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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES FOR THE DESIGN OF THE BOCA DAM SPILLWAY

TRUCKEE STORAGE PROJECT, NEVADA-CALIFORNIA

Hydraulic Laboratory Report No. Hyd.-225

ENGINEERING AND GEOLOGICAL
CONTROL AND RESEARCH DIVISION

J. N. Bradley

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Branch of Design and Construction
Engineering and Geological Control
and Research Division
Denver, Colorado
January 15, 1947

Laboratory Report No. 225
Hydraulic Laboratory
Tests by: J. H. Douma
Compiled by: C. V. Adkins
Reviewed by: J. N. Bradley

Subject: Hydraulic model studies for the design of the Boca Dam Spillway--Truckee Storage Project--Nevada-California.

PROBLEM

Early in 1937 the hydraulic laboratory was authorized to construct a model of the Boca Dam Spillway, Figure 1, for the purpose of studying the entrance conditions to the gate section; the flow through the gate section and the chute leading to the stilling pool; the energy dissipation in the stilling pool; and for obtaining head-discharge and coefficient curves for the spillway.

THE PROTOTYPE

Boca Dam is located on the Little Truckee River in California, approximately 20 miles west of Reno, Nevada, Figure 2. The structure is an earth embankment having a maximum height of 110 feet and a crest length of 1,650 feet. The spillway, in the left abutment of the dam, is a concrete-lined open channel terminating in a concrete-lined stilling pool, and will have a total length of approximately 555 feet. The maximum capacity of the spillway is 8,000 second-feet. Flow over the spillway will be controlled by two radial gates each 19 feet long and 16 feet high, installed at the crest of the spillway.

MODEL TESTS

The person who conducted the model study on the Boca Dam Spillway is no longer with this Bureau and the writer was not present when the

tests were conducted. The data and drawings received by him for the purpose of writing the report were meager, therefore many of the desirable details have been omitted rather than to make vague or unsupported statements concerning them. The information presented is believed to be the correct interpretation of the available data.

Initial model tests indicated that a few refinements should be made on the original design. The spillway design as first tested is shown on Figure 1. Photographs of the entrance transition of this design are shown in Figure 3A and B. Four transitions were tested simultaneously with two different shapes of overflow section. There was no information to indicate the undesirable features of the various entrance transitions but the fourth one, Figure 3C and D, and Figure 4, was recommended for prototype construction. The jet did not follow the surface of the original overflow section. The surface of the section immediately downstream from the crest axis was raised slightly by changing it to a parabolic shape, Figure 5. The resulting design proved satisfactory and was recommended. The coefficient curves for both the original and the recommended entrances and overflow sections are shown on Figure 6 for the gates fully open.

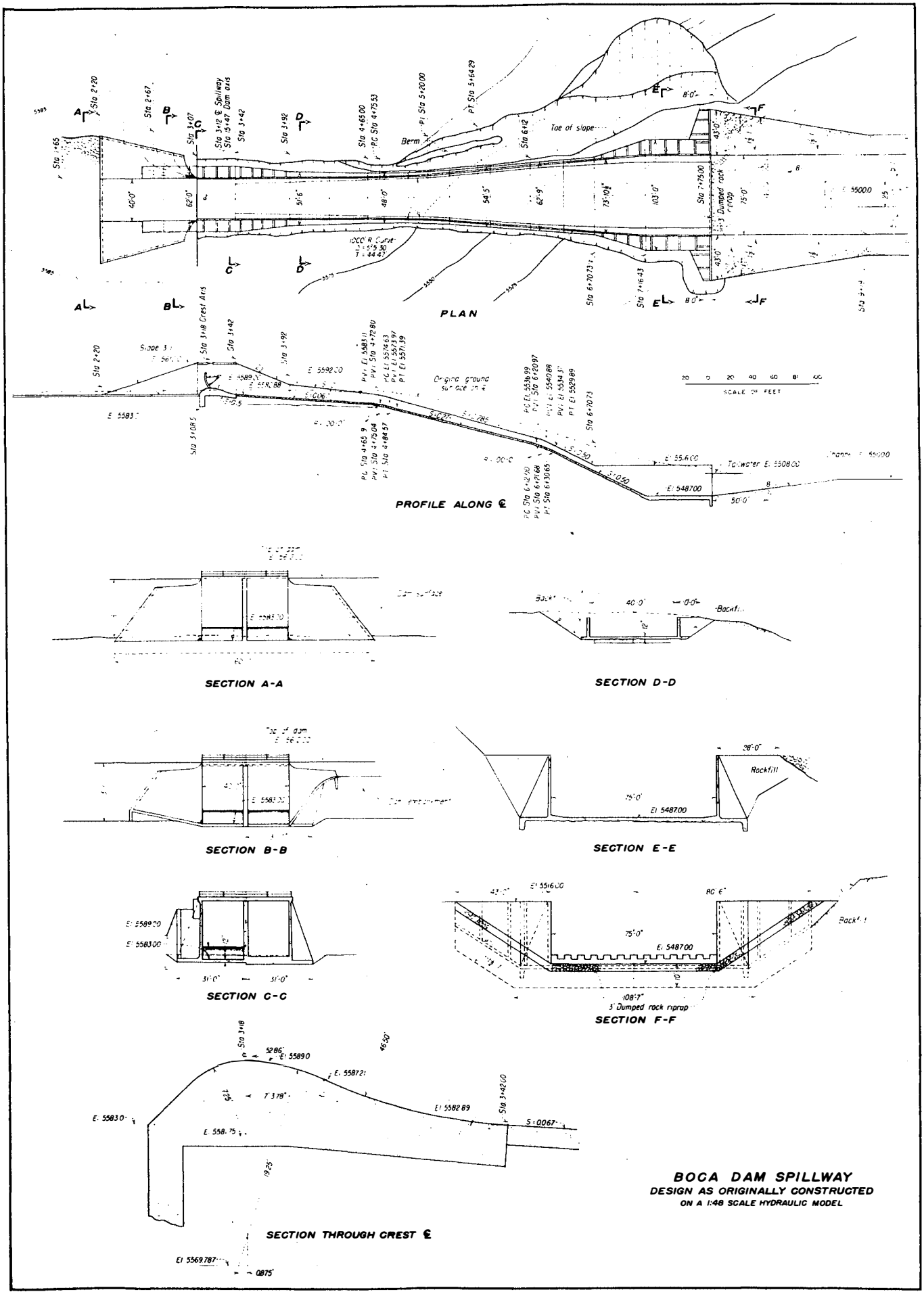
Observations were made of the flow conditions in the chute connecting the gate section with the stilling pool. The most adverse conditions appeared to be for a discharge of 4,380 second-feet passing through one gate fully open and the other one open 1.5 feet. These conditions were not considered of a serious nature, particularly since there was still ample freeboard. Water-surface profiles along the chute walls for two discharges are shown on Figure 7. Figure 8A and B are views looking upstream toward the spillway crest and gate section.

Several runs were made using various combinations of channel and stilling pool floor elevations to determine the proper elevation of the stilling pool floor with respect to the channel bottom to keep the tail-water from sweeping out, and at the same time to keep the velocities from becoming excessive as the water passed from the stilling pool to the channel. The original sill was included in each of these runs. The most satisfactory combination, averaging hydraulic performance and economy of construction, was with the pool floor at elevation 5487 and the channel floor at elevation 5498.

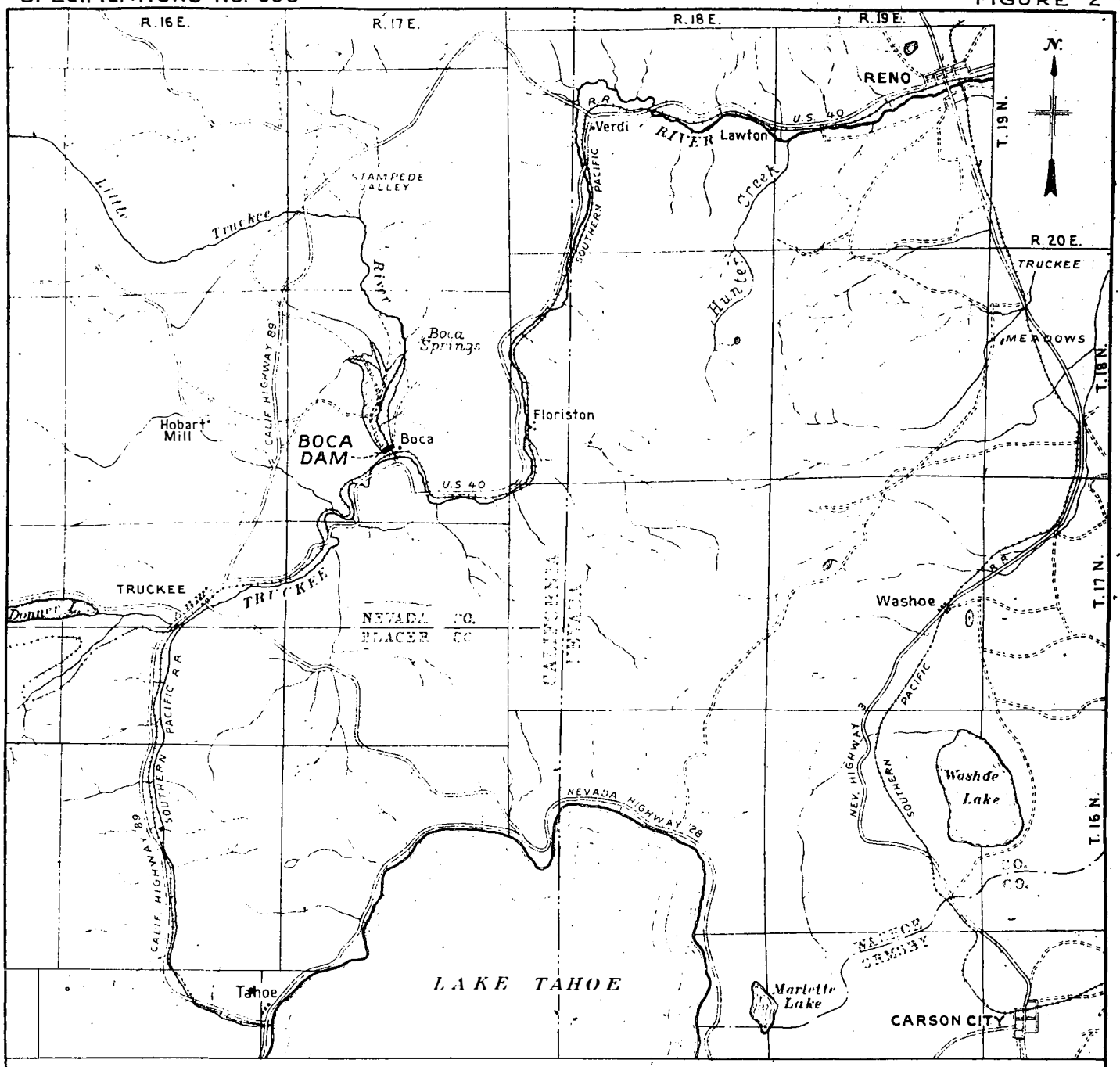
The remaining problems were to determine the necessary height of the stilling pool walls and to investigate the possibilities of improving the energy dissipation in the stilling pool. Approximately 30 different tests were made, using various types and arrangements of dentates and end sills. From these tests two schemes of almost equal satisfaction were evolved. One was the original Rehbock sill at the downstream end of the horizontal pool floor, and the other was a solid sill at the same location, accompanied by a set of dentates on the horizontal floor, a distance of 10 feet upstream from the solid sill. Both of these schemes were accompanied by a set of dentates at the upstream end of the pool on the toe of the 2:1 sloping apron. Photographs 9A and B show the two arrangements of the teeth and sills in the stilling pool. Photographs C and D in Figures 8 and 9 show flow conditions in the pool for the two sill arrangements. The water surface in the pool was smoother and the scour downstream from the riprap was less severe when using the dentates and solid sill in the stilling pool. However, the Rehbock sill was recommended because; (1) the scouring of the channel could not damage the spillway structure; (2) the designers had intended for the channel to be scoured to some extent; and (3) the Rehbock sill was the same one already designed for the prototype.

The model indicated that there was about 1.5 feet of difference between the normal channel water surface for a satisfactory jump and the water surface at which the tailwater swept out of the pool when using the Rehbock sill. Rather than operate on such a narrow margin the channel bottom was raised to elevation 5500. The tops of the stilling pool walls were set at elevation 5516. Figure 4, revised November 8, 1940, shows the elevations of the stilling pool floor and walls to be 5487 and 5516 respectively, as was indicated by the model tests. Figure 10, revised September 18, 1941, shows the elevations of the stilling pool floor and walls to be 5489 and 5514 respectively. These changes were made subsequent to completion of the model tests. The writer was unable to obtain information pertaining to the reason for the changes and has assumed that they were the result of either construction or economic problems encountered in the field subsequent to the laboratory work.

FIGURE 1

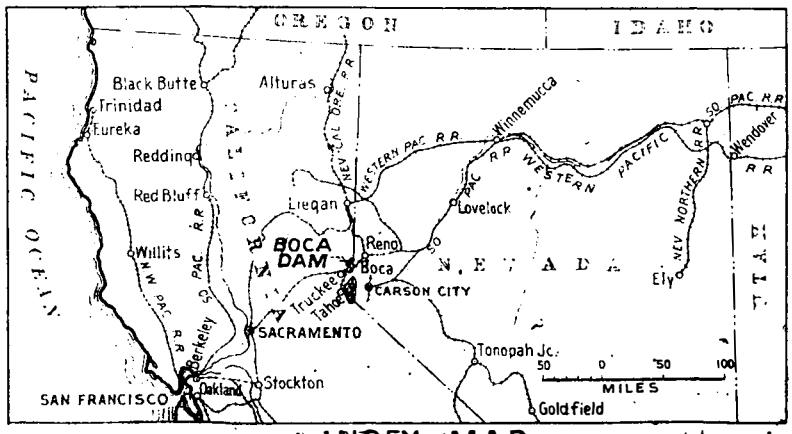


BOCA DAM SPILLWAY
DESIGN AS ORIGINALLY CONSTRUCTED
ON A 1:48 SCALE HYDRAULIC MODEL



VICINITY MAP

1 0 1 2 3 4 5
Scale of Miles



INDEX MAP

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
TRUCKEE STORAGE PROJECT-NEVADA-CALIF.

BOCA DAM
LOCATION MAP

DRAWN W.E.C. SUBMITTED
TRACED M.T.Y. RECOMMENDED
CHECKED APPROVED

28479 | DENVER, COLORADO, AUG. 24, 1936 | 247-D-31

A. Original spillway approach.
Q=4000 sec.-ft. One gate open.

B. Original spillway approach.
Q=8000 sec.-ft. Two gates open.

C. Recommended spillway approach.
Model dry.

D. Recommended spillway approach.
Q=8000 sec.-ft. Two gates open.

BOCA DAM SPILLWAY APPROACH
1:48 Model

FIGURE 4

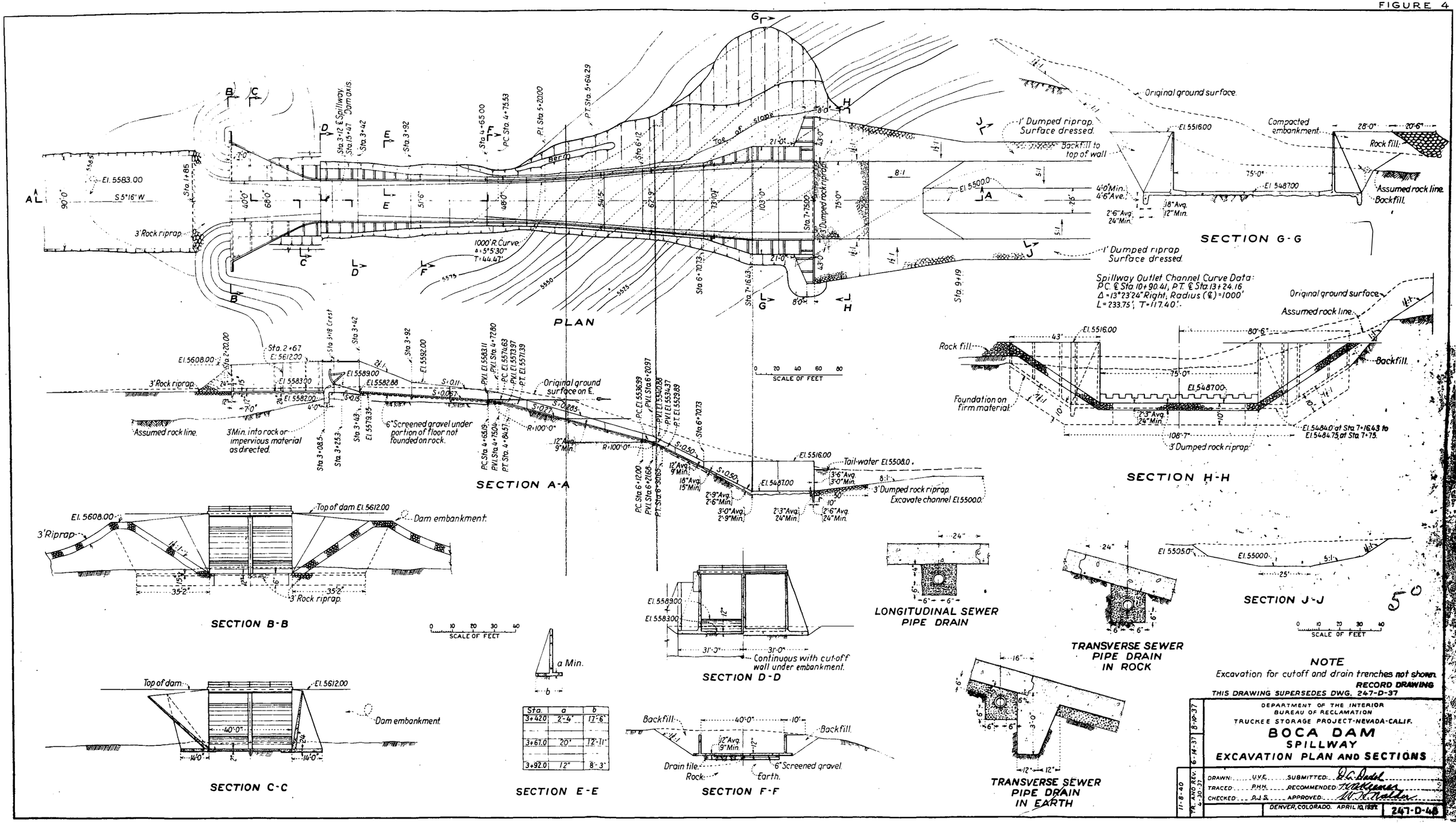
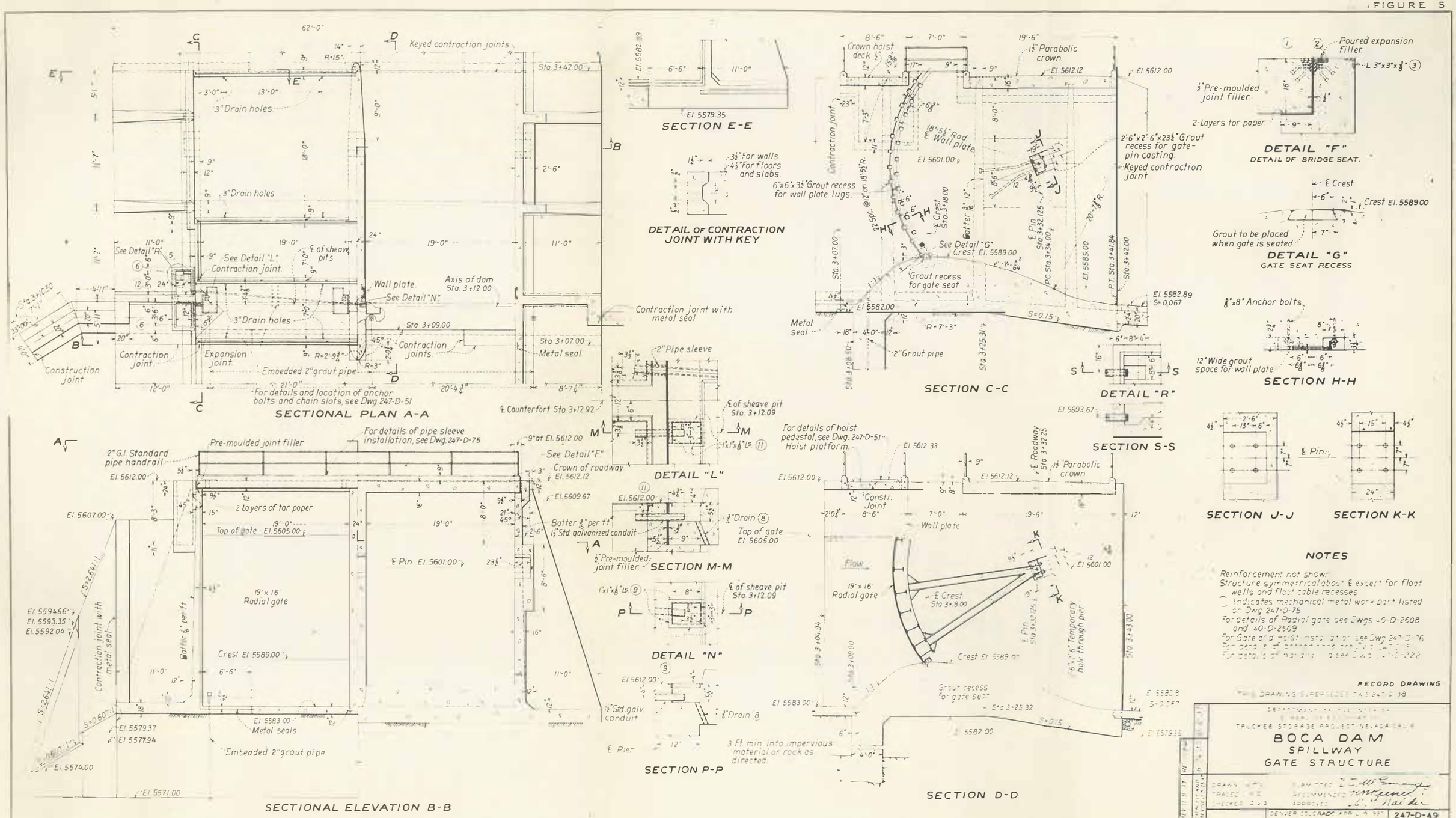
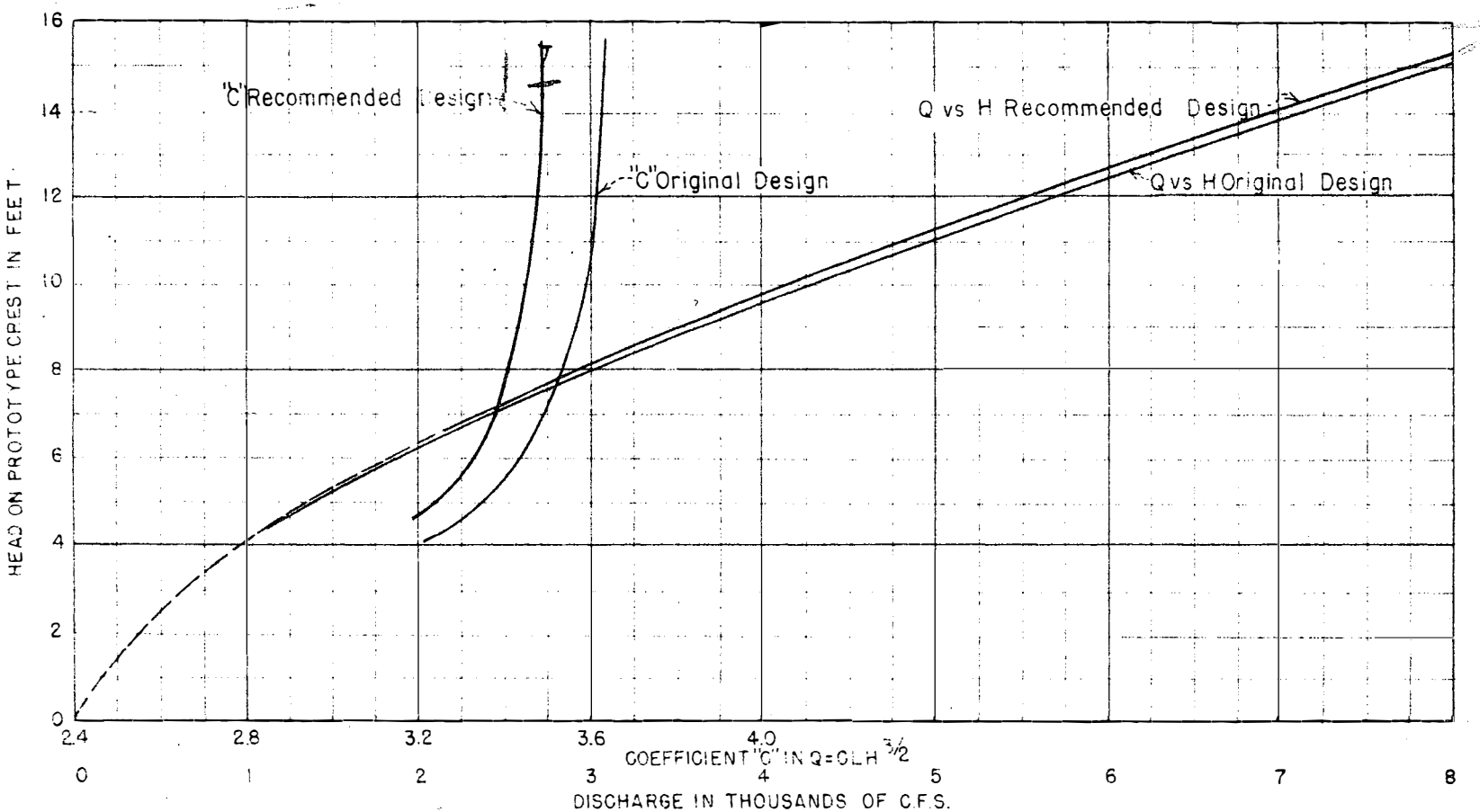

PLAN
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
SECTION G-G
SECTION H-H
SECTION J-J
LONGITUDINAL SEWER PIPE DRAIN
TRANSVERSE SEWER PIPE DRAIN IN ROCK
TRANSVERSE SEWER PIPE DRAIN IN EARTH
SCALE OF FEET
Spillway Outlet Channel Curve Data:
P.C. ℄ Sta. 10+90.41, P.T. ℄ Sta. 13+24.16,
Δ = 13°23'24" Right, Radius (℄) = 1000'
L = 233.75', T = 117.40'.
1000' R. Curve
Δ = 5°5'30"
T = 44.47'
Original ground surface.
Assumed rock line.
Backfill.
Rock fill.
Foundation on firm material.
Tail-water El. 5508.0
Excavate channel El. 5500.0
Continuous with cut-off wall under embankment.
Top of dam El. 5612.00
Dam embankment.
3' Rock riprap.
3' Dumped rock riprap.
1' Dumped riprap. Surface dressed.
Backfill to top of wall
Compacted embankment.
Drain tile.
Rock.
Earth.
6" Screened gravel.
6" Screened gravel under portion of floor not founded on rock.
3' Min. into rock or impervious material as directed.
Berm
Toe of slope
NOTE
Excavation for cutoff and drain trenches not shown.
RECORD DRAWING
THIS DRAWING SUPERSEDES DWG. 247-D-37
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
TRUCKEE STORAGE PROJECT-NEVADA-CALIF.
BOCA DAM
SPILLWAY
EXCAVATION PLAN AND SECTIONS
DRAWN: U.V.E.
TRACED: P.H.H.
CHECKED: D.J.S.
SUBMITTED: D. C. Dodd
RECOMMENDED: T. K. Greenes
APPROVED: W. H. Nolder
DENVER, COLORADO. APRIL 10, 1932
247-D-48
11-8-40
4-30-37
6-14-37
8-19-37

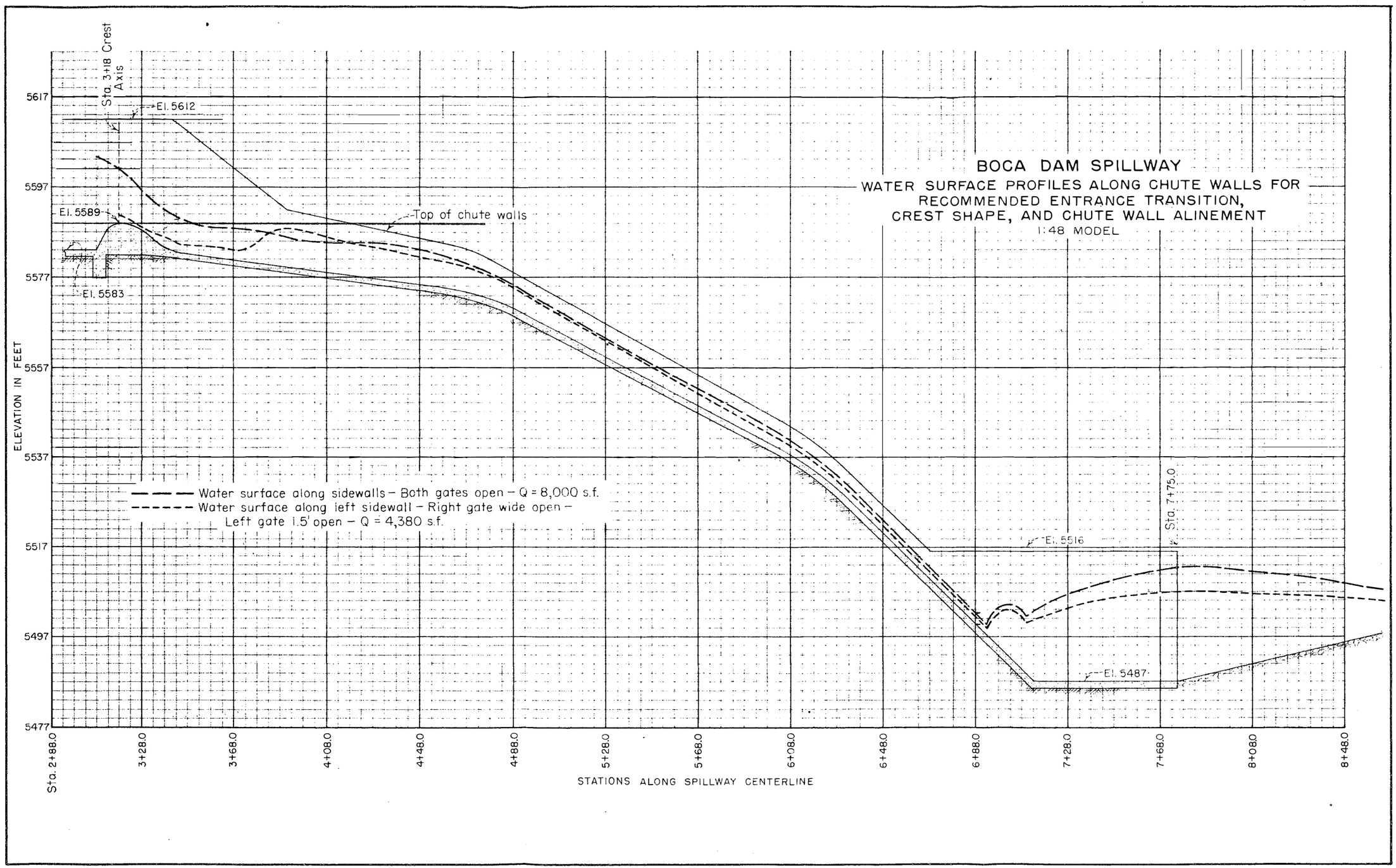
FIGURE 5


SECTIONAL PLAN A-A
SECTIONAL ELEVATION B-B
SECTION E-E
DETAIL OF CONTRACTION JOINT WITH KEY
SECTION C-C
DETAIL "F"
DETAIL OF BRIDGE SEAT.
DETAIL "G"
GATE SEAT RECESS
DETAIL "R"
SECTION S-S
SECTION H-H
SECTION J-J
SECTION K-K
DETAIL "L"
SECTION M-M
DETAIL "N"
SECTION P-P
SECTION D-D
NOTES
Reinforcement not shown.
Structure symmetrical about ℄ except for float wells and float cable recesses.
( ) Indicates mechanical metal work part listed on Dwg 247-D-75
For details of Radial gate see Dwgs 40-D-2608 and 40-D-2609
RECORD DRAWING
BOCA DAM
SPILLWAY
GATE STRUCTURE
247-D-49



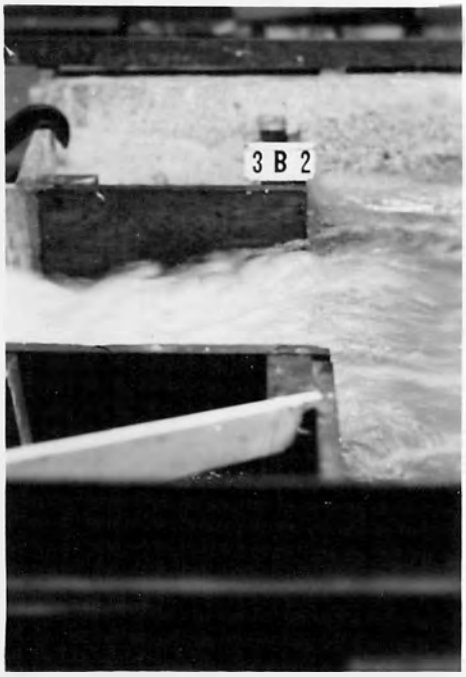
BOCA DAM SPILLWAY
COEFFICIENT AND DISCHARGE CURVES
AS DETERMINED FROM A1:48
HYDRAULIC MODEL

FIGURE 6

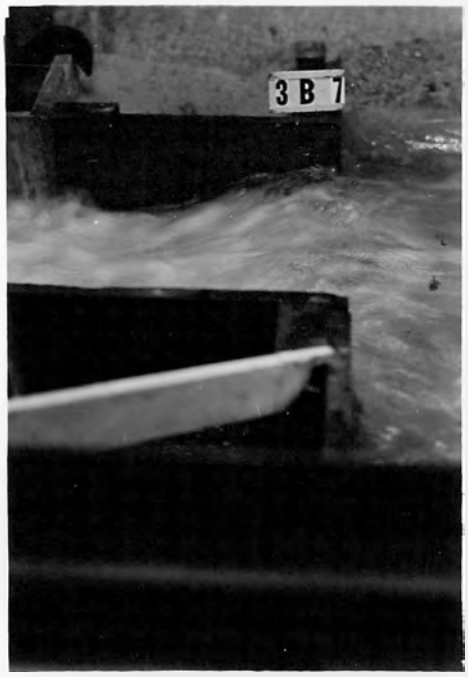

BOCA DAM SPILLWAY
WATER SURFACE PROFILES ALONG CHUTE WALLS FOR RECOMMENDED ENTRANCE TRANSITION, CREST SHAPE, AND CHUTE WALL ALINEMENT
1:48 MODEL
Sta. 3+18 Crest Axis
El. 5612
El. 5589
El. 5583
Top of chute walls
El. 5516
El. 5487
Sta. 7+75.0
Water surface along sidewalls – Both gates open – Q = 8,000 s.f.
Water surface along left sidewall – Right gate wide open – Left gate 1.5' open – Q = 4,380 s.f.
ELEVATION IN FEET
5617
5597
5577
5557
5537
5517
5497
5477
Sta. 2+88.0
3+28.0
3+68.0
4+08.0
4+48.0
4+88.0
5+28.0
5+68.0
6+08.0
6+48.0
6+88.0
7+28.0
7+68.0
8+08.0
8+48.0
STATIONS ALONG SPILLWAY CENTERLINE

A. Looking upstream towards spillway crest and gate section.

B. Looking upstream. Discharge of 8000 sec.-ft. passing over crest.



C. Dentates and solid sill in pool. Discharge of 8000 sec.-ft. passing through two gates T.W. elevation = 5508.0



D. Rehbock sill in pool. Discharge of 8000 sec.-ft. passing through two gates T.W. elevation = 5508.0.

BOCA DAM SPILLWAY OVERFLOW SECTION AND STILLING POOL
1:48 Model

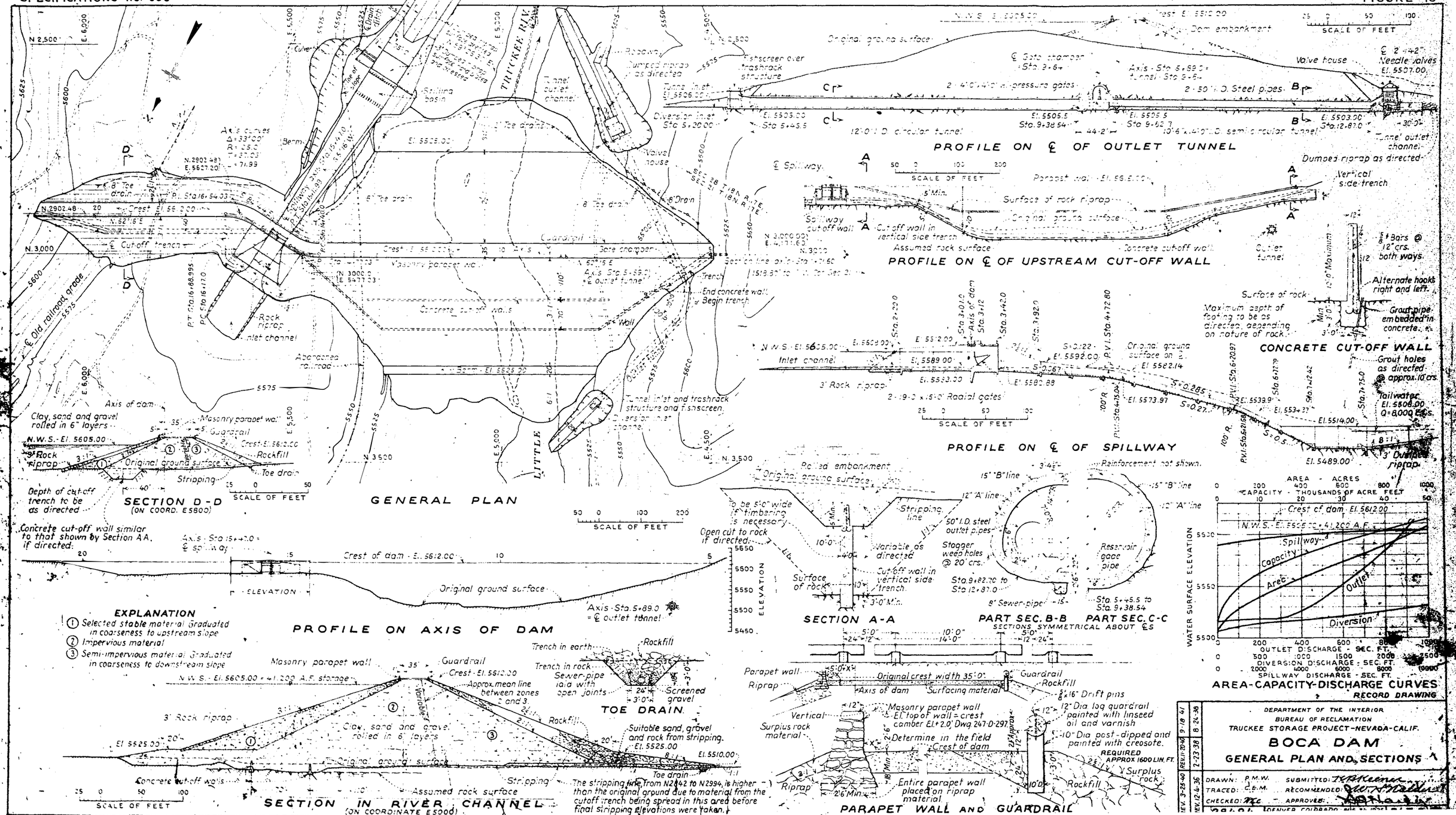
A. Looking downstream into pool. Rehbock sill in place.

B. Looking downstream into pool. Solid sill and dentates in place.

C. Looking upstream into pool with Rehbock sill. Discharge = 4000 s.f. T.W. elev. = 5503.0.

D. Looking upstream into pool with solid sill and dentates. Discharge=4000 s.f. T.W.elev.= 5503.0.

BOCA DAM SPILLWAY STILLING POOL
1:48 MODEL


GENERAL PLAN
SCALE OF FEET
TRUCKEE RIV.
LITTLE
Stilling basin
Tunnel outlet channel
Tunnel inlet and trashrack structure and fishscreen
Diversion inlet channel
Valve house
Dumped riprap as directed
Fishscreen over trashrack structure
Tunnel inlet
Diversion inlet Sta. 5+20.00
Masonry parapet wall
Guardrail
Gate chamber
Concrete cut-off walls
Rock riprap
Inlet channel
Abandoned railroad
Old railroad grade
Cut-off trench
End concrete wall
Begin trench
Axis of dam
Clay, sand and gravel rolled in 6" layers
N.W.S. - El. 5605.00
Rock riprap
Original ground surface
Stripping
Rockfill
Toe drain
Depth of cut-off trench to be as directed
SECTION D-D
(ON COORD. E5800)
Concrete cut-off wall similar to that shown by Section AA, if directed.
Crest of dam - El. 5612.00
Original ground surface
Axis - Sta. 5+89.0 = ℄ outlet tunnel
PROFILE ON AXIS OF DAM
EXPLANATION
1 Selected stable material Graduated in coarseness to upstream slope
2 Impervious material
3 Semi-impervious material Graduated in coarseness to downstream slope
Masonry parapet wall
Guardrail
Crest - El. 5612.00
N.W.S. - El. 5605.00 = 41,200 A.F. storage
Approx. mean line between zones 2 and 3
3' Rock riprap
Clay, sand and gravel rolled in 6" layers
Rockfill
Suitable sand, gravel and rock from stripping.
El. 5525.00
El. 5510.00
Original ground surface
Concrete cut-off walls
Stripping
Assumed rock surface
Toe drain
SECTION IN RIVER CHANNEL
(ON COORDINATE E5000)
The stripping line from N2842 to N2994, is higher than the original ground due to material from the cutoff trench being spread in this area before final stripping elevations were taken.
Trench in earth
Trench in rock
Sewer-pipe laid with open joints
Screened gravel
TOE DRAIN
Dam embankment
Original ground surface
Gate chamber Sta. 3+6
Axis - Sta. 5+89.0 = Tunnel - Sta. 9+6
2 - 4'-0" x 4'-0" H. pressure gates
2 - 50" I.D. Steel pipes
Valve house
2 - 42" Needle valves El. 5507.00
12'-0" I.D. circular tunnel
10'-6" x 4'-0" I.D. semi circular tunnel
Tunnel outlet channel
Dumped riprap as directed
PROFILE ON ℄ OF OUTLET TUNNEL
℄ Spillway
Parapet wall - El. 5616.00
Surface of rock riprap
Original ground surface
Vertical side trench
Spillway cut-off wall
Cut-off wall in vertical side trench
Assumed rock surface
Concrete cut-off wall
Outlet tunnel
PROFILE ON ℄ OF UPSTREAM CUT-OFF WALL
Alternate hooks right and left.
Grout pipe embedded in concrete.
Surface of rock
Maximum depth of footing to be as directed, depending on nature of rock.
CONCRETE CUT-OFF WALL
Grout holes as directed @ approx. 10' crs.
Tailwater El. 5508.00 Q=8,000 C.F.S.
3' Dumped riprap
Inlet channel
3' Rock riprap
2 - 19'-0" x 16'-0" Radial gates
Original ground surface on ℄
PROFILE ON ℄ OF SPILLWAY
Rolled embankment
Original ground surface
Reinforcement not shown.
Stripping line
Open cut to rock if directed.
Variable as directed
Surface of rock
Cut-off wall in vertical side trench
50" I.D. steel outlet pipes
Stagger weep holes @ 20' crs.
Sta. 9+82.70 to Sta. 12+87.0
Reservoir gage pipe
8" Sewer-pipe
Sta. 5+45.5 to Sta. 9+38.54
SECTION A-A
PART SEC. B-B
PART SEC. C-C
SECTIONS SYMMETRICAL ABOUT ℄S
Parapet wall
Riprap
Original crest width 35'-0"
Axis of dam
Surfacing material
Guardrail
Rockfill
5/8" x 16" Drift pins
Masonry parapet wall El. top of wall = crest camber El. + 2.0' Dwg. 247-D-297
Determine in the field
Crest of dam
Vertical
Surplus rock material
12" Dia. log guardrail painted with linseed oil and varnish
10" Dia. post - dipped and painted with creosote.
REQUIRED APPROX. 1600 LIN. FT.
Surplus rock
Entire parapet wall placed on riprap material
PARAPET WALL AND GUARDRAIL
AREA - ACRES
CAPACITY - THOUSANDS OF ACRE FEET
Crest of dam El. 5612.00
N.W.S. - El. 5605.00 = 41,200 A.F.
Spillway
Capacity
Area
Outlet
Diversion
WATER SURFACE ELEVATION
OUTLET DISCHARGE - SEC. FT.
DIVERSION DISCHARGE - SEC. FT.
SPILLWAY DISCHARGE - SEC. FT.
AREA-CAPACITY-DISCHARGE CURVES
RECORD DRAWING
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
TRUCKEE STORAGE PROJECT-NEVADA-CALIF.
BOCA DAM
GENERAL PLAN AND SECTIONS
DRAWN: P.M.W.
TRACED: C.E.M.
CHECKED:
SUBMITTED:
RECOMMENDED:
APPROVED:
DENVER, COLORADO