UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF TANTANGARA DAM OUTLET WORKS
MURRUMBIDGEE-EUCUMBENE DIVERSION PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY, AUSTRALIA

Laboratory Report No. Hyd-441

DIVISION OF ENGINEERING LABORATORIES

COMMISSIONER'S OFFICE
DENVER, COLORADO

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ACKNOWLEDGMENT

The author wishes to express his appreciation to Messrs. John R. Ewers and Peter T. Brown, Engineers with the Snowy Mountain Hydro-Electric Authority, Australia, for their able assistance during this hydraulic model study.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Commissioner's Office--Denver
Division of Engineering Laboratories
Hydraulic Laboratory Branch
Hydraulic Structures and
Equipment Section
Denver, Colorado
Date: September 23, 1958

Laboratory Report No. Hyd-441
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Subject: Hydraulic model studies of Tantangara Dam outlet works--Murrumbidgee-Eucumbene Diversion Project--Snowy Mountains Hydro-Electric Authority, Australia

PURPOSE OF THE STUDY

This model study was made for the purpose of developing an adequate control structure and stilling basin for the Murrumbidgee-Eucumbene Diversion tunnel.

CONCLUSIONS[1/]

1. The fixed wheel gate as shown in Figure 4 will operate satisfactorily for heads up to 160 feet. The streamlined upstream edge of the gate bottom will prevent fluctuating pressures and excessively low (cavitation) pressures on the bottom web of the gate. The baffle plates on the sides of the gate are necessary to restrict the undesirable downward flow between the outside wall of the slot and the gate.

2. The side walls in the passage or "throat," downstream from the control gate slot, should be streamlined to prevent cavitation pressures in this region. An elliptical shape, with a minor to major axis ratio of 1:5 as shown in Figure 7F, will keep the wall and floor pressures in a safe range for all gate openings and discharges.

3. The stilling basin floor should continue level with the bottom of the gate water passage for a distance of 61.58 feet from the downstream face of the control gate, then sweep upward on a 78-foot-radius vertical curve for 29.48 feet, then follow a reverse 78-foot-radius vertical curve for an additional 29.48 feet to come tangent to the invert of the downstream tunnel at Station 4+30.96, (Figure 12).

1/ Subsequent to these model studies the plans for Tantangara Dam were modified and the maximum head on the control gate was reduced from 160 feet to 105 feet. The stilling basin discussed in this report was developed for a maximum head of 160 feet. After the modified plans were received, computations were made for a reduced size stilling basin to accommodate the lower head of 105 feet. Appendix I contains the computations and recommendations for the modified structure.

4. Two baffle piers should be placed 49.58 feet downstream from the control gate to aid in the formation of the hydraulic jump which will dissipate the energy of the high velocity flow entering the basin. Flow, without objectionable surges and waves, will be maintained in the entrance to the 10-mile-long unlined tunnel by placing 10 transverse beams and a 20-foot-long wave suppressor across the basin as shown in Figure 12.

5. The roof of the basin should be 3 feet higher than the downstream tunnel roof to provide an air passage above the waves and surges that occur in the basin upstream from the wave suppressor.

6. When the reservoir is near maximum elevation and the gate is between 16 and 25 percent open, the jet sweeps the backwater into the basin and the control gate operates under free discharge. For other combinations of head and gate opening, the water in the stilling basin backs up against the gate and it operates under submerged conditions. Figures 14 and 15 are discharge charts for the gate showing discharge versus upstream head for various gate openings; however, these charts are valid only for conditions as they exist in the recommended design of the control structure.

INTRODUCTION

The Murrumbidgee-Eucumbene Diversion Project is located in the Australian Alps area of southeastern Australia. The Snowy Mountains Hydro-Electric Authority, which is responsible for the development of the project, has established its headquarters at Cooma near the site of construction approximately 220 miles southwest of Sydney. Tantangara Dam, about 40 miles northwest of Cooma, is a part of this project. The associated reservoir stores water from the Murrumbidgee River, and this water may be diverted as required through the outlet works and a 10-1/2-mile-long unlined tunnel to Lake Eucumbene.

Tantangara Reservoir feeds water into a 10-foot-diameter pressure tunnel at heads up to approximately 160 feet. The control structure, 300 feet downstream of the inlet, contains two 6- by 7-foot fixed wheel gates; the upstream one is used in emergencies and the downstream gate regulates the discharge of water from the pressure tunnel to an underground stilling basin. An unlined 10-foot 2-inch horseshoe tunnel extends 10-1/2 miles downstream from the stilling basin, and is designed to flow free under the maximum discharge of 600 cfs.

The model studies discussed in this report were performed to determine the most economical and hydraulically acceptable design for the control structure.

THE INVESTIGATION

The Model

The model of the outlet works control structure, built to a scale of 1:10, was sufficiently large to permit accurate calibration and determination of the hydraulic characteristics of the system. The model included the gate chamber and gates, the stilling basin, and a short section of the horseshoe tunnel downstream from the stilling basin (Figure 1). The conduit upstream from the gate chamber was not modeled.

The fixed wheel control gate model was built up of brass plates and included two non-rising operating stems (Figure 2). One side and the top and bottom of the gate chamber were welded 1/4-inch plate; the other side was made of 3/4-inch transparent plastic (Figure 3) to enable viewing of the gate leaf and flow patterns in the chamber during operation. One side and the arched roof of the stilling basin were of transparent plastic; the remainder of the basin was made of 3/4-inch plywood. The roof section was made as a unit so that it could be easily removed to allow access to the basin.

Water was furnished to the model through the laboratory venturi meters, with which accurate discharge measurements as low as 0.4 cfs (125 cfs prototype) could be made. The depth of water in the outlet tunnel was controlled by means of a tailgate at the downstream end of the model.

The pressures in this report are expressed in feet of water with atmospheric pressure as a datum.

Gate Structure Studies

Regulating gate. The model fixed wheel control gate had a diaphragm-type pressure cell mounted flush with the bottom of the lower web on the gate center line. This cell together with four piezometers, two in the gate bottom and two in the side of the gate, were used to determine vibration tendencies and pressure distributions pertaining to the gate. For conditions of maximum design head and discharge, the control of the jet beneath the gate shifted rapidly between the upstream and downstream lips of the gate (Figure 4 D-1). The average pressure beneath the gate, as determined by piezometer readings, was approximately 40 feet of water positive (prototype), but recordings made with the diaphragm-type cell disclosed the presence of rapidly fluctuating pressures which dropped down into the cavitation range.

The extended upstream gate lip was cut off flush with the bottom web of the gate (Figure 4 D-2), leaving a sharp, right angled corner on the upstream edge. With this design and with maximum head and discharge, the average piezometric pressure beneath the gate was about 95 feet and the magnitude of the pressure fluctuations was decreased to about 20 feet. However, the pressure fluctuations were sufficiently intense to cause considerable vibration of the gate leaf.

The upstream edge of the gate bottom was rounded as shown in Figure 4 D-3. With this configuration, the pressure fluctuations on the gate bottom were about 10 feet. The upstream edge was then streamlined as shown in Figure 4 D-4. With this design, the maximum pressure fluctuation was about 4 feet. This shape (Figure 4 D-4) is recommended for the bottom of the control gate.

During studies of the water passage downstream from the control gate, it was noted that a high-velocity jet flowed down the space between the side of the gate and the outside wall of the gate slot. When this flow was restricted, the pressures on the side walls downstream from the gate were somewhat improved. Consequently, a plate was attached to either side of the gate at the level of the lower web to partially block this flow and thereby improve the pressure conditions in the area of the elliptical throat. The recommended fixed-wheel control gate is shown in Figure 4.

Flow passage. Under conditions of maximum design head and discharge, cavitation pressures were found to exist downstream from the slots of the regulating gate (Figure 6). Attempts were made to relieve the low-pressure zones by means of air vents (Figure 7B). These vents were unsatisfactory due to the fluctuation in pressures and the adverse effect the additional air had on the operation of the basin.

A plate projecting into the stream was installed at the downstream face of the control gate slot (Figure 7C). With this flow passage the jet oscillated from side to side and increased the turbulence in the basin. An air vent was inserted in back of the restricting plate, but the conditions in the basin were not improved.

Several shapes of streamlined "throats" just downstream from the gate slots were tested. With the shape consisting of a simple curve (Figure 7D), the pressures on the side walls were in the cavitation range, but with elliptical shapes (Figure 7E and 7F) pressure conditions were improved; the amount of improvement depending on the minor-major axis ratio of the ellipse (Figure 6). It was found that an elliptical shape with a minor-to-major axis ratio of 1:5 kept the pressures up to a minimum of negative 3 feet for maximum head and discharge conditions. This shape (Figures 6 and 7F) is recommended for prototype construction. The discharge coefficient for the recommended gate is shown in Figure 5.

Stilling basin Studies

During the initial testing of the stilling basin, the arched roof was in position over the stilling basin. However, to provide more rapid access to the floor of the stilling basin for changing baffle piers and transition sections, the roof section was replaced by vertical walls above elevation 3964. The roof was reinstalled for the tests of the recommended design.

Preliminary operation. Tests on the preliminary design stilling basin (Figure 8A and 11A) indicated in general that the operation was unsatisfactory. Large surges and waves traveled the length of the basin, filling the basin to the top of the arched roof and breaking away to form a trough 12 or more feet deep (Figure 8B and C). This action was accompanied by surges of air alternately blowing out and sucking in at the downstream end of the horseshoe tunnel.

At maximum head and discharge the jet from beneath the gate followed one of two paths. In one instance the jet shot up to the surface of the stilling pool and skipped across the water surface causing extremely rough flow conditions (Figure 9A). In the other instance, the jet descended to the floor near the upstream end of the basin (Figure 9B) and flowed along the floor to the downstream end of the basin and, on rising to enter the tunnel, caused a severe boil and generally rough conditions in the basin (see Figure 8B and C). The direction of the jet could not be predicted but, once established, both types appeared to be stable and are examples of a flow phenomena reported by Bakhmeteff 1/.

Basin floor elevation. With the preliminary design the probable path of the jet downstream from the control gate could not be predicted. This uncertainty was eliminated by raising the basin floor to the level of the floor of the gate (Figure 11B). With this configuration, the jet remained on the basin floor throughout the full range of discharge and head.

Baffle piers. In order to stabilize the formation of the hydraulic jump, various sizes, numbers, and placement of baffle piers were tested to determine the best combination for optimum stilling basin performance. The recommended installation consists of two streamlined piers, 3 feet high, placed 49.58 feet downstream from the control gate as shown in Figure 12. Pressures on the sides and top of the baffle piers were measured to assure that adverse pressure conditions did not exist. The results of these pressure studies are shown in Figure 10.

Three chute blocks placed 10 feet downstream from the control gate (Figure 11B) tended to decrease the turbulence and the roughness* of the water surface in the hydraulic jump. However, since the velocity of the jet in this area is about 100 fps, the danger of cavitation exists and the use of the chute blocks is not recommended.

1/ "The Flow Through Slits" by B. A. Bakhmeteff and N. V. Feodoroff Proc. Fourth Midwestern Conference on Fluid Mechanics, 1955.

*When the basin is operating under maximum discharge and head, the Froude number is 14.6. This is in a range where the hydraulic jump is normally quite rough.

Basin-tunnel transition. The surging hydraulic jump caused large surface waves which carried downstream into the horseshoe tunnel. Added to these waves were surface undulations resulting when the water downstream from the baffle piers surged upward to enter the tunnel. It appeared that a gradual transition from basin to tunnel would tend to decrease these latter disturbances.

Some flow improvement was obtained by sloping the basin floor downstream from the baffle piers upward to the level of the horseshoe tunnel (Figure 11C). However, in each of the arrangements tested, surface disturbances occurred above each abrupt change of slope. The surface disturbances were reduced by using a floor transition consisting of two long-radius vertical curves. The best flow conditions resulted with a transition about 59 feet long starting 12 feet downstream from the baffle piers as shown in Figure 11D. This transition permitted a gradual increase in velocity from the 22-foot-deep flow in the basin to the 8.5-foot-deep flow in the horseshoe tunnel. However, large surface waves originating in the hydraulic jump continued to surge into the horseshoe tunnel portal.

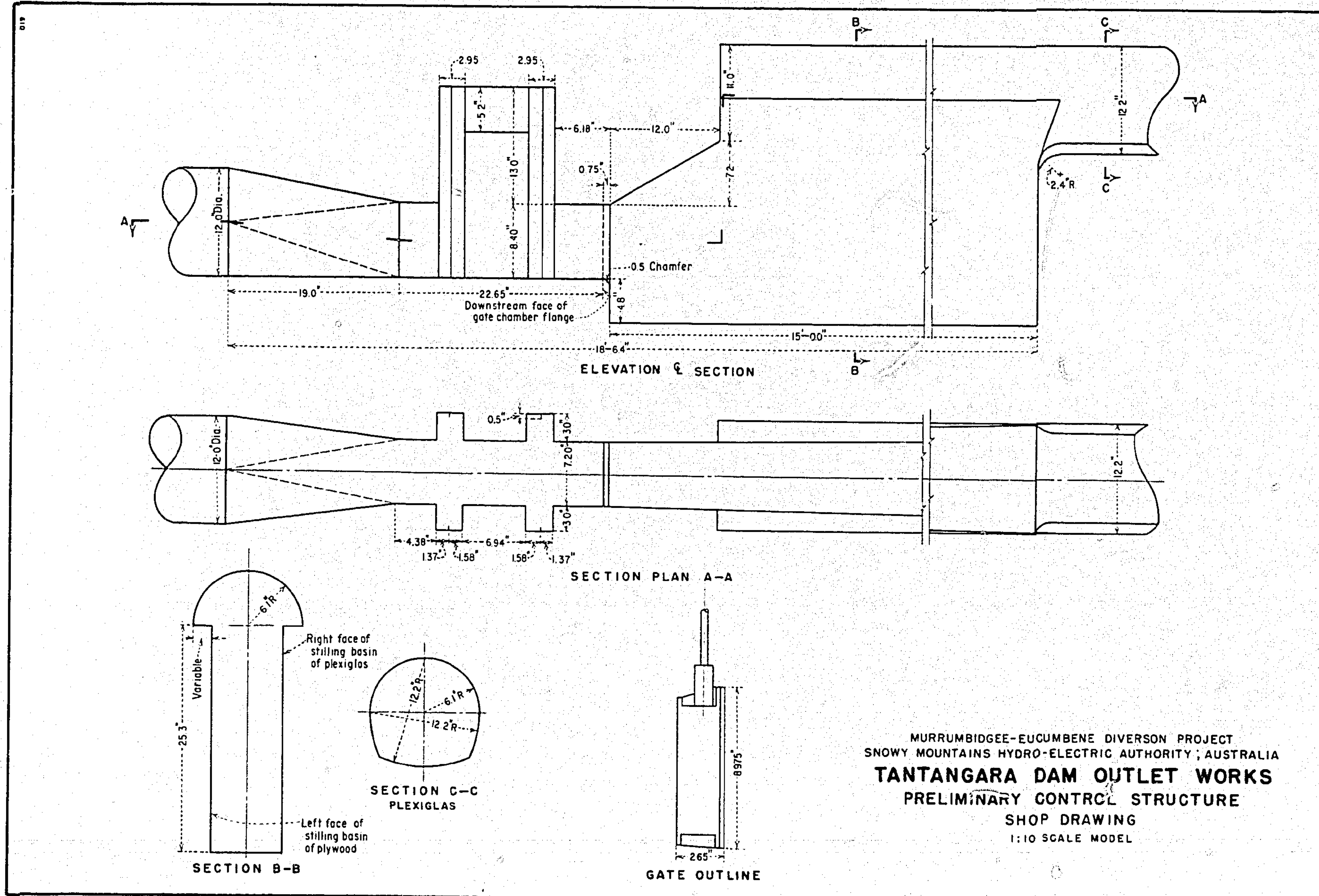
Wave suppressor. Tests of various forms of wave suppressors were undertaken to find a means of reducing the large surface waves. Flat-plate-type wave suppressors were placed at various locations across the full width of the basin. No beneficial results were obtained with the suppressors placed upstream from the baffle piers. When the suppressor was placed in the path of the rising jet downstream from the baffle piers (Figure 11E), the surface undulations were reduced but objectionable surface boils occured above each end of the suppressor. A series of transverse beams were placed across the channel in the area of the highest part of the jump. The beams improved surface conditions considerably and it was found that a 20-foot-long wave suppressor, in combination with the beams, produced satisfactory water surface conditions in the entrance to the horseshoe tunnel. The recommended arrangement of beams and wave suppressor is shown in Figure 12.

The roof of the stilling basin was raised 3 feet above the level of the roof of the horseshoe tunnel to permit the passage of air between the large waves upstream from the wave suppressor and the roof of the basin.

Recommended Design

The recommended control structure is shown in Figure 12 and 13C. The structure will operate satisfactorily for any combination of head and discharge up to the maximum design head of 160 feet and a discharge of 600 cfs. The flow conditions existing when this system operates under maximum head and discharge are conducive to an exceedingly rough hydraulic jump (Figure 13A). However, the transverse beams and the wave suppressor will assure a tranquil water surface at the entrance to the downstream tunnel (Figure 13B).

When the Tantangara reservoir water surface is near maximum, and the control gate is opened between 16 and 25 percent, the jet sweeps the water away from the downstream face of the gate and it operates under free discharge conditions. For other combinations of gate opening and head, water rushes upstream from the crest of the jump and submerges the gate. The discharge charts for the gate in the recommended design are shown in Figures 14 and 15.



MURRUMBIDGEE-EUCUMBENE DIVERSON PROJECT

SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY ; AUSTRALIA

TANTANGARA DAM OUTLET WORKS

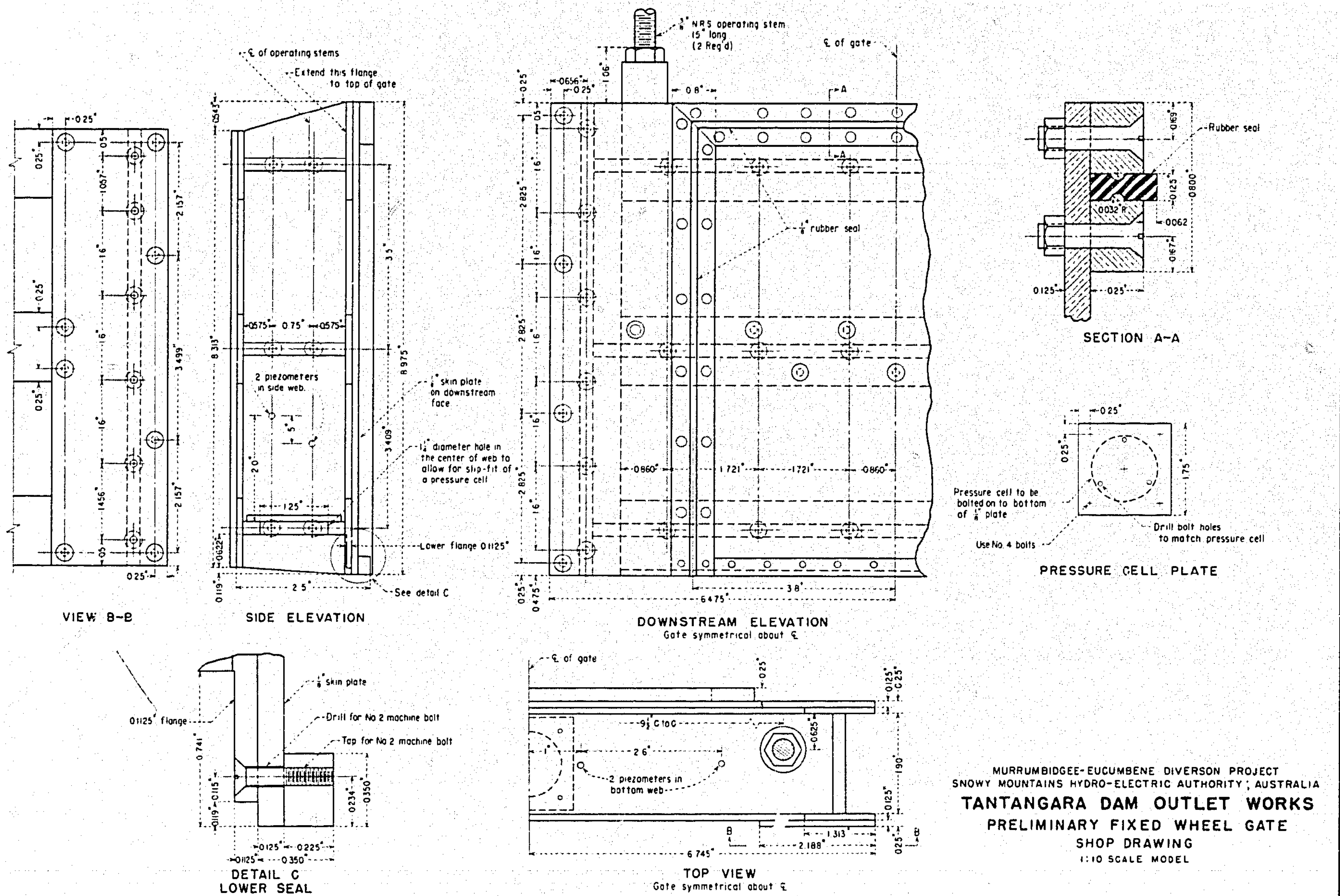
PRELIMINARY CONTROL STRUCTURE

SHOP DRAWING

1:10 SCALE MODEL

FIGURE 1

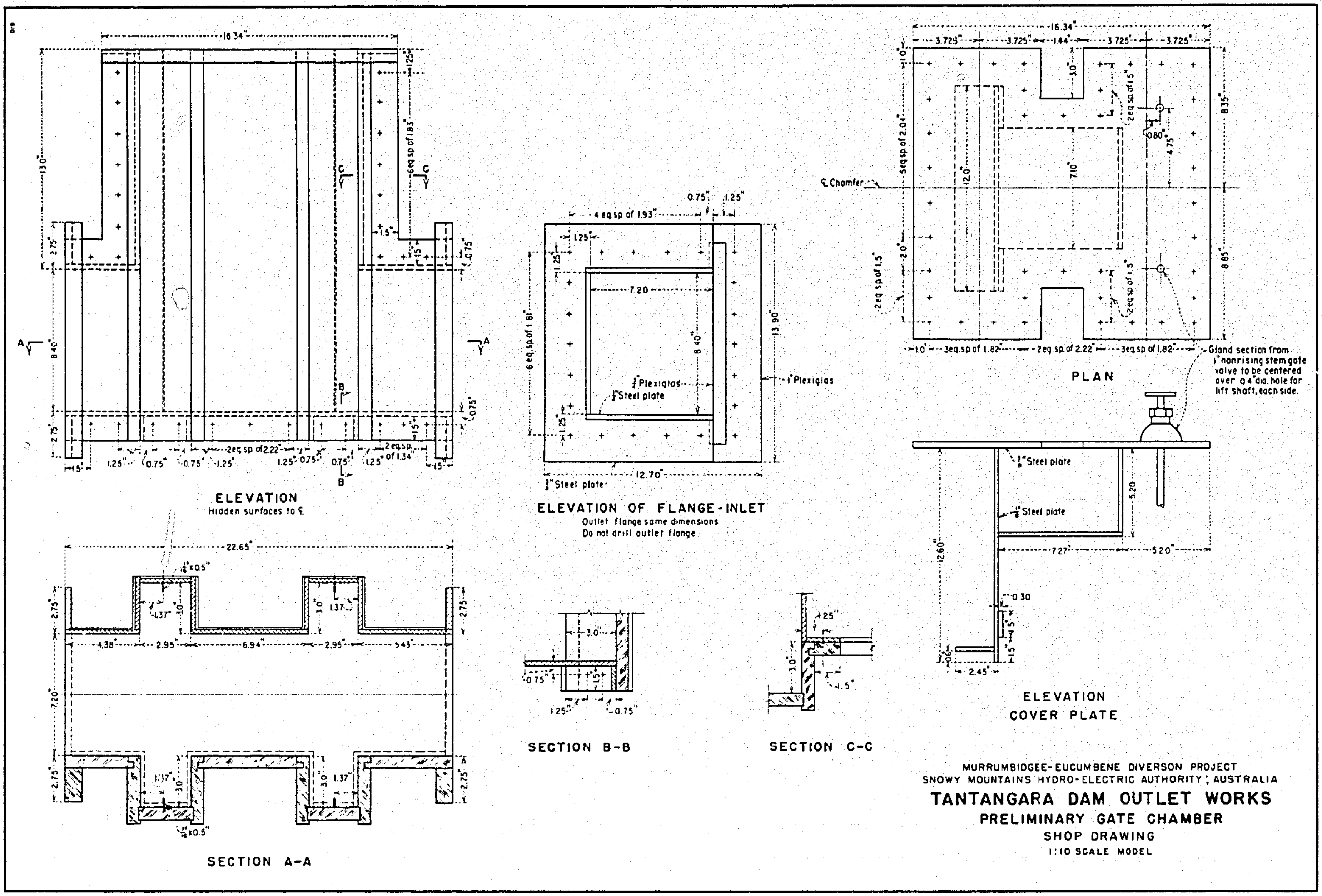
REPORT HYD. 441



MURRUMBIDGEE-EUCUMBENE DIVERSON PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY ; AUSTRALIA

TANTANGARA DAM OUTLET WORKS
PRELIMINARY FIXED WHEEL GATE
SHOP DRAWING
1:10 SCALE MODEL

FIGURE 2
REPORT HYD. 441



MURRUMBIDGEE-EUCUMBENE DIVERSON PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY, AUSTRALIA

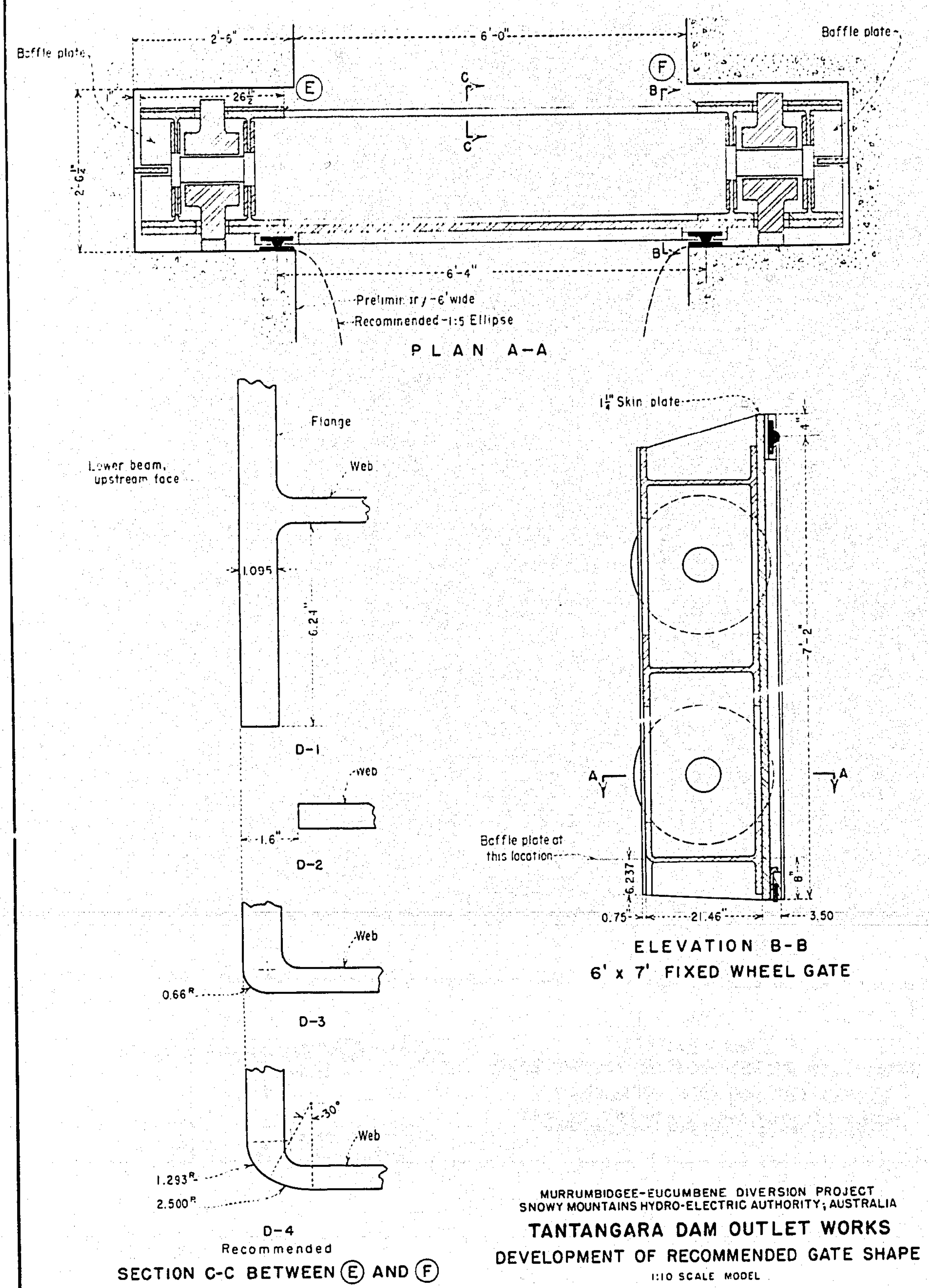
TANTANGARA DAM OUTLET WORKS

PRELIMINARY GATE CHAMBER

SHOP DRAWING

1:10 SCALE MODEL

FIGURE 3
REPORT HYD. 441

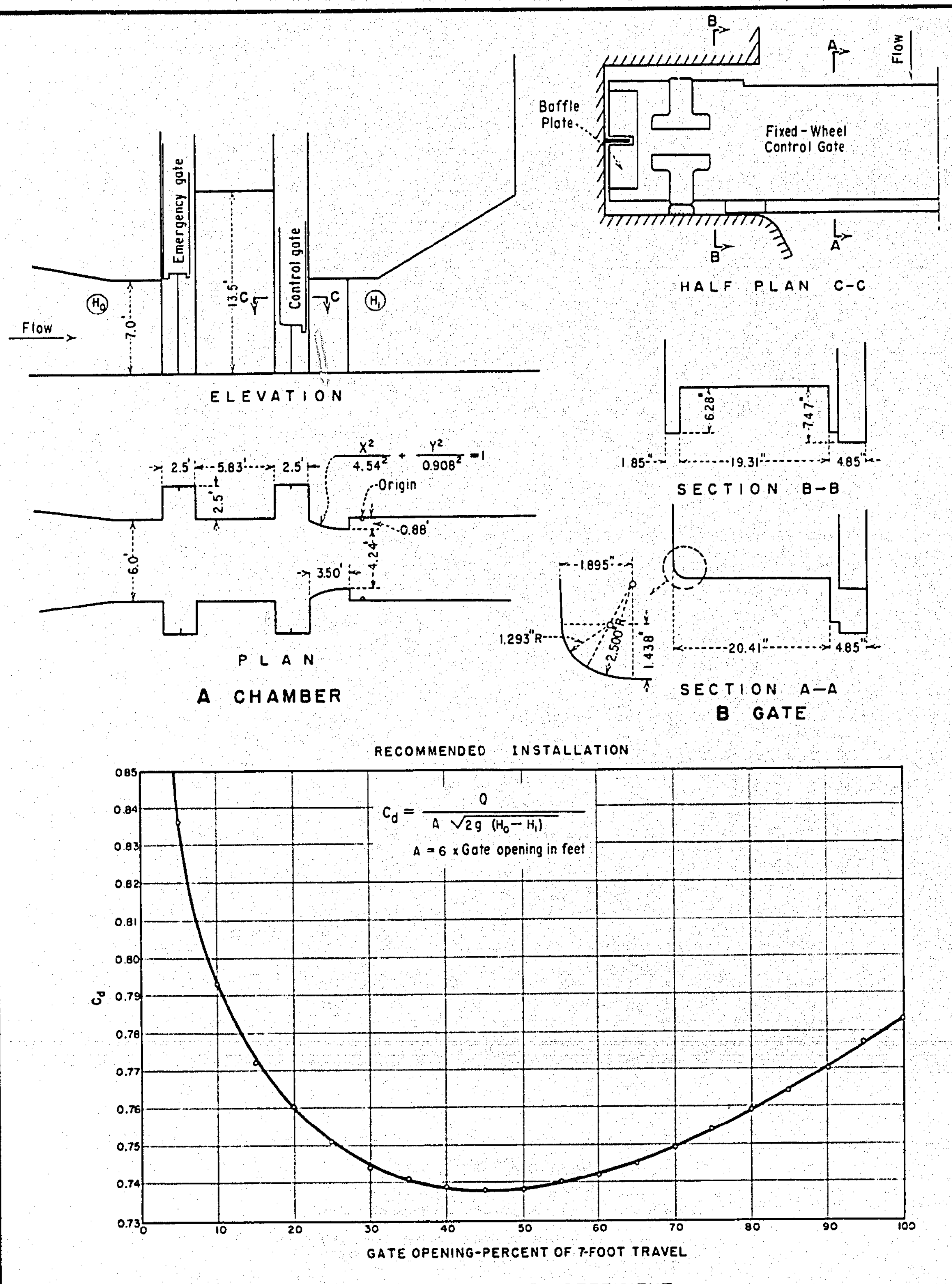


MURRUMBIDGEE-EUCUMBENE DIVERSION PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY; AUSTRALIA

TANTANGARA DAM OUTLET WORKS

DEVELOPMENT OF RECOMMENDED GATE SHAPE

1:10 SCALE MODEL



$$\frac{X^2}{4.54^2} + \frac{Y^2}{0.908^2} = 1$$

$$C_d = \frac{Q}{A\sqrt{2g\,(H_o - H_1)}}$$

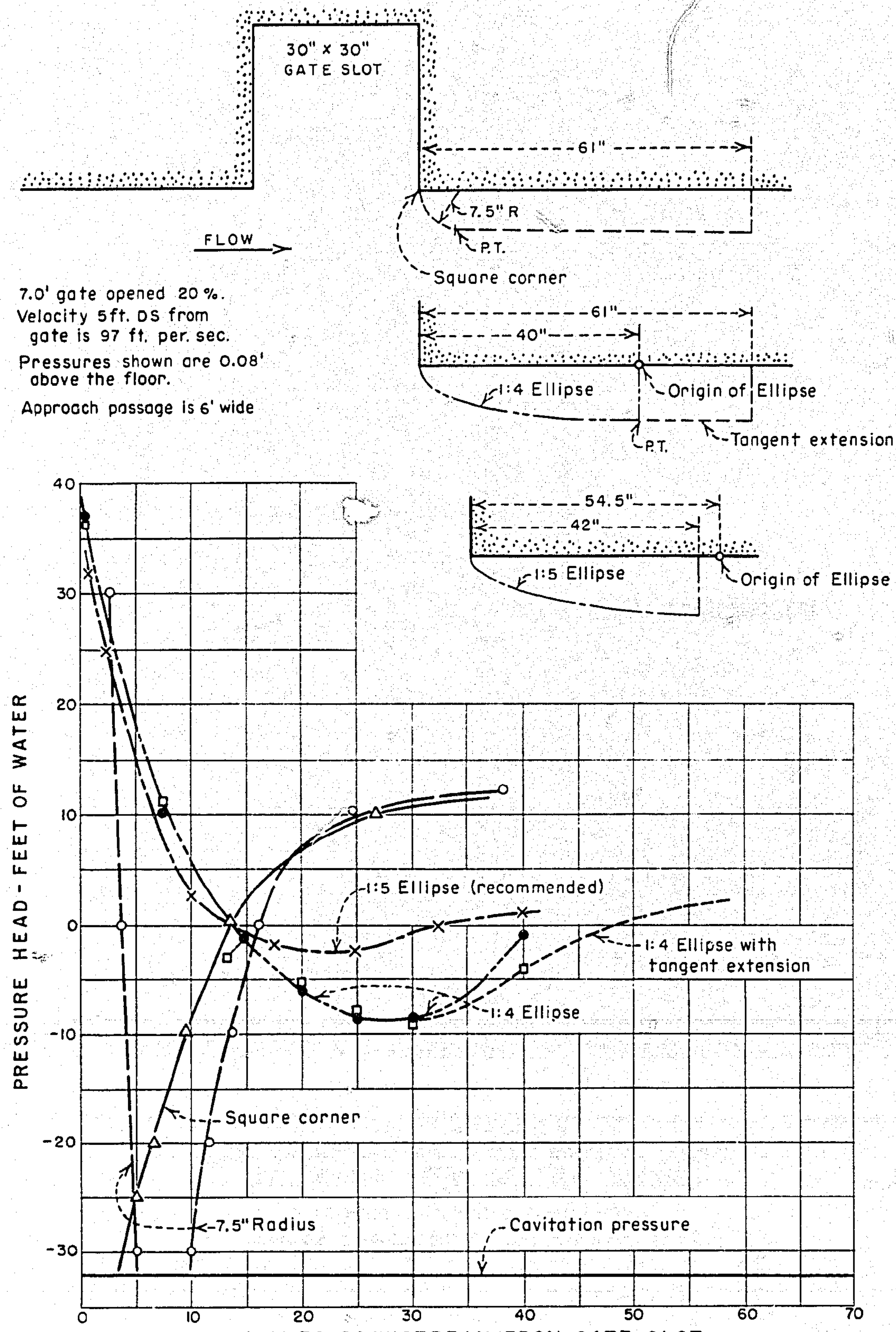
C DISCHARGE COEFFICIENT

MURRUMBIDGEE-EUCUMBENE DIVERSION PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY; AUSTRALIA

TANTANGARA DAM OUTLET WORKS

DISCHARGE COEFFICIENT
RECOMMENDED DESIGN

610



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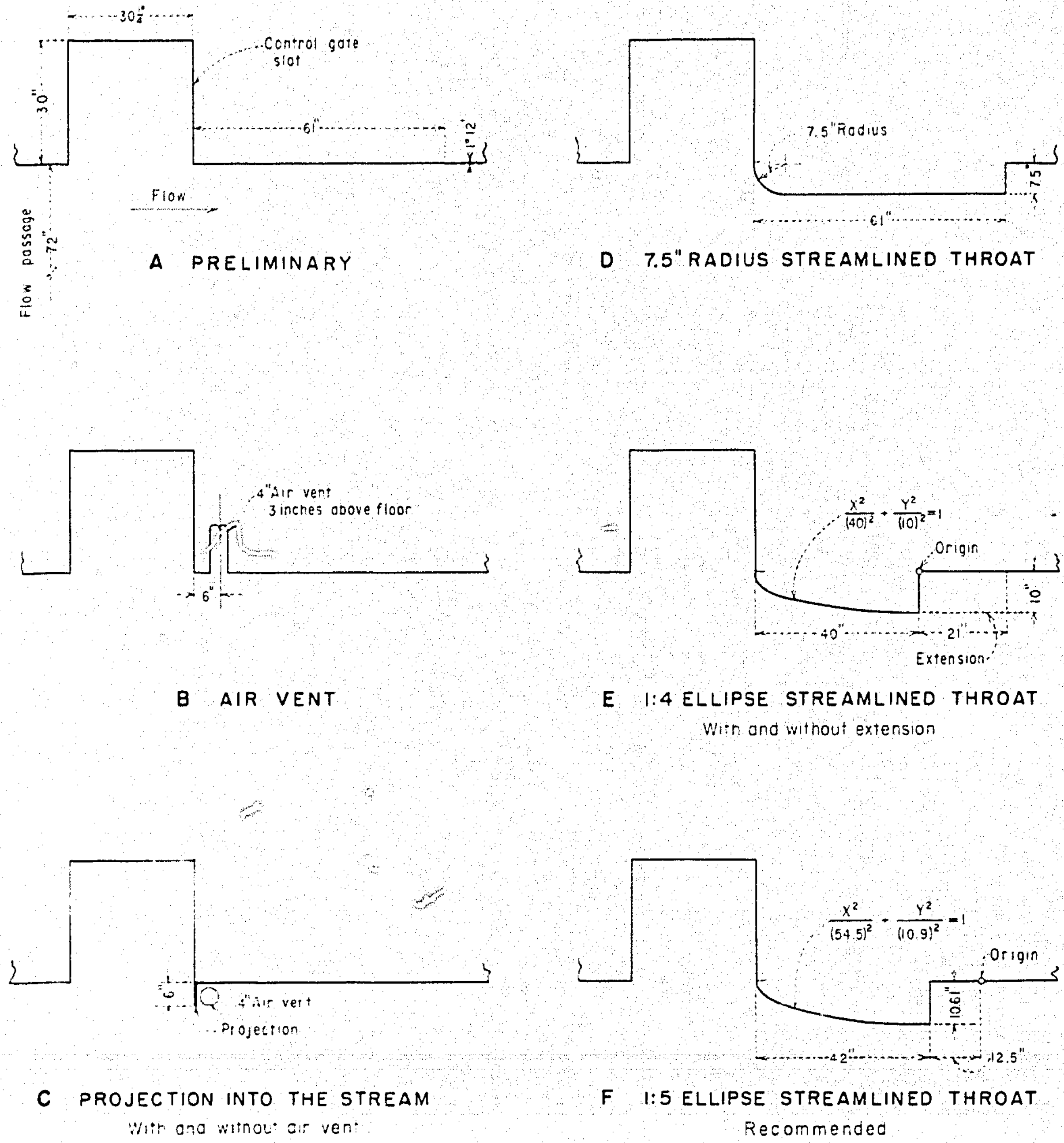
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY; AUSTRALIA

TANTANGARA DAM OUTLET WORKS
PRESSURE DISTRIBUTION IN GATE CHAMBER THROAT
VARIOUS DESIGNS

1:10 SCALE MODEL



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SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY; AUSTRALIA

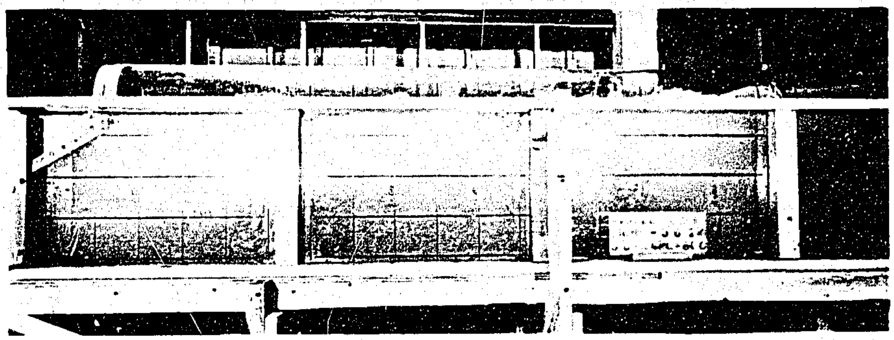
TANTANGARA DAM OUTLET WORKS

DEVELOPMENT OF RECOMMENDED GATE-CHAMBER FLOW PASSAGE

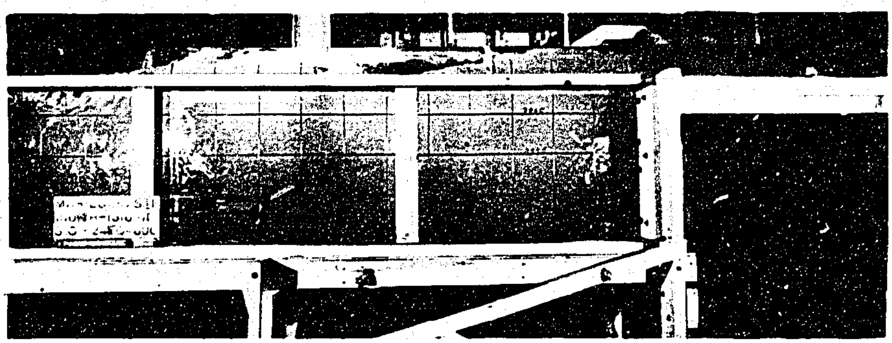
1:10 SCALE MODEL

Figure 8
Hyd. 441

A. Preliminary Model.

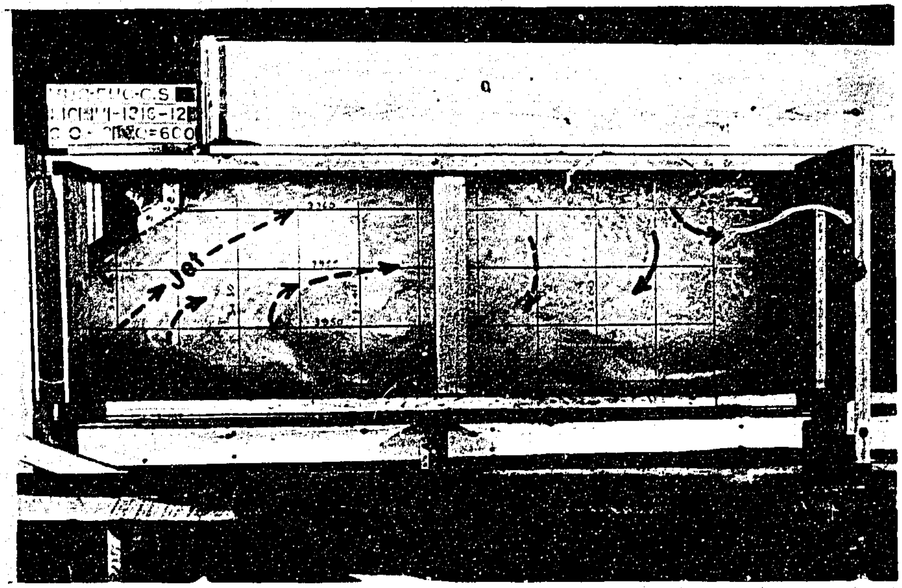


B. From Sta. 3+25 to Sta. 4+20
G.O. = 24%; Q = 600 cfs.

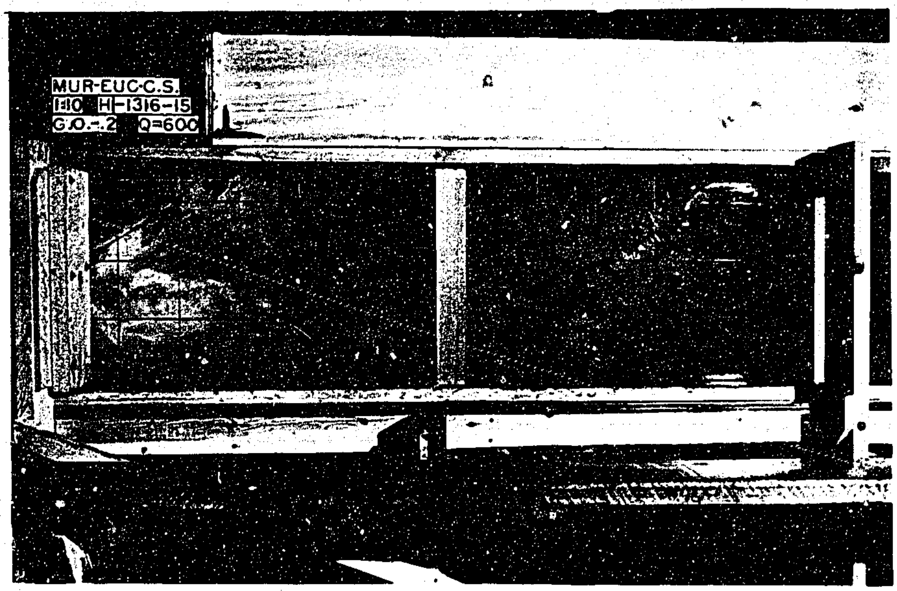


C. From Sta. 3+90 to Sta. 4+90
G.O. = 24%; Q = 600 cfs.

MURRUMBIDGEE-EUCUMBENE DIVERSION PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY; AUSTRALIA
TANTANGARA DAM OUTLET WORKS
Preliminary design; note rough water surface
1:10 scale model

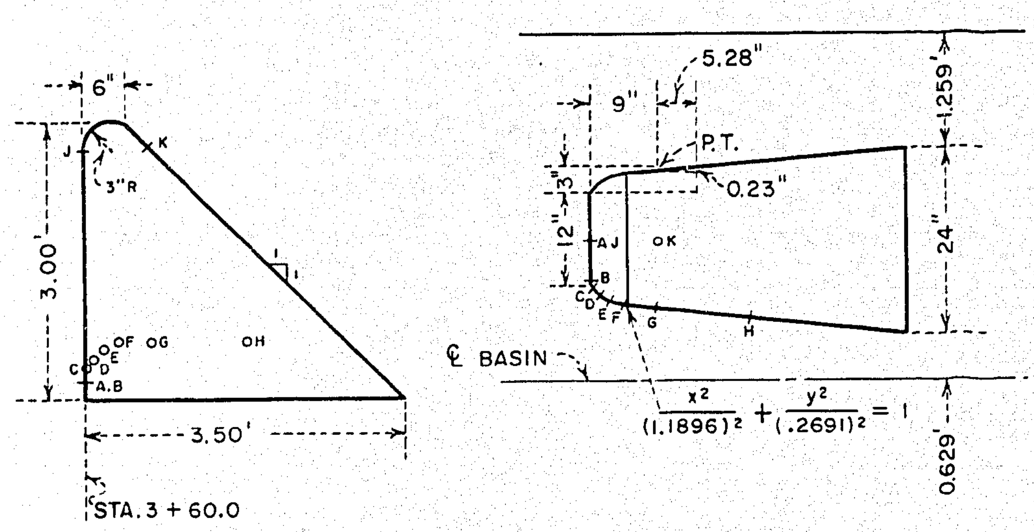


A. Jet shooting up to the surface.

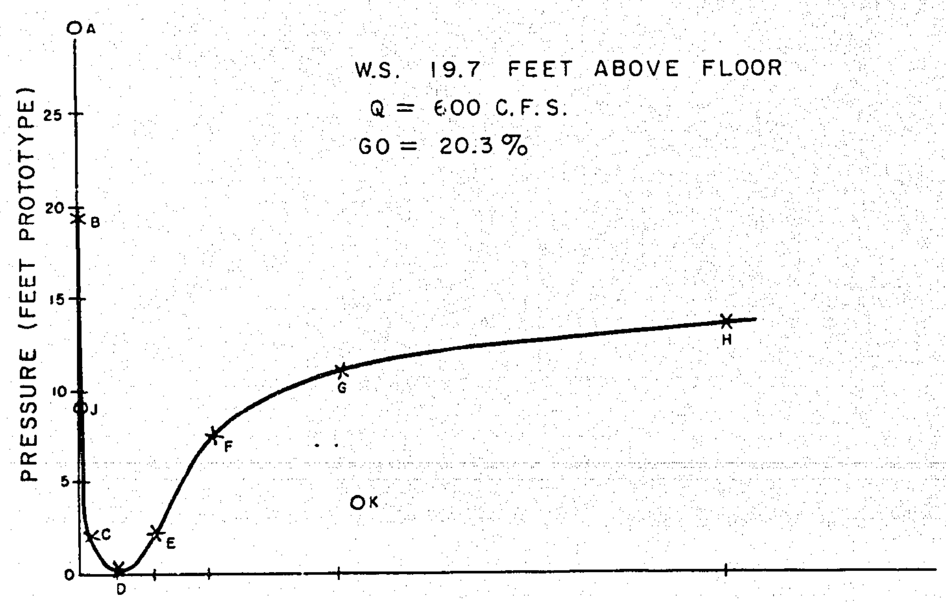


B. Jet flowing along the floor.

MURRUMBIDGEE-EUCUMBENE DIVERSION PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY; AUSTRALIA
TANTANGARA DAM OUTLET WORKS
Preliminary design showing both level and rising jet
1:10 scale model



PEIZOMETER	A	B	C	D	E	F	G	H	J	K	
HEIGHT ABOVE FLOOR	.2	.2	.3	.4	.5	.6	.6	.6	2.75	2.75	(FEET PROTO.)
DIST. DOWNSTREAM PIER FACE	0	0	.02	.1	.2	.35	.7	1.75	0	.75	(FEET PROTO.)

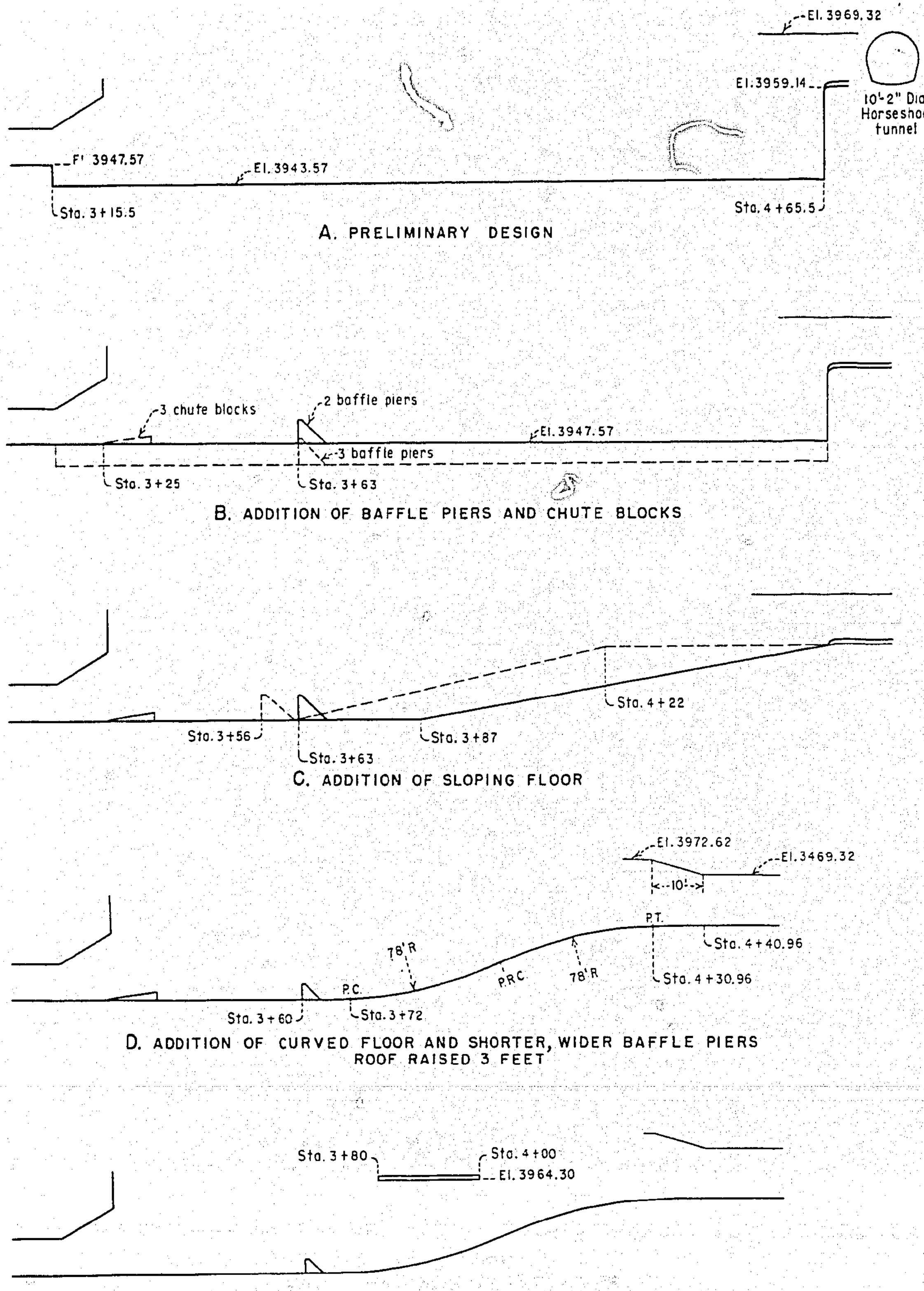


MURRUMBIDGEE-EUCUMBENE DIVERSON PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY; AUSTRALIA

TANTANGARA DAM OUTLET WORKS

PRESSURE DISTRIBUTION
RECOMMENDED BAFFLE PIER

1:10 SCALE MODEL



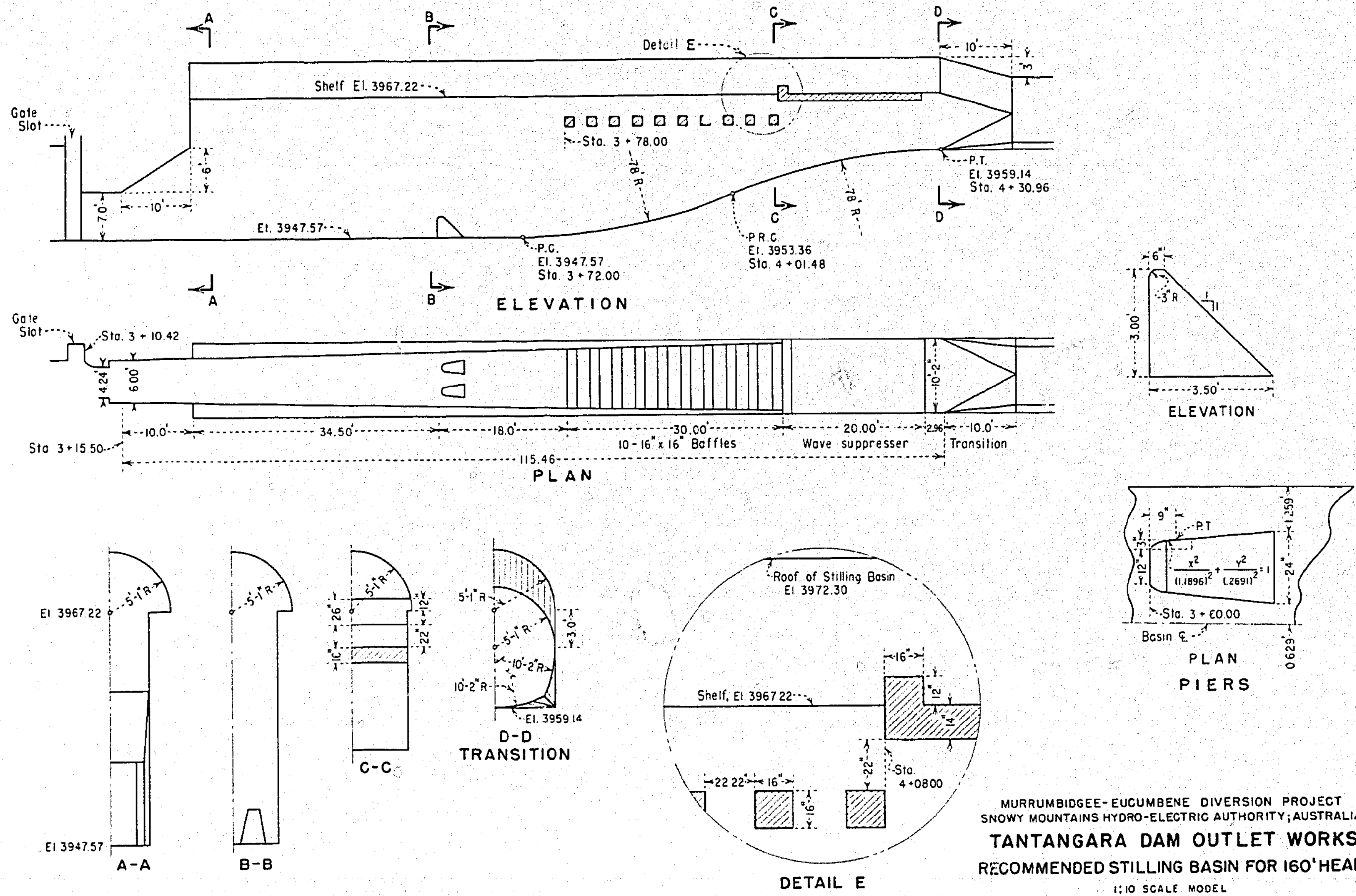
MURRUMBIDGEE-EUCUMBENE DIVERSION PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY; AUSTRALIA

TANTANGARA DAM OUTLET WORKS

STILLING BASIN DEVELOPMENT

1:10 SCALE MODEL

610



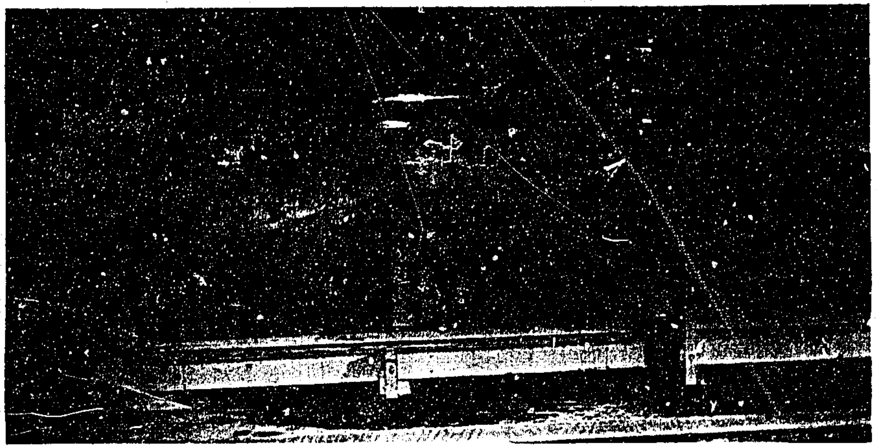
MURRUMBIDGEE-EUCUMBENE DIVERSION PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY; AUSTRALIA

TANTANGARA DAM OUTLET WORKS

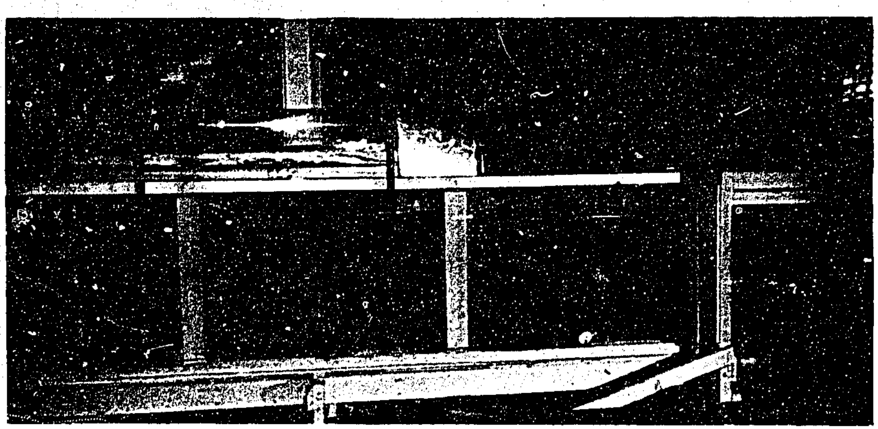
RECOMMENDED STILLING BASIN FOR 160' HEAD

1:10 SCALE MODEL

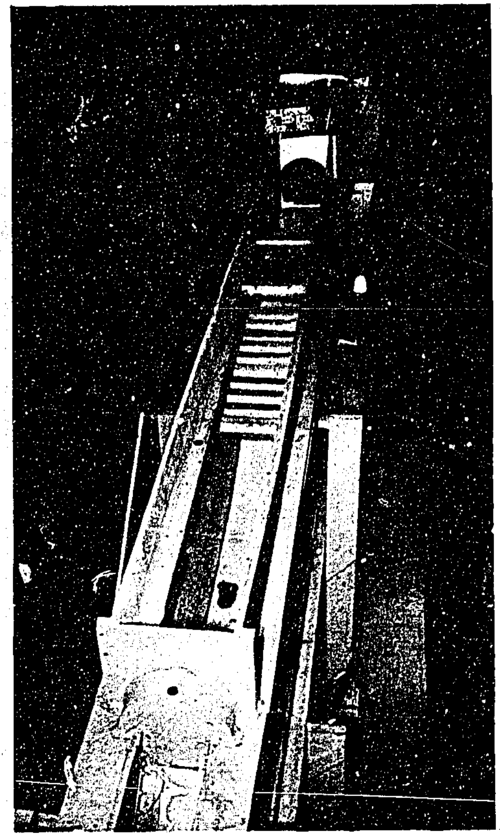
FIGURE 12
REPORT HYD. 441



A. From the Gate to Sta. 4+05
(Gate seal is Sta. 3+10.42)
G.O. = 19%; Q = 600 cfs.



B. From Sta. 3+90 to Sta. 4+85
G.O. = 19%; Q = 600 cfs.



C. Recommended Design.

MURRUMBIDGEE-EUCUMBENE DIVERSION PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY; AUSTRALIA
TANTANGARA DAM OUTLET WORKS
Recommended design
1:10 scale model

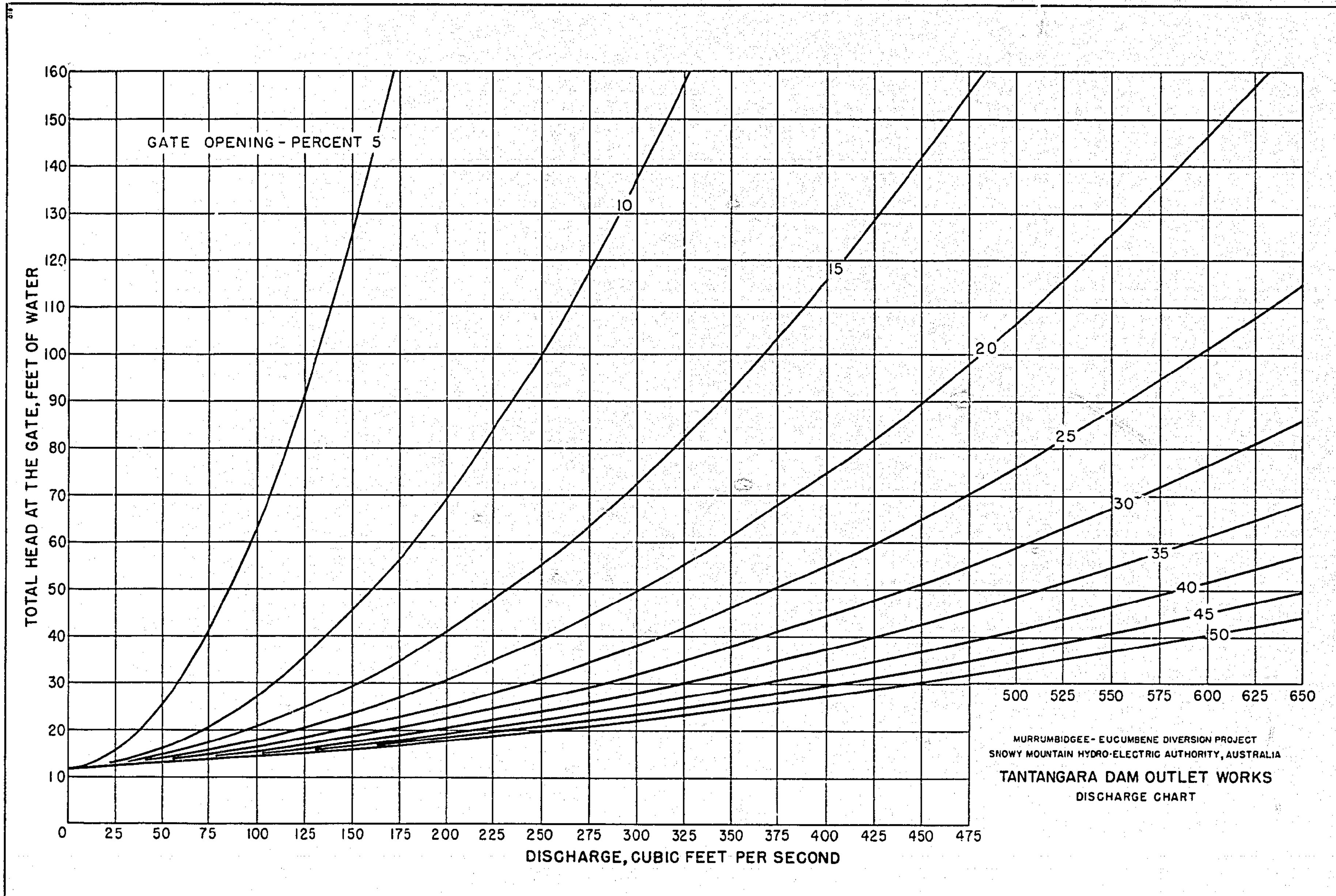


FIGURE 14
REPORT HYD 441

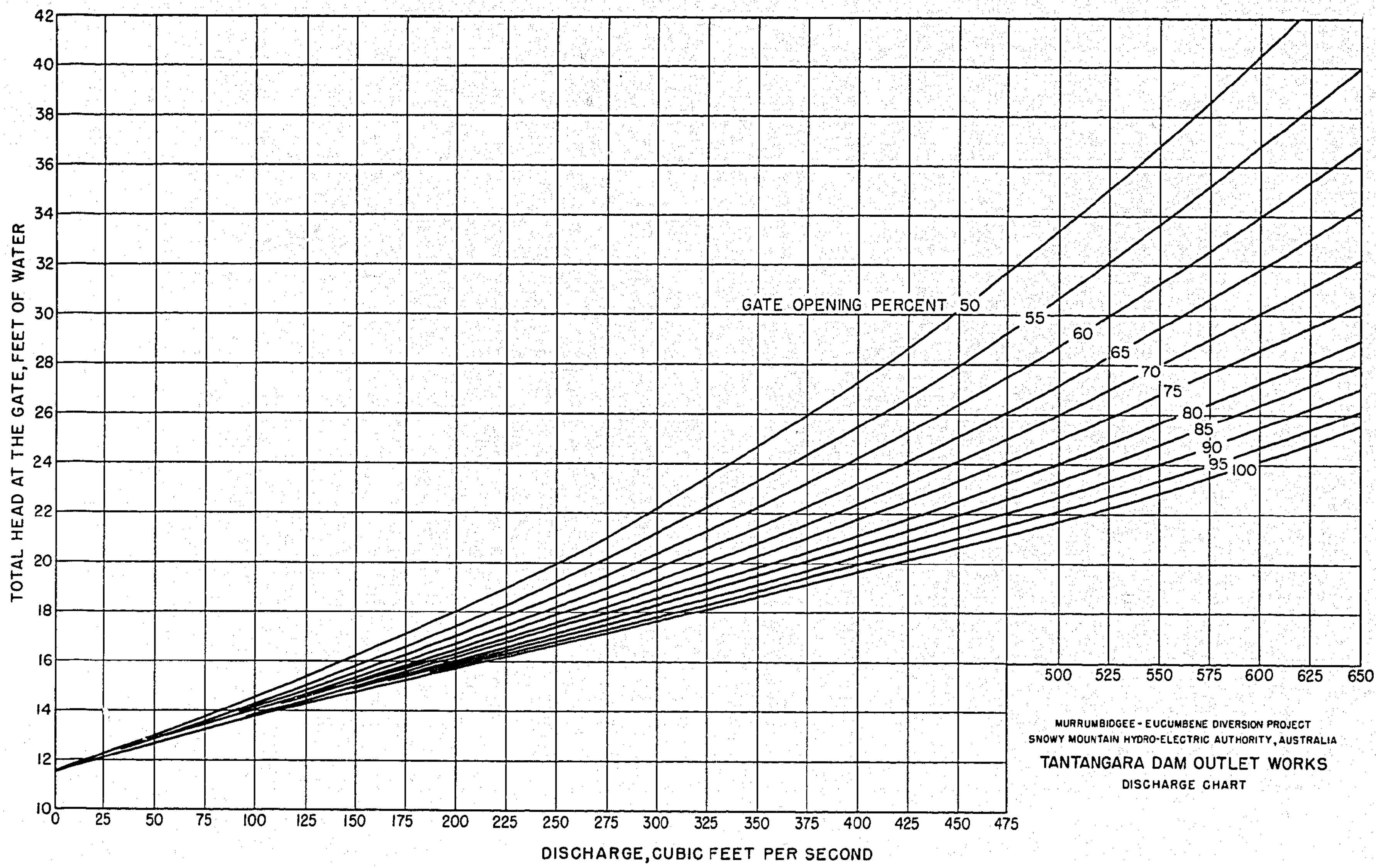


FIGURE 15
REPORT HYD. 441

APPENDIX 1

C O P Y CJW

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Snowy Mountains Hydro-Electric Authority
P. O. Box 332, Cooma North, New South Wales, Australia

Airmail: March 7, 1958

To: Assistant Commissioner and Chief Engineer Attention D-220

From: Senior Engineering Advisor

Subject: Murrumbidgee-Eucumbene Tunnel Designs--Murrumbidgee-Eucumbene Diversion

Design of the Murrumbidgee-Eucumbene Tunnel including intake, control and outlet works was carried out by the Bureau on the basis of information and requirements outlined in the Authority's Interim Project Report of January 1957. The designs prepared by the Bureau comply with all requirements given therein and include an energy dissipator immediately downstream of the control gate.

Subsequently, plans were modified to include construction of a concrete gravity dam at Tantangara with full supply level at RL 4035, which is 72 feet less than the reservoir level adopted for the design of the tunnel and associated works. In view of this change in operating head savings may be effected by moving the gate shaft upstream, thereby reducing the depth of the shaft and dimensions of the energy dissipator immediately downstream of the gate.

Some regulating conditions, as recently summarized by the Engineer-in-Charge Civil Engineering Design, follow:

"Consideration has been given to the desired degree of regulation of flow through the tunnel. No difficulties are foreseen in regard to operation of the tunnel in the free-flow or in the full-flow condition, but it seems undesirable that the tunnel be operated in a condition intermediate between full-flow and free-flow as any transient pressure waves could cause damage in the unlined tunnel.

Three alternate methods of gate operation have been considered and these methods are compared below:

METHOD A

Flow regulated so that the tunnel flows part-full at all times. In this method the gate is required to regulate for 20% of the time as for the remainder of the time the river flow is less than the free-flow capacity of the tunnel (500 cusecs). However, the maximum discharge capacity is less than that for full flow operation (620 cusecs).

METHOD B

Flow regulated so that tunnel flows either part full or full for its entire length and operation in the intermediate condition is avoided as far as practicable. This method would involve operation in accordance with Method A up to RL 3992, which is the level in Tantangara Reservoir above which it is possible to fully open the gate and achieve full-flow throughout the tunnel. This would permit the discharge capacity of the tunnel to be increased to 620 cusecs for the higher levels in the reservoir. The main disadvantage of this method is the operation in the transition stage for short periods when the reservoir water level passes through RL 3992.

METHOD C

Flow regulated so that tunnel operation is intermittently full flow or zero. This method would require that the gate operated intermittently for a large proportion of the time, which means that the flow would pass through the transition stage each time the gate is opened. In order to ensure that the tunnel flowed full at all times it would be necessary to raise the minimum operating level from RL 3960 to approximately RL 3992.

It is proposed in the Investigations Report that remote control be provided for the regulating gate together with remote indication of the gate position. It is also proposed that remote indication of water level be provided. Thus, it will be possible to have the remote control of gate opening depend on reservoir water level and the selection of the amount of gate opening can be either manual or automatic. It is considered that the control of gate opening would be a more routine and less complicated procedure if the tunnel were operated part-full at all times. As the difference in the maximum discharge capacity (part-full and full) is only approximately 120 cusecs it is considered that operation in the part-full condition will not cause any significant loss in water diversion.

Operation of the tunnel part-full at all times is preferred (Method A). This method avoids operation in the transition stage between full and part-full and control of gate opening would be fairly straightforward."

A sketch DT-H-9 "Murrumbidgee Portal - Murrumbidgee-Eucumbene Tunnel - Alternative Arrangement" (two prints enclosed) has been prepared which, together with the above notes, summarizes present requirements, and it is asked that designs proceed along the suggested lines and within the broad limits of the proposed change indicated in Section B (17) of Supplementary Notice No. 1 to Contract No. 20, 034.

It is regretted that finalization of Authority thoughts on this feature of the Project has been delayed. Several alternatives, which involved relatively major changes, have been under consideration and were only eliminated definitely as of this date.

s/ Fred E Cornwell
t/ Fred E. Cornwell
Senior Engineering Advisor

In duplicate
Enclosure

As a result of the change in plans mentioned in the foregoing letter from SMHEA, the maximum head on the control gate was reduced from 160 to 105 feet, permitting a reduction in the size of the stilling basin. The new basin dimensions were computed as follows, without additional model studies:

1. Values existing in the basin as determined by model studies and recommended for the initial plan:

$H = 160$ feet; $Q = 600$ cfs

$V_1 = 99$ fps

$D_1 = 1.42$ feet

$D_2 = 22.5$ feet

$L = 74$ feet (end of hydraulic jump)

$$F = \frac{99}{1.42\ g} = 14.6$$

2. Computed from Laboratory Report No. Hyd-399 (Laboratory Research Study on Stilling Basins):

a. For the initial plan:

$D_1 = 1.42$ feet

$F = 14.6$

$D_2 = 20\ D_1 = 28.4$ feet (Hyd-399)

$L = 2.8\ D_2 = 79.5$ feet (Hyd-399)

b. For the modified plans:

$H = 105$ feet; $Q = 600$ cfs

$D_1 = 1.72$ feet

$V_1 = 82$ fps

$$F = \frac{82}{1.72\ g} = 11.0$$

$D_2 \cong 15.2\ D_1 = 26.2$ feet (Hyd-399)

$L = 2.8\ D_2 = 73.4$ feet (Hyd-399)

3. Computations based on the ratio of the dimensions for the initial and modified plans as determined from Hyd-399 and applied to the initial model study results:

	Hyd-399 Initial	Hyd-399 Modified	Ratio	Initial test	Modified (Test X Ratio)
D_2	28.4	26.2	0.923	22.5	20.75
L	79.5	73.4	.923	74.0	68.25

4. These computations indicated that the basin dimensions determined by model study for the initial plans could be modified and new dimensions recommended for the modified plans without the need for further model studies. Consequently, the following memorandum was prepared for the Bureau design branch concerned with this control structure.

The drawing, Figure 16, shows the recommended stilling basin for the revised maximum head of 105 feet. Since the relative elevations of the gate and the horseshoe tunnel downstream from the stilling basin have been reduced 1.75 foot, the discharge charts, Figures 14 and 15, may be used for modified stilling basin as shown in Figure 16 by reducing the total head values by 1.75 foot.

C O P Y CJW

Memorandum
To: Chief, Canals Branch
Attention: W. W. Schneider

Denver, Colorado
April 1, 1958

From: Chief, Division of Engineering Laboratories

Subject: Murrumbidgee-Eucumbene tunnel intake control structure

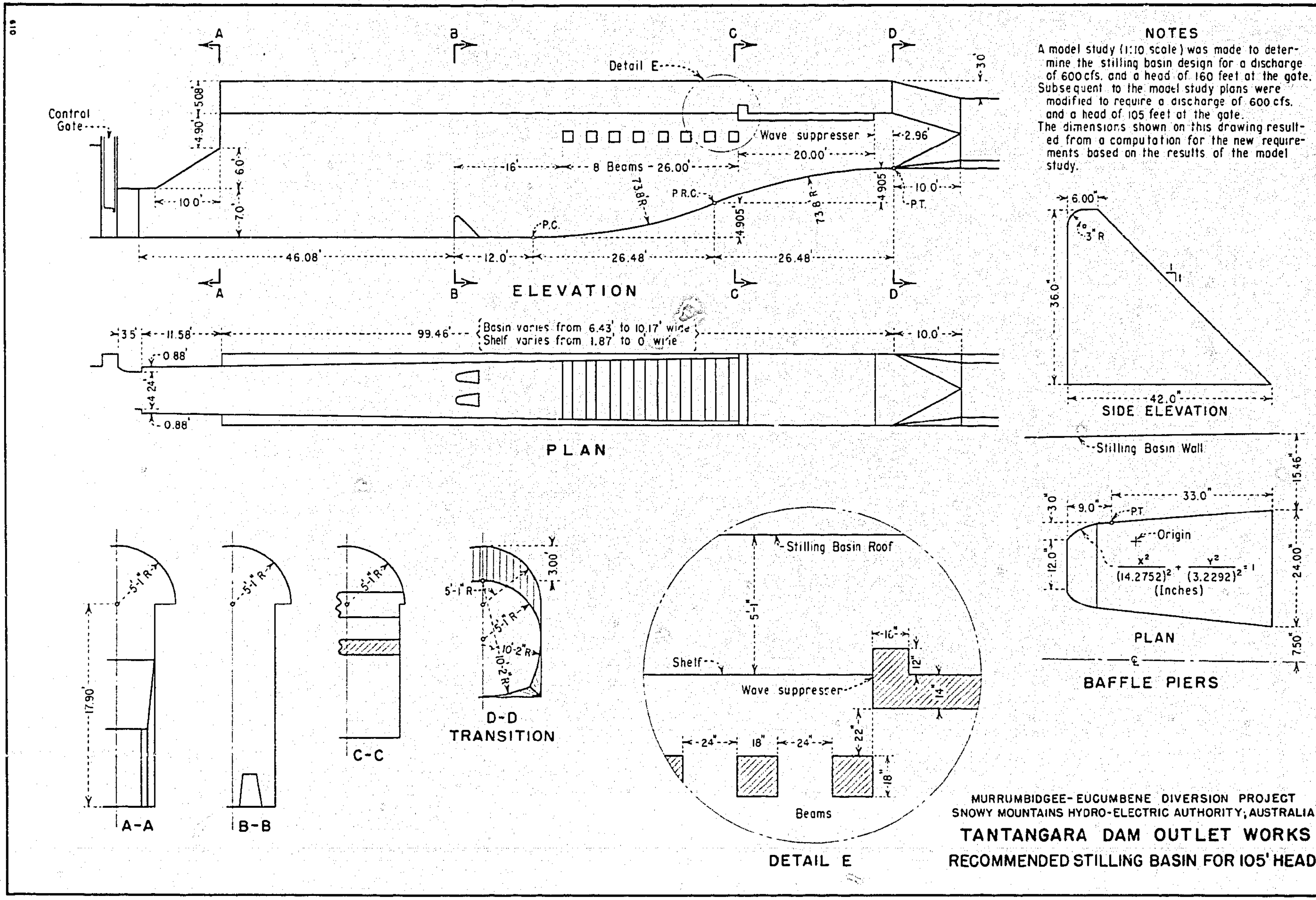
Model studies have been completed for the design of a stilling basin to dissipate the energy of 600 cfs entering the pool with a velocity of 99 feet per second. The plans at the time of the model study assumed a reservoir water surface elevation of 4107 and a stilling basin floor elevation of 3947.6, or a head of about 160 feet on the gate. Recent modification of the plans by SMHEA indicate that the maximum reservoir elevation will now be 4052 which reduces the head at the gate to about 105 feet. The discharge will remain at 600 cfs. The authority by letter dated March 7, 1958, asked for revised dimensions for the energy dissipator using the lower design head.

The stilling basin determined by model study was somewhat shorter and shallower than the minimum values computed using the data from Hydraulic Laboratory Report No. Hyd-399. The water surface in the jump was extremely rough; however, by placing 10 beams and a 20-foot-long wave suppressor across the basin, tranquil flow was maintained in the entrance to the 10-mile-long unlined tunnel which leads to Adaminaby Reservoir. To arrive at an acceptable design for the new basin, computations were made (using the Hyd-399 design curves) for the initial head conditions and for the lower head of the modified plan. The ratio of these values was applied to the basin dimensions developed by model study to determine the minimum dimensions for the new basin. These dimensions are shown on the accompanying drawing.

The basin design for the initial plans was the most economical which could be developed by model study, and the computed dimensions of the modified basin are considered a minimum for proper operation of the stilling basin. It is believed that the new basin under the smaller head will operate as satisfactorily as that developed for the higher head, and that further model studies are unnecessary.

The information contained in this memorandum will be included in the Hydraulic Laboratory report covering the studies made on the control structure. The report will be completed in the near future.

s/W. H. Price



NOTES

A model study (1:10 scale) was made to determine the stilling basin design for a discharge of 600 cfs. and a head of 160 feet at the gate. Subsequent to the model study plans were modified to require a discharge of 600 cfs. and a head of 105 feet at the gate. The dimensions shown on this drawing resulted from a computation for the new requirements based on the results of the model study.

MURRUMBIDGEE-EUCUMBENE DIVERSION PROJECT
SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY, AUSTRALIA

TANTANGARA DAM OUTLET WORKS

RECOMMENDED STILLING BASIN FOR 105' HEAD

FIGURE 16
REPORT HYD. 441