UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF THE DAVIS AQUEDUCT TURNOUTS AT STATIONS 15.4 AND 11.7 WEBER BASIN PROJECT--UTAH

Hydraulic Laboratory Report No. Hyd-442

DIVISION OF ENGINEERING LABORATORIES

COMMISSIONER'S OFFICE
DENVER, COLORADO

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Commissioner's Office--Denver
Division of Engineering Laboratories
Hydraulic Laboratory Branch
Hydraulic Structures and
Equipment Section
Denver, Colorado
September 15, 1958

Laboratory Report No. Hyd-442
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Subject: Hydraulic model studies of the Davis Aqueduct turnouts at Stations 15.4 and 11.7--Weber Basin Project, Utah

PURPOSE

The studies were made to determine the adequacy of the proposed structures in controlling high velocity flows from partly opened gate valves, and to determine any design changes needed for satisfactory operation.

CONCLUSIONS

1. Satisfactory performance will be obtained in the Station 15.4 structure if the inverted L-shaped baffle is made 3 feet high, and better performance will be obtained if splash deflectors are added at the sidewalls just ahead of the baffle (Figure 1). In this turnout the pipeline enters the structure horizontally.

2. Satisfactory performance will be obtained in the Station 11.7 structure if the baffle is made 3 feet high with the upstream projection tipped down 30° from a right angle, and if splash deflectors are added to the side walls. The spray will be further reduced if a splashboard is added ahead of the baffle (Figure 8). In this turnout the pipeline enters the structure at a 45° downward slope.

3. Riprap or other adequate protection should be provided on the canal surfaces near these outlet structures to prevent erosion of the canal bed and possible undermining of the structure.

INTRODUCTION

Some of the turnout structures on the Davis Aqueduct will operate at heads considerably in excess of 100 feet and will therefore require some means of dissipating the energy in the flow before it is released into open channels for delivery to users. The preliminary design of the energy dissipator was similar to the box-with-baffle type developed by hydraulic model tests for the Franklin Canal drains and wasteways.[1] However, there were differences in the operating conditions in these two cases. In the Franklin Canal structures water issued from partly filled conduits at fairly high velocity and entered through the headwalls of open-top boxes to impinge on inverted L-shaped baffles. In the Davis Aqueduct turnouts water discharged at much higher velocities from partly opened gate valves located in the headwalls and impinged on inverted L-shaped baffles (Figure 1A). The higher velocities, although of relatively smaller quantities, and the directional change of the flow leaving the valves as the valve openings were changed, made it difficult to predict the performance of the Davis Aqueduct turnout structures. Hydraulic model studies were therefore made on two typical structures.

THE MODELS

Models of two turnouts were built to a scale of 1 to 2.46 (Figures 1 and 8). A discharge of 1.05 cfs at a velocity of 51 fps through a 6-inch valve approximately 12 percent open represented 10 cfs at 80 fps in the prototype. A second discharge of 0.47 cfs at a velocity of 67.4 fps represented 4.1 cfs at 106 fps. Prototype values will be used in the following paragraphs that report the results of the model tests.

TURNOUT 15.4

The floor of Turnout 15.4 was horizontal and the long leg of the baffle was vertical (Figure 1). In the preliminary design of this turnout, water from the valve was deflected by the inverted L-shaped baffle to the upstream headwall. A portion of the water splashed from the headwall to overtop the baffle and fall into the downstream pool (Figure 2). The pool was turbulent but the exit velocity of approximately 3 fps over the end sill for a discharge of 10 cfs was acceptable. An increase in the depth and length of the pool to reduce the turbulence was discussed but the increase was not tested in the model.

The splash behind the baffle increased with an increase in velocity. The shape of the jet and the upward flow direction from the partially opened valve caused the water to splash over the baffle and side walls (Figure 3). The flow conditions in the pool downstream from the baffle were satisfactory for a valve discharge of 4.1 cfs at a velocity of 106 fps, but the splash upstream from the baffle was objectionable because of the possibility of spray saturating the ground in the vicinity of the structure.

1/ "Impact-type Energy Dissipators for Flow at Pipe Outlets" Franklin Canal, Bostwick Division, Missouri River Basin Project, by A. J. Peterka. Report No. Hyd-398.

The splash was reduced to an acceptable value for the 4.1 cfs discharge when the height of the baffle was increased from 24 to 36 inches (Figures 1B and 5).

Flow conditions upstream of the baffle were improved for the 10 cfs discharge although a small amount of water was deflected upward on the headwall (Figure 4). The increased baffle height did not improve the pool flow conditions over those of the preliminary design, but with the exit velocity still approximately 3 fps over the end sill the design was acceptable. The 36-inch baffle was therefore recommended for the 15.4 turnout. Although not studied on this design, the two 8-inch-wide deflectors at the side walls between the baffle and headwall, shown on Figure 1B, would prevent water overtopping the baffle.

Unsatisfactory flow conditions resulted when the passage under the baffle was closed and the water filled the space upstream of the baffle, submerged the valve, flowed over the top of the baffle, and plunged into the downstream end of the turnout (Figure 6). Severe turbulence occurred upstream of the baffle and in the pool. Flow conditions were acceptable for 4.1 cfs (Figure 7) but closure of the baffle was not recommended because of unsatisfactory flow conditions at larger discharges.

TURNOUT 11.7

The inlet pipe and valve of Turnout 11.7 were at a 45° downward angle with respect to the horizontal pool, and the baffle was at right angles to the axis of the valve (Figure 8A).

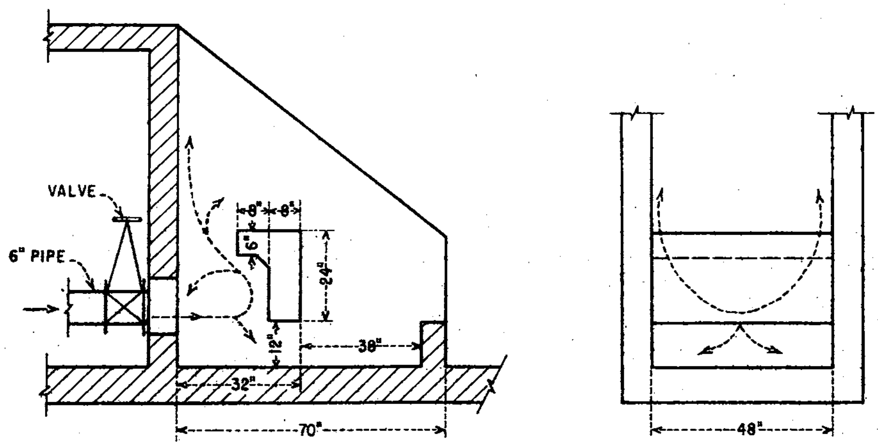
Water from the valve was turned upstream against the headwall by the top leg of the baffle. A part of the water was deflected upward on the headwall and carried over the baffle into the downstream pool (Figure 9). Spray at the upstream corners of the turnout carried over the side walls. The pool downstream from the baffle was less turbulent than the pool of Turnout 15.4, but the turnout was not satisfactory because of excessive turbulence and spray.

A 15° rotation of the baffle about the uppermost edge improved the flow conditions at the headwall by deflecting the water downward, but the turbulence in the downstream pool was increased. The design was not satisfactory because of the pool turbulence, but the test showed that it was desirable to have a baffle at a 90° angle to the valve jet, to have an opening of 1 foot at the bottom, and to have a downward slope of the lower surface of the top leg.

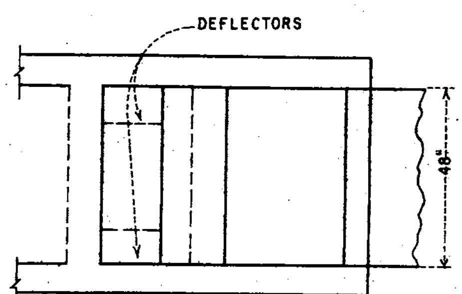
A 30° wedge was added to the lower surface of the top leg of the baffle and the baffle was rotated back to be at a right angle to the valve axis (Figure 8B). This change improved the flow conditions at the headwall, but a part of the water from the baffle was turned downward into the valve jet to cause considerable spray. The length of the long leg of the baffle was then increased by approximately 4-1/8 inches to compensate for the 30° wedge and the baffle was raised to maintain a 1-foot clearance between the baffle bottom and the floor. The water was turned toward the headwall by this new baffle and did not interfere with the valve jet (Figure 10).

Spray in the turnout corners upstream from the baffle was objectionable and two 8-inch-wide deflectors between the baffle and headwall were installed at each side of the turnout (Figure 8B). These deflectors confined all but a small amount of the water to the space behind the baffle (Figure 11). It was possible to confine this water by placing a splashboard across the two deflectors (Figure 8B). It is believed that a space for aeration of 3-inch minimum width and 32 inches long (equal to the open distance between deflectors) should be provided between the splashboard and the headwall.

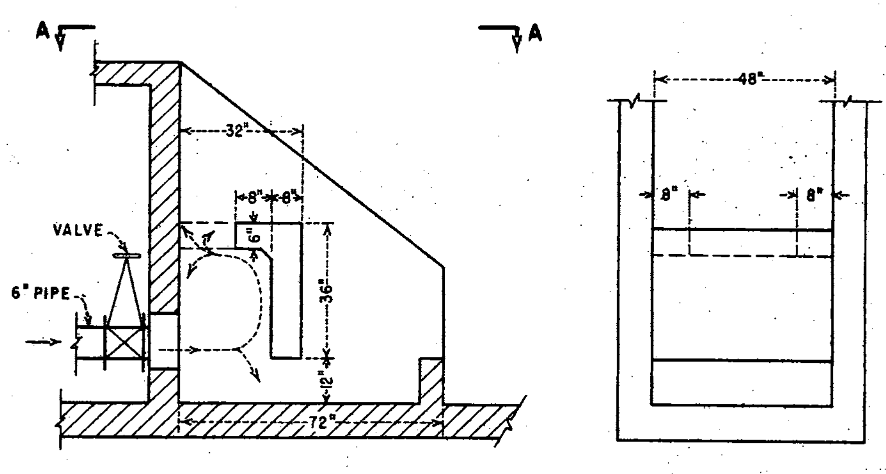
Flow conditions in the pool below the baffle were satisfactory for both the 10 and 4.1 cfs discharges (Figure 11). The 30° wedge on the top leg of the baffle and the two 8-inch-wide side wall deflectors were recommended for the turnout. A splashboard may be added to the field structure if objectionable spray occurs.



A. PRELIMINARY DESIGN-FLOW PATTERN



SECTION A-A



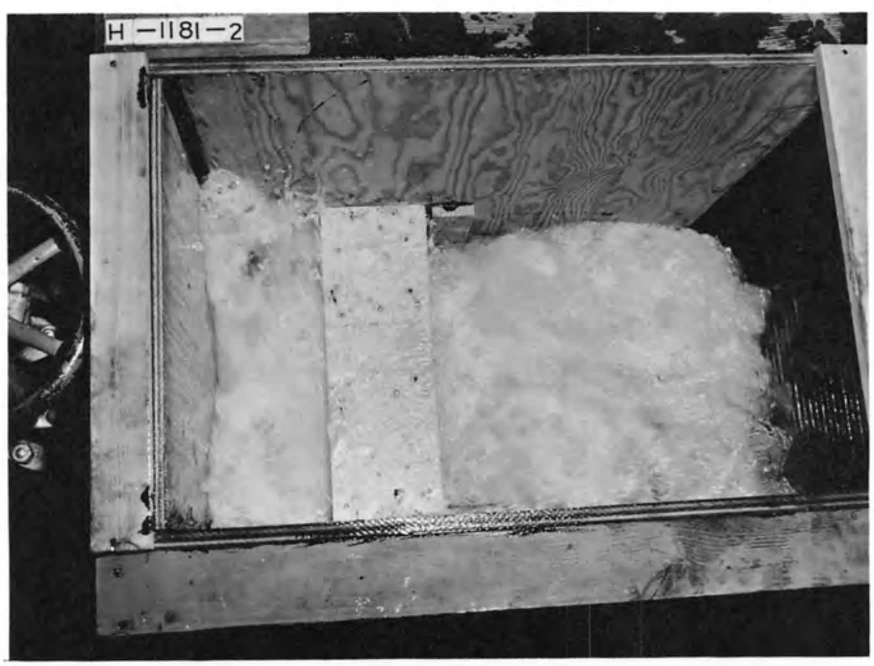
B. RECOMMENDED DESIGN

DAVIS AQUEDUCT TURNOUTS

TURNOUT AT STATION 15.4

1: 2.46 SCALE MODEL

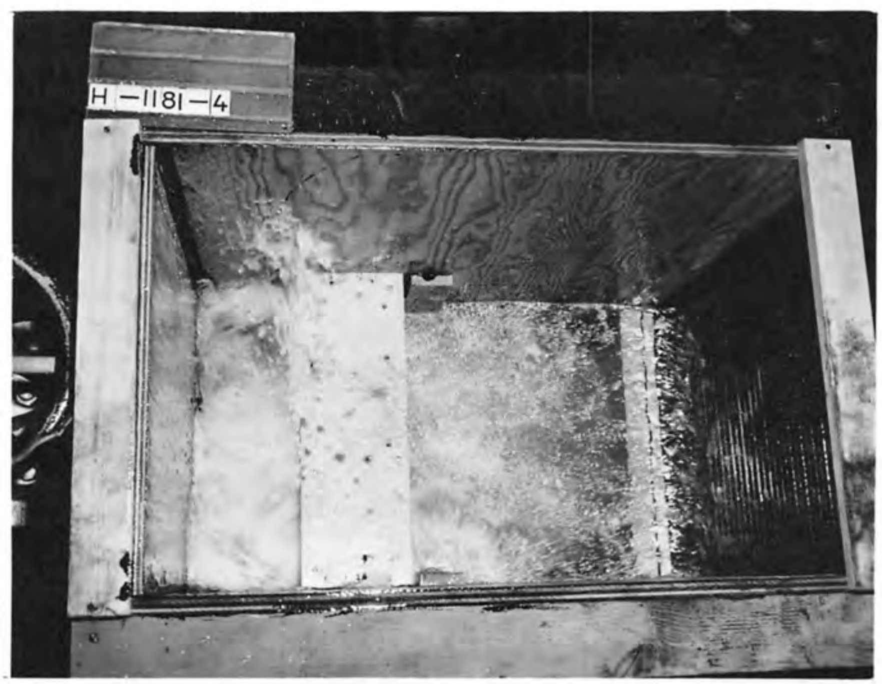
A. View from downstream



B. View from top

DAVIS AQUEDUCT TURNOUTS
Station 15.4--Preliminary Design with 24-inch baffle
10 cfs flow at 80 fps with 100 foot head
1:2.46 scale model

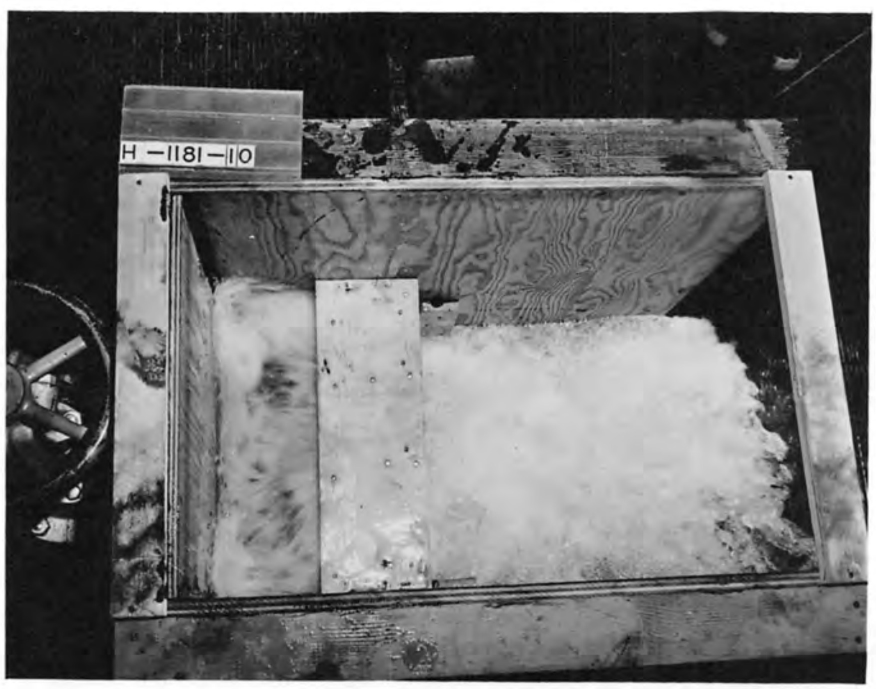
A. View from downstream



B. View from top

DAVIS AQUEDUCT TURNOUTS
Station 15.4--Preliminary Design with 24-inch baffle
4.1 cfs flow at 106 fps with 175 foot head
1:2.46 scale model

A. View from downstream



B. View from top

DAVIS AQUEDUCT TURNOUTS
Station 15.4--Recommended Design with 36-inch baffle
10 cfs flow at 80 fps with 100 foot head
1:2.46 scale model

Figure 5
Report Hyd 442

A. View from downstream

B. View from top

DAVIS AQUEDUCT TURNOUTS
Station 15.4--Recommended Design with 36-inch baffle
4.1 cfs flow at 106 fps with 175 foot head
1:2.46 scale model

A. View from downstream

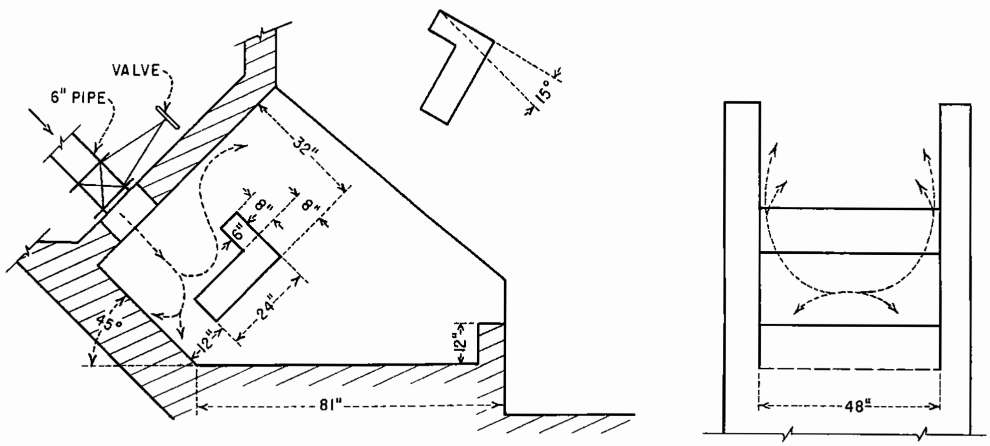
B. View from top

DAVIS AQUEDUCT TURNOUTS
Station 15.4--Preliminary Design with passage under baffle blocked. 10 cfs flow at 80 fps with 100 foot head
1:2.46 scale model

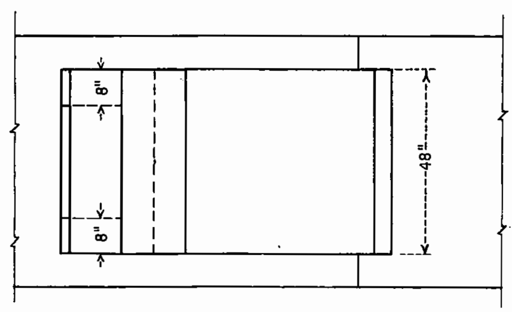
A. View from downstream

B. View from top

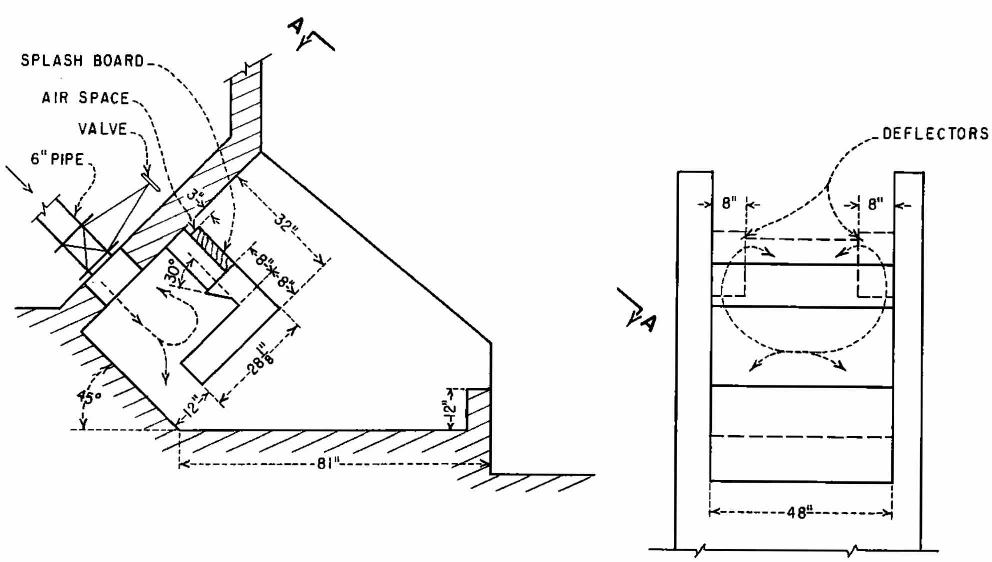
DAVIS AQUEDUCT TURNOUTS
Station 15.4--Preliminary Design with passage under baffle blocked. 4.1 cfs flow at 106 fps with 175 foot head
1:2.46 scale model



A. PRELIMINARY DESIGN-FLOW PATTERN



SECTION A-A



B. RECOMMENDED DESIGN

DAVIS AQUEDUCT TURNOUTS

TURNOUT AT STATION 11.7

1:2.46 SCALE MODEL

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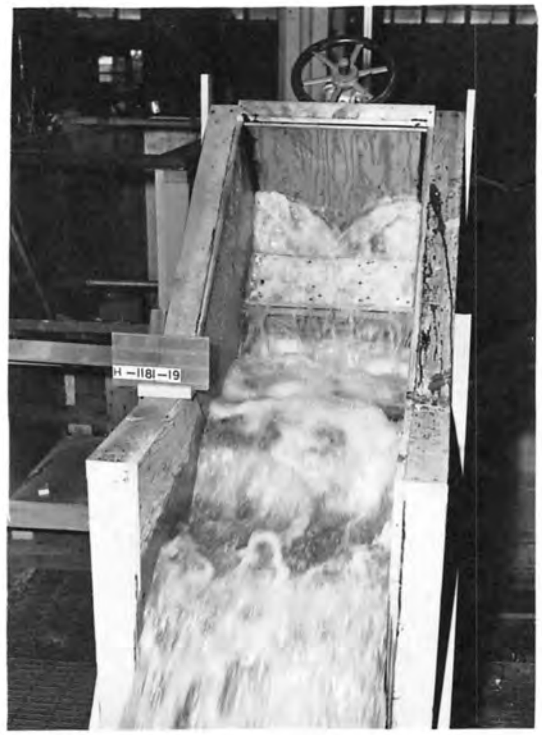
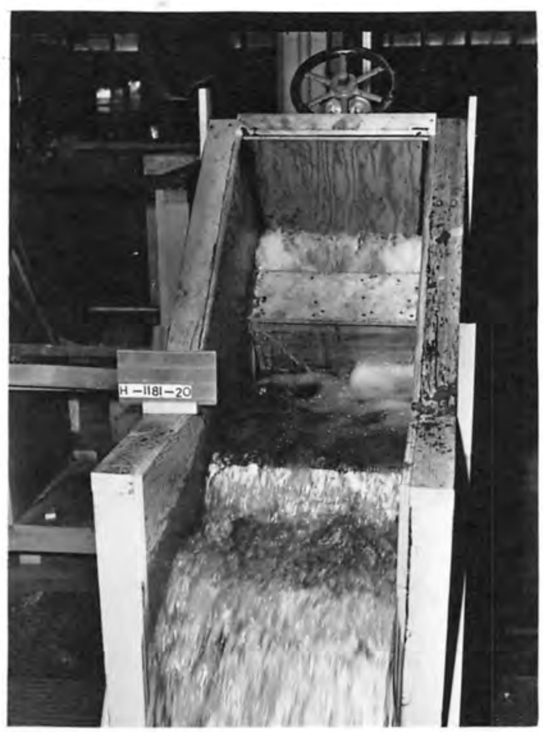


A. 10 cfs flow at 80 fps with 100 foot head



B. 4.1 cfs flow at 106 fps with 175 foot head

DAVIS AQUEDUCT TURNOUTS
Station 11.7--Preliminary Design with 24-inch baffle
1:2.46 scale model

A. 10 cfs flow at 80 fps with 100 foot head

B. 4.1 cfs flow at 106 fps with 175 foot head

DAVIS AQUEDUCT TURNOUTS
Station 11.7--28-inch baffle with 30° wedge on
under side of top leg
1:2.46 scale model

A. 10 cfs flow at 80 fps with 100 foot head

B. 4.1 cfs flow at 106 fps with 175 foot head

DAVIS AQUEDUCT TURNOUTS
Station 11.7--Recommended Design - 28-inch baffle
with 30° wedge, and 2 8-inch sidewall deflectors