UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF FORT LARAMIE CANAL DESILTING BASIN--NORTH PLATTE PROJECT--WYOMING-NEBRASKA

Hydraulic Laboratory Report No. Hyd-313

RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

May 4, 1951

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Laboratory Report No. Hyd-313
Hydraulic Laboratory
Compiled by: E. J. Carlson
Reviewed by: C. W. Thomas
E. W. Lane

Subject: Hydraulic model studies of Fort Laramie Canal Desilting Basin--North Platte Project

SUMMARY

In accordance with a letter dated September 20, 1949, to Head, Research and Geology Division from Acting Head, Canals Division, subject, "Request for model study of a desilting basin with guide walls or vanes to produce the most effective desilting action--Whalen Diversion Dam--Fort Laramie Canal--North Platte Project," a 1:120 undistorted hydraulic model of the Fort Laramie Canal desilting basin was built in the Hydraulic Laboratory. The request for this model study resulted from a report of a field trip made by E. W. Lane in July 1948 to the North Platte Project at which time an inspection of the Fort Laramie Canal desilting basin was made.

To compensate for the small scale, ground bakelite, with a specific gravity of 1.45, was used as the movable bed material. This material was chosen after trying several sand, coal, and plastic materials and making visual observations of their action with the scale discharge. Later some tests were made using 30-mesh uniform sand with the model slope and discharge distorted to cause movement of the sand. The tests using sand, with the model on a steeper slope, were made in an endeavor to obtain scour in the model similar to that observed in the prototype. After making one test that produced a deposit of the ground bakelite in the model basin similar to the sediment deposited in the prototype, the remaining tests were conducted to determine the pattern and rate of scour during a sluicing operation. In effect, the tests simulated sluicing operations in the basin after the canal had been carrying a normal discharge for approximately 2 to 3 days in the prototype with the normal sediment load coming into and depositing in the basin.

Tests were made with the basin as now operating, that is, with no guide walls, and with 1, 2, and 3 guide walls in the upstream

portion. Tests were made with the left downstream corner near the sluice gates cut back and also with the corner rounded to a larger radius than in the present prototype. Because of the small scale chosen for the model, the tests were of a qualitative, comparative nature only.

Based on observations of all tests, the model study showed that one guide wall placed in the upstream portion of the basin would be as effective in improving the flow during sluicing operations as the two or three walls recommended in the field trip report by E. W. Lane. The single wall was approximately 130 feet long, 4 feet high on the upstream 20 feet, tapering to 5 feet high on the downstream end. To give the wall more flexibility and make the installation so the amount of water diverted on each side of the guide wall could be changed, it was recommended that the upstream 20 feet of the wall be movable, so its angle could be changed to effect a more efficient operation if required in the prototype. The model tests showed that very little improvement could be gained by cutting back the left downstream wall near the sluice gates nor by increasing the radius of curvature of the wall.

For the record, some tests were run with a guide wall extending the full length of the desilting basin, as shown in Figures 4 and 5A, located so it divided the basin in two equal parts. The sluicing operation was then carried on, using gates at the upper end of the guide wall and flushing alternate sides of the basin with the full discharge. The velocity was much greater in the half basin width than the full width and the same amount of sediment was flushed from the entire basin in approximately one-half the time consumed when no guide wall was used.

The results evolved from these model studies and the recommendations made were developed through the cooperation of the staffs of the Diversion Dam Section and the Hydraulic Laboratory. During the course of the studies, Mr. F. E. Rippon, Mr. A. W. Kidder, and others from the Canals Division visited the laboratory to discuss the test results.

The model tests were conducted directly by Mr. O. S. Hanson and Mr. W. R. Melin under the direct supervision of Mr. E. J. Carlson, Mr. C. W. Thomas, and Mr. E. W. Lane.

In the interim between the completion of the model studies and completion of this report, a Parshall flume was constructed approximately one-half mile downstream from the desilting basin on the Fort Laramie Canal. Construction of this 15-foot throat Parshall flume in the canal caused the water surface in the basin to be approximately 2.0 feet higher than before construction of the Parshall flume for the normal discharge of 1,450 cfs. Raising the water surface in the basin has reduced the amount of sand entering the basin to a point where it has only required sluicing one time during the 1950 irrigation season.

INTRODUCTION

The Fort Laramie Canal desilting basin is located in the upper end of the Fort Laramie Canal, near the Whalen Diversion Dam on the North Platte Project, approximately 12 miles northwest of Torrington, Wyoming, as shown in Figure 1. The existing desilting basin was constructed in 1924 to keep the coarse sand out of the canal. Several unsuccessful attempts had been made between 1917 and 1924 to control the sand using various designs. Refer to article by Ivan E. Houk in Engineering News-Record, Vol. 100, No. 24, pp 922-926.

The Whalen Diversion Dam and headworks are located on the downstream end of a bend in the North Platte River. The Fort Laramie Canal headworks is located on the inside or convex side of the bend and the Interstate Canal headworks is on the outside or concave side of the bend. Following the laws of action of sediment on bends in rivers, a much greater amount of sediment is found downstream from the inside convex side of the bend at the Fort Laramie Canal headworks than on the outside concave side at the Interstate Canal headworks. A pipe arrangement built in front of the Interstate headworks successfully removes the major portion of the coarse sand load from the water entering Interstate Canal. A similar arrangement was built into the Fort Laramie Canal headworks, but because of the much greater sediment load on this side of the river, the concrete pipes soon became clogged with sediment. To alleviate the sediment problem, a new heading was constructed for Fort Laramie Canal, a short distance above Whalen Diversion Dam. This new heading was rendered inoperative a large part of the time due to shifting sand deposits so it was abandoned. A sand trap of nominal size, located in the canal approximately 0.6 of a mile below the dam, was entirely too small to be effective. The methods for controlling the sand described above proved to be failures so in the Summer of 1924 the present desilting basin was designed and was constructed during the Winter of 1924-25, Figures 2 and 3. From 1925 to the present time, the basin has been operating continuously and, in general, quire satisfactorily.

In a field trip report by E. W. Lane dated September 27, 1948, he suggested that the sluicing operations of the Fort Laramie Canal desilting basin could probably be improved by building one or several guide walls in the spreading entrance to the desilting basin and possibly rounding the left corner near the sluice gates. He also recommended that a hydraulic model built on a small scale would give the desired information as to the location and number of walls that would give the best sluicing action, and whether any improvement could be made by rounding the left corner near the sluice gates.

A letter dated September 20, 1949, to the Head, Research and Geology Division, from the Acting Head, Canals Division, requested that a hydraulic model study of the Fort Laramie Canal desilting basin be made as suggested in the field trip report by E. W. Lane, referred to above.

Based on the recommendations of E. W. Lane and because the funds alloted for such a study were limited, the model was constructed to a very small scale, 1:120. It was thought that a hydraulic study using a small table top model could be done for less cost than a study using a larger model.

CONSTRUCTION OF THE MODEL

After the scale of the model was chosen, design data showed that the model could be built on top of a metal table available in the laboratory. With the metal table it was easy to solder templates in an outline form to which concrete could be screeded to the proper shape and dimensions of the basin as shown in Figure 8A. The side walls were extended higher than the scale of the model indicated in order that the discharge and depth could be increased over and above those required by the model scale if it were desirable. It was felt that if sand was used as a model sediment, greater velocities would be required to move it than the undistorted scale velocities based on the 1:120 scale ratio. The tests made with sand proved this to be true.

A storage tank, pump, and piping system were built as an integral part of the model so it could be operated independently from the rest of the laboratory and could be moved rather easily. A 2-inch plastic Venturi meter, as shown in Figure 8B, was installed in the pipe line to measure the discharge through the model. A calibration curve of this meter is shown in Figure 9. To eliminate the vibration of the motor and pump being transmitted to the model, rubber couplings were used where the pump connected to the piping system. The pump and motor were mounted on the floor so the only connection between the model and the pump was through rubber couplings.

SELECTION OF A MOVABLE BED MATERIAL

Soon after the model was completed and put in operating condition, several materials were placed in the model with the scale discharge flowing and visual observations made to determine the material which would act most like the sand in the prototype. The list below gives the properties of the various materials tried.

PROPERTIES OF MATERIALS TRIED AS SEDIMENT FOR FORT LARAMIE CANAL DESILTING WORKS MODEL

Name	Color	Shape	Sp gr in air	Water absorption in 24 hr percent by wt	Size range
Styron	Blue	Angular	1.05-1.065	0.03- .05%	1.0 -5.0 mm
Saran	Lt green	Angular	1.65-1.75	0.1%	0.0625-1.0 mm
Plexene T A	Black	Subangular	1.06		
Tenite No. 1 (Acetate)	Red	Cubical	1.28	2.0 -6.0 %	0.25 -4.0 mm
Tenite No. 2 (Acetate butyrate)	Grey	Cubical	1.15-1.24	1.0 -2.4 %	1.0 -5.0 mm
Plexiglass Y-100	White	Angular	1.18	0.4 %	0.25 -1.0 mm
Coal	Black	Angular			0.0625-4.0 mm
Bakelite* No. 2498	Black	Angular	1.45	0.3 %	0.0625-3.0 mm
Bakelite	Red	Angular	1.45	0.3 %	0.0625-3.0 mm
Sand 16 mesh Tyler		Angular	2.65	0	1.20 -2.35 mm
Sand* 30 mesh Tyler		Angular	2.65	0	0.59 -1.20 mm

*Materials used as sediment in the model.

For the undistorted scale discharge, the black, ground bakelite gave a pattern more similar to the prototype sediment than any of the other materials. This material was chosen for the model sediment. However, several tests were made with the discharge increased considerably in which 30-mesh uniform sand and uniform sand of 0.2-mm average diameter were used. Size analysis curves of the ground bakelite and the uniform sand of 0.2-mm average diameter are shown in Figure 10. The 30-mesh sand falls in the size range of 0.6 to 1.2 mm.

MODEL TESTS

The initial tests were made using the ground bakelite as sediment. With the sluice gates closed and the water surface in Fort Laramie Canal held at elevation 4278.8, a discharge of 1,450 cfs was run through the model. At intervals of 10 minutes, deposits of 250 cc each of black bakelite plastic were fed into the channel just downstream of the head gates. This sediment was carried downstream and deposited in the basin. In the basin, the sediment traveled forward as a bed-load wave. After feeding sediment to the model in this manner for approximately 2 hours, the sediment appeared to follow the general trend of the deposit of sediment in the prototype as determined from descriptions by Ivan Houk, Engineering News-Record, Volume 100, No. 24, pp 922-926, and field trip reports by E. W. Lane and W. M. Borland. Making this same test a few times showed that the deposit in the model was very close to the position and depth of deposit in the prototype.

The bulk of the testing was done by first depositing sediment in the model basin in accordance with the deposit, described by Ivan E. Houk in an article listed above, and then going through a sluicing operation with the discharge set at a given value. During the sluicing operation the water surface in the lower part of the basin was below the top of the skimming weir. The skimming weir height was established for the normal discharge of 1,450 cfs by counting and measuring the 4- by 4-inch flashboards in the field, used above the top of the concrete sill.

Tests were made using discharges of 1,450, 2,000, and 3,000 cfs and sluicing for 4.1 minutes which corresponded to a sluicing time of 45 minutes in the prototype. The deposits left after sluicing with these conditions were not very similar to the deposits left in the prototype. Although the quantities of sediment removed seemed quite similar to the quantities removed in the prototype, the pattern of remaining sediment was widely different.

The next test was made with the initial sediment deposit lower on the left side of the basin. This had a tendency to draw more of the sluicing discharge over to the left side leaving a deposit on the right side of the basin and around the skimming weir when the 45-minute sluicing operation was finished. All descriptions and photographs of the actual basin show there is a deposit upstream from the skimming weir after sluicing operations are complete. At the end of an irrigation season, it is very common to sluice the basin several times in an effort to remove more sand. Even with several sluicing operations, without appreciable sediment inflow between sluicings, it was impossible to remove very much of the sediment deposited just upstream from the skimming weir.

After obtaining a close similarity between deposit in the prototype basin and model basin after a sluicing operation, tests were made in which one, two, and three guide walls were placed in the upstream portion of the desilting basin. This was done in an effort to improve the removal of sediment from the basin by guiding the water into the expanding portion of the basin proper.

Photographs and descriptions of the prototype desilting basin, during a sluicing operation, show a large eddy forming on the right side of the basin just downstream from the expanding portion of the basin. The guide walls that were tried eliminated the large eddy and distributed the flow more evenly in the basin. However, the tests showed that one comparatively short guide wall, Figures 4 and 5B, would spread the water as evenly as two or three walls.

Guide Walls Leading to Sluice Gates

A series of tests were made in an effort to improve the distribution of flow into the sluice gates. In the present operation of the prototype the sharp change in direction of the water along the left side of the basin, as it enters the sluice gates, causes considerable draw-down and results in a much shallower depth in the left sluice gate than in the others.

Two guide walls, Figures 4 and 6B, were tried in the downstream part of the basin to guide the water from the basin, around the curve and into the sluiceways. This arrangement improved the distribution of water but when sand was placed in the basin and a continuous sluicing operation was carried out, the sand built up higher than the top of the guide walls. The guide walls were as high as the skimming weir and it would be impractical to build the guide walls higher. For intermittent sluicing, the sand did not build up higher than the walls and the flow was distributed more evenly across the sluice gates, but the improvement was insufficient to warrant this construction in the prototype.

Tests were made with the corner near the sluice gates cut back, Figures 4 and 7B, with a modified curve, Figures 4 and 7A, and with a rounded submerged extension, Figures 4 and 6A. The tests with the curve cut back increased the amount of water through the left gate but there was still a sharp change in direction which caused considerable draw-down and piling up of the water in the left gate entrance. The improvement effected by using a modified curve and also the extended submerged curve was so slight that they were discarded. It was decided that a design that would considerably improve the flow conditions at the sluice gates would be costly and that the cost would materially exceed the benefits.

OBSERVATIONS ON PROTOTYPE

Before the irrigation season started in 1950, a 15-foot throat Parshall flume was constructed on Fort Laramie Canal approximately 1 mile downstream from the desilting basin. For normal flows of 1,450 cfs the Parshall flume caused the water surface to be approximately 2.0 feet higher in the desilting basin which necessitated raising the walls on the basin.

The backwater caused by installing the Parshall flume downstream from the basin had reduced the velocity at the entrance to the head gates so the amount of sediment now drawn into the basin has been reduced considerably. These conditions were noted after the model study was completed. If the sand entering the basin continues at the greatly reduced rate, the installation of a guide wall to improve the sluicing may not be necessary.

The Parshall flume has created an objectionable feature in that it has reduced the maximum discharge that can be obtained in the canal from approximately 2,000 cfs to 1,590 cfs. Prior to building the Parshall flume, the general practice was to turn an excess quantity of water down the canal for a sufficient length of time after sluicing the basin to replace the water that had been kept out of the canal during the 30 to 45 minutes when all the water was diverted down the sluiceway.

A typical schedule followed before the Parshall flume was built, as obtained from Harry M. Hendrickson, gate tender foreman, is given below.

1. Discharge in canal at beginning of schedule, 1,440 cfs.

2. Sluice gates were opened, discharge was increased to 2,000 cfs at head gates, settling basin was sluiced for 30 minutes.

3. Sluice gates were closed and basin was filled in approximately 8 minutes, leaving the discharge at 2,000 cfs.

4. 2,000 second-feet was passed down the canal for 13 minutes.

5. 1,740 second-feet was passed down the canal for 1 hour.

6. 1,640 second-feet was passed down the canal for 1 hour.

7. 1,740 second-feet was passed down the canal for 1 hour.

8. Flow was reduced to normal discharge of 1,440 cfs.

Now that the maximum flow possible in the canal has been reduced to 1,590 cfs due to installation of the Parshall flume, it is obvious that the above schedule cannot be followed.

ADDITIONAL TESTS

At the suggestion of F. E. Rippon, Canals Division, a single guide wall, Figures 4 and 5A, was installed throughout the full length of the basin dividing the basin in two equal channels. Gates were installed at the upper end so the total flow could be diverted to either channel during sluicing and the flow could be diverted through both channels during normal flow in the canal. In this way, a much higher discharge and velocity could be obtained in the partial basins during sluicing thereby making the efficiency of the basin higher.

Tests were made for two conditions of sluicing operations: (1) the basin was sluiced with no wall installed and, (2) the basin was sluiced with the full length wall installed and the discharge passed through one side of the basin then the other side. The volumes of sediment removed in a given time were measured. The table below gives the comparison of runs made with the full length wall and with no wall in the model.

COMPARISON OF SLUICING TESTS WITHOUT AND WITH FULL LENGTH WALL IN PLACE

Run No	Condition of model	Amount sediment deposited before run	Amount sluiced	Time of run	Discharge	Remarks
*29	Wall in place	3,500 cc	610 cc	5 min	4,700 cfs	Right half sluiced first
30	Wall in place	3,500 cc	1,300 cc	10 min	4,700 cfs	Left half sluiced first
31	Wall in place	3,500 cc	1,730 cc	10 min	4,700 cfs	Right half sluiced first
32	Wall removed	3,500 cc	610 cc	10 min	4,700 cfs	
**33	Wall in place	4,200 cc	3,100 cc	2 min	2,000 cfs	
34	Wall in place	4,200 cc	Not measured	3 min	2,000 cfs	
35	Wall removed	4,200 cc	1,900 cc	2 min	2,000 cfs	

*Runs 29-32, inclusive, used uniform sand, 0.59-1.2 mm.
**Runs 33-35, inclusive, used ground bakelite 0.0625-3.0 mm.

RECOMMENDATIONS AND CONCLUSIONS

It is concluded that very little was saved on the cost of the hydraulic model study by making the model to a very small scale.

Because the model scale was so small, similarity of the turbulence in the model and prototype was impossible. However, by forcing the model, it was possible to get similarity of sediment deposit prior to sluicing and after a sluicing operation was completed. All of the tests were made on a qualitative basis and changes were based on visual observations. Because it was possible to obtain similarity in the sediment movement by distorting the discharge, distorting the slope, shaping the sand bed, etc., it is felt that recommendations can be made that will improve the flow through the basin during sluicing operations.

A single guide wall with a projected length of 125 feet along the centerline of the basin gave the best performance in the model tests considering over-all cost and operation. This wall will be submerged during normal flow in the canal and during sluicing operations the top will be above the water surface. The wall is 4 feet high at the upstream end and 5 feet high at the downstream end with the upstream 20 feet movable, as shown in Figures 4 and 5B. Before this wall is installed, it is recommended that further studies be made of the action of the prototype basin with the Parshall flume installed downstream.

From the results of the very limited studies made with a single guide wall extending the full length of the basin, it is believed that the basin can be sluiced much more efficiently by this method. However, the tests were not extensive enough to be conclusive.

FIGURE I

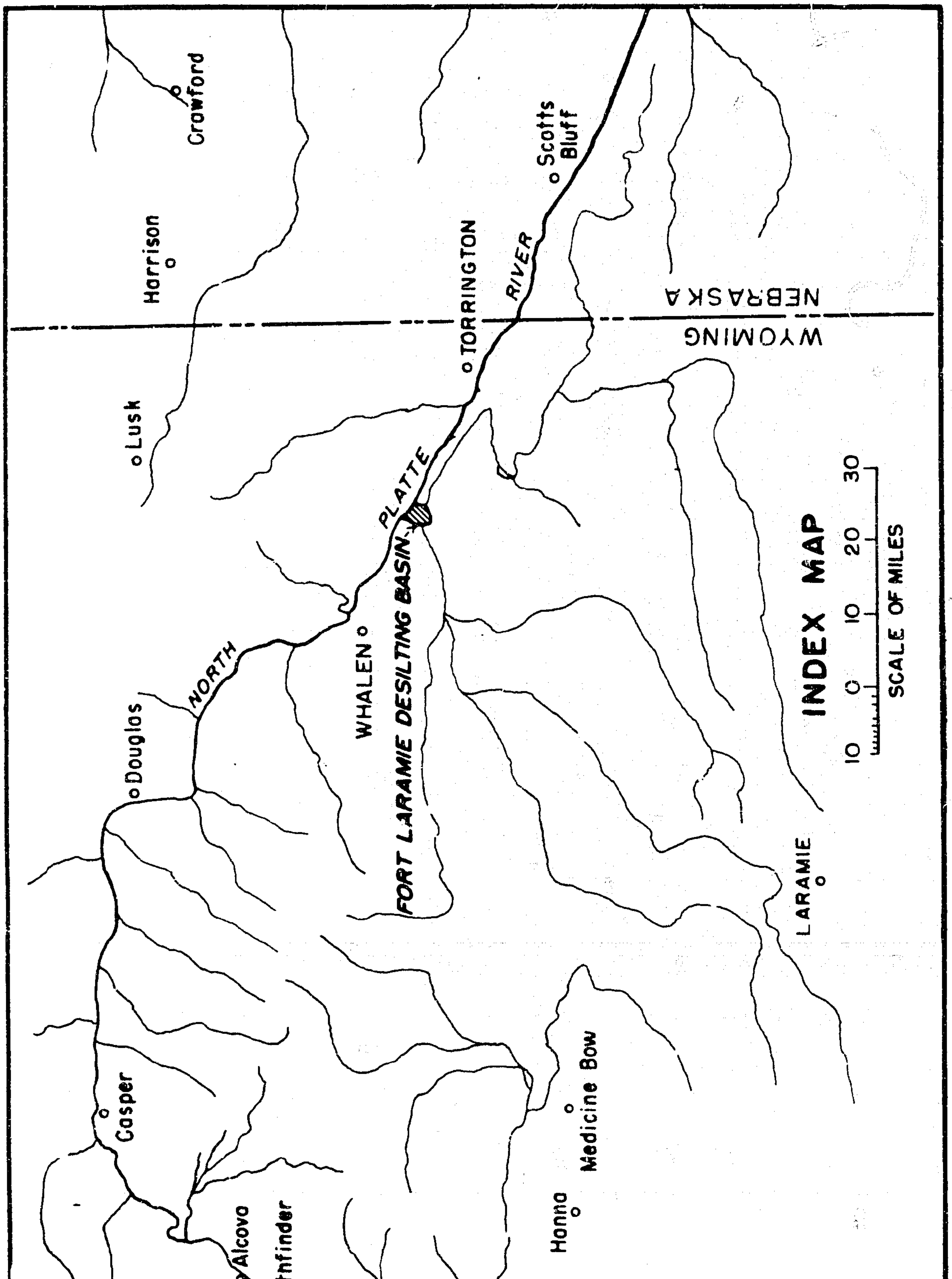
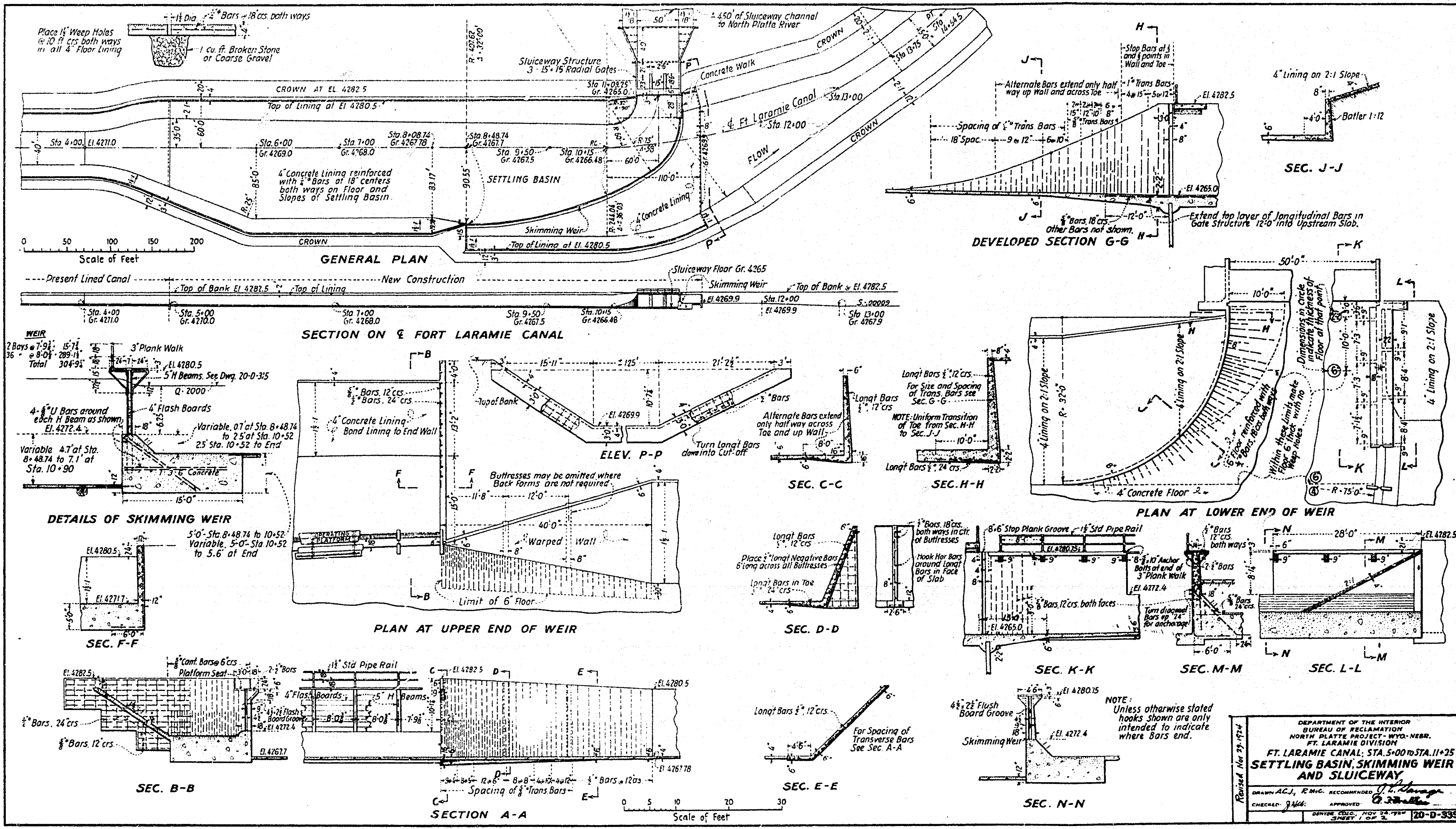

Crawford
Harrison
Lusk
Douglas
Casper
Alcova
Pathfinder
Hanna
Medicine Bow
WHALEN
FORT LARAMIE DESILTING BASIN
NORTH
PLATTE
RIVER
TORRINGTON
Scotts Bluff
NEBRASKA
WYOMING
LARAMIE
INDEX MAP
10 0 10 20 30
SCALE OF MILES

FIGURE 2

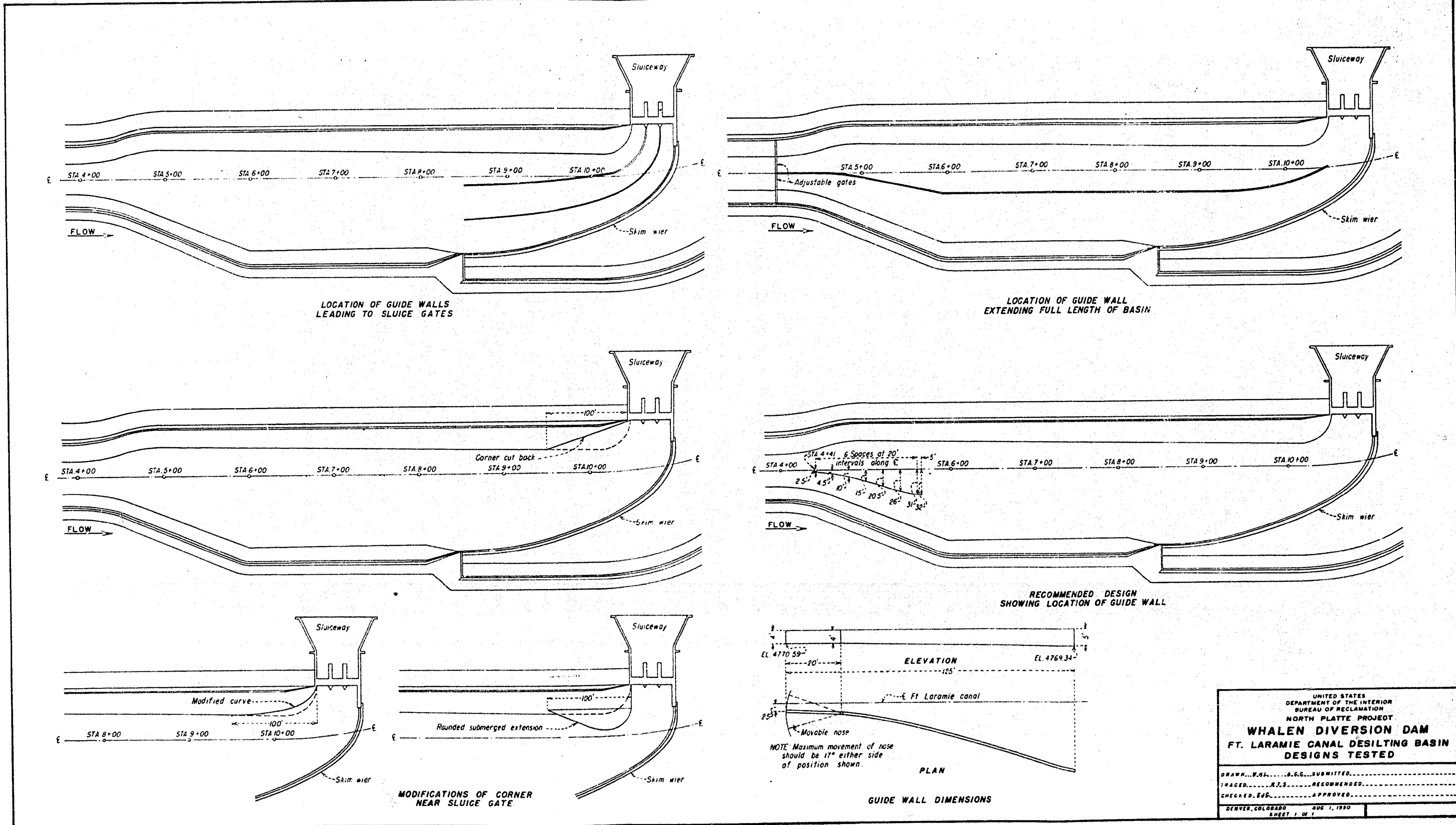

GENERAL PLAN
Scale of Feet
SETTLING BASIN
Sluiceway Structure 3 - 15' x 15' Radial Gates
Concrete Walk
CROWN AT EL. 4282.5
Top of Lining at El. 4280.5
℄ Ft. Laramie Canal
FLOW
Skimming Weir
4" Concrete Lining reinforced with ½" Bars at 18" centers both ways on Floor and Slopes of Settling Basin
Place 1½" Weep Holes @ 10 ft. crs. both ways in all 4" Floor Lining
1 cu. ft. Broken Stone or Coarse Gravel
450' of Sluiceway channel to North Platte River
DEVELOPED SECTION G-G
Extend top layer of longitudinal Bars in Gate Structure 12'-0" into Upstream Slab.
SEC. J-J
4" Lining on 2:1 Slope
Batter 1:12
SECTION ON ℄ FORT LARAMIE CANAL
Present Lined Canal
New Construction
Sluiceway Floor Gr. 4265
Top of Bank El. 4282.5
Top of Lining
DETAILS OF SKIMMING WEIR
3" Plank Walk
5" H Beams. See Dwg. 20-D-315
4" Flash Boards
1:3:6 Concrete
PLAN AT UPPER END OF WEIR
Buttresses may be omitted where Back Forms are not required
Warped Wall
Limit of 6" Floor
ELEV. P-P
Turn Longt. Bars down into Cut-off
SEC. C-C
SEC. H-H
NOTE: Uniform Transition of Toe from Sec. H-H to Sec. J-J
PLAN AT LOWER END OF WEIR
4" Concrete Floor
4" Lining on 2:1 Slope
Dimensions in Circle indicate thickness of Floor at that point.
SEC. F-F
SEC. D-D
SEC. K-K
SEC. M-M
SEC. L-L
SEC. B-B
SECTION A-A
SEC. E-E
SEC. N-N
Scale of Feet
NOTE: Unless otherwise stated hooks shown are only intended to indicate where Bars end.
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NORTH PLATTE PROJECT - WYO.-NEBR.
FT. LARAMIE DIVISION
FT. LARAMIE CANAL; STA. 5+00 TO STA. 11+25
SETTLING BASIN, SKIMMING WEIR AND SLUICEWAY
Revised Nov. 29, 1924
DENVER, COLO. NOV. 24, 1924
SHEET 1 OF 2
20-D-339

A. Looking downstream towards skimming weir.

B. Looking upstream towards headworks. Skimming weir in foreground.

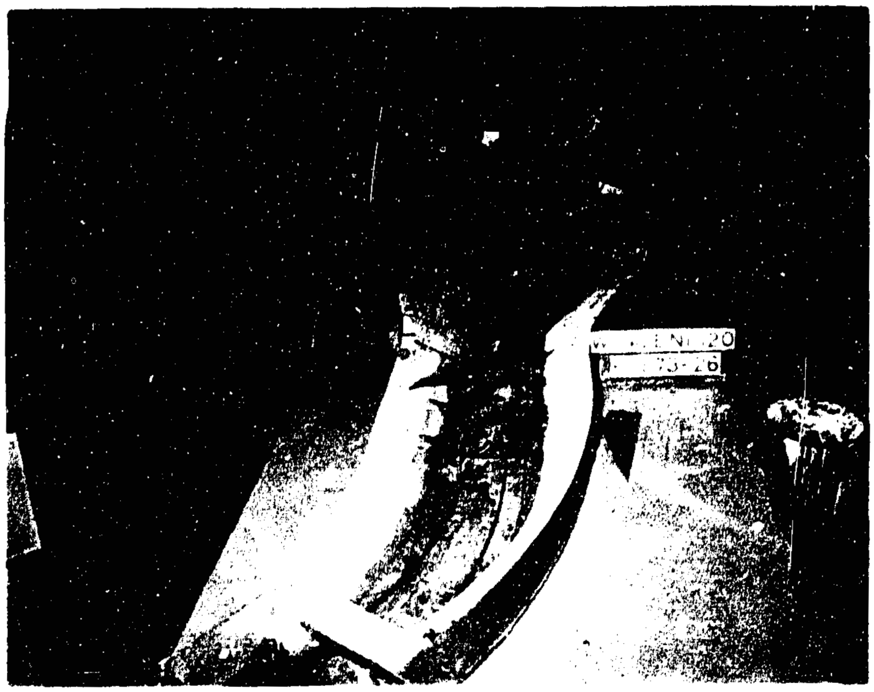
FORT LARAMIE CANAL DESILTING BASIN

FIGURE 4



Sluiceway
FLOW
Skim wier
STA 4+00
STA 5+00
STA 6+00
STA 7+00
STA 8+00
STA 9+00
STA 10+00
LOCATION OF GUIDE WALLS LEADING TO SLUICE GATES
Adjustable gates
LOCATION OF GUIDE WALL EXTENDING FULL LENGTH OF BASIN
Corner cut back
100'
STA 4+41
6 Spaces at 20' intervals along ℄
RECOMMENDED DESIGN SHOWING LOCATION OF GUIDE WALL
Modified curve
Rounded submerged extension
MODIFICATIONS OF CORNER NEAR SLUICE GATE
ELEVATION
EL. 4770.59
EL. 4769.34
125'
20'
℄ Ft Laramie canal
Movable nose
NOTE: Maximum movement of nose should be 17° either side of position shown.
PLAN
GUIDE WALL DIMENSIONS
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NORTH PLATTE PROJECT
WHALEN DIVERSION DAM
FT. LARAMIE CANAL DESILTING BASIN
DESIGNS TESTED

FIGURE 5

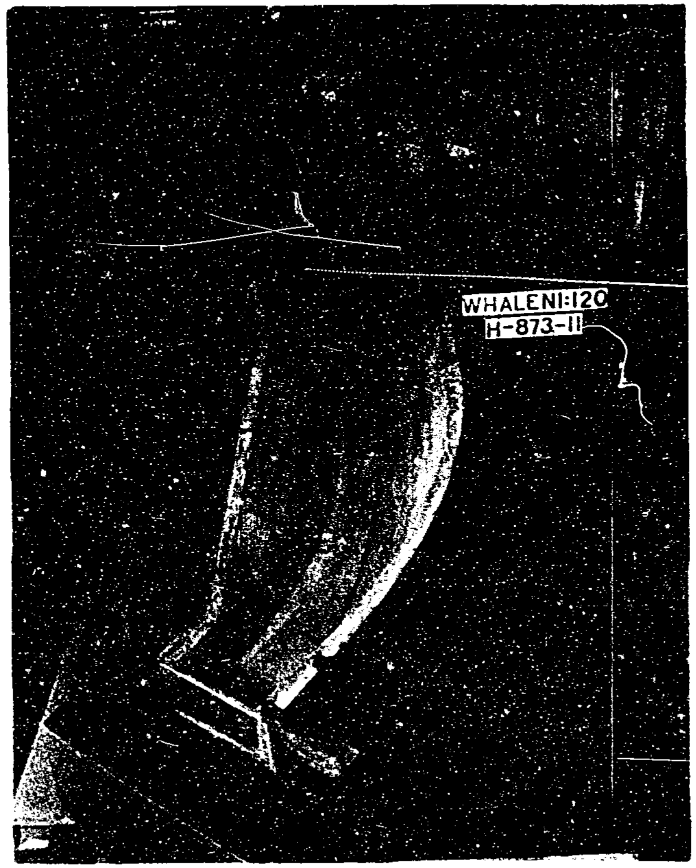


A. Wall extending full length of basin.

B. Single guide wall in upstream part of basin.

GUIDE WALLS

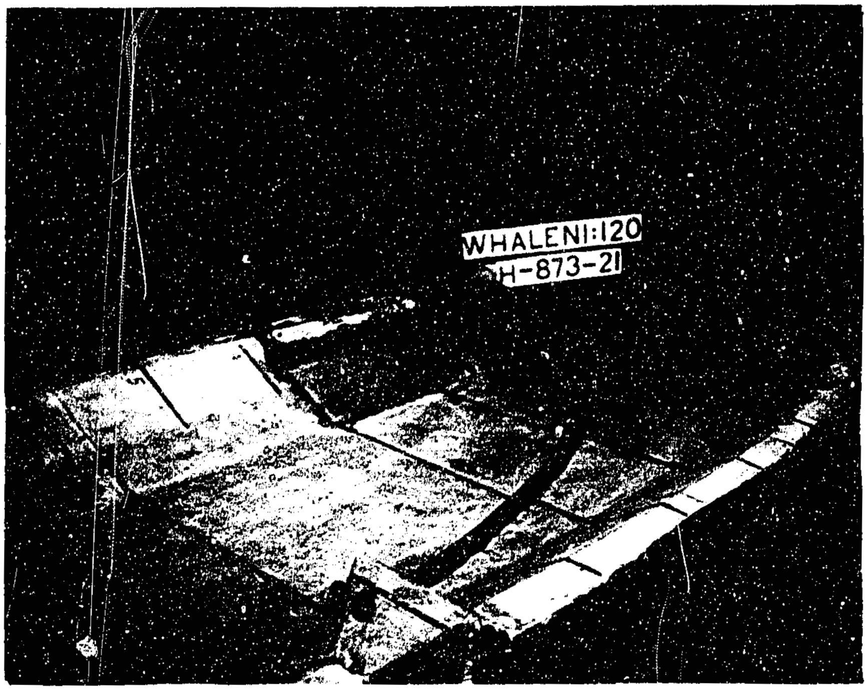
A. Submerged rounded extension near sluice gate.



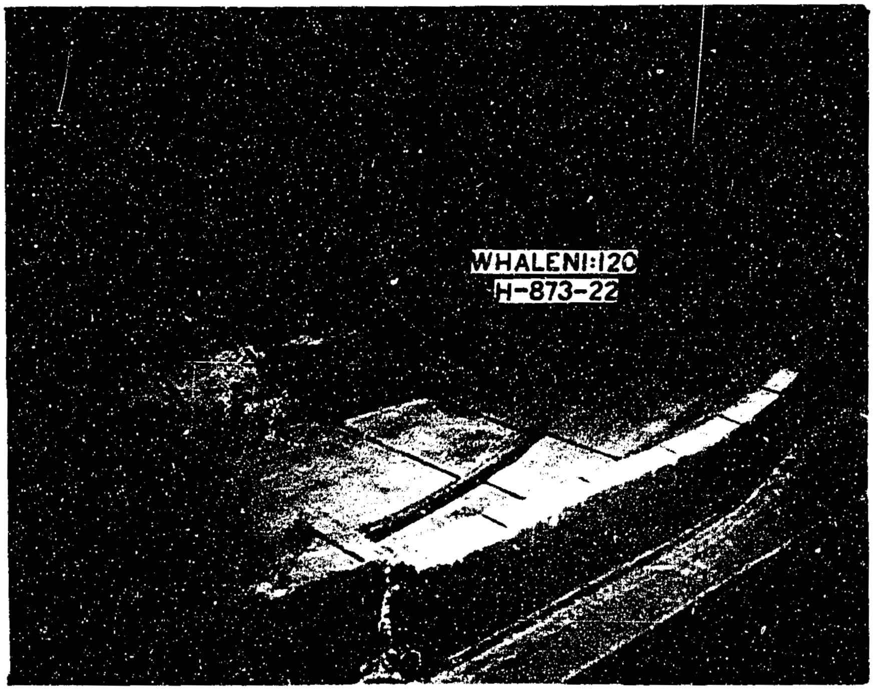
B. Guide walls leading to sluice gates.

GUIDE WALLS AND MODIFIED CORNER NEAR SLUICE GATES

FIGURE 6

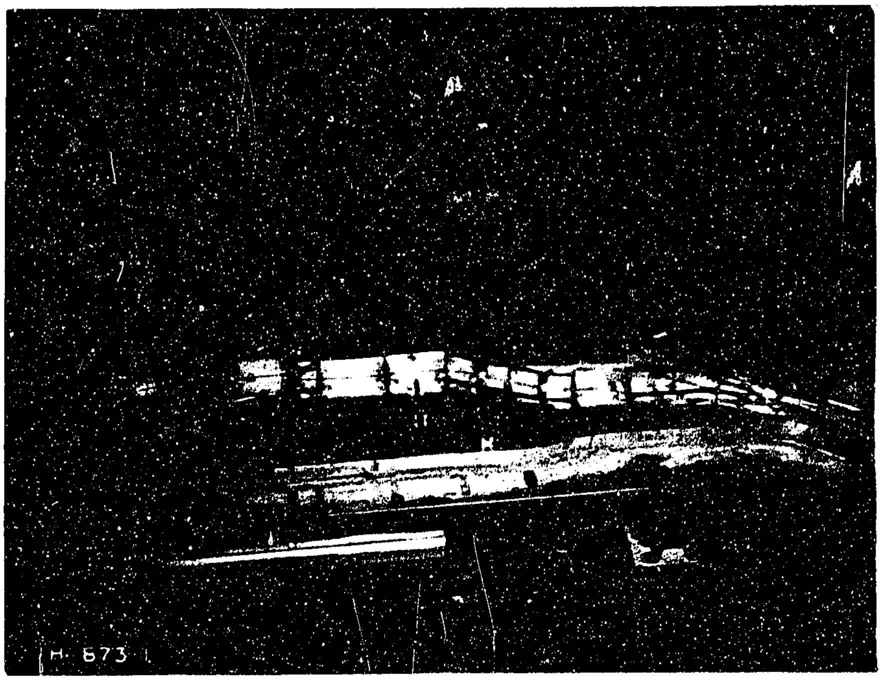


A. Modified curve of corner near sluice gate.



B. Wall cut back to straight fillet near sluice gate.

MODIFICATIONS OF CORNER NEAR SLUICE GATES

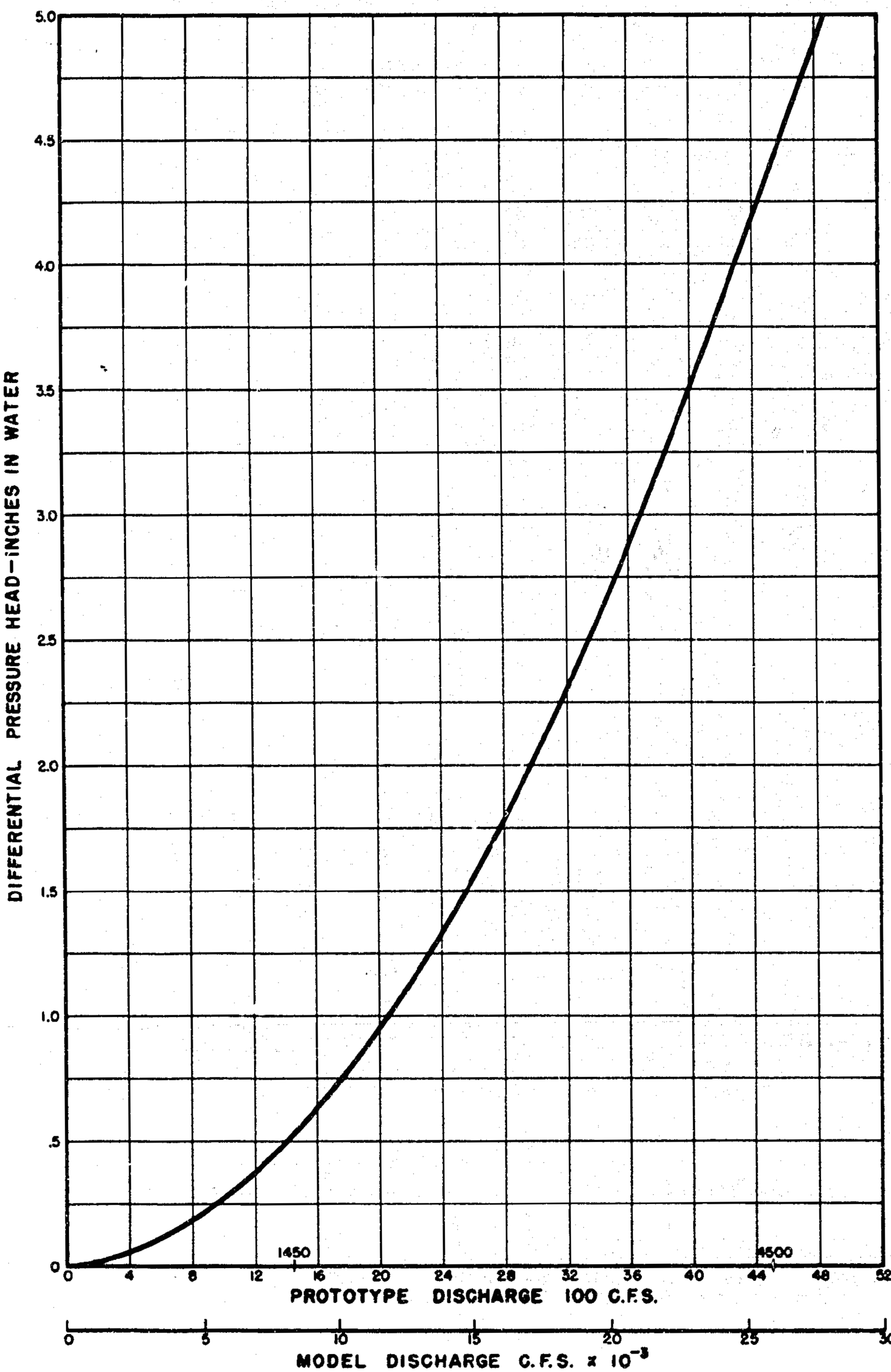


A. Metal templates in place before placing concrete.

B. Two-inch Venturi meter, manometer, and calibration curve.

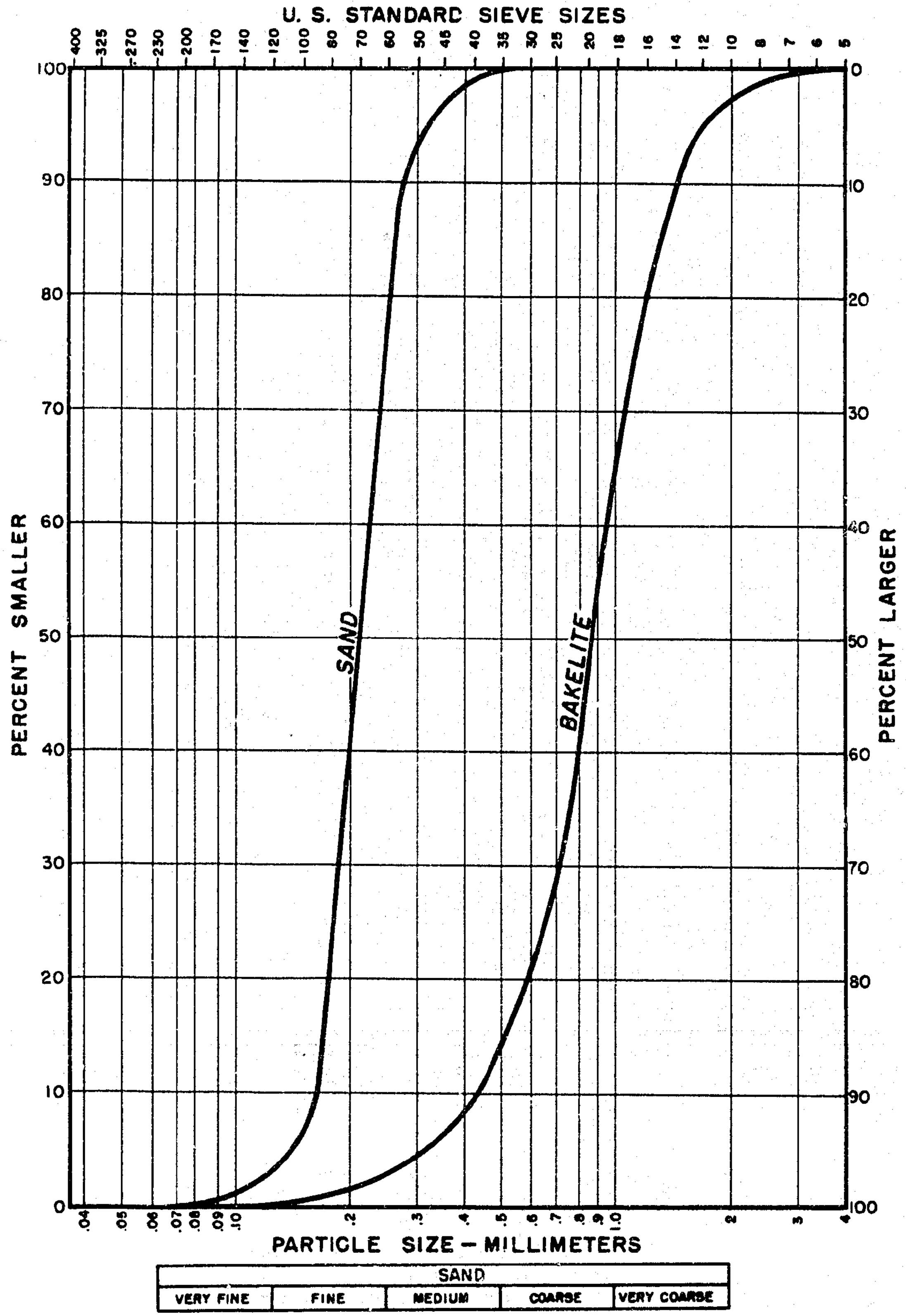
MODEL UNDER CONSTRUCTION

FIGURE 9



CALIBRATION CURVE FOR 2-INCH VENTURI METER
WHALEN DESILTING BASIN MODEL
FORT LARAMIE CANAL

FIGURE 10



SEDIMENT SIZE ANALYSIS

BAKELITE #2498, BLACK

UNIFORM SAND, AVERAGE DIAMETER 0.21 MM