PROGRAM • • • • •

NATIONAL DAM SAFETY

RIO GRANDE BASIN

SOHIO L-BAR TAILINGS DAM

VALENCIA COUNTY, N.M.

NM00413

PHASE 1 INSPECTION REPORT

PREPARED BY: TIERRA ENGINEERING CONSULTANTS INC.

FOR: U.S. ARMY CORPS OF ENGINEERS & THE STATE OF NEW MEXICO
AUGUST, 1979

05 Report File #2

9803160248 790816
PDR ADOCK 04008904
C PDR

NATIONAL DAM SAFETY PROGRAM . . . . .

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Sohio L-Bar Tailings Dam
State Located:	New Mexico
County Located:	Valencia
Date of Inspection:	16 August 1979
Inventory Number:	NM00413

<u>Brief Assessment of Dam and Recommended Action</u>:

The dam is considered to have a high hazard potential according to Table 2 of Appendix D of the National Program of Inspection of Dams. This classification is appropriate because of the nature of the stored materials and solution waters.

The diversion works should accommodate the Probable Maximum Flood (PMF). A technical analysis is needed to define the ability of the diversion channels to carry the PMF. Overtopping could cause erosion and possible breaching of the dam. The south diversion channel as presently designed accommodates 42 percent of the PMF. The north diversion channel as presently designed accommodates 72 percent of the PMF.

Seepage sloughs and boils or solution cavities are present on the downstream slope and toe. These should be repaired and seepage discharge faces armored, filtered or otherwise designed and constructed to provide a controlled discharge that does not allow sloughing or boils. Additional piezometers should be installed and monitored and seepage and stability studies should be performed after piezometer data is available to assure the stability of the dam to determine if liquefaction is a problem, and to determine the nature and criticality of the downstream boils.

The effect of low pH solutions on soils should be evaluated to assure the near and long term stability of the dam both from piping potential and also from settlement of underlying soil.

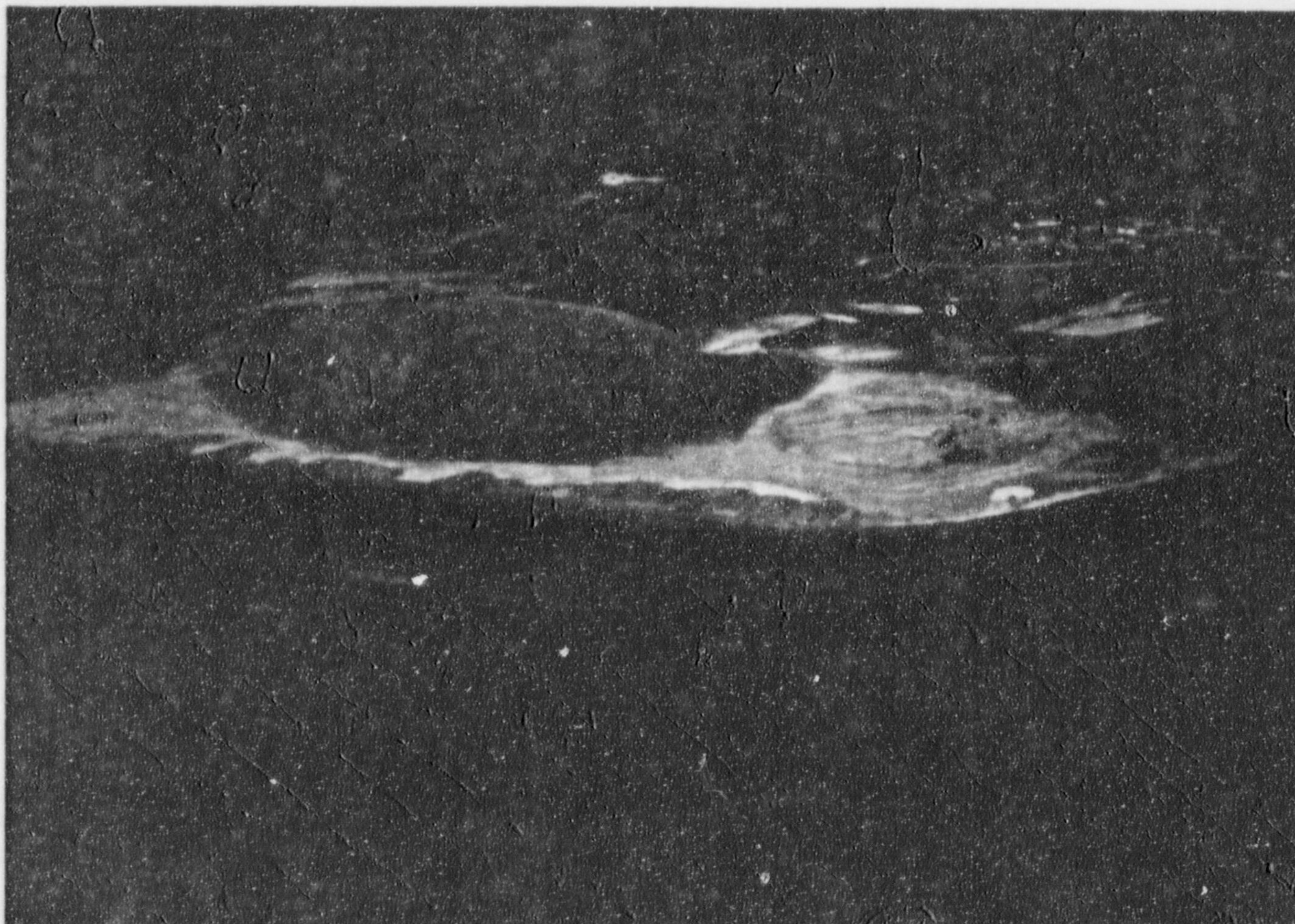
The dam is, therefore, considered a serious hazard until detailed studies prove otherwise or corrective measures are completed. Phase II investigations as specified above are required to be performed by the owner. These should commence and be completed as soon as possible. The owner should develop a contingency plan for protection of the public.

Richard B. Catanach
N.M.P.E. #4457

TIERRA ENGINEERING CONSULTANTS, INC.

SOHIO L-BAR

TAILINGS DAM



OVERVIEW OF DAM

VALENCIA COUNTY, NEW MEXICO

AUGUST 1979

SOHIO L-BAR TAILINGS DAM

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM SOHIO L-BAR TAILINGS DAM
INVENTORY NUMBER NM00413

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The authority for performance of the inspection and preparation of this report is the National Dam Inspection Act, Public Law 92-367, authorizing the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspections throughout the United States. President Carter directed the Secretary of the Army, on 28 November 1977, to commence at once, inspection of non-Federal dams that present a high potential for loss of life and property damage. On 20 July 1979, the Governor of the State of New Mexico requested Corps of Engineer assistance to evaluate the safety of mill tailing dams. The Phase I inspection was conducted by Tierra Engineering Consultants, Inc. under contract with the U.S. Army Corps of Engineers, Albuquerque District.

b. Purpose of Inspection. The Sohio L-Bar Tailings Dam is listed as a uranium tailings dam containing more than 50 acre-feet of solution or being over 25 feet in height. The purpose of inspecting the dam was to determine if dangerous conditions exist at this site that could lead to a failure and subsequent loss of life and property damage downstream and report the condition of the dam to the Governor of New Mexico.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Sohio L-Bar Tailings Dam is unlike dams which are used for impoundment of runoff water. It is designed to receive no inflow of runoff and it has no spillway. Runoff from the adjacent watersheds is diverted to bypass the impoundment and dam. The only inflow into the reservoir is the tailings slurry pumped to the site and rainfall which would fall directly onto the site.

The main dam extends across a gently sloping, wide drainage area on the west. The northeast end of the reservoir is marked by a natural saddle, beyond the saddle the ground slopes away from the tailings dam to the northeast. A saddle dam was constructed over the natural saddle to increase capacity of the tailings dam.

Sohio L-Bar Tailings Dam is currently at an elevation of 6193 feet M.S.L. at the lowest point and elevation 6197 feet M.S.L. at the highest point. The dam is about 41 feet above the ground surface elevation.

The maximum height of the dam is at the west end where the dam is 45 feet above the original ground surface. The ultimate elevation of the dam will be 6220 feet M.S.L. about 70 feet above the original ground surface. The saddle dam is at an elevation of 6220 feet M.S.L. The saddle dam is about 30 feet above the original ground surface. At ultimate height, the main dam will have an embankment length of 4000 feet. The length of the embankment of the saddle dam is 1500 feet.

The dam was initially constructed with a compacted earth fill starter dam. The starter dam was about 2000 feet long and 30 feet high with side slopes of 2½ Horizontal on 1 Vertical upstream and slopes of 3 Horizontal on 1 Vertical downstream. The starter dam was provided with a continuous vertical chimney drain. The chimney drain is connected to five foot by five foot horizontal finger drains, at 100 foot centers. The dam is currently being raised by the spigoting method. The spigoting method of construction is an upstream construction operation which involves deposition of mill tailings slurry at the current crest of the dam. The solution flows towards a central impoundment. This method allows deposition of the heavier sands near the embankment and finer materials, "slimes," settle towards the center of the dam. The dam is then raised as necessary by dozing sand materials into a dike around the perimeter as required to contain the tailings and solution. A floating barge decant system removes clear solution from the center of the pond. The decant system discharges into a downstream pond. Mill tailings are delivered to the pond by means of a steel pipeline.

The tailings dam area is protected from upstream runoff by two diversion channels. Typical sections of the channels are shown on drawings 37-G-03 and 04, Appendix A. Construction drawings and actual dimensions were not verified in the field. The south diversion channel which is the larger is shown in photos 20 and 21, Appendix F. Project plans, sections and details are shown on construction drawings, Appendix A.

b. Location. Sohio L-Bar Tailings Dam is located in the Cebolleta Grant about 1 mine north of Section 23, Township 11 North, Range 5 West, (projected Section 14, Township 11 North, Range 5 West), Valencia County, about 16 miles north of Laguna, New Mexico (See Vicinity Map, Appendix A).

c. Size Classification. In accordance with Table 1 of Appendix D of the National Program of Inspection of Dams, Sohio L-Bar Tailings Dam is an intermediate-size structure by capacity criteria with greater than 1000 acre-feet and an intermediate-size structure by height criteria with a current height of 41 feet. These criteria would classify Sohio L-Bar Tailings Dam as an intermediate-size structure.

d. Hazard Classification. In accordance with Table 2 of above reference, the hazard classification of Sohio L-Bar Tailings Dam is high. This classification is felt to be appropriate because of the nuclear materials contained in the tailings and the acidity of the solution waters. The pH of the solution and seepage waters is about 1.0. The general topography downstream of the dam is quite flat (See photos 18 and 19, Appendix F) and flood waters immediately downstream would not be concentrated. However, since site-specific studies near inhabited areas were not conducted, it is appropriate to assume that human life may be endangered by the tailings and solution and, therefore, to assess the hazard as high.

e. Ownership. Sohio L-Bar Tailings Dam is owned by the Sohio Western Mining Company, P.O. Box 25201, Albuquerque, New Mexico 87125.

f. Purpose of Dam. Sohio L-Bar Tailings Dam is used for deposition and storage of tailings and solution water utilized in the uranium milling operation.

g. Normal Operational Procedures. The normal operating procedure is to route tailings to the dam by pipeline in a water-tailings slurry. The tailings are spigoted or discharged into the reservoir through rubber lines at the areas where additional tailings can be accomodated. The slimes and tailings solution then flow into the pond and are allowed to clarify. The clarified solution is decanted by a barge-mounted pump. The water is then recirculated back to the plant for re-use.

1.3 PERTINENT DATA

a. Drainage Area. Extensive data is available on the Sohio Tailings Dam, as presented in the drawings in Appendix A. A drainage map is provided in Appendix C. Conventional data on a water storage reservoir, such as the elevations of different storage pools, are not relevant to this structure. The dam impounds and is partially built from tailings which are brought to it by pipeline. It is designed to receive no inflow of runoff and it has no spillway. Instead, runoff from the adjacent watersheds is diverted to bypass the impoundment and dam. Rainfall and runoff could jeopardize the structure in one of the following ways: Direct rainfall onto the pond in excess of freeboard would cause overtopping; rainfall on the dam surface (downstream slope) could cause erosion and/or accelerate gullying and piping; a flood flow from the adjacent watersheds could overtop the diversion channel and erode the structure from the outside. To address these questions, the primary data of value are: Freeboard within the impoundment; size and character of the upstream drainage area; and the nature and capacity of the structures used to divert water around the impoundment.

A freeboard of about five feet is maintained in the tailings pond, according to design data (see drawing 37-G-03 in Appendix A). Records from the end of June, 1979, indicate that there was a freeboard of 3.35 feet (file data, State Engineer's Office). At the time of the inspection, the minimum freeboard was five feet.

As shown on Drawing 37-G-05, Appendix A, there is a small drainage area of 37.3 acres north of the impoundment. A diversion channel with a capacity of 280 c.f.s. has been built to capture runoff from this area; the channel discharges to the valley downstream of the dam. Drawing 37-G-04 shows that the channel is trapezoidal, 4 feet deep with a 4-foot bottom width and 1:2 side slopes. The upslope side grades to the natural land surface, permitting runoff to enter the channel from the watershed. On the south side of the impoundment, the drainage area is 230 acres (drawing 37-G-05). A diversion channel with capacity of 840 c.f.s. has been built to carry runoff from the watershed, and discharge it downstream of the dam. Drawing 37-G-03 shows the cross-section of this ditch. It is a modified trapezoidal channel. The drawing indicates that when mining is completed, the channel will be enlarged, but the capacity of the enlarged channel is not referenced. Runoff from a small area of about 5.4 acres east of the impoundment is controlled by a roadway drainage system, which discharges into the arroyo just east of the starter dam. Slopes in the drainage areas above the impoundment average about 10 percent. Most of the land is rocky and covered with grass; however, considerable impervious surface exists in the area of the mill and along roadways.

b. Elevations. All elevations are given in mean sea level. Based on topographic maps and current surveys prepared as part of water rights filings and project design:

Top of Dam: Elevation 6193 feet (current) Elevation 6220 feet (ultimate)

Maximum pool-design surcharge: Not applicable

Full flood control pool: Not applicable

Spillway crest (updated): None

Streambed at centerline of dam: Elevation 6152 feet

Maximum tailwater: Not expected to occur.

c. Reservoir.

Length of normal pool: Not applicable

d. Storage. (acre-feet)

Normal pool: 1,100 acre-feet (current) approximately, based upon design area-capacity curve.
4,300 acre-feet (ultimate), approximately, based upon design area-capacity curve.

Dead Storage: Not applicable

Top of Dam: 1,600 acre-feet (current), approximately, based upon extrapolation of area-capacity curve.
5,300 acre-feet (ultimate), approximately, based upon extrapolation of area-capacity curve.

Design Surcharge: Not applicable

e. Reservoir Surface (acres).

Normal pool: 98 acres (current)
160 acres (ultimate)

f. Design and Construction History. The design and construction of a tailings dam is an ongoing process which is updated periodically and includes suggested raises and stability analysis. The most current report for this dam is the Woodward-Clevenger and Associates, Inc. Report dated February, 1974, which addresses itself to "Engineering and Geologic Investigations and Consultations," which is available from the State Engineer's Office or from the New Mexico Environmental Improvement Division. It was the understanding of the inspection team that a visit by the consultant is made on a yearly basis.

The dam was begun in 1976 with a 30 foot high clay starter dam and was recently raised using tailings and an upstream construction procedure, as shown in construction drawings in Appendix A.

g. Outlet Works.

Type: Decant barge with discharge line around the tailings and dam.

Closure: Valves and pump

Access: Ramp

Regulating Facilities: The intake level is regulated by pumping as required.

h. Spillway. None

i. Diversion Channels. Two channels have been constructed. Stated capacities are 840 c.f.s. for the south side and 280 c.f.s. for the north side. Locations and sections are presented on plans in Appendix A.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Limited design data for Sohio L-Bar Tailings Dam are available from the State Engineer's Office in Santa Fe, New Mexico. Available data consist of plans for the dam and appurtenances, specifications and a geologic and stability presentation. Information available from the Environmental Improvement Division consists of plans for the dam and appurtenances, specifications, a hydrologic and ground water presentation and a geologic and stability presentation.

2.2 CONSTRUCTION

Construction is an ongoing process. Materials used are sands from the tailings for current raises. The starter dam was constructed of a clayey, semi-impervious material. Borings and laborabory testing results are available in the Woodward-Clevenger Report on file in the State Engineer's Office. A print showing the section used for the starter dam is presented in Appendix A, plates 37-G-02 and 03. Material used for construction was an engineered fill and utilized on site materials for the compacted fill dam. The successive lifts required to contain the tailings above the height of the starter dam are constructed using an upstream method which is detailed in Appendix A, plate 37-G-03. The method in general consists of pushing coarse tailings sands, which have been deposited near the dam, into a berm. Materials are not compacted except by the passage of the construction equipment. Several raises are anticipated as shown on above referenced plate. The first of these raises was being constructed at the time of the inspection and photos in Appendix F show the berm as constructed. Construction control is provided by the mine owner and the construction is performed under contract with local construction companies.

2.3 OPERATION

Some data on operation of the structure is available at the State Engineer's Office relative to water usage and reservoir levels. Day-to-day discharge and inflow records are not available in the State Engineer's Office. Records as related to mill operation are available at the project office. The Environmental Improvement Division maintains an operation file, relative to radiation releases.

a. Availability. The files in the State Engineer's Office include much of the data needed for evaluation.

b. Adequacy. Studies performed for the dam include a stability and geologic investigation, a hydrologic and ground water investigation and studies required for preparation of plans and specifications and construction. A review of available data indicates that studies performed were adequate for initial construction. Additional studies evaluating the performance of the structure should be performed to verify initial design concepts and construction.

c. Validity. Examination of State Engineer's File data indicate that the material properties used in the stability analysis are acceptable. Use of the reported embankment properties and the slopes of the dam used would lead to safety factors near the ones reported. The location of the phreatic surface, however, should be re-evaluated as sloughing is noted on the new tailings dike and solution holes were observed near the crest of the starter dam. A higher phreatic surface would require verification that the drain is operating and new stability analysis to assure the stability of the dam. High phreatic surfaces would also cause concern that liquefaction could become a problem. Therefore, the liquefaction potential should be addressed for the portions of the dam constructed from tailings. Determination of the phreatic surface, if appropriate, should be performed immediately.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Sohio L-Bar Tailings Dam was conducted on 16 August 1979, by representatives from Tierra Engineering Consultants, Inc., Lee Wilson and Associates, and the Sohio Western Mining Company Representatives. The inspection team consisted of the following:

Ed Maurer
Sohio Western Mining Company

Bill Turner
Sohio Western Mining Company

Jim Bazemore
Sohio Western Mining Company

Merill Allen
Sohio Western Mining Company

Dave Jenkins, Geologist
Lee Wilson and Associates

Ed Ytuarte, Engineer
Tierra Engineering Consultants, Inc.

Richard Catanach, Engineer
Tierra Engineering Consultants, Inc.

The dam, downstream area and upstream area was inspected. The water surface elevation at the time of the inspection was approximately 6188 feet M.S.L. Photographs are shown in Appendix F.

b. Dam.

(1) Crest. Construction of the first tailings dam above the starter dam has been completed. The dam was raised using tailings in the immediate vicinity of the crest. See photos 2, 7, 8 and 9, Appendix F. The crest is backed by a sand tailings beach of several hundred feet, however, at the time of the inspection, tailings were being discharged immediately adjacent to the crest. If tailings are dumped next to the crest and have no access to the main pool, then the slimes also settle near the crest and provide a layer of weak material underlying future raises of the dam.

Seismicity and stability of the dam are of concern and discussed in Section 6, paragraph f.

(2) Downstream Face and Downstream Toe Area. The downstream face and the downstream toe area of the dam provide the areas of most concern. On the new Phase I lift, seepage is emerging at the level of the crest of the starter dam and several "solution holes" or "boils" were observed. See photos 22, 23 and 24, Appendix F. Portions of the slope have sloughed and the as-built slope appears quite steep. In the sloughed areas the slopes are nearly vertical, see photo 24, Appendix F. The remainder of the dam appears to have been constructed to design criteria with some exceptions where the work was not yet completed. Photo 6, Appendix F illustrates where additional work is required to complete the structure.

Cracks were noted on downstream face of the starter dam starting approximately 100 feet from the piezometer line and continuing 200 feet north. These cracks run downstream on the face and seem to be concentrated mostly mid-way on the dam. The largest crack is about 6 inches wide, perhaps more than 2 feet to 3 feet deep and approximately 10 feet to 15 feet long. See photo 35, Appendix F.

The chimney drain is exposed on the crest surface of the starter dam. See photo 10, Appendix F. On the lower starter dam slopes, there are cracks which appear to be erosion channels and holes in a dispersive soil. See photos 35, 36 and 37, Appendix F. At the toe, seepage is emerging from the finger drains quite high on the slopes. See photos 25, 26, 27 and 28, Appendix F. Solution waters ponded in the seepage collection channel appear to be reacting with the underlying soils as evidence by bubbling and scum on the surface. See photo 29, Appendix F.

The pipeline used to carry mine tailings to the reservoir is located on the crest of the starter dam. The pipeline is not equipped with a safety shut-off switch. The return pipeline for seepage waters is buried under the crest of the dam. See photos 32 and 33, Appendix F. The roads are not well maintained for patrolling and the pond is not lighted to allow night-time observation.

(3) Upstream Diversion Channels. The upstream diversion channels are not designed to carry the flows required by Corps of Engineer's criteria for dam evaluation. The channels have stated capacity of 280 C.F.S. and 840 C.F.S. The Corps' criteria indicates a Probable Maximum Foood (PMF) of 388 C.F.S. and 2000 C.F.S. from the north and south watersheds respectively. The Corps' values were obtained using the chart labeled "Maximum Experienced Peak Discharges" presented in Appendix C. The channels are in good condition with no noted blockages. Photos 20 and 21, Appendix F, show the south channel.

(4) Decant System. The decant system was not inspected, as it does not affect the stability of the dam.

(5) Saddle Dam. The saddle dam appears to be in good condition except for rodent activity and the apparent reaction of solution waters with the earth dam or foundation at the upstream (west) toe. This is evidenced by bubbling and scum on the surface. Rodent activity was present at all levels of the dam from the crest to the downstream toe, however, most of the burrows were located near the downstream toe to about the mid-height of the dam. See photos 40 through 43, Appendix F, for the saddle dam.

3.2 EVALUATION

a. Crest. The crest requires repairs to assure its stability. Sloughed areas should be filled and the seepage discharge faces should be armored, filtered or otherwise designed and constructed to provide a controlled discharge for seepage waters. Emerging seepage waters should be gathered and conveyed to a safe discharge point. The downstream slope and crest should be constructed to the configuration suggested by the consultant in the Woodward-Clevenger report and as presented in the plans shown in Appendix A. Adequate freeboard should be maintained and borrow for future raises obtained in a manner that allows drainage to reach the pond area.

b. Downstream Face and Downstream Toe Area. The downstream face and downstream toe area require study to determine the effects of low pH solutions on soils to assure the near and long term stability of the dam from piping potential and also from settlement and cracking. The same analysis is required for the foundation materials. The high exit face on the finger drains should be evaluated to assure that the dam is stable under these conditions. The stability of the structure under seismic activity is discussed in Section 6.

c. Upstream Diversion Channels. The carrying capacity and configuration of diversion channels should be evaluated and upgraded to provide safe discharge of upstream flood water.

d. Saddle Dam. The saddle dam requires maintenance to fill rodent holes and eliminate the burrowing animals. The dispersive soil study required for the starter dam should be applied to the saddle dam also.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

Sohio L-Bar Tailings Dam is used to store mine tailings and to decant solution for re-use. All tailings and solution are transported to the dam in a steel pipeline and then spigoted over the crest at the location where additional tailings can be accommodated. The only other waters which can reach the pool are rainwaters or an overtopping of the diversion channels. There is no spillway and the pool is maintained well inside the tailings pile and against the saddle dam. The only means of emptying the solution would be to pump the pond dry.

4.2 MAINTENANCE OF DAM

The Sohio Western Mining Company is responsible for maintenance of the project.

4.3 MAINTENANCE OF OPERATING FACILITIES

The Sohio Western Mining Company is responsible for maintenance of operating facilities.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

There are no warning systems.

4.5 EVALUATION

Maintenance is required on the downstream slopes to fill in sloughed areas caused by seepage. The sloughs tend to steepen slopes and provide areas of low stability. The road system should be upgraded to assure accessibility to all parts of the main dam and saddle dam even in bad weather. A warning system should be established and maintained on the dam. This could take the form of an emergency shutoff on the mine tailings lines and lighting of the structure so that trained patrols could observe the structure at night. Seepage should be monitored to assure that quantity or character of flow does not change dramatically in a short time.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. The minimum standard for the Sohio Dam is the ability to safely pass a Probable Maximum Flood (PMF). As discussed in Section 1.3, the dam is not a conventional structure which retains normal runoff. Rather, the design provides for runoff to bypass the impoundment completely. Therefore, the analysis of the design flood is not a conventional study in which the adequacy of the spillway is evaluated. Rather, it is necessary to consider the combined influence of rainfall and runoff in and near the structure from within or without.

Data on the design of the diversion channels is contained in Sohio's 1974 environmental report to the New Mexico Environmental Division (then Department). This report is available in the Environmental Improvement Division office in Santa Fe, New Mexico. The estimated PMF is 20 inches, and the 100-year runoff for the drainage south of the impoundment was estimated to have a peak of 210 C.F.S. The PMF runoff was estimated to be 4200 C.F.S. The channel has a capacity of 840 C.F.S., sufficient to pass the 100-year event but not the PMF. Therefore, the channel would overflow during a PMF event, possibly causing runoff to erode the tailings dam from the outside or the pond to fill causing either overtopping of the dam or an erosional breach which could permit a tailings spill. The report gave no information on runoff from the northern part of the watershed, but a similar situation is presumed to exist there.

Application of the Albuquerque District Corps of Engineers envelope curve for maximum experienced peak discharges (PMF curve included in Appendix C) indicates that the peak discharge from the southern watershed would be expected to be about 2000 C.F.S. This is less than estimated by Sohio, but still above the capacity of the diversion channel. Use of the Albuquerque District Curve indicates the peak discharge from the northern watershed would be about 388 C.F.S. The channel velocities at the high flows should be evaluated to assure that they do not endanger the channel by erosion.

A PMF of 20 inches would not in itself cause overtopping of the impoundment if a freeboard of 5 feet is maintained. However, if the actual freeboard is only a few feet, as has been observed, then the PMF itself would represent a potential danger to the structure.

A technical analysis is needed to define the ability of the channels to carry the PMF without causing erosion and possible breaching of the dam. This analysis must take into consideration the rise in the impoundment which would occur with a PMF, especially given the freeboard which is normally maintained. Further, the analysis must consider the fact that erosional gullies, burrows, cracks and incipient piping could add to the breaching potential.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observation. The embankment appears to be stable with the exception of the seepage noted at the base of the recently raised tailings dam and the high seepage line noted on the starter dam. These items, along with possible dispersive soil conditions when exposed to acidic solutions, need to be assessed.

b. Design and Construction Data.

(1) A design analysis of the tailings dam was conducted by Woodward-Clevenger and Associates. The results indicate that the dam is stable if constructed to the configurations shown and if the phreatic lines are as assumed. The dam should be re-evaluated after piezometer data is obtained to establish the existing phreatic surface and present dam configuration. A seepage analysis should also be performed to assure that the holes at the crest are not a hazard, or caused by dispersion of the earth materials.

(2) Construction is an ongoing process and records are maintained on site when the embankment is raised.

c. Operating Records. Limited operating records are available in the State Engineer's Office as to lake levels and water added. Records as related to mill operation are available at the Project Office.

d. Postconstruction Changes. Ongoing.

e. Geology. Geological conditions at the site are described in a report to Sohio prepared by Woodward-Clevenger and Associates in 1974. Unless otherwise stated, all the information presented in this section is obtained from the referenced report. A 5-20 foot thickness of overburden is found beneath the dam and impoundment site. This material is dominantly stiff, slightly moist clays which are porous and which will collapse under load when wetted. Capping much of the area are basaltic gravels, cobbles and occasional boulders. During our inspection, limestone gravels and cobbles were also observed in the overburden material.

The overburden lies on firm to medium hard bedrock which becomes very hard with depth. The bedrock is stratigraphically part of the lower Mancos Formation, which is exhibited here as a shale with siltstone and sandstone, dipping 2-3° North. The upper part of the bedrock is a thin-bedded and highly fractured claystone. It contains gypsum in the beds and fractures; from 2-6 inches of the upper 10 feet of the bedrock is (in composite) made up of gypsum. Based on information provided to the inspection team during our field visit, the overburden and/or bedrock probably contains calcareous minerals which wou'' be dissolved by acidic seepage waters.

The report indicated that there was no evidence of faulting in the vicinity of the structure. U. S. Geological Survey Map GQ-209 shows no faults in the vicinity. However, it should be noted that the nature of the soils and rocks in the area make it difficult to identify faults.

Woodward-Clevenger concluded that the overburden and bedrock are capable of supporting the dam, with minimal foundation preparation. It was recommended that the dam be constructed using the clay overburden soils at optimum moisture content or above, in order to achieve as much plasticity as possible in the dam and thus minimize the risk of c "cking and subsequent piping when settlements of the porous overlying sandy clays occur as the dam foundation soils become wet. Information on the actual construction material is limited. Presumably the material could contain some calcareous minerals, as observed in the overburden (alluvium) downstream of the dam.

At the time of the Woodward-Clevenger investigation, there was no free water observed in the overburden or near-surface bedrock beneath the (then-proposed) dam and impoundment. It was predicted that seepage through the starter dam would be minimal, since the dam would be constructed of available clay soils which would be essentially 'impervious' when compacted (quotes in original report, page 21). Some seepage was expected to occur through the overburden soils, but the quantity was expected to be small. Seepage which penetrated the clay overburden was expected to move more rapidly once it reached the fractured shale bedrock. Even though the clay overburden is considered nearly impervious, a seepage rate of as much of 225 gpm was conservatively estimated by the Woodward-Clevenger Report. The report considered it more likely that the seepage rate would be on the order of 135 gpm. It was recommended that piezometers be installed within the dam, and monitoring wells were recommended for downstream of the dam. No recommendations were provided to measure the phreatic surface in the overburden and bedrock beneath the dam.

Coarse tailings are being used to build dams above and upstream of the clay starter dam. A chimney and finger drain system has been installed in the starter dam to carry seepage. Seepage is evident at the toe of the starter dam. According to a letter from Woodward-Clyde Consultants to Sohio (dated 12 September 1978) the seepage occurs at points coincident with the placement of the finger drains. The seepage exits as much as six feet above the bottom of the seepage collection ditch that parallels the toe of the starter dam. The design drawings indicate that the finger drains could cause seepage to appear at least four feet above the bottom of the ditch. The reason for the higher exit point is not known. The drains may extend as high as six feet above the seepage ditch. Or, reactions of acidic seepage water with limestone boulders in the drain material could be causing precipitates of other minerals which have blocked the drain, forcing seepage up into the structure. However, Sohio officials report that the drain material consists only of basalt boulders; if this report is accurate, the first explanation for the seepage exit point is more likely.

The piezometers are installed above the elevation of the top of the finger drains, and thus do not provide data on the phreatic surface. The piezometers have been dry since installation according to Sohio officials. The Woodward-Clyde letter noted that it is vital to the stability of the dam to establish a phreatic level well below the downstream face and recommended installation of piezometers for monitoring of this surface. In a letter to Sohio on 1 March 1979, the New Mexico State Engineer stated that the company had not monitored ground water seepage in a manner acceptable to the State Engineer.

The seepage was clear at the time of our inspection. Air bubbles were observed in the bottom of the ditch. According to Sohio officials who accompanied the inspection, the bubbles are caused by acid reactions with clays in the overburden beneath the dam. The acid is caused by seepage from the seepage collection ditch which gathers water from the finger drains, rather than underseepage. The dam has been affected by erosion gullies, shrinkage cracks and animal burrows according to all inspection reports on file; such features along with possible incipient piping were visible at the time of our visit. Drainage in the seepage ditch and runoff from the road on the dam contribute to the erosion problems.

A number of questions must be resolved in order to properly evaluate the stability of the dam. First, the nature of seepage through and beneath the structure should be monitored in a manner which will permit: a) definition of the general phreatic surface in the dam, overburden and bedrock materials, to include areas beneath and upstream of the dam as well as downstream; b) definition of variations in this surface associated with the finger drains and the seepage ditch. Second, any material which would be subject to significant seepage (based on the above analysis) should be investigated to determine if it would be adversely affected by the seepage. Adverse effects which, if extensive enough, could be a source of concern include: Solution of carbonates from the dam material, drain material, overburden or bedrock; precipitation of minerals in the finger drains; solution of gypsum from the bedrock; collapse of the foundation overburden or dam if wetted; piping associated with seepage through the various materials. The evaluations will require more definite information on dam and drain materials than is now available, as well as a more extensive network of piezometers.

f. Seismic Stability. Sohio L-Bar Tailings Dam is located in seismic zone 2. A seismic zone map and an epicenter map are presented in Appendix A. A seismic evaluation of the Grants Uranium Belt area was made by Allen Sanford in a 1975 report to Kerr-McGee, available from the New Mexico State Environmental Improvement Division. This report concluded that the maximum earthquake expected in the area in a 100-year period would have a magnitude of 5. This size event could also be considered as the maximum credible earthquake for this area. This event would cause ground motions with a vertical acceleration of 0.1g. This analysis is not much different from the predicted acceleration of 0.06g given in the Woodward-Clevenger Report; for our investigation, an acceleration of 0.1g was considered appropriate for evaluating seismic stability. The possibility of liquefaction due to earthquake loading was not addressed in the Woodward-Clevenger Report. With the possibility of a high phreatic surface as discussed in paragraph 2.4.c. and 3.1.b.(2) the potential for liquefaction increases, and should therefore be addressed.

SECTION 7 - ASSESSMENT AND REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Based on the visual inspection of 16 August 1979, several existing conditions should be corrected in the near future to prevent further deterioration and assure continued safe operation of the project. These repairs and changes are discussed in paragraph 7.2.

The dam is considered to have a high hazard potential according to Table 2 of Appendix D of the National Program of Inspection of Dams. This classification is appropriate because of the nature of the stored materials and solution waters.

The diversion works should accommodate the Probable Maximum Flood (PMF). A technical analysis is needed to define the ability of the diversion channels to carry the PMF. Overtopping could cause erosion and possible breaching of the dam. The south diversion channel as presently designed accommodates 42 percent of the PMF. The north diversion channel as presently designed accommodates 72 percent of the PMF.

Seepage sloughs and boils or solution cavities are present on the downstream slope and toe. These should be repaired and seepage discharge faces armored, filtered or otherwise designed and constructed to provide a controlled discharge that does not allow sloughing or boils. Additional piezometers should be installed and monitored and seepage and stability studies should be performed after piezometer data is available to assure the stability of the dam, to determine if liquefaction is a problem, and to determine the nature and criticality of the downstream boils.

The effect of low pH solutions on soils should be evaluated to assure the near and long term stability of the dam both from piping potential and also from settlement of underlying soil.

The dam is, therefore, considered a serious hazard until detailed studies prove otherwise or corrective measures are completed. Phase II investigations as specified above are required to be performed by the owner. These should commence and be completed as soon as possible. The owner should develop a contingency plan for protection of the public.

b. Necessity for Phase II. Phase II investigations by the owner, as described in paragraph 7.2(b) are required to further evaluate the safety of the structure. These studies should commence and be completed as soon as possible.

c. Urgency. Under present operating conditions, there is no immediate danger to the dam, however, Phase II investigations must be completed to fully access future operation policies.

7.2 REMEDIAL MEASURES

To minimize the possible loss of life and property and to assure continued safe operation, the following items are required:

a. Operation and Maintenance Measures.

(1) All eroded faces on the dam should be filled and the seepage discharge faces armored, filtered or otherwise designed and constructed to provide a controlled discharge.

(2) An emergency shutdown system should be implemented to prevent a washout of the dam by a break in the tailings delivery line.

(3) The dam area roads should be improved to allow easy patrol and monitoring on a 24-hour basis. Safety berms should be installed on the roads to provide safe travel and to prevent the washing away of the dam slopes. Lighting should be provided to assure that night patrols can make adequate inspections.

(4) An emergency plan should be implemented and patrol personnel instructed on required action in the event of danger to the structure. Personnel should also be instructed on items to look for in performing patrols (i.e., increased seepage or change in character of flow, etc.).

b. Additional Investigations.

(1) The seepage and stability analysis should be upgraded as soon as results of piezometers are available. Study should include an analysis on nature and criticality of boils on downstream toe. Also if a high phreatic surface is found that would affect future raises of the dam, the potential of liquefaction of the tailing berms should be addressed.

(2) The diversion channels should be evaluated to assure safe discharge of the PMF storm.

(3) The effects of low pH solutions on soils should be evaluated to assure the near and long term stability of the dam both from piping potential and also from settlement of underlying soil and the effects on surface materials.

(4) Type of aggregate used for finger drains should be determined.

c. Additions to Current Operating Procedures. A warning system and emergency action plan should be developed for this project. Discussion of such a plan is presented in ASCE Publication, "The Evaluation of Dam Safety," page 463. See Appendix G.

APPENDIX A

COLOR VICINITY MAP

SEISMIC ZONE MAP,

EARTHQUAKE EPICENTER MAP

AND CONSTRUCTION DRAWINGS

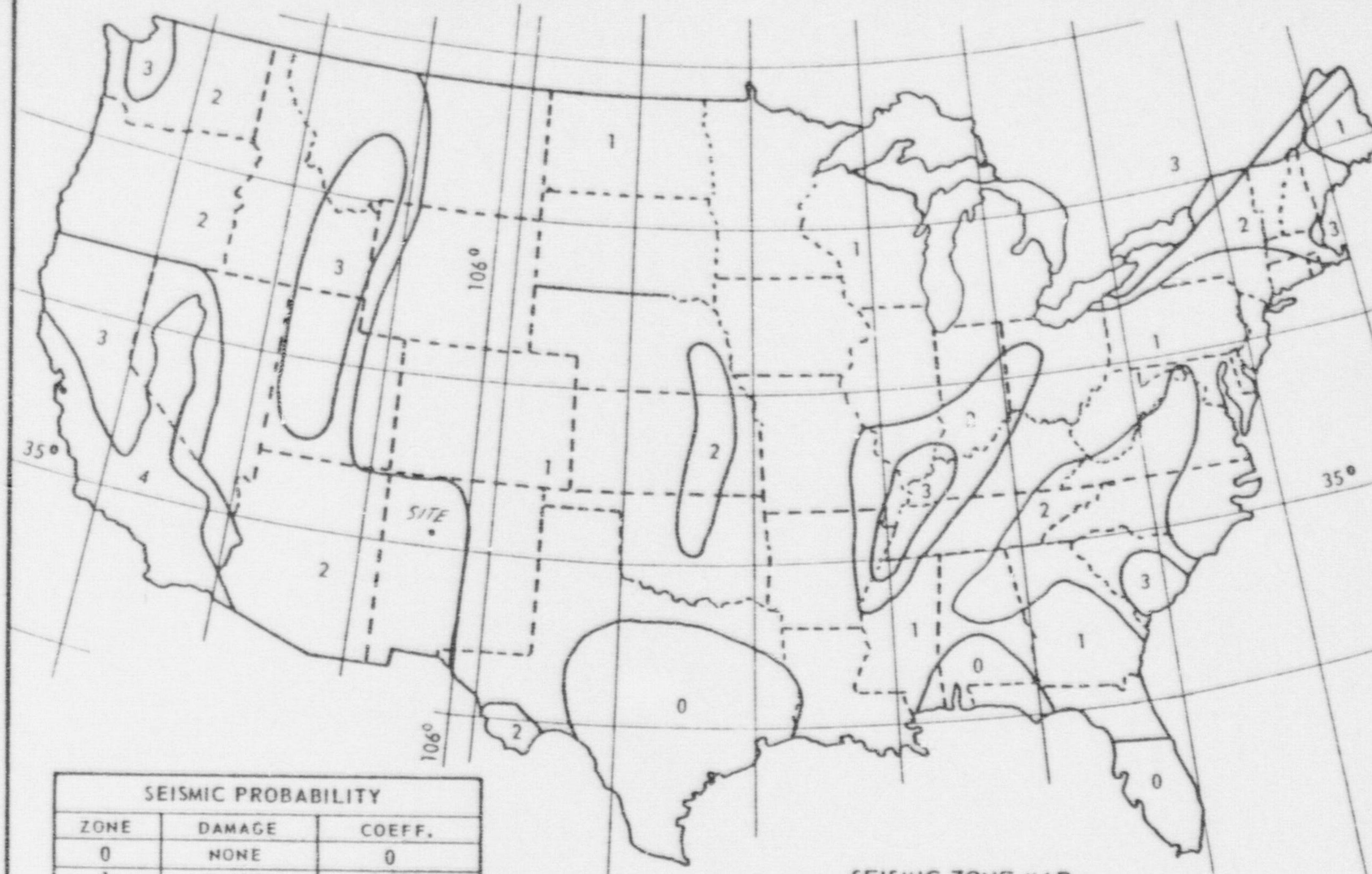
LOCATION MAP

0 5 10 20 30 40

SCALE - MILES

REFERENCE: Road Map of New Mexico. Issued by the New Mexico State Highway Department.

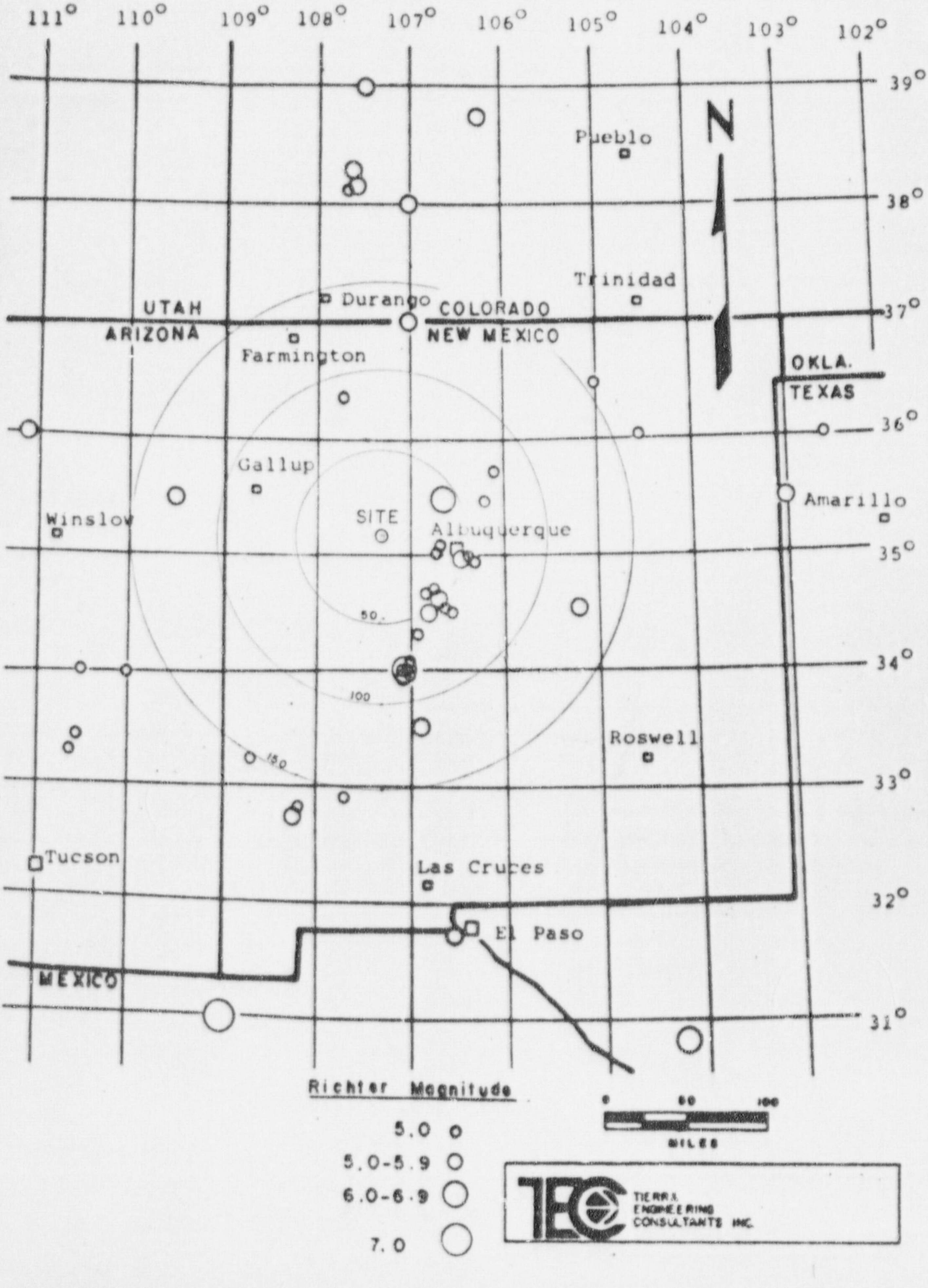
From TM 5-809-10/ NAVFAC P-355/AFM 88-3, Chapter 13; April 1973



SEISMIC PROBABILITY		
ZONE	DAMAGE	COEFF.
0	NONE	0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

SEISMIC ZONE MAP
of
CONTIGUOUS STATES

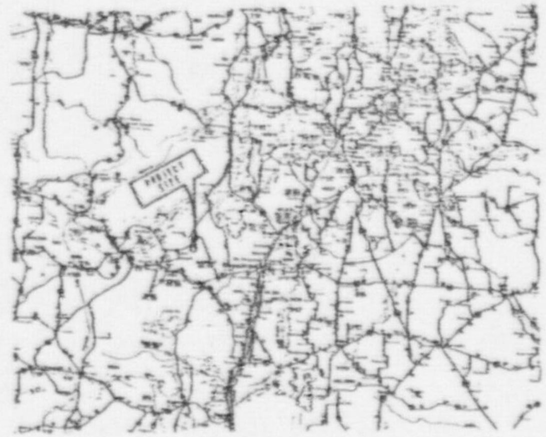
EARTHQUAKE EPICENTER MAP



TAILINGS DISPOSAL SYSTEM

DRAWING INDEX

SHEET NO.	DRAWING NO.	TITLE
1 OF 9	37 - G - 08	TAILINGS DISPOSAL SYSTEM INDEX, MAP & FILING STATEMENT
2 OF 9	40 - G - 01	PROJECT VICINITY MAP
3 OF 9	40 - S - 05	L-BAR RANCH PROPERTY LINE
4 OF 9	37 - G - 01	AREA PLAN
5 OF 9	37 - G - 02	STARTER DAM PLAN & SECTION
6 OF 9	37 - G - 03	MISCELLANEOUS SECTIONS & DETAILS SHEET 1
7 OF 9	37 - G - 04	MISCELLANEOUS SECTIONS & DETAILS SHEET 2
8 OF 9	37 - G - 05	MASTER DRAINAGE PLAN
9 OF 9	37 - G - 06	STARTER DAM DRAINS PLAN & PROFILE



LOCATION MAP

State of New Mexico) ss.
County of Santa Fe)

I hereby certify that the accompanying maps and statements have been duly considered by me and are approved as to form and content and were duly accepted for filing on the 14 day of June 1976

State Engineer: S.E. REYNOLDS (SEE NOTE)

NOTE:
DRAWINGS AND SPECIFICATIONS WERE ACCEPTED FOR FILING BY A LETTER FROM STATE ENGINEER [illegible]

STARTER DAM AND TAILINGS RETENTION AREA

L-BAR URANIUM PROJECT

I, L. C. Jacobsen, for Sohio Petroleum Company, claimant, whose post office address is [illegible] [illegible] Street N.E., Albuquerque, New Mexico has caused to be [illegible] by a qualified Registered Professional Engineer and Land Surveyor the starter dam and tailings reservoir as hereinafter described and [illegible], hereby make these several statements [illegible] and offer these maps and statements for acceptance and filing in compliance with the laws of the State of New Mexico.

LOCATION: The dam and tailings reservoir is located
in Section 19 PROTRACTED
Township 11 N
Range 5 W

PROPERTIES:	Starter Dam	Final Dam
Maximum height above foundation	50 FT	70 FT
Maximum length	2000 FT	4000 FT
Maximum width at base	150 FT	350 FT
Crest width	20 FT	20 FT
Slope of downstream face	3 TO 1	3½ TO 1
Area of reservoir	50 ACRES	160 ACRES

CLAIMANTS CERTIFICATE
State of New Mexico
County of ____________

I, L. C. Jacobsen, being first duly sworn, upon my oath, State I am the [illegible] Operations of Sohio Petroleum Company, a corporation duly organized under the laws of the State of New Mexico, that the accompanying maps and statements consisting of ________ sheets were made under the authority of the Board of Directors of said Corporation and that, in their behalf, I have read and examined the statements and representations thereon and state that the same are true to the best of my knowledge and belief.

By
SOHIO PETROLEUM COMPANY
Claimant

Subscribed and sworn to before me this 4 day of June 197_

Notary Public

My Commission expires June 23, 1976

State of New Mexico) ss.
County of Bernalillo)

I, [illegible], being first duly sworn, upon my oath state that I am the registered professional engineer who made the maps of the Tailings Dam [illegible] [illegible] that such maps consisting of ____ sheets prepared by or under my direction and that the same are true and correct to the best of my knowledge and belief.

Registered Professional Engineer and/or Land Surveyor

License No. 5473 [illegible]

Subscribed and sworn to before me this 5 day of May 1976

Notary Public

SHEET 1 of 9

DESIGN APPROVED Date: 6-21-76
APPROVED FOR CONSTRUCTION Date: 6-21-76

FLUOR UTAH, INC.

SOHIO PETROLEUM COMPANY
L-BAR URANIUM PROJECT
ALBUQUERQUE NEW MEXICO

TAILINGS DISPOSAL
INDEX, MAP & FILING STATEMENT

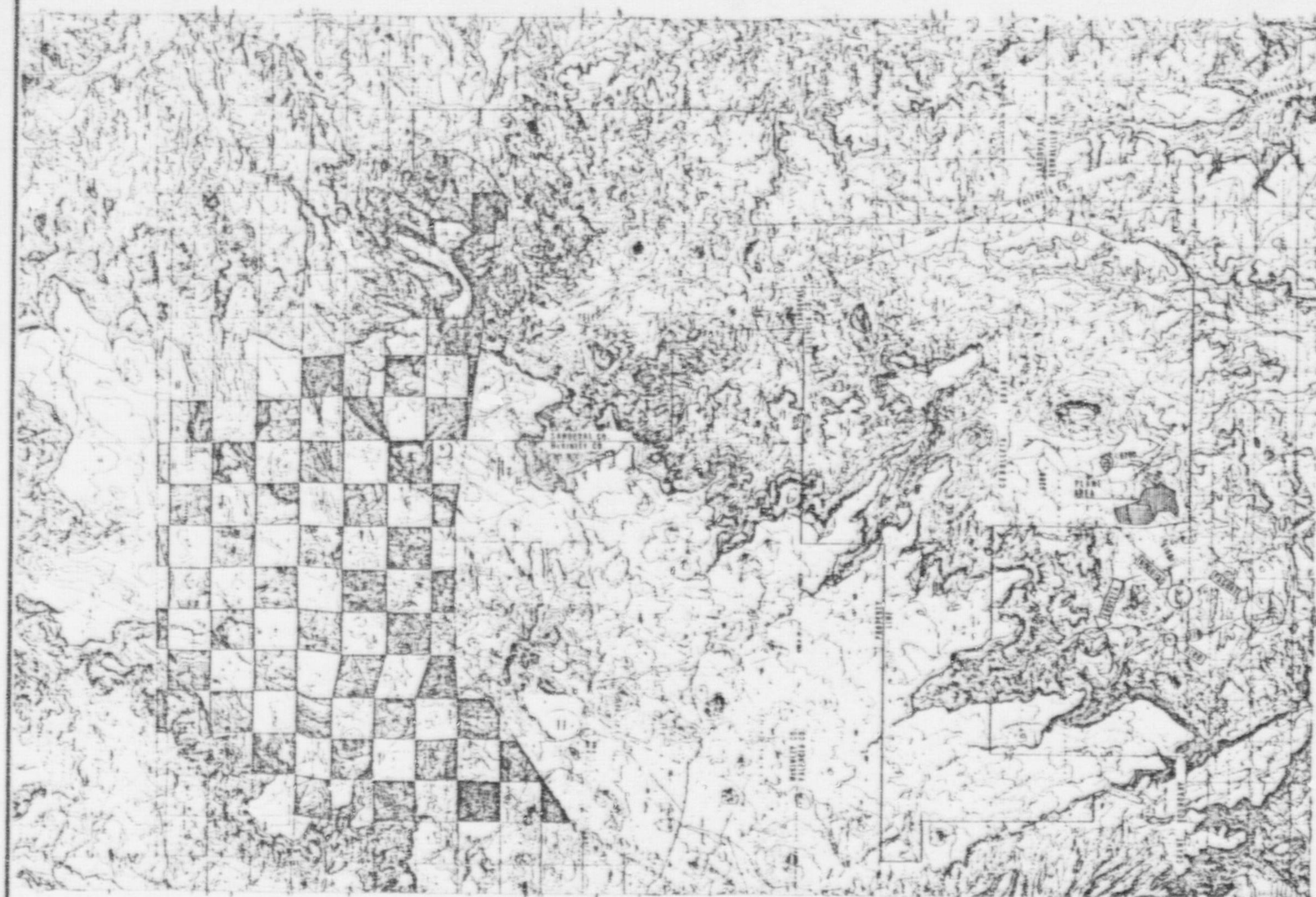
7712 Y

37-G-08

VICINITY MAP

SCALE IN FEET

FLUOR UTAH, INC.	SOHIO PETROLEUM COMPANY L-BAR URANIUM PROJECT NEW MEXICO	SHEET 2 of 9	DESIGN APPROVED APPROVED FOR CONSTRUCTION PROJECT VICINITY MAP
		7712 G	40-G-01



SHEET	DESIGN APPROVED
3 of 9	APPROVED FOR CONSTRUCTION

FLUOR UTAH, INC.

SOHIO PETROLEUM COMPANY
L-BAR URANIUM PROJECT
ALBUQUERQUE NEW MEXICO

L-BAR RANCH PROPERTY LINE

7712 G

40-G-05

FLUOR UTAH, INC.	SOHIO PETROLEUM COMPANY L-BAR URANIUM PROJECT ALBUQUERQUE NEW MEXICO	SHEET 4 of 9	TAILINGS DISPOSAL AREA PLAN	37-G-01

FIGURE 3.4 C

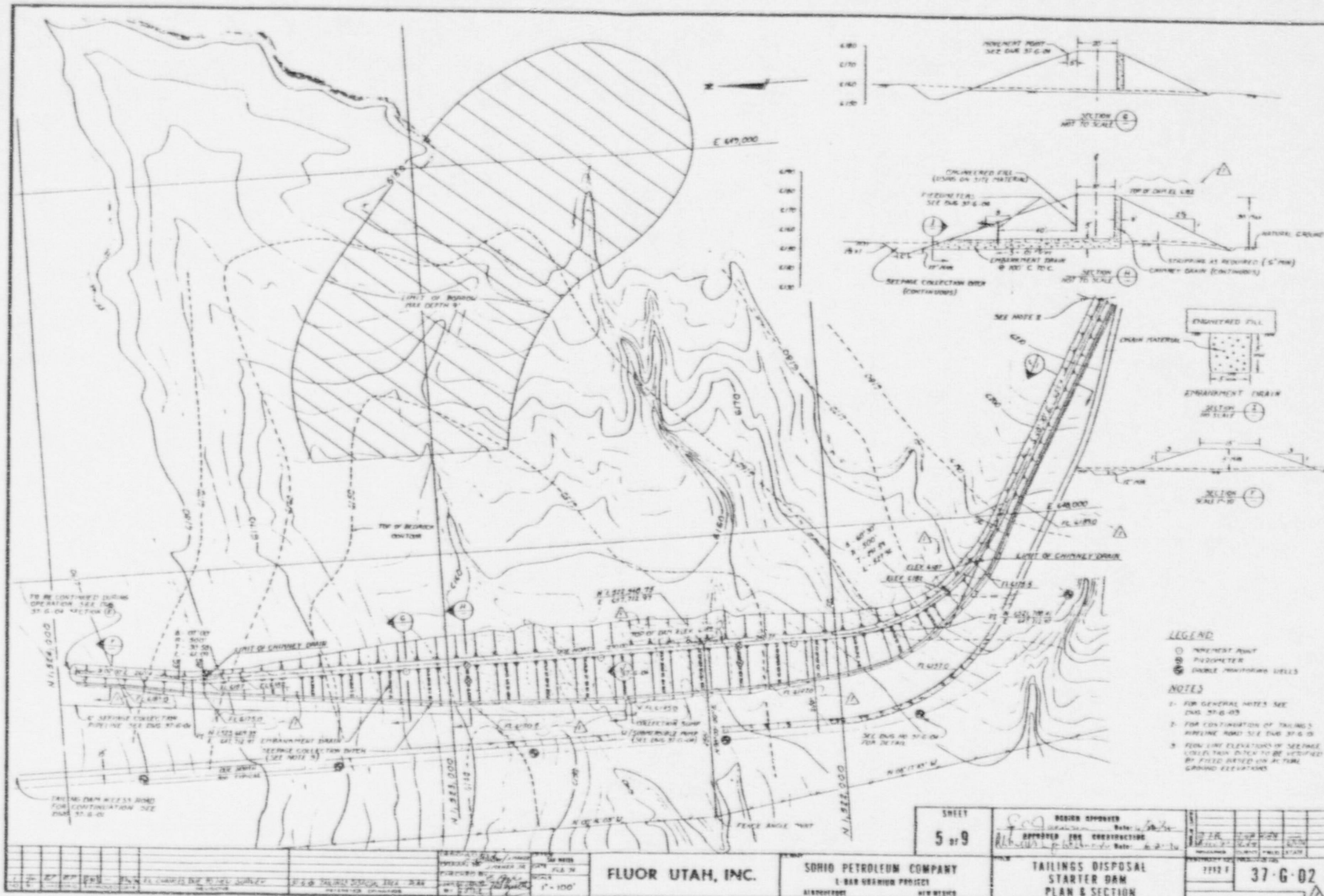

LEGEND
NOTES
SHEET
5 OF 9
FLUOR UTAH, INC.
SOHIO PETROLEUM COMPANY
TAILINGS DISPOSAL
STARTER DAM
PLAN & SECTION
37-G-02
EMBANKMENT DRAIN
LIMIT OF CHIMNEY DRAIN
FENCE ANGLE POINT

FIGURE 3.4 A

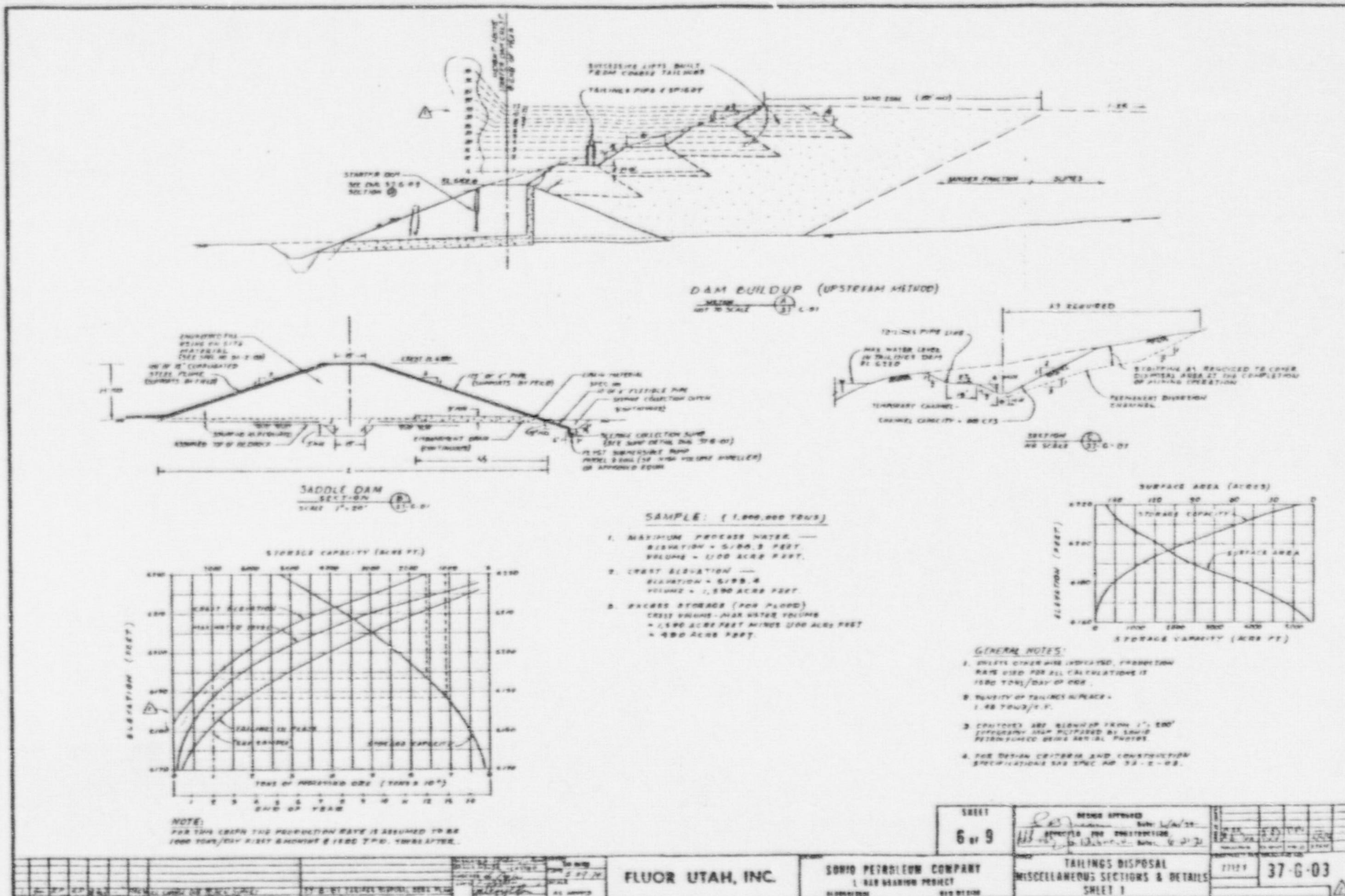

DAM BUILDUP (UPSTREAM METHOD)
SADDLE DAM
SAMPLE: (1,000,000 TONS)
1. MAXIMUM PROCESS WATER —
ELEVATION = 6188.3 FEET
VOLUME = 1100 ACRE FEET.
2. CREST ELEVATION —
ELEVATION = 6193.4
VOLUME = 1,590 ACRE FEET.
3. EXCESS STORAGE (FOR FLOOD)
CREST VOLUME - MAX WATER VOLUME
= 1,590 ACRE FEET MINUS 1100 ACRE FEET
= 490 ACRE FEET.
STORAGE CAPACITY (ACRE FT.)
ELEVATION (FEET)
TONS OF PROCESSED ORE (TONS x 10^6)
END OF YEAR
NOTE:
FOR THIS GRAPH THE PRODUCTION RATE IS ASSUMED TO BE 1000 TONS/DAY FIRST 8 MONTHS & 1500 T.P.D. THEREAFTER.
SURFACE AREA (ACRES)
STORAGE CAPACITY (ACRE FT.)
GENERAL NOTES:
1. UNLESS OTHERWISE INDICATED, PRODUCTION RATE USED FOR ALL CALCULATIONS IS 1500 TONS/DAY OF ORE.
2. DENSITY OF TAILINGS IN PLACE = 1.48 TONS/C.Y.
3. CONTOURS ARE BLOWN UP FROM 1" = 500' TOPOGRAPHY MAP FURNISHED BY SOHIO PETROLEUM CO. USING AERIAL PHOTOS.
4. FOR DESIGN CRITERIA AND CONSTRUCTION SPECIFICATIONS SEE SPEC. NO. 37-C-02.
SHEET 6 of 9
FLUOR UTAH, INC.
SOHIO PETROLEUM COMPANY
L-BAR URANIUM PROJECT
TAILINGS DISPOSAL
MISCELLANEOUS SECTIONS & DETAILS
SHEET 1
37-G-03

FIGURE 3.4 B

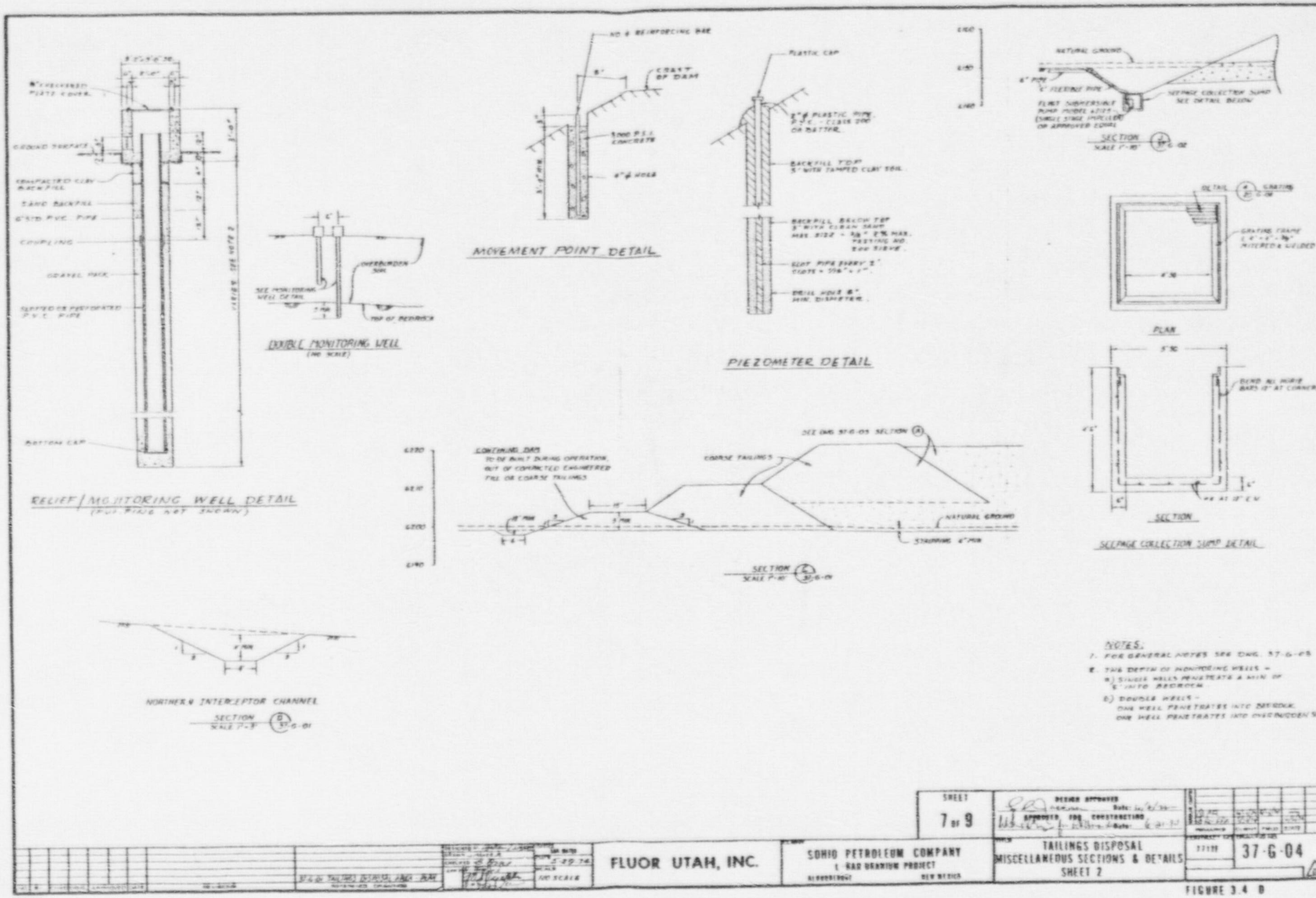
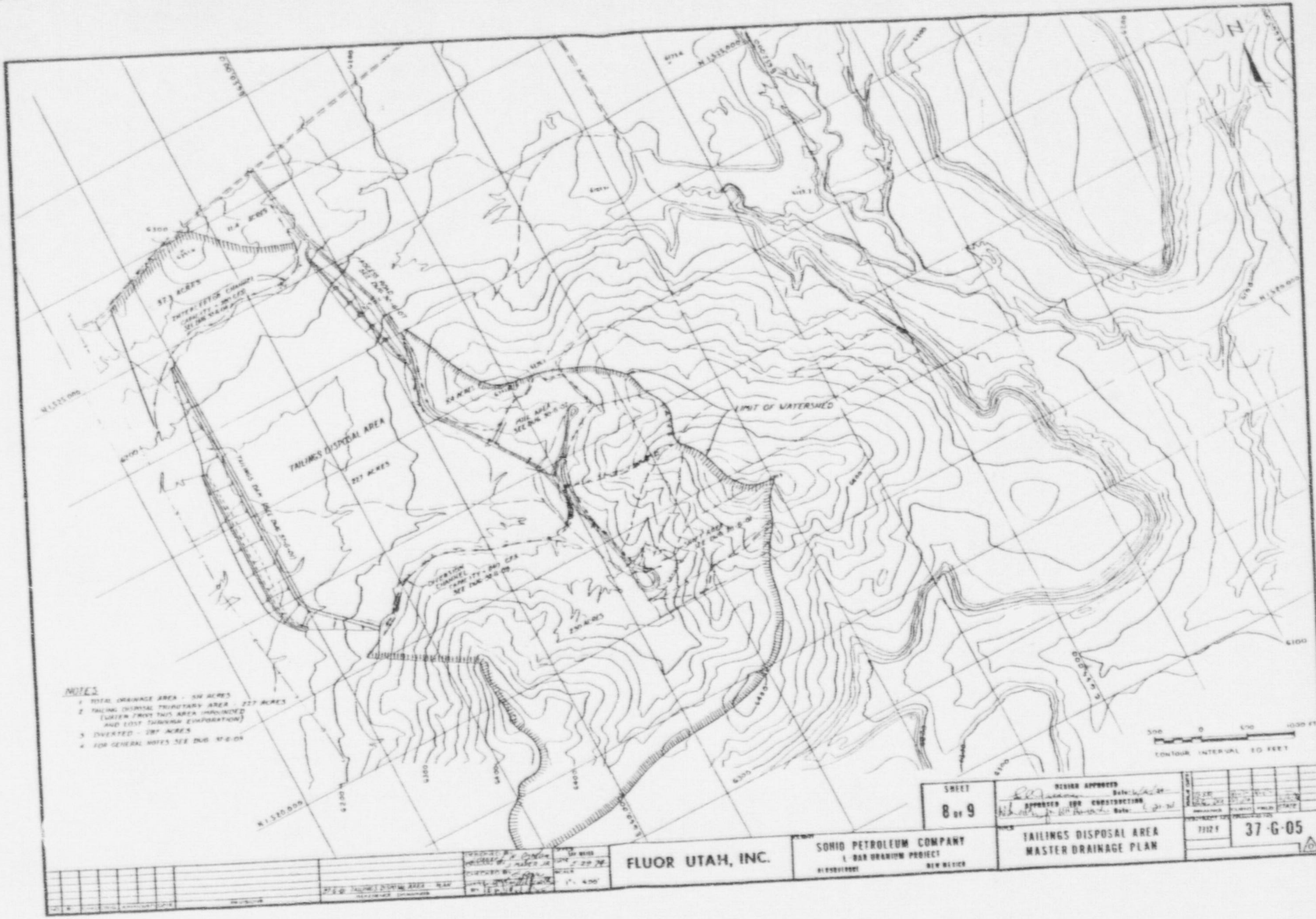
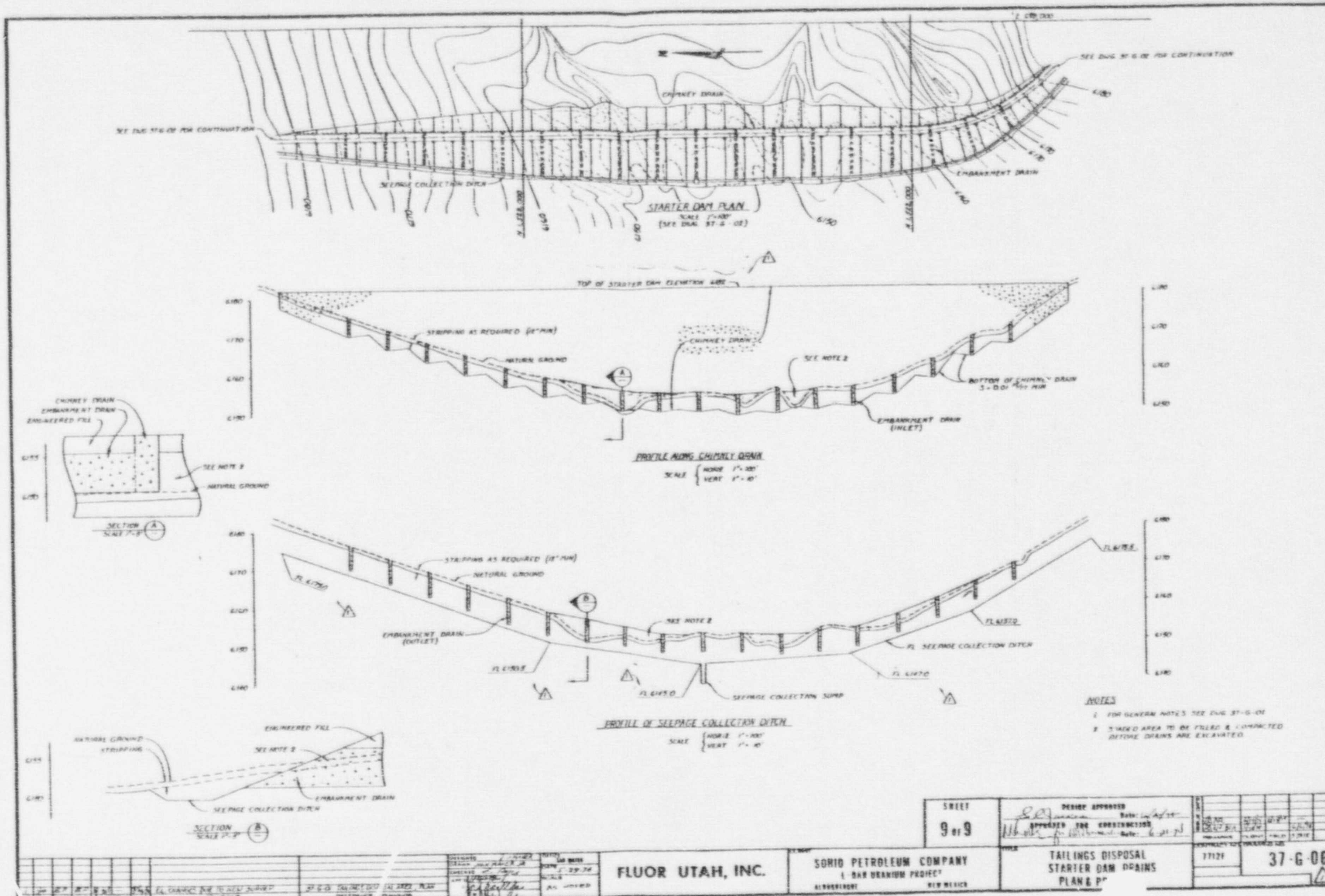

RELIEF / MONITORING WELL DETAIL
DOUBLE MONITORING WELL
MOVEMENT POINT DETAIL
PIEZOMETER DETAIL
SECTION
PLAN
SEEPAGE COLLECTION SUMP DETAIL
NORTHERN INTERCEPTOR CHANNEL
NATURAL GROUND
COARSE TAILINGS
NOTES:
1. FOR GENERAL NOTES SEE DWG. 37-G-03
2. THE DEPTH OF MONITORING WELLS -
a) SINGLE WELLS PENETRATE A MIN OF 6' INTO BEDROCK.
b) DOUBLE WELLS -
ONE WELL PENETRATES INTO BEDROCK.
ONE WELL PENETRATES INTO OVERBURDEN SOIL
SHEET 7 OF 9
FLUOR UTAH, INC.
SOHIO PETROLEUM COMPANY
L BAR URANIUM PROJECT
NEW MEXICO
TAILINGS DISPOSAL
MISCELLANEOUS SECTIONS & DETAILS
SHEET 2
37-G-04

FIGURE 3.4 D


NOTES
1 TOTAL DRAINAGE AREA - ACRES
2 TAILING DISPOSAL TRIBUTARY AREA - 227 ACRES (WATER FROM THIS AREA IMPOUNDED AND LOST THROUGH EVAPORATION)
3 DIVERTED - ACRES
4 FOR GENERAL NOTES SEE DWG.
TAILINGS DISPOSAL AREA
227 ACRES
LIMIT OF WATERSHED
CONTOUR INTERVAL 10 FEET
SHEET
8 OF 9
DESIGN APPROVED
APPROVED FOR CONSTRUCTION
FLUOR UTAH, INC.
SOHIO PETROLEUM COMPANY
L-BAR URANIUM PROJECT
NEW MEXICO
TAILINGS DISPOSAL AREA
MASTER DRAINAGE PLAN
37-G-05


STARTER DAM PLAN
SCALE 1"=100'
(SEE DWG. 37-G-02)
SEE DWG 37-G-02 FOR CONTINUATION
CHIMNEY DRAIN
EMBANKMENT DRAIN
SEEPAGE COLLECTION DITCH
TOP OF STARTER DAM ELEVATION 6182
STRIPPING AS REQUIRED (12" MIN)
NATURAL GROUND
SEE NOTE 2
BOTTOM OF CHIMNEY DRAIN
EMBANKMENT DRAIN (INLET)
PROFILE ALONG CHIMNEY DRAIN
SCALE HORIZ 1"=100' VERT 1"=10'
CHIMNEY DRAIN
EMBANKMENT DRAIN
ENGINEERED FILL
SECTION A
EMBANKMENT DRAIN (OUTLET)
PL SEEPAGE COLLECTION DITCH
SEEPAGE COLLECTION SUMP
PROFILE OF SEEPAGE COLLECTION DITCH
SCALE HORIZ 1"=100' VERT 1"=10'
NATURAL GROUND
STRIPPING
SEEPAGE COLLECTION DITCH
SECTION B
NOTES
1. FOR GENERAL NOTES SEE DWG 37-G-01
2. SHADED AREA TO BE FILLED & COMPACTED BEFORE DRAINS ARE EXCAVATED.
SHEET 9 OF 9
DESIGN APPROVED
APPROVED FOR CONSTRUCTION
FLUOR UTAH, INC.
SOHIO PETROLEUM COMPANY
L-BAR URANIUM PROJECT
ALBUQUERQUE NEW MEXICO
TAILINGS DISPOSAL
STARTER DAM DRAINS
PLAN & P
37-G-06

APPENDIX B

CHECK LIST OF ENGINEERING DATA, DESIGN, CONSTRUCTION & OPERATION

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM: Sohio L-Bar Tailings Dam

I.D. # NM00413

ITEM	REMARKS
AS-BUILT DRAWINGS	As-built drawings not available, construction drawings presented in Appendix A.
REGIONAL VICINITY MAP	Presented in Appendix A.
CONSTRUCTION HISTORY	None available for inspection.
TYPICAL SECTIONS OF DAM	Shown on drawings. Clay starter dam with chimney drain and horizontal drainage blanket. Upstream raises of dam built from successive lifts of coarse tailings.
OUTLETS - PLAN	Not Available
- DETAILS	Not Available
- CONSTRAINTS	Not Available
- DISCHARGE RATINGS	Not Available
RAINFALL/RESERVOIR RECORDS	Not Available
DESIGN REPORTS	"Engineering and Geologic Investigations and Consultation" Report by Woodward-Clevenger and Associates, Inc., dated February 1974, on file at State Engineer's Office.
GEOLOGY REPORTS	Same as above
DESIGN COMPUTATIONS	Not available for review.
HYDROLOGY & HYDRAULICS	"Hydrologic and Ground Water Investigation" Report by Woodward-Clevenger and Associated, dated September 1973, on file at Environmental Improvement Division.
DAM STABILITY	"Engineering and Geologic Investigations and Consultation" Report by Woodward-Clevenger and Associates, Inc., dated February 1974, on file at State Engineer's Office.
SEEPAGE STUDIES	Same as above

CHECK LIST (Cont'd)

ITEM	REMARKS
MATERIALS INVESTIGATIONS	Same as above
POST-CONSTRUCTION SURVEYS OF DAM	Dam is not monumented and no surveys have been performed.
BORROW SOURCES	Shown in Plans, Appendix A. Design investigation studies addressed in "Engineering and Geologic Investigations and Consultation" Report by Woodward-Clevenger and Associates, Inc., dated February 1974, on file at State Engineer's Office.
MONITORING SYSTEMS	Piezometer network
MODIFICATIONS	None noted
HIGH POOL RECORDS	Reservoir levels not recorded
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None Available
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	No record of any.
MAINTENANCE OPERATION RECORDS	None on file or officially recorded.
SPILLWAY PLAN SECTIONS DETAILS	Spillway not provided
OPERATING EQUIPMENT PLANS & DETAILS	Not Available

APPENDIX C

CHECK LIST OF
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA,
DRAINAGE MAP AND
CURVE OF MAXIMUM
EXPERIENCED PEAK DISCHARGES

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: North of impoundment, there is a 37.3 acre drainage area. On south side drainage area is 230 acres. Slopes average 10%, land is rocky and covered with grass, with considerable impervious surface.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 6188' present (1100 AF and normal pool), 6220' ultimate (4400 AF and normal pool)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N/A

ELEVATION MAXIMUM DESIGN POOL: 6214 Feet

ELEVATION TOP DAM: 6193 present, 6220 ultimate

CREST:

a. Elevation 6193-6197 feet
b. Type Tailings
c. Width Variable
d. Length 4,000 ft.
e. Location Spillover None
f. Number and Type of Gates None

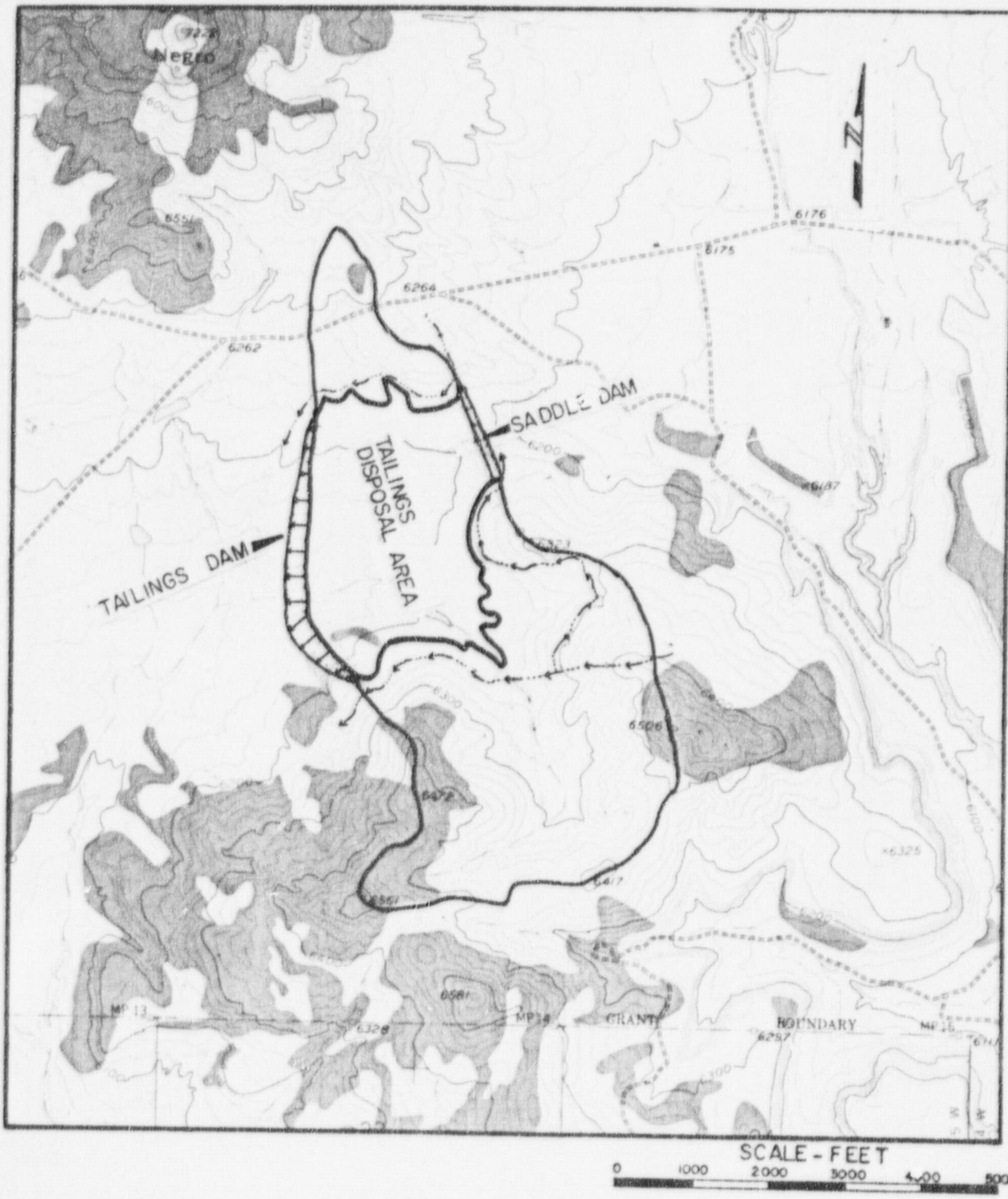
OUTLET WORKS:

a. Type Floating Barge decant unit
b. Location South Abutment
c. Entrance inverts Variable
d. Exit inverts Information not available
e. Emergency draindown facilities None

HYDROMETEOROLOGICAL GAGES:

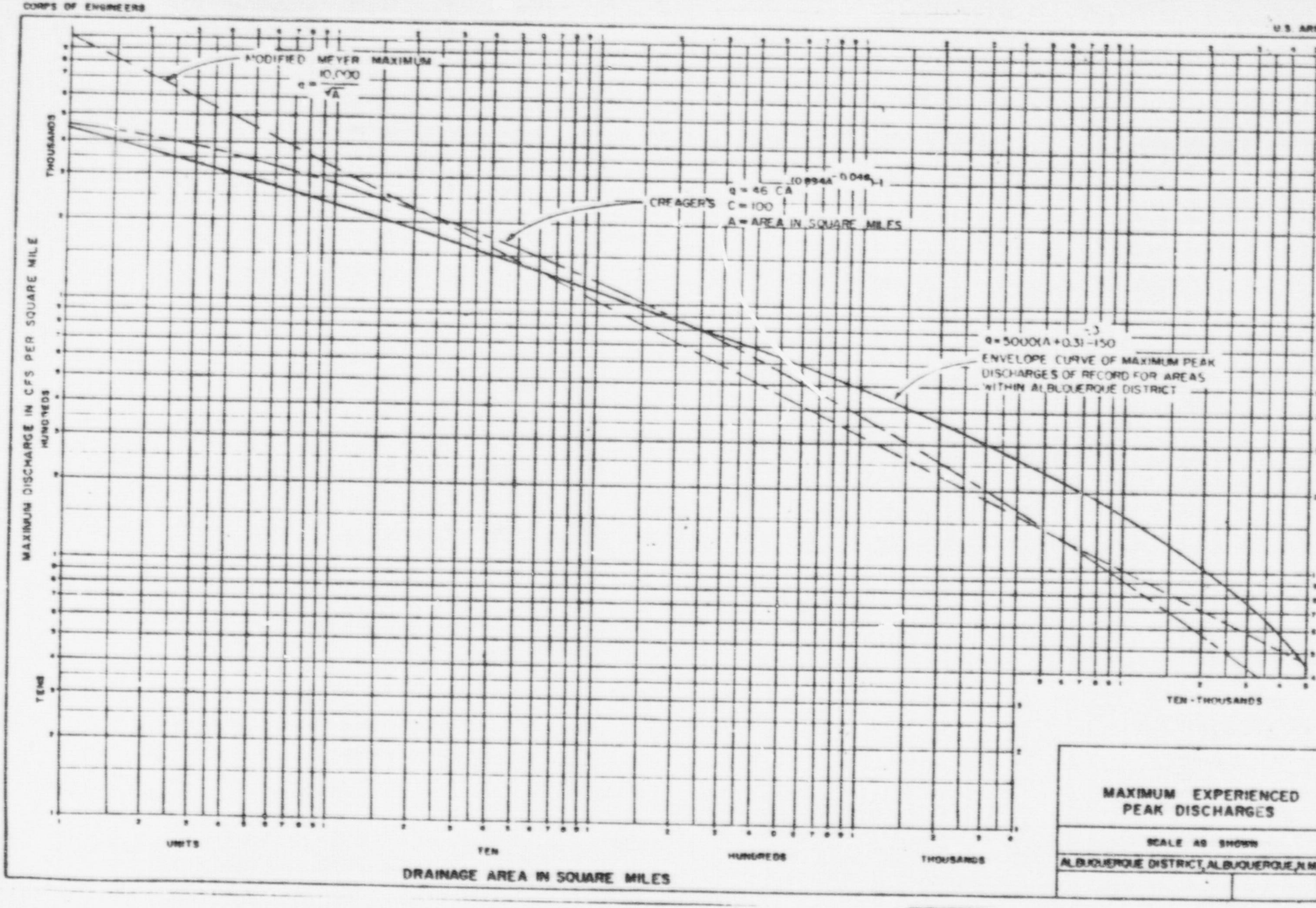
1. a. Type: Recording rain gages
   b. Location: San Mateo, Laguna
   c. Records: National Weather Service Albuquerque Sunport
2. a. Type: Non-recording rain gages
   b. Location: Grants - Milan Airport
   c. Records: National Weather Service Albuquerque Sunport
3. a. Type: Peak discharge
   b. Location: Encinal Creek, 6.8 miles north of Casa Blanca
   c. 1937-39, 1959 present U.S.G.S. Water Resources Division, 505 Marquette NW, Albuquerque, NM

MAXIMUM NON-DAMAGING DISCHARGE: Not assessed



DRAINAGE AREA FOR
SOHIO L-BAR TAILINGS DAM

TEC TIERRA ENGINEERING CONSULTANTS INC.


CORPS OF ENGINEERS
U.S. ARMY
MODIFIED MEYER MAXIMUM
$q = \frac{10,000}{\sqrt{A}}$
CREAGER'S $q = 46\ CA^{(0.894A^{-0.048})-1}$
C = 100
A = AREA IN SQUARE MILES
$q = 5000(A+0.3)^{-1/3} - 150$
ENVELOPE CURVE OF MAXIMUM PEAK DISCHARGES OF RECORD FOR AREAS WITHIN ALBUQUERQUE DISTRICT
MAXIMUM DISCHARGE IN CFS PER SQUARE MILE
THOUSANDS
HUNDREDS
TENS
UNITS
TEN
HUNDREDS
THOUSANDS
TEN-THOUSANDS
DRAINAGE AREA IN SQUARE MILES
MAXIMUM EXPERIENCED PEAK DISCHARGES
SCALE AS SHOWN
ALBUQUERQUE DISTRICT, ALBUQUERQUE, N.M.

APPENDIX D

CHECK LIST OF

VISUAL INSPECTION

CHECK LIST
VISUAL INSPECTION
PHASE 1

Name Dam Sohio L-Bar Tailings Dam   County Valencia   State New Mexico   ID# NM00413

Type of Dam Slurry-Tailings Deposit   Hazard Category High

Date(s) Inspection 16 August 1979   Weather Slightly Cloudy   Temperature 75-80

Pool Elevation at Time of Inspection 6188 Water Surface   Tailwater at Time of Inspection N/A

Inspection Personnel:

Richard B. Catanach TIERRA ENGINEERING CONSULTANTS	Ed Maurer SOHIO WESTERN MINING CO.	Jim Bazemore SOHIO WESTERN MINING CO.
Edward Ytuarte TIERRA ENGINEERING CONSULTANTS	Bill Turner SOHIO WESTERN MINING CO.	Merill Allen SOHIO WESTERN MINING CO.
Dave Jenkins LEE WILSON AND ASSOCIATES		

Richard B. Catanach /Recorder

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	Several cracks and holes were observed on the downstream slope of the starter dam. The cause is not apparent.	A study should be conducted to evaluate the source of cracking.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	Sloughing is present at the location of the finger drain exits. Bubbling and scum are present in the toe drain indicating that chemical activity is occuring.	Evaluate chemical activity.
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	The first stage tailings dam has a number of sloughs which should be repaired. The starter dam has erosion gullies caused by runoff from the crest and/or seepage from the first-stage tailings dam.	Provide safety berms on roads and safe discharge faces for seepage. Also provide seepage collection system.
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	No data available	
RIPRAP FAILURES		

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No erosion or movements noted at junctions of main or saddle dam and abutments.	
ANY NOTICEABLE SEEPAGE	Seepage and boils were noted at the toe of the first stage tailings dam. Seepage is also emerging on the slope of the starter dam at each of the finger drains.	Evaluate seepage control and stability. Install piezometers.
STAFF GAGE AND RECORDER		
DRAINS	The finger drains were operating, however, the seepage was quite high on the slope. Limestone aggregates were found on the face of the drains.	Review finger drain aggregate sources to confirm that limestone not used for drain materials as it would react with solution waters.

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
OUTLET CONDUIT	Outlet consists of a pump-mounted on a barge and a line laid around the north end of the dam.	
INTAKE STRUCTURE		
OUTLET STRUCTURE		
OUTLET CHANNEL		
VALVE		

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Spillway Not Provided	
APPROACH CHANNEL		
DISCHARGE CHANNEL		
FOOT BRIDGE		

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The downstream area is very flat with scrub vegetation.	
APPROXIMATE NO. OF HOMES AND POPULATION	No homes were observed, however, it would require a hydrological study to determine depths and directions of flow and since the materials in themselves are hazardous, it would be prudent to assume a high risk potential if flows left the property.	Conduct study to determine effects of dam breach.
APPRCXIMATE NO. OF HOMES AND POPULATION		

SADDLE DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CREST	The crest appears to be in good condition, except for erosion from rainfall drainage.	
SLOPES	The slopes had animal burrows and also some evidence of the dispersive cracking seen on the main starter dam.	Remove burrowing animals. Apply results of dispersive soil study on main dam to saddle dam also.
TOE OF STRUCTURE	The downstream toe is in good condition. The upstream toe appears to have some chemical activity occuring as evidenced by bubbling and scum on the surface.	
SETTLEMENT OR MOVEMENT	No instrumentation provided.	The soil study should address the effects of solution waters on the foundation to prevent settlement or failure by piping.

APPENDIX E

SUMMARY OF ENGINEERING DATA AS PER APPENDIX I OF OCE RECOMMENDED GUIDELINES FOR SAFETY INSPECTION OF DAMS

APPENDIX E
SUMMARY OF ENGINEERING DATA AS PER APPENDIX I OF OCE RECOMMENDED GUIDELINES FOR SAFETY INSPECTION OF DAMS

1. General Project Data.

   a. Regional Vicinity Map. See Appendix "A"

   b. As-Built Drawings. As-built drawings not available, construction drawings in Appendix "A"

2. Hydrologic and Hydraulic Data.

   a. Drainage Area and Basin Characteristics. See Section 1.3 of report.

   b. Elevation at Normal Pool. Elevation 6188 present
Elevation 6214 ultimate

   c. Storage Capacity. 1,100 acre-feet present
4,400 acre-feet ultimate

   d. Elevation of Flood Control Pool. Elevation 6193 present
Elevation 6220 ultimate

   e. Flood Control Storage. 490 acre-feet present
850 acre-feet ultimate

   f. Elevation of Maximum Design Pool. Elevation 6214

   g. Surcharge Storage. Not applicable

   h. Freeboard. 5 feet present (reported)
6 feet ultimate (reported)

   i. Elevation of Top of Dam. Elevation 6193 present
Elevation 6220 ultimate

   j. Spillway Features. Spillway not provided.

   k. Outlet Works. See Section 1.3 (g) of report.

   l. Emergency Spillway. Spillway not provided.

   m. Flashboards, Fuse Plugs, etc. None

   n. Dikes and Flood Walls. None

   o. Hydrometeorological Gages. None

   p. Maximum Nondamaging Discharge. Not determined

3. Foundation Data and Geological Features. See Paragraph 6.1 (e).

4. Properties of Embankment and Foundation Materials. See Paragraph 6.1 (e)

5. Concrete Properties. No testing or evaluation records available.

6. Electrical and Mechanical Equipment. Outlet gage manually operated.

7. Construction History. See Section 1.3 (f) of report.

8. Water Control Plan. None available

9. Operation Record. None available

10. Earthquake History. None available

11. Inspection History. Data not available to the inspection team.

12. Principal Design Assumptions and Analysis.

    a. Hydrologic and Hydraulic. See Section 5 and Appendix C.

    b. Stability and Stress Analysis. Section 5 and Appendix C.

    c. Seepage and Settlement Analysis. Section 5 and Appendix C.

APPENDIX F

PHOTOS OF SOHIO L-BAR TAILINGS DAM

16 AUGUST 1979

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
EMBANKMENT

PHOTO 1 - OVERVIEW OF MAIN EMBANKMENT FROM NORTH END LOOKING SOUTH.

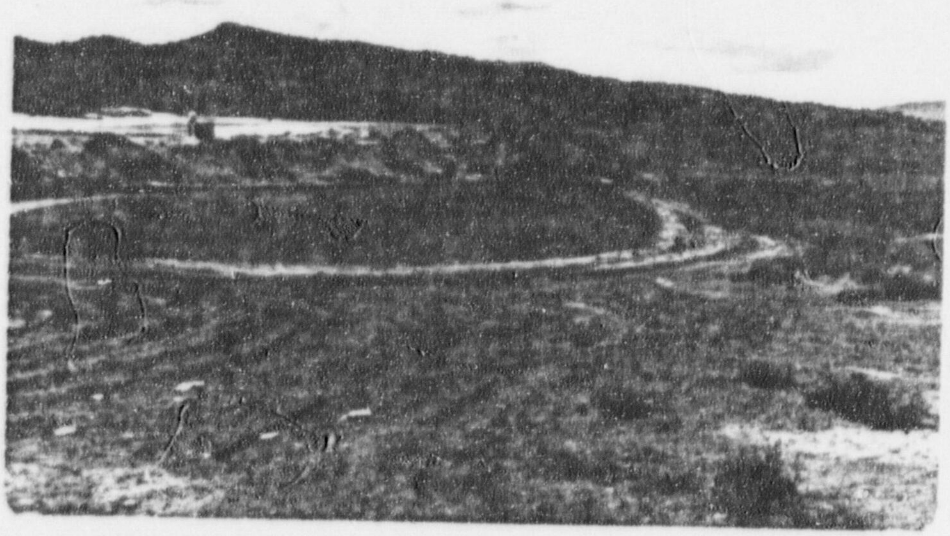


PHOTO 2 - VIEW OF DOWNSTREAM SLOPE FROM NORTH END LOOKING SOUTH. NOTE STARTER DAM AND STAGE I LIFT OF TAILINGS DIKES.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
EMBANKMENT

PHOTO 3 - VIEW OF DOWNSTREAM SLOPE AND COLLECTOR DITCH FROM NORTH LOOKING SOUTH. NOTE LOCATION OF RETURN PUMP STATION.

PHOTO 4 - CLOSE-UP VIEW OF DOWNSTREAM SLOPE, LOOKING FROM NORTH TO SOUTH. NOTE SEEPAGE COLLECTOR DITCH AT TOE OF STARTER DAM.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
EMBANKMENT

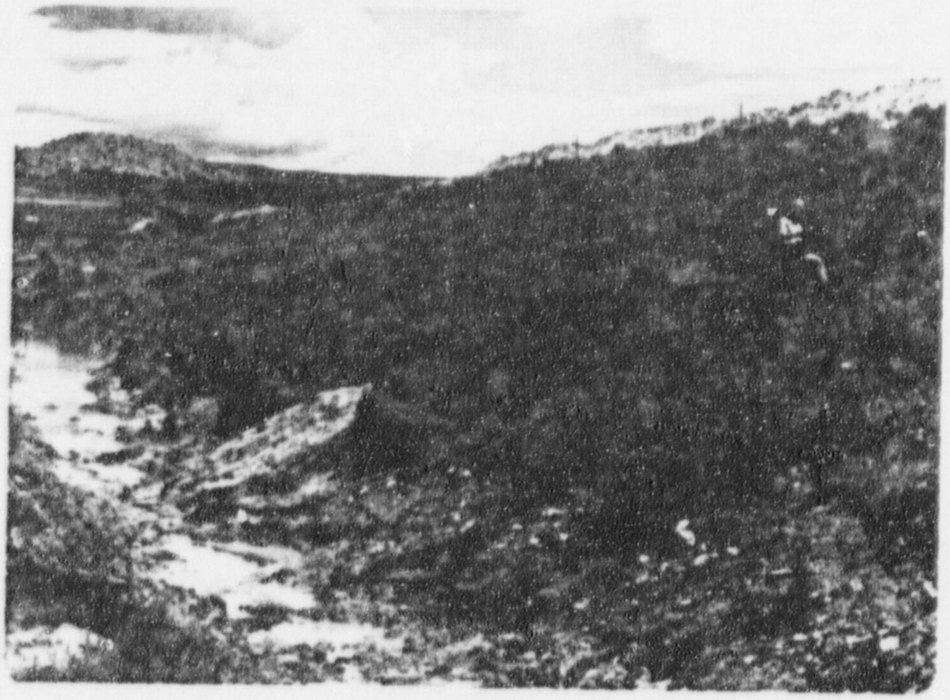


PHOTO 5 - VIEW OF DOWNSTREAM SLOPE OF STARTER DAM, LOOKING FROM SOUTH TO NORTH. NOTE SEEPAGE WATER IN SEEPAGE COLLECTOR DITCH.

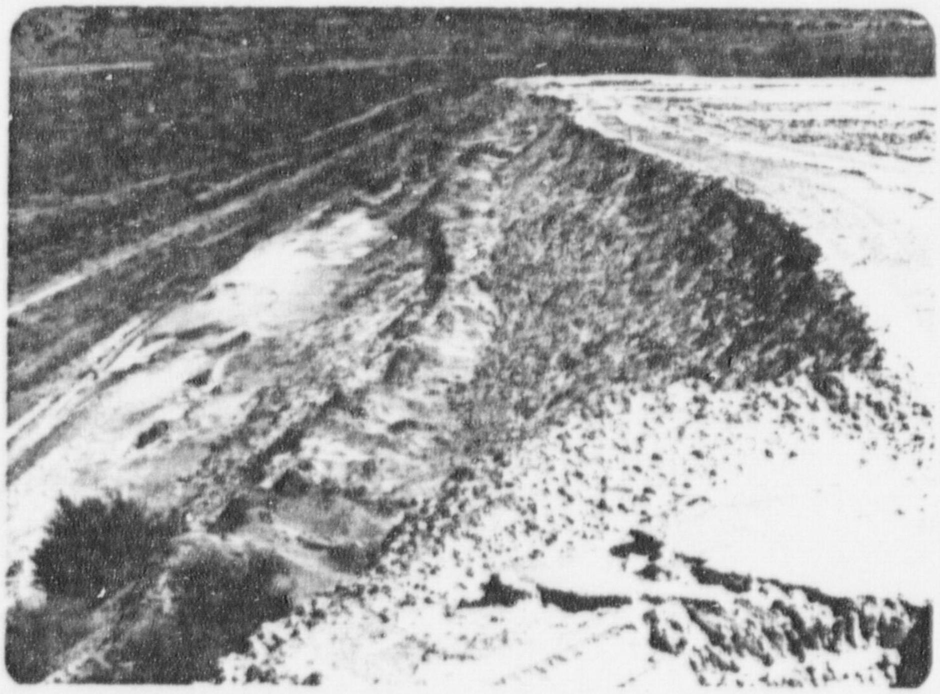


PHOTO 6 - VIEW OF DOWNSTREAM SLOPE OF STAGE I LIFT OF TAILINGS DIKES. NOTE ROAD ON CREST OF STARTER DAM AND SEEPAGE ON TOE OF STAGE I LIFT OF TAILINGS DIKES

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
CREST

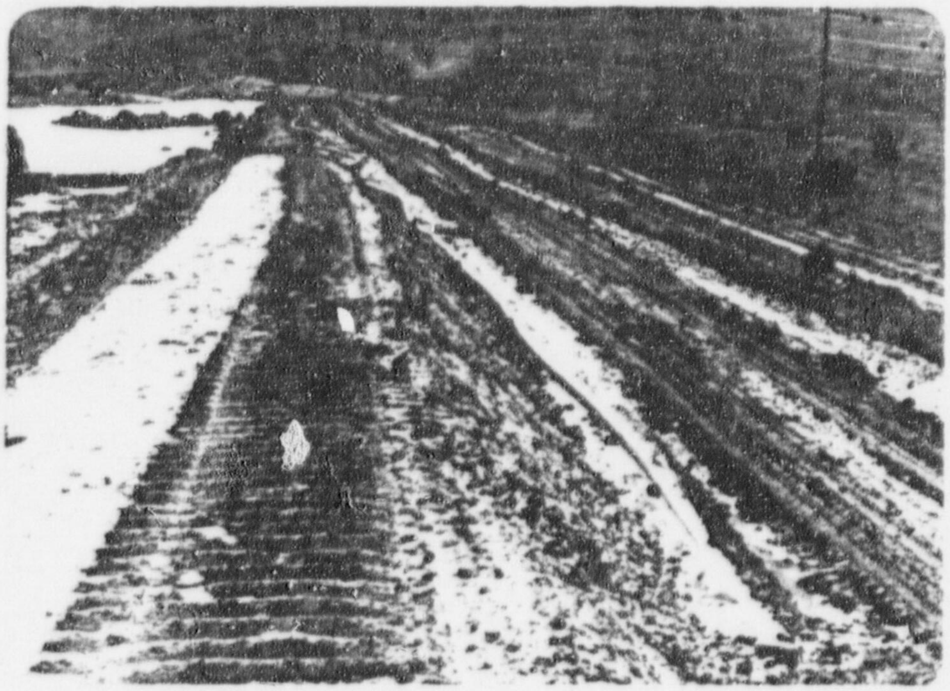


PHOTO 7 - VIEW OF CREST OF STAGE I TAILINGS DIKE AND CREST OF STARTER DAM (RIGHT SIDE OF PHOTO), LOOKING FROM NORTH TO SOUTH.

PHOTO 8 - VIEW OF CREST OF STARTER DAM (LEFT SIDE OF PHOTO) AND STAGE I TAILINGS DIKE, LOOKING NORTHWEST FROM SOUTH END OF STAGE I LIFT. NOTE BORROW AREA IMMEDIATLEY IN FRONT OF STAGE I TAILING DIKE.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
CREST

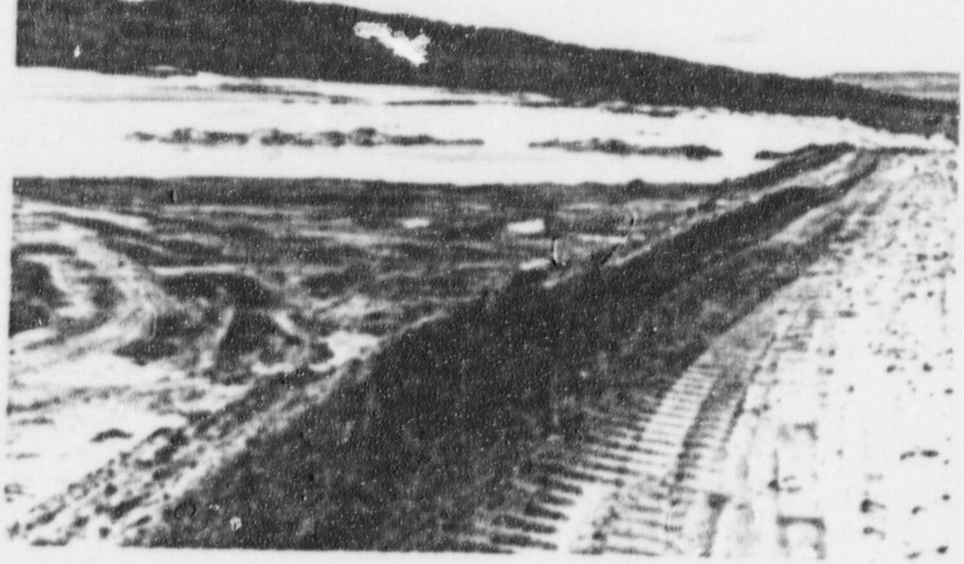


PHOTO 9 - VIEW OF CREST OF STAGE I DIKE AND RESERVOIR, FROM NORTH ABUTMENT LOOKING SOUTH.

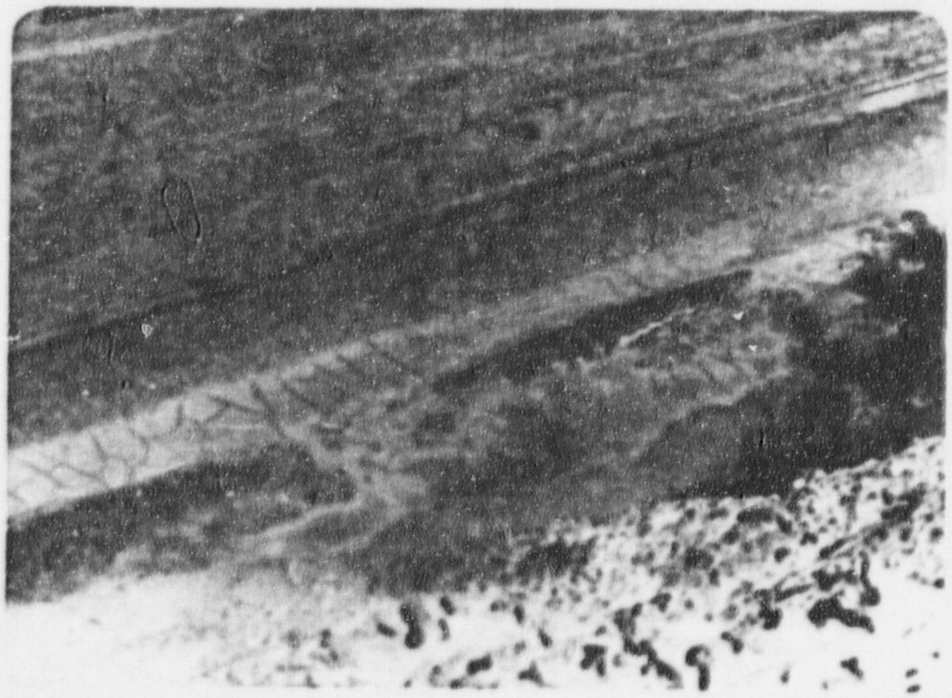


PHOTO 10 - VIEW OF CREST OF STARTER DAM. NOTE CHIMNEY DRAIN (GRANULAR MATERIAL IN CENTER OF PHOTO).

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
CREST

PHOTO 11 - VIEW OF UPSTREAM SLOPE LOOKING FROM NORTH TO SOUTH. NOTE RUBBER HOSES AND DISCHARGE OPERATION IN BACKGROUND.

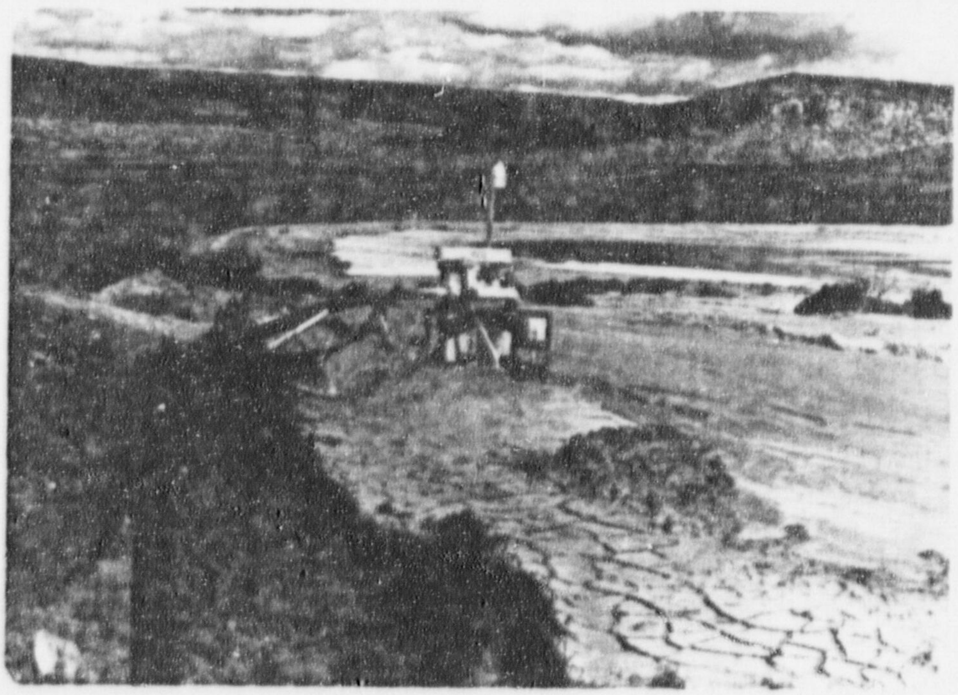


PHOTO 12 - VIEW OF UPSTREAM SLOPE LOOKING SOUTH TO NORTH. SLURRY PUMP AND DISTRIBUTION STATION IN FOREGROUND.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
UPSTREAM

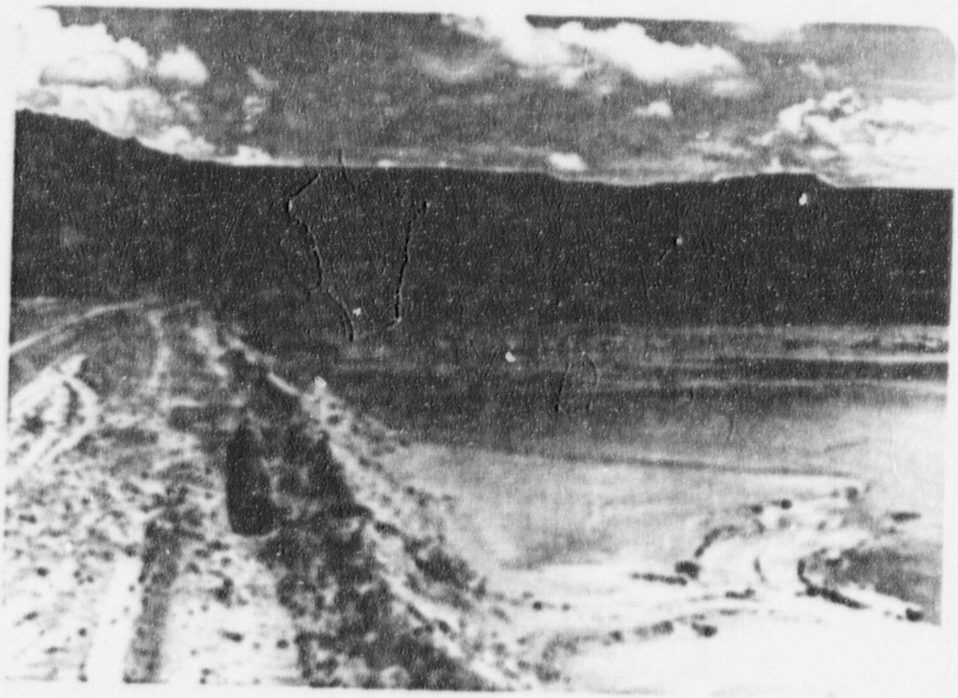


PHOTO 13 - VIEW OF UPSTREAM SLOPE LOOKING FROM SOUTH TO NORTH. NOTE SLIME DEPOSITION NEAR NEW DIKE CREST.

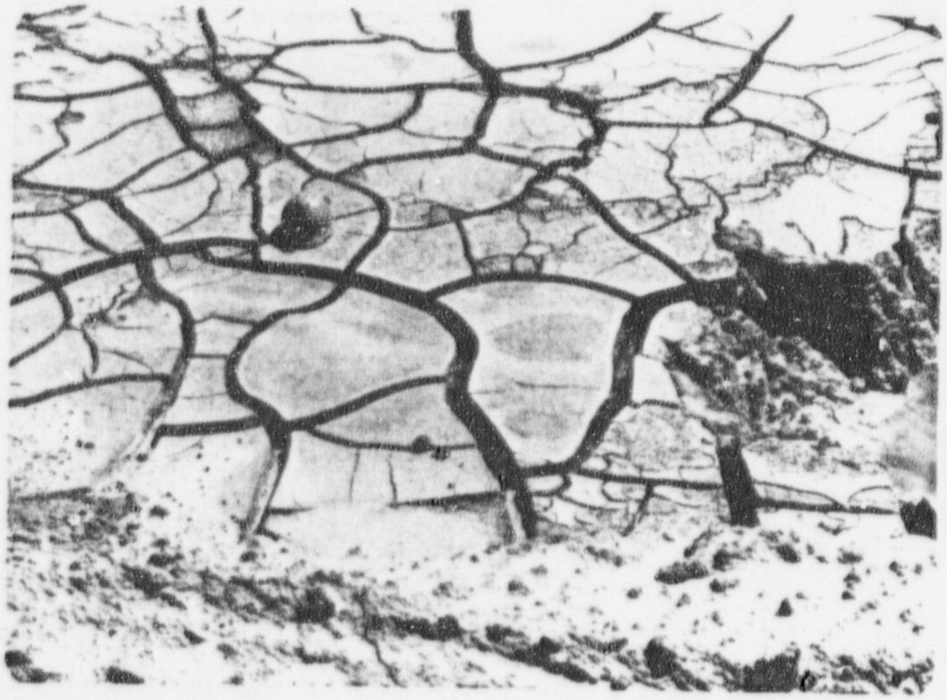


PHOTO 14 - VIEW FROM EMBANKMENT SHOWING SLIMES DEPOSITED NEAR EMBANKMENT CREST.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
RESERVOIR

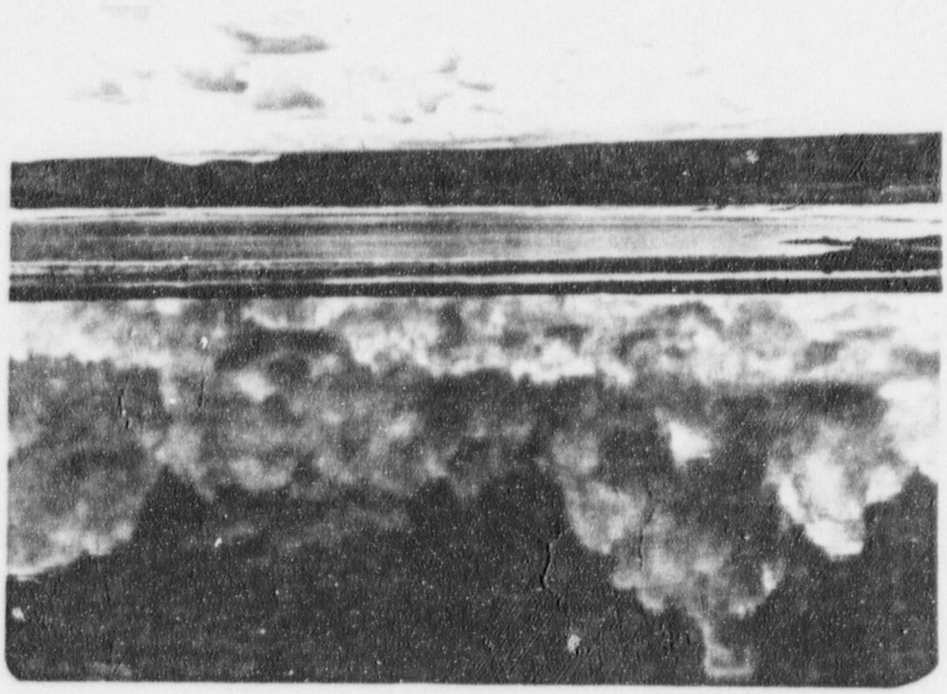


PHOTO 15 - VIEW OF RESERVOIR AND MAIN TAILINGS DAM FROM SADDLE DAM. NOTE INTERMEDIATE DIKE IN FOREGROUND CONSTRUCTED FOR SEGREGATION OF SLURRY WATER.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
RESERVOIR

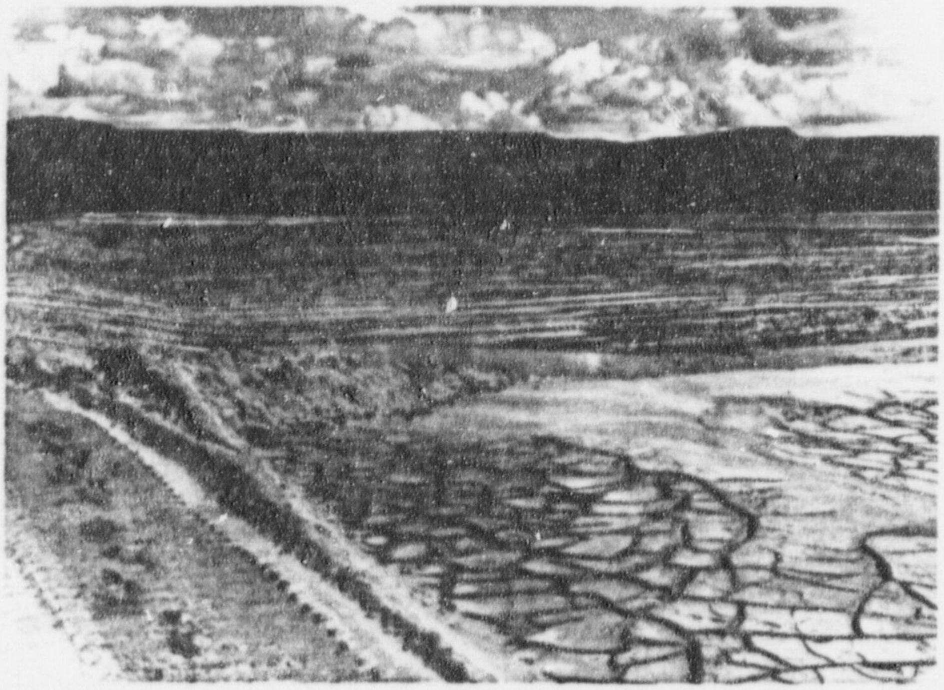


PHOTO 16 - VIEW OF RESERVOIR LOOKING NORTH.

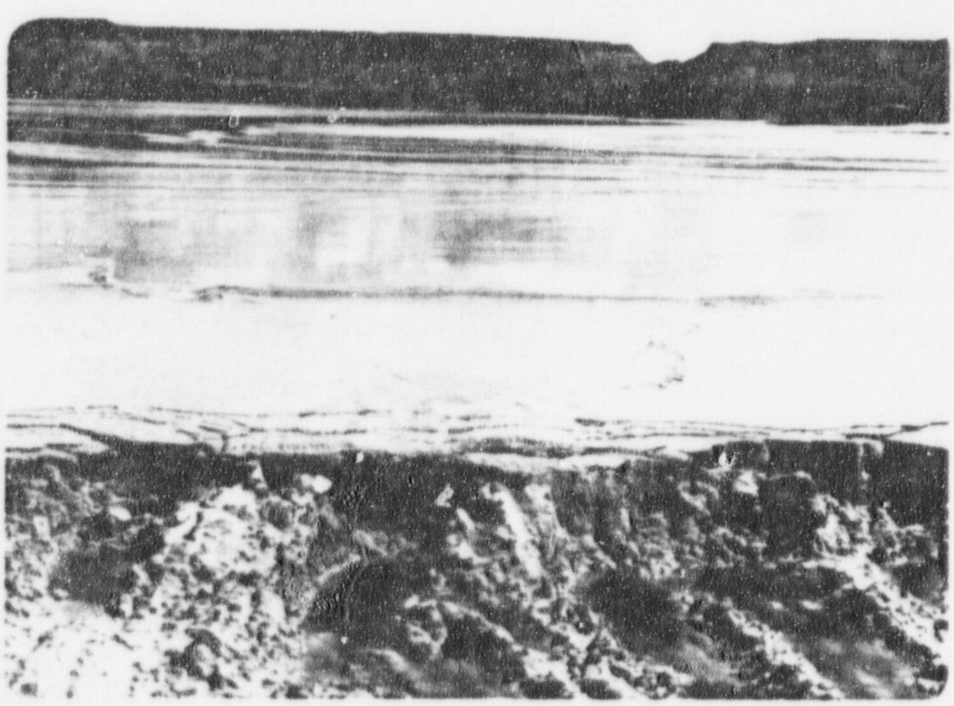


PHOTO 17 - VIEW OF RESERVOIR LOOKING SOUTH. NOTE PIT IN BEACH APPROXIMATELY 2 FEET DEEP.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
DOWNSTREAM AREAS

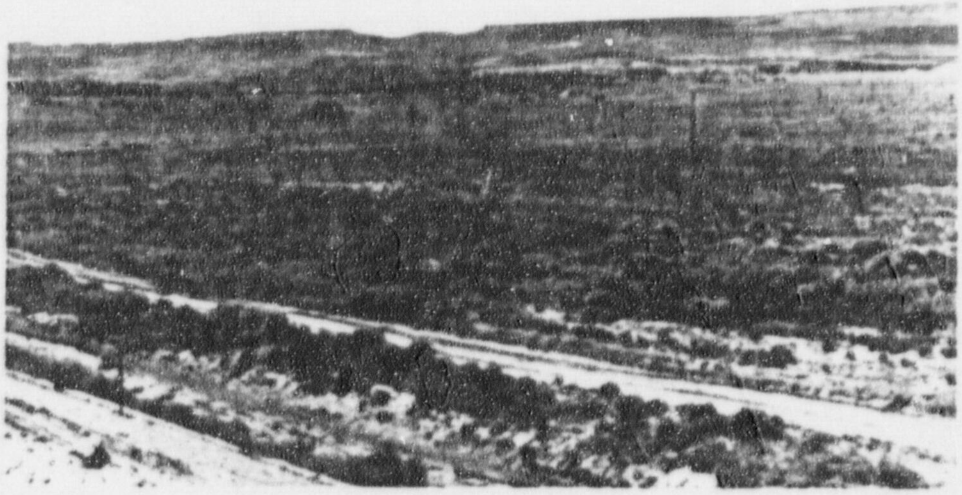


PHOTO 18 - VIEW OF DOWNSTREAM NATURAL DRAINAGE LOOKING WEST FROM DAM.

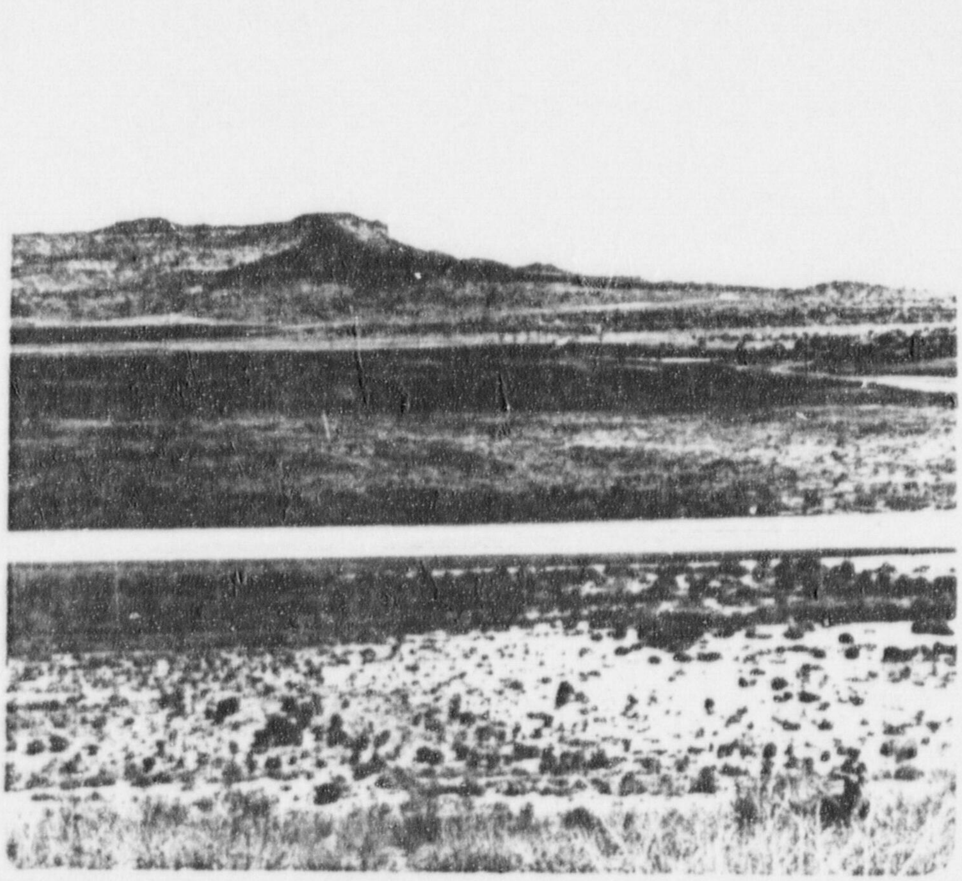


PHOTO 19 - VIEW OF DOWNSTREAM NATURAL DRAINAGE LOOKING NORTHEAST FROM SADDLE DAM. NOTE:WATERS BETWEEN DAM AND HIGHWAY ARE FROM RAINFALL.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
DIVERSION CHANNEL

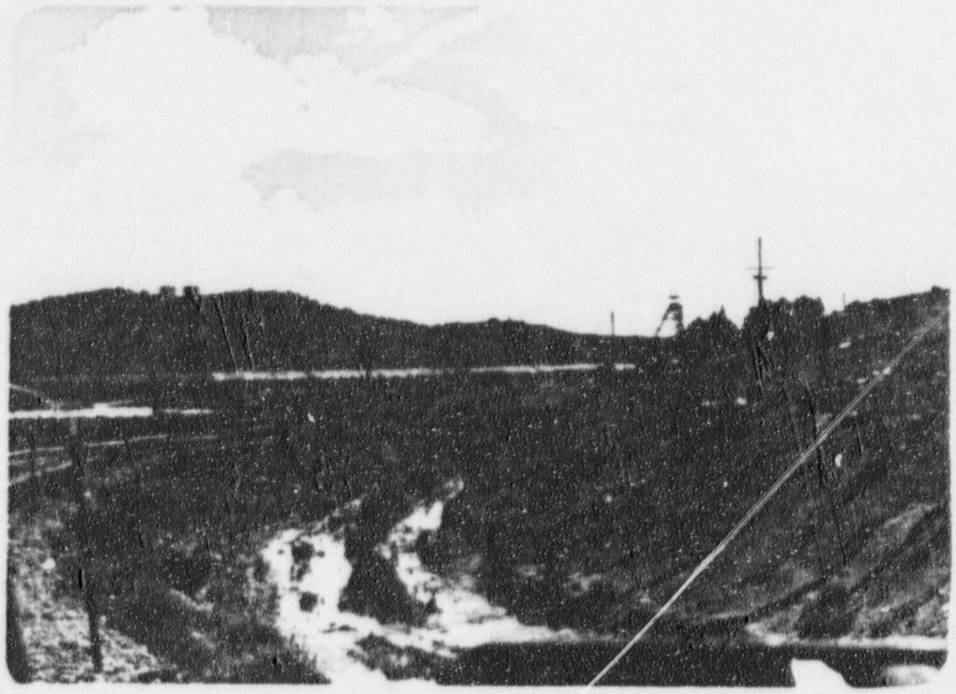


PHOTO 20 - VIEW OF SOUTH DIVERSION CHANNEL LOOKING FROM SOUTH TO NORTH.

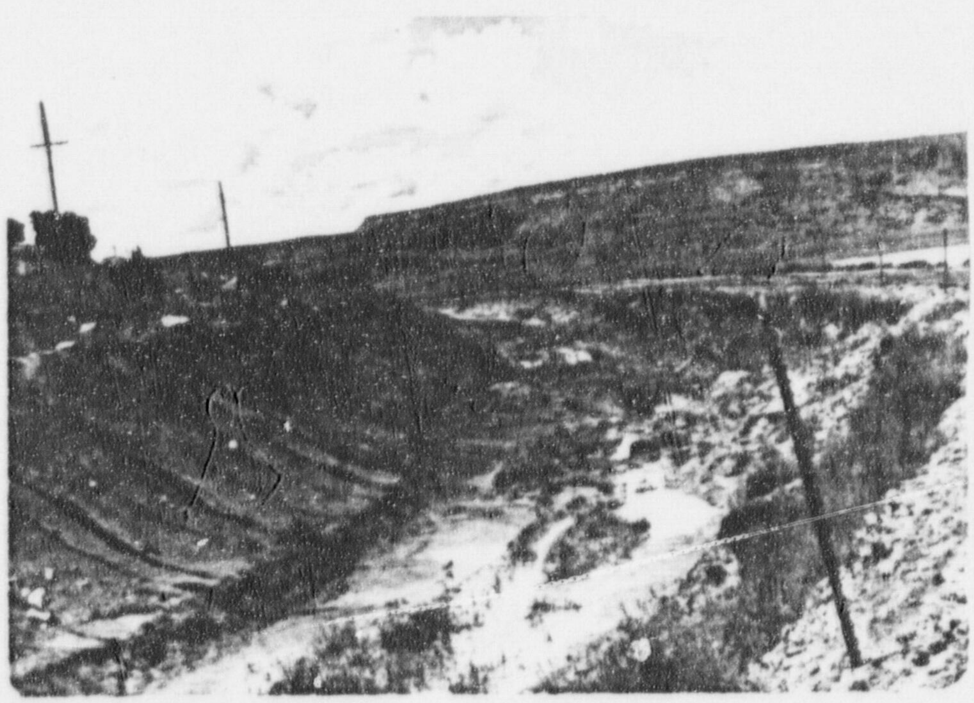


PHOTO 21 - VIEW OF SOUTH DIVERSION CHANNEL LOOKING FROM NORTH TO SOUTH.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
SEEPAGE

PHOTO 22 - VIEW OF SEEPAGE AND BOILS AT TOE OF STAGE I DIKE ON CREST OF STARTER DAM.

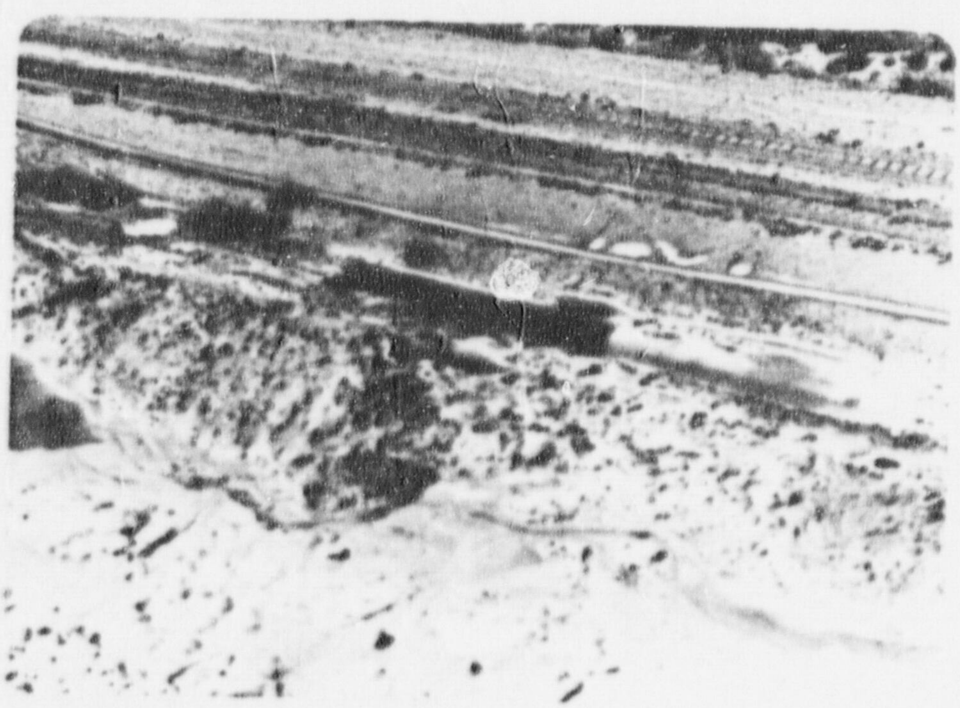


PHOTO 23 - VIEW OF SEEPAGE AT TOE OF STAGE I DIKE ON CREST OF STARTER DAM.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
SEEPAGE

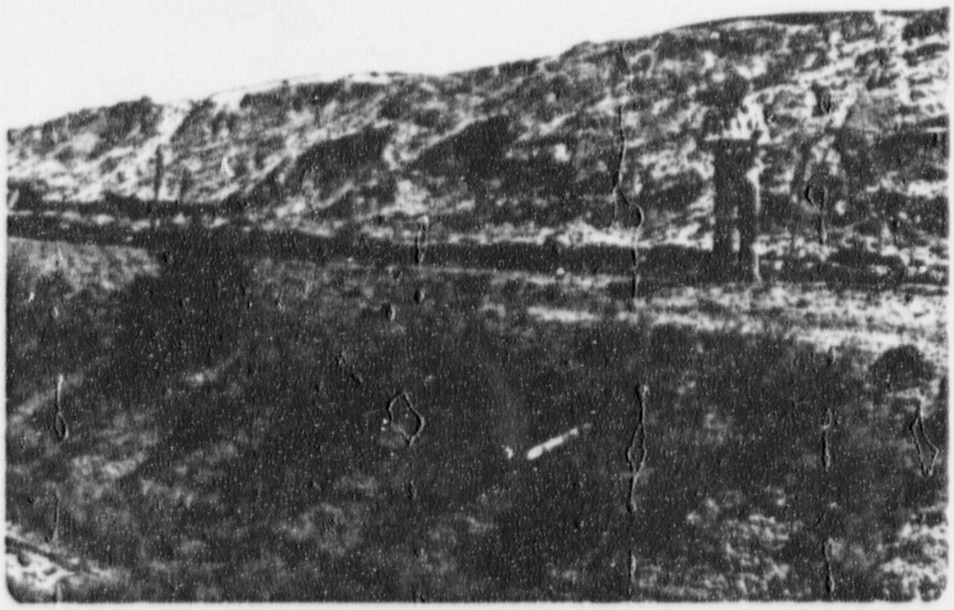


PHOTO 24 - VIEW OF SLOUGHING AND EROSION ON DOWNSTREAM SLOPE OF STAGE I TAILINGS DIKE.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
FINGER DRAINS

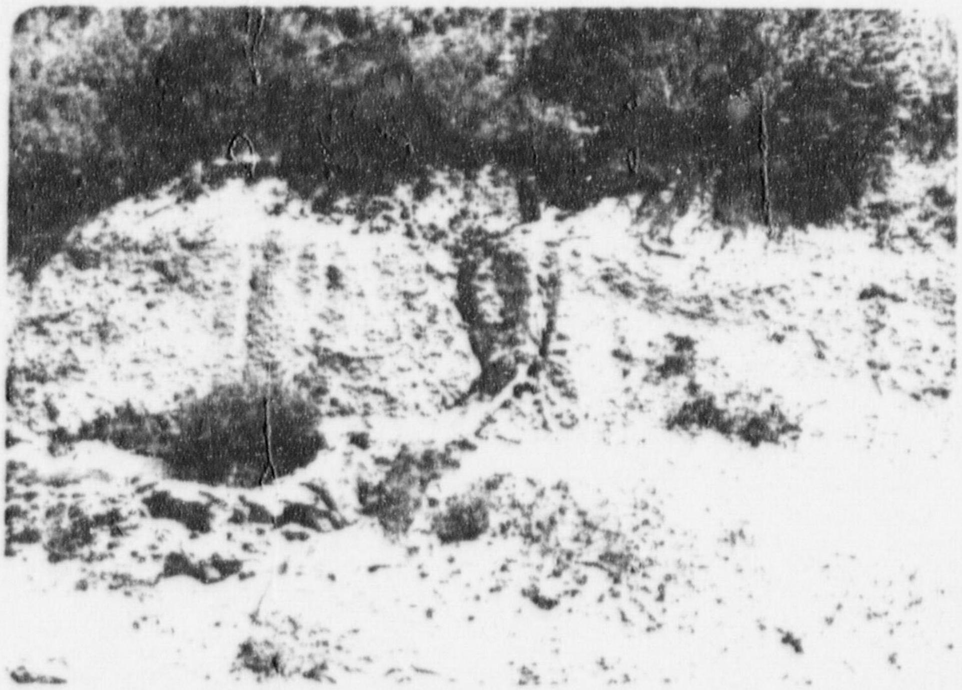


PHOTO 25 - VIEW OF FINGER DRAIN (BELOW STAKE) AND DOWNSTREAM FACE.

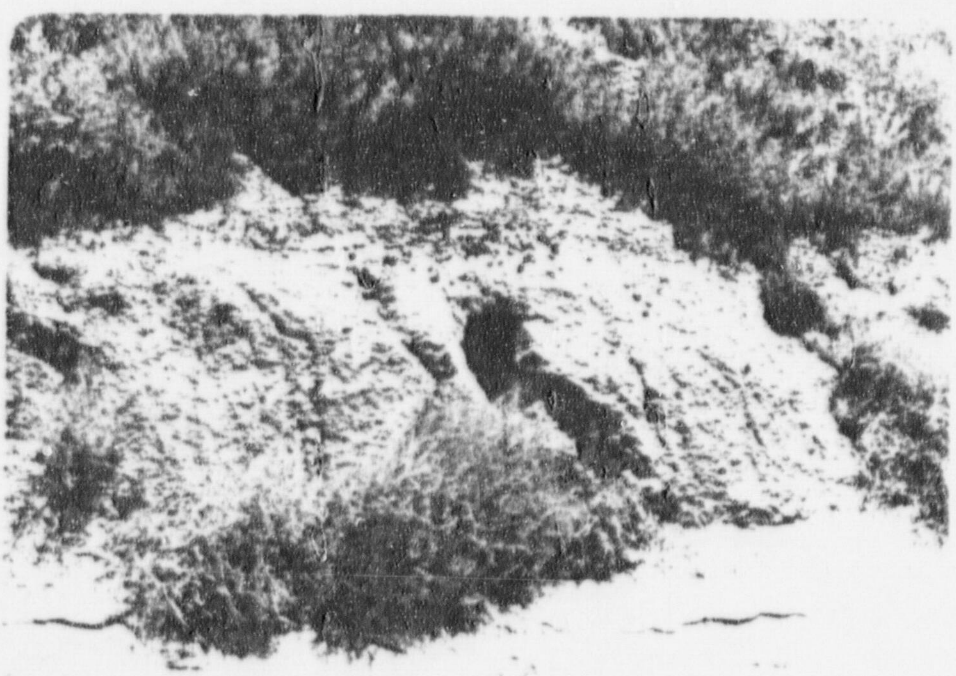


PHOTO 26 - VIEW OF FINGER DRAIN AND EROSION HOLE. NOTE POSSIBLE DISPERSIVE SOIL.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
FINGER DRAINS

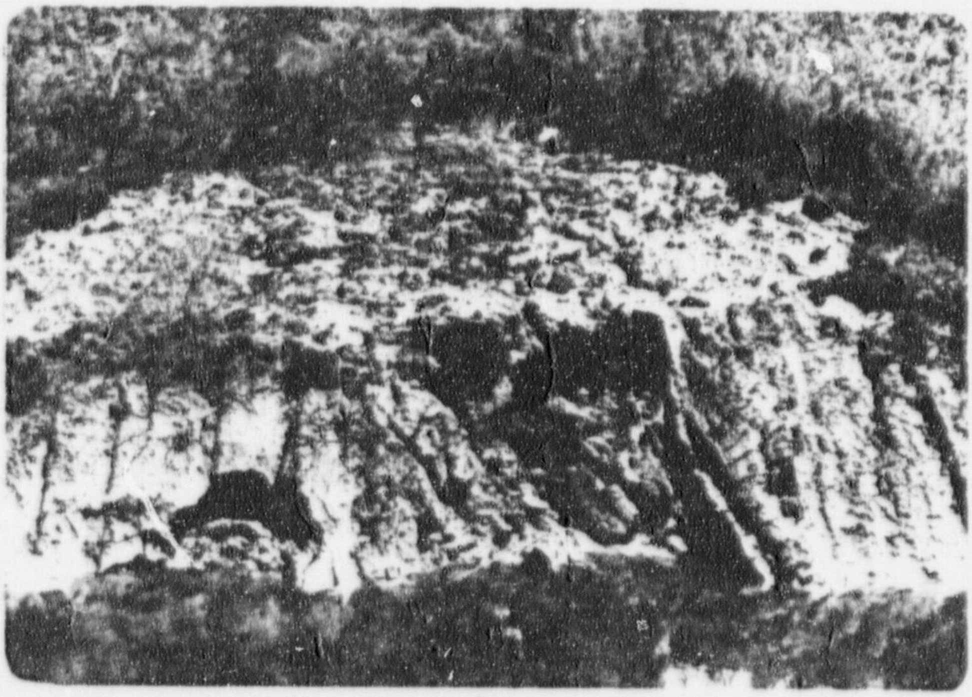


PHOTO 27 - VIEW OF FINGER DRAIN AND RESULTING EROSION AND SLOUGHING.

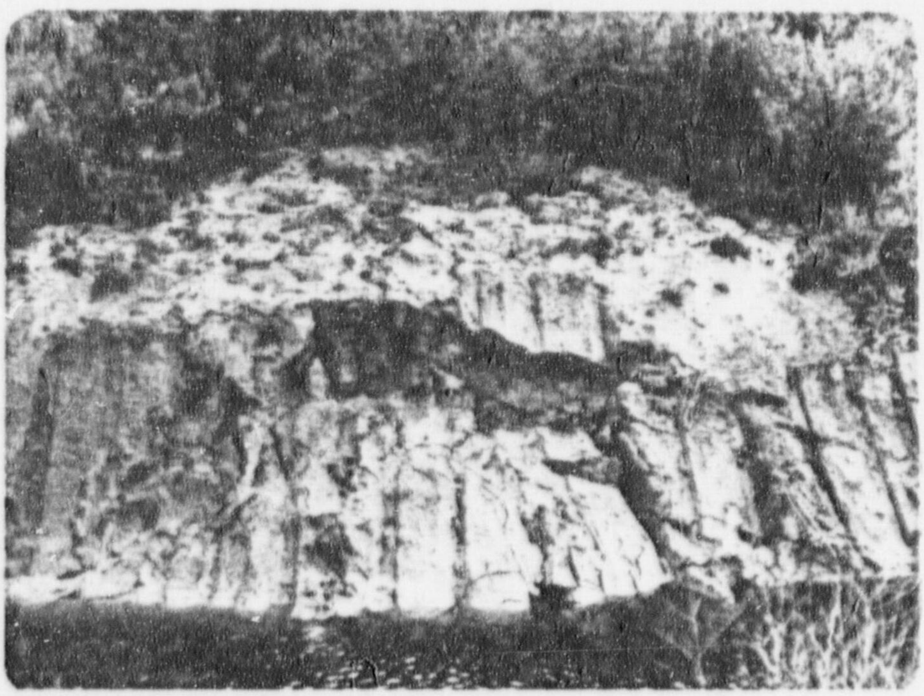


PHOTO 28 - VIEW OF FINGER DRAIN AND RESULTING SLOUGHING.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
SEEPAGE COLLECTION DITCH

PHOTO 29 - VIEW OF SEEPAGE COLLECTION DITCH. NOTE GAS BUBBLES IN CENTER OF PHOTO CAUSED EITHER BY CHEMICAL REACTIONS OR A SAND BOIL.

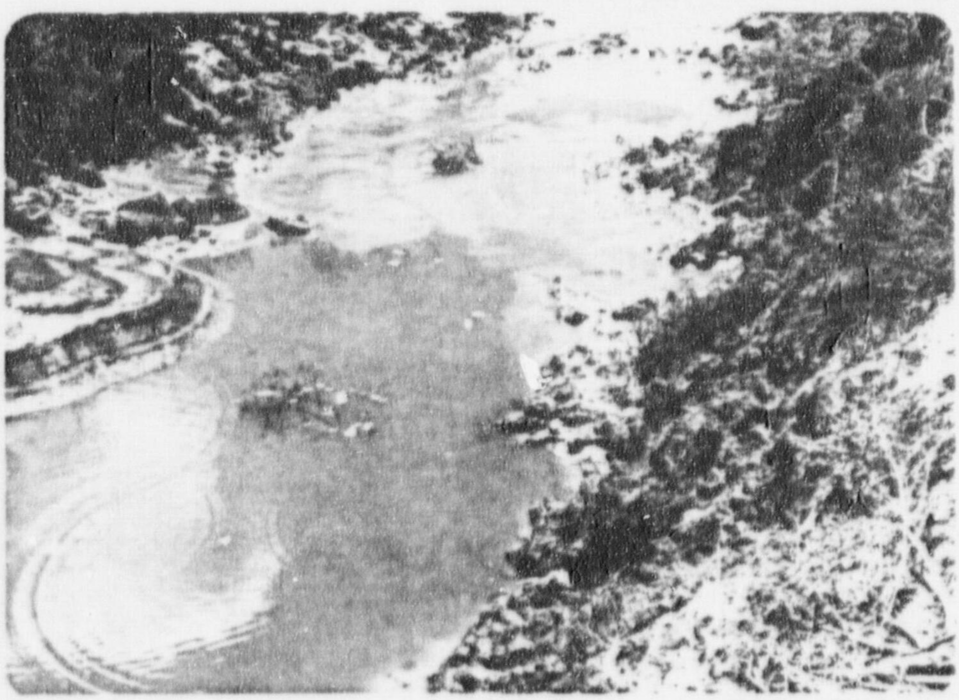


PHOTO 30 - VIEW OF SEEPAGE COLLECTION DITCH. NOTE IRON OXIDE DISCOLORATION IN SEEPAGE WATER.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
SEEPAGE RETURN SYSTEM

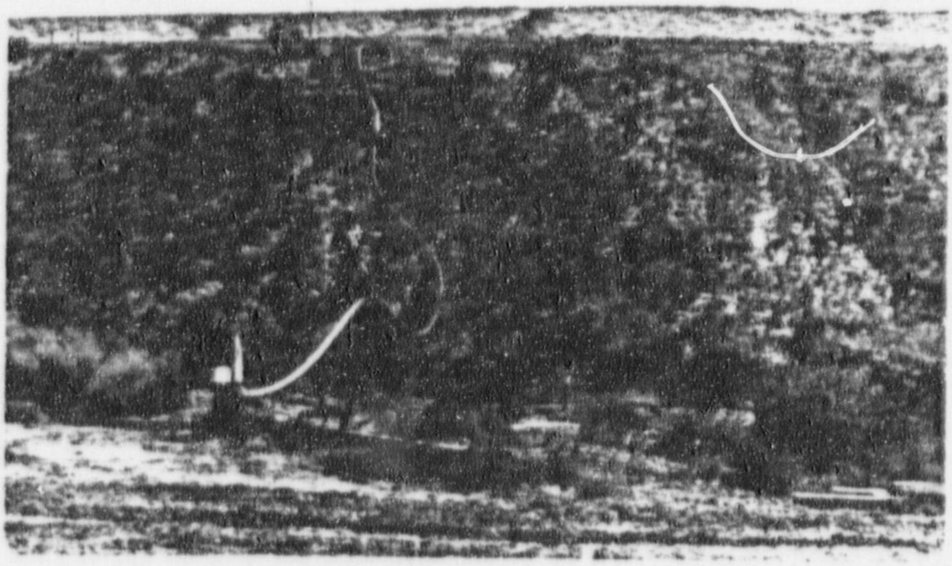


PHOTO 31 - VIEW OF SEEPAGE COLLECTION PUMP AND LINE UP EMBANKMENT INTO RESERVOIR.

PHOTO 32- VIEW OF LINE FROM CREST OF DAM LOOKING DOWNSTREAM. NOTE:LINE IS BURIED IN EMBANKMENT.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
SEEPAGE RETURN SYSTEM

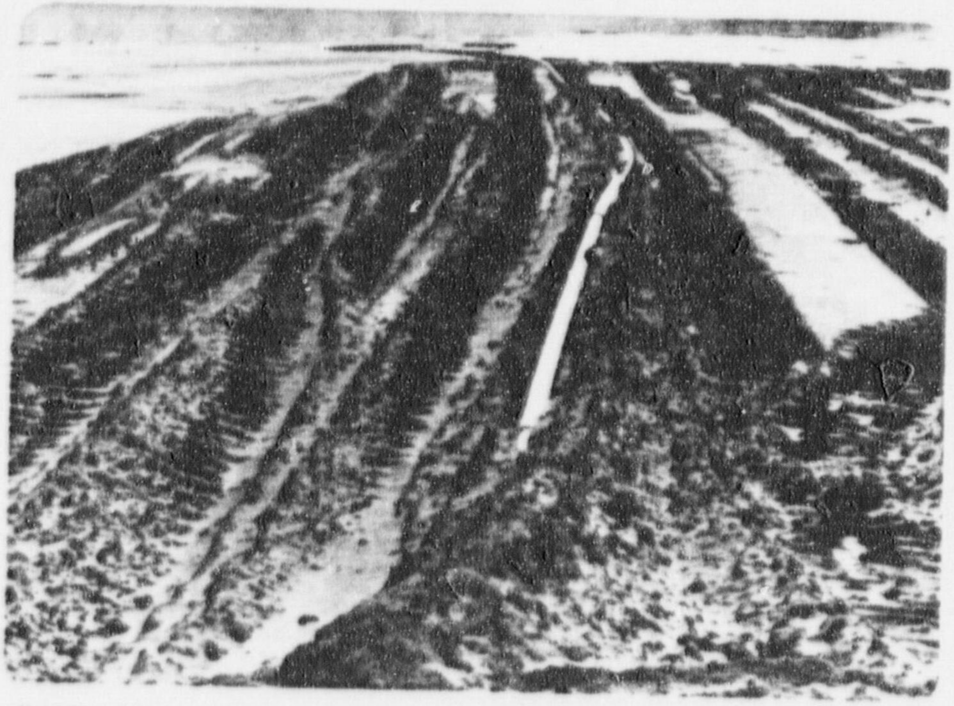


PHOTO 33 - VIEW OF LINE FROM CREST TO RESERVOIR FROM CREST OF DAM LOOKING TOWARD POND AREA.

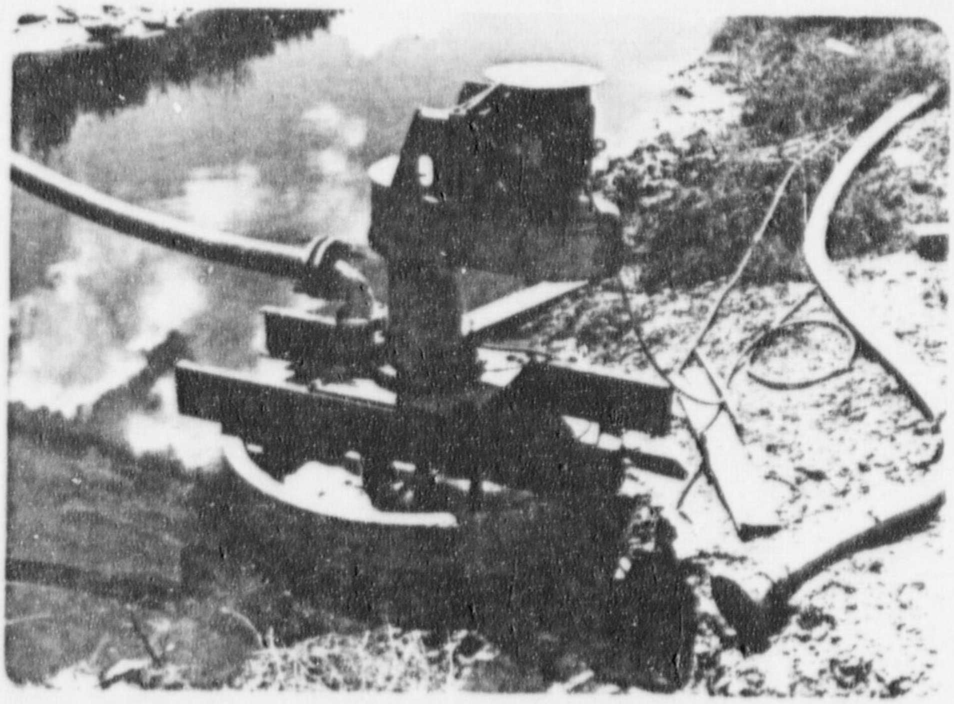


PHOTO 34 - CLOSE-UP VIEW OF SEEPAGE COLLECTION DITCH AND PUMP.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
CRACKS & SLOUGHS

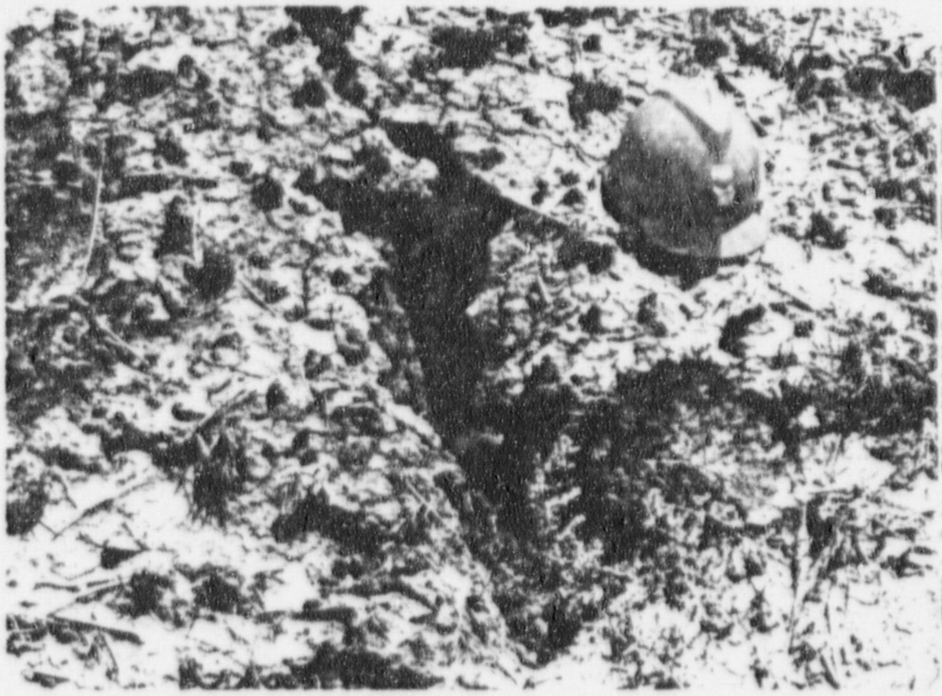


PHOTO 35 - VIEW OF CRACKING ON DOWNSTREAM SLOPE APPROXIMATELY HALFWAY UP EMBANKMENT.

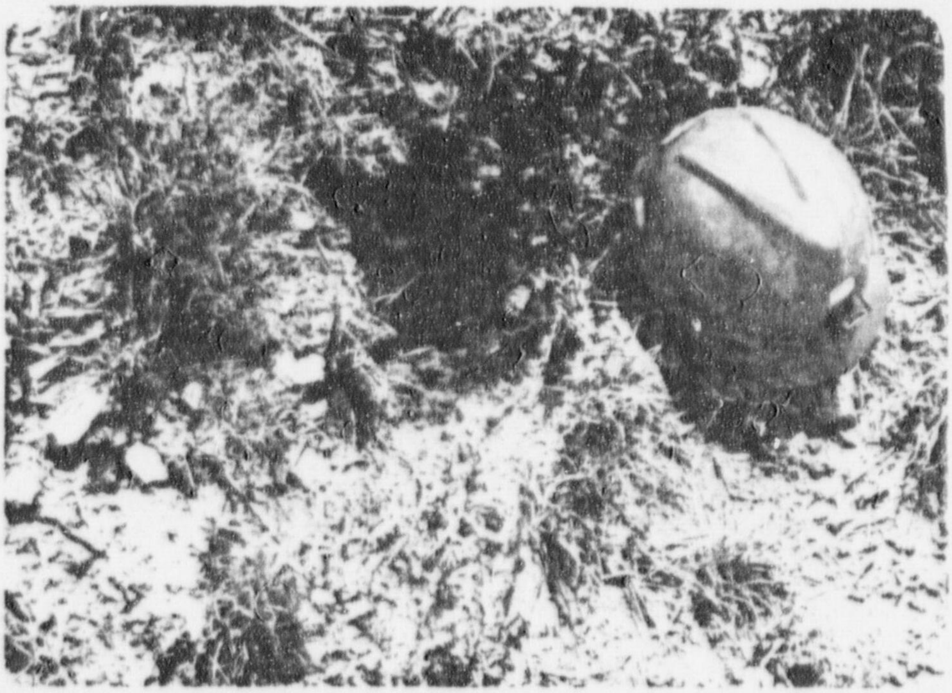


PHOTO 36 - VIEW OF HOLE IN DAM. NOTE: CRACKING OR HOLES ARE NOT CONTINUOUS.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
CRACKS & SLOUGHS

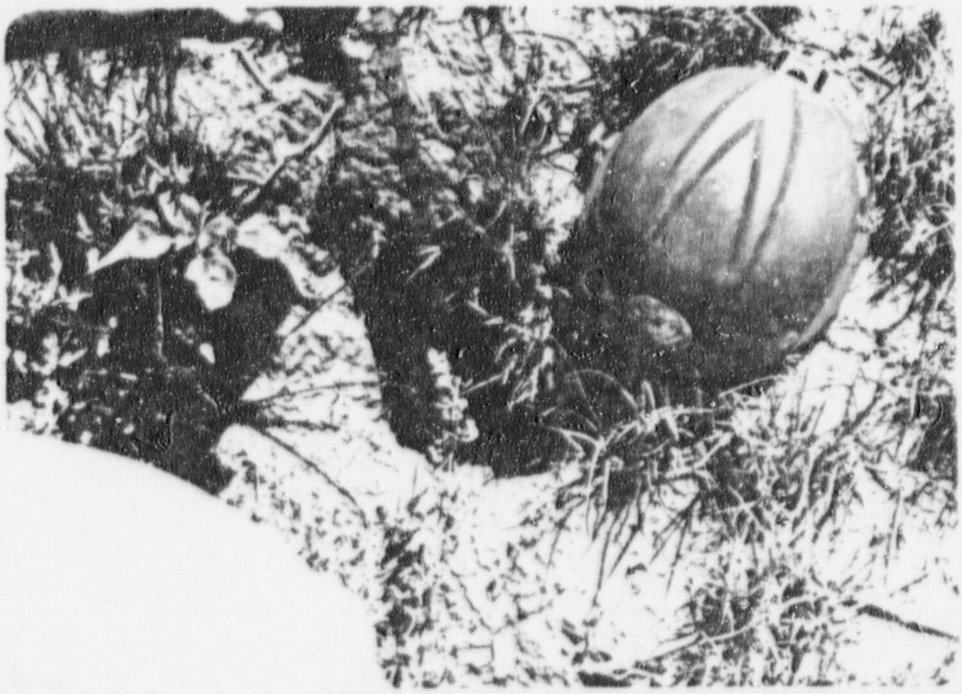


PHOTO 37 - CLOSE-UP VIEW OF HOLE IN DAM.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
OPERATIONS

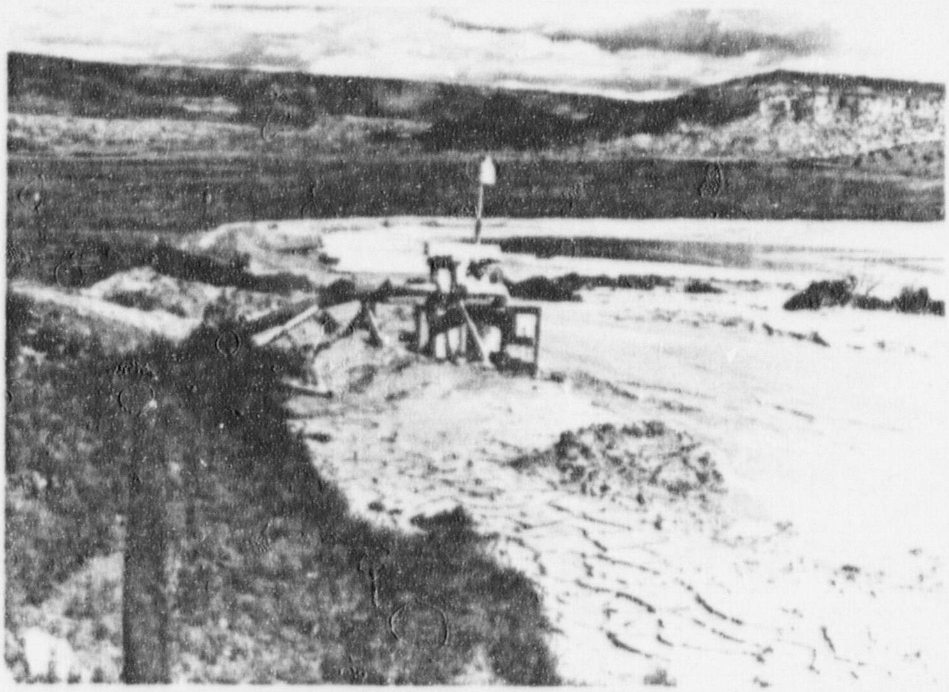


PHOTO 38 - VIEW OF DISCHARGE AND PUMP LOOKING NORTHWEST FROM SOUTH END OF STAGE I DIKE.

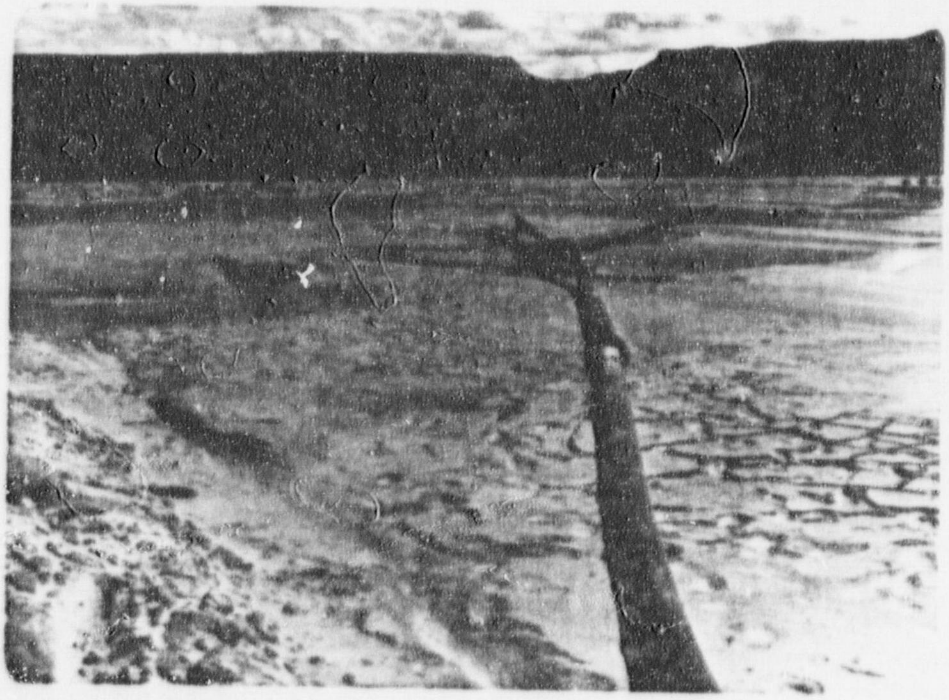


PHOTO 39 - VIEW OF TAILINGS SLURRY DISCHARGE LINE AT NORTH END OF DAM.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
SADDLE DAM

PHOTO 40 - VIEW OF CREST AND UPSTREAM SLOPE OF SADDLE DAM, LOOKING FROM NORTH TO SOUTH.

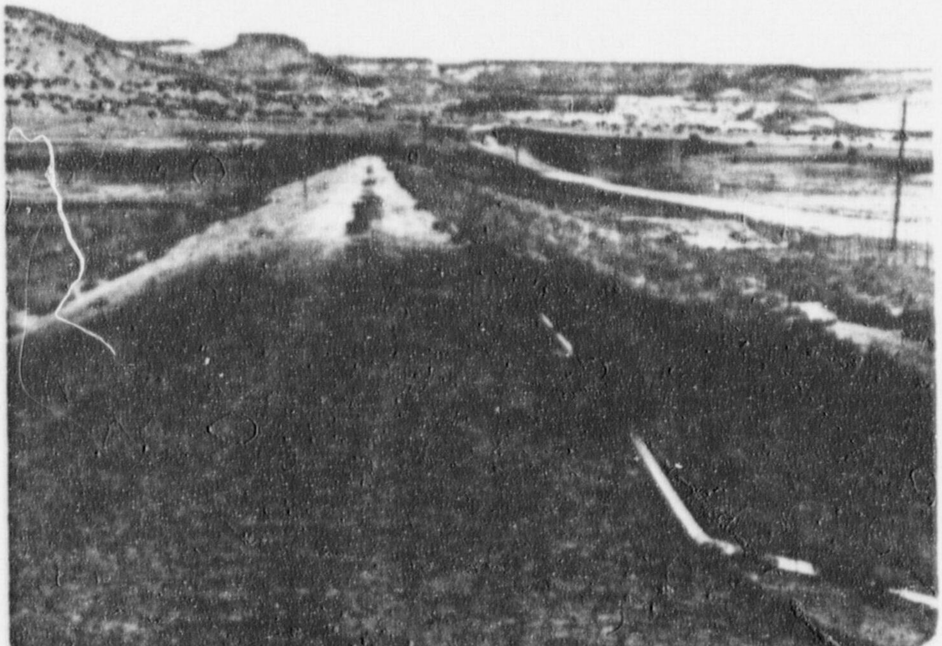


PHOTO 41 - VIEW OF CREST AND DOWNSTREAM SLOPE OF SADDLE DAM, LOOKING FROM SOUTH TO NORTH.

SOHIO L-BAR TAILINGS DAM
16 AUGUST 1979
ANIMAL BURROWS
SADDLE DAM

PHOTO 42 - VIEW OF ANIMAL BURROW.

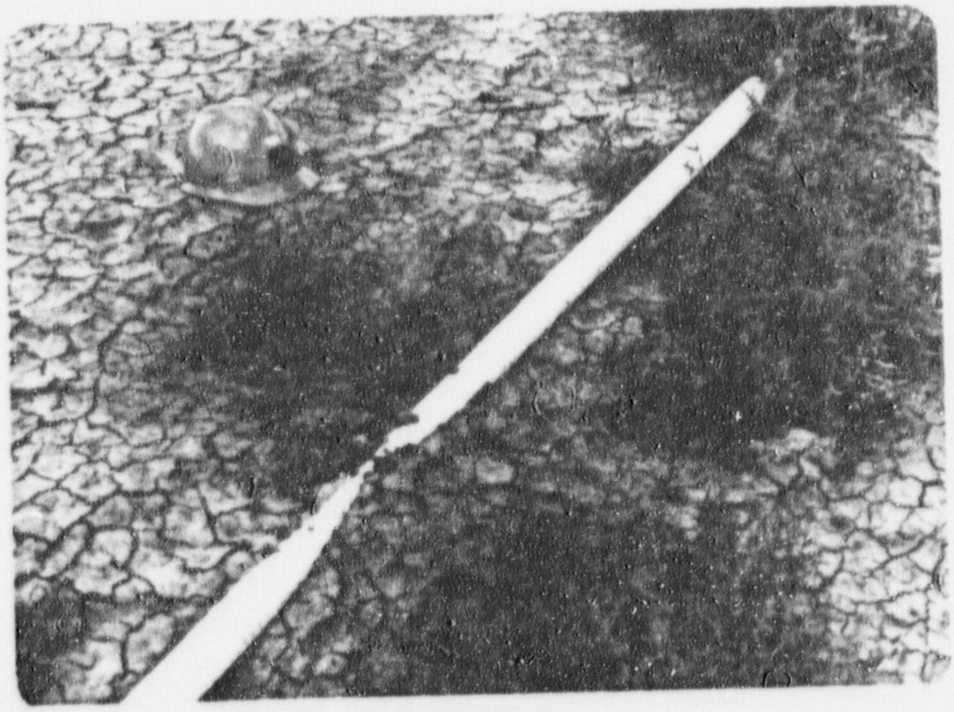


PHOTO 43 - VIEW OF ANIMAL BURROW.

APPENDIX G

WARNING SYSTEM

AND

EMERGENCY ACTION PLAN

PROPOSED ADDITIONS TO INSPECTION GUIDELINES

by Desloge Brown,[1] F. ASCE

The primary purpose of dam inspection is to prevent the failure of a dam. Despite our efforts, dams have failed. The loss of life resulting from a failure is influenced very strongly by the efficacy of the warnings transmitted to those downstream which permit them to evacuate the areas of potential flooding. The Johnstown flood in 1889 killed 2,000 to 3,000 persons. The St. Francis Dam failure in 1928 killed 350. Vaiont in 1963 killed 3,000. On the other hand, Baldwin Hills in 1963 killed only 5 and Teton, despite half a billion dollars in property damages, resulted in only 11 deaths. The differences were due to the ability to disseminate a warning and evacuate the downstream areas.

An effective warning system must be preplanned. The dam operating personnel must know who to notify to spread the alarm. There are also other steps that operators can sometimes take to minimize the effect of a failure, such as reducing inflow from upstream

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[1]Head, Section of Inspections
Division of Licensed Projects
Bureau of Power
Federal Power Commission

The views presented herein are those of the author and not necessarily those of the Federal Power Commission.

dams. On August 15, 1975, the Federal Power Commission issued instructions to all its licensees to prepare emergency action plans, submit them to the Commission's staff, and instruct all operating and supervisory personnel in their implementation.

Similar plans should be prepared by all owners of dams of such size that failure would be a hazard to downstream personnel and property. The following outlines the instructions issued by the Federal Power Commission and amplified by staff guidance. The inclusion of similar guidance in the proposed Inspection Guidelines would be an effective way to disseminate such advice to all dam owners and is so proposed.

"CHAPTER 6 - EMERGENCY ACTION PLANS

"Recent dam failures show that dams do fail despite instrumentation, reviews of design, and regular inspections of the structures. The effects of such failures should be minimized to the extent possible by preplanning the actions to be taken in such event.

"Each owner should study the effect on downstream areas of a failure of his dam. If the dam failure would have little or no effect on downstream interests, owing to the small quantity of water released or the lack of any downstream development or activity which might be affected, no further planning would be necessary. If, however, the sudden release of the stored water could be hazardous to life or cause significant damage to property downstream, plans should be made and instructions provided operators and attendants regarding the actions to be taken in such an emergency.

"To be effective, these emergency actions must include plans for notification of law enforcement agents; appropriate Federal, state, and local agencies; operators of downstream water-related activities; and those residents endangered. Other actions should be considered such as reductions in reservoir inflow by limiting the outflow from upstream dams or control structures.

"The following are guidelines for the preparation of emergency action plans.

"The owner should first hypothesize possible failure situations from warning signs of possible failure to the almost instantaneous failure such as might result from an earthquake. Plans should be designed to prevent complete failure or to minimize the impact of failure on the environment. It should include a list of personnel to be notified in order that expedient action can be taken. For example, in the event of an indication of a possible failure, steps might be taken to lower the reservoir by opening the gates and reducing the quantity of water which would be released by the failure. The personnel to be contacted to authorize this action and to mobilize state and local emergency forces should be set forth and kept up to date. In the event of a failure taking place, the inflow to some reservoirs might be reduced through closing of upstream dams. The proper authorities for carrying out such actions should be provided plant personnel. The notification action includes public officials, news media, and owners or operators of downstream dams or other water-related facilities. These plans must be in detail, posted in an appropriate place in the control center, and thoroughly understood by all personnel.

"Emergency action planning does not necessarily require an engineering study, although some engineering evaluation could be necessary for specifying the possible types of failures which might occur. A short analytical study by a small team combining structural design, hydraulics, and operating procedure backgrounds would probably be sufficient to draw up a plan. Simply stated, the plan should state in detail what steps would be taken in the event of various possible or actual failures to prevent or minimize possible hazards to life and property."