Walla Walla River Basin Fish Screens Evaluations

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Walla Walla River Basin Fish Screens Evaluations

Annual Report

January 2006 - December 2006

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Summary

Pacific Northwest National Laboratory evaluated Gardena Farms, Little Walla Walla, and Garden City/Lowden II Phase II fish screen facilities and provided underwater videography beneath a leaking rubber dam in the Walla Walla River basin in 2006. Evaluations of the fish screen facilities took place in early May 2006, when juvenile salmonids are generally outmigrating.

At the Gardena Farms site, extended high river levels caused accumulations of debris and sediment in the forebay. This debris covered parts of the bottom drum seals, which could lead to early deterioration of the seals and drum screen. Approach velocities were excessive at the upstream corners of most of the drums, leading to 14% of the total approach velocities exceeding 0.4 feet per second (ft/s). Consequently, the approach velocities did not meet National Marine Fisheries Service (NMFS) design criteria guidelines for juvenile fish screens.

The Little Walla Walla site was found to be in good condition, with all approach, sweep, and bypass velocities within NMFS criteria. Sediment buildup was minor and did not affect the effectiveness of the screens.

At Garden City/Lowden II, 94% of approach velocities met NMFS criteria of 0.4 ft/s at any time. Sweep velocities increased toward the fish ladder. The air-burst mechanism appears to keep large debris off the screens, although it does not prevent algae and periphyton from growing on the screen face, especially near the bottom of the screens.

In August 2006, the Gardena Farm Irrigation District personnel requested that we look for a leak beneath the inflatable rubber dam at the Garden City/Lowden II site that was preventing water movement through the fish ladder. Using our underwater video equipment, we were able to find a gap in the sheet piling beneath the dam. Erosion of the riverbed was occurring around this gap, allowing water and cobbles to move beneath the dam. The construction engineers and irrigation district staff were able to use the video footage to resolve the problem within a couple weeks.

We had hoped to also evaluate the effectiveness of modifications to louvers behind the Nursery Bridge screens when flows were higher than 350 cubic feet per second, (cfs) but were unable to do so. Based on the one measurement made in early 2006 after the modified louvers were set, it appears the modified louvers may help reduce approach velocities. The auxiliary supply water system gates also control water through the screens. Evaluating the effect of different combinations of gate and louver positions on approach velocities through the screens may help identify optimum settings for both at different river discharges.

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1.0 Introduction

The Northwest Power and Conservation Council (NPCC) Columbia River Basin Fish and Wildlife Program lists fish protection through effective screening of irrigation diversions as an essential element in its plan to restore declining steelhead and salmon runs (NPCC 1984, 1987, 1994, 2000). Over the past 20 years, the Bonneville Power Administration (BPA) and the Council have expanded the screening efforts to include periodic site evaluations.

The evaluation of existing screen sites is important to ensure that the sites continue to achieve the goals of protecting fish from entrainment and from harm within the screen facility itself (McMichael et al. 2004). Criteria for the design of Phase II fish screen facilities were developed by the National Marine Fisheries Service (NMFS 1995). These criteria are used as guidelines in determining whether a site is constructed, operated, and maintained in a way that protects juvenile salmonids. The evaluations conducted for BPA by the Pacific Northwest National Laboratory (PNNL) and reported here focused on fish screen facilities at four sites in the Walla Walla River basin—two in southeastern Washington and two in northeastern Oregon.

The Gardena Farms diversion is on the west bank (river left) of the Walla Walla River at river mile 36.9 (Figure 1). The fish screen facility is situated on the canal, approximately 500 ft downstream of the diversion dam. The Gardena Farms fish screen site was constructed in 1999. This facility now consists of seven rotary drum screens and one blank metal bulkhead in the upstream screen bay and was evaluated in May during juvenile salmonid outmigration.

The Little Walla Walla diversion is at river mile 47 on the west bank of the Little Walla Walla River, within the city limits of Milton-Freewater, Oregon (Figure 1). The Little Walla Walla site was constructed in 2000 and now consists of a set of 11 flat plate screens made of stainless steel wedgewire with wiper arm brushes to keep the screens free of debris. This site also was evaluated in early May.

The Garden City/Lowden II site is about 2 mi east of the town of Lowden off Highway 12 in Washington (Figure 1), at river mile 31. The facility is an inclined plate screen with eight 6-ft-high $\times$ 4-ft-wide screen panels. The site was evaluated in early May.

The Nursery Bridge Fishway is sited on the east bank (river right) of the Walla Walla River near the town of Milton-Freewater, Oregon (Figure 1). The fish screen is at the upstream end of the fish ladder and is used to draw water through the auxiliary water supply to increase attraction flow at the fish ladder entrances. This facility consists of two horizontal-bar screens facing each other with a channel between.

The methods currently used for evaluating screening facilities were developed while conducting similar studies at fish screen facilities in the Yakima River basin (Blanton et al. 1998, 1999, 2000; Chamness et al. 2001; Carter et al. 2002, 2003; McMichael et al. 2004). These evaluations addressed three main questions:

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

Figure 1. Sites of Fish Screen Facilities in the Walla Walla River Basin

2.0 Methods

We collected water-velocity measurements, underwater video recordings, and general operational data (e.g., screen submergence and fish presence) in 2006 at Gardena Farms, Little Walla Walla, and Garden City/Lowden II screen sites using equipment and techniques described in the following sections.

2.1 Water-Velocity Measurements

Water velocities were measured using an acoustic Doppler velocimeter (SonTek ADV, SonTek/YSI, Inc., San Diego, California). The ADV emits sound at 10 kHz. The frequency of the returning sound waves increases or decreases, depending on whether the water is flowing toward 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. Return times to each of three receivers extending out at an angle from the transmitter are used to calculate the three-dimensional water velocity at a point 3.9 in. below the probe. Velocities typically were recorded at each sampling point along the screen for 30 s at a rate of 2 Hz (two data points per second) and stored in a computer file.

Measurements of water velocity were taken at two to five evenly spaced points along the front of each screen, depending on the type and size of screen. The probe was mounted on a crossbar attached to a vertical pole so that the probe was positioned about 3 in. from the screen face. Measurements were taken at 20% (high) and 80% (low) of the depth as measured from the surface at sites with forebay depths greater than 48 inches and at 60% (mid) of the depth at sites with forebays less than 48 in. deep. All measurements were taken with the axes of the probe oriented to measure water flowing parallel (sweep) and perpendicular (approach) to the screen face, regardless of the orientation of the screen.

Many flat plate screens are oriented vertically, with the screen face perpendicular to the forebay floor. At the Garden City/Lowden II site, however, the flat plate screen is oriented 45 degrees from vertical. At this site, the pole on which the probe was mounted was held parallel to the screen face (i.e., at a 45-degree angle) and measurements were taken parallel and perpendicular to the slanted screen face. A small brace was used to keep the probe approximately 2–3 in. from the screen.

Cleaning brushes and air bursts were turned off at fixed plate screen sites during velocity measurements, but no changes in operation were made at drum screen sites during data collection. Average sweep and approach velocities and root mean square values were calculated for each position at each site.

2.2 Underwater Video

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 underwater camera (Multi SeaCam 1050, DeepSea Power & Light, San Diego, California) connected to a digital video recorder (Video Walkman Model GV-D800, Sony Corporation of America), which in turn was connected to a pair of video glasses (Eye-Trek Model FMD-200, Olympus America Inc., Center Valley, Pennsylvania). The advantage of this system was that it allowed the person operating the camera to see what was being recorded 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.

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 also was 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 in the office where viewing conditions were better, and images of interest were digitally captured using VideoWave image-capturing software (Roxio Labs, division of Sonic Solutions, Novato, California).

2.3 General Operational Data

Additional data collected during each evaluation included

- general site descriptions and photographs
- screen conditions
- screen submergence levels

- cleaning-system operation
- fish presence
- debris observed in the forebay.

Presence or absence of operator control aids, such as water gauges and drum submergence marks on screen frames, also were noted.

2.4 Data Analyses

National Marine Fisheries Service criteria for fish screen design describe velocity and general operational conditions that would be expected to provide safe passage for juvenile salmonids (NMFS 1995). The criteria include

- maintaining a uniform flow distribution over the screen surface to minimize approach velocities
- keeping approach velocities at ≤ 0.4 ft/s
- achieving sweep velocities greater than approach velocities
- maintaining a gradual and efficient acceleration of flow from the upstream end of the site into the bypass entrance to minimize delay of out-migrating salmonids
- maintaining screen submergence between 65% and 85% for drum screen sites.

Bypass flows were evaluated along with sweep and approach velocities in front of the screens except at Garden City/Lowden II, where the river flows past parallel to the screens and into a fish ladder. Because there are no formal criteria for how sites should be operated, we compared our measurements to the design criteria for juvenile fish screens, which serve as a guide to how the screen site should function if operated and maintained properly.

3.0 Results and Discussion

Comparisons of NMFS criteria with our measured values for bypass flows and sweep and approach velocities are presented here for each fish screen site.

3.1 Gardena Farms

The Gardena Farms screen site was visited on May 1, 2006, when stream flows were about 382 cfs. Submergence was 77% and within the NMFS criteria. The first screen bay at the upstream end of the site was not evaluated because it contains a metal bulkhead that prevents water movement into the canal. Approach and sweep velocities were measured at the remaining seven drum screens as well as in the bypass at 60% of forebay depth (mid) at five positions in front of each drum screen. As can be seen in Figure 2, sweep increased slightly toward the bypass, and the bypass flow was higher than sweep.

River levels were high for an extended period in spring 2006, carrying a lot of sediment and debris downstream. Accumulations of aquatic vegetation and woody debris covered the bottom seal in a number of places and probably affected water flow past and through the screens. Debris was lower and approach values were higher at the upstream ends of most of the screens because of back eddies downstream of the cement pier noses between each drum screen bay. In all, 5 of the 35 approach velocities (14%) exceeded

Figure 2. Approach and Sweep Velocities at Gardena Farms Site, May 2006. Velocities measured at 60% of forebay depth.

NMFS criteria of 0.4 ft/s. Sweep velocities across the screens also were not uniform. Sweep tended to increase slightly along each drum and then abruptly drop at the downstream end of the drum. This may have been caused by the excessive debris or by backup of water against the pier nose between screen bays.

At this site, debris is allowed to accumulate until low water later in the season, when the site is shut down and cleaned out using heavy equipment. While this is a practical approach to removing the debris, it does not prevent the approach velocity hot spots and possible wear and tear on the screens caused by excessive debris. It might be possible to airburst or otherwise move some of the vegetation and woody debris away from the screens in season. Because the stoplogs are raised behind the screens to increase flow and move sediment along the bottom of the screen bays, the sand might be able to move through more freely.

The bypass ramp was between 6 and 8 in. above the bottom on arrival, but the site was flushed and the ramp properly seated before we left the site. Screen and seal material that could be seen were in excellent condition, and cheeks between the drum frame and cement structure were caulked.

3.2 Little Walla Walla

The Little Walla Walla site was visited on May 2, 2006, when river flow was about 305 cfs. Approach and sweep velocities were measured at 20% and 80 % of the forebay depth (high and low depths, respectively) at three locations in front of each of the 11 screen panels. Sweep generally increased toward the bypass and was always greater than the approach velocities (Figure 3). Bypass velocity was greater than sweep, and all approach velocities were well below the 0.4 ft/s criterion. Sediment increased in the lower half of the site, with up to 3 in. of sediment accumulating near the screens.

Figure 3. Approach and Sweep Velocities at Little Walla Walla Site, May 2006. Velocities measured at 20 and 80% of forebay depth.

Video surveys indicated the seals and screen material were in good condition and clean, and the site appeared to be operated and maintained in a way that protects juvenile salmonids.

3.3 Garden City/Lowden II Screens

The Garden City/Lowden II site was visited also on May 2, 2006, to evaluate velocities during peak juvenile salmonid migration. There is no bypass structure at this site; water flows past the inclined flat plate screens into the fish ladder. Air bursts from behind the screens are used to prevent debris buildup by moving loose debris away from the screen face. Flow through the screens is controlled by baffles behind the screens.

Velocity data and underwater video were collected when river discharge in the Walla Walla River was about 305 cfs, with 14.5 cfs flowing into the canal. Although water depth was less than 4 ft, we collected two sets of measurements at 20% (high) and 80% (low) of the water depth because of the long sloped screen face. The probe was positioned parallel to and approximately 2–3 in. above the sloping screen face. Figure 4 shows sweep velocities in May increasing downstream, and 30 of 32 approach velocities (94%) less than 0.4 ft/s.

Video surveys indicated the screen and seals were in good condition, with minor periphyton buildup visible. The bottom edge of the sloped screen is set on a short vertical cement wall. Caulking between this short wall and the underlying horizontal foundation is coming loose or is missing in a few places, and should be replaced to prevent enlargement of the crack from “piping” water through the cement or entraining small fish. Some sediment also builds up in the aftbay behind the screens. Generally, this site was operated in a way that should protect juvenile salmonids.

Figure 4. Garden City/Lowden II Approach and Sweep Velocities in May 2006. Velocities measured at 20 and 80% of forebay depth.

In late August, Gardena Farms Irrigation District staff requested that we survey the dam with our underwater video equipment to look for a suspected leak beneath the cement support for the inflatable rubber diversion dam. The concrete dam sits on top of metal sheet pilings driven vertically into the streambed. Enough water appeared to be leaking beneath the dam to affect water flow (and fish migration) through the fish ladder.

On the downstream side of the dam, we found erosion of the streambed around a pipe through the sheet piling beneath the cement structure (Figure 5). The 6-in. diameter pipe was near the middle of the streambed and had been used during construction to drain water past the work zone. On the upstream side, we found the erosion did not go straight through beneath the dam. Instead, erosion had created a fairly large depression in the streambed near the fish ladder on the south bank (river left), exposing the bottom of the cement dam and sheet piling. Water was moving along the sheet piling from this depression to the gap around the pipe near the center of the streambed. Cobbles and small boulders were tumbling around in the force of the water moving through this gap. The sight of the rocks tumbling around was impressive, and a small video clip can be viewed by clicking on the button beneath Figure 5. Although the pipe was capped, the gap in the sheet piling had been apparently backfilled with riprap but not covered with metal.

An engineer with the firm that had designed and constructed the dam and the Gardena Farms Irrigation District staff were able to immediately see what and where the problem was and get measurements on the size of the gaps. Within a few weeks, the pipe had been removed, a metal plate put in place across the gap in the sheet piling, and large rip rap mixed with finer gravel used to fill the holes on both the upstream and downstream sides of the dam.

Figure 5. Video Clip of Active Streambed Erosion Around Pipe Under Garden City/Lowden II Diversion Dam. View looking upstream at the 6 in. diameter pipe extending through a gap in the sheet piling. Stadia rod is marked off in tenths of feet.

3.4 Nursery Bridge Fishway

Although Nursery Bridge Fishway is designed to provide passage for adult salmonids on the east side of the Walla Walla River, juvenile salmonids also use the facility as they migrate out in the spring. Water enters the screens portion of the site through a tunnel beneath and constrained by a bridge. As can be seen in Figure 6, the angle of the tunnel causes water to enter the screen facility at an angle, hitting the western panels more directly.

Figure 6. Plan View of Part of Nursery Bridge Fishway and Screens

On May 25, 2004, measurements by Vucelick and McMichael (2004) indicated that 38% of the approach velocities exceeded 0.4 ft/s (Table 1). They then tried adjusting the louvers to reduce approach velocities but were able to lower the percentage by only 8%. They hypothesized that gaps between individual louvers and between the louvers and cement walls could allow excessive flow through the screens. Based on their recommendations, the louvers were modified in September 2005.

Table 1. Comparison of Walla Walla River Discharge to Approach Velocities at Nursery Bridge

Date	River Discharge at Pepper Bridge (cfs)	Percentage of Approach Velocities Above 0.4 ft/s
December 18, 2002	83.2	16%
January 7, 2003	202	8%
March 27, 2003	413	33%
May 25, 2004	145	38% and 30%
March 7, 2006	242	0%

On March 7, 2006, under moderate river conditions, with Nursery Bridge louvers almost shut, and with the auxiliary water supply gates at normal settings, all approach velocities were less than 0.4 ft/s .

We had hoped to evaluate the site at higher river flows. However, river levels fluctuate rapidly this close to the Blue Mountains (Figure 7) and without much forewarning. We were unable to mobilize quickly enough to evaluate the site when river discharge was above 350 cfs and the main river channel was on the same side of the channel as the facility. Consequently, we have been unable to determine how much the louver modifications have helped reduce approach velocities. Although not conclusive, based on our one evaluation at a moderate river discharge and normal settings for the facility gates, it appears setting the modified louvers to minimize flow through the screens may help reduce approach velocities. We recommend evaluating the effect of different auxiliary water supply gate openings when the louvers are nearly shut. These gates control the amount of water moving through the screens, and there may be optimal gate settings in combination with louver settings that would help reduce approach velocities. Gate positions were noted in March 2006 (reported in Chamness 2006) but were not recorded during earlier evaluations.

Figure 7. Walla Walla River Stream Flow Between October 2004 and September 2005 at Pepper Bridge. The monitoring site is about 7 mi downstream from Nursery Bridge. Plot shows rapid fluctuations in river discharge. (Source: Washington State Department of Ecology 2007)

4.0 Conclusions

The 2006 evaluations of the Gardena Farms, Little Walla Walla, and Garden City/Lowden II sites indicate they are generally being operated and maintained in a way that should effectively provide safe and efficient passage for juvenile fish. At the Gardena Farms site, 14% of the approach velocities exceeded NMFS criterion of 0.4 ft/s and could pose a hazard to small juvenile salmonids if they were to become impinged. Debris and sediment covered the bottom seal in a number of places at this site as well. Debris load in the river was unusually high this year, but there may be ways to keep some of the debris away from the screens until it can be removed in the summer.

Both the Garden City/Lowden II and Little Walla Walla sites were found in good condition and being maintained and operated in a way that should protect fish. The leak beneath the Garden City dam was found by Gardena Farm Irrigation District personnel, who moved as quickly as possible to examine, assess, and resolve the problem. Our portable video system provided a good way to examine the problem safely and obtain some general measurements with which to determine the size of the problem. This enabled the engineer to identify a solution and have the materials and equipment on hand before dewatering the site for repairs.

Nursery Bridge screens were not evaluated under this year's contract because we were unable to get to the site when river discharge was at the desired level. Modified louvers may help overcome a design that directs water toward one of the two screens. The settings of the various gates in the auxiliary water system should be evaluated while the louver settings stay fixed, to determine if they can be set to provide attraction water for adult salmonids while still protecting juveniles from excessive approach velocities.

Since 2001, PNNL has evaluated each of these sites at least twice and found they are normally maintained and operated to protect juvenile salmonids (McMichael et al. 2001; Vucelick and McMichael 2003, 2004; Chamness 2006). Irrigation district personnel are generally proactive in caring for their sites, checking on them frequently and fixing problems as they arise. Modifications to the louvers at Nursery Bridge may have helped reduce approach velocities. We recommend evaluating the effect of different auxiliary water supply gate openings when the louvers are nearly shut, to determine if there are optimal gate settings to reduce approach velocities and still provide attraction flows for adult salmonids.

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