PAP-32 MARTIN Schroeder

Memorandum

Denver, Colorado
April 3, 1951

Chief Engineer

Through: Head, Research and Geology Division

C. W. Thomas

Operating characteristics of some of the hydraulic structures on Colorado-Big Thompson Project east of the Continental Divide

1. The observations contained in this report were made on an unofficial trip to structures on the Colorado-Big Thompson Project for the purpose of studying existing hydraulic conditions. Since there has been much discussion concerning the behavior of some of the structures, my personal observations are presented for your information. Your approval is requested to provide carbon copies to the interested offices listed at the close of this memorandum.

2. On Saturday morning March 31, 1951, I drove to the steel siphon through which the Horsetooth Feeder Canal crosses the Big Thompson River. Inspection of this structure indicated that the expansion joint on the downstream (north) end of the steel tube had possibly frozen or otherwise become restricted sometime during the winter, and all the contraction had occurred on the upstream (south) end. The expansion joint at this end was open approximately 6 inches. The movement was so severe that it had pulled the south pier toward the river until it was cracked and out of plumb. The walkway and handrails on top of the tube were also separated by a distance of approximately 4 inches. The drain valve that had frozen and broken on March 18, 1951, had been repaired and was apparently watertight. Check marks on the steel tube, stakes driven into the bank, and marks on the rocks around the south end of the steel siphon indicated that the project was carefully observing the movement at the expansion joint.

3. The next stop was at the inlet to the tunnel diversion from the Big Thompson to the Horsetooth Supply conduit. Water was being diverted at this structure into the tunnel, and the grating was apparently keeping the coarser material out of the inlet to the tunnel. No unusual features were observed at this structure. A photograph of flow conditions is enclosed.

4. The next stop was at the Parshall measuring flume below Olympus Dam. A concrete structure has been built in the bed of the Thompson River at this location. Normal releases from the dam will be measured through a 15-foot throat Parshall flume. The flume is flanked on each side by an ogee crest approximately 20 feet long joined to vertical abutments that extend above the crest some 10 feet. The structure is in excellent condition, and it appears that a good accurate measurement will be obtained of the releases from Estes Lake

through Olympus Dam. A shelter house and, presumably, a recorder inside is installed on the right bank of the river. A cable-type rating station has been installed upstream from the ogee structure. There may be some difficulty in obtaining a continuous rating curve for this structure because there may be a break at the transition point where the Parshall flume will no longer carry the discharge, and the flow over the ogee is of shallow depth. It is possible that the rating for the Parshall flume, which is built with a moderate depth (it appeared to be about 2 feet to 30 inches deep), can be projected through this transition by obtaining a current meter rating of the ogee crest. The curve may have a definite break in it, but it may be possible to connect the two portions of the curve, the one from the Parshall and the one from the ogee, so that a reasonable degree of accuracy may be obtained even through this transition section. A photograph of this installation is enclosed.

5. The next stop was at the Estes Park field office. Since it was Saturday, only a small force was in the office. I talked to Mr. Dickey and Mr. Skinner. They advised that I call the watermaster, Mr. Phil Johns, at the powerhouse and determine exactly what the program for diverting water for the day might be. Mr. Johns advised over the phone that the water would be turned into West Portal at 11 a.m. The rate of flow would be 225 cubic feet per second, or one-half the capacity of Adams Tunnel. He estimated that the flow would reach East Portal approximately 1:30 p.m., so that any inspection of the weir at East Portal and the chute at Marys Lake would, of necessity, have to be completed prior to the time the water arrived. Mr. Johns also stated that Marys Lake had been drained to remove the cofferdam in front of the Estes Power Plant penstock, and that he was going to Marys Lake and to East Portal and would meet me at one or the other of the places and answer any questions that I might have.

6. I proceeded to Marys Lake and observed the removal of the cofferdam in front of the Estes penstock trashracks. This removal was being accomplished by means of a bulldozer operating in the water. The lake was almost completely drained. After observing this operation a short time, I drove to the Marys Lake Power Plant and walked around the lake edge to the bypass chute where it enters the lake.

7. This chute was originally built of reinforced concrete in the form of a 6- by 6-foot tube. The cover had been blown off from the high watermark of the reservoir down to the level portion

of the outlet, about 13 feet of the horizontal section remained. Pictures were taken of the shattered concrete and the condition of the chute. It was interesting to note that the entire structure was badly shattered as if subjected to tremendous forces. A longitudinal crack extends along the bottom of the chute. Another crack exists where the walls have been loosened from the bottom slab. No measurements were made of the length of the slab that had been removed, but a complete report is being prepared by the project regarding the extent of the damage and proposed repairs. I worked my way up the chute to enter the covered portion. Just above the high water line of the reservoir, where the cover remains on the chute, the concrete appears to be in good condition. There is one longitudinal crack running up the bottom of the chute, but the sides and top appear, from a very cursory examination without a light, to be in fair condition. There were some peculiar markings on both sides of the chute just above the high watermark. They appeared to slope downward and fan out from a point near the bottom and may be stress cracks. A picture showing this pattern, together with other views of the damage, is enclosed.

8. From Marys Lake, I drove to the East Portal of Adams Tunnel and made an inspection of the weir in the stop-log slot at the entrance to Aspen Creek siphon. This is a trapezoidal weir with a 7-foot crest length and a height of 5 feet. The side slopes are 1/4:1 as prescribed for a Cipolletti weir. The blade is made of 1/8-inch steel, has been welded and dressed down, and appeared to be in good shape. The most serious defect in this weir is that it has been placed at the downstream edge of the stop-log slot, and the stop logs extend upstream from the weir a distance of approximately 8 inches. Heavy timbers were used for the bulkhead, and the crest of the weir was placed approximately 6 feet above the bottom of the structure and 6 inches above the top of the stop logs. Canvas had been placed over the bulkhead to assist in making it watertight. It was not possible to get to the weir through the trashrack to check the level or make a close examination of the blade. All inspection was made through the trashrack from a point approximately 4 feet upstream from the weir blade. A hand level was used to sight on the weir crest and, apparently, it was level. The weir blade was probably plumb because it was wedged against the downstream side of the stop-log slot. These stop-log slots are usually carefully plumbed to avoid binding of the stop logs. Had it not been for the fact that the weir blade was placed on the downstream side of the stop logs, this installation looked fairly good; see attached photographs. A stilling-well

has been anchored to the center pier of the structure of the spillway side, and a recorder placed in this well. The Type-F Stevens recorder from the temporary Parshall flume had been used up until Saturday, and during the time I was at the East Portal the F-type recorder was removed and a Stevens A-35 was installed on the stilling-well. A permanent staff gage was also installed on the left side of the spillway structure. This gage is upstream from the weir a sufficient amount to be easily readable and beyond the draw-down. The zero of this staff gage was referred to the weir crest with a rod and level and permanently attached to the concrete, and should serve as a very accurate means of obtaining a check on the recorder.

9. There is a 10-foot steel Parshall flume on the entrance to the 36-inch temporary pipe at the East Portal of the Adams Tunnel. This flume is set at a relatively high level in the lake and is above the normal water surface expected. It is possible that with a 550-second-foot flow passing over the weir, the water surface will be above the entrance to this Parshall flume, and it will be necessary to place a temporary bulkhead of sandbags across the throat of the flume to prevent water from flowing into the 2 miles of 36-inch pipe that extend down Wind River to the Thompson River.

10. The 30-inch concrete conduit to carry the natural flow of Wind River through East Portal Reservoir is well protected as shown in the enclosed photograph.

11. The water arrived at East Portal of the Adams Tunnel about 1:30 p.m., and within an hour the pool had been filled and the flow stabilized so that flow conditions on the weir could be observed. The approach conditions are not good. The water approached the combination spillway and entrance to Aspen Creek siphon structure and flows around the center pier into the siphon entrance where the weir is located. The flow around this pier causes a whirl which is carried through the trashrack and through the weir, causing very unstable conditions on the left side. This turbulence affected approximately half the length of the weir. The turbulence in the water may be seen in the lower portion of the enclosed photograph. At 2:45 p.m., the flow was apparently stable, and there was a 3.94-foot head on the weir. According to the discharge table for the weir, this head would correspond to a flow of 208 cfs. The A-35 recorder was set, and the paper started on the chart.

12. The flow from the tunnel into the small reservoir at the East Portal is satisfactory. The water emerges from the tunnel below critical depth and a hydraulic jump forms just at the portal of the tunnel (enclosed photographs), and the water enters the lake very smoothly.

13. When I arrived at the chute at Marys Lake Power Plant, the flow apparently had leveled out, and a steady flow condition prevailed down the chute. No unusual conditions were observed in this flow. The velocity was quite high, since the chute is very steep. The spread of the sidewalls at the lower end of the chute was not effective and the major portion of the flow was following down the center of the chute, not spreading into the full area as intended. (See enclosed photographs.)

14. I left the chute and drove around the lake and to the siphon spillway leading to the chute. Mr. Johns had the building unlocked when I arrived, and we went inside to observe flow conditions at the entrance to the siphon spillway. All was quiet in the building, and we had observed the steady flow for a period of probably 10 or 15 minutes, when, suddenly, air started rushing in through a broken window and through the vents, and in a few seconds it was apparent that the siphon had primed. This siphon emptied the forebay and lowered the water surface 30 inches in a period of approximately 15 seconds. It took approximately 30 seconds for the forebay to refill to the original level and it again emptied in about 15 seconds. This cycle was repeated a number of times while the observations were being made and while the chute at the downstream end was being observed from the top of the hill.

15. The flow during the priming and breaking of the siphon spillway was very spectacular. Since the lake was low, a flow approximately three times the amount entering the forebay rushed down the chute in a slug, and literally swept the water out of the south side of the lake toward the north side. Then the flow entirely ceased for a short period, the water in the lake rushed back, and the cycle was again repeated.

16. While viewing this phenomenon the reason for the failure of the structure could be visualized. When the siphon was discharging the water was swept away from the exit of the chute. During the interium period that was necessary for the forebay to fill, the water in the lake rushed toward the structure. Since this time was approximately double the time that the flow was discharging, an

appreciable reverse velocity could be acquired. When the cover was on the chute and the lake at normal level, the 36 square feet of exit area was under a static pressure of more than 56,000 pounds. If a reverse velocity prevailed, the momentum would increase as the square of this velocity. Although no calculations have been made the collision between the next slug of water down the chute and this reverse flow would certainly produce tremendous pressures and resultant stresses in the structure if the two flows were opposed.

17. Mr. Johns stated that during the time the chute had previously operated, he had never noticed this phenomenon, and had assumed that there was steady flow down the chute as was noted at the time we first arrived at the forebay. From the appearance of the breakage and damage in the chute, this surging flow apparently prevailed for some time during the past season, when the flow was being diverted around the powerhouse.

18. I proceeded to the bottom of the chute to observe the conditions there more closely, but the flow had stabilized by the time I arrived. I waited for several minutes but the siphon did not prime and the flow continued in an orderly manner.

19. After leaving Marys Lake, I stopped briefly at the power plant at Estes Park to observe the damage to the riprap on the right side of the tailrace. Operating personnel stated that there was very minor damage to the riprap, and since Lake Estes was high, it could not be seen. When the lake is low, it had been observed by project personnel that the original hand-placed riprap projected slightly beyond the concrete training wall. When the by-pass came into action, the flow was along the concrete wall, and the high velocity struck these projecting rocks, moved a few of them out into the pool, and washed away some backfill. A couple of loads of rock had been dumped back into the hole, and they were of the opinion that nothing further was needed. They were very much surprised to hear that extensive repairs were being contemplated to this pool. It was possible to note, even with the high water, a few rocks that had been dumped into the hole where the erosion is alleged to have occurred.

Enclosures 14

Copy to: Regional Director, Denver, Colorado
District Manager, South Platte River District
Head, Canal Engineering Division

Noted: April 19, 1951.
This is a very excellent report of an unofficial field trip. The intermittent action of the siphon spillway at Mary's Lake forebay seems to account for the failure of the chute.
L. N. McClellan. Chief Engineer

PICTURES OF HYDRAULIC STRUCTURES ON THE EAST SIDE OF THE CONTINENTAL DIVIDE--COLORADO-BIG THOMPSON PROJECT--REGION 7

Taken by C. W. Thomas--March 31, 1951

H-983-1. Close-up of diversion structure on Big Thompson River to tunnel entrance of Horsetooth Supply Conduit.

H-983-6. The 15-foot Parshall flume and measuring control below Olympus Dam--Taken from the bed of Devils Gulch. Flow from Devils Gulch entering from right of picture downstream from Parshall flume.

H-983-12. Bypass chute at Marys Lake Power Plant showing shattered concrete at junction of left wall and bottom in curved portion of chute.

H-983-16. Bypass chute at Marys Lake Power Plant--Looking downstream at damaged structure from right side--Showing 13 feet of cover remaining.

H-983-17. Pattern on right wall of chute near high water surface elevation of the lake.

H-983-19. Looking down at the breakage in the chute from left side.

H-983-20. The 7-foot trapezoidal weir in the stoplog slots at the entrance to Aspen Creek Siphon. This weir is between the trashracks and the transition entrance to the siphon proper. The gage well is shown just to the left of the pier that separates the siphon entrance from the spillway section.

H-983-22. A close-up of the left edge of the weir showing the 8-inch stoplogs projecting upstream from the weir blade.

H-983-24. The east portal of Adams Tunnel--Looking across the reservoir between the tunnel portal and the entrance to Aspen Creek Siphon. Protective cover over 30-inch reinforced concrete tube to pass natural flow of Wind River through the reservoir extends through center of photograph.

H-983-28. Flow conditions on the weir with approximately 3 feet of head on the weir crest.

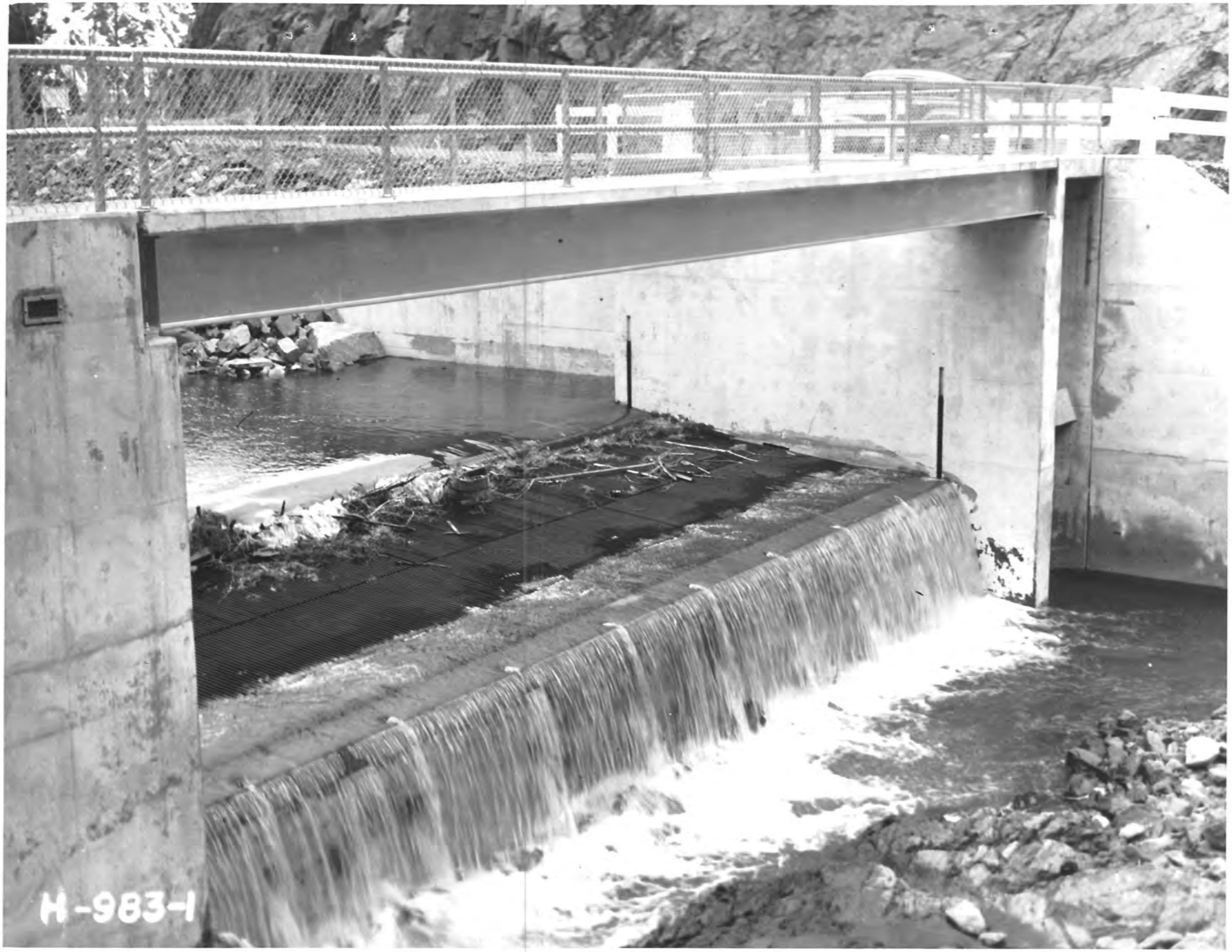
H-983-30. Flow conditions at the outlet end of Adams Tunnel--Discharge approximately 210 second feet, note that the hydraulic jump forms just at the protective curtain at the portal of the tunnel.

H-983-31. The dam at East Portal Reservoir, the temporary Parshall flume, and the entrance to Aspen Creek Siphon as seen from the east portal of Adams Tunnel.

H-983-33. Flow conditions in the by-pass chute at Marys Lake Power Plant with a flow of approximately 210 second feet--Looking downstream from the hill above the chute.

H-983-34. A close-up of the water leaving the chute and discharging into the lake. The lake had been drained so that the water jumped free of the structure into the lake bed.

H-983-35. Looking downstream at the flow conditions from the slab over the chute--Discharge approximately 210 second feet.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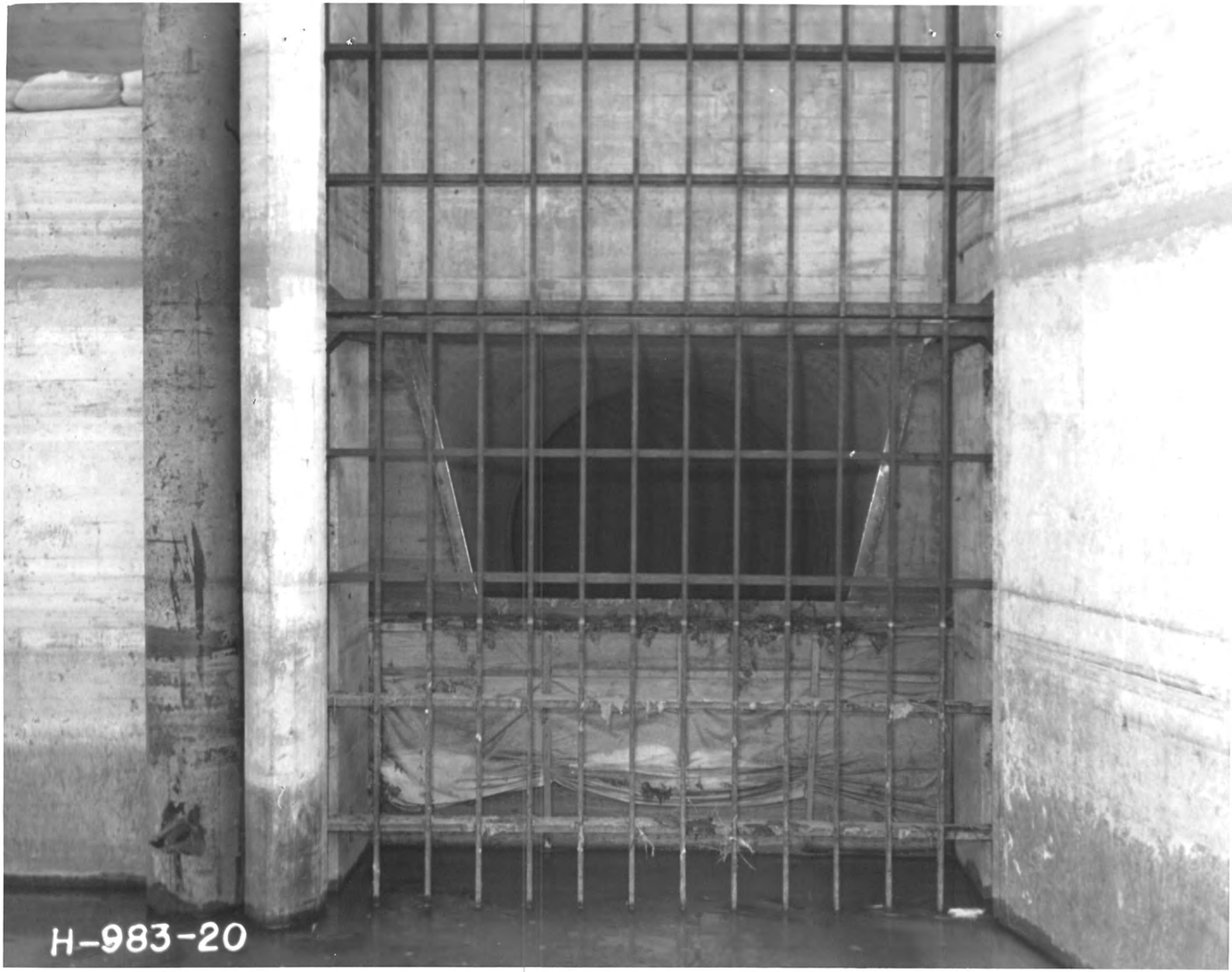
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