PAP-828

Sure-Flo Screen Tests

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by

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Background

In the last decade, increasing concern for fisheries has created interest in excluding fish from water diversions with minimal impact to fish. In order to accomplish this objective, an improved understanding of fish screen hydraulics and fishery response to various conditions is needed. Resource agencies have adopted standards that require that screens meet a maximum approach velocity criteria of 0.2 ft/s in some areas. As a result, the Water Resources Research Laboratory (WRRL) at the U.S. Bureau of Reclamation (Reclamation) in Denver is currently conducting research to study the performance of cylindrical fish screens for shedding debris and to provide an effective positive barrier for fish exclusion. As a part of this program, the Sure-Flo screen manufactured by Perfection Sprinkler Company was loaned to Reclamation to evaluate the performance of their present screen design.

The Model

The Sure-Flo SCS8 screen (figure 1) was tested in a WRRL facility designed to test fish screens. The facility consists of a 5.5-ft-wide by 5-ft-deep recirculating flume (figure 2). The screen was installed on a pipe leading to the suction side of a recirculating pump and located beside a clear plexiglass window to allow viewing and underwater video taping of screen operation. The Sure-Flo SCS8 screen consists of a 20-in diameter outer rotating drum made of a grid mesh and driven by a spray wash system operated at 65 lb/in^2. The screen has an inside tube about 8-in in diameter with circular openings of various sizes designed to control intake flow to provide a uniform flow distribution through all areas of the screen. The screen was installed with the spay wash jet directed toward the one o'clock position as specified by the manufacturer. Flow velocity in the flume and through the screen was controlled by adjusting control valves on pipes extending from the recirculating pump.

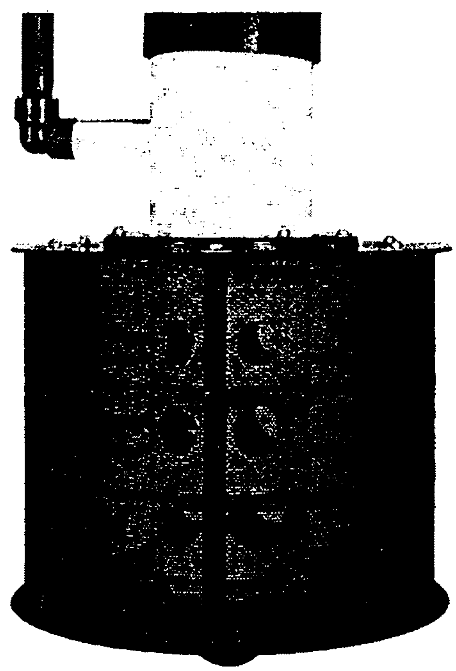

Figure 1. Sure-Flo self cleaning strainer.

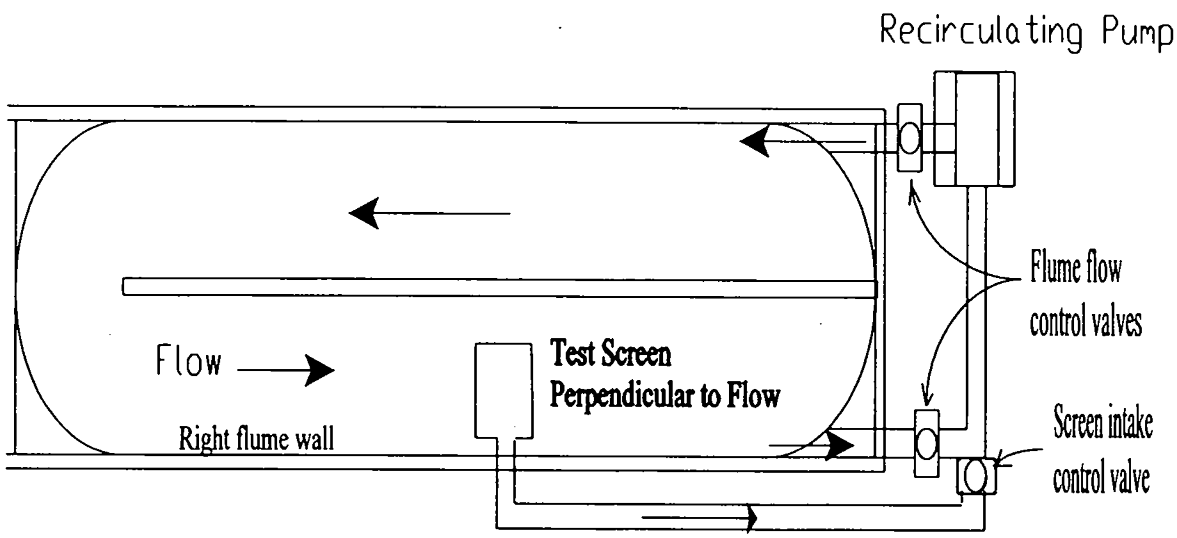

Figure 2. Layout of fish screen test facility.

Study Objectives

Model tests were conducted with the screen oriented in two different configurations:

a) with the screen surface perpendicular to the flow field (figure 2) and

b) with the screen surface parallel to the flow (an elbow was added to rotate the screen 90 degrees with the leading edge into the flow).

Investigations were conducted to determine:

1) The approach velocity distribution into the screen (normal velocity component measured 3-in off the screen) measured at intervals along the length of the screen with;

   a) sweeping velocities (velocity component parallel to the screen) greater than or equal to twice the average approach velocity (for river installations). This condition was set up with a high recirculating velocity (HFV) through the flume and,

   b) a near-zero sweeping or reduced flume velocity (RFV) component (typical of lake installations).

Note that the high sweeping velocity condition is not applicable to the situation where the screen is positioned perpendicular to the flow since the flume velocity is in the same direction as approach velocities into the screen.

2) The screen's ability to shed large aquatic debris (Egeria was used in the tests).

3) The screen's potential to provide an effective positive barrier for fish.

4) Headloss through the screen

For each of the above conditions the screen was tested for two flow rates:

a) The specified rated capacity for the screen (1150 gpm).

b) Low intake condition (449 gpm).

Test Setup and Results

In order to simulate an approximate reservoir withdrawal condition (reduced flume velocity), the flume discharge valve was completely closed so that flow was discharging through the test screen only. A true reservoir condition could not be simulated in the flume. However, reasonable qiescent conditions were created by installing a perforated plate upstream from the screen during reservoir tests. Velocities measured across the width of the flume 6 ft upstream from the screen are shown in figure 3.

For the river condition, it should be noted that due to the nature of the test flume configuration, flow rounding a sharp corner about 17 ft upstream from the test screen causes flow velocities on the right side of the flume to be greater than those on the left side on the approach to the screen. Figure 3 also shows the flow distribution across the width of the flume for the HFV condition.

Velocity Measurements and Dye Tests

Screen performance was evaluated by measuring approach and sweeping velocities at a 3-in distance from the outer screen surface (as required to meet velocity criteria) (figures 4 through 11). Velocities were measured with a Sontek acoustic doppler velocimeter (ADV probe) at 3-in intervals at the top, right, and left center lines along the length of the screen to determine the overall flow distribution. Velocities were also measured at a distance of 0.5-in from the screen surface with the screen oriented parallel to the flow to give an indication of the near screen velocity field (figures 12 and 13). For all test cases, positive approach velocities indicate flow is going into the screen, while positive sweeping velocities indicate flow is in the downstream direction. Dye tests were also used to visually verify the results from these tests.

It is worth noting that the screen's inside tube, which is 12-in less in diameter than the screen, provides control through the screen. Also, since the velocities are measured through a control volume outside of the screen (0.5 in and 3.0 in off the screen), applying the measured velocities to the assumed control volume may not represent the total through-screen flow. However, although assessing the total through-screen flow may be important information for the manufacturer and designer of the screen, it does not affect the screen's ability to meet required screen criteria, since current National Marine Fisheries Service criteria is based on velocities measured at a 3-in distance from the screen.

Debris Tests

Tests were conducted to test screen performance for shedding large debris. For these tests, observations and videotape were used to assess screen performance while operating at maximum capacity (1149 gpm) . Egeria, which is a long stringy aquatic weed that has a tendency to wrap around obstacles in the flow, was deposited into the flume and was easily shed by the screen for both screen configurations. Although some debris was drawn onto the screen for short periods of time, the spray was system was effective in removing any debris that had become attached to the screen.

Fish Tests

Tests were also conducted to view fish behavior in the vicinity of the screen. Ten each of trout, splittail and striped bass, ranging 3-in to 6-in in length, were used for the the screen configuration perpendicular to the flow; while 25 splittail, 3-in to 5-in in length, were used for the parallel configuration. The fish were placed into the flume with the screen again operating at maximum capacity for both tests. Although many fish passed close to the screen, they had a tendency to avoid the screen especially when coming into the vicinity of the spray wash jet and none came into contact with it.

Headloss

A pressure tap was installed at the centerline of the screen discharge pipe approximately 3.5 ft downstream from the screen to determine the headloss through the screen (Table 1).

Screen Orientation	Discharge (gal/min)	Headloss (ft)
Perpendicular to Flow	448	0.7
Parallel to Flow	448	0.8
Perpendicular to Flow	1149	1.7
Parallel to Flow	1149	2.6

Conclusions

Screen Orientation Perpendicular to Flow

Figures 4 and 5 show the flow distribution along the length of the screen for each case tested. The following conclusions were determined from the study:

- Tests conducted with the screen oriented perpendicular to the flow show that the upstream approach velocities measured along the length of the screen for the HFV condition are about twice the magnitude of those for the RFV condition. This occurs because the flow in the flume is in the same direction as approach velocities into the screen. As a result, the screen's ability to meet resource agency velocity criteria is dependent on average streamline flow velocity upstream from the screen.

- The approach velocities measured along the upstream centerline show that the control or baffled openings along the length of the screen performed well to maintain an even flow distribution into the screen, despite an uneven flow distribution across the width of the flume. Fluctuations in the velocities measured along the upstream centerline are all within 20 % of the average upstream centerline velocity for each condition tested.

- Approach velocities measured along the downstream centerline were somewhat erratic due to the recirculation that occurs on the downstream side of the screen, as well as disturbance from the spray wash jet.

- Dye tests verified that an area of recirculation occurs on the downstream side of the screen near the bottom. Dye tests also showed that the spray wash jet near the top of the screen caused some flow which had been drawn into the outer screen drum to be returned back outside the drum on the downstream side.

- The screen performed well in shedding large debris. Although some debris recirculated next to the screen on the downstream side of the screen, no debris remained attached to the screen.

- Tests with fish showed that although many fish passed close to the screen, none of the fish tested were drawn into it.

- Headloss through the screen ranged from 0.7 ft at a flow of 448 gpm to 1.7 ft at 1149 gpm.

Screen Orientation Parallel to Flow

Figures 6 through 13 show the flow distribution along the length of the screen for each case tested. The following conclusions were determined from the study:

- Tests conducted with the screen surface oriented parallel to the flow showed a fairly uniform velocity distribution on the left, top, and right centerlines along the length of the screen, with the following exceptions:
  a) In general, approach velocities at the upstream end of the screen are lower due to separation that occurs at the leading edge of the screen.
  b) At the lower discharge, approach velocities measured on the left centerline of the screen are more erratic due to their small magnitude relative to the flow coming from the spray wash jet. In some cases, this causes some flow to come out of the screen.

- Although velocity distributions were fairly uniform along the length of screen, they were not uniform around the circumference of the screen from centerline to centerline. Velocities measured along the top and right centerlines were strongest with fluctuations that rarely exceeded 25 % of their respective average centerline velocity. The velocities measured along the left centerline were weakest and a little more erratic. Some of these differences are likely due to the spray wash jet exiting the left side of the screen and may also be affected by the uneven flow distribution across the test flume.

- Dye tests were used to confirm the results of these tests and demonstrated that some of the flow entering the outer screen drum from the right or top centerlines would sometimes exit near the top left side of the screen.

- Again the screen performed well in shedding large debris. Egeria was deposited into the flume and was easily shed by the screen. Although some debris was drawn onto the screen on the right side, no debris remained attached to the screen.

- Tests with fish showed that although many fish passed close to the screen, none of the fish tested were drawn into it.

- Headloss through the screen oriented parallel to the flow is greater than when it is perpendicular to the flow because of the additional losses caused by the 90 degree elbow that was added to change the screen orientation. Headloss ranged from 0.8 ft at a flow of 448 gpm to 2.6 ft at 1149 gpm.

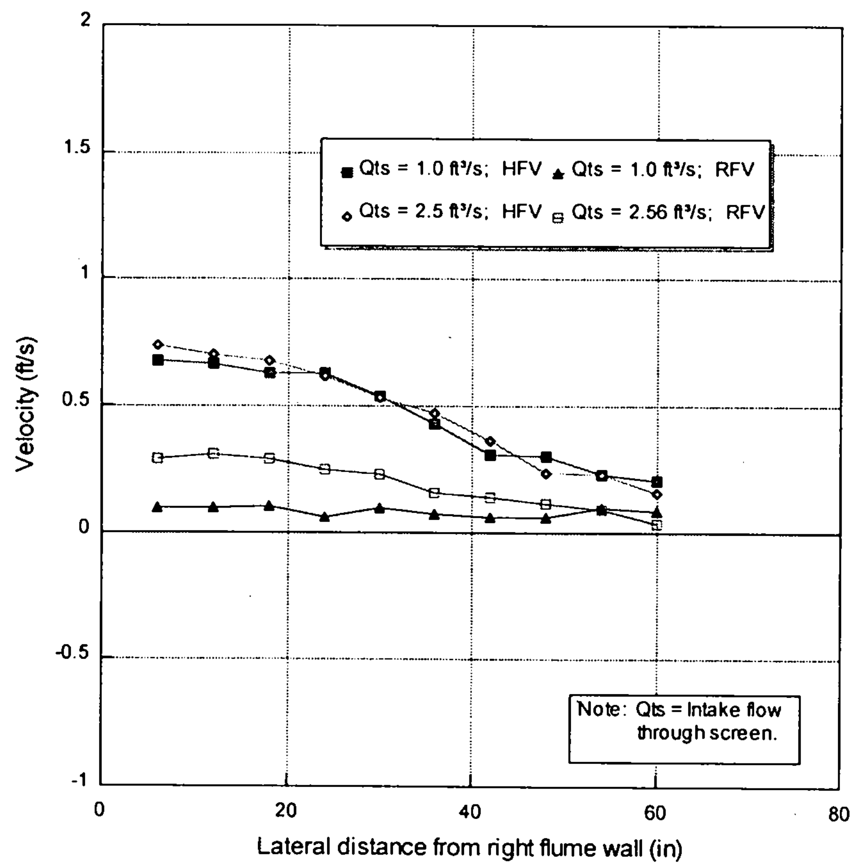

Figure 3. Flume velocity distribution.

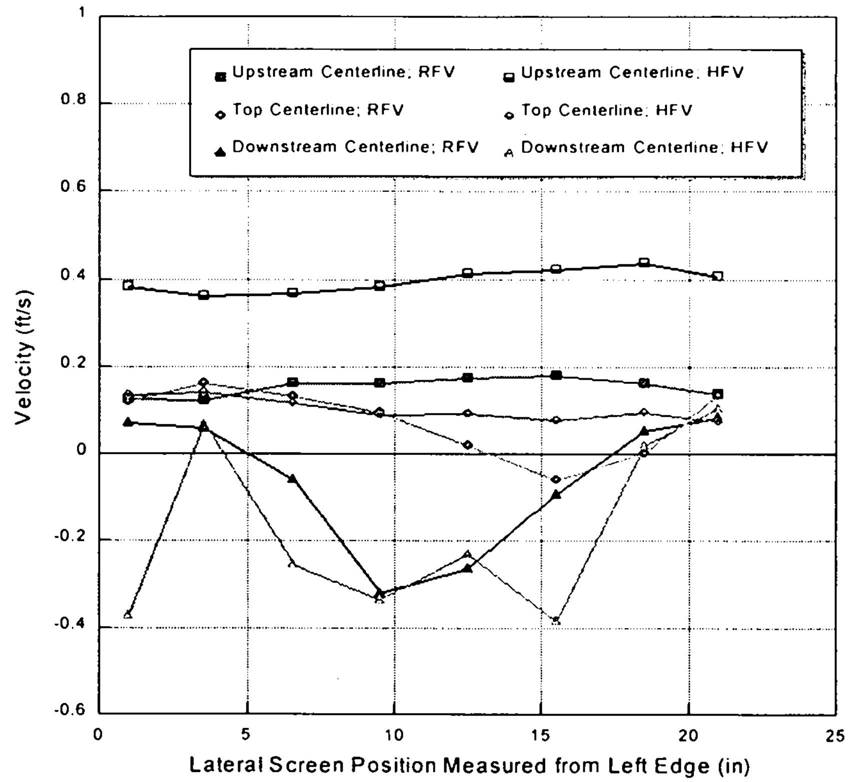

Figure 4. Approach velocities for a screen intake of 449 gpm with the screen surface oriented perpendicular to flow.

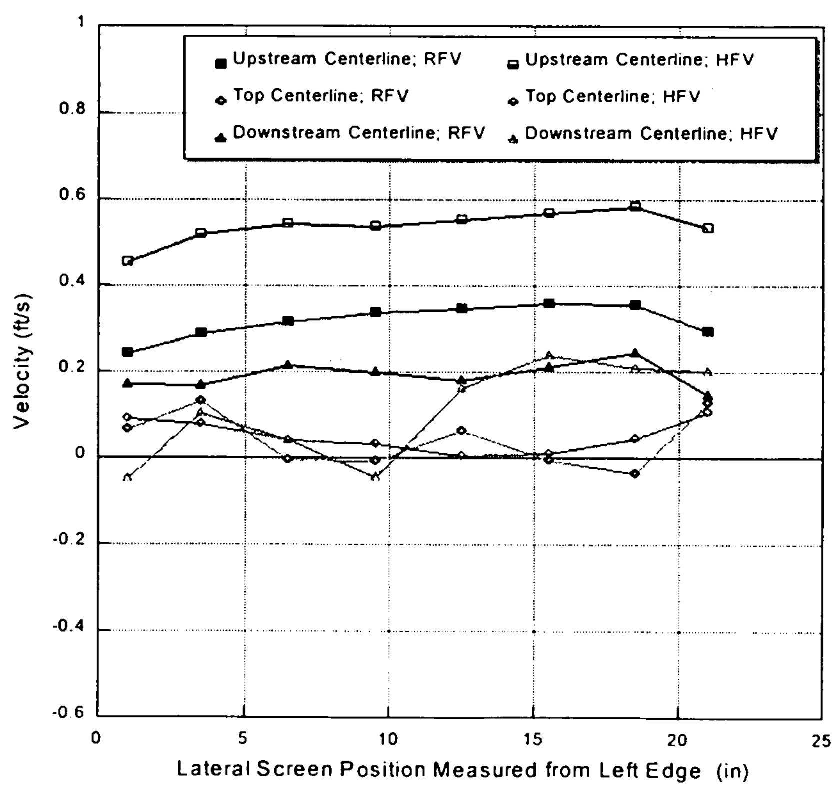

Figure 5. Approach velocities for a screen intake of 1150 gpm with the screen surface oriented perpendicular to flow.

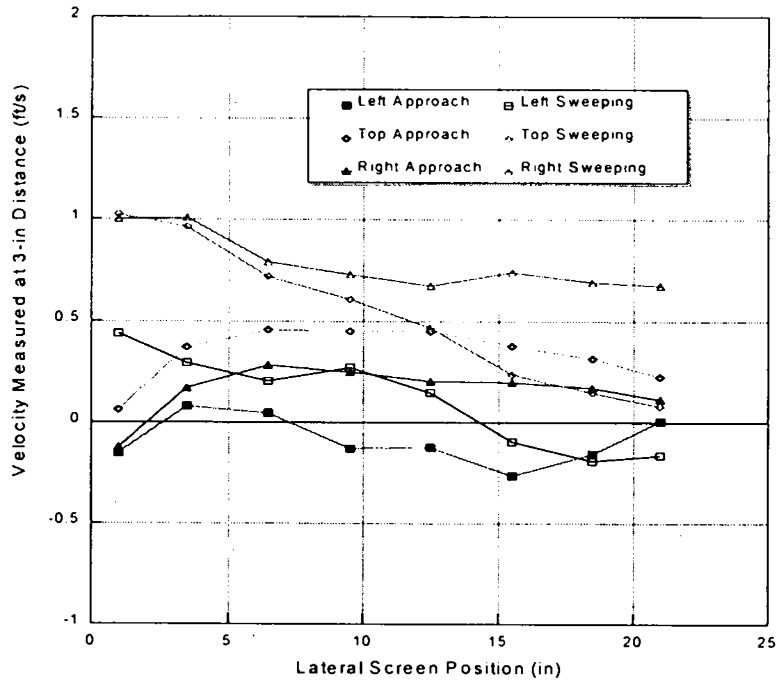

Figure 6. Approach and sweeping velocities measured 3-in from the screen for a screen intake of 448 gal/min and high sweeping flow. Screen orientation is parallel to flow.

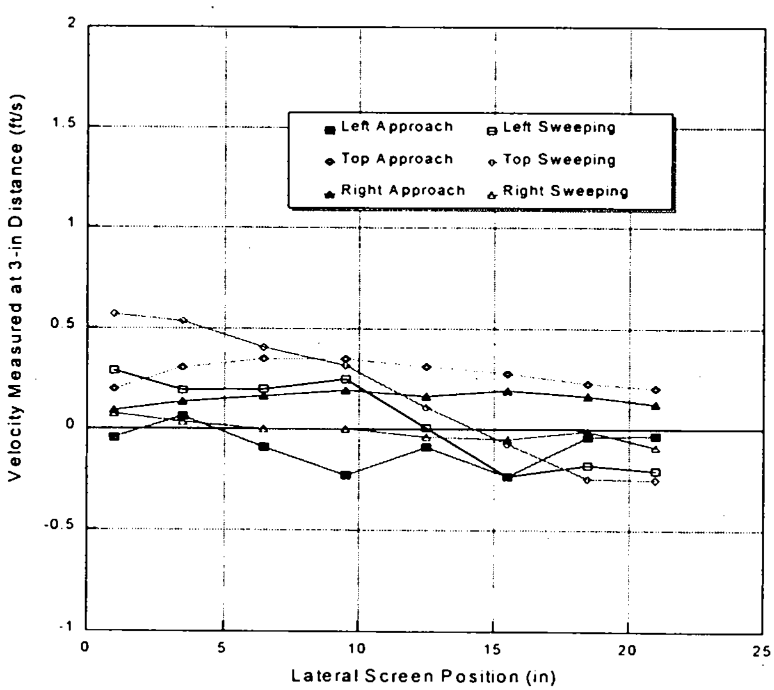

Figure 7. Approach and sweeping velocities measured 3-in from the screen for a screen intake of 448 gal/min and reduced sweeping flow. Screen orientation is parallel to flow.

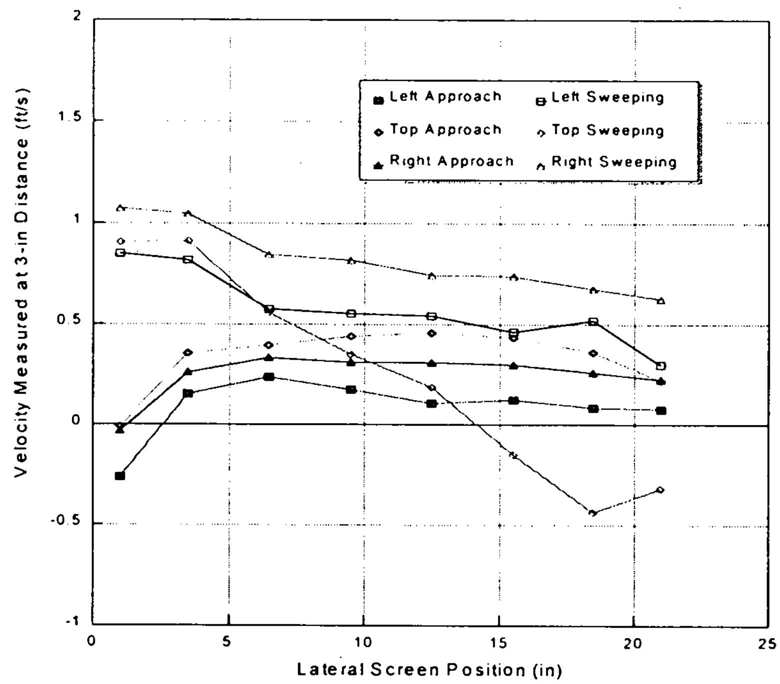

Figure 8. Approach and sweeping velocities measured 3-in from the screen for a screen intake of 1149 gal/min and high sweeping flow. Screen orientation is parallel to flow

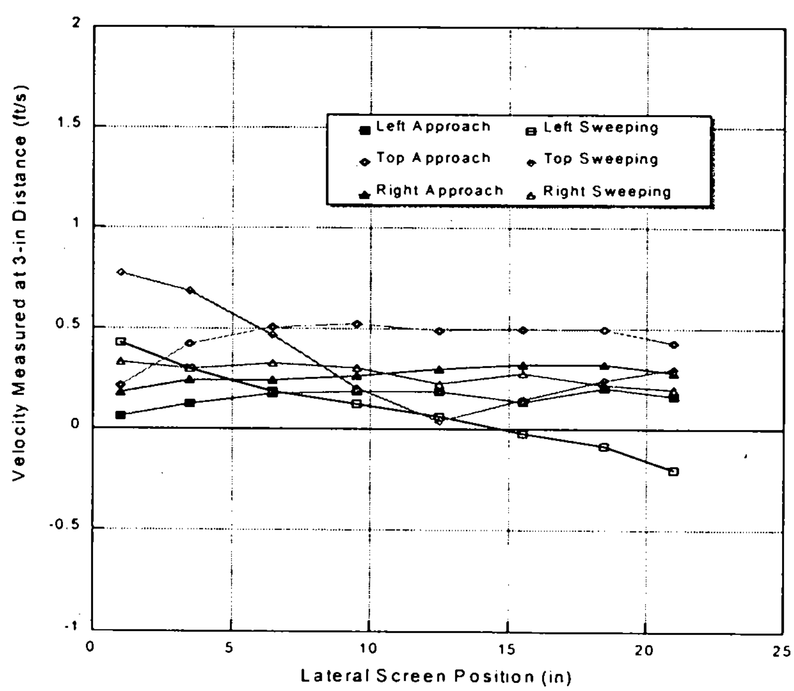

Figure 9. Approach and sweeping velocities measured 3-in from the screen for a screen intake of 1149 gal/min and reduced sweeping flow. Screen orientation is parallel to flow.

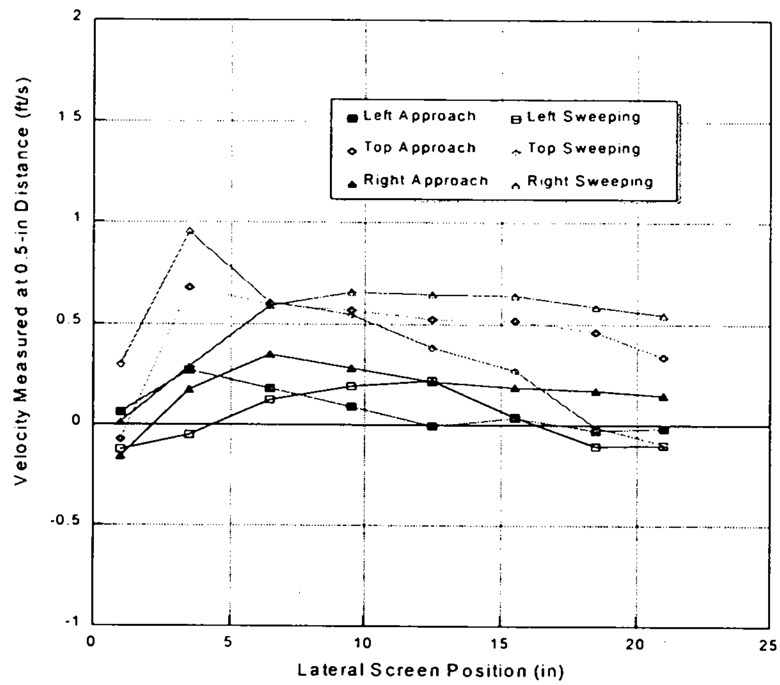

Figure 10. Approach and sweeping velocities measured 0.5-in from the screen for a screen intake of 448 gal/min and high sweeping flow. Screen orientation is parallel to flow

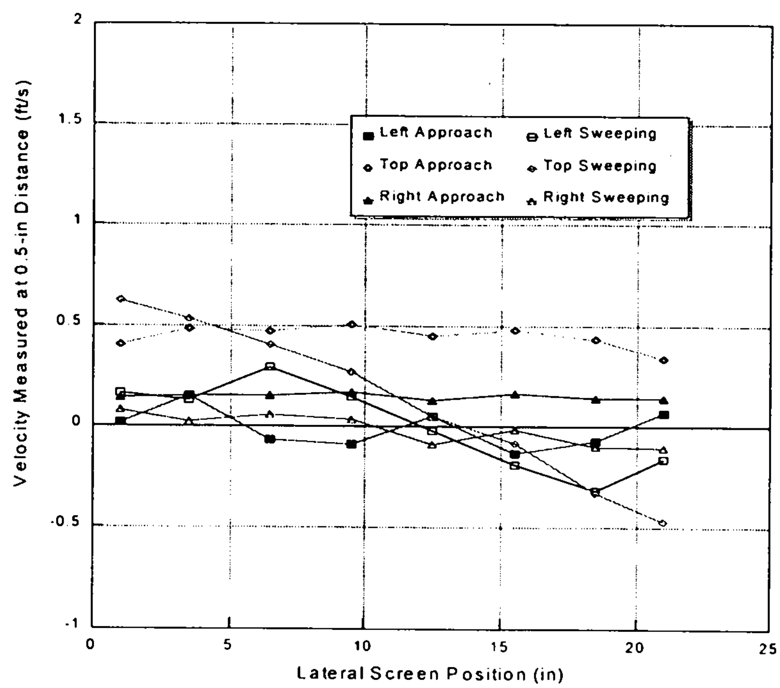

Figure 11. Approach and sweeping velocities measured 0.5-in from the screen for a screen intake of 448 gal/min and reduced sweeping flow. Screen orientation is parallel to flow.

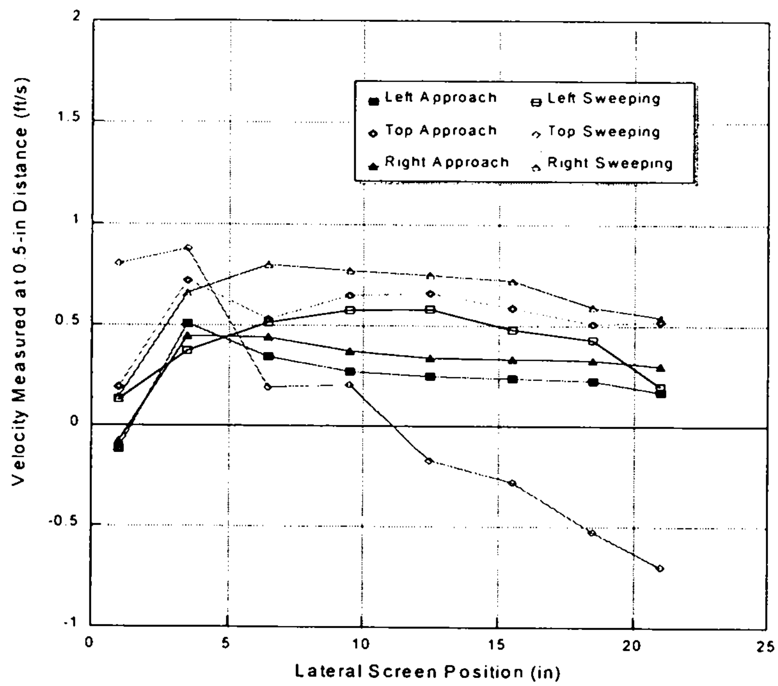

Figure 12. Approach and sweeping velocities measured 0.5-in from the screen for a screen intake of 1149 gal/min and high sweeping flow. Screen orientation is parallel to flow.

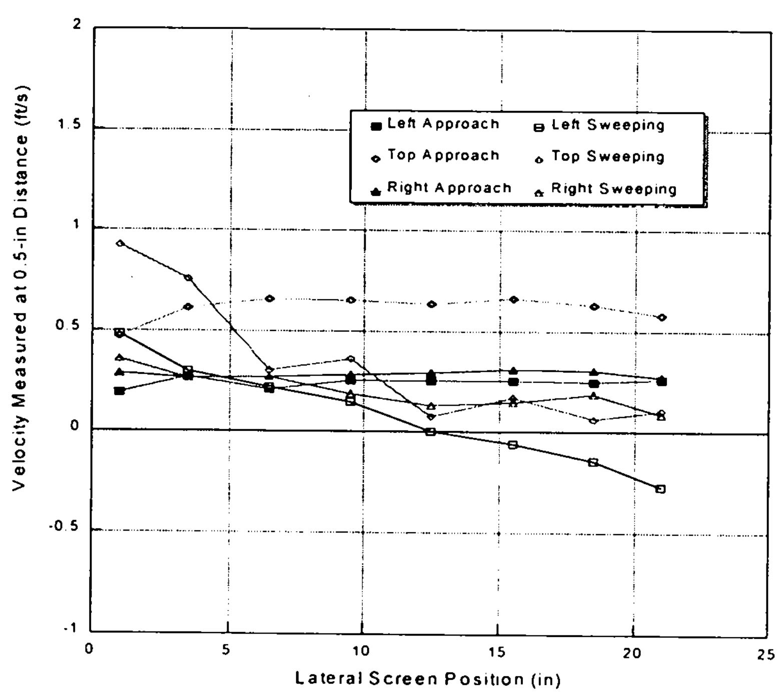

Figure 13. Approach and sweeping velocities measured 0.5-in from the screen for a screen intake of 1149 gal/min and reduced sweeping flow. Screen orientation is parallel to flow.