UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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HYDRAULIC LABORATORY REPORT NO. 190

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HYDRAULIC MODEL STUDIES ON REPAIRS TO THE CALIFORNIA WASTEWAY
YUMA PROJECT
ARIZONA-CALIFORNIA

By

R. C. Besel

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Denver, Colorado

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Branch of Design and Construction
Engineering and Geological Control
and Research Division
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Laboratory Report No. 190
Hydraulic Laboratory
Compiled by: R. C. Besel
Reviewed by: J. N. Bradley
J. E. Warnock

Subject: Hydraulic model studies on repairs to the California Wasteway - Yuma Project, Arizona-California.

1. Purpose of Study. Difficulties experienced in the operation of the California Wasteway dictated that a change in design was necessary. During the last year of operation there has been considerable erosion on the left side of the channel downstream from the stilling pool. This erosion was mainly due to a lowered tailwater condition produced by the continued retrogression of the Colorado River since construction of Boulder Dam. The Hydraulic Laboratory was requested to study the problem by means of a model and furnish the basis for the redesign of the Wasteway.

2. History of the Prototype Structure. The California Wasteway and Check are located on the Yuma Main Canal immediately upstream from the entrance to the siphon under the Colorado River, at Yuma, Arizona. The Wasteway is used to release all surplus water carried by the canal and not required for irrigation of project lands located in Arizona. A short canal approximately one-half mile long connects the Wasteway with the Colorado River. The Yuma Project diverts approximately 2000 second-feet of water from the All-American Canal for power generation at the Siphon Drop Power Plant. After passing through the power plant, 1000 second-feet enters the Colorado River Siphon and another 1000 second-feet are wasted directly into the Colorado River through the California Wasteway.

The Wasteway was rebuilt in 1927 after a series of minor failures. The first reconstruction was according to plans formulated by the Colorado River Board of Engineers. The stilling pool of the structure, as redesigned, was unsymmetrical with respect to the center line of the gates with the result that a major portion of the flow was concentrated along the left side of the stilling pool, (figure 1).

Subsequent to the reconstruction in 1927, the wasteway functioned satisfactorily in spite of the alignment as there then existed ample tailwater in the river. Since the construction of Boulder Dam, considerable retrogression has taken place in the river resulting in a materially lowered water surface below the wasteway stilling pool.

At the present, the tailwater elevation is approaching the limit at which the stilling pool will function effectively. Due to the unsymmetry of the structure, the hydraulic jump is imperfectly formed at the left side of the stilling pool and considerable erosion of the rock protection downstream from the structure is occurring. Rock has been placed in the canal at the downstream end of the stilling pool to protect the wasteway structure as a temporary measure.

3. Description of the model. The model of the California Wasteway as constructed on a 1:30 scale is shown on figure 2. The model included the wasteway and check structures and a section of the canal upstream from the wasteway gates. The headbox and main canal were constructed of wood and lined with sheet metal. The wasteway was constructed of plywood with the joints sealed with white lead. The warps were a mixture of Plaster of Paris and cement. The downstream section of the canal leading from the wasteway to the river was lined with fine sand to study the scouring action. Although the grain size was not to scale, this was not important as only general scour patterns were of interest.

Test Procedure. The operation of the wasteway showed various objectionable features (figure 3). Flow through the wasteway gate structure was undesirable as the two downstream (with relation to the canal) gates were running full while the upstream gate flowed half full. Several types of vanes were tried at the entrance to correct this condition. Vanes proved undesirable as they interferred with the flow in the main canal. The capacity of the wasteway was not limited at the present flow, consequently, the use of vanes was discarded.

The unsymmetrical alignment of the stilling pool was the next problem needing correction. A hydraulic jump formed diagonally across the stilling pool causing considerable erosion at the left end of the pool. A solution to this problem would be to direct more of the flow to the right side of the stilling pool. Vanes were placed in the chute on the 3:1 slope to distribute the flow more uniformly across the apron. This idea was later discarded as the vanes were difficult to construct and at least twelve would be required to produce satisfactory results. After much consideration it was decided that a training wall, replacing the warped section of the canal on the right side, would be more economical than the vanes (figure 4). This training wall improved the stilling pool operation but the tailwater was still insufficient to produce a satisfactory jump. The tailwater elevation was raised, however, by placing a sill three feet high in the stilling pool. This produced a satisfactory hydraulic jump.

Another sill was then placed upstream from the 3:1 slope in an effort to evenly distribute the flow across the wasteway slope. Sills of different cross sections and in different locations in the channel were tried, but one uniform in height and placed as shown in figure 4 was the most satisfactory.

A 2:1 sloping apron was placed at the end of the stilling pool to reduce the erosion of the river bed. This apron had incorporated on it five rows of teeth to reduce the velocity of the water and to minimize erosion. A row of teeth was placed on the end of the stilling pool apron to break up the flow before releasing it down the slope. This apron reduced the erosion to a minimum, and because of its length it should protect the structure against further retrogression of the river in the future (figure 5). The training walls were extended downstream to the end of the apron to prevent erosion of the canal banks.

From figure 2 it can be observed that the present wasteway contains a deflector baffle on the left wall. Throughout the tests the model was operated with and without the use of the baffle. In no case did it improve the flow conditions decisively. It is, therefore, recommended that this baffle be removed from the final design.

5. Recommended design. The hydraulic laboratory recommends that a sill two feet high be placed above the 3:1 slope, that a vertical training wall be constructed in the stilling pool to provide more symmetrical flow, that a sill three feet high be placed in the stilling pool, and that the 2:1 sloping apron with teeth be placed downstream from the end of the stilling pool apron (figure 5A). Figure 5B shows the river bed in place for the recommended design.

The recommended design of the wasteway was tested with different quantities of water from 500 second-feet to 2000 second-feet. Figures 6 and 7 show flows of 1000 and 2000 second-feet for various tailwater elevations. At all times the operation was satisfactory. Figure 8A and B show the scour pattern after a flow of 2000 second-feet for a period of 1½ hours. This flow uncovered the tops of the second row of teeth on the 2:1 sloping apron.

The cost of the repairs have been held to a minimum and only the essential changes have been recommended to make the operation satisfactory.

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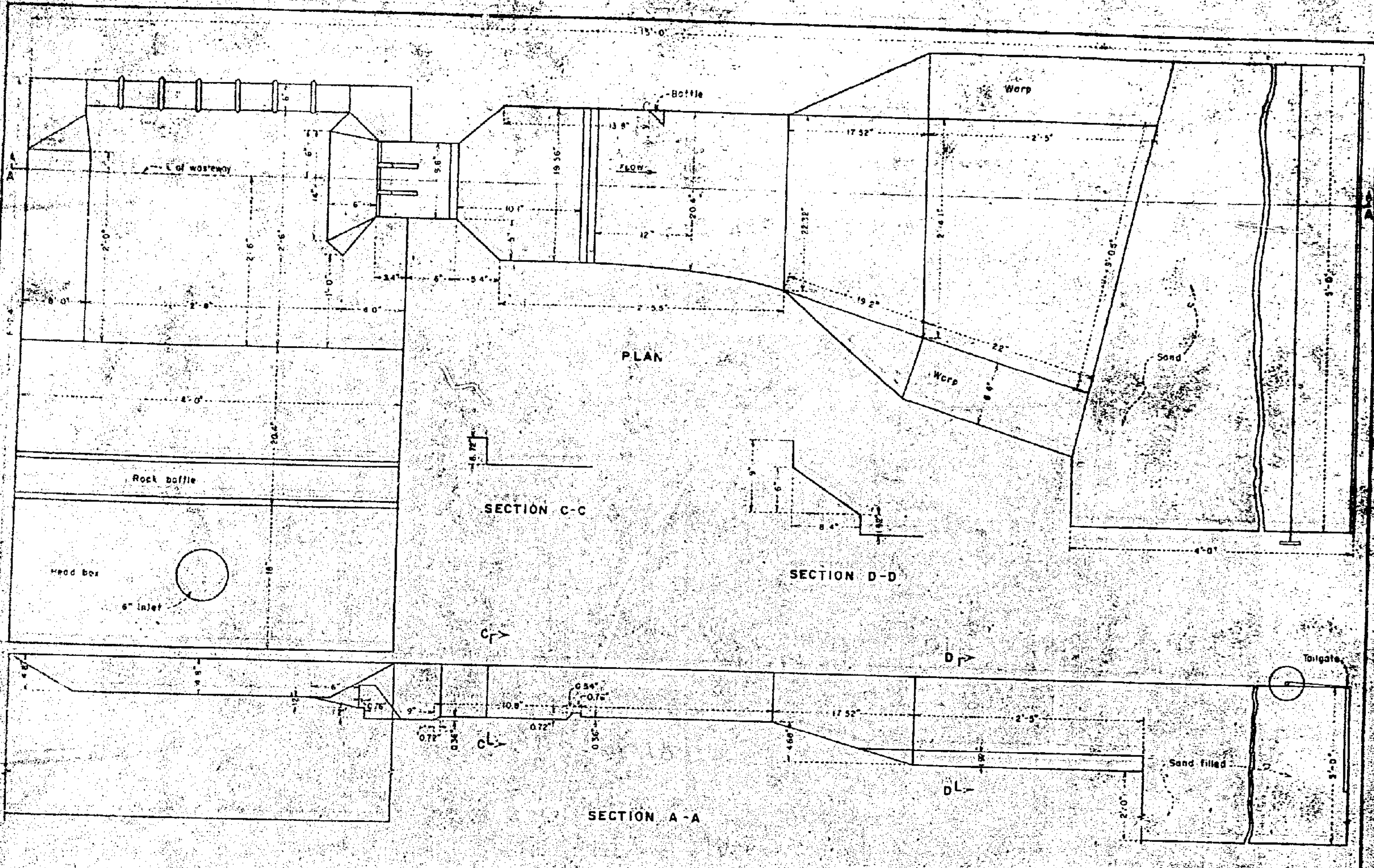
Looking downstream from gate structure. Discharge approximately 1000 second-feet.

PRESENT PROTOTYPE STRUCTURE

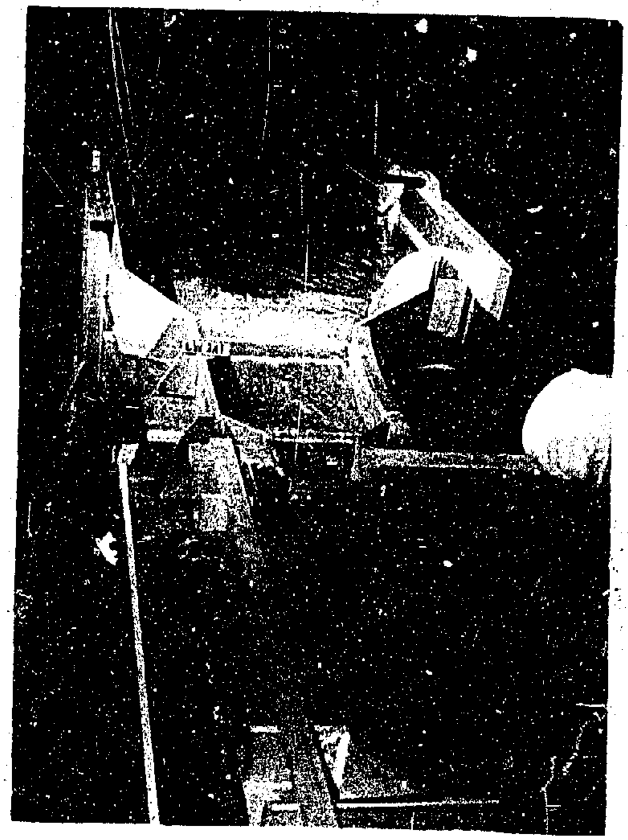


YUMA PROJECT–ARIZONA–CALIFORNIA
COLORADO RIVER FRONT AND LEVEE SYSTEM
CALIFORNIA WASTEWAY REPAIR
HYDRAULIC MODEL–ORIGINAL DESIGN
SCALE 1:30

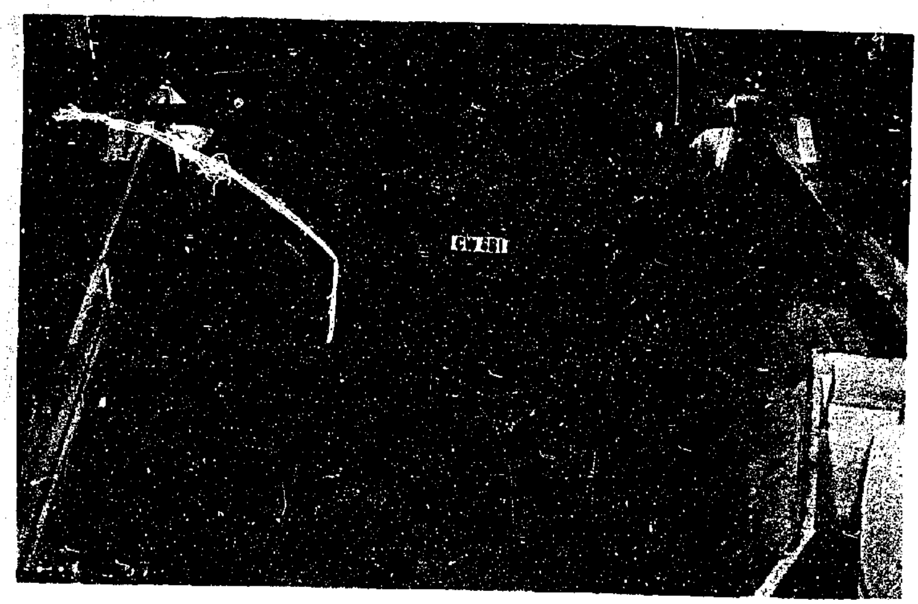
FIGURE 2

3

A. Model of present structure.

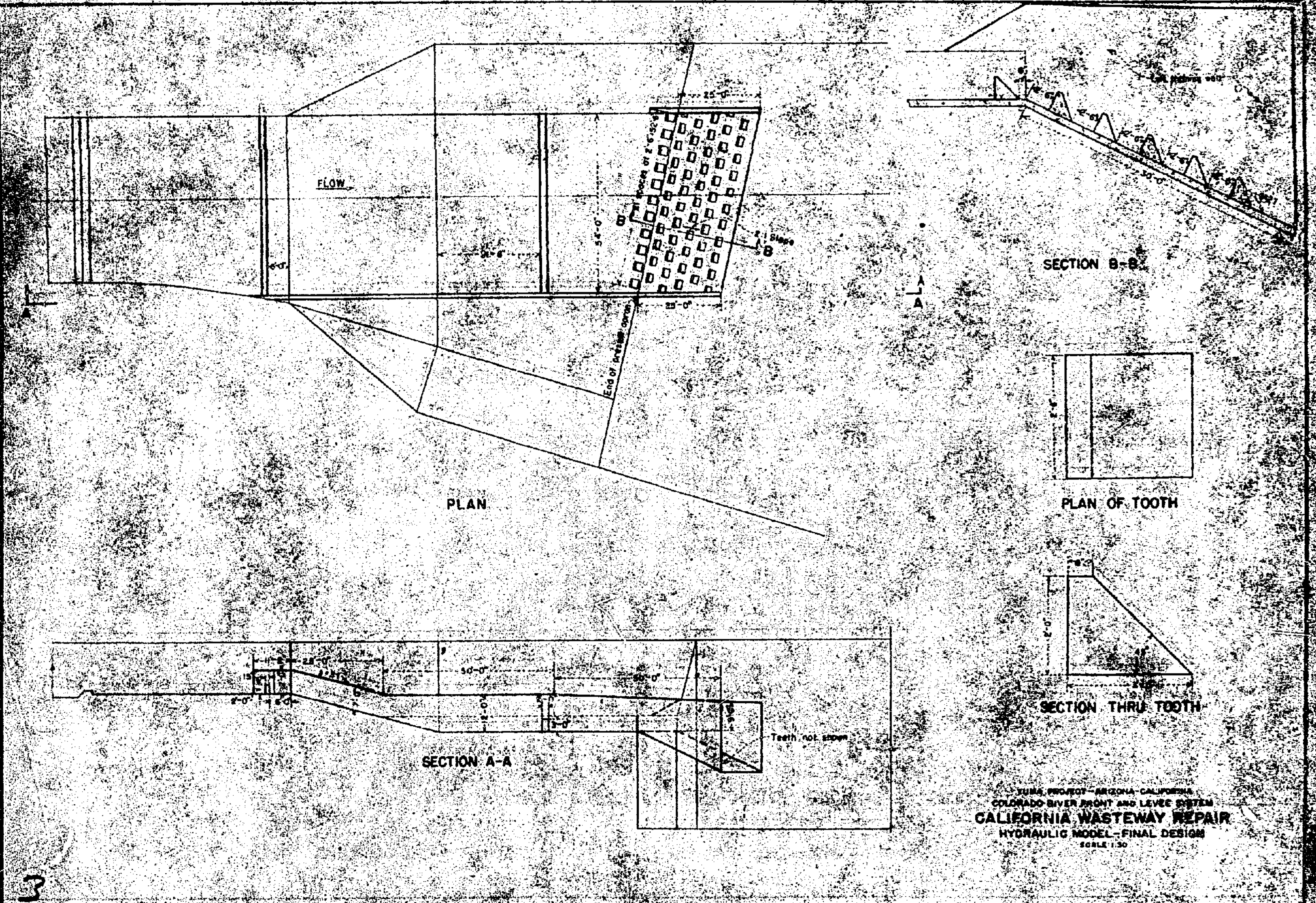


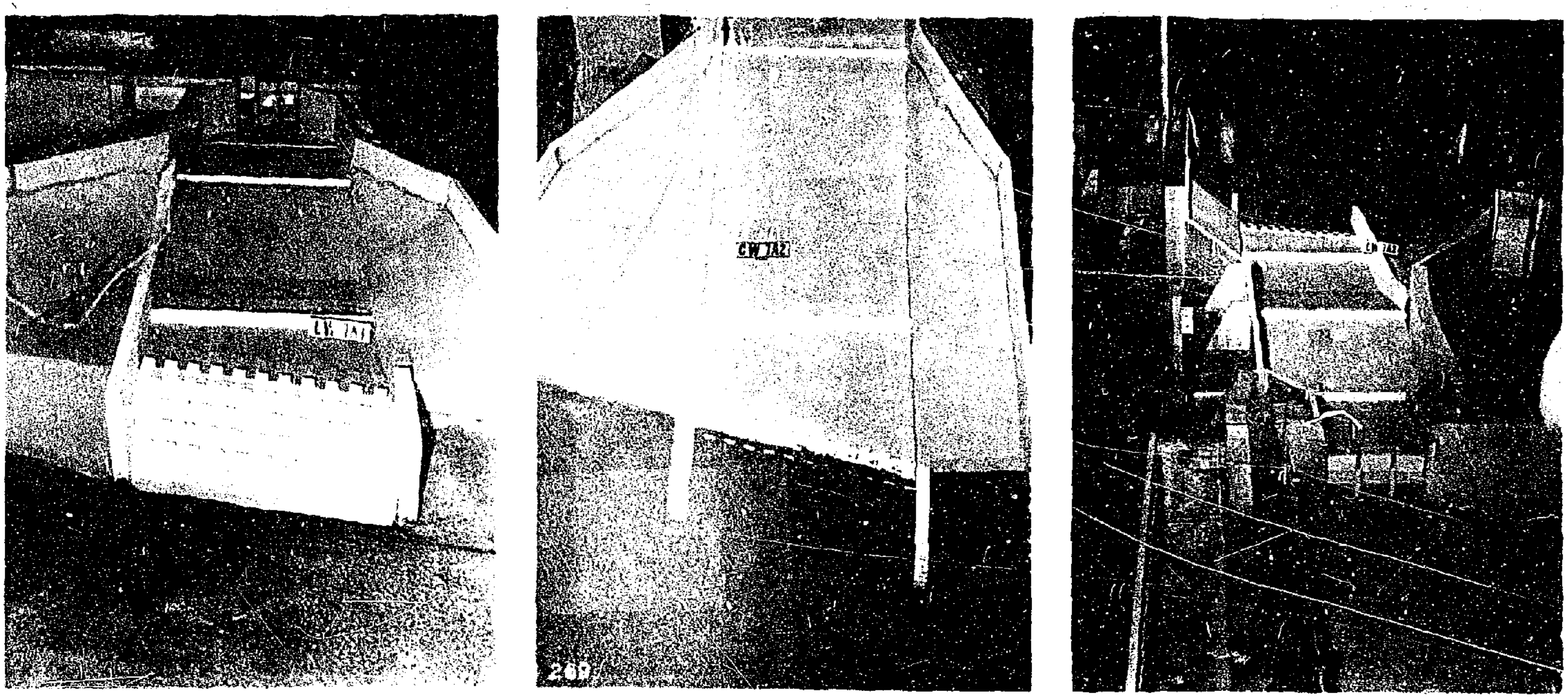
B. Flow of 1000 second-feet through Wasteway.



C. Erosion of left side after flow of 1000 second-feet.

SETUP AND FLOW CONDITIONS OF PRESENT WASTEWAY STRUCTURE


FLOW
End of pressure apron
2:1 Slope
PLAN
SECTION B-B
PLAN OF TOOTH
SECTION THRU TOOTH
Teeth not shown
SECTION A-A
YUMA PROJECT—ARIZONA-CALIFORNIA
COLORADO RIVER FRONT AND LEVEE SYSTEM
CALIFORNIA WASTEWAY REPAIR
HYDRAULIC MODEL—FINAL DESIGN
SCALE 1:30



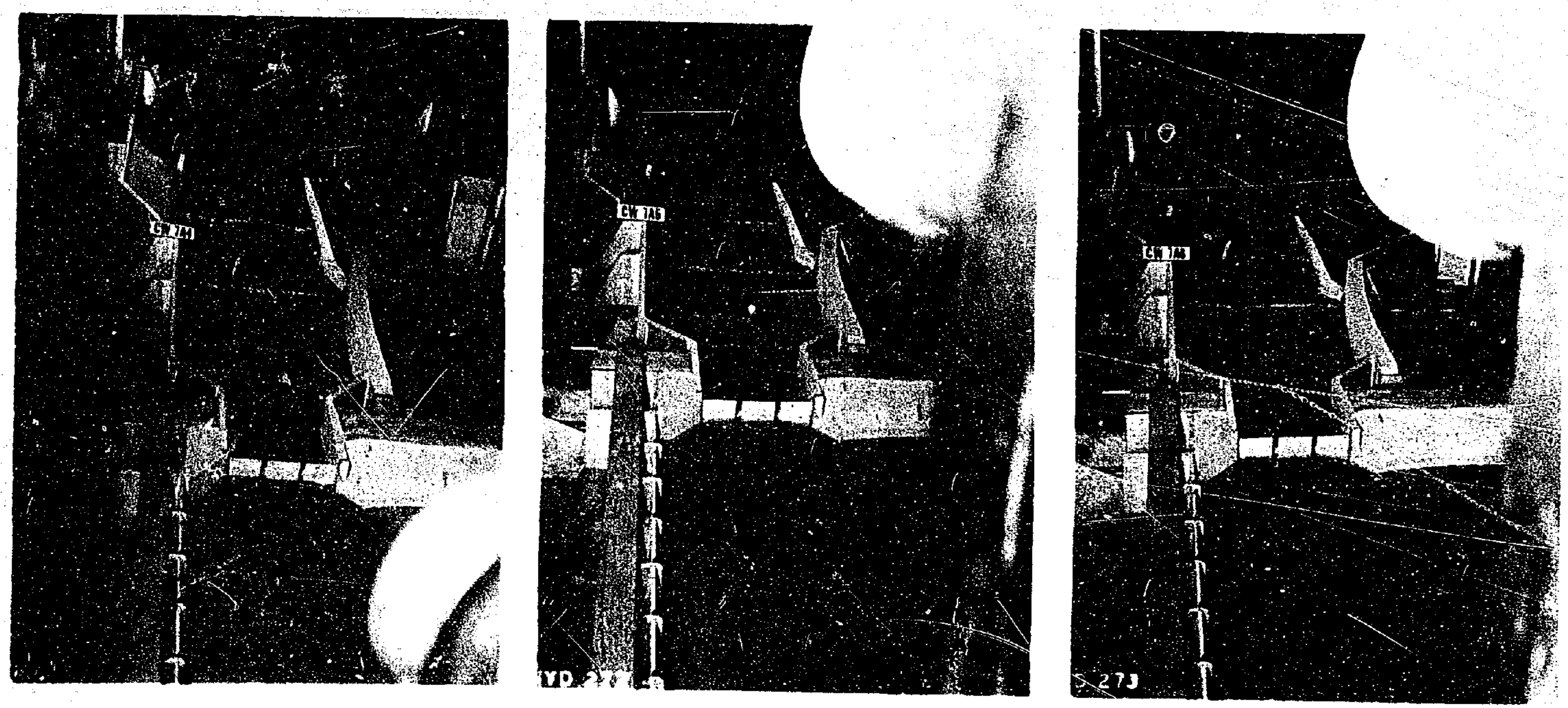
A. Looking upstream apron uncovered.

B. Looking upstream apron covered.

C. Looking downstream.

FIGURE 5

RECOMMENDED REPAIRS



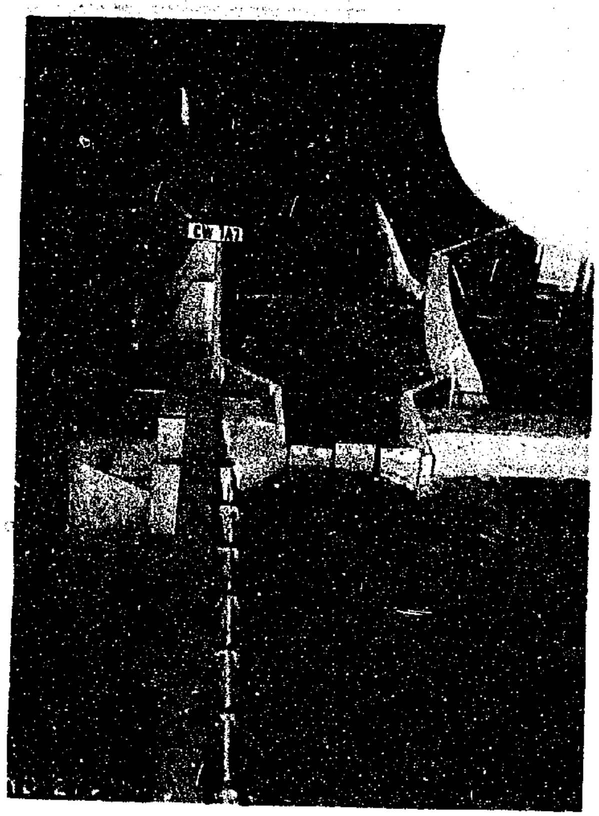
A. Flow of 1000 second-feet.
High tail water.

B. Flow of 1000 second-feet.
Low tail water.

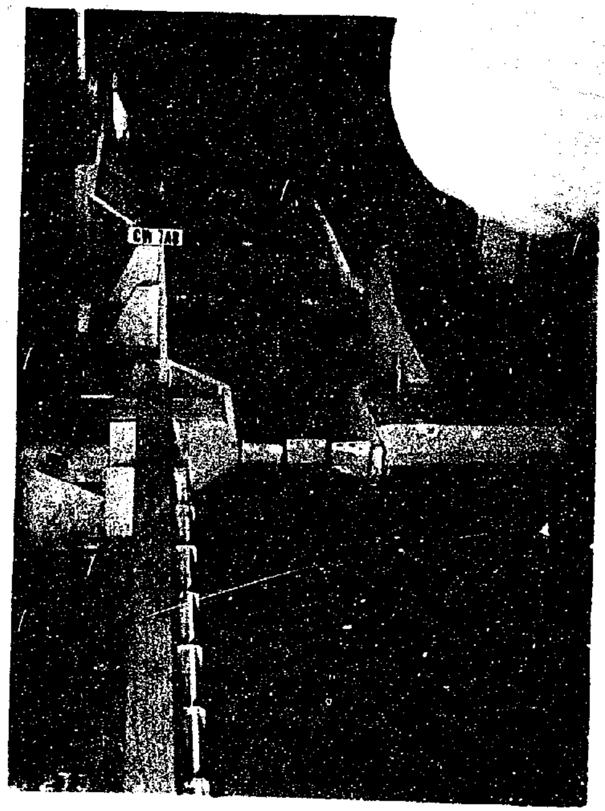
C. Flow of 1000 second-feet.
No tail water.

RECOMMENDED REPAIRS

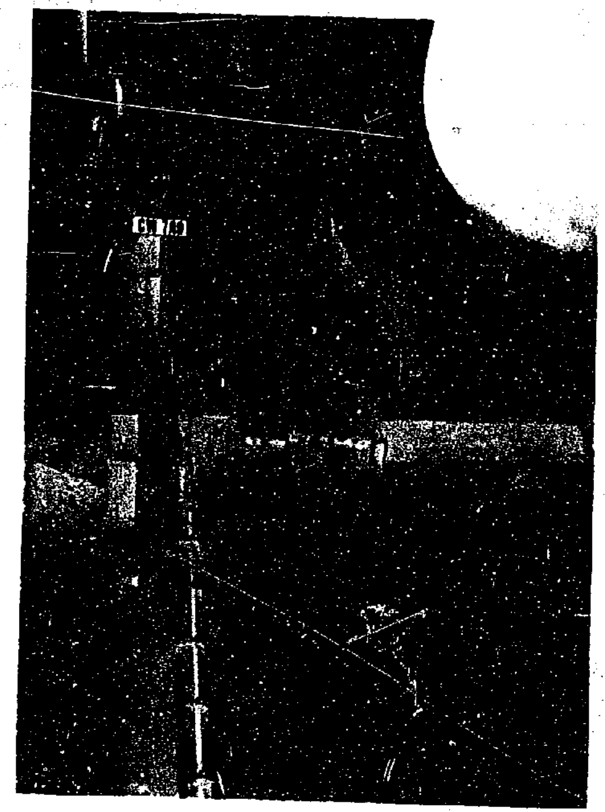
FIGURE 7



A. Flow of 2000 second-feet.
High tail water.

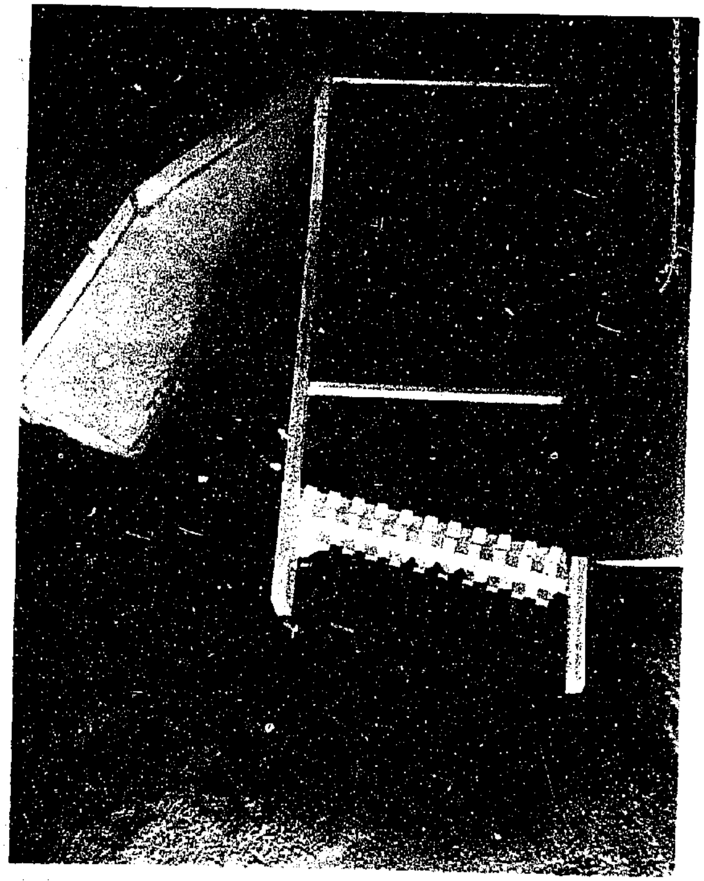


B. Flow of 2000 second-feet.
Low tail water.

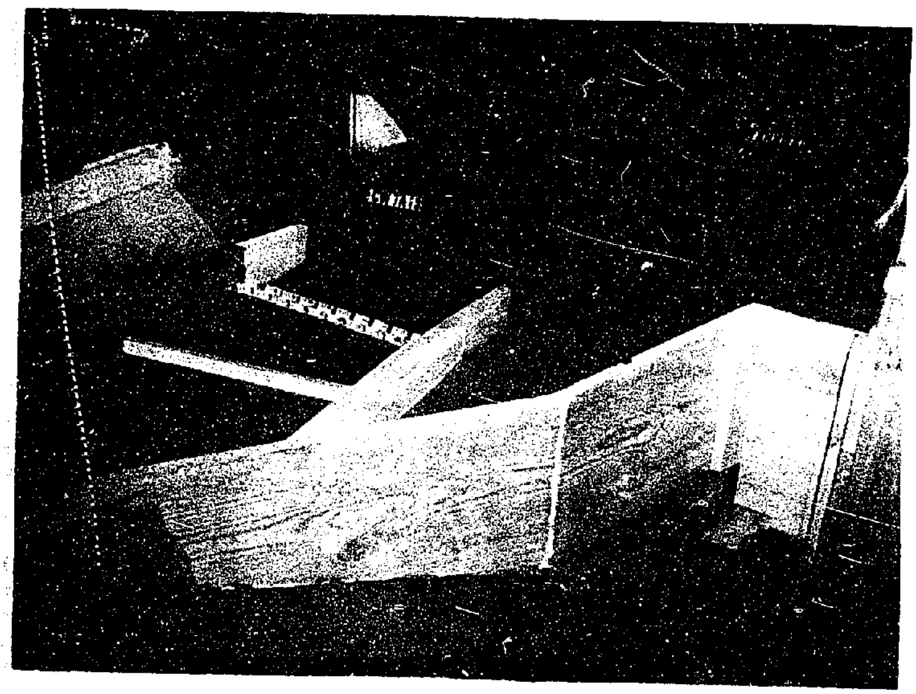


C. Flow of 2000 second-feet.
No tail water.

RECOMMENDED REPAIRS



A. Lookirg upstream. Erosion after 1½ hours 2000 second-feet flowing.



B. Looking downstream. Erosion after 1½ hours 2000 second-feet flowing.

RECOMMENDED REPAIRS