PAP-801

Traveling Water Screen Tests

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by

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Background

In the last decade, increasing concern for fisheries combined with an explosion in the spread of many exotic aquatic weeds has created a renewed need for improved methods of excluding both fish and debris from water diversions. The U.S. Bureau of Reclamation is currently conducting research to study the performance of fish screens for fish and debris control. Traveling water screens are one possible solution to this problem. To address the issue of how debris can best be removed, with minimal impact to fish, bio-engineering studies are being conducted with a traveling screen manufactured by Farm Pump and Irrigation Co. (FPI) at Reclamation's Water Resources Laboratory in Denver, Colorado. The FPI traveling water screen is a wire-mesh-belt screen that captures debris on the upstream screen face as water passes through the screen structure. The screen's wire-mesh-belt rotates carrying impinged debris material out of the water and over the crest of the screen structure. Debris material is then washed off the screen by a high pressure spray system on the back side.

The Model

A 4-ft wide by 8-ft tall FPI traveling water screen was installed in a 5.5 ft wide by 5 ft deep recirculating flume (figure 1). The test facility is designed to test fish screens in the presence of aquatic debris and fish as typified by many Reclamation water diversion sites. The debris screen was installed beside a clear plexiglass window to allow viewing and underwater video taping of screen operation, debris removal and fish behavior. Using the test facility, screen performance can be evaluated for a wide range of flow conditions in the presence of different debris loads, types and fish species.

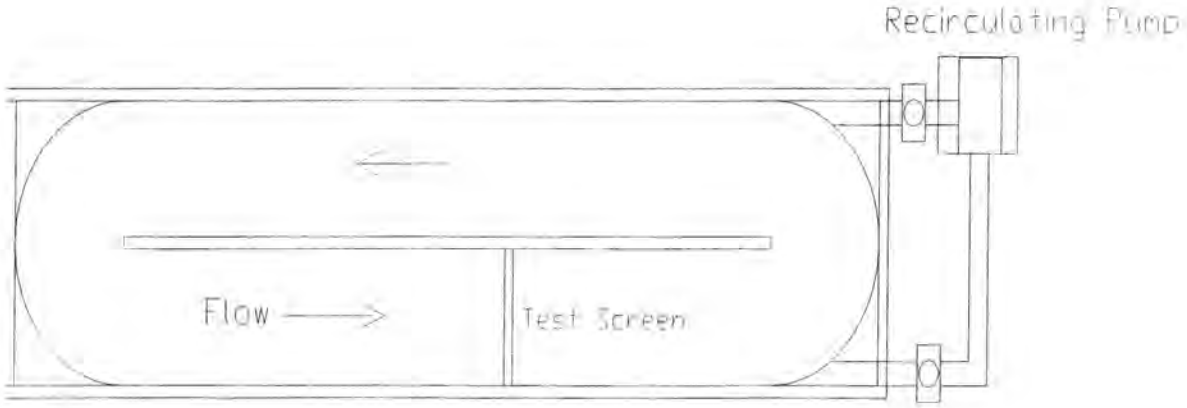

Figure 1. Layout of fish screen trash rake test facility.

Study Objectives

Model tests are being conducted to determine screen performance for the cases of:

- debris removal as the prime objective,
- debris removal and fish exclusion as combined objectives,
- and debris removal and fish passage as combined objectives.

The first two objectives listed are commonly associated with water diversion intakes. The third objective is less common, but is a major design objective at several Reclamation fish screening facilities where high concentrations of debris impact operation of screen bypasses or temporary holding facilities.

Results

Debris Removal Tests

Tests of debris removal as the prime objective were conducted with using a screen mesh size of 0.5 by 0.5 inch (the standard mesh size). For these tests, the screen was positioned normal to the flow and at an angle of 45 degrees to the channel invert. Varying concentrations of debris were added to the flow to observe debris removal and screen cleaning effectiveness. Figures 2 through 4 show the screen loaded with varying amounts of Egeria (a common aquatic weed) and sticks. The screen performed well in removing fragmented and long strands of Egeria and releasing it from the screen onto the debris conveyor system. Sticks accumulating against the screen were easily removed from the flow and released from the screen during rotation. The spray wash system removed any remaining debris clinging to the screen. Both continuous and intermittent screen operation tests were conducted. Intermittent operation testing involved turning off the screen rotation and allowing large amounts of debris to accumulate on the upstream face of the screen. Debris (Egeria, sticks and domestic trash) was allowed to accumulate into a 3 to 4 inch thick matt which resulted in a head drop across the screen of about .5 ft. The screen was then turned on to remove the packed debris matt. The screen again performed well, removing nearly all the material during the first screen rotation.

Combined debris removal and fish barrier tests

The traveling water screen was aligned at an angle of 26 degrees relative to the flow or center wall of the flume (figure 5). About 10% of the flow was passed by the screen to a fish bypass channel. The configuration is typical of standard fish screen designs. A fine mesh screen was used (0.125 by 0.125 inch openings) to prevent passage of fish or debris through the screen. The screen was tested at an angle inclined relative to the invert at 80 degrees. Normally the traveling screen is installed at a shallower angle to effectively remove debris. However, we were interested in specific applications at existing facilities where the screen would be required to be installed at a steep angle due to site limitations. For this case, modifications were implemented to assist in removing the debris.

Small debris such as duckweed and leaves were initially introduced into the flow. The small debris that was carried into the screen readily stuck to the screen and remained attached to the screen as it moved to the top of its rotation where the spray wash system removed the debris. However when large amounts of larger debris such as egeria or water hyacinth were introduced into the flow, the debris had a tendency to roll off the screen because of the steep angle. As a result, several modifications were investigated to allow the large debris to be carried up and over the screen. Steel "fingers", curved upward, were attached to the horizontal flights to help remove the debris (figure 6). This worked fairly well for the egeria as long as it had not accumulated into a tight roll larger then the width of the fingers. However a small amount of egeria slipped off the screen from between the fingers and continued to accumulate into a roll that became larger and tighter. In addition, very little of the water hyacinth was picked up because of its large size and inability to attach to the fingers.

For the next set of tests, a brush with 5 inch bristles of fairly high stiffness (.060 WSN; American Brush Co.) was attached to one of the flights. This worked well for both the egeria and hyacinth (figure 7). The 5 inch bristles simply lifted the egeria and hyacinth up and over the screen. Again, when the egeria was allowed to accumulate into a roll larger then the width of the brush it had a tendency to roll off the brush. However, if brushes are installed on all flights, the spacing will be close enough that this should not occur. Additional flights with brushes could also be installed to reduce spacing if necessary in areas of excessive amounts of debris.

In the future, it may be beneficial to conduct more extensive tests of this screen configuration with different sized brushes and with brushes installed on every flight. It may also be desirable to conduct tests with the screen installed at shallower angles and with fish introduced into the flow.

Debris removal and fish passage tests

The screen was positioned normal to the flow and inclined at 45°. A 2" by 4" open mesh screen was placed on the screen frame. A 15-inch wide chute was installed immediately upstream of the screen so that tests could be conducted with approach velocities up to a maximum of 5 ft/s (figure 8). The objective of testing a large open mesh screen is to determine if the screen can be used to collect and remove significant amounts of aquatic plant debris from fish bypass channels and holding facilities. Aquatic plants like Egeria, water milfoil and water hyacinth are the target species. The screen performed well in allowing fish less than 3 inches in length to pass through the large mesh screen unharmed. These tests showed that small debris passes through the screen, although some small sticks are caught between the mesh weave; however large debris is easily collected and removed. The tests conducted thus far demonstrate there is potential use for this configuration to allow passage of fish less that 3 inches in length and to prevent clogging of large debris for applications such as bypass entrances.

Figure 2. Screen loaded with Egeria during intermittent tests.

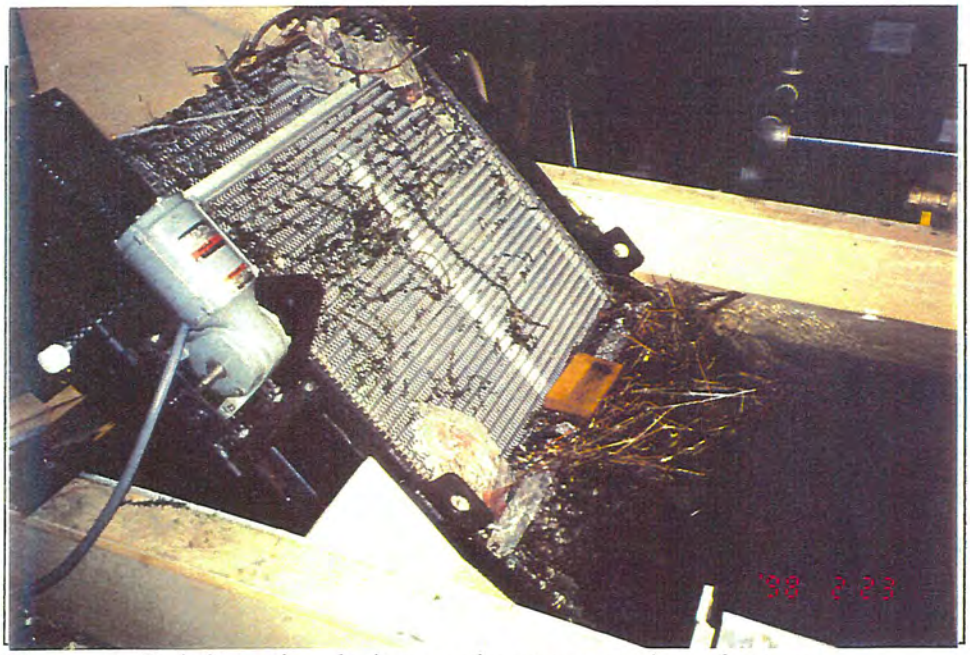

Figure 3. Debris testing during continuous operation of screen.

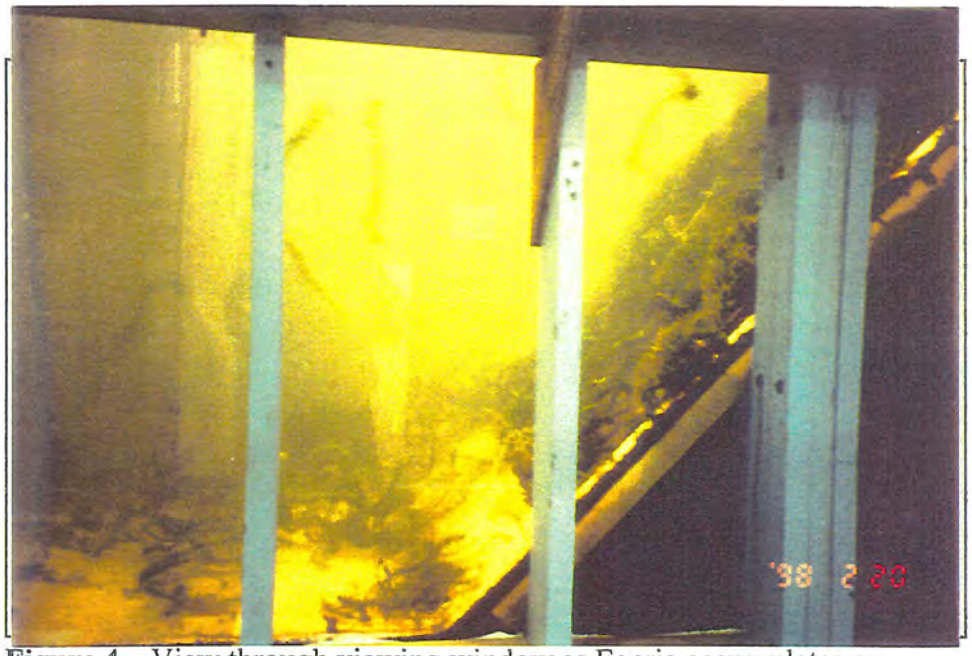

Figure 4. View through viewing window as Egeria accumulates on screen during intermittent test.

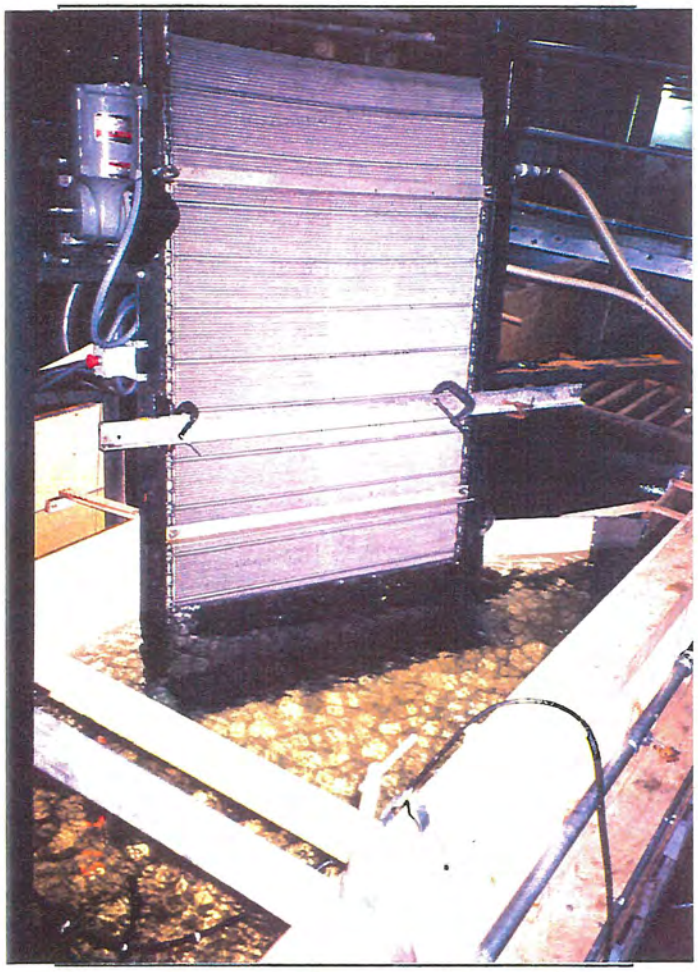

Figure 5. Fine mesh screen (0.125-inch by 0.125-inch) installed as a fish barrier and to remove debris.

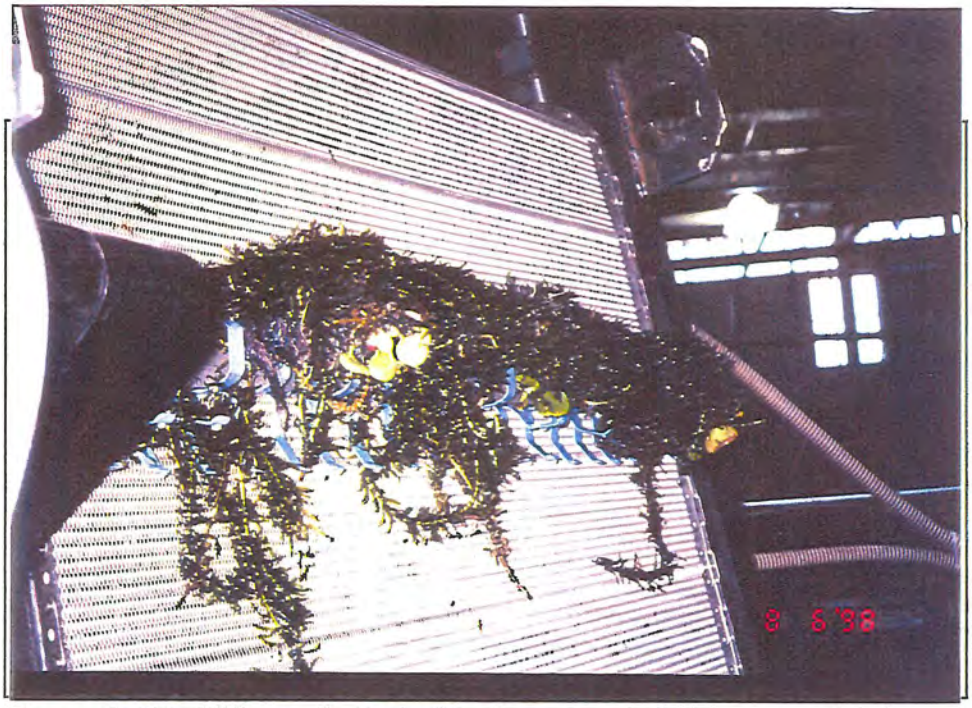

Figure 6. Steel "fingers" attached to the screen to help remove debris.

Figure 7. A 5-inch brush attached to the screen is effective for removing large debris.

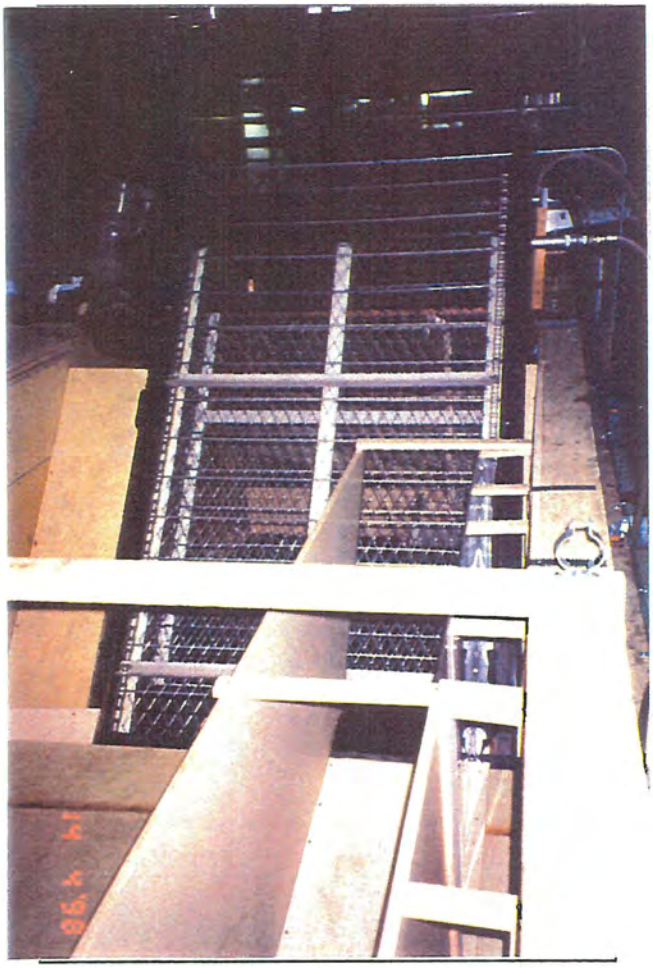

Figure 8. Large mesh screen (4-in by 2-in openings) tested for fish passage.