HYD 104

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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HYDRAULIC LABORATORY REPORT NO. 104

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HYDRAULIC MODEL STUDIES OF MURDOCK DIVERSION DAM PROVO RIVER PROJECT - UTAH

By

F. C. Lowe

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Denver, Colorado

February 13, 1942

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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
February 13, 1942

Laboratory Report No. 104
Hydraulic Laboratory
Compiled by: F. C. Lowe

Reviewed by:

Subject: Hydraulic model studies in the design of Murdock diversion dam - Provo River Project, Utah.

INTRODUCTION

The Murdock diversion dam will be constructed on the Provo River, seven miles north of Provo, Utah, to replace the smaller existing structure which forms the headworks of the Provo Reservoir canal (figures 1 and 2). This new structure will include the canal headworks, a sluiceway to control the normal flow of the river up to 1,000 second-feet, and an overthrow weir to pass flood waters. The capacity of the canal itself will be 550 second-feet, while the sluiceway and overflow weir will be designed for a maximum flood of 5,000 second-feet.

A hydraulic model of the Murdock diversion dam was constructed to study the canal headworks and to observe the scour downstream from the sluiceway and the overflow weir (figures 3 and 4). As this diversion dam was similar to other designs built by the Bureau of Reclamation, few revisions were necessary in the model to achieve a final design. Training walls were included in the abutments upstream from the dam to improve the flow into the canal headworks (figure 2). Scour downstream from the sluiceway was reducing by lowering the sluiceway bucket one foot, and the buckets at the toe of the overflow weir were revised (figure 3).

Although this final design of the spillway buckets at the toe of the overflow weir was satisfactory for the Murdock Dam, the design should not be applied indiscriminately to similar structures as investigations have not been sufficiently general to determine any general rules for the design of spillway buckets.

MODEL

A 1 to 40 scale model was built and tested in the hydraulic laboratory (figures 3 and 4). The diversion dam was constructed similar to the prototype, except the trashracks and fish screens were not installed in the headworks of the canal. As revisions were anticipated in the buckets of the sluiceway and overflow weir, these structures were designed to permit changes. To observe the scour patterns downstream from the dam, the topography was made with sand. Upstream from the dam, however, this sand topography was stabilized with cement. The total flow was measured by a venturi meter, and the flow into the canal headworks was measured by a small triangular weir.

HEADWORKS STUDY

The headworks of the Provo Reservoir canal consists of an entrance channel 42 feet wide divided into two 20-foot openings by a pier which supports the trashracks and fish screens installed in each opening (figure 2). From these openings, the water discharges through an inlet transition into a rectangular flume 16 feet wide. A radial gate at the entrance of this flume controls the flow into the canal proper, which is 200 feet downstream from the gate.

The width of the 20-foot openings in the entrance channel was so determined that the velocity through them would not exceed two feet per second, the maximum to prevent fish from being trapped on the screen. Therefore, it was important that the velocity of flow into the headworks be uniformly distributed. To determine if this were true, dye was injected into the model flow upstream from the headworks. The velocity distribution for the original design was satisfactory. This also held true regardless of whether the old diversion dam was removed or not; but this structure will be removed to improve the appearance of the site. Some consideration was also given to removing the hummock in the center of the river bed, which diverted the flow into a channel along the left bank (figure 3). However, when a test was made by obstructing the river channel, so the current would not swing toward the left bank, a condition which assimilated the removal of the hummock, the flow of water into the headworks was not uniform as before; so it was decided not to remove the hummock.

During these tests, the fish screens and trashracks were not installed, for it was assumed that the flow into the headworks would be improved by passing through the screens, so, their installation in the model was unnecessary.

Although the original design of the headworks was considered generally satisfactory, two revisions were made in the final design which affected the flow into the headworks. First, training walls were placed on the upstream abutments of the dam (compare figure 2 with figure 3). Model tests indicated that these training walls improved the flow into the headworks. The second revision was a change in the alinement of the overflow weir. However, this change in alinement was small, so it was not incorporated in the model tests as it was considered negligible.

SCOUR DOWNSTREAM FROM THE DAM

In addition to observing the flow into the canal headworks, the scour downstream from the sluiceway and overflow weir was studied at discharges of 1,000, 3,000, and 5,000 second-feet, prototype (figures 5 and 6). A high tailwater elevation permitted the use of buckets at the toe of these structures (figure 3), their function being to turn the flow of the water over the dam into the tailwater at an angle as to form a roller eddy with a horizontal axis over the bucket. When a bucket is properly designed for a given tailwater elevation, the energy of the flow will be dissipated into the tailwater above the river bed, and the scour on the river bed will be a minimum.

The scour downstream from the sluiceway was considerable when the sluiceway was operating alone at a discharge of 1,000 second-feet. It was apparent that this scour was due to an insufficient tailwater elevation at the sluiceway exit since no roller eddy formed over the sluiceway bucket nor was the flow through the sluiceway itself appreciably retarded by the tailwater. To correct this condition, the sluiceway bucket was lowered one feet prototype, and was extended downstream 1½ feet (figure 3 final design).

Although this revision to the bucket reduced the scour downstream from the sluiceway, it caused some scour at the toe of the adjacent overflow weir. To minimize this latter scour, the training walls on each side of the sluiceway were extended downstream 1½ feet.

The scour downstream from the overflow weir was not excessive, but it was felt that the bucket at its toe could be improved. An objectionable feature of this bucket, type 1 figure 3, was that the slope at its toe was 3/4 to 1 while a 1 to 1 slope was considered as a better design in previous model studies. Four additional types of buckets, types 2 to 5, figure 3, were compared with the original design, type 1, by replacing a portion of the original with the other types, each in a successive test. Unfortunately, the scale model was too small to permit anything more than a qualitative comparison. Types 2 and 3 showed better scour conditions than did type 1, while that of type 4 did not differ greatly, and type 5, a long-radius bucket, caused more scour downstream than did type 1. Type 2 was selected for the final design since it functioned as well as any other and also required the least amount of concrete to build.

FIGURE 1

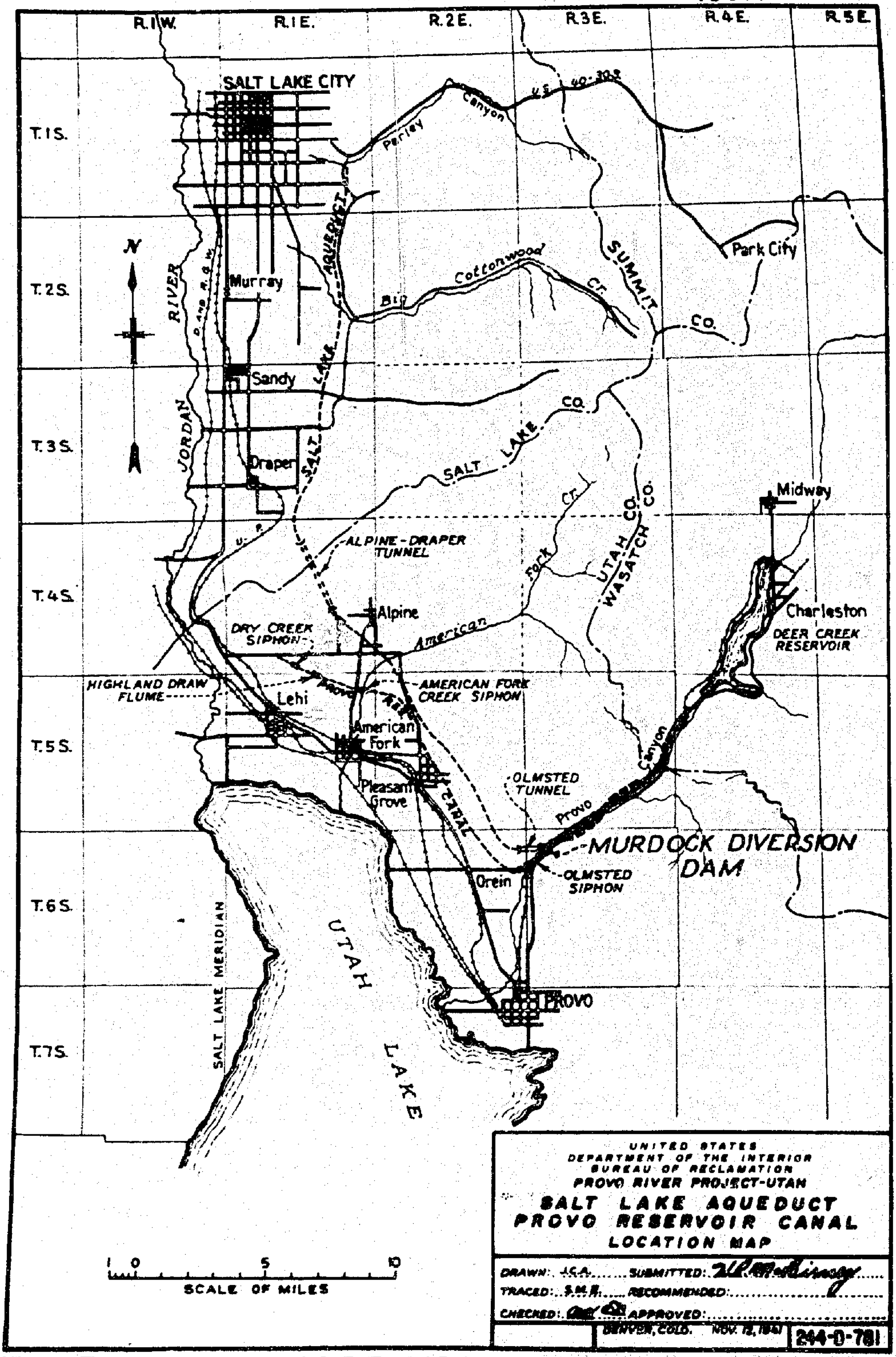
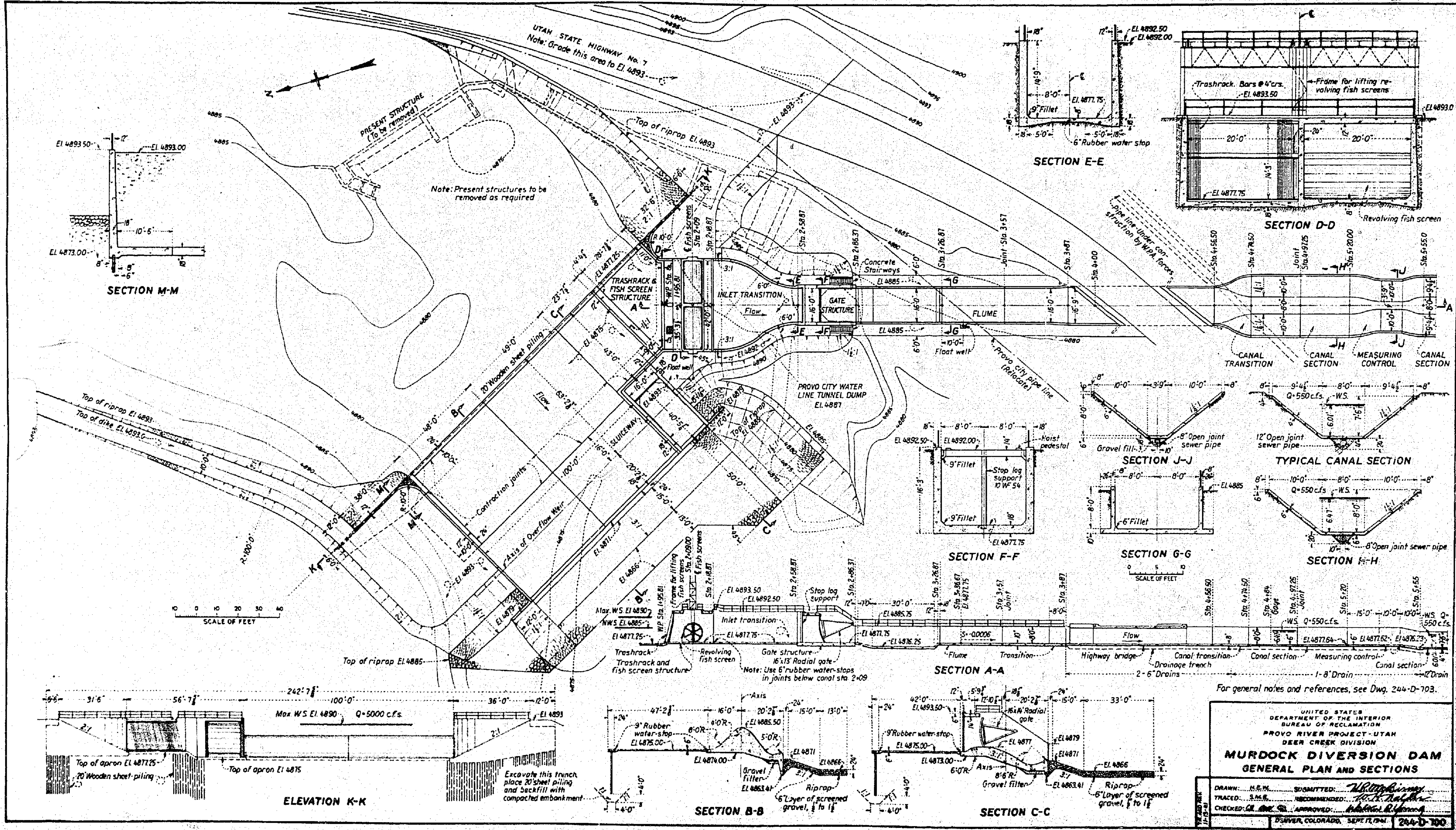
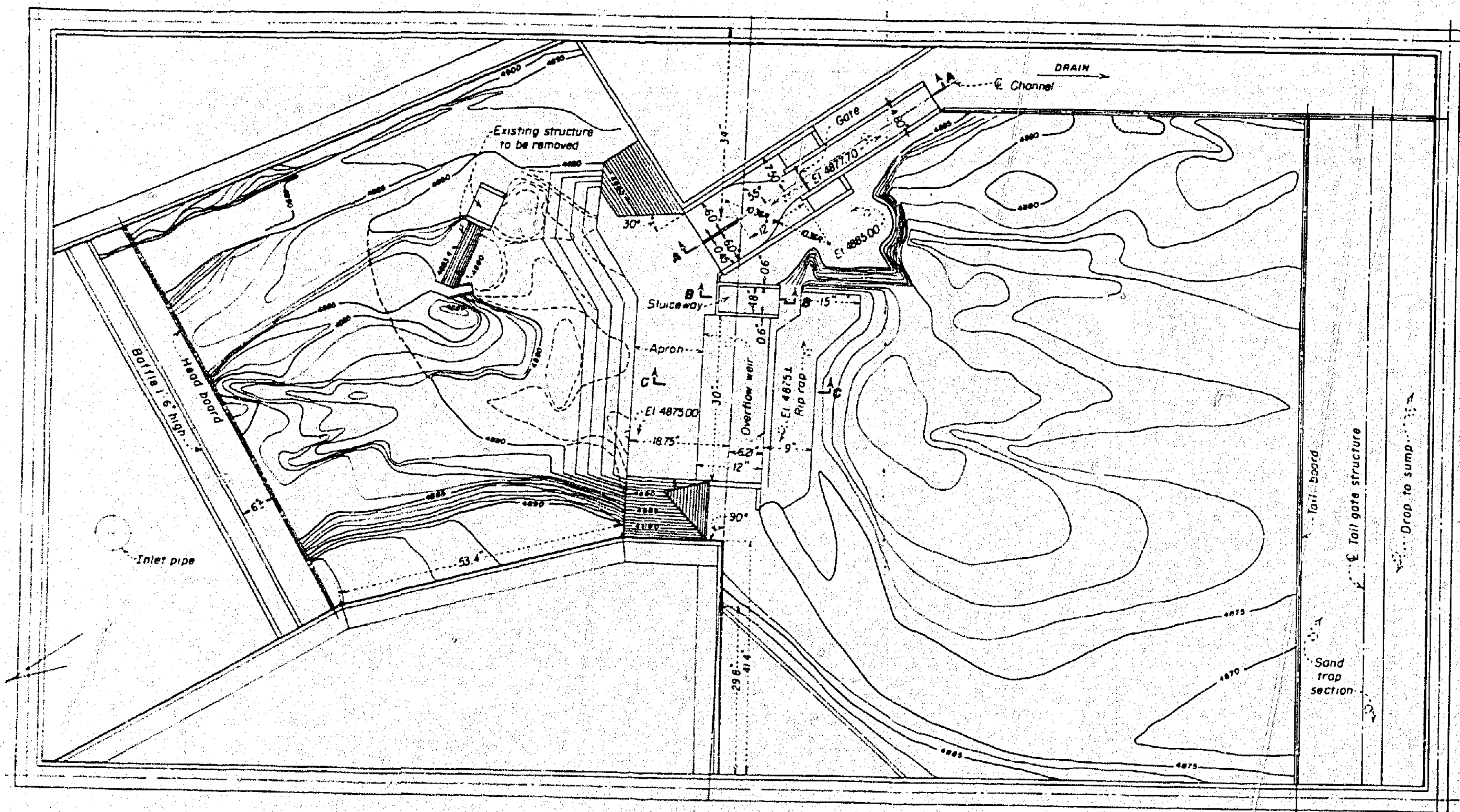

R.1W.
R.1E.
R.2E.
R.3E.
R.4E.
R.5E.
T.1S.
T.2S.
T.3S.
T.4S.
T.5S.
T.6S.
T.7S.
N
SALT LAKE CITY
Parley Canyon
U.S. 40-303
AQUEDUCT
Murray
Big Cottonwood Cr.
SUMMIT CO.
Park City
JORDAN RIVER
Sandy
SALT LAKE CO.
Draper
SALT LAKE
ALPINE-DRAPER TUNNEL
American Fork Cr.
UTAH CO.
WASATCH CO.
Midway
Alpine
DRY CREEK SIPHON
Charleston
DEER CREEK RESERVOIR
HIGHLAND DRAW FLUME
AMERICAN FORK CREEK SIPHON
Lehi
American Fork
Pleasant Grove
CANAL
OLMSTED TUNNEL
Provo Canyon
MURDOCK DIVERSION DAM
OLMSTED SIPHON
Orem
UTAH LAKE
SALT LAKE MERIDIAN
PROVO
0 5 10
SCALE OF MILES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PROVO RIVER PROJECT-UTAH
SALT LAKE AQUEDUCT
PROVO RESERVOIR CANAL
LOCATION MAP
DRAWN: J.C.A. SUBMITTED:
TRACED: S.M.R. RECOMMENDED:
CHECKED: APPROVED:
DENVER, COLO. NOV. 12, 1941
244-D-781

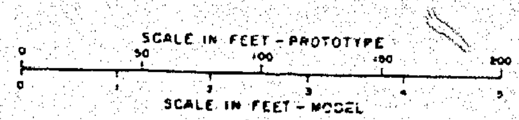
FIGURE 2

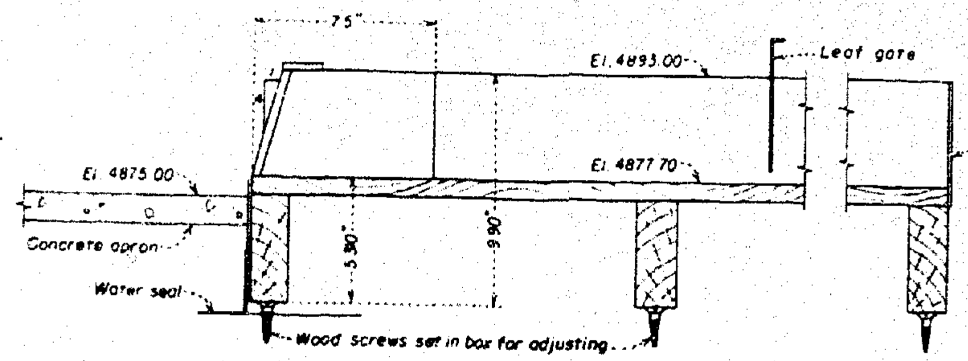


UTAH STATE HIGHWAY No. 7
Note: Grade this area to El. 4893
PRESENT STRUCTURE (To be removed)
Note: Present structures to be removed as required
Top of riprap El. 4893
TRASHRACK & FISH SCREEN STRUCTURE
INLET TRANSITION
GATE STRUCTURE
FLUME
Concrete Stairways
Float well
SLUICEWAY
Contraction joints
Axis of Overflow Weir
20' Wooden sheet piling
PROVO CITY WATER LINE TUNNEL DUMP El. 4887
Provo city pipe line (Relocate)
Pipe line-Under construction by W.P.A. forces
CANAL TRANSITION
CANAL SECTION
MEASURING CONTROL
CANAL SECTION
Top of riprap El. 4885
Top of dike El. 4893.0
SCALE OF FEET
SECTION M-M
SECTION E-E
6" Rubber water stop
SECTION D-D
Trashrack. Bars @ 4" crs.
Frame for lifting revolving fish screens
Revolving fish screen
SECTION F-F
Stop log support 10 WF 54
Hoist pedestal
SECTION G-G
SECTION J-J
8" Open joint sewer pipe
Gravel fill
TYPICAL CANAL SECTION
12" Open joint sewer pipe
Q=550 c.f.s.
SECTION H-H
SECTION A-A
Trashrack and fish screen structure
Revolving fish screen
Gate structure 16'x13' Radial gate
Note: Use 6" rubber water-stops in joints below canal sta. 2+09
Flume
Transition
Highway bridge
Drainage trench
Canal transition
Canal section
Measuring control
2 - 6" Drains
1 - 8" Drain
12" Drain
For general notes and references, see Dwg. 244-D-703.
ELEVATION K-K
Max. W.S. El. 4890
Q=5000 c.f.s.
Top of apron El. 4877.25
20' Wooden sheet-piling
Top of apron El. 4875
Excavate this trench, place 20' sheet piling and backfill with compacted embankment
SECTION B-B
9" Rubber water-stop
Gravel filter
Riprap
6" Layer of screened gravel, 1/4" to 1 1/2"
SECTION C-C
16'x14' Radial gate
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PROVO RIVER PROJECT - UTAH
DEER CREEK DIVISION
MURDOCK DIVERSION DAM
GENERAL PLAN AND SECTIONS
DRAWN
TRACED
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
DENVER, COLORADO, SEPT. 12, 1941
244-D-700

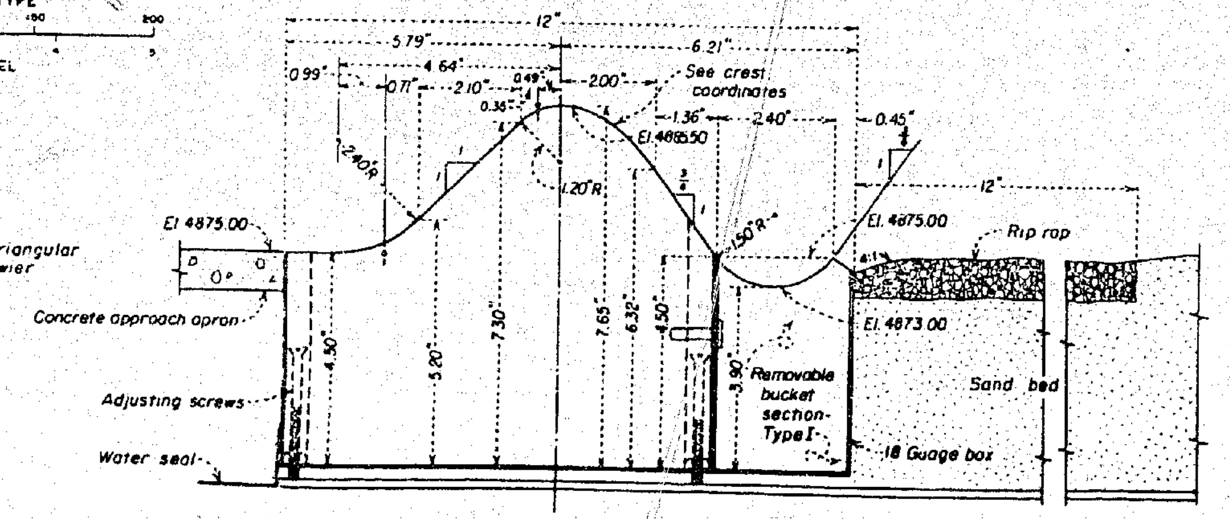


PLAN

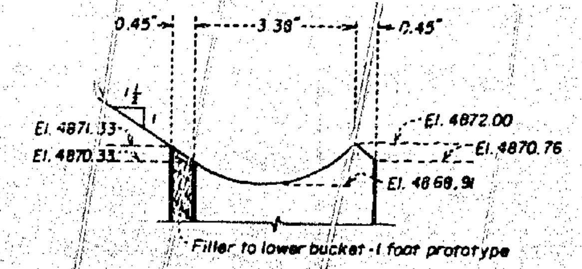




SECTION A-A - CANAL HEADWORKS



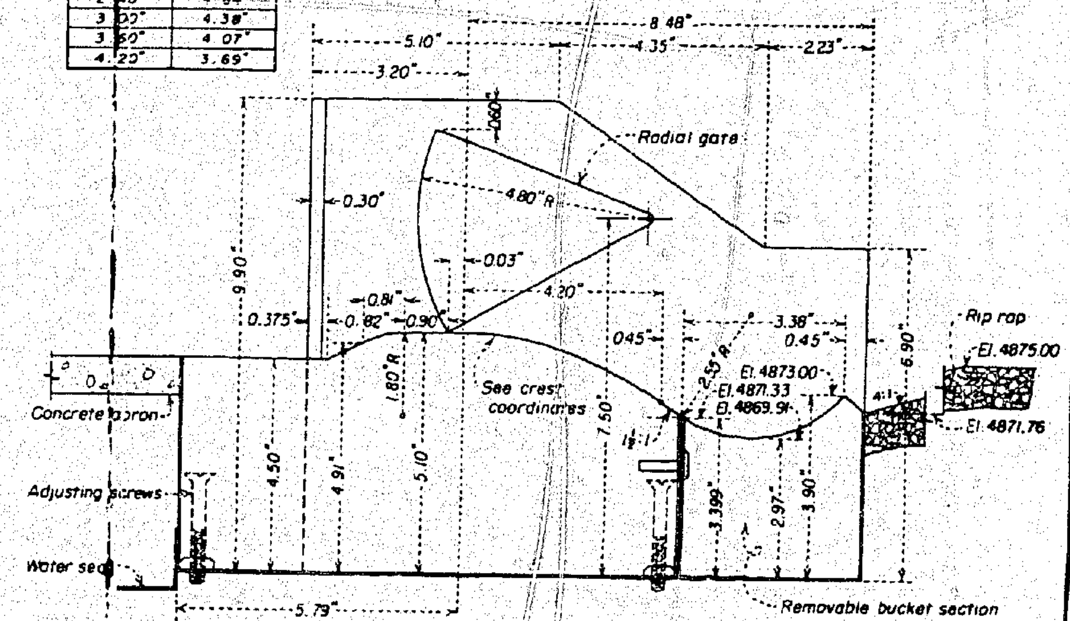
SECTION C-C - OVERFLOW WIER



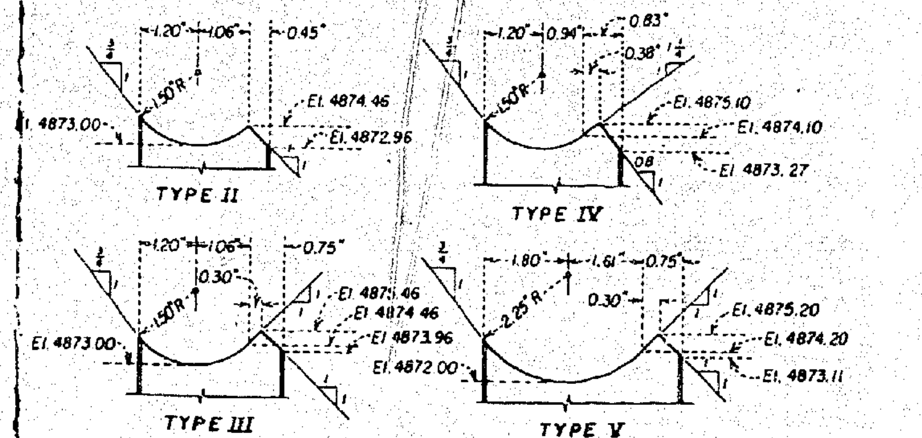
SLUICEWAY BUCKET

FINAL DESIGN

CREST COORDINATES	
HORIZ.	VERT.
0	5.10"
0.60"	5.07"
1.20"	4.99"
1.80"	4.84"
2.40"	4.64"
3.00"	4.38"
3.60"	4.07"
4.20"	3.69"



SECTION B-B - SLUICEWAY



OVERFLOW WIER BUCKETS

TYPE II FINAL DESIGN

CREST COORDINATES	
HORIZ.	VERT.
0	7.65"
0.30"	7.62"
0.60"	7.53"
1.20"	7.17"
1.80"	6.57"
2.00"	6.32"

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PROVO RIVER PROJECT - UTAH
DEER CREEK DIVISION

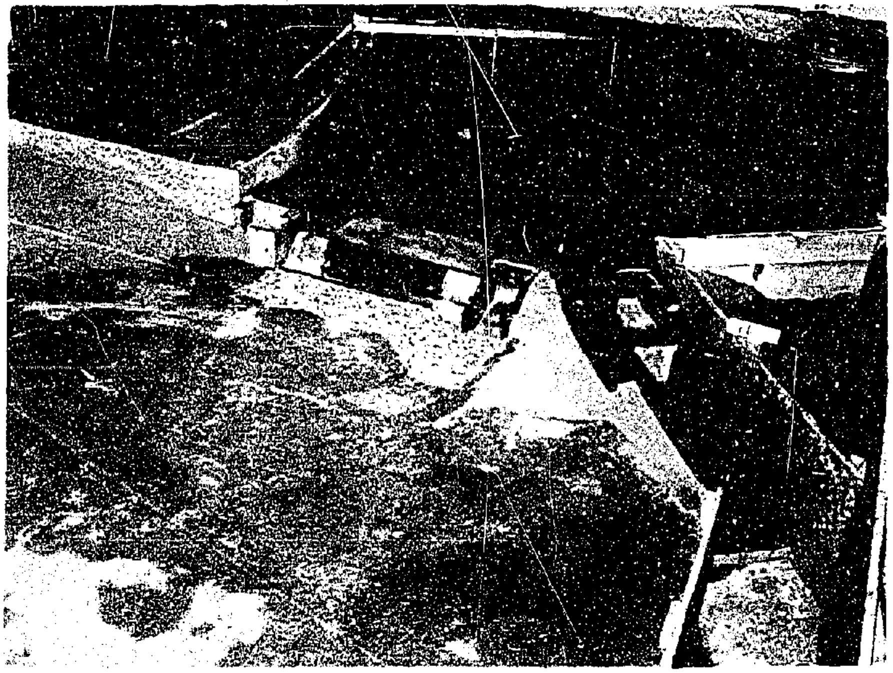
MURDOCK DIVERSION DAM

HYDRAULIC MODEL STUDIES - 1:40 SCALE

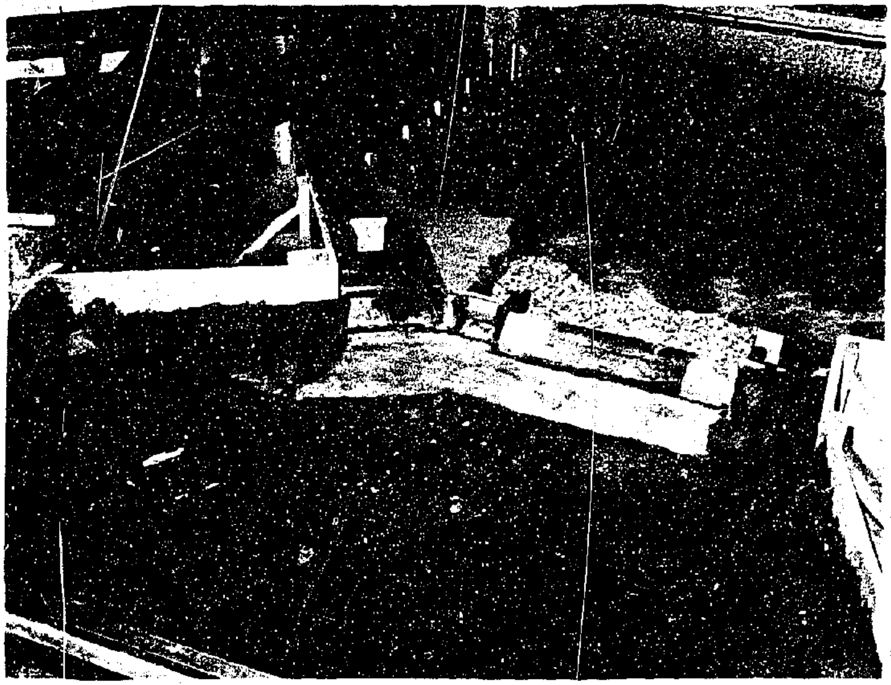
GENERAL PLAN AND SECTIONS OF MODEL

DRAWN F.C.L. SUBMITTED
TRACED F.C.-H.S. RECOMMENDED
CHECKED APPROVED

DENVER, COLORADO - JULY 11, 1941 244-D-6[illegible]



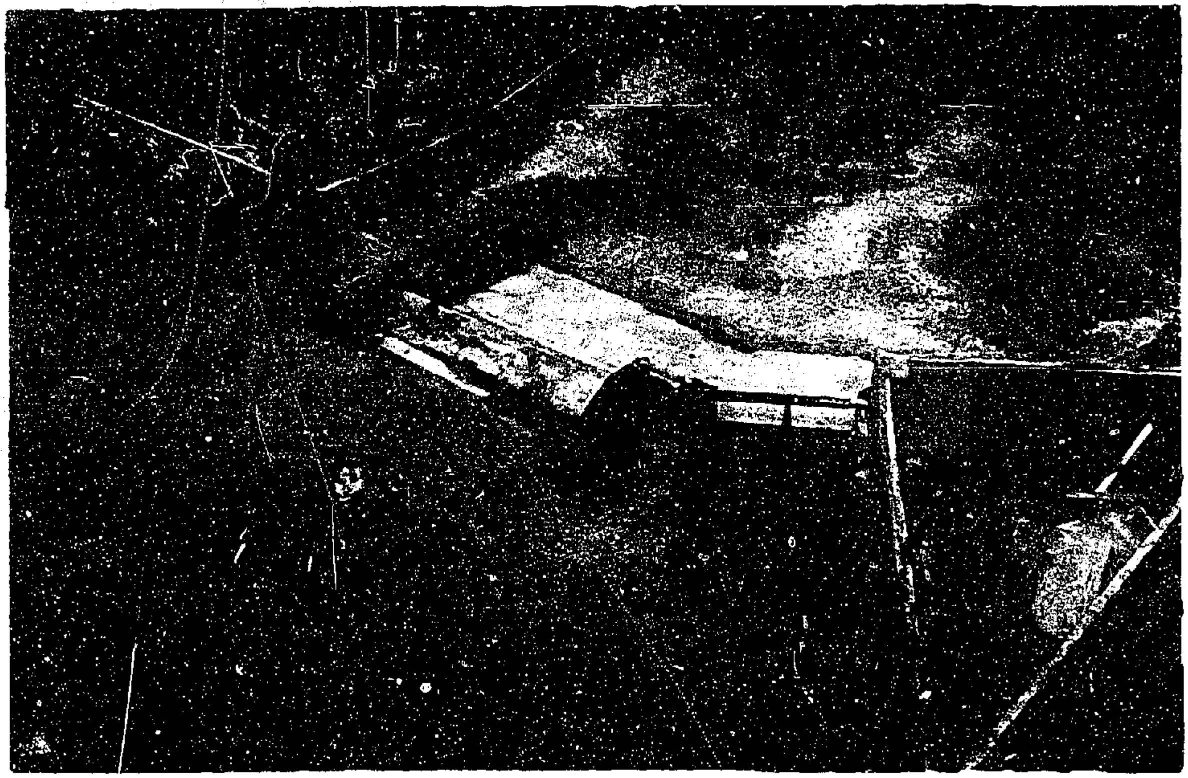
LOOKING UPSTREAM



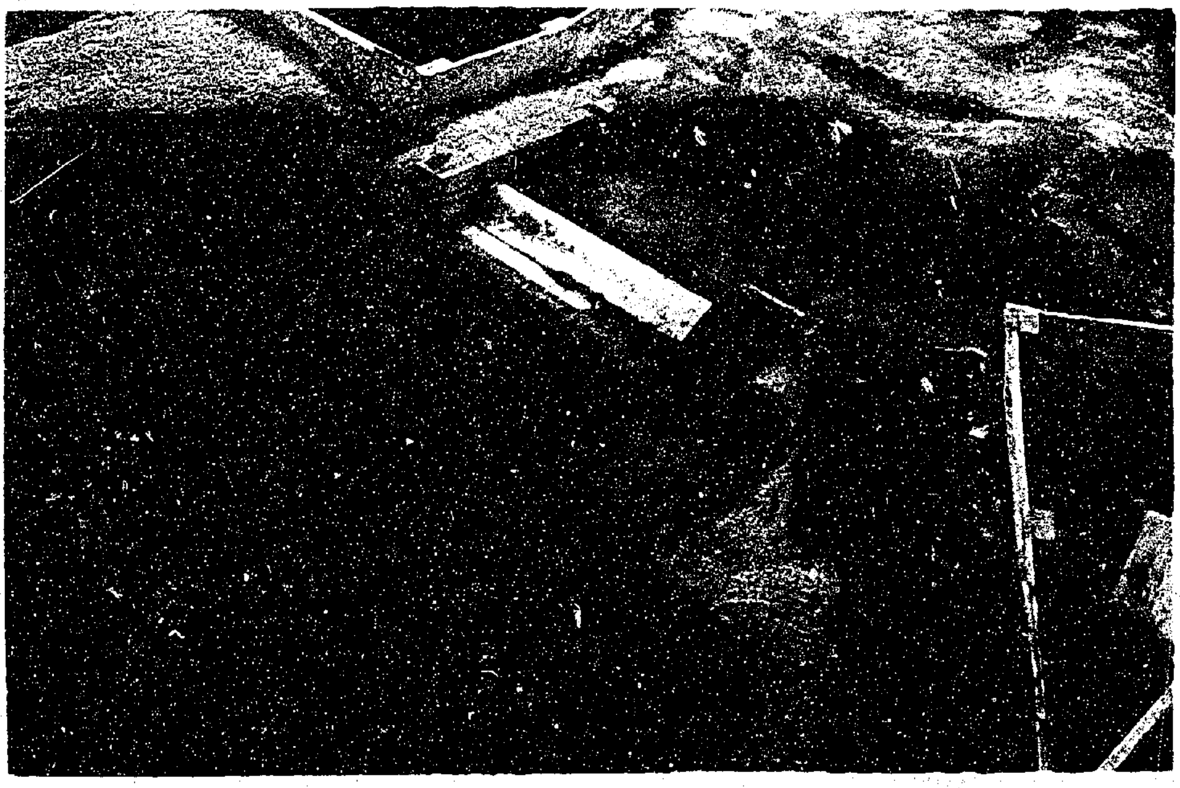
LOOKING DOWNSTREAM

1:40 SCALE MODEL MURDOCK DIVERSION DAM

ORIGINAL DESIGN



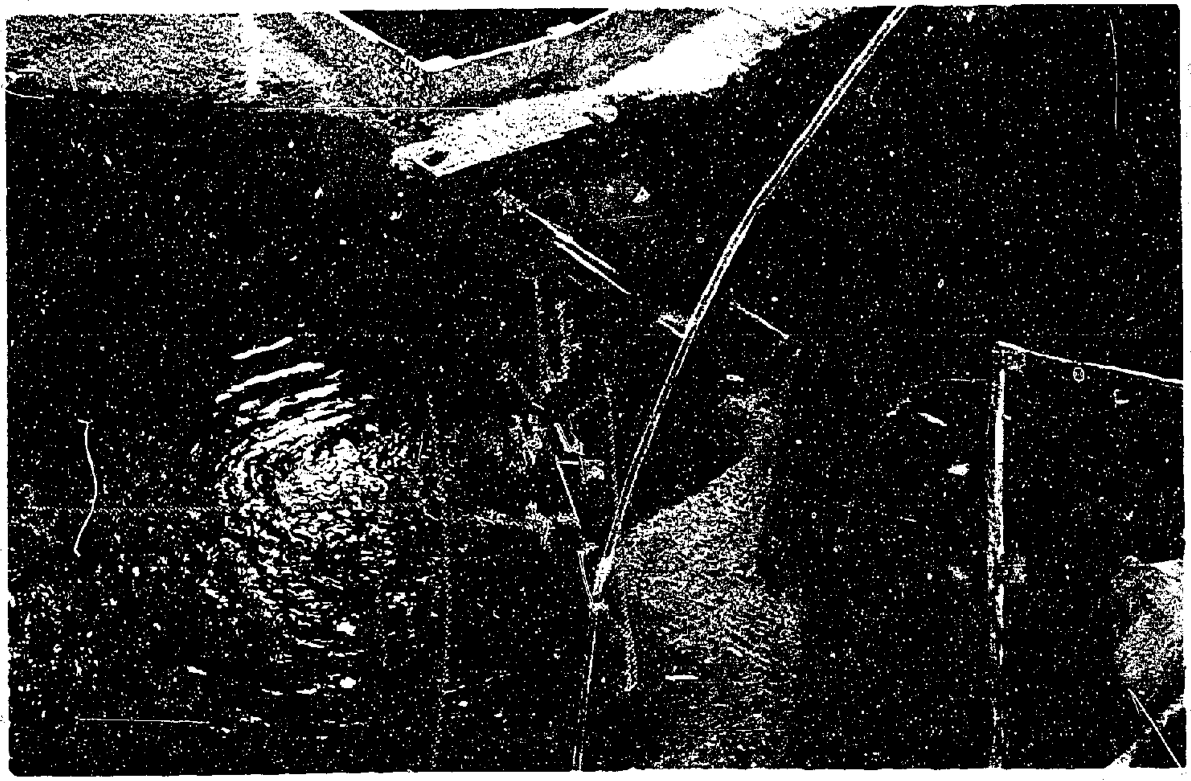
ORIGINAL RIVER BED



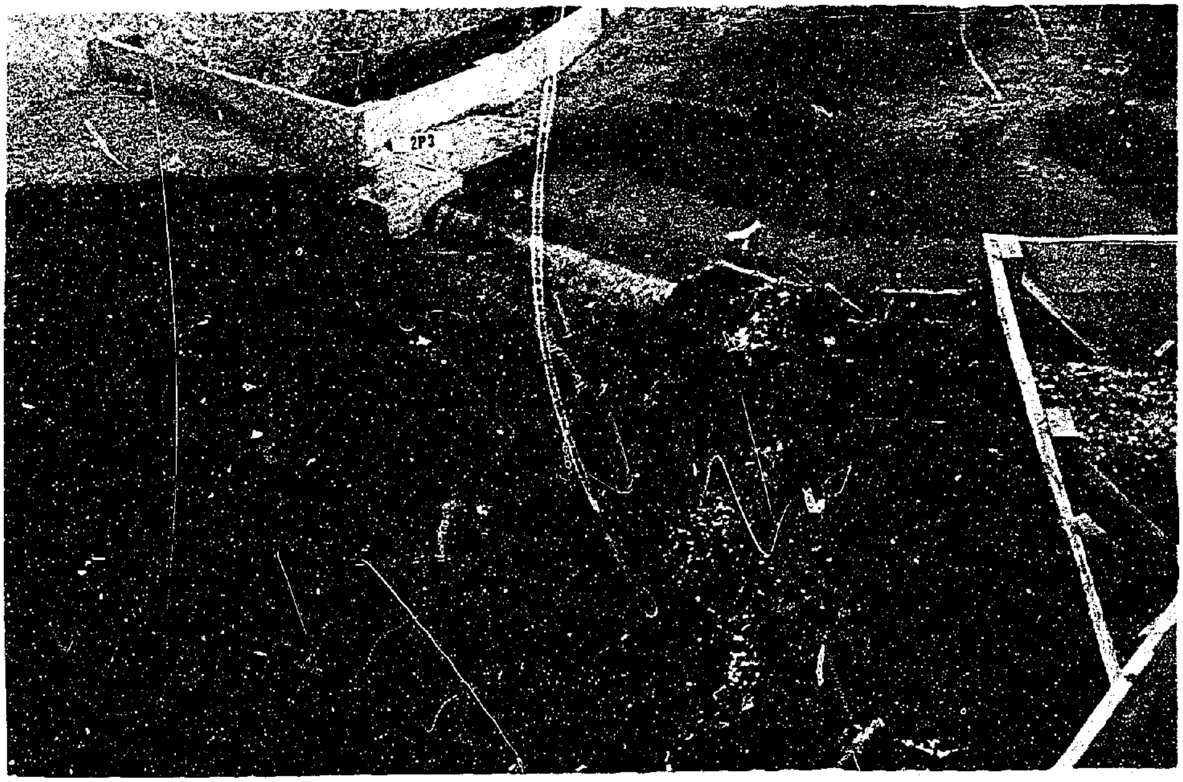
SCOUR AFTER MAXIMUM DISCHARGE (5000 SECOND FEET)

1:40 SCALE MODEL MURDOCK DIVERSION DAM

FINAL DESIGN



SLUICEWAY DISCHARGE (1000 SECOND FEET)



MAXIMUM DESIGN DISCHARGE (5000 SECOND FEET)

1:40 SCALE MODEL MURDOCK DIVERSION DAM

FINAL DESIGN