Washington Phase II Fish Diversion Screen Evaluations in the Yakima River Basin

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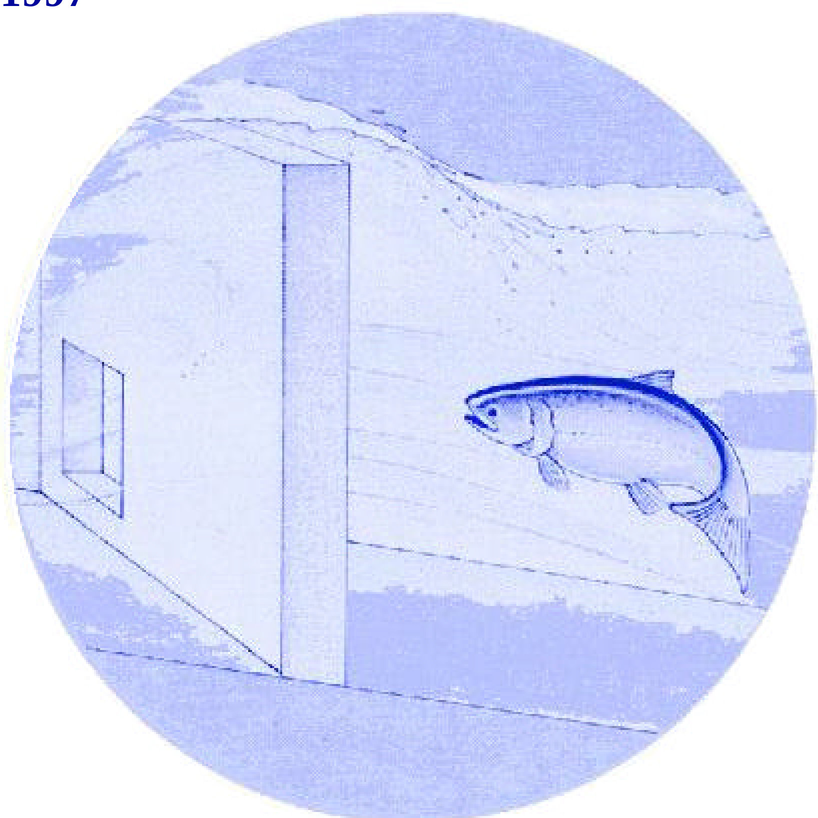
1997



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Washington Phase II Fish Diversion Screen Evaluations in the Yakima River Basin, 1997

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Summary

The Pacific Northwest National Laboratory evaluated 19 Phase II screen sites in the Yakima River Basin at least three times each between April 30 and August 22, 1997. The sites were examined to determine if they were being effectively operated and maintained to provide fish a safe, efficient return to the river. Data were collected to determine if velocities in front of the screens and in the bypass met current NMFS criteria and promoted timely fish bypass, if fish were protected from injury due to impingement, entrainment, and predation, and whether bypass outfall conditions allowed fish to safely return to the river. A bi-directional flow meter and underwater video system were essential in completing the investigation.

In general, water velocity conditions at the screen sites were acceptable by NMFS standards. High approach velocities and slow bypass flow were the most common problems noted. Although velocities often fluctuated from one sampling location to the next, average sweep and approach velocities were very good. In general, fish should not be impinged or experience delays in returning to the river under normal operating conditions.

Most screens were properly sealed to prevent fish entrainment and injury, although potential problems were identified at several screen sites. Three sites had gap openings from the forebay to the aftbay, allowing fish to be entrained. Other sites had spaces larger than 3/32 inch where small fish could become trapped. Some drum screens had flat spots but these were not been confirmed as underwater gaps, primarily because of siltation. On rare occasions, seals were intact, but cracked or turned under.

Submergence levels at the drum screen sites exceeded 85% for one third of our evaluations. Eight of 12 drum screen sites experienced high water levels during at least one evaluation. Only one operating site’s submergence was measured at less than 65% submergence. Two flat plate screen sites were completely overtopped with water during one evaluation each. Although 1997 was an extreme high-water year, these overtopping events point out that some screens do not completely protect fish under the full range of potential operating conditions.

Water depths at the outfall pipe were acceptable at all but four sites. Generally, water depths were low near the end of the irrigation season due to low river flows. Rock removal around the outfall pipe or pipe extension would improve the situation.

We gauged the potential for predation by qualitatively measuring the types and amount of cover provided for predators in front of the screens and by recording random observations of fish large enough to be considered predators in the forebay. Predation was more likely to occur at drum screen sites than at flat plate screen sites. Drum sites provide more predator hiding places because greater amounts of woody

debris accumulate under the drums and against the concrete walls that divide one screen bay from the next. Four sites had both woody debris and large fish present. These four sites were considered most likely to experience juvenile salmonid loss to predation. Periodic removal of woody debris from underneath the curvature of drum screens would decrease the likelihood of predation at these sites.

Screens were generally well maintained. Automated cleaning brushes functioned properly, chains and other moving parts were well greased, and inoperative and algae-covered drum screens were eventually repaired and cleaned. However, removal of sediment build-up and accumulated woody debris are areas where improvement should be considered. Maintenance checks should include observation of bypass outfalls on a regular basis, as conditions at the end of the bypass pipe are likely to change seasonally, especially in streams with high gradients or unstable gravel.

Post-season evaluations were conducted at 11 sites in November to try and confirm seal and drum screen defects, and locations of excessive sedimentation. This proved effective in several cases, but the winterization process eliminated some of the evidence. Several forebay areas had already been cleared of silt. It was difficult to evaluate screens and seals when the screens were in the storage position because the screens could not be rotated. Also, two sites remained in full operation while others were submerged, precluding detailed examination of parts still under water.

Periodic, regular screen evaluations will increase the effectiveness of screen operation and maintenance practices by confirming the effectiveness (or ineffectiveness) of screen operating procedures at individual sites. Where procedures are being followed and problems still occur, evaluation results will suggest means to improve the procedures to better protect fish at screening facilities.

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Introduction

Water from Western rivers was first diverted for agricultural purposes in the mid-1850's. None of these diversions were equipped with fish protection devices until the 1920's. The Mitchell Act, passed in 1938, provided funding to initiate some of the programs that currently evaluate screen irrigation diversions in Washington, Oregon, and Idaho. More recently, the Bonneville Power Administration (BPA) and the Northwest Power Planning Council (Council) expanded on screening efforts to protect and enhance fish populations. The Council's Columbia River Fish and Wildlife Program (Program) lists fish protection through effective screening of irrigation diversions as an essential element in their plan to restore declining steelhead *(Oncorhynchus mykiss)* and salmon runs (NPPC 1984, 1987, 1994).

The criteria used to measure screen effectiveness have changed over the years as a result of research providing information on how fish behave as they encounter screening facilities. Maximum allowable approach velocities have been decreased, while required sweep velocities have been increased. Also, screen opening size has been decreased to just 3/32 of an inch to prevent very early life stages of salmonids from becoming entrained in irrigation canals. These new requirements (developed by the National Marine Fisheries Service (NMFS) and adopted by fisheries agencies from Washington, Oregon, and Idaho) have required the development of new screens to replace older, less effective screens. In response to these actions, BPA has established a monitoring and evaluation program to ensure that new and updated screening facilities meet fish protection standards.

The Yakima River Basin was selected as one site to enhance salmon and steelhead runs in the middle Columbia River Basin. Through a regional Conservation and Electric Power Plan implemented under the Pacific Northwest Electric Power Planning and Conservation Act, the BPA and the Bureau of Reclamation (BoR) have funded construction of and improvements to fish passage and protection facilities at irrigation diversions in the Yakima River Basin. Construction and enhancements of the Phase II Screens are part of this plan.

PNNL staff conducted fisheries evaluations at seven Yakima Basin screening facilities from 1985 to 1990. These studies were conducted at Phase I screening facilities, including the Sunnyside Screens (Neitzel et al. 1985), the Richland and Toppenish/Satus Screens (Neitzel et al. 1986), the Wapato Screens (Neitzel et al. 1988), the Toppenish Creek Screens (Neitzel et al. 1990a), the Westside Screens (Neitzel et al. 1990b), and the Town Screens. These studies determined whether fish that entered an irrigation canal were safely diverted back to the river. Another study measured water velocities at three additional Phase I screening facilities (the Easton, Chandler, and Wapato Screens) to determine whether they met NMFS criteria and promoted safe fish diversion back to the river (Abernethy et al. 1990). Two additional studies were conducted at PNNL's aquatic ecology laboratory in Richland, Washington using modular drum screens built by the Washington Department of Fish and Wildlife (Abernethy et al. 1996, Neitzel et al. 1997). These studies determined fish survival through submerged orifices and how well two screen configurations met NMFS screening criteria. The methods developed while conducting these studies were incorporated into the 1997 Phase II screen site surveys.

This study covers work performed by PNNL scientists at 19 Phase II screen facilities in 1997. The three main questions addressed in this evaluation were:

1. Are screens designed, operated, and maintained to meet NMFS criteria standards over a wide range of conditions?
2. Do velocities/flows meet NMFS criteria?
3. Are screens effective at protecting fish from injury and from unnecessary migration delay?

The report briefly describes the methods used to evaluate the effectiveness of the facility, provides results and a discussion with recommendations for improving facility effectiveness, operation, and maintenance. The appendix provides physical descriptions and photographs of the facilities evaluated.

Methods

Nineteen operating screen sites in the Yakima, Naches, and Tieton River basins were evaluated between April 30 and August 22, 1997 (Figure 1).

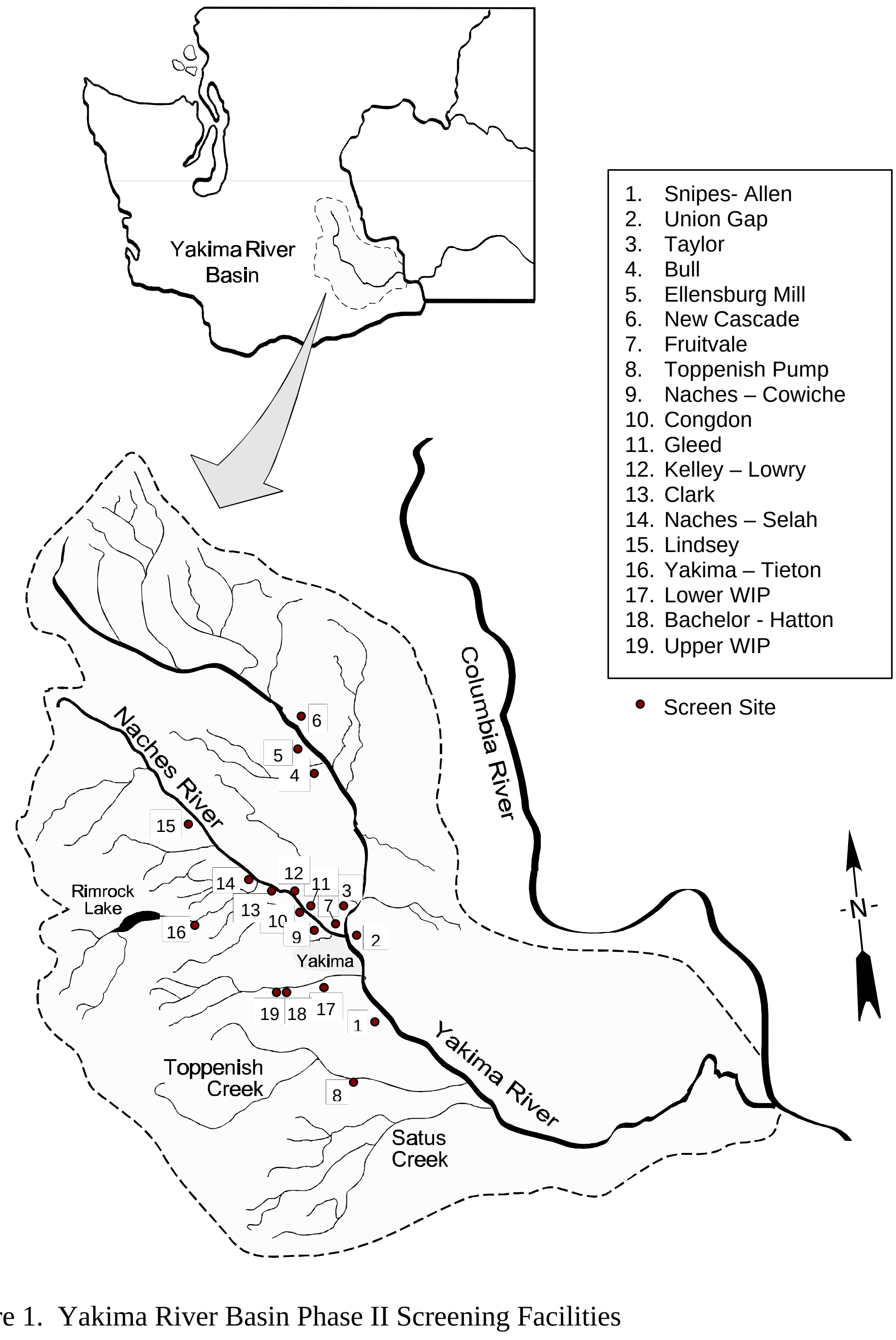


Figure 1. Yakima River Basin Phase II Screening Facilities

Each of the 19 sites was visited three times. The three rounds of evaluations were conducted during early May, late June/early July, and mid August. Three types of data were collected. These included water velocity measurements (Figure 2), underwater video footage, and general data (i.e., screen submergence, bypass conditions, fish presence, operator aids). During the first evaluation, video footage was not acquired due to high water turbidity. The third evaluation was the only round during which nets were placed immediately downstream of the screens to capture and identify fish found in irrigation canals.

Eleven screen sites were visited on November 20, 1997. The purpose was to examine screen sites while forebays were relatively dry. It was our intention to confirm information from underwater video data collected during previous investigations. Some factors considered were silt and debris accumulation, seal integrity, and screen condition.

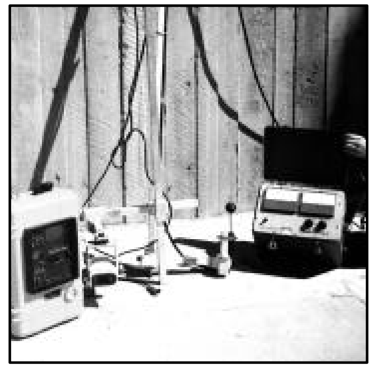


Figure 2. Underwater Video Equipment and Water Velocity Probe.

Velocity Measurements

Equipment

Water velocities in front of the screens and in the bypass were measured with a Marsh McBirney Model 511® electromagnetic water current meter. The meter used a bi-directional probe (Figure 3) that allowed measurement of flows in two directions (approach and sweep) simultaneously. Output was read visually from a panel gage. The probe was securely mounted to a horizontal arm that extended approximately 12 inches from a vertical pole. The length of the horizontal arm and its position on the vertical pole were adjustable. The probe support assembly was positioned at least 12 inches downstream or outside the probe’s sensors to minimize interference from the vertical pole when taking velocity readings.

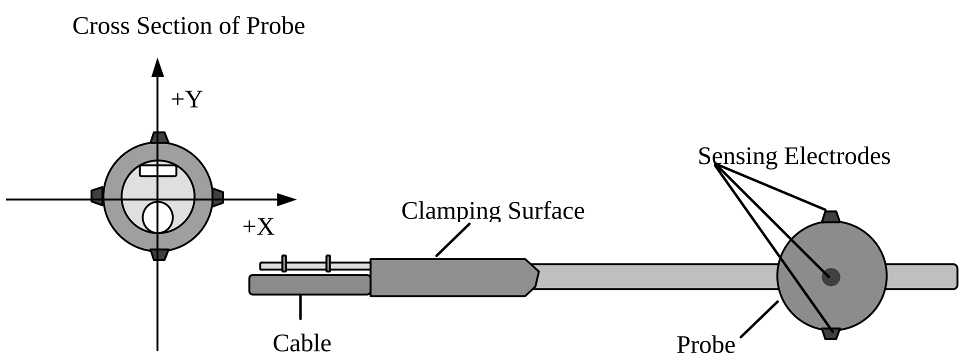


Figure 3. Bi-directional Electromagnetic Probe Used for Measuring Water Velocity

At several sites with very small drum screens, a smaller, unidirectional electromagnetic water current meter probe (Marsh McBirney Model 2000®) was used to measure velocity because it could be placed closer to the bottom of the screen than the bi-directional probe.

Probe Positioning

Velocity measurements were taken in front of all screens. The vertical pole was placed close to the front of the screen, but was never in contact with the screen face. The bottom of the pole rested on the concrete forebay floor (usually on the raised sill), but the pole was not allowed to come in contact with metal (e.g., walking platform, gantry, or girder), to reduce the likelihood of electrical interference. The probe was mounted on the horizontal arm so that it pointed upstream and was positioned within 3 inches of the screen face. Because the screens are constructed at an angle to the canal flow, all measurements were taken with the probe orientation parallel (sweep) and perpendicular (approach) to the screen face, not to canal flow. Measurements were taken across the screen face at 0.2 and 0.8 of the water depth. Velocity measurements were taken at either three or five evenly spaced positions across each screen or panel.

Velocities were also measured in the bypass. Two measurements were recorded. The first was taken immediately inside the vertical slot bypass entrance at mid water depth. The second was recorded halfway between the bypass entrance and the overflow weir, again at mid water depth.

Data Collection and Analysis

Flow measurements were taken in front of every screen during all three site visits. Power to drum screens and cleaning brushes was disconnected to decrease the likelihood of electrical interference. An average ± standard deviation of the sweep and approach velocities at each site was calculated for each visit.

Underwater Video Surveillance

Equipment

An underwater video system was used to investigate screen seal condition, and to monitor debris build-up and fish presence. The system consisted of a high-sensitivity remote camera (Sony, model HVM-352®) with a wide-angle lens (70° Sony, model VCL-06HS®). The camera was housed in a water-resistant case (Sony, model WPC-140®) and connected by 66 feet of quadraxial cable to an 8-mm camcorder (Sony, model CCD-FX710 Handycam Hi-8®) in a weatherproof housing. The case was fitted with external weatherproof controls, a 4-in black and white monitor, and internal battery power supply for the system. The underwater camera operates at extremely low light levels (< 1 lux), so that artificial light sources were not necessary to obtain video images during daylight hours.

Camera Positioning

The camera was securely mounted under a horizontal arm that extended approximately 15 inches from a vertical pole. The length of the horizontal arm and its position on the vertical pole was adjustable. The camera was usually angled slightly downward to observe the area between the screen and the bottom seal where there was a potential for finding gaps. The camera was moved from upstream to downstream, following the side and bottom seal/screen interfaces. Flatplate screens had vertical seals between panels that were also observed and recorded on videotape. Where there were signs of excessive debris or of fish presence, images were also recorded showing the forebay area and/or bypass.

Data Collection and Analysis

Video footage was recorded only during the second and third site visits because high turbidity (>6 NTU) precluded video analysis during the first round. All screens and seals were videotaped during each of the two evaluations. Written observations were also made when something of interest was seen (i.e. faulty seals, gaps, fish). The videotapes were reviewed in detail using a video cassette recorder (Sony, model EV-C200 Hi-8®) and a 12-in black and white video monitor (Panasonic, model TR-124-MA®). Images of interest were digitized using Snappy Video Snapshot® Version 2.0 software.

General Data Collection

Other data collected included:

- general site descriptions and photographs
- screen and seal conditions
- screen submergence levels
- cleaning system operation and the incidence of headloss across the screen face
- bypass flow conditions
- bypass outfall flow conditions
- fish presence in front of and/or behind screens
- observations of debris in the forebay or bypass
- the presence or absence of operator control aids such as water gages and drum submergence marks on screen frames

These data were recorded during every site visit, with the exception of fish presence behind the screens. In August, fyke nets were placed behind screens at 9 sites including Clark, Congdon, Ellensburg Mill, Kelley Lowry, Lindsey, Naches Cowiche, Snipes Allen, Taylor, and Upper WIP. The nets, made of 1/8 in. knotless netting, were attached to rectangular metal frames that could be adjusted to fit the width of the canal or gate opening. The ends of the net were cinched shut with cable ties. The nets were usually placed immediately behind a gate allowing water into the irrigation canal. By shutting off the flow to all gates but the one where the net was placed, we could direct a strong current into our net and be reasonably certain that any fish entering the canal was captured.

The nets were put in place at mid-afternoon and checked for fish after dusk and then again in the morning, after dawn. Retrieval took less than 10 minutes. The nets were emptied, cleaned, and repositioned if they were to be checked again. Fish found in the nets were identified to species if possible, and measured. Fork lengths were recorded for all fish; head widths were recorded for very small fish. Live fish were returned to the river from which they had come, below the diversion dam.

Results

Phase II screening facilities in the Yakima Basin are protecting fish from injury and entrainment and generally meet NMFS screening criteria. However, our identification of site-specific problems indicates that site evaluations are beneficial and effectively identify problem areas that routine operation and maintenance does not address. The results are described in two sections. Overall results indicate trends related to water velocities, screen integrity, and operations and maintenance practices at all sites. Site-specific results provide more detailed information for individual sites.

Overall

Water velocity measurements, underwater video findings, and general data collection results for all screen sites are described in this section.

Velocity

The National Marine Fisheries Service (NMFS) has defined several conditions concerning velocity that screen operators should try to achieve at all sites (NMFS 1995). These include:

- Maintaining a uniform flow distribution over the screen surface to minimize approach velocity
- Keeping approach velocities less than or equal to 0.4 feet per second (fps)
- Achieving sweep velocities that are greater than approach velocities, and
- Effecting a bypass flow greater than or equal to the maximum flow velocity vector resultant upstream of the screens.

In addition, there should be a gradual and efficient acceleration of flow into the bypass entrance to minimize delay by outmigrants.

Water velocities at the 19 screen sites evaluated were highly variable, both spatially and temporally. Site-specific information is given following these overall results. Flows were not often uniform over screen surfaces. Often, there were distinct differences between top and bottom approach velocity values. Where a pattern could be determined, it often showed that approach velocities were higher at the center of drum screens and lower at the ends of the screens. There were not any obvious patterns to the fluctuations of approach velocity observed at flat plate screens.

Of 18 screen sites evaluated (no velocity data was collected at Gleed), only two sites were always within criteria for approach velocities (Table 1). Areas of screen (i.e., top, bottom, upstream, downstream) that exceeded these criteria were dependent on factors individual to the sites. Overall, 86 percent of all approach velocity measurements met criteria.

Table 1. Percent of Approach Velocity Measurements that Exceeded the NMFS Criteria of 0.4 Feet per Second (fps) by Screen Site.

Screen Site	Percent of Approach Velocity Measurements > 0.4 fps	Sample Size (Number of Measurements)
Clark	0.0	22
Ellensburg Mill	0.0	78
Union Gap	2.3	88
Kelley Lowry	3.3	60
Lindsey	3.3	30
Snipes Allen	3.3	80
New Cascade	4.2	66
Taylor	4.2	48
Naches Selah	5.5	108
Naches Cowiche	6.6	60
Lower WIP	8.3	24
Yakima Tieton	10.5	192
Bachelor Hatton	12.5	120
Fruitvale	12.5	32
Upper WIP	17.5	120
Congdon	31.1	90
Bull	36.1	36
Toppenish Pump	43.0	144

Sites where greater than 10% of the approach velocities measured exceed criteria may indicate potential problems due to flow imbalance, poorly-sized screens, or over-use by the irrigator.

Averaging velocities for each screen site presented a clearer picture of the flows at these sites (Table 2). Considering only averages, sweep velocity is always greater than approach velocity. All ratios were equal to or greater than 1.5, except at Snipes Allen, where the average sweep velocity was only 1.33 times greater than the average approach.

Table 2. Mean Sweep and Approach Velocities ± Standard Deviations at Each Site.

Site	Mean Sweep Velocity ± S.D.	Mean Approach Velocity ± S.D.
Bachelor Hatton	0.81 ± 1.03	0.25 ± 0.25
Bull	0.79 ± 0.29	0.28 ±0.25
Clark	0.20 ± 0.09	0.04 ± 0.06
Congdon	0.62 ± 0.17	0.41 ± 0.10
Ellensburg Mill	0.35 ± 0.09	0.18 ± 0.07
Fruitvale	1.38 ± 0.10	0.10 ± 0.24
Kelley Lowry	0.54 ± 0.08	0.21 ± 0.08
Lindsey	0.45 ± 0.22	0.21 ± 0.14
Lower WIP	0.38 ± 0.43	0.19 ± 0.18
Naches Cowiche	0.64 ± 0.15	0.25 ± 0.11
Naches Selah	1.13 ± 0.21	0.19 ± 0.14
New Cascade	0.66 ± 0.14	0.20 ± 0.20
Snipes Allen	0.28 ± 0.22	0.21 ± 0.09
Taylor	0.30 ± 0.15	0.20 ± 0.11
Toppenish Pump	1.02 ± 0.49	0.46 ± 0.27
Union Gap	1.22 ± 0.25	0.17 ± 0.12
Upper WIP	0.87 ± 0.56	0.30 ± 0.17
Yakima Tieton	1.68 ± 0.44	0.26 ± 0.21

Mean top sweep velocities were greater than mean bottom sweep velocities at all but two sites, Clark and Fruitvale (Figure 4). In fact, top and bottom sweep values were significantly different ($p = 0.004$) when all sites are considered together. Mean top and bottom approach velocities were more evenly mixed. Ten sites had greater top approaches, seven had greater bottom approaches, and one site (Snipes Allen) had identical top and bottom approach velocities.

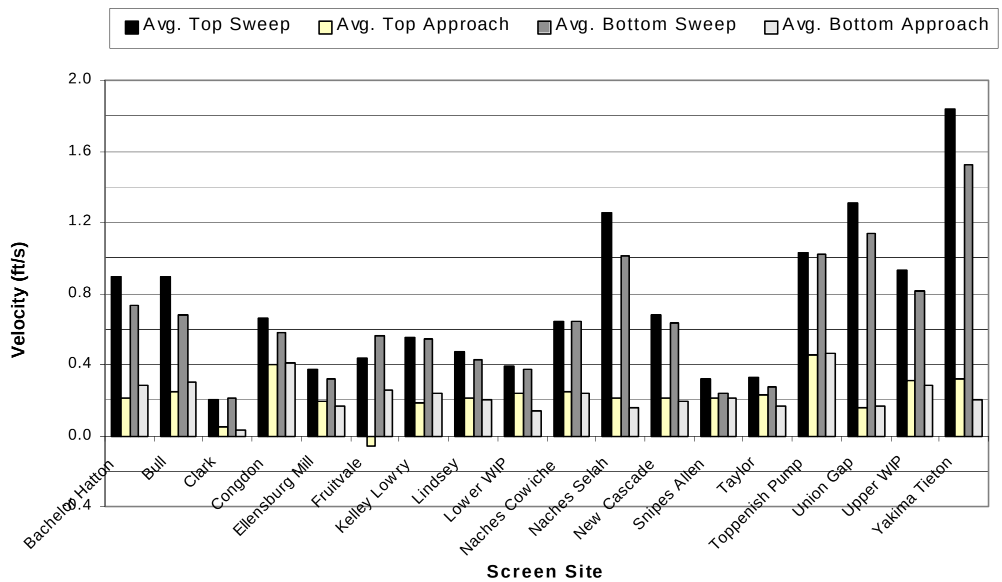


Figure 4. Average Top and Bottom Sweep and Approach Velocities for All Sites Surveyed.

Only two sites, Congdon and Toppenish Pump, had average approach velocities that exceed the NMFS criteria of 0.4 fps.

The four largest approach to sweep ratios occurred at flat plate screen sites. In general, flow patterns in front of flat plate screens were more constant than those in front of drum screens (Figures 5 and 6). In addition, sweep and approach velocities were more distinct at flat plate screens.

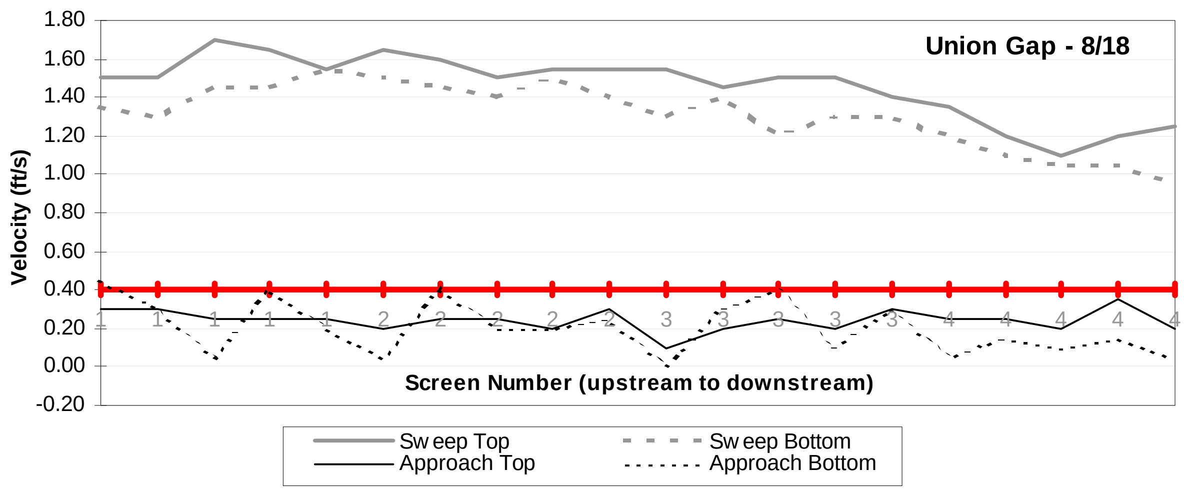


Figure 5. Typical Water Velocity Patterns in Front of a Flat Plate Screen

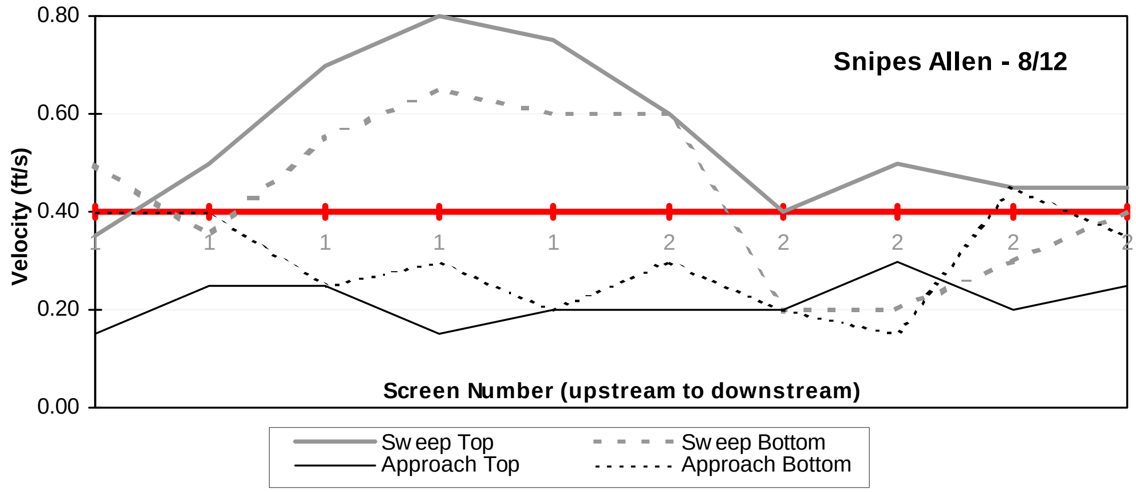


Figure 6. Typical Water Velocity Patterns in Front of a Drum Screen

Sweep velocities at the flat plate screens were generally greater than at drum screens while retaining approach velocities under 0.4 fps. This condition is likely to minimize the time it takes for fish to reach the bypass.

Bypass flows were usually faster than the average flow past the screens (Figure 7). Only three of nineteen sites had average bypass velocities less than their average sweep velocities, i.e., Bachelor Hatton, Union Gap, and Upper WIP. One explanation was that at Bachelor Hatton, large accumulations of sediments (up to 11 inches in depth) were observed in the bypass during all three evaluations. At Union Gap, the weir gate was never observed in the full open position. However, it was being operated according to the operating criteria that recommend that 1 foot of water flow over the weir. At Upper WIP, while the weir gate was always in full open position, sedimentation was present and rocks blocked flows from the outfall pipe.

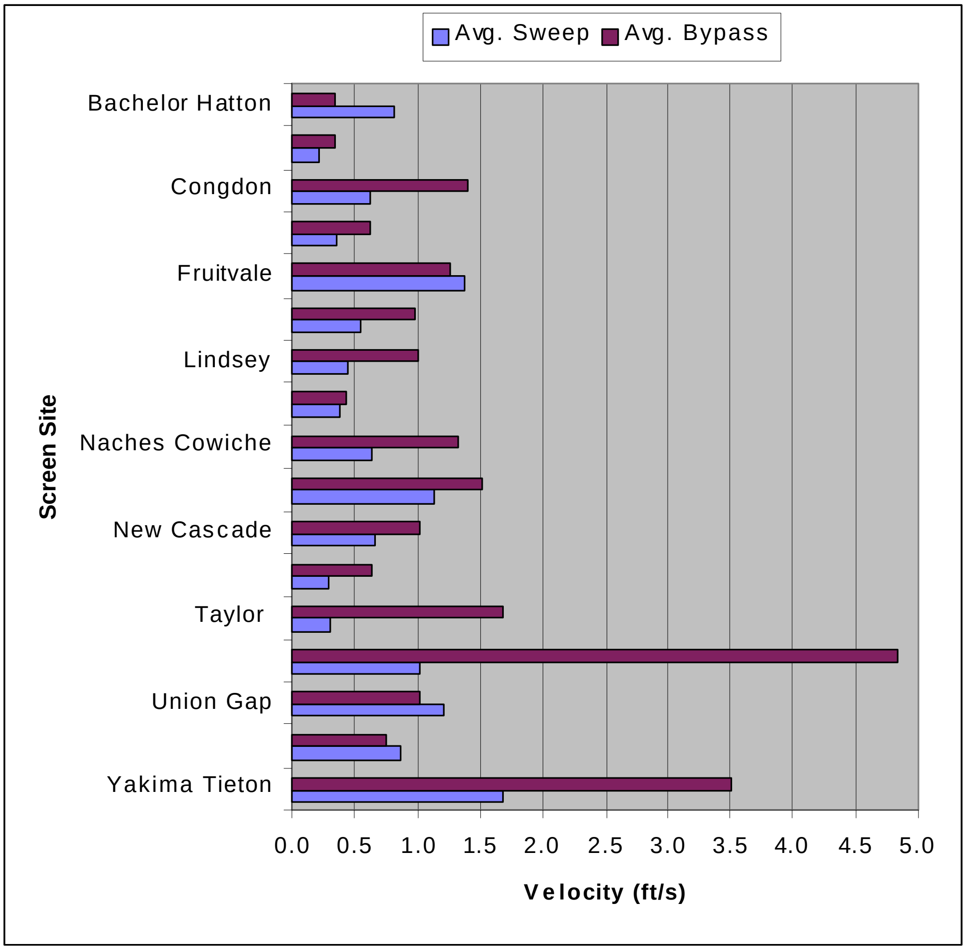


Figure 7. Average Sweep and Bypass Velocities by Site.

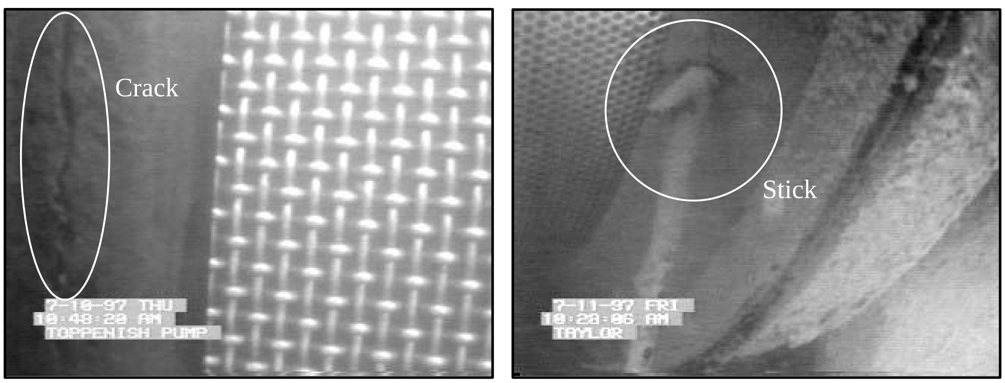
Underwater Video

Underwater video proved most useful in evaluating the condition of the screen seals and the amount and types of debris that accumulated at a site.

Most of the visible screen seals were in good condition (approximately 83%). Bottom frame seals were sometimes buried in sediment and could not be evaluated. Drum screen seals classified in "good condition" were tight against the screen and not cracked or punctured in any way. Many rubber seals were covered in algae, but this was not considered a defect. Flat plate screen sealant was generally in good condition. Using underwater video, we were able to identify screens with bad seals and bowed drums because gaps appeared as that part of the screen rotated past the bottom seal (Figure 8).

Figure 8. Gap at the Bottom of Screen 4, Bachelor Hatton

Other seal problems such as potential punctures and cracks were also observed using underwater video (Figure 9).



(a) (b)

Figure 9. (a) Stick Possibly Puncturing a Screen Seal at Taylor and (b) What May be a Cracked Seal at Toppenish Pump.

One seal was tucked under the frame (Figure 10), creating a possible pinch point for small fish seeking to get around the drum screen. In this position the seal is relatively loose and it is easy to pass debris or perhaps even a fish between the screen and the seal.

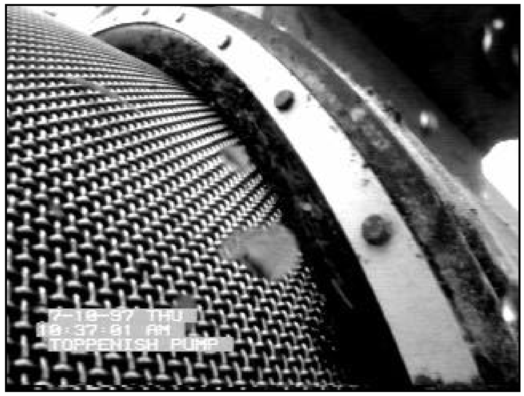
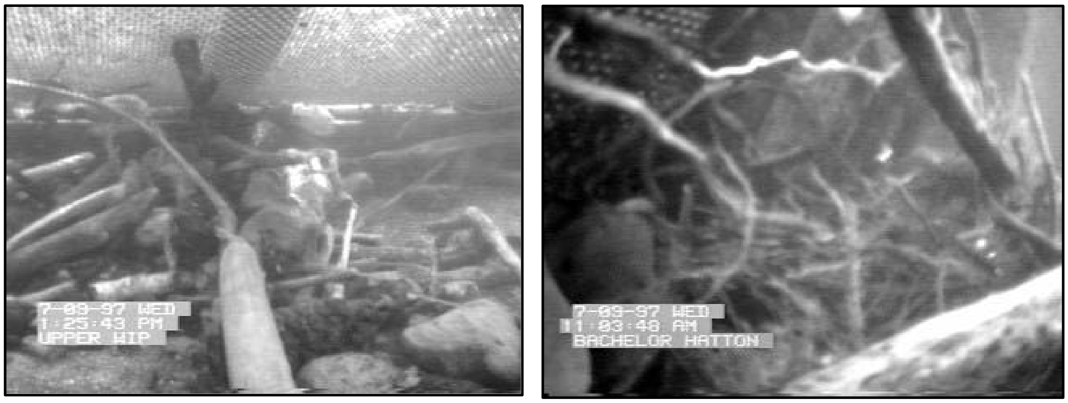


Figure 10. Drum Screen Seal Tucked underneath the Metal Frame at Toppenish Pump

Finally, observations made with underwater video indicated that additional seals might be needed to keep juvenile fish from injuring themselves as they navigate past the screens. Young fish can (and do) squeeze into very small places. The fish shown in Figure 11 was observed wriggling to escape the crack between the drum screen and the concrete wall between screens. However, it was not able to free itself during our observation. The fish was approximately 45 mm fork length.

Figure 11. Fish Wedged between a Drum Screen and Concrete Divider at Upper WIP

Underwater video allows researchers to monitor and document sediment and debris accumulation in front of a screen. This is important because debris can severely decrease seal life, cause drag on screen motors, and provide cover for predator fish species. Most often, it is impossible to see this debris from above the water’s surface. While a pole can be placed in the water to gage the depth of accumulated sediments, one can not determine exactly the kind of debris present and how it is affecting water flow through or past the screen. Figures 12 through 14 depict some of the debris that had accumulated in front of the screen sites evaluated in this study.



(a) (b)

Figure 12. Woody Debris at (a) Bachelor Hatton and at (b) Upper WIP

Figure 13. Cobble Accumulated in Front of Screens at Bachelor Hatton

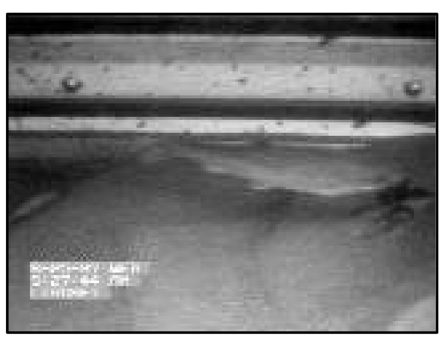
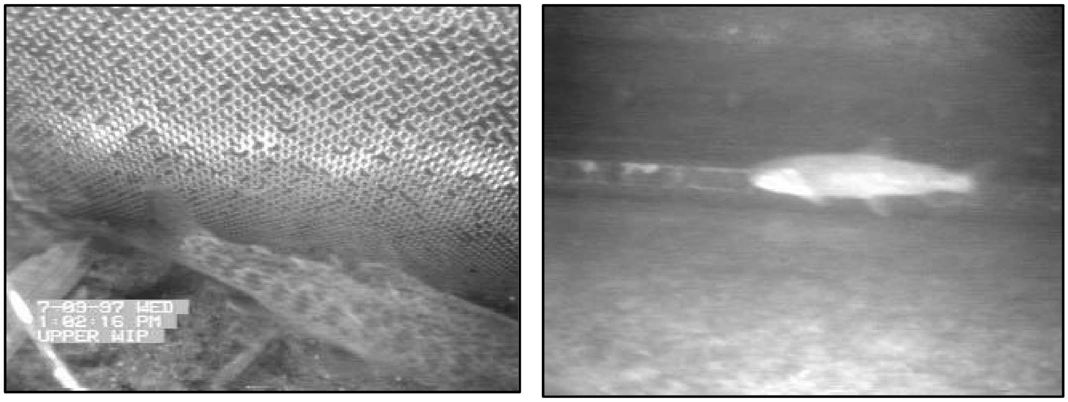


Figure 14. Sand and a Fish in Front of Screens at Lindsey

As indicated in the previous figure and in the one below (Figure 15), fish images can also be captured with the underwater video system, although it is not currently the best means to identify fish species present at a site. However, other observations such as fish size, behavior, and orientation to current can be made.



(a) (b)

Figure 15. Fish Captured on Videotape in Front of Drum Screens at (a) Upper WIP and at (b) Bachelor Hatton

General Data

Screen Submergence Levels

Water levels are generally expected to cover between 65% and 85% of a drum screen's diameter. At higher water levels fish may roll over the top of the screen and enter the canal. Lower water levels can prevent the screen from efficiently removing debris from the forebay area.

Percent screen submergence was calculated at every drum screen site for each evaluation. The percent of time that screens met these guidelines was 67.5%. Levels exceeded 85% submergence for 30% of our evaluations. Parts of the exceedences were due to high water levels (flooding), but parts were also due to poor operation. High water levels occurred at eight of twelve drum screen sites (Clark, Congdon, Kelley Lowry, Lindsey, Lower WIP, Naches Cowiche, Snipes Allen, and Taylor). Most of these sites experienced high levels for only one evaluation period; however the Lindsey site exceeded the criteria all three times and the Congdon site two times. Only one screen site was measured below 65% submergence. This was the Lower WIP site, which was 62.5% submerged on 4/30/97.

Flat plate screen sites do not have the same roll over and debris removal issues to contend with as rotary drum screens. However, should a screen become completely submerged, fish can freely enter the irrigation canals by swimming over top of the screen. Total screen submergence was observed at two of six flat plate screen sites, Bull and Fruitvale. The side channel of the Yakima River that flows past the Bull site has no headgate control. During the spring flooding there was too much water and the screen was overtopped. Subsequent sandbagging and strategic placement of cement “ecology” blocks around the screen structure prevented a recurrence. Fruitvale’s screen was also overtopped by several inches on 8/18/97. This appeared to be an isolated incident, as there were no records of overtopping in the site logbook. Water at the site was too turbid for good underwater video images. Operations and maintenance personnel at the site remarked that the water had been clear earlier in the day and that water levels had been normal. Adjustments were made before we left the site to decrease the water level in the forebay.

Bypass Outfall Conditions

The NMFS established a number of guidelines and criteria concerning bypass conduit design and outfall conditions (NMFS 1995). These criteria state that, “for diversions 25 cfs and greater, the required pipe diameter shall be greater than or equal to 24 inches (61 cm) and that the minimum depth of open-channel flow in the bypass conduit shall be greater than or equal to 9 inches (23 cm), unless otherwise approved by the NMFS”. Pipe diameter criteria exist primarily to minimize debris clogging and sediment deposition, and to facilitate cleaning. For screens with a diversion flow less than 25 cubic feet per second (cfs), the requirements are a 10-inch diameter pipe and a minimum allowable water depth in the pipe of 1.8 inches (4.6 cm).

All the screens with bypasses that were evaluated, with the exception of Clark, Lindsey, and Lower WIP, are designed and built for diversion flows that can be greater than or equal to 25 cfs. Many of the sites had bypass pipes with diameters much smaller than the NMFS criteria (Table 3). Most of the sites appeared to meet the minimum requirements for in-pipe water depth, although it was impossible to be certain when the outfall was submerged.

Table 3. Bypass Pipe Diameter and Water Depth Criteria, where YES=Yes, NO=No, SUB=Submerged, and N/A = Not Applicable (bypass outfall not evaluated). Water depth criteria are presented for each of the sites' three evaluations, in chronological order.

Screen Site	Meets Minimum Pipe Diameter Criteria	Meets Minimum Water Depth Criteria
Diversion ≥ 25 cfs		
Bachelor Hatton	NO	SUB / SUB / SUB
Congdon	NO	SUB / SUB / SUB
Ellensburg Mill	NO	SUB / SUB / SUB
Fruitvale	NO	YES / YES / YES
Kelley Lowry	NO	SUB / SUB / SUB
Naches Cowiche	NO	YES / SUB / SUB
Naches Selah	YES	NO/ YES / YES
New Cascade	NO	YES / YES / YES
Snipes Allen	N/A	N/A
Taylor	YES	SUB / YES / SUB
Toppenish Pump	YES	SUB / SUB / SUB
Union Gap	NO	NO / NO / NO
Upper WIP	NO	SUB / SUB / SUB
Yakima Tieton	YES	YES / SUB / YES
Diversion < 25 cfs		
Clark	YES	SUB / SUB / SUB
Lindsey	YES	YES / YES / YES
Lower WIP	NO	SUB / SUB / SUB

Operator Control Aids

Although not required, visual operator control aids are extremely useful for maintenance and operations personnel periodically inspecting sites. They compliment the operating criteria and help to "flag" operational or procedural problems. Operator aids include marks indicating submergence level on drum screen frames, water depth or elevation gages in the forebay, aftbay, and irrigation canal, and marks indicating how far headgate, bypass weir, or canal intakes are open. Providing highly visible indicators of screen system operation as it relates to NMFS criteria or of proper water diversion to the canal can save time and reduce incidences of operator error that may result in fish impingement, entrainment, or stranding at a site.

Most sites were equipped with gages measuring elevation or water depth, although gages were not always present in front of and behind the screens. Drum screen submergence marks existed at only two sites, Lindsey and Taylor. No sites had any means to easily gage how far open weir gates or other headgates were open.

Fish Capture

Nets were placed behind screens at the nine sites listed under Methods. Fish were captured at six of these sites (Congdon=13, Ellensburg Mill=1, Lindsey=2, Naches Cowiche=1, Taylor=33, Upper WIP=1). No salmonids were captured. Fish sizes ranged from a 16-mm forklength (FL) cyprinid with a 1.5-mm head width to a 124 mm FL chiselmouth *(Acrocheilus alutacers)* and a 129 mm FL squawfish *(Ptychocheilus oregonensis)*. Fish species captured and their average sizes are shown in Table 4. Species captured or otherwise observed at individual sites are detailed in the site-specific results.

Some of the smallest fish captured could pass through screen openings and become entrained. Others obviously entered the canal by different means. They could have been entrained as juveniles, rolled over a screen if submergence levels were high, swum up the outfall, or passed the creek outlet to use the canal and aftbay as rearing habitat.

Table 4. Fish Species Captured at Nine Phase II Screen Sites and Their Mean Fork Lengths, August 1997. Nets were placed downstream of the fish screens.

Species (Number Captured)	**Mean Fork Length (mm)**
Chiselmouth, *Acrocheilus alutaceus* (10)	105
Unidentified cyprinids spp. (3)	18
Mountain whitefish, *Prosopium williamsoni* (5)	76
Pumpkinseed, *Lepomis gibbosus* (4)	85
Redside shiner, *Richardsonius balteatus* (13)	80
Sculpin, *Cottus* sp. (2)	23
Speckled dace, *Rhinichthys osculus* (1)	77
Squawfish, *Ptychocheilus oregonensis* (2)	117
Sucker, *Catostomus* sp. (4,7)	102, 22

Post-Season Inspections

The eleven sites visited on 11/20/97 included two flat plate screen sites and nine drum screen sites. They included Fruitvale and Naches Selah, Bachelor Hatton, Upper WIP, Lower WIP, Toppenish Pump, Naches Cowiche, Snipes Allen, Kelley Lowry, Congdon, and Clark. Six of the nine drum screen sites were still wet, although in most cases, the sites had been winterized (drum screens had been raised). Upper WIP and Bachelor Hatton were still in operation and were going to operate through the winter. Aerators were either in place or planned for deployment in the forebays to keep ice from forming on the screens. Both flat plate screen sites were dry.

Particular problem areas are highlighted in the site-specific section of this report. The most common issue was sedimentation in front of and behind the screens.

Site Specific

More detailed information about each screen site is presented below. Sites are categorized by screen type, i.e., rotary drum, fixed plate, or vertical traveling screen. Where screens or panels are referred to as numbers (i.e., Screen 1, Panel 3), number one is always the screen or panel furthest upstream and closest to the diversion.

<u>Rotary Drum Screens</u>

Bachelor Hatton

The Bachelor Hatton site was evaluated 4/30/97, 6/24/97, and 7/9/97. The site was also visited 8/12/97, but water was being fully diverted to the upstream diversion at the Upper WIP site. Therefore, the screens were practically dry and there was nothing to measure at that site in August.

Bachelor Hatton flows showed a general trend during the entire evaluation period, as sweep velocities were quite distinct from approach velocities in front of Screens 1 through 3, but merged together in front of Screen 4 (Figures 16-18). During the June evaluation, an eddy in front of Screens 1 and 2 produced negative sweep velocity values. Approach velocities during the three evaluation periods were relatively consistent. Average approach values were less than 0.4 fps except for the June top approach, which averaged 0.41 fps. Maximum approach flows at this site were 0.8 fps, in front of Screen 4 on 4/30 and 7/9/97. Of all approach velocity measurements taken at Bachelor Hatton, 12.5% exceeded criteria.

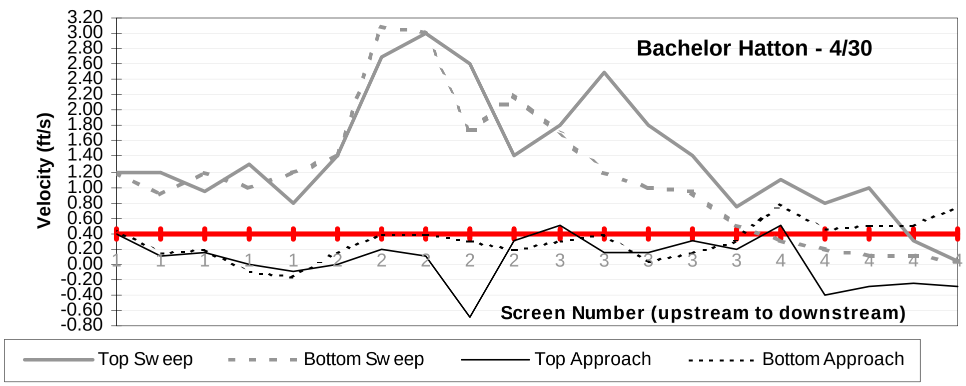


Figure 16. Water Velocities at Bachelor Hatton, 4/30/97

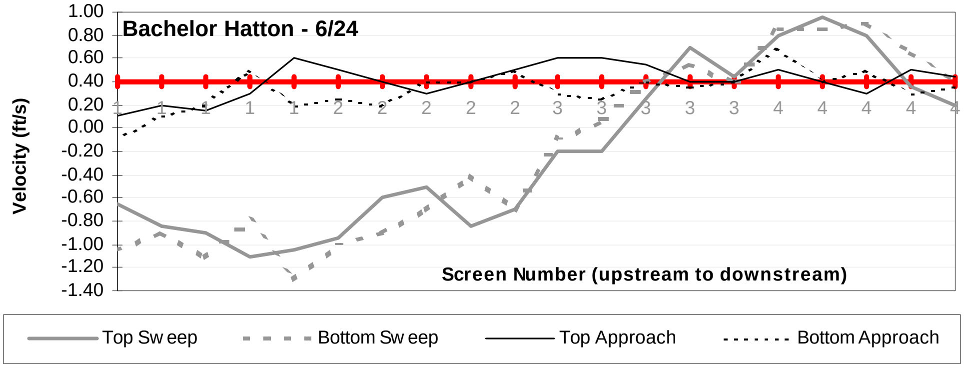


Figure 17. Water Velocities at Bachelor Hatton, 6/24/97

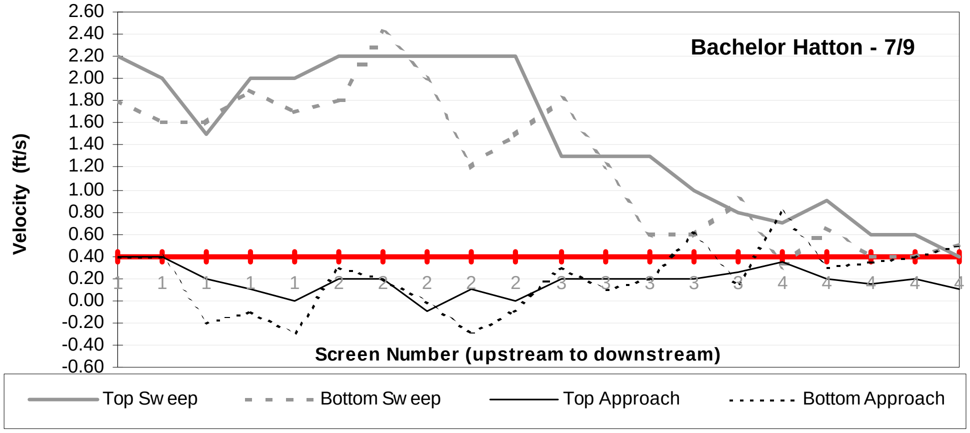


Figure 18. Water Velocities at Bachelor Hatton, 7/9/97

Underwater video revealed gaps at Screens 2 and 4 between the bottom seal and screen interface. Sediment usually did not cover bottom seals or appear to interfere with water velocity at this site. However, some sticks and twigs were present in front of Screen 4 and in the bypass. Silt measured 5 inches on top of the sill in front of Screen 4 and up to 10 inches deep in the bypass. Rocks were present at the downstream ends of Screens 1 and 2.

Water was moving very slowly behind the bypass weir during the July evaluation. Bypass flow was only 0.3 fps, much slower than the 0.8 fps average sweep velocity in front of the screens.

Screens were always observed to be turning freely. Water depths measured at the bypass outfall were never < 1 ft. Submergence at Bachelor Hatton always met criteria standards. Drum submergence at this site averaged 75.4%.

Although a net was not placed behind the screens, fish were observed in both the forebay and aftbay. Fish species observed in the forebay include dace *(Rhinicthys* spp.*)*, suckers *(Catostomus* spp.*)*, and minnows *(Cyprinidae)*. Fish in the aftbay also included salmonids *(Oncorhynchus* spp.*)*; several trout appeared to be 150 to 200 mm in length.

A post-season inspection was made on 11/20/97. The site was back in operation and ready to operate through the winter. Two aerators were running in the forebay to keep water from freezing on the screens. By standing behind the screens and observing the flow patterns, it was obvious that more water was passing through Screens 1 and 2 than through Screens 3 and 4, as the measurements recorded on 7/9/97 indicated.

It was also noted that the creek channel near the bypass outfall had shifted. In the future it may be necessary to dredge a new route to allow for fish to pass back to the main creek channel.

Clark

The Clark site was evaluated 5/6/97, 6/25/97, and 8/7/97. Water velocities at the Clark site were extremely low (sweep velocities ranged from 0.05 to 0.35 fps). Approach velocities never exceeded the criteria. Sweep velocities always equaled or exceeded approach velocities (Figures 19-21).

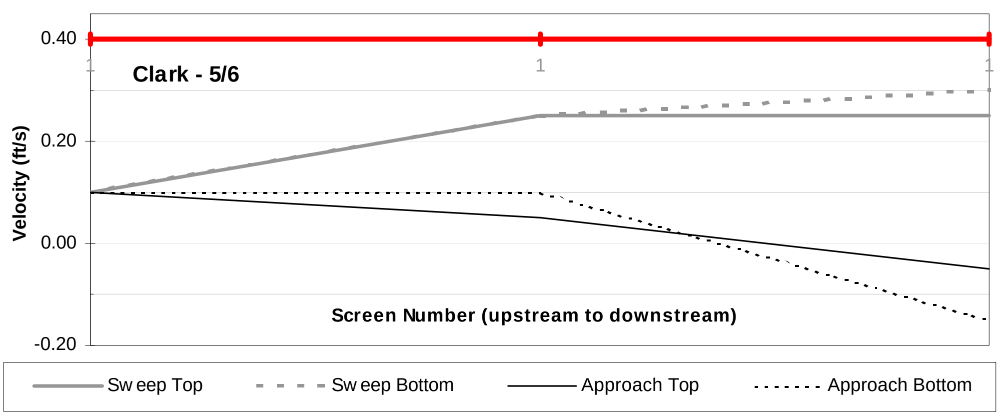


Figure 19. Water Velocities at Clark, 5/6/97

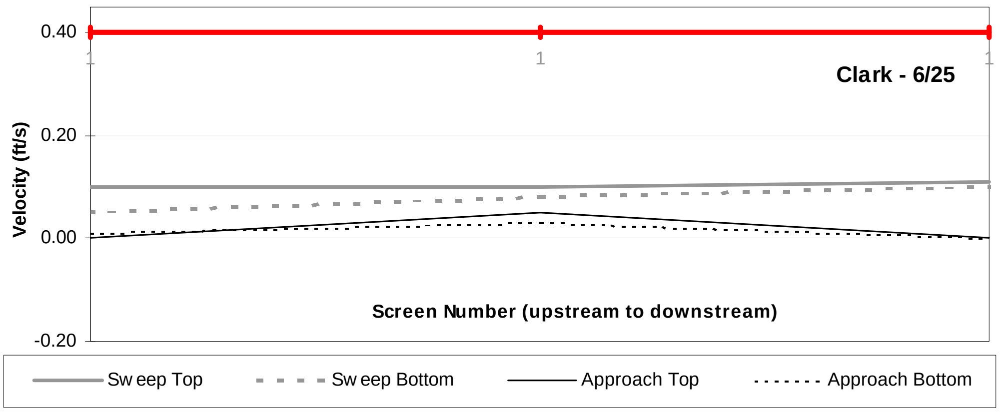


Figure 20. Water Velocities at Clark, 6/25/97

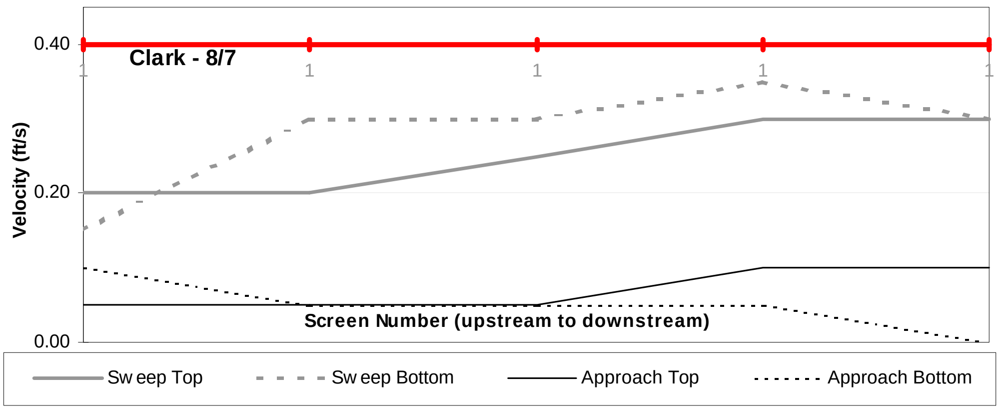


Figure 21. Water Velocities at Clark, 8/7/97

Side and bottom seals at Clark appeared to be in good condition. Between the first and second evaluations, a large amount of algae had attached to the screen surface. This occurred because the screen was not rotating. Crews had manually removed this growth when the screen was evaluated the third time and the screen was again rotating, though very slowly (one full rotation in 20 minutes). Some algae and sand were present on the bottom, but the screen was not blocked.

Water depth at the bypass outfall was 14 inches near the end of the season, but the water depth decreased to 9 inches before a fish could reach the creek.

Screen submergence criteria were narrowly exceeded during the third site evaluation (86.1%).

A net was set in the canal at this site on 8/7/97, but no fish were captured or observed.

A post-season evaluation was conducted on 11/20/97. The paddlewheel was not turning and while the water was low, it appeared this site will always be under water. The best way to inspect the side and bottom seals would be with an underwater video camera.

Congdon

The Congdon site was evaluated 5/2/97, 6/25/97, and 8/6/97.

Some trends in approach velocities were evident at this site. For example, top sweep velocities were usually greater at the middle of each screen than at the ends (Figures 22-24). Bottom sweep velocities showed a similar pattern, but were not as pronounced. Approach velocities were much more constant. Sweep velocities were generally greater than approach velocities, but there were exceptions, mainly in front of Screens 1 and 2. High approach velocities were common at this site as 31.1% of all approach velocities measured exceeded the 0.4 fps criteria. High approaches were measured during all three evaluations and occurred in front of all three screens.

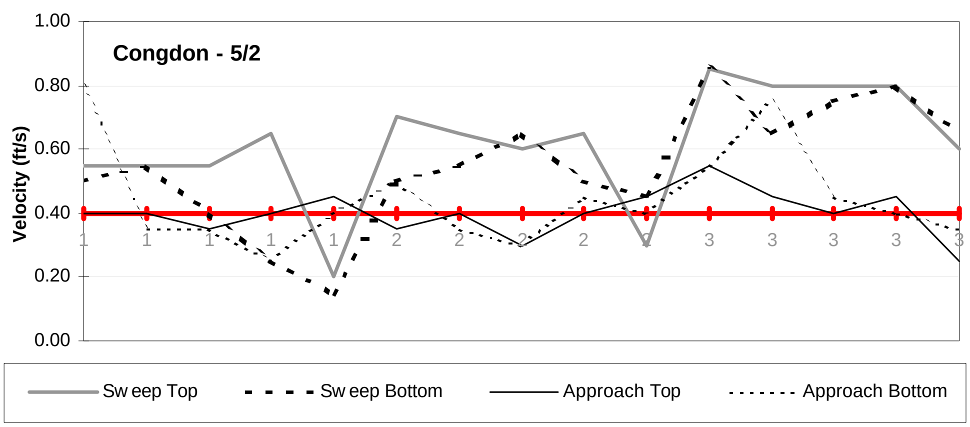


Figure 22. Water Velocities at Congdon, 5/2/97

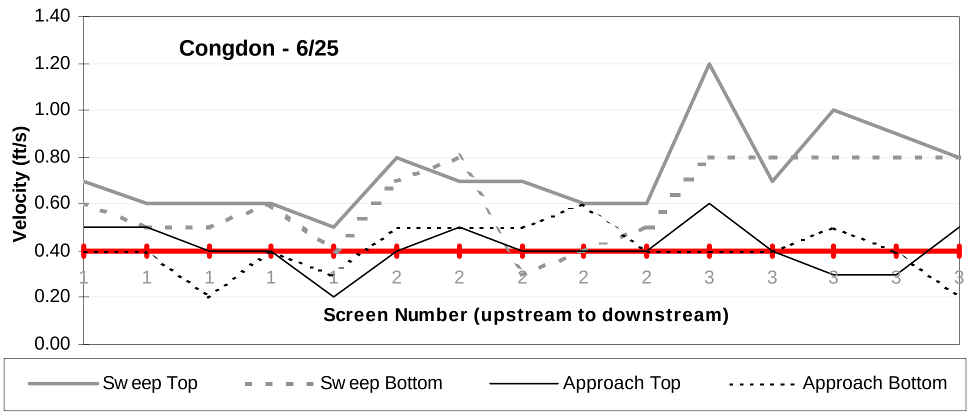


Figure 23. Water Velocities at Congdon, 6/25/97

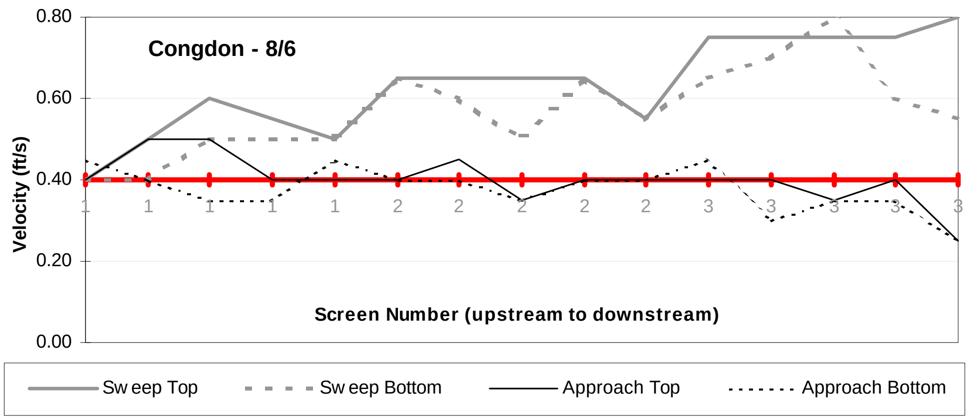


Figure 24. Water Velocities at Congdon, 8/6/97

Underwater video observations at Congdon revealed a small gap (approximately 0.5 in) where Screen 3 and its bottom seal contacted. Above-water evaluations indicated that all three screens had potential gaps along the bottom seal. Screen 2 had two of the largest flat spots. The depressions occurred between the internal metal bands that gave the screen its shape (Figure 25).

Figure 25. Flat Spot in Screen 2 at Congdon

Sediments accumulated at the Congdon site over the course of the summer. During the first evaluation, silt did not reach the top of the 6-in. sill. However, by the third evaluation, silt had buried the sill and was covering some bottom seals and parts of the screens. The most affected area was in front of Screen 2 where the screen was buried in 6 inches of silt, sand, and sticks. Because this site is located in a public park, garbage such as pop cans made up a higher percentage of debris submerged in front of the screens than at other sites. Large sticks were also lodged near the screens at the bottom of the water column.

Screen submergence levels slightly exceeded criteria during two of three evaluations (87.5% on 6/25/97; 87.5% on 8/6/97). Screens always rotated smoothly. Water always flowed freely within the bypass and there were no problems were associated with the bypass outfall.

A net was placed behind the screens at the Congdon site on 8/6/97. Fourteen fish were captured (Table 5). Because most of the fish were very small, head widths were recorded along with forklengths. Screen mesh openings are approximately 0.1 inches (2.5 mm) at Congdon, which would allow entrainment of these fish (with the exception of the speckled dace). No salmonids were captured or observed at this site.

Table 5. Fish Species Captured at Congdon, 8/6/97

Species	**Number of Fish**	**Forklength (mm)**	**Head Width (mm)**
Speckled dace, *Rhinichthys osculus*	1	77	---
Redside shiner, *Richarsonius balteatus*	3	15 to 23	0.9 to 2.0
Sucker, *Catostomus* sp.	7	18 to 26	1.8 to 2.5
Minnow	3	16 to 20	1.5 to 2.0

A post-season evaluation was performed on 11/20/97. The screens were raised and the site was dry. Silt and debris had been cleared from the forebay. Flat spots in the screens up to ¼-inch deep were confirmed. However, the bottom seals appeared able to compensate for the indentations and no gaps were observed with the screens in a stationary position. We were unable to rotate screen 3 to confirm the gap observed earlier with underwater video.

Kelley Lowry

The Kelley Lowry site was evaluated 5/6/97, 6/30/97, and 8/18/97. Water was turbid during the June and August evaluations so bottom seals were not clearly visible with the underwater video camera.

Water velocities were quite consistent from one evaluation to the next at this site (Figures 26-28). Sweep velocities were fairly constant, and fast enough to encourage fish to move toward the bypass. Velocities noticeably increased at the bypass entrance and continued to increase toward the weir. Sweep velocities were always greater than their corresponding approach velocities. Most approach velocities met criteria. Only 3.3% of all measurements exceeded 0.4 fps. These instances both involved a bottom approach value at the upstream end of Screen 1.

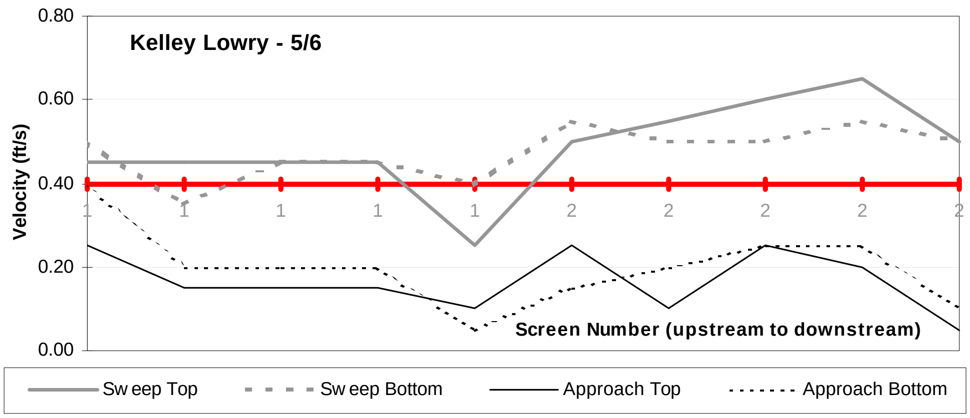


Figure 26. Water Velocities at Kelley Lowry, 5/6/97

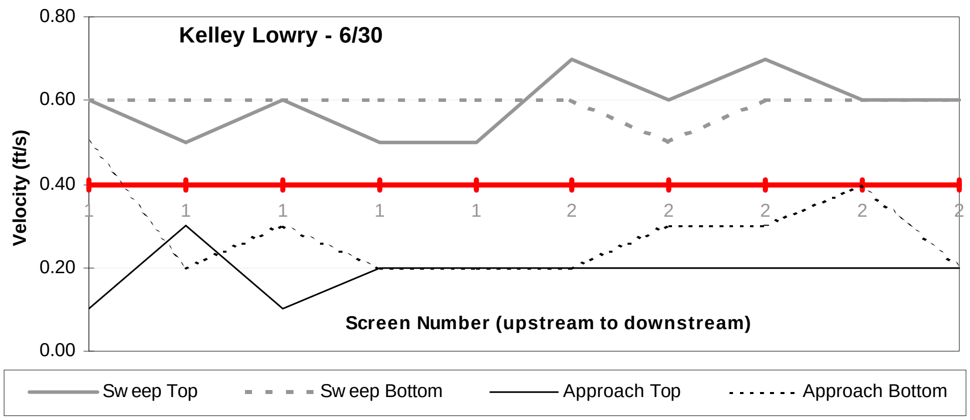


Figure 27. Water Velocities at Kelley Lowry, 6/30/97

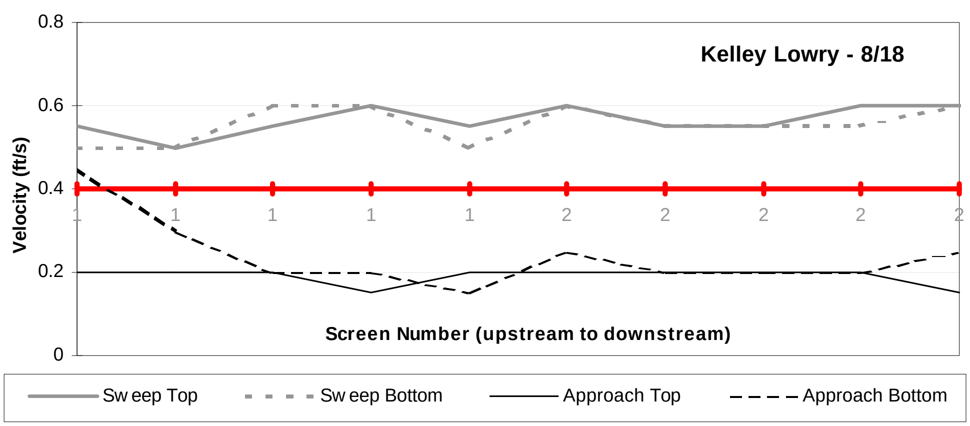


Figure 28. Water Velocities at Kelley Lowry, 8/18/97

Underwater video did not show any seal defects or gaps between screens and seals. Sediment levels did increase from the first to the third evaluation. Maximum sediment depth on top of the sill was 5 inches, which was enough to cover the bottom seal. More sediment was found downstream than upstream. Silt and algae-covered sticks were piled in the downstream corners of both screens. Although the screens were always turning freely, there appeared to be excessive build-up of algae and diatoms on the screen surface.

Water was always flowing freely in the bypass and bypass outfall conditions always met criteria. The screen submergence level was 85.4% on 8/18/97, higher than the 79% and 77% submergence levels of the first two evaluations, but not high enough to be of concern.

No nets were set at the Kelley Lowry site and no fish were observed in the forebay or aftbay.

A post-season evaluation was performed on 11/20/97. The site was dry and the screens were raised. Large amounts of silt were present in the forebay and behind both screens in the aftbay. Screen 2 had several flat spots ¼-inch deep.

Lindsey

The Lindsey site was evaluated 5/5/97, 6/25/97, and 8/7/97.

Sweep velocities at Lindsey always increased toward the bypass (Figures 29-31). Approach velocities exceeded 0.4 fps only once, at the top, upstream end of the screen. Sweep velocities equaled or exceeded approach velocities.

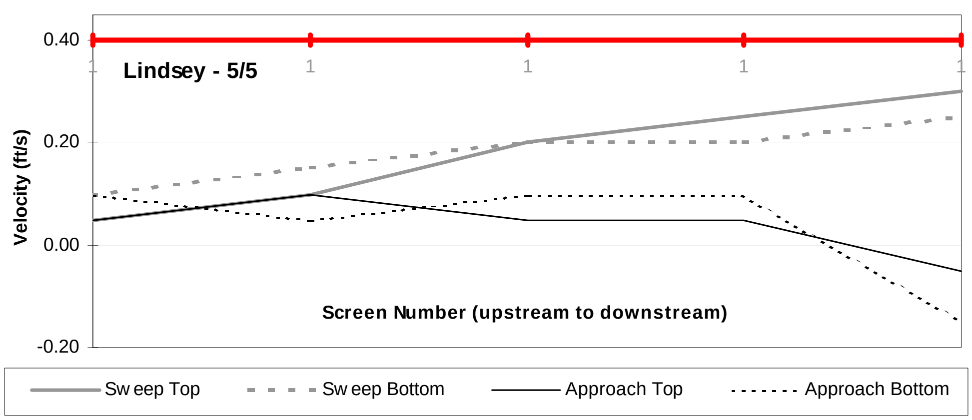


Figure 29. Water Velocities at Lindsey, 5/5/97

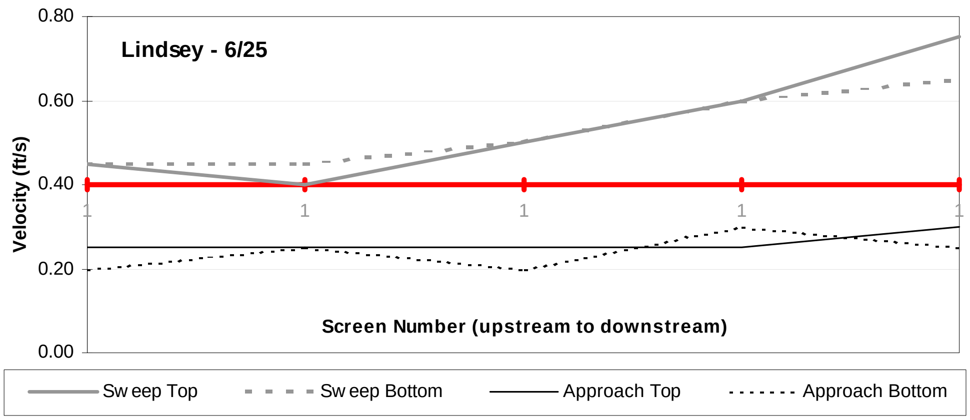


Figure 30. Water Velocities at Lindsey, 6/25/97

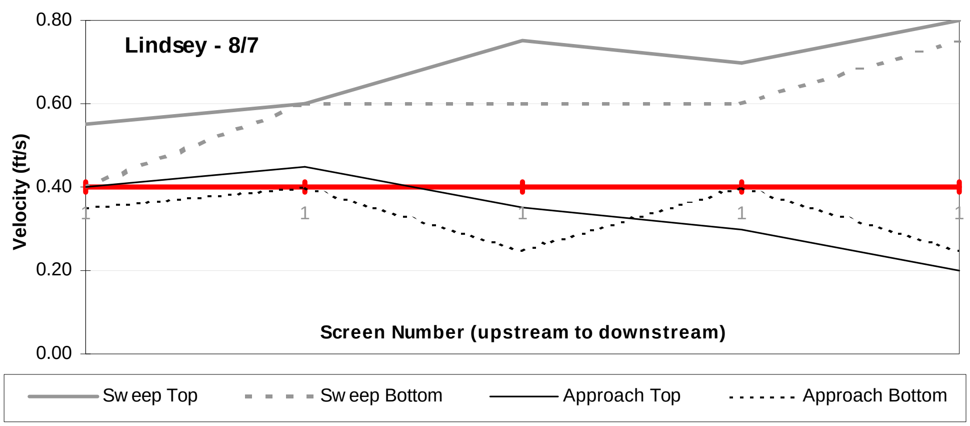


Figure 31. Water Velocities at Lindsey, 8/7/97

Underwater video footage indicated that seals at this site were in good condition. However, silt and sand were very deep in front of the screen during the second and third evaluations. The screen was partially buried so that bottom seals were no longer visible. Sand depth in front of the screen was as great as 13 inches near the upstream end. The amount of sand decreased next to the bypass, but was still at least 6 inches above the sill. Sand was also piled deep in the aftbay.

The screen was always turning freely despite the great amounts of sediment. Screen submergence values were high during all three site visits (88.9% on 5/5, 86.1% on 6/25, 87.5% on 8/7). Water flowed freely through the bypass at all times, but water depth at the bypass outfall was only 8 inches during the last evaluation. Removal of some large cobble from the outfall area would resolve the problem.

A net was set at Lindsey on 8/7/97. Two juvenile whitefish *(Prosopium* sp.*)* were captured behind the screen (59 mm and 65 mm FL). Several salmonids were observed in the forebay (~50 mm FL). A dead rainbow trout (180 mm) was found lying on the ground near the bypass entrance on 8/7/97.

This site was not evaluated in November.

Lower WIP

The Lower WIP site was evaluated 4/30/97, 6/24/97, and 8/12/97. The screens had been raised on 8/4/97 so there was no need take measurements during the third site visit. At that time Ahtanum Creek was practically dry because all water was being diverted at the Upper WIP screen site. Thus, velocity measurements were taken only during the first two evaluations, and underwater video was recorded only during the second evaluation.

There were no obvious patterns for sweep or approach velocities except that velocities were generally greater in June than in April (Figures 32 and 33). Sweep velocities varied and were not always greater than corresponding approach velocities. The criterion for approach velocities was not met for 8.3% of the total approach measurements. The high approach velocities occurred at the upstream end of Screen 1.

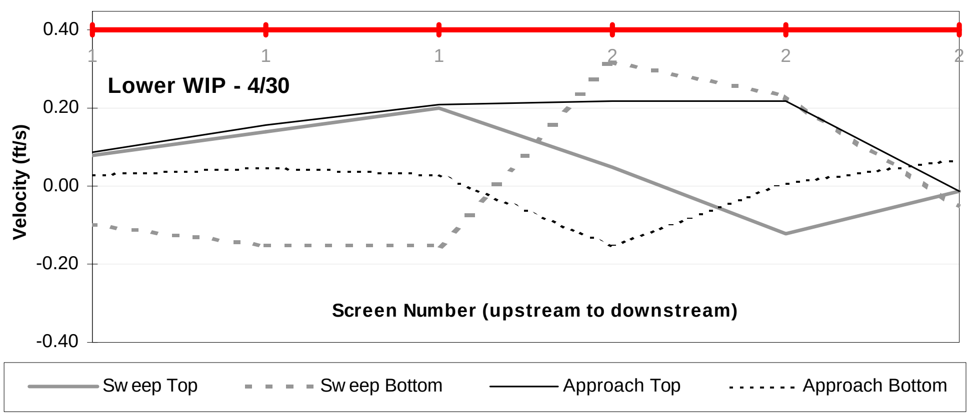


Figure 32. Water Velocities at Lower WIP, 4/30/97

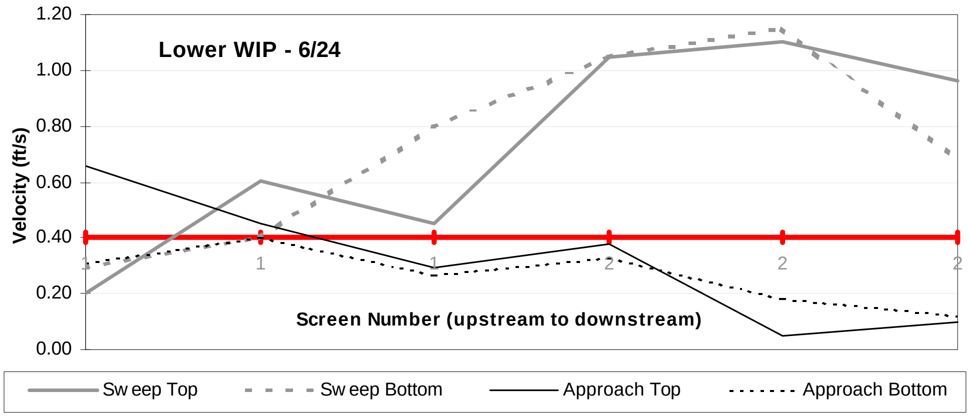


Figure 33. Water Velocities at Lower WIP, 6/24/97

Underwater video at Lower WIP indicated that the seals were in good condition but that sedimentation was a concern. Ahtanum Creek had very low flows in April, but was at a high water stage during the month of June. This caused dramatic changes in the conditions observed at the site over time. In April, there were only 2 inches of sediment on top of the sill. By June, 11 inches of sediment had piled up in front of Screen 1, with lesser amounts in front of Screen 2. The drum screen diameter is 24 inches, so nearly half the screen was buried in silt. Not surprisingly, screen submergence in June was 95.8% and there was a 2-inch headloss across the screen. Screen submergence was below criteria in April at only 62.5%. Also in April, there were 2 inches of silt in the bypass and bypass flow was virtually non-existent. By June, there were 15.5 inches of silt in the bypass and water was flowing at a fast 1.2 fps.

Screens continued to turn freely even with the large amounts of sediment piled in front of them. The screens appeared to be in good condition, but there was no way to determine the condition of the seals below the silt. If the seals are abraded, they may need to be replaced for the next irrigation season.

Nets were not set at this site in September because the screens had been raised, allowing any fish from the creek to enter the canal. Hundreds of dace were present within large puddles of standing water in the Ahtanum Creek streambed. Great numbers of juvenile suckers and minnows filled the forebay and irrigation canal when the site was evaluated in August.

A post-season evaluation was conducted on 11/20/97. The screens were raised, but the site was still quite wet. Water was backed up behind the bypass pipe because of the pipe's small diameter (approximately 6 inches), but the water was flowing freely at the outfall. It was noted that the "greater than one foot depth" outfall requirement would be difficult to adhere to at this site because the creek is rarely that deep at this location.

Naches Cowiche

The Naches Cowiche site was evaluated 5/2/97, 6/25/97, and 8/6/97.

Sweep velocities were varied between visits. They increased toward the bypass except during the second evaluation (Figures 34-36). Sweep velocities were usually higher than approach velocities. The only exception occurred when a bottom approach velocity exceeded the criteria at the upstream end of Screen 1 on 5/2/97. Approach velocities exceeded criteria for 6.6% of all measurements.

Bypass flows were good during the first and third evaluations. However, water was moving very slowly in the bypass (0.2 fps) when it was measured in June. The bypass ramp was raised too high for water to flow over it. Small amounts of water were seeping around the edges of the ramp, but fish could not pass over the weir. Also, the submergence level of 86.7% slightly exceeded criteria. After these data were recorded in June, WDFW personnel arrived, noted the slow flows, and made adjustments to the ramp that corrected the problem.

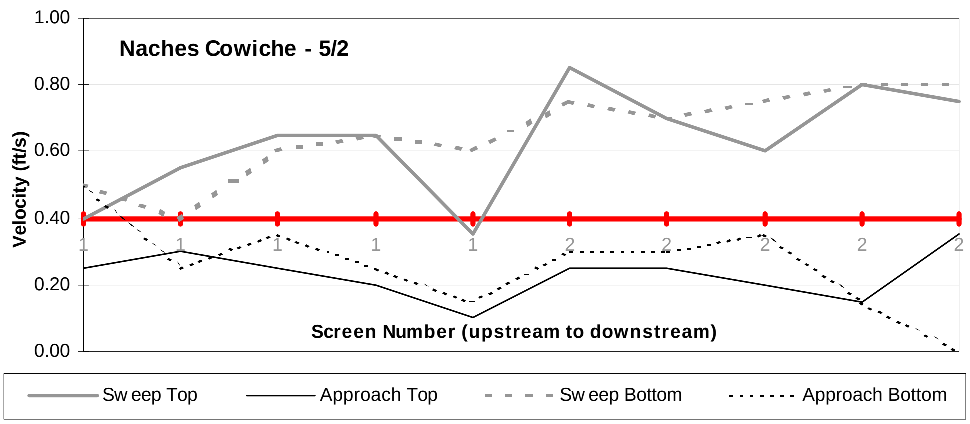


Figure 34. Water Velocities at Naches Cowiche, 5/2/97

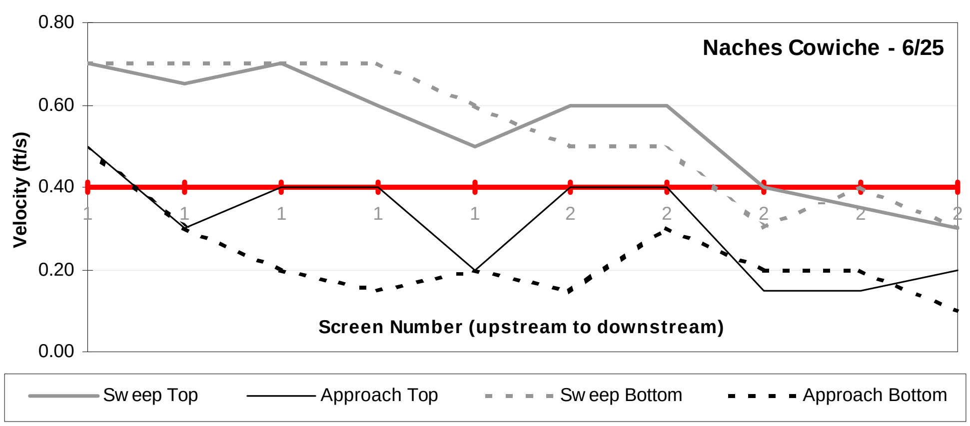


Figure 35. Water Velocities at Naches Cowiche, 6/25/97

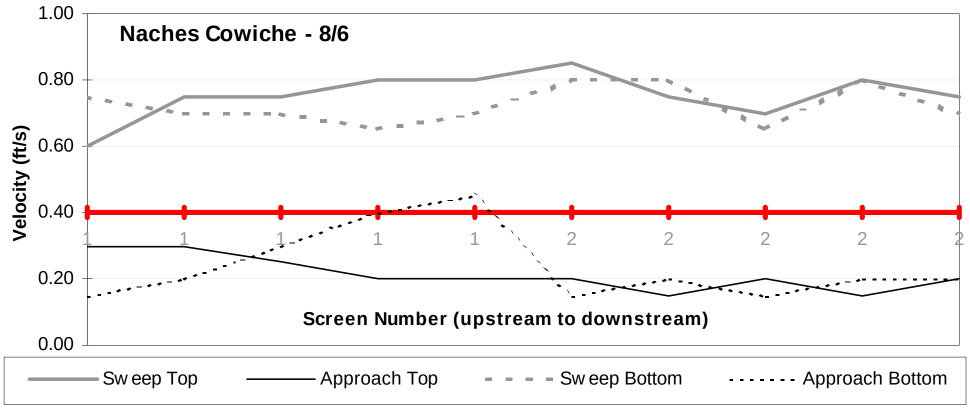


Figure 36. Water Velocities at Naches Cowiche, 8/6/97

Side and bottom seals that were visible appeared to be in good condition. Above-water visual inspections identified a flat spot near the middle of Screen 1 that could create a gap when that section of the screen passes the bottom seal. However, no gaps were identified using the underwater video system. Underwater video did reveal that sand and silt were piled several inches away from the screens in most places. Maximum silt depth was 3 inches in front of Screen 1, where it covered the bottom screen seal. The screen seal was also covered at the middle of Screen 2. The forebay contained a large “dune” of sand that tapered off before it reached the screens. Other debris sighted along the bottom of the screens included sticks in front of Screen 1 and some small logs at the downstream end of Screen 2. The screens always turned without any jerking motion.

A net was set behind the screens on 8/6/97. Only one small sculpin, *Cottus* spp., (21-mm FL, 4-mm head width) was captured. Still, many fish were observed at this site. On the evening of August 6, more than 15 fish were seen swimming in the aftbay. One school was comprised of at least 12 redside shiners, *Richardsonius balteatus*. Other fish observed were several 6- to 12-inch trout, including one char, possibly a brook trout, *Salvelinus fontinalis*, as under-water video in front of the screens confirmed the presence of at least one brook trout (Figure 37).

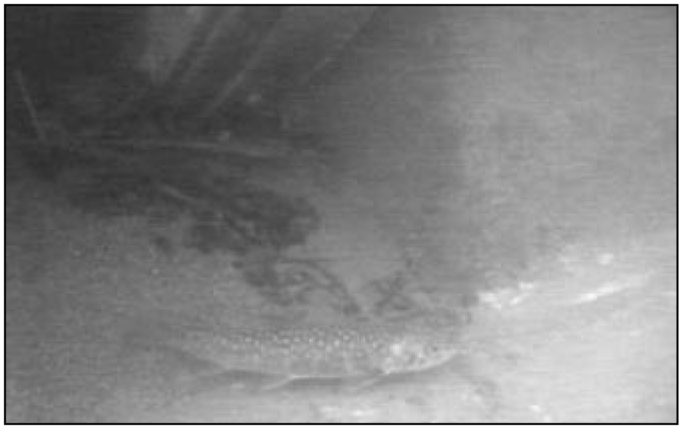


Figure 37. Trout at Naches Cowiche, 8/6/97

A post-season evaluation was conducted on 11/20/97. This site was dry. The screens were raised and silt and debris immediately in front of the screens had been cleared. A large amount of silt was still present just upstream from the forebay. The long horizontal screen seams were grooved although not as deeply as observed at the Toppenish Pump site. See the Toppenish Pump site-specific results for a full description of this occurrence and a photograph.

New Cascade

The New Cascade site was evaluated 5/1/97, 6/26/97, and 8/13/97. Difficulties were encountered attempting to collect water velocities because of electrical interference. However, reliable velocity data was collected 5/1/97.

These flows were very inconsistent from one sample location to another, but do give a general representation of what was happening in front of the screens (Figure 38). Sweep velocities increased gradually toward the bypass and were greatest inside the bypass. Sweep velocities were always greater than their respective approach velocities. Only 4.2% of the approach measurements were greater than 0.4 fps.

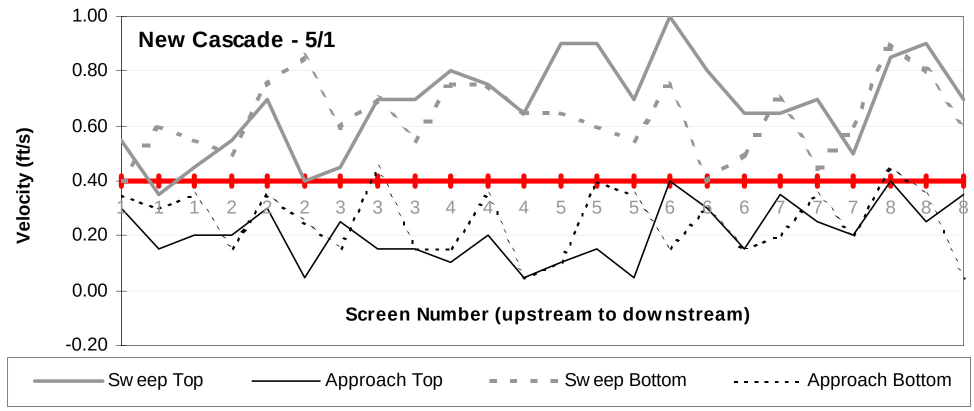


Figure 38. Water Velocities at New Cascade, 5/1/97

Visual inspection above the water indicated flat spots in Screens 6, 7, and 8 that could have created gaps between the screen and bottom seal. The gap at the downstream end of Screen 7 was confirmed with underwater video. The other two gaps were not confirmed with the video, in part because sediment sometimes covered the bottom seals.

Debris consisted of roots, twigs, tumbleweeds, leafy plant material, and sand. It congregated in the corners of most screens, and was not as dense at mid-screen. Most of the sand came only to the level of the bottom seal and did not bury the screen. The screens always rotated freely and submergence levels were always within criteria (average = 83.3%).

No net was set behind the New Cascade screens and no fish were observed in the aftbay or irrigation canal. Many fish were recorded on the underwater video in front of the screens (approximately 20 fish per site evaluation). Species sighted include redside shiners *(Richarsonius balteatus)*, mountain whitefish *(Prosopium williamsoni)*, and chinook salmon *(Oncorhynchus tshawytscha)*.

No post-season evaluation was performed at New Cascade.

Snipes Allen

The Snipes Allen site was evaluated 5/2/97, 6/23/97, 7/10/97, and 8/12/97.

Velocities varied widely among site visits (Figures 39-42). Most bottom sweep velocity measurements increased toward the bypass, but this was not always the case for top sweep velocities. No obvious patterns were noted for approach and sweep velocities. Approach velocities often exceeded sweep velocities, in no particular pattern. During the first site visit, sweep velocities were negative in front of Screen 1.

This was confirmed as there was some backflow of water from the river into the bypass due to flooding events. Net bypass flow was measured as 0.0 fps in May. Therefore, at this site fish bypass under high flows must be active (i.e., fish cannot passively drift through the bypass). Only 3.3% of all approach measurements throughout the summer exceeded the criteria.

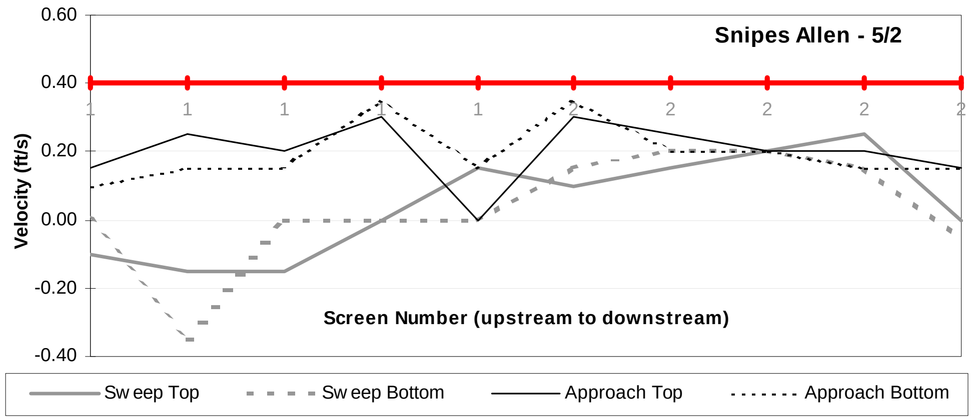


Figure 39. Water Velocities at Snipes Allen, 5/2/97

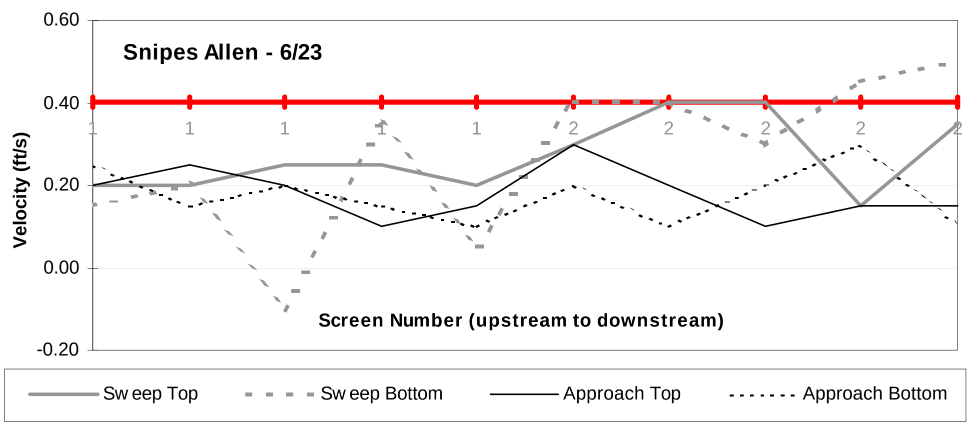


Figure 40. Water Velocities at Snipes Allen, 6/23/97

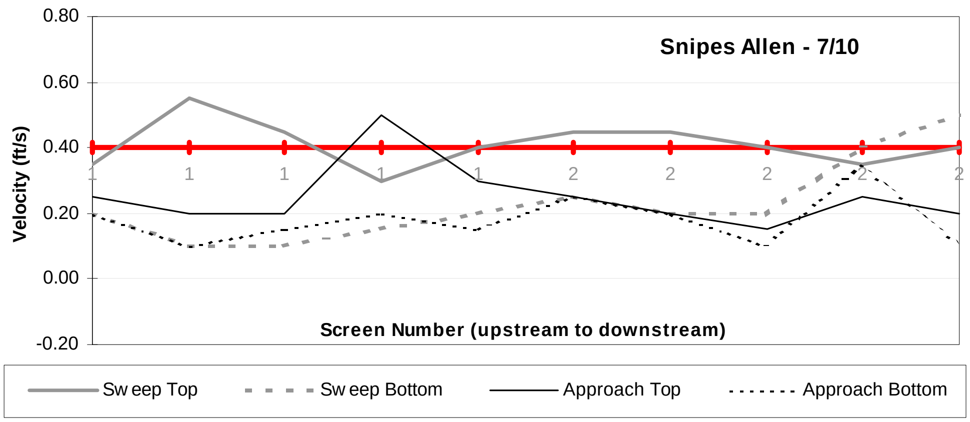


Figure 41. Water Velocities at Snipes Allen, 7/10/97

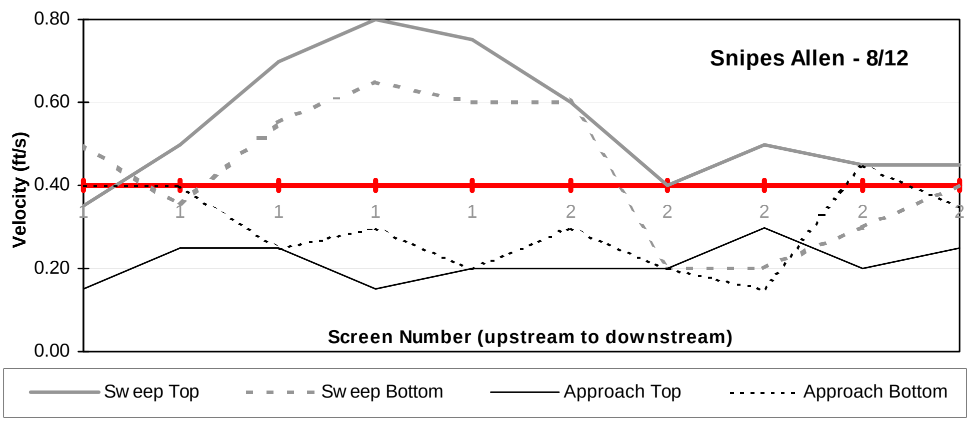


Figure 42. Water Velocities at Snipes Allen, 8/12/97

Visual inspections above water indicated that both screens at Snipes Allen had flat spots. Gaps between the screen and bottom seal could not be confirmed, however, because sediments covered the bottom seals. The flat spots were found in the center of the screens near the horizontal seams. More silt was found in front of Screen 1 than Screen 2. Maximum silt depths were 7 inches, observed during the May evaluation. Lesser amounts of silt were noted in subsequent evaluations, but there was still enough to cover the bottom seals in most instances. There was also an abundance of aquatic macrophytes growing in the forebay at Snipes Allen (Figure 43).

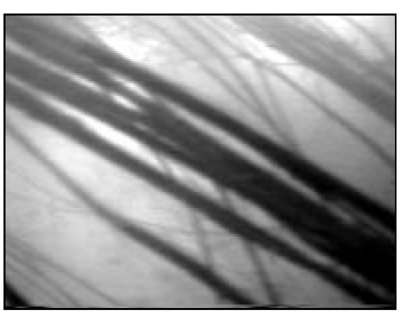


Figure 43. Macrophytes in the Forebay at Snipes Allen

During the May and June evaluations it was noted that the bypass weir ramp was in an odd position compared to the other sites evaluated. It appeared to be in the flushing position. The bottom section of the ramp had been flipped backwards so that the ramp handle was resting on the top section of the ramp (Figure 44). Fish could swim underneath the ramp or over the top.

Screen 1 sometimes jerked as it rotated instead of operating smoothly. Percent screen submergence was 89.6 % during the 7/10/97 evaluation.

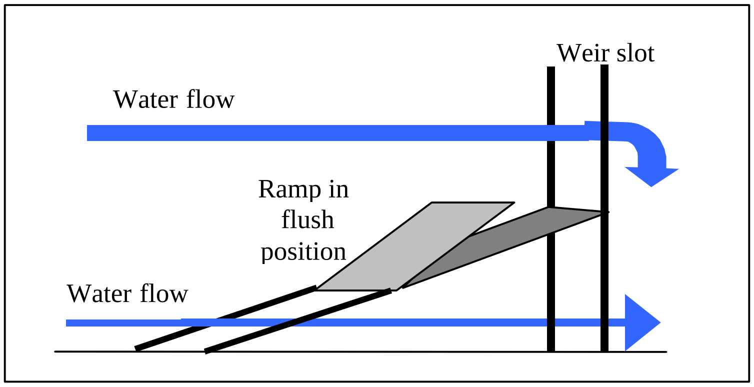


Figure 44. Snipes Allen Bypass Configuration on 5/2/97 and 6/23/97

A net was set at Snipes Allen on 8/12/97. While no fish were captured, two crayfish (51 mm and 64 mm long) were found in the net the following morning. Fish were not observed in the aftbay or irrigation canal at this site, but several unidentified species were caught on videotape immediately in front of the screens.

Taylor

The Taylor site was evaluated 4/30/97, 7/11/97, and 8/13/97.

Sweep velocities at the Taylor site were generally slow, averaging only 0.3 fps (Figures 45-47). This could only partly be attributed to flood conditions at the site that caused negative flow in the fish bypass during April. Water levels in the river were not at flood stage in June or August, but sweep velocities were still low. Approach velocities often exceeded these low sweep velocities even though 95.8% of the approach velocity measurements were at or below 0.4 fps.

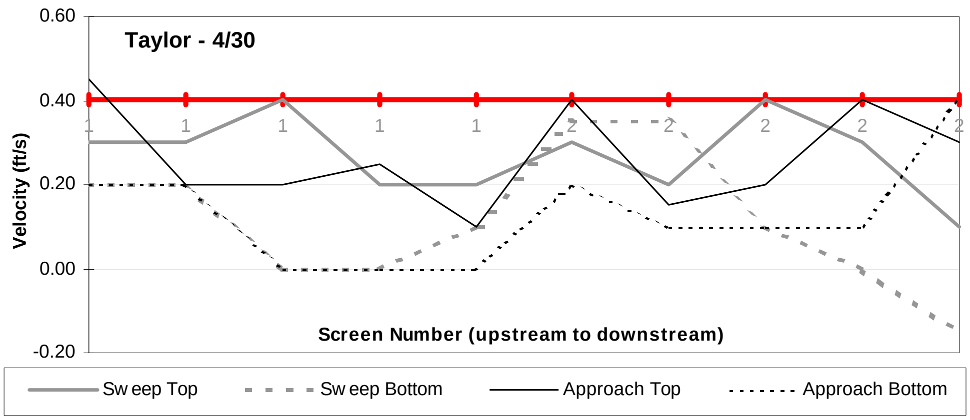


Figure 45. Water Velocities at Taylor, 4/30/97

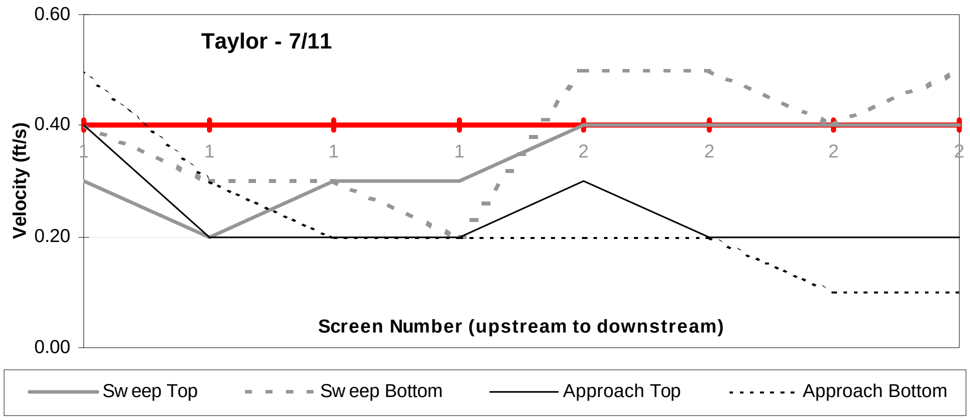


Figure 46. Water Velocities at Taylor, 7/11/97

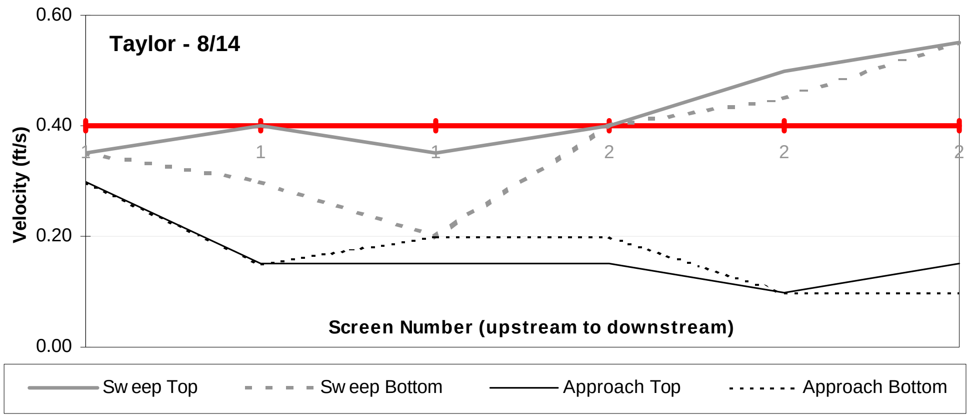


Figure 47. Water Velocities at Taylor, 8/14/97

During April, 11.5 inches of sediment had accumulated in front of Screen 1. Underwater video showed that sand and sticks were blocking the screens in June and August. During these months, sediments reached depths of 10-11 inches in front of Screen 1 and 2-10 inches in front of Screen 2. The bottom seal of Screen 1 was never visible, although the bottom seal of Screen 2 was occasionally seen. Small flat spots were noted from an above-water vantage in both screens. These could not be verified using underwater video because of the deep sand deposits.

In April, Screen 1 sometimes jerked as it rotated. This jerking motion was not observed in subsequent visits. Screen submergence exceeded criteria on 8/13/97 (90%).

A net was set behind the screens at the Taylor site on 8/13/97 and many fish were captured (Table 6). However, this is not necessarily an indication that fish were entrained at this site since they could easily have swum up the ditch outfall near the Elks Golf Course at Selah Gap (Easterbrooks, pers. comm.). This can also be confirmed based on the size of the fish captured (Table 6), as many were 1+ age. No fish were observed in the forebay.

Table 6. Fish Species Captured at Taylor, 8/13/97

Species	Number of Fish Captured	Forklength (mm), x ± SD
Chiselmouth	10	104.6 ± 12.0
Pumpkinseed	4	84.8 ± 13.2
Redside shiner	10	92.3 ± 7.1
Squawfish	2	116.5 ± 12.5
Sucker sp.	4	101.8 ± 12.0
Mountain whitefish	4	76.5 ± 21.0

No post-season evaluation was performed at this site.

Toppenish Pump

The Toppenish Pump site was evaluated 4/30/97, 6/23/97, 7/1/97, and 8/12/97. Underwater video was not recorded 6/23 because high water turbidity caused poor visibility.

Approach velocities at Toppenish Pump were consistently high; 43% of all approach velocity values exceeded 0.4fps (Figures 48-51). Except during the first evaluation, sweep velocities usually exceeded approach velocities. The sweep velocities were relatively constant, but picked up speed in front of Screens 5 and 6 and on into the bypass.

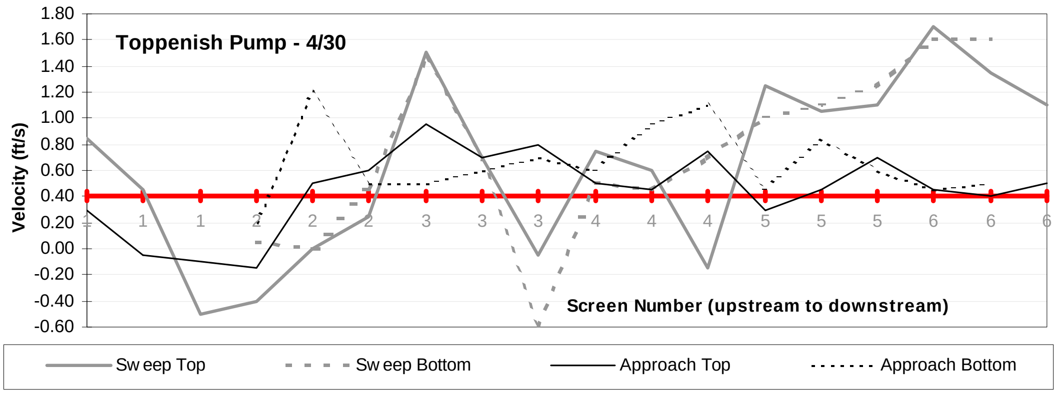


Figure 48. Water Velocities at Toppenish Pump, 4/30/97

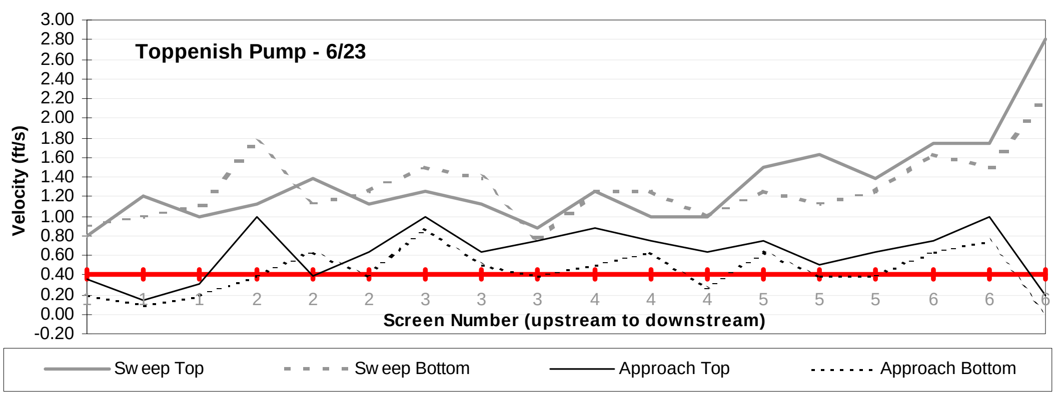


Figure 49. Water Velocities at Toppenish Pump, 6/23/97

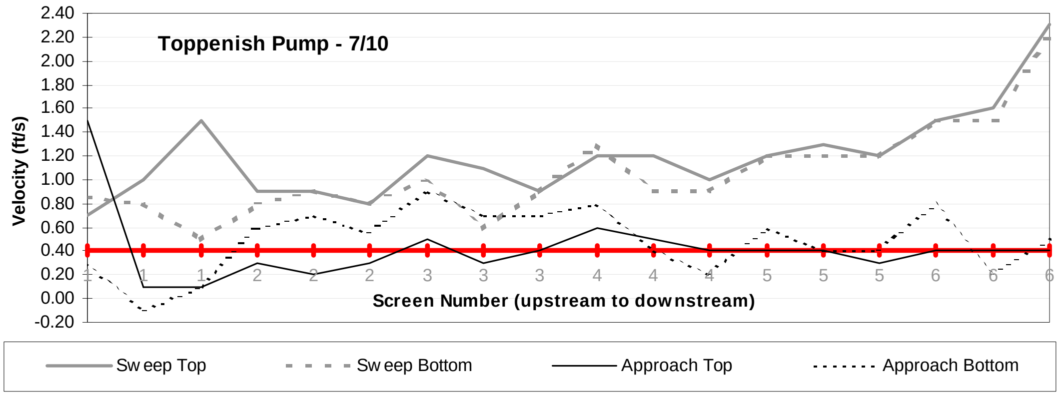


Figure 50. Water Velocities at Toppenish Pump, 7/10/97

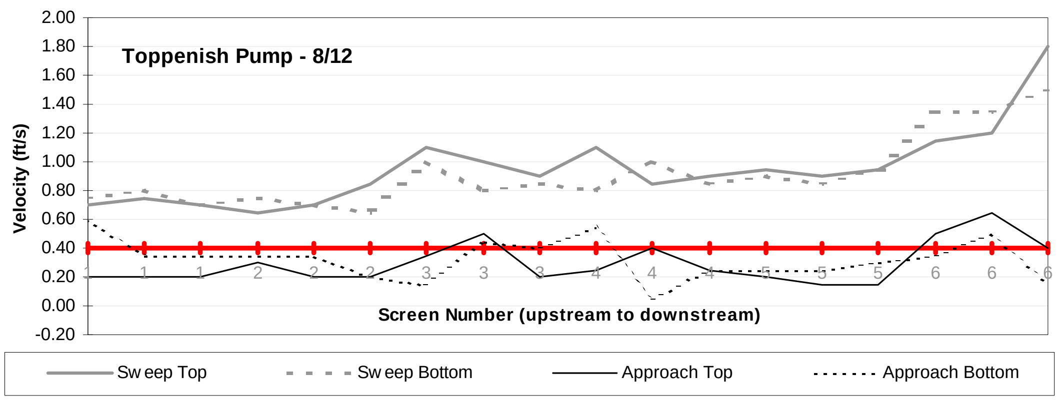


Figure 51. Water Velocities at Toppenish Pump, 8/12/97

Screen 1 was inoperative April through July. It was functioning properly during the August evaluation. It was noted in July and August that the upstream side seal on Screen 2 was folded under the frame and not functioning properly.

Sediment was present at this site and generally deeper at the downstream end of each screen. Overall, forebay sediments increased downstream, reaching a maximum depth of 8 inches in front of Screen 6. Bottom seals were covered with sediment approximately 30% of the time. Other debris included large sticks and small logs that were wedged under Screens 1, 2, 3 and 4. In April, the bypass was also jammed with a large amount of woody debris.

Screen submergence always met criteria at Toppenish Pump. Submergence values were 81.7%, 75%, 83%, and 75.8% during each of our respective visits.

Nets were not set at Toppenish Pump, however, approximately 10 redside shiners were observed swimming in the aftbay.

A post-season evaluation was conducted on 11/20/97. The drum screens were raised but water was still flowing through the forebay and into the canal and bypass. The turned-under seal on Screen 2 was easily examined with the screen out of the water. It appeared that the rubber seal was mounted almost perpendicular to the screen, instead of being allowed to bend horizontally, flush with the screen (Figure 52). If the wire on the drum was at all off-center, its rotation could have gradually moved the seal toward the frame until it was turned underneath itself. Seals on other drums showed indications that they were also moving toward the frames. A wider rubber seal might prevent this from happening.

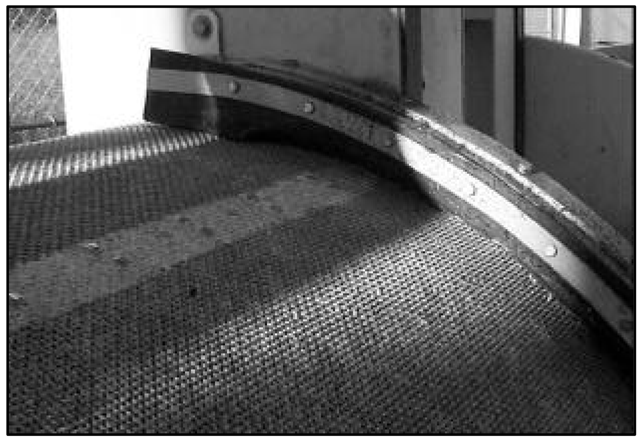


Figure 52. Tucked-under Seal at Toppenish Pump, Screen 2

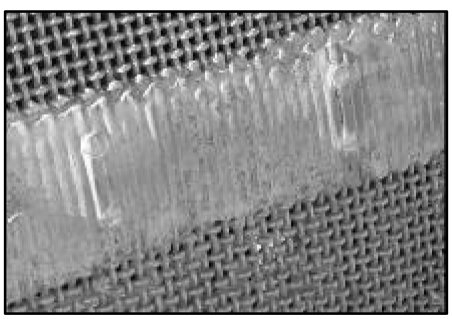


Figure 53. Grooves in the Seam, Toppenish Pump

The long center seams of many drums were grooved (Figure 53). It is assumed that the wire mesh is cutting the bottom seal as the drum rotates. This indicated that the seal and screen were flush, however any future shifting may create gaps where a worn bottom seal no longer meets the wire mesh.

Upper WIP

The Upper WIP site was evaluated 4/30/97, 6/24/97, and 7/9/97. No data was collected in August when all of Ahtanum Creek was being diverted into this irrigation canal. At this time, the bypass was completely blocked to keep fish from returning to the dry creek bed below the diversion.

Sweep and approach velocities were inconsistent between evaluations (Figures 54-56). In April, sweep velocities were low in front of Screens 1 and 2 and did not exceed approach velocities. Sweep velocities were higher in front of Screens 3 and 4 and distinguishable from the approach velocities. In June, sweep and approach velocities were distinct except near the bypass where sweep velocities were dramatically lower. In August, sweep velocities were generally higher than approach velocities, but the two sweep values (top and bottom) differed. As top sweeps decreased toward the bypass, bottom sweeps increased. Of all approach measurements recorded at this site, 17.5% were greater than 0.4 fps. These exceedences occurred only during June and July. There was no pattern across the screens.

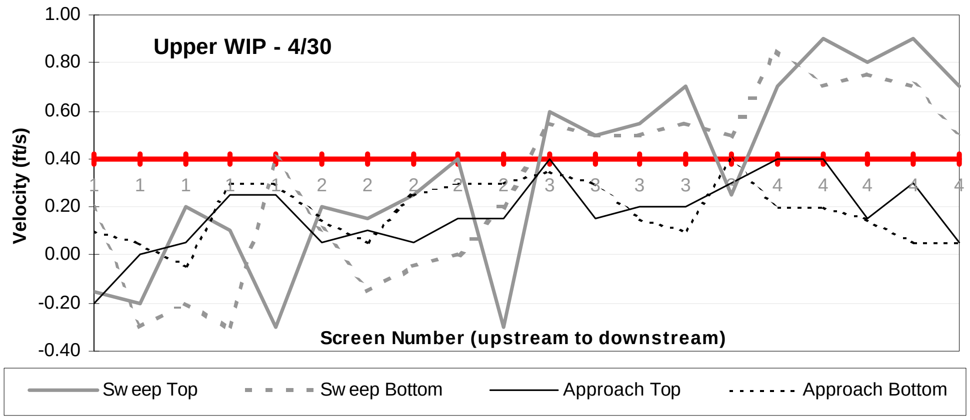


Figure 54. Water Velocities at Upper WIP, 4/30/97

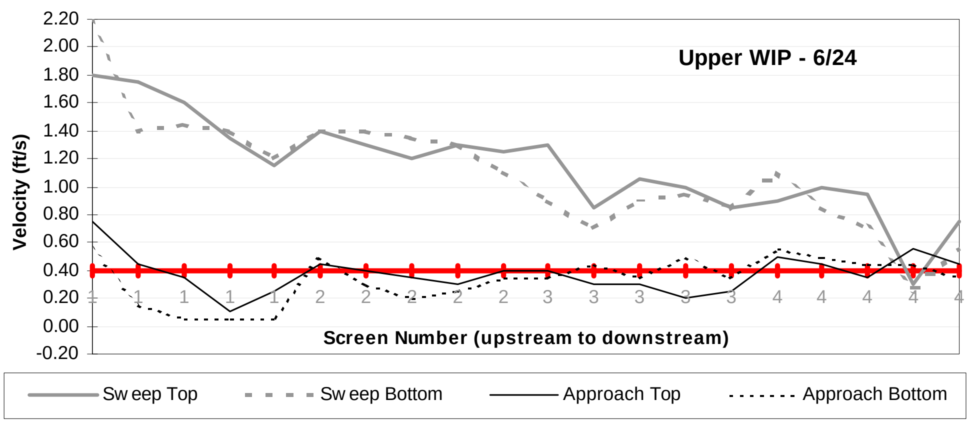


Figure 55. Water Velocities at Upper WIP, 6/24/97

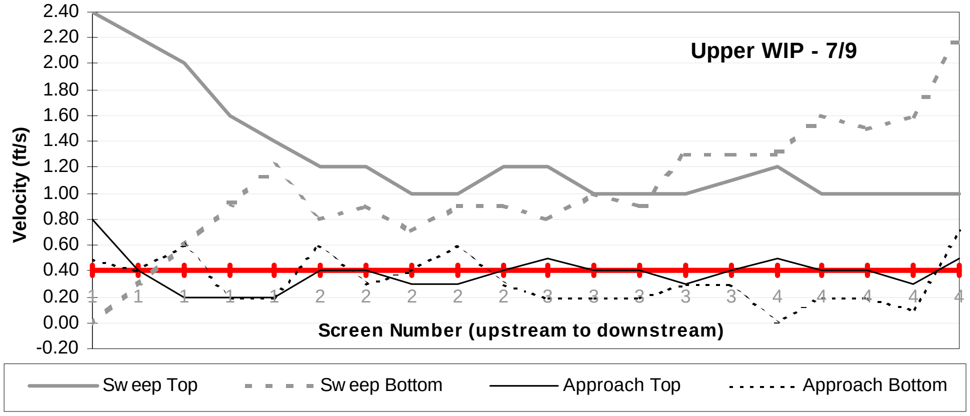


Figure 56. Water Velocities at Upper WIP, 7/9/97

Underwater video and above-water observations indicated that siltation was a concern at Upper WIP. In June, nearly 20 inches of sediment had accumulated in front of Screen 2. This screen had the deepest sediment deposits. Other screens had between 0 and 12 inches of silt. Trashracks had not been installed as late as the July evaluation and some large sticks and logs had lodged near the bottom of Screens 3 and 4 (Figure 57). More silt was found upstream; more woody debris downstream. The seals that were visible appeared to be in good condition.

Figure 57. Woody Debris Accumulation at Upper WIP

Screen submergence met criteria during every evaluation. Submergence levels were measured as 83.3%, 77.1%, and 81.3%. Some bank erosion was noted near the upstream end of the forebay around the edges of the concrete form.

Water depths at the bypass outfall in June and July were not adequate. Removal of cobble and boulders at the outfall in July improved bypass flow and provided a deeper channel for fish to travel to the main part of the creek.

A net was set behind the screens at Upper WIP on 8/19/97. Only one fish was captured. This was a small sculpin (25 mm FL, 3.2 mm head width). One crayfish (64 mm long) was also captured. Three other fish were observed in front of Screens 1 and 3 with the underwater video camera. At least one was a large (>150 mm) trout or squawfish. The other two unidentified fish were smaller, approximately 65 mm long.

A post-season inspection was performed on 11/20/97. This site was still in full operation and will be operating continuously through the winter. The logbook indicates that aerators will be placed in the forebay area to keep water from freezing on the screens.

The drum screens show obvious patterns that indicate where the screen is and is not rubbing against the bottom seal. The presence and absence of algae growth on the wire mesh is the indicator (Figure 58).

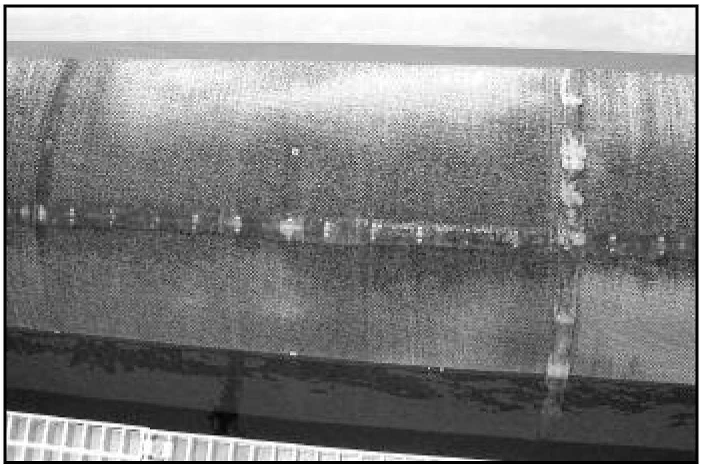


Figure 58. Evidence of Poor Bottom Seal Contact on an Upper WIP Drum Screen, as Indicated by the Presence and Absence of Algae Growth.

Fixed Plate Screens

Bull

The Bull site was evaluated 5/1/97, 6/26/97, and 8/13/97. Water velocities were not recorded in June because new grating had been installed and bolted in place and we were unable to access the screen. Underwater video was recorded only during the final evaluation for the same reason.

Sweep and approach velocities at Bull were quite consistent (Figures 59 and 60). Sweep velocities averaged 0.78 fps and approach velocities averaged 0.27 fps. However, 36.1% of all approach velocities measured at this site were greater than 0.4 fps. High approaches occurred across the entire length of the screen. Sweep velocities did not increase toward the bypass.

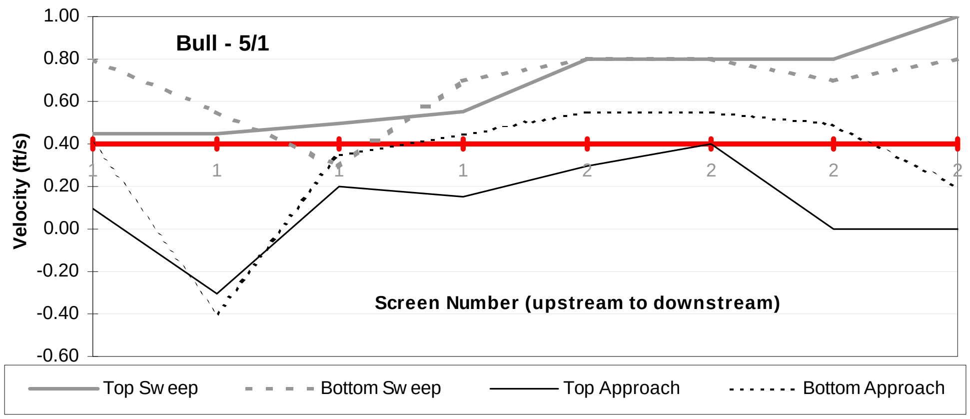


Figure 59. Water Velocities at Bull, 5/1/97

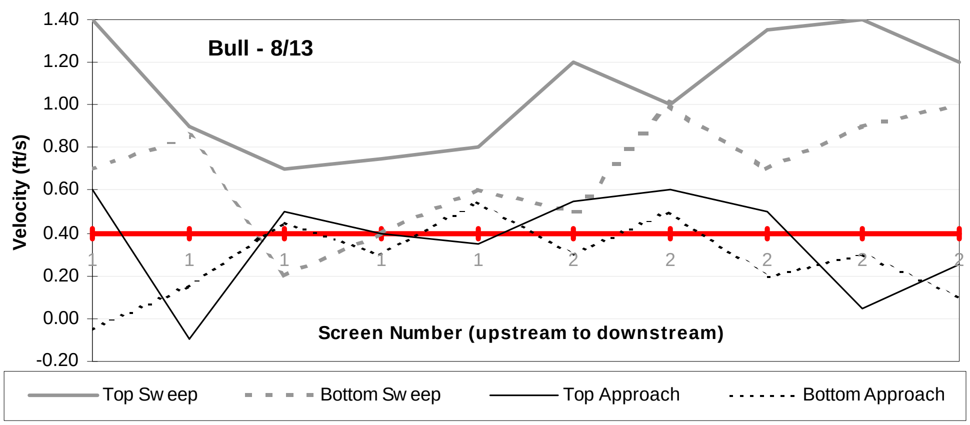


Figure 60. Water Velocities at Bull, 8/13/97

Underwater video revealed no major problems associated with seals at the Bull site, although two small areas were noted where sealant was beginning to deteriorate. These areas were along the downstream side seal of Panel 1 and at the bottom center of Panel 2. The area immediately in front of the screens was free of debris.

Flooding was a problem at Bull in 1997. During late April the screens were entirely submerged allowing fish to swim directly into the irrigation canal. Washington Department of Fish and Wildlife crews subsequently surrounded the area with sandbags and ecology blocks to keep water from over-topping the screens again. There are plans to install headgates at the side channel entrance in the future (Easterbrooks, pers. comm.).

Nets were not set at the Bull site and no fish were observed in either the forebay or aftbay. No post-season evaluations were conducted at this site.

Ellensburg Mill

The Ellensburg Mill site was evaluated 5/1/97, 6/26/97, and 8/13/97.

Water velocities in front of the Ellensburg Mill screen covered a wide range of values during the three site evaluations (Figures 61-63). Sweep velocities were never very high, although they did exceed approach velocities in most cases. Exceptions were during the third evaluation in August and involved low bottom sweep velocities. Sweep velocities did not noticeably increase closer to the bypass. Approach velocities never exceeded the 0.4 fps criteria, but flow readings indicated that water moved faster at the bottom center of each panel than near the ends at the same depth.

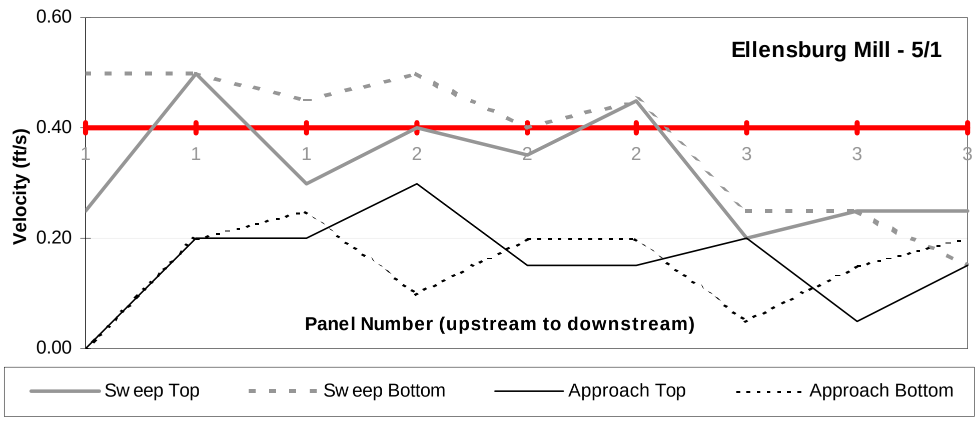


Figure 61. Water Velocities at Ellensburg Mill, 5/1/97

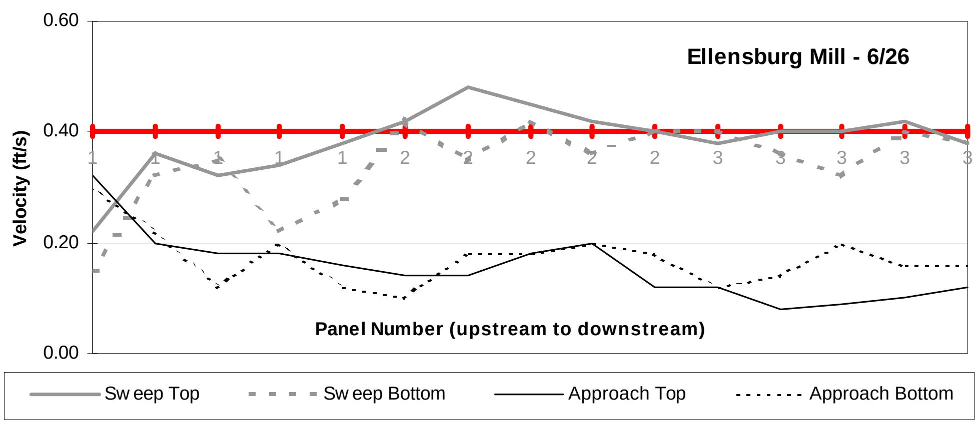


Figure 62. Water Velocities at Ellensburg Mill, 6/26/97

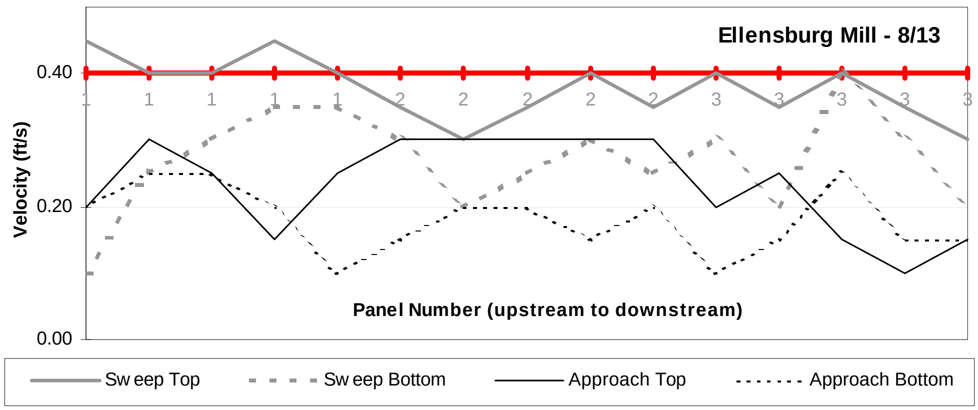


Figure 63. Water Velocities at Ellensburg Mill, 8/13/97

Underwater video revealed that siltation was not a problem at this site. Maximum silt depth was approximately 1 inch. Most screen seals were in excellent condition. A small gap occurred in the sealant at the bottom between Panels 1 and 2 because Panel 2 was installed slightly higher than Panel 1. Some small rocks were embedded in the sealant at the bottom of Panel 1, but this did not pose a problem to fish.

During our initial inspection, the automated cleaning brush was not reaching 1 foot of screen at the upstream end. This was corrected by our second screen evaluation and the brush appeared to be effective in keeping debris off the screen.

A number of fish were present at Ellensburg Mill. A net was placed in the canal on 8/13/97 to capture fish that may have been entrained in the canal. Only one fish was captured. It was a cyprinid measuring 22 mm forklength (FL) and 2 mm head width. In addition, a school of approximately twelve 50-75 mm fish were observed swimming in the aftbay, although the species was not identified. Fish observed in the forebay included squawfish, juvenile largemouth bass, and redside shiners. Two squawfish (180 mm and 240 mm FL) were captured in the forebay.

No post-season evaluation was conducted at this site.

Fruitvale

The Fruitvale site was evaluated 5/2/97, 6/25/97, and 8/18/97. Electromagnetic interference affected water velocity measurements. Velocities were not recorded at all during the final evaluation because interference was so great. This screen was 100% submerged for a short period of time (several hours at most) on 8/18/97. The water was extremely turbid at this time, therefore underwater video was recorded only in June.

Keeping in mind the incidence of electromagnetic interference, velocities were generally good at this site (Figures 64 and 65). Sweep velocities exceeded approach velocities, except for several times when approach velocities exceeded criteria. Approach velocities were greater than 0.4 fps in 12.5% of the measurements. In June, most of the top approach velocity values were negative values. While there were some eddies, most of these negative readings should be attributed to electromagnetic interference.

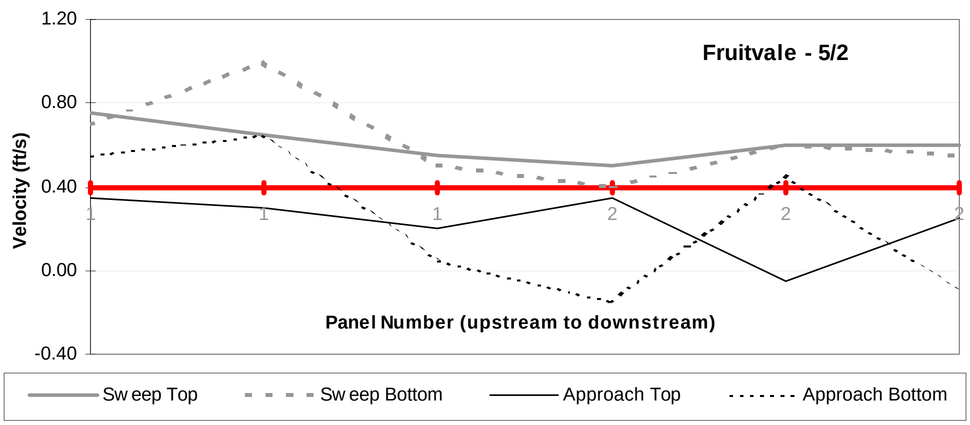


Figure 64. Water Velocities at Fruitvale, 5/2/97

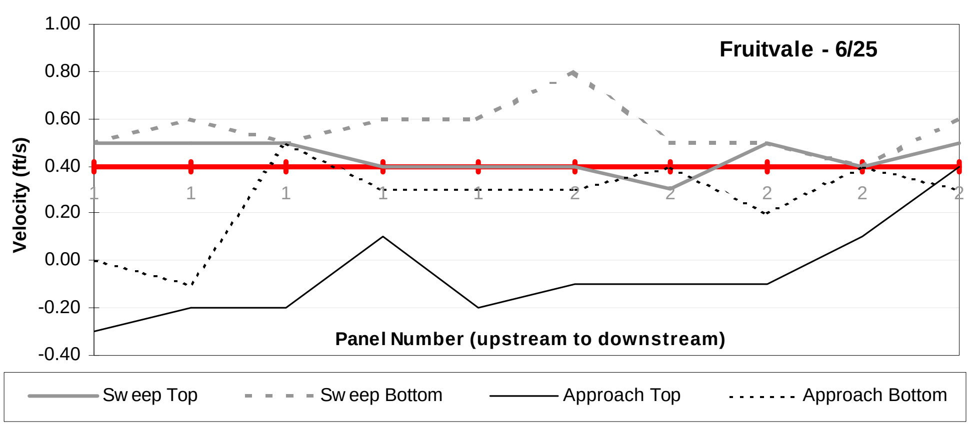


Figure 65. Water Velocities at Fruitvale, 6/25/97

Underwater video indicated that screens at Fruitvale were in very good condition. The only place where sealant appeared to be missing was a small area at the bottom of Panel 2. Sedimentation is not a problem at this site. The maximum silt depths observed were approximately 1 to 2 inches.

Measured bypass flows were very good. Velocities at the bypass entrance were significantly higher than the sweep velocities in front of the screens and continued to increase toward the weir.

Water depth at the bypass outfall was less than 1 foot deep during the first evaluation. A 1-foot extension to the bypass pipe would prevent this from recurring.

Nets were not set at the Fruitvale site and no other observations of fish presence at the site were recorded.

A post-season evaluation was conducted on 11/20/97. This site was completely dry and the forebay had been cleared of silt but several inches of silt were accumulated between the screen and the louvers. The irrigation canal contained great amounts of sediment (Figure 66). The bypass ramp had been left in a flushing position. The last logbook entry was on 10/8/97. It did not document any of the winterization process.

Figure 66. Sedimentation in the Canal at Fruitvale, 11/20/97

Naches Selah

The Naches Selah site was evaluated 5/6/97, 6/25/97, and 8/7/97.

Water rapidly swept past the Naches Selah screen (average = 0.96 fps). Sweep velocities fluctuated and did not show any marked trends across the length of the screen, although top sweep values were almost always greater than bottom sweep values (Figures 67-69). Approach velocities also showed marked variation between sampling sites, but most (94.5%) were less than 0.4 fps. Sweep velocities were always greater than their corresponding approach velocities.

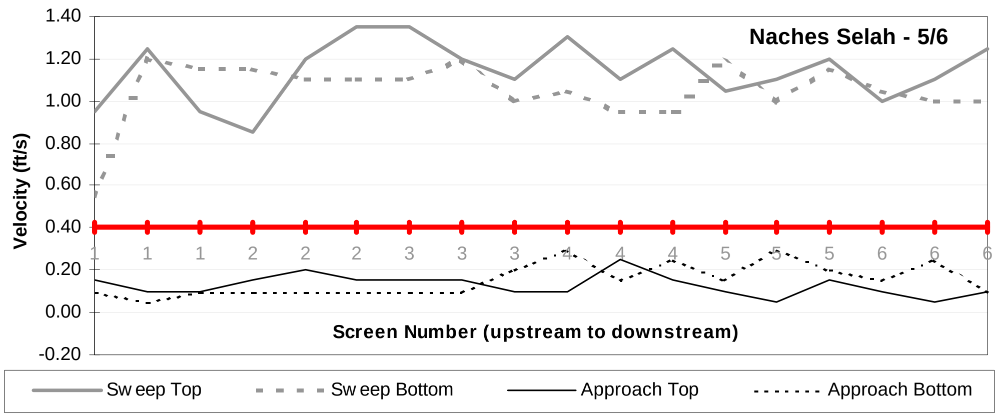


Figure 67. Water Velocities at Naches Selah, 5/6/97

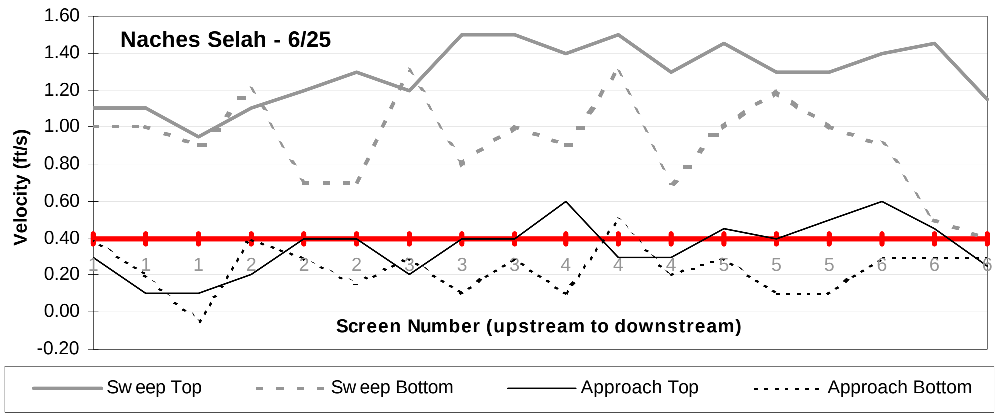


Figure 68. Water Velocities at Naches Selah, 6/25/97

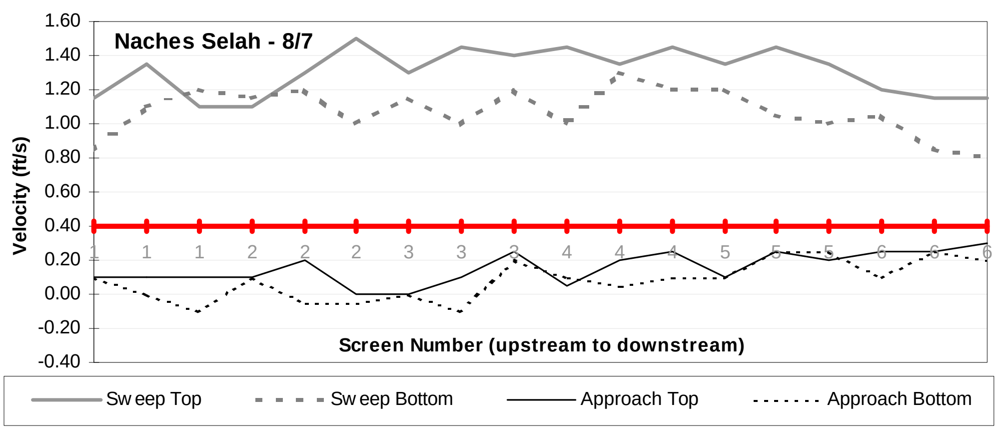


Figure 69. Water Velocities at Naches Selah, 8/7/97

Underwater video confirmed that sedimentation was not a problem at this site. Maximum sediment depths were just 1 inch at the downstream end of the screen. A clump of tree branches was observed at the entrance to the bypass, but they did not block the water channel. There were several areas where the sealing agent was peeling or where the concrete base appeared damaged. These areas included:

1. Seal coming undone along the bottom of Panel 1 between the screen and concrete.
2. Small gap between Panels 1 and 2 at the bottom.
3. Missing sealant between Panels 3 and 4 along the bottom.

The screens were in good condition and the cleaning brush was effective at removing leafy debris from the screen face. In August, the brush was set to operate only once per hour unless a 2-inch head differential was detected. Debris did accumulate over the course of the hour, but most was removed when the brush swept past it.

Nets were not set at this site and fish were not observed in the aftbay or irrigation canal. However, the underwater video camera did capture images of several juvenile salmonids in the bypass on 8/7/97 (Figure 70). These fish were approximately 50 to 70 mm FL.

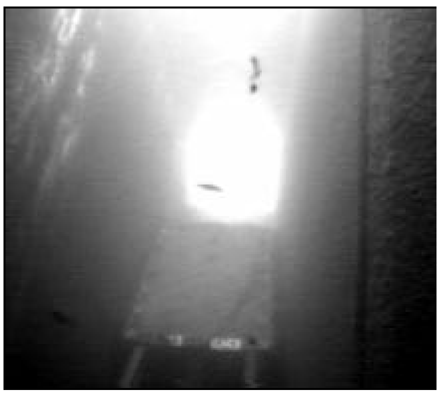


Figure 70. Juvenile Salmonids *(Oncorhynchus* spp.*)* in the Bypass at Naches Selah, 8/7/97

A post-season evaluation was performed on 11/20/97 when the site was mostly dry. A large silt deposit was located against the screens in the aftbay, near the bypass. Some silt had built up behind the louvers. Water appeared to be leaking through between panels 2 and 3. This was the only location where silt had been washed away between the louvers.

Union Gap

The Union Gap site was evaluated 5/2/97, 6/24/97, and 8/18/97.

Sweep velocities at Union Gap were always greater than approach velocities (Figures 71-73). Top sweep velocities were generally greater than bottom sweep velocities, but both tended to decrease near the bypass entrance. Bypass flows were always slower than the average sweep velocity in front of the screens.

Approach velocities were greater than 0.4 fps for only 2.3% of all approach velocity measurements. Approach velocities were not constant across the length of the screen. Some patterns suggest that approach velocities were greatest at the center of the screens and slower near the ends of the screens (Figure 71).

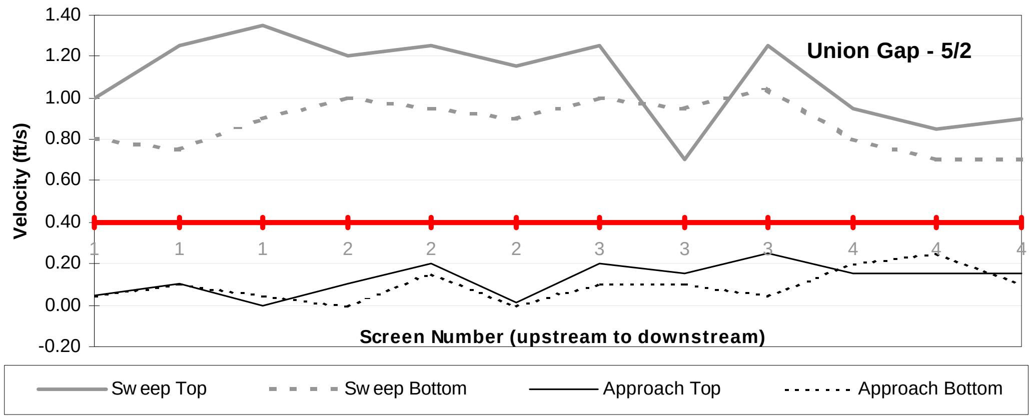


Figure 71. Water Velocities at Union Gap, 5/2/97

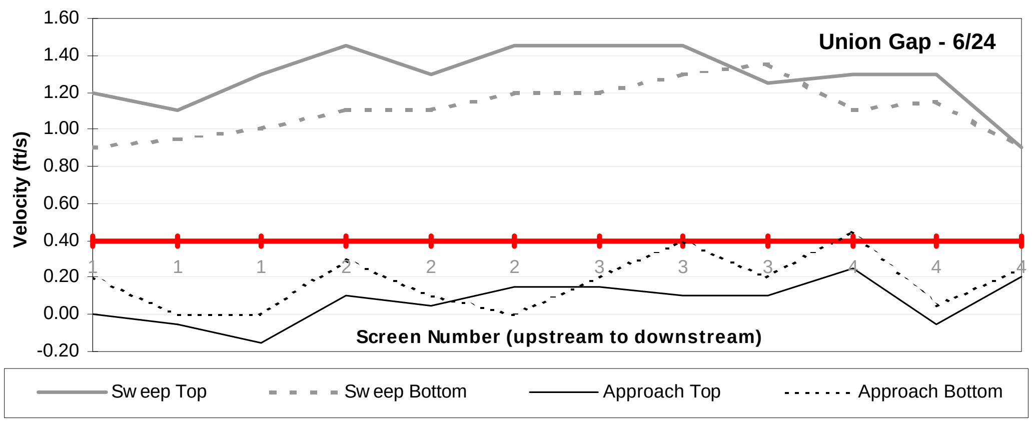


Figure 72. Water Velocities at Union Gap, 6/24/97

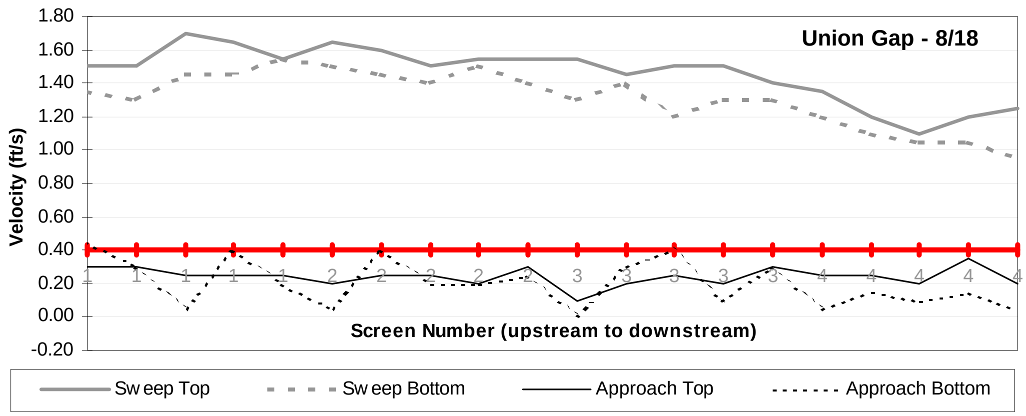


Figure 73. Water Velocities at Union Gap, 8/18/97

Underwater video indicated that sedimentation was not a concern at Union Gap. Maximum gravel and sand deposit depths were only 1 inch in front of the panel furthest downstream. Panel 3 had a very short segment of loose sealing material along its bottom.

A net was not set at Union Gap. However one small, unidentified fish was observed by underwater video in the bypass channel. At least 100 juvenile cyprinids were observed swimming in the shallow water of the irrigation canal on 8/18/97.

Yakima Tieton

The Yakima Tieton site was evaluated 5/1/97, 6/30/97, and 8/14/97. During the May evaluation, river levels were artificially lowered so construction could be completed at the site.

Sweep and approach velocities did not overlap at Yakima Tieton (Figures 74-76). Sweep velocities were sufficiently fast enough to move fish to the bypass and showed a marked increase at the bypass entrance. Top approach velocities were greater than 0.4 fps along the upstream half of the screen in June and August (10.5% of all approach measurements).

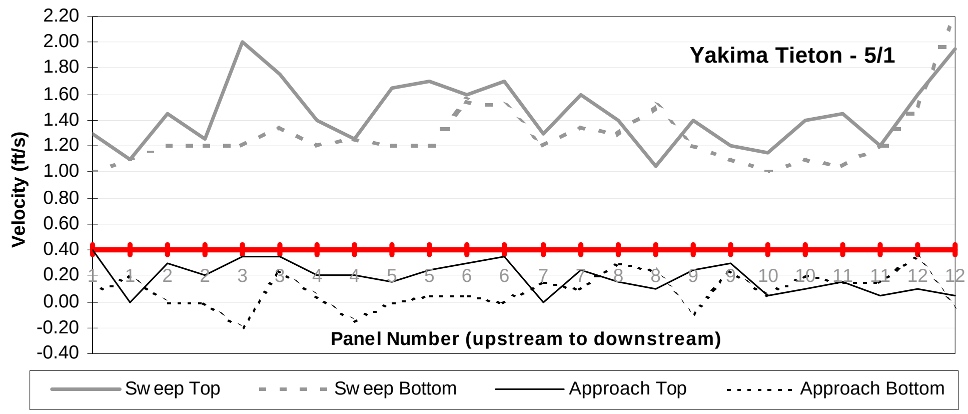


Figure 74. Water Velocities at Yakima Tieton, 5/1/97

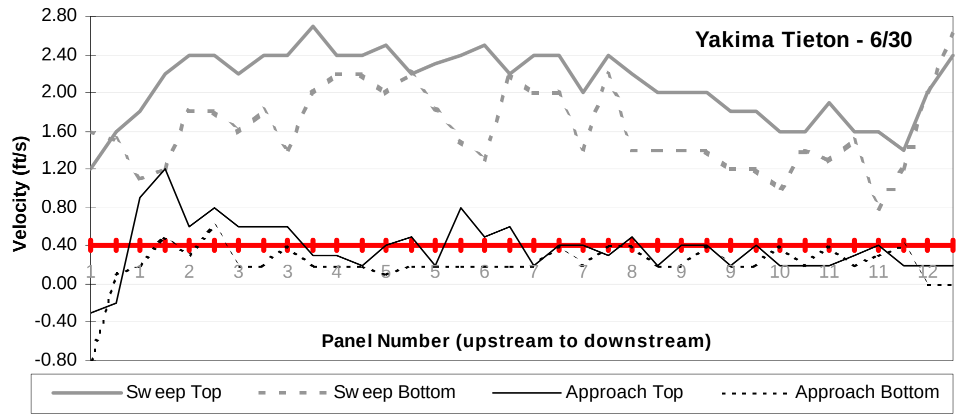


Figure 75. Water Velocities at Yakima Tieton, 6/30/97

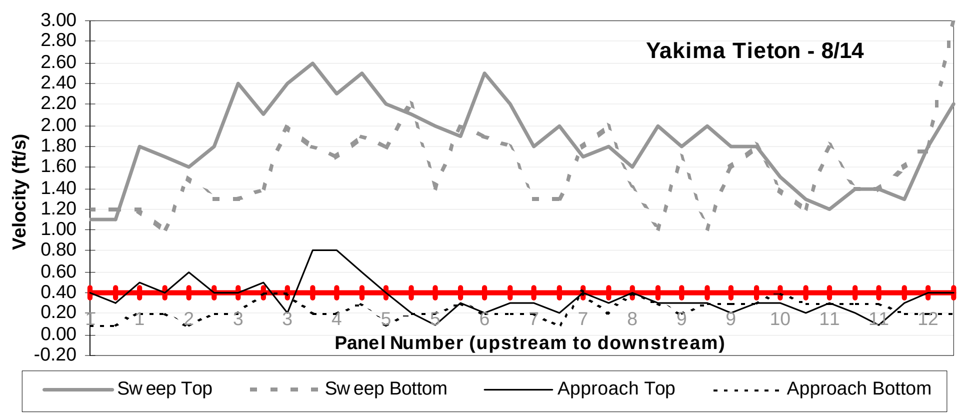


Figure 76. Water Velocities at Yakima Tieton, 8/14/97

In August, the bypass was partially blocked with large woody debris. The weir appeared to be in an almost full-open position, but water was not flowing freely. Sticks and branches were wedged in the weir slot such that water only flowed underneath them. The water was very forceful and turbulent once it passed the blockage. Water hit the far wall and rushed powerfully back in the direction of the screens.

Sediments accumulated in front of the downstream screens in May when the water levels were dropped. Up to 10 inches of small gravel and stones were piled in front of Panels 9 through 12. This was remedied when water levels were returned to normal as they were for the remaining evaluations. Only one inch of gravel was observed on these occasions. Underwater video revealed that the screen’s sealant was deteriorating. Caulking detached in many places, especially along the bottoms of the downstream panels (Figure 77). Also, the presence of a dark strip of debris along the bottom of the screen panels indicated that the brush was not effectively cleaning the bottom 6 inches of the screen (Figure 77).

Figure 77. Missing Sealant and Debris Collected on the Screen at Yakima Tieton where the Cleaning Brushes do not Reach. Rocky Substrate Can also be Seen.

No net was set at Yakima Tieton and no fish were observed at the site. No post-season inspection was conducted at Yakima Tieton.

Vertical Traveling Screen

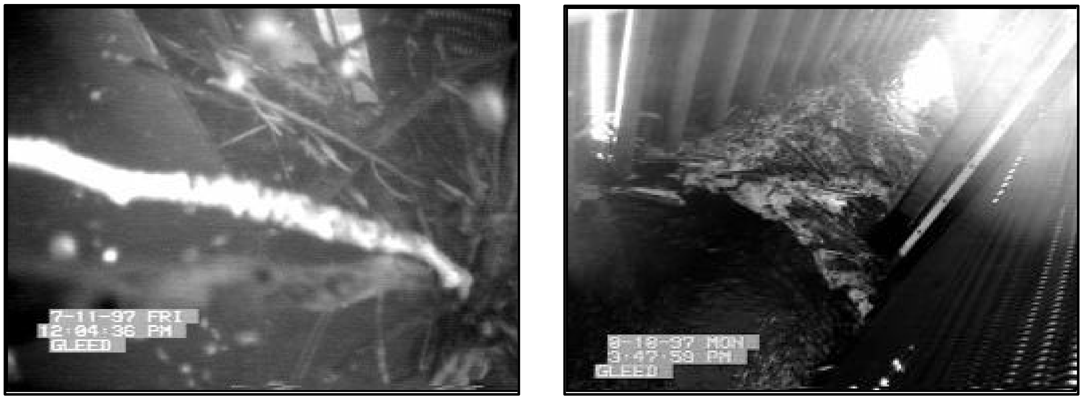
Gleed

The Gleed site was evaluated 5/2/97, 7/11/97, and 8/18/97. Severe electrical interference was encountered at Gleed precluding any velocity measurements. Visual observations of surface flow patterns were recorded instead. Underwater video footage was difficult to obtain at this site because of the extremely fast current. Damage to the screen platform also made it difficult to fit our camera in front of Screen 1. Also, large amounts of debris lodged between the trashrack and the screens kept the camera from reaching the bottom seals in several places.

The underwater video footage indicated that woody debris was a concern at this site. The trashrack was covered with large metal panels to protect the screens from trees that were swept down the river during flood events (Figure 78). The panels protected the screens, but affected the flow of water.

Figure 78. Woody Debris at the Gleed Diversion

Water was observed flowing past the screens in two directions. At the downstream end in front of Screens 3 and 4, water swirled around the metal panels and moved upstream past the screens. Water flowed in a more conventional direction past Screens 1 and 2. Where these two water flows met they trapped large amounts of debris. The area in front of Screen 2 was almost completely filled with sticks (Figure 79). The video camera was blocked at about mid depth by sticks wedged tightly between the metal panel and the screen.



(a) (b)

Figure 79. Woody Debris Accumulated in Front of Screen 2, Gleed. (a) Underwater view of sticks along the side seal; (b) Above-water view. The bottom of the picture is downstream; the top is upstream.

Bottom seals were visible in front of Screens 3 and 4 and appeared to be in good condition. All side seals observed were also in good shape. No sediments have accumulated along the bottom of the screens because of the fast sweep velocities.

The screens have taken a beating from the woody debris, however. Figure 80 shows a segment of Screen 4 where the wire became bent out of shape enough to allow a small fish to become entrained. Similar wear patterns were observed on the other screens. The wire mesh is designated to be replaced with a plastic belt material that meets the new screening criteria (3/32-inch) prior to the 1998 irrigation season (Easterbrooks, pers. comm.).

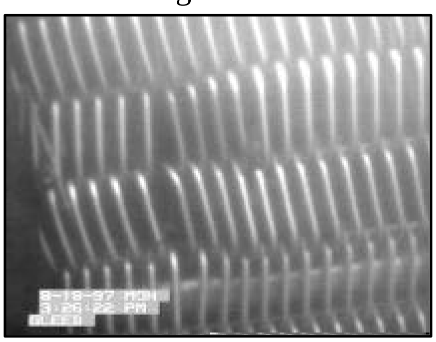


Figure 80. Bent Wires on Screen 4, Gleed

No nets were set at the Gleed site and no other fish observations were made.

Discussion and Recommendations

Fish screens in the Yakima Basin are designed to direct fish that have been diverted from a river and into irrigation canals back to the river without killing or injuring them or delaying their migration. This study was designed to determine if screen sites are being operated and maintained in a manner that promotes safe fish passage. Data were collected to determine if:

- flows in front of screens promote fish bypass without chance of delay or impingement
- screens are adequately sealed to prevent fish injury or entrainment
- screen submergence levels preclude fish roll-over or entrainment, yet promote debris removal
- bypass outfall conditions promote safe fish access to the river
- conditions in front of screens deter predation of juvenile salmonids

Water Velocities and Flows

In most instances, water velocity conditions at the screen sites were acceptable by NMFS standards. Although velocities often fluctuated from one sampling location to the next, average flows were very good. For the most part, fish should not become impinged or experience delays in returning to the river. However, some instances where further attention should be directed are highlighted below.

Bachelor Hatton

Nearly 13% of all approach velocity measurements at Bachelor Hatton exceeded the 0.4 fps criteria. Approach velocities in front of the screen closest to the bypass were usually highest, sometimes reaching 0.8 fps. This flow balance problem can probably be corrected (or reduced) by adjusting porosity boards.

Water flow over the adjustable bypass weir was never set in compliance with proper operating criteria, which suggest flow depth over the weir should be 0.9 to 1.1 ft to achieve a bypass channel entrance velocity about 1.5 times greater than the velocity in the screen structure forebay area. Maximum depth over the weir during our evaluations was 0.38 ft. This caused sediment buildup at the entrance to the bypass. It also explains why bypass flows at Bachelor Hatton were always less than the average sweep velocity in front of the screen structures. This condition could potentially delay fish passage through the bypass.

During part of the summer, almost all Ahtanum Creek was diverted upstream at the Upper WIP site, leaving the streambed near Bachelor Hatton dry. At this time the bypass at Bachelor Hatton was blocked. This is acceptable as long as the stream is low. However, when stream flow is adequate there should also be adequate bypass flow and the bypass should be opened to allow for fish passage.

Bull

More than 36% of all approach velocity measurements at Bull exceeded criteria. The maximum approach velocities measured were 0.6 fps. High velocities were recorded in front of both panels, both at 0.8 and 0.2 of the water depth. It may be possible to adjust the baffles behind the screen to reduce approach velocities.

Congdon

The mean approach velocity for the Congdon site was just 0.41 fps, but there were values recorded as high as 0.8 fps. Just over 31% of all approach velocity measurements exceeded criteria. High values were recorded in front of all three screens. Generally, the highest values were recorded at the upstream end of each screen. Although both high submergence and high approach velocities occurred at this site, review of usage/withdrawal rates did not indicate that more screen area is needed to meet NMFS criteria.

Fruitvale

Nearly 13% of all the approach velocity measurements recorded at Fruitvale exceeded criteria. The highest velocities were recorded in front of the panel furthest upstream. The maximum value recorded was 0.65 fps. Slight adjustment of the baffles behind the upstream panel could be made to reduce flow through this section of the screen.

Toppenish Pump

Toppenish Pump had the highest percentage of approach velocity values that exceeded criteria (43%). The average approach velocity at this site was 0.46 fps. Conditions were most favorable to safe fish passage during the August evaluation when approach velocities averaged only 0.31 fps. Differences noted between this evaluation and those previous were that porosity boards behind the four most upstream screens had been removed and that the screen furthest upstream had been cleaned and was operational.

Union Gap

Bypass flows at Union Gap were always slower than the average sweep velocity in the screen structure forebay area. According to the operating criteria, adequate water was flowing over the bypass weir. Bypass flow was fast, compared to other sites evaluated, however it was sluggish in relation to the site's average sweep velocity. This does not promote rapid movement of fish into the bypass. It may be necessary to increase bypass flow requirements at this site or make other adjustments to bring this site into compliance.

Upper WIP

Nearly 18% of all approach velocity measurements at Upper WIP exceeded 0.4 fps. These high flows were all recorded during June and July. The fastest velocities occurred in front of the screen furthest upstream, although velocities exceeding criteria were recorded in front of all four screens. During June and July, bypass flows were extremely low compared to sweep velocities in front of the screens. This probably contributed to the increased approach velocities. Bypass flows may have been slow because of blockage at the outfall. Rocks that had accumulated near the end of the pipe due to streambed shifting were removed after data was collected in July. Bypass flows improved immediately.

Yakima Tieton

Almost 11% of all approach velocity measurements at Yakima Tieton exceeded criteria. Approach velocities were high (up to 0.8 fps) in front of the six upstream panels. Baffles behind these panels should be adjusted to create slower, more uniform flows through the screen.

Seals

Most screens were properly sealed to prevent fish entrainment and injury, although gaps were identified at several screen sites. Some gaps are open from the forebay to the aftbay, allowing for fish entrainment in the canal. Other gaps were spaces larger than 3/32 inch where small fish can become stuck and face potential injury or death. Some drum screens had flat spots that were visible above water but could not be confirmed underwater, primarily because of siltation. In this case, a little sediment may be a good thing if it blocks a potential entrainment pathway. On rare occasions seals were cracked or turned underneath the drum screen frame. Sites with gaps or other seal problems are identified below. Again, screens are numbered starting with the screen furthest upstream.

Bachelor Hatton

Gaps between the screen and the bottom seal large enough for fish to become entrained were observed with the underwater video system at Screens 2 and 4. It was unclear whether the rubber seal or the drum shape was the cause, but the gaps should be sealed prior to the 1998 irrigation season to protect juvenile salmonids from entrainment.

Congdon

A gap between the screen and the bottom seal large enough for fish to become entrained was observed with the underwater video system at Screen 3. Flat spots observed in Screens 1 and 2 may create gaps along the bottom seal, although this was not apparent with the underwater video camera.

Ellensburg Mill

A small hole exists between Panels 1 and 2 where they meet at the bottom. Panel 2 was installed slightly higher than Panel 1. It is unclear whether the hole was open all the way through to the opposite side, but any small gap big enough for a fish to enter is a potential injury site.

Gleed

Impacts from large woody debris at Gleed have damaged some screen material. Screen 4 wires have been bent enough to allow entrainment of small fish. The other screens should be examined closely to make sure they do not have gaps as well, if screen material replacement does not occur prior to the 1998 irrigation season. The screen material currently used at Gleed did not meet NMFS guidelines for mesh opening sizes and may not provide enough entrainment protection for bull trout *(Salvelinus malma)* and resident rainbow trout/steelhead *(Oncorhynchus mykiss)* stocks.

Naches Selah

Sealant appeared to be missing along the bottom seal in several places, including areas under Panel 1, between Panels 1 and 2, and between Panels 3 and 4.

New Cascade

A gap between the screen and the bottom seal, large enough for fish to become entrained, was observed with the underwater video system at Screen 7. Flat spots observed in Screens 6 and 8 may have created gaps along the bottom seal, although this was not apparent with the underwater video camera.

Snipes Allen

Flat spots were observed in Screens 1 and 2 that may have created gaps along the bottom seal, although this was not apparent with the underwater video camera.

Taylor

Small flat spots were observed in Screens 1 and 2 that may have created gaps along the bottom seal. Also, a stick may have punctured one side seal (not identified by screen number), as was shown in Figure 8a.

Toppenish Pump

The upstream seal at Screen 2 was folded underneath the metal frame. All side seals at this site appeared to be too short to adequately span the distance between the frame and the drum. Replacing the side seals for every drum screen with wider ones would ensure that other side seals do not turn under in the future. Underwater video also showed what appeared to be a cracked side seal (not identified by screen number), as was shown in Figure 9.

Upper WIP

Underwater video footage at this site showed a small fish caught in the crack between the screen frame and concrete divider at the downstream end of Screen 3. It may be advisable to seal these gaps with a “soft” seal that is not permanent and that would not hinder raising the drums for storage in the fall, if further evidence of fish injury or death in these small cracks is uncovered.

Submergence

Submergence levels at the screen sites often exceeded 85%. High water levels occurred across the three site visits, not only during the period of high Spring runoff, as shown in Table 7. Eight of 12 drum screen sites experienced high water levels during at least one evaluation. This creates an opportunity for small fish to be carried over the screens and down the canal. Only one operating screen site’s submergence was ever measured at less than 65% submergence. This can keep a screen from properly self-cleaning although this screen site appeared to be free of small debris. Two flat plate screen sites were completely overtopped with water during one evaluation each. Although 1997 was an extreme high-water year, these overtopping events point out that some screens do not completely protect fish under the full range of potential operating conditions. Although it may not be practical using physical barriers to completely prevent entrainment under extreme conditions, every reasonable effort should be made to locate and construct facilities to protect fish during spring freshet conditions. Fish swimming at the water surface could easily enter the irrigation canal during these periods.

Drum screen sites that were observed exceeding 85% submergence are Clark, Congdon, Kelley Lowry, Lindsey, Lower WIP, Naches Cowiche, Snipes Allen, and Taylor (Table 7). The site that was less than 65% submerged was Lower WIP on 4/30/97.

It is highly recommended that marks indicating the range of preferred submergence levels be painted directly on at least one drum screen frame at each site. Operations personnel can then easily determine when a screen is outside the range and make adjustments to headgate settings, porosity boards, or submergence gates (if present) to keep it operating properly and to keep fish out of the irrigation canal.

Flat plate screen sites that were overtopped were Bull and Fruitvale (Table 7).

Table 7. Evaluation Periods When Screen Sites Exceeded 85%

Screen Site	Period 1 (April and May 1997)	Period 2 (June and July 1997)	Period 3 (August 1997)
Drum Screens			
Clark			X
Congdon		X	X
Kelley Lowry			X
Lindsey	X	X	X
Lower WIP		X	
Naches Cowiche		X	
Snipes Allen		X	
Taylor			X
Flat Plate Screens			
Bull	X		
Fruitvale			X

Bypass Outfall Conditions

Water depths at the outfall pipe were acceptable at all but four sites. Clark, Fruitvale, Lindsey, and Upper WIP all had shallow water depths at the pipe exit during at least one evaluation period.

Water depths were low at Clark, Lindsey, and Upper WIP near the end of the irrigation season due to low river flows. However, fish movement in August is usually low and the impacts of shallow water at the bypass outfall are probably negligible. Usually, just a small amount of rock removal around the area next to the outfall pipe would greatly improve the situation. Water was low at Fruitvale at the beginning of the season. A one-foot pipe extension would ensure that fish were safely returned to the creek.

Bypass pipes were often a smaller diameter than recommended by NMFS. The WDFW and BOR have largely disregarded this criterion because they feel it adds unnecessary cost to the projects (Easterbrooks, pers. comm.). Because the sites have trashracks that keep out the large floating debris, these agencies assume that even the smaller pipe diameters will be able to pass the design bypass flow and any debris likely to enter the pipe. We did not observe any bypass pipe blockages during our evaluations. The Lower WIP site, however, did appear to back up water near the pipe entrance. The pipe diameter was measured at just eight inches. Further evaluations should monitor bypass flow at this site, as results from this year's studies are not definitive. Should this pipe size prove to slow fish passage to the river, installation of a wider pipe should be considered.

Predation

Predation of juvenile salmonids at a screen site would be difficult to measure without employing additional expensive and labor-intensive methods of observation. Instead, we gauged the potential for predation by qualitatively measuring the types and amount of cover provided for predators in front of the screens and by recording random observations of fish large enough to be considered predators in the forebay.

Predation is more likely to occur at drum screen sites than at flat plate screen sites because there are more hiding places for large fish to hide at these sites. For example, greater amounts of woody debris tend to accumulate underneath the curvature of the drums and against the concrete walls that divide one screen bay from the next. Screen sites with excessive woody debris were Bachelor Hatton, Congdon, Naches Cowiche, New Cascade, Taylor, Toppenish Pump, and Upper WIP.

Woody debris was also observed in the bypass at Naches Selah and in front of screens at Gleed. The debris at Naches Selah could be considered good cover for predators, but the water velocities at Gleed are high and therefore not conducive to fish lying in wait, making predation unlikely.

Relatively large fish, some of which were potential predator species, were observed with the underwater video camera in the forebays of Bachelor Hatton, Ellensburg Mill, Naches Cowiche, New Cascade, Toppenish Pump, and Upper WIP.

Thus, sites that had both woody debris and large fish present were Bachelor Hatton, Naches Cowiche, New Cascade, Toppenish Pump, and Upper WIP. These four sites should be considered most likely to experience juvenile salmonid loss to predation. Periodic removal of woody debris from underneath the curvature of drum screens could help decrease the likelihood of predation at these sites.

Operations and Maintenance

Screens were well maintained at most sites. Automated cleaning brushes functioned properly, chains and other moving parts were well greased, and inoperative and algae-covered drum screens were repaired and cleaned. However, removal of sediment build-up and accumulated woody debris are areas where improvement should be considered. Sediments blocking the flow of water through the screen can affect sweep and approach velocities and contribute to the increased incidence of screen submergence above 85%. Woody debris that has lodged underneath the curvature of drum screens cannot be seen from above water, but should be removed regularly. Sticks and logs affect flow past the screens and provide cover for piscivorous fish. They can also potentially block bypass pipes.

Maintenance checks should include observation of bypass outfalls on a regular basis, e.g. weekly. Often, the removal of small rocks from the outfall area dramatically improves bypass flow and increases the water depth from the outfall pipe to the channel, allowing fish safe passage from the bypass into the river. Conditions at the end of the bypass pipe are likely to change seasonally, especially in streams with high gradients or unstable gravel. It is also possible that blockages at the end of the bypass pipe could be diagnosed behind the ramp in the fish bypass structure. A visual aid at the bypass structure could identify when a problem at the outfall exists.

Screens were not always operated according to established operating procedures. Bypass flow was not always adequate, and screens were over and under-submerged. We sometimes encountered operations personnel at the sites. Generally, they corrected bypass flows but did not concern themselves with screen submergence. Changes to the screen system were often made subjectively. Gates were opened and closed until water flows “looked right”, not until a particular operating criterion was met. Again, submergence marks on drum screens and marks on the overflow bypass weirs indicating how much water is cresting over the top would be a simple means to enhance compliance with operating procedures. Since screen tenders keep a log of activities, information about submergence and bypass flow could be more easily documented if operator aids were present.

Table 8 summarizes the areas where attention should be directed to improve fish bypass at individual screen sites.

Table 8. Summary of Problem Areas at Individual Screen Sites

	Screen Site	**> 10% of Approach Velocities Exceed 0.4 fps**	**Bypass Flow Slower than Screen Sweep Velocities**	**Damaged Seal or Screen**	**Submergence Outside Criteria at Least Once**	**Excessive Sand, Silt, or Woody Debris**	**Bypass Outfall Sometimes < 1 ft Deep**
Drum Screens	Bachelor Hatton	●	●	●		●	
	Clark				●		●
	Congdon	●		●	●	●	
	Kelley Lowrey				●	●	
	Lindsey				●	●	●
	Lower WIP				●	●	
	Naches Cowiche				●		
	New Cascade			●			
	Snipes Allen			●	●		
	Taylor			●	●	●	
	Toppenish Pump	●		●		●	
	Upper WIP	●	●	●		●	●
Vertical Plate Screens	Bull	●			●		
	Ellensburg Mill			●			
	Fruitvale	●			●		●
	Naches Selah			●			
	Union Gap		●				
	Yakima Tieton	●					
Vertical Traveling Screen	Gleed			●		●	

Conclusion

Planned future work includes monitoring most or all of these 19 sites again in 1998. Two consecutive years of data collection should provide an indication of trends in water flow patterns, excessive debris and siltation problems, bypass outfall conditions, and more. Also in 1998, nets will be set behind screens during early evaluations (early May and late June) to capture juvenile salmonids soon after hatching, when they are smallest and most likely to be entrained.

These screen evaluations are valuable because they provide information that can substantiate the effectiveness of screen operations and maintenance practices for protecting fish. Water velocity measurements and underwater video evaluations also expose areas of concern or potential problems that routine maintenance does not typically reveal.

Also, in the case of new or modified screen sites where operating procedures have not been refined, detailed evaluations can pinpoint areas where the procedures may need to be altered. For example, where operating procedures are in place and being followed but approach velocity, bypass flow, or other parameters do not fall within NMFS criteria, evaluations will identify the problem areas and alert screen operators that the reasons for noncompliance should be investigated. For example, actual canal water usage might be examined to confirm that irrigators are not drawing more water than they are allowed. If all possibilities have been explored and no reasons for the problems are found then operating criteria should be modified to meet NMFS criteria and to protect fish.

An ideal fish screening program combines routine operations and maintenance with a monitoring program to evaluate the effectiveness of these practices at protecting fish at individual screen sites. By including water velocity and underwater video evaluations in the process, the greatest protection will be provided for fish.

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Appendix A – Site Descriptions

Appendix A - Site Descriptions[1]

Rotary Drum Screens

1. Bachelor Hatton

Originally two separate diversions from Ahtanum Creek, the Bachelor Creek and Hatton Creek diversions were combined in 1994. The new diversion is about 50 cubic feet per second (cfs) and is screened just downstream from the headgates. Fish are bypassed back to Ahtanum Creek.

The screening facility includes four rotary drum screens that are each 4 feet in diameter by 12 feet long. Screens are constructed of 6-14 stainless steel wire mesh (nominal 3/32-inch openings). They are in operation any time diversions are being made from Ahtanum Creek.

The bypass is a full-depth, 18-inch wide rectangular channel that is 11 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into 3-foot wide by 8-foot long downwell. Bypass flows are then conveyed through a 15-inch diameter PVC pipe for 182 feet to the river.

[1] Site descriptions are taken in part from the Designer's Operating Criteria developed for individual fish screening facilities by the Unites States Department of the Interior Bureau of Reclamation, Pacific Northwest Regional Office in Boise, Idaho, and from the Washington Department of Fish and Wildlife Fish Facilities Operating Criteria/Procedures.

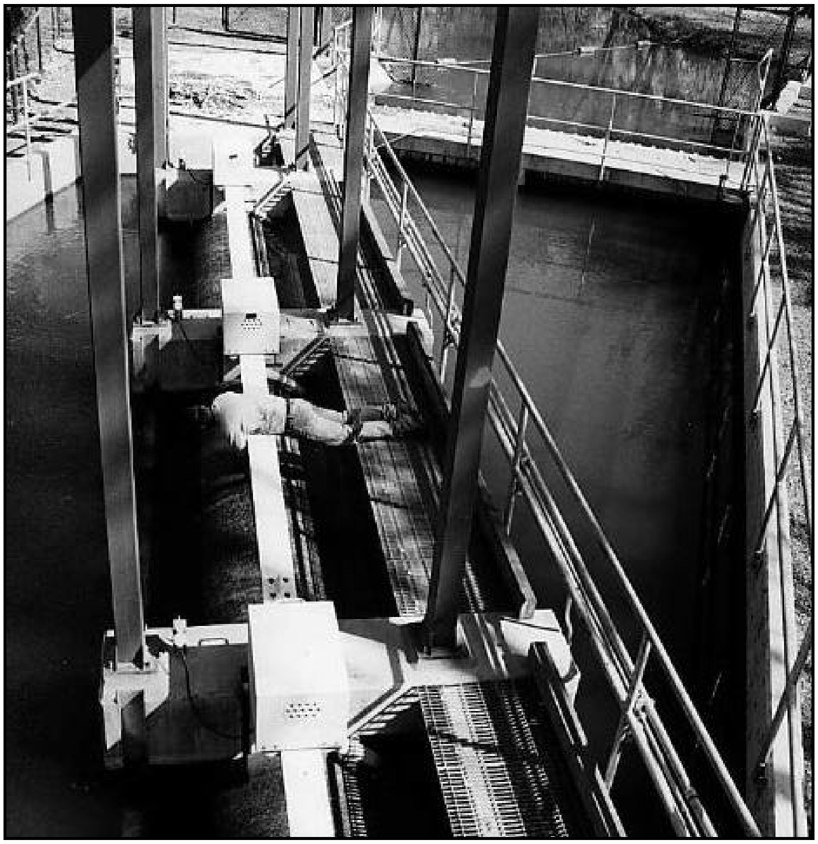
2. Clark

The Clark Ditch Diversion (approximately 10 cfs) is located on the left bank of the Naches River near Naches, Washington.

The screening facility consists of one rotary drum screen that is 3 feet in diameter by 8 feet long. The screen is constructed of perforated plate with 3/32 inch diameter holes on 5/32 inch staggered centers.

The bypass is a full-depth, 18-inch wide rectangular channel that is 9.5 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into 3-foot wide by 6-foot long downwell. Bypass flows are then conveyed through a 15-inch diameter PVC pipe for 123 feet to the river.

3. Congdon

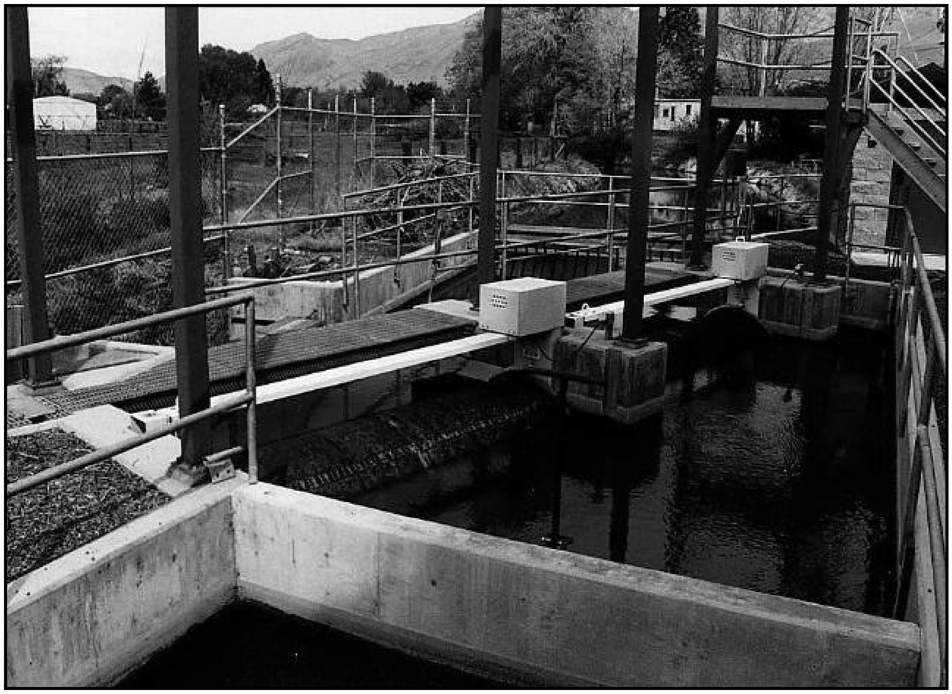


The Congdon canal diversion (approximately 55 cfs) is located on the right bank of the Naches River about 4 miles east of Naches, Washington and adjacent to Eschbach Park.

The screening facility includes three rotary drum screens that are each 4 feet in diameter by 12 feet long. Screens are constructed of 4.5 mesh by 12 gauge (4.5-12) stainless steel woven wire mesh. The openings are approximately 1/8 inch.

The bypass is a full-depth, 18-inch wide rectangular channel that is 11 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into 3-foot wide by 8-foot long downwell. Bypass flows are then conveyed through a 12-inch diameter PVC pipe to the outfall.

4. Kelley Lowry



The Kelley Lowry diversion (approximately 40-50 cfs) is located on the left bank of the Naches River (north channel) near Naches, Washington. The current Kelley Lowry fishscreen facility (improved during the 1993/94-construction period) replaces the screens originally placed at each ditch and consolidates them into one facility upstream of the separation of the two ditches.

The facility now consists of two rotary drum screens, each 4 feet in diameter by 12 feet long. The drum screens are constructed of 4.5-12 woven wire mesh (1/8-inch openings).

The bypass entrance channel is a full-depth, 18-inch wide rectangular channel that is 10.5 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into a 3-foot wide by 8-foot long downwell. Bypass flows are then conveyed to the Naches River through a ~15-inch diameter PVC pipe for 5 feet to the river.

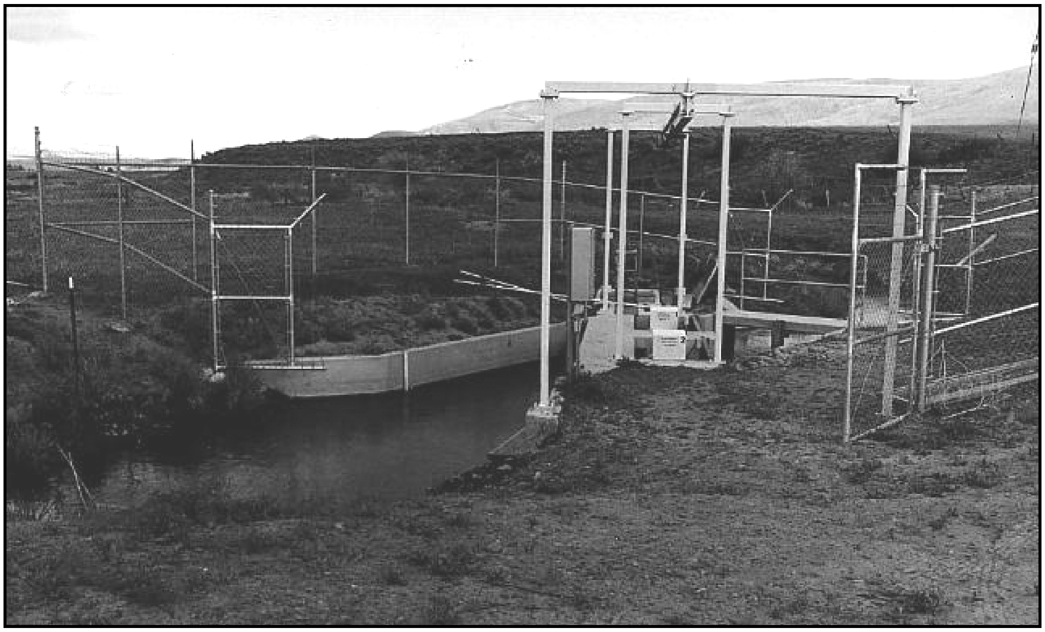
5. Lindsey

The Lindsey Ditch Diversion (approximately 20 cfs) is located on the right bank of the Naches River about two miles upstream of the Rattlesnake Creek confluence in Yakima County, Washington. The current Lindsey fishscreen facility replaces a screen that did not adequately protect juvenile and adult anadromous fish during canal diversions.

The facility now consists of one rotary drum screen, 3 feet in diameter by 12 feet long. The screen is constructed of perforated stainless steel with 3/32-inch diameter holes on 5/32-inch staggered centers.

The bypass entrance channel is a full-depth, 18-inch wide rectangular channel that is 9 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into 3-foot wide by 6-foot long downwell. Bypass flows are then conveyed to the Naches River through an 18-inch diameter PVC pipe for 27 feet to the river.

6. Lower WIP



The Lower WIP Canal Diversion (built to handle just 6.4 cfs) is located on the right bank of Ahtanum Creek about 1.5 miles south of the town of Ahtanum, Washington. The current Lower WIP Fishscreen Facility was installed around 1993 because no fish protective facilities were present at the site.

The facility now consists of two rotary drum screens, each 2 feet in diameter by 6 feet long. The screen panels are constructed of perforated stainless steel with 1/8-inch diameter holes.

The bypass entrance channel is a full-depth, 12-inch wide rectangular channel. Bypass flows are then conveyed 120 feet to the Ahtanum Creek through an 8-inch diameter PVC pipe.

7. Naches Cowiche

The Naches Cowiche canal diversion (approximately 40 cfs) is located on the left bank of the Naches River near the city of Yakima, Washington. The current Naches Cowiche screen and bypass replace a facility that did not meet design criteria for the approach velocity and attraction flows.

The facility now consists of two rotary drum screens, each 5feet in diameter by 12 feet long. The screens are constructed of 4.5-12 stainless steel woven wire mesh (1/8-inch openings).

The bypass entrance channel is a full-depth, 18-inch wide rectangular channel that is 8.5 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into 3-foot wide by 8-foot long downwell. Bypass flows are then conveyed through an 18-inch diameter PVC pipe for 203 feet to the river.

8. New Cascade

The New Cascade Canal Diversion (approximately 150 cfs) is located on the left bank of the Yakima River about 7 miles northwest of the city of Ellensburg, Washington. The current New Cascade fishscreen facility is an improvement over the old facility, which had an inadequate bypass and severely rusted screens.

The facility consists of eight rotary drum screens, each 6 feet in diameter by 10 feet long. The screens are constructed of 4.5-12 stainless steel woven wire mesh (1/8-inch openings).

The bypass entrance channel is a full-depth, 18-inch wide rectangular channel that is 15 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into a 3-foot wide by 9-foot long downwell. Bypass flows are then conveyed through an 18-inch diameter PVC pipe for 101 feet to the river.

9. Snipes Allen

The Snipes Allen canal diversion (approximately 25-30 cfs) is located on the left bank of the Yakima River near Buena, Washington. The current Snipes Allen fishscreen facility was completed in 1993.

The facility now consists of two rotary drum screens, each 4 feet in diameter and 12 feet long. The screens are constructed of 4.5-12 woven wire mesh (1/8-inch openings).

The bypass entrance channel is a full-depth, 18-inch wide rectangular channel that is 10 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into 3-foot wide by 8-foot long downwell. Bypass flows are then conveyed through an 18-inch diameter PVC pipe for approximately 500 feet to the river.

10. Taylor

The Taylor Ditch diversion (approximately 10 cfs) is located on the right bank of the Yakima River about 5 miles northeast of Selah, Washington. The fishscreen is located on the canal, downstream from the diversion dam. The Taylor fishscreen facility was completed in 1993.

The facility now consists of two rotary drum screens, each 2.5 feet in diameter and 8 feet long. The screens are constructed of perforated plate with 1/8-inch diameter holes on 5/32-inch staggered centers.

The bypass entrance channel is a full-depth, 12-inch wide rectangular channel that is 9.5 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into a 3-foot wide by 8-foot long downwell. Bypass flows are then conveyed through a 10-inch diameter PVC pipe for 90 feet to the Yakima River.

11. Toppenish Pump

The Toppenish Pump diversion (about 90 cfs) is located on the right bank of Toppenish Creek in Yakima County, Washington. There was no screening facility at the site prior to construction of the current facility.

The facility consists of six rotary drum screens, each 5 feet in diameter by 12 feet long. The screens are constructed of 4.5-12 woven wire mesh (1/8-inch openings).

The bypass entrance channel is a full-depth, 18-inch wide rectangular channel that is 13 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into an L-shaped downwell. The two sections are 3 feet wide by 6.5 feet long and 3 feet wide by 8.5 feet long. Bypass flows are then conveyed through a 24-inch diameter PVC pipe for 232 feet to the river.

12. Upper WIP

The Upper WIP canal diversion (approximately 40 cfs) is located on the right bank of Ahtanum Creek about 12 miles southwest of Yakima, Washington within the Yakima Indian Reservation. The screens are located on the canal, about 70 feet downstream from the diversion. There was no screening facility at the site prior to construction of the current facility in 1996 and 1997.

The facility consists of four rotary drum screens, each 4 feet in diameter and 12 feet long. The screens are constructed of 4.5-12 stainless steel woven wire mesh. This provides clear openings of 0.117 inch and a net open area of 20 percent.

The bypass entrance channel is a full-depth, 18-inch wide rectangular channel. An adjustable weir gate at the end of this channel controls flows that then drop into a 3-foot wide by 9-foot long downwell. Bypass flows are then conveyed through a 21-inch diameter PVC pipe for 475 feet to Ahtanum Creek.

Fixed Plate Screens

1. Bull


The current Bull Diversion fishscreen facility (improved during the 1996/97 construction period) replaces a drum screen that did not meet design criteria for the protection of juvenile and adult anadromous fish during canal diversions. The Bull ditch diversion (approximately 20 cfs) is located on a side channel on the left bank of the Yakima River about 1 mile southwest of the city of Ellensburg, Washington.

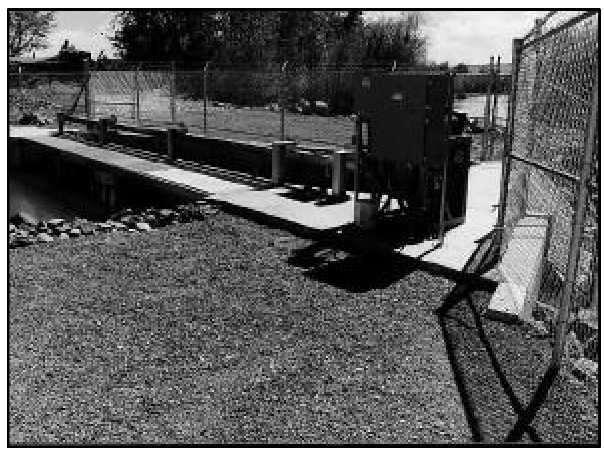
The facility is comprised of two vertical flat plate screens, each 6 feet high by 13 feet long. The screen panels are constructed of perforated plate stainless steel with 3/32-inch diameter holes spaced on 5/32-inch centers.

No fishscreen bypass is required at this site since the screen is located at the entrance to the diversion. The screen is cleaned using a motor-driven ganged brush cleaning system.

2. Ellensburg Mill

The Ellensburg Mill canal diversion is located on a side channel of the Yakima River about 2 miles west of the city of Ellensburg, Washington. The current Ellensburg Mill fishscreen facility (improved during the 1996/97 construction period) replaces a drum screen that did not meet design criteria for the protection of juvenile and adult anadromous fish during canal diversions.

The facility now consists of three vertical flat plate screen panels, each 6 feet high by 12 feet long. The screens are constructed of 0.069-inch (1.75-mm) wedge wire fabric placed with slots oriented vertically. Control baffles installed immediately downstream of these panels allow flows to be regulated to maintain uniform approach velocities.



A mechanical cleaning brush moves back and forth over the length of the screen to keep the screen free of debris.

The bypass entrance channel is a full-depth, 18-inch wide rectangular channel that is 8 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into 3-foot wide by 6-foot long downwell. Bypass flows are then conveyed through a 16-inch diameter PVC pipe for 72 feet to the river.

3. Fruitvale

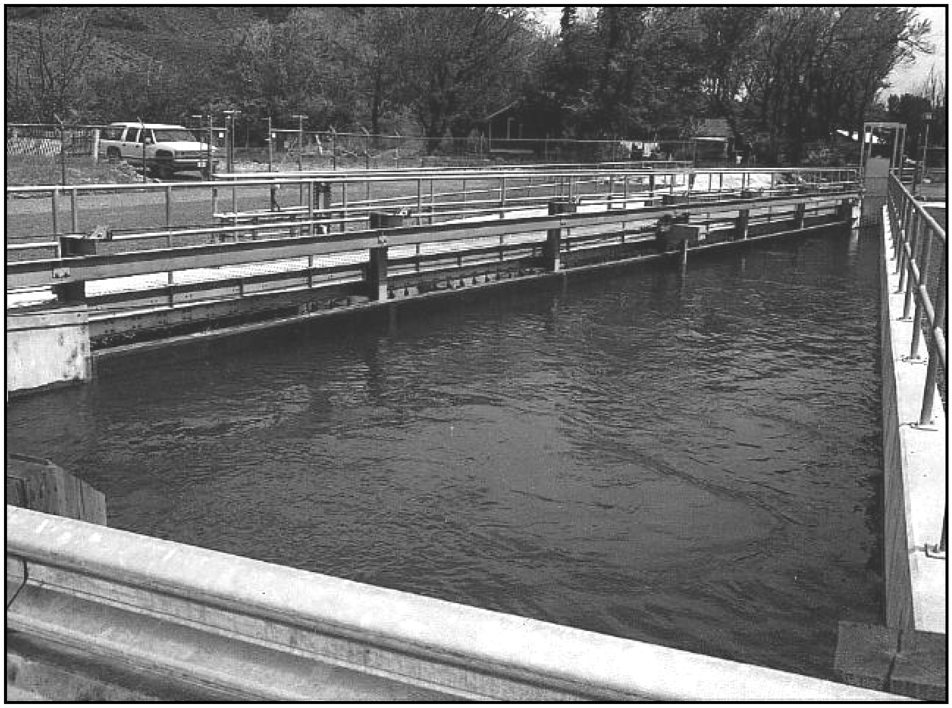
The Fruitvale canal screen (approximately 100 cfs) is located on the right bank of the Naches River near Yakima, Washington.

The facility now consists of two vertical flat plate screen panels, each 4.5 feet high by 14 feet long. The screen panels are constructed of perforated stainless steel with 3/32-inch diameter holes spaced on 5/32-inch centers. Control baffles installed immediately downstream of these panels allow flows to be regulated to maintain uniform approach velocities.

A mechanical cleaning brush moves back and forth over the length of the screen to keep the screen free of debris.

The bypass entrance channel is a full-depth, 18-inch wide rectangular channel that is 10 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into 3-foot wide by 9-foot long downwell. Bypass flows are then conveyed to the Naches River through a 18-inch diameter PVC pipe for 70 feet to the river.

4. Naches Selah



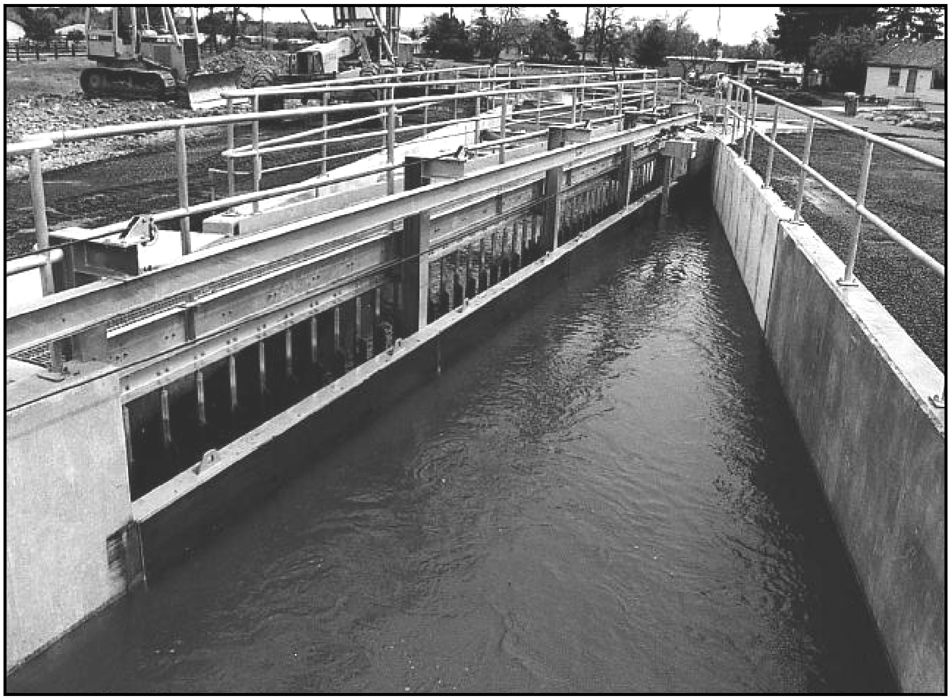
The Naches Selah canal diversion (approximately 175 cfs) is located on a left bank of the Naches River about ½ mile upstream of the Tieton River confluence in Yakima County, Washington. The current Naches Selah fishscreen facility (improved in 1995) replaces a drum screen that did not meet design criteria for the protection of juvenile and adult anadromous fish during canal diversions.

The facility now consists of six vertical flat plate screen panels, each 6 feet high by 13.5 feet long. The screens are constructed of 0.069-inch (1.75-mm) wedge wire fabric placed with slots oriented vertically. Control baffles installed immediately downstream of these panels allow flows to be regulated to maintain uniform approach velocities.

A mechanical cleaning brush moves back and forth over the length of the screen to keep the screen free of debris.

The bypass entrance channel is a full-depth, 24-inch wide rectangular channel that is 11 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into 4-foot wide by 10-foot long downwell. Bypass flows are then conveyed through a 24-inch diameter PVC pipe for 220 feet to the river.

5. Union Gap



The Union Gap canal diversion (approximately 50 cfs) is located on the left bank of the Yakima River about 1.5 miles downstream of the Naches River confluence near Yakima, Washington. The fish screens are located on the canal, about ½ mile downstream from the diversion. The current Union Gap fishscreen facility (improved during the 1995 and 1996) replaces a drum screen that did not meet design criteria for the protection of juvenile anadromous fish during canal diversions.

The facility now consists of four vertical flat plate screen panels, each 5 feet high by 11 feet long. The screens are constructed of 0.069-inch (1.75-mm) wedge wire fabric placed with slots oriented vertically. Control baffles installed immediately downstream of these panels allow flows to be regulated to maintain uniform approach velocities.

A mechanical cleaning brush moves back and forth over the length of the screen to keep the screen free of debris.

The bypass entrance channel is a full-depth, 18-inch wide rectangular channel that is 10 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into an angled downwell with sections that are 3 feet wide by 4.5 feet long and 3 feet wide by 5 feet long. Bypass flows are then conveyed through a 15-inch diameter PVC pipe for 153 feet to the Roza Wasteway.

<u>**6. Yakima Tieton**</u>

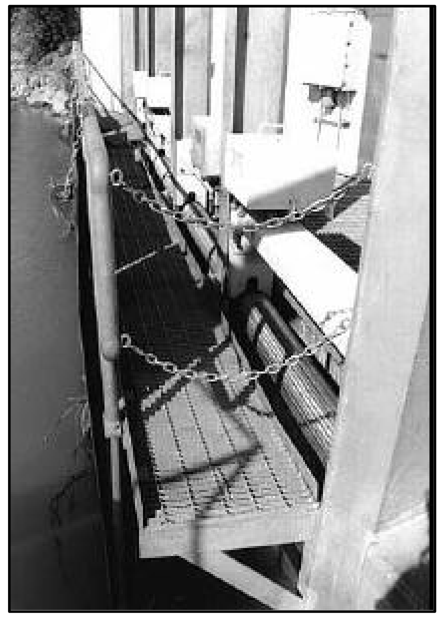
The Yakima Tieton canal diversion (approximately 250 cfs) is located on the right bank of the Tieton River about 7 miles downstream of Tieton Dam near Rimrock, Washington. The current facility (built during the 1996/1997 winter season) replaces a structure that did not meet design criteria for the protection of juvenile and adult anadromous fish.

The facility consists of 12 vertical flat plate screen panels, each 7 feet high by 12 feet long. The panels are constructed of 0.069-inch (1.75-mm) wedge wire fabric with slots oriented vertically. Control baffles are incorporated immediately downstream from the screen panels to regulate flow as needed to maintain uniform approach velocity at the screen.

The bypass entrance channel is a full-depth, 24-inch wide rectangular channel that is 16 feet long. An adjustable weir gate at the end of this channel controls flows that then drop into 3-foot wide by 8-foot long downwell. Bypass flows are then conveyed through a 27-inch diameter PVC pipe for 316 feet to the Tieton River.

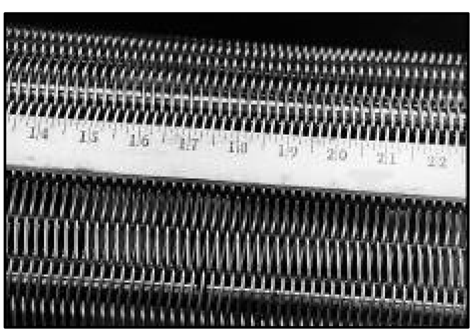
Vertical Traveling Screen

1. Gleed



The Gleed Ditch screens are located on the left bank of the Naches River near Naches, Washington. The current Gleed Ditch fishscreen facility replaces screens that did not meet design criteria for the protection of juvenile and adult anadromous fish during canal diversions.

The facility now consists of four vertical traveling screens, each 6.6 feet wide and 10 feet long. The stainless steel, continuous belt screen material is made from 14 gauge wire and has 5 loops or openings per inch (horizontal) and 1.5 openings per inch (vertical). The openings are 1/8 inch wide by 5/8 inch long. Because it is constructed of continuous-looped (spiral) wire, the openings are staggered so that the loops overlap. For a fish to be entrained, it would have to pass diagonally through the screen. Because of the new criteria dictating 3/32-inch openings, the Gleed screening material will be changed to a plastic belt material that meets the new criteria for the 1998 season (Easterbrooks, pers. comm.).



No bypass is required at this site since the screen is located at the entrance to the diversion.