

UNITED STATES GOVERNMENT

Memorandum

Memorandum

TO : Chief Engineer
Through: Chief, Dams Branch
 Chief Designing Engineer
FROM : Head, Concrete Dams Section

Denver, Colorado
DATE: August 3, 1964

SUBJECT: Failure of Two Medicine Dam

Two Medicine Dam is located in the northwestern part of Montana on Two Medicine River just outside the southeast boundary of Glacier National Park. Storage created by the dam backs water into Lower Two Medicine Lake. The road to the town of Two Medicine in the park passes the damsite. The dam was designed by the Bureau of Reclamation for the Bureau of Indian Affairs. Construction of the dam was started in July 1911 and was completed in August 1913. Indian and white labor were used in its construction. The storage capacity created by the dam was 13,500 acre-feet at spillway crest elevation 4874.

The dam consisted of a slab and buttress reinforced concrete spillway section with counterforted wing walls located in the river channel and earth embankment sections on both abutments. The total length of the structure is 860± feet. The right embankment is 650± feet long and the left embankment 140± feet long.

The spillway structure is supported on timber cribbing on a glacial moraine of fine sand and gravel foundation. Total height of the spillway structure from streambed to top of retaining walls is 37 feet. Total height from streambed to spillway crest 27 feet. Three rows of sheet piling were driven under the spillway structure normal to the river. Details of the dam, the foundation, earth embankments and the spillway structure are shown on the attached Drawings No. S-3709, and S-3397, sheets 1, 2 and 3. Four openings 6 feet wide are provided in the sloping face of the spillway structure. These can be closed off by wooden stop logs. Ladder rungs down the face of the structure at each opening have been provided for access to insert or remove the logs. A 5-foot by 5-foot opening with a slide gate and operating mechanism was added to the center pier about 1940. The spillway crest is a broad flat crest 8 feet 6 inches in width. There are three piers on the crest which support a walkway. The distance between piers is 14 feet, making the total available length of the spillway crest 56 feet. A timber gate shown on the elevation view of the crest on sheet 2 of Drawing No. 3397 was never added to the structure. Discharge over the spillway crest drops on to a concrete apron with chute blocks at the end. Downstream of this apron is an extended timber apron supported on cribbing.

The dam was operated with the stop logs always in place according to the following statement furnished by the Bureau of Indian Affairs: "Placing and removal of the stop logs has never been considered a 'regulatory'

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operation, ie. as a means of regulating inflows into the reservoir, but only as a means of adjusting the water level in order to make needed repairs." For safe operation, a minimum of 5 feet of freeboard for the earth embankments should have been required during maximum flooding conditions. With all stop logs in place and with the water surface at elevation 4879, 5 feet below the dam crest, it is estimated that the combined discharge of the spillway and outlet is about 2400 cfs. Under the same conditions with water surface at elevation 4884, the crest of the dam, it is estimated that the combined discharge of the spillway and outlet is about 5500 cfs.

As a result of heavy rains in the area around June 7 and 8 of this year, which created above normal discharge, the dam failed, see Photographs No. 1, 2, 3, and 4. The failure occurred by overtopping of the embankments at about 3:30 p.m. on June 8. On June 11, accompanied by Mr. G. R. Hanson, Chief, Field Engineering Branch, Projects Office, Great Falls, I visited the site of the dam and examined the portions of the structure still standing. The request to make this inspection was made by the Regional Director, Region 6. Before going to the site, we stopped at the Office of the Project Engineer, Bureau of Indian Affairs, Blackfeet Indian Reservation, Browning, Montana, where we reviewed drawings, examined recent pictures and discussed the failure of the dam. The Bureau of Indian Affairs calculated that the peak discharge during the flood was 9,600 cfs and the Geological Survey in their letter of July 15, 1964 stated the maximum water surface elevation to be 4883.3. Since all the stop logs were in place and since the calculated capacity of the spillway and outlet was much less than the estimated discharge, the dam failed because of inadequate spillway capacity being available.

The failure of the dam, in all likelihood, started at the contact between the earth embankments and the retaining walls as the freeboard on the embankment decreased with the rising reservoir. In these areas there was a definite indication of settlement in the embankments. Photograph No. 5, taken in 1913, and Photograph No. 6, taken at a more recent date, show perhaps as much as 3 feet of settlement at the counterforted retaining walls. This area would form the shortest and easiest path for discharge over the embankments. Insufficient compaction of material in this area or shrinkage of the material from the wall due to drying would increase this weakness. Once the water could find a path through the embankment, the dam was doomed.

With piping started at both abutments, it was not long before the portions of the embankments adjacent to both sides of the spillway were washed away. The greater portion of the discharge must have passed on the right side of the spillway for it is in this area that the river formed a new channel and is now running. The counterforted retaining wall at the right

side of the spillway has been washed away except for a part of the upstream section. As the flood flow cut through the embankment, it evidently undermined the footing of the counterforted retaining wall and the wall toppled into the newly created river channel, see Photograph No. 4. Similar action took place on the left side of the spillway, but the flood receded before this wall completely failed. This wall had tilted sufficiently towards the abutment to allow the stop logs in the first spillway opening to be unseated and washed away, see Photographs No. 2 and 3. It is not known how much of the timber cribbing which served as a spillway apron has been washed away. The row of timber sheet piling at the heel of the spillway structure and at the end of the apron can still be seen in place.

No thought should be given to rehabilitating the present structure. If the dam is to be replaced, a new structure should be built using modern day concepts of design.

E. R. Schultz

Enclosures

NOTED: AUG 18 1964

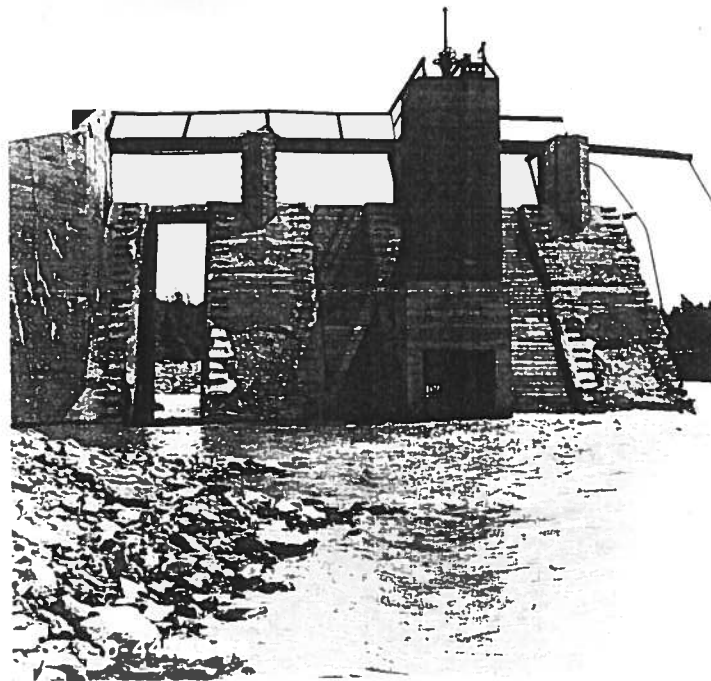
[Signature]
Chief Engineer

Jensen 8-13

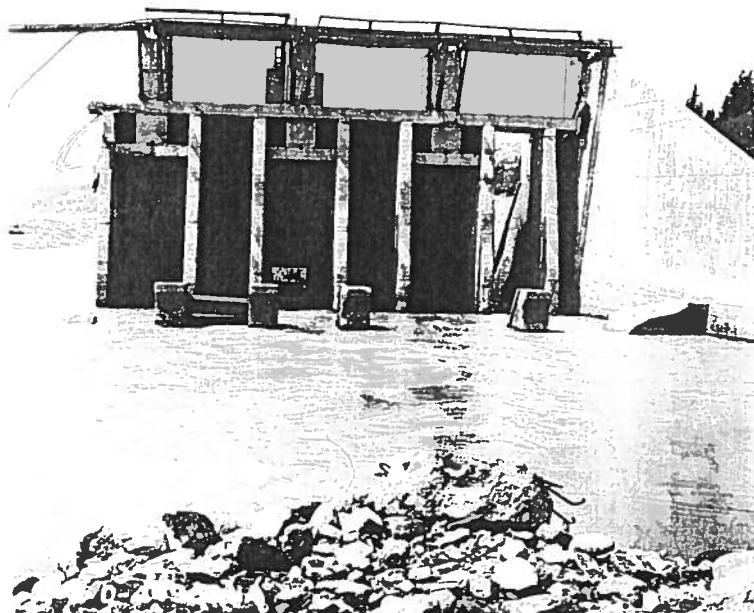
Arthur
9-14
Jensen



Photograph No. 1
Two Medicine Dam - View from left abutment. 6-11-64



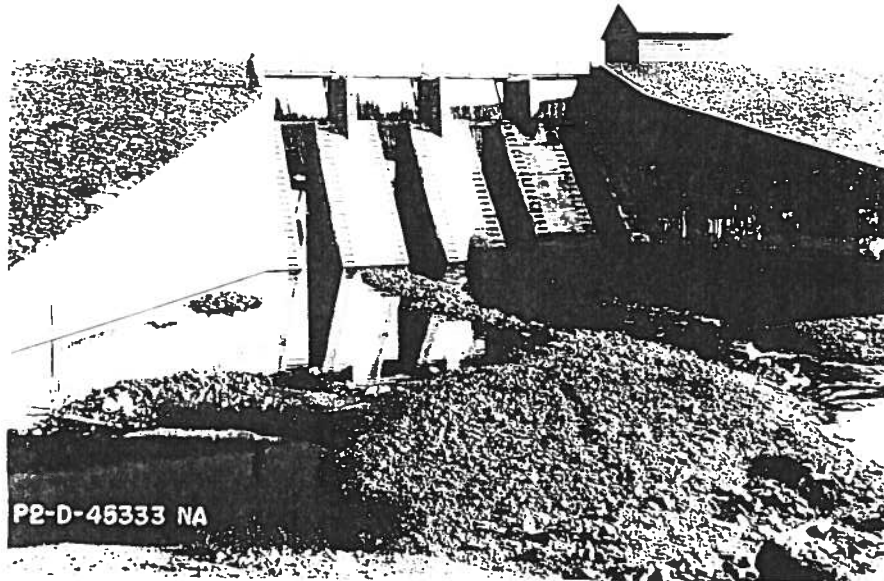
Photograph No. 2
Two Medicine Dam - Spillway section, looking downstream. 6-11-64



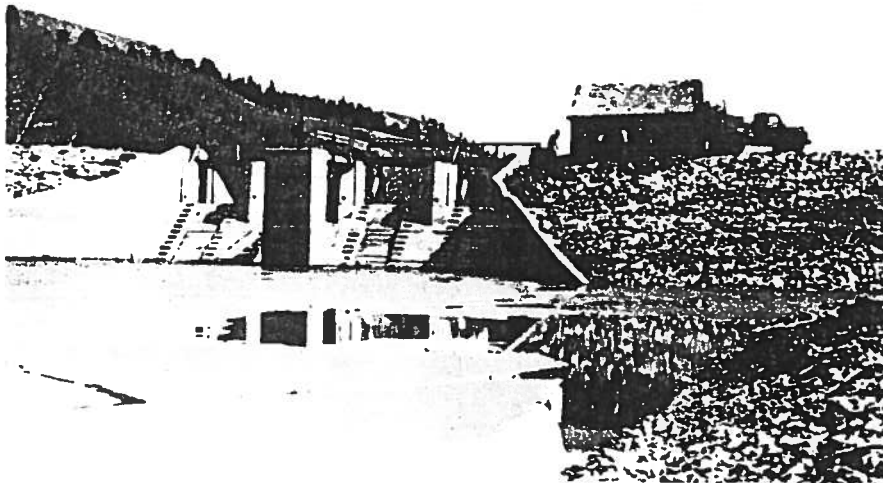
Photograph No. 3
Two Medicine Dam - Spillway section, looking upstream. 6-11-64



Photograph No. 4
Two Medicine Dam - View of right embankment showing remains of
spillway retaining wall. 6-11-64



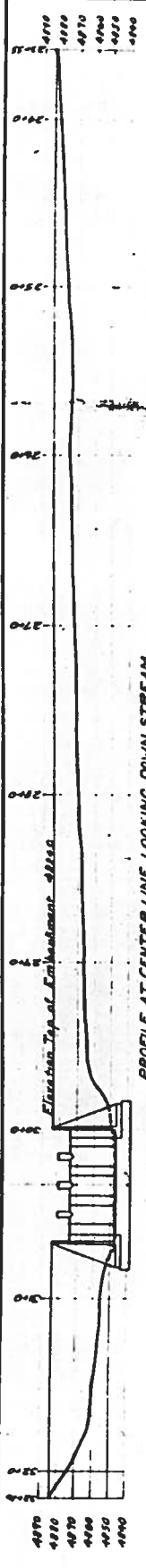
Photograph No. 5
Two Medicine Dam - View of dam taken upon
completion of construction, 6-1913



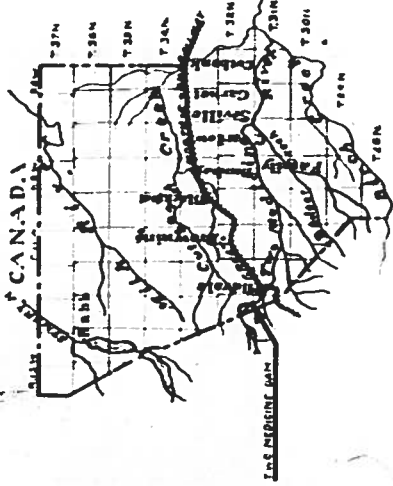
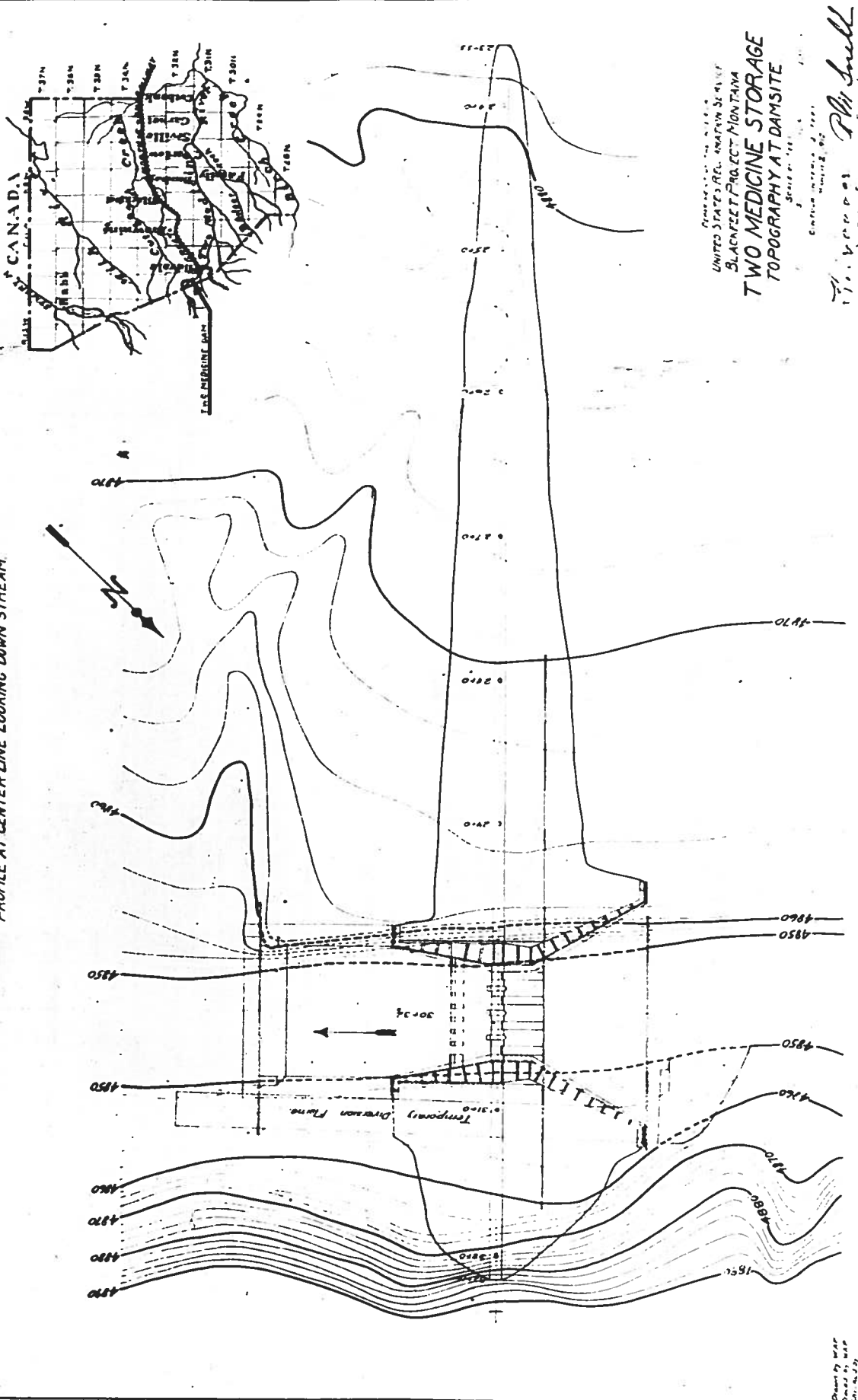
Photograph No. 6
Two Medicine Dam - View showing embankment settlement
at spillway counterforted retaining walls.

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PROFILE AT CENTER LINE LOOKING DOWN STREAM

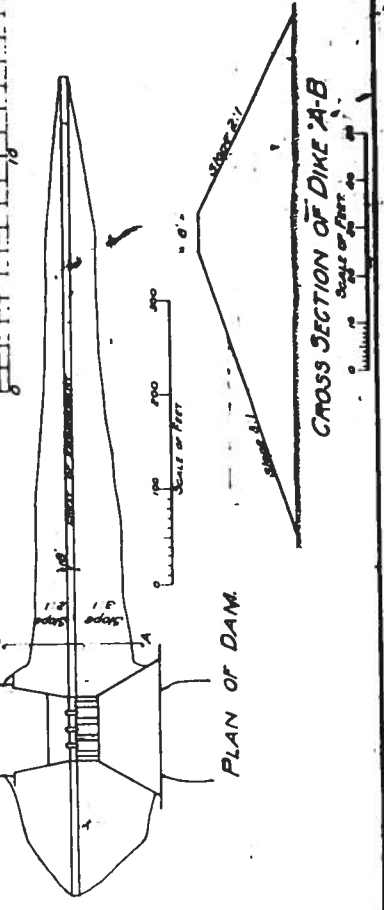
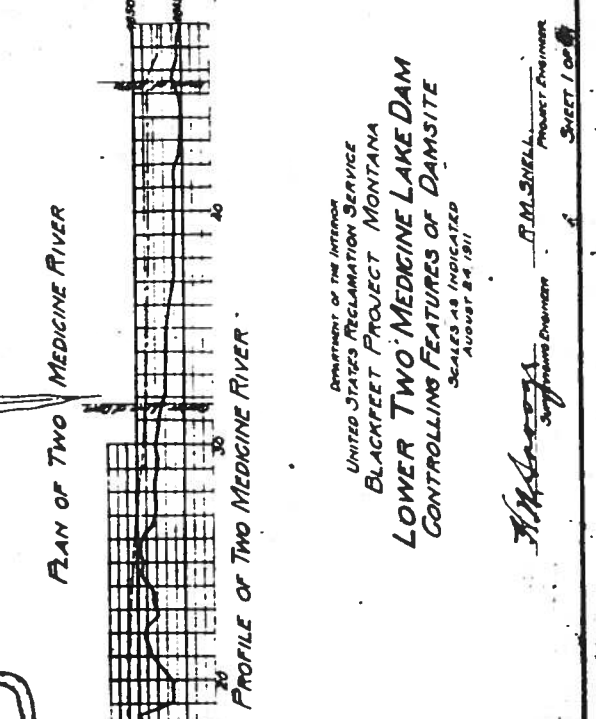
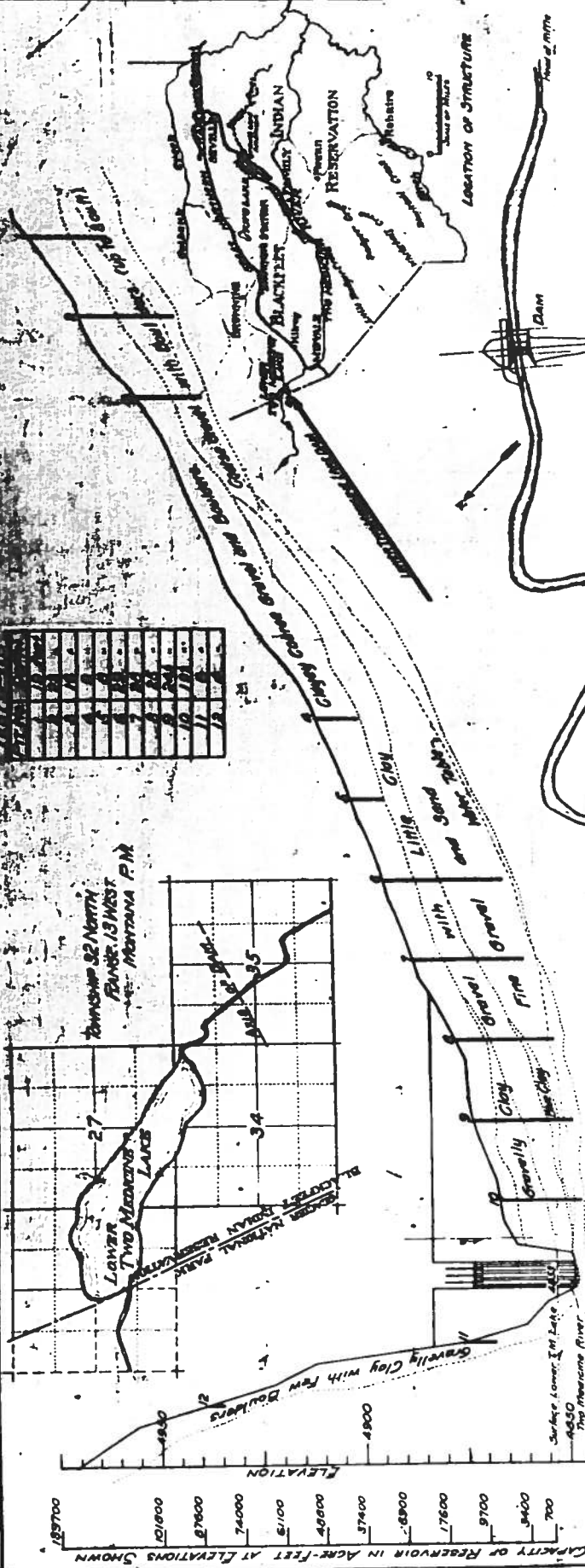


UNITED STATES REGULATORY DISTRICT
BLACKFEET PROJECT MONTANA
TWO MEDICINE STORAGE
TOPOGRAPHY AT DAM SITE

Contract No. 4-1-1937
P. H. Smith
P. H. Smith

555 F-21-S-3709

Drawn by WAF
Checked by WAF
June 21, 1937

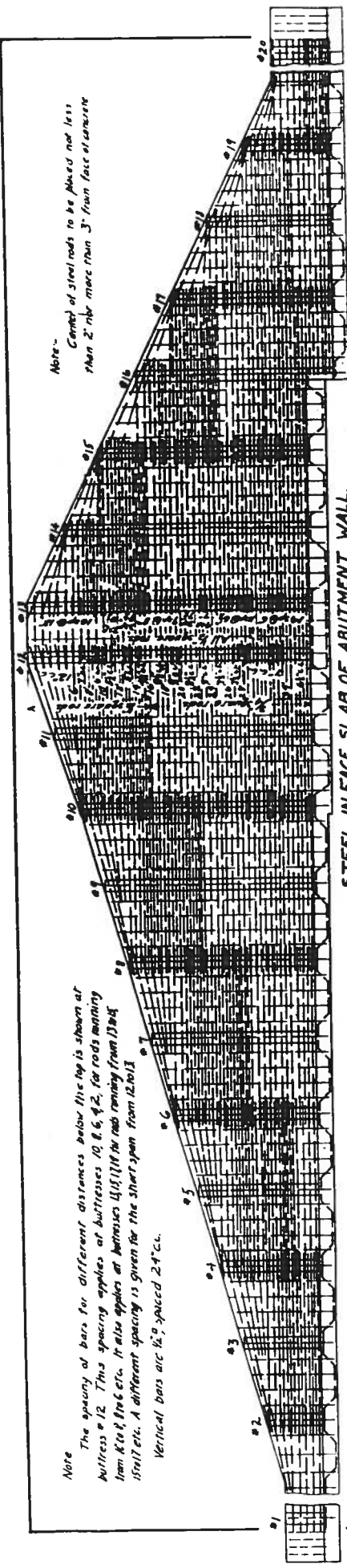


DEPARTMENT OF THE INTERIOR
 UNITED STATES RECLAMATION SERVICE
 BLACKFEET PROJECT MONTANA
LOWER TWO MEDICINE LAKE DAM
 CONTROLLING FEATURES OF DAMSITE
 SCALES AS INDICATED
 AUGUST 25 1911

H. M. Shelton
 Surveying Engineer
 P. M. Shell
 Project Engineer
 SHEET 1 OF 4

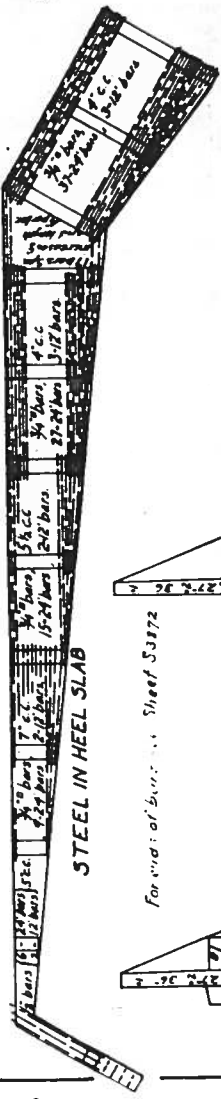
F-228-3397

Note -
Camp of steel rods to be placed not less than 2" nor more than 3" from face of concrete



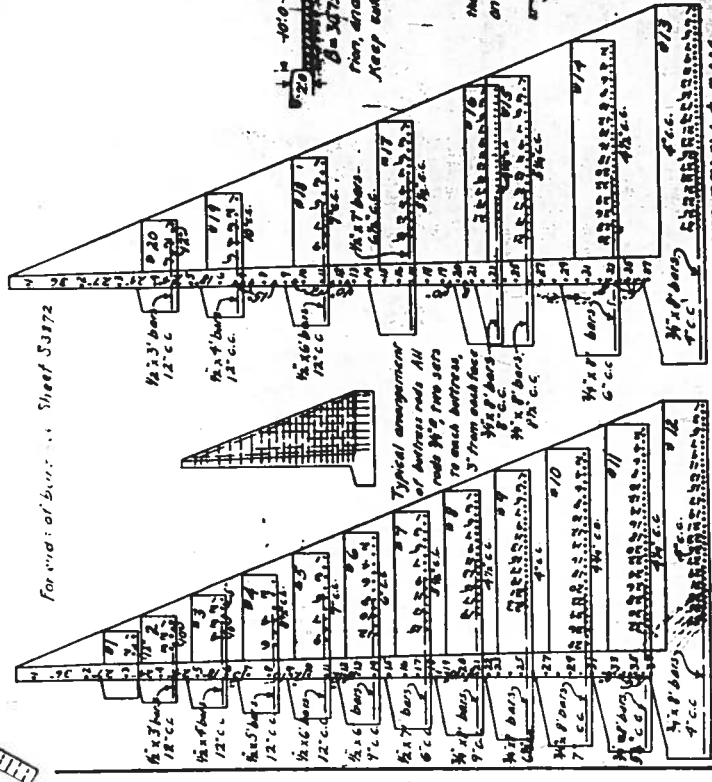
Note
The spacing of bars for different distances below the top is shown at buttress #12. This spacing applies at buttresses 10, 8, 6, 4, 2, for rods running from #1 to #12 etc. It also applies at buttresses 4, 1, 11 for rods running from #12 to #1 etc. A different spacing is given for the short span from #2 to #11.
Vertical bars are 1/2" spaced 24" c/c.

STEEL IN FACE SLAB OF ABUTMENT WALL.



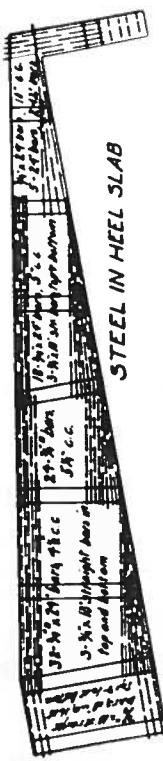
STEEL IN HEEL SLAB

For vertical bars see Sheet S-3372



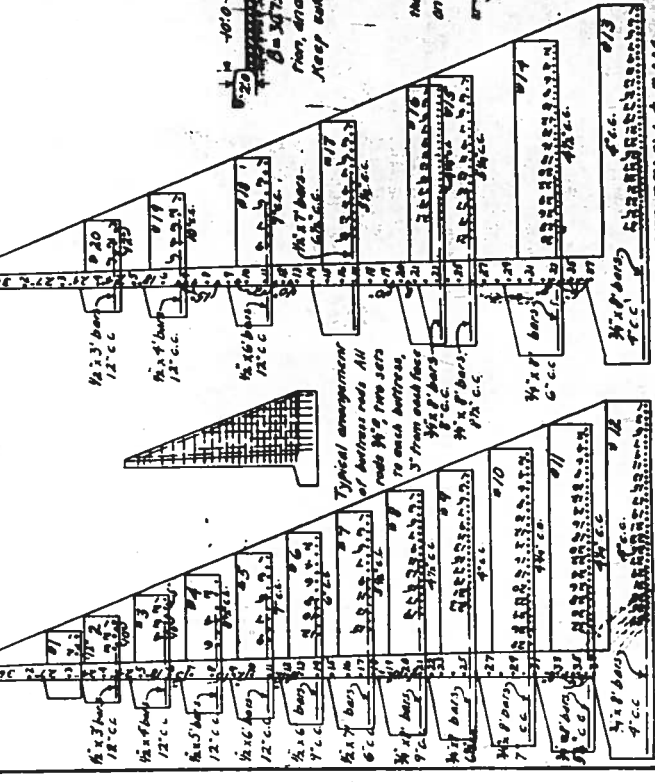
BUTTRESSES ABOVE & OF DAM

BUTTRESSES BELOW & DAM



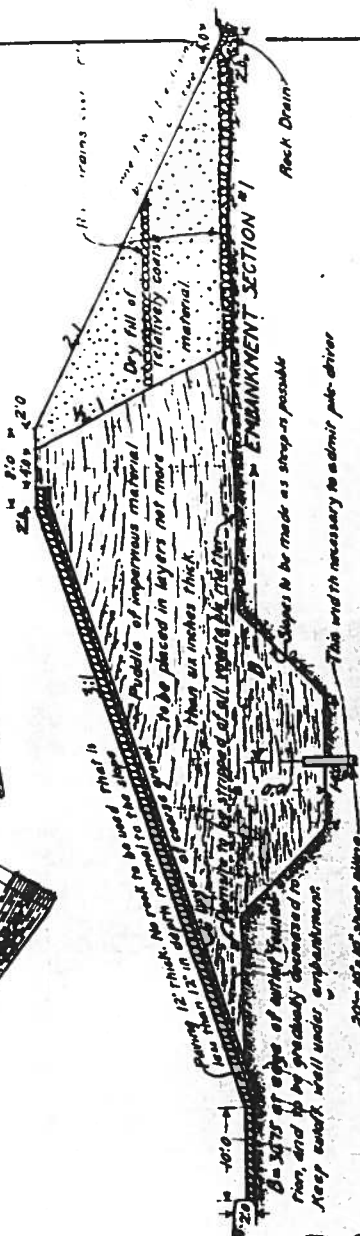
STEEL IN HEEL SLAB

For vertical bars see Sheet S-3372



BUTTRESSES ABOVE & OF DAM

BUTTRESSES BELOW & DAM



EMBRANKMENT SECTION #1

This embankment to be made as steep as possible

A berm 18" wide is to be left between the toe of the slope and the buttress

20'-10 1/2" shear plug

Keep embankment well under embankment

20'-10 1/2" shear plug

20'-10 1/2" shear plug

20'-10 1/2" shear plug

20'-10 1/2" shear plug

20'-10 1/2" shear plug

20'-10 1/2" shear plug

EMBRANKMENT SECTION #2

Section #2 extends from the outer structure 200' into the southwest bank and 80' into the northeast bank.

Section #3 extends from the ends of section #1 to the ends of the dam.

Section #4 extends from the ends of section #1 to the ends of the dam.

Section #5 extends from the ends of section #1 to the ends of the dam.

Scale of feet

1" = 20'

1/2" = 10'

3/4" = 15'

1" = 20'

1/2" = 10'

3/4" = 15'

1" = 20'

1/2" = 10'

3/4" = 15'

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
BLACKFEET PROJECT MONTANA
TWO MEDICINE STORAGE
STEEL IN ABUTMENTS AND
SECTIONS OF EMBANKMENT

Scale of feet

1" = 20'

1/2" = 10'

3/4" = 15'

1" = 20'

1/2" = 10'

3/4" = 15'

1" = 20'

1/2" = 10'

3/4" = 15'

Approved: _____
Checked: _____
SHEET 303

553

S-3397
1919/F-19-B

Drawn by: _____
Checked by: _____
Date: _____