PAP-441

BUREAU OF RECLAMATION
HYDRAULICS BRANCH

PROGRESS REPORT

HYDRAULIC MODEL STUDY

YELLOWTAIL AFTERBAY SLUICEWAY

BY

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PAP-441

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Bureau of Reclamation

INFORMATIONAL ROUTING

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Memorandum

To: Regional Director, Billings, Montana
Attention: UM-210

From: Chief, Hydraulics Branch

Subject: Progress Report on Hydraulic Model Study of Yellowtail Afterbay Sluiceway

Purpose

Since installation of the deflector plates in the sluiceway, material has been found in the basin that has caused erosion damage to the concrete between the plates and the chute blocks. The purpose of the model study was to identify the problem and determine a solution. This memorandum reports the model test results as of July 18, 1983.

The Model

The model includes 180 ft of the upstream reservoir, the sluiceway, the width necessary to model the spillway bays, and 225 ft of the downstream river channel. The upstream topography was formed (using pea gravel) to El. 3157 immediately upstream of the sluiceway, then sloping up to El. 3160. The downstream area included the riprap slopes below the spillway and sluiceway with pea gravel forming the rest of the river channel. It was determined that the solution to the problem in the sluiceway basin could probably be determined by modeling only the sluiceway. The time and cost involved in modeling the spillway at this time would have exceeded the time and cost estimates; however, it may be added at a later date.

Investigation

The following is a description of testing, analysis, and results of the tests to date:

1. Velocities were taken upstream and downstream of the sluiceway using a pygmy velocity meter. These velocities were taken at the bottom and 0.2, 0.6, and 0.8 of the depth with and without the deflectors in place. The average upstream velocities ranged from about 6.5 ft/s on the bottom just upstream of the gates to about 1.6 ft/s near the surface 18 ft upstream of the gates for a discharge of 4,200 ft^3/s at reservoir El. 3191. With this operating

condition, average velocities just downstream of the endsill varied from about 4.6 ft/s near the bottom to 3.5 ft/s near the surface. Velocities for a discharge of 2,500 ft^3/s, with the deflector plates installed, required use of a current meter under repair at this time. The data will be attained as soon as possible.

2. Initial operation of the model showed an area of local scour occurring upstream of the left sluiceway bay and along the face of the sluiceway crest. At this time it appeared that no material was being brought into the stilling basin from the area downstream of the endsill. Testing was confined to the area upstream of the sluiceway gates as a source of the material. This area was fed with sediment ranging in size from very fine sand to pea gravel representing prototype sizes of 0.14 to 3.5 in. The sediment formed a slope down toward the sluiceway gates and any material moving to within about 9 ft of entrance was immediately carried under the gates into the basin. To form this bed,sediment was fed into the area upstream of the sluiceway continuously for 1 week.

These tests indicated that the sediment could have originated from the area upstream of the sluiceway entrance. This phase of the investigation was suspended until field data could be obtained defining the bed configuration in this area.

3. The deflector plates were then modified in an attempt to allow the basin to self-clean. The modifications included cutting a horizontal slot 9 in deep along the upstream edge the full width of the plate and cutting a slot 22.5 in deep and 18 in wide on the upstream edge in the center of the plate. The purpose was to force a portion of the jet along the invert of the chute down to the floor of the basin to clean out the material. Neither of these deflector plate modifications cleaned the basin. It was determined that too much of the jet would have to be diverted downward to allow the basin to self-clean and the purpose of the deflector plates (prevent nitrogen supersaturation) would be defeated.

4. The next tests involved unequal gate operations which might draw material into the basin from either the area downstream of the spillway or sluiceway stilling basins. These tests showed that this could definitely affect the flow patterns, particularly if the left gate were closed more than the middle and right gates. The large amount of flow entering the right gate caused the velocities to increase along the sloped bed upstream of the sluiceway entrance causing material to travel into the sluiceway basin from this area. Material already deposited in the stilling basin bays moved to the bay with the lowest velocity, and it appeared that if material was located below the endsill it would move upstream.

5. These gate operation tests led to further investigation of the low discharge range. The model was tested at reservoir El. 310 with 1-, 2-, and 3-ft gate openings producing discharges of about 900, 1,400,

and 2,500 ft^3/s. The discharge was then held at 2,500 ft^3/s and the reservoir raised to El. 3191. Finally, with the reservoir at El. 3191, the discharge was slowly increased to 4,200 ft^3/s.

To help visualize the flow patterns just downstream of the sluiceway, strings were attached to the endsill on the centerline of and between each deflector and vertically along both side walls at the end of the basin. The velocity at the endsill for 900 ft^3/s was very low as the strings remained almost vertical. As the discharge increased, turbulence developed downstream of the endsill which caused the flow to oscillate back and forth and move small pockets of material into the basin. Material was steadily brought into the basin as the discharge reached 2,500 ft^3/s and reservoir El. 3191. Erosion below the endsill occurred primarily along the edges, moving material laterally to the center and then upstream over the endsill and along the basin floor, eventually depositing in the left and right bays. The material continued to be drawn into the basin until the jet plunged to the floor of the basin at about 3,500 ft^3/s. At this point the material that had collected in the basin began moving from bay to bay and up and down the curved chute below the deflector plates. Some of the material was separated and forced out of the basin as the current on the basin floor had reversed and was flowing downstream. Not all of the material was flushed out of the basin; however, the material that moved out was deposited downstream of the endsill near the center in a pattern very similar to the prototype. When the discharge was reduced, this same material would again enter the basin, as previously described.

6. This transfer of material from below the sluiceway endsill into and out of the basin has been documented with photographs. Photographs of each discharge condition tested are enclosed. We also plan to prepare a video tape of this action.

7. Flow patterns in the downstream channel were traced by placing dye, confetti, and fine sand in certain locations attempting to locate a possible source of the material. These tests showed that a large counterclockwise eddy developed in the area in front of the radial gate spillway, but anything placed immediately downstream of the sluiceway riprap moved directly down the river channel.

Conclusions

The model has verified the data obtained from the prototype regarding the location of the material in the basin and of deposits downstream of the endsill. We feel more prototype information is needed to help identify possible sediment sources both upstream and downstream of the sluiceway. A reservoir sounding has been requested. This will not be possible until the discharge from the structure is lowered or until the annual seepage tests are made in October. It does not appear that material will pass into the area below the sluiceway endsill from a downstream source unless

there is a large deposit located next to the wall between the right bay of the spillway and the sluiceway. It is hard to envision gravel or cobbles moving across the large riprap that has been placed below each structure. Information regarding the location of any loose gravel or cobbles downstream of the spillway might also be of value.

D. L. King

Enclosures

Blind to: D-221 (Arai)
D-1531 (file)

KLHouston:flh

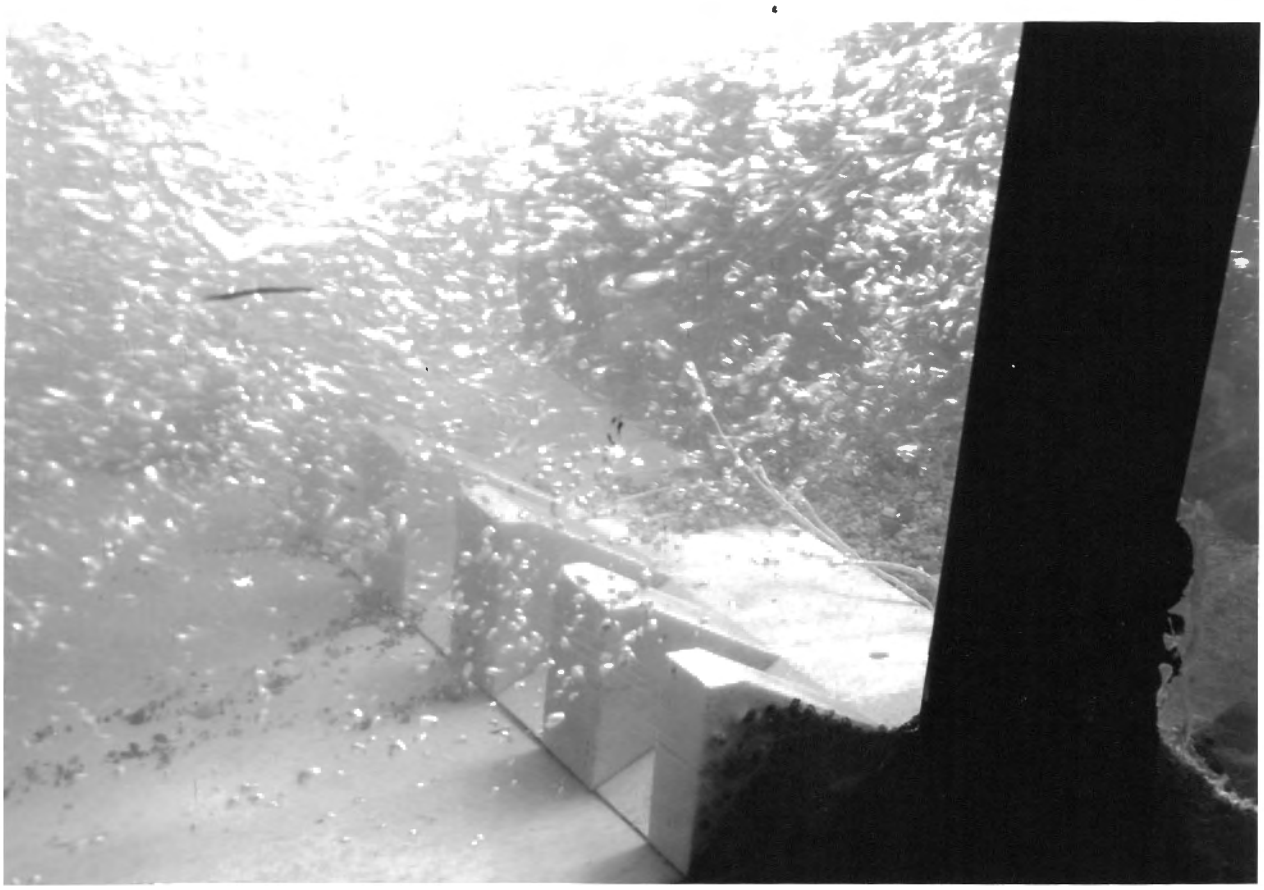

Figure 1. - Q = 2,500 ft^3/s, reservoir El. 3191
Flow along the bottom of basin is going upstream and bringing material into the basin.

Figure 2. - Material drawn into the basin from downstream of the endsill collected in the right and left bays.

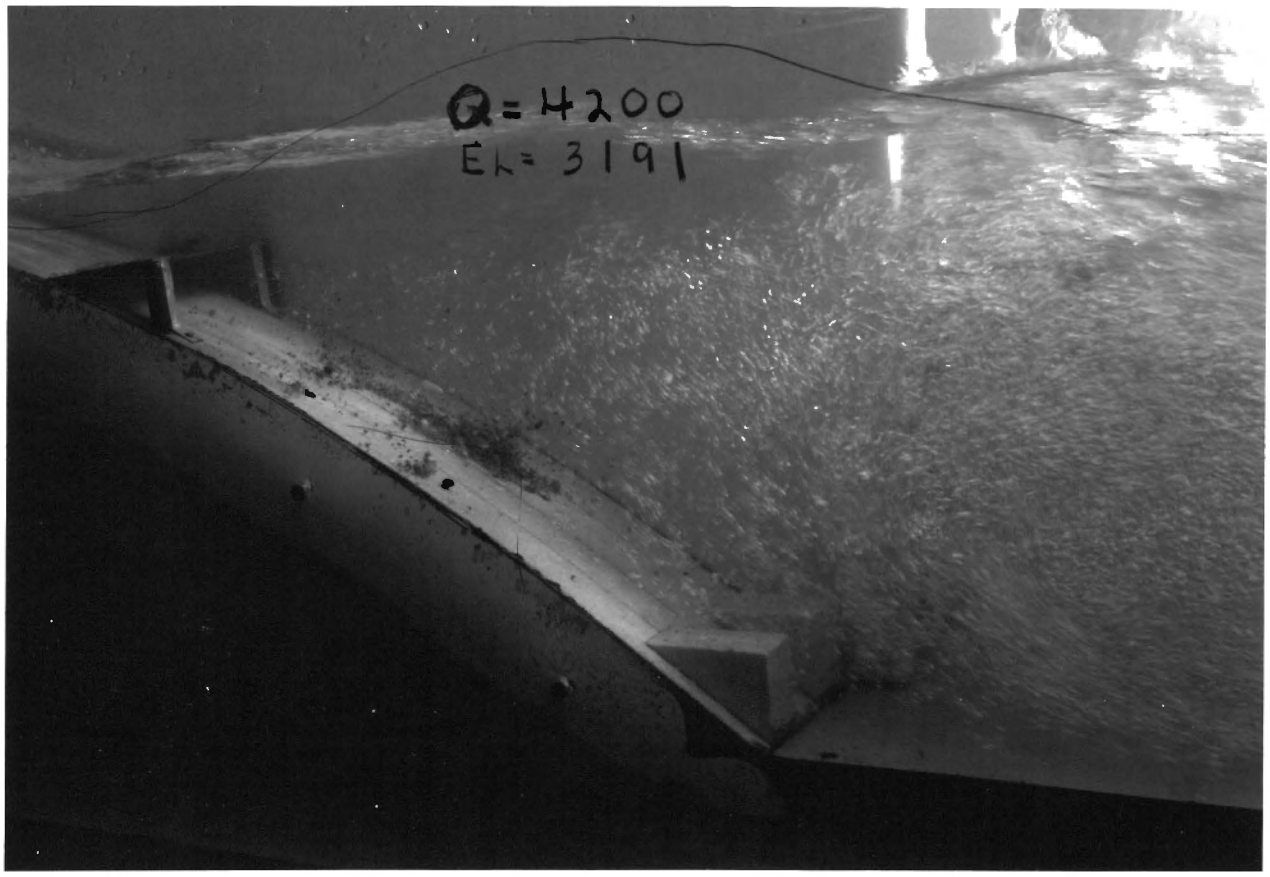

Figure 3. - Q = 4,200 ft^3/s, reservoir El. 3191

Material moves up and down the chute slope between the deflector plate and the blocks. The material also transfers from bay to bay.

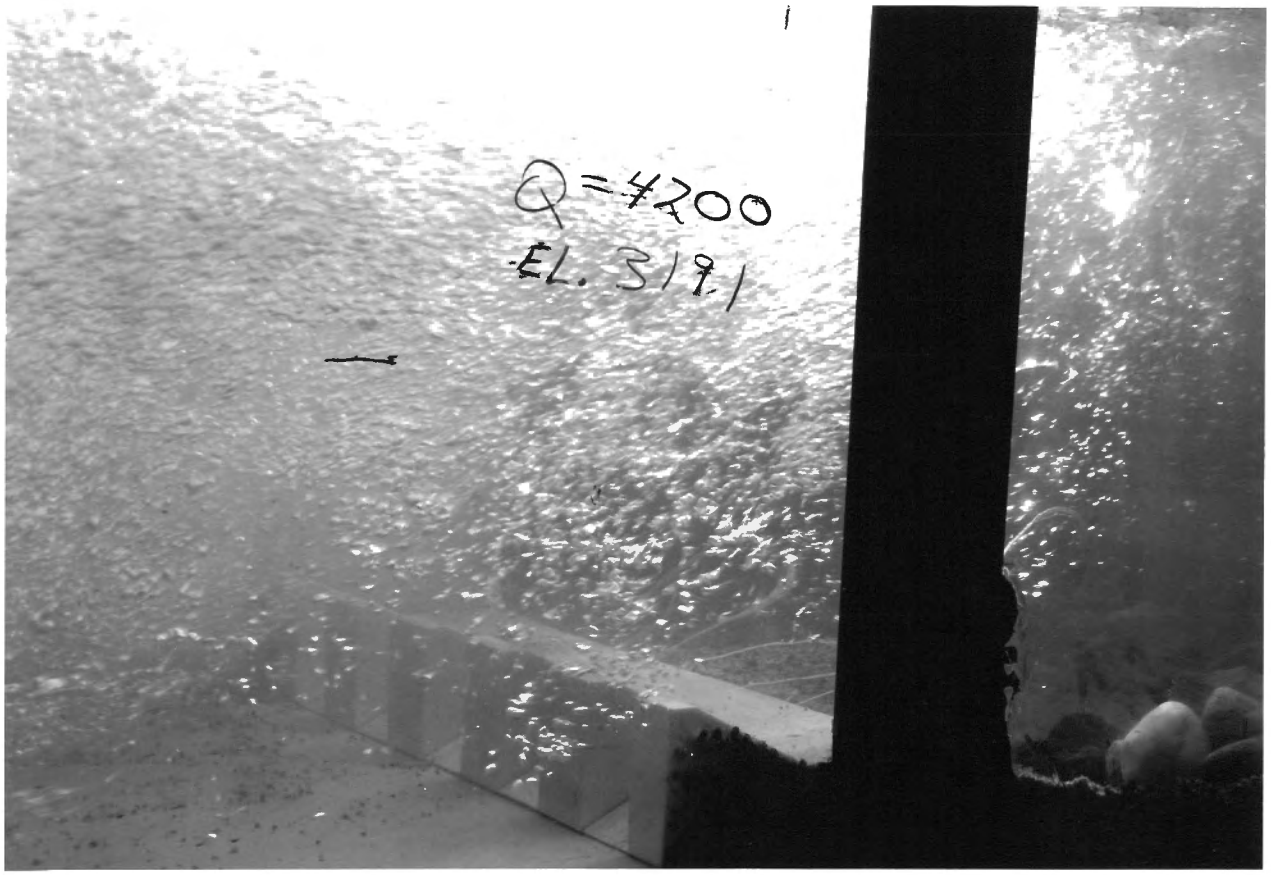

Figure 4. - Q = 4,200 ft^3/s, reservoir El. 3191

The flow along the bottom of the basin is now going downstream. Some of the material collected in the basin washes out and deposits below the endsill in the center.