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Managing Water in the West

Hydraulic Laboratory Technical Memorandum

Durango Pumping Plant Fish Screens Field Evaluation

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Hydraulic Investigations and Laboratory Services Group
Denver, Colorado

August 2009

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by

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Animas-La Plata Project, Colorado
Upper Colorado Region

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REVISIONS					
Date	Description	Prepared	Checked	Technical Approval	Peer Review

Introduction

The Durango Pumping Plant, located in Durango, Colorado, diverts up to 280 ft^3/s from the Animas River through the Ridges Basin inlet conduit and into Lake Nighthorse. The pumping plant consists of an intake structure, a service yard, and a surge chamber (figure 1). The intake structure allows water from the river to pass through a positive-barrier fish screen and into the pumping plant. The 100-ft-long fish screen keeps fish from entering the pumping plant. A fish bypass pipe at the end of the fish screen carries fish to the river downstream from the pumping plant.

River flow enters the intake through a trashrack structure and follows a curved section to a 23-ft-wide inlet channel with an invert elevation of 6429.75. Twenty feet downstream from the end of the curve, the fish screens are oriented at an angle of 10 degrees with the right side of the inlet channel (figure 2). The ten fish screen bays are 9.63 ft wide by 8 ft high. The screen material has a mesh size of 1.75 mm with an open area of approximately 40%. Solid steel barrier panels above the fish screens extend 13.17 ft to the ground surface. A brush cleaner system runs at a regular interval to remove debris that accumulates on the screen face. Seven vertical louvers (baffles) were installed behind each fish screen panel to allow lateral adjustment of the flow through the screen (figure 3).

Figure 1. Artist's rendering of the Durango intake structure, fish screen, and pumping plant (drawn by J.F. Pattie).

Figure 2. Dewatered fish screen structure with brush cleaner. The bypass pipe is at the narrow end of the screening structure.

Figure 3. Seven adjustable vertical louvers behind each screen can be set to optimize flow uniformity through the fish screen panels.

The objective of this field evaluation was to examine the hydraulic performance of the fish screening structure for the given operating condition. The evaluation included an assessment of velocity magnitudes and uniformity at the screen face and debris accumulation in the screening facility. All vertical louvers behind the fish screens were initially set by field personnel to 10% open as recommended by the mechanical design team. In the field evaluation, the vertical louvers were adjusted to optimize approach velocity uniformity along the screen face. The evaluation was conducted shortly after the maximum pumping rate of 280 ft^3/s was reached during the initial filling of the reservoir in June 2009.

Fish Screening Criteria

The channel velocity is the velocity of the flow approaching the fish screen from the intake, consisting of approach, sweeping, and vertical velocity components. The approach velocity is the velocity component perpendicular to, and in front of, the screen face. The sweeping velocity is the horizontal velocity component parallel and adjacent to the screen face. The vertical velocity component is typically near zero and is usually of no concern.

When the approach velocity into the screen is too high, fish can be impinged on the screen face. Zones of high and low velocity are adjusted with the vertical louvers to produce near-uniform approach velocities over the length of the screen. Since the vertical louvers extend the full height of the screen, there is no control mechanism on the screening structure to adjust the vertical velocity distribution. Judgment must be used to determine whether the screen uniformity is acceptable. The sweeping velocity should be greater than the approach velocity in order to guide fish along the screen and into the fish bypass pipe. More information on conducting fish screening evaluations can be found in *Guidelines for Performing Hydraulic Field Evaluations at Fish Screening Facilities* (Reclamation, 2009).

Fisheries criteria vary by region, species, life stage, and season. The Durango Pumping Plant fish screen was designed in 2002 to have an approach velocity of 0.5 ft/s (Gill and DeMoyer, 2002). During the planning for this field work, Mr. Jim White from the Colorado Division of Wildlife was contacted to discuss any requirements for fish screening evaluations in the Animas River (J. White, personal communication, March 2009). According to Mr. White, there is currently no fish screening criteria in this region, so the design approach velocity of 0.5 ft/s was used as the target value for adjusting the approach velocity uniformity on the Durango Pumping Plant fish screen.

Mr. Rich Valdez, consulting fisheries expert to the Colorado Division of Wildlife, was contacted regarding recommended fish screen velocities for native suckers. Mr. Valdez said that adult suckers should be able to avoid impingement with approach velocities less than 2 ft/s. However, larval suckers act as neutrally buoyant particles and can be entrained into the pumping plant since the screen size is larger than the larvae (R. Valdez, personal communication, March 2009). Mr. Valdez mentioned that the best strategy for minimizing entrainment of drifting larvae would be cessation of pumping for about a month during the peak larval drift period, however he recommended that a more thorough examination of larval sizes be collected in different years to ascertain interannual periodicity and larval appearance.

The highest velocities along the fish screen structure will occur at the maximum pumping rate during a low river flow. From the physical model study of the intake structure, a minimum river flow of 580 ft^3/s will maintain a fish bypass flow rate of 30 ft^3/s and a fully submerged fish screen at the maximum pumping rate (Gill and DeMoyer, 2002). Since the pumping plant began to pump at full capacity for the first time in May 2009 and it was not clear if the pumping plant could continue to operate at the low river discharge specified in the model study due to physical or political constraints, a fish screen evaluation was conducted as soon as was feasible.

Materials and Methods

Velocity data were collected with a SonTek/YSI 16-MHz Micro ADV (acoustic Doppler velocimeter). Data were collected at 25 or 50 Hz for 30 seconds at a sample volume located 5 cm below the acoustic transceivers. The ADV was placed inside of a modified 50-lb sounding weight (figure 4). The ADV transducers were located in a pocket to protect the probe from debris and contact with the channel bottom. The conditioning module was secured in a metal pipe to prevent rotation of the probe (figure 5). The sounding weight was suspended 9 ft in front of the brush cleaner with a metal cable attached to the brush cleaner traversing cable (figure 5). An electric winch was mounted on top of the brush cleaner to control the vertical position of the instrument by raising and lowering the sounding weight. The brush cleaning control system was used to move the instrument along the screens to the desired lateral sampling location.

Figure 4. Bottom side of the modified 50-lb sounding weight.

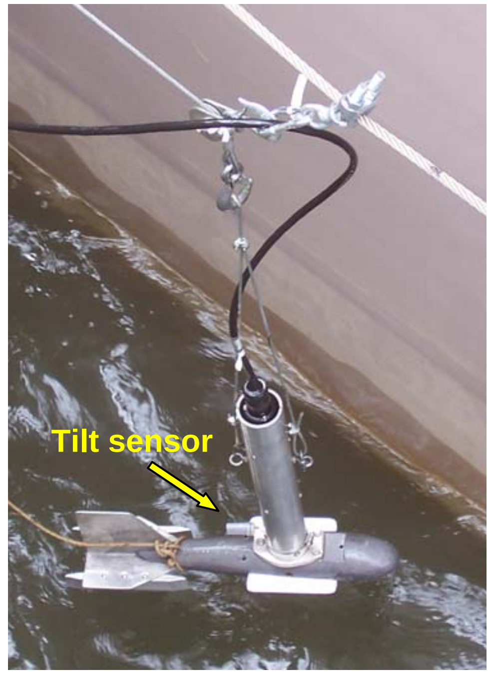

Figure 5. ADV mounted inside of a 50-lb sounding weight. A tilt sensor was attached to the pipe.

Additional fins were added to the front side of the sounding weight to reduce movement of the instrument in the flow. In order to orient the sounding weight parallel to the screen rather than into the flow, a rope was attached to the back of the weight and affixed to the brush cleaner system. To minimize interference from the brush cleaner arm, the instrument was mounted 9 ft in front of the brush. With sweeping velocities of around 1 ft/s, the brush cleaner system should have minimal effect on the velocity readings.

An Onset HOBO Pendant-G (three-dimensional tilt sensor) data logger was attached to the pipe surrounding the ADV's conditioning module to document the orientation of the sounding weight while in the flow (this sensor can be seen in figure 5 on the back side of the pipe). There was concern that the drag on the sounding weight would cause the ADV to tilt. ADV rotation was controlled with a tagline. The tilt sensor data were analyzed to detect vertical tilt or rotation of the sounding weight. Tilt sensor data were collected at a 1 second interval and were analyzed to determine if the tilt angles were large enough to change the magnitude of the 3-dimensional velocity vectors. The typical tilt angle was between 2 and 3 degrees. For sweeping velocities of 1 ft/s, a 3 degree tilt angle will create an apparent vertical velocity of 0.05 ft/s. Likewise, the sweeping velocity vector would under-register by only 0.001 ft/s. As a result, tilt angles were considered minimal and were not corrected for in the velocity data processing.

With this setup, data were collected approximately 6 to 9 inches from the screen face (figure 6). In order to measure closer to the screen, a boom cart was positioned on the access platform and the instrument and sounding weight were lowered against the screen face (figure 7). With the boom cart setup, data could be collected 3 inches from the screen face; however, the brush cleaning system could not be operated while the instrument was in the water. During the time needed to collect data on a screen, submerged debris began to clog the screen. Velocity data collected with the boom cart revealed high and low velocity regions produced by localized debris. Although this near-screen setup appeared to produce accurate velocity data, the data were not repeatable so they could not be used to gain an overall view of the screen performance needed for vertical louver adjustment. Conversely, with the brush cleaner setup, the brush cleaned the screen prior to each measurement. Although the instrument measured velocities further from the screen face, this setup provided repeatable measurements required to make vertical louver adjustments.

Figure 6. ADV mount attached 9 ft upstream from brush cleaner system.

Figure 7. ADV mount attached to boom cart on access platform.

During the first week of testing, the pumping plant discharge was held constant at a maximum pumping rate of 280 ft^3/s with Animas River flows ranging from 1,340 to 1,570 ft^3/s. During the second week of testing, the pumping rate was reduced to 263 ft^3/s because one pump was down for repairs. Animas River flows ranged from 1,660 to 1,870 ft^3/s. The river flow did not change fast enough to noticeably affect velocity data over the course of a test. The fish screens were submerged by at least 3 ft throughout the evaluation.

Results

Data were collected at mid-depth along the screen (4 ft from the invert) to document velocities with the initial vertical louver setting of 10% open (figure 8). For these tests, a 30-lb sounding weight was used instead of the 50-lb sounding weight. After this test, it was determined that the 50-lb weight held position better and it was used for all remaining tests. Although the setup for this test was not ideal because of the smaller sounding weight, this initial view of the approach velocities along the screen showed that more flow enters through the downstream screen bays (5 through 10) than the upstream screen bays (1 through 4). The ADV was oriented to register a positive approach velocity into the screen, so the sweep velocity was measured in reference to the upstream direction. Therefore, all sweeping velocity measurements are negative.

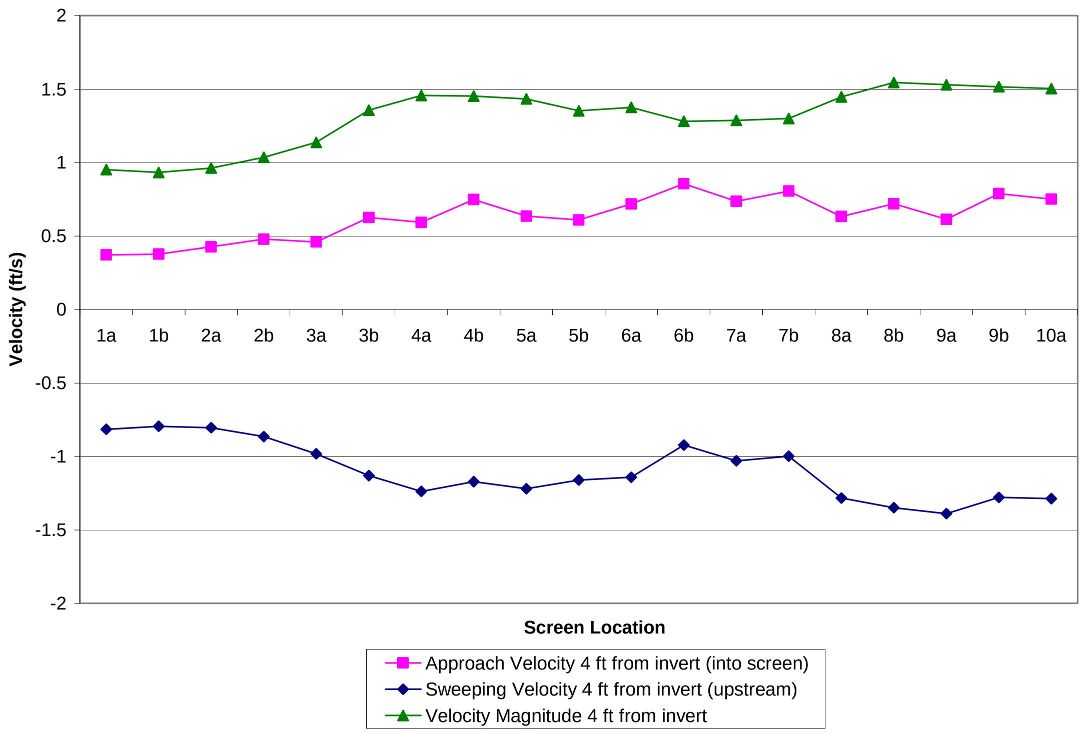

Figure 8. Mid-depth velocity data along the fish screen at two lateral points per screen. All screens were set to an initial 10% vertical louver opening. Location 1a is the upstream point on screen 1 and location 1b is the downstream point on screen 1, etc. The downstream point on screen 10 (location 10b) could not be accessed with this instrument setup. The mean approach velocity over the length of the screen was 0.63 ft/s with a standard deviation of ±0.15 ft/s. The river discharge was 1,340 ft^3/s and the pumping rate was 280 ft^3/s.

In order to improve velocity uniformity along the length of the screen face, the vertical louvers located behind certain screens had to be individually adjusted. The bolts on the baffle adjustment assemblies were rusted shut, so the process of adjusting the seven vertical louvers at each screen required considerable time and effort. The vertical louvers on screens 5 through 10 were adjusted to approximately 6% open to drive more flow through the upstream screens. Screens 1 through 4 remained set at 10% open.

The headloss across the fish screen increased from about 0.35 ft to 0.75 ft during continuous brush cleaning operation. A headloss value of less than 1 ft on the screen is desirable. Data were collected at three vertical elevations in order to assess the vertical velocity gradient over the height of the screen (figure 9).

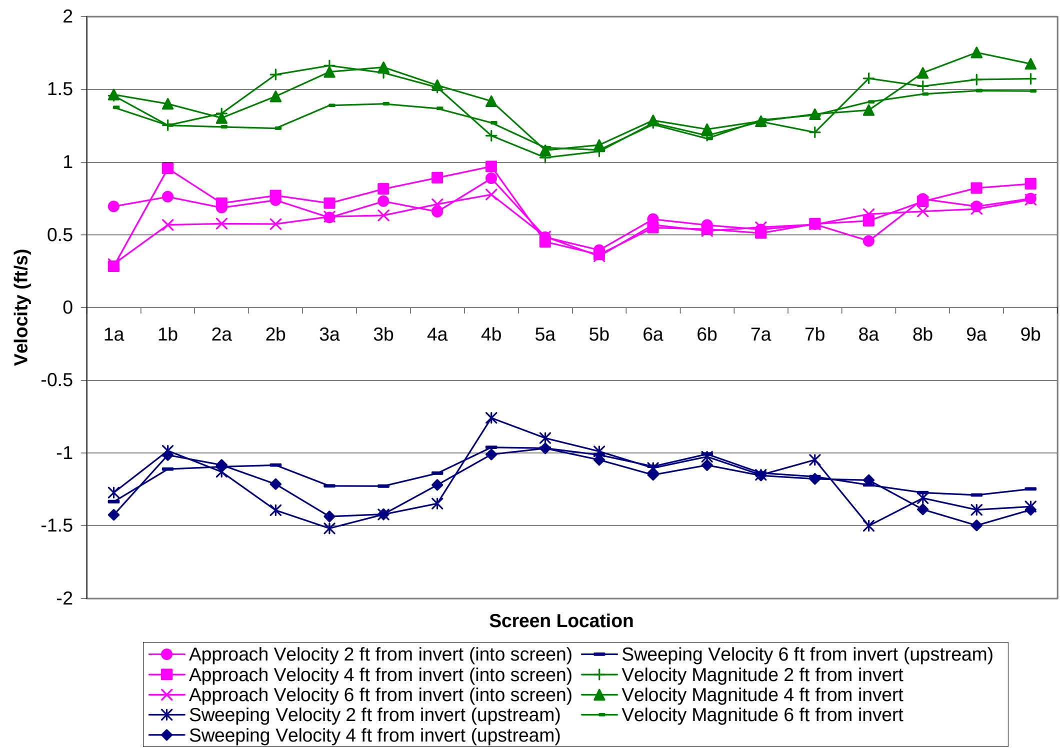

Figure 9. Velocity data along the fish screen at two lateral points per screen. Data were collected vertically at 2 ft, 4 ft, and 6 ft above the invert. Screens 1 through 4 were set to a 10% vertical louver opening and screens 5 through 10 were set to a 6% vertical louver opening. The mean approach velocity over the length of the screen was 0.61 ft/s with a standard deviation of ±0.19 ft/s. The river discharge was 1,460 ft^3/s and the pumping rate was 280 ft^3/s.

Velocities at the bottom, middle, and top of the screen were similar at most screen locations. In locations where significant vertical discrepancies existed, local debris accumulation was likely the cause. For this vertical louver configuration, approach velocities were low along screens 1 and 5. The vertical louvers on screen 1 were adjusted to approximately 12% open and the vertical louvers on screen 5 were adjusted to approximately 8% open. The vertical louver configuration for the rest of the screen produced acceptable approach velocity uniformity.

In this final louver configuration, a full array of velocity data was collected at 4 lateral positions and 3 depths per screen, for a total of 12 measurements per screen. For this data set, the river discharge increased to 1,870 ft^3/s while the pumping rate was reduced to 263 ft^3/s. Velocity data collected with the final vertical louver configuration is shown in figure 10.

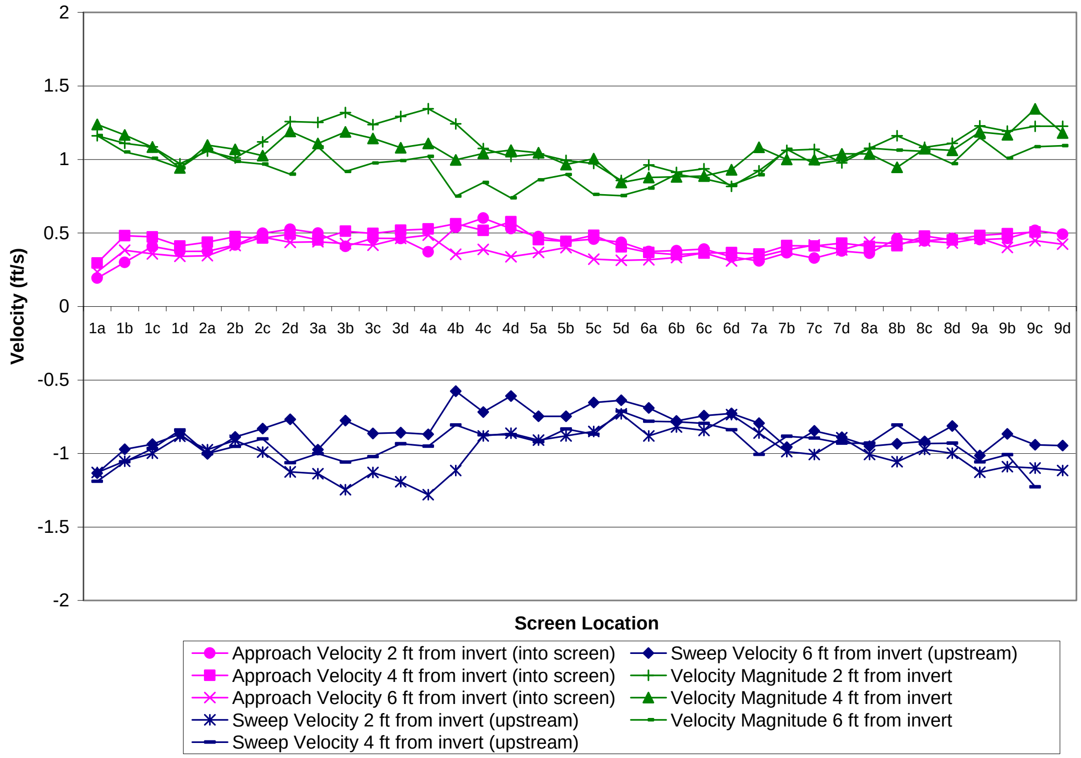

Figure 10. Velocity data along the fish screen at four lateral points per screen. Data were collected vertically at 2 ft, 4 ft, and 6 ft above the invert. Screen 1 was set to a 12% vertical louver opening, screens 2 through 4 were set to a 10% vertical louver opening, screen 5 was set to an 8% vertical louver opening, and screens 6 through 10 were set to a 6% vertical louver opening. The mean approach velocity over the length of the screen was 0.42 ft/s with a standard deviation of ±0.07 ft/s. The river discharge was 1,870 ft^3/s and the pumping rate was 263 ft^3/s.

The mean approach velocity across all screen panels was 0.42 ft/s with a standard deviation of ±0.07 ft/s. Sweeping velocities were always higher than approach velocities by an average ratio of 2.2:1. Flow through the upstream half of screen 1 continued to be lower than the remaining screen panels. The approach velocity in this region could not be increased with vertical louver adjustments. The approach flow conditions from the intake structure likely causes flow patterns that limits flow through this screen section. It is interesting to note that a similar flow pattern at screen 1 was measured in the physical model study (Gill and DeMoyer, 2002).

Velocity data on screen 10 was collected separately by using the boom cart setup, however the data collected on the screen was not repeatable. Debris had collected at the bypass pipe entrance in front of screen 10 and this debris produced low approach velocities and even some reverse flow out of the screen.

Conclusions and Recommendations

Detailed velocity measurements collected during the Durango Pumping Plant fish screen evaluation were used to set the best vertical louver configuration for the flow conditions observed. With the initial post-construction baffle setting of 10% open for all louvers, velocity data showed that more flow entered through the downstream screen bays (5 through 10) than the upstream screen bays (1 through 4). To optimize approach velocity uniformity across the screen face, screen 1 baffles were set to a 12% open, screens 2 through 4 were set to 10% open, screen 5 was set to 8% open, and screens 6 through 10 were set to 6% open in the final baffle configuration.

Results show that the mean approach velocity for 108 data points was 0.42 ft/s with a standard deviation of ±0.07 ft/s. During testing, the river flow rate was low, but it was not at the minimum threshold for full pumping at the pumping plant. The adjustment of the baffles to optimize approach velocities along the screen, however, should still be valid. The final vertical louver configuration should be sufficient for the foreseeable future. Another fish screen evaluation will be needed if there are changes at the facility, such as changes in maximum pumping rate, operational procedures, screen material, fish protection status, or revised fish screening criteria.

Debris accumulation on the fish screen had to be considered when interpreting the velocity measurements. It is recommended that the brush cleaner continue to run at a regular interval and a debris removal system be developed to reduce debris accumulation at the fish bypass entrance.

References

Bureau of Reclamation. (2009). *Guidelines for Performing Hydraulic Field Evaluations at Fish Screening Facilities*. United States Department of the Interior, Bureau of Reclamation, Water Resources Technical Publication, Denver, CO.

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