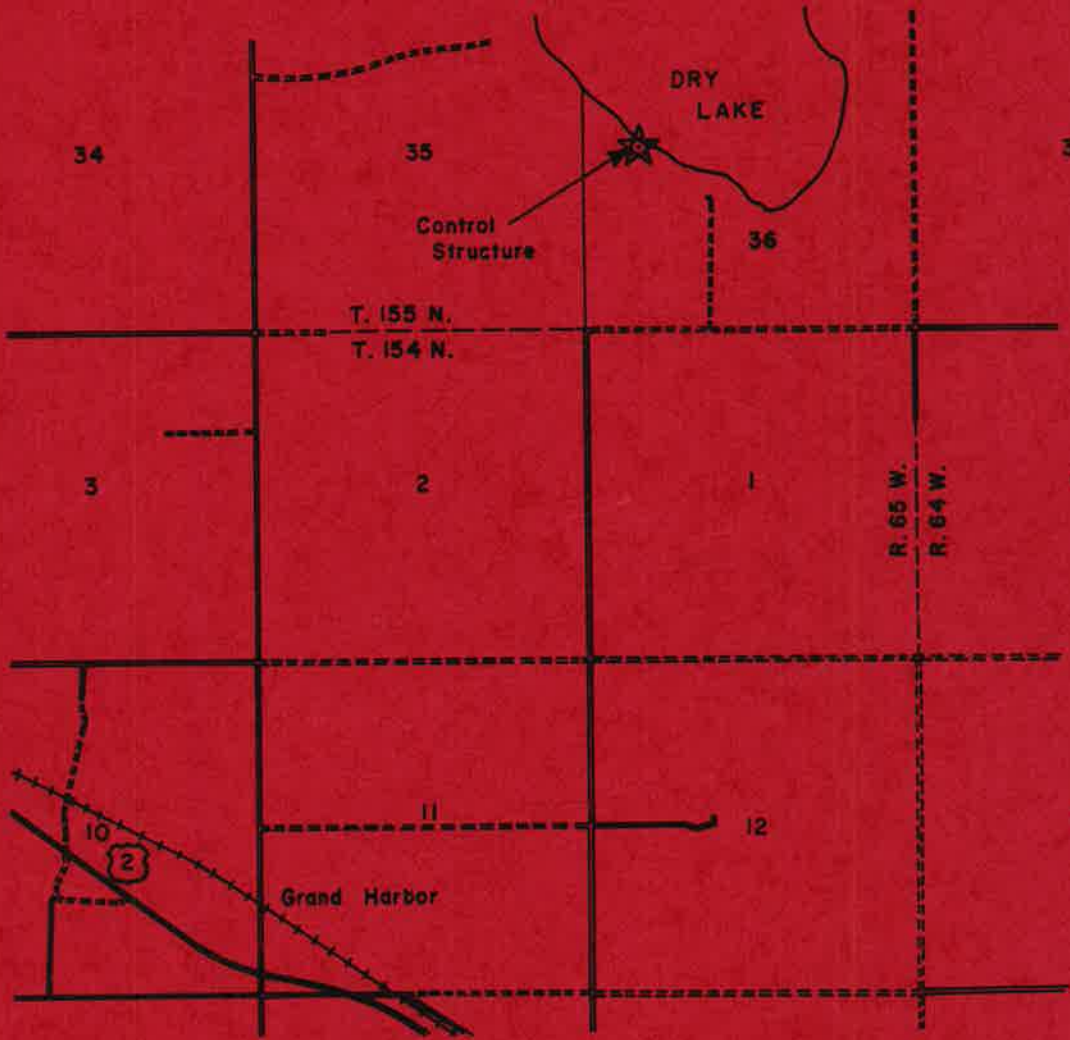
INVESTIGATION AND REPAIR OF THE CHANNEL "A" CONTROL STRUCTURE

STARKWEATHER WATERSHED



NORTH DAKOTA
STATE WATER COMMISSION

NOVEMBER 1984

SWC PROJECT 842

INVESTIGATION REPORT

OF THE

CHANNEL "A" CONTROL STRUCTURE

RAMSEY COUNTY

SWC PROJECT NO. 842

INSPECTED AND REPORTED BY:

Cary Backstrand P.E.
Chief, Regulatory Section

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Design Engineer

Edgar W. Schmidt, P.E.
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UNDER THE DIRECTION OF:

David A. Sprynczynatyk, P.E.
Director, Engineering Division

INVESTIGATION REPORT
OF THE
CHANNEL "A" CONTROL STRUCTURE
STARKWEATHER WATERSHED
SWC PROJECT NO. 842

The purpose of this report is to present the results of the State Water Commission's investigation and partial repair of the Channel "A" control structure and also the comments and opinions of staff based on site observations. The opinions expressed in this report are based on the conditions observed at the structural site only.

This report was requested by Robert Garske, Chairman, Ramsey County Water Resource District.

The Channel "A" control structure is located at the south end of Dry Lake in Section 36, Township 155 North, Range 65 West, approximately 7½ miles northwest of Devils Lake in Ramsey County (See Photos A and B).

The following is the sequence of events that took place when this office was first notified that water was bypassing the Channel "A" control structure. The report shows the dates that site inspections and observations were conducted and what work was performed.

May 2, 1984 - (Reported by Cary Backstrand, Chief, Regulatory Section)

Dave Sprynczynatyk received a phone call from Bob Garske on May 2. Prior to the call, Bob and other Board members had inspected the Channel "A" control structure and found a considerable amount of water bypassing the structure. I was directed by Dave to immediately fly to Devils Lake and make an on-site inspection. John Klingenberg, North Central Engineers, was also contacted and agreed to meet me at Devils Lake. Bob Garske, Dick Regan, John Klingenberg and myself conducted the on-site inspection (See Photos C and D).

With the gates closed, two (2) pronounced boils were evident immediately downstream from the structure which indicated to me movement of water underneath the structure (See Photos E and F). The larger of the two boils was located near the center of the channel. Pieces of rock which appeared to be shale about the size of a thumb nail were being pumped from underneath the structure and were visible in the boil (See Photos G and H). There was also a visible flow of water along the east downstream wingwall (See Photo I). Undoubtedly, the flow of water has been partly responsible for the erosion and slumping of the channel slope adjacent to the soil side of the wingwall (See Photo J).

The three radial gates were opened to eliminate the head difference between the upstream and downstream side of the control structure. As the flow increased the boils decreased and were no longer visible when the gates were completely open.

We left the gates in an open position and returned to Devils Lake. I informed the Board that it would be necessary to hire a contractor and install, as soon as possible, a plug upstream from the structure. Bob Garske contacted George Durbin, a local contractor, who joined the group at a local cafe. It was decided that the channel block would be constructed at a point approximately 30 feet upstream from the control structure that would also provide an equipment platform for any necessary repairs.

I then flew back to Bismarck and made an oral report of the field inspection to Dave Sprynczynatyk. We did not perform any tests other than a visual inspection. I felt that the situation could deteriorate quite quickly, therefore, necessitating the field decision to leave the gates open, to equalize any pressures on the structure, and to close the channel above the structure so engineering tests could be made.

May 8, 1984 - (Reported by Arland C. Grunseth & Ronald A. Swanson)

The following personnel inspected the project site:

T. K. Lybeck, Consultant to the Ramsey County WRD, Devils Lake
John Klingenberg, North Central Engineers, Jamestown
George Durbin, Excavating Contractor, Devils Lake
Ron Swanson, Design Engineer, SWC
Arland C. Grunseth, Construction Engineer, SWC

The control structure was clearly visible and free of sediment. An earthen cofferdam had been constructed about 12 feet upstream of the structure. The sediment build-up on the downstream was partially drying out. There was one pronounced sinkhole about 2 feet x 1 foot at the downstream edge of the structure slightly east of the mid-point (See Photo 1). This appeared to be caused by the continuing flow of water and suspended material carried by a very small differential of head from the upstream face of the structure, under the upstream cutoff wall, underneath the slab, under the downstream cutoff wall and up through the sediment deposit.

A 3½-foot lath was poked into the upstream muck and in some places would penetrate full length with no resistance. In other areas, it would hit some hard material, possibly rock riprap. A backhoe was used to excavate a pit about 6 feet upstream from the structure and it seemed to encounter some solid natural material.

It appeared that some material had been moved from under the structure and replaced by a thin soupy mixture. It was almost impossible to determine how much of the structure was supported by a solid foundation. There may be huge pockets of muck that will need to be replaced by some solid material, such as grout. Quantities could vary greatly, so would any cost estimate.

An attempt was made to reconstruct the geologic conditions at the site. Based on construction photos available from the project file, the structure and channel appeared to be excavated into glacial drift and oxidized Pierre Shale. The test borings indicated the structural slab should have been supported by bedrock shale.

Examination of the backfill material upstream of the structure, indicated glacial till was used in the backfill operations. The material was brown to gray in coloration and composed of fine to coarse sand with disseminated gravels and shale particles.

As previously mentioned, very little if any resistance was determined when pushing a 3½-foot lath into the backfill material. If glacial till (CL&SC) is compacted in the dry and at maximum dry density and optimum moisture, penetration resistance should not allow the above condition. After a period of time, standing water will undoubtedly cause backfill to assume a saturated weight, but will still allow for design loads and penetration resistance well above the conditions observed.

Therefore, it is the opinion of the observers that proper backfill operations were probably not employed, that adequate compaction was probably not achieved, and that pertinent design and construction techniques were ignored and overlooked during construcion operations. Improper compaction could then account for erosion and cavitation beneath the structure. In the event the backfill material contained an abundance of oversized rock, i.e. (greater than 4 inches in diameter) uncontrolled seepage would be greatly increased. Rocks greater than 4 inches in diameter have no place in compacted fills tamped with hand-operated power tampers.

As previously discussed, the formation of boils immediately downstream of the structure, accompanied by intense and visible agitation of soil particles from within the boils, are indicative of unstable foundation conditions due to uncontrolled underseepage. The discharge of a mixture of soil and water, instead of clear water, is a warning in itself of deteriorating foundation conditions. In most cases of seepage and underseepage or a combination of both, it must be recognized that uncontrolled development of erosion and cavitation are conducive to piping, boils and other conditions which may endanger the entire structure.

Recommendations were:

1. Close the gates and impound about 2 feet of water behind the structure. With a minimum amount of time and with the use of a color dye tracer, one should be able to determine if seepage is occurring beneath the structure.

2. If underseepage is occurring, the existing backfill must be excavated and the foundation dewatered adequately, to further investigate and determine any structural damages and necessary repairs.

3. Further seepage control methods are dependent upon a number of factors; foremost among these is the character of the foundation. In this case, it would have to be determined if the foundation soil is glacial till or shale. In the event the soil is shale, it would also have to be determined if the shale is plastic, or fractured and jointed.

Once the aforementioned has been determined, several alternative methods of seepage cutoff control can be examined. Economic factors will be recognized.

June 11, 1984 - (Reported by Edgar W. Schmidt, Dam Safety Engineer)

I went up to meet with Bob Garske and the Ramsey County Water Resource Board on Monday June 11, 1984. I arrived there about 1:45 p.m., and we drove out to the structure. The gated structure had been diked off so no water was flowing.

We first lowered the gates and used a 3-inch pump to transfer water across the dike. The gates leaked enough so that one could only get about 2 inches of head on the gates. Dirt and sand were shoveled against the leaks under the gates, and we finally got about 6 to 8 inches of head. No flow under the structure could be detected at this time.

At this point Mr. Durbin was requested to install a pipe across the dike. He only had 12-inch PVC pipe and therefore two 20-foot lengths were requested. The pumping was stopped and two pipe sections were installed between 5 and 5:30 p.m.

Water was allowed to fill the area between the dike and the gates. The water was rather muddy but no unusual flow could be detected on the downstream side of the structure. The gates were still leaking. At this point it was decided to leave one section of pipe inplace and remove the other section. This would allow a minimum controlled flow during the night.

Tuesday morning at about 9:00 a.m., we arrived to find the water level had dropped about 5 inches from the previous evening and now the boils were evident. The weather was misty and cloudy and no pictures were taken.

A pail full of yellow-green dye was prepared and poured into the impounded water near the east end of the structure. Although the dye was concentrated in this area upstream, it did not emerge from the boils immediately downstream. After about one hour, the center gate was opened to allow the remainder of the water to drain out. Most of the water and dye had by that time already seeped away through the openings under the radial arm gates.

Next the gate was closed and the water within the impoundment was allowed to reach the level of Dry Lake once more. A 5-gallon pail of blue dye was prepared and then poured into the water near the west end of the structure. Shortly after this, a small vortex was noted about 3 feet east of the west pier. It took the dye about 4 to 5 minutes to reach the vortex area and another 2 to 3 minutes to emerge from the boils (See Figure 1). Therefore, it appears that one of the major uncontrolled seepage paths extends from west to east beneath the structure. Its flow is evidently along the path of least resistance, emerging in several areas along the face of the downstream wall and east wing-wall.

The gates were again opened to permit drainage of the impounded water. Both upstream and downstream areas were probed with a lath. In several places the lath could be shoved about 3½ feet into material that appeared to be gritty or somewhat gravelly. At the boil holes, a lath could be pushed as much as 4 to 4½ feet into material with little resistance. Sand and some shale particles were also observed near the boils.

CHANNEL "A" CONTROL STRUCTURE

STARKWEATHER WATERSHED

S.W.C. PROJECT NO. 842

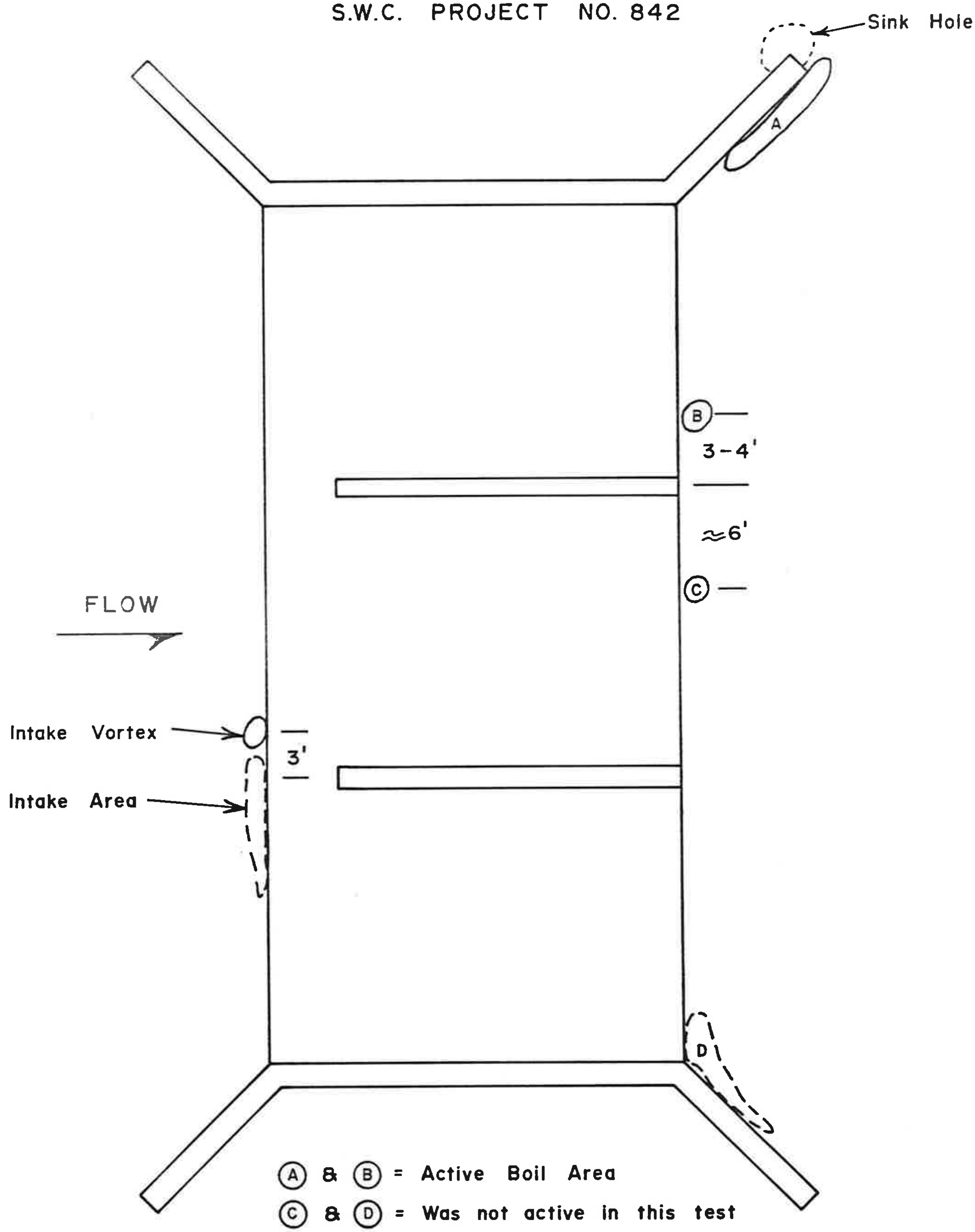


FIGURE 1

Dependent upon excavation and inspection of the upstream area, two possible alternatives can be considered to repair the structure. One would be to excavate and pour a concrete cap. The second would be to excavate the front face and place an impervious, compacted clay cutoff wall (clay core) in front of the structure. Both cases would require foundation grouting beneath the floor of the structure. A rough estimate of 25 to 100 cubic yards of grout may be required.

Dry Lake was estimated at elevation 1447.0$\pm$0.5 mean sea level.

June 26, 1984 - (Reported by Arland C. Grunseth, Construction Engineer)

I arrived at the project site about 12:30 p.m. Also with me were Gary McDowall and Robert Bucholz, Engineering Technicians with the State Water Commission. The temporary earthen cofferdam had partially washed out and water was being discharged through the radial gates. At approximately 1:00 p.m., a D-6 cat provided by Durbin Excavating arrived at the site. By 3:30 p.m., the cofferdam had been reconstructed. We then pumped out the water that had pooled between the structure and cofferdam. Upon completion of the pumping operations, we inspected the structure as much as existing conditions would allow. Except for the steel forms left in place, little could be observed beneath the structure.

Visitors at the site were Bob Garske and Ernest Weed, Ramsey County Water Resource District.

June 27, 1984 - (Reported by Arland C. Grunseth, Construction Engineer)

I arrived at the project site at 7:15 a.m. Also present were Gary McDowall and Robert Bucholz. Water had seeped in during the night, requiring the upstream area be pumped again (See Photos 2, 3 and 4). At approximately 8:00 a.m., a Caterpillar 215 hydraulic excavator owned by Durbin Excavating began excavating material immediately upstream of the structure. The excavation area was approximately 64 feet in length and 10 feet in width. The depth averaged about 4 feet below the floor slab. During the excavation operations the steel forms were removed, in order that the upstream cutoff wall could be exposed and viewed. During and after the excavation operations, the following observations were made:

1. Although it was extremely difficult to determine the firmness or consistency of the backfill material, the material appeared to be very wet and soft.
2. The material contained some amounts of black, odorous, organic material. Rocks ranging in size from 4 to 12 inches or more in diameter were common.
3. Upon removal of the steel forms, the concrete cutoff wall was fully exposed.

The irregularity of the concrete wall indicated the forms were not properly tied or supported (See Photo 5). The face of the concrete was very uneven and in several places large concrete chunks protruded beyond the normal facing (See Photos 6, 7, 8, 9 and 10). Rebar was exposed, both along the face of the wall and at the bottom of the wall (See Photos 11 and 12).

Upon completion of the excavation and inspection of the structure at approximately 10:00 a.m., I departed for Devils Lake. George Durbin was unavailable, but I was able to reach him by phone. He informed me that any backfill operations upstream of the structure would have to wait until the following Monday, July 2, 1984, because of other job commitments he had scheduled. We further discussed what equipment we would need for excavation and backfill operations and agreed to use his personnel as well as ours in completing the work before Wednesday, July 4, 1984.

July 2, 1984 - (Reported by Arland C. Grunseth, Construction Engineer)

We left Bismarck at 5:00 a.m., and arrived at Devils Lake about 8:00 a.m. Durbin's equipment and personnel arrived about 9:00 a.m. As in the past, we had to first pump and remove the water and muck from within the cofferdam area.

The above pumping and excavation work posed no major problems, except for some minor water seepage coming from beneath the structure and through the lower portion of the cofferdam. To assure a good base for our backfill operations, we extended our excavation into firm, hard shale over the entire area. This allowed for a final depth of 4½ to 5 feet below the floor slab along the entire length of the structure. The excavation area measured about 64 feet in length and 10 feet in width. A Warner-Swasey Hopto hydraulic excavator was used in the excavation work.

Upon completion of the aforementioned excavation work, we began to backfill the area. The borrow material was acquired from an area just east of the structure. This material had been previously excavated during construction of the channel and had then been placed and shaped to form the upper flat land surface (See Photo 13).

Prior to this work, we had taken two samples of the borrow material. Both samples submitted to our soils laboratory consisted of fine-grained material within the CL soil group. Standard Proctor compaction (ASTM D-698 Method A) tests were made on the minus No. 4 fraction of the samples submitted. The test data for the samples are shown in the following table:

TABLE 1 - REPORT OF TESTS OF BORROW MATERIAL

Sample No.	Gradation Analysis Sand -#4+#200	Fines -#200	LL	PI	Class	Proctor Density	Optimum Moisture
	%	%	%			pcf	%
1.	37	62	38	17	CL	104.1	20.3
2.	37	58	39	18	CL	104.0	21.1

Transporting, spreading and compacting the backfill material was accomplished by a John Deere 694-B rubber tired loader; a John Deere 555 crawler tractor with loader; a Case 350 crawler tractor with loader, pulling a Ray Go compactor (Model No. Rumbler SF-54A); and a hand-held tamper (See Photo 14). The manual tamper was used almost exclusively for tamping along the upstream wingwalls, where, it was virtually impossible to get any other compaction equipment in position (See Photo 15).

Some minor problems were encountered when backfill operations first began. Due to the depth, confined working area and only one entry and exit location, controlled movement of equipment was somewhat slow and arduous. The problem was also compounded by water seepage, causing some of the material to become too wet and requiring its removal. However, after the first foot of backfill was inplace, a firm base was established and backfill operations proceeded in a normal manner with adequate density and no water control problems.

As previously mentioned, the confined working area caused considerable immobility of equipment when backfill operations first began. However, once we had about 2 feet of backfill in place and the seepage problem controlled, the decision was made to enlarge our working area. Not only did this improve our controlled movement of equipment, but it also provided for an additional 10 feet of impervious cutoff, upstream of the structure. The aforementioned was accomplished by simultaneously excavating and reconstructing the cofferdam in a manner that provided the additional cutoff area. During the same operation, we were also able to extend the cutoff bottom into the shale bedrock. Both the excavation and backfill operations proceeded very smoothly and quite rapidly.

Once finished with the above, we continued our backfilling operations. The enlarged working area provided more mobility for the equipment; increased compaction capabilities and soil densities; and a greater upstream area of well compacted clayey soils. The impervious cutoff, as built, should reduce and control the quantity of underseepage beneath the structure and prevent uncontrolled seepage and internal erosion from developing.

Visitors at the site were Richard Regan and James Braaten, Ramsey County Water Resource District.

<u>July 3, 1984</u> - (Reported by Arland C. Grunseth, Construction Engineer)

We arrived at the project site about 8:00 a.m. Much to our satisfaction the entire backfilled area was dry and firm (See Photo 19). We checked the upper surface for wet and spongy conditions, but discovered none.

After waiting for sometime, Durbin's trucks delivered one load of pitrun sand-gravel and two loads of rock. Several inches of the sand-gravel mixture were placed over the fill material, and then covered with several inches of gravel rock (See Photos 20 and 21). The filter-rock riprap protection served a dual purpose: (1) to provide drainage and yet prevent the movement of the base material due to flowing water, and (2) to further prevent erosion of the underlying sand and fines.

Upon completion of the aforementioned before noon, the project work was inspected and approved by Robert Garske and Richard Regan, Ramsey County Water Board members. Pending approval of a qualified contractor to perform foundation grouting, the Board members were informed that the final phase of project work would be delayed for several weeks. This was necessary in order that Commission engineers could review and evaluate Contractor's proposals and estimated costs.

July 30, 1984 - (Reported by Ronald A. Swanson, Design Engineer)

On July 30, 1984, I went to the Channel "A" project to monitor the core drilling operation being done by Dahl's Industrial Tool Company, West Fargo, North Dakota. Upon arrival at the site, I inspected the earthwork operations that had been completed on July 3, 1984. The surface of the clay core was firm and dry. No soft or wet areas were observed.

Don Dahl and his two-man crew arrived on the site at noon and setup their drilling equipment. I pointed out the locations that the plans indicated should be the most likely spots to avoid drilling through the reinforcing steel. The drilling proceeded and 6-inch diameter core samples were removed and examined (See Photos 25 and 26). The log of the results are shown on Figure 2, which gives the location of the drill holes and the depths of the void measured.

Also, the relative locations of the reinforcing steel were determined to be significantly different from that shown on the plans. There were two types of discrepancies observed. First, the bars were supposed to be positioned so as to provide 2 inches of cover over the top layer of steel and 3 inches of cover below the bottom steel. The actual cover was 4 inches in both cases. Secondly, some of the bars appeared to be mislocated horizontally by as much as 6 inches.

The concrete appeared to be good quality and consistency. No voids were observed in core samples or in holes. The concrete was observed by the drillers as being dense and hard to drill. The downstream area next to the south edge of the structure was saturated and all core holes were full of water. All holes were sounded and the bottom seemed to consist of a soft gravel into which a stick could easily be pushed several inches.

There did not appear to be any settlement damage to the structure, although the southeast corner seemed to be slightly lower. There was some cracking in the thinner portions of the abutment walls, but this may have been there previously.

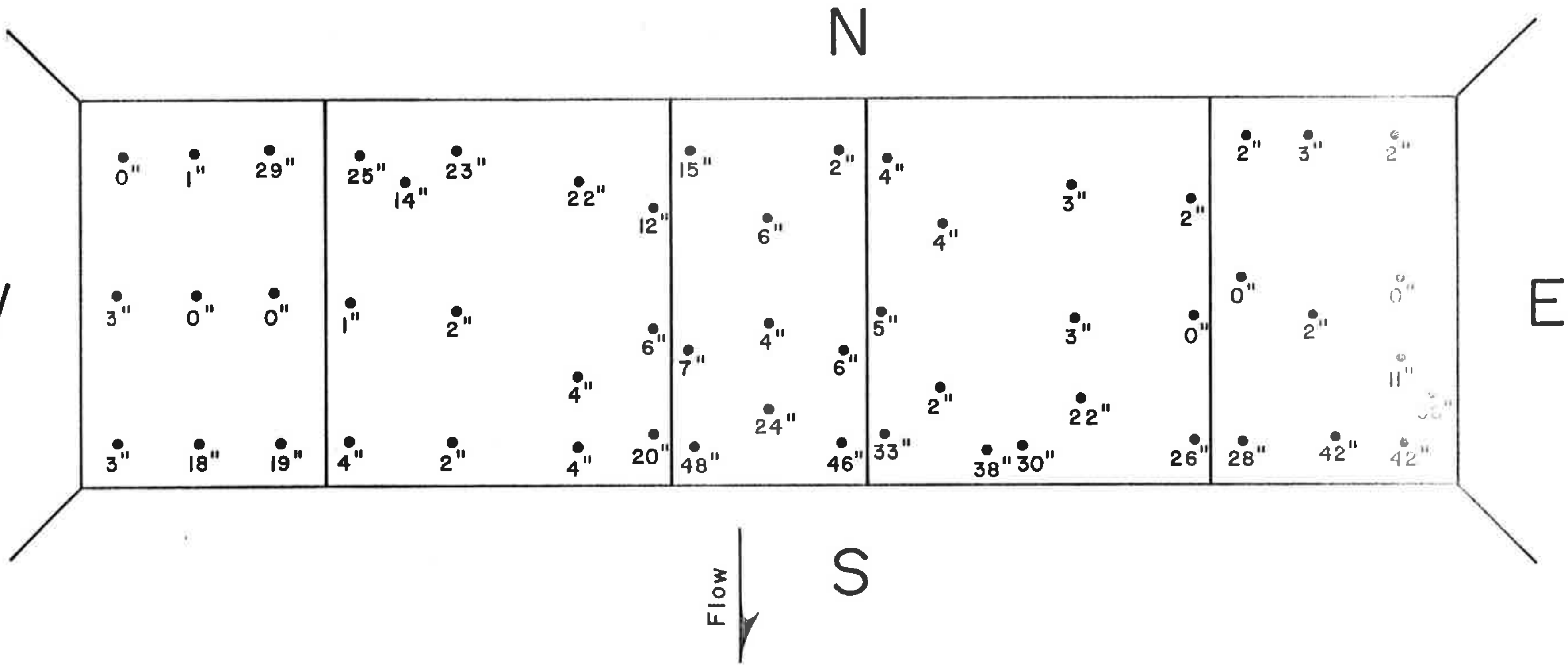
The structure was only partially bearing on material which may be mostly saturated and may be in a condition of near failure. The sooner that the undermined areas can be filled with grout or concrete the better things will be.

Don Dahl proposed to pump the concrete into the structural foundation and then to top it off with more concrete which would be tamped and

CHANNEL "A" CONTROL STRUCTURE

STARKWEATHER WATERSHED

S.W.C. PROJECT NO. 842



STRUCTURAL PLAN

SHOWING DRILL HOLES & VOID DEPTHS

Scale: 1/8"=1'-0"

FIGURE 2

vibrated in place. This would appear to be the most feasible method of filling the voids.

August 2 and 3, 1984 - Reported by Ronald A. Swanson, Design Engineer)

On August 2, 1984, I returned to the Channel "A" project to monitor the concrete operation. Don Dahl was drilling the additional inspection holes: two on the east wingwall and one on the west wingwall (See Photo 27). All three holes had dry, firm earth behind them, indicating that erosion had not carried out the material from behind the wingwalls.

I checked out the relative elevations of the five concrete slabs with a level. The southeast corner was about 4 inches lower than the west half of the structure. This would seem to indicate an overall settlement of the structure in the area of the greatest amount of voids. The structure may have been constructed low in this area, but it hardly appears likely that it would have been built 4 inches low initially. See the attached sketch for the rod readings.

On August 3, 1984, the voids were filled by Dahl with concrete furnished and pumped by Lake Ready Mix of Devils Lake. The mix design provided was as follows:

6¼ bags of cement -	588 lb.
Sand -	1,450 lb.
3/4 inch rock -	1,575 lb.
24 gal. water -	190 lb.
	3,803 lb/cy.

This was to be 5 inch slump
The strength was to be 3500 psi.

The concrete was pumped into the voids until the holes were filled (See Photos 28 and 29). Then a trough was placed over the hole and more concrete placed into it and vibrated down until no more would be accepted

(See Photos 30 and 31). This process was started at the west end and proceeded systematically until the east end was filled. It appeared that the vibration process was insuring that all voids were being filled. Two cylinders were taken from the second truck and two more from the third (See Photo 32). I told them to break two at 7 days and two at 28 days. The compressive strength test results are shown on Table 2. It required slightly less than 30 cubic yards to fill the voids. The left over concrete was used to fill the hole eroded near the east downstream wingwall (See Photo 27).

The operation proceeded smoothly and it appeared to be doing a good job of filling the voids. Three core samples were retained showing examples of the type of steel placement workmanship used in the construction.

August 15, 1984 - (Reported by Arland C. Grunseth, Construction Engineer)

While on my way to Grafton on the above date, I stopped at the Channel "A" site to make some general observations. The earthen cofferdam was still in place and undisturbed. The entire clay core surface was dry and hard. I probed the core's surface for possible wet, soft or spongy conditions, but none could be observed. The downstream area showed no signs of water passing around or under the structure. I reported my observations and comments to the Board at a later date.

twin city testing
and engineering laboratory, inc.
P.O. BOX 1196, 2005 GATEWAY DRIVE
GRAND FORKS, ND 58201
PHONE 701/775 3168

COMPRESSION TESTS OF CONCRETE CYLINDERS

PROJECT: SWC Project #842
Channel "A" Control Structure

DATE REPORTED: August 14, 1984
August 31, 1984

REPORTED TO: Lake Ready Mix (3)
P.O. Box 664
Devils Lake, ND 58301

COPIES TO: 2- ND State Water Board
State Office Building
900 East Boulevard
Bismarck, ND 58505

FIELD DATA:				
Job Identification	1A	1B	1C	1D
Date Cast	8-3-84	8-3-84	8-3-84	8-3-84
Age to be Tested, days	11	11	28	28
Slump	Not Given			
Air Content	Not Given			
Location of Placement	Not Given			
Specified Strength @ 28 days				
Mix Proportions:	Not Given			
Cement				
Fine Aggregate				
Coarse Aggregate				
Admixture				
Concrete Furnished by	Lake Ready Mix			

COMPRESSIVE STRENGTH: Test Method - ASTM C39, 6" X 12" Cylinder, Area 28.26 Sq. In.

Laboratory Number	543409-1	543409-2	543409-3	543409-4
Date Received	8-14-84	8-14-84	8-14-84	8-14-84
Method of Curing:				
Days on Job & Enroute	11	11	11	11
Days Lab. Cured-ASTM C192	--	--	17	17
Age at Test, days	11	11	28	28
Load at Failure, pounds	86,000	84,500	99,500	94,500
Strength, psi.	3040	2990	3520	3340

REMARKS:

TABLE 2

Twin City Testing and Engineering Laboratory, Inc.
By Dennis Coulter

CHANNEL "A" CONTROL STRUCTURE

PROJECT PHOTOS

1984

Photo A - Aerial View of the Channel
"A" Control Structure and a Portion of
the Southern Tip of Dry Lake
May 2, 1984

Photo B - View Looking North at Dry Lake
and its Outlet Into Channel "A"
May 2, 1984

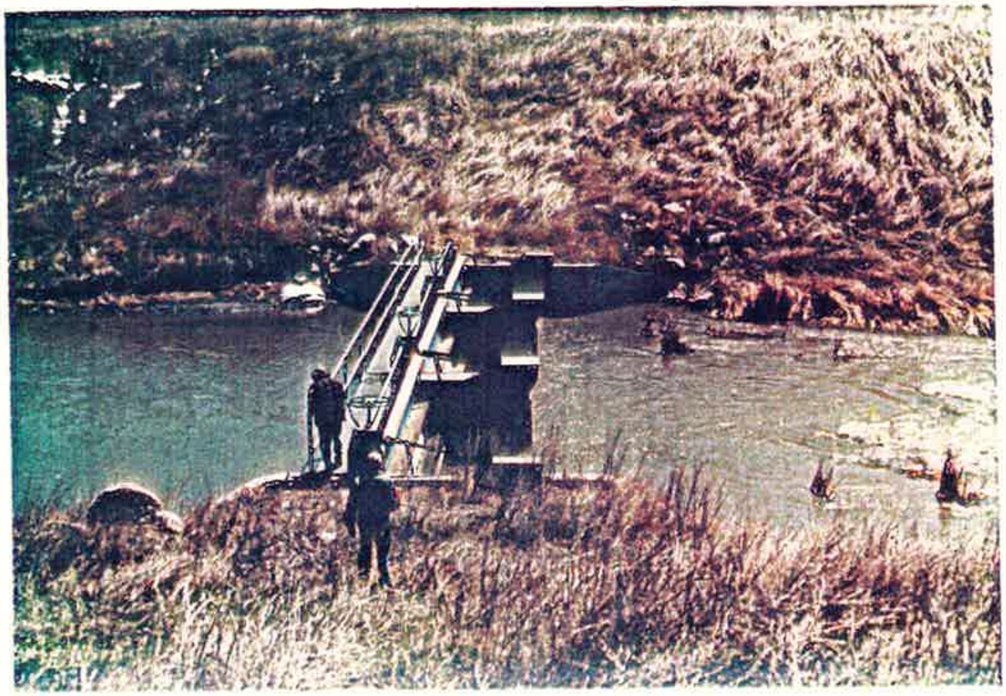


Photo C - Channel "A" Control Structure
Viewed From the East Looking West
May 2, 1984

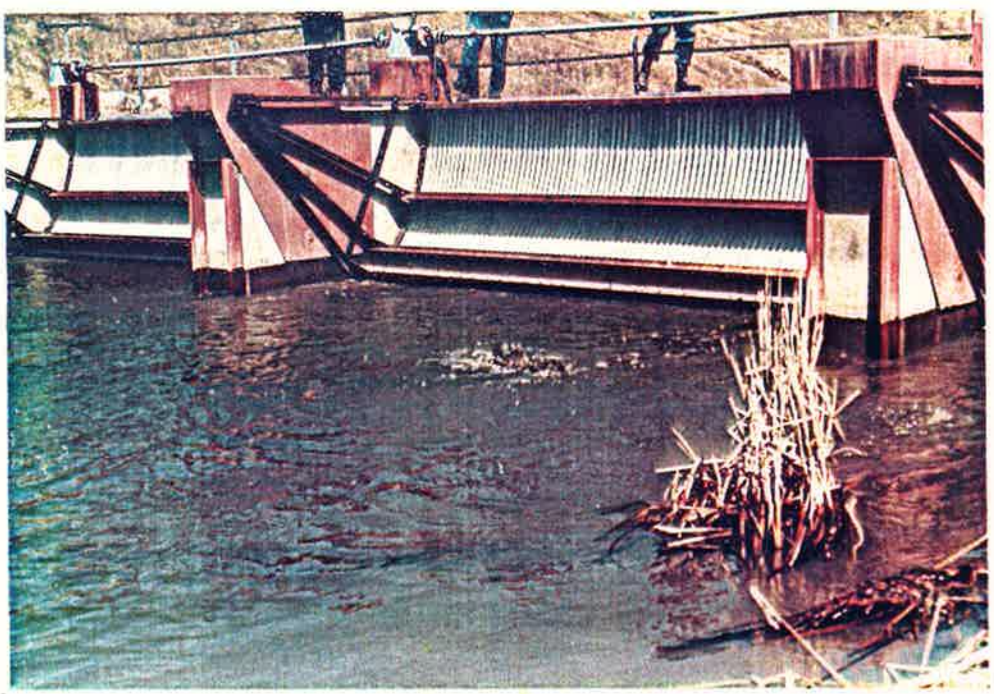


Photo D - The Structure Viewed From
Downstream. Note the Closed Gates and
the Boil Near the Center of the Photo
May 2, 1984

Photo E - May 2, 1984
The Upper and Lower Photos Show Two
Pronounced Boils Immediately
Downstream of the Structure

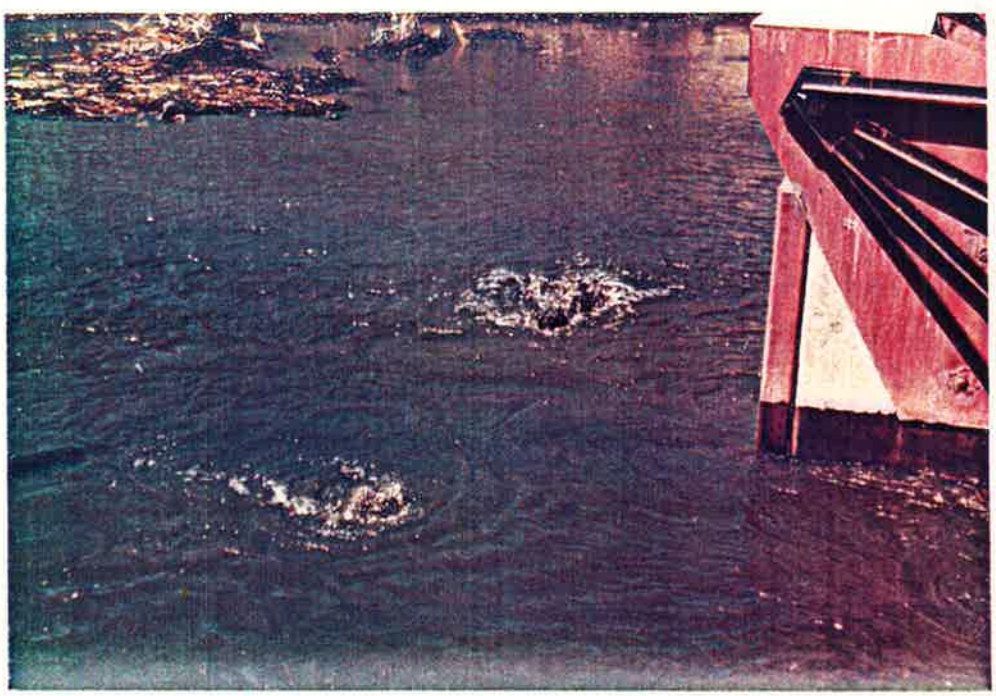


Photo F - May 2, 1984

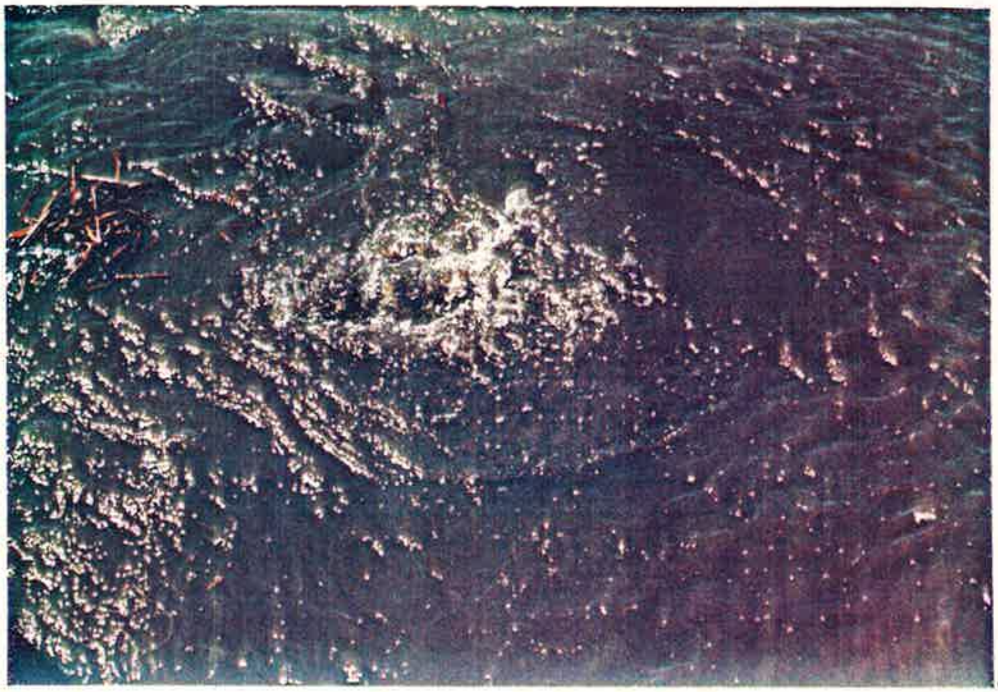


Photo G - May 2, 1984
The Upper and Lower Photos Show a
Close-up View of the Two Pronounced
Boils. Note the Absence of Clear Water
Near the Boils, Especially Photo "G".

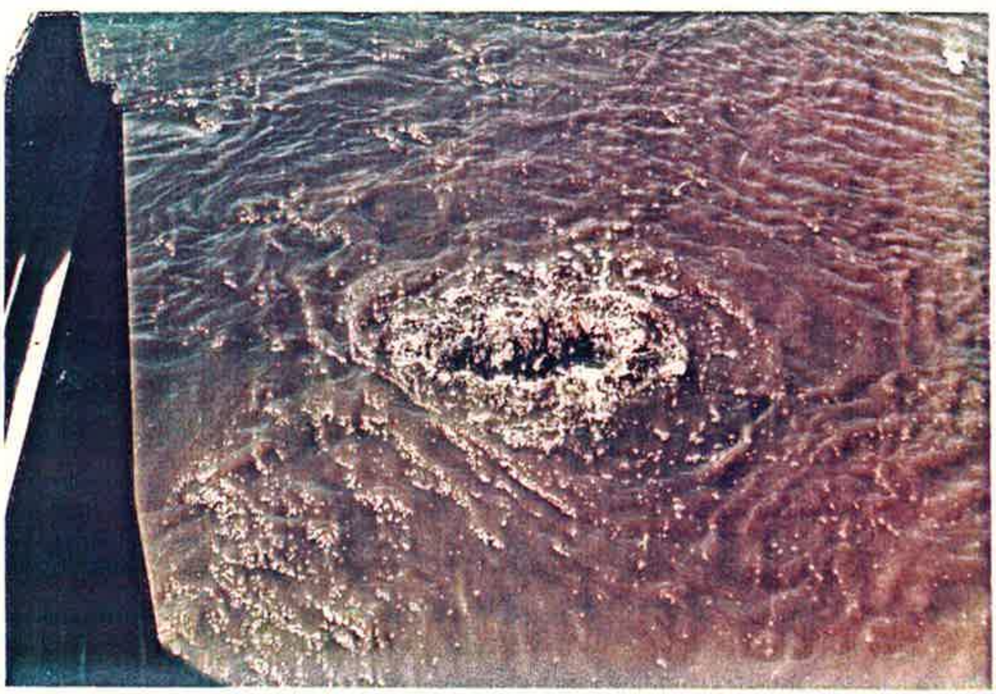


Photo H - May 2, 1984

Photo I - View of the East Downstream Wingwall
Water was Reportedly Flowing Along
the Soil Side of the Wingwall and
Emerging in the downstream Pool
May 2, 1984

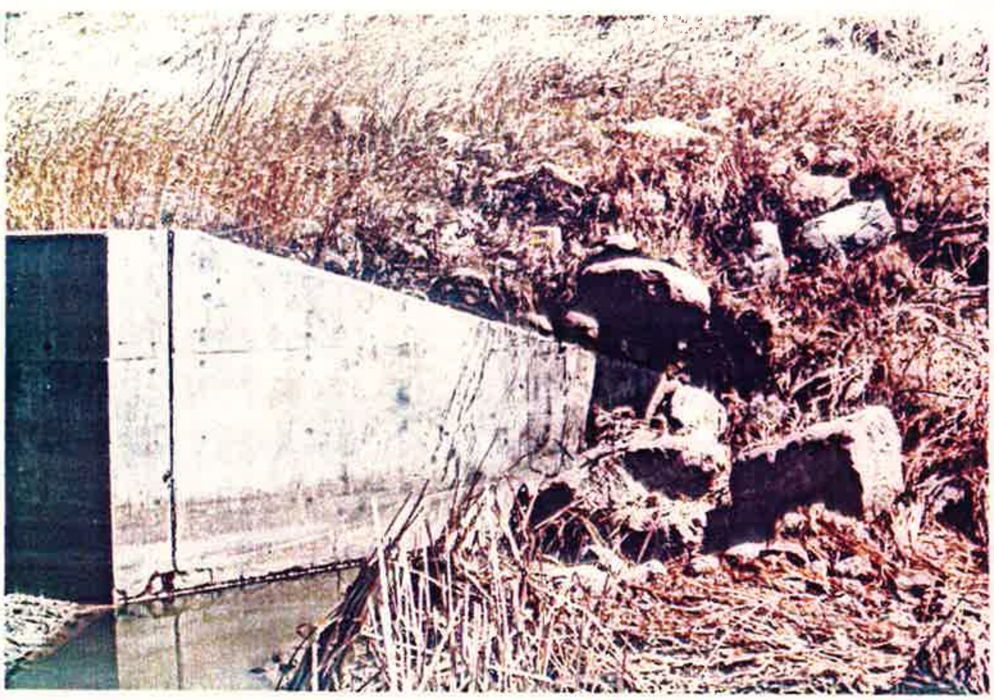


Photo J - Close-up View of East Downstream Wingwall
Note the Area that has Slumped Due to
Seepage Adjacent to the Wingwall
May 8, 1984

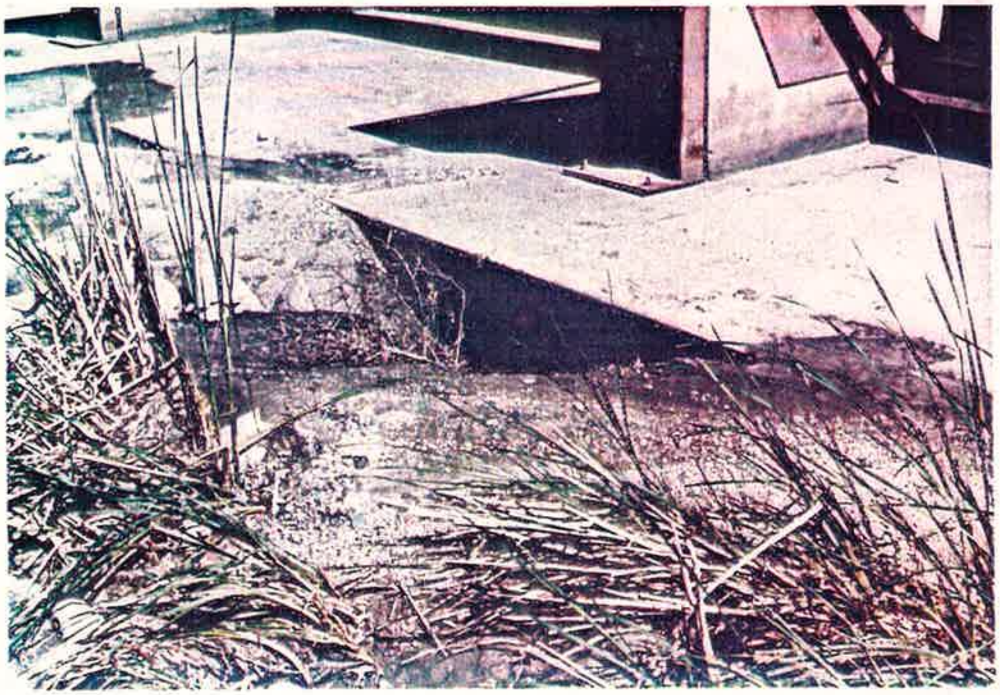


Photo No. 1 - Sink Hole Downstream of Structure
6-27-84

Photo No. 2 - Pumping Operations Begin
6-27-84

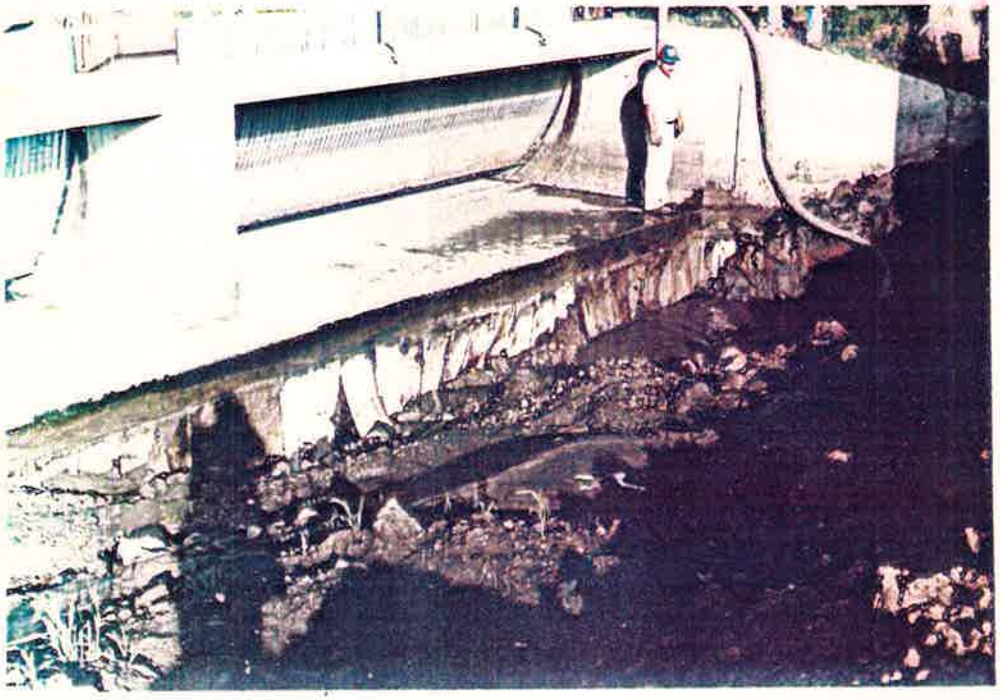


Photo No. 3 - Pumping Operations In Progress
Note Excavated Sump
Some of the Steel Forms Have Been Removed
While Others Are Still Inplace
6-27-84

Photo No. 4 - Excavation and Pumping
Operations Nearing Completion
6-27-84

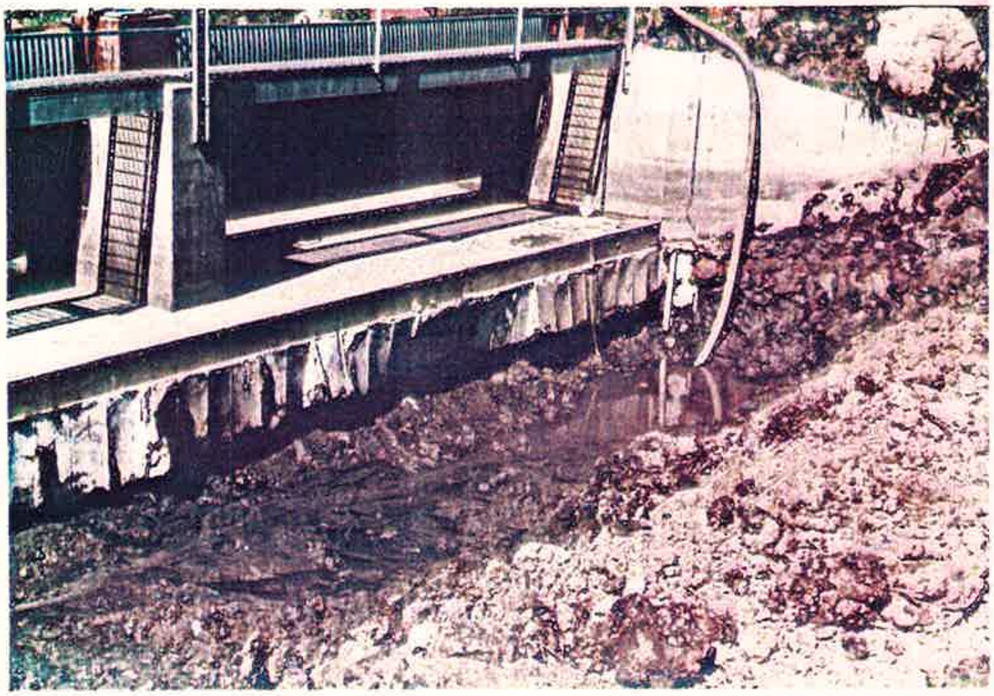


Photo No. 5 - View of Upstream Wall
Note the Apparent Lack of Good Work,
Improper Forming and the Irregularity
of the Concrete Wall
6-27-84

Photo No. 6 - Close-up View of Upstream Wall
West Portion of Structure
6-27-84

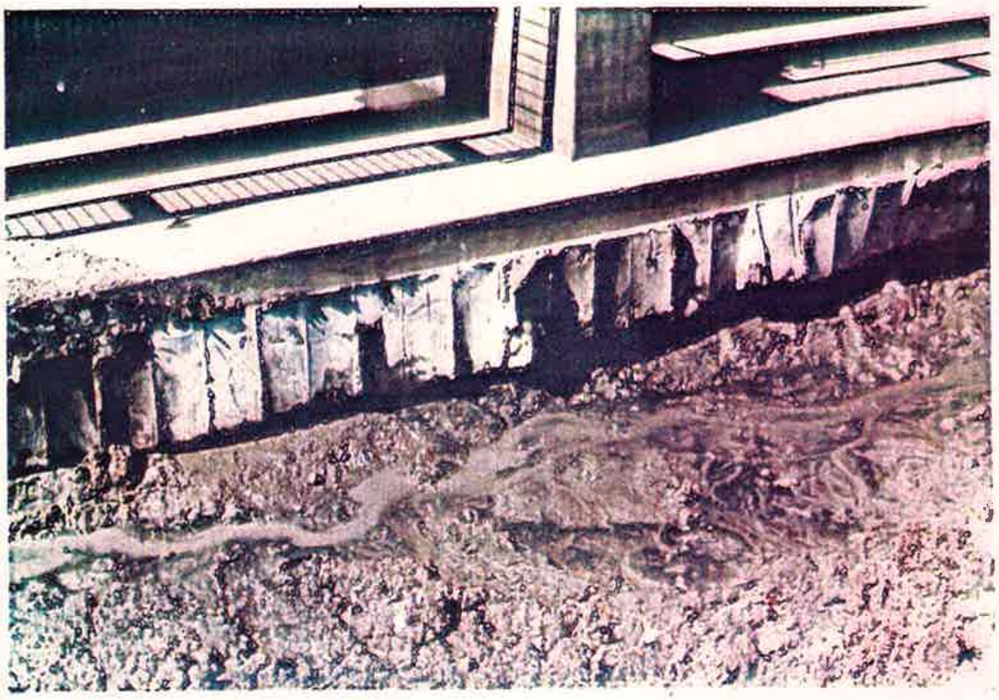


Photo No. 7 - Close-up View of Upstream Wall
Middle Portion of Structure
6-27-84

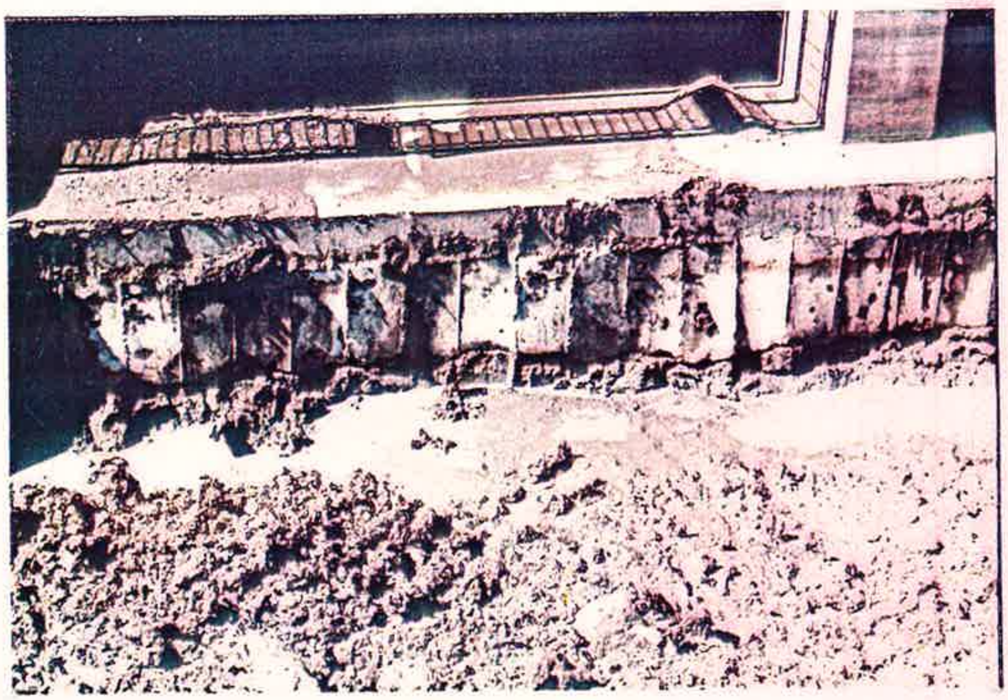


Photo No. 8 - Close-up View of Upstream Wall
East Portion of Structure
6-27-84

Photo No. 9 - 7-2-84
The Upper and Lower Photos Show Further
Evidence of Poor Workmanship and
Improper Construction Methods. Note the
Large Chunk of Concrete Protruding
Beyond the Face of the West Upstream
Wingwall and the Wood Framework Left Inplace

Photo No. 10 - 7-2-84

Photo No. 11 7-2-84
The Upper and Lower Photos Show
Exposed Rebar and Cavitation
Beneath the Structure

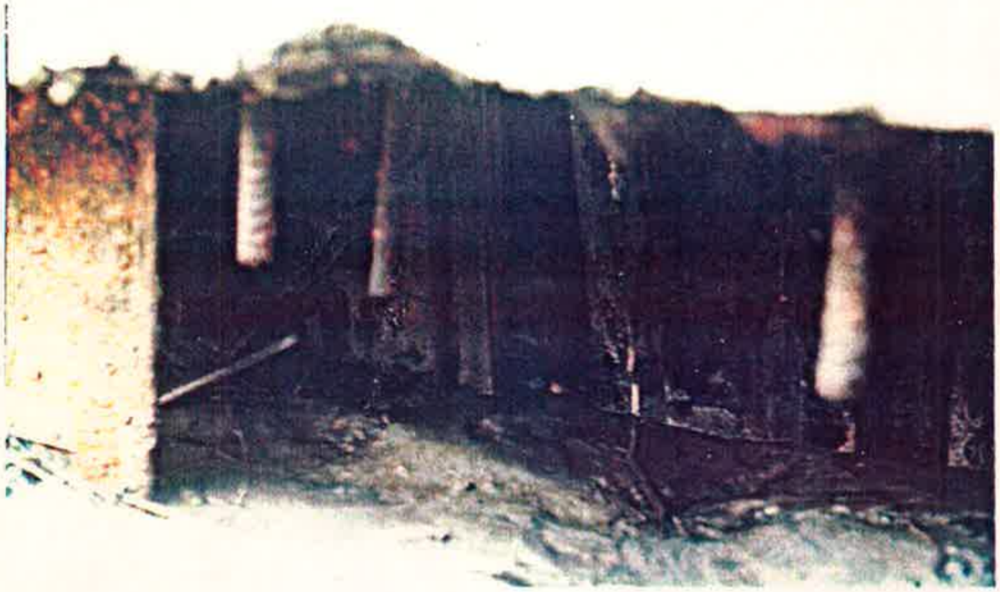


Photo No. 12 7-2-84

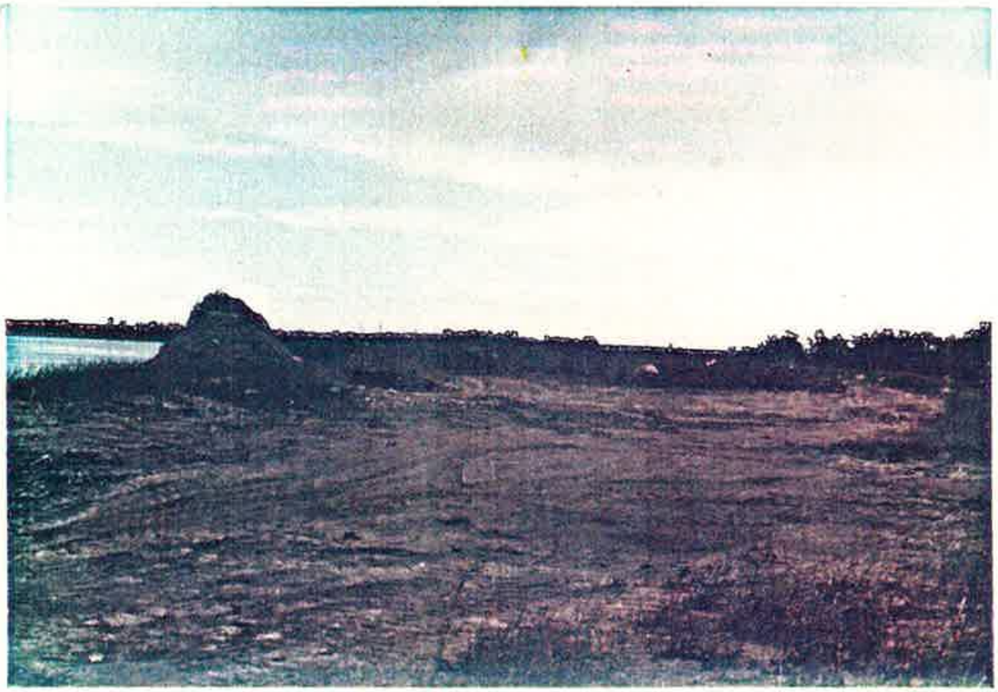


Photo No. 13 - Borrow Area
Located East of Structure
7-2-84

Photo No. 14 - Construction Equipment
Upper Left: Warner Swasey Excavator
Upper Middle: Case 350 Crawler Tractor
Upper Right: JD555 Crawler Tractor
Lower Right: JD644-B Loader
7-2-84

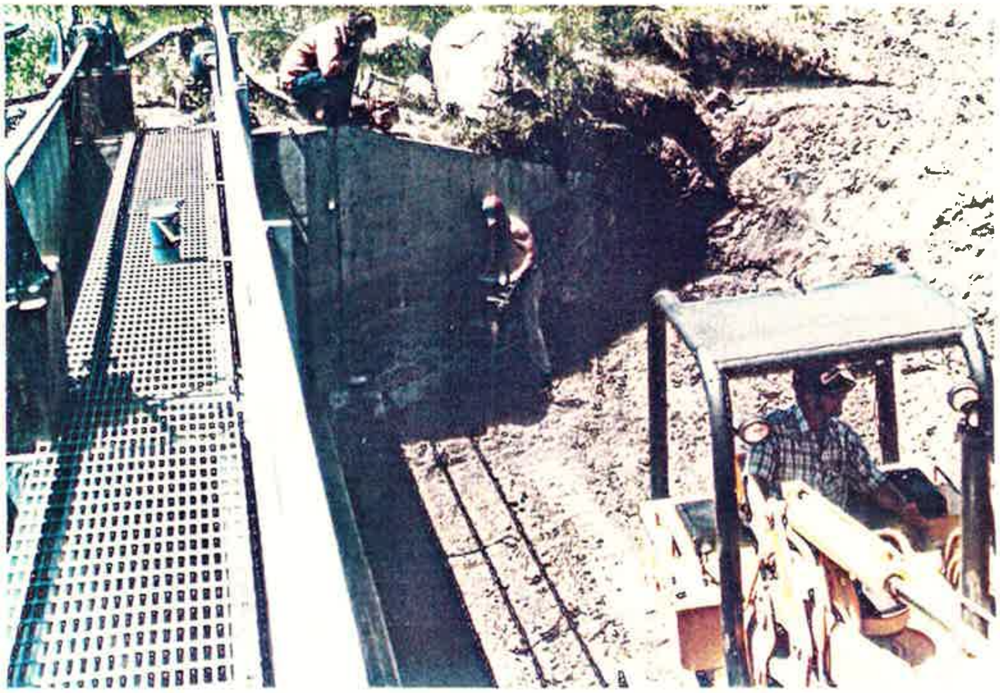


Photo No. 15 7-2-84
Bob Bucholz, SWC Employee Operating
Manual Compactor Along West Upstream Wingwall

Photo No. 16 - Compaction & Excavation Operations
Case 350 Crawler Tractor Pulling Ray Go Compactor
Note the Bucket of the Excavator - At this Point, We Had
Begun to Excavate Into the Existing Cofferdam to Enlarge
Our Impervious Cutoff Area.
7-2-84

Photo No. 17 7-2-84
Gary McDowall, SWC Employee, Spreading
Backfill Material With Our JD-555

Photo No. 18 - View of Compaction Operations
Note the Entry and Exit Ramp
to the Left of Equipment
7-2-84

Photo No. 19 - Tuesday 8:00 p.m. 7-3-84
View of Structure & Completed Earthen Backfill
Note the Dry Condition of Entire Area After
Completing Backfill Operations the Previous Day

Photo No. 20 7-3-84
Placing the Sand-Gravel Filter Blanket

Photo No. 21 7-3-84
Close-up View of the Gravel-Rock Inplace

Photo No. 22 7-3-84
View of Structure, Clay Core and Cofferdam
The Upper Portion (A) of the Cofferdam Represents the Material that was Excavated on July 2, 1984, to Enlarge the Claycore. The Lower Portion (B) Represents The Original Height of the Cofferdam as First Built

Photo No. 23   7-3-84
The Upper and Lower Photos, Looking West,
Show the Project Upon Completion of the
1st Phase of Repair

Photo No. 24   7-3-84

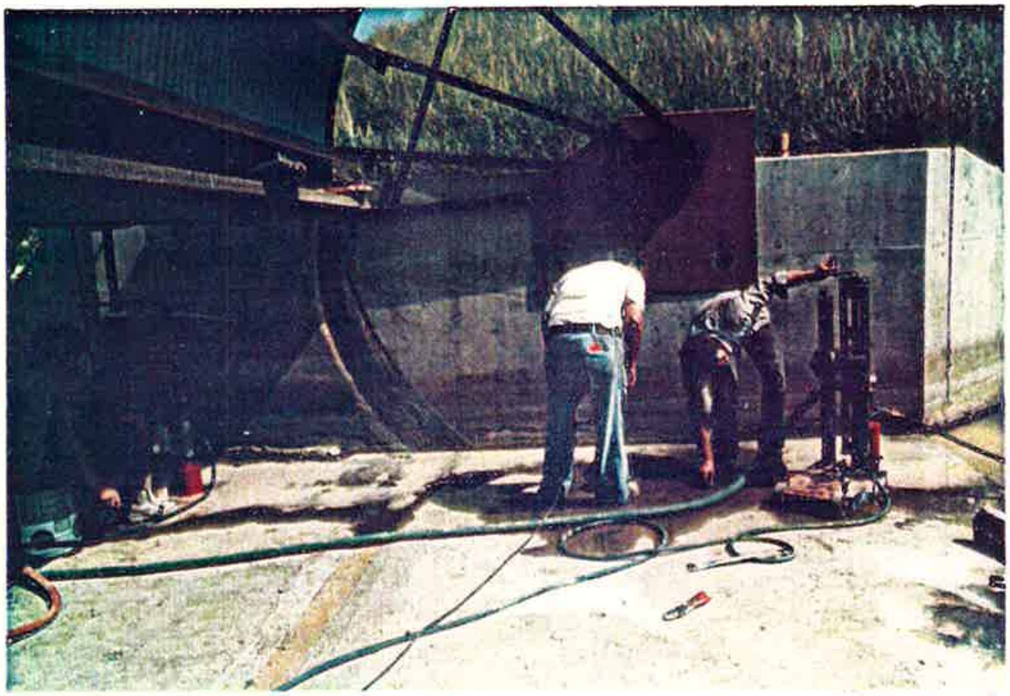


Photo No. 25   7-30-84
Drilling Operations In Progress

Photo No. 26   7-30-84
Close-Up View of 6-Inch Diameter Core Sample
Removed From Structural Floor

Photo No. 27   8-2-84
Close-up View Showing Inspection Hole
On East Wall and an Eroded Area Near
The East Downstream Wingwall

Photo No. 28   8-3-84
Concrete Pumping Operations
The Concrete is Delivered to the Site by a
Truck Mixer, Discharged by Chute into a
Pumper, and Then Pumped by Hose into
Holes Previously Drilled on the Structural Floor

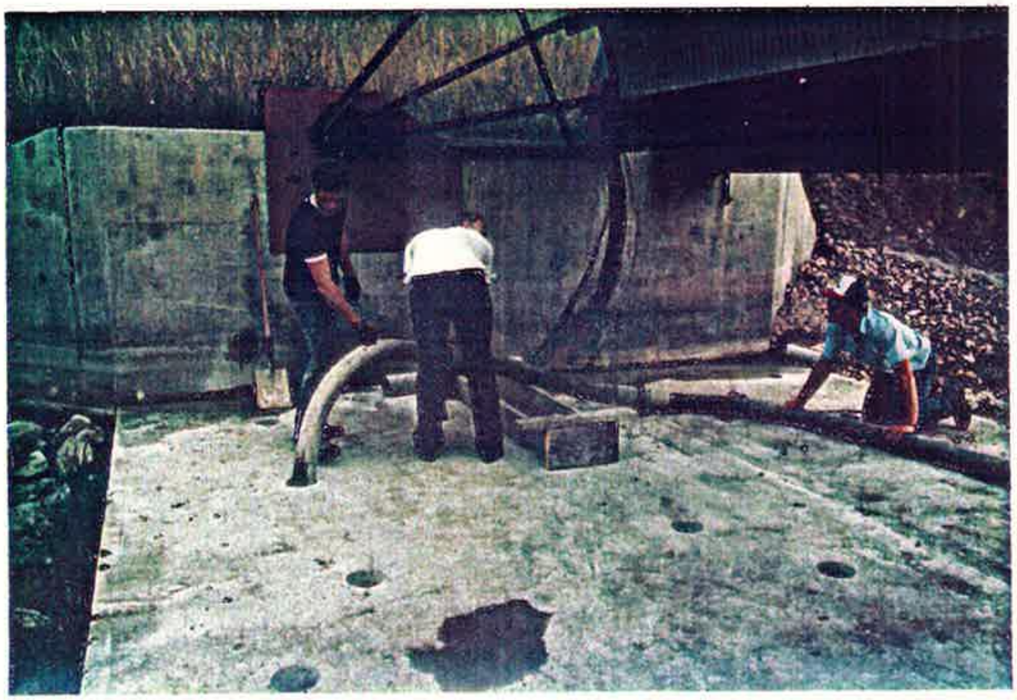


Photo No. 29 8-3-84
Concrete Pumping Operations
Close-Up View of Concrete Being
Pumped into the Structural Foundation
Note the Drilled Holes on the Floor
An Attempt Was Made to Pump Concrete into Each Hole

Photo No. 30 8-3-84
View Showing Concrete Being Vibrated
Down into the Structural Foundation

Photo No. 31 8-3-84
Another View of Concrete Simultaneously Being Pumped and Vibrated into the Structural Foundation. The Man Wearing the Blue Shirt is Don Dahl, Owner and Manager of Dahl's Industrial Tool Company, West Fargo, North Dakota

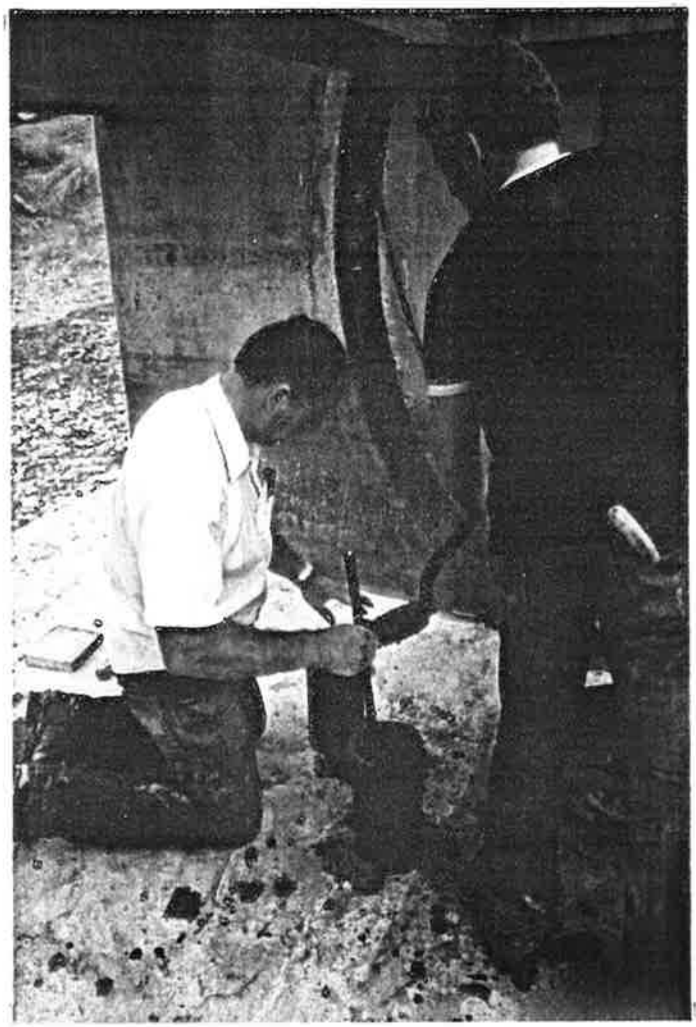


Photo No. 32 8-3-84
Making Concrete Specimens in the Field, in Accordance With ASTM Designation C31. The Compressive Strength of the Molded Concrete Cylinders Were Later Determined by Twin City Testing and Engineering Laboratory, Inc., Grand Forks, North Dakota