UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF THE OUTLET WORKS AND WASTEWAY FOR LOVEWELL DAM BOSTWICK DIVISION MISSOURI RIVER BASIN PROJECT

Hydraulic Laboratory Report No. Hyd-400

ENGINEERING LABORATORIES

COMMISSIONER'S OFFICE
DENVER, COLORADO

May 20, 1955

HYD 400

CONTENTS

LIST OF FIGURES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Commissioner's Office
Engineering Laboratories
Denver, Colorado
May 20, 1955

Laboratory Report No. Hyd-400
Hydraulic Laboratory
Written by: W. P. Simmons, Jr.
Reviewed and
checked by: J. W. Ball

Subject: Hydraulic model studies of the outlet works and wasteway for Lovewell Dam--Bostwick Division--Missouri River Basin Project

PURPOSE

Hydraulic model tests were made of the outlet works and wasteway to study the flow conditions and determine the capacity of the proposed structure, and to ascertain any design changes needed to assure satisfactory operation.

CONCLUSIONS

1. The basic preliminary design structure was made to operate satisfactorily by the addition of two large baffle blocks in the stilling basin, a culvert-type wave suppressor near the basin end, a cover over the basin, and a headwall and cover at the wasteway gate; and by relocating the inlet pipe to the wasteway gate weir well, and providing a less abrupt taper at the upstream end of the bottom corner fillets just downstream from the control gate.

2. Two large baffle blocks placed near the upstream end of the stilling basin produced a better hydraulic jump in the basin and reduced the wave action (Figure 6). The flood handling capacity of the basin was thus increased (Figure 11A). The small chute blocks in the preliminary design were found to be ineffective.

3. A 45-foot-long culvert-type wave suppressor placed near the downstream end of the basin greatly improved the flow conditions at the wasteway gate and canal entrance when releases were made at partial gate openings at moderate and high heads (Figures 7, 8, and 9). With this suppressor and the two large baffle blocks in the stilling basin, the flow at the wasteway gate and in the supply channel to the canal was satisfactory at all applicable combinations of head and rate of flow.

4. Wetting of the fill material next to the stilling basin by spray and flying water can be prevented by placing a 50-foot long cover over the basin. The cover should be placed not lower than elevation 1577.0 to avoid heavy buffeting by the water.

5. A vertical wall with a 2-foot wide horizontal shelf placed directly over and just upstream of the wasteway gate will prevent water wastage due to waves overtopping the gate (Figure 12).

6. Much smaller water surface fluctuations are obtained in the weir well when the inlet of the wasteway gate float well supply pipe is moved from its initial location on the left channel wall to a region of quieter flow at the right wall.

7. An emergency flow passage, or flood-out, from the main channel to the wasteway gate float well is required to quicken the gate's response when the rate of rise of water surface in the channel is greater than that which might be expected during normal operation. A stop-board controlled opening through the channel wall to the float well should be satisfactory.

8. The upstream ends of the bottom corner fillets just downstream from the control gate will not cause objectionable fins of water if a rate of taper of 1:4 is used in place of the 1:1 slope of the preliminary design (Figure 6).

9. When flows of about 1,270 cfs are passed through the fully opened control gate the flow strikes the hinge blocks. The water will be below the blocks when the gate opening is smaller than about 92 percent.

10. The flow conditions at the canal entrance were improved only slightly over the ones obtained with the preliminary design without the basin blocks and wave suppressor when the wasteway inlet was moved farther downstream.

RECOMMENDATION

The operation of this outlet works structure should be supervised carefully enough to insure that no releases are made at a rate greater than about 1,270 cfs.

ACKNOWLEDGMENT

Close liaison was maintained between the personnel in the Dams Branch and in the Hydraulic Laboratory during the model testing program.

INTRODUCTION

Lovewell Dam is an earth fill structure located about midway between the east and west boarders of Kansas and 8 miles south of the Nebraska line (Figure 1). It will offer flood protection to farms and cities downstream and provide storage and control for irrigation water. The dam rises 88 feet above the bed of White Rock Creek and the main section has a crest length of about 4,000 feet (Figure 2). A dike continues to the left for another 4,500 feet. Two 25- by 20-foot radial spillway gates at the right abutment will control the reservoir elevation and release flood discharges as required. A hydraulic-jump type stilling basin is provided to convert the high velocity spillway releases into low velocity flows that will not seriously erode the river channel. The outlet works, which will release water to the irrigation canal, lies to the right of the spillway structure. It consists of a closed conduit from the face of the dam to the radial-type high-head control gate, a closed conduit from the gate to the stilling basin, an open channel Y-section, a wasteway for emergency use, and a channel leading to the irrigation canal (Figure 3). A measuring station at the end of this channel will measure the rate of flow turned into the canal. The measurements will be made with propeller-type meters located at the downstream ends of two flow passages, or barrels, that are formed by a vertical wall on the center line of the channel and a submerged cover Check gates a short distance downstream will hold the channel water surface to elevation 1570.5 at all discharges so that the barrels will always flow full. At low flows the discharge may all be directed into one of the passages to produce the velocity needed for good meter readings. At higher discharges the flow will be equally divided between the two passages.

The wasteway is provided to prevent overtopping of the structure and flooding of the irrigation canal in the event of excessive releases from the control gate or improper settings of the measuring station check gates (Figure 4). During all normal outlet works operation the automatically controlled wasteway gate will remain closed. However, if the water surface in the channel to the canal should for any reason rise above approximately elevation 1571.0, water will enter the float well and cause the wasteway gate to open (Figure 5). When the cause of the abnormally high water surface has been corrected, the wasteway gate will automatically close as the water in the float well escapes through an orifice-controlled drain pipe.

Good flow conditions without large waves and surges and with an approximately symmetrical velocity distribution must prevail at the measuring station to permit accurate flow measurements. Also, reasonably good flow conditions are required in the vicinity of the automatic wasteway gate so that the control system will not tend to open and close the gate unnecessarily due to waves. To determine the flow conditions that could be expected within the turnout structure, and to determine any design changes that might be needed to insure satisfactory performance, model studies were requested by the Dams Branch. The model that was constructed, the tests that were made, and the results that were obtained during this test program are discussed in this report.

1:18 SCALE MODEL

A scale ratio of 1:18 was selected for the hydraulic model after considering the size of model desired, the space available in the laboratory, and the cost of construction. The model included a head box to represent the reservoir, the bellmouth and closed conduit to the control gate, the radial-type control gate, the conduit and stilling basin downstream, and the Y-section, wasteway, and channel to the canal (Figure 6). The model was constructed mainly of wood and was made waterproof with a plastic coating. An oil base paint was applied as a final coat to enhance the appearance, provide smooth flow surfaces, and give the necessary color separation for good photographic reproductions. All details necessary for good representation of the prototype operation were included in the model, such as the corner fillets in the conduits and the slots for the emergency gate just upstream of the control gate. Suitable gages and piezometers were installed as required to determine the water surface elevations and pressures within the model. Water was supplied through the central laboratory system which contains calibrated Venturi meters for measuring the rate of flow, and the water discharged from the model was returned to the laboratory reservoir for recirculation.

INVESTIGATION

Preliminary Design

At low reservoir elevations and with the control gate at or near the full open position, the flow conditions within the structure were satisfactory (Figure 7A). However, at smaller gate openings with moderate or high heads the flow conditions were much too rough for proper operation of the wasteway gate or good flow measurements at the canal entrance (Figures 7B and C). The capacities of the wasteway and the supply channel to the canal were adequate and no pressure less than -0.3 foot of water was found on the stilling basin chute at any applicable combination of discharge and reservoir elevation. The rate of flow that the stilling basin could pass without sweeping out the pool was also adequate but the capacity was further increased when baffle blocks were installed to improve the flow conditions in the basin. When high-velocity flows were discharged from small openings of the control gate, objectionable fins of water formed at the rather abrupt ends of the bottom corner fillets just downstream from the gate.

The rough flow conditions downstream from the stilling basin were materially improved when a wall was placed in the wasteway entrance of the Y-section to eliminate the wasteway from the structure and make a continuous 16-foot-wide channel. This indicated that better flow conditions could be obtained in the supply channel by a change in the location of the wasteway. This method of improvement was not considered justified due to the advanced state of the initial design and the necessity of establishing the final design so that construction drawings could be prepared. Moreover, the initial tests on the model indicated that satisfactory conditions could be obtained without a relocation of the wasteway.

Baffle Blocks in the Stilling Basin

Blocks of various shapes and sizes were installed in the upstream portion of the stilling basin floor to improve the hydraulic jump. Good results were obtained by using a few blocks of relatively large size, and best performance was obtained with an upstream projection at the block top (Figure 6). Two such blocks, 4.7 inches high in the model and placed 8 inches downstream from the toe of the parabolic slope and 1 inch from each sidewall, gave good performance. Equivalent blocks are recommended for the prototype structure. No serious erosion is expected on these blocks, but in the event that the upstream extension should be eroded off the blocks, satisfactory flow conditions should still prevail. The greater rate of flow that the basin with the blocks can pass without having the pool swept out is shown in Figure 11A. The small chute blocks proposed in the preliminary design were found to be ineffective and should be omitted from the structure.

Culvert-type Wave Suppressor

Experience with previous structures has shown that considerable reduction in wave action can be obtained by the use of culvert-type wave suppressors. These suppressors consist basically of a passageway created by a roof of moderate length over the channel with a headwall high enough to make all the flow pass beneath the roof. They are relatively inexpensive to build, effective, and pleasing in appearance (Figure 8). The first suppressor tried on the model of the Lovewell outlet works was the equivalent of 40 feet in length and was located at the downstream end of the stilling basin where the sidewalls diverged. Much smoother flow conditions were obtained at the wasteway gate and in the supply channel. A number of different length suppressors placed at various stations and elevations near the downstream end of the stilling basin were tried. A 36-foot-long suppressor at the downstream end of the 8-foot-wide basin section was not satisfactory, primarily because the upstream end was in a region of extreme turbulence. A 30-foot-long suppressor extending downstream from the point where the side walls begin to diverge, Station 5+22.81, was moderately effective. Upstream extensions to this suppressor of 9 and 15 feet provided considerably improvement, particularly the 15-foot one which produced a 45-foot-long structure. A 45° sloped top surface in the entrance aided the water's entry under the roof and a gradual upslope of the downstream 30 feet of the 45-foot suppressor improved the exit conditions.

Measurements were made to determine the effect of the 45-foot-long suppressor upon the reservoir elevation needed to pass 635 cfs through the structure. With no suppressor installed in the structure and with the control gate fully open and the water surface at the canal entrance at elevation 1570.50, a reservoir elevation of 1571.71 was required. With the 45-foot-long suppressor installed so that the first 15 feet of cover was in the parallel section at the end of the basin and at elevation 1568.00, and the last 30 feet sloped upward in the expanding section of the basin to end at elevation 1570.00, the required reservoir elevation was 1571.84. When the horizontal portion of the suppressor cover was raised to elevation 1569.00, the required reservoir elevation for a 635 cfs flow decreased to 1571.78. This latter reservoir elevation was not excessive for the prototype structure, and the suppressor cover was found to be equally as effective at elevation 1569.00 as at elevation 1568.00. Further raising of the suppressor cover resulted in reduced effectiveness of the suppressor in controlling wave action.

The control exerted on the flow by the stilling basin baffle blocks and 45-foot-long culvert-type wave suppressor produced satisfactory flow conditions within the structure at all applicable combinations of head and rate of flow (Figures 9 and 10). At all flows up to the normal design rate of 635 cfs good conditions exist at any appropriate combinations of reservoir elevation and gate opening. At flows from 635 cfs to the maximum predicted flood flow of 1,270 cfs, conditions are rougher, but are within safe limits and are considered satisfactory. The curves of Figure 11A show the relation of reservoir elevation to the rate of flow for releases made by the control gate at openings of 10 percent increments, and the condition where the water at the canal entrance is maintained at elevation 1570.50. The curves of Figure 11B are for the case where the water surface elevation at the canal entrance follows a computed backwater curve for the unchecked canal. The backwater curve is also shown in Figure 11B. The gate opening is taken as the vertical distance from the conduit floor to the gate bottom. The curves in both plots show a transition range in which the submerged jump that occurs at the gate at partial openings and low heads changes to an unsubmerged jump and the water depth downstream of the gate ceases to influence the head differential on the gate.

The curves giving the reservoir elevations and discharges where stilling basin sweepout just begins, with and without the basin blocks, are shown in Figure 11A. The maximum rate of flow for the basin with the blocks is about 1,700 cfs. The water surface profiles for a flood flow of 1,270 cfs with the control gate fully opened and partly closed, and for the design flow of 635 cfs at the maximum reservoir elevation of 1610.30 are shown in Figure 11C.

Cover Over Stilling Basin

It was noted during the model studies that spray and slugs of water overtopped the stilling basin walls. The designers felt that the ground in the vicinity of this basin should not be permitted to become saturated by waters from the basin and that measures should be taken to keep the water within the structure. Accordingly, the walls of the model stilling basin were raised the equivalent of 1, 3, and 5 feet above the original 1574.00 elevation, but even with the 5-foot extension, considerable water was still thrown out of the basin. Complete control was obtained by placing a cover across the basin, but there was concern about this cover because it might be repeatedly struck by the higher waves. Observation of the model indicated that the cover was struck rather heavily when set at elevation 1574.00, but that the buffeting became light and much less frequent when the side walls and cover were raised to elevation 1577.00. The necessary length of cover was found to be about 50 feet, prototype, and it is recommended that this length cover be used and that it be set not lower than elevation 1577.00. The cover should start at the basin entrance, Station 4+03.84. A cover 5 feet long should also be placed across the basin at the upstream end of the sloped approach at the suppressor entrance.

Headwall at Wasteway Gate

The combination of the stilling basin blocks and the 45-foot-long wave suppressor produced moderately quiet conditions in the main channel and at the wasteway gate (Figure 9). However, the residual waves at the 635 cfs flow were still large enough to cause occasional overtopping of the gate, the top of which was at elevation 1571.50, or 1 foot above the average water surface. The wastage of water due to this overtopping would be undesirable and unsightly on the prototype structure and steps were taken to stop it. The simplest method seemed to be to increase the height of the gate to obtain additional freeboard, but this was not effective at the ends of the gate where trapped waves occasionally rose above the side walls. Best results were obtained by placing a 1-foot-thick curtain wall directly above and immediately upstream of the gate, and by extending a 2-foot-wide horizontal cover upstream from this wall at elevation 1573.00 (Figure 12). In the prototype structure a rubber sealing strip will extend horizontally downstream from the bottom corner of the wall and an angle iron strip along the top of the waste gate will rest upon the seal strip when the gate is fully closed.

The relation of rate of flow to the wasteway gate opening when the water surface within the outlet structure is held at elevation 1570.50 is shown in Figure 13A. The relation of rate of flow to the reservoir elevation with the wasteway gate full open and the canal checked full off is shown in Figure 13B. The maximum rate of flow that the wasteway can pass is about 1,080 cfs, and at this flow the channel water surface is at elevation 1573.72, or nearly at the top of the elevation 1574.00 side walls. If a slightly greater flow is attempted through the gate, the water surface touches the gate headwall and orifice flow results. This requires a greater upstream head for the same rate of discharge and the side walls are overtopped.

The relation of gate opening to reservoir elevation for a 635 cfs flow with the tail water at elevation 1570.50 is shown in Figure 13C. The relation of the rate of flow to the reservoir elevation with the control and wasteway gates full open and with the unchecked canal is shown in Figure 13D. The flow conditions at the waste gate for a discharge of 635 cfs are shown in Figure 12.

Water Surface Fluctuations in Automatic Gate Well

The automatically controlled wasteway gate is actuated by a float contained in a well that is supplied with water from a second well, the latter being connected by a pipe to the main channel (Figure 5). A weir of adjustable height is placed between the float and second or weir well and this weir crest will be set to an elevation somewhat above the normal operating water surface elevation. Whenever the canal supply channel water surface exceeds this elevation flow will occur from the weir well into the float well. If the channel water surface persists at a high elevation, sufficient water will enter the float well to lift the float and open the waste gate. When the flow into the well stops the gate will close as the water is drained from the well by a small orifice-controlled outlet.

Satisfactory operation of the wasteway gate will depend upon the sensitivity of response of the float well water surface to changes in the average water surface elevation in the channel. In the Lovewell outlet structure it is imperative that there be little lag between changes in elevation of the channel water surface and the float well surface because under extreme conditions a rate of rise of about 1-1/4 inches per second is possible in the structure, and both the structure and canal downstream must not be overtopped before the waste gate opens to carry off the excess flow. This rapid response requires a relatively large supply pipe between the channel and the weir well. Unfortunately the large connecting pipe also permits large water surface fluctuations in the weir well when fluctuations occur in the vicinity of the pipe entrance. Excessive fluctuations in the weir well water surface can cause the weir to be overtopped and water may pass into the float well and gradually fill it to the point that the wasteway gate opens. This, of course, is undesirable.

A scale size weir well, without weir, was connected by a scale-size pipe line to the left channel wall at Station 6+18.50 and elevation 1562.54. The fluctuations within the well were about 3/8 inch model, which was greater than the 1/4 inch fluctuations in the channel in the vicinity of the supply pipe. This greater fluctuation was apparently due to eddy currents at the pipe inlet superimposing their energy upon the 1/4 inch surface fluctuations in the channel. When the location of the inlet pipe was moved downstream to a region of more quiet flow at Station 6+42.00, the well surges decreased to slightly over 1/4 inch. Surges a little less than 1/4 inch occurred when the 4-inch long inlet pipe was placed in the right hand wall at the original 6+18.50 station. This was the best location found for the inlet pipe but it was an appreciable distance from the weir and float wells. A scale pipe line was constructed to represent the necessary length of line and number of elbows to lead from this inlet opening to the weir well location. The line came out of the wall horizontally at elevation 1564.05, turned vertically downward and then turned horizontal again to cross under the channel to the weir well. With this arrangement the water surface fluctuations in the well were less than 1/8 inch. This degree of fluctuation was believed to be small enough so that no appreciable overtopping would occur at the weir crest, and it is recommended that the inlet be placed on the right hand channel wall at the above mentioned location.

An analysis of the rate of response of the automatic gate with the longer supply pipe, to the possible rate of rise of water within the structure, indicated that ample speed would be obtained for all except the most extreme conditions. To accommodate these extreme conditions it was decided that an opening, or flood-out, should be provided through the left channel wall directly into the float well. The invert of this opening should be at elevation 1571.00 and provisions should be made for stop boards to obtain the desired crest height. The flow into the well should be directed so as not to plunge down onto the float.

Interference of Control Gate Hinge Blocks at High Flows

Two standing waves occurred in the closed conduit section between the control gate and stilling basin when flows of about 1,270 cfs were passed with the control gate wide open (Figure 10A, conduit shown without cover). The crest of the first wave was at the approximate location of the hinges of the control gate, and to determine the effect of the hing blocks on the flow, scale-size blocks were installed in the model (Figure 14A). Tests showed that the blocks would be partially submerged under the above operation conditions, but that this should be no cause for concern (Figure 14B, conduit shown without cover). If desired, the flow may be directed beneath the blocks by slightly closing the gate, but a larger standing wave is created farther downstream (Figure 14C). A gate position of about 92 percent open, or smaller, will eliminate the wave and produce good flow. This 8 percent closure will decrease the flow from 1,270 to 1,200 cfs at reservoir elevation 1576.20.

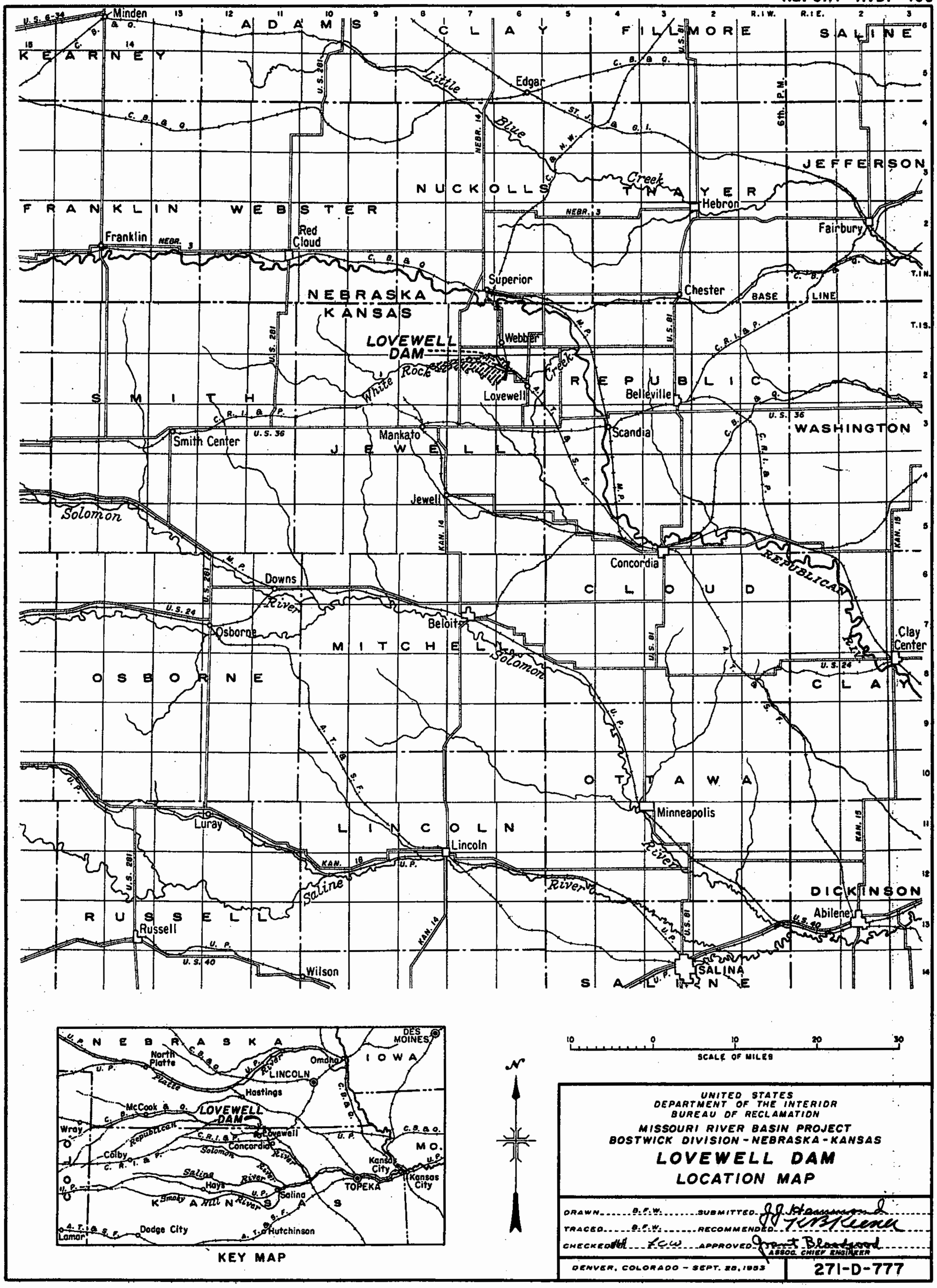
Fillets Downstream from the Control Gate

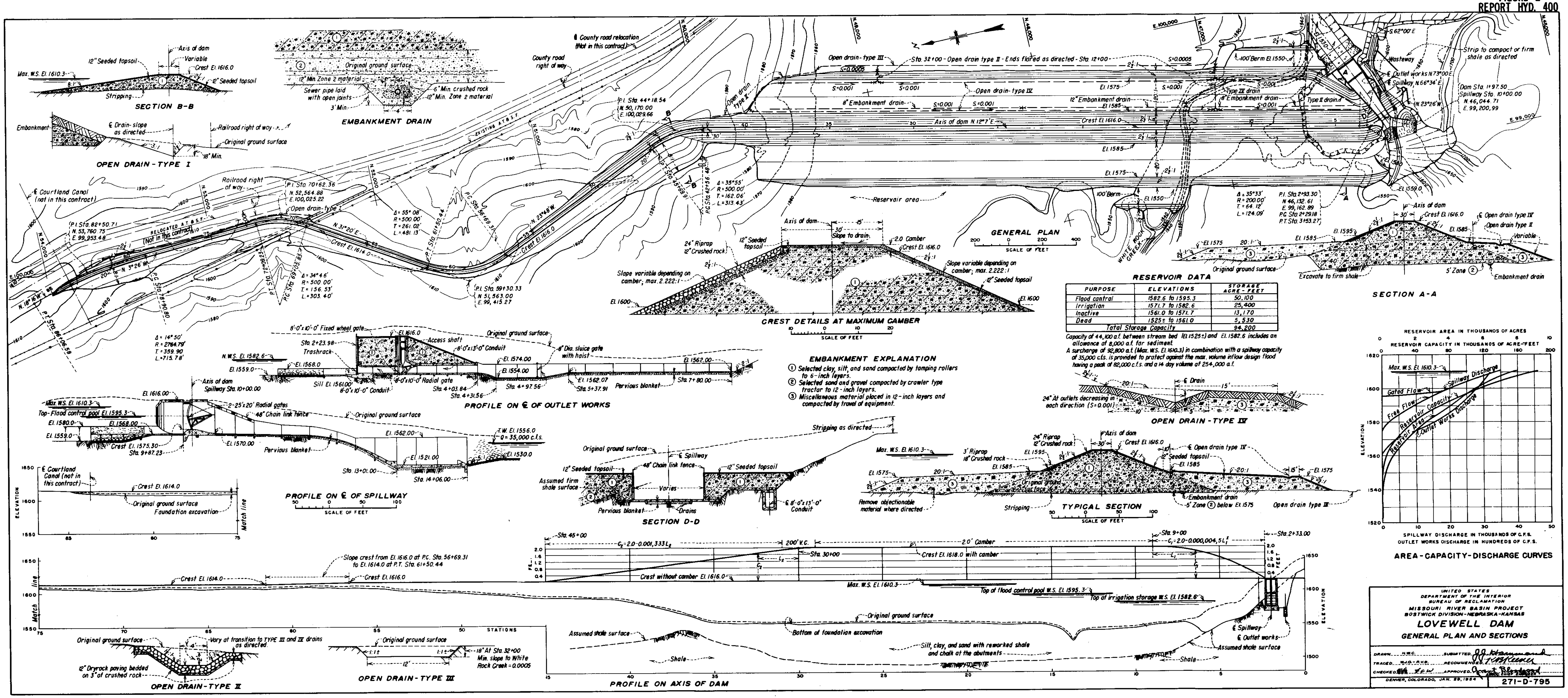
The abrupt upstream ends of the bottom corner fillets in the conduit just downstream from the control gate (Figure 6) caused undesirable fins of water when the gate was operated at small openings under high heads. These fins were eliminated by changing the ends of the fillets to the more gradual taper of 4:1 (Figure 6).

Change in Location of Wasteway Entrance

Visual analysis of the flow near the waste gate disclosed that the wave action in the Y-section was aggravated by waves reflected from the waste gate face. This was substantiated by the reduction obtained in the wave action when a wall was placed in the Y-section to eliminate the wasteway and form just the 16-foot-wide curved channel. A brief test was made to determine if good flow conditions could also be obtained by moving the wasteway entrance farther downstream. The alignment of the wasteway was changed so that it entered the main channel near the downstream end of the curve (Figure 15A). The wave action at the entrance to the irrigation canal was better than that for the preliminary design without the basin blocks and wave suppressor, but was not considered satisfactory (Figure 15B). Considerable wave action persisted at the waste gate and 1/4-inch water surface fluctuations occurred in the weir well, the well having its inlet pipe located just upstream from the gate. In general, the flow conditions were not as good as those obtained when the wasteway was completely blocked out of the structure. It is possible that some location might be found where the wasteway would not aggravate the wave action, but no further tests were justified at the time.

FIGURE 1
REPORT HYD. 400





RESERVOIR DATA

PURPOSE	ELEVATIONS	STORAGE ACRE-FEET
Flood control	1582.6 to 1595.3	50,100
Irrigation	1571.7 to 1582.6	25,400
Inactive	1561.0 to 1571.7	13,170
Dead	1525± to 1561.0	5,530
Total Storage Capacity		94,200

Capacity of 44,100 a.f. between stream bed (El. 1525±) and El. 1582.6 includes an allowance of 8,000 a.f. for sediment.
A surcharge of 92,800 a.f. (Max. W.S. El. 1610.3) in combination with a spillway capacity of 35,000 c.f.s. is provided to protect against the max. volume inflow design flood having a peak of 82,000 c.f.s. and a 14 day volume of 254,000 a.f.

FIGURE 3
REPORT HYD. 400

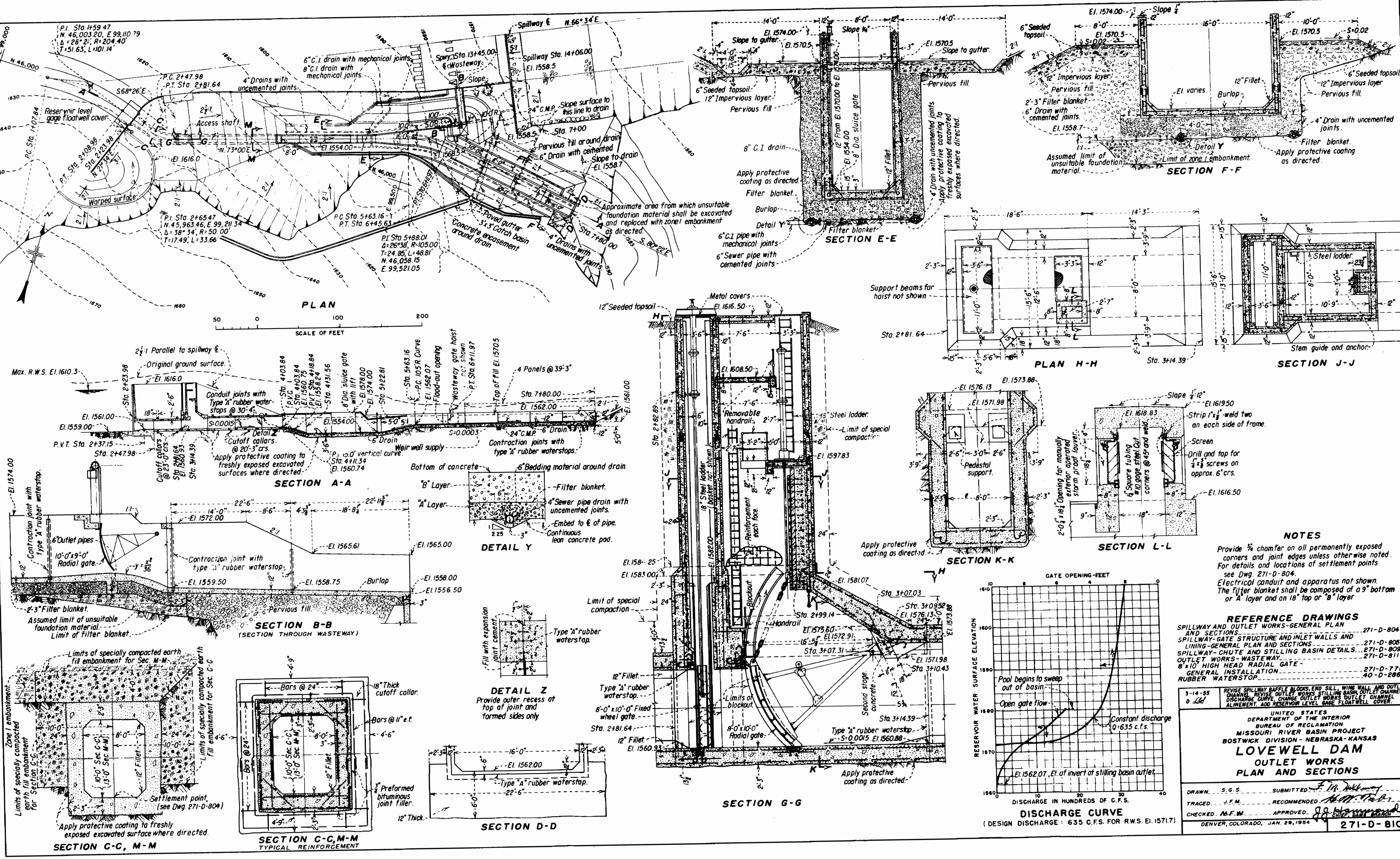
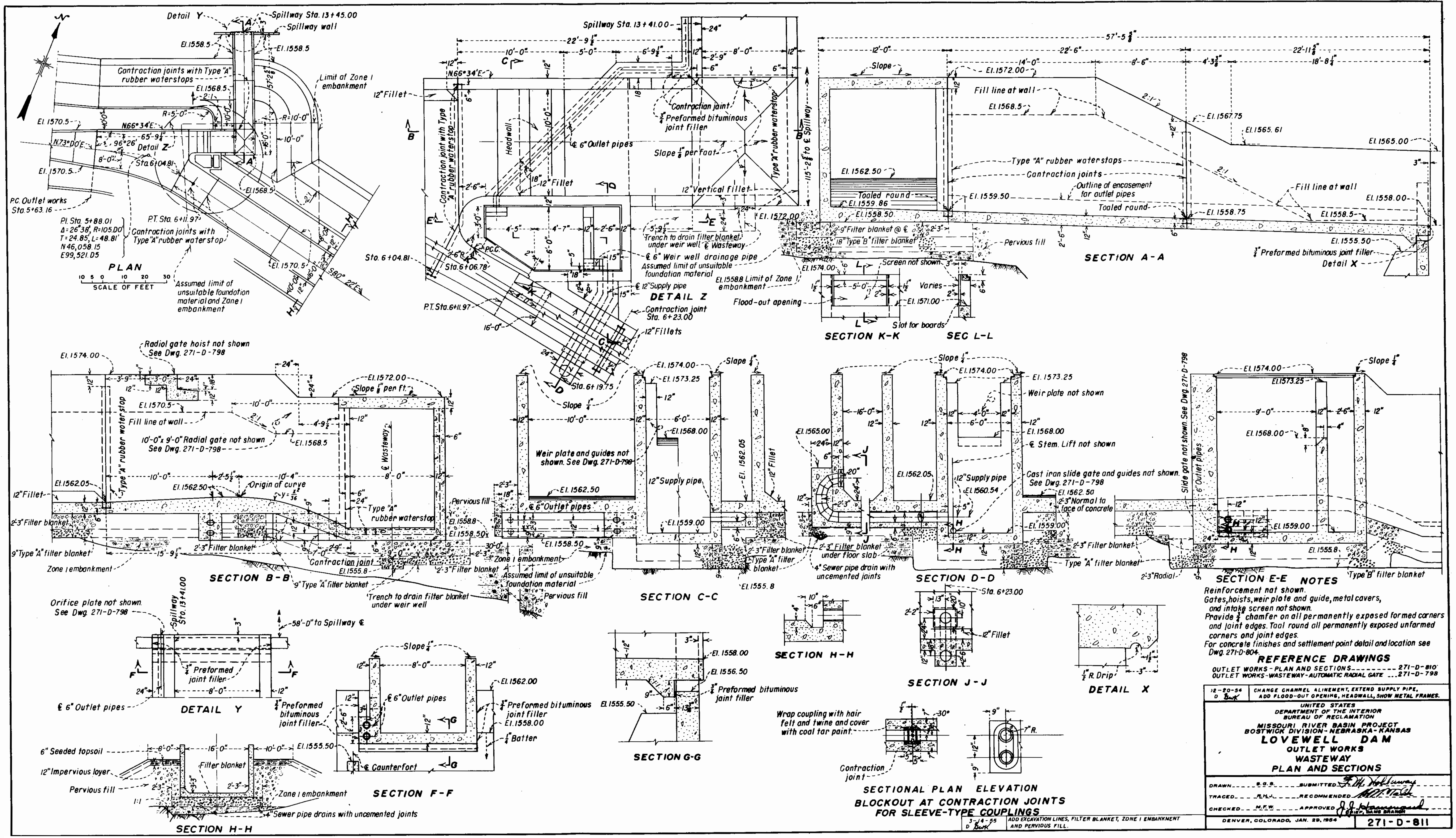
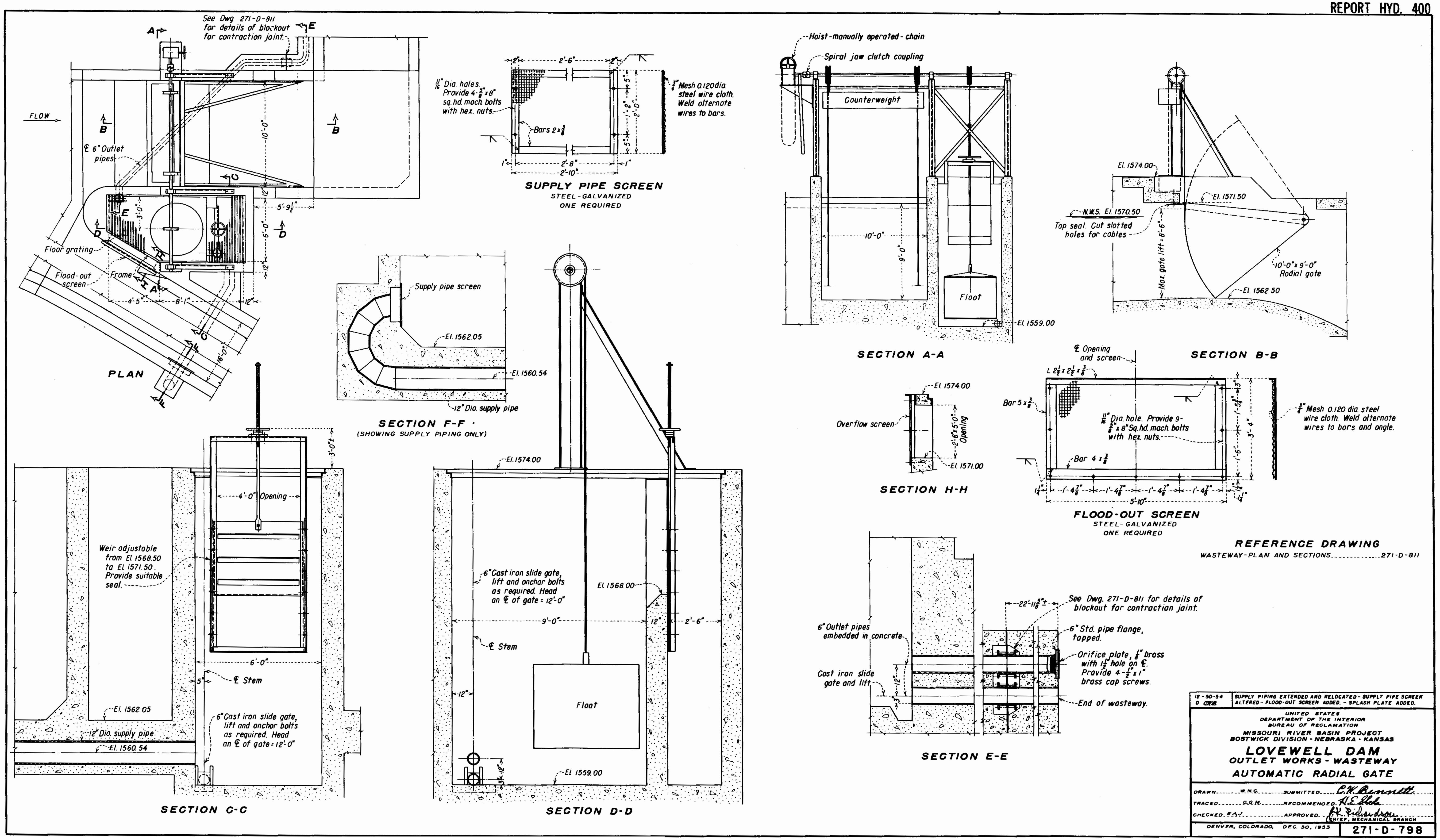
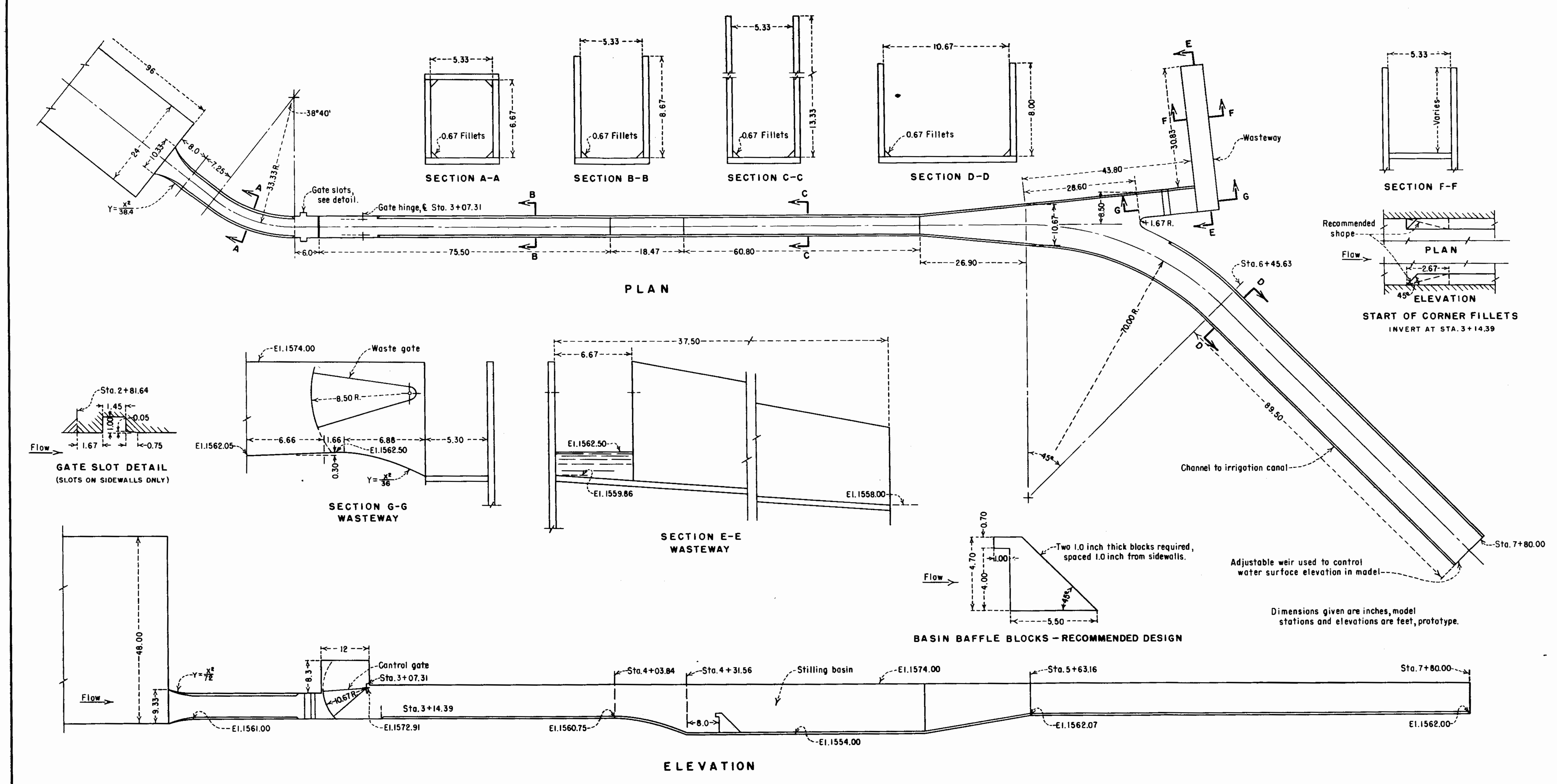


FIGURE 4
REPORT HYD. 400




See Dwg. 271-D-811 for details of blockout for contraction joint.
FLOW
℄ 6" Outlet pipes
Floor grating
Flood-out screen
Frame
PLAN
SUPPLY PIPE SCREEN
STEEL-GALVANIZED
ONE REQUIRED
11/16" Dia. holes. Provide 4-5/8"x8" sq. hd. mach bolts with hex. nuts.
Bars 2x3/8
Mesh 0.120 dia. steel wire cloth. Weld alternate wires to bars.
Supply pipe screen
El. 1562.05
El. 1560.54
12" Dia. supply pipe
SECTION F-F
(SHOWING SUPPLY PIPING ONLY)
Hoist-manually operated-chain
Spiral jaw clutch coupling
Counterweight
Float
El. 1559.00
SECTION A-A
El. 1574.00
El. 1571.50
N.W.S. El. 1570.50
Top seal. Cut slotted holes for cables
Max gate lift = 8'-6"
10'-0" x 9'-0" Radial gate
El. 1562.50
SECTION B-B
Overflow screen
2'-6" x 5'-0" Opening
El. 1571.00
SECTION H-H
℄ Opening and screen
L 2½ x 2½ x 3/8
Bar 5 x 3/8
11/16" Dia. hole. Provide 9-5/8" x 8" Sq. hd. mach. bolts with hex. nuts.
Bar 4 x 3/8
3/8" Mesh 0.120 dia. steel wire cloth. Weld alternate wires to bars and angle.
FLOOD-OUT SCREEN
STEEL-GALVANIZED
ONE REQUIRED
REFERENCE DRAWING
WASTEWAY-PLAN AND SECTIONS 271-D-811
4'-0" Opening
Weir adjustable from El. 1568.50 to El. 1571.50. Provide suitable seal.
℄ Stem
El. 1562.05
12" Dia. supply pipe
El. 1560.54
6" Cast iron slide gate, lift and anchor bolts as required. Head on ℄ of gate = 12'-0"
SECTION C-C
El. 1574.00
El. 1568.00
Float
El. 1559.00
SECTION D-D
See Dwg. 271-D-811 for details of blockout for contraction joint.
6" Std. pipe flange, tapped.
6" Outlet pipes embedded in concrete
Orifice plate, 1/8" brass with 1½" hole on ℄. Provide 4-½" x 1" brass cap screws.
Cast iron slide gate and lift
End of wasteway.
SECTION E-E
12-30-54 D CKB SUPPLY PIPING EXTENDED AND RELOCATED - SUPPLY PIPE SCREEN ALTERED - FLOOD-OUT SCREEN ADDED. - SPLASH PLATE ADDED.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
BOSTWICK DIVISION - NEBRASKA - KANSAS
LOVEWELL DAM
OUTLET WORKS - WASTEWAY
AUTOMATIC RADIAL GATE
DRAWN W.H.C. SUBMITTED C.W. Bennett
TRACED C.G.H. RECOMMENDED H.E. Slob
CHECKED E.A.J. APPROVED F.K. Richardson CHIEF, MECHANICAL BRANCH
DENVER, COLORADO, DEC. 30, 1953
271-D-798



LOVEWELL OUTLET WORKS AND WASTEWAY

MODEL ARRANGEMENT AND DETAIL

1 : 18 MODEL

516

Y-Section

Canal Supply Channel--Station 7+55.00

A. Minimum Reservoir Elevation 1571.71. Control gate full open.

Y-Section

Canal Supply Channel--Station 7+55.00

B. Reservoir Elevation at Maximum Irrigation Storage. Elevation 1582.60
Control gate 33% open.

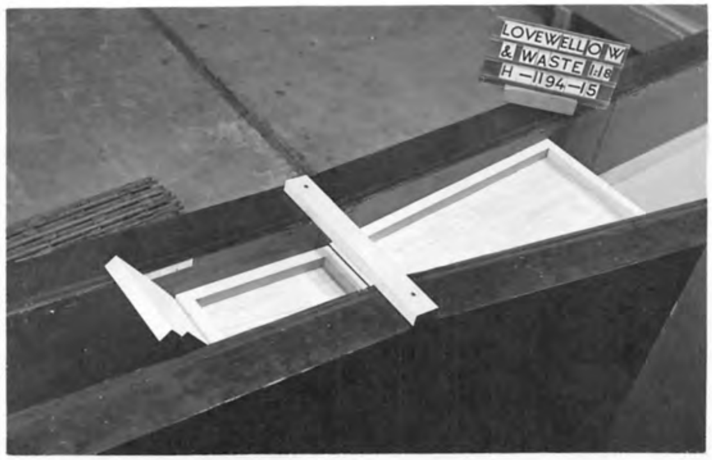
Y-Section

Canal Supply Channel--Station 7+55.00
Note curve in water line on sidewall.

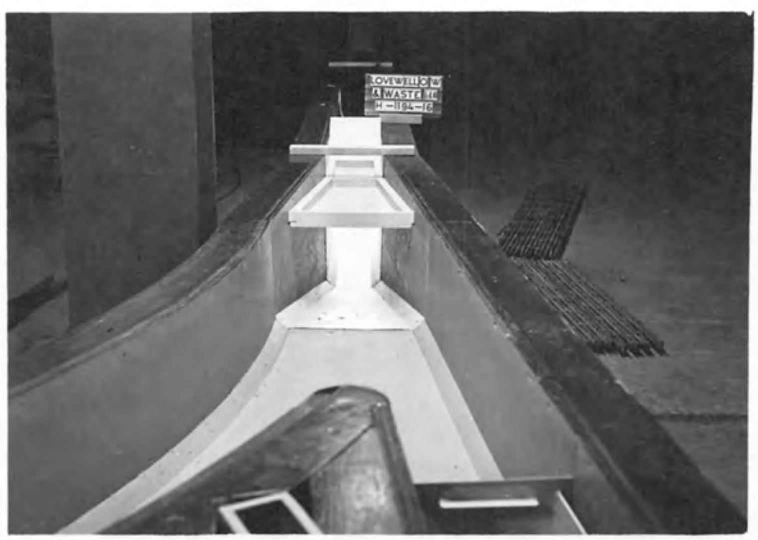
C. Maximum Reservoir Elevation 1610.30. Control gate 20% open.

LOVEWELL OUTLET WORKS AND WASTEWAY

Flow Conditions of Preliminary Design
Discharge of 635 cfs with Water Surface of Canal at Elevation 1570.50
1:18 Model



A. Side view. Flow is from left to right.



B. View from downstream.

LOVEWELL OUTLET WORKS AND WASTEWAY

Culvert-Type Wave Suppressor
1:18 Model

Y-Section

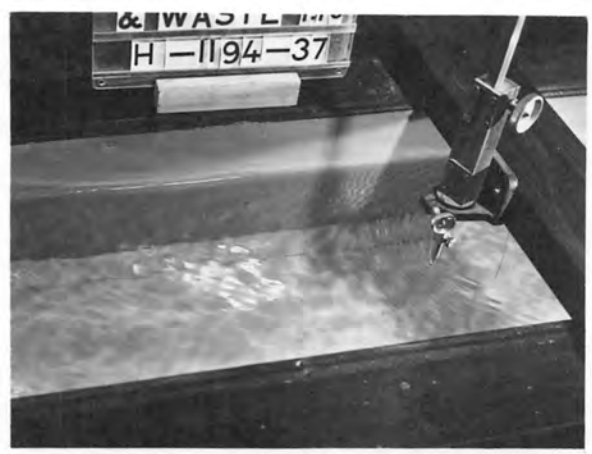
A. Minimum Reservoir Elevation 1571.78. Control gate full open.

Y-Section

Canal Supply Channel--Station 7+55.00

B. Reservoir Elevation at Maximum Irrigation Storage. Elevation 1582.60. Control gate 33% open.

Y-Section



Canal Supply Channel--Station 7+55.00

C. Maximum Reservoir Elevation 1610.30. Control gate 20% open.

LOVEWELL OUTLET WORKS AND WASTEWAY

Flow Conditions with Basin Blocks and Wave Suppressor
Discharge of 635 cfs with Water Surface at Canal at Elevation 1570.50
1:18 Model

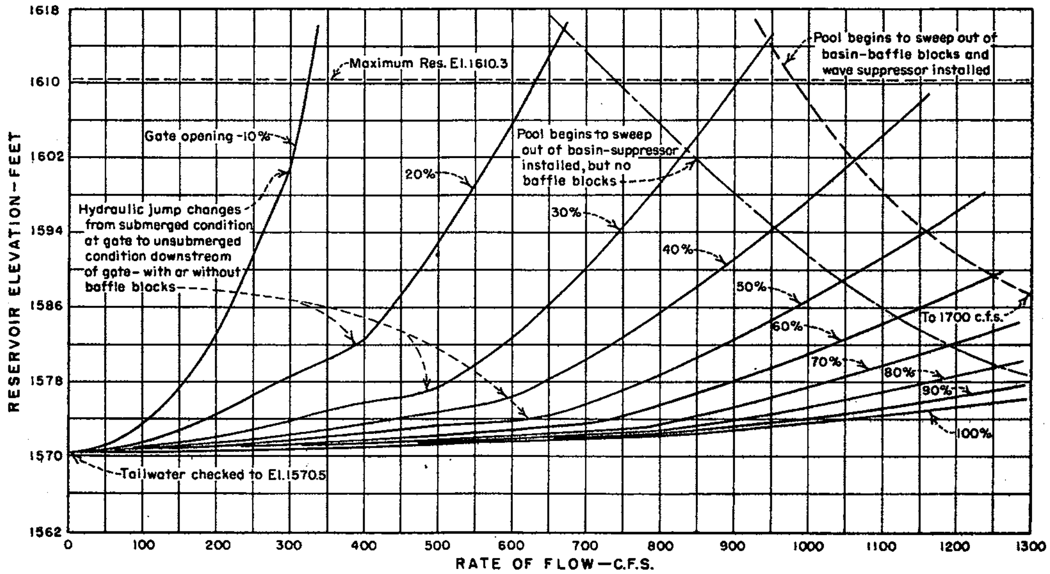
A. Water Passage below Control Gate.

B. Stilling Basin.

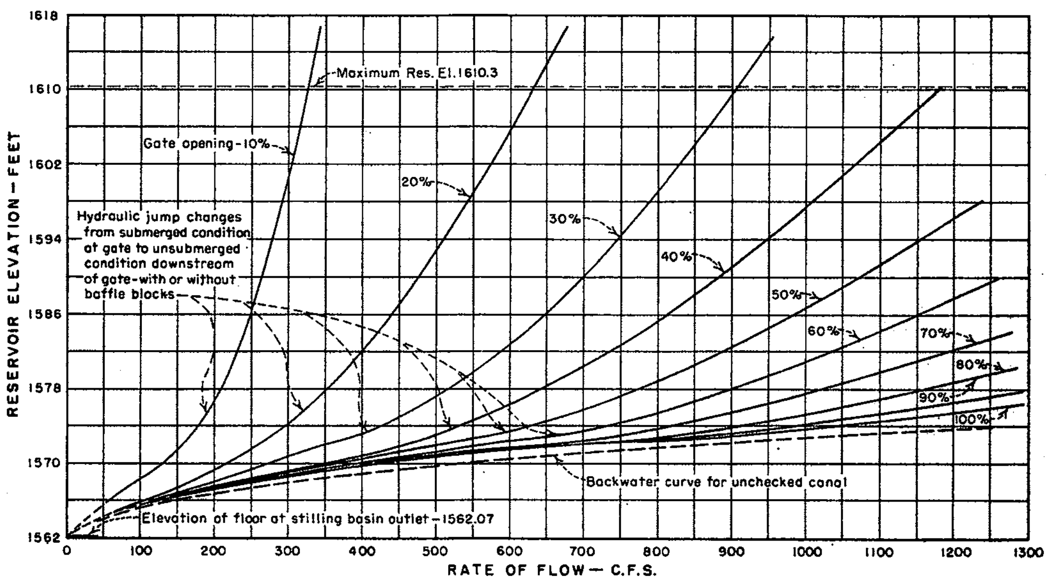
C. Y-Section 635 cfs Released by Wastegate and 635 cfs in Canal Supply Channel.

LOVEWELL OUTLET WORKS AND WASTEWAY

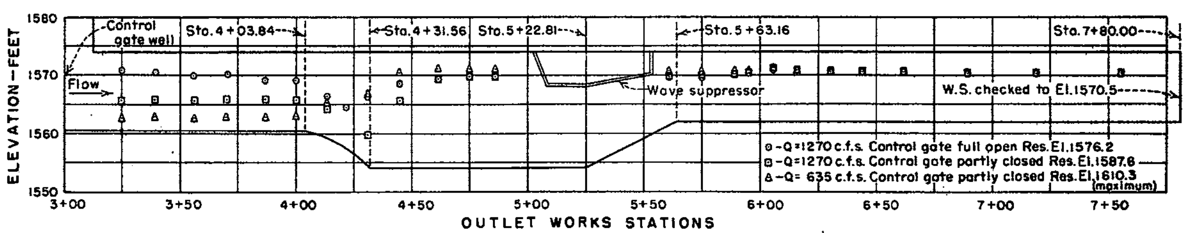
Flow Conditions With Basin Blocks and Wave Suppressor
Discharge of 1270 cfs with Water Surface of Canal at Elevation 1570.50
Control Gate Full Open and Reservoir at Elevation 1576.20
1:18 Model



A—RATE OF FLOW-VS-RESERVOIR ELEVATION WITH CANAL WATER SURFACE CHECKED TO EL.1570.50



B—RATE OF FLOW-VS-RESERVOIR ELEVATION WITH WATER SURFACE OF UNCHECKED CANAL FOLLOWING BACKWATER CURVE
(GATE OPENING IS THE VERTICAL DISTANCE FROM FLOOR TO GATE BOTTOM.)



C—WATER SURFACE PROFILES

LOVEWELL OUTLET WORKS AND WASTEWAY

RATE OF FLOW-VS-RESERVOIR ELEVATION FOR CONTROL GATE, AND WATER SURFACE PROFILES IN STRUCTURE

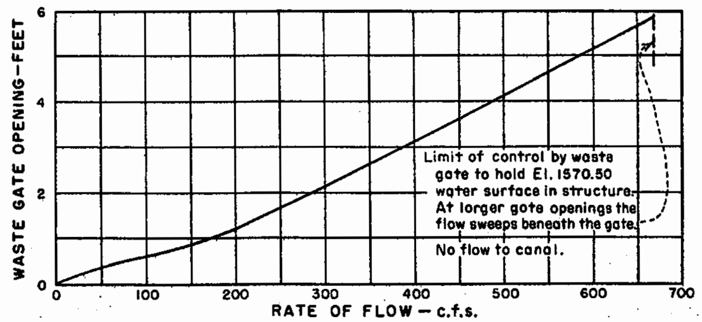
1:18 MODEL

A. Gate Controlling the Flow with Water Surface Elevation at Canal Entrance--1570. 50.

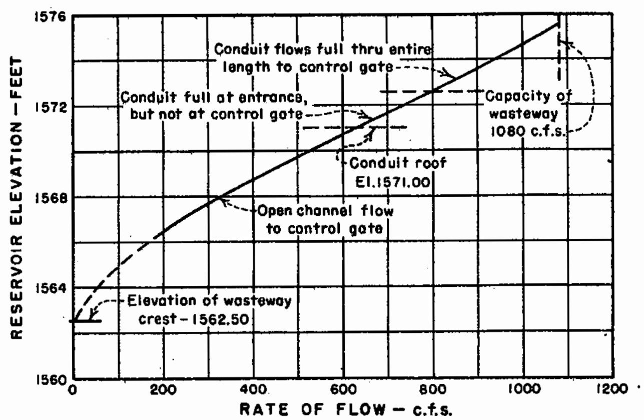
B. Gate Fully Opened. Water Surface Elevation at Canal Inlet--1570. 10.

LOVEWELL OUTLET WORKS AND WASTEWAY

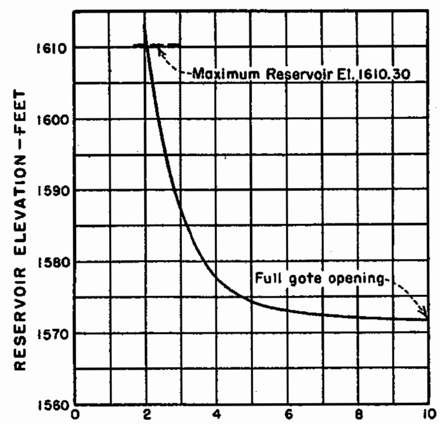
Flow Conditions at Wasteway Gate
Discharge of 635 cfs--No Flow to Canal
1:18 Model



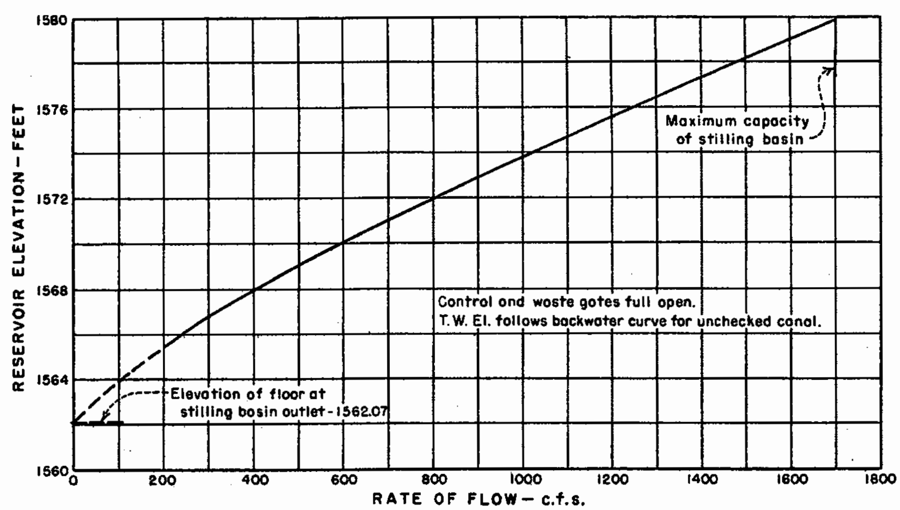
A—RATE OF FLOW -VS- WASTEWAY GATE OPENING WITH WATER SURFACE AT CANAL ENTRANCE AT EL. 1570.50



B-RATE OF FLOW -VS-RESERVOIR ELEVATION FOR FULL OPEN WASTEWAY GATE AND NO FLOW TO CANAL



C—GATE OPENING -VS- RESERVOIR ELEVATION FOR FLOW OF 635 C.F.S.



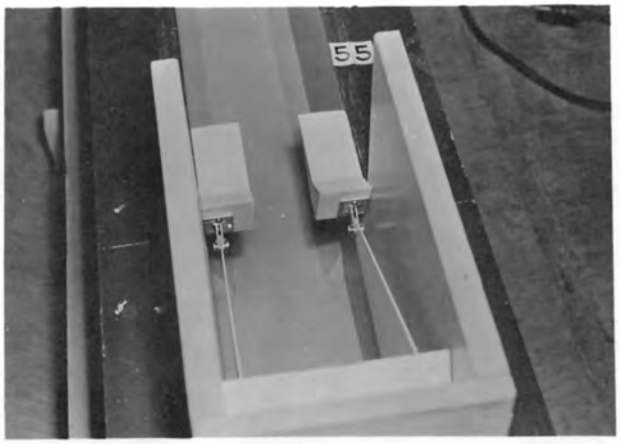
D—RATE OF FLOW -VS- RESERVOIR ELEVATION FOR FULL OPEN WASTEWAY GATE AND UNCHECKED CANAL

LOVEWELL OUTLET WORKS AND WASTEWAY

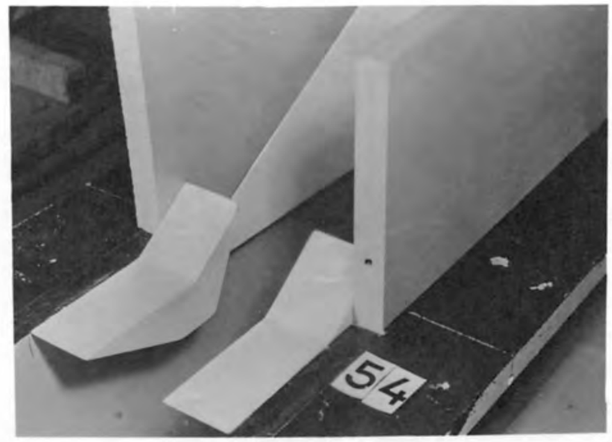
PERFORMANCE CURVES FOR WASTEWAY

1:18 MODEL

516



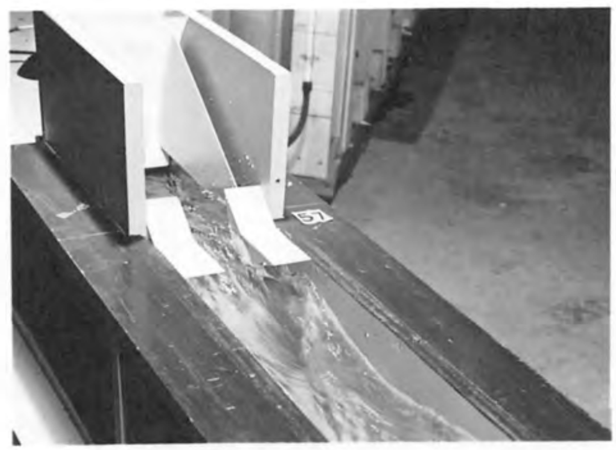
View from right side.



View from upstream.

A. Control Gate Hinge Blocks

View from upstream.



View from left side.

B. Flow With Gate Full Open

Standing wave moves to Station 3+18 when gate is closed 4%.

Standing waves move to Station 3+58 when gate is closed 7%. At greater closures the wave disappears.

C. Flow With Small Gate Closures.

- Model shown with no cover on section of closed conduit below control gate -

LOVEWELL OUTLET WORKS AND WASTEWAY

Interference of Hinge Blocks on Flow and Effect of Slightly Closing Control Gate - Discharge of 1270 cfs.
1:18 Model

A. Original Wasteway Entrance Closed by Curved Wall and New Entrance Provided Downstream.

B. Turbulence Occurs Due to Velocity Impact on Right Wasteway Wall. Full Open Control Gate with Reservoir Elevation 1571.71

LOVEWELL OUTLET WORKS AND WASTEWAY

Effect of Moving Wasteway Entrance Downstream
Discharge of 635 cfs with Full Open Control Gate
1:18 Model