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

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Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

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Yakima River Basin Phase II Fish Screen Evaluations, 2003

J. A. Vucelick
G. A. McMichael
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Prepared for the U.S. Department of Energy
Bonneville Power Administration
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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

In 2003, the Pacific Northwest National Laboratory (PNNL) evaluated 23 Phase II fish screen sites in the Yakima River Basin as part of a multi-year project for the Bonneville Power Administration on the effectiveness of fish screening devices. PNNL collected data to determine whether velocities in front of the screens and in the bypasses met the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries, formerly the National Marine Fisheries Service [NMFS]) criteria to promote safe and timely fish passage. In addition, PNNL conducted underwater video surveys to evaluate the environmental and operational conditions of the screen sites with respect to fish passage.

Based on evaluations in 2003, PNNL concluded that:

- In general, water velocity conditions at the screen sites met fish passage criteria set by the NOAA Fisheries.
- Conditions at most facilities would be expected to provide for safe juvenile fish passage.
- Conditions at some facilities indicate that operation and/or maintenance should be modified to improve juvenile fish passage conditions.
- Automated cleaning brushes generally functioned properly; chains and other moving parts were typically well greased and operative.
- Removal of sediment buildup and accumulated leafy and woody debris could be improved at some sites.

Acknowledgments

The successful completion of this project depended on the involvement and cooperation of many people. David Byrnes, Bonneville Power Administration, directed the project. John Easterbrooks, Ray Gilmour, David Floyd, and Pat Schille of the Washington Department of Fish and Wildlife, and Tom Leonard of the U.S. Bureau of Reclamation provided valuable background information on the sites and also comments on the operation and maintenance of individual sites. Traci Degerman, PNNL, and Jennifer Panther, Tara Schwartz, and Adam Sealock, PNNL Office of Fellowship Programs Fellows, assisted with the field work.

Acronyms

ADV	acoustic Doppler velocimeter
BPA	Bonneville Power Administration
cfs	cubic feet per second
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPPC	Northwest Power Planning Council
PNNL	Pacific Northwest National Laboratory
RMS	root-mean-square
USBR	U.S. Bureau of Reclamation
WDFW	Washington Department of Fish and Wildlife
WIP	Wapato Irrigation Project

Contents

Figures

Tables

1.0 Introduction

Irrigation has played an important role in the development of the middle Columbia River Basin. Water has been diverted from western rivers since the mid-1850s to irrigate crops. During the 1920s, some of these diversions were equipped with fish protection devices, but it wasn't until the Mitchell Act of 1938 provided funding to protect fish that screening irrigation diversions and evaluating their effectiveness truly got under way (Bryant and Parkhurst 1950).

In more recent history, the Bonneville Power Administration (BPA), under guidance from the Northwest Power Planning Council (NPPC), expanded screening efforts to protect and enhance fish populations. The NPPC's Columbia River Fish and Wildlife Program lists effective screening of irrigation diversions as an essential element in their plan to restore declining steelhead and salmon runs (NPPC 1984, 1987, 1994, 2000).

Research on the effectiveness of fish screening devices initiated changes in design and operating procedures of screening facilities over the years. For example, maximum allowable screen size openings decreased as protecting fish at their earliest developmental stages became a concern. These and other new requirements for fish protection are developed by the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) (formerly National Marine Fisheries Service [NMFS]) and adopted by individual state agencies. In addition, the BPA has established a monitoring and evaluation program to ensure that new and updated screening facilities meet current fish protection standards.

As a part of the BPA's monitoring and evaluation program, Pacific Northwest National Laboratory (PNNL) researchers have conducted fish screen evaluations in the Yakima Basin since 1985. Initially, PNNL monitored Phase I screening facilities to determine whether fish that entered irrigation canals were diverted back to the river safely (Neitzel et al. 1985, 1986, 1988, 1990a, 1990b). Additional studies examined water velocities in front of the screens to determine whether NOAA Fisheries criteria were being met (Abernethy et al. 1990). Two studies conducted at PNNL's Aquatic Laboratory in Richland, Washington, used modular drum screens constructed by the Washington Department of Fish and Wildlife (WDFW) to determine fish survival through submerged orifices and the relative effectiveness of two screen configurations at bypassing fish (Abernethy et al. 1996; Neitzel et al. 1997). The methods currently used for evaluating screening facilities were developed while conducting these earlier studies (Blanton et al. 1998, 1999; Chamness et al. 2001; Carter et al. 2002).

As the Phase II screening program continued, more sites were evaluated by PNNL for the BPA. In 2000, 21 Phase II sites were evaluated. The Powell-LaFortune and Wilson Creek sites were added in 2001 for a total of 23 sites. No sites were added in 2002 or 2003. The evaluations of these sites addressed two main questions:

1. Are screens designed, operated, and maintained to meet NOAA Fisheries criteria over a wide range of conditions?

2. Are screen sites effective at protecting fish from injury and from unnecessary migration delay?

2.0 Methods

Twenty-three operating screen sites in the Yakima, Naches, and Tieton River basins were evaluated three times between May 6 and September 19, 2003. PNNL researchers collected three types of data at each site, based on criteria set by the NOAA Fisheries for Phase II fish screen facilities. The types of data collected include water velocity measurements, underwater video, and general operational data (e.g., screen submergence, bypass conditions, fish presence).

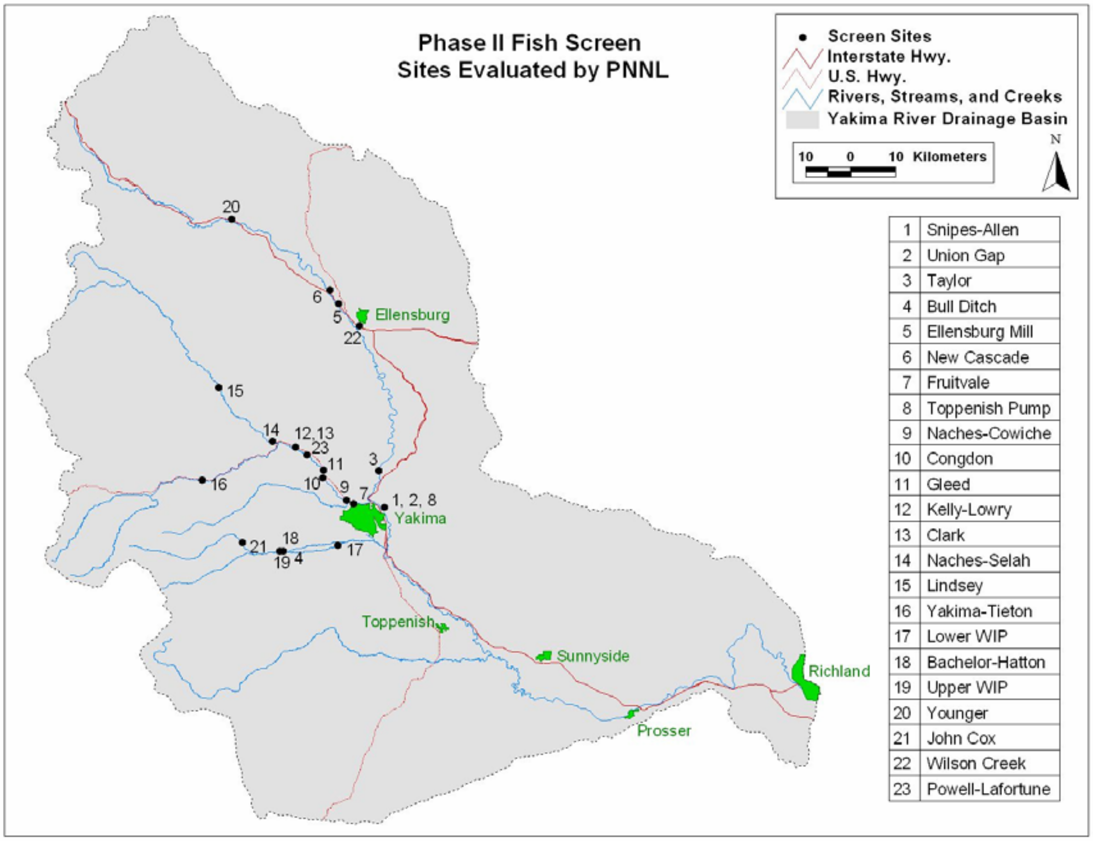

Figure 1. Yakima River Basin Phase II Fish Screen Facilities

The NOAA Fisheries criteria for Phase II fish screen sites define velocity and general operational conditions that would be expected to promote safe fish passage through Phase II screen sites (NMFS 1995). These include the following:

- A uniform flow distribution over the screen surface to minimize approach velocity.
- Approach velocities less than or equal to 0.4 ft/s.
- Sweep velocities that are greater than approach velocities.

- A bypass flow greater than or equal to the maximum flow velocity vector resultant upstream of the screens (generally the sweep velocity).

- A gradual and efficient acceleration of flow from the upstream end of the site into the bypass entrance to minimize delay of emigrating salmonids.

- Screen submergence between 65% and 85% for drum screen sites.

In addition, the NOAA Fisheries states that silt and debris accumulation should be kept to a minimum. For this report, the accumulation of silt and/or debris was considered excessive if the intersection of the seal and the screen was buried. Screen operators should try to achieve these criteria at all sites throughout the year. In this report, PNNL generally compared the field measurements of water velocity, underwater video, and general data collection results for each screen site to the NOAA Fisheries criteria. The following sections detail how each type of data was collected and Section 3.0 contains the results of the comparisons for each site.

2.1 Water Velocity Measurements

2.1.1 Equipment

With the exception of some locations at Ellensburg Mill, water velocities in front of the screens and in the bypass were measured using a SonTek acoustic Doppler velocimeter (ADV). The ADV emits sound at 10 kHz. The frequency of the returning sound waves increases or decreases depending on whether the water is flowing towards or away from the ADV receiver. The difference between the emitted frequency and the received frequency is used to calculate the velocity of the water. The probe uses three receivers extending out at an angle from the transmitter to calculate the three-dimensional water velocity at a point 10 cm below the probe. Figure 2 shows the ADV probe.

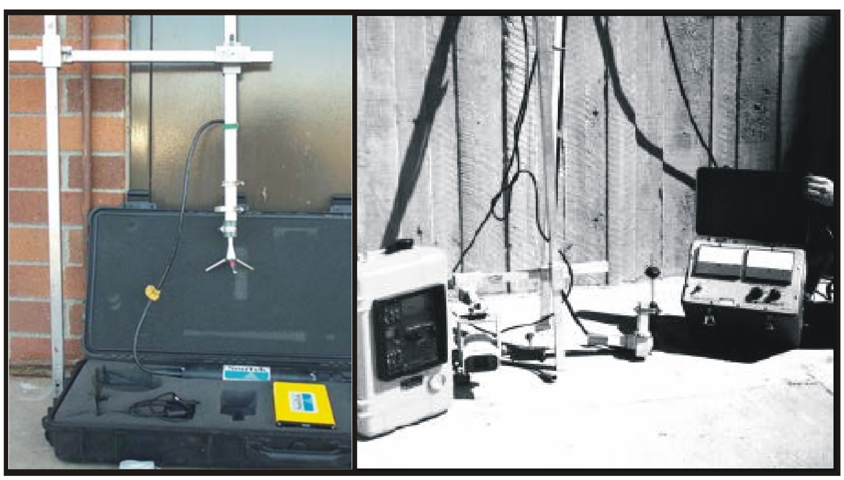

Figure 2. Acoustic Doppler Velocimeter Probe Equipment (left) and Marsh-McBirney 511® Velocity Meter (far right)

The ADV probe was securely mounted to a horizontal metal arm that extended approximately 12 in. from a vertical pole. The probe was oriented into the current with the support assembly downstream or off to the side to minimize interference from the vertical pole when taking velocity readings. The length of the horizontal arm and its position on the vertical pole were adjustable. Velocities were typically recorded at each sampling point along the screen for 40 s at a rate of 2 Hz and stored in a computer file.

When the water was too shallow or there was too much vegetation or debris in the forebay, water velocities were measured using a Marsh-McBirney Model 511® electromagnetic water current meter. The meter uses a bi-directional probe that allows measurement of velocities in two directions (approach and sweep) simultaneously. Output was read visually from a panel gauge and recorded. Figure 2 shows the Marsh-McBirney probe on the right.

2.1.2 Data Collection and Analyses

Measurements of water velocity were taken at three to five evenly spaced points along the front of each screen and in the entrance to the bypass. The vertical pole was placed close to the front of the screen but not allowed to come in contact with the screen surface. The probe was positioned as close to the screen surface as possible, usually about 3 in., though it was impossible to get that close in some cases. The height that the probe was set from the bottom depended on the depth of water in the forebay. In cases where the forebay depth was less than 48 in., one set of measurements was taken at 0.6 × depth from the surface. In cases where the forebay depth was greater than or equal to 48 in., measurements were taken at two depths (0.2 × depth from the surface and 0.8 × depth from the surface). All measurements were taken with the axes of the probe oriented to measure water flowing parallel (sweep) and perpendicular (approach) to the screen face.

Flow measurements were taken in front of every screen during site visits. Automatic cleaning brushes were usually turned off during velocity measurements, while drum screens were allowed to operate as normal during measuring. Average sweep and approach velocities were calculated for each visit to each site, and seasonal averages were calculated at the end of all surveys.

Graphical representations of velocity data include lines for mean sweep and approach velocity measurements, a reference line at 0.4 ft/s (which represents the NOAA Fisheries criteria for approach velocity), and a shaded area representing sediment accumulation in front of the screens as estimated with the support pole for the velocity probe, where the pole came to rest on the sill and in the bypass. The error bars on the velocity graphs represent the root-mean-square (RMS) of the turbulent velocity fluctuations about the mean velocity. The RMS value is equal to the standard deviation of the individual velocity measurements.

2.2 Underwater Video

2.2.1 Equipment

An underwater video system was used to investigate screen seal condition and to monitor debris buildup and fish presence. The video system consisted of a digital deep-sea camera (DeepSea Power and

Light, Inc., model MULTI-SEACAM 1050) connected to a digital video recorder (Sony Video Walkman, model GV-D800), which in turn was connected to a pair of video glasses (Olympus Eye-Trek, model FMD-200) (Figure 3). The advantage of this system was that it allowed the person operating the camera to see what they were recording while in the field, thus providing better video quality and a greater potential for problem identification. In addition, the end product of this system was digital video which greatly improved the quality of still pictures captured from the video.

Figure 3. Underwater Video System

2.2.2 Data Collection and Analyses

The camera was securely mounted on a vertical pole and adjusted as needed at each site. The camera was usually angled slightly downward to look for potential gaps between the screen and the bottom seal. The camera was usually moved from upstream to downstream, following the side and bottom seal/screen interfaces. The bypass was also inspected, looking both upstream and downstream for signs of excessive debris or fish presence.

Written observations were made in the field when something of interest was seen with the camera (i.e., debris, gaps, and fish). All videos were later reviewed in detail, and images of interest were digitally captured using Optimas™ software.

2.3 General Data

Additional data collected during each evaluation included the following:

- General site descriptions and photographs
- Screen and seal conditions
- Screen submergence levels
- Cleaning system operation and the incidence of head loss across the screen face
- Bypass flow conditions
- Bypass outfall conditions
- Fish presence
- Observations of debris in the forebay, bypass, or outfall

- Presence or absence and condition of operator control aids such as water gauges and drum submergence marks on screen frames.

2.4 Problem Tracking

The problem identification and tracking program implemented in 2002 in response to comments from the Independent Scientific Review Panel provided increased accountability of operations and maintenance in cases when problems were fixable within the season. Agency response ranged from excellent to poor, but overall, the program seems to aid in serving fish passage and protection goals. When a problem such as a blocked bypass or excessive debris was identified at a screen site, the responsible agency was notified immediately by the field personnel and asked notify PNNL when the issue was rectified or when a repair schedule was implemented (Table 1). When PNNL received notice that a problem had been fixed, a team was sent to the site to re-evaluate whether operating conditions met NOAA Fisheries criteria for safe fish passage. This protocol was also used during the 2003 evaluations.

Table 1. Agency Responsible for the Operation and Maintenance of Each Fish Screen Facility. WIP = Wapato Irrigation Project; USBR = U.S. Bureau of Reclamation; WDFW = Washington Department of Fish and Wildlife.

Fish Screen Facility	Responsible Agency
Bachelor-Hatton	USBR
Bull Ditch	WDFW
Clark	WDFW
Congdon	WDFW
Ellensburg Mill	WDFW
Fruitvale	WDFW
Gleed	WDFW
John Cox	USBR
Kelly-Lowry	WDFW
Lindsey	WDFW
Lower WIP	USBR
Naches-Cowiche	WDFW
Naches-Selah	WDFW
New Cascade	WDFW
Powell-LaFortune	WDFW
Snipes-Allen	WDFW
Taylor	WDFW
Toppenish Pump	USBR
Union Gap	WDFW
Upper WIP	USBR
Wilson Creek	USBR
Yakima-Tieton	USBR
Younger	WDFW

3.0 Results and Discussion

This section presents the overall results first and then describes each site in more detail. The site-by-site descriptions are organized into three groups: rotary drum screens, flat-plate screens, and vertical traveling screens.

3.1 Overall Results

3.1.1 Water Velocity Measurements

Although velocities often fluctuated widely from site to site and over time, average sweep velocities for the year exceeded average approach velocities for the year (Table 2). Only 2 out of 23 screen sites had mean approach velocities greater than the mean sweep velocities in 2003. Mean approach velocities were generally below the NOAA Fisheries criteria of less than or equal to 0.4 ft/s. The number of sites with average approach velocities greater than 0.4 ft/s decreased from 9 in 2002 to 3 in 2003, and the sites that had average approach velocities greater than 0.4 ft/s were the same sites that exceeded the criteria over the past several years (Table 3). The number of sites that had bypass velocities that were slower than sweep velocities increased from 9 in 2002 to 14 in 2003 (Table 4, Figure 4).

Overall, 94% of all approach velocity measurements met the NOAA Fisheries approach criteria of less than or equal to 0.4 ft/s (4% more than in 2002). This was slightly lower than the 97% reported in 2001; however, 2001 was an exceptionally low-water year, and many sites did not have enough water to meet other criteria, such as submergence and bypass flow. Similar conditions existed in 2003, with many sites unable to meet bypass flow requirements. Areas of the screen (i.e., top, bottom, upstream, downstream) that exceeded approach criteria were dependent on factors at the individual sites.

Water velocities at each site were often highly variable, both spatially and temporally. Flows were typically not uniform over screen surfaces. Often, there were distinct differences between top and bottom approach velocity values, but there was no obvious pattern associated with those differences.
To standardize problem reporting, PNNL calculated average velocities for each screen site for each evaluation and for the whole season. Sites with greater than 10% of approach velocities greater than 0.4 ft/s were considered to be in violation of NOAA Fisheries criteria (Table 4). Also, considering season averages, sweep velocity was greater than approach velocity at all except 2 sites (Table 2, Figure 4). However, 14 of the 23 sites had bypass velocities that were slower than the average sweep (Table 4, Figure 4). This is much worse than patterns observed last year and is an area of concern because slow bypass velocities relative to sweep velocities could result in migration delay.

Table 2. Mean Sweep and Approach Velocities (± standard deviation (S.D.) at Phase II Fish Screen Facilities in the Yakima River Basin in 2003. WIP = Wapato Irrigation Project.

Screen Type	Site	Mean Sweep Velocity ± S.D.	Mean Approach Velocity ± S.D.	Ratio of Sweep to Approach
Drum Screens	Bachelor-Hatton	0.66 ± 0.34	0.18 ± 0.11	3.67
	Clark	0.26 ± 0.15	0.11 ± 0.07	2.36
	Congdon	0.57 ± 0.11	0.31 ± 0.05	1.84
	John Cox	0.54 ± 0.42	0.27 ± 0.28	2.00
	Kelly-Lowry	0.58 ± 0.15	0.24 ± 0.05	2.42
	Lindsey	0.3 ± 0.05	0.25 ± 0.08	1.20
	Lower WIP	0.19 ± 0.13	0.21 ± 0.15	0.90
	Naches-Cowiche	0.51 ± 0.11	0.20 ± 0.05	2.55
	New Cascade	0.52 ± 0.17	0.20 ± 0.07	2.60
	Powell-LaFortune	0.53 ± 0.19	0.13 ± 0.07	4.08
	Snipes-Allen	0.33 ± 0.12	0.21 ± 0.06	1.57
	Taylor	0.31 ± 0.17	0.15 ± 0.09	2.07
	Toppenish Pump	0.77 ± 0.43	0.10 ± 0.18	7.70
	Upper WIP	1.16 ± 0.40	0.20 ± 0.16	5.80
	Wilson Creek	0.48 ± 0.14	0.21 ± 0.07	2.29
Vertical plate screens	Bull Ditch	0.54 ± 0.49	0.16 ± 0.13	3.38
	Ellensburg Mill	0.21 ± 0.16	0.06 ± 0.05	3.50
	Fruitvale	0.45 ± 0.18	0.17 ± 0.05	2.65
	Naches-Selah	1.04 ± 0.22	0.26 ± 0.15	4.00
	Union Gap	1.12 ± 0.21	0.28 ± 0.09	4.00
	Yakima-Tieton	1.67 ± 0.45	0.25 ± 0.10	6.68
	Younger	0.55 ± 0.28	0.21 ± 0.07	2.62
Vertical travelling screen	Gleed	0.16 ± 0.83	0.30 ± 0.24	0.53

Table 3. Annual Percent of Approach Velocity Measurements that were in Excess of the NOAA Fisheries Criteria of Less Than or Equal to 0.4 ft/s for Each Screen Site by Year. The shaded numbers represent sites for which greater than 10% of the approach velocities for the year were in excess of 0.4 ft/s.

Screen Type	Screen Site	Percent of Approach Velocity Measurements >0.4 ft/s					
		1998	1999	2000	2001(d)	2002	2003
Drum Screens	Bachelor-Hatton	34.1	0	15.4	(e)	2.5	1.7
	Clark	0	(a)	0	0	0	0.0
	Congdon	4.4	8.3	7.1	13.3	11.1	6.7
	John Cox	(c)	(c)	39.3	(e)	27.5	34.8
	Kelly-Lowry	0	0	0	20.0	0	0.0
	Lindsey	0	0	0	0	0	0.0
	Lower WIP	(b)	0	0	(e)	38.9	5.6
	Naches-Cowiche	0	12.5	2.6	5.0	1.7	0.0
	New Cascade	(a)	0	1.4	(e)	2.5	0.0
	Powell-LaFortune	(c)	(c)	(c)	0	0	1.7
	Snipes-Allen	0	0	0	0	0	0.0
	Taylor	0	0	0	0	0	0.0
	Toppenish Pump	60.0	25.4	9.4	3.3	31.1	5.8
	Upper WIP	9.4	2.5	3.3	(e)	5	8.3
	Wilson Creek	(c)	(c)	(c)	0	4.4	0.0
Vertical plate screens	Bull Ditch	2.9	14.7	22.2	0	12.5	4.9
	Ellensburg Mill	0	33.3	25.9	0	0	0.0
	Fruitvale	(a)	0	17.5	0	5.6	0.0
	Naches-Selah	2.8	27.8	28.7	8.3	29.6	20.4
	Union Gap	5.0	22.9	12.5	4.2	2.8	9.7
	Yakima-Tieton	5.2	2.1	1.4	2.1	14.4	2.8
	Younger	(c)	0	8.3	0	33.3	0.0
Vertical travelling screen	Gleed	(a)	14.3	17.5	0	17.4	28.8

(a) No data; electrical interference prevented velocity measurements.
(b) No data; flooded in May and nearly dry by July 1998.
(c) Not sampled.
(d) Based on September data only, except Snipes-Allen, Taylor, Toppenish Pump, Naches-Selah, and Union Gap.
(e) No data; equipment problems in May and June, and site was dry in September.

Table 4. Summary of Problem Areas Identified at Yakima River Basin Phase II Screen Sites in 1999 through 2003. The different symbols represent different years. John Cox was not evaluated in 1999, and Powell-LaFortune and Wilson Creek were not evaluated in 1999 or 2000.

		≥10% of Approach Velocities > 0.4 ft/s					Bypass Velocities Slower than Sweep Velocities at Least Once					Damaged Screen or Seal					Submergence Outside Criteria at Least Once					Excessive Silt or Debris at Least Once					Bypass Outfall < 1 ft at Least Once				
Screen type	Site	'99	'00	'01 [a,b]	'02	'03	'99	'00	'01 [a,b]	'02	'03	'99	'00	'01	'02	'03	'99	'00	'01	'02	'03	'99	'00	'01	'02	'03	'99	'00	'01	'02	'03
Drum Screens	Bachelor-Hatton		▽					▽				■		✱			■	▽		⋀	❖		▽		⋀	❖					
	Clark																	▽	✱												❖
	Congdon		▽	✱	⋀						❖						■		✱												
	John Cox		▽		⋀	❖				⋀	❖			✱		❖		▽								❖		▽	✱		❖
	Kelly-Lowry			✱					✱	⋀	❖							▽	✱			■	▽	✱	⋀	❖					
	Lindsey										❖	■							✱												
	Lower WIP				⋀		■			⋀	❖					❖	■				❖	■		✱	⋀	❖					
	Naches-Cowiche	■							✱		❖														⋀	❖					
	New Cascade										❖	■		✱	⋀		■	▽	✱		❖		▽	✱	⋀						❖
	Powell-Lafortune								✱	⋀	❖								✱	⋀					⋀	❖					❖
	Snipes-Allen							▽	✱	⋀	❖						■									❖					
	Taylor										❖								✱		❖			✱	⋀	❖					
	Toppenish Pump	■			⋀							■				❖		▽	✱	⋀		■	▽	✱	⋀	❖					
	Upper WIP									⋀		■			⋀	❖					❖	■	▽		⋀	❖			✱		
	Wilson Creek								✱	⋀	❖				⋀				✱					✱							
Vertical Plate Screens	Bull Ditch	■			⋀																			✱							
	Ellensburg Mill	■	▽				■		✱			■		✱								■		✱	⋀	❖					
	Fruitvale		▽								❖						■		✱												
	Naches-Selah	■	▽		⋀	❖		▽	✱	⋀	❖	■													⋀				✱		❖
	Union Gap	■	▽				■		✱	⋀	❖	■													⋀						
	Yakima-Tieton				⋀			▽	✱					✱	⋀														✱		
	Younger				⋀									✱																	
Vertical traveling screens	Gleed	■	▽		⋀	❖																■									

a) Based on September data only, except Snipes-Allen, Taylor, Toppenish Pump, Naches-Selah, and Union Gap.
b) No data available for Bachelor-Hatton, John Cox, Lower WIP, New Cascade or Upper WIP.

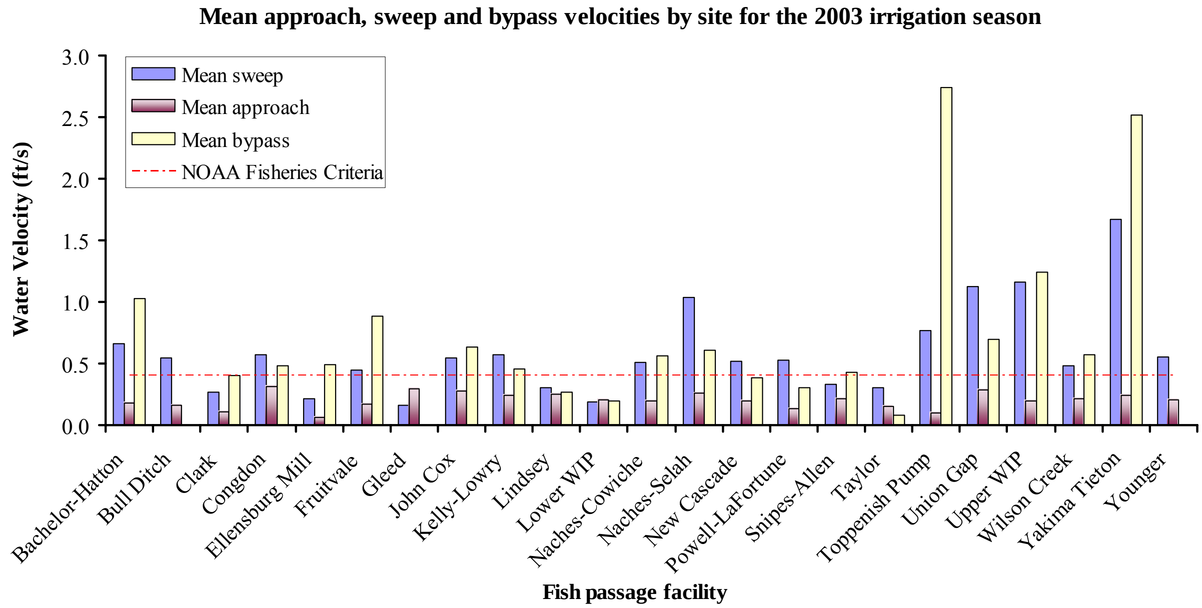

Figure 4. Mean Approach, Sweep, and Bypass Velocities at Phase II Fish Screen Facilities in the Yakima River Basin in 2003 Shown Against a Reference Line for the NOAA Fisheries Approach Criteria (less than or equal to 0.4 ft/s)

3.1.2 Underwater Video

Underwater video was used to inspect the conditions of the seals, to look for gaps between the seals and the screens that could allow small fish to pass through the site into the canal or be entrained or otherwise harmed, to record fish presence at the sites, and to monitor and document sediment and debris accumulation in front of the screens. The latter is important because debris can severely decrease seal life, cause drag on screen motors, and provide cover for fish predator species. Eleven sites were recorded as having excessive silt or debris at least once during 2003, one less than in 2002 (Table 4). Ten of these were drum screen sites.

Most screens were properly sealed to prevent fish entrainment and injury. In general, visible screen seals were in good condition. Bottom frame seals were sometimes buried in debris or aquatic plants and could not be evaluated. All drum screen seals that were classified as in “good condition” were tight against the screen and not cracked, warped, or punctured in any way. Many of the drum screen sites had expanding foam insulation placed between the concrete sides of the facility and the metal “cheeks” of the drum frame. This blocked off an area that could have entrained small fish, although they could not normally have moved into the aftbay (canal) through this route. Flat-plate screen seals were generally in good condition with the exception of some panels showing loose or missing caulking (e.g., Yakima-Tieton and Union Gap). Many of the flat-plate sites with loose or missing caulking were in poor condition in previous years and have never been improved. These sites were not identified under the problem-tracking protocol because these are problems that would not be expected to cause delay or injury to migrating fish as long as the site meets NOAA Fisheries criteria for approach velocity.

A few potential problems were identified in 2003. Four sites had loose or damaged seals that might have allowed fish to be entrained or caused physical damage to them (Table 4). All of these problems were new but were not processed through the problem-tracking protocol because they were identified through an office review of the video tapes that was not performed until after the irrigation season was over. Interestingly at two of these sites, the problem was identified during the June survey, but was not seen in September.

3.1.3 General Data

In 2003, most sites were operating in a manner that would be expected to provide safe passage for juvenile salmonids. Some sites, such as Lindsey, were well maintained, well designed, and rarely exceeded criteria; while others, such as Bachelor-Hatton, have had problems over the past several years.

Automated cleaning brushes generally functioned properly; chains and other moving parts were well greased and operative. The WDFW's screen shop staff were generally prompt in repairing and/or cleaning screens. The percent of sites with excessive debris problems had been on the rise over the past several years. In 2003 the numbers had improved slightly, with 48% of sites having accumulated an excessive amount of sediment or debris. Compare this with 52% in 2002, 35% in 2001, and 24% in 2000 (Table 4). The buildup of sediment and debris is a concern because it can create habitat for predators and cause mechanical brushes or drums to become less effective or even cease functioning.

3.1.3.1 Screen Submergence Levels

Phase II rotary drum screens are designed to be operated at submergence levels between 65% and 85%. At higher submergence levels, fish may roll over the top of the screen and enter the canal. Lower submergence levels can prevent the screen from efficiently removing debris from the forebay area. In 2003, 33% of drum screens were outside submergence criteria at least once, up from 20% in 2002.

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 flat-plate screen become completely submerged, fish can freely enter the irrigation canals by swimming over the top of the screen. Therefore, beginning in 2001, flat-plate screen sites were marked in Table 3 only if screens were completely submerged at any point during the irrigation season. Total screen submergence was not observed during our surveys in 2003. However, notes in the operator's logbook at Fruitvale indicate that the screens were overtopped for several days in late August and early September.

3.1.3.2 Bypass Outfall Conditions

The NOAA Fisheries 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 in. and that the minimum depth of open-channel flow in the bypass conduit shall be greater than or equal to 9 in., 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 of less than 25 cubic feet per second (cfs), the requirements are a 10-in.-diameter pipe and a minimum allowable water depth in the pipe of 1.8 in. All screens with bypasses that were evaluated with the exception of Bull Ditch, Clark, John Cox, Lindsey, Lower Wapato Irrigation Project (WIP), Taylor, Wilson Creek, and Younger are designed and built for diversion flows greater than 25 cfs. Many sites had bypass pipes with diameters much smaller than the NOAA Fisheries criteria. However, all sites met the minimum requirements for in-pipe water depth in 2003.

3.1.3.3 Operator Control Aids

Visual operator control aids, while not required, are extremely useful for the maintenance and operations personnel who inspect the sites. Operator aids complement the operating criteria and help "flag" operational or procedural problems. Operator aids include marks indicating submergence level on drum screen frames; water depth or elevation gauges 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 NOAA Fisheries criteria or to 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 gauges measuring elevation or water depth, although gauges were not always present both in front of and behind the screens. Drum screen submergence marks were present at most sites but were often difficult to read due to weathering, and later in the season because of the growth of algae. As a result of this study, PNNL recommends regular cleaning and repainting of these marks to facilitate operator adjustments and evaluation.

3.2 Rotary Drum Screens

3.2.1 Bachelor-Hatton

The Bachelor-Hatton site was evaluated May 6, 2003; June 18, 2003; and September 19, 2003, although no water was present at the site in September. In May and June, 100% and 95% of approach velocities met NOAA Fisheries criteria, respectively (Figures 5 and 6). In May, sweep velocity did not generally increase from the upstream screens to the downstream end of the site, although the bypass velocities were greater than the average sweep velocity. In June, the sweep velocity generally increased from the upstream screens to the downstream end of the site, and the bypass velocity was greater than the average sweep. The sweep velocity in front of screen one was generally negative or flowing upstream. Because of the design of the site, water entering through the headgates normally contacts the screens somewhere around screen 2 and then separates into two components: one that moves downstream towards the bypass and another that moves upstream, potentially confusing fish.

No operator control aids such as submergence marks painted on the screen frames or gauges for measuring water depth have been installed at this site. However, submergence calculations revealed that the site exceeded criteria in May (94% submergence) but met criteria in June (84% submergence).

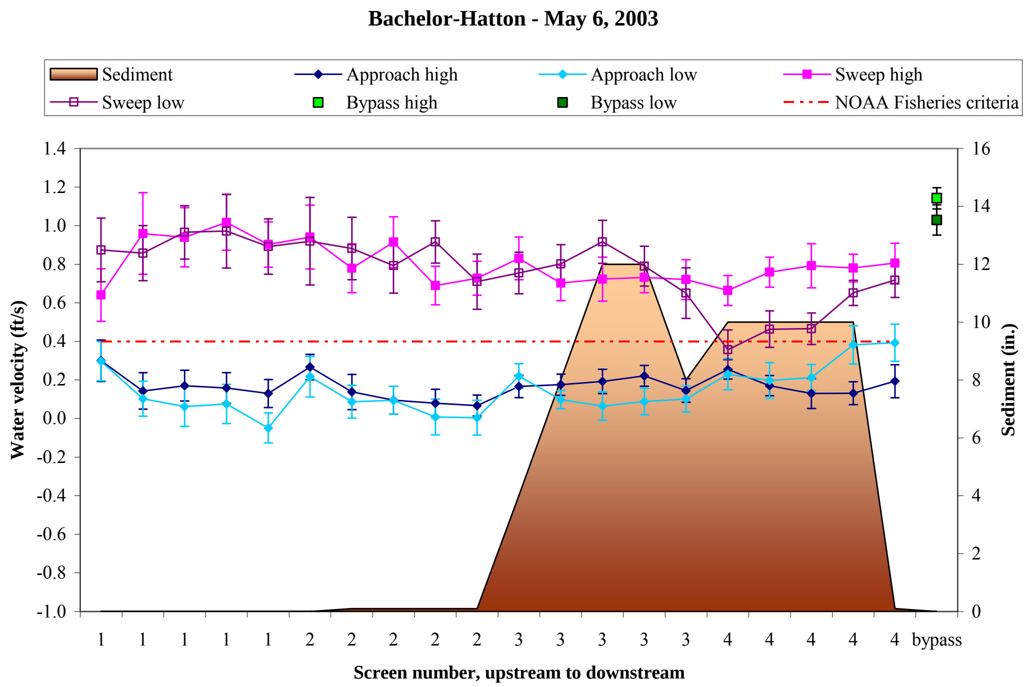

Figure 5. Water Velocities and Sediment Accumulation at Bachelor-Hatton in May 2003. Error bars (± the root-mean-squared [RMS]) represent turbulence at each point.

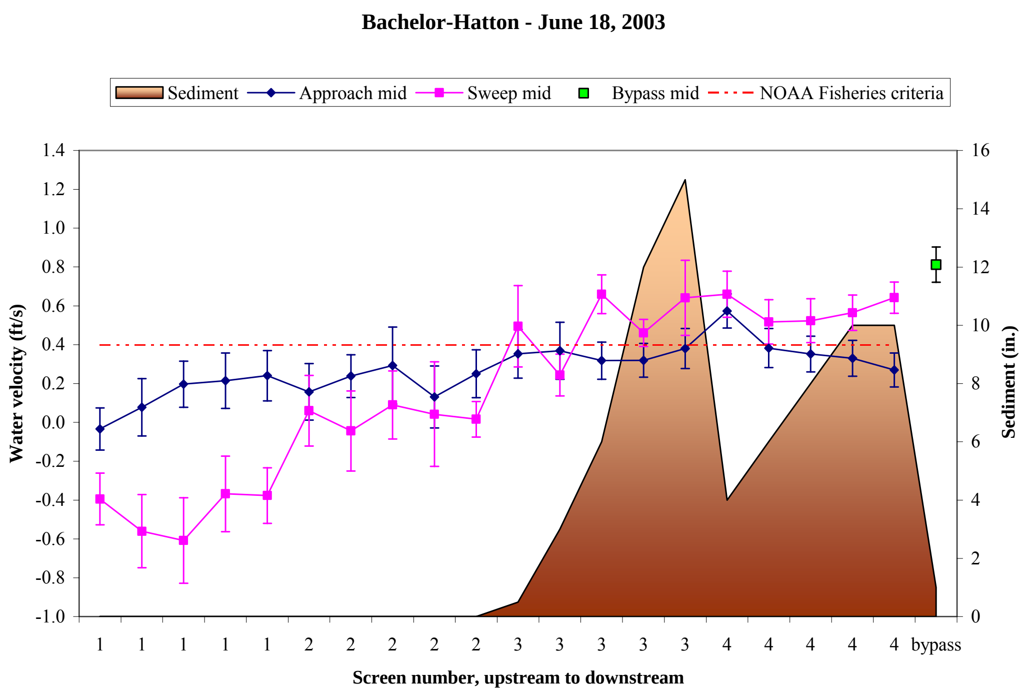

Figure 6. Water Velocities and Sediment Accumulations at Bachelor-Hatton in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

Video surveys in all three months showed that the visible portions of the screen seals were in good condition. Approximately 12 in. of sediment had accumulated in front of screens 3 and 4 in May, which increased to a maximum of 15 in. in June. A fair amount of twigs and other debris were present in front of screen 4 and in the bypass during all surveys. Bypass conditions were good in May and June, and bypass outfall conditions met standards for safe fish passage in May and June. Flooding in early spring rerouted the stream away from the outfall. A small channel was dug to provide some flow of water to and from the outfall pipe, but water levels in this small channel may not stay consistently deep enough, and predation by birds or mammals could occur.

3.2.2 Clark

The Clark screening facility was visited on May 9, 2003; June 24, 2003; and September 19, 2003. Water velocities at this site complied with NOAA Fisheries criteria during all surveys. All approach values were less than 0.4 ft/s, and sweep velocities were always higher than approach velocities (Figures 7, 8, and 9). The water velocity in the bypass was always greater than the average sweep velocity, and except for September, there was a clear increase in sweep velocity from upstream to downstream within the site. These conditions created a clear trajectory towards the bypass and would be expected to expedite fish passage through the site.

The condition of the screen and seals was good throughout all surveys. Little sediment was present in front of the screens in May, and none was present in June or September. Screen submergence met

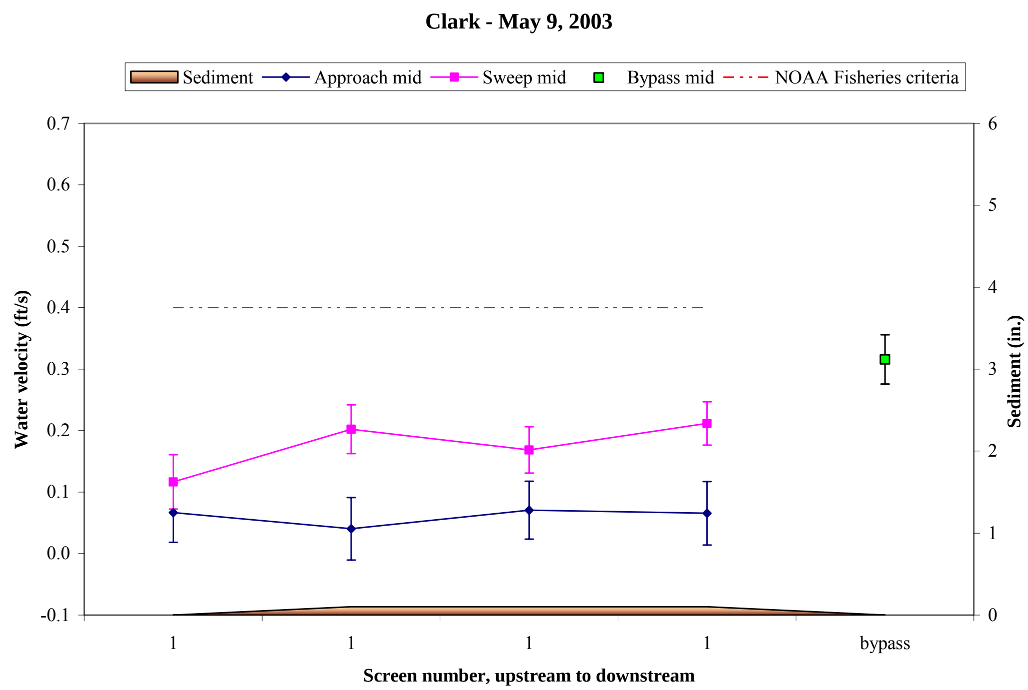

Figure 7. Water Velocities and Sediment Depths at Clark in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

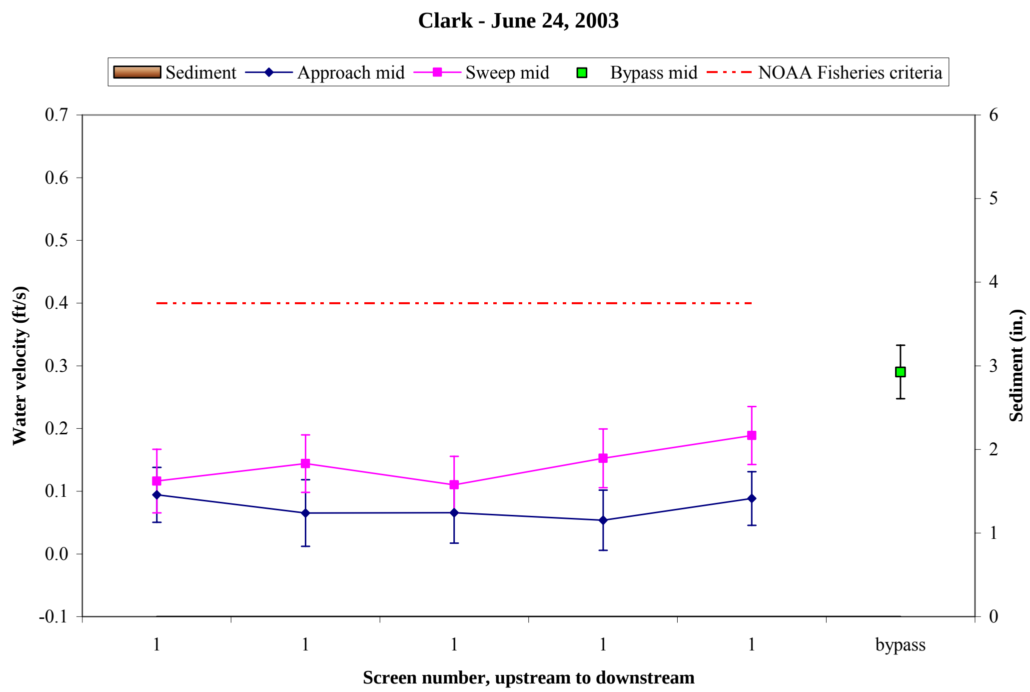

Figure 8. Water Velocities and Sediment Depths at Clark in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

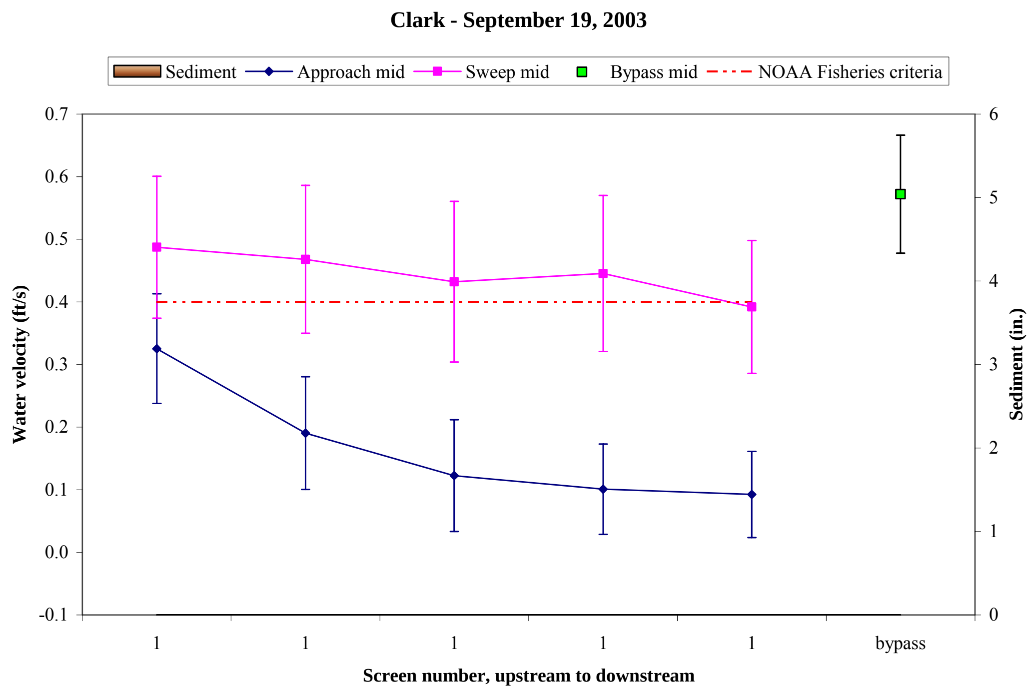

Figure 9. Water Velocities and Sediment Depths at Clark in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

criteria during all site visits, at 84% in May, 85% in June and 83% in September. No water was observed flowing over the headgates during any survey, although the logbook indicated flooding earlier in January and again in May with water over the headgates and some erosion of the screens facility around the downwell and the top of the irrigation canal. Apparently the screen may have been overtopped at that time as well. Water always flowed freely over the weir and through the bypass outfall. In June, the water at the point of discharge was less than 1 ft.

3.2.3 Congdon

The Congdon facility was evaluated on May 9, 2003; June 26, 2003; and September 16, 2003. In May, June, and September approach velocities met NOAA Fisheries criteria 93%, 100%, and 87% of the time, respectively (Figures 10, 11, and 12). Sweep velocities were always higher than approach velocities, although the velocity in the bypass was lower than the average sweep in June and September.

The screen seals were in good condition. There was very little sediment in front of the screens during all of the surveys. Submergence was at the high end of the criteria range throughout the survey period: 85% during May, 87% in June, and 83% in September. The depth of water flowing over the weir and through the outfall met NOAA Fisheries criteria. Water ran freely through the bypass, and the surging at the bypass outfall mentioned in previous years was not observed in 2003.

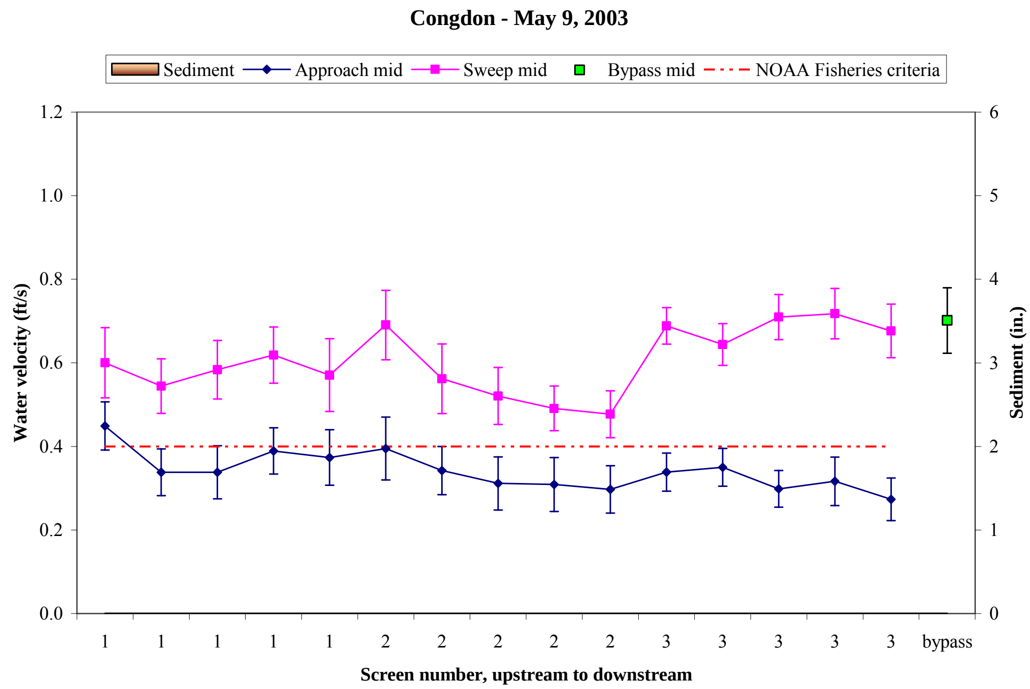

Figure 10. Water Velocities and Sediment Levels at Congdon in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

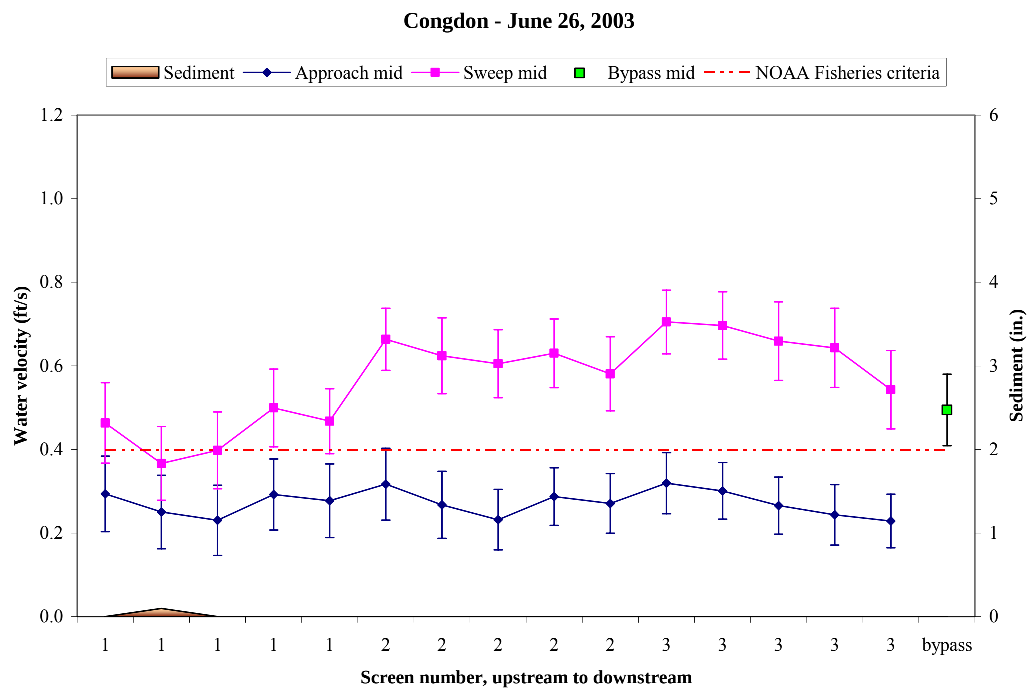

Figure 11. Water Velocities and Sediment Depths at Congdon in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

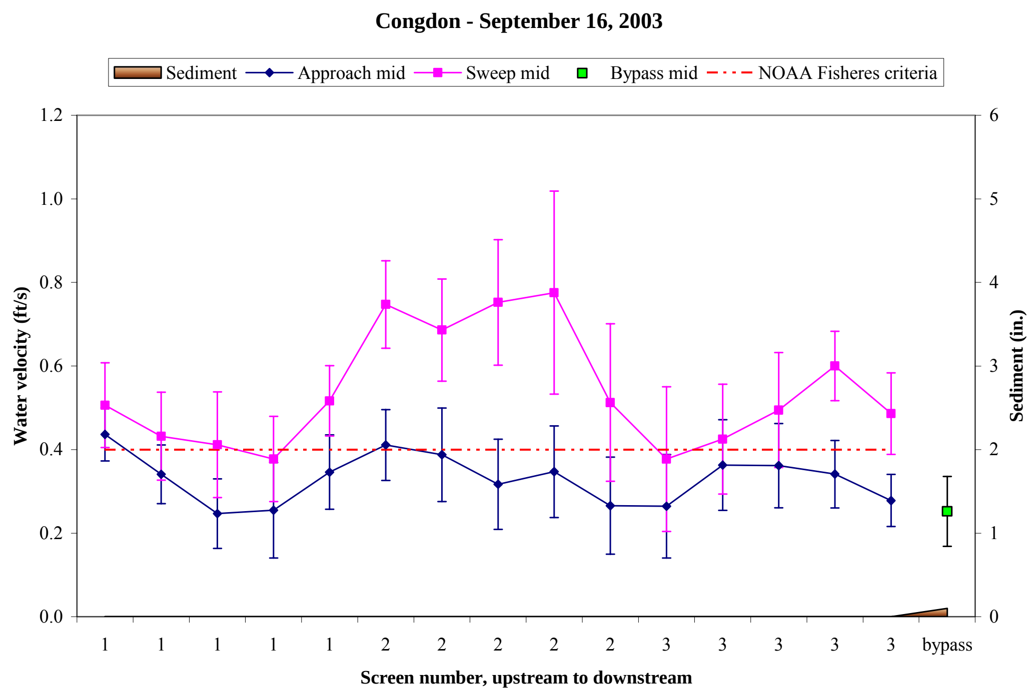

Figure 12. Water Velocities and Sediment Depths at Congdon in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.4 John Cox

The John Cox site was evaluated on May 6, 2003; June 18, 2003; and September 19, 2003. In May and September, 100% of approach velocities met NOAA Fisheries criteria, though in June all measured approach velocities were greater than 0.4 ft/s (Figures 13, 14, and 15). In May and September, the sweep velocity increased towards the downstream end of the site and the bypass velocity was greater than the average sweep. In June there was no increasing trend in the sweep velocity and the bypass velocity was slower than the average sweep velocity. The bypass was flushed by Jim Rice with the USBR after the velocity measurements, and that jettisoned the accumulated sediment out of the bypass. Tom Leonard was notified on June 19 concerning the extremely high approach velocities, though he did not report back on whether any changes were made to improve the conditions.

The screen seals appeared to be in good condition throughout the survey period, and the gap between the bottom seal and screen 2 noted in 2001 was not present in 2002. Submergence met NOAA Fisheries criteria in May and June, at 85% and 80%, respectively, though submergence had dropped to 61% in September. In June, there was a lot of woody debris in front of the screens and in September, there was enough sediment accumulation to cover the bottom seal and woody debris prevented flow measurements at the upstream end of screen 2.

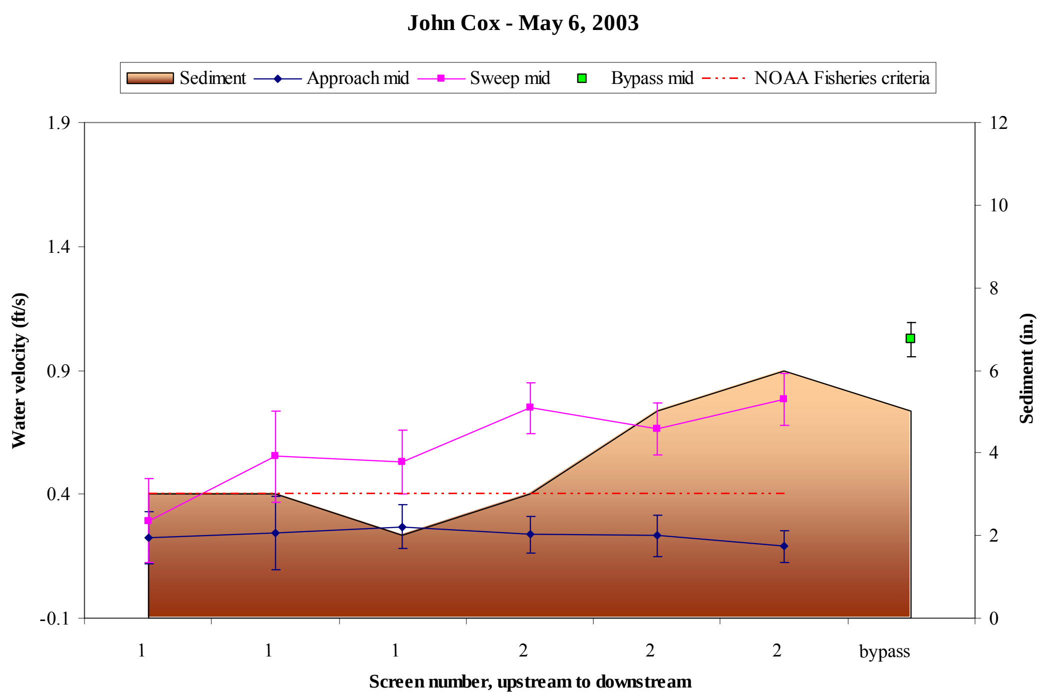

Figure 13. Water Velocities and Sediment Depths at John Cox in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

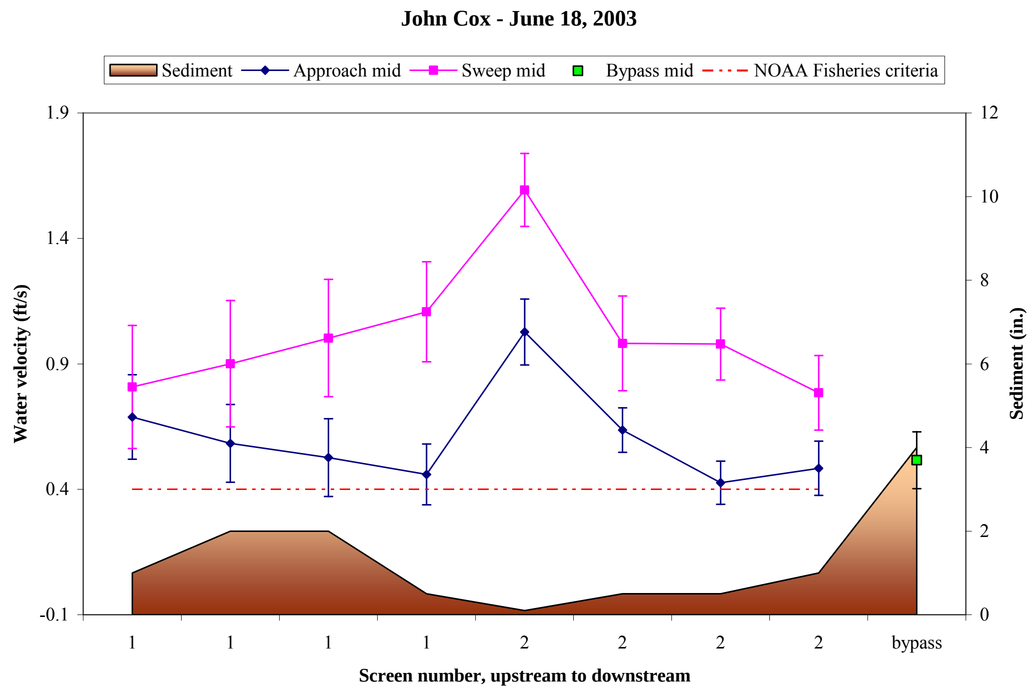

Figure 14. Water Velocities and Sediment Depths at John Cox in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

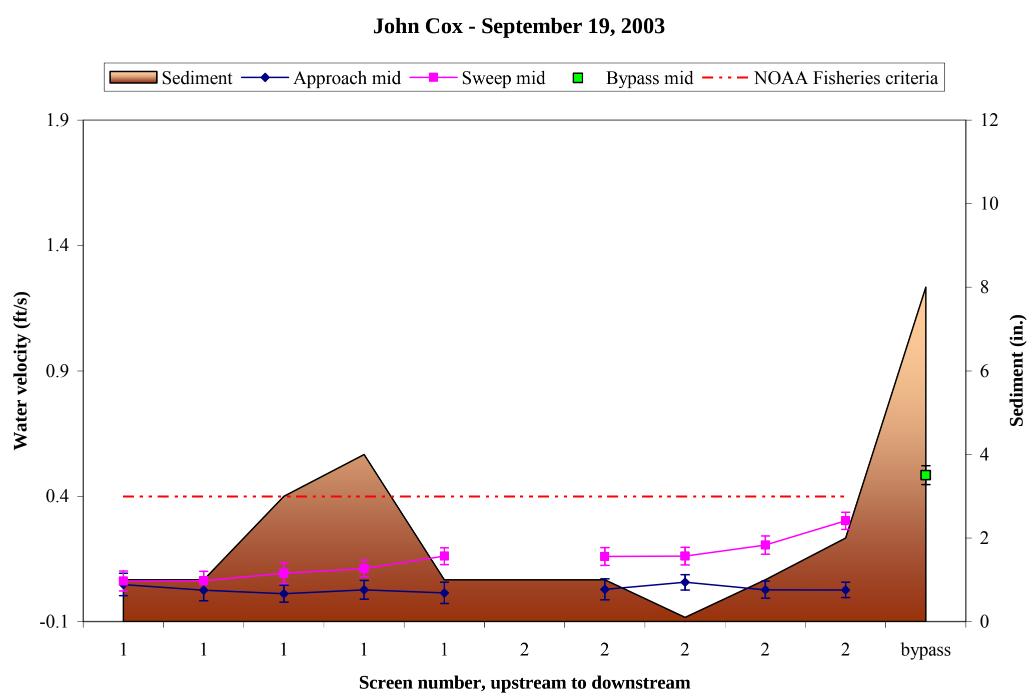

Figure 15. Water Velocities and Sediment Depths at John Cox in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.5 Kelly-Lowry

The Kelly-Lowry site was evaluated on May 7, 2003; July 2, 2003; and September 19, 2003. All approach velocities met NOAA Fisheries criteria during all surveys (Figures 16, 17, and 18). Sweep velocities were always higher than approach velocities, though sweep velocities did not increase towards the bypass. The bypass velocity was slower than the average sweep velocity during all surveys.

The screen seals all looked to be in good condition. A significant amount of debris had built up on the trash rack before the May survey and was present throughout the survey period. There was also a large pile of debris approximately 2 ft tall in the forebay in May. The gaps between the metal screen frames and the concrete wall noted in 2001 and 2002 were filled with spray-in insulation sometime before the May 2003 survey.

Bypass conditions were conducive to safe fish passage in May and appeared to be passable in July and September, though the path to the outfall was too overgrown in June and September to measure it. Water ran freely over the weir, and the PNNL researchers did not observe any accumulation of debris at the outfall pipe. The depth of water at the outfall was greater than 1 ft in May, and appeared to be greater than 1 ft in July and September. Water discharge at the outfall surged slightly in May, and was smooth in July and September.

Operator control aids were present, and the submergence marks on the drum screen frame appeared to have been repainted.

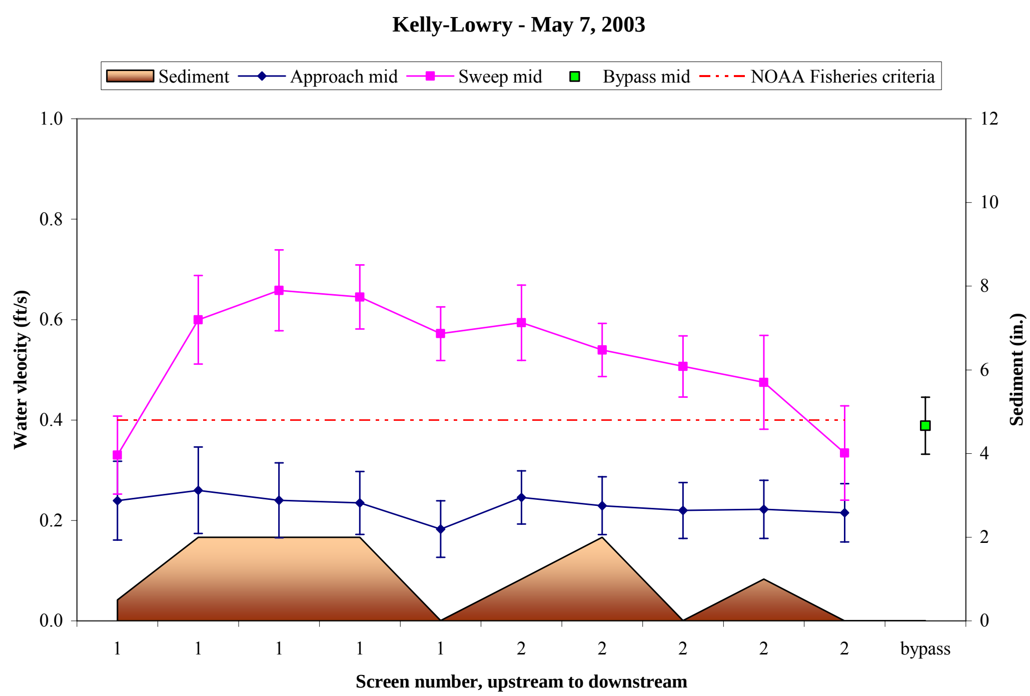

Figure 16. Water Velocities and Sediment Depths at Kelly-Lowry in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

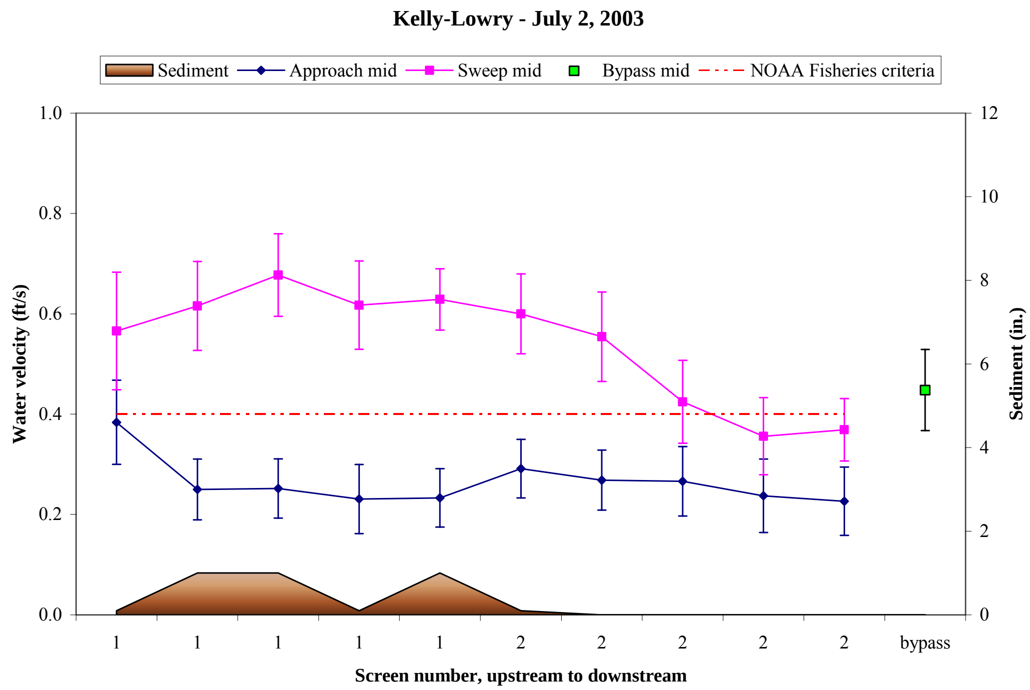

Figure 17. Water Velocities and Sediment Depths at Kelly-Lowry in July 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

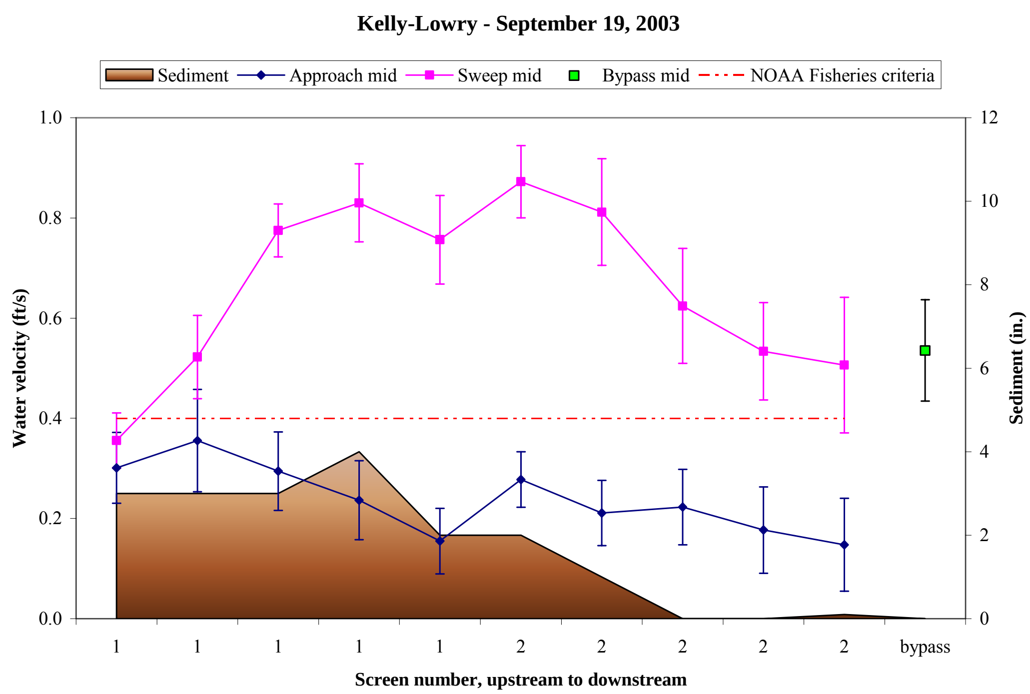

Figure 18. Water Velocities and Sediment Depths at Kelly-Lowry in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.6 Lindsey

The Lindsey site was evaluated on May 13, 2003; June 19, 2003; and September 17, 2003. During all surveys, 100% of approach velocity values met NOAA Fisheries criteria (Figures 19, 20, and 21). Sweep velocities were greater than approach velocities in May and September, and the bypass velocity was greater than the average sweep velocity in June and September. In June, sweep increased from the upstream end of the site towards the bypass.

The screen seals were in good condition, and the drum moved leaf matter and other floating debris into the canal effectively. In May submergence was slightly below NOAA Fisheries criteria at 62% (criteria = 65% to 85%). Ray Gilmore was contacted on May 13 concerning the low submergence, although no operational changes were made to correct the condition. Notes in the logbook subsequent to our May site visit indicate submergence dropped to approximately 40% before the river level rose and changes in the operating conditions were made to increase the submergence level. Submergence met criteria in June and September at 85% and 66%, respectively. The gaps between the metal frame of the screen and the cement wall were filled with expanding foam insulation that will prevent entrainment of small fish in these gaps.

Bypass conditions were conducive to safe fish passage. Water flowed freely over the weir and through the outfall, where the depth was always greater than 1 ft.

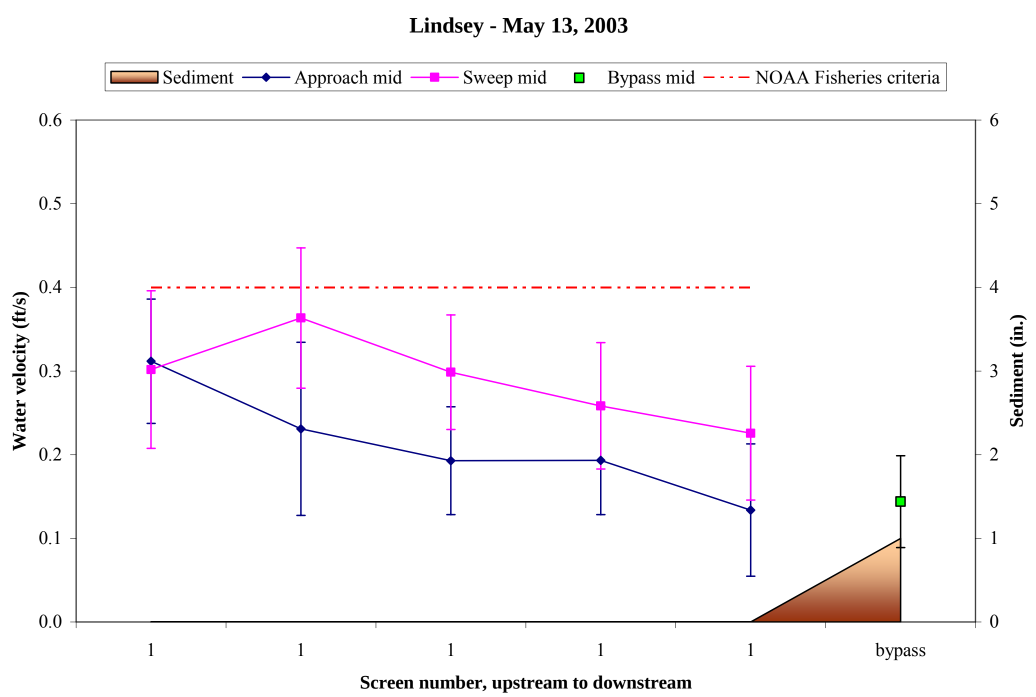

Figure 19. Water Velocities and Sediment Depths at Lindsey in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

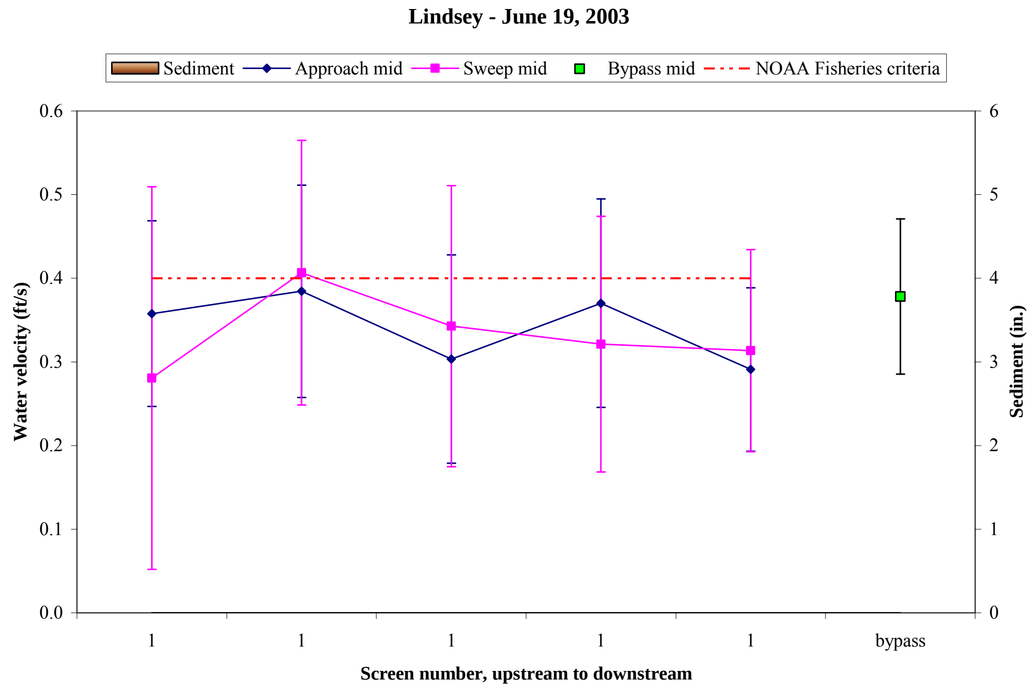

Figure 20. Water Velocities and Sediment Depths at Lindsey in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

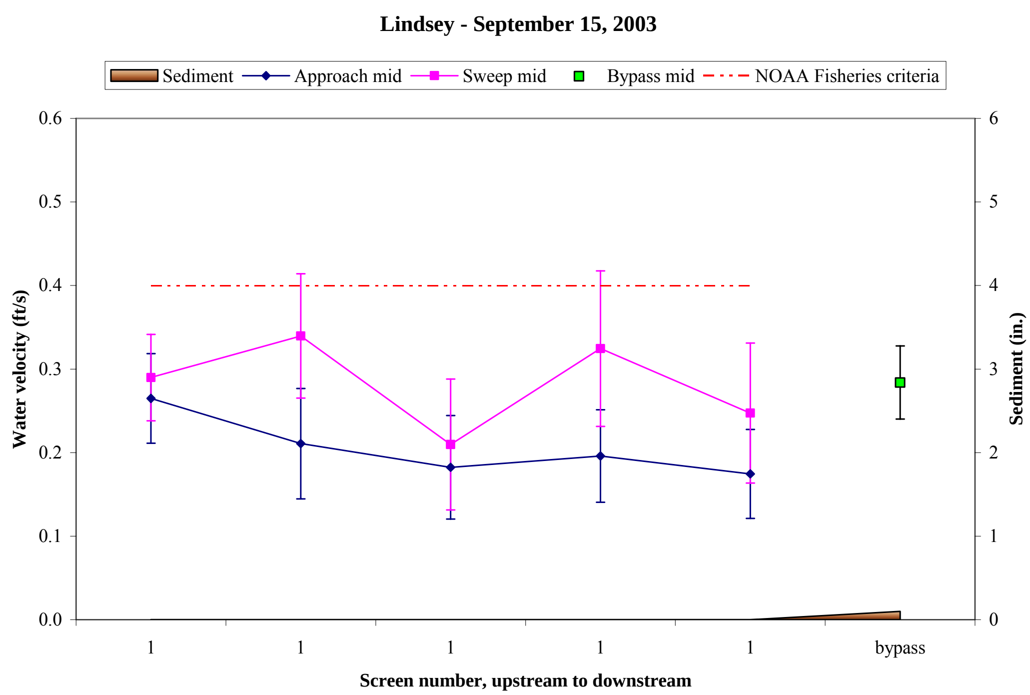

Figure 21. Water Velocities and Sediment Depths at Lindsey in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.7 Lower Wapato Irrigation Project (WIP)

The Lower WIP site was visited on May 7, 2003; July 1, 2003; and September 19, 2003. In May, 83% of approach velocities met NOAA Fisheries criteria. That figure increased to 100% in July and September. In May, approach velocities were greater than sweep velocities. In September, sweep velocities increased towards the downstream end of the site, and the bypass velocity was greater than the average sweep velocity (Figures 22, 23, and 24). In May and June, sweep velocities did not increase towards the downstream end of the site and the bypass velocities were slower than the average sweep. In May, water flowed backwards from the downwell into the bypass due to an obstruction in the bypass pipe. The notes in the logbook indicate that the obstruction was not removed until June 27. This set of conditions could lead to delay for migrating fish.

During May and July, an excessive amount of sand was present in the forebay, in front of the screens, and in the bypass. At the shallowest point in July there was only 4 in. of water over the sand. Submergence met criteria in May at 80%. In July and September, submergence was slightly outside criteria limits at 64% and 88%, respectively. Sediment deposits at the site were removed in August and September. In September, the bypass appeared to be backed up; there was no drop into the downwell, probably due to high stream flows. Bypass outfall conditions met NOAA Fisheries criteria during all surveys, although it was noted in June that if the water level in the stream was to drop fish could become trapped because the fish channel in the diversion dam was blocked.

The screen seals that were visible (i.e., not obstructed by sediment or debris) appeared to be in good condition, although there were some gaps higher up on the side seals that would not be expected to cause any problems because they should not ever be under water.

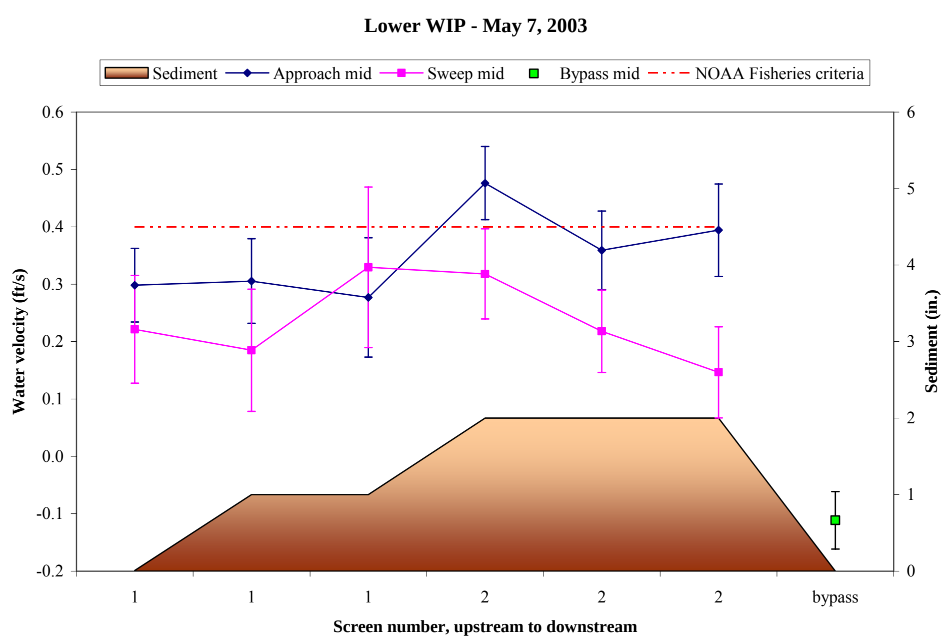

Figure 22. Water Velocities and Sediment Depths at Lower Wapato Irrigation Project (WIP) in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

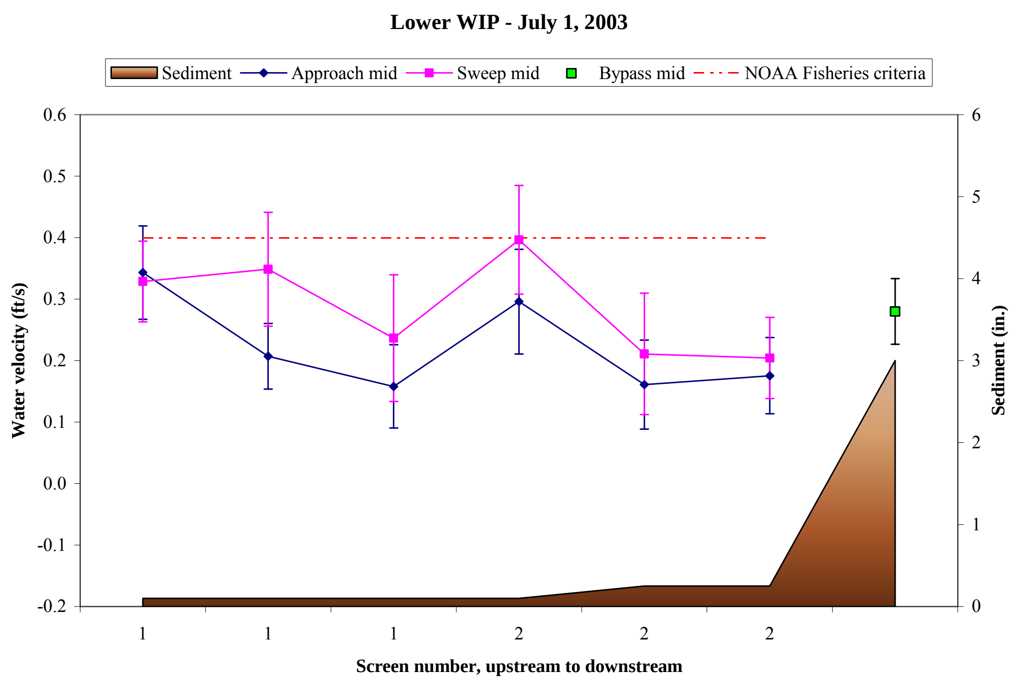

Figure 23. Water Velocities and Sediment Depths at Lower Wapato Irrigation Project (WIP) in July 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

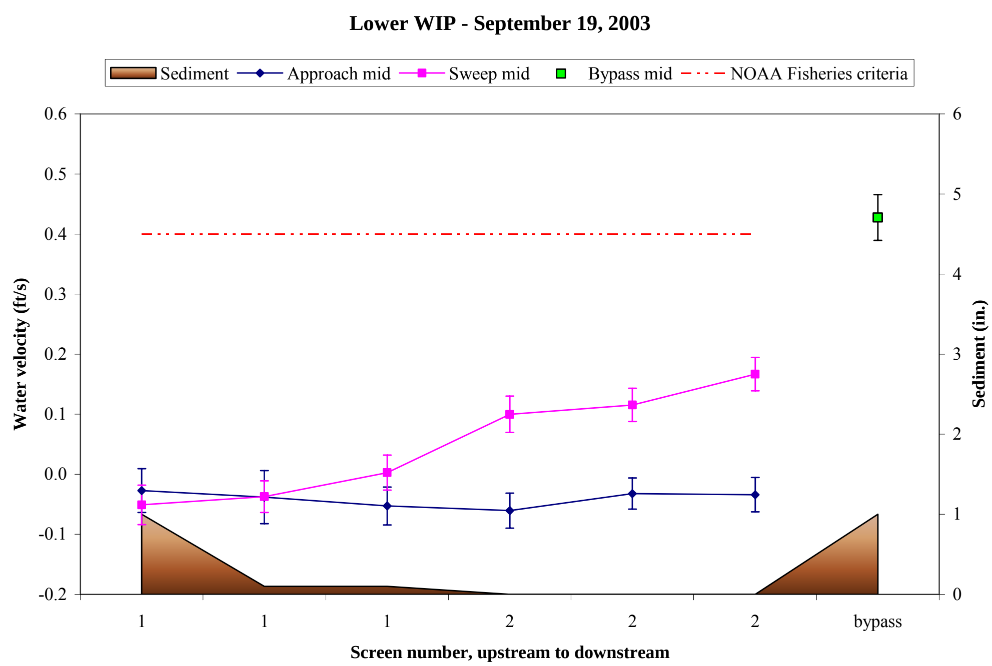

Figure 24. Water Velocities and Sediment Depths at Lower Wapato Irrigation Project (WIP) in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.8 Naches-Cowiche

The Naches-Cowiche site was evaluated on May 8, 2003; June 26, 2003; and September 19, 2003. During all surveys, 100% of approach values met NOAA Fisheries criteria (Figures 25, 26, and 27). Sweep velocities were always higher than approach velocities but did not increase towards the bypass in May or June. The average bypass velocity was faster than the average sweep velocity during May and September, but not in June.

The stoplogs in front of the screens prevented an evaluation of the bottom seals with the video camera. All other visible seals were in good condition. During the June and September evaluations it was evident that debris had built up between the stoplogs and the screens. Submergence was within criteria during all visits and bypass conditions were generally good for safe fish passage. In June, the bypass outfall became plugged. It was cleaned out on the morning of June 26, and two dead fish were found. Fish in the screen facility have no way out if the outfall is blocked, although WDFW raises the weir to prevent movement through the bypass if blockage is suspected. In 2002, there was some concern that the design of the bypass outfall did not compensate enough for the shifting riverbed because it became filled with rock when flows were high. The outfall channel has been dug out several times in the past, only to get filled in again when the river level rose. Sometime before our September evaluation, ecology blocks were placed on three sides of the outfall channel in an attempt to stop rocks from being shifted into the outfall channel.

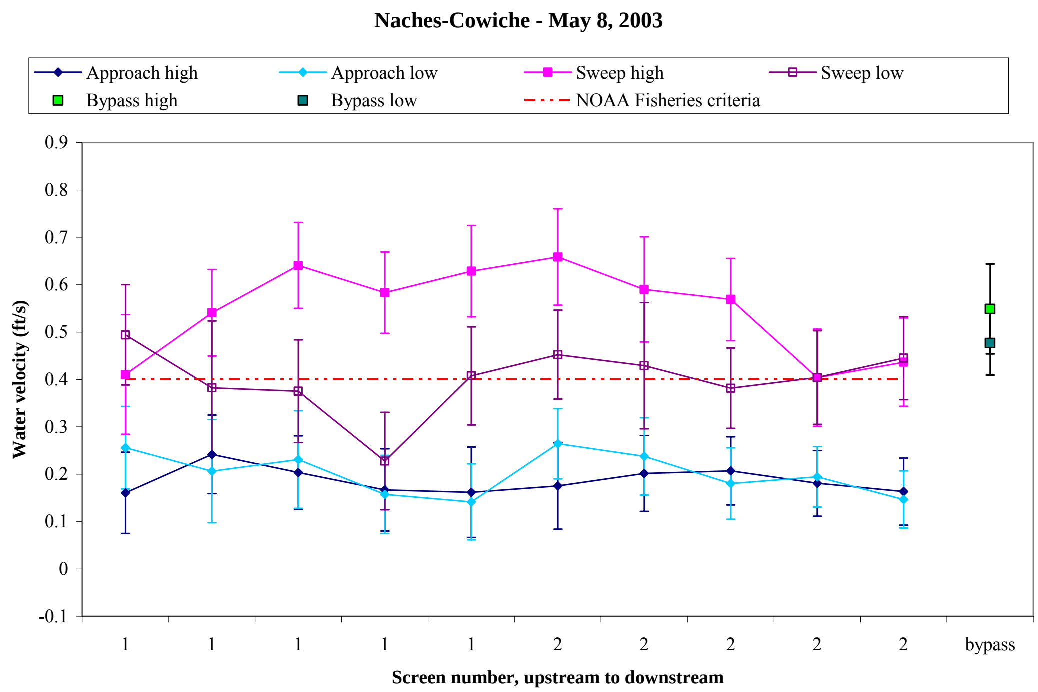

Figure 25. Water Velocities and Sediment Depths at Naches-Cowiche in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

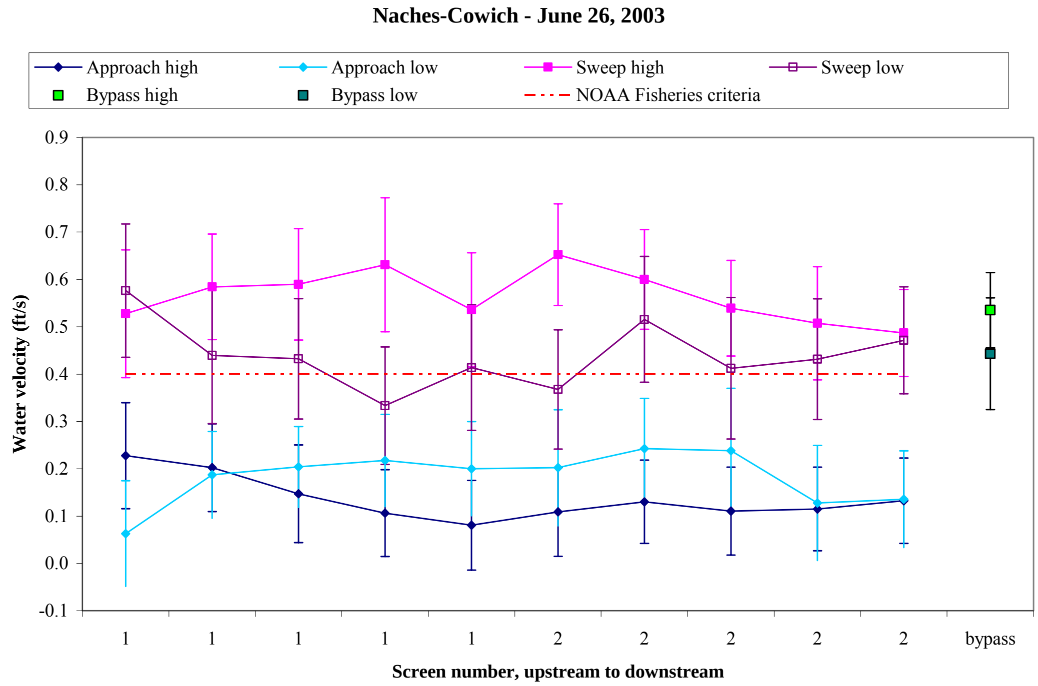

Figure 26. Water Velocities and Sediment Depths at Naches-Cowiche in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

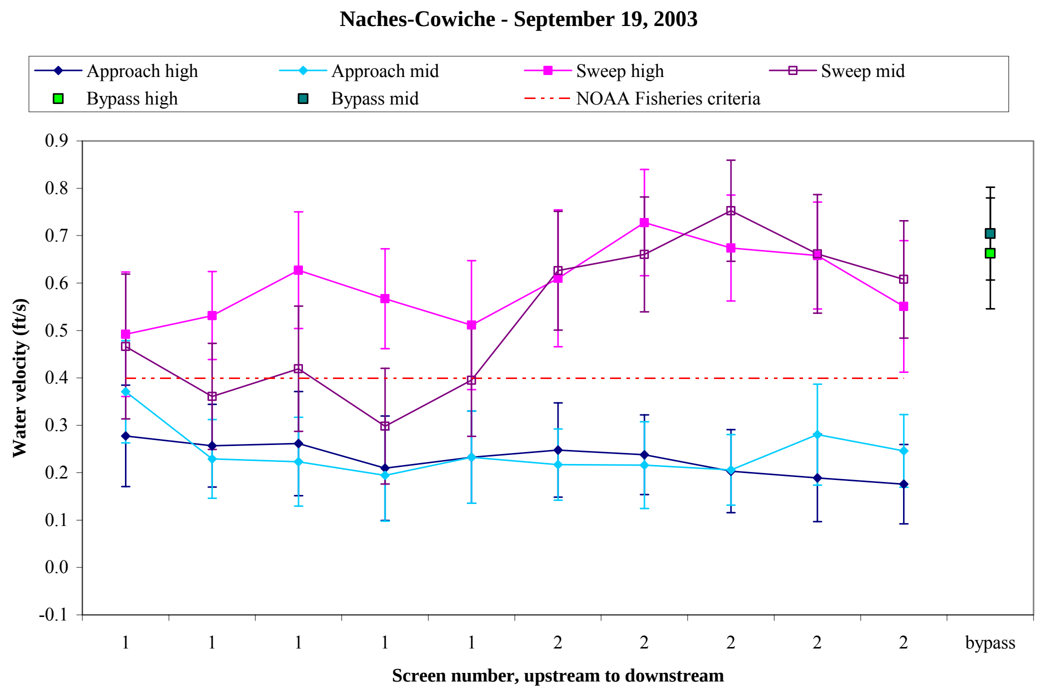

Figure 27. Water Velocities and Sediment Depths at Naches-Cowiche in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.9 New Cascade

The New Cascade site was evaluated on May 12, 2003; June 25, 2003; and September 15, 2003. During all surveys, 100% of approach velocities met NOAA Fisheries criteria (Figures 28, 29, and 30). Sweep velocities were generally faster than approach velocities, and sweep velocities increased slightly towards the bypass in June. Bypass velocities were faster than the average sweep velocity during June.

Submergence slightly exceeded criteria in May, June, and September, at 90%, 89%, and 88%, respectively. Ray Gilmore was notified on May 12 of the high submergence level. No changes were made in operating conditions. In the past this site has had problems with sediment buildup, especially in the downstream corners of the screen bays. However, very little sediment accumulation occurred during the 2003 season. All bottom seals were replaced in the fall of 2002, as were the left side seal on screen 1 and the right side seal on screen 8, which had been warped for several years. All seals appeared to be in good condition, and all cheeks were sealed with expanding foam insulation.

Bypass conditions were conducive to safe fish passage during all surveys. Water flowed freely over the weir and through the outfall, where the depth was greater than 1 ft except in June when the depth in the outfall apron was only 9 in. However, the depth in the stream just beyond the fish outfall apron was greater than 12 in.

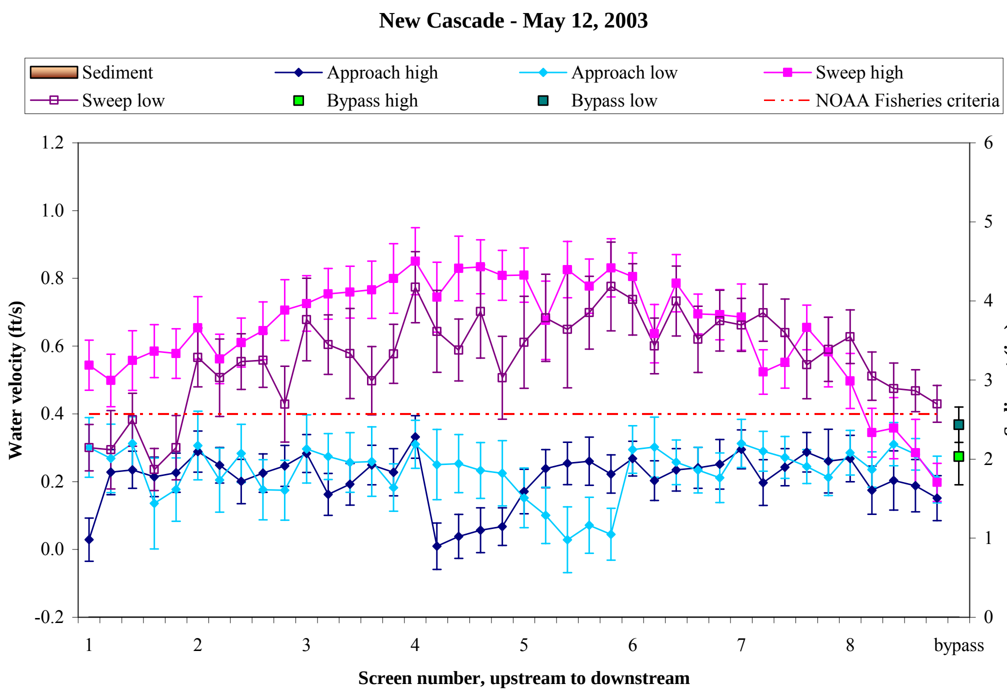

Figure 28. Water Velocities and Sediment Depths at New Cascade in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

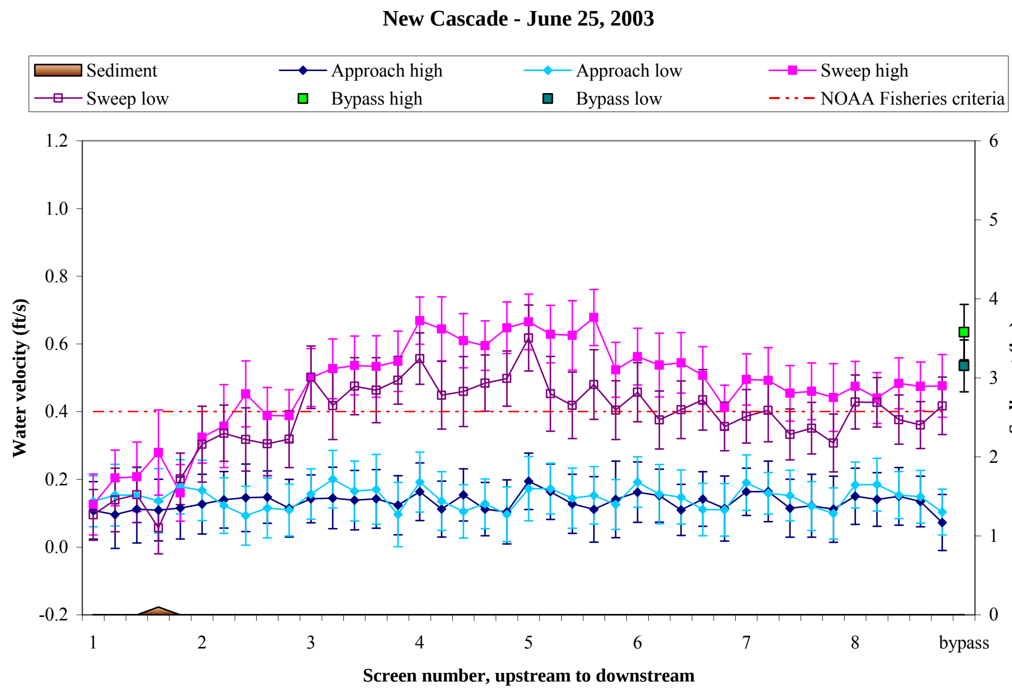

Figure 29. Water Velocities and Sediment Depths at New Cascade in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

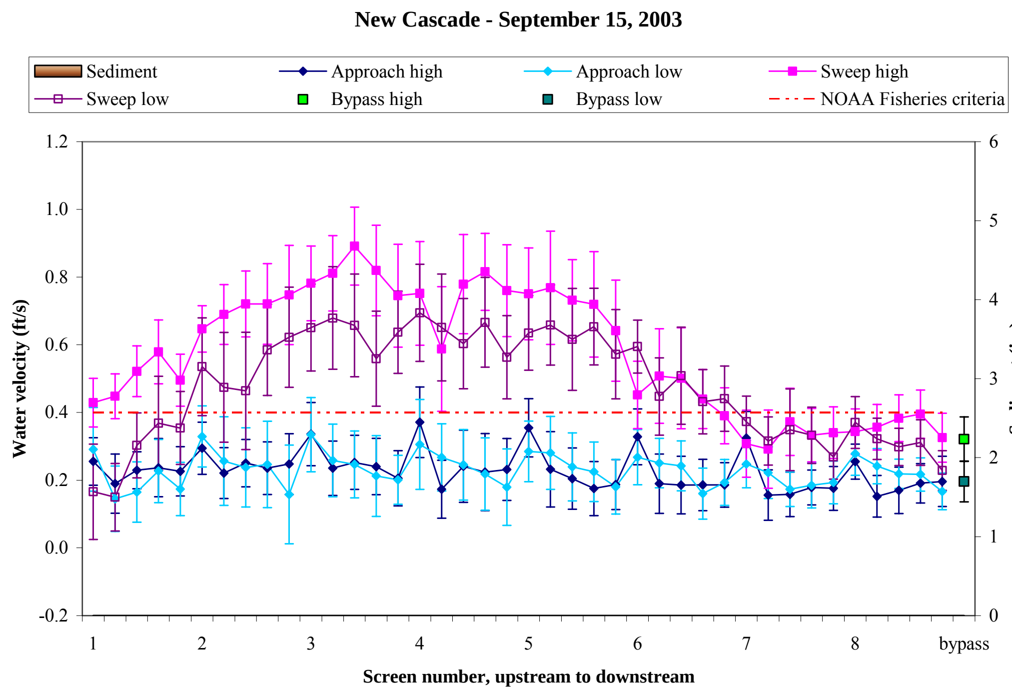

Figure 30. Water Velocities and Sediment Depths at New Cascade in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.10 Powell-LaFortune

The Powell-LaFortune site was evaluated on May 9, 2003; June 26, 2003; and September 16, 2003. In May and June, 100% of approach velocities met NOAA Fisheries criteria. In September, 95% of approach velocities met NOAA Fisheries criteria. Sweep velocities were always higher than approach velocities but did not generally increase towards the bypass (Figures 31, 32, and 33). Bypass velocities were slower than the average sweep velocity. Percent submergence met the NOAA Fisheries criteria in May, June, and September at 77%, 80%, and 72% respectively.

In the past, this site has had problems meeting NOAA Fisheries criteria for submergence, and while submergence was within criteria during our visits in 2003, these problems continued throughout the 2003 irrigation season. Notes in the site operator's logbook state that submergence was low (10% to 60%) almost every time the site was visited by WDFW staff May through mid-July, when a wing dam was installed in the river. After that point, submergence was generally at the high end of the criteria range to above criteria (between 82% and 100%). The Powell-LaFortune site has two trash racks: one on the canal leading to the site and the other at the head gates, farther upstream. The trash racks at the head gate often plug with excessive debris and are not cleaned regularly. Notes in the site operator's logbook state that on May 17, enough debris had built up on the head-end trash rack to cause more than 13 in. of head loss across the debris, and PNNL observed similar conditions during the September inspection. The PNNL researchers recommend that the upper trash rack be cleared of debris by the water users as a part of their daily operations procedures.

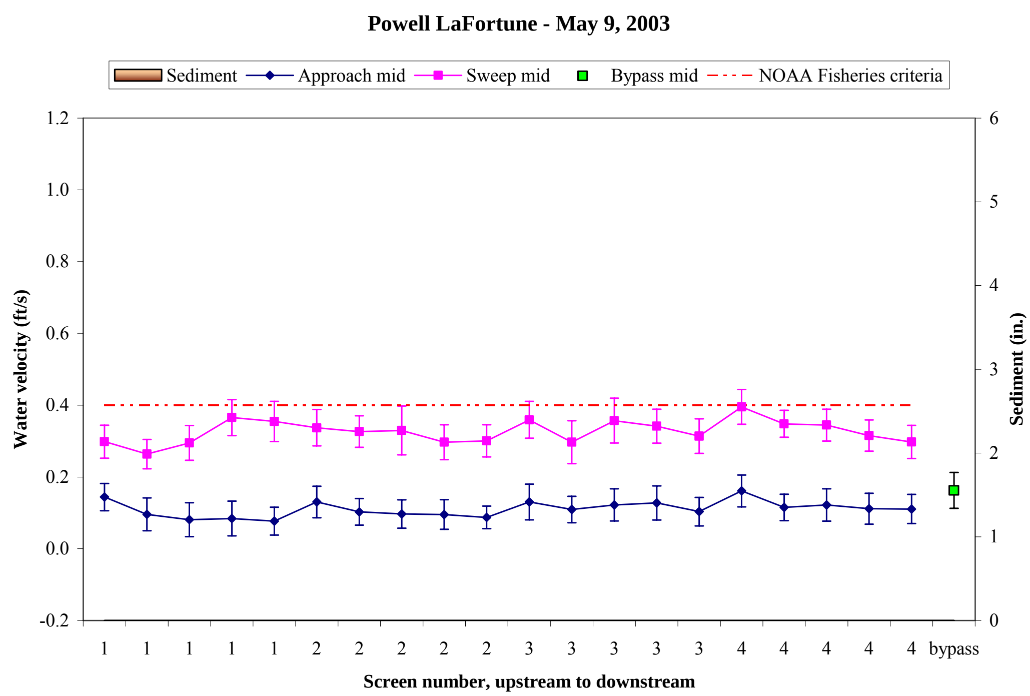

Figure 31. Water Velocities and Sediment Depths at Powell-LaFortune in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

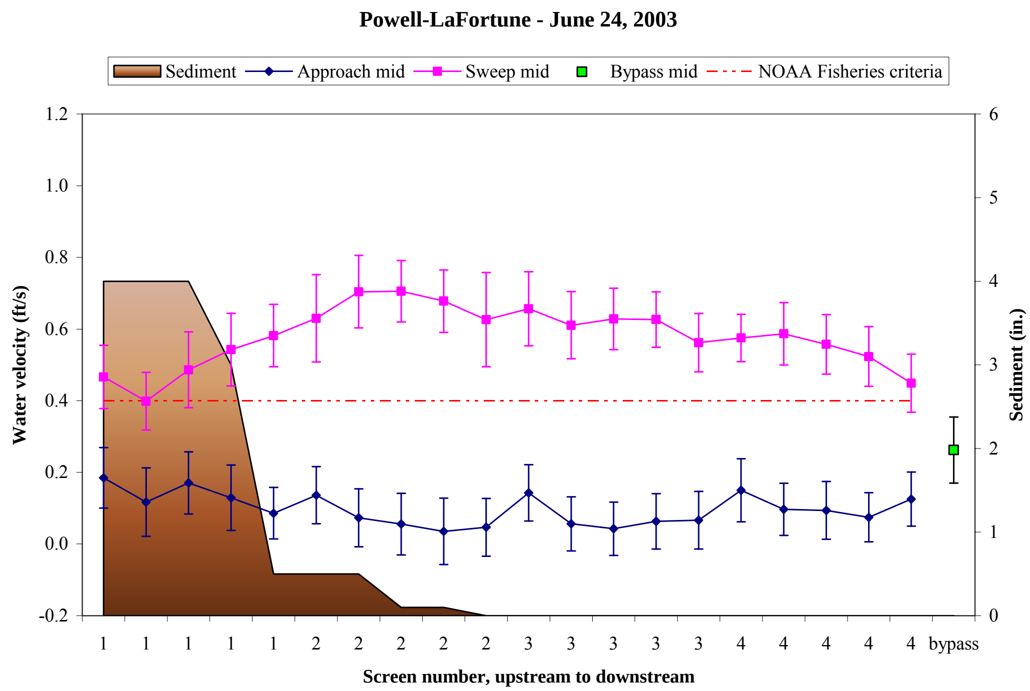

Figure 32. Water Velocities and Sediment Depths at Powell-LaFortune in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

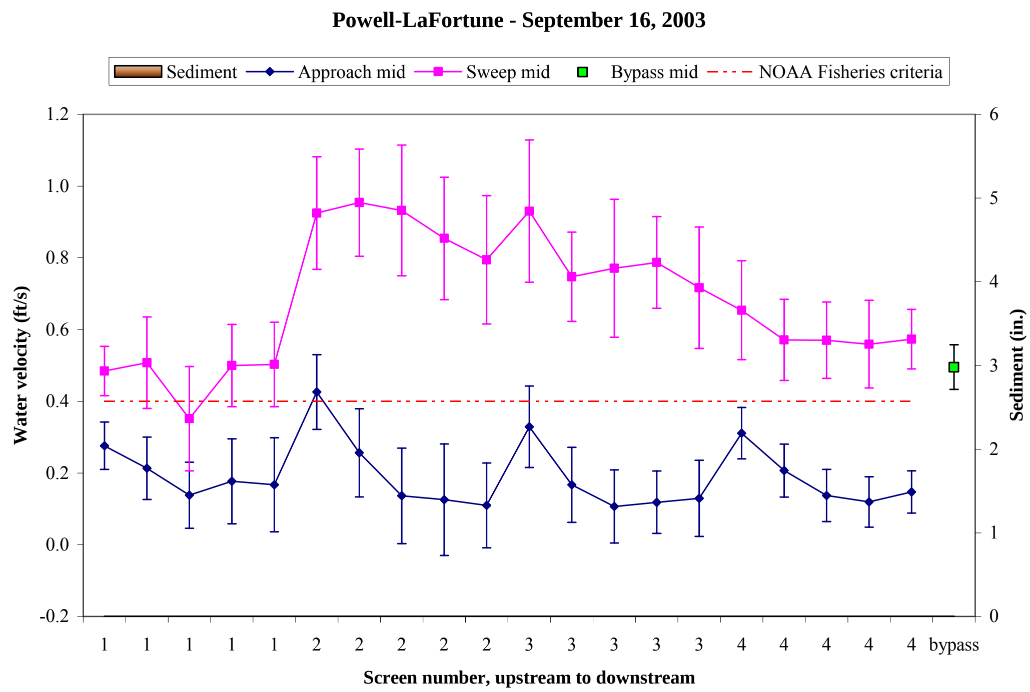

Figure 33. Water Velocities and Sediment Depths at Powell-LaFortune in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

All visible seals were in good condition, as was the screen material. An accumulation of sediment and/or debris covered some of the bottom seals during all surveys. Bypass conditions appeared to be conducive to safe fish passage. The downwell at this site is unusually deep, and the water level in it is relatively shallow. To mitigate for these conditions, the WDFW installed boards in the downwell on April 7 to create a pool for fish to fall into safely. During all surveys, water flowed freely over the weir and through the outfall, and water depth in the outfall pipe met NOAA Fisheries criteria, though the water depth at the point of discharge (over the outfall apron) was slightly less than 1 ft during all surveys. The depth of water in the river just beyond the apron was always greater than 1 ft.

3.2.11 Snipes-Allen

The Snipes-Allen site was evaluated on May 7, 2003; June 17, 2003; and September 23, 2003. All approach velocities met NOAA Fisheries criteria during all surveys (Figures 34, 35, and 36). Sweep velocities were generally higher than approach velocities during all surveys (Figures 34, 35, and 36). Sweep velocities did not increase towards the bypass except in September, and the average bypass velocity was slower than the average sweep velocity in May and June.

The screens and screen seals at this site were in good condition during all surveys. Screen submergence at met NOAA Fisheries criteria during all surveys. However, past problems with debris catching on the trash racks continued in 2003, and notes in the logbook state that submergence was often below criteria, and that at times there was no bypass flow. The accumulation of debris in the space behind the trash rack that was noted in 2002 was removed before the 2003 irrigation season.

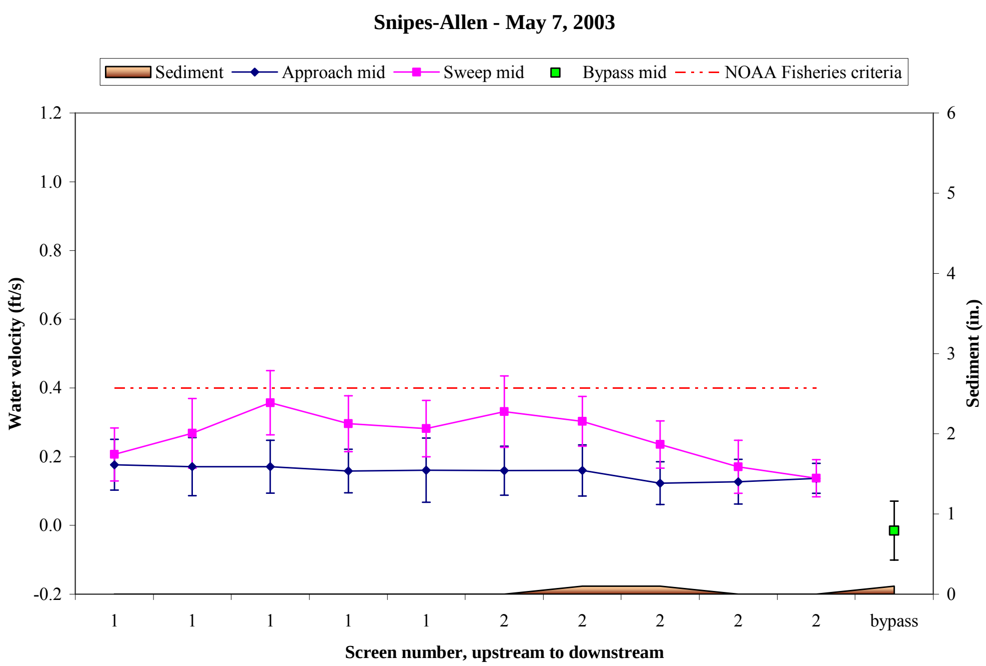

Figure 34. Water Velocities and Sediment Depths at Snipes-Allen in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

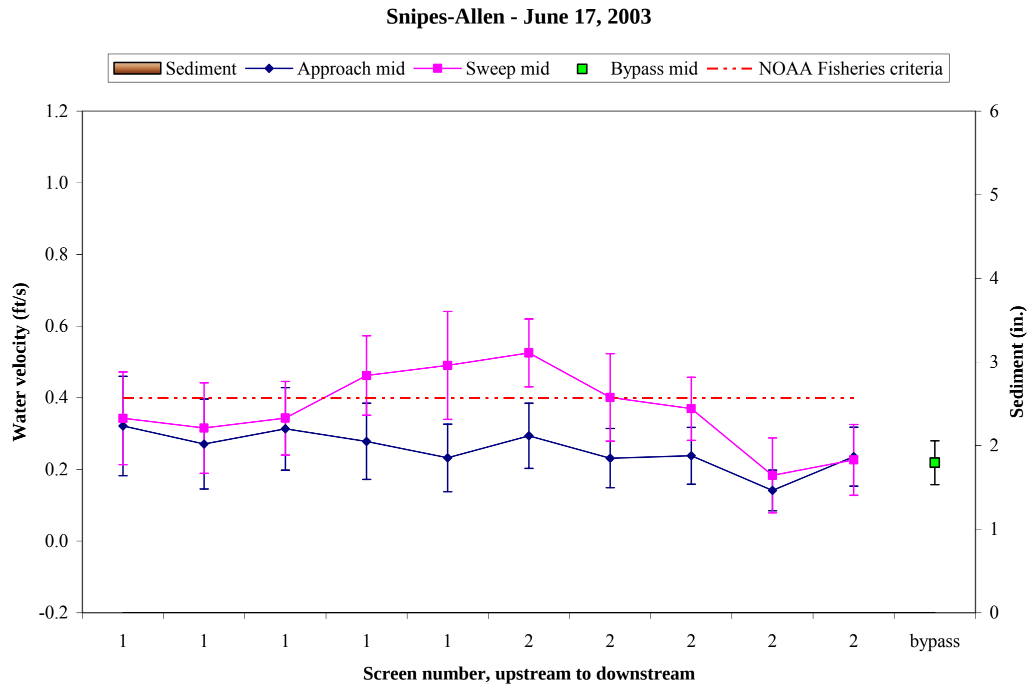

Figure 35. Water Velocities and Sediment Depths at Snipes-Allen in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

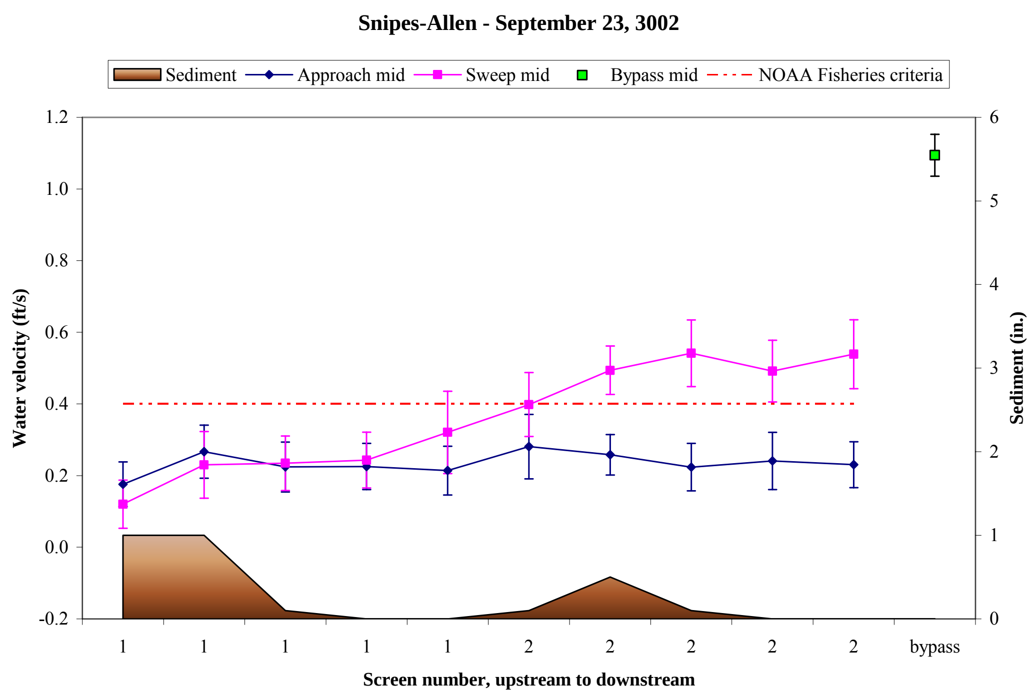

Figure 36. Water Velocities and Sediment Depths at Snipes-Allen in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

Bypass conditions were generally safe for fish passage during all three evaluations. In the past, this site has had many problems with bypass obstructions, and it appeared that these problems had been resolved for 2003. During our evaluations, water ran freely behind the weir and out the outfall, and water depth at the point of discharge was always greater than 1 ft. However, it is apparent from notes in the logbook that there was not always enough flow through the headgates to produce bypass flow. Construction of the diversion dam has diverted all water (except leakage) through the site. Accumulation of debris on the trash rack may be to blame for problems with low submergence and bypass flow. We would recommend that the trash rack be cleaned as a part of daily ditch operations.

3.2.12 Taylor

The Taylor site was evaluated on May 8, 2003; June 26, 2003; and September 16, 2003, although the site was essentially shut down for the season before our September survey. All approach velocities met NOAA Fisheries criteria in May and June (Figures 37 and 38). Sweep velocities were greater than approach velocities in June, but the bypass velocity was always less than the average sweep velocity. Percent submergence was below criteria during the survey in May at 35%. In June, submergence met criteria with 72%.

Screen and seal condition appeared to be fine and the gaps between the metal frame of the screens and the cement walls were filled with expanding foam insulation. In June, water flowed freely over the weir into the downwell. Outfall conditions appeared to meet criteria limits in May and June though evaluation was difficult because the area was overgrown.

This site has had many problems meeting submergence and flow criteria over the past several years. Flows in the stream tend to be inconsistent within the irrigation season, and the main channel has shifted away from the screen site, making it even more difficult to divert water to the site, especially when flows are low. Notes in the site logbook indicate that submergence fluctuated between 20% and greater than 100% (screens were overtopped on June 8) between our May and June evaluations. Ray Gilmore was notified on May 12, 2003 of the low submergence, although there was nothing he could do about it because the stream level was low.

Because of the history of problems at this site and the change in stream conditions, we strongly recommend that the design of this site and its diversion be reevaluated and that changes be made to put the site into compliance with the NOAA Fisheries criteria.

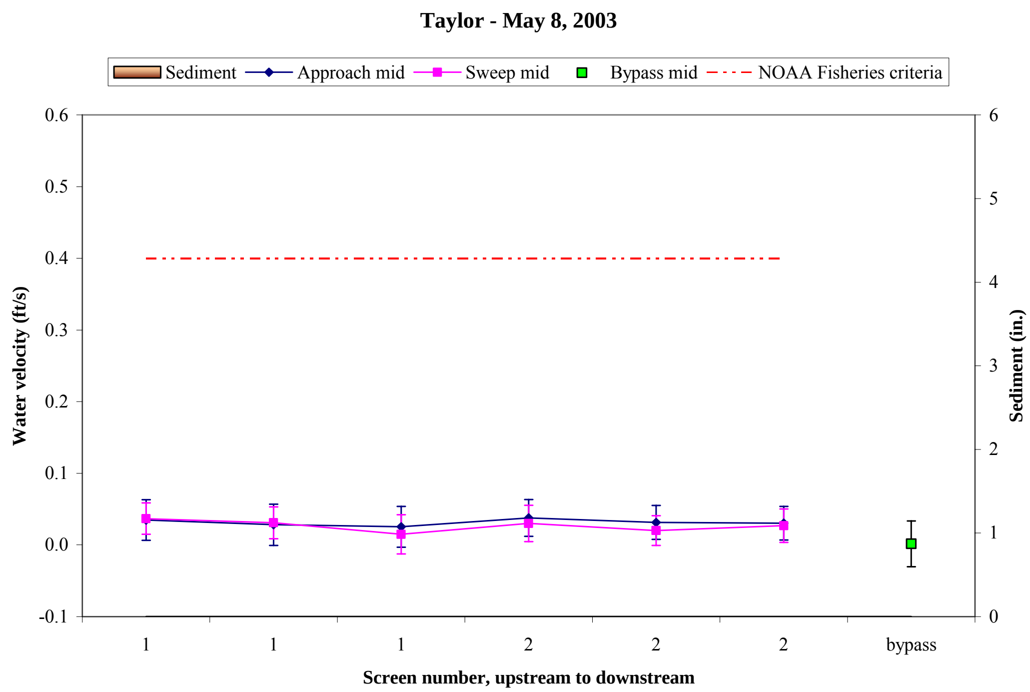

Figure 37. Water Velocities and Sediment Depths at Taylor in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

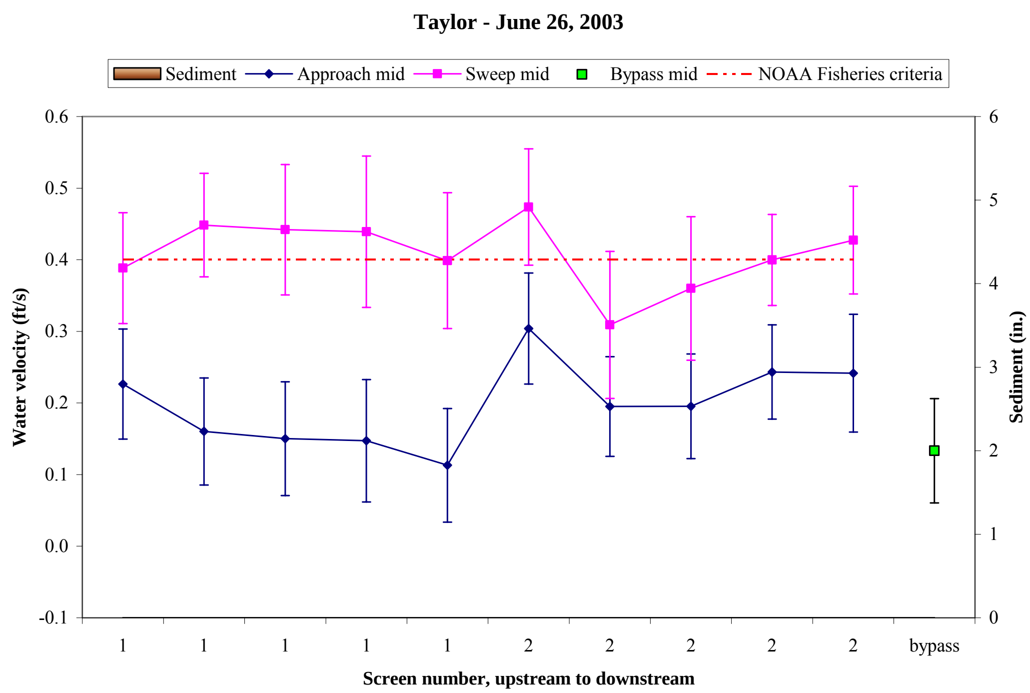

Figure 38. Water Velocities and Sediment Depths at Taylor in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.13 Toppenish Pump

The Toppenish Pump site was visited on May 7, 2003; June 17, 2003; and September 23, 2003. In May, June, and September, 90%, 95%, and 97% of approach velocities met NOAA Fisheries criteria, respectively. This was a great improvement over 2002, when an average of 31% of approach velocities were >0.4 ft/s. Sweep velocities were generally higher than approach velocities, except in front of screen 1 (Figures 39, 40, and 41). Sweep velocities generally increased towards the bypass, and bypass velocities were always higher than sweep velocities. Submergence was calculated to be slightly low in May at 64% and met criteria in June and September at 79% and 72%, respectively.

Visible seals appeared to be in good condition during all surveys, with the exception of one or more warps in the upstream side seal on screen 5. During all surveys, sediment and debris covered some to nearly all of the bottom seals. The gaps between the metal frames of the drums and the cement walls of the site were not caulked. Bypass conditions were favorable during all surveys, though there was a small amount of debris floating on the water surface at the outfall.

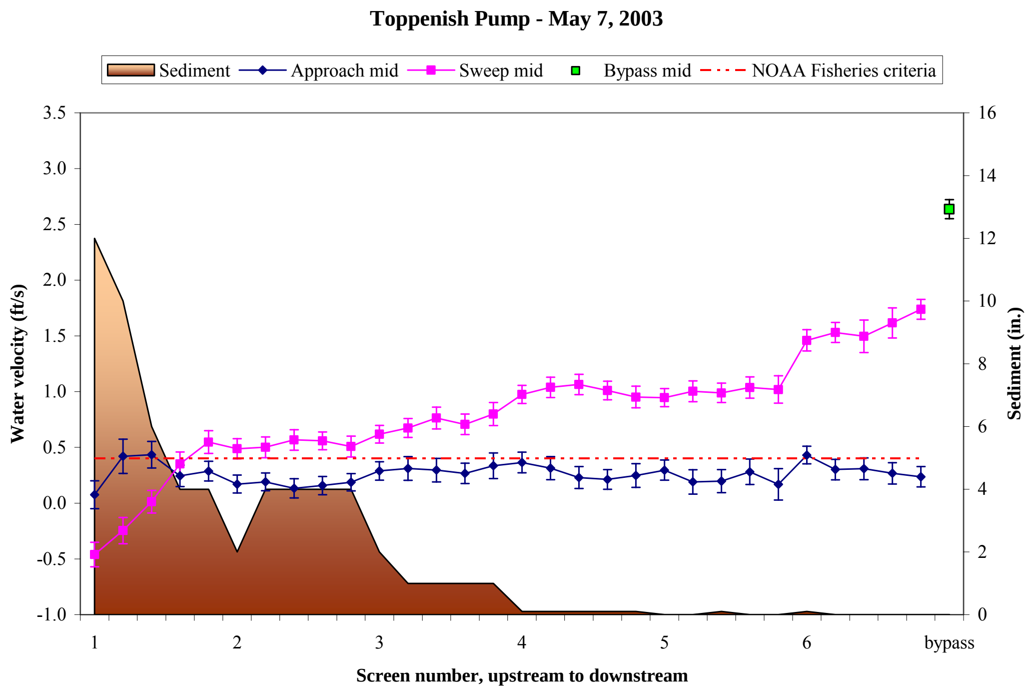

Figure 39. Water Velocities and Sediment Depths at Toppenish Pump in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

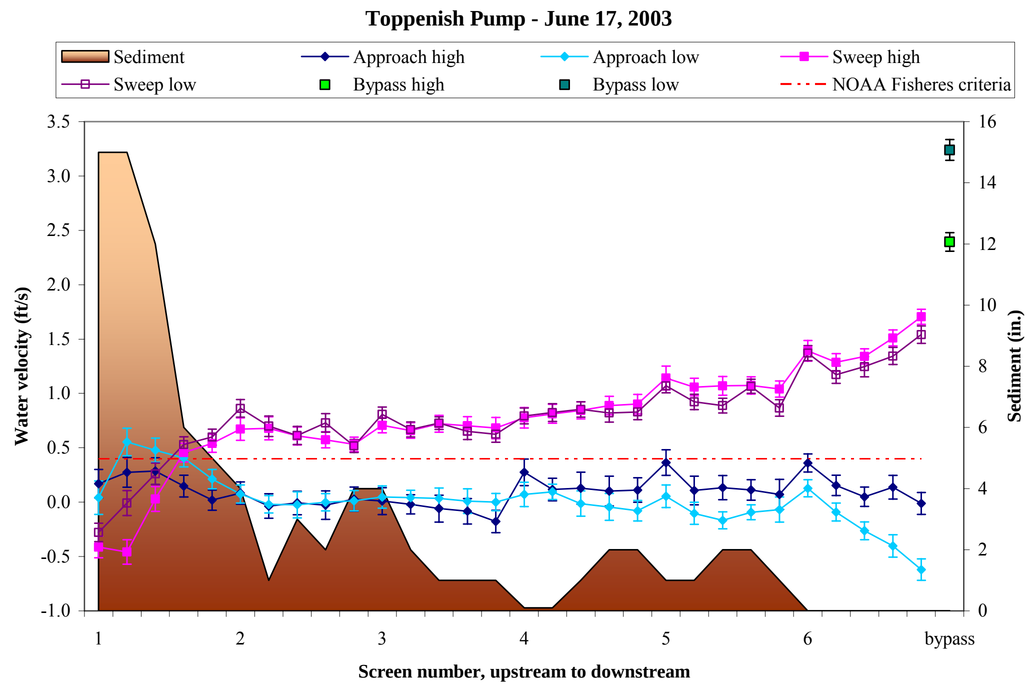

Figure 40. Water Velocities and Sediment Depths at Toppenish Pump in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

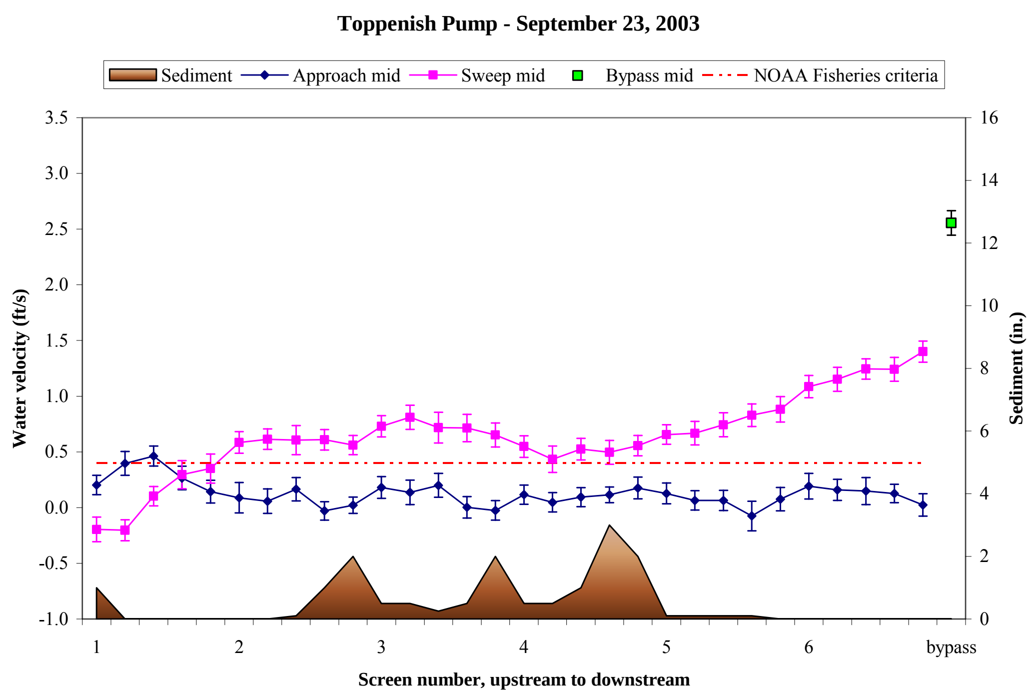

Figure 41. Water Velocities and Sediment Depths at Toppenish Pump in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.14 Upper Wapato Irrigation Project (WIP)

The Upper WIP site was visited on May 6, 2003; June 18, 2003; and September 19, 2003. The site was shut down for the season before the survey in September. Eighty-eight percent of approach velocities met NOAA Fisheries criteria in May, and 100% of approach velocities met NOAA Fisheries criteria in June (Figures 42 and 43). During both surveys, sweep velocities were much more turbulent than approach velocities. Sweep velocities did not increase towards the bypass, and the bypass velocity was only slightly greater than the average sweep velocity.

Screen submergence exceeded NOAA Fisheries criteria at 96% submergence in May and met criteria in June with 84% submergence. The screens seals were replaced in 2001 and have already begun to show some wear. There were two small warps in the downstream side seal on screen 2. Bypass conditions were generally good in May and June, although in June there was a large log in the forebay that had branches poking into the bypass and another in the downwell. Water ran freely behind the weir and out the outfall. The water depth at the point of discharge was greater than 12 in. in May and June, which satisfied NOAA Fisheries criteria and should be expected to provide sufficient water to allow for safe fish passage.

The gaps between the metal frames of the drums and the cement walls of the forebay were not caulked. The PNNL researchers recommend that these be filled with expanding foam insulation to prevent harm to migrating fish.

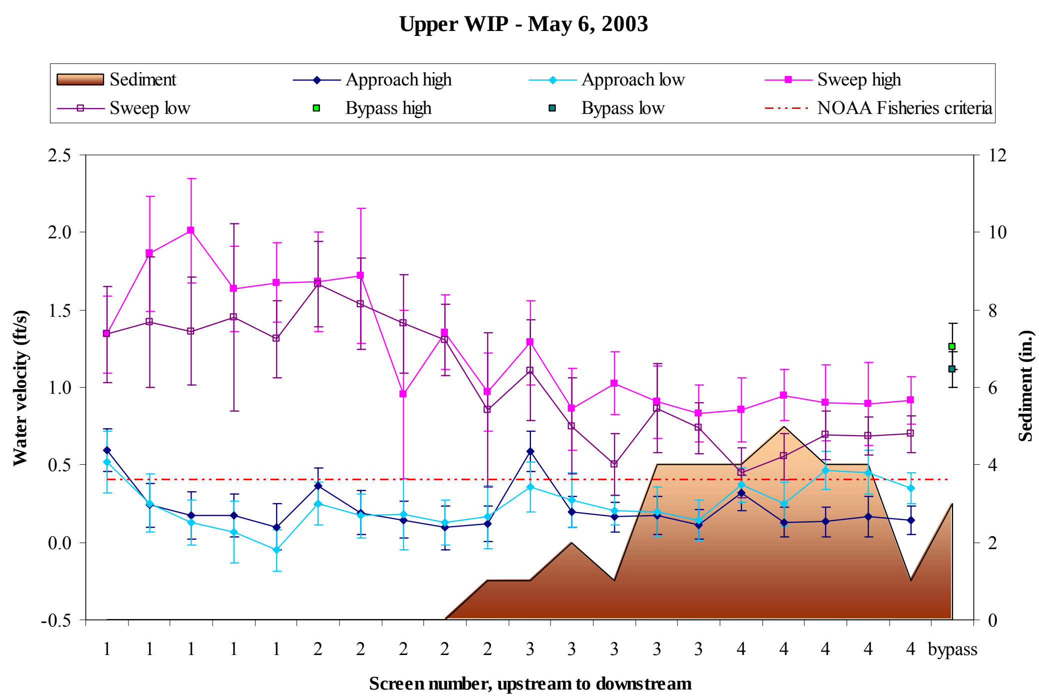

Figure 42. Water Velocities and Sediment Depths at Upper Wapato Irrigation Project (WIP) in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

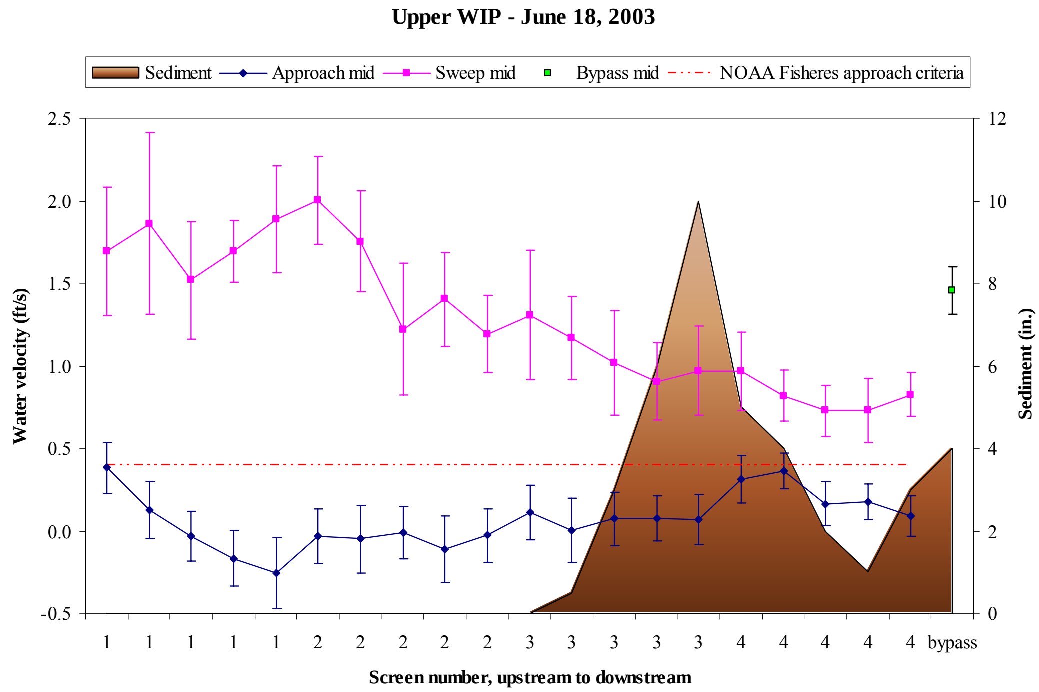

Figure 43. Water Velocities and Sediment Depths at Upper Wapato Irrigation Project (WIP) in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.15 Wilson Creek

The Wilson Creek site was visited on May 13, 2003; June 25, 2003; and September 15, 2003. All measured approach velocities met NOAA Fisheries criteria during all surveys (Figures 44, 45, and 46). Sweep velocities were always greater than approach velocities. Sweep velocities did not increase towards the bypass except in September, and the average bypass velocity was slower than the average sweep velocity in May and June.

Submergence met criteria during all surveys. There was 2 in. of head loss over the screens in May. This was probably due to growth of algae on and inside of the screens, which tends to partially or fully plug the screen holes. The screen material was in good condition during all surveys, as were all seals. The gaps between the metal frames of the drums and the concrete walls of the forebay were filled with expanding foam insulation to prevent harm to migrating fish.

Drums turned freely and evenly during all surveys and rolled leaf matter into the aftbay. Bypass conditions were safe for fish passage during all surveys. Water flowed freely over the weir and out the outfall. The outfall pipe was submerged during all surveys and the depth at the point of discharge was greater than 1 ft.

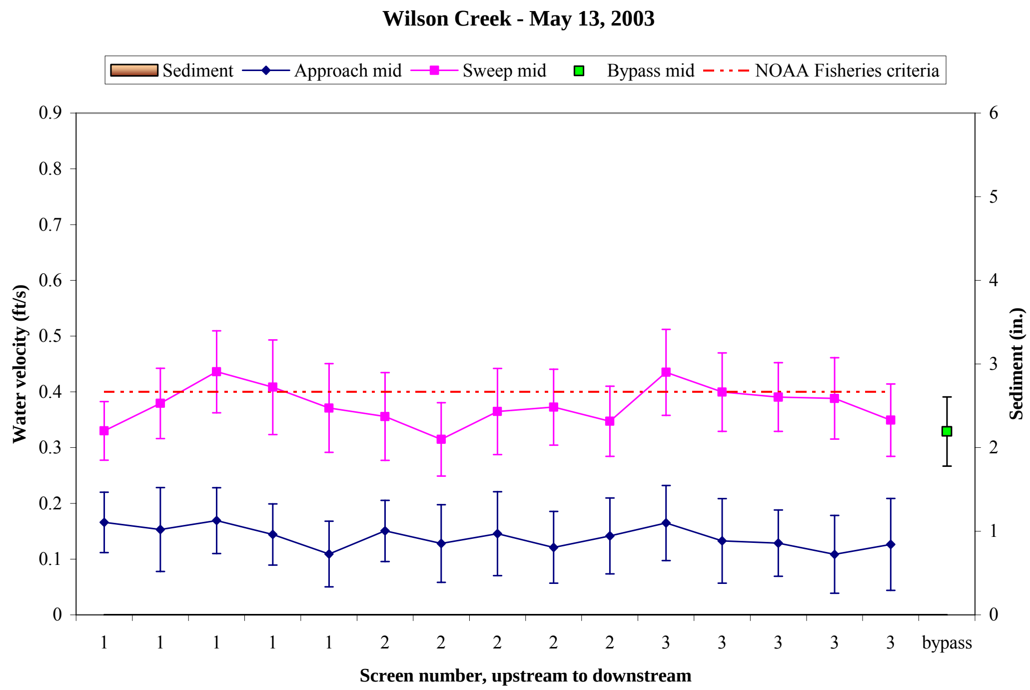

Figure 44. Water Velocities and Sediment Depths at Wilson Creek in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

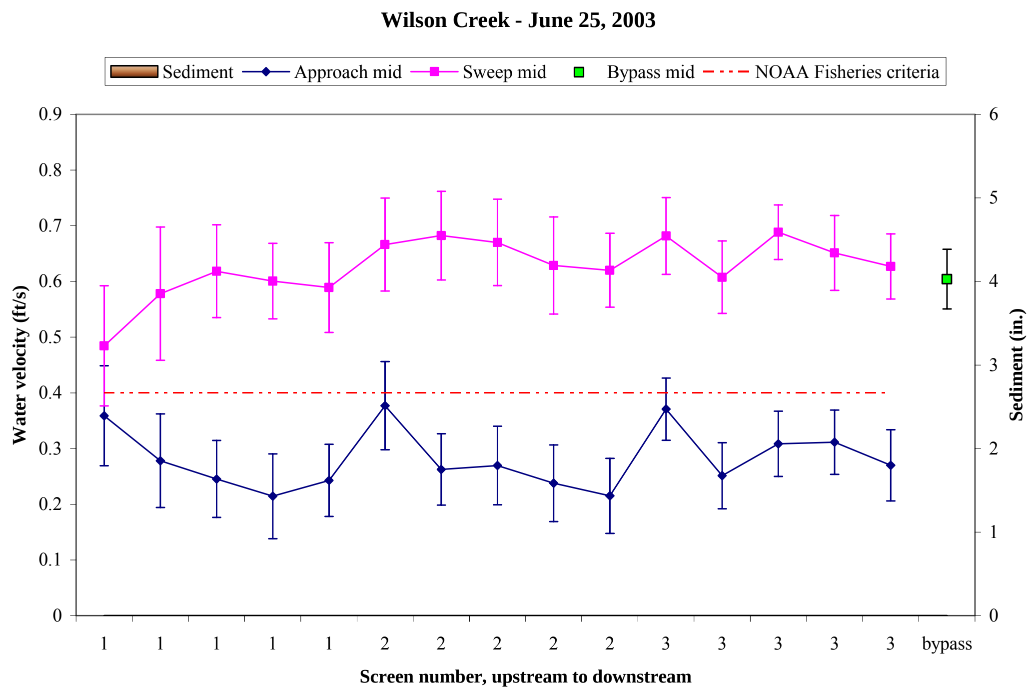

Figure 45. Water Velocities and Sediment Depths at Wilson Creek in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

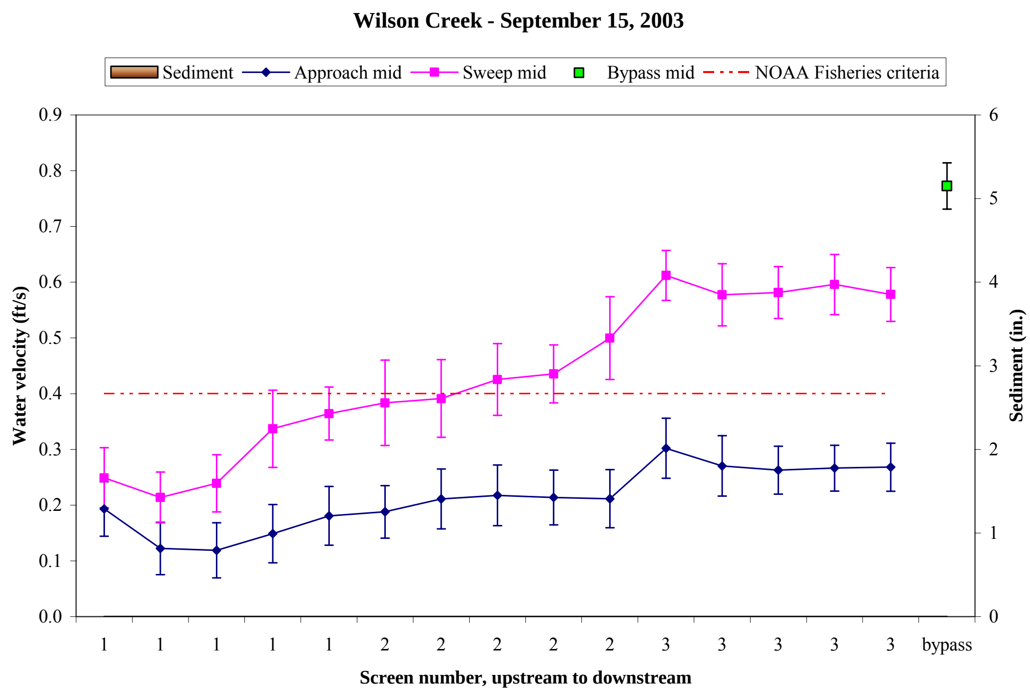

Figure 46. Water Velocities and Sediment Depths at Wilson Creek in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.3 Vertical Plate Screens

3.3.1 Bull Ditch

The Bull Ditch site was evaluated on May 12, 2003; June 25, 2003; and September 16, 2003. Sweep velocities were generally higher than approach velocities in May but not in June or September (Figures 47, 48, and 49). Approach velocities met NOAA Fisheries criteria 92%, 94%, and 100% of the time in May, June, and September, respectively. Sweep velocities tended to decrease over the length of the site, and in September, both sweep and approach velocities at the downstream end of the site were approximately zero.

All screens and seals appeared to be in good condition during the surveys. Very little debris was present during any of the surveys in 2003 compared with previous years. The log installed upstream of the upstream trash rack to prevent sediment accumulation was still present in 2003. The brushes operated effectively to remove debris from the screen face except in September when there was some algae growth on the screens.

Low-sweeping velocities at the downstream end of the site combined with the presence of predator habitat may result in the delay of and predation on migrating salmonids. Low-sweeping velocities are controlled in part by the metal plates placed between the screens and the channel, and changes in their position may help increase sweep velocities. The slower water may also cause sediment accumulation at

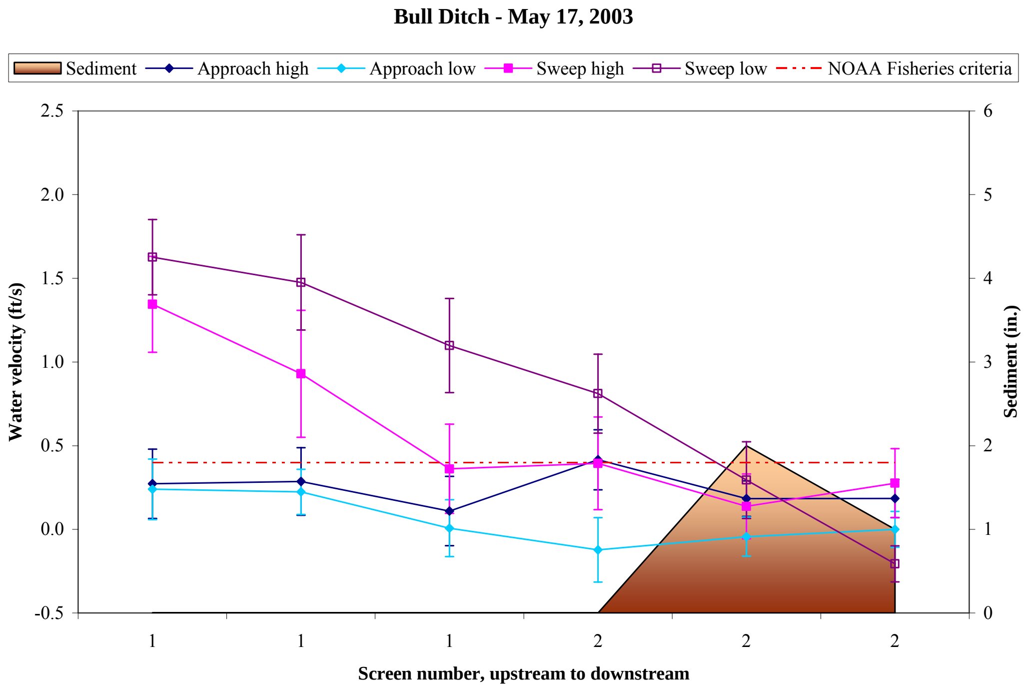

Figure 47. Water Velocities and Sediment Depths at Bull Ditch in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

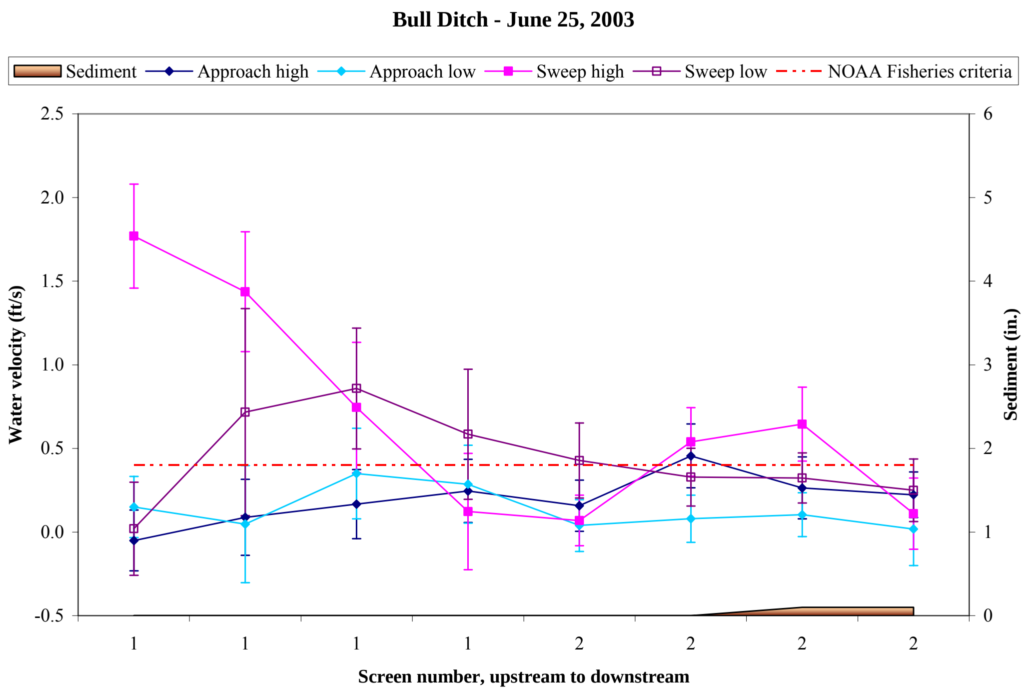

Figure 48. Water Velocities and Sediment Depths at Bull Ditch in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

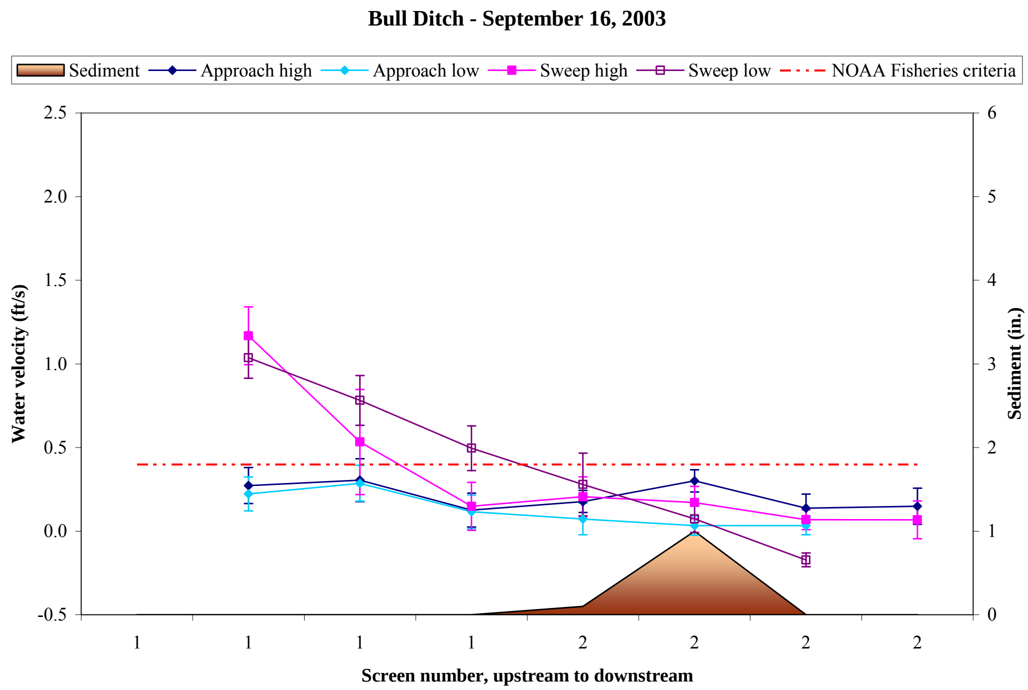

Figure 49. Water Velocities and Sediment Depths at Bull Ditch in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

the downstream end of the site. This site has been tentatively scheduled for removal during the 2003 winter. If it continues to be used, the PNNL researchers recommend that procedures be evaluated to increase sweep velocities and minimize predator habitat growth and sediment accumulation.

3.3.2 Ellensburg Mill

The Ellensburg Mill site was visited on May 12, 2003; June 25, 2003; and September 15, 2003. Because of aquatic vegetation growth in the forebay, the Marsh-McBirney 511® flow meter was used to measure velocity at the low position in May and June; consequently, turbulence values are not available for those measurements. All approach velocities met NOAA Fisheries criteria during all surveys (Figures 50, 51, and 52). Sweep velocities were generally higher than approach velocities. Sweep velocities did not increase towards the bypass, although the bypass velocity was greater than the average sweep velocity during all surveys.

The screens appeared to be in good condition during all surveys, but the seals between the screens were partially missing and may need to be replaced. In May and June, bottom seals were not evaluated due to growth of aquatic plants in the forebay. While this is not generally a concern at flat-plate screen sites, the September video survey revealed that the bottom seals may also need to be replaced as the caulking is missing in places. The mechanical brushes effectively removed algae and debris from most of the screen surfaces, though there were patches, especially towards the bottoms of the screens that remained covered with algae.

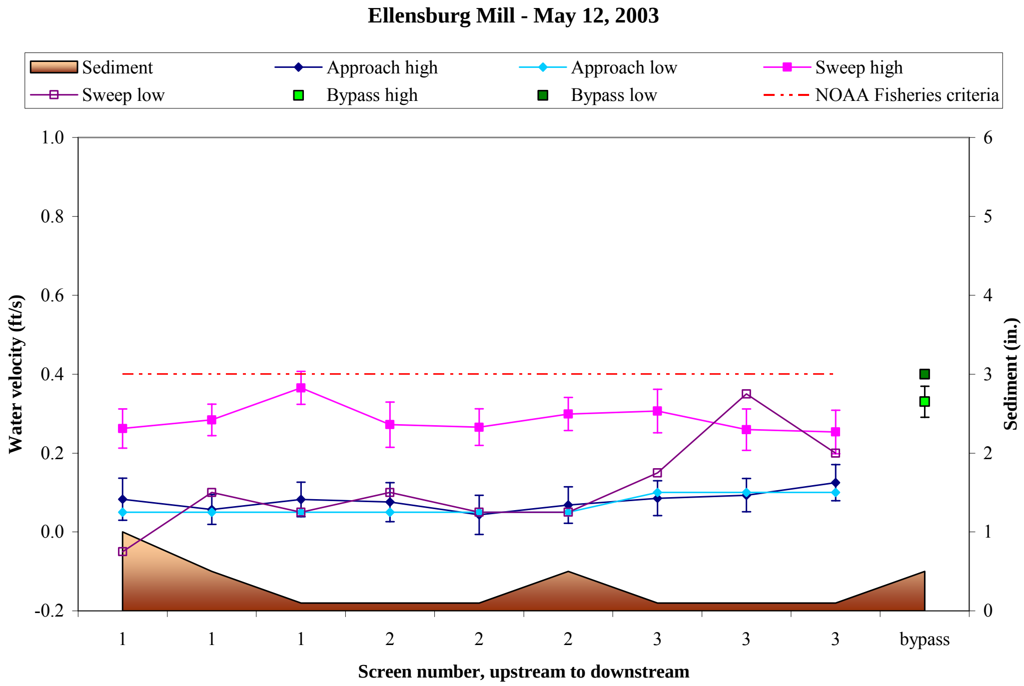

Figure 50. Water Velocities and Sediment Depths at Ellensburg Mill in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

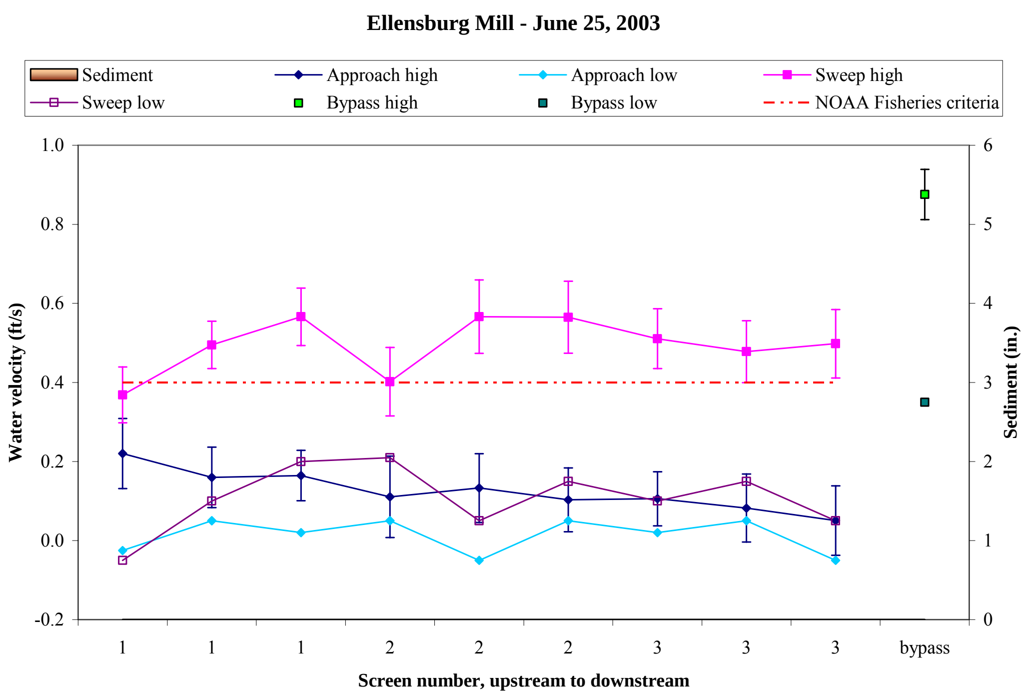

Figure 51. Water Velocities and Sediment Depths at Ellensburg Mill in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

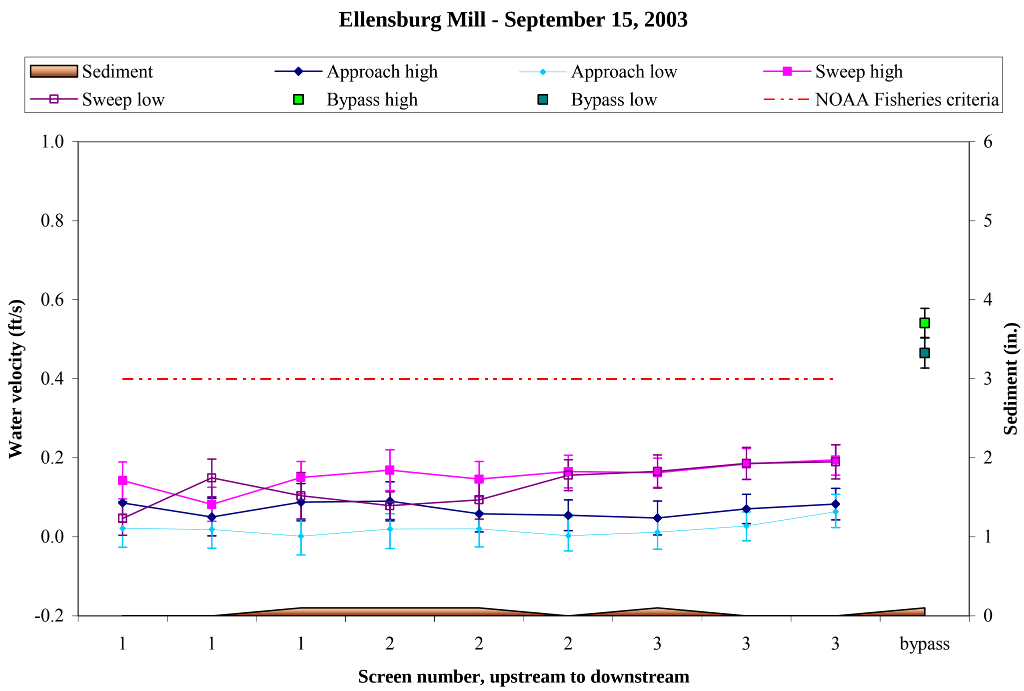

Figure 52. Water Velocities and Sediment Depths at Ellensburg Mill in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

Many fish were observed at this site during all of the surveys. In May, there was a large fish near the bypass ramp that was likely a Northern pike minnow. In June, there were several small (approximately 5-in.) fish that were trout and Northern pike minnow. In September, there was a large rainbow trout in the bypass.

3.3.3 Fruitvale

The Fruitvale site was visited on May 8, 2003; June 26, 2003; and September 16, 2003. During all surveys, 100% of approach velocities met NOAA Fisheries criteria (Figures 53, 54, and 55). Sweep velocities were generally higher than approach velocities and increased towards the bypass in September. Bypass velocities were higher than the average sweep velocity in May and September.

During all surveys, water ran freely over the weir and out the outfall, and outfall conditions met NOAA Fisheries criteria for safe fish passage. However, notes in the logbook indicated that at some point in July there was no water flowing over the bypass ramp, and the ramp and flushgate were closed. On July 27, 2003, the bypass was flushed to allow three to four dozen fish out of the forebay. Over the last several years this site has had difficulty maintaining bypass flow during July and August. Salmonid smolts are not expected to migrate during this period, and as long as there is enough water movement to maintain oxygen levels in the water, the flow conditions would not be expected to be a problem. However, because this problem seems to be persistent and it has been shown to affect some fish, we recommend that operating conditions be modified to allow fish passage during these low-flow periods.

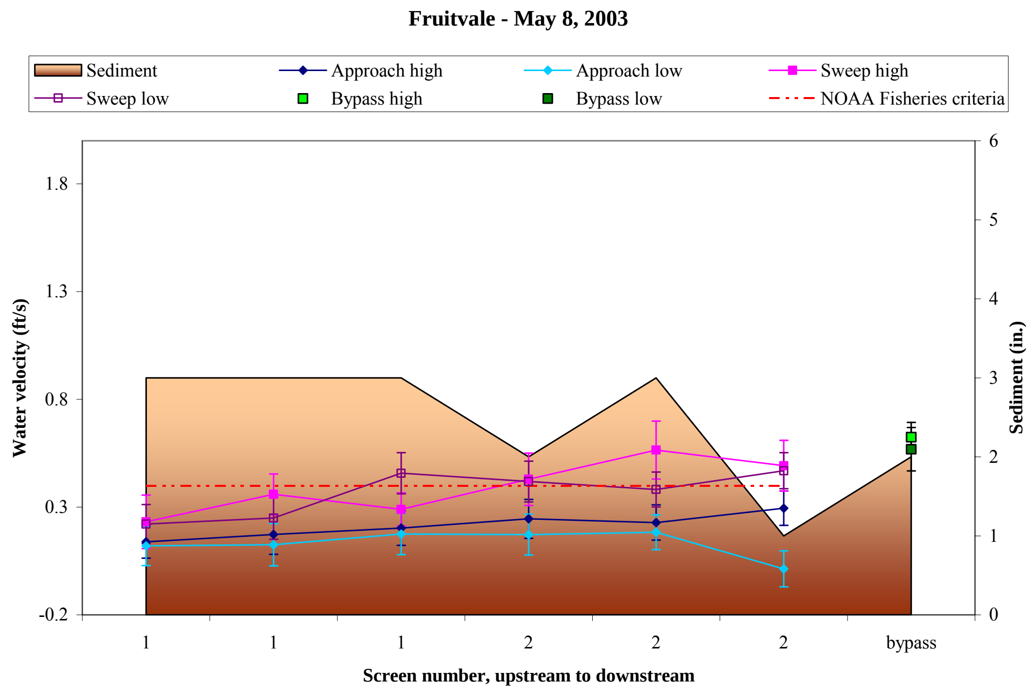

Figure 53. Water Velocities and Sediment Depths at Fruitvale in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

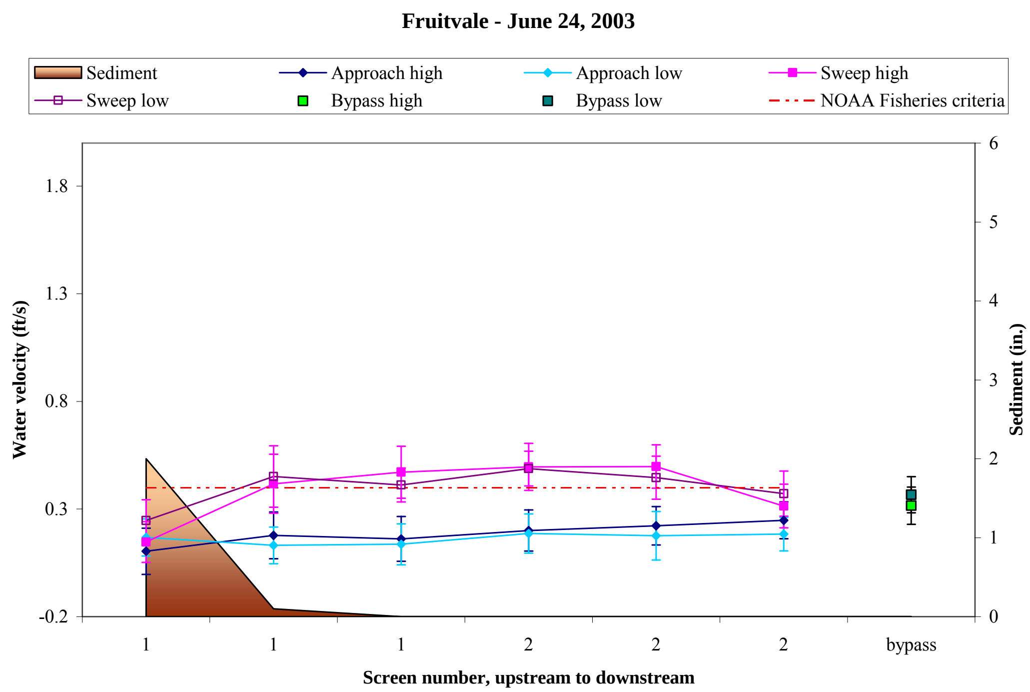

Figure 54. Water Velocities and Sediment Depths at Fruitvale in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

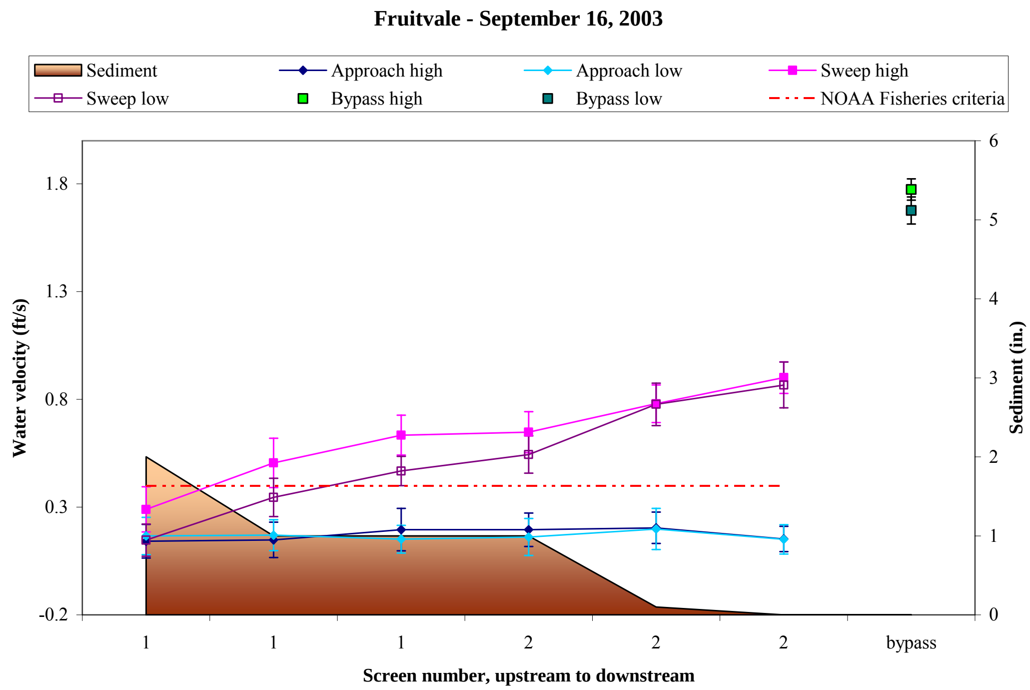

Figure 55. Water Velocities and Sediment Depths at Fruitvale in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

The level of sediment accumulation in the forebay was reasonable during all surveys, however in June we observed a gigantic pile of sediment in the aftbay that came within 2 to 3 in. of the surface of the water. Generally this would not be a concern, but the pile of sediment infiltrated the screen louvers, many of which could not have been moved while the sediment was present. While maintenance and care of the forebay is generally sufficient, any problem in the aftbay that affects the operation of the site, like this giant pile of sediment, needs to be addressed as well.

The mechanical brushes operated effectively to remove debris from the screens during all surveys. The screens appeared to be in good condition, although the seals on the upper parts of the screens appeared somewhat weathered, and the video survey revealed that the caulking along the bottom of the screens was loose or missing in places.

3.3.4 Naches-Selah

The Naches-Selah site was visited on May 13, 2003; June 24, 2003; and September 16, 2003. In May, June, and September, 92%, 72%, and 75% of approach velocities met NOAA Fisheries criteria, respectively (Figures 56, 57, and 58). Sweep velocities were always greater than approach velocities but did not increase towards the bypass. The average bypass velocity was slower than the average sweep velocity during all surveys. Ray Gilmore was notified of the high approach velocities on June 26. Dave Floyd made changes to the operating conditions on July 2, but the changes did not put the site in compliance with the NOAA Fisheries criteria, and in September the approach velocities were still high. Ray Gilmore was notified again on September 17, although there was not much he could do. This site has one of the worst records as far as meeting NOAA Fisheries velocity criteria, and while the numbers for 2003 are an improvement over 2002, they are still low (Table 4). The PNNL researchers recommend that site operating procedures and/or site structure be modified to protect migrating fish from injury as they pass through this site.

The screens are patched in places, but they appeared to be in good condition during all surveys. The caulking between the screens and under the screens was missing in places.

Water flowed freely over the weir during all surveys, though the bypass pipe in the downwell was only halfway submerged. Notes in the logbook on July 10 state that someone had been fooling around with bypass settings for six weeks, and at times the ramp was cranked up above the water level. Checkboards were placed just below the outfall pipe in the cement apron sometime before the May survey, which backed the water up, but in June the water depth beyond the checkboards in the apron was only 2 in., and continued to be below the minimum criteria set by NOAA Fisheries throughout the season. Someone had also been changing the site conditions prior to the July 2 visit by lowering the fish gate at the head of the bypass approximately 1-2 ft into the bypass flow, causing extremely high bypass flow (4 cfs). At that time, WDFW did not know who had been changing the settings, but the fish gate was returned to its normal raised position.

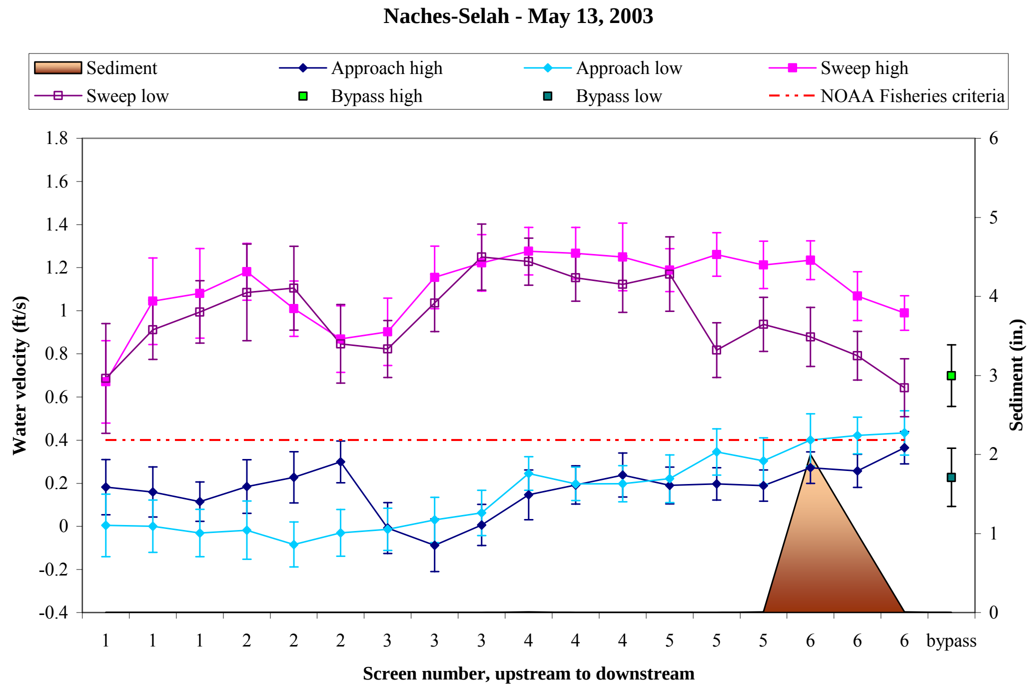

Figure 56. Water Velocities and Sediment Depths at Naches-Selah in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

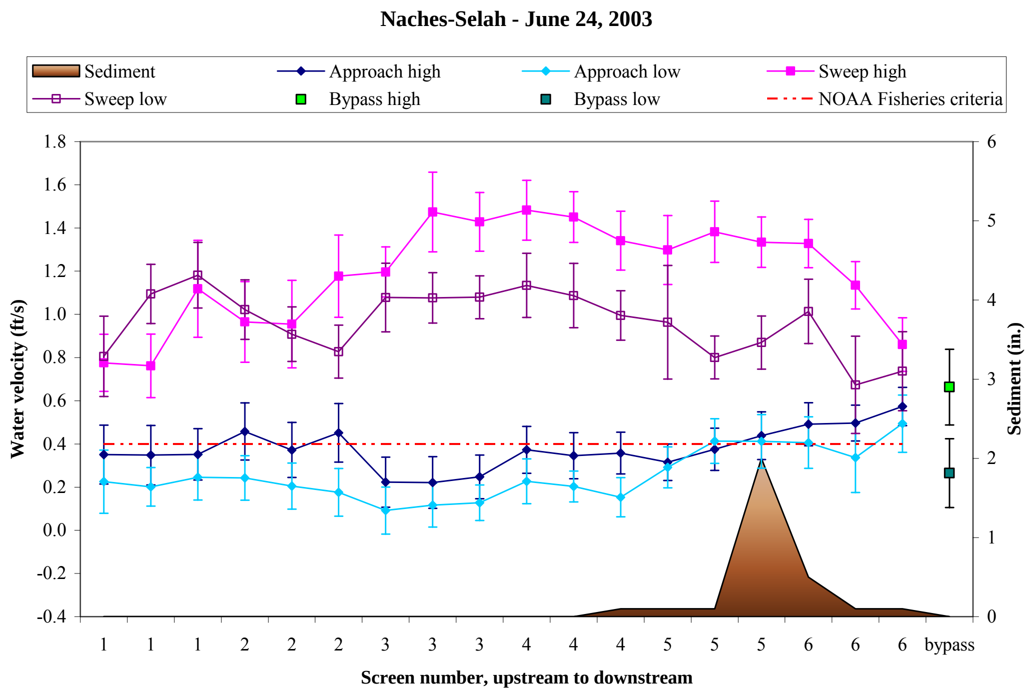

Figure 57. Water Velocities and Sediment Depths at Naches-Selah in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

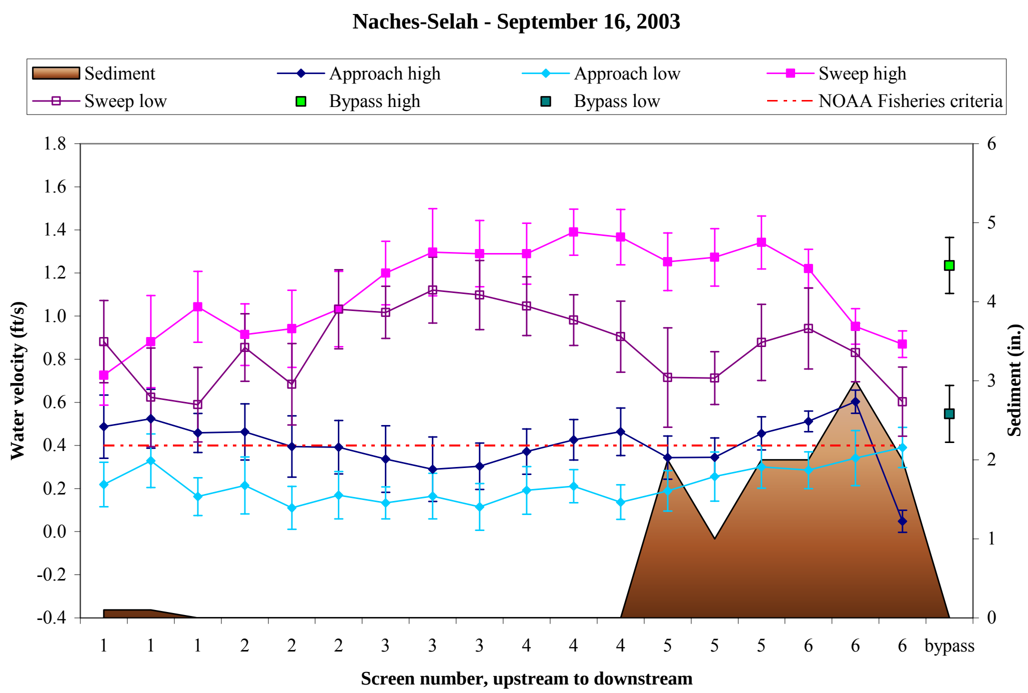

Figure 58. Water Velocity and Sediment Depths at Naches-Selah in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.3.5 Union Gap

The Union Gap site was evaluated on May 8, 2003; June 24, 2003; and September 16, 2003. In May, June, and September, 100%, 71%, and 100% of approach velocities met NOAA Fisheries criteria, respectively (Figures 59, 60, and 61). Sweep velocities were always higher than approach velocities, but did not increase toward the bypass. The average bypass velocity was slower than the average sweep velocity. Ray Gilmore was notified on June 24 that greater than 10% of the approach velocity measurements exceeded 0.4 ft/s. Follow-up measurements taken on June 26 after changes in operating conditions showed that velocities were still high. PNNL followed up again on July 2, and approach velocity conditions met the NOAA Fisheries criteria.

The screen material was in good condition during all surveys. The seals on all screens were missing in places, as they have been for the past several years. No algae or aquatic plant growth was observed in the forebay during 2003.

Bypass conditions were safe for fish passage during all surveys. Water ran freely behind the weir and through the outfall pipe, and the water depth at the point of discharge was always greater than 1 ft.

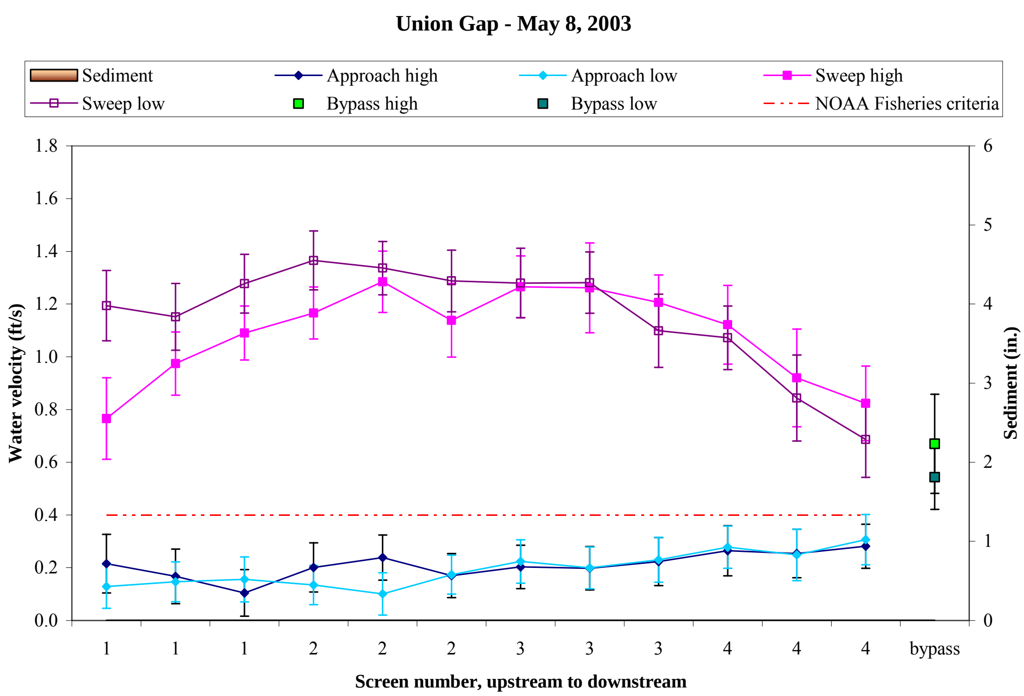

Figure 59. Water Velocities and Sediment Depths at Union Gap in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

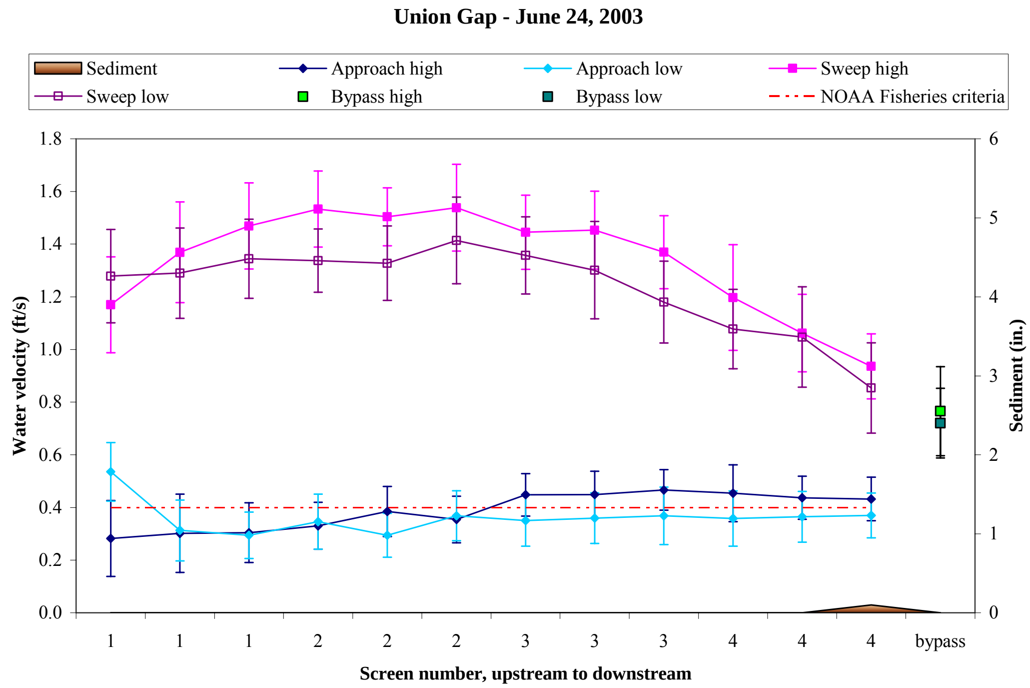

Figure 60. Water Velocities and Sediment Depths at Union Gap in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

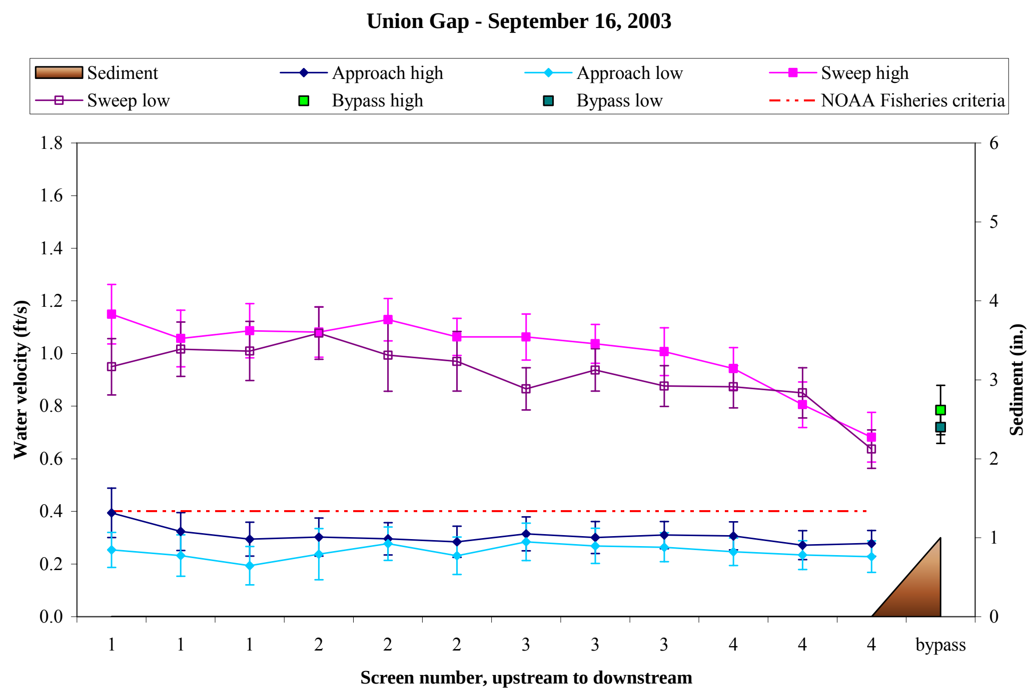

Figure 61. Water Velocities and Sediment Depths at Union Gap in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.3.6 Yakima-Tieton

The Yakima-Tieton site was evaluated on May 14, 2003; June 19, 2003; and September 17, 2003. In May, June, and September, 97%, 94%, and 100% of approach velocities met NOAA Fisheries criteria, respectively (Figures 62, 63, and 64). Sweep velocities were always higher than approach velocities. Sweep velocities did not increase towards the bypass, and the average bypass velocity was always higher than the average sweep velocity.

The screens appeared to be in good condition during all surveys. Several of the screen seals have missing or failing caulking and have been in a similar condition for the past several years. These screens should be re-caulked.

Bypass and outfall conditions met NOAA Fisheries criteria during all surveys in 2003. Water flowed freely over the weir and out the outfall, and the water depth at the point of discharge was always greater than 1 ft.

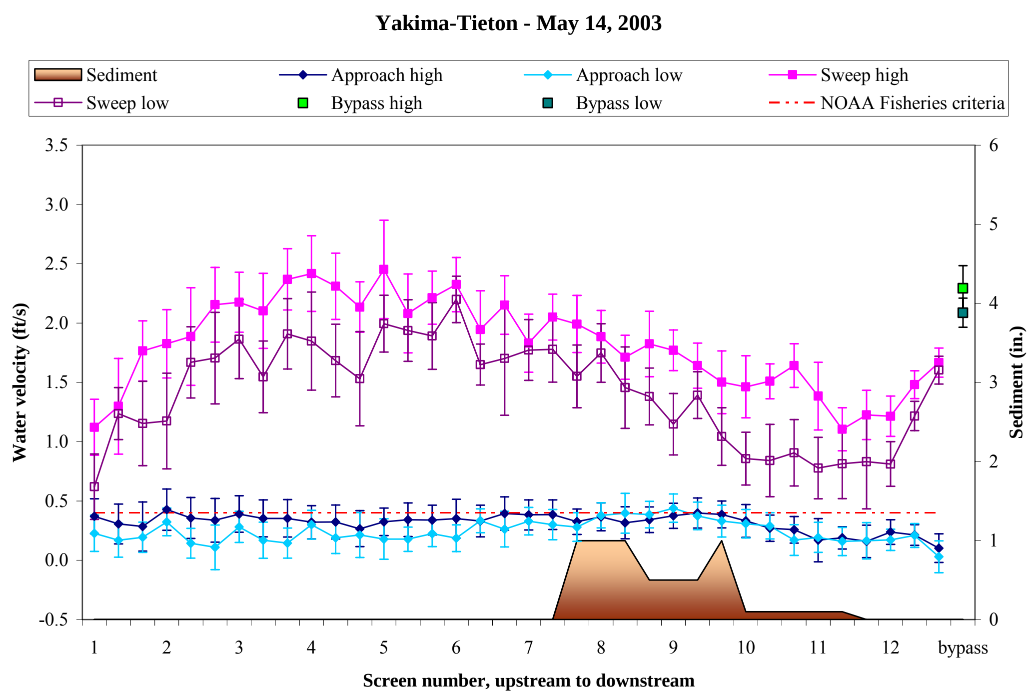

Figure 62. Water Velocities and Sediment Depths at Yakima-Tieton in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

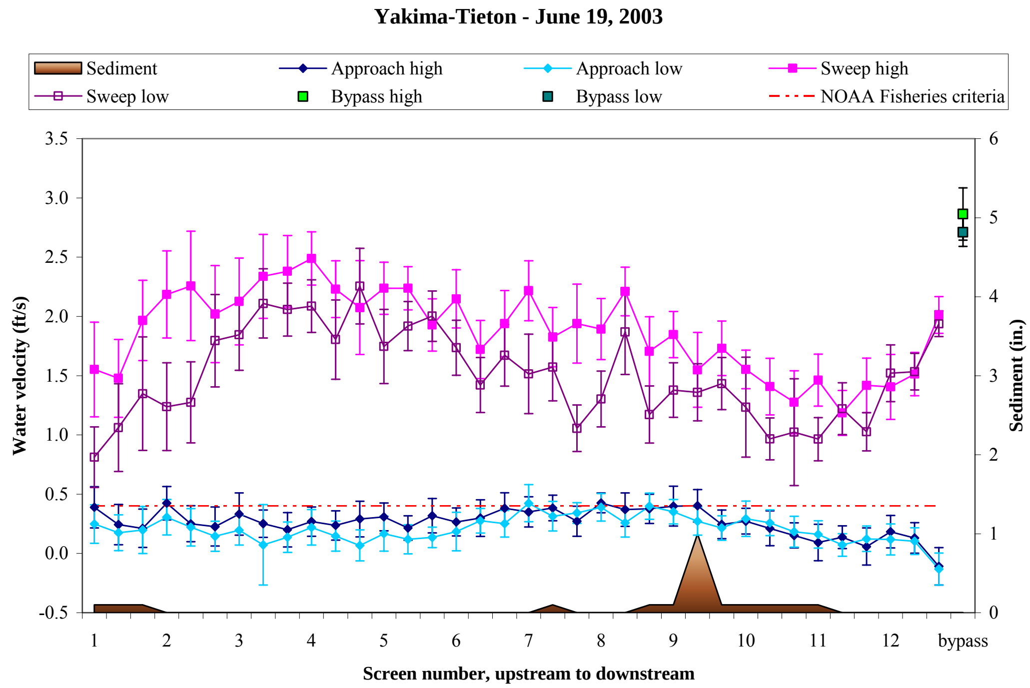

Figure 63. Water Velocities and Sediment Depths at Yakima-Tieton in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

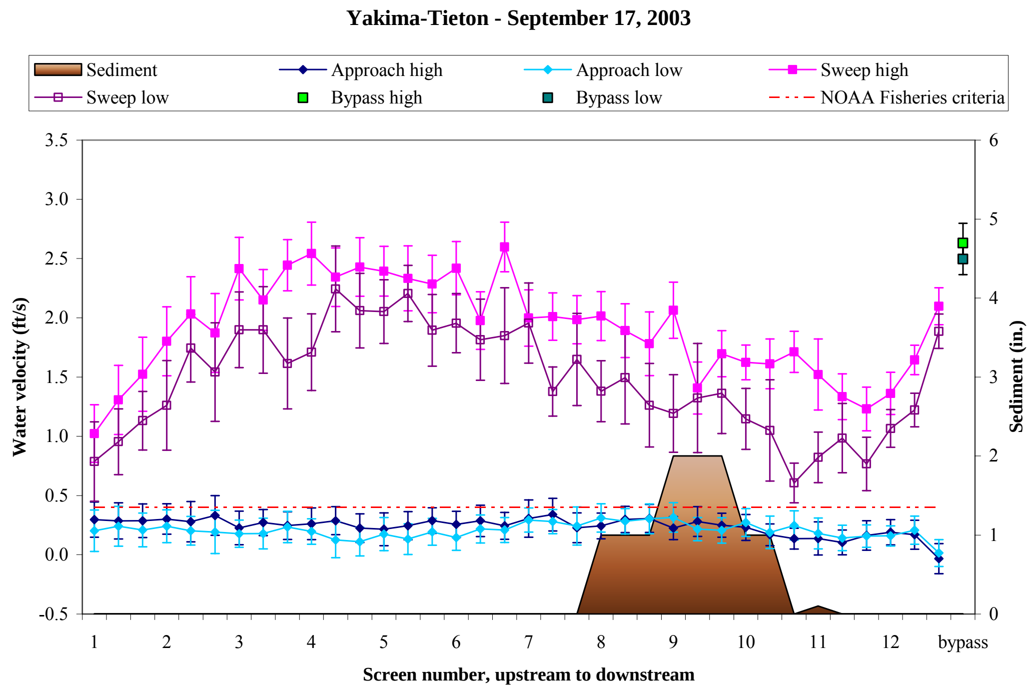

Figure 64. Water Velocities and Sediment Depths at Yakima-Tieton in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.3.7 Younger

The Younger site was visited on May 12, 2003; June 25, 2003; and September 15, 2003. All approach velocities met NOAA Fisheries criteria during all surveys (Figures 65, 66, and 67). Sweep velocities were generally higher than approach velocities, though they did not increase towards the downstream end of the site.

In May, there was no flow over the checkboards in the forebay, effectively blocking passage through the site. A large trout was present at the time. Ray Gilmour was notified about the blockage on May 12, 2003, and he fixed the problem the same day.

The upstream seal on screen 1 and the downstream seal on screen 2 were lacking caulking in places. Sediment accumulation was not an issue at this site in 2003. The brushes seemed to be mostly effective, although the screens became plugged from cottonwood fluff sometime in June.

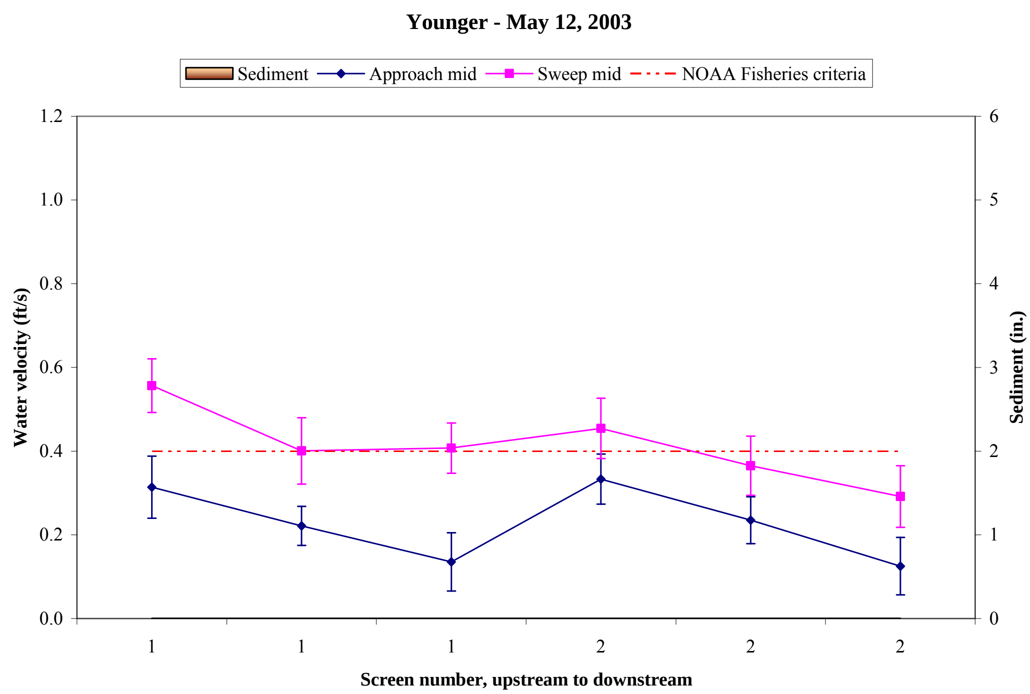

Figure 65. Water Velocities and Sediment Depths at Younger in May 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

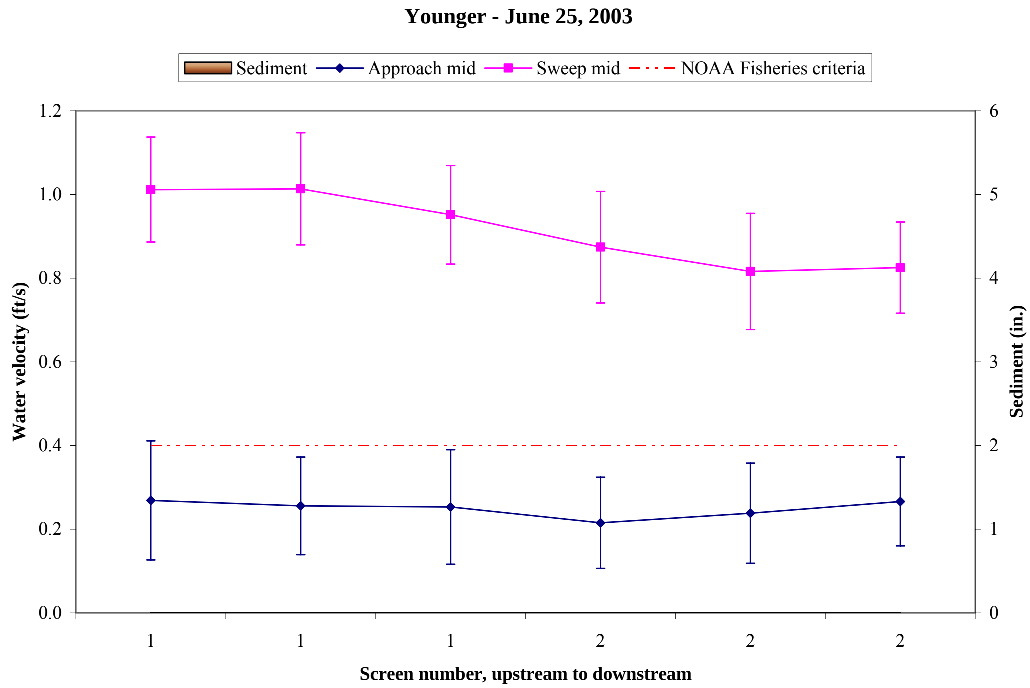

Figure 66. Water Velocities at Younger in June 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

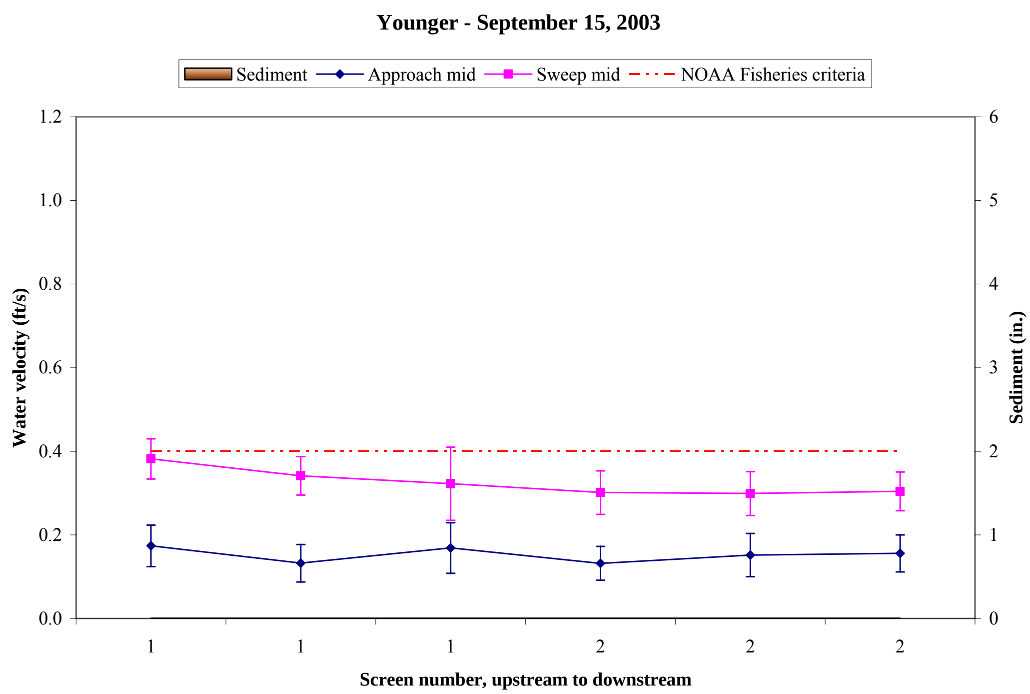

Figure 67. Water Velocities at Younger in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.4 Vertical Traveling Screen

3.4.1 Gleed

The Gleed site was evaluated on May 13, 2003; July 2, 2003; and September 19, 2003. In May, July, and September, 56%, 75%, and 79% of approach values met NOAA Fisheries criteria of less than or equal to 0.4 ft/s, respectively (Figures 68, 69, and 70). In May, anti-silt boards were positioned in front of screen 1, so no velocity data were taken. Aside from fast water, fish encountering this site also had to deal with highly turbulent water, without a clear trajectory. Sweep velocities were not always greater than approach velocities and did not increase towards the downstream end of the site.

Ray Gilmore was notified on May 13 concerning the high approach velocities at 44% of the measured points in May. On May 19, the anti-silt boards were removed in an attempt to decrease the approach velocities by taking water in at the upper end of the site. No follow-up evaluation was completed until the July survey, when approach velocities still exceeded the NOAA Fisheries criteria. Mr. Gilmore was contacted again regarding the issue on July 3. No changes were made, and the September survey showed that approach velocities still exceeded criteria. The design of this site allows for approach velocities to be controlled to some extent by metal plates that are located between the screens and the channel. Gaps between these plates allow water to move in toward the screens, but in such concentrated locations that the approach velocities can be quite high at times. An evaluation of the hydraulics associated with the plates and the screens may lead to a better solution to this problem.

There were no problems with sediment buildup at this site, although there seemed to be much more floating woody debris than in past years. Floating boards were installed across the site entrance to try and protect the screens from the floating debris. The screen material was in good condition. This site has a flow-through bypass that was generally in good condition during our surveys. However, notes in the logbook indicate that the ditch company completely blocked off the bypass and trash-carrying slot in mid-July.

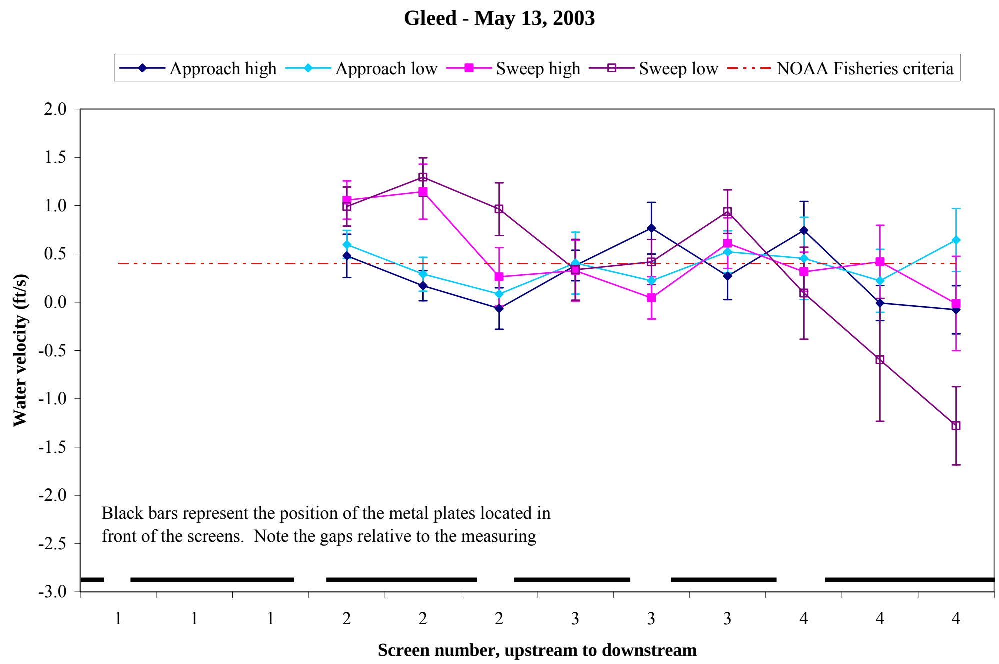

Figure 68. Water Velocities and Sediment Depths at Gleed in May 2003. Measurements were not taken in front of screen one because a sheet of plywood had been placed directly in front of the screen. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

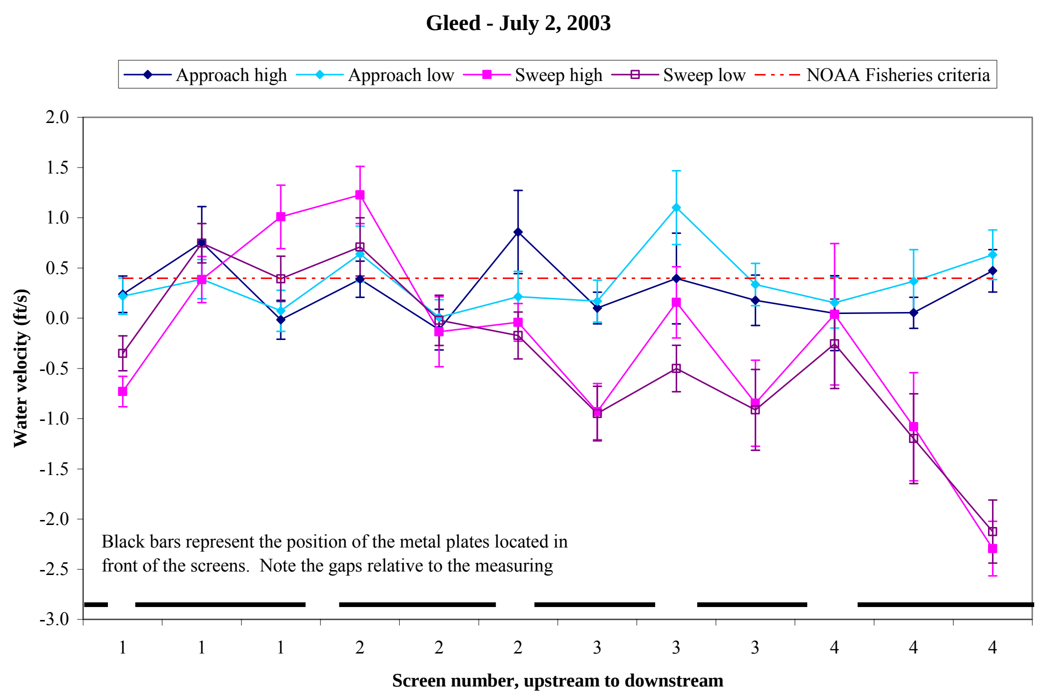

Figure 69. Water Velocities and Sediment Depths at Gleed in July 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

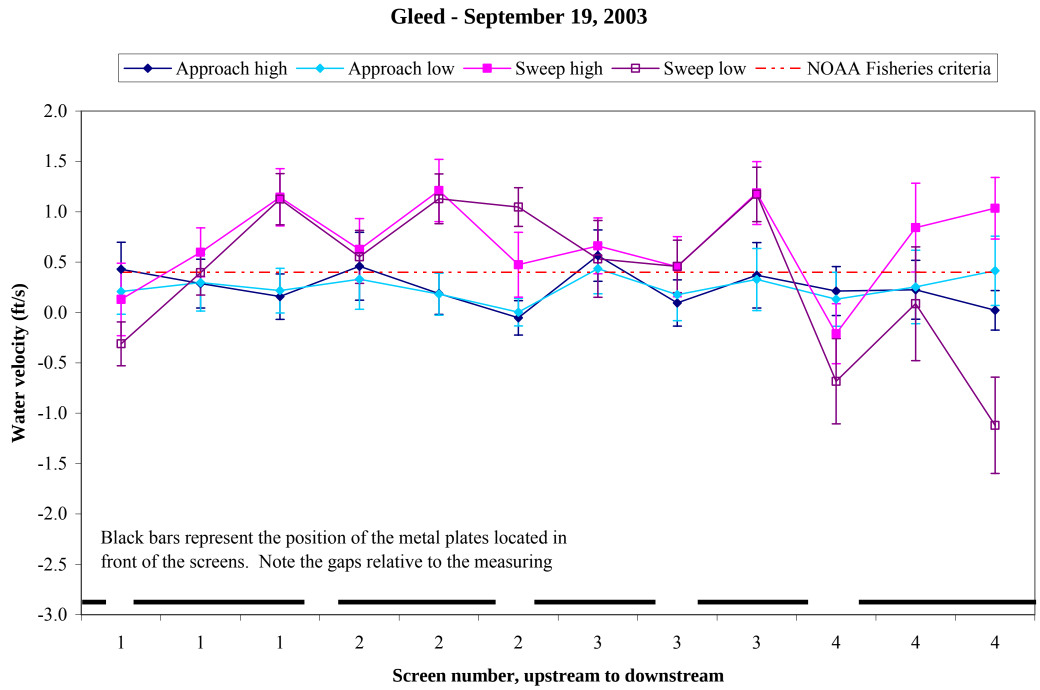

Figure 70. Water Velocities and Sediment Depths at Gleed in September 2003. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

4.0 Conclusions

The 2003 evaluations of 23 Phase II fish screen facilities in the Yakima River Basin by PNNL indicate that the facilities were generally designed, constructed, operated, and maintained to effectively provide fish a safe and efficient return to the river. Sweep velocities were generally higher than approach velocities and lower than bypass velocities, which should provide fish with safe passage back into the river without delays.

Most screens were well maintained and properly sealed to prevent fish entrainment and injury, although some potential problems were identified at each screen site. These included lack of caulking at flat-plate screens (e.g., Yakima-Tieton) and excessive accumulation of debris at some of the sites (e.g., Toppenish Pump). The lack of caulking creates gaps that could potentially entrain fish, while debris buildup could create habitat for predators and, in some cases, inhibit the ability of the site to function properly. The automated cleaning brushes at flat-plate screen sites generally functioned properly; chains and other moving parts were well greased and operative. Drum screen sites generally functioned properly to roll debris into the aftbay.

Continued periodic 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. The continuance of the problem-tracking protocol can assist in this process by making the agencies responsible for operations and maintenance more accountable for proper maintenance and operation of the sites and by allowing the researchers to more easily ascertain which sites may need more attention. Where procedures are being followed and problems still occur, evaluation results can be used to suggest means to better protect fish at screening facilities. There has been a progressive improvement in the maintenance and effectiveness of fish screen facilities in the Yakima River Basin during the past several years, in part, as a result of regular screen evaluations and the rapid feedback of information necessary to improve operations and design of these important fish protection devices.

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