmon *O. tshawytscha* smolts; and fall chinook salmon fry. Evaluations were conducted during typical spring flows.

(a) NPPC (Northwest Power Planning Council). 1984. Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council, Portland, Oregon.
NPPC (Northwest Power Planning Council). 1987. Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council, Portland, Oregon.

ACKNOWLEDGMENTS

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ABSTRACT

We evaluated the effectiveness of new screening facilities at the Toppenish Creek, Wapato, and Sunnyside canals in southcentral Washington State. Screen integrity tests indicated that fish released in front of the screens were prevented from entering the canal behind the screens. Screen efficiency estimates are 99% (±0.6%) for Toppenish Creek, 99% (±0.3%) for Wapato, and 98% (±0.5%) for Sunnyside. During 1987 at the Wapato Canal, we estimated screen efficiency was 97% (±1%).

We conducted descaling tests at the Toppenish Creek Screens. We estimated that 0.2% of steelhead *Oncorhynchus mykiss* smolts released during tests were descaled. None of the fish released through the fish return pipe were descaled.

We measured the time required for fish to move through the screen facilities. The time required for 50% of the test fish to exit the Toppenish Creek Screen forebay was 4 to 9 h for rainbow trout fry and up to 39 h for steelhead smolts. The time for 50% of the test fish to exit the Wapato and Sunnyside screen forebays was less than 8 h. As with past studies, exit times varied with canal flow and species. After 39 h at Toppenish Creek, half the steelhead smolts were still in the forebay when canal flows were 20 cfs. At Sunnyside, half the chinook salmon fry exited the forebay in 1 h or less.

Methods used in 1988 were the same as those used at Sunnyside in 1985 and in subsequent years at Richland, Toppenish/Satus, and Wapato. The methods and previous 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 Yakima Indian Nation.

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INTRODUCTION

The Yakima River Basin historically has supported significant salmon runs. During the late 1800s, between 500,000 and 600,000 adult salmon and steelhead *Oncorhynchus* spp. returned yearly to the Yakima River and its tributaries (Bureau of Reclamation 1984). Salmon runs included several races: spring, summer, and fall chinook salmon *O. tshawytscha*, coho salmon *O. kisutch*, sockeye salmon *O. nerka*, and steelhead *O. mykiss*. Some runs are now extinct or are nearing extinction. In the early 1980s, spawning escapement averaged about 2000 salmonids (Bureau of Reclamation 1984). Today, there is no sockeye run in the Yakima River Basin, and in 1983 only 37 coho salmon passed the Prosser Diversion Dam (Hollowed 1984). Recent improvements in efforts to manage and enhance salmonid runs in the Yakima River increased the total spawning escapement to 5- to 10-thousand adults in the late 1980s (Fast et al. 1986).

Reduced numbers of salmonids returning to the Yakima River Basin reflect many factors. Spawning and rearing habitat is less because of reduced instream flow downstream from irrigation diversion dams. Ineffective fish passage facilities for adults and juveniles at diversion dams cause high mortality during migration. Additionally, many Yakima River fish are killed while passing hydroelectric dams on the mainstem Columbia River.

The Pacific Northwest Electric Power Planning and Conservation Act (Public Law 96-501) was passed to enable preparation and implementation of a regional Conservation and Electric Power Plan. The Northwest Power Planning Council, which administers the Plan, 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 enhancing salmon and steelhead runs. Under the Plan, the Bonneville Power Administration (BPA) and the Bureau of Reclamation (BR) fund the construction of fish passage and protection facilities at irrigation and hydroelectric diversions in the Yakima River Basin (Figure 1). BPA also provides funds to the Yakima Indian Nation to increase production of spring chinook salmon in the Yakima River Basin.

Construction of the Wapato, Sunnyside, and Toppenish Creek Canal Fish Screening Facilities (Wapato, Sunnyside, and Toppenish Creek Screens) was completed in 1985, 1987, and 1988 respectively. During 1985, BPA asked the Pacific Northwest Laboratory (PNL) to evaluate the effectiveness of these diversion facilities in returning fish that had entered the canals to the river. The work plan for this study was designed to determine if diverted fish are safely and expeditiously returned to the river. Tests were

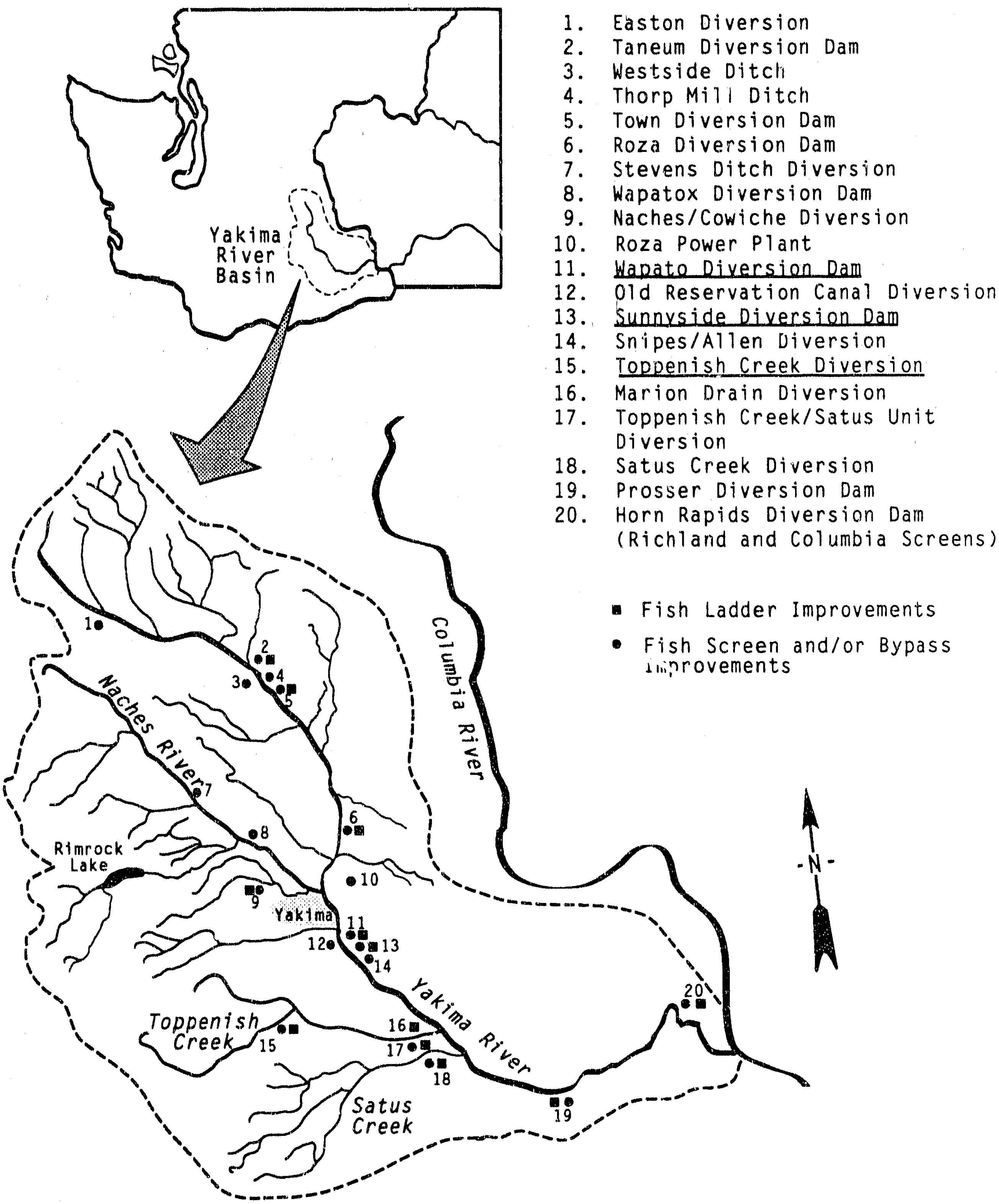

FIGURE 1. Yakima River Basin Showing Locations of the Toppenish Creek, Wapato, and Sunnyside Canal Fish Screening Facilities and Other Fish Protection and Passage Facilities

conducted to 1) evaluate conditions or circumstances that affect fish survival as they 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.

This report covers work completed in 1988 by PNL fisheries staff at the Wapato, Sunnyside, and Toppenish Creek Screens. The report describes each screen facility, methods used to evaluate screen effectiveness, and test results. Our findings are discussed and compared with those from previous tests at the Sunnyside Screens (Neitzel et al. 1985), the Richland and Toppenish/Satus Screens (Neitzel et al. 1987), and the Richland and Wapato screens (Neitzel et al. 1988). The report includes three appendices. Appendix A describes the work plan prepared to guide the evaluations and associate specific objectives with the methods used during the evaluations. Appendix B includes data tables for the Sunnyside Screens in 1985, the Richland and Toppenish/Satus Screens in 1986, the Richland and Wapato Screens in 1987, and the Wapato, Sunnyside, and Toppenish Creek screens in 1988. Appendix C describes the operating criteria used to set flows at the screening facilities.

STUDY AREAS

During 1988, we conducted studies at Toppenish Creek, Wapato, and Sunnyside screening facilities. Toppenish Creek study area included the canal from trash rack to fish bypass, the canal immediately behind the screens, and the fish return pipe. The Wapato and Sunnyside study areas included screen forebays, terminus of the fish bypass system, and the canal behind the screens. Our study area description includes the site operating conditions.

TOPPENISH CREEK SCREENS

Water is diverted from Toppenish Creek into the Toppenish Creek Canal about 8.3 km (5 mi) south of White Swan, Washington (Figure 2). Carrying capacity of the Toppenish Creek Canal is about 1.7 m^3/s [60 cubic feet per second (cfs)]. Canal flow varies from 0.3 to 1.7 m^3/s (10 to 60 cfs) seasonally and is regulated at the canal head gates about 75 m (246 ft) upstream of the Toppenish Screens. The screening facility (Figure 3) diverts fish that enter the canal and directs them back to Toppenish Creek. Trash racks placed in the canal about 10 m (33 ft) upstream of the screening facility "filter" out large debris that could damage the screens or interfere with flow control through the screen facility.

The screening facility houses three rotary-drum screens with axes parallel to the length of the structure (Figure 3). Each screen is about 4 m (12 ft) wide and 1.8 m (6 ft) in diameter. Screen mesh openings are 3.18 mm (1/8 in.). Water depth at the screens varies with canal flow. The average water depth across the face of the screens is about 1 m (3 ft).

The rotary screens are installed at an angle of 26° to canal flow. This orientation provides a ratio of sweeping velocity to approach velocity equal to or exceeding 2:1 (Easterbrooks 1984). Maximum-allowable approach velocity is 0.15 m/s (0.5 f/s). Screen orientation and flow-velocity differential help direct fish to the fish return pipe and back to the creek.

WAPATO CANAL

The Wapato Diversion (Figure 2) is located at river kilometer (km) 172 [river mile (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/s (2000 cfs).

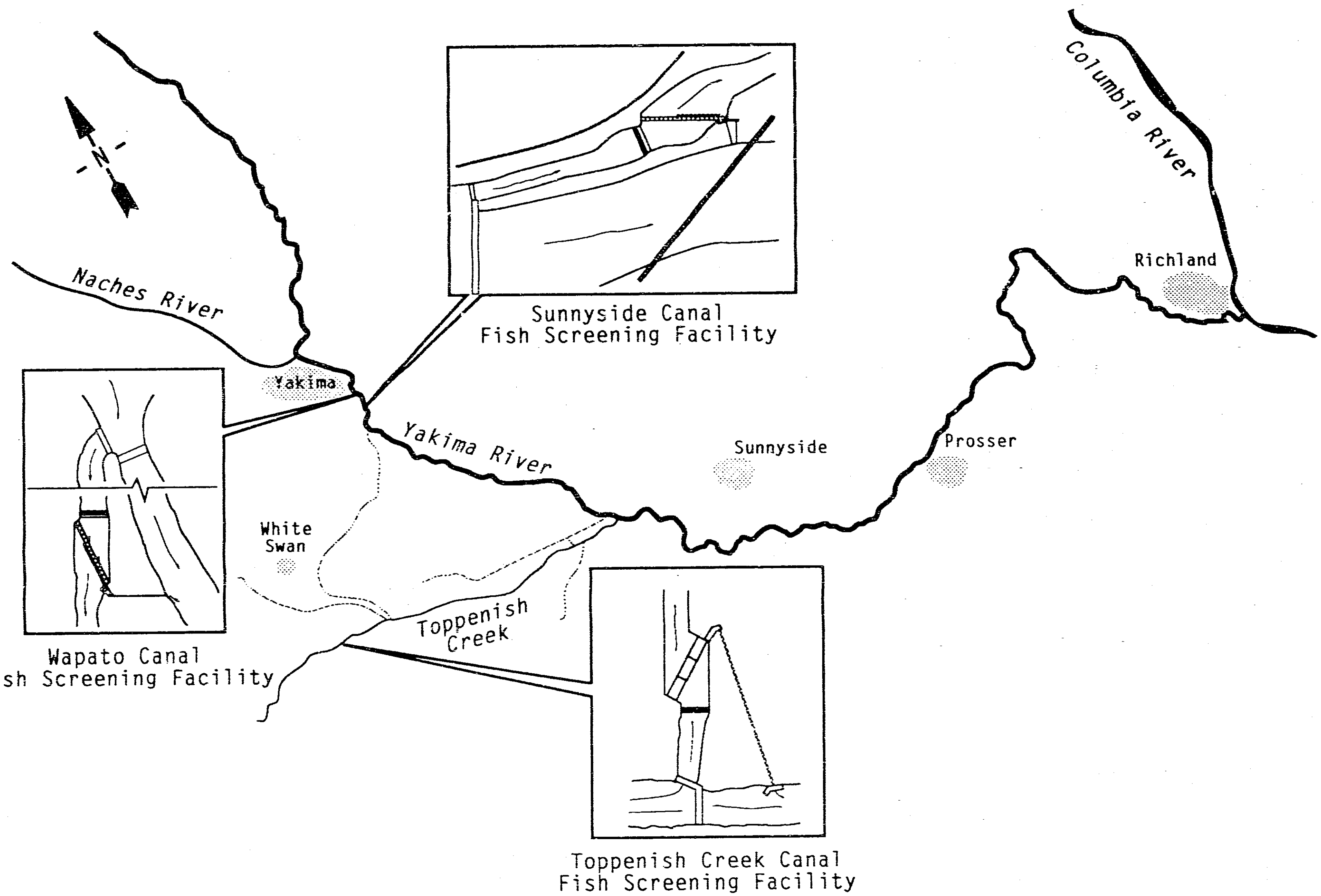

FIGURE 2. Toppenish Creek, Wapato, and Sunnyside Canal Fish Screening Facilities in the Yakima River Basin

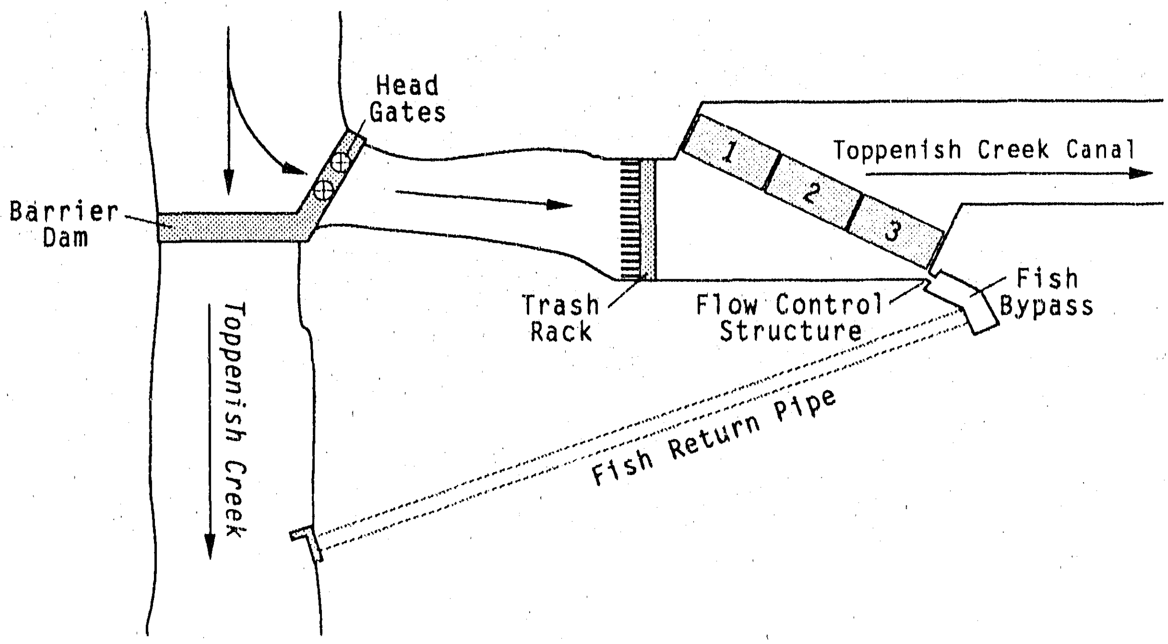

FIGURE 3. Flow Control Structure and Fish Bypass System in the Toppenish Creek Canal Fish Screening Facility

The Wapato Screens are located about 1 km (0.6 mi) downstream of the head gates for the Wapato Canal. The screening facility (Figure 4) diverts fish entering the canal and directs them back to the Yakima River.

Trash racks from the old screening facility are immediately upstream of the new Wapato Screens. The racks "filter" out debris entering the canal. The screening facility houses 15 rotary drum screens with axes parallel to the length of the structure (Figure 4). 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; depth across the face of the screens at full canal level is normally about 3.7 m (12 ft).

The flow control structure and separation chamber are located at the downstream end of the screen facility (Figure 4). Two fish bypass pipes and the terminal bypass, each with a flow of about 1.4 m^3/s (50 cfs), feed into the separation chamber. During normal operation, about 4.2 m^3/s (150 cfs) of water enter the separation chamber. About 0.9 m^3/s (30 cfs) of water and all fish in front of the rotating 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/s (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 pump-back system.

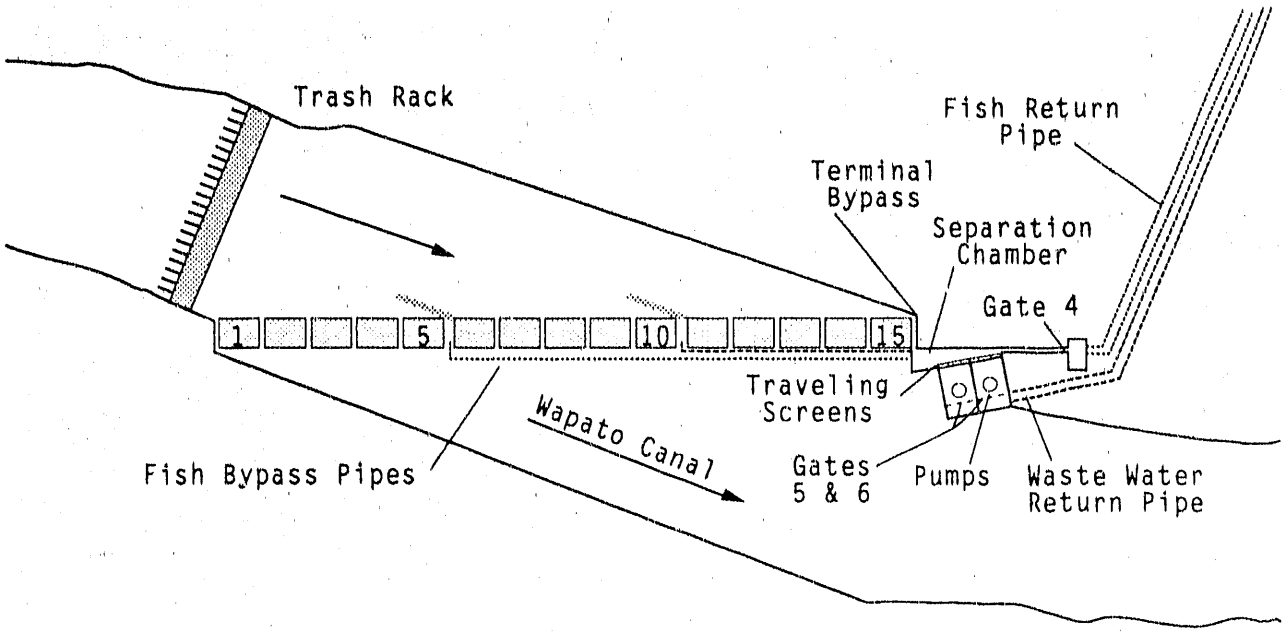

FIGURE 4. Flow Control Structure and Fish Bypass System in the Wapato Canal Fish Screening Facility

The pump-back 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. Flow over the weirs is reduced when the pumps are operating. 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).

SUNNYSIDE CANAL

The Sunnyside Diversion (Figure 2) is located at river km 167 (RM 103.8) on the Yakima River. The diversion directs water from the Yakima River into the Sunnyside Canal. Canal operation begins in early March and continues through the irrigation season usually until mid-October. Canal capacity is about 37 m^3/s (1300 cfs).

The Sunnyside Screens are located about 0.4 km (0.25 mi) downstream of the head gates of the Sunnyside Canal. The screening facility (Figure 5) diverts fish entering the canal and directs them back to the Yakima River. The trash rack immediately upstream of the Sunnyside Screens "filters" out debris entering the canal. The screening facility houses 17 rotary-drum

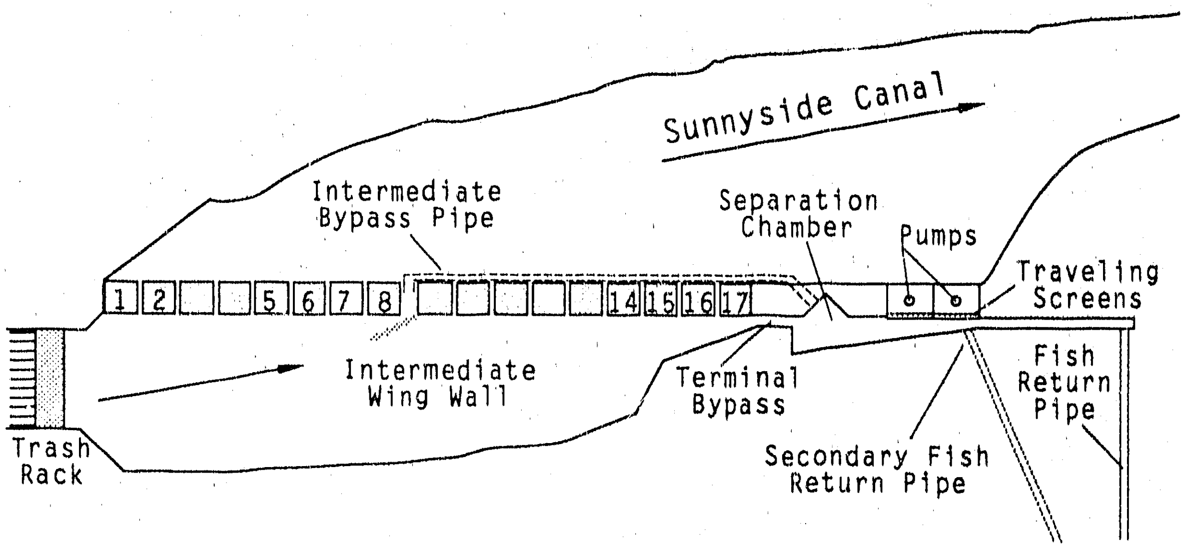

FIGURE 5. Flow Control Structure and Fish Bypass System in the Sunnyside Canal Fish Screening Facility

screens (Figure 5) with axes parallel to the length of the structure. Each screen is about 3.7 m (12 ft) wide and 4.6 m (15 ft) in diameter. Water depth at the screens varies with canal flow. Water depth across the face of the screens at full canal level is normally about 4.3 m (14 ft).

The flow control structure and separation chamber (Figure 5) are located at the downstream end of the screen facility. An intermediate bypass pipe and the terminal bypass, each with a flow of about 1.4 m^3/s (50 cfs), feed into the separation chamber. During normal operation, about 2.8 m^3/s (100 cfs) of water enter the separation chamber. About 0.6 m^3/s (20 cfs) of water, and all fish in front of the screens, pass through the flow control structure and out the primary fish return pipe. Two bypass water return pumps, each with a pumping capacity of 1.1 m^3/s (40 cfs), are located behind vertical traveling screens near the terminus of the separation chamber. Traveling screens are equipped with screen washers to prevent fish and debris from being entrained in the pumpback system. During periods when one or no pumps are operating, water is discharged through a secondary fish-return pipe.

METHODS

Two types of studies were conducted in 1988: descaling tests at Toppenish Creek, and screen integrity tests, at Toppenish Creek, Wapato, and Sunnyside. In descaling tests, 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 fish were held for post-test observation. Native salmonids entering the diversion canal were also monitored during release/capture tests. In screen integrity tests, fish were released both in front of and behind the screens. Fish were recaptured as they appeared in the fish return or in fyke nets mounted behind the drum screens.

TEST FISH

The species selected for testing were recommended by fisheries biologists from the Washington State Department of Fisheries (WDF), the U.S. Fish and Wildlife Service (USFWS), and the Yakima Indian Nation. Species selection was based on the potential for a specific salmonid population encountering a screening facility during their rearing and outmigration. Selection was dependent on the species, race, and size of salmonids occurring in the Yakima River drainage upstream of each diversion.

Steelhead and resident rainbow trout use the Yakima River and its tributaries, including Toppenish Creek. Spring chinook salmon use the Yakima River and some of the tributaries above the Wapato and Sunnyside diversions. Fall chinook salmon, which now spawn only downstream of the Wapato Diversion, may use upriver areas as the population builds. Additionally, fall chinook salmon are currently reared in net pens in the Wapato Screen forebay. These fish are released as fingerlings in front of the screens.

Steelhead smolts were selected to evaluate descaling and rainbow trout fry (<50 mm) were chosen to evaluate screen integrity at the Toppenish Creek Screens. Fall chinook salmon fry (<60 mm) were selected for screen integrity tests at the Wapato and Sunnyside Screens.

Steelhead

Yearling steelhead were obtained from the Washington Department of Wildlife Lyon's Ferry Hatchery. Wells-strain steelhead were hatched, reared, and adipose fin-clipped at the hatchery prior to acquisition. Fish weighing about 15 fish/kg (6 to 8 fish/lb) were transferred to PNL on March 8, 1988. The fish were acclimated outdoors in fiberglass circular tanks supplied with a mixture of Columbia River and well water at 10°C. Fish were cold-branded using stainless steel rods cooled by liquid nitrogen. Fish were acclimated to temperatures expected at Toppenish Creek at least 1 week before release.

Rainbow Trout

Rainbow trout fry used in the Toppenish Creek integrity tests were obtained from PNL-brood stock spawned in November 1987. Eggs were hatched in vertical-flow incubators supplied with 10°C well water. Fry were transferred to troughs and reared at 10°C until testing. Rainbow trout fry averaged 47.3 mm (2 in.) fork length (FL) and weighed 1.3 g (350 fish/lb) when tested.

Fall Chinook Salmon

Fall chinook salmon eyed eggs were obtained from the Bonneville Hatchery, operated by the Oregon Department of Fish and Wildlife. Eggs were spawned at the WDF's Priest Rapids Hatchery near Mattawa, Washington, reared to the eyed stage at the Willamette Hatchery, and transferred as eyed eggs to the Bonneville Hatchery. Eggs were transferred to PNL on January 22, 1988. The eggs were hatched in vertical-flow incubators supplied with 10°C well water. Fry were transferred to troughs and reared at 10°C until used for screen integrity tests at Wapato and Sunnyside. Fry weighed 830 fish/kg (375 fish/lb) and measured 49 mm (2 in.) FL at testing.

SAMPLING EQUIPMENT

Fish were captured either within the screening facility, at the terminus of the primary fish-return pipe, or in the canal behind the screens, based on the test objective. Inclined planes were custom-built to fit the fish bypass structures at each site. A seine, dip nets, and an electroshocker were used to collect fish at the terminus of the Toppenish Creek fish return pipe. Fyke nets mounted in stoplog slots behind the rotary-drum screens were used to collect fish behind the screens. Temporary fish holding facilities were installed at each test site to acclimate test fish.

Inclined Plane

Fish were captured with an inclined plane in the fish return between the last rotary-drum screen and the head of the fish return pipe. The inclined plane at the Toppenish Creek Screens (Figure 6) was 1.9 m (6.3 ft) long and 0.9 m (3.0 ft) wide. The front face of the plane was hinged so that the slope of the plane could be changed to adjust the flow of water reaching the fish live box. Solid walls, tapering from 0.9 m (3 ft) at the entrance to 0.3 m (1.0 ft) at the live box, acted as splash guards to reduce fish loss from the plane. The live box [0.36 m (1.2 ft) long by 0.9 m (2.5 ft) wide, 100 l (26 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].

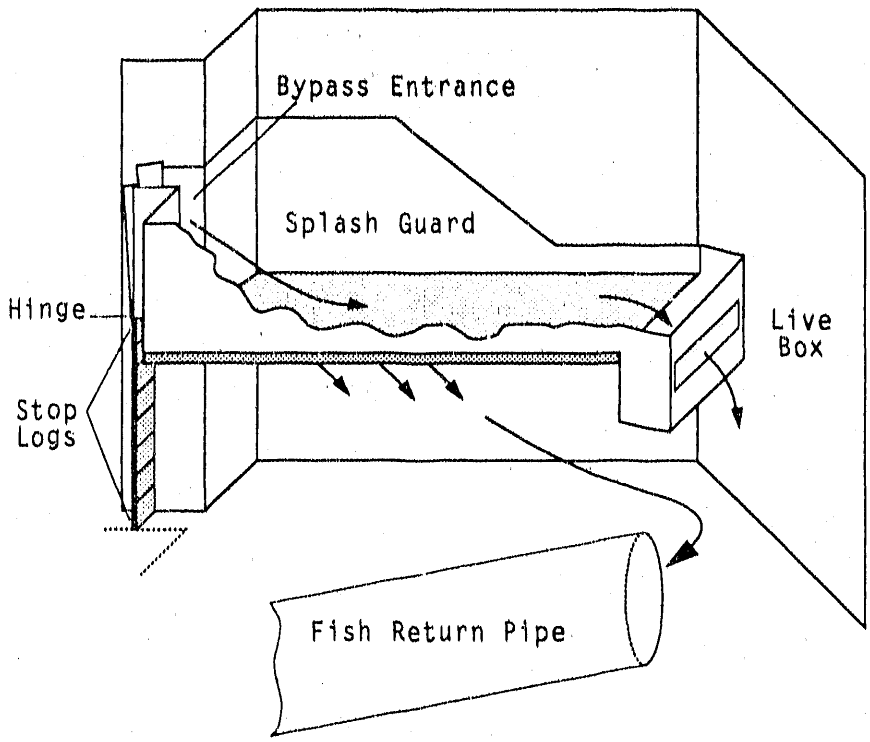

FIGURE 6. Inclined Plane Used at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

Flow was directed over the plane by inserting dam boards in the upstream stoplog slot 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 Wapato captured fish in the primary fish return downstream of Gate 4 at the terminus of the fish return slot (Neitzel et al, 1987). 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 [0.3 m (1 ft) long by 0.61 m (2 ft) wide and 0.46 m (1.5 ft) deep] with a volume of 85 l (22 gal) was attached to the end of the plane. Aluminum walls [0.6 m (2 ft) high] were welded to the edges 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 stop-logging 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 plane used at Sunnyside was similar to that used at Toppenish Creek, having a hinged front face and solid-metal splash guards. The plane was built to fit in the primary fish-return slot and was 0.56 m (1.8 ft) wide, 3.0 m (9.8 ft) long. A live box (0.3 m long, 0.56 m wide, and 0.3 m deep with a volume of 50 l) was attached to the end of the plane. The 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 by inserting dam boards in the upstream stoplog slot in the fish bypass slot.

Inclined planes were lowered into position with hand hoists. The perforated plates were brushed periodically to prevent clogging by vegetation and debris because clogging restricted the plane's ability to filter water and separate fish from the bypass water.

Fyke Nets

Fyke nets were used to capture fish in integrity tests at all sites. At Toppenish Creek, one net was placed behind each drum screen. The nets were 3.8 m (12.5 ft) wide and 1.2 m (4 ft) deep. Tops of the nets were above the waterline, and bottoms of the nets settled into the mud on the canal floor. The net tapered over a length of 2.4 m (8 ft) from a 12.5 by 4 ft mouth down to a 0.6 m- (2 ft-) square cod-end net. The cod-end net was 1.8 m (6 ft) long, resulting in an overall length of 4.3 m (14 ft). The cod-end net was tied shut with a rope. Fish and trash were removed from the cod-end of the nets without lifting the net mouths from the water.

Six fyke nets were used in the Wapato Canal screen integrity tests. Because of the screen width at Wapato, two nets were required behind one screen. The nets were fished immediately downstream of three selected screens during a test. The nets were 3.65 m (12 ft) square. Tops of the nets were above the waterline, and net bottoms settled into the mud on the canal floor. Nets tapered from a 3.65-m- (12-ft-) square mouth 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. Net frames were raised from the water to recover fish in the nets.

Eight fyke nets were used at Sunnyside. Nets were fished immediately downstream of four selected screens during testing. Two nets, one fishing the upper one-third and one fishing the lower two-thirds of the water column, were used behind each of the four screens (Figure 7). Two nets per screen were used because of the location of the intermediate fish bypass pipe behind the screens. The mouth of the top net was 3.7 m (12.2 ft) wide and 1.5 m (5 ft) deep, and the mouth of the bottom net was 3.7 m (12.2 ft) wide and 2.8 m (9.0 ft) deep. Both nets were 9.1 m (30 ft) long. The nets tapered from the mouth dimensions to a 0.6 m- (2 ft-) square cod-end net over a length of 6.1 m (20 ft). The cod-end nets were 3.0 m (10 ft) long and were tied shut. Each pair of net frames were bolted together to prevent fish from passing between the nets. Net frames were raised from the water to recover fish in the nets.

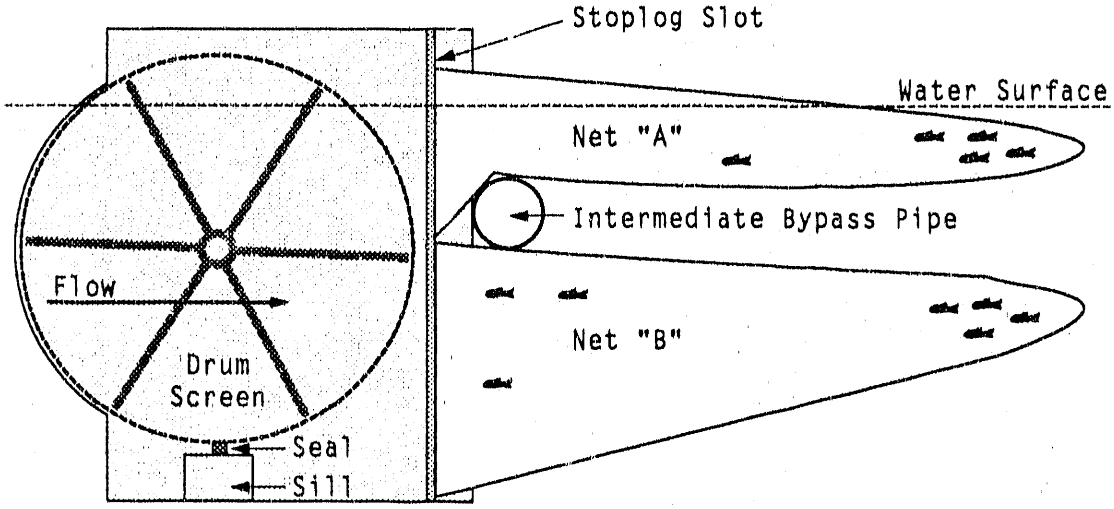

FIGURE 7. Fyke Nets Used in Integrity Tests at the Sunnyside Screens, Spring 1988

Electrofishing

At the Toppenish Creek Screens, an alternator and gas-powered generator were used to electrically stun fish. Stunned fish were collected with a beach seine at the terminus of the fish return pipe. The shocker probes were placed near the end of the pipe, and the seine was used to confine stunned fish until they could be captured by dip net.

HOLDING FACILITIES

Temporary facilities were installed to hold fish during descaling evaluation and to retain some fish for 96 h after capture. A mobile laboratory containing 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 each site. All tanks were supplied with canal water pumped from behind the screens. The mobile lab was equipped with fluorescent lighting to evaluate fish captured during both the day and night for descaling under similar light conditions.

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. Evaluation criteria included modifications established in 1985 (Neitzel et al. 1985). Baseline descaling condition was determined by randomly sampling groups of test fish before 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 Toppenish Creek Screens involved introducing branded steelhead 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 late March. Tests were initiated under low canal flow conditions. Flows were increased to maximum flows during the tests (Phase III, Appendix A). Fish were also released at the head of the fish return pipe and captured at the end in tests to evaluate effects of passage through the pipe (Phase IIb, Appendix A). Native salmonids were monitored during tests at the Toppenish Creek Screens (Phase IVa, Appendix A).

Screen integrity was evaluated at the Toppenish Creek, Wapato, and Sunnyside Screens by releasing branded rainbow trout or 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, rainbow trout, 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. Brands were applied at least 1 week before release. Brands were approved by the National Marine Fisheries Service (NMFS) and were distinguishable from all other brands used in the Columbia River Basin.

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 Toppenish Creek and Wapato or Sunnyside Screens were 2.0 h and 1.3 h, respectively. Loading densities did not exceed 120 g of fish/l (1 lb/gal). Water temperature in the transporter changed less than 1°C during transit. Test fish were netted from the transporter and placed in holding tanks at the facility for acclimation before release. There were no losses attributable to transporting stress.

Fish Release Locations

For descaling evaluation, test fish were released uniformly across the canal downstream of the trash rack at the Toppenish Creek. To evaluate the fish return pipe at Toppenish Creek, fish were released into the head-end of the pipe. Fish used in screen integrity tests were released in two locations. At Toppenish Creek, fish were released just upstream of the first rotary screen near the structure wall and uniformly across the mouth of the fyke nets positioned on the downstream side of the rotary screens. At Wapato and Sunnyside, fish were released in three locations: next to the concrete piers just upstream of the screens, in the fish bypass below each set of screens, and in fyke nets behind the screens.

Release Controls

Baseline condition of test fish was estimated by sampling each group before release at the Toppenish Creek Screens. Baseline-condition evaluations were conducted inside the mobile laboratory under artificial light. For Phase IIa tests, 210 fish were sampled for baseline condition and 755 fish were released into the Toppenish Creek 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. Fish were anesthetized in MS-222, examined to determine the extent of scale loss, and returned to a holding tank. About 150 of the test fish were held 96 h to monitor delayed mortality. After fish recovered from the anesthetic, they were released to the creek or river via the fish return pipe.

Fish were captured by electroshocker and beach seine in Phase IIb tests at the Toppenish Creek Screens. Fish were dipnetted from the seine quickly to reduce damage caused by turbulence in Toppenish Creek. Fish were anesthetized with MS-222, examined, held in a bucket until they had recovered from the anesthetic, and then were released into the creek.

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 fish were released within the screening facility.

In tests at Toppenish Creek, the inclined plane was fished up to 41 h after fish were released. Groups of fish were released both in front of and behind the screens at three different times: early afternoon, late afternoon, and evening. The fyke nets were left in place throughout the Phase IVb tests. Nets were cleaned and the fish were retrieved from the cod-end of the nets several times each day.

STATISTICAL ANALYSIS

The amount of time for test fish to move from their release point to the inclined plane is estimated by the hours required to capture 50% of a test group. Capture efficiency of the inclined plane and the fyke nets used for screen integrity tests are estimated from the number of fish captured during a test. These data are used to estimate the efficiency of the screen in preventing fish from passing from the screen forebay to the canal downstream of the screens.

Descaling and Mortality Estimates

Estimates of the percent of fish descaled or killed were based on the number of test fish caught. Descaled fish were considered dead in evaluating results. The lower and upper confidence intervals, LCI and UCI, respectively, are estimated by

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

and

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

where B equals the number of dead or descaled fish, n equals the number of fish caught, and F equals a ratio of the estimates for the mean and individual sample variances. The estimates were calculated from Mainland's Tables (Mainland et al. 1956)

Data for replicate tests were combined to obtain a mean estimate. The estimate assumes each fish behaved independently (i.e., fish within a test did not behave more similarly than did fish between tests and there were no interactions among fish within a test). Although some interaction among fish is expected, it is an assumption necessary for the analytical methods used. All tests were conducted in the same manner to reduce non-independent behavior.

Screen Efficiency Estimates

The number of screens and bypass systems are different at the three facilities tested. Therefore, the number of nets and the computation of screen efficiency varied. For Toppenish Creek, which has three screens, screen efficiencies were computed for each screen and for the entire facility. The 15 rotary-drum screens at the Wapato Screens are divided into three sections of five screens each separated by intermediate wing walls and bypass pipes. Screen efficiency estimates were computed for each of the screen sections in addition to an overall estimate. The 17 rotary-drum screens at Sunnyside are divided into 2 sections of eight and nine screens, separated by an intermediate wing wall.

At Toppenish Creek, three tests with three groups of fish were conducted. Fyke nets were placed behind each screen for each test. Four screen efficiency tests were performed at Wapato. The first involved all three screen sections, specifically screens 5, 10, and 15; the second, Section 3, screens 13, 14, and 15; the third test, Section 1, screens 3, 4, and 5; and the fourth, Section 3, screen 15. Although the method for estimating each section and the system is the same, input data are different in each case.

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}). Net retention is assumed to equal net efficiency at some sites, in which case net retention equals 1. Given these quantities, the formula for computating 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:

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

where X_{ip} equals the number of fish released upstream of the screens and caught in the inclined plane. N represents the total number of fish released into the section being estimated. For some estimates and the overall estimate, 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. Thus, 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.

Efficiencies per set must also be defined. Input data for each section are as 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 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 remaining in the cod-end, and N_{nr} is the number originally placed in the net cod end.

For overall efficiencies, individual section efficiencies cannot be 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, the following equation is used:

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

Here EFF_{sc} indicates our estimate while true $[EFF_{sc}]$ indicates the true or actual value of 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 ($EFF_{nc} \times EFF_{nr}$), 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 and higher-order effects have been neglected. We assumed 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 above. In the case of EFF_{ncr}, variances were computed individually for EFF_{nc} and EFF_{nr} and propagated throughout. The variable X_{net}, the number of fish caught in the nets from those 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

At Toppenish Creek, fish that passed through the bypass system were not descaled or killed, and moved out of the forebay of their own volition. The angled rotary-drum screen design at Toppenish Creek, Wapato, and Sunnyside prevented most fish from entering the canal downstream of the screens. Improperly installed or maintained side and bottom seals will allow fish to swim through the screen facility.

Data for Toppenish Creek, Wapato, and Sunnyside, in 1988, are presented as they relate to the objectives of each phase outlined in the work plan in Appendix A. A detailed summary of catch data, estimates for percent of test fish descaled or killed, and estimates of screen efficiency are presented in Appendix B.

PHASE I TESTS

Phase I tests were designed to evaluate components within the fish diversion system other than the rotary drum screens. The Toppenish Creek fish bypass system contains no structures other than the drum screens; therefore, no Phase I tests were conducted. Phase I tests were conducted at Sunnyside during 1985 (Neitzel et al. 1985). Phase I tests have not been conducted at Wapato (Neitzel et al. 1988) because fish are not descaled as they move from the trash racks to the fish return pipe.

PHASE II TESTS

Phase II tests evaluate the effects on fish of 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). During 1988 we conducted Phase IIa and IIb tests at Toppenish Creek. Phase II tests were completed at Sunnyside in 1985 (Neitzel et al. 1985) and at Wapato in 1987 (Neitzel et al. 1988). At Toppenish Creek, we released fish at the trash racks and captured them before they entered the fish return pipe. In addition to evaluating fish descaling and mortality, we estimated how long released fish remained in the Toppenish Creek screen forebay. We also tested the potential effects of passage through the fish return pipe.

Phase IIa

Tests at the Toppenish Creek Screens were conducted in late March. Three groups of branded steelhead smolts were released behind the trash racks, one group of 250 fish was released during low canal flow (20 cfs), and groups of 255 and 250 fish were released during full canal flow (50 cfs). Of 250 steelhead planted during low canal flow, 144 (58%) were captured on the inclined plane in the fish return during the next 72 h. The plane was not fished for 2 h during the day following the low flow release because the inclined plane became plugged with detritus when the canal flow was changed from 20 to 50 cfs. Of 505 steelhead released during full canal flow, 395 (78%) were caught during the following 48 h. A total of 539 test fish were examined for descaling; only one fish (0.2%) was descaled (Table 1). This rate was within the 95% confidence interval for the condition controls (Appendix B). None of the 143 fish held for 96 h died.

Downstream movement of steelhead released for descaling evaluations was monitored each half-hour as the fish appeared on our sampling plane in the fish return. The rate and percent recovery for steelhead (Figure 8 and Table 2) indicate that salmonid smolts are not flushed from the Toppenish Creek screen forebay; rather, they move through the screen forebay of their own volition. The recovery rate was lower for steelhead released during low canal flow.

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. Because this tested a specific component of the fish return system, results are presented with Phase IIb.

Thirteen groups of 10 steelhead each were released at the head of the Toppenish Creek Screens fish return pipe. Of 130 steelhead released, 106 were captured and evaluated for descaling; none of the fish were descaled (Appendix B).

PHASE III TESTS

Test fish were released during two canal flows at Toppenish Creek: 20 cfs, which represents canal flow during the early spring, and 50 cfs, representing canal flow during the major irrigation-withdrawal period. Fish were not descaled at either flow. Movement of steelhead smolts from

TABLE 1. Descaling and Mortality Data from Release and Capture Tests with Steelhead *Oncorhynchus mykiss* Smolts at the Toppenish Creek Fish Screening Facility, Spring 1988

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

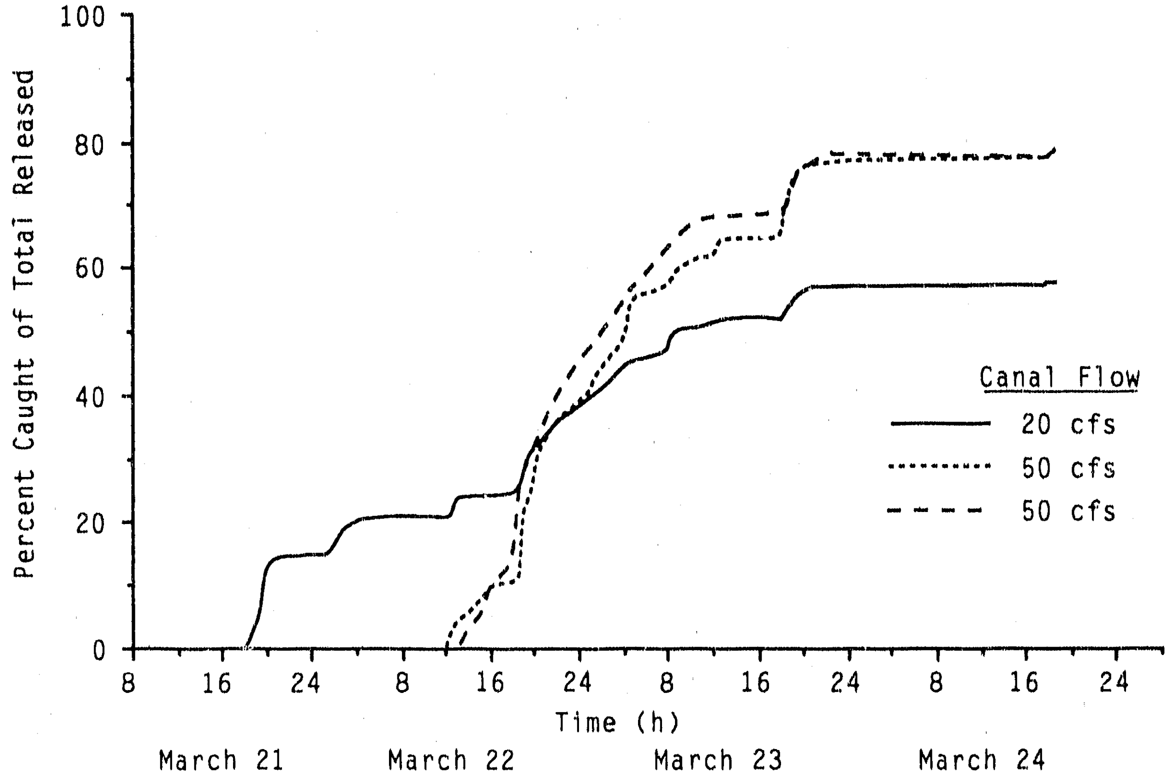

FIGURE 8. Movement of Steelhead *Oncorhynchus mykiss* Smolts Based on Capture of Release Fish at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

TABLE 2. Estimated Time to Capture 50% of Steelhead *Oncorhynchus mykiss* Smolts Released in Descaling Tests at Toppenish Creek Fish Screening Facility, Spring 1988

Canal Flow (cfs)	Number Released	Number Caught	Percent Caught	Time to Catch 50% (h)
20	250	144	57.6[a]	39.0
50	255	199	78.0	16.0
50	250	196	78.4	14.0

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

the screen forebay through the fish return was slower during low canal-flow conditions.

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 salmonids. Drum screens were monitored to determine if fish were impinged. Rainbow trout fingerlings were released at the Toppenish Creek screens and fall chinook salmon fingerlings were released at the Wapato and Sunnyside screens to test for possible passage through, around, or over the rotary drum screens. Additionally, fyke nets were placed downstream of the Wapato and Sunnyside screens while Yakima Indian Nation biologists released fall chinook salmon from rearing pens in the Wapato Screen forebay.

Phase IVa. Toppenish Creek Screens

The only native salmonids captured during tests at the Toppenish Creek Screens were juvenile rainbow trout and/or steelhead. The 462 fish we examined (average of 13 cm FL, range 7.0 to 19.5 cm) did not have strong smoltification characteristics. Three adult steelhead kelts (~ 60 cm FL) were caught on the inclined plane, indicating that steelhead spawning occurs upstream of the Toppenish Creek Diversion.

No predacious fish other than rainbow trout/steelhead were caught at the Toppenish Creek Screens. Both the native rainbow trout and test fish that were released during descaling tests preyed on the smaller rainbow trout that were released in the forebay for screen integrity tests (Phase IVb).

Phase IVb. Toppenish Creek Screens

A total of 3073 rainbow trout fry (47.3 mm FL) were released in front of the screens and 900 were released in the mouth of fyke nets behind the screens to evaluate the effectiveness of angled rotary drum screens in preventing fish from entering the irrigation canal behind the screens (Table 3). Of 3073 fish released in front of the screens, 2373 (79%) were recovered in the fish return and 11 (0.4%) were recovered in the fyke nets, 2 behind screen 1, and 9 fish behind screen 3. Additionally, 6 native rainbow trout (8.5 - 19.6 cm FL) were caught in the fyke nets; 2 behind screen 1, and 4 behind screen 3. No fish were caught behind screen 2 except for net control fish. Of 900 rainbow trout released in the mouths of fyke nets behind the drum screens, 522 (58%) were recovered from fyke nets, and 37 (4%) were recovered on the inclined plane (Table 4).

Approximately 20% of the rainbow trout fry released in front of the screens were not recovered. Predation in the screen forebay by test fish and wild steelhead was confirmed by examining the gut contents of fish captured on the inclined plane. Rainbow trout fry were not flushed from the Toppenish

TABLE 3. Capture Data for Rainbow Trout Fry *Oncorhynchus mykiss* Released During Screen Integrity Tests at the Toppenish Creek Fish Screening Facility, Spring 1988

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

TABLE 4. Capture Efficiency of the Inclined Plane and Fyke Nets Used During Screen Integrity Tests at the Toppenish Creek Fish Screening Facility, Spring 1988

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

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

Creek Screen forebay (Table 5). Some fish were captured on the inclined plane immediately after release. Most fish were recovered on the plane after sunset on the first night following their release (Figure 9). Few fish were captured after more than 24 h of release.

Phase IVa. Wapato Canal

Phase IVa observations were completed at the Wapato Screens in 1987 (Neitzel et al. 1987) and were not repeated. Some predatory fish (largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieui*, northern squawfish *Ptychocheilus oregonensis*) were caught during tests in 1987, although losses to predation were minimal. However, this year, massive numbers of hatchery-reared coho salmon *O. kisutch* released in early May were present in the Wapato Screen forebay and preyed on the chinook salmon fry released during Phase IVb tests.

Phase IVb. Wapato Canal

A total of 8235 fall chinook salmon fry were released in screen integrity tests at the Wapato Screens (Table 6). Fish were released in front of the screens, in the intermediate and terminal fish bypasses, and in the mouths and cod ends of fyke nets positioned behind the screens.

Of 500 fish released in the intermediate and terminal bypasses during the first three tests at Wapato Screens, 385 (77% average, range 71%-85%) were captured on the inclined plane. Of 100 fish released in the terminal bypass in the fourth test, 96 (96%) were captured on the inclined plane. The difference in catch rate between the first three tests and the fourth test probably reflects predation on fall chinook salmon by coho salmon

TABLE 5. Estimated Time to Capture 50% of Rainbow Trout *Oncorhynchus mykiss* Fry Released in Screen Integrity Tests at Toppenish Creek Fish Screening Facility, Spring 1988

Tes. Group	Number Released	Number Caught	Percent Caught	Time (h) to Catch 50%
1	1024	868	84.8	4.0
2	1024	724	70.7	9.0
3	1025	781	76.2	4.0

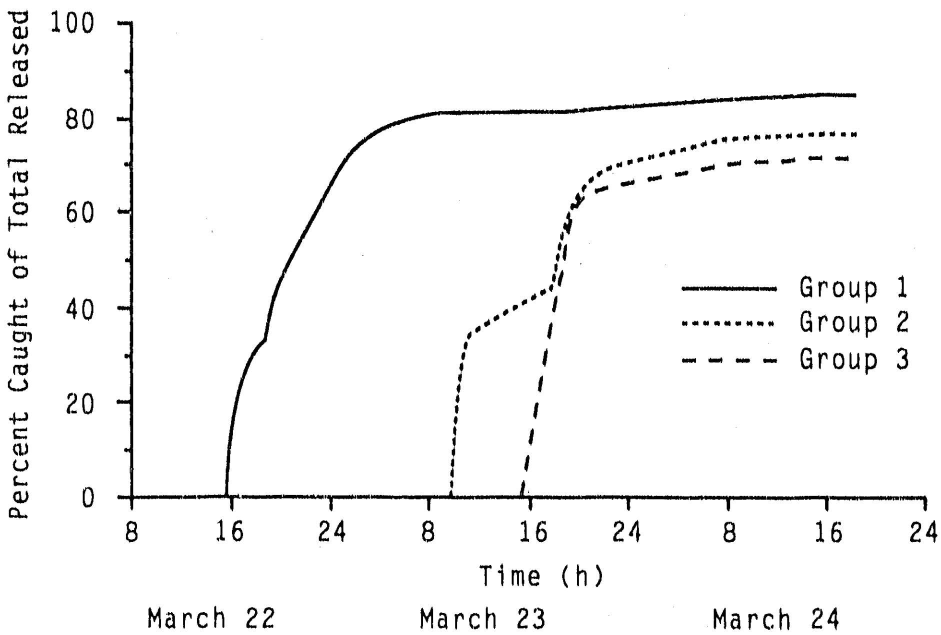

FIGURE 9. Movement of Rainbow Trout Fry *Oncorhynchus mykiss* Based on Capture of Released Fish in the Bypass During Screen Integrity Tests at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

smolts in earlier tests. Catch efficiency of fyke nets varied from 79% to 97%, and net retention efficiency ranged from 85% to 90% (Table 7).

A large number of salmonid smolts, primarily coho salmon, were present in the Wapato Screen forebay during our tests. When major movement through the fish return commenced after sunset, fish collection in the bypass was terminated and the inclined plane was removed from the return. Fyke nets were fished only until 1900 h during the first test but were fished overnight in the second, third and fourth tests.

Of 6235 fish released in front of the screens, 4380 (70% average, range 51% to 92%) were caught in the fish return, and 43 (0.7%) were caught in the

TABLE 6. Capture Data for Fall Chinook Salmon Fry *Oncorhynchus tshawytscha* Released During Screen Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1988

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

TABLE 7. Capture Efficiency of Inclined Plane and Nets and Retention Efficiency for Fyke Nets Used During Screen Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1988

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

(a) Screens are numbered from the upstream (NUMBER 1) to the downstream screen nearest the separation chamber (NUMBER 15).

fyke nets behind the screens. Other salmonids were also caught in the fyke nets. Forty coho salmon smolts were caught behind screen 15 in the second test (Table 6).

Fall chinook salmon fry released in the fish bypasses were not flushed as rapidly through the separation chamber and into the fish return slot (Figure 10, Table 8) as was observed during integrity tests conducted at the Wapato Screens in 1987 (Neitzel et al. 1987). Lower bypass flows caused by an inoperable vertical traveling screen in the separation chamber may have contributed to the slower movement rate and lower fish recoveries.

In addition to the integrity tests, we monitored screens 13 - 15 at Wapato with fyke nets during release of the Yakima Indian Nation's (YIN's) fall chinook salmon from net pens in the Wapato forebay. About 200,000 salmon were released on the evening of May 18. An additional 50,000 fall chinook salmon were released earlier in the afternoon before our fyke nets were in place. The nets were fished overnight and removed about 0700 h May 19. The inclined plane was not used during the monitoring.

Most fall chinook salmon released from the pens moved out of the screen forebay overnight. A total of 190 fall chinook salmon (80 mm FL) were caught in our fyke nets (Table 9). Some recovered fish were badly cut and crushed. Screens 13 and 14 prevented fish from passing into the canal behind the drum screens. The 185 fish recovered from fyke nets behind screen 15 represent less than 0.1% of the total number of fish released.

Sunnyside Canal, Phase IVb

A total of 6185 fall chinook salmon fry were released at the Sunnyside Screens (Table 10) in front of the screens, in the intermediate and terminal fish bypasses, and in the mouths of fyke nets behind the screens. Of 400 fish released in the intermediate and terminal bypasses, 317 (79%)

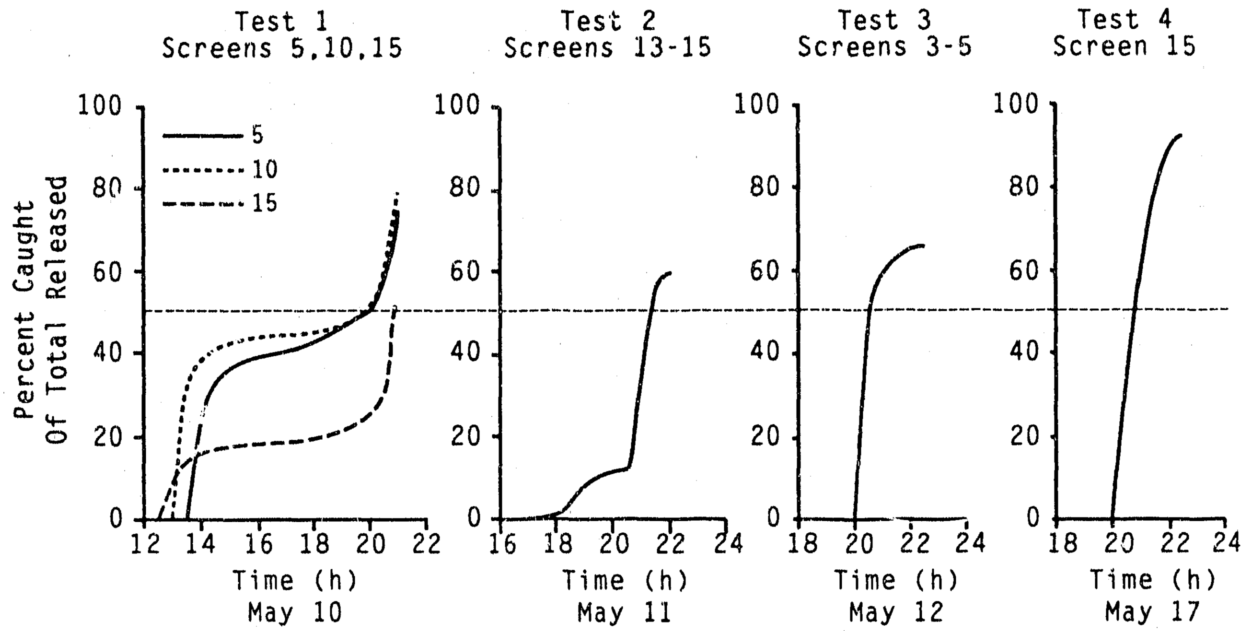

FIGURE 10. Movement of Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Based on Capture of Released Fish in the Bypass During Screen Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1988

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

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

were captured in the fish return. Of 1599 fish planted in the mouths of fyke nets, 1310 (82%) were recovered from the nets (Table 11).

Coho salmon smolts were also present at the Sunnyside Screens during our tests. When major movement of salmonid smolts commenced after sunset, fish collection in the fish return was terminated and the inclined plane was removed. Fyke nets were fished overnight for all tests. Of 4186 fish released in front of the screens, 3273 (78% average, range 71% - 85%) were caught in the fish return, and 60 (1.4%) were caught in the fyke nets

TABLE 9. Capture Data from Fyke Nets Behind Selected Screens at the Wapato Canal Fish Screening Facility After the Release of Yakima Indian Nation (YIN) Fall Chinook Salmon *Oncorhynchus tswhawytscha* from Net Pens in the Wapato Screen Forebay, Spring 1988

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

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

behind the screens. Eleven salmonids, including some of our test fish that were not identifiable, 1 coho and 2 chinook salmon smolts, were also caught in fyke nets behind the drum screens.

Fall chinook salmon fry released in the fish bypasses were flushed rapidly through the separation chamber and into the fish return slot. All fish released in the bypasses were recovered within 30 minutes of release. Test fish released in front of the screens also moved quickly through the bypass system (Figure 11 and Table 12). Most fish were collected on the inclined plane during the first hour after release; however, small numbers were caught throughout the period when the inclined plane was monitored.

We also monitored screens 8 and 17 at the Sunnyside Screens with fyke nets during the release of YIN's fall chinook salmon from net pens in the Wapato Screens forebay. About 200,000 salmon were released on the evening of May 18. An additional 50,000 salmon were released earlier in the afternoon before our fyke nets were in place. The fyke nets were fished overnight and removed the next morning. The inclined plane was fished until 2100 h to determine the first arrival of released fish at Sunnyside Screens. The first arrival of fall chinook salmon occurred about 2 h after release at the Wapato Screens. A total of 185 fall chinook salmon (80 mm FL) were caught in fyke nets (Table 13). Some fish were badly cut and crushed. Screen 8 prevented passage of fish into the canal behind the drum screens. The 183 fish recovered from fyke nets behind screen 17 represent <0.1% of the total released.

TABLE 10. Capture Data for Fall Chinook Salmon Fry *Oncorhynchus tshawytscha* Released During Screen Integrity Tests at the Sunnyside Fish Screening Facility, Spring 1988

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

TABLE 11. Capture Efficiency of the Inclined Plane and Fyke Nets During Integrity Tests at the Sunnyside Canal Fish Screening Facility, Spring 1988

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

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

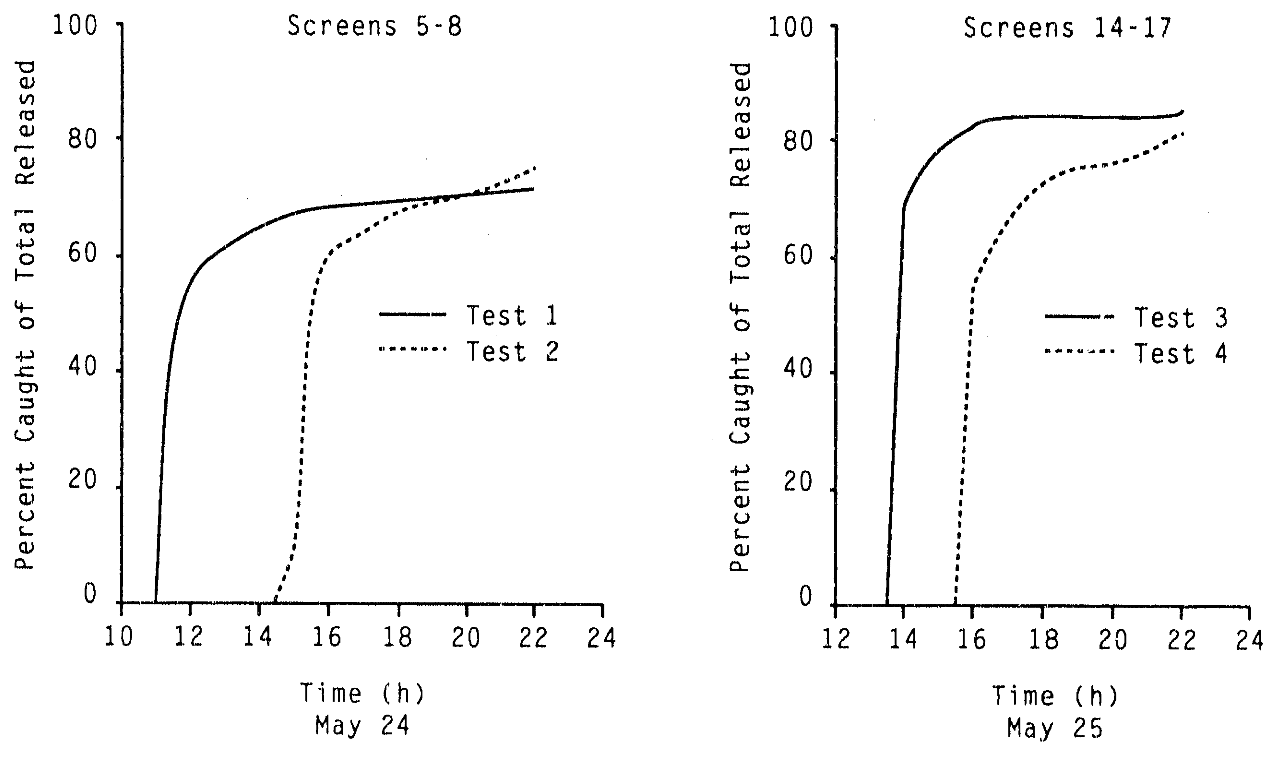

FIGURE 11. Movement of Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Based on Capture of Released Fish in the Bypass During Screen Integrity Tests at the Sunnyside Canal Fish Screening Facility, Spring 1988

TABLE 12. Estimated Time to Capture 50% of Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released in Integrity Tests at the Sunnyside Fish Screening Facility, Spring 1988

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

TABLE 13. Capture Data from Fyke Nets Behind Selected Screens at the Sunnyside Canal Fish Screening Facility After Release of Yakima Indian Nation (YIN) Fall Chinook Salmon *Oncorhynchus tshawytscha* Fingerlings from the Wapato Screens Forebay, Spring 1988

Screen Number	Net[(a)]	Fyke Net Captures	
		YIN Fish	Other Salmon[(b)]
8	A	2	2
8	B	0	0
17	A	26	2
17	B	157	5
Total		185	9

(a) Net A is the top net. Net B is the bottom net (Figure 7).
(b) Includes smolt-sized and 0-age salmonids.

DISCUSSION

Screening facilities in the Yakima River 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. This section discusses data collected at Toppenish Creek, Wapato, and Sunnyside during 1988, and relates the 1988 data to those collected at Sunnyside, Toppenish/Satus, Richland, and Wapato (Neitzel et al. 1986, 1987, 1988) from 1985 through 1987.

FISH SURVIVAL AT SCREENING FACILITIES

Based on release and capture data at five screening facilities, fish are not descaled or killed during passage in front of the rotary drum screens or through the fish bypass systems. As in previous descaling evaluations at the Sunnyside, Richland, Toppenish/Satus, and Wapato screens, the condition of test fish after passing through the bypass system at Toppenish Creek is similar to that of control fish.

POTENTIAL FOR PREDATION AT SCREENING FACILITIES

Screening facilities could affect predator/prey relationships if the screens concentrate prey or increase the exposure of prey to predators because of stress, injury, or delayed migration. Based on samples we have collected, loss to predation by native species does not appear to occur. However, hatchery-released salmonids diverted into the screen forebay may increase predation pressure at screen sites. We observed hatchery reared steelhead smolts feeding on our test fish at Toppenish Creek, and coho salmon smolts feeding on our test fish at Wapato and Sunnyside. Low bypass flows may prolong smolt residence time in screen forebays, thus increasing predation pressure on salmonid fry.

Toppenish Creek Screens

Some predation was observed at the Toppenish Creek Screens following release of 0-age rainbow trout fry in the forebay. Juvenile rainbow trout and steelhead, primarily fish released during descaling evaluation, were present in the forebay and opportunistically fed on the smaller fry. Predation, therefore, appeared to be related to the artificial and temporary predator-prey population structure created by the release of test fish.

Emergence of salmonid alevins in Toppenish Creek may commence later than the peak steelhead smolt migration. No native 0-age rainbow trout fry were captured during 4 days of sampling at the Toppenish Creek Screens. Regardless, the natural predator-prey population structure in the screen forebay should be similar to that in Toppenish Creek because fish movement through the forebay is not impaired when adequate bypass flows are provided.

Wapato Screens

Coho salmon released in the Yakima River upstream of the Wapato Screens were present in the forebay and preyed on fall chinook salmon that we released on May 10 through 13. Predation occurred in front of the screens as well as in the fish bypass system. We conclude this from the following. During 1987, more than 90% of the test fish released into the bypass and in the forebay were caught on the plane. In similar tests conducted during 1988, with coho smolts in the forebay, less than 80% of the test fish were caught on the plane (Table 14). After the coho smolts were "flushed" out of the forebay; more than 90% of the test fish were caught. An inoperable traveling screen in the separation chamber, during 1988 tests, resulted in bypass flows that were less than those recommended in the operating criteria. Flow through the fish return pipe was increased to more than 35 cfs from May 13 through 17. The increased flow was provided to compensate for the reduced bypass flow through the traveling screens and to "flush" the coho salmon from the screen forebay. Few coho salmon smolts were captured in a test conducted on May 17, and the capture rate for test fish was similar to rates observed in 1987 tests.

TABLE 14. A comparison of capture efficiency data during screen efficiency tests at the Wapato Canal Fish Screening Facility, Spring 1987 and 1988

	Number of Fish		
Year	Released in Bypass	Caught on the Plane	Percent
1987	600	571	95
1988[a]	600	481	80
1988[b]	100	95	95
	Number of Fish		
	Released in Forebay	**Caught on the Plane**	**Percent**
1987	6614	6011	90
1988[a]	6235	4380	70
1988[b]	1039	959	92

a Coho smolts were in the forebay and bypass during these tests.
b Coho smolts migrated out of the facility before this test started

Sunnyside Screens

Few predacious fish were observed at the Sunnyside Screens on May 24 through 26 and fewer salmonid smolts were observed than during tests at the Wapato Screens. Although no predatory activity was apparent in the screen forebay, the capture rate for test fish in the fish return was lower than expected based on the catch rate of test fish at the Wapato Screens in similar tests. Failure to completely seal the primary fish return so that all bypass water crossed our inclined plane (i.e., reduced plane efficiency), and not predation, may have resulted in lower capture rates.

POTENTIAL FOR FISH DELAY AT SCREENING FACILITIES

One objective of the angled screen facility design is to provide a facility that safely and rapidly returns fish from the diversion canal to the river (Easterbrooks 1984). Although, fish are not "flushed" from the screen forebay back to the river, the screening facilities do not impede voluntary movement and migration under normal operating conditions. Conversely, inadequate bypass flows resulting from improper operation, inoperable components in the bypass system, low canal flows or forebay elevations, or blockages in the fish return can impair fish movement through the bypass system and contribute to migration delays.

Flow through the fish return pipe at Toppenish Creek Screens was severely restricted before we initiated testing. Normal bypass flows were not attainable because the fish return slot was backed up with water. The fish return was plugged by boulders that had washed into the mouth of the pipe during high stream flows in winter. The creek bed is unstable at the end of the fish return pipe, and the pipe may become plugged again. Besides restricting water flow, a partially plugged pipe would probably injure fish. No injuries were observed for fish passing through the unobstructed pipe.

An inoperable traveling screen in the separation chamber resulted in low bypass flows during integrity tests at the Wapato Screens. With one screen plugged, bypass flows were reduced so that the inclined plane in the fish return could be operated effectively. Lower bypass flows contributed to slower movement through the fish separation chamber, lower fish capture in the return, and increased predation of our test fish by hatchery-released coho salmon smolts in the screen forebay and separation chamber.

FISH PASSAGE THROUGH OR OVER ROTARY DRUM SCREENS

The designed sweeping/approach velocity ratio helps guide fish into the fish bypass, and screen mesh openings (3.18 mm, 1/8 in.) are small enough to prevent fish passage through the drum screens. Tests were conducted at the Toppenish Creek, Wapato, and Sunnyside Screens to determine if any fish were impinged by or passed through the screens.

Toppenish Creek Screens

No fish passed over the drum screens at the Toppenish Creek; some fish, including two smolt-size rainbow trout, were caught in fyke nets behind two of the three screens. No native fish or fish released in front of the screens were captured in the fyke net behind screen 2. Faulty screen seals were the probable avenue of passage. Fish released in the fyke nets were also captured in the fish return, indicating that fish could move in either direction through the screen seals.

Wapato Screens

Results from integrity tests at Wapato Screens were similar to those observed in 1987 (Neitzel et al. 1987). Test fish passed through the seals on some drum screens, and over some screens as they rotated. Passage over the screens ("rollover") was generally limited to test fish released close to the screen face at the water surface. We observed one wild spring chinook salmon fry passing over screen 15. Rollover also appeared to be related to fish size. Fall chinook salmon (75 mm FL) released from YIN net pens did not pass over screens. Although several weak or disoriented fish were impinged briefly on the screen face, their mass prevented them from rolling over the drum screens. Additionally, the new seals installed along the circumference at each end of the drum screens appeared to be tighter than was the case before 1988.

Almost half the test fish recovered in fyke nets behind the screens probably resulted from rollover. Sixty test fish were caught in fyke nets (Table 6); 27 rolled over the screens. Capture of coho salmon smolts indicated that screen seals were poor at screen 15. After screen seals were repaired, few coho salmon smolts were captured behind screen 15. The lower catch could reflect the improved seals, fewer coho present in front of the screens, or a combination of both. Captures of fall chinook salmon in fyke nets behind screens 13-15 during release of fish from YIN net pens indicated that passage continued to occur at screen 15 despite repairs. The few fish caught behind screens 13 an 14, and some of the fish caught behind screen 15, were severely cut and crushed. Although the number of fish captured in nets was less than 0.1% of release, their presence confirms the need for meticulous maintenance and care of screen seals.

Sunnyside Screens

Monitoring of screens 8 and 17 during YIN release of fall chinook salmon indicated that seals at screen 17 were faulty. Repairs were made just prior to tests at Sunnyside Screens. Although few smolt-size fish were caught at the Sunnyside Screens after the seal repairs were made, fewer fish were present in the screen forebay than during tests at Wapato Screens.

Most test fish captured in fyke nets behind the screens were the result of rollover. However, some fish counted as "rollovers" were injured or were stuck in the seal at the downstream end of the screens. Several fish passed over screen 7 with their heads crushed between the seal and screen face.

SUMMARY

Release and capture and monitoring studies have been conducted at five diversion screen facilities in the Yakima River Basin: Sunnyside Screens (Neitzel et al. 1985), Richland Screens (Neitzel et al. 1986, 1987), the Toppenish/Satus Screens (Neitzel et al. 1986), Wapato Screens (Neitzel et al 1987), and Toppenish Creek Screens. The objective was to determine if fish diverted into an 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; or 3) fish are prevented from passing through or over the screens. These possibilities are addressed in various phases of the work plan (Appendix A).

PHASE I

Phase I tests were conducted at Sunnyside Screens with chinook salmon and steelhead smolts. Test data indicated that fish safely pass through all components of the bypass system. No Phase I tests were conducted at Richland, Toppenish/Satus, or Toppenish Creek screens because the fish bypass systems do not incorporate intermediate and terminal bypasses, traveling screens, or fish water pumpback systems in their designs. No Phase I tests were conducted at Wapato Screens because components of the fish passage facility did not significantly differ from components at the Sunnyside Screens, which were proven safe for fish passage.

PHASE II

Phase IIa tests are complete at five screening facilities. At Sunnyside Screens, fish were released at either the trash racks or head gates. Fish captured after moving through the screen forebay and diversion system were not injured or killed. At Richland, Toppenish/Satus, Wapato, and Toppenish Creek screens, fish were released only at the trash racks. Captured fish were not killed or injured. Tests at Sunnyside, Wapato, and Richland Screens were conducted with chinook salmon and steelhead smolts. Tests at Toppenish/Satus and Toppenish Creek Screens were conducted with steelhead smolts.

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

PHASE III

Phase III tests were conducted at Richland, Toppenish Creek, 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 Toppenish Creek and Wapato Screens were conducted during low and full canal flows. Although fish were not injured or killed in either test, movement rate was slower during low canal flows. Opportunities to conduct tests under different canal flows were limited because of delays in construction and startup at Sunnyside, Richland, and Toppenish/Satus screens. Sunnyside and Toppenish/Satus screens were evaluated only under full canal flows and Richland Screens only under minimum flows.

PHASE IV

Native fish were collected during all bypass tests. Gut contents of predacious fish were examined. Predacious bird activity was monitored near each screening facility. Although predation by native species does not appear to occur at screening facilities, hatchery-released salmonids sometimes congregate in the screens forebay, and prey on salmonid fry. The data we have collected cannot be used to infer that predation at the screens is greater than predation in the river.

Rotary drum screens were examined to determine if fish were impinged on or passed over the screens. Successful integrity tests were completed at the Richland, Toppenish Creek, Sunnyside, and Wapato screens. Richland Screens are effective at preventing fish from entering the irrigation canal; although some fish passed over screens and through faulty screen seals at the Toppenish Creek, Sunnyside, and Wapato screens, screen efficiency is near 99%. Screen integrity tests at Toppenish/Satus were unsuccessful because we did not collect any fish, including our control fish, downstream of the screens.

RECOMMENDATIONS

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

Although data indicate that fish are not descaled or killed as they are diverted by the screening facilities, descaling tests should continue at future diversion sites to assess potential site-specific problems and correlate descale to canal operations (Phase III). Canal operating conditions are of greatest concern during canal startup, and 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 directly attributed to the screens. However, increased predation on fish that pass through the screening facilities should be quantified relative to predation in the river. Although native predacious fish populations do not appear to concentrate within the screening facilities, hatchery-released salmonids can pose a predation threat if the fish do not migrate from the river following release. The location and operation of irrigation diversions should be considered in planning future hatchery releases.

Operating criteria should stress that fish bypass flow is important to achieving effective fish bypass. Fish are not involuntarily delayed at or within the screening facilities when bypass flows are set according to operating criteria and properly maintained. The potential for fish delay in screen facilities should be compared to migration rates for fish that remain in the river. At Wapato Screens, low bypass flows, whether caused by low forebay elevation or malfunctioning components in the bypass system, may contribute to slower fish movement through the facility. Boulders that blocked the mouth of the fish return pipe at Toppenish Creek Screens resulted in reduced bypass flows and were a potential site for fish injury. The fish bypass system should be thoroughly checked and calibrated at each screening facility at the beginning of each irrigation season.

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

Passage of salmonids over the drum screens is rare. High approach velocities at some screens may result in a small number of salmonid fry being lost over the screens; however, larger fingerlings and fry cannot pass over the drum screens. Passage over screens appeared 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 screens to achieve uniform flow appeared to reduce rollover of test fish at Wapato Screens.

Operating criteria for each screening facility should be reviewed annually to address changes in screens operations. Criteria must correspond with measurement facilities at the screens. Some staff gauges needed to adjust bypass at the Wapato Screens are not installed. Additionally, changes in operations resulting from inoperable components in the bypass system need to be addressed. For example, when the traveling screens are inoperable, there are several options for operating the bypass. Traveling screens can be removed and water and fish will return to the river through the waste-water pipe over Gates 5 and 6. This could result in injuring fish because the waste-water pipe is not designed to transport fish.

With one traveling screen out of service, it could be left in place and twice the flow passed through the operable screen. This increases the probability of impinging fish on the traveling screen. Although flow could be increased through the primary fish return pipe, the capacity of this pipe to safely return fish to the river has not been assessed. Another option may be to reduce flows in the bypass when only one traveling screen is in service. With this option, fish travel time may be affected. For those options that may be used regularly or for long periods of time, potential fisheries impacts of the operational and maintenance procedure should be assessed.

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APPENDIX A

WORK PLAN

The work plan for all BPA-funded screen evaluations consists of four phases. Phases I through III are mark/release studies to determine changes in fish condition and transit time through 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 for migrating fish populations.

The work plan addresses a generic facility (i.e., head gates, trash rack, screens, fish-water-pumpback system, separation chamber, and fish return pipe). Although some facility components may be different or not used at a given facility; however, the four-phase concept will be applied as practicable. 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. The decision determines the first phase of the work plan to be implemented at a site.

PHASE I

Phase I tests are conducted to determine the condition of fish after passage through the fish diversion components of a 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, number of fish killed (both immediately and after 4 days), and 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 assure collected fish are not being injured or stressed by the system. Tests are conducted by releasing fish in and near the collection system. Efficiency and handling are evaluated throughout the tests.

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

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

A hypothesis as to the fate of noncollected fish for each release is based on catch efficiency data collected during control tests, the duration of sample effort, and data from replicate tests when available.

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

PHASE II

Phase II tests are conducted to determine fish condition 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 test depends on whether 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, 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 and collected at the terminus of the fish return pipe. Percent descaling, number killed (immediately and after 4 days), and rates and extent of injuries are noted. Releases are made in and near the collection system to determine collection efficiency and handling effects. 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 are determined. Expected results include: 1) 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) 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, are determined. Species tested are the same as in Phase I, if possible. The number released are determined by the same criteria used in Phase I.

Fish are released in individual components of the bypass system and collected at the terminus of the component or the primary fish return pipe, depending on the data needed and the possibility of sampling within the component. Condition of fish at the discharge and through the bypass and secondary separation chamber, transit time across the facility, and transit time through the secondary separation chamber are determined. Expected results include identification of 1) hypothesis as to the fate of noncollected fish; 2) bypass components that adversely affect 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 determine screen operating conditions and canal flow changes that may affect screens efficiency. Test design, test organisms, and most study objectives are the same as those in Phases I and IIa. Operational conditions that maximize screen efficiency, effectiveness of screens over a range of flows, and factors that affect fish transit time through the facilities are determined. Expected results include: 1) any change in effectiveness of the facility over a range of canal flows, and 2) 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; Phase IVa examines presence and temporal distribution of predators near the screens, Phase IVb examines rates of impingement on 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 near the facility. Proposed monitoring locations 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. Presence of fish populations near the facility and fish passage through the facility are noted. Expected results include: 1) qualitative determination of the fish predator populations near the facility; 2) effectiveness of screens in keeping fish from entering the canal downstream of the screens; and 3) arrival time at the screen facility for salmonid populations.

Phase IVb.

Phase IVb monitoring examines the rotating screens and the vertical traveling screens. If necessary, Phase IVb objectives may be met with studies other than monitoring. For example, marked fish may be released in front of the screens, and subsequent monitoring behind the screens will indicate if fish enter the canal through or over the screens. Rates of impingement on the rotating and traveling screens are determined. Expected results include: 1) impingement rate on rotating screens; 2) the rate of impingement on the traveling screens; and 3) operational conditions that increase impingement. This task is not necessary if impingement does not occur during operation of the facility. The latter is evaluated during Phase I and II.

APPENDIX B

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

This appendix contains data collected from 1985 through 1987 at Sunnyside (Neitzel et al. 1985), Richland (Neitzel et al. 1986, 1987), Toppenish/Satus (Neitzel et al. 1986), and Wapato Canal (Neitzel et al. 1987) Fish Screening Facilities. Data collected 1988 at Toppenish Creek, Wapato, and Sunnyside Screens are presented. Data are sometimes combined (i.e., individual trials within a test series were combined for a single estimate). Descaled fish were considered dead for the estimates presented. Dead and descaled fish were combined to evaluate screen performance.

Data from Sunnyside Screens (Neitzel et al. 1985) indicate that fish are safely diverted from the canal to the river (Tables B.1 through B.7). Tables B.1 and B.2 represent evaluation of the inclined plane and fyke net. Both samplers collected fish without killing or descaling. Tables B.3 and B.4 represent evaluations of test fish condition before release in the canal or screen facility. Test fish were in good condition before release. Tables B.5 and B.6 show results of screening facility evaluations. Descaling data from upriver hatchery and native fish are shown in Table B.7. Table B.45 shows the estimated times for test fish to move through the Sunnyside Screen Facility. Screen integrity tests indicate that less than 2% of test fish pass through or over the screens. Screen integrity data are presented in Tables B.46 through B.48.

Data from Richland Screens (Neitzel et al. 1986) indicate that fish are safely diverted from the canal to the river. Data from the 1986 evaluation are shown in Tables B.8 through B.15. Data from the 1987 evaluation is shown in Tables B.25 and B.29. Tables B.8 and B.9 represent the evaluation of inclined plane and fyke nets. The inclined plane collected fish safely. The fyke net descaled too many fish to be used as an effective collection device at the terminus of the Richland Canal return pipe during flows of 0.6 m^3/sec (20 cfs). Therefore, we used an electroshocker to collect fish and evaluate the fish return pipe. Tables B.10 and B.11 represent evaluations of test fish condition before their release in the canal. Fish were in good condition before release. Tables B.12 and B.13 show results of screening facility evaluations. Table B.14 gives estimated times for test fish to move through the Richland Screen Facility. Descaling data from upriver hatchery and native fish are shown in Table B.15 (1986 data) and Table B.25 (1987 data). Screen integrity data at Richland Canal in 1987 are shown in Table B.29.

Data from the Toppenish/Satus Screens indicate that fish are safely diverted from the canal to the river. Data are presented in Tables B.16 through B.19. Table B.16 represents evaluations of test fish condition before release in the canal. The fish were in marginal condition before testing. Water temperature at the canal during testing was near 20°C; therefore we acclimated test fish to near 20°C. Although scales were loose on test fish and many became descaled during acclimation and transport, the test data are useful. The condition of test fish was not degraded by passage through the screen diversion based on comparing test and control populations. Table B.17 shows results of screening facility evaluations. 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 Wapato Screens indicate that fish are safely diverted from the canal to the river. Evaluation of potential screen passage at Wapato indicates that few fish pass through and over the screens; estimated numbers based on tests with fall chinook salmon fry are less than 2%. Data from the tests at the Wapato Screens are shown in Tables B.20 through B.24, B.26 through B.28, and B.30 through B.32. Data in Table B.20 represents evaluations of the inclined plane and nets used to capture fish at Wapato Screens. The plane and nets safely collected fish. Table B.21 and B.22 represent evaluations of test fish condition before release in the canal. Fish were in good condition before release. Tables B.23 and B.24 show results of screening facility evaluations. Table B.26 presents descaling data on upriver native and hatchery salmonids captured during evaluation tests. Table B.27 shows data from a test of the fish return pipe at Wapato Screens. Table B.28, B.32, and B.41 give data used to estimate migration time through the screen facility for test fish. Tables B.30, B.31, B.42, B.43, and B.44 give the data from screen integrity tests at Wapato Screens.

Data from Toppenish Creek Screens indicate that fish are safely diverted from the canal to the river (Tables B.33 through B.40). Table B.33 represents evaluation of the inclined plane. The plane collected fish without killing or descaling. Table B.34 represents evaluations of test fish condition before release in the canal or screen facility. Test fish were in good condition before release. Data for descaling evalutions are shown in Tables B.35 and B.38. Table B.36 shows estimated times for test fish to move through the Toppenish Creek Screen Facility. Tables B.39 and 40 show results of screen integrity evaluations. Less than 1% of test fish pass through or over the screens.

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

TEST REPLICATE	NUMBER OF FISH PLACED IN NET	CAPTURED	DESCALED OR KILLED	PERCENT DESCALED OR KILLED	95% CONFIDENCE INTERVAL
1	10	7	0	0	0-41.0
2	10	9	0	0	0-33.6
3	10	10	0	0	0-30.8
4	10	10	0	0	0-30.8
5	10	10	0	0	0-30.8
6	10	8	0	0	0-37.0
7	10	10	0	0	0-30.8
8	10	10	0	0	0- 4.8
TOTAL	80	74	0	0	0- 4.8

TABLE B.2. Percentage of Steelhead *Oncorhynchus mykiss* and Chinook Salmon *O. 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	0-36.0
Steelhead 2	50	28	0	0	0-12.3
Steelhead 3	55	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 *Oncorhynchus mykiss* Smolts 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
CanalHead Gates	20	0	0	0-16.8

TABLE B.4. Percentage of Chinook Salmon *Oncorhynchus tshawytscha* Smolts 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 *Oncorhynchus mykiss* Smolts Descaled or Killed in Each Test at Sunnyside Canal Fish Screening Facility, Spring 1985

RELEASE SITE	TEST REPLICATE	NUMBER OF FISH			PERCENT	95%
		RELEASED	CAPTURED	DESCALED OR KILLED	DESCALED OR KILLED	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 *Oncorhynchus tshawytscha* Smolts Descaled or Killed in Each Test at Sunnyside Canal Fish Screening Facility, Spring 1985

RELEASE SITE	TEST REPLICATE	NUMBER OF FISH			PERCENT DESCALED OR KILLED	95% CONFIDENCE INTERVAL
		RELEASED	CAPTURED	DESCALED OR KILLED		
Primary Fish Return Pipe	1	100	83	0	0	0.0-4.4
	2	100	64	2	3.1	0.4-10.8
	3	100	75	0	0	0.0-4.8
	4	100	60	1	1.7	0.0-8.9
	5	100	89	0	0	0.0-4.1
Intermediate Bypass	1	100	82	2	2.4	0.3-8.5
	2	100	95	0	0	0.0-3.8
	3	100	99	0	0	0.0-3.7
	4	100	95	2	2.1	0.3-7.4
	5	100	97	0	0	0.0-3.7
Terminal Bypass	1	100	98	2	2	0.3-7.2
	2	100	96	1	1	0.0-5.7
	3	100	98	0	0	0.0-3.7
	4	100	98	3	3.1	0.6-8.7
	5	92	86	1	1.2	0.0-6.3
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	0.2-14.7

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

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

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

REPLICATE	NUMBER OF FISH RELEASED	NUMBER OF FISH CAPTURED	NUMBER OF FISH DESCALED OR KILLED	PERCENT DESCALED OR KILLED	95% CONFIDENCE INTERVAL
1-L[a]	50	26	0	0	0.0-13.2
L-control	50	50	0	0	0.0- 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 a flow rate of 0.6 m^3/sec through the fish return pipe.
(b) The H designation indicates tests at a flow rate of 1.6 m^3/sec through the fish return pipe.

TABLE B.10. Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled Before Being Used in Tests at Richland Canal Fish Screening Facility, Spring 1986

	NUMBER OF FISH			PERCENT	95%
REPLICATE	RELEASED	CAPTURED	DESCALED OR KILLED	DESCALED OR KILLED	CONFIDENCE INTERVAL
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 *Oncorhynchus tshawytscha* Smolts Descaled Before Being Used in Tests at Richland Canal Fish Screening Facility, Spring 1986

	NUMBER OF FISH			PERCENT	95%
REPLICATE	RELEASED	CAPTURED	DESCALED OR KILLED	DESCALED OR KILLED	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 *Oncorhynchus mykiss* Smolts at Richland Canal Fish Screening Facility, Spring 1986

	NUMBER OF FISH			PERCENT	95%
REPLICATE	RELEASED	CAPTURED	DESCALED OR KILLED	DESCALED OR KILLED	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/s)	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	0	0.0	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 (h) to Catch 50% and 95% of Test Fish Captured at Richland Canal Fish Screening Facility, Spring 1986

SPECIES	TIME TO CATCH (h)			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 DESCALED OR KILLED	95% CONFIDENCE INTERVAL
	CAPTURED	DESCALED OR KILLED		
Chinook Salmon[a]	64	3	4.7	1.0-11.0
Coho Salmon	17	3	17.7	3.8-48.0
Steelhead	51	3	5.9	1.3-18.9

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

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

	NUMBER OF FISH			PERCENT	95%
REPLICATE	RELEASED	CAPTURED	DESCALED OR KILLED	DESCALED OR KILLED	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	22.0-32.9
TOTAL	311	311	82	26.4	22.0-32.9

TABLE B.17. Descaling and Mortality Data from Release and Capture Tests with Steelhead *Oncorhynchus mykiss* Smolts at Toppenish/Satus Canal Fish Screening Facility, Spring 1986

	NUMBER OF FISH			PERCENT	95%
REPLICATE	RELEASED	CAPTURED	DESCALED OR KILLED	DESCALED OR KILLED	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 (h) to Catch 50% and 95% of Test Fish Captured at Toppenish/Satus Canal Fish Screening Facility, Spring 1986

SPECIES	TIME TO CATCH (h) GROUP	50%	95%	NUMBER OF FISH RELEASED	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	DESCALED OR KILLED	PERCENT DESCALED OR KILLED	95% CONFIDENCE INTERVAL
Steelhead (1-age)	20	0	0	0.0-16.8
Steelhead (0-age)	69	0	0	0.0-05.2
Coho Salmon (1-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 *Oncorhynchus tshawytscha* and Steelhead *O. mykiss* 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	0-33.6
Steelhead	10	9	0	0	0-33.6
TOTAL	20	18	0	0	0-17.7
Spring Chinook	10	10	0	0	0-30.8
Spring Chinook	10	10	0	0	0-30.8
TOTAL	20	20	0	0	0-16.8

TABLE B.21. Percentage of Steelhead *Oncorhynchus mykiss* Smolts That Were Descaled Before Being Used in Tests at Wapato Canal Fish Screening Facility, Spring 1987

REPLICATE	CANAL FLOW (CFS)	NUMBER OF FISH EXAMINED	DESCALED	PERCENT DESCALED	95% CONFIDENCE INTERVAL
1	800	65	0	0	0-5.52
2	800	67	1	1.5	0.04-8.04
3	800	68	0	0	0-5.28
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	0- 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	0	0	0- 3.62
TOTAL		400	1	0.25	0.01-1.39

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

REPLICATE	CANAL FLOW (CFS)	NUMBER OF FISH EXAMINED	NUMBER OF FISH DESCALED	PERCENT DESCALED	95% CONFIDENCE INTERVAL
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
TOTAL		400	0	0	0-0.92

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

GROUP	CANAL FLOW (CFS)	RELEASE TIME (H)	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	0	0	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	2000	0800	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	2000	1900	142	125	2	0	1.4	0.19-5.66
2	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
TOTAL			1715	1158	10	6	1.4	0.79-2.24

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

GROUP	CANAL FLOW (CFS)	RELEASE TIME (H)	NUMBER RELEASED	NUMBER CAPTURED	NUMBER DESCALED	NUMBER DEAD	PERCENT DESCALED	95% CONFIDENCE INTERVAL
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
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	23.2	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 flow at Wapato Screens.
(b) Totals for all 1-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 (h) to Capture 50% and 95% of the Test Fish Released at Wapato Canal Fish Screening Facility, Spring 1987

SPECIES	FLOW CANAL (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 *Oncorhynchus tshawytscha* Fry Released at Richland Canal Fish Screening Facility, Spring 1987

TEST	NUMBER	RELEASE	HOURS	SAMPLING METHOD			% CAPTURED IN	
GROUP	RELEASED	SITE	SAMPLED	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

(a) Screens are numbered from the upstream (NUMBER 1) to downstream screen nearest the separation chamber (NUMBER 15).

Table B.31. Capture Data for Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released During Screen Integrity Tests at Wapato 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	BYPASS RELEASED	BYPASS CAPTURED	NUMBER OF TEST FISH: RELEASED	CAPTURED IN PLANE	CAPTURED IN FYKE NET	CAPTURED IN OTHER
1	5	100	58	100	54	100	99	723	695	2	0
1	10	100	56	100	39	100	98	724	700	1	0
1	15	100	73	100	61	100	96	723	631	26[(b)]	0
2	13	100	97	100	92	100	93	1470	1278	6	0
2	14	100	97	100	98	--	--	--	--	14	1
2	15	100	119[(c)]	100	121[(c)]	--	--	--	--	39	38
3	3	50	24	100	22	100	88	1472	1311	3	0
3	4	50	21	100	23	--	--	--	--	0	0
3	5	50	34	100	33	--	--	--	--	6	0
4	8	50	35	100	58	100	97	1502	1396	0	0
4	9[(d)]	50	48	100	5	--	--	--	--	0	0
4	10	50	40	100	76	--	--	--	--	2	0
TOTAL		900	702	1200	682	600	571	6614	6011	99[(e)]	39

(a) 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 (h) to Capture 50% and 95% of Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry 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 (h) 50%	TIME TO CATCH (h) 95%
1	Upstream Bypass	100	99	99.0	<0.25[a]	<0.25
3	Upstream	100	88[b]	88.0	<0.50	1.00
1	Screen 5[c]	723	695	96.1	<0.25	1.25
3	Screen 3	1472	1311	89.1	0.50	6.00
1	Middle Bypass	100	98	98.0	<0.25	<0.25
4	Middle Bypass	100	97	97.0	<0.50	1.00
1	Screen 10	724	700	96.7	<0.25	0.75
4	Screen 8	1502	1396	92.9	<0.50	2.00
1	Downstream Bypass	100	96	96.0	<0.25	0.50
2	Downstream Bypass	100	93	93.0	<0.50	<0.50
1	Screen 15	723	631[d]	87.3	<0.50	5.00
2	Screen 13	1470	1278[d]	86.9	<0.50	1.50

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

TABLE B.33. Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled or Killed in Tests of the Inclined Plane at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

REPLICATE	NUMBER OF FISH			PERCENT DESCALED	95% CONFIDENCE INTERVAL
	RELEASED	CAPTURED	DESCALED		
1	10	10	0	0.00	0-31
2	10	10	0	0.00	0-31
3	10	10	0	0.00	0-31
4	10	10	0	0.00	0-31
5	10	10	0	0.00	0-31
6	10	10	0	0.00	0-31
7	10	9	0	0.00	0-34
8	10	10	0	0.00	0-31
9	10	10	0	0.00	0-31
10	10	10	0	0.00	0-31
TOTAL	100	99	0	0.00	0- 4

TABLE B.34. Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled Before Being Used in Tests at the Toppenish Creek Canal Fish Screening Facility, Spring 1988

REPLICATE	NUMBER OF FISH		PERCENT DESCALED	95% CONFIDENCE INTERVAL
	EXAMINED	DESCALED		
1	70	0	0.00	0-5
2	70	0	0.00	0-5
3	70	0	0.00	0-5
TOTAL	210	0	0.00	0-2

TABLE B.35. Descaling and Mortality Data from Release and Capture Tests with Steelhead *Oncorhynchus mykiss* Smolts at the Toppenish Creek Fish Screening Facility, Spring 1988

CANAL FLOW (CFS)	NUMBER				PERCENT		95% CONFIDENCE INTERVAL
	RELEASED	CAPTURED	DESCALED	DEAD	CAPTURED	DESCALED	
20	250	144	0	0	57.6	0.00	0-2
50	255	199	1	0	78.0	0.50	0-3
50	250	196	0	0	78.4	0.00	0-2
Total	755	539	1	0	71.4	0.19	0-1
Wild Fish		462	1	0	-	0.22	0-1

TABLE B.36. Estimated Time to Capture 50% of Steelhead *Oncorhynchus mykiss* Smolts Released in Descaling Tests at Toppenish Creek Fish Screening Facility, Spring 1988

CANAL FLOW	NUMBER		PERCENT CAUGHT	TIME TO CATCH 50% (h)
	RELEASED	CAUGHT		
20 cfs	250	144	57.6(a)	39.0
50 cfs	255	199	78.0	16.0
50 cfs	250	196	78.4	14.0

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

TABLE B.37. Estimated Time to Capture 50% of Rainbow Trout *Oncorhynchus mykiss* Fry Released in Screen Integrity Tests at Toppenish Creek Fish Screening Facility, Spring 1988

TEST GROUP	NUMBER		PERCENT CAUGHT	TIME TO CATCH 50% (h)
	RELEASED	CAUGHT		
1	1024	868	84.8	4.0
2	1024	724	70.7	9.0
3	1025	781	76.2	4.0

TABLE B.38. Percentage of Steelhead *Oncorhynchus mykiss* Smolts Descaled In Pipe Tests at the Toppenish Creek Fish Screening Facility, Spring 1988

TEST GROUP	NUMBER OF FISH			PERCENT DESCALED	95% CONFIDENCE INTERVAL
	RELEASED	CAPTURED	DESCALED		
1	10	a	0	-	-
2	10	a	0	-	-
3	10	a	0	-	-
4	10	a	0	-	-
5	10	a	0	-	-
6	10	a	0	-	-
7	10	a	0	-	-
8	10	a	0	-	-
9	10	a	0	-	-
10	10	a	0	-	-
11	10	a	0	-	-
12	10	a	0	-	-
13	10	a	0	-	-
Total	130	106	0	0.0	0-3

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

TABLE B.39. Capture Data for Rainbow Trout *Oncorhynchus mykiss* Fry Released During Screen Integrity Tests at the Toppenish Creek Fish Screening Facility, Spring 1988

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

TABLE B.40. Capture Efficiency of the Inclinded Plane and Fyke Nets Used During Screen Integrity Tests at the Toppenish Creek Fish Screening Facility, Spring 1988

SCREEN	CAPTURE PROBABLITIY ESTIMATE INCLINED PLANE	CAPTURE PROBABLITIY ESTIMATE FYKE NET	SCREEN EFFICIENCY	95% CONFIDENCE INTERVAL
1	0.987	0.597	0.999	1.00-1.00
2	0.987	0.650	1.000	1.00-1.00
3	0.987	0.493	0.992	1.00-1.00
a	0.966	0.580	0.966	0.95-0.98
All Screens	0.987	0.580	0.991	0.99-1.00

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

TABLE B.41. Estimated Time to Capture 50% of Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released in Screen Integrity Tests at the Wapato Fish Screening Facility, Spring 1988

TEST GROUP	SCREENS	NUMBER RELEASED	NUMBER CAUGHT	PERCENT CAUGHT	TIME TO CATCH 50% (h)
1	5	1044	775	74.2	6.5
1	10	1041	816	78.4	7.0
1	15	1042	535	51.3	7.5
2	13-15	1041	620	59.6	4.5
3	3-5	1028	675	65.7	0.5
4	15	1039	959	92.3	1.0

TABLE B.42. Capture Data for Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released During Screen Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1988

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

TABLE B.43. Capture Efficiency of the Inclined Plane and Nets and Retention Efficiency for Fyke Nets Used During Screen Integrity Tests at the Wapato Canal Fish Screening Facility, Spring 1988

SCREEN SECTION[a]	PROBABILITY ESTIMATE: PLANE CAPTURE	PROBABILITY ESTIMATE: NET CAPTURE	PROBABILITY ESTIMATE: NET RETENTION	SCREEN EFFICIENCY	95% CONFIDENCE INTERVAL
1-5	0.805	0.793	0.850	0.995	0.99-1.00
6-10	0.770	0.950	0.900	0.998	0.99-1.00
11-15	0.810	0.918	0.888	0.984	0.98-0.99
15	0.960	0.950	0.880	0.994	0.99-1.00
1-15	0.802	0.968	0.874	0.991	0.99-1.00

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

TABLE B.44. Capture Data from Fyke Nets Behind Selected Screens at the Wapato Canal Fish Screening Facility After the Release of Yakima Indian Nation Fall Chinook Salmon *Oncorhynchus tshawytscha* from Net Pens in the Wapato Screen Forebay, Spring 1988

SCREEN	NET[a]	FYKE NET CAPTURES: YIN FISH	FYKE NET CAPTURES: OTHER SALMONIDS
13	A	(b)	(b)
13	B	1	0
14	A	1	0
14	B	3	1
15	A	37	2
15	B	148	1
Total		190	4

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

TABLE B.45. Estimated Time to Capture 50% of Fall Chinook *Oncorhynchus tshawytscha* Fry Released in Screen Integrity Tests at the Sunnyside Fish Screening Facility, Spring 1988

TEST GROUP	NUMBER RELEASED	NUMBER CAUGHT	PERCENT CAUGHT	TIME TO CATCH 50% (h)
1	1045	746	71.4	1.0
2	1047	791	75.5	1.0
3	1047	891	85.1	<0.5
4	1047	845	80.7	<0.5

TABLE B.46. Capture Data for Fall Chinook Salmon *Oncorhynchus tshawytscha* Fry Released During Screen Integrity Tests at the Sunnyside Fish Screening Facility, Spring 1988

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

TABLE B.47. Capture Efficiency of the Inclined Plane and Fyke Nets Used During Screen Integrity Tests at the Sunnyside Canal Fish Screening Facility, Spring 1988

SCREEN SECTION[a]	PROBABILITY ESTIMATE PLANE CAPTURE	NET CAPTURE	SCREEN EFFICIENCY	95% CONFIDENCE INTERVAL
3-8 (test 1)	0.750	0.908	0.967	0.96-0.98
3-8 (test 2)	0.800	0.888	0.988	0.98-1.00
3-8	0.775	0.898	0.977	0.97-0.98
9-17 (test 3)	0.750	0.688	0.986	0.98-1.00
9-17 (test 4)	0.870	0.794	0.992	0.99-1.00
9-17	0.810	0.741	0.989	0.98-0.99
3-17	0.793	0.819	0.983	0.98-0.99

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

TABLE B.48. Capture Data From Fyke Nets Behind Selected Screens at the Sunnyside Canal Fish Screening Facility After the Release of Yakima Indian Nation Fall Chinook Salmon *Oncorhynchus tshawytscha* Fingerlings From the Wapato Screens Forebay, Spring 1988

SCREEN NUMBER	NET[a]	FYKE NET CAPTURES YIN FISH	OTHER SALMONIDS[b]
8	A	2	2
8	B	0	0
17	A	26	2
17	B	157	5
Total		185	9

(a) Net A is the top net. Net B is the bottom net (Figure 7).
(b) Includes smolt-sized and 0-age salmonids.

APPENDIX C

OPERATING CRITERIA FOR THE FISH SCREENING FACILITIES AT SUNNYSIDE, TOPPENISH/SATUS, AND WAPATO CANALS

Appendix C contains the operating criteria for each of the fish screens that we evaluated during 1988. 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 the Wapato Screens are on pages C.12-C.15. Text describing the operating criteria appears on pages C.12-C.13, and a diagram of the Wapato Screens is on page C.14. A graph summarizing weir crest height adjustment based on canal surface elevation is on page C.15.

The operating criteria for the Toppenish Creek Screens are on pages C.16 and C.17. The text describing the operating conditions is on page C.16. A diagram of the screens is on page C.17.

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 ft. 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 ~~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.

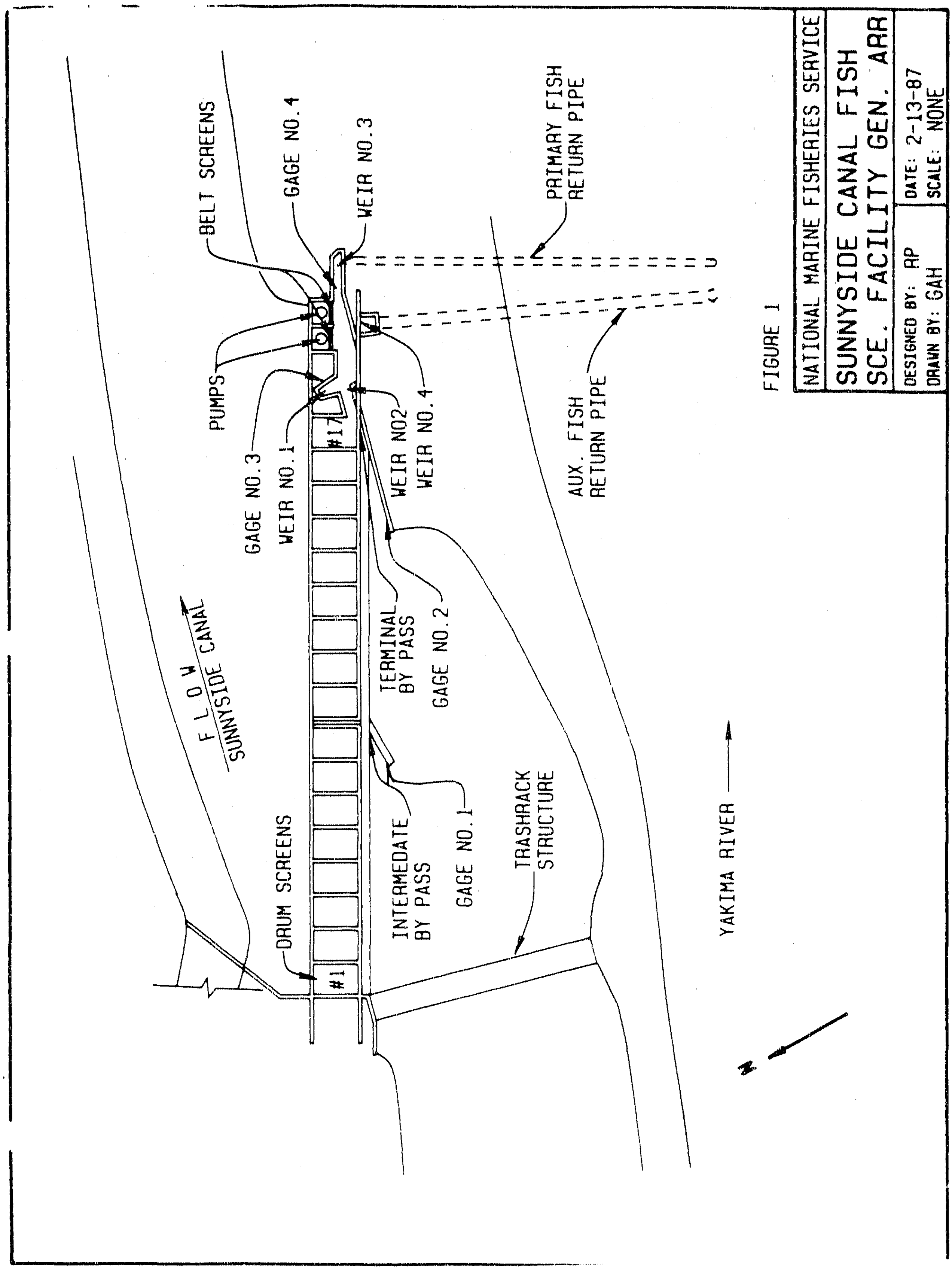
Note that "on blocks" means that two concrete blocks are placed beneath the bottom-most log to create a 8-inch ± gap between the concrete slab and the bottom log.

Screen bay No.	Steel logs/timber logs/ 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

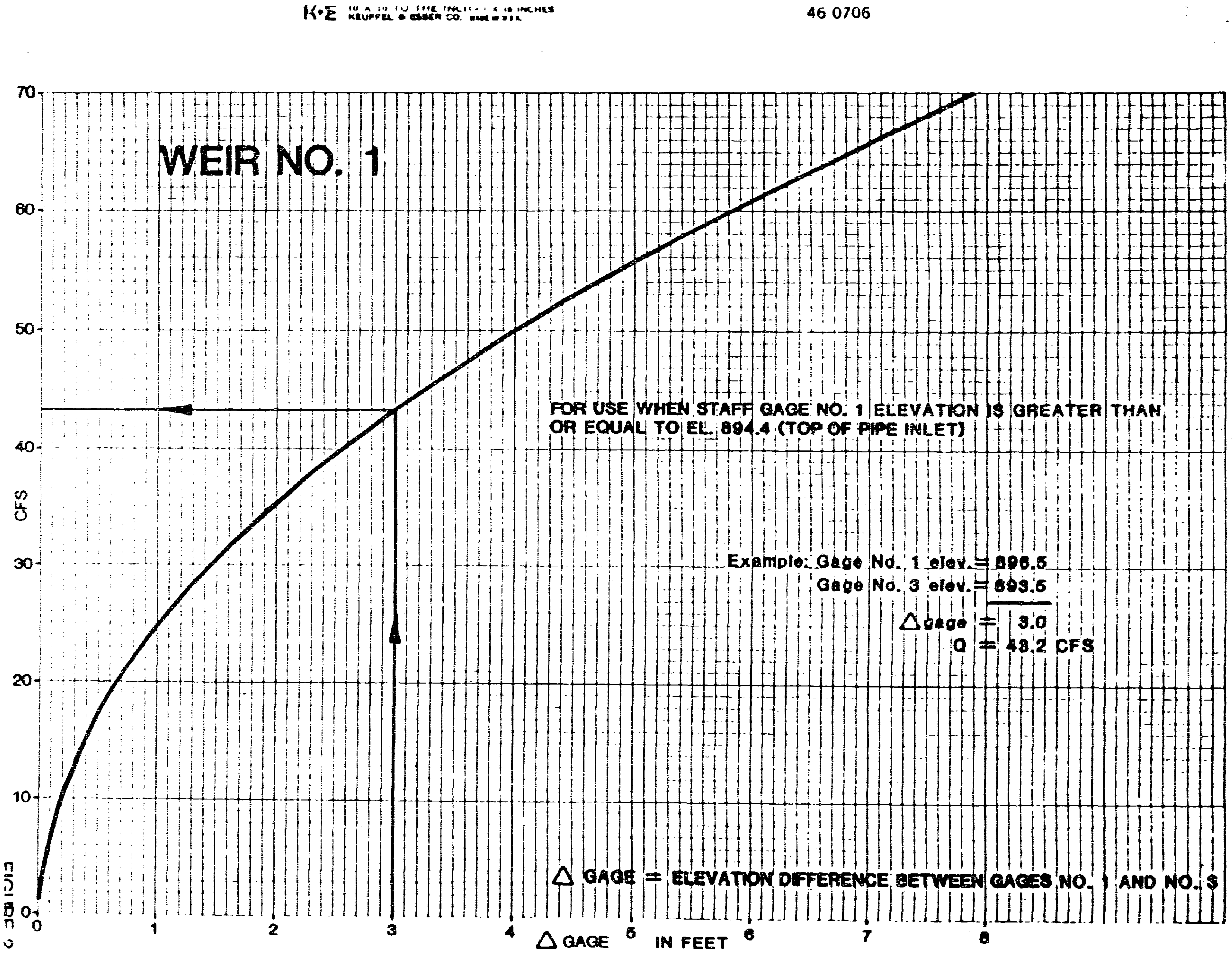
10	3 steel/5 timber/on blocks
11	1 steel/2 timber/on blocks
12	1 steel/2 timber/on blocks
13	2 steel/3 timber/on blocks
14	2 steel/3 timber/on blocks
15	None
16	None
17 (downstream-most bay)	None

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 1/2-inch to meet "as-build" concrete dimensions.

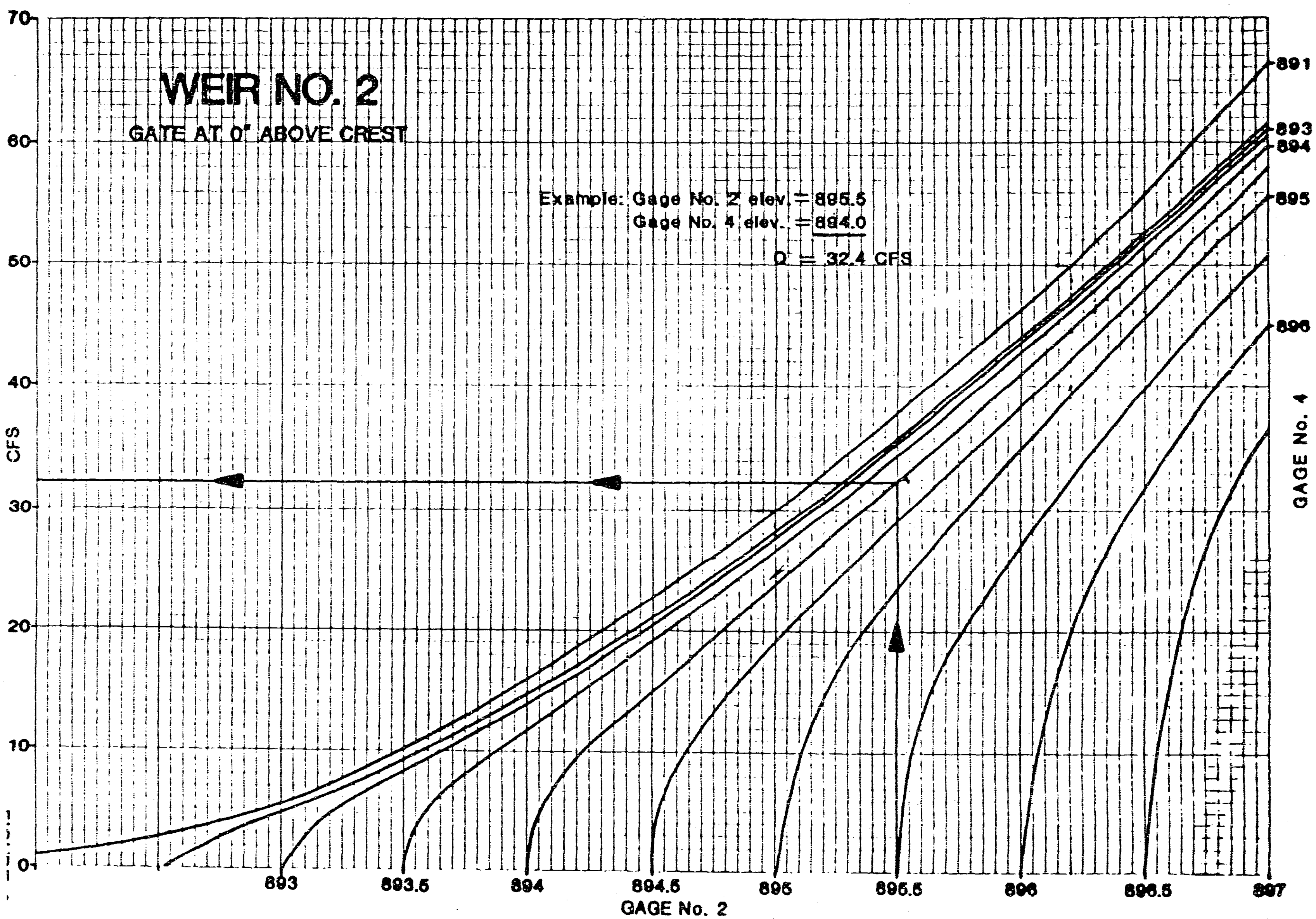


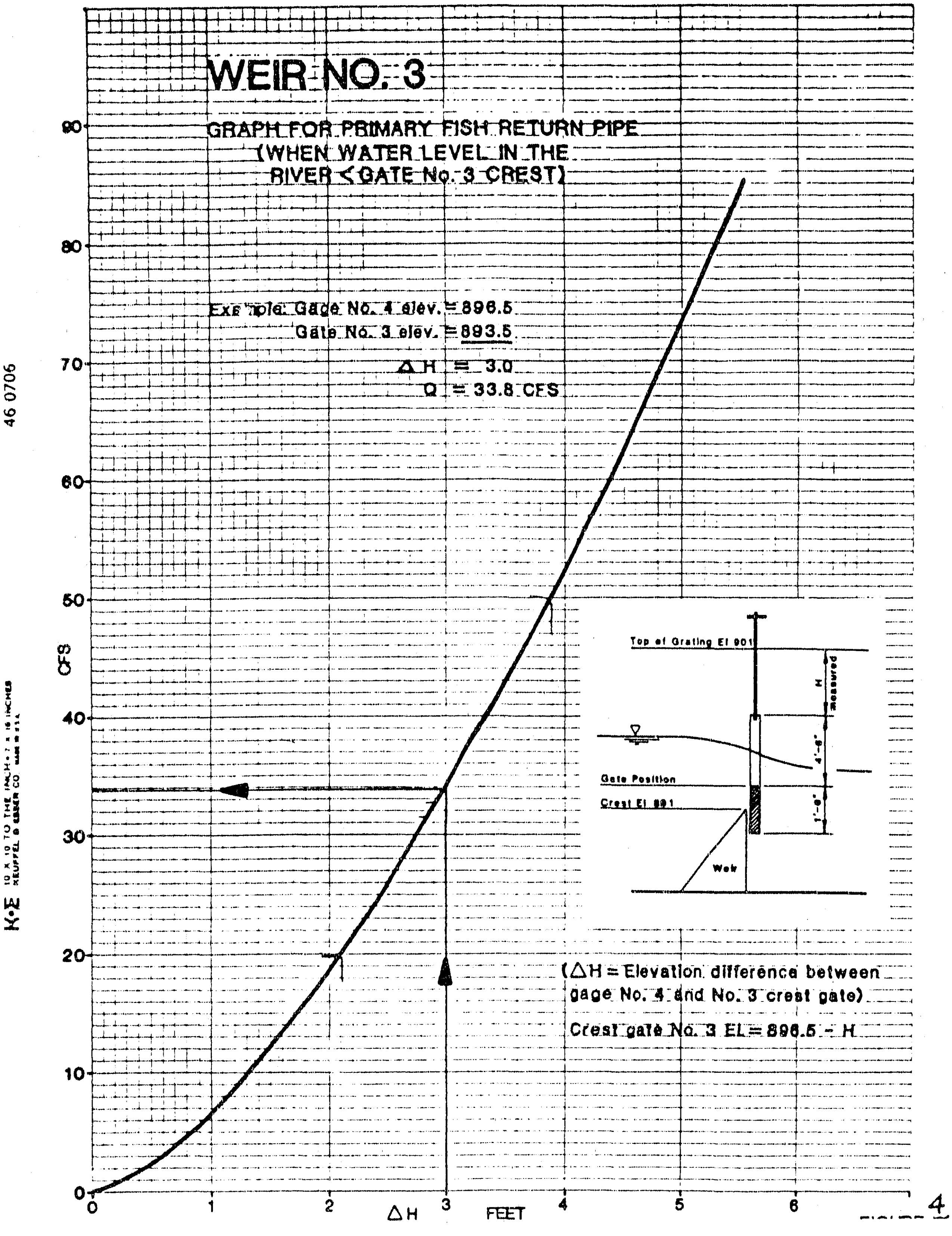
BELT SCREENS
GAGE NO.4
WEIR NO.3
PRIMARY FISH RETURN PIPE
PUMPS
GAGE NO.3
WEIR NO.1
#17
WEIR NO2
WEIR NO.4
AUX. FISH RETURN PIPE
FLOW
SUNNYSIDE CANAL
TERMINAL BY PASS
GAGE NO.2
DRUM SCREENS
#1
INTERMEDIATE BY PASS
GAGE NO.1
TRASHRACK STRUCTURE
YAKIMA RIVER
N
FIGURE 1
NATIONAL MARINE FISHERIES SERVICE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



K•E KEUFFEL & ESSER CO.
46 0706
WEIR NO. 1
70
60
50
40
30
20
10
0
CFS
0
1
2
3
4
5
6
7
8
FOR USE WHEN STAFF GAGE NO. 1 ELEVATION IS GREATER THAN OR EQUAL TO EL. 894.4 (TOP OF PIPE INLET)
Example: Gage No. 1 elev. = 896.5
Gage No. 3 elev. = 893.5
△gage = 3.0
Q = 43.2 CFS
△ GAGE = ELEVATION DIFFERENCE BETWEEN GAGES NO. 1 AND NO. 3
△ GAGE IN FEET

FIGURE 2


WEIR NO. 2
GATE AT 0" ABOVE CREST
Example: Gage No. 2 elev. = 895.5
Gage No. 4 elev. = 894.0
Q = 32.4 CFS
CFS
0
10
20
30
40
50
60
70
893
893.5
894
894.5
895
895.5
896
896.5
897
GAGE No. 2
891
893
894
895
896
GAGE No. 4



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 Position
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

4

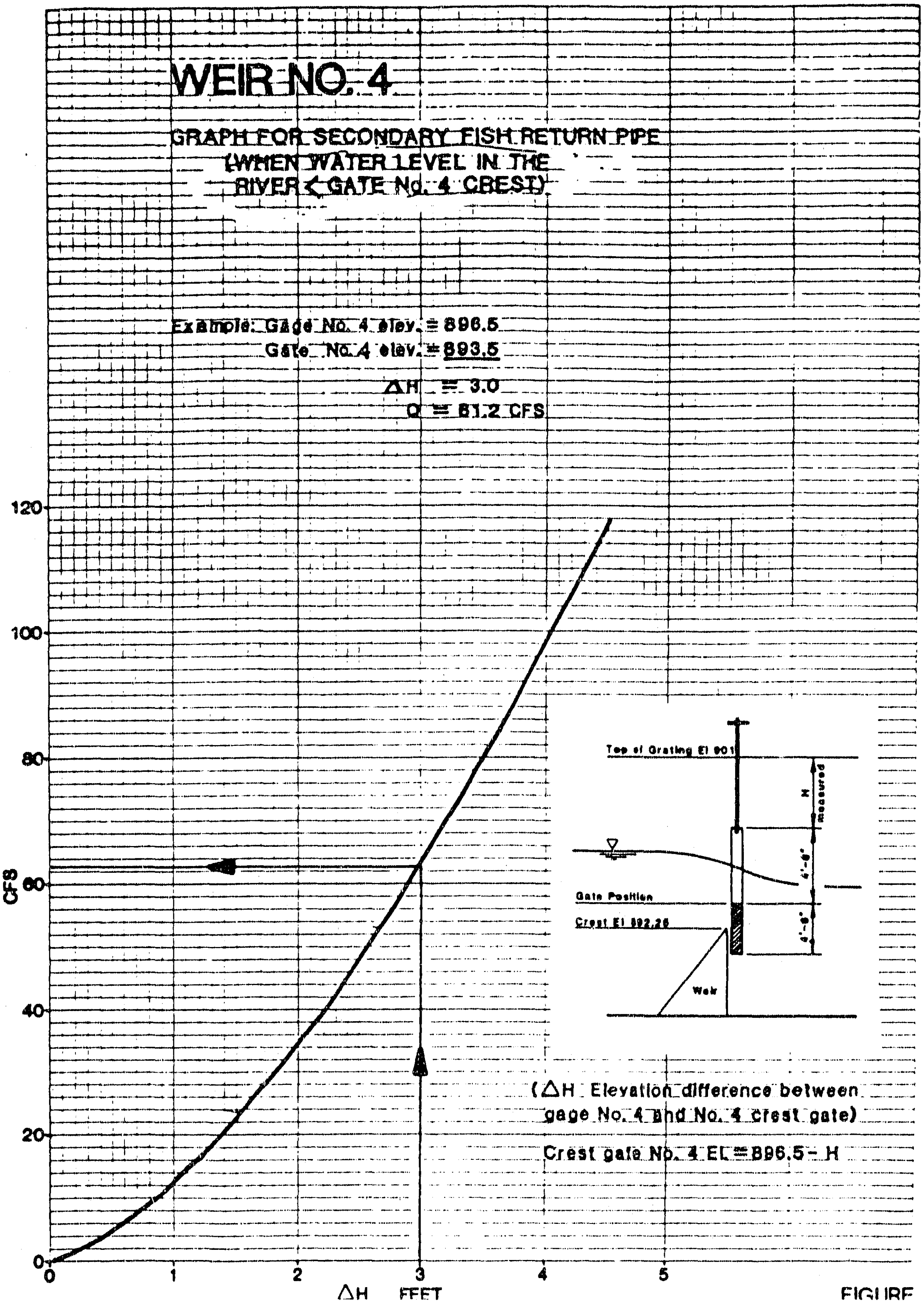
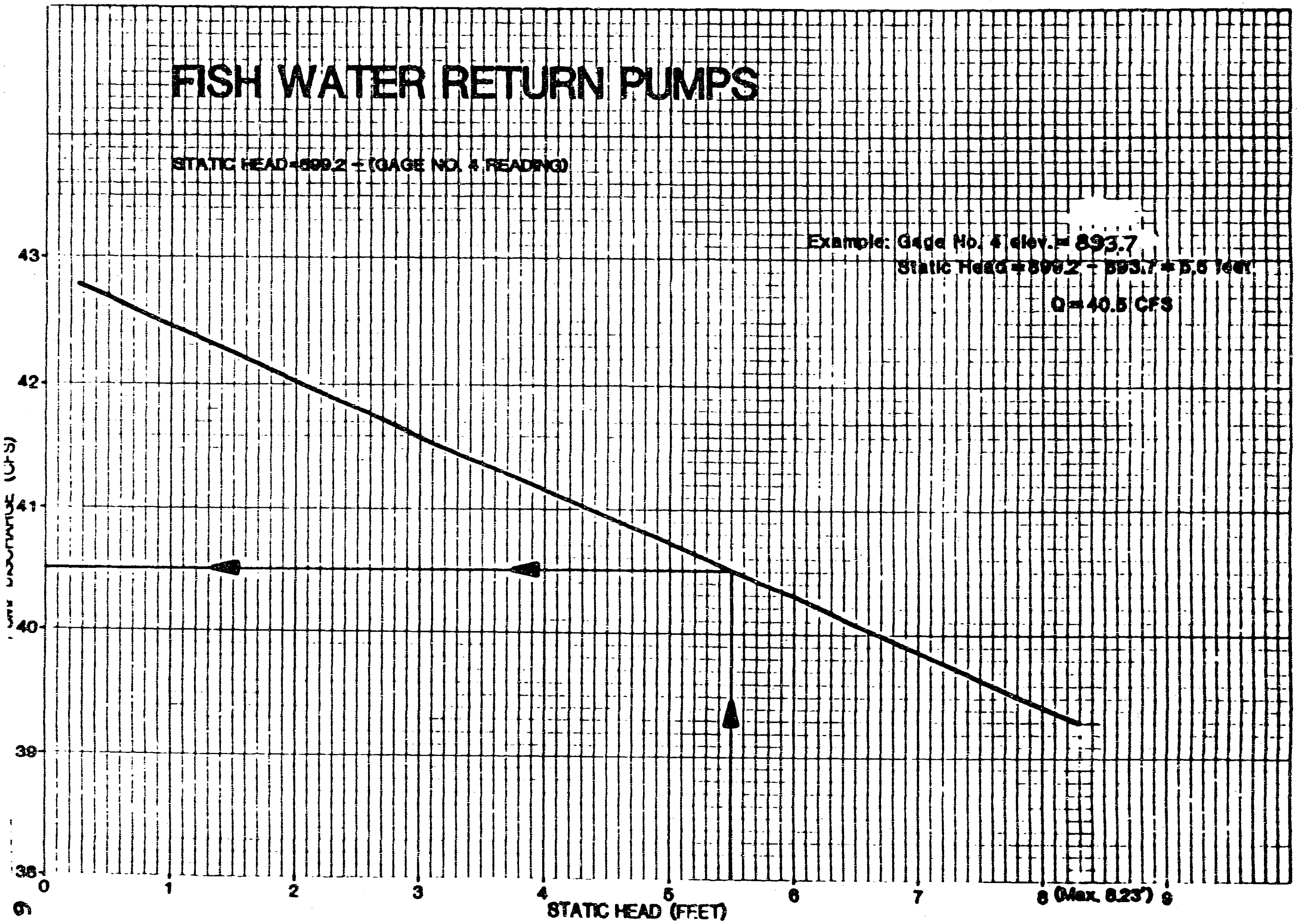

WEIR NO. 4
GRAPH FOR SECONDARY FISH RETURN PIPE
(WHEN WATER LEVEL IN THE
RIVER < GATE No. 4 CREST)
Example: Gage No. 4 elev. = 896.5
Gate No. 4 elev. = 893.5
ΔH = 3.0
Q = 61.2 CFS
CFS
0
20
40
60
80
100
120
1
2
3
4
5
ΔH FEET
Top of Grating El 901
H
Measured
4'-6"
4'-6"
Gate Position
Crest El 892.26
Weir
(ΔH Elevation difference between
gage No. 4 and No. 4 crest gate)
Crest gate No. 4 EL = 896.5 − H

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 (Max. 8.23')
9
STATIC HEAD (FEET)

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 #1, #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 stoplog) 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.

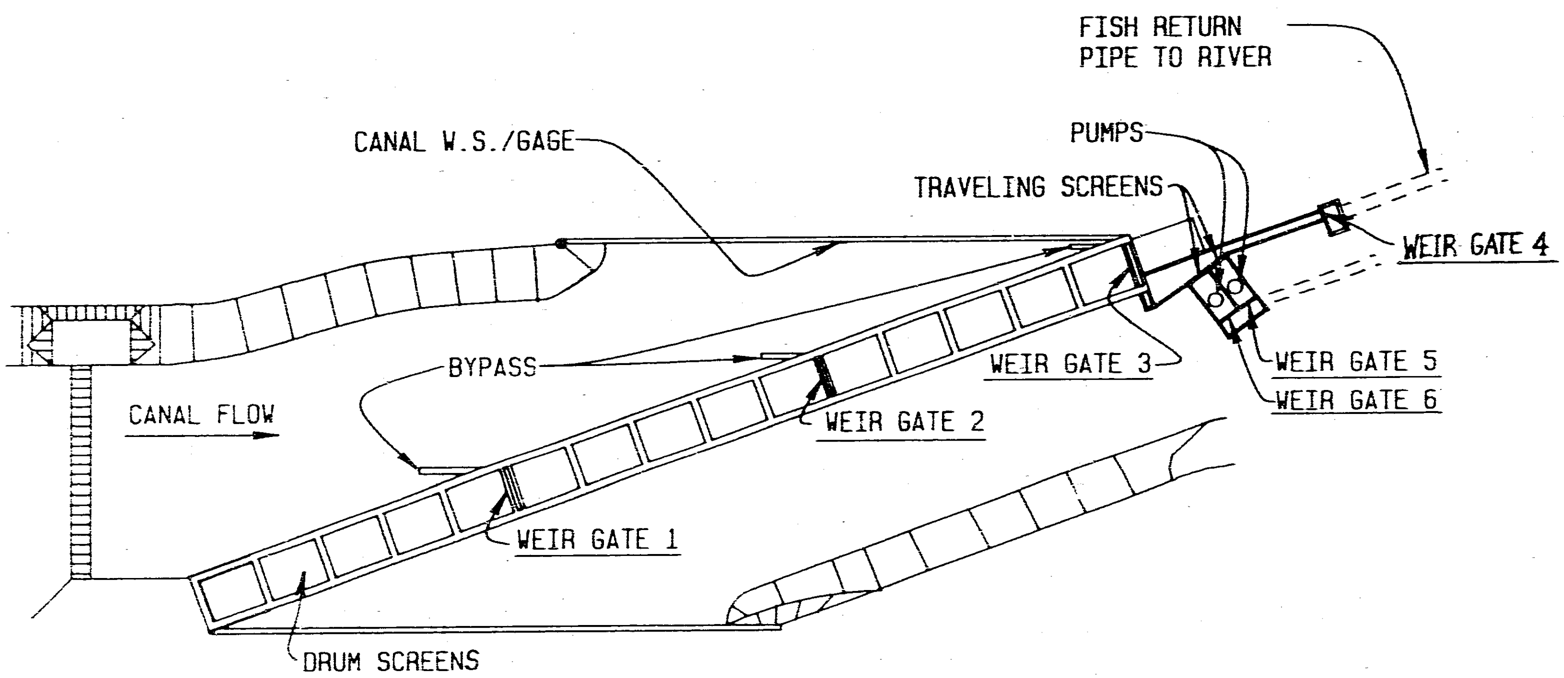
Operation with Pumpback:

1. Set weir gates #1, #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 #1, #2 & #3 equally to obtain 3.5' difference. Note: This is very important since for certain conditions the 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.



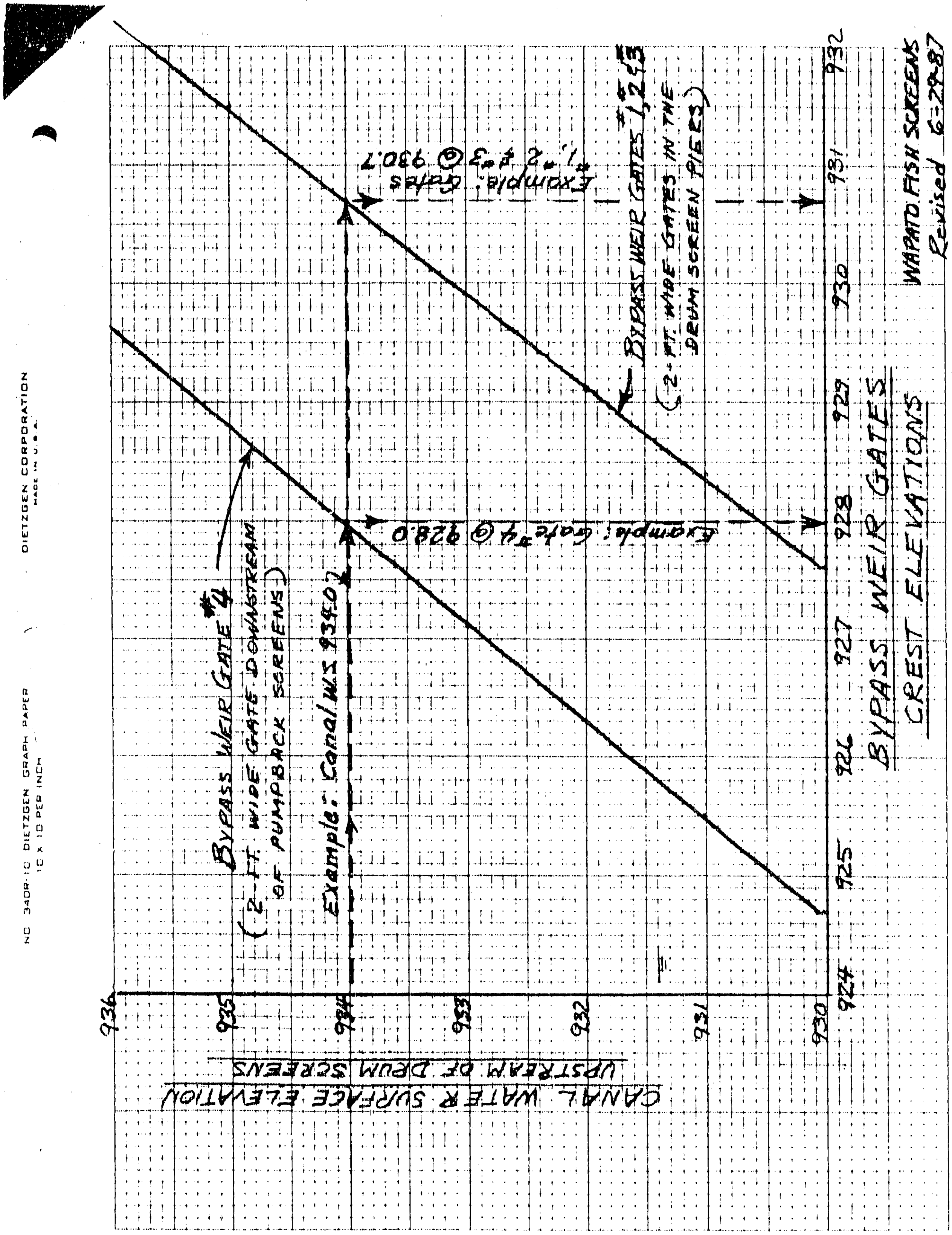
WAPATO CANAL FISH SCREEN FACILITY PLAN

NATIONAL MARINE FISHERIES SERVICE

WAPATO CANAL FISH SCREEN FACILITY

DESIGNED BY: R.P. DATE: 2 - 30 - 87
DRAWN BY: G.A.H. SCALE: -

CAD FILE: WAPCAFSF


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

Revised 6-29-87

TOPPENISH CREEK DIVERSION SCREENS OPERATING CRITERIA

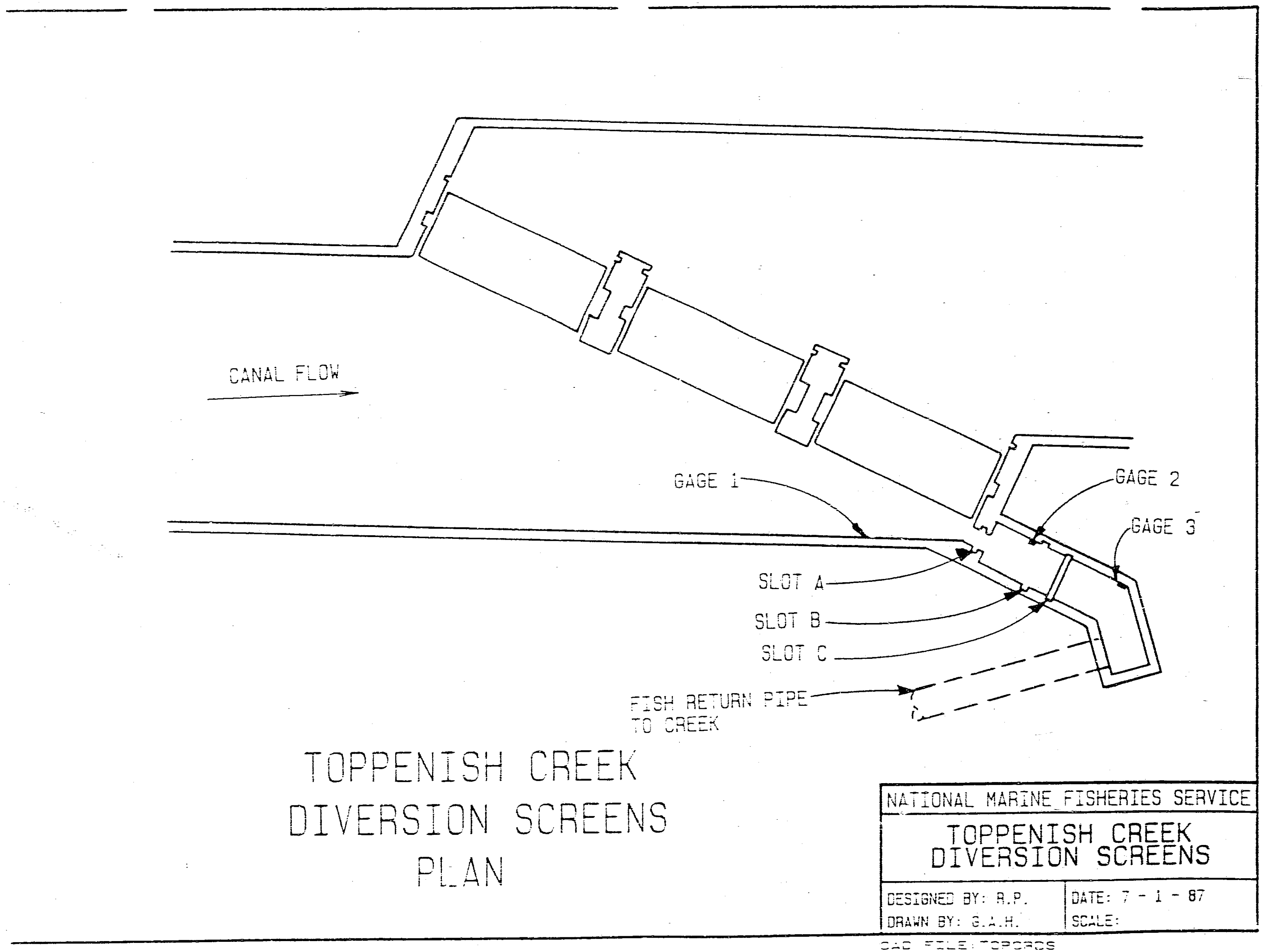
1. Normal canal water surface is to be checked up at a location down the canal to operate between elevation 1307.5 and 1308.0 as read on gage No. 1 (see attached sketch). The water surface is not to exceed elevation 1308.2, to avoid fish being carried over the screen drums.

2. Flow through the bypass slot and fish return pipe is controlled by stoplogs placed in slot C in a manner to form an overflow weir. Slots A and B are to be empty.

3. Fish return flow required is 16 cfs when ample flow is available and when adequate head differential exists between the canal water surface and the river water surface at the fish return pipe outfall location. To provide at least 16 cfs flow, maintain the crest (top) elevation of the stoplogs in slot C at least 1.4 feet lower than the canal water surface at gage No. 2 immediately upstream of slot B.

   NOTES: When very high flows occur in Toppenish Creek of over 500 cfs the head differential from the canal to the creek at the fish return pipe outfall may not be adequate to provide the full 16 cfs fish return flow.

   At very low creek flows when spill over the dam has stopped, the fish return flow may be reduced by addition of stoplogs in slot C to provide flow needed in the canal downstream of the screening facility. If additional stoplogs are inserted it is important that they be removed when creek flows once again increase or canal demand drops, so that full fish return flow is restored.


CANAL FLOW
GAGE 1
GAGE 2
GAGE 3
SLOT A
SLOT B
SLOT C
FISH RETURN PIPE
TO CREEK
TOPPENISH CREEK
DIVERSION SCREENS
PLAN
NATIONAL MARINE FISHERIES SERVICE
TOPPENISH CREEK
DIVERSION SCREENS
DESIGNED BY: R.P.
DATE: 7 - 1 - 87
DRAWN BY: G.A.H.
SCALE:
CAD FILE:TOPCRDS

END

DATE FILMED

12 / 21 / 90