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National Oceanic and Atmospheric Administration
National Marine Fisheries Service

# Traveling Screen for Removal of Debris From Rivers

DANIEL W. BATES, ERNEST W. MURPHEY, and MARTIN G. BEAM



SEATTLE, WA.
October 1971

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# Traveling Screen for Removal of Debris From Rivers

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## ABSTRACT

This report describes the features and operation of a traveling debris screen, installed within a 12.2-m wide test flume in the Grande Ronde River near Troy, Oreg. The National Marine Fisheries Service developed the screen to improve removal of debris from canals and rivers of the Pacific Northwest and to reduce costs of removal. Trash racks are now used to remove debris, but they have been considered impractical because of maintenance difficulties during floods and because of their large size.

## INTRODUCTION

Diversion structures installed in rivers to deflect fish migrating through hazardous areas need to be protected from damage by large debris. This need is now met with trash racks of conventional design. These racks are considered impractical, however, because of maintenance difficulty during floods and because of the size of the structure required.

The traveling debris screen[3] described in this report was developed by the National Marine Fisheries Service to overcome these disadvantages. It introduces such features as a wire-rope suspension structure and an endless traveling screen that will contribute to the successful deflection and removal of debris.

The screen may be generally described as a conveyor belt, placed on edge in a diagonal line (20° angle to direction of stream) across the path of debris. The impinged material is carried easily and rapidly into a quiet pond for removal by conveyor.

The traveling debris screen was installed in a concrete test flume in the Grande Ronde River near Troy, Oreg., during the spring of 1967. At this site an island divides the river into two channels; the test flume occupied the full width of the left-bank channel. The test flume was 103.7 m long, 12.2 m wide, and 3.7 m deep. It was capable of holding all or any portion of the channel flow. Three electrically operated steel gates at the head of the structure controlled flow. Rate of flow was regulated by stop logs at the downstream end of the channel.

This report describes the design and operation of the screen and the results of three series of mechanical tests on its effectiveness and stability.

[1] Present address: 1450 Murphy Creek Road, Grants Pass, Oreg. 97526.
[2] Present address: Marine Dept., P.O. Box 10142, The Terrace, Wellington, New Zealand.
[3] The traveling debris screen was developed concurrently with studies of experimental traveling screens for deflecting juvenile migrants into a bypass for safe passage (Bates, Murphey, and Prentice, 1970; Bates and VanDerwalker, 1970) and incorporates certain features of the traveling screens.

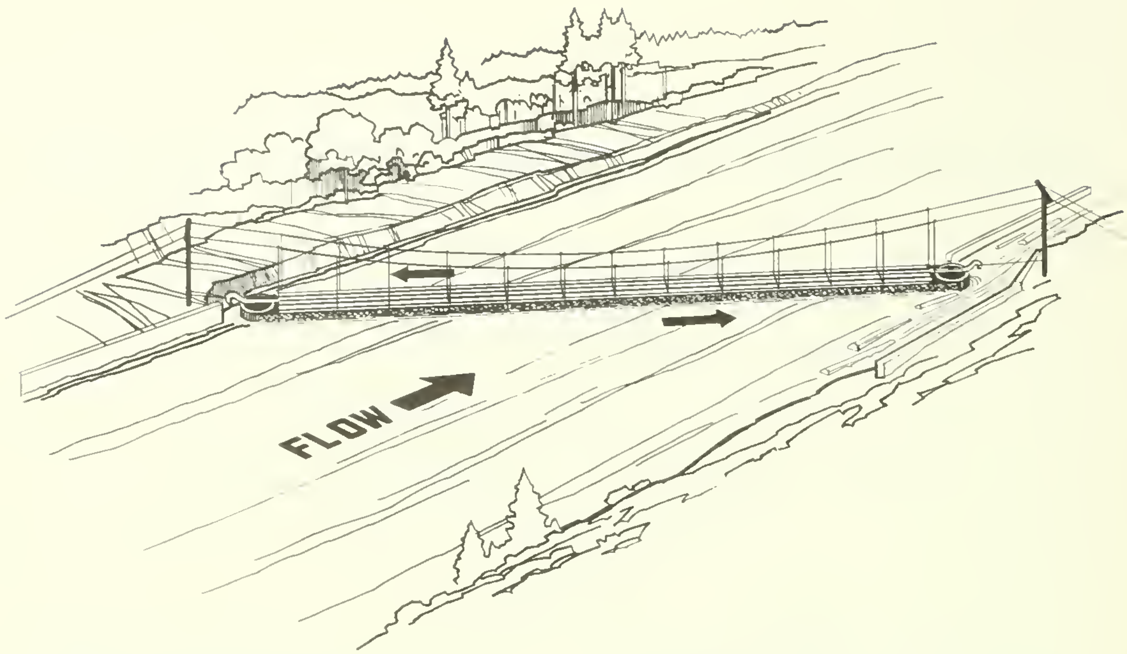


Figure 1. The traveling debris screen and supporting structure.

## DESCRIPTION OF TRAVELING DEBRIS SCREEN

A diagrammatic sketch of the traveling screen and supporting structure, installed at a stream site for transfer of debris into a holding pond, is shown in Figure 1. Looking somewhat like a conveyor belt on edge, the screen traveled through the water on a 20° angle to the direction of flow, carrying with it the impinged debris into the holding pond (Figure 1). All operating assemblies, with the exception of the screen, were out of the water to simplify and minimize maintenance.

The structural design, mechanical aspects, and screen support system of the debris screen are described in the following sections.

### Structural Design

The structural portion of the screen provided the support system for the traveling or mechanical members. It included a wire-rope suspension system, the stiffening members and cables, and the endless track.

**Suspension system.**—To obtain a supporting system for the screen that could be installed readily on a wide channel without need for expensive piers in the water, a wire-rope suspension system was used. The main suspension system consisted of two preformed steel cables, 16.0 mm in diameter (each 6 strands and composed of 19 wires), which supported the 19.5-m long screen (Figure 2). The two ends of the cables were fastened directly onto the concrete

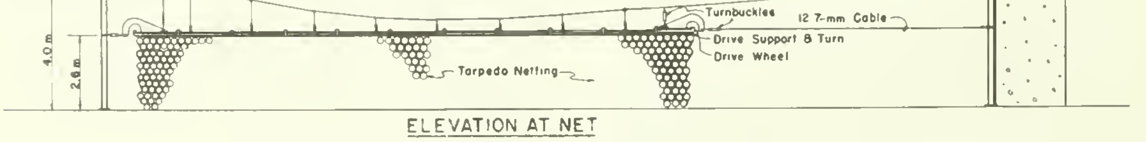


Figure 2. Elevation view of traveling debris screen.

walls of the test flume. This simple attachment was possible because of the limited weight of the debris screen and appurtenances, or structure, and the limited water pressure (loading value[4]) against it. Vertical suspenders of 9.6-mm chain were clamped to the main cables at 2.1-m intervals. The suspenders carried the longitudinal stiffening members used as a base for mounting the track, the carriers, and the cable-formed screen.

The velocity of the water passing through the screen directly affected the loading value—with an increase in water velocity, the loading value increased. The effect of increased loading values on a traveling debris screen is not as important as that on a traveling fish screen, as the former has a great amount of open area, resulting in reduced drag.

**Stiffening members and cables.**—Longitudinal stiffening members used as a base for mounting the endless track, the carriers, and the cable-formed screen consisted of a series of 1.2-m long brackets spaced at 2.1-m intervals along the length of the structure.

The longitudinal stiffening members were given vertical support at 2.1-m vertical intervals by suspenders of 9.6-mm chains clamped to the two main cables. Turnbuckles in the suspender chains provided for adjustment of the vertical alignment of the track, walkway, and the longitudinal stiffening members. Water forces against the screen were so minimal that counter-resistance was not required.

**Track design and support.**—The endless track, 43 m in circumference (Figure 3), was composed of a 19.2-mm black pipe through which was passed a 16-mm prestressed cable. By tightening this cable, the track became snugly interlocked for smooth travel of the carriages. The track at either end was shaped to conform to the curve of the end turns and then welded into place.

## Mechanical Aspects

The mechanical design included all traveling assemblies such as the power-drive units, the bull wheels or sheaves, haul line or traction line, carriages and cable connectors, and manner of screen attachment.

**Drive system.**—A central hydraulic drive system powered the two bull wheels installed at opposite ends of the structure. The hydraulic drive system included a 10-hp gasoline-powered engine, a pressure relief valve, and a manual two-way flow control valve. The two hydraulic orbit motors, each with a sprocket attached to the drive shaft, were mounted beneath the bull wheels on adjustable plates. Each sprocket was fitted into a No. 50 roller chain attached along the inside circumference of the bull wheel. When each hydraulic orbit motor was driven by oil forced under high pressure into the motor, the sprocket rotated in the mesh of the roller chain and turned the bull wheel.

**Bull wheels.**—The bull-wheel design was patterned after those on conventional ski-tow systems. The two bull wheels were 1.2 m in diameter, and the 10.2-cm wide, flat outside surface of each wheel, around which the haul line passed, was faced with rubber to prevent spillage and wear of the haul line.

**Haul line.**—The haul line was formed of a 9.6-mm diameter flexible steel cable held under 863-kg tension by coiled springs. The haul line formed a complete circuit about both bull wheels.

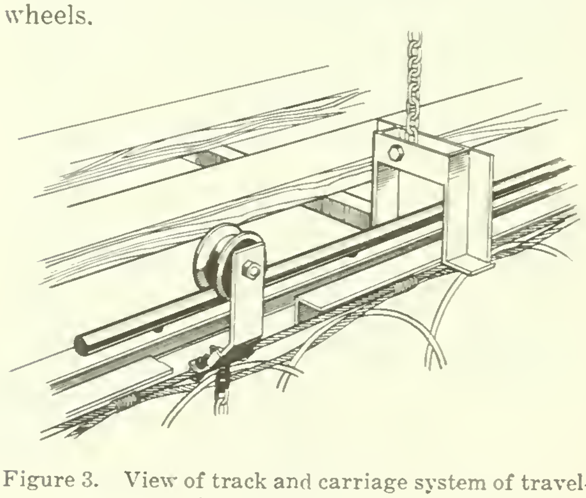

Figure 3. View of track and carriage system of traveling debris screen.

## Screen and Support System

The endless cable-formed screen was 2.6 m high and 43 m in circumference. The support

[4] Either wind or water pressure against a traveling screen and its appurtenances is considered a "loading value." The loading value can be affected by the amount of debris impinging on the screen.

system for the screen consisted of grooved wheels as carriages.

**Carriages.**—A series of grooved wheels (carriers), 10.2 cm in diameter and spaced at 1.8-m intervals, were installed to carry the weight of the screen and water reaction forces on the screen. Each wheel was faced with rubber to eliminate noise and reduce wear along the running surfaces.

**Screen and attachment.**—The netting, originally manufactured for Naval torpedo defense, consisted of a 6.4-mm cable formed into 35.6-cm diameter rings, each interwoven with one another to form an endless cable-formed screen (Figure 4). We used the heavy cable woven through the top rings of the screen to attach the screen to the individual carriages with flat iron bar connectors (Figure 3).

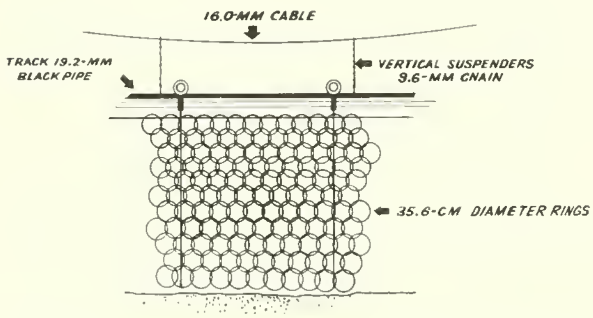


Figure 4. Elevation view of a section of the traveling debris screen.

## Bypass and Debris Impoundment Area

The traveling debris screen was assembled in the concrete test flume in the Grande Ronde River. Viewed from upstream, the screen (Figure 1) traveled left to right with the downstream end in line with a 3.7-m wide bypass. The bypass led into an impoundment area for the debris. Test logs impinged on the screen were carried across the canal and released into the bypass leading into the impoundment area.

# OPERATION OF TRAVELING DEBRIS SCREEN

A plan view of the traveling debris screen is shown in Figure 5. The endless cable-formed screen traveled across the canal on a 20° angle to flow, passed around the end turn, and returned upstream through the water to the point of origin.

To reduce the impact of debris sweeping against the screen, travel speed was matched to the velocity of approach.[5]

Viewed from upstream, the screen traveled left to right. Test logs that swept onto the screen were carried across the canal and released at the downstream end of the structure into a 3.7-m wide bypass leading into a debris impoundment area.

In evaluating the efficiency of the screen, we conducted three series of tests. The purpose

[5] Average travel rate of water approaching a fish screen or debris screen is also called "approach velocity." The rate of water passing through the screen is called "velocity through the screen."

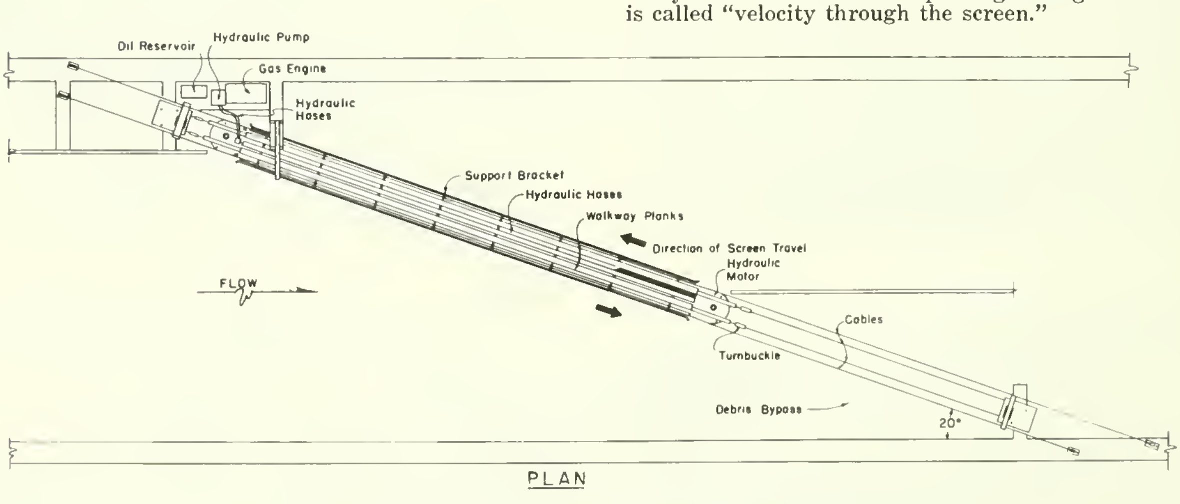


Figure 5. Plan view of the traveling debris screen.

of test series I was to determine the impact of a log weighing 1,362 kg (6.1 m long and 0.92 m in diameter) against the screen as a factor of three approach velocities, 0.15, 0.6, and 1.2 m per second (mps). Travel rate of the screen was matched to each approach velocity. Test series II was to determine whether logs (6.1 m long and 40.6 cm in diameter) with 1.2-m long stubbed branches extending through the loops of the cable netting would be released from the screen as the log entered into the bypass, just prior to the screen's return upstream. Test series III was to determine the horsepower requirements of the debris screen when it was traveling without water in the canal in contrast to traveling with water moving at various velocities of approach. No special test materials were required.

Water depth for all tests was held as constant as possible at 1.7 m (4.7 ft). For each test the logs were dropped into the canal at the upstream end and allowed to be carried by the flow onto the screen.

## EFFECTIVENESS OF TRAVELING DEBRIS SCREEN

We conducted 128 tests in the three test series. Of these, 21 tests (test series I) were related to the study of log impact against the net. Table 1 shows that the horsepower required to move the screen did not increase through impact of the 1,362-kg log against it and indicated the ease with which large debris could be handled.

Forty-four tests (test series II) were conducted to determine the possibility of log holdup on the screen. Without exception, all stubbed branches enmeshed in the cable loops slipped away as the screen started its travel around the end turn.

Table 1. Comparative horsepower requirements of traveling debris screen as factor of water approach velocity and debris load (travel rate of screen matched to velocity of approach).

| Water approach velocity (mps) | Horsepower requirements (hp) | | |
|---|---|---|---|
| | without log | with log1/ | increase |
| 0.15 | 0.40 | 0.40 | 0 |
| 0.61 | 1.00 | 1.00 | 0 |
| 1.22 | 3.00 | 3.00 | 0 |

1/ Weight, 1,362 kg; length 6.1 m; diameter 0.92 m.

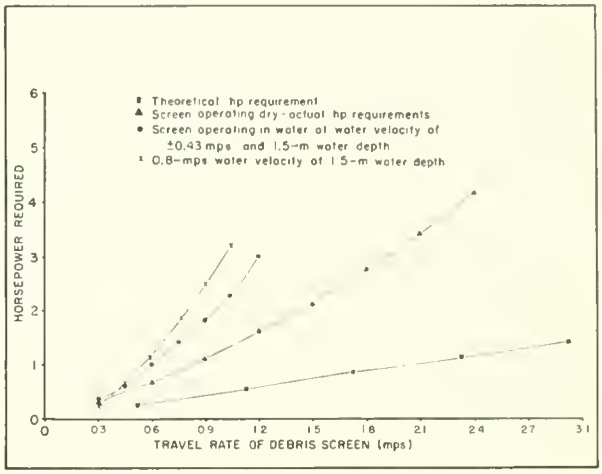


Figure 6. Curves of drag forces on debris screen.

The results of 63 drag tests (test series III) are plotted in Figure 6. (Each of the 21 plotted values in Figure 6 represents the mean of three tests.) We found that only 3 hp were needed to move the screen at 1.0 mps in a water approach velocity of 0.8 mps and that an extensive drop in horsepower requirements could be achieved by reducing the travel rate of the screen: A 50% reduction in the screen travel rate (0.5 mps) reduced the horsepower requirements to a minimal 0.5 hp (Figure 6).

Although water reaction forces[6] against the debris screen were not appreciable because of the extensive open area of the 35.6-cm diameter loops, it did become necessary at higher velocities to add weights to the bottom of the net to prevent undue deflection from the vertical position. Weights were required only at velocities above 0.9 mps.

In the fall, long streamers of moss passing downstream with the flow became enmeshed with the cable loops. To release the material, hand picking was required.

During the 7-month period of testing, the debris screen traveled a distance of 5,474 km over a period of 1,900 hr without breakdown or call for maintenance.

## SUMMARY AND CONCLUSION

During a 2-year period of intermittent operation, it was clearly indicated that the traveling debris screen combines all the advantages

[6] Water reaction force is the sum of water friction and water pressure against the screen.

of the stationary trash rack plus others such as low construction and maintenance cost, efficient deflection of debris, simplicity of design, and ease with which it collects, transports, and releases debris. Its one major disadvantage is the collection of streamers of moss which, as they are carried downstream, become entangled in the cable rings. The accumulation of moss can be rapid and troublesome.

The debris screen, as described, appears to be practical for canal and river flows of considerable magnitude, limited only by the seasonal passage of moss.

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