

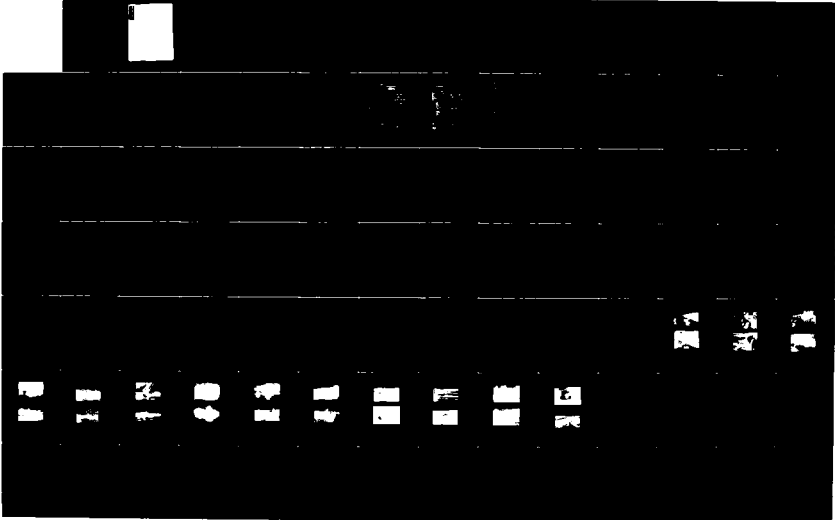
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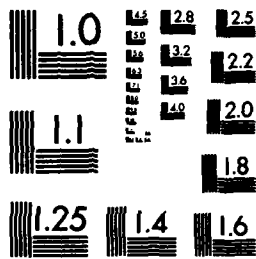
MULTIPLE-PURPOSE PROJECT OSAGE RIVER BASIN BIG BULL  
CREEK KANSAS HILLSDALE (U) CORPS OF ENGINEERS KANSAS  
CITY MO KANSAS CITY DISTRICT F C WALBERG ET AL. SEP 84  
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Appendix V to the Hillsdale Lake O&M Manual	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MULTIPLE-PURPOSE PROJECT OSAGE RIVER BASIN, BIG BULL CREEK, KANSAS HILLSDALE LAKE OPERATION AND MAINTENANCE MANUAL, APPENDIX V EMBANKMENT CRITERIA & PERFORMANCE REPORT	5. TYPE OF REPORT & PERIOD COVERED Embankment criteria and Performance Report from 24 Apr. 1976 to 19 Sep 1981	
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The purpose of this report is to provide the significant design, construction and operational information which can be used by engineers to (1) familiarize themselves with the project (2) reevaluate the embankment in the event unsatisfactory performance occurs and (3) provide guidance for designing comparable future projects.		

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OPERATION AND MAINTENANCE MANUAL

HILLSDALE LAKE  
BIG BULL CREEK, KANSAS

APPENDIX V

EMBANKMENT CRITERIA AND  
PERFORMANCE REPORT

SEPTEMBER 1984

DEPARTMENT OF THE ARMY  
KANSAS CITY DISTRICT, CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI



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NOTE:

This is a condensed volume of the Hillsdale Embankment Criteria Report. Plates containing record control laboratory test results and instrumentation data have been removed to make the report less voluminous. Summaries of laboratory tests and typical instrumentation data are provided in this volume. The following plates are not included in this volume, but can be obtained upon request from the Kansas City District.

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OPERATION AND MAINTENANCE MANUAL  
HILLSDALE LAKE  
BIG BULL CREEK, KANSAS

APPENDIX V  
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

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203	Air Cell Piezometer P-78-1	0-15-932
204	Air Cell Piezometer P-80-1	0-15-933
205	Open Tube Piezometer P-82-1	0-15-934
206	Open Tube Piezometer P-82-2	0-15-935
207	Open Tube Piezometer P-83-2	0-15-936
208	Open Tube Piezometer P-84-1	0-15-937
209	Open Tube Piezometer P-85-1	0-15-938
210	Open Tube Piezometer P-86-1	0-15-939
211	Open Tube Piezometer P-87-1	0-15-940
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214	Open Tube Piezometer P-90-1	0-15-943
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250	Open Tube Piezometer P-104-11	0-15-980
251	Open Tube Piezometer P-104-12	0-15-981
252	Open Tube Piezometer P-104-13	0-15-982
253	Open Tube Piezometer P-104-14	0-15-983
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OPERATION AND MAINTENANCE MANUAL  
HILLSDALE LAKE  
BIG BULL CREEK, KANSAS

APPENDIX V

CHAPTER 1

INTRODUCTION

1-01. Purpose and Scope of Report. The purpose of this report is to provide in one volume the significant information needed by engineers to familiarize themselves with Hillsdale Lake, reevaluate the embankment in the event unsatisfactory performance occurs, and provide guidance for designing comparable earth dams. The scope of this report provides a summary record of significant design data, design assumptions, specification requirements, construction equipment, construction procedures, construction experience, field control and record control test data, and embankment performance as monitored by instrumentation during construction and during initial lake filling.

1-02. Project Purpose. The project purposes include flood control, water supply, water quality control, and recreation, including fish and wildlife enhancement. The percentages of benefits assigned to the authorized purpose are 24 percent for flood control, 48 percent for water supply, 20 percent for water quality control and 8 percent for recreation. The average benefits, at 1977 price levels, attributable to the Hillsdale Lake over a 100-year period total \$2,962,000.

1-03. Project Authorization. The Hillsdale Lake was authorized as a flood control project by the Flood Control Act of 1954 (Public Law 83-780) which states in part:

"The comprehensive plan for the Missouri River Basin, approved by the Act of June 28, 1938, and as amended and supplemented, is hereby further modified to include the project for flood protection on the Osage River and tributaries, Missouri and Kansas, substantially in accordance with the recommendations of the Chief of Engineers, in House Document Numbered 549, Eighty-first Congress."

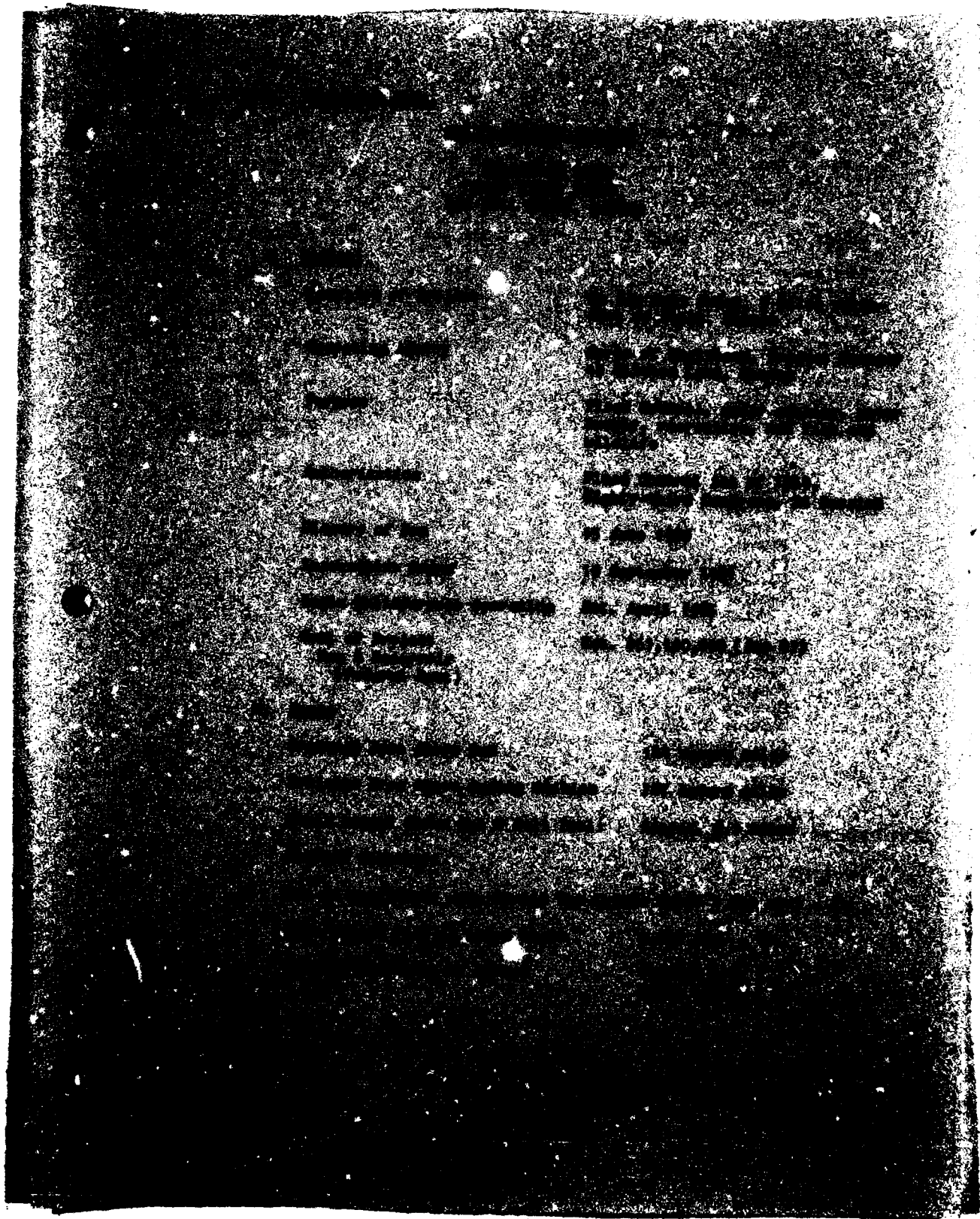
House Document No. 549, 81st Congress states in part:

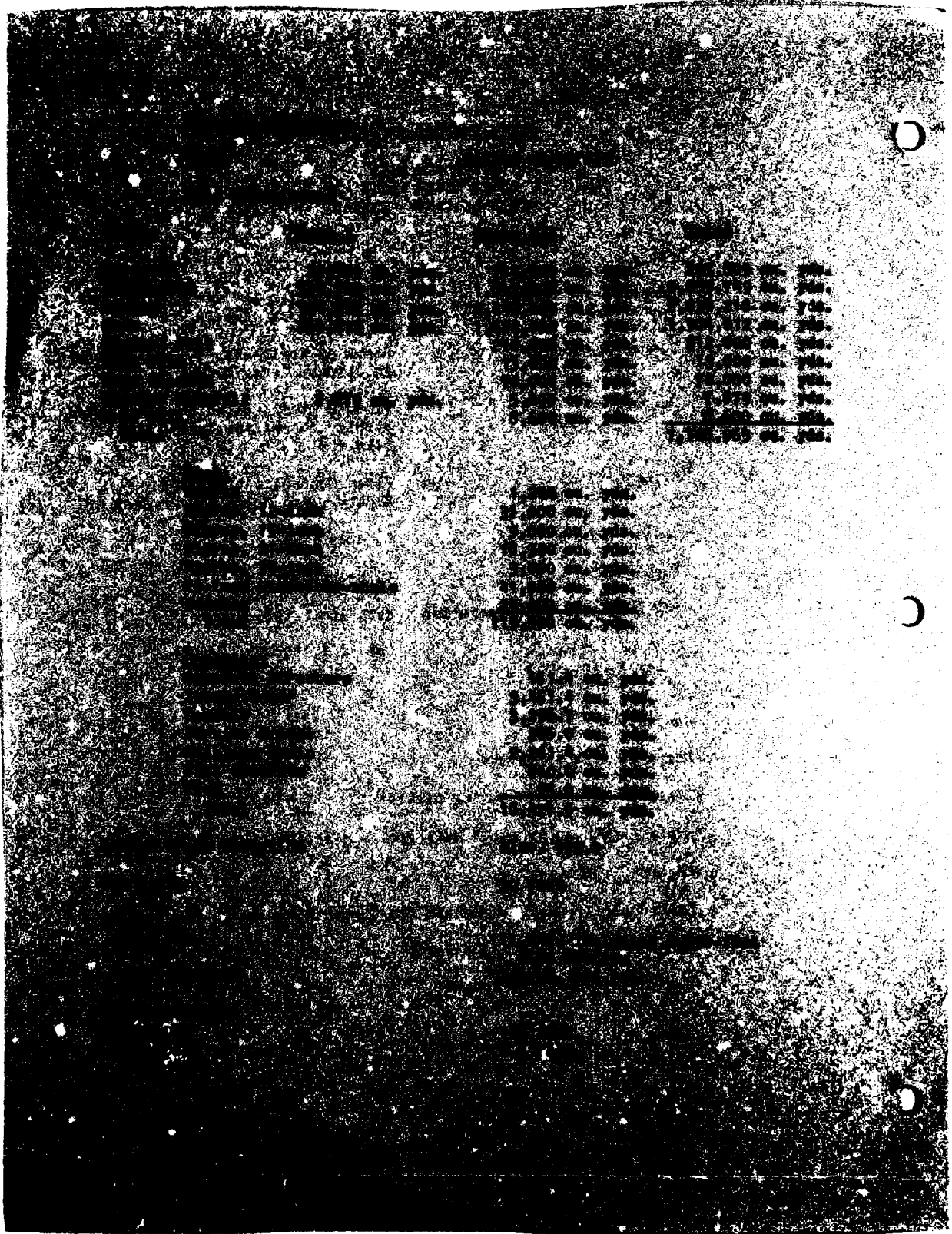
"The Osage River Basin plan consists of a nine-reservoir system (Hillsdale included) to be operated as a multiple-purpose project with the primary purpose of flood control. . . . the nine-reservoir system would control a drainage area of 11,500 square miles or 75 percent of the total area of the basin. The system will provide a very high degree of protection from flooding on the Osage River; reduce flood heights on the Missouri and Mississippi Rivers; provide storage for increasing low-water flows for the improvement of water supply, abatement of pollution, and improvement of navigation; and facilities for the production of hydroelectric power."

## CHAPTER 2

### PROJECT DESCRIPTION

2-01. Project Location. The Hillsdale Dam is located on the Big Bull Creek, Kansas, approximately 2 1/2 miles west of U.S. Highway No. 169 and 5 miles northwest of Paola, Kansas. The dam is located in Miami County with the lake extending north into Johnson County. Location and vicinity maps are shown on plate 1. Major thoroughfares and project access is shown on plate 2. A general plan of the damsite is shown on plate 3.





20 feet  
 20 feet  
 7 feet  
 7 feet  
 12 feet  
 12 feet  
 20 feet (interior)  
 20 feet  
 20 feet  
 19 feet

**4. Economic**  
 See Table 1  
 Elev. 936.0

**Storage Storage:**

Location of Storage	Elevation of top of tank	Storage area (sq. ft.)	Storage Allocation			
			Initial		100-year	
			(cu. ft.)	(cu. ft.)	(cu. ft.)	(cu. ft.)
Area 1	935.0	7,000	10.9	84,000	10.5	81,000
Area 2	937.0	2,000	9.9	78,000	8.8	68,000
			(1.5)	(31,000)		
<b>Total</b>			<b>20.8</b>	<b>160,000</b>	<b>19.3</b>	<b>149,000</b>

**5. Utilities**

Location: Just beyond right abutment  
 Type: Uncontrolled limited service  
 Elev. Storage: Elev. 935.0  
 Capacity: 20 feet  
 Notes: 1.7 cu. ft.  
 2.7 cu. ft.

**INTAKE**

**Location** Station 47+00, near left abutment

**Size** 11' 6" by 15' 0" foot sliding gate

**Capacity at top millimeter level**

**Q<sub>10</sub> Gate** 4,300 c.f.s.  
**Top Gate** 6,150 c.f.s.

**Capacity at Spillway Design Level**

**Q<sub>10</sub> Gate** 4,520 c.f.s.  
**Top Gate** 7,400 c.f.s.

**Intake elevation at intake** Elev. 668.0

**Intake elevation at outlet** Elev. 665.0

**Length of Conduit:**

**Normal to Portal** 600 feet  
**Headwater only** 659.15 feet

**Notes:**

**Sluiceway** Two 6' 6" by 15' 6" hydraulically operated fabricated slide gates

**Main Emergency** One 6' by 15' 7" fixed wheel cast-iron hand operated fabricated gate



2-03. Lake Description. Based on the multipurpose pool elevation of 917 feet above mean sea level, Hilldale Lake has 51 miles of shoreline, a mean depth of 27 feet, a mean breadth of approximately 1 mile, and a length of approximately 6 miles. The major topographic feature of the region is the Bull Creek Valley which is joined from the northeast by the Little Bull Creek Valley. Mature to submature dissection of the plain has resulted in a topography characterized by gently rolling uplands and comparatively broad valleys. Maximum relief in the area is approximately 180 feet. Valley slopes are somewhat steeper along Big Bull Creek than along Little Bull Creek. The steeper slopes and valley walls are mainly brush and timber covered.

2-04. Dam Description. The dam is a zoned, compacted earthfill embankment with a crest length of 11,640 feet which includes a 2,590 foot dike section on the upper right abutment. Crest width of the embankment is 30 feet with the dike section having a crest width of 15 feet. The embankment has a central impervious core across the valley with random and berm zones both upstream and downstream. The impervious core is tied to bedrock with a cutoff trench across the valley. The embankment includes an inclined pervious drain to intercept through seepage. The inclined pervious zone drains to pervious stringers extending to the downstream toe in the valley and to continuous pervious blankets extending to the toe on the abutments. The maximum height above streambed is 100 feet, while the height above flood plain is approximately 75 feet. The elevation of the top of dam is 952.2 which provides 4.2 feet of freeboard above the spillway design flood. The upper right abutment embankment (dike section) is not zoned. It consists of compacted impervious material from the spillway excavation. The lower right abutment embankment includes the Big Bull Creek where closure was made. The various embankment sections include the upper right abutment, lower right abutment, main valley reach, Little Bull Creek area, outlet works, and the left abutment. Details of the various sections are shown in the typical embankment sections on plates 13 and 14. The outlet works is not perpendicular to the dam axis therefore the conduit section and transitions are at different locations upstream and downstream. The outlet works section consists entirely of impervious material with the exception of the pervious backfill surrounding the conduit downstream of the dam axis. The upstream slope protection is designed to provide slope protection at the more frequent pool elevation and on the steep slopes near the embankment crest. Rock protection from the toe extending as high as Elevation 905.2 consists of limestone and shale obtained from required excavation. Riprap and bedding provides protection to Elevation 921.0 with a grass covered 1 on 3 slope transitioning to a 1 on 10 slope between Elevation 921.0 and 942.2. Rock protection consisting of 21 inch riprap provides slope protection from Elevation 942.2 to the crest of the dam.

2-05. Spillway. The spillway is located on the right abutment of the dam. The spillway is a limited service, uncontrolled, flat crested notch type. It is 50 feet wide and level throughout its 4,950 feet of length. It has a crest elevation of 935.0 feet, m.s.l., and 1 on 3 excavated side slopes.

2-06. Outlet Works. The outlet works is located near the toe of the left abutment and consists of an approach channel, intake tower and service bridge, cut-and-cover conduit, stilling basin, and outlet channel. The approach channel is approximately 1,750 feet long with an excavated bottom width of 30 feet and 1 on 2.5 side slopes. The approach channel originates at

the confluence of the Scott Branch and Big Bull Creek and intersects Little Bull Creek prior to connecting with the approach walls and intake structure. A combination wet well-dry well intake tower consists of a combination trash fender and trashrack structure, streamlined inlet, gate passageways, a transition from the gate passageway to the conduit, a multilevel low flow intake within the trashrack structure, two wet wells with a single cable-hoist operated emergency gate, a dry well with two hydraulically operated service gates, an operating floor, a service deck, and an entrance house. Access to the structure is provided by a service bridge from the embankment to the intake structure. The 11.67- by 15.92-foot oblong conduit is located in open-cut excavation and is covered with impervious material, upstream and pervious downstream of the dam axis. The total length of the conduit and intake structure, portal to portal, is approximately 802 feet long. The stilling basin and downstream transition structure provides for energy dissipation by a conventional hydraulic jump to prevent serious erosion of the downstream channel. In cross section, the stilling basin is a U-wall type structure. Baffles and an end sill are built into the stilling basin floor slab. Walkway platforms are provided at the top of the stilling basin walls for observation and fishing. Ramps constructed along the riprap adjacent to the outlet provide fishermen access to the outlet channel.

2-07. Reservoir Operations. Hillsdale Lake is one unit in a system of multiple-purpose projects which comprise a comprehensive plan for flood control and water resource development in the Missouri River basin and its Osage River tributary basin. Flood control storage in Hillsdale Lake acts in conjunction with the other flood storage projects in the Osage River basin to reduce flooding on the Marais des Cygnes, Osage and Lower Missouri River. Hillsdale Lake will have storage for sediment, low-flow supplementation, water supply, and flood control. Sediment storage will provide 11,000 acre-feet of sediment allocation for a 100-year design period. The 68,000 acre-feet multipurpose pool allocation will furnish a water supply withdrawal of 32 cubic feet per second on a 2 percent chance dependability and low flow supplementation of 13 cubic feet per second based on a 10 percent chance. Results of a historical period of record reservoir operation are shown on plate 18, as a Lake Stage Frequency Curve for Hillsdale Lake.

## CHAPTER 3

### GEOLOGY

3-01. Physiography. Hillsdale Lake is located in the northeastern part of the Osage Plains section of the Central Lowlands physiographic province. This section is characterized by a series of plains separated by eastward facing escarpments formed by differential erosion of Pennsylvanian limestone and shale strata which dip gently westward. Big Bull Creek and Little Bull Creek rise in the southwestern corner of Johnson County near the town of Gardner, Kansas. The two streams merge about 1,000 feet downstream of the dam axis and flow in incised channels with a moderate amount of meandering. At the damsite the flood plain is about 3,000 feet wide. Isolated terrace deposits of Wisconsinan age occur in Big Bull Creek valley upstream and downstream of the dam axis. The valley slopes are mantled primarily with residual soils and some colluvial material (lean and fat clays) ranging in thickness from 0 to 20 feet.

3-02. Description of Overburden. The description of the overburden is based on observations made during the excavation of the cutoff trench.

a. Valley Alluvium. The valley alluvium consists of up to 30 feet of Pleistocene and recent deposits of lean and fat clays with clayey sand several feet thick at the base. Valley alluvium across the valley, except where the Drum limestone was eroded away in the Big Bull Creek channel (Station 80+10 to 82+30). Lean and fat clay deposits vary from 25 to 30 feet thick. The Pleistocene and recent deposits contain very few sand and gravel deposits. A 3-foot thick sand and gravel deposit with a minor amount of water exists between Station 80+00 and 82+20 on the upstream side of the trench. A small deposit of sand and gravel one foot thick exists between Stations 104+00 and 105+00. These sand and gravel deposits correspond to the creek crossings.

b. Upland Overburden. On the right abutment, overburden ranges in thickness from 6 to 20 feet and consists largely of residual fat clay derived from weathering of the Lane shale formation. The maximum thickness occurs from Station 36+00 to Station 46+00. From Station 44+00 to Station 75+00 the Lane shale is absent and residual clays are resting directly on weathered Iola limestone. From Station 75+00 to Station 79+00 fat and lean clays are resting on the Chanute shale. Bedrock between Station 75+00 to Station 78+50 is a moderately hard, friable, very fine grained, thin bedded, tan, sandstone. The steep slope from Station 78+00 down to Big Bull Creek at Station 79+00 is thinly mantled. There is less than 6 feet of fat clay and many large sandstone slabs from the overlying Chanute shale. On the left abutment overburden is comparatively thin. From Station 105+00 to Station 112+00 the overburden ranges from 6 to 12 feet thick over the Chanute shale. From Station 112+00 to Station 116+00 the overburden was on the Iola limestone. From Station 116+00 to Station 124+00 the overburden is on the Lane shale. From Station 112+00 to Station 124+00 the overburden is composed of lean and fat clays. Limestone fragments were not common and no sand was noted from Station 105+00 to Station 124+00.

3-03. Bedrock Stratigraphy. Bedrock units present at the damsite are of the Pennsylvanian System, Lansing, and Kansas City groups. They consist of alternating beds of limestone and shale with occasional zones of sandstone and siltstone. Unexposed similar sedimentary strata extend about 2,000 feet to the Precambrian basement. The bedrock units are described, in descending order, in the following paragraphs:

a. Lansing Group.

(1) Plattsburg Formation. These units were not encountered in the excavations.

(a) Spring Hill limestone is 14 feet thick, moderately hard, dense to finely crystalline with occasional pits. It is light gray and massive to thin bedded with shaly partings.

(b) Hickory Creek shale is 0.5 foot thick, soft, platy, calcareous and dark gray.

(c) Merriam limestone is 2.5 feet thick, moderately hard, dense to finely crystalline, oolitic, thin bedded, fossiliferous and light gray.

(d) Bonner Springs shale is 19 feet thick, soft to very soft and platy with calcareous partings. It is light to dark gray with a maroon zone near the center. A moderately hard, very fine grained sandstone occurs at the base.

(2) Wyandotte Formation.

(a) Farley limestone, Island Creek shale (0.1 foot thick) and Argentine limestone members total about 14 feet thick. They are moderately hard, dense, thin-bedded, with wavy shale partings and light gray to buff with light blue mottling. These units were not encountered in the excavations.

(b) Lane shale member is about 100 feet thick, soft to occasionally very soft, clayey to sandy, platy, gray to dark gray with occasional carbonaceous partings and limestone nodules. The upper half includes sandstone, moderately hard, fine grained, micaceous, occasionally calcareous, thin bedded and gray.

(3) Iola Formation.

(a) Raytown limestone member is about 17 feet thick, moderately hard, dense to finely crystalline, argillaceous, fossiliferous, thin to medium, wavy bedded and light bluish gray. The ledge contains two thin shale beds.

(b) Muncie Creek shale member is 0.5 feet thick, soft, clayey, calcareous, gray with occasional phosphate nodules.

(c) Paola limestone member is 2.5 feet thick, moderately hard, dense, fossiliferous, thick bedded and light gray.

(4) Chanute Formation.

(a) Chanute shale is approximately 30 feet thick, soft to moderately hard, clayey to silty, platy to massive, dark gray to green with pinkish limestone nodules. Sandstone and siltstone beds are common in the upper part. A soft shale underclay with numerous slickensides occurs beneath a thin coal seam near the middle. The sandstone and siltstone are moderately hard, very fine grained, calcareous, thin bedded and gray to brown. The siltstone is often interlaminated with shale.

(b) In the outlet works excavation several zones within the Chanute shale formation have been recognized. They are described in descending order, below.

Zone A is about 5 feet thick. It is shale, soft, platy to fissile and dark gray with occasional moderately hard siltstone beds.

Zone B is about 8 feet thick. It consists of siltstone and sandstone, moderately hard, thin bedded to laminated, calcareous, light and dark gray with a 3/4 inch thick coal seam at the base.

Zone C is about 5.5 feet thick. It is shale, soft, blocky and dark gray with numerous slickensides.

Zone D is about 1.8 feet thick. It is soft, blocky, purple shale with numerous slickensides.

Zone E is about 5 feet thick. It is siltstone, moderately hard, thin to medium bedded, calcareous and greenish gray with limestone lenses and nodules.

Zone F is about 3.5 feet thick. It is shale, soft, laminated and gray. It contains numerous tight vertical joints.

(5) Drum Formation. Cement City limestone member is 4 feet thick, moderately hard, dense to finely crystalline, thin to medium bedded, fossiliferous, light gray with thin green wavy shale partings.

(6) Cherryvale Formation. The Quivira shale member is the only unit encountered in the excavations.

(a) Quivira shale member is 12 feet thick, soft, clayey to silty and dark gray. It contains siltstone and underclay and occasional very soft partings and bands. A thin coal seam commonly occurs in the upper 4 feet. The lower portion is often interlaminated with moderately hard, light gray siltstone.

(b) Westerville limestone member is 2.5 feet thick, moderately hard, thin-bedded, argillaceous, brownish gray with green shaly partings and zones of nodular limestone in a matrix of green shale.

(c) Wea shale member is 21 feet thick, soft to moderately hard, clayey to silty, platy, occasionally calcareous and contains siltstone bands and partings. It is dark gray to green gray.

(d) Block limestone member is 14 feet thick, moderately hard, dense to very finely crystalline, thin wavy bedded, light brownish gray with occasional light blue mottling and numerous dark gray, soft shale partings.

(e) Fontana shale member is 14 feet thick, soft to moderately hard, clayey to silty, platy, dark gray to green gray with occasional limestone partings.

(f) Winterset limestone member is 20 feet thick, moderately hard to hard, finely crystalline, argillaceous, cherty, thick bedded, and light gray.

3-04. Bedrock Structure. The damsite is located on the Prairie Plains homocline. The term is applied to strata that dip in one direction at a uniform angle. The regional dip is 20 to 30 feet per mile to the northwest. The regional dip, however, is not apparent at the damsite; instead, the local strata dip slightly to the northeast at a rate of about 15 feet per mile. The rock units are at a lower elevation on the left abutment than on the right.

3-05. Bedrock Weathering. From Station 45+00 to Station 58+00 the Raytown limestone in the cutoff trench was weathered with open joints and clay pockets. The upper six to eight feet of the ledge was excavated down to a shale parting near Elevation 910. From Station 69+00 to Station 72+00 the Chanute shale was soft and weathered. The upper five feet were excavated to expose a firm unweathered shale surface. From Station 75+00 to Station 78+50, up to five feet of weathered Chanute shale was excavated. From Station 79+50 to Station 106+30 a five foot thick ledge of weathered Drum limestone and three feet of the underlying Quivira shale were excavated. From Station 106+30 to Station 114+15, the upper five feet of weathered Chanute shale was excavated. A clay filled joint in the Raytown limestone was encountered on the downstream wall of the cutoff trench at Station 114+34. From Station 114+15 to Station 118+50 Raytown limestone forms the floor of the trench. From Station 118+50 to Station 121+00 the upper two feet of weathered Lane shale was excavated.

3-06. Leaching and/or Solution Activity. Several solution cavities were encountered in the Paola limestone and Chanute shale on the walls of the outlet works excavation.

3-07. Jointing. Joints in the Raytown and Drum limestones on the floor of the cutoff trench were tight and indistinct in the abutments and joints in the Drum were open in the valley. The major joints strike north 45 degrees to 65 degrees east. The minor joints strike north 30 degrees west. The joints were cleaned and filled with grout. During foundation grouting they tested tight. A few joints were noted in the Raytown limestone on the floor of the cutoff trench. A few joints were noted in the Drum limestone on the floor of the cutoff trench from Station 79+00 to Station 79+50. They were also tight. Numerous joints were found in the Chanute shale in the stilling basin foundation. The joints were vertical and open for a depth of about 7 inches. One set strikes south 80 degrees east and the other set strikes north 25 degrees east.

3-08. Ground Water. Overburden and bedrock units at the damsite and in the reservoir were expected to be poor aquifers. The excavations through the

fat clays of the cutoff trench disclosed only two clayey, gravelly, sand areas in the old channels of Big and Little Bull Creeks. Except for the initial discharge when first disturbed, groundwater seepage was insignificant. Groundwater seepage in the outlet works excavation was also minimal. Pressure testing indicated the underlying shales and limestones were relatively impervious. Small yields had been reported in the Chanute shale in wells outside the reservoir. Excavation of the Iola and Drum limestones confirmed that they were poor aquifers. Jointing was well defined and slightly open only in the outcrop areas. Grouting confirmed the limestones and shales were tight except for one small area in the Chanute shale that accepted most of the grout injected. This area was a sandstone lense near the top of the Chanute shale. Occasional open joints in this sandstone probably supply what little well water is available in the area.

## CHAPTER 4

### HISTORY OF PROJECT DESIGN

4-01. Investigations Prior to Project Authorization. Studies prior to project authorization consist of reports prepared by the Corps of Engineers, reports of other agencies, flood damage investigations, special field investigations, and the report on the Osage River and Tributaries (Missouri and Kansas), House Document No. 91, Seventy-third Congress and other information used in the preparation of House Document No. 549, Eighty-first Congress, which is the project document.

4-02. Investigations Subsequent to Authorization. Post authorization studies included topographic surveys, subsurface explorations, and preliminary contacts with governmental agencies and local groups having an interest in the project. Design studies leading to the following DMs were initiated.

TABLE 1

#### Hillsdale Design Memorandums

DM Number	Title
1	Project Economics
2	Hydrology
3	General
3	Appendix E - Recreation Resources
4	Preliminary Cost Allocation
5	Source of Construction Materials
6	Administrative Facilities
6	Supp 1, Administrative Facilities
7	Soil Data & Embankment Design
7	Supp A, Soil Data & Embankment Design
8	Outlet Works and Spillway
9	Miami County Road Relocations
10	Access Roads
11	Real Estate
11	Supp A, Miami Co. Rd. Relocations
12	Relocation of Power and Telephone Lines
13	Master Plan
14	Petroleum & Pipeline Relocations
15	Interpretive Prospectus and Exhibit Design Concept
16	Lake Clearing
17	O&M Water Supply
18	Initial Reservoir Filling Plan

Preliminary embankment design quantities were evaluated for several sites to be considered in the site selection procedure. A site selection conference was held in February of 1969 with a summary of the data presented being published in a report. Geologic investigating and soil testing to determine strength characteristics and moisture-density relationships of proposed borrow material as well as the stress-strain and consolidation characteristics and



strength parameters of the foundation materials proceeded while the General Design Memorandum was being prepared. The additional foundation information resulted in a revised embankment. Details of the modified design are presented in Design Memorandum No. 7, Soil Data and Embankment Design, March 1971. In response to review comments to DM 7 a Supplement presenting the results of additional exploration and testing of the foundation shales was prepared in December 1971. The outlet works embankment design and the conduit location were revised in the supplement. Stage construction was planned to allow observation and analysis of the foundation conditions during excavation of the cutoff trench. Advance plans and specifications for Stage I were submitted October 1974. Advance plans and specifications for Stage II were submitted February 1976. Based on results of additional testing of the Quivira shale and evaluation of the foundation conditions during Stage I construction, a revised embankment design was presented in January 1978 in Design Memorandum No. 7, Supplement A, Soil Data and Embankment Design. Stage III plans and specifications were submitted April 1978.

4-03. Changes in Project Plan. The following changes have been made to the project as planned in the General Design Memorandum.

a. Top of Dam. The top of dam has been changed from Elevation 953.0 feet, m.s.l. to Elevation 952.2 feet, m.s.l. This change was the result of modifying the practice of rounding up the top of dam elevation to an even foot.

b. Conduit. A 13.5 foot diameter single horseshoe conduit was recommended in the General Design Memorandum, but conduit studies and comments on similar projects indicated that an oblong conduit be used.

c. Intake Tower. Changes in the intake tower design to conform with the oblong conduit and other modifications are presented in Design Memorandum No. 8, Outlet Works and Spillway.

d. Stilling basin. Hydraulic stilling basin model studies for Fort Scott and Clinton Lakes were recently conducted at Waterways Experiment Station (WES). Based on these studies, the Hillsdale stilling basin has been modified to include the results of these studies.

e. Spillway control sill. The spillway control sill has been deleted.

f. Project name. In accordance with EC 1130-2-75, dated 10 August 1970, the name "Hillsdale Reservoir" is changed to "Hillsdale Lake."

g. Embankment. Investigations subsequent to the GDM revealed the Quivira shale underclay with a lower shear strength than assumed. This resulted in an embankment design with flatter slopes to provide stability. This redesign resulted in the embankment presented in DM No. 7, which proposed construction of the embankment, outlet works, spillway and toe roads in one contract. Limited test data on the Chanute shale underclay resulted in additional drilling and testing after submission of DM No. 7. The test results indicated a lower residual strength. The revised strength required the 1 on 6 slope in the conduit section to be changed to 1 on 8. The revised embankment required moving the tower upstream, however, borings indicated the

adequacy of the bedrock would become marginal. This required a change in the conduit location. The location was changed from being perpendicular to the dam axis at Station 113+10 to being skewed 9 degrees from perpendicular at Station 113+60. The proposed one contract construction of the embankment was changed to stage construction to allow an evaluation of the foundation conditions and any required changes in the embankment design to be accomplished prior to the embankment construction. Changes in design prior to construction include the following.

(1) Embankment section. The upstream and downstream embankment toes were adjusted inward to provide a 1.4 safety factor for the partial pool and steady seepage cases. The reduced safety factor was believed to be appropriate based on the conclusion the Quivira underclay was not continuous or extensive. The resulting revised embankment sections are shown on plates 65, 66 and 67. The change in location of the toes varies from 90 feet to 140 feet.

(2) Pervious. A change in the pervious was made on the basis of economy. A significant cost savings was made by using 50 foot wide pervious stringers in the valley section in lieu of the continuous blanket. The inclined pervious slope was also changed to 1 on 1 instead of 1 on 0.5 to conserve pervious.

(3) Riprap. An evaluation of the riprap design determined that the necessity for carrying riprap above Elevation 921.0 was marginal. Using stockpiled rock from required excavation in the lower portions of the embankment instead of riprap provided a significant savings. Riprap would also be placed on the top 10 feet of the embankment. The revised slope protection is shown on plate 16.

(4) Grout curtain. A change in the design of the grout curtain as shown in the embankment DM was made during the preparation of the Stage I plans and specifications. The grout curtain across the valley floor (Station 79+50 through Station 106+50) was eliminated. Exploratory borings and pressure testing indicated the bedrock strata are sufficiently impermeable, and that a grout curtain is not required to prevent adverse seepage through bedrock underlying the valley cutoff trench.

(5) Clay blanket. An upstream 3 foot thick (CH) clay blanket was constructed to Range 1000 upstream on the right abutment. The blanket prevents seepage through an exposed (see plates 4 and 5) geologic section from the Raytown limestone to the Drum limestone. The blanket did not withstand the wave action and surface runoff, and repair and protection was required before initial filling. The blanketed area was protected by placing filter fabric over the blanket followed by 15-inch riprap over the fabric. Protection does not extend below Elevation 898.

## CHAPTER 5

### FOUNDATION AND EMBANKMENT DESIGN

#### 5-01. Foundation Investigations.

a. Investigations Prior to Construction. Geological investigations of the damsite included field reconnaissance, review of geologic literature, analysis of air photos, survey of water wells, review of gas and oil well log-sand exploratory drilling. Two hundred and ninety borings were made at the damsite. Fifty-five were bedrock core borings, thirteen were combination undisturbed and core borings, and forty-four were drive borings. Sixty-four drive or auger borings were made in the borrow areas. Twenty-seven bedrock borings were hydraulically pressure tested. Nearly all the borings tested tight but one boring, C-81 accepted 16.7 gpm in the weathered upper two feet of the Chanute shale. Bedrock cores were 1-7/8, 2-1/8 and 6-inch diameter and overburden borings ranged from 3 to 6-inch diameter. Nineteen piezometers were installed in the flood plain to obtain information on water level fluctuations.

b. Investigations During Construction. During excavation of the cutoff trench, the contractor drilled several air tract holes into exposed bedrock on both abutments to determine depth and extent of joints and weathering in the Raytown limestone. Several exploratory NX core holes were drilled horizontally into the sloping faces of the Raytown limestone. They were pressure tested and grouted during Stage I and Stage II construction. Government drill crews drilled 135 drive holes, 12 auger holes, 9 NX core holes, one combination drive and core hole and 10 test pits.

#### 5-02. Embankment Foundation.

a. Right Abutment (Station 6+00 to Station 79+00). --The right abutment extends almost 1.4 miles across a gentle slope. Overburden thickness ranges from 5 to 25 feet, consisting primarily of residual fat clay with a lesser amount of lean clay and minor amounts of sandy and silty clays. Water contents range from 14 to 31 percent. Liquid limits as high as the low seventies are common. Bedrock units immediately underlying the overburden are as follows by approximate stationing: Lane shale from Station 6+00 to 42+00, Raytown limestone from Station 42+00 to 63+00, Paola limestone from sta. 63+00 to 74+00, and the Chanute Shale from Station 74+00 to 79+00. The thin Muncie Creek Shale, less than 0.5 feet thick, lies stratigraphically between the Raytown and Paola limestones and contacts the overburden for an insignificant horizontal distance at Station 63+00. Overburden-shale contacts are in general, transitional. Weathering in the form of staining extends as much as 10 feet into shales and sandstone but depth to firm rock is generally within 5 feet of the shale surfaces and slightly less in sandstone. In limestones, weathering in the form of partially clay-filled and open bedding planes and joints extends to a depth of 7 feet and occasionally deeper. Where the limestones are extremely weathered, cobbles, boulders, pinnacles and "float" rock have developed to a thickness of 3 to 4 feet. Raytown and Paola limestones and a sandstone phase of the Chanute Shale crop out along the Big Bull Creek valley wall just upstream of the damsite, with the Drum limestone appearing farther upstream. These bedrock strata, except the Drum limestone,

are also exposed along Scott Branch as it flows roughly parallel to the dam axis 1,000 to 2,000 feet upstream. The location and elevation of these outcrops, all below flood pool elevation, dictate the grout curtain limits in the right abutment.

b. Valley (Station 79+00 to Station 106+00). --The valley overburden consists of alluvium from 22 to 30 feet thick. Lean and fat clays predominate, although up to 3 feet of clayey gravelly sand commonly overlies the bedrock surface. Water contents of the clay generally range in the twenties and low thirties, while the water content of the basal gravelly sand material range from 15 to 45 percent. Liquid limits of the fat clay range up to 63. Borings and outoff trench excavation indicate that the bedrock surface underlying the valley alluvium is comparatively level with a gentle increase in apparent dip toward the left abutment. With one exception, (UC-51) bedrock borings encountered weathered Drum limestone underlying the alluvium in the valley embankment area. At boring UC-51, located about 250 feet upstream of sta. 80+00, the Quivira Shale forms the bedrock surface. Weathering in much of the Drum limestone has opened closely spaced (0.2 foot) wavy shale partings and vertical joints in the valley while the bedrock joints in the abutments remain tight and indistinct. In some instances the weathering has extended through the 4 ± foot thick Drum limestone into the top of the Quivira Shale. A thin coal seam or very carbonaceous shale (0.5 ± foot thick) with associated shale underclay occurs within the upper 4 feet of the Quivira shale. This soft shale underclay has occasional very soft partings and bands. Direct shear (S) tests indicate that the soft shale is weak. It is concluded that the "weak" zone is probably not continuous or extensive based on detailed evaluation during the excavation of the outoff trench.

c. Left Abutment (Station 106+00 to Station 121+40). --Overburden in the left abutment is residual soil except for the alluvium in the lower portion adjacent to Little Bull Creek. Thickness of the overburden ranges from 7 to 28 feet and consists primarily of lean and fat clays. Two to 3 feet of clayey sand commonly occurs directly overlying the bedrock surface when this surface is the Chanute shale. Water contents of the overburden range from 19 to 41 percent. Liquid limits of the overburden are generally below 60. Bedrock units immediately underlying the overburden are as follows along with approximate stationing: Chanute shale from sta. 106+00 to 111+70, Paola limestone from Station 111+70 to 112+20, Raytown limestone from Station 112+20 to 116+00, and the Lane shale from Station 116+00 to 121+40. The thin Muncie Creek shale, less than 0.5 foot thick, will contact the overburden for an insignificant horizontal distance at approximate Station 112+20. Weathering in limestone, shales and sandstones is as described for the right abutment in paragraph 5-02.e.

5-03. Laboratory Tests. Samples taken from the foundation and the borrow areas were tested in the laboratory to establish soil parameters necessary for the design of the embankment. In general, disturbed samples obtained from the borrow areas were used for remolded testing and samples taken from the foundation were used for undisturbed testing. Identification and classification tests were run routinely on jar samples from both areas. During construction, record control samples were tested to determine the actual characteristics of the in-place fill. The laboratory tests were performed in general accordance with EM 1110-2-1906, "Laboratory Soils Testing."

a. Remolded Tests. Based on the results of the classification tests on jar samples, composites were made from sacks of similar material. Remolded, direct shear "S", and triaxial unconsolidated-undrained, "Q", and consolidated-undrained, "R", tests were performed on these composites. Standard compactions were conducted prior to the strength tests to obtain the moisture content versus dry density relationships. The results from these compaction tests are presented on Plate 46. The test specimens were reconstituted by kneading compaction to dry densities of 95 percent of maximum and at moisture contents ranging from 2.8 percent below optimum to 4.8 percent above optimum. Specimens were tested immediately so as not to allow a thixotropic strength gain.

(1) Remolded Triaxial Compression Tests. The remolded triaxial test specimens were constructed by kneading eight lifts of soil into a split mold and scarifying between each lift. Nominal specimen dimensions were 1.4 inch diameter by 3 inch height. Both "Q" and "R" tests were performed at confining pressures ranging from 0.5 to 4.0 t.s.f. The points on the Mohr circles used to define the strength envelopes were the stresses on a 60 degree plane at failure. Failure was assumed to occur at 15 percent strain if the deviator stress had not peaked beforehand. A summary of the remolded triaxial "Q" and "R" tests is presented on Plate 47.

(2) Remolded Direct Shear "S" Tests. The direct shear specimens were made by kneading the material into a 3.0 or 3.5 inch square box to a thickness of 0.5 inch. A summary of test results used in Design Memorandum No. 7 is presented on Plate 46. During construction, additional remolded direct shear tests were performed on borrow area material. The results of these additional tests supported the original strength envelope. The compaction tests that accompany these additional shear tests are shown on Plate 77, and the actual shear test results are on Plates 78 and 79.

b. Undisturbed Tests. Undisturbed samples (discussed in paragraph 5-01.a.) from both the foundation overburden and the bedrock were tested in the laboratory. All test specimens were hand trimmed in a humidity controlled room to minimize disturbance and moisture loss.

(1) Foundation Overburden. The foundation overburden samples were used for consolidation, direct shear, and triaxial "Q" and "R" tests.

(a) Triaxial tests. Triaxial test specimens were generally tested in sets of 3, each at a different confining pressure. They were trimmed so that all three specimens were from the same layer. Specimen dimensions were 1.4 inch diameter by 3-inch height. The points on the Mohr Circle with normal stresses of  $\frac{\sigma_1 + \sigma_3}{2}$  and shearing stresses of  $\frac{\sigma_1 - \sigma_3}{2}$  were used to define the strength envelope. Summaries of foundation overburden strengths are presented on Plates 50 and 51.

(b) Direct Shear "S" Tests. The direct shear test specimens were trimmed into 3.5 inch square shear boxes to a height of 0.5 inch. Some of the tests were performed on a direct shear machine capable of shearing the specimen, then reversing the direction of shear 180 degrees, and shearing the

specimen again without releasing the normal load in the process. In order to obtain the strength at large strain, this procedure was repeated with no reduction in shear strength occurred from additional shearing. A summary of foundation overburden "S" strengths is presented on Plate 49.

(2) Foundation Shales. Only "S" strengths were used for shales in the design. Both the Chanute shale and the Quivira shale were tested for shear strength along the bedding planes and across the bedding planes. The results of these shear tests performed for Design Memorandum No. 7 are presented on Plate 57. It was felt that additional testing was required to support the design strengths used for the shale underclays, so additional direct shear and "R" tests were performed and presented in two supplements to Design Memorandum No. 7. The summary of test results from the first supplement is shown on Plate 57, and the summary from the second supplement (Supplement A) is shown on Plate 58. Although these additional tests resulted in decreasing the residual strength for the Chanute shale, they indicated peak strengths for the Quivira shale to be significantly higher than those used in Design Memorandum No. 7. For design calculations the original "S" strength was used even though the additional tests showed it to be very conservative. For stability analyses performed for this report, it was believed that a revised strength envelope drawn such that one-third of the test results were below it and two-thirds were above it was more appropriate.

c. Record Control Tests. Record control samples taken during construction were used for determining the in place shear strength of the fill. Triaxial "Q", "R", and "R" and direct shear tests were performed on these samples.

(1) Triaxial "Q" Tests. The "Q" test specimens were trimmed from record control samples in pairs; one was tested at a confining pressure of 3.0 t.s.f. and the other at 6.0 t.s.f. Although the specimens were not 100 percent saturated, the strength envelopes were chosen with  $\tan \beta = 0$ . For the saturated condition, the point on the Mohr circle corresponding to the stresses on the failure plane coincides with the point of intersection with a line drawn tangent to the circles. This is the point that was used in defining the strength envelope. It has a normal stress value of  $\frac{\sigma_1 + \sigma_3}{2}$  and a shearing stress value of  $\frac{\sigma_1 - \sigma_3}{2}$ . A summary of record control "Q" test results is shown on Plates 80 and 81, and the individual test results are shown on Plates 88 through 103.

(2) Triaxial "R" Tests. The record control "R" test specimens were generally tested in pairs with one consolidated at 3.0 t.s.f. and the other at 6.0 t.s.f. The Design Memorandum No. 7 constructed the strength envelope through the points corresponding to a normal stress of  $\frac{\sigma_1 + \sigma_3}{2}$  and a shearing stress of  $\frac{\sigma_1 - \sigma_3}{2}$  for undisturbed "R" tests. A summary of record control "R" test results prepared in this manner is presented on Plates 82 and 83. This method of constructing the envelope appears to be inconsistent with the way it is used for slope stability calculations. It is felt that a more appropriate method is to plot the point of shear strength at failure on the plane of failure, against the effective normal consolidation stress on the failure plane. A summary of test results prepared in this manner is shown on Plates 84 and 85, and the individual tests are presented on Plates 104 through 119.

(3) Triaxial "R" and Direct Shear Tests. Four "R" tests were run on record control samples. These R tests yielded nearly the same results as a drained direct shear test by considering the effective stresses on a 60 degrees failure plane. A summary of "S" strengths from both drained direct shear and triaxial "R" is shown on Plates 86 and 87, and the individual "R" and direct shear tests are shown on Plates 120 through 136.

e. Identification of Dispersive Clays. After construction, two areas of the spillway were sampled because they exhibited dispersive behavior. Three types of tests commonly used to identify dispersive clays were performed on these samples. The tests included the lab dispersion, pinhole erosion, and chemical pore water analysis (% Na.). These tests indicated that one area was dispersive while the other was not. The test results are presented on Plates 151A and 151B.

5-04. Embankment. For purpose of embankment design, the dam was divided into six reaches because of the various foundation conditions that exist across the valley. Embankment sections are shown on Plates 13 and 14.

a. Upper Right Abutment (Station 6+10 to Station 60+00). The height of the embankment in this reach varies from 0 to 21 feet. The relatively flat 1 on 6 slopes were designed for aesthetic reasons rather than slope stability. The embankment with seeded slopes requires little maintenance and blends in with the natural surroundings. This portion of the embankment is not zoned, it is constructed of compacted clay and shale from the spillway excavation. Water will be against the upstream slope only at very infrequent intervals (once in excess of 50 years), and then only for a few days at a time. The embankment with seeded slopes requires little maintenance and blends in with the natural surroundings. An inspection trench extends from Station 6+10 to Station 43+75 under the embankment. A cutoff trench to the lower shale seam of the Raytown limestone exists from Station 43+75 to Station 56+55.5. The Raytown limestone on the downstream side of the cutoff trench was covered with a filter material and a pervious blanket. The 1 on 6 slopes transition to 1 on 4 slopes from Station 56+00 to Station 60+00. Downstream pervious blanket begins at Station 59+00 with the pervious extending all the way to the toe between Station 59+00 and Station 60+00. Riprap slope protection on the upstream slope starts at Station 56+00.

b. Lower Right Abutment (Station 60+00 to Station 81+00). The height of the embankment varies from 21 feet to 100 feet in this reach. It includes the Big Bull Creek channel where closure was made. The embankment transitions from Station 60+00 to Station 64+00 where the upstream slope is 1 on 3 from the top of dam to Elevation 928.2 and 1 on 10 to the ground surface. The downstream slope is 1 on 3 from top of dam to elevation 925.8 and 1 on 12 to the ground surface. From Station 73+00 to Station 81+00 the upstream 1 on 10 slope extends to Elevation 900.2 and continues on a 1 on 4 slope to the ground surface. The downstream 1 on 12 slope extends to elevation 900.7 and continues on a 1 on 4 to the ground surface from Station 73+00 to Station 87+00. The primary design consideration in this reach was the Quivira shale underclay. The absence of Drum limestone over a portion of this reach

reduced slope stability and required a larger section than elsewhere. Design of this section was based on the conclusion that the "weak" zone in the Quivira shale underclay was not continuous. This section was designed to provide a factor of safety of 1.4 for the steady seepage and partial pool slope stability cases.

c. Main Valley (Station 81+00 to Station 96+30). The height of the embankment in this reach is approximately 75 feet. This reach contains the Stage I embankment (See Plate 6 for limits of Stage I embankment) constructed from cutoff trench and outlet works excavation. The Stage I embankment was constructed prior to the completion of design of the rest of the embankment. The upstream slope is 1 on 3 from top of dam to Elevation 928.2, a 1 on 10 to Elevation 916.2, a 20 foot flat section at Elevation 916.2 from range 2+07 to range 2+27, 1 on 10 to Elevation 892.2, and 1 on 4 to the ground surface. The flat section was the result of inadvertently specifying that the Stage I embankment be constructed to the grade line of the top of the riprap rather than the bottom of the riprap. The Stage I embankment was overbuilt by two feet, the thickness of the slope protection, requiring a 20 foot flat section in the 1 on 10 slope. The downstream slope is 1 on 3 from top of dam to Elevation 925.8, 1 on 12 to Elevation 905.7, and 1 on 4 to the ground surface. The Quivira shale which was underclay was the primary design consideration in this reach. The Stage I embankment was designed assuming there was a low strength zone in the Quivira Shale continuous across the valley. The conclusion that this was not the case was made after the Stage I embankment was constructed. Therefore, the upstream toe of this reach extends further upstream than the redesigned sections where the toes were adjusted inward.

d. Little Bull Area (Station 96+30 to Station 111+70). The height of the embankment in this reach is approximately 75 feet. The upstream slope is 1 on 3 from top of dam to Elevation 928.2, 1 on 10 to Elevation 905.2, and 1 on 4 to the ground surface. The downstream slope is 1 on 3 to Elevation 925.8, 1 on 12 to Elevation 905.7, and 1 on 4 to ground surface. The foundation overburden "Q" and "R" strengths are lower in this reach than in the main valley. Also a zone of fat clay with a slightly lower "S" strength, which is present in the main valley, is not present in the Little Bull area. The differences proved to be of little consequence in the design of the section. The lower "Q" strengths resulted in a construction halt at Elevation 927.

e. Conduit Section (Station 111+70 to 115+70). The conduit, stilling basin, and intake structure are founded on Chanute shale. The upstream slope is 1 on 3 from top of dam to Elevation 928.2, 1 on 8 to Elevation 898.2, and 1 on 4 to the ground surface. The downstream slope is 1 on 3 from top of dam to elevation 925.8, 1 on 8 to the service road, 1 on 3 to Elevation 881, and 1 on 2 to the ground surface. The steeper embankment sections in the conduit are possible because an all impervious and pervious section is used and the Quivira Shale lies below a much more competent Drum limestone and part of the Chanute Shale. The Chanute Shale contains calcareous siltstone and sandstone and tests indicate a high crossbed shear strength. The width of the conduit section and transition zone is 300 feet. The outlet works are not perpendicular to the dam axis therefore the conduit section and transitions are at different locations upstream and downstream. The primary design



consideration in this reach was the Chanute shale underclay. Because of the large difference between the peak and residual values for the "S" strength not all factors of safety were above 1.0 using residual strengths. The stability was considered adequate because design strengths were conservatively picked and an analysis based on residual strengths is inherently conservative.

f. Left Abutment (Station 113+70 to Station 120+35). The height of the embankment in this reach varies from 67 feet to 0 feet. The upstream slope is 1 on 3 from top of dam to elevation 928.2, 1 on 8 to elevation 898.2, and 1 on 4 to the ground surface. The downstream slope is 1 on 3 from top of dam to elevation 929.0, 1 on 8 to the service road, and 1 on 3 to the ground surface. Between Station 114+70 and 115+70 the impervious section transitions into a zoned section with a random and berm zone. The upper breakpoint was raised and the slopes steepened to accommodate foundation conditions that are somewhat different in this reach.

5-05. Zoning. The zoning of the embankment was selected to make maximum use of materials from required excavations and to minimize the need for material from commercial sources, and to satisfy the requirements for stability and seepage control.

a. Impervious. A central impervious zone is used across the valley. This zone is larger than necessary to control through seepage and is so sized because impervious material is readily available. Impervious consisted of CL and CH overburden material as based on the Unified Soil Classification System in accordance with Waterways Experiment Station Technical Memorandum 3-357. Impervious upstream of the dam axis contains less than 5 percent gravel. Shale material was not permitted for impervious. Compaction requirements were at least 95 percent of maximum dry density as determined by the standard effort compaction test described in EM 1110-2-1906. Placement moisture contents were limited to a range of 3 percent above optimum to 2 percent below optimum.

b. Pervious. An inclined drain downstream of the impervious core and a horizontal blanket with stringers extending to the downstream toe were designed to intercept seepage through the embankment and control seepage as it exits the downstream portion of the embankment. The downstream blanket extends from Station 59+00 to Station 120+30 and is continuous to Range 1+00 downstream. Stringers 50 feet wide and 3 feet thick extend to the toe at Stations 90+00, 95+00, 100+00, and 105+00. The blanket is continuous on the left abutment from Station 111+70 to Station 120+30. The blanket is continuous on the right abutment from Station 59+00 to the top of the left stream bank of Big Bull Creek extending to the centerline of the existing gully or downstream toe. There is also a pervious drain on the downstream side of the cutoff trench which is buried from Station 44+82 to Station 75+00 on the right abutment and from Station 116+00 to Station 118+88 on the left abutment. From Station 75+00 to Station 116+00 the inclined drain in the cutoff trench is brought up to the pervious blanket. The inclined drains have a minimum horizontal thickness of 6 feet and the blanket has a minimum thickness of 3 feet. A one foot thick crushed stone filter was placed between the pervious drain in the cutoff trench and the face of the Drum Limestone and Iola Formation where joints up to 1/2 inch width existed. Compaction requirement was a minimum relative density of 70 percent.

c. Random. Random zones were provided for use of sandy or gravelly materials. Random material consists of overburden material, except OH, Pt, MH, and OL. Materials with liquid limit above 60 were not allowed in the random zone. Also shale materials were not permitted. Compaction and moisture control were the same as impervious.

d. Berms. Berms consist of shale and other material from required excavation which was unsuitable or in excess of the requirements for impervious and random. The outer portion of the upstream berm was constructed with CH material.

5-06. Seepage Control. By using embankment zoning, a cutoff trench, and a grout curtain, through seepage and underseepage will be controlled to prevent excessive water loss and to insure the safety of the embankment.

a. Through Seepage. Through seepage will be controlled by the combination of the impervious core and pervious drain. The impervious core will keep the quantity of through seepage small. The pervious drain will intercept any seepage that exits from the downstream face of the impervious core. This will insure that the phreatic line will remain well within the embankment and will not adversely affect the stability of the downstream slope.

b. Underseepage. Underseepage will be controlled by a cutoff trench across the valley. The cutoff trench was excavated through the Drum limestone across the valley. Pressure tested borings into the bedrock strata below the cutoff trench substantiate the strata are sufficiently impervious to prevent adverse seepage through the bedrock underlying the cutoff trench. The bedrock in the valley is overlain by 15 feet or more of clay for more than a mile up and downstream of the dam axis. An inclined pervious zone exists on the downstream side of the cutoff trench to intercept any underseepage and to act as a filter to prevent piping of the impervious material.

c. Abutment Seepage. Seepage through the abutments will be controlled by the curtain grouting and the upstream clay blanket on the right abutment. The cutoff trench was excavated into sound bedrock from Station 43+75 to Station 79+50. The cutoff trench extends to Station 121+00 on the left abutment. Some seepage through the abutments is possible, however such seepage will not adversely affect the safety of the project because any flow would have lengthy seepage paths through rock formations.

d. Grouting. Grouting verified that bedrock units are tightly jointed and relatively impermeable. Out of 500 holes drilled in the right abutment, grout was injected into 12 holes. Most of the grout was injected into a sandstone lense in the Chanute shale. In the left abutment grout was injected in 11 of 202 holes drilled. Most of the grout was injected into the limestones. Approximately 280 sacks of grout were injected into bedrock.

5-07. Selected Design Strengths. In selecting design values, stress strain compatibility, the relationship of maximum shear strength to ultimate shear strength, the number of tests, the nature of the material, and the location of the material with respect to potential failure surfaces, were all considered.

a. Adopted Foundation Strength.

(1) Foundation Overburden. The foundation overburden was divided into different reaches, and in the main valley the overburden was divided by layers of lean and fat clay.

(a) "Q" strength. For the abutments, a design "Q" shear strength of  $C = 0.90$  t.s.f.,  $\tan \phi = 0$  was used. For the main valley, a design "Q" shear strength of  $C = 0.20$  t.s.f.,  $\tan \phi = 0.20$  was used for normal stresses up to 3 t.s.f., and  $C = 0.80$  t.s.f.,  $\tan \phi = 0$  for normal stresses above that. For the Little Bull area, a design "Q" shear strength of  $C = 0.1$  t.s.f.,  $\tan \phi = 0.10$  was used for normal stresses up to 3 t.s.f., and  $C = 0.40$  t.s.f.,  $\tan \phi = 0$  for normal stresses above that. Foundation "Q" strengths are summarized on Plate 50.

(b) "R" strength. For the abutments and main valley, a design "R" strength of  $C = 0.3$  t.s.f.,  $\tan \phi = 0.20$  was used. For the Little Bull area, a design "R" strength of  $C = 0.1$  t.s.f.,  $\tan \phi = 0.2$  was used. Foundation "R" strengths are summarized on Plate 51.

(c) "S" strength. For the abutments, a design "S" shear strength of  $C = 0$ ,  $\tan \phi = 0.35$  was used. For lean clays in the valley, a design "S" shear strength of  $C = 0$ ,  $\tan \phi = 0.45$  was used. And for fat clays in the valley,  $C = 0$ ,  $\tan \phi = 0.35$  was used. Residual "S" strengths of  $C = 0$ ,  $\tan \phi = 0.25$ ,  $0.30$ , and  $0.25$  were also used for these respective cases. Foundation "S" strengths are summarized on Plate 49.

(d) Residual strengths. Although "residual" (large strain) "S" shear strengths based on test results for the foundation clays were used in the stability studies in DM 7, an examination of the safety factors and corresponding failure planes show the Quivira underclay to be the dominant factor. The critical failure planes are in each case along the Quivira and only cross through the foundation clays. Since the foundation clays are alluvial deposits they have been basically deposited horizontally. The residual "S" shear tests on these materials were conducted along a horizontal orientation also. As in the case of sedimentary rocks the horizontal shear strength is generally less than the "cross bed" shear strength. It is reasonable to assume this would be valid for the subject foundation clays also. Therefore, on the basis of orientation and the short length of the critical failure planes in the foundation clays the peak shear strengths in DM 7 were used in the stability studies with residual strengths for the Quivira shale.

(2) Foundation shales. The shear strengths used for the Quivira shale in the original design were a peak strength of  $\tan \phi = 0.21$  and a residual strength of  $\tan \phi = 0.13$ . These strengths were based on the results of drained direct shear tests performed during the preparation of the embankment Design Memorandum. Limited test data were available as a basis for these design strengths, but it was believed that these were the only tests representative of a possible weak or soft zone in the Quivira Shale underclay. In later testing performed from samples obtained during exploratory work at the time the cutoff trench was excavated, only one test with a peak strength of  $\tan \phi = 0.20$  approached the original peak design strength. All other test

results were significantly higher. The test data summary is presented on plates 57 and 58. After extensive exploration and testing failed to substantiate a continuous low strength zone in the Quivira Shale underclay a very conservative peak strength of  $\tan \phi = 0.21$  was not changed, instead, redesign of the embankment used a reduced safety factor requirement. The testing of the Quivira shale had been directed at determining the strength of the suspected soft zone in the underclay, thus only the softer, worst case, samples were tested. Since the zone is discontinuous the residual shear strength conditions should not exist. Because of the discontinuity of the soft zone and the fact that the test program produced conservative strength values a design strength for analyses conducted for this report was selected such that two-thirds of the test values exceed the design value. The selected strength value was  $\tan \phi = 0.37$ .

b. Adopted Embankment Strengths. The strengths of the impervious, random, and pervious were assumed to be the same during design. The higher strength of the pervious zone was ignored to simplify stability analysis. A design "Q" strength of  $C = 0.70$  t.s.f.,  $\tan \phi = 0.0$ ; a design "R" strength of  $C = 0.20$  t.s.f.,  $\tan \phi = 0.18$ ; a design "S" strength of  $C = 0$ ,  $\tan \phi = 0.45$  was used. The "Q" and "R" strengths correspond to the strength envelopes through points on the Mohr circle representing stresses on the failure plane. Record control testing during construction indicated the design strengths were conservative. The design strengths were obtained from testing remolded test specimens from the borrow areas. The prepared specimens were compacted to 95 percent which was the minimum condition allowed in the field. Material compacted to higher dry densities and dry of optimum, representing the actual field condition, should have higher strengths. A summary of the record control test data is presented in the following table.

TABLE 2

Record Control Tests

## HILLSDALE R.C. TESTS

Material	"Q"		"R" ( $\bar{\sigma}_H$ vs $\bar{\sigma}_V$ )		$R\left(\frac{\sigma_1 - \sigma_3}{2} \text{ vs. } \frac{\sigma_1 + \sigma_3}{2}\right)$		"S"	
	c, tsf	tan $\theta$	c, tsf	tan $\theta$	c, tsf	tan $\theta$	c, tsf	tan $\theta$
Rt. Abut Impervious Zone	1.45	0.00	0.65	0.24	0.62	0.20	0.00	0.46
Rt. Abut. Random Zone	1.43	0.00	0.66	0.22	0.58	0.20	0.0	0.46
Main Valley Impervious Zone	1.32	0.00	0.85	0.22	0.76	0.20	0.00	0.48
Main Valley Random Zone	1.00	0.00	0.44	0.32	0.35	0.26	0.00	0.46
Little Bull Impervious Zone	1.32	0.00	0.49	0.29	0.41	0.25	0.00	0.51
Little Bull Random Zone	1.33	0.00	0.55	0.28	0.46	0.24	0.00	0.47
Conduit Impervious Zone	1.30	0.00	0.39	0.33	0.31	0.27	0.00	0.52
Left Abut. Impervious Zone	1.30	0.00	0.73	0.31	0.64	0.25	0.00	0.47
Left Abut. Random Zone	1.08	0.00	0.76	0.42	0.56	0.33	0.00	0.57

The consolidated-undrained test data are presented showing strengths representing the envelope drawn tangent to the Mohr circles and strengths representing the shear strength at failure on the failure plane versus the effective normal consolidation stress on the failure plane. The latter strength envelope is more appropriate in stability analysis as a relationship between shear strength and effective normal or consolidation stress the failure plane prior to undrained shear.

c. Adopted Design Strengths. The following table presents the physical soil properties used in reevaluating the stability of the embankment.

TABLE 3

PHYSICAL SOIL PARAMETERS

Material	Unit Weight (pcf)		"Q"		"R"		"S"	
	Saturated	Drained	c (tsf)	Tan $\phi$	c (tsf)	Tan $\phi$	c (tsf)	Tan $\phi$
Lower Right Abutment (Station 81+00)								
Berm	115	110	0.10 0.40	0.10 0.00	0.10	0.20	0.00	0.35
Random	125	120	1.43	0.00	0.66	0.22	0.00	0.46
Impervious	125	120	1.45	0.00	0.65	0.24	0.00	0.46
Foundation Clay	115	110	0.20 0.80	0.20 0.00	0.30	0.20	0.00	0.45
Quivira Shale	140	-	-	-	-	-	0.00	*0.21
Main Valley (Station 90+00)								
Berm	115	110	0.10 0.40	0.10 0.00	0.10	0.20	0.00	0.35
Random	125	120	1.00	0.00	0.44	0.32	0.00	0.46
Impervious	125	120	1.32	0.00	0.85	0.22	0.00	0.48
Foundation Clay, CH	115	110	0.20 0.80	0.20 0.00	0.30	0.20	0.00	0.35
Foundation Clay, CL	115	110	0.20 0.80	0.20 0.00	0.30	0.20	0.00	0.45
Drum Limestone	165	-	-	-	-	-	0.00	0.70
Quivira Shale	140	-	-	-	-	-	0.00	*0.21
Little Bull Area (Station 104+00)								
Berm	115	110	0.10 0.40	0.10 0.40	0.10	0.20	0.00	0.35
Random	125	120	1.33	0.00	0.55	0.28	0.00	0.47
Impervious	125	120	1.32	0.00	0.49	0.29	0.00	0.51
Foundation Clay, CL	115	110	0.10 0.40	0.10 0.00	0.10	0.20	0.00	0.45
Drum Limestone	165	-	-	-	-	-	0.00	0.70
Quivira Shale	140	-	-	-	-	-	0.00	*0.21

\*Quivira shale strength revised to  $C = 0.00$  tsf and  $\tan \phi = 0.37$  which represents an envelope through the lower one-third of the record control test results.

5-08. Stability Analysis. The The stability analysis of the original embankment design is presented in Design Memorandum No. 7, Soil Data and Embankment Design, Appendix B. The analysis was performed with a computer program compatible with the wedge method of analysis presented in EM 1110-2-1902 with two exceptions. The slope of the "side" force was assumed to be constant throughout the active wedge, and the angle of the failure plane was

assumed to be the same for each material in the active wedge. The analytical cases used in design were the end of construction condition for the upstream and downstream slopes, sudden drawdown and partial pool conditions for the upstream slope, and steady seepage condition for the downstream slope. Earthquake safety factors were checked for the partial pool, steady seepage and construction cases.

a. Design Assumptions. The higher strengths of the pervious zone and the cutoff trench were not used in the analysis. These are conservative and simplifying assumptions. For the end of construction case it had been assumed consolidation during construction was negligible and the line of saturation was at the ground surface. For the partial pool cases it was assumed the line of saturation to be horizontal at the pool elevation, considered. For the steady seepage case it was assumed the lake elevation to be at the spillway crest which is conservative in that this is the maximum pool that can be stored. For steady seepage at maximum surcharge pool, no additional saturation was assumed. Vertical equipotential lines were assumed. Sudden drawdown cases assumed the embankment was saturated to the upper pool limit and the pool was lowered to multipurpose pool instantaneously with no drainage of pore water.

b. Embankment Stability. The embankment was analyzed at various locations representing differing foundation conditions existing at the site. The stability analyses for the lower right abutment, main valley, Little Bull area, outlet works section, and left abutment are summarized on plates 59 to 63. Revised conduit location and conduit embankment section required a reanalysis of the outlet works section (plate 64). The designed embankment was based on the assumption that a "weak" zone or seam in the Quivira underclay was continuous across the entire valley. Since the continuity of seam was uncertain it was decided to retain the original design with the provisions to redesign the embankment after an evaluation of the Quivira underclay.

(1) Embankment redesign. Based on the extensive number of explorations and laboratory shear tests it was concluded that the "weak" zone in the Quivira underclay was not continuous or extensive. However, rather than discount the presence of this weak layer by choosing a higher design strength, it was believed to be more appropriate to use a very conservative peak strength and require a reduced safety factor. The embankment section was revised to provide an approximate safety factor of 1.4 for the steady seepage and partial pool cases. Although the safety factors for the end of construction, earthquake, and rapid drawdown cases were checked, the resulting safety factors did not influence the revised embankment. Normally a minimum 1.0 safety factor for the earthquake case is considered desirable. However, in view of recent developments in earthquake engineering which indicate the pseudo-static method of determining earthquake safety factors does not adequately take into account soil dynamic strength. However, the design strength safety factors around 1.0 for the earthquake case, are adequate since none of the materials are potentially liquefiable. Considering the improbability of residual shear conditions for a rapid drawdown case, those safety factors were not considered significant for the revised embankment section. Three embankment stations were selected for stability analyses: Station 81+00, 91+00, and 104+00. (See plates 65, 66 and 67 for details.) The revised section safety factors shown in color on the above plates are as follows:

TABLE 4

Design Memorandum Stability Studies

<u>Station</u>	<u>Peak Strength Safety Factor</u>	<u>DM Supplement Residual Strength Safety Factor</u>
<u>Station 81+00</u>		
End of construction	1.72	-----
Rapid drawdown from spillway crest	1.21	-----
Partial pool	1.41	1.10
Steady seepage	1.39	1.00
Earthquake	1.05	-----
<u>Station 90+00</u>		
End of construction	1.68	-----
Steady seepage	1.40	1.02
Earthquake	1.00	-----
<u>Station 104+00</u>		
Construction halt Elev. 930.2	1.39	-----
Rapid drawdown from spillway crest	1.21	-----
Partial pool	1.44	1.13
Steady seepage	1.39	1.02
Earthquake	1.00	-----

Note: Upstream embankment was constructed in Stage I, therefore, upstream safety factors apply as shown in the original DM 7.

(2) Stability reevaluation. For this report, the embankment stability was reevaluated based on as built conditions. Stability analyses during design assumed excess pore pressure from construction had dissipated in the embankment and foundation shales for the partial pool and steady seepage cases. Actual instrumentation data indicates the upstream overburden is saturated with a piezometric surface that reflects the pool elevation. Excess pore pressures have not dissipated either in the impervious zone nor in the Quivira shale. The embankment was analyzed for the steady seepage and partial pool cases using present construction induced pore pressure levels.

(a) Method of analysis. The computer program used for design does not facilitate the analysis of uplift forces in the foundation. A computer program, SSTAB1-BR, developed for the Bureau of Reclamations by Stephen G. Wright, University of Texas, Austin, was used because it can analyze a noncircular failure surface with a phreatic surface in the embankment and pore water pressures in the foundation. SSTAB1-BR uses Spencer's procedure to calculate the safety factor for specified noncircular slip surfaces. It is a special solution of the Morgenstern and Price method in which all the interslice side forces are assumed to have the same inclination. The program satisfies all conditions of equilibrium. The two



unknown parameters, F, (the safety factor) and theta,  $\theta$ , (the side force inclination) are varied simultaneously. By iteration, a convergent solution is found with the net force and moment imbalance less than specified values. The method does not compute the same safety factor as the wedge analysis prescribed in EM 1110-2-1902. The side forces are inclined throughout the failure block using Spencer's procedure, while only the earth force in the active wedge is inclined in the wedge analysis. A hand wedge analysis using the inclined side forces from SSTAB1-BR for the steady seepage case at station 81+00 resulted in a safety factor of 1.62. A hand study using the EM prescribed wedge method resulted in a safety factor that was 0.2 less than Spencer's safety factor.

(b) Safety factors. The embankment sections considered in the redesign analyses were evaluated for the partial pool, rapid drawdown and steady seepage cases. Increased embankment strengths based on record control test results were used with the design foundation strengths. Quivira shale strength was  $C=0$ ,  $\tan \phi=0.21$ . The reevaluated safety factors are shown in the following table.

TABLE 5

Stability Studies Using Embankment Strengths from  
Record Control Tests And Design Foundation Strengths

Case	DM Supplement Safety Factor <u>(Required)</u>	Safety Factor <u>(From Studies)</u>
Rapid Drawdown (from Spillway Crest)	1.2	1.39
Rapid Drawdown (from Maximum Surcharge)	1.0	1.30
Partial Pool (Sta. 81+00)	1.4	1.54
Steady Seepage (Sta. 81+00)	1.4	1.13
Steady Seepage (Sta. 90+00)	1.4	1.15
Steady Seepage (Sta. 104+00)	1.4	1.15

The rapid drawdown and partial pool cases indicated higher safety factors. The steady seepage cases showed lower factors of safety. The factors of safety obtained were considered very conservative because the foundation strengths were obtained to reflect the fact that the soft zone in the Quivira shale is continuous. Therefore, the Quivira shale strength was revised to represent an envelope where two-thirds of the test values exceeded the envelope. The revised foundation strength ( $\tan \phi=0.37$ ) resulted in the following factors of safety.

TABLE 6

Stability Studies Using Embankment Strengths From  
Record Control Tests And Revised Foundation Strengths

<u>Case</u>	<u>Safety Factor (Required)</u>	<u>Safety Factor (From Studies)</u>
Rapid Drawdown (from Spillway Crest)	1.2	2.00
Rapid Drawdown (from Maximum Surcharge)	1.0	1.90
Partial Pool (Sta. 81+00)	1.5	2.17
Steady Seepage (Sta. 81+00)	1.5	1.63
Steady Seepage (Sta. 90+00)	1.5	1.64
Steady Seepage (Sta. 104+00)	1.5	1.69

The most critical case was steady seepage at Station 81+00. This section occurs in the closure area where the excess pore pressures from construction are the highest. The calculated factor of safety is above the required 1.5 and will continue to increase as the pressures in shale continue to dissipate. This critical case was evaluated by a hand wedge analysis that yielded a safety factor of 1.62.

5-09. Settlement. Settlement analyses, based on consolidation tests, were run on the foundation overburden. The maximum total settlement in the valley was anticipated to be 1.5 feet. Settlement analyses of the embankment were not performed because experience indicates there will be very little consolidation of the embankment after construction. Settlement plates were installed in the foundation overburden to monitor foundation settlement during and after construction. Crest settlement monuments were also installed on the crest of the dam to measure post construction settlement. The settlement plates show a maximum of 1.4 feet of settlement with over a foot occurring during construction. The crest settlement monuments indicate uniform settlement of less than 0.2 feet.

5-10. Slope Protection. Requirements for upstream slope protection were investigated for three separate segments of the dam. Fetches for each segment were determined in accordance with the radial fetch method as described in Technical Memorandum No 132. Wave heights were selected in accordance with Technical Manual No. 132. Overland wind velocities were determined from a wind analysis of records for Topeka, Kansas over a 23 year period. A 50 m.p.h. wind velocity was used to size the stone protection at multipurpose

pool to reduce some of the inherent risks in the area of frequent pool levels. "The Criteria for Riprap Wave Protection in Missouri River Division," dated June 1974, were generally used for riprap slope protection design. Riprap design data is shown on Plate 17.

CHAPTER 6

CONSTRUCTION HISTORY

6-01. General. The Hillsdale embankment was built under three contracts supervised by the Kansas City District, Corps of Engineers. The Contractor for the Stage I contract was J. A. Tobin Construction Company, Kansas City, Kansas. Cutoff trench, outlet works channel and diversion channel were excavated and part of the embankment was constructed under this contract. Stage I work started in April 1976 and was completed in December 1977. The Stage II Contractor was Southwest Construction Corporation, Oklahoma City, Oklahoma, work was initiated in June 1977 and completed in May 1980. The outlet works were constructed under the Stage II Contract. The embankment was completed under the Stage III Contract, work began in July 1978 with the completion of the embankment in July 1982.

6-02. Modifications. The following modifications were made to the contracts.

TABLE 7

Modifications

Stage I

<u>Modification No.</u>	<u>Subject</u>
P00001	Pervious and Filter Material Changes
P00002	Time Extension Due to Weather Delays
P00003	Time Extension Due to Weather Delays
P00004	Time Extension Due to Weather Delays
P00005	Time Extension Due to Weather Delays
P00006	Unit Price of Cutoff Trench Cleanup Class I.

Stage II

<u>Modification No.</u>	<u>Subject</u>
P00001	Excavation for Pier
P00002	Time Extension Due to Ironworkers Strike and Weather Delays
P00003	Bubbler System
P00004	Handrails and Kickplates for Intake Tower
P00005	Electrical Work and Lightning Protection
P00006	Time Extension Due to Weather Delays
P00007	Electrical Work
P00008	Time Extension Due to Weather Delays
P00009	Test Holes in Conduit Monolith Nos. 2 and 3

TABLE 7 (continued)

Stage II (continued)

<u>Modification No.</u>	<u>Subject</u>
P00010	Time Extension Due to Weather Delays
P00011	Hydraulic Pipe Support Brackets, Valves, and Pulley Assembly for Emergency Gate
P00012	Emergency Gate Crane Bumper Plates
P00013	Administrative Change of Contractors Address
P00014	Time Extension Due to Weather Delays
P00015	Emergency Gate Storage Bracket and Lifting Beam Ring
P00016	Administrative Change of Payment Office
P00017	Additional Conduit Roof Form
P00018	Time Extension Due to Weather
P00019	Administrative Change of Contractors Address
P00020	Suspension of Work on the Tower
P00021	Administrative Change of Contractors Address
P00022	Constructive Welding Changes

Stage III

<u>Modification No.</u>	<u>Subject</u>
P00001	Well - Plugging
P00002	Lightening Protection Work
P00003	Grouting Spring at Outlet Works, Sta. 55+50
P00004	Castle Dimensions on PYLON DETAIL
P00005	Culvert Length of Outlet Works Road 2, Sta. 1+65
P00006	Crest Elevation of the Upstream Cofferdam
P00007	Time Extension Due to Weather Delays
P00008	Deletion of Requirement to Obliterate South Access Road
P00009	Well - Plugging, Well No. 5 and 10
P00010	Construction of Upstream Rock Service Road
P00011	Service Bridge Abutment Fill
P00012	Deletion of Required Timber Clearing
P00013	Culvert for South Access Road, Sta. 101+00
P00014	Time Extension due to Weather Delays

TABLE 7 (continued)  
Stage III (continued)

<u>Modification No.</u>	<u>Subject</u>
P00015	Wash Checks in Ditch of North Access Road, Concrete Ditch Liner for Toe Service Road, and Earth Cover Over Pervious Wick.
P00016	Stoplogs, Apertures, Trash Racks, and Lifting Beam Remedial Work
P00017	Administrative Change of Payment Office
P00018	Guardrails for Toe Service Road
P00019	Electrical Work
P00020	Time Extension Due to Weather Delays
P00021	Extension of South Access Road
P00022	Bituminous Surfacing
P00023	Bituminous Tack Coat Pavement Markings for the South Access Road, Dam Road, and North Access Road
P00024	Additional Costs due to Non-availability of Work Areas and Delay of Diversion
P00025	Crushed Stone Base Course Quantities

Modifications significant to the performance on construction of the embankment are discussed below.

a. Modification P00001. This change to the Stage I contract was necessary to insure adequate seepage control in the areas where the Chanute and Lane shales existed in the cutoff and to insure adequate seepage control in the areas where the jointed structures of the Drum and Raytown limestones existed in the cutoff trench. This change consisted of the following:

- (1) Pervious fill was placed against the Raytown limestone in the left abutment area.
- (2) From approximately Station 106+40 to 112+30, the bottom of the cutoff was widened and pervious was placed against the downstream side of the trench. The pervious formed a drain extending to the ground surface.
- (3) From approximately Station 71+90 to 79+15, the bottom of the cutoff trench was widened and pervious was placed against the downstream side of the trench. The pervious formed a drain extending to the ground surface, but not above Elevation 900.0 in the area where none was encountered.
- (4) From Station 44+50 to 71+90, pervious was placed to a height of two feet above the top of bedrock on the downstream slope of the cutoff trench.

(5) From approximate Station 79+00 to 106+50, a one foot horizontal width of crushed stone filter material was placed against the Drum limestone on the downstream side of the cutoff trench.

(6) A one foot horizontal width of crushed stone filter material was placed between the Raytown limestone and the pervious drain where open joints exceeded one-fourth inch in width.

b. Modification P00006. This change to the Stage III contract required the elevation of the upstream cofferdam to be raised from Elevation 895.0 to 906.0. The change was made as a result of additional hydrologic studies indicating inadequate overtopping protection.

c. Modification P00010. This modification to the Stage III contract provided an upstream service road on the embankment for access to observation devices and access to the upstream slope for repair of potential wave damage.

d. Modification P00015. This modification to the Stage III contract required a 1-foot cover over the pervious drain in the closure area during the 1980-1981 winter shutdown to prevent contamination of the pervious material. The earth cover was compacted and shaped to drain away from the drain. The cover was removed and the pervious material was cleaned with top lift being recompacted the following spring.

#### 6-03. Cutoff trench.

a. Excavation. Cutoff trench excavation was characterized as overburden, Class I, or Class II rock. The Contractor was required to determine the suitability for usage in the embankment at the time of excavation with unsuitable material to be placed in diversion dikes or channel fill stockpiles. The cutoff trench excavation was maintained in the dry during excavation, cleanup, grouting, and backfilling. Blasting operations and methods of ripping were controlled so that the gradations of the materials were suitable for use in the embankment. Slopes, 1 on 1 or steeper, in bedrock were presplit or sawed, the Quivira shale in the cutoff trench was required to be sawed. The approximate limits of the cutoff trench were shown on the construction drawings with the actual limits determined from the condition of the bedrock.

(1) Cutoff trench in limestone formations. Within the cutoff trench on each abutment, the upper surface of the Iola and Drum were completely exposed prior to removal of any portion of the formation. Rock excavation was completed prior to construction of the grout curtain.

(2) Cutoff trench in shale formations. Excavation was continued to a depth necessary to remove all desiccated, deteriorated, fractured, and weathered rock that was determined to be unsatisfactory. Equipment used in the material was mounted on rubber tires to prevent damage to the final bedrock surface. Excavation of shale was a continuous operation to the final depth except where grouting on shale surface (station 106 to station 115) resulted in 3 to 5 feet of chanutte shale being excavated after grouting.

Within 24 hours after exposure, final bedrock surfaces were cleaned, inspected and backfilled with a minimum of 12 inches of embankment material. During the period of exposure, bedrock surfaces were sprayed with water as needed to prevent drying. Within 48 hours after exposure three feet of embankment material was required to be placed. The length of the reach of the trench that was allowed to be open was restricted to the length that could be excavated, cleaned, inspected, and embankment placed as required.

b. Cutoff trench cleanup. Cleanup of the bedrock surface was performed on the floor and where directed on the bedrock portion of the sideslopes. Cleanup consisted of removing unsound, fractured or loose rock, and other objectionable material. Cleanup was accomplished by barring, picking, brooming, and when directed, by use of air-water jetting. All overhangs, cavities or large joints, and irregularities in the bedrock were cut back, excavated, and backfilled with pervious or filled concrete.

c. Grouting. Preliminary investigations prior to construction indicated that a single line grout curtain was needed in both abutments. Grouting was performed from the floor of the cutoff trench on bedrock. Grout holes were drilled with a pneumatic rotary drill using 2 1/2 inch diameter non-coring bits. All holes were drilled, washed, pressure tested, and grouted in stages from the top down. Primary holes were drilled on 20-foot centers with secondary holes midway between and tertiary holes midway between the primary and secondary holes. The holes were inclined landward 30 degrees and 45 degrees from vertical. Some holes were drilled parallel to the dam axis, some were directed upstream 45 degrees and some 65 degrees. The grout consisted of 3 cubic feet of water and 1 cubic foot of cement. Grouting verified that bedrock units in the abutments are tightly jointed and relatively impermeable. Out of 500 holes drilled in the right abutment, grout was injected into 12 holes. Most of the grout was injected into a sandstone lense in the Chanute shale. Approximately 260 sacks of grout were injected, mostly in four of the 12 holes. In the left abutment out of 202 holes drilled, 19.4 sacks of grout were injected into 11 holes. Most of the grout was injected into the limestones. A total of approximately 280 sacks of grout were injected into bedrock and 1,205 sacks were used for backfill. Grout hole drilling totalled 22,699 lineal feet. A grouting summary is shown in Table 8.

TABLE 8

Summary of Grouting

<u>Left Abutment</u>	<u>Lineal Feet Drilled</u>	<u>Sacks of Grout Injected</u>
75 Primary Holes	2,473	11.0
74 Secondary Holes	2,250	8.4
53 Tertiary Holes	1,232	0
202 TOTAL	5,955	19.4



TABLE 8 (continued)

<u>Right Abutment</u>	<u>Lineal Feet Drilled</u>	<u>Sacks of Grout Injected</u>
168 Primary Holes	5,732	148.7
166 Secondary Holes	5,590	105.13
<u>166 Tertiary Holes</u>	<u>5,377</u>	<u>6.0</u>
500 TOTAL	16,699	259.83

BACKFILL: - 1,205 Sacks

279.23 Sacks = 0.0123 Sacks Per Foot of Hole  
22,699 Lineal Feet

Right Abutment Grout Curtain Extension  
Station 77+00 to Station 79+40

13 Primary Holes	499	0.8
12 Secondary Holes	455	0
<u>1 Tertiary Hole</u>	<u>50</u>	<u>0</u>
26 TOTAL	1,004	0.8

Conduit Grouting

6 Primary Horizontal Holes at station 59+62.5	150	27
4 Primary Radial Holes at station 60+00	<u>96</u>	<u>0</u>
10 TOTAL	246	27

d. Changes as a Result of Construction Experience. A reach of the grout curtain, Station 76+00 to Station 79+45 was deleted from the Stage I contract because a large detached block of sandstone was discovered in the right abutment area. Because blasting was required to remove the block, grouting of this reach was deferred to the Stage III contract. Evaluation of the foundation, during Stage I particularly the Quivira shale and Raytown limestone, as a result of the construction of the cutoff trench lead to redesign of the embankment and modifications to the cutoff trench and previous drain.

6-04. Outlet Works. The outlet works as described in paragraph 2-04 was constructed under the Stage II contract with excavation initiated in August 1977. The entire outlet works are founded on the Chanute shale. Special surfaces and bearing surfaces, surfaces with slopes 1 on 1 or steeper which concrete was placed against, were excavated to leave the surfaces as nearly undisturbed as possible. Materials outside the excavation lines and grades indicated on the drawings was replaced with fill concrete. Excavation of the last 2 feet for special surfaces was performed immediately prior to placing concrete. Approach and outlet channel profile and sections and conduit grouting details are shown on Plate 22. Progress of construction under the Stage II contract fell behind resulting in scheduling problems during Stage III.

6-05. Embankment Construction. The embankment was constructed under the Stage I and Stage III contracts from materials obtained from required excavation and supplemented from upstream borrow. All suitable materials obtained from required excavation were used in the embankment. Unsuitable materials excavated in order to obtain suitable borrow material were used in channel fill, diversion dike or wasted back into the valley borrow areas.

a. Foundation Treatment. Prior to placement of fill the foundation was cleared of depressions by flattening the slopes of the depressions and filling them with compacted layers of material appropriate for the embankment zone in which they were located. Existing wells in overburden were back-filled with impervious material and wells in bedrock were grouted. Earth foundation areas were thoroughly stripped and loosened by plowing or discing to a depth of 8 inches. Roots and other debris uncovered in the process of loosening were removed and then the foundation was compacted with a rubber-tired roller or other heavy loaded rubber-tired equipment. When fill was constructed against an existing earth slope it was processed through the loose or dried material on the surface so that the existing material and the new fill was bonded together.

b. Embankment Materials.

(1) Impervious material consists of CL and CH (liquid limit not more than 60) overburden material as based on the Unified Soil Classification System in accordance with Waterways Experiment Station Technical Memorandum 3-357. Impervious material placed upstream of the dam axis contains less than 5 percent gravel. There is no shale material in the impervious material. Impervious in the conduit area consists of CL material only. There were no liquid limit restrictions on the impervious dike section on the right abutment.

(2) Pervious was Kansas River sand obtained from approved commercial sources. The material was required to be clean free-draining, durable, natural sand within the following gradation ranges as determined by washing over the specified sieves.

<u>Sieve size</u>	<u>Percent by weight passing</u>
No. 4	90-100
No. 16	55-85
No. 50	5-20
No. 200	0-5

(3) Random consists of overburden material, except OH, Pt, MH, and OL, from required excavation. Shale material was not allowed in the random zone. Materials with liquid limit above 60 were not used in the random zones except the outer 5 feet of the upstream slope below Elevation 942.2 which was required to be CH material with no restrictions on liquid limit.

(4) Berm material consists of shale and other material from required excavation which was unsuitable or in excess of the requirements for impervious and random.

(5) Clay blanket consists of CH material obtained from required excavation and supplemented with CH material from borrow.

c. Placement. Fill was not placed on any part of the embankment foundation until the area had been inspected and approved. All embankment material, except material for the diversion dike and channel fill was placed and compacted in the dry. No frozen material was allowed to be placed in the embankment. Fill was not allowed to be placed on or above frozen material. Water was not allowed to pond on the embankment and the surface was maintained so that construction equipment was able to travel on the embankment. The top surface of the fill within any zone was maintained approximately horizontal, except as otherwise approved. The differential in height of fill at the contact between adjacent zones of the embankment was limited to 3 feet. During construction, the embankment was sloped with grades not steeper than 5 percent and not less than 2 percent to facilitate surface drainage. Compacted fill adjacent to the pervious was maintained so that the compacted pervious fill was not below the adjacent support fill. Immediately after compaction of the pervious additional pervious fill was placed to maintain the uncompacted fill above the adjacent fill. Materials disturbed after compaction were reprocessed and recompactd. Materials were distributed throughout the embankment so that the fill was free of lenses, pockets, streaks, and layers of amterial differing substantially in texture or gradation from the surrounding material of the specified type. The travel distance of hauling equipment across the surface prepared for material placement was kept to a minimum. Successive loads of material was dumped at locations on the fill as directed or approved by the Contracting Officer. Material was spread in approximately horizontal layers. In zones where materials were adjacent to zones of significantly coarser materials, the coarse materials were sufficiently well graded to provide filter action so the fine material would not infiltrate into the voids of the coarse material. In general material was distributed in the impervious zone so that the more impervious materials were placed upstream of the axis of the dam. The more gravelly clays and less impermeable materials were placed downstream of the axis of the dam. In general, the more impermeable of the random material was placed adjacent to the impervious zone and the more permeable random was placed in the outer portion of the random fill. Whenever the surface of any layer developed ridges, or bridged, or became to smooth to bond properly with the succeeding layer it was loosened by scarifying before the next lift was placed. When a rubber-tired roller was used each lift surface was scarified prior to placement of the next lift. Before any layer was roller, it was processed by disking to the depth of the uncompacted layer thickness. When the surfa became unduly wet or dry, it was processed and rerolled. Frozen fill was disked and properly recompactd before additional material was placed. This same procedure was used then the surface had cracked due to drying, had softened due to an increase in surface moisture content, and when tying into a previously built portion of the embankment. When the work was stopped on an area, it was smooth-bladed and sealed with either rubber-tired or smooth-wheel rollers to prevent absorption of rainfall and to facilitate drainage.

d. Compaction. The embankment was constructed to the following minimum compaction criteria. A procedure specification was used to meet these criteria.

TABLE 9

Compaction Criteria

<u>Material</u>	<u>Criteria</u>
Impervious fill	95 percent maximum dry density (standard effort)
Random fill	95 percent maximum dry density (standard effort)
Pervious fill	70 percent relative density
Berm fill	Compaction by rubber-tired roller

Compaction equipment, layer thickness, and number of passes for the various materials were specified with additional passes required as directed to obtain the desired compaction. A complete pass consisted of complete coverage of the area to be compacted with each trip of the roller overlapping the adjacent trip by not less than 2 feet. The specified compaction requirements are as follows:

TABLE 10

Compaction Procedure

<u>Type of fill and compaction equipment</u>	<u>Maximum uncompacted lift thickness (inches)</u>	<u>Minimum number of passes</u>
<u>Pervious</u>		
Plate vibratory compactor	6	As required to obtain specified relative density
Vibratory rollers	12	3
<u>Impervious #</u>		
Tamping roller	8	6
<u>Random and clay blanket</u>		
Tamping roller	8	6
Rubber-tired roller	12	3
<u>Berm</u>		
Rubber-tired roller	24	2
<u>Diversion dike</u>	24	Traffic compacted

TABLE 10 (continued)

<u>Type of fill and compaction equipment</u>	<u>Maximum uncompacted lift thickness (inches)</u>	<u>Minimum number of passes</u>
<u>Special backfill</u> Power tamper	3	As required to provide compaction equivalent to adjacent embankment material
<u>Channel, waste, and area fills</u>	No. max.	None required
<u>Rock fill</u>	36	None required

#When placed over a rock foundation, the lift thickness shall be 6 inches and compaction shall be two passes with a rubber-tired roller until the impervious zone reaches 18 inches thickness over the rock foundation. If the rubber-tired roller causes breakage of shale foundation, the ballast shall be lessened or the use of other rollers may be used as approved by the Contracting Officer.

The following list of equipment used during the construction of the embankment includes the compaction equipment.

TABLE 11

Equipment Used for Embankment Construction

<u>Make</u>	<u>Model</u>	<u>Equipment</u>	<u>Number</u>	<u>General use</u>
Hercules	WSX83-60120	Sheepsfoot Roller, 40,000 lb.	2	Soil compaction
Gebhard	#22	Sheepsfoot roller, 48,000 lb.	1	Soil compaction
Hyster	455A	Self propelled sheeps- foot roller, 49,000 lb.	1	Soil compaction
Ferguson	Rt-100S	Pneumatic roller, 100,000 lb.	2	Soil compaction
Raygo	320A	Vibratory roller, 14,340 lb.	1	Pervious fill compaction
Raygo	410A	Vibratory roller, 21,400 lb.	1	Pervious fill compaction

TABLE 11 (continued)

<u>Make</u>	<u>Model</u>	<u>Equipment</u>	<u>Number</u>	<u>General use</u>
Mikasa Sanlya	MVC-300G	Hand operated vibrator, 500 lb.	1	Pervious fill compaction
Ground Pounder		Hand operated compactor, 200 lb.	1	Pervious fill compaction
		Crane operated drop hammer	1	Backfill compaction adjacent to structure
Caterpillar	657B & 631	Scrapers	14	Borrow material excavation and haul
(Various)		Rear dump haulers		Borrow material haul
Euclid	B-70	Bottom dump haulers, 40 cu yd	17	Borrow material haul
Holland		Mobile belt loaders	2	Borrow material excavation
		Water trucks	2	Saturating pervious fill
Grade-All	1100	Gradall	1	Cutoff trench excavation & riprap placement

Additional equipment used include motor graders, bulldozers, bucket loaders, backhoes, dragline, and disks.

The Raygo 320A vibratory roller did not meet the specifications for weight, drum diameter, or drum width, however it was approved based on test data verifying the desired density could be obtained with this roller. Bedrock irregularities in the foundation and bedrock slopes under compacted impervious fill and adjacent to concrete structures required special compaction techniques to insure compaction was equivalent to adjacent embankment material. Compaction of the backfill along the conduit was obtained by air operated "powder puffs," a crane operated drophammer and wheel rolling with a rubber-tired loader.

e. Moisture Control. The upper limit of moisture content was 3 percent above the optimum moisture content and the lower limit was 2 percent below optimum for the impervious and random material. Material placed on the embankment with a moisture content exceeding 3 percent above optimum was spread and permitted to dry, assisted by disking as necessary, until the

moisture content was uniform and reduced to within the limits. Material placed with a moisture content less than 2 percent below optimum was sprinkled on the fill and worked with disks until the moisture content was within the required limits. Water applied to the fill was controlled so that free water would not appear on the surface during or subsequent to rolling. The pervious material was required to be wetted as necessary to facilitate compaction. Pervious material was maintained essentially saturated during compaction. Moisture content was controlled to the extent required to facilitate movement of compaction equipment.

f. Construction Control Procedures. The quality of the construction was controlled through a contractor quality control program and the government's quality control program and the government's quality assurance sampling and testing procedures.

(1) Quality Control. The contractor established a quality control system to maintain quality of his work as well as that of his subcontractors and to maintain compliance with the plans and specifications.

(2) Quality Assurance. Control tests were conducted by the government to verify the quality of the embankment. Testing was performed in accordance with Engineering Manual EM 1110-2-1906, Laboratory Soils Testing, and Hillsdale Lake specifications, and Hillsdale Lake field and laboratory testing manuals.

(a) Impervious and Random Fill. The most important control feature for the impervious and random fill was the moisture content range. This range was specified to have an upper limit of 3 percent above optimum and a lower limit of 2 percent below optimum. Materials placed at a moisture contents within this range and using the specified lift thickness and number of passes should have dry densities not less than 95 percent of maximum. During Stage I and Stage III construction over 1600 sand cone density tests were performed to insure that this criteria was being met. Plate 75 shows the moisture content results from these field tests by showing plots of Deviation From Optimum Moisture Content vs. Number of Tests. Material which did not have moisture contents within the specified range or did not have dry densities of at least 95 percent of maximum, were generally reworked. Maximum dry density and optimum moisture content were determined by the standard compaction test. Prior to and during construction, a large number of 5 point compaction curves were established. To determine the compaction curve applicable to a particular field test, a one point compaction test run on the material at a moisture content slightly below optimum. Most of these field tests included a liquid limit, and occasionally a plastic limit determination. In addition to the field density tests, 211 record control samples were taken. These samples were sent to the MRD Laboratory for more extensive testing to check the physical properties assumed for design. Results from both the field control tests and the record control tests are presented in plates 70 through 151.

(b) Berm Fill. The only moisture content control for the berm fill was the ability of the roller to travel on it. No record control tests and a very limited number of field density tests were taken on this fill material.

(c) Pervious Fill. The compaction criteria for the pervious fill was based on a relative density of 70 percent. The field density tests consisted of both the sand cone method and the nuclear method. Along with each field density test a mechanical analysis was performed to insure that the gradation fell within the range specified.

(d) Undisturbed Samples. Samples were obtained for record control testing. Sampling procedure involved excavating down to a pervious lift leaving a smooth surface, and pushing a 6-inch diameter cylinder into the compacted material. Undisturbed samples of the embankment were also obtained using the 5-inch Shelby tube sampler.

6-06. Spillway. The spillway was excavated as shown on Plate 15. Excavation was accomplished by scrapers and dragline with the excavated material placed in dike section on the upper right abutment. Subsequent to completion of construction erosion of the spillway side slopes indicated the possibility of dispersive clay in the spillway subsequent laboratory conformed the dispersive clay. Evidence of the dispersive clay in the dike section cannot be found. The spillway was excavated into the Lane shale where moisture content required excavation by dragline and some of this material was placed in upstream berms section.

6-07. Diversion and Closure. The diversion channel as shown on Plate 7 was excavated during Stage I to divert Little Bull Creek to Big Bull Creek. The embankment was constructed to a minimum elevation of 913 prior to diversion. Final diversion through the outlet works followed the following sequence of events. Excavation of approach and outlet channels, except channel blocks were completed and riprap was placed in the outlet channel. The upstream and downstream channel blocks in the outlet works channel were removed, with the upstream plug removed last. A construction haul road across Big Bull Creek was used for the diversion dike. Foundation preparation included such excavation, stream bank excavation and cleanup of bedrock in the closure area. Stream banks were excavated to 1 on 3 slopes concurrently with placement of channel fill upstream of cofferdam. Upstream cofferdam was constructed to Elevation 906.0 and downstream cofferdam to Elevation 873. Excavation, cleanup and grouting was completed. Closure was made in 15 June 1980.



## CHAPTER 7

### INSTRUMENTATION

7-01. General. Embankment instrumentation was installed during construction to provide movement measurements, pore water pressure measurements both in the foundation and embankment, and groundwater levels for use in evaluating the performance of the dam. The Contractor was responsible for the installation of some of the devices and some were installed by the government. Six types of observation devices were installed in the embankment: open tube piezometer devices, air-operated piezometer devices (pressure cells), inclinometers, foundation settlement devices, alignment monuments, and crest settlement monuments. Construction sequence, topography, and geology were considered in locating each device. Plate 152 shows the location of each device. One line of piezometers was located in the closure area, a second line across the main valley area, and a line in the Little Bull Creek channel area. Additional piezometers are located in the abutments.

#### 7-02. Piezometers.

a. Air-operated Piezometers. There are 14 air-operated piezometers installed, 1 in the embankment, 6 in the overburden, and 7 in the foundation. Generally, the air cells indicate the upstream overburden is saturated, and the Drum limestone is fairly open allowing water to reach the Quivira shale with little headloss. The foundation air operated piezometers are located in the upper portion of the Quivira shale directly below the Drum limestone and they show a fairly rapid response to pool fluctuations.

b. Open Tube Piezometers. There are 52 open tube piezometers and 4 foundation settlement gages with open tube piezometers installed, 12 in the embankment, 13 in the overburden (including settlement gage piezometers), and 31 in the foundation.

c. Performance. It is suspected that the fluctuation with the pool of the upstream piezometers in the Quivira is a result of influence from seepage through the limestone layer overlying the shale. This is supported by the fact the upstream piezometric levels of piezometers whose tips are located deeper in the Quivira do not respond as quickly or as high as those closer to the limestone. The piezometers in the Quivira downstream of the dam axis do not fluctuate with the pool. Piezometers in the Quivira shale under the embankment indicate excess pore water pressure is still present from construction, however, it is dissipating. Piezometers in the Drum limestone in the valley indicate the Drum is open jointed and the cutoff trench is functioning with upstream devices response to pool changes. The Drum appears to be much tighter in the abutments than in the valleys, with pore water pressure build up during construction and little or no dissipation. Piezometer data agrees with observations made during construction, the Drum was weathered and upon jointed in the cutoff trench across the valley and

tightly jointed and relatively impermeable in the abutments. The Westerville limestone which underlies the Quivira shale also appears to be relatively impervious showing pore water pressure buildup during construction with slow dissipation. All of the piezometers in the embankment are located in the impervious zone, and they generally show a continued dissipation of construction pore pressure with the highest pressures in the bottom of the cutoff trench. Piezometer data is presented on Plates 193 through 260. Details of observation devices are shown on Plate 153.

7-03. Inclinometers. Eleven inclinometers are installed in the embankment to provide a means of measuring horizontal movements at different depths within the foundation and embankment. The locations of these devices are shown on Plate 153 with individual plots of movement on Plates 261 through 271. Inclinometer data shows movement up to 3 inches with most of it occurring during the first year. Generally readings are fluctuating indicating movement has stopped.

7-04. Foundation Settlement Plates. There are four foundation settlement plates located in the foundation overburden. Actual settlement agrees with the predicted settlement of 1.5 feet. Plates 193 through 196 show settlement data with the maximum total settlement 1.43 feet and the rate of settlement decreasing. Most of the settlement occurred during construction.

7-05. Alignment Monuments. Four lines of alignment monuments provide horizontal and vertical movement measurements. Alignment data is presented on Plates 156 through 192. Alignment monument lines A, B, and C indicate a decreasing rate of settlement. The settlement is predominately in the closure area on lines A, B, C. Line D is submerged. The maximum total vertical movement is 0.251 feet of settlement on line A. The largest total horizontal movement is 2.63 centimeters.

7-06. Crest Settlement Monuments. Nine crest settlement monuments indicate uniform settlement. The maximum settlement is 0.135 feet in the closure area. The centerline profile surveyed at 100-foot intervals shows close agreement with the crest settlement monuments indicating uniform settlement.

PHOTOGRAPHS

PHOTOGRAPHS

HILLSDALE

Embankment Criteria and Performance Report



1. Right Abutment Cutoff Trench.



2. Station 116+50. Downstream Slope of Cutoff Trench.

HILLSDALE

Embankment Criteria and Performance Report

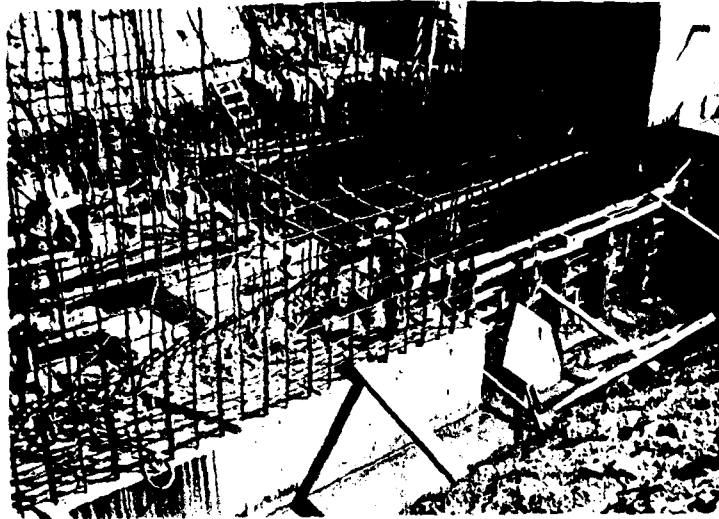


3. Cutting Box Sample From Quivira Shale.



4. Sand Cone Density Test in Pervious Fill.

HILLSDALE  
Embankment Criteria and Performance Report



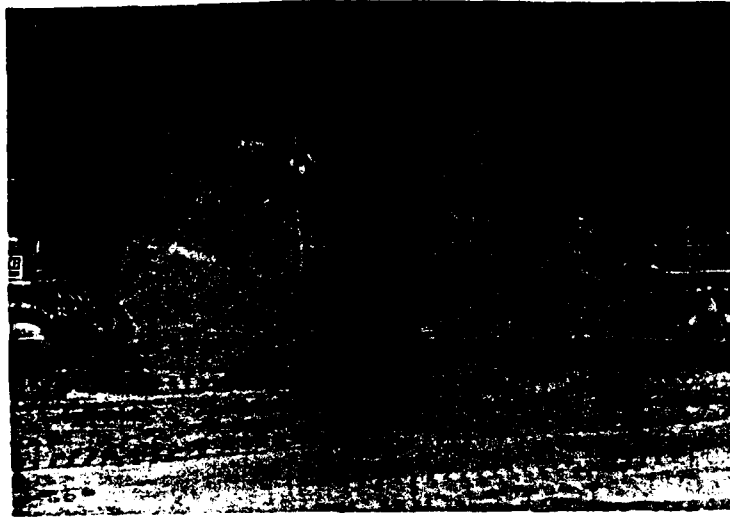
5. Placing Reinforcement for Conduit.



6. Constructing Conduit.

HILLSDALE

Embankment Criteria and Performance Report

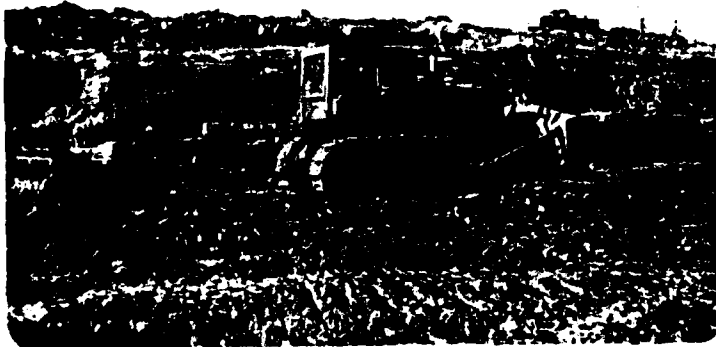


7. Mobile Belt Loader Used for Excavating Borrow Material.

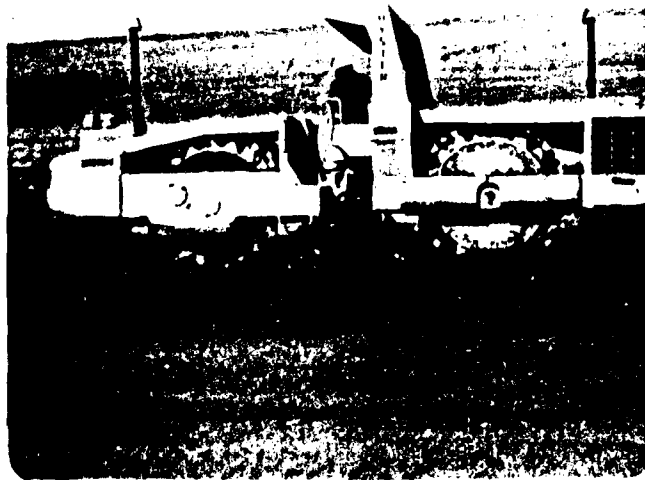


8. Bottom-Dump Haulers.

HILLSDALE  
Embankment Criteria and Performance Report



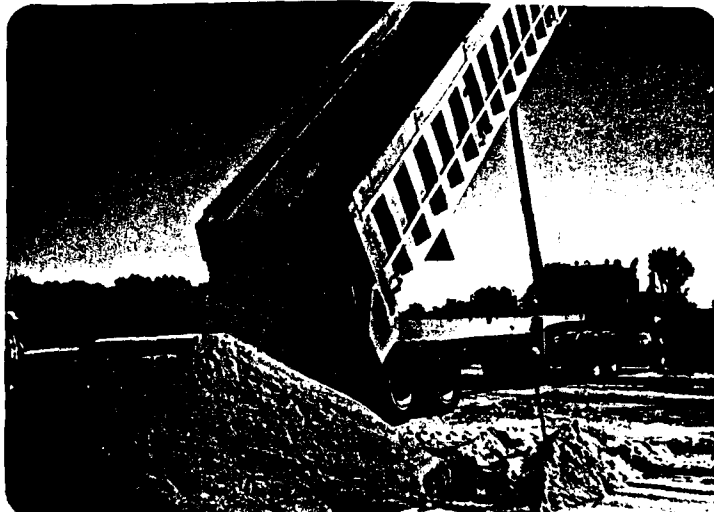
9. Bulldozer and Disk Used in Scarification



10. Self-Propelled Sheepsfoot Roller.



HILLSDALE  
Embankment Criteria and Performance Report

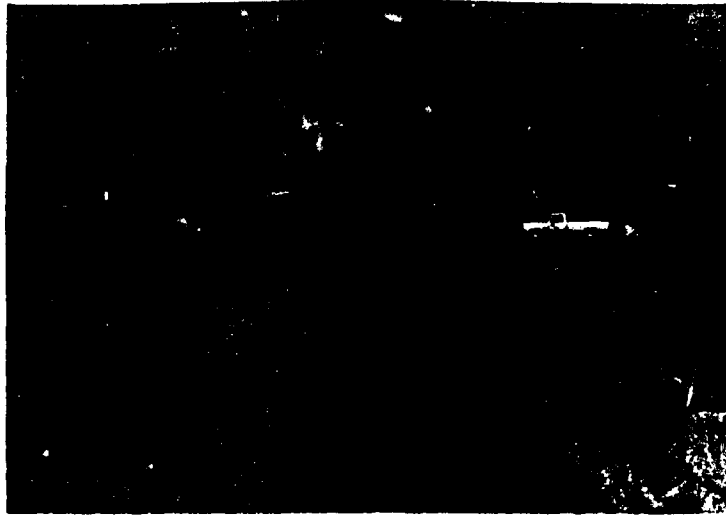


11. Rear-Dump Hauler Transporting Pervious Material.



12. Vibratory Roller Compacting Pervious Fill.

HILLSDALE  
Embankment Criteria and Performance Report

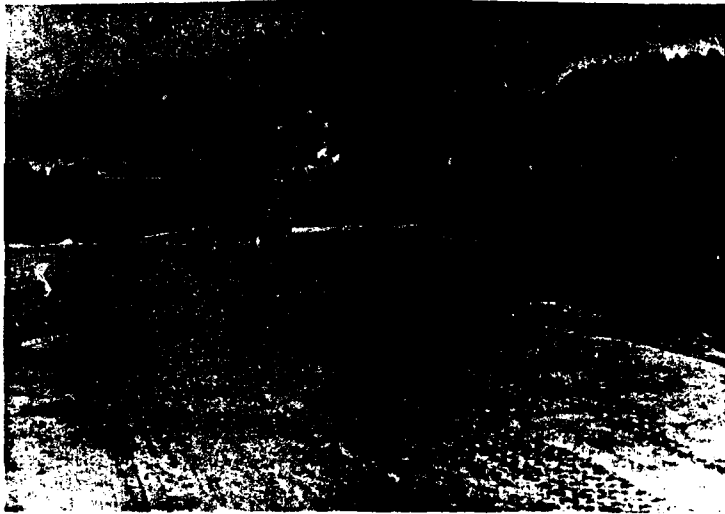


13. Spreading Pervious Blanket.

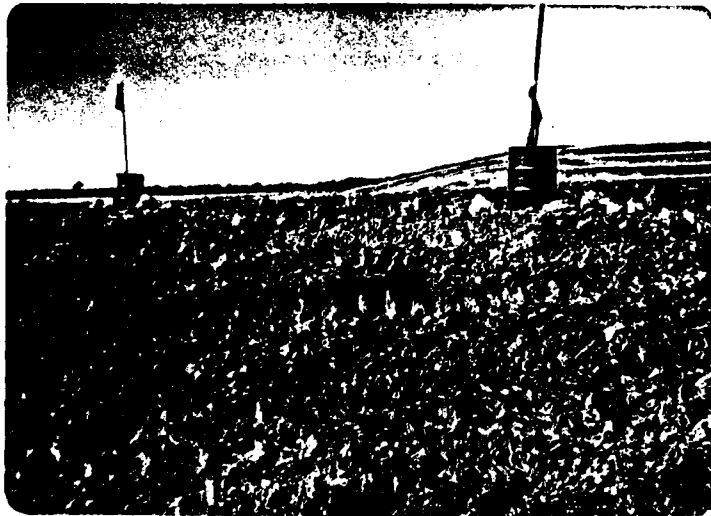


14. Watering Pervious Material.

HILLSDALE  
Embankment Criteria and Performance Report



15. Compacting Pervious Fill.

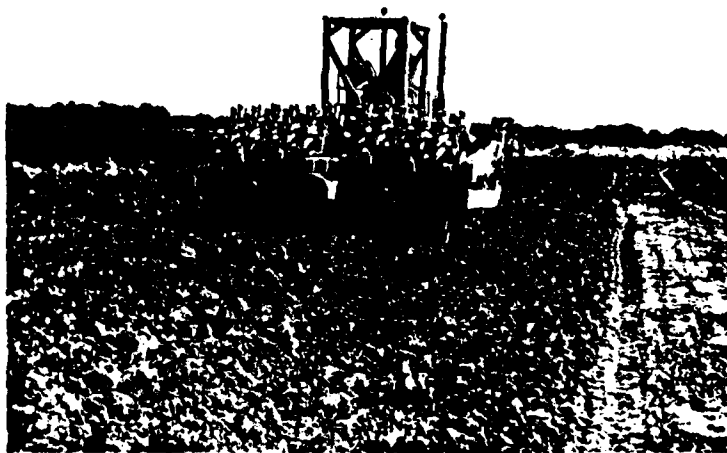


16. Protection for Instrumentation During Construction.  
(Foundation Settlement Devise on Left and Piezometer on Right).

HILLSDALE  
Embankment Criteria and Performance Report



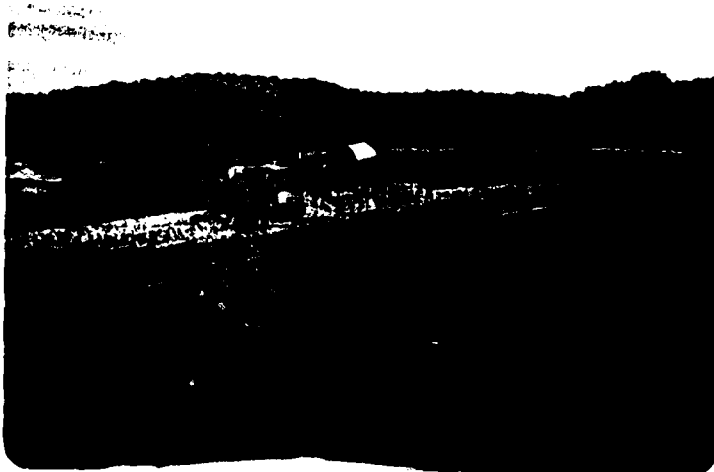
17. Grading Embankment Fill.



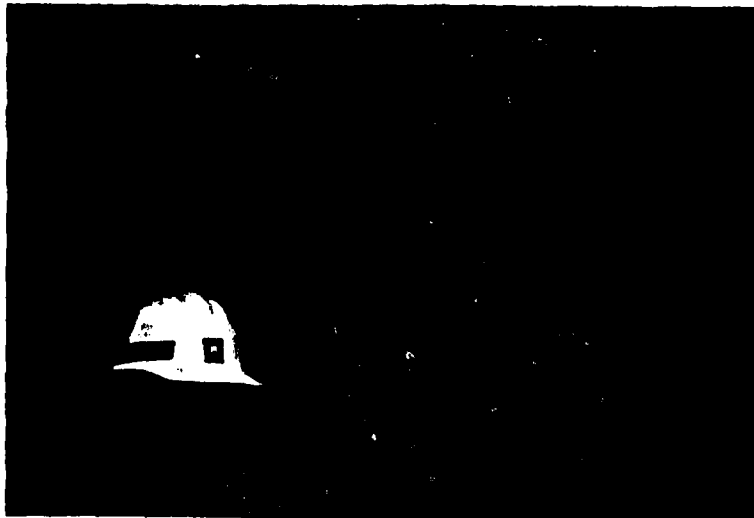
18. Compacting Fill.

HILLSDALE

Embankment Criteria and Performance Report



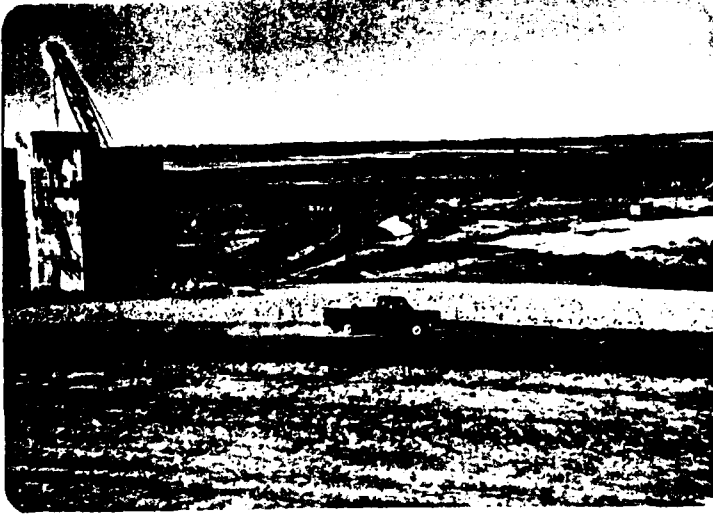
19. Placing Riprap on the Upstream Slope Near Left Abutment.



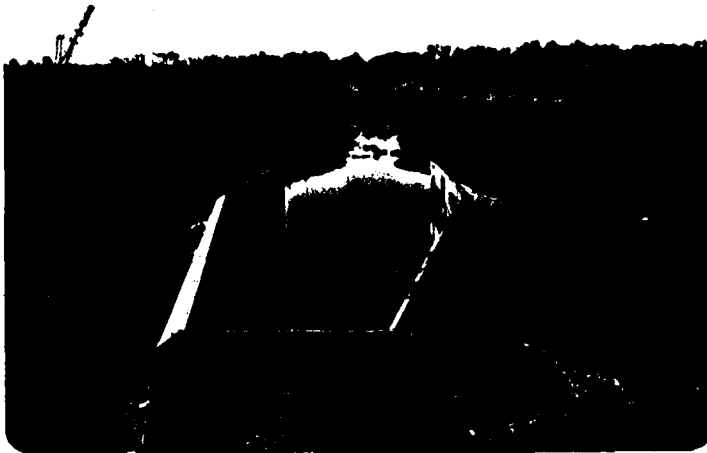
20. Twelve Inch Riprap in Place.

HILLSDALE

Embankment Criteria and Performance Report



21. Intake Tower.



22. Stilling Basin.

HILLSDALE

Embankment Criteria and Performance Report



23. Placing Limestone and Shale on Upstream Slope of the Cofferdam.



24. Fill Placement in the Closure Area.

HILLSDALE  
Embankment Criteria and Performance Report



25. Survey Monument.

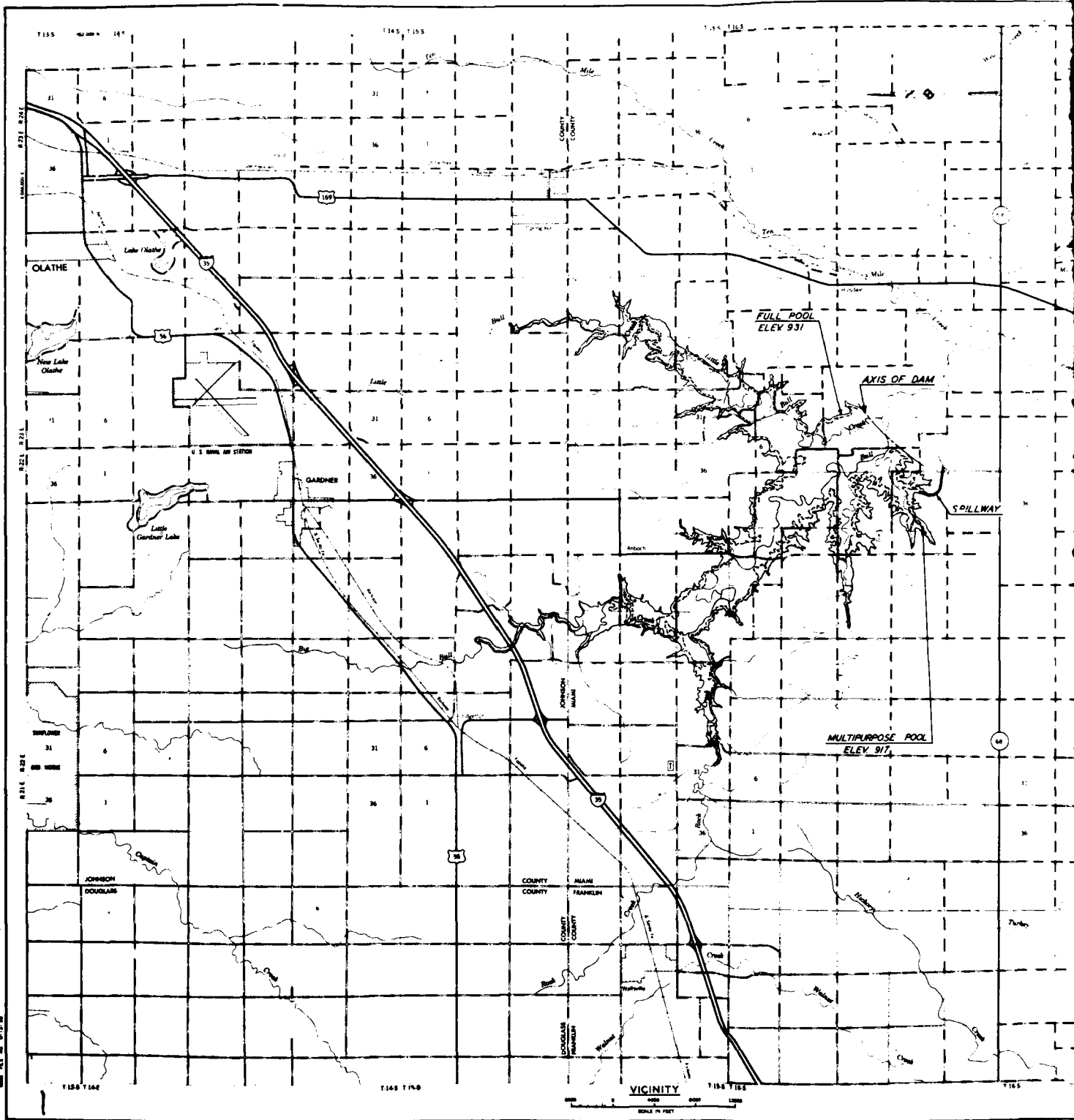


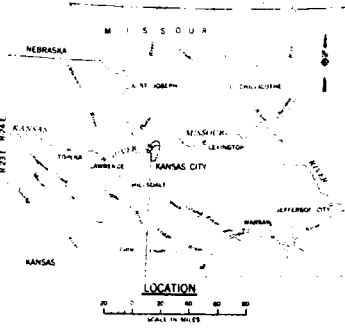
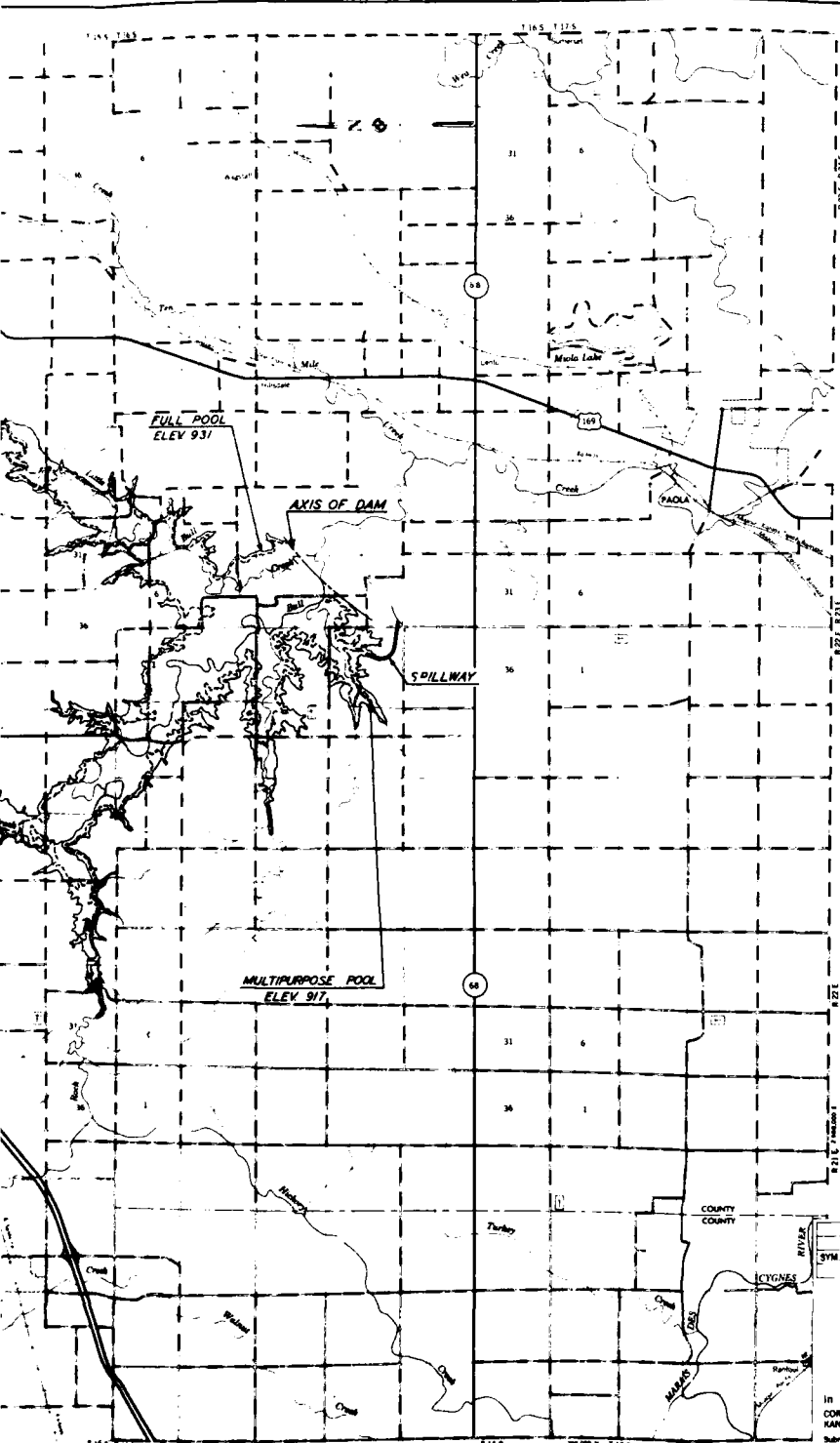
26. Station 94+00. Downstream Slope.



DRAWINGS

DRAWINGS





SYN	DESCRIPTION	DATE	APP'D.
	REVISIONS		

**HILLSDALE LAKE**  
BIG BULL CREEK

**LOCATION AND VICINITY**

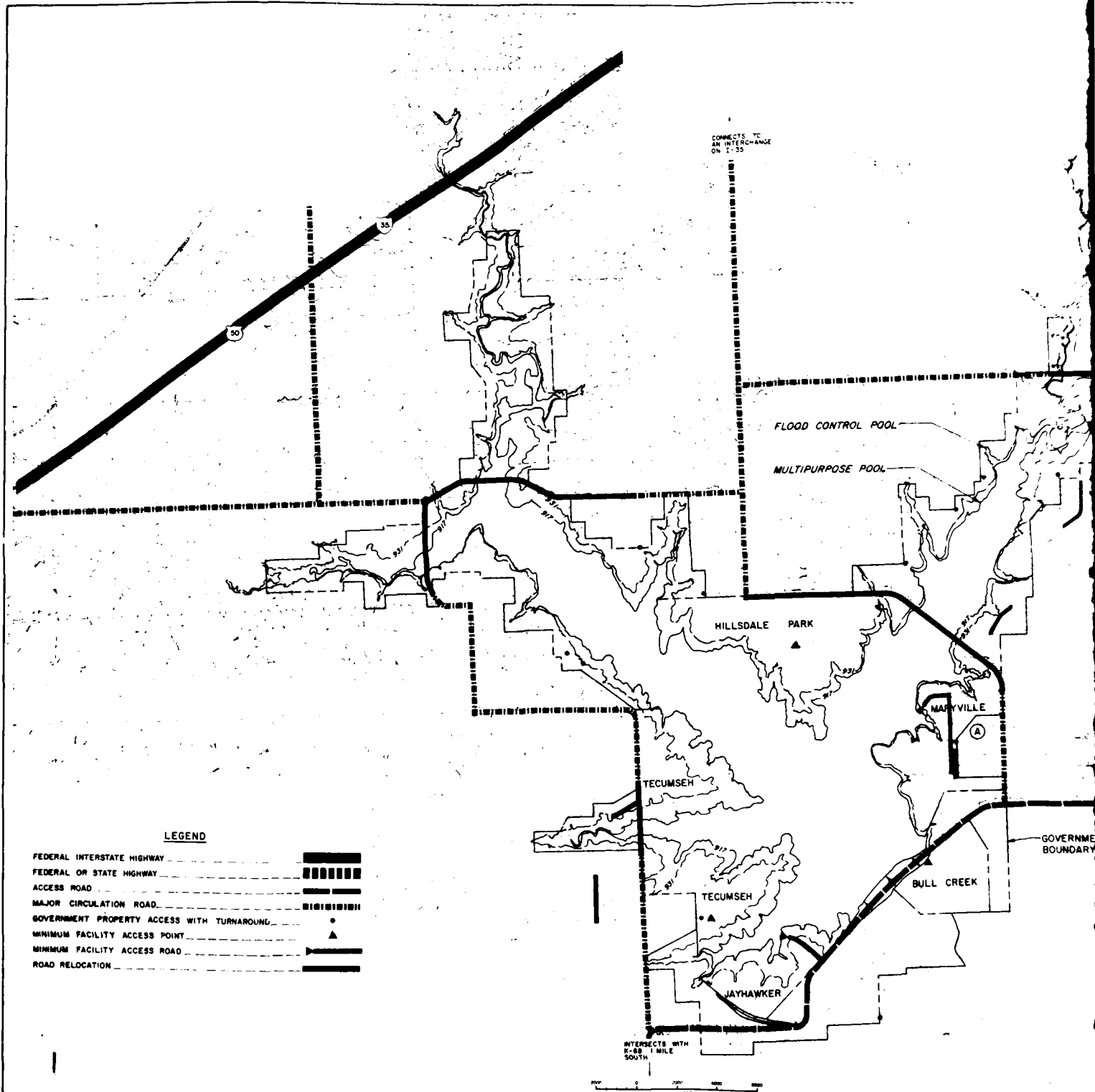
In 1 sheet  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

Sheet No. 1

Scale: as shown  
U. S. ARMY  
MARCH 1971

Submitted by: *[Signature]*  
Checked by: *[Signature]*  
Designed by: *[Signature]*  
P.S.T. P.S.T. RFD DM-7

PLATE NO 1



**LEGEND**

- FEDERAL INTERSTATE HIGHWAY
- FEDERAL OR STATE HIGHWAY
- ACCESS ROAD
- MAJOR CIRCULATION ROAD
- GOVERNMENT PROPERTY ACCESS WITH TURNAROUND
- MINIMUM FACILITY ACCESS POINT
- MINIMUM FACILITY ACCESS ROAD
- ROAD RELOCATION

CONNECTS TO  
AN INTERCHANGE  
ON I-50

FLOOD CONTROL POOL

MULTIPURPOSE POOL

HILLSDALE PARK

MARYVILLE

GOVERNMENT  
BOUNDARY

TECUMSEH

TECUMSEH

BULL CREEK

JAYHAWKER

INTERSECTS WITH  
R-69 1 MILE  
SOUTH



CONNECTS TO  
AN INTERCHANGE  
ON I-35

FLOOD CONTROL POOL

MULTIPURPOSE POOL

HILLSDALE PARK

MARYVILLE

TECUMSEH

GOVERNMENT  
BOUNDARY

BULL CREEK

TECUMSEH

JAYHAWKER

INTERSECTS WITH  
K-66 1 MILE  
SOUTH

SYN	DESCRIPTION	DATE	APP'D.
(A)	Relocated Min Fac. Rd alignment & added access point		

BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
MASTER PLAN

MAJOR THOROUGHFARES AND PROJECT ACCESS

In 1 sheet  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

Sheet No 1

Scale: as shown  
U. S. ARMY  
FEBRUARY 1979

Submitted

Recommended

Approved

PROJECT ENGINEER

CHIEF DIVISION BRANCH

PLATE NO.

DESIGNED BY  
DHR

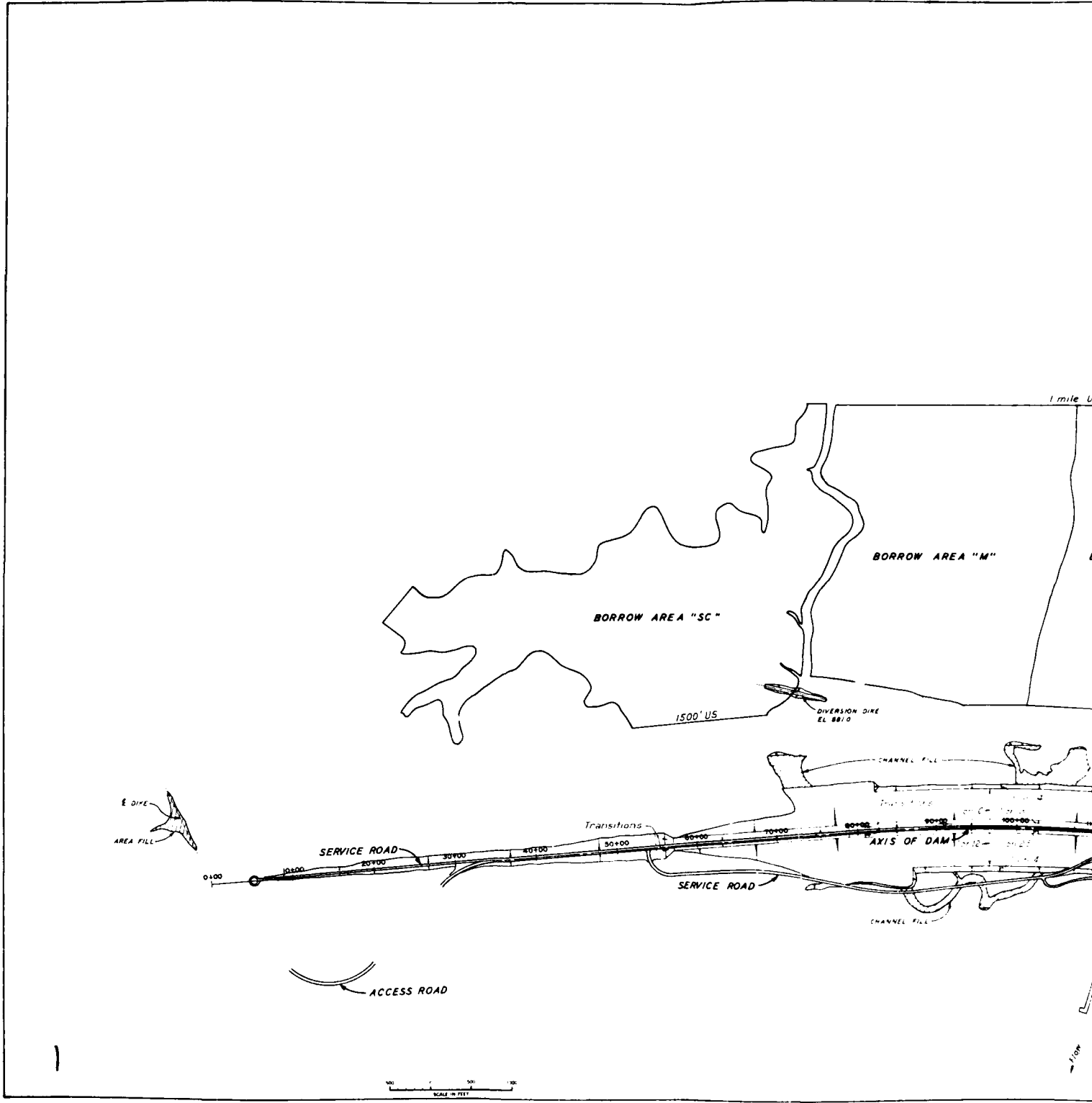
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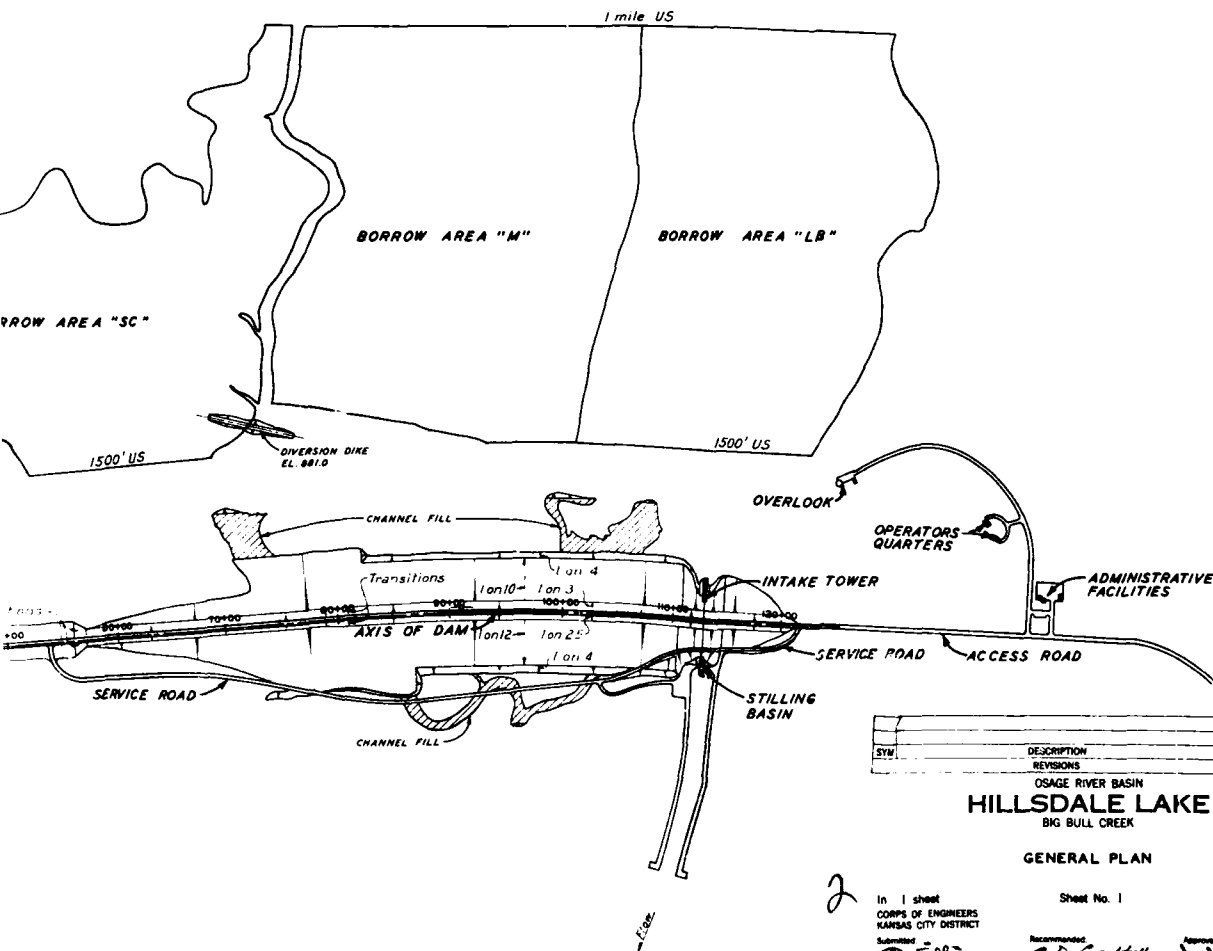
CHECKED BY  
WJH

DM-13

0-15-612

PLATE NO. 2





SYM.	DESCRIPTION	DATE	APP'D.
	REVISIONS		

OSAGE RIVER BASIN  
**HILLSDALE LAKE**  
 BIG BULL CREEK

GENERAL PLAN

2

In 1 sheet  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT

Submitted by *R. J. ...*  
 CHECKED BY *J. C. ...*  
 COMPILED BY *J. C. ...*

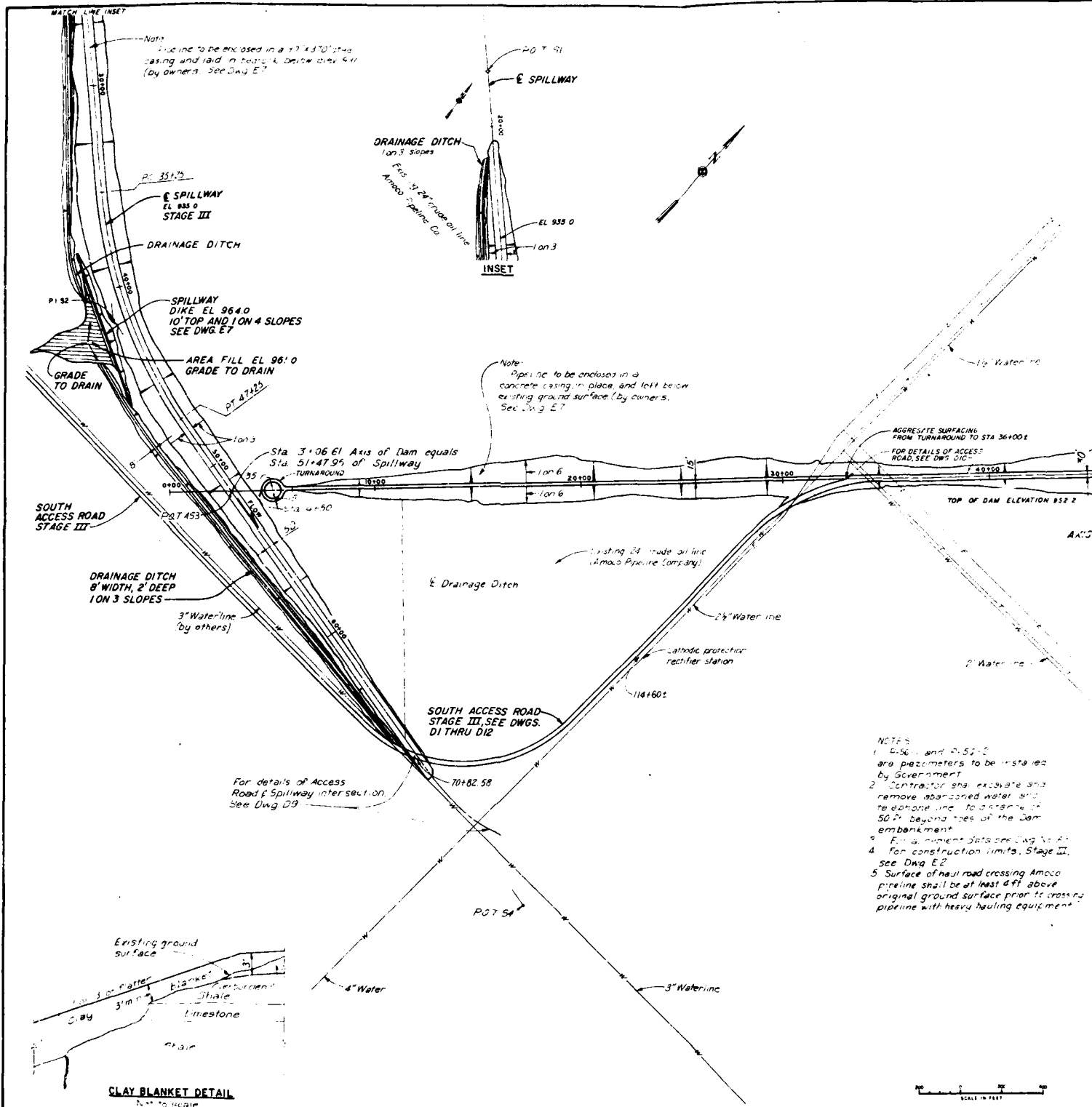
Sheet No. 1

Scale: as shown  
 U. S. ARMY  
 MARCH 1976

Recommended by *R. D. ...*  
 CHECKED BY *R. D. ...*  
 R.F.D.

Approved by *[Signature]*  
 FILE NO.  
 DM-7 0-15-182

PLATE NO. 3



Note: Pipe to be enclosed in a 17" x 30" pipe casing and laid in trench below elev. 941 (by owners. See Dwg. E7)

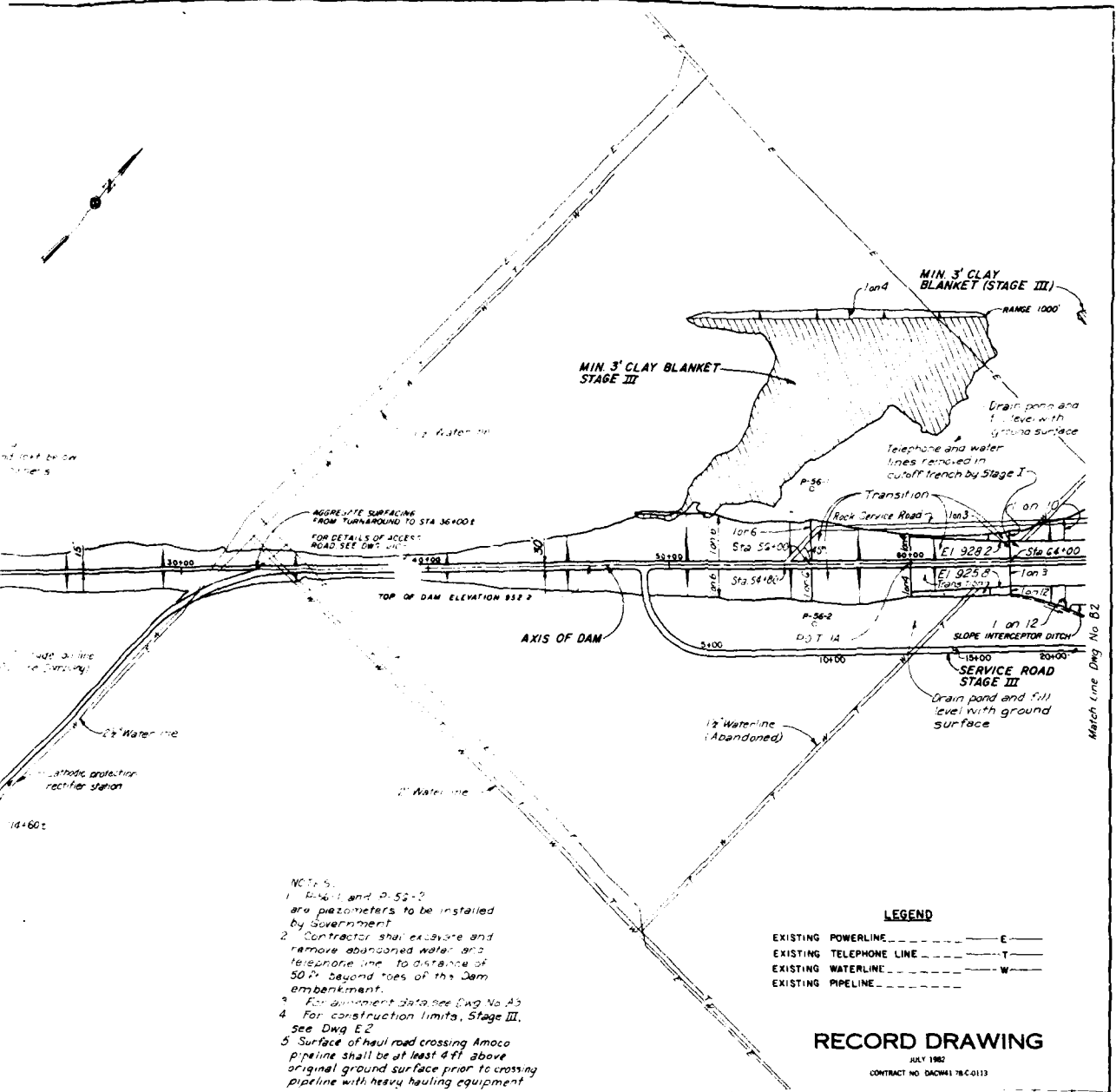
Note: Pipe to be enclosed in a concrete casing, in place, and left below existing ground surface (by owners. See Dwg. E7)

- NOTES
1. E.S.G. and P.S.I. are piezometers to be installed by Government.
  2. Contractor shall excavate and remove abandoned water and telephone line to a distance of 50' beyond toes of the Dam embankment.
  3. Elevation data see Dwg. E1 & E2.
  4. For construction limits, Stage III, see Dwg. E2.
  5. Surface of haul road crossing Amoco pipeline shall be at least 4 ft. above original ground surface prior to crossing pipeline with heavy hauling equipment.

CLAY BLANKET DETAIL  
NOT TO SCALE

SCALE IN FEET  
0 10 20 30





- NOTES:
1. P-56-2 and P-55-2 are piezometers to be installed by Government
  2. Contractor shall excavate and remove abandoned water and telephone line to distance of 50' beyond toes of the Dam embankment.
  3. For alignment data see Dwg No. A5
  4. For construction limits, Stage III, see Dwg E-2
  5. Surface of haul road crossing Amoco pipeline shall be at least 4'ff above original ground surface prior to crossing pipeline with heavy hauling equipment

**LEGEND**

EXISTING POWERLINE	---	E
EXISTING TELEPHONE LINE	---	T
EXISTING WATERLINE	---	W
EXISTING PIPELINE	---	P

**RECORD DRAWING**

JULY 1982  
CONTRACT NO. DACW4178-C-0113

Revised for "As Built" conditions

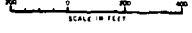
SYM.	DESCRIPTION	DATE	APP'D.
	REVISIONS		

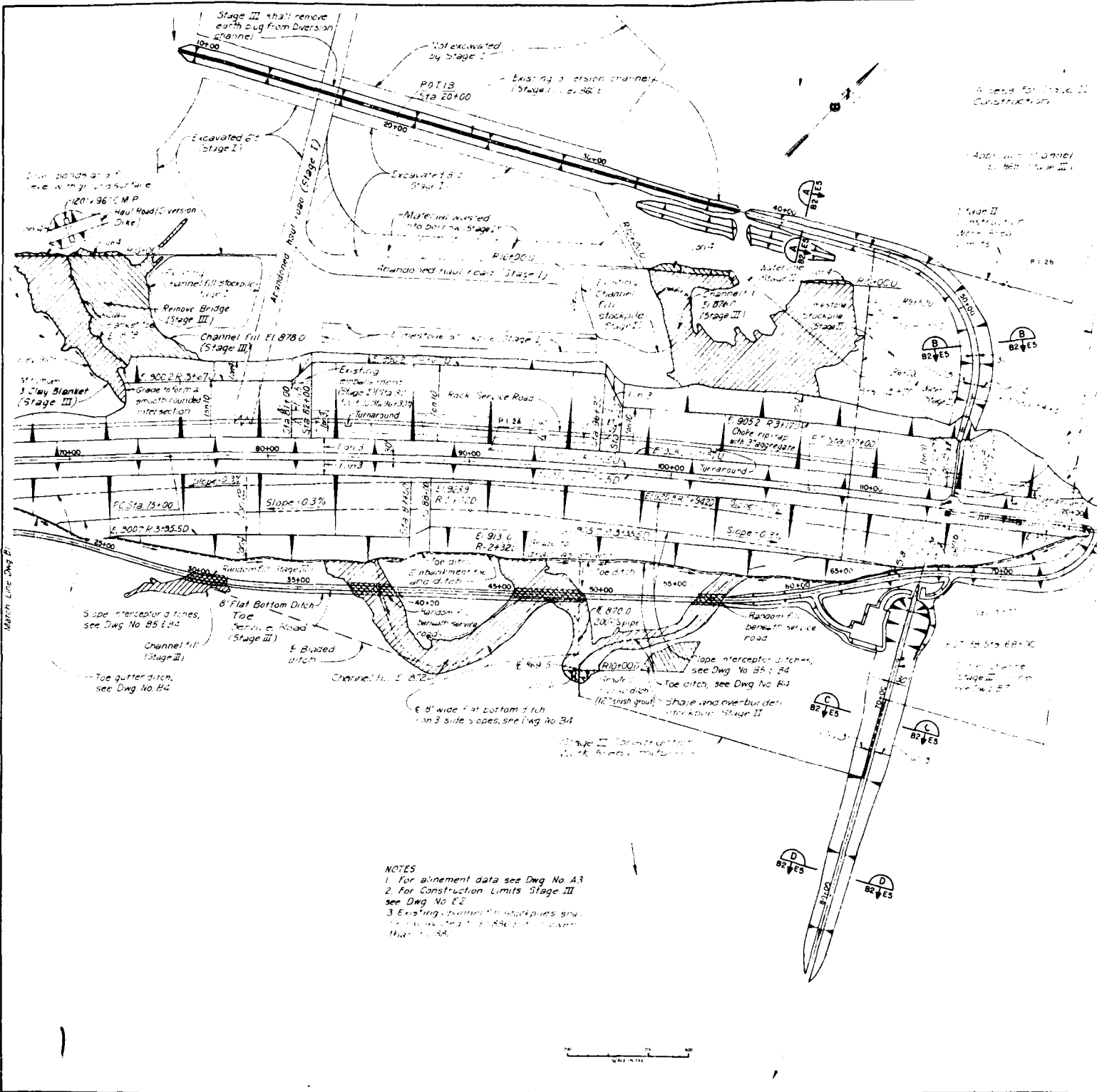
BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
STAGE III CONSTRUCTION  
**EMBANKMENT PLAN**

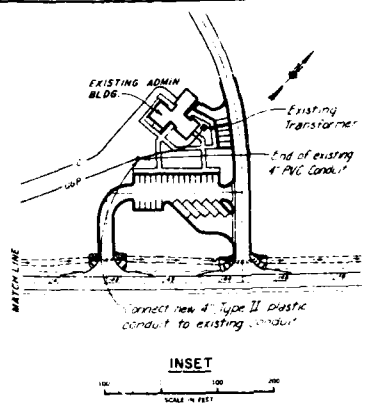
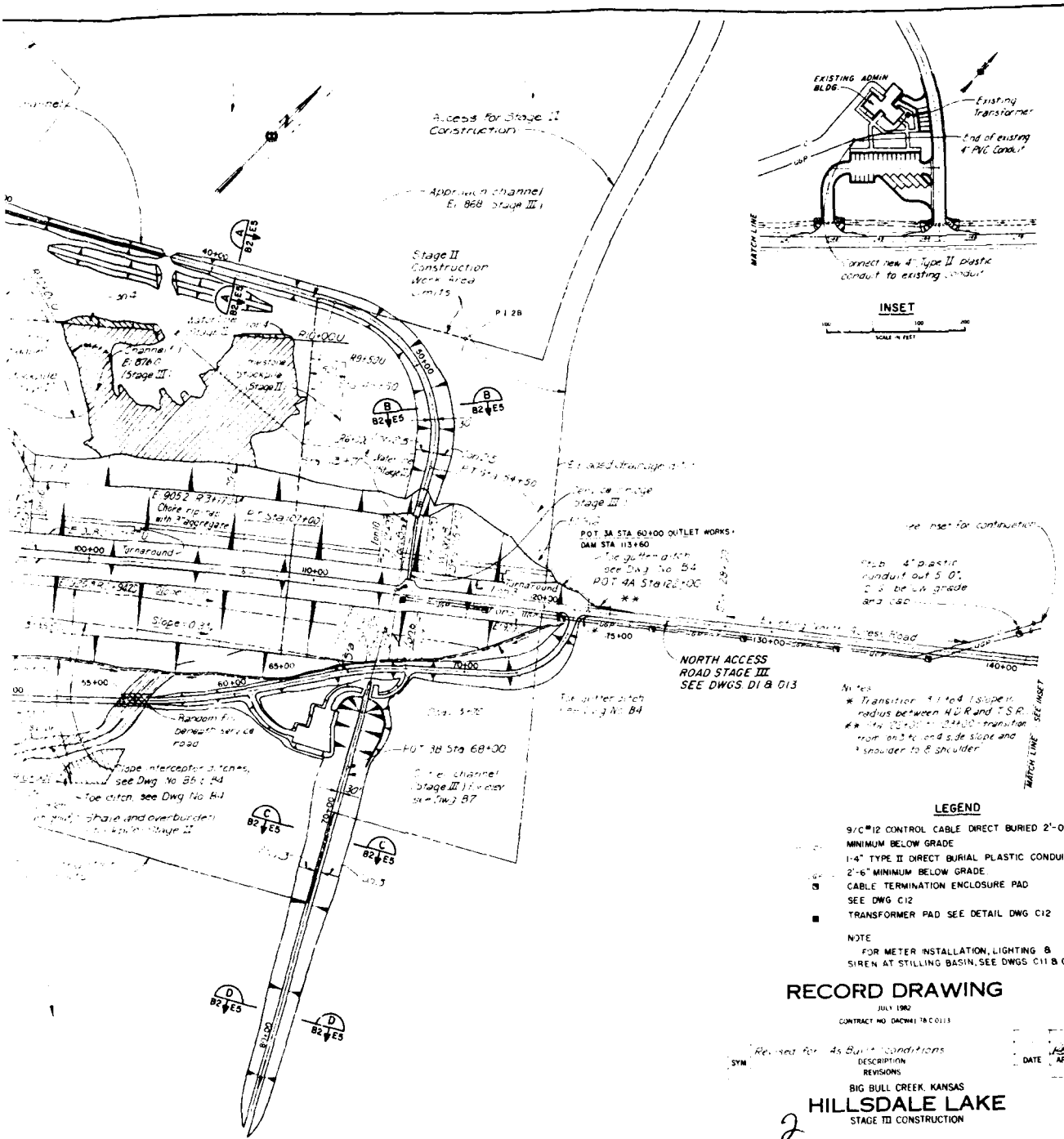
Dwg No 81  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT  
Submitted by: *[Signature]*  
Checked by: YGF  
Reviewed by: R.L.D.

Scale: as shown  
U.S. ARMY  
APRIL 1978

Recommended by: *[Signature]*  
Checked by: RGF  
CREATED BY: RGF  
FILE NO. 0-15-884







INSET  
SCALE IN FEET  
0 100 200

See inset for continuation  
4\"/>

Notes  
\* Transition 1:1 to 1.5 slope  
radius between H.D.R. and T.S.R.  
\*\* Sta. 122+00 to 124+00 - transition  
from on 3% and 5% side slope and  
1' shoulder to 8' shoulder

**LEGEND**

- 9/8" 12 CONTROL CABLE DIRECT BURIED 2'-0" MINIMUM BELOW GRADE
- 1-4" TYPE II DIRECT BURIAL PLASTIC CONDUIT
- 2'-6" MINIMUM BELOW GRADE
- CABLE TERMINATION ENCLOSURE PAD SEE DWG C12
- TRANSFORMER PAD SEE DETAIL DWG C12

NOTE  
FOR METER INSTALLATION, LIGHTING & SIREN AT STILLING BASIN, SEE DWGS C11 & C12

**RECORD DRAWING**

JULY 1962  
CONTRACT NO. DACW41-62-0015

Revised for As Built conditions  
SYN DESCRIPTION REVISIONS DATE APP'D

**HILLSDALE LAKE**  
STAGE II CONSTRUCTION

EMBANKMENT PLAN

Dwg. No. 82  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

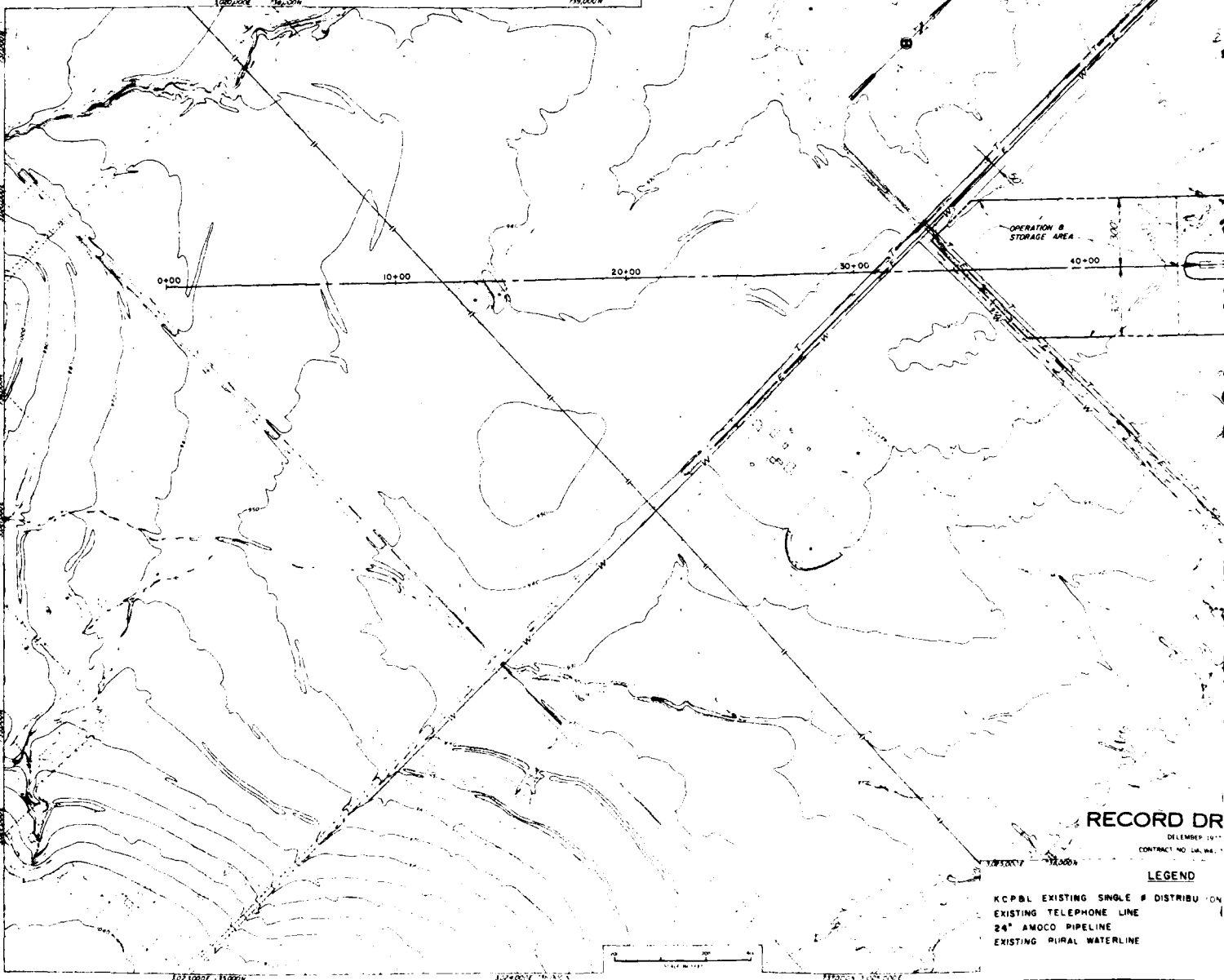
Scale as shown  
U. S. ARMY  
APRIL 1978



0-15-685

PLATE NO. 5

ALIGNMENT DATA													
PI	POT	LATITUDE	DEPARTURE	AZIMUTH	DISTANCE	STATION	P.C. STA.	P.T. STA.	Δ	D	T	R	L
	1A	741.328.74	3.024.70.63	221° 30'	302.60'	60+00							
	2A	743.652.44	3.026.76.56	229° 30'	2262.60'	75+00	00+00	07+00	81° 47'	0° 15'	1602.60'	22.988.31'	3200.00'
	3A	745.121.88	3.028.48.05	229° 30'	840.00'	113+60							
	4A	745.667.42	3.029.23.79			122+00							
	1B	744.447.62	3.025.23.54			20+00							
	2B	746.079.36	3.027.30.33	238° 30'	3122.96'	143+50	00+30	00	90° 52'	10'	572.96'	572.96'	900.00'
	3A	745.121.88	3.028.48.05	328° 30'	1122.96'	60+00							

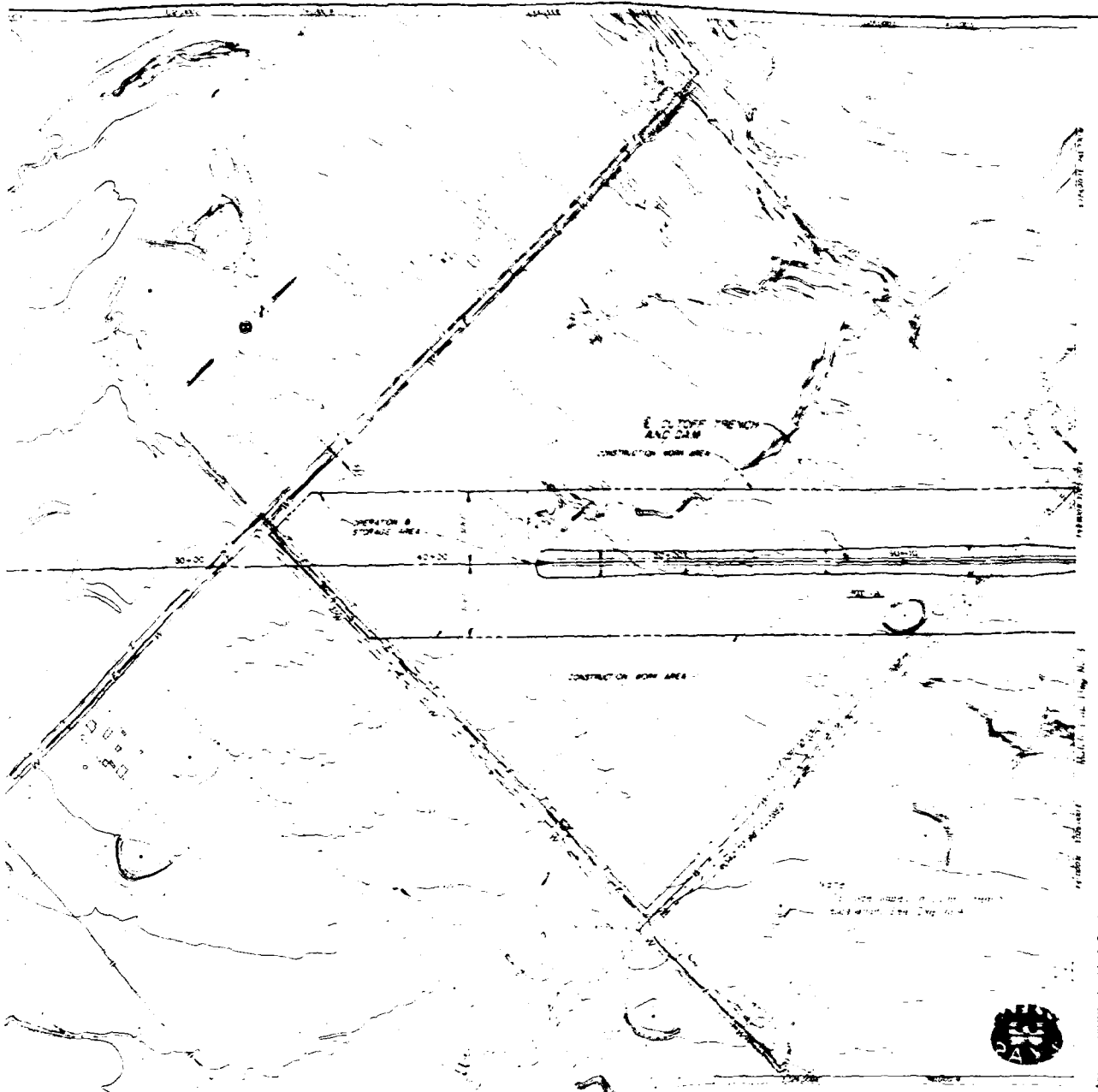


**RECORD DR**

DECEMBER 1977  
CONTRACT NO. LA 44-1

**LEGEND**

- KCPBL EXISTING SINGLE # DISTRIBUTION
- EXISTING TELEPHONE LINE
- 24" AMOCO PIPELINE
- EXISTING RURAL WATERLINE



**RECORD DRAWING**

DATE: 12/15/54

PROJECT: HILLSDALE LAKE

**LEGEND**

- FOR BL. EXISTING 30" DIA. P. DISTRIBUTION LINE
- EXISTING TELEPHONE LINE
- 24" AMOCO PIPELINE
- EXISTING RURAL WATER LINE

**HILLSDALE LAKE**

STAGE 2 CONSTRUCTION

**PLAN OF CUTOFF TRENCH AND EMBANKMENT ALIGNMENT DATA**

Drawn by: [Signature]  
 Checked by: [Signature]  
 Date: FEBRUARY 1955  
 Scale: AS SHOWN  
 Project No. 2-3-442

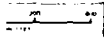
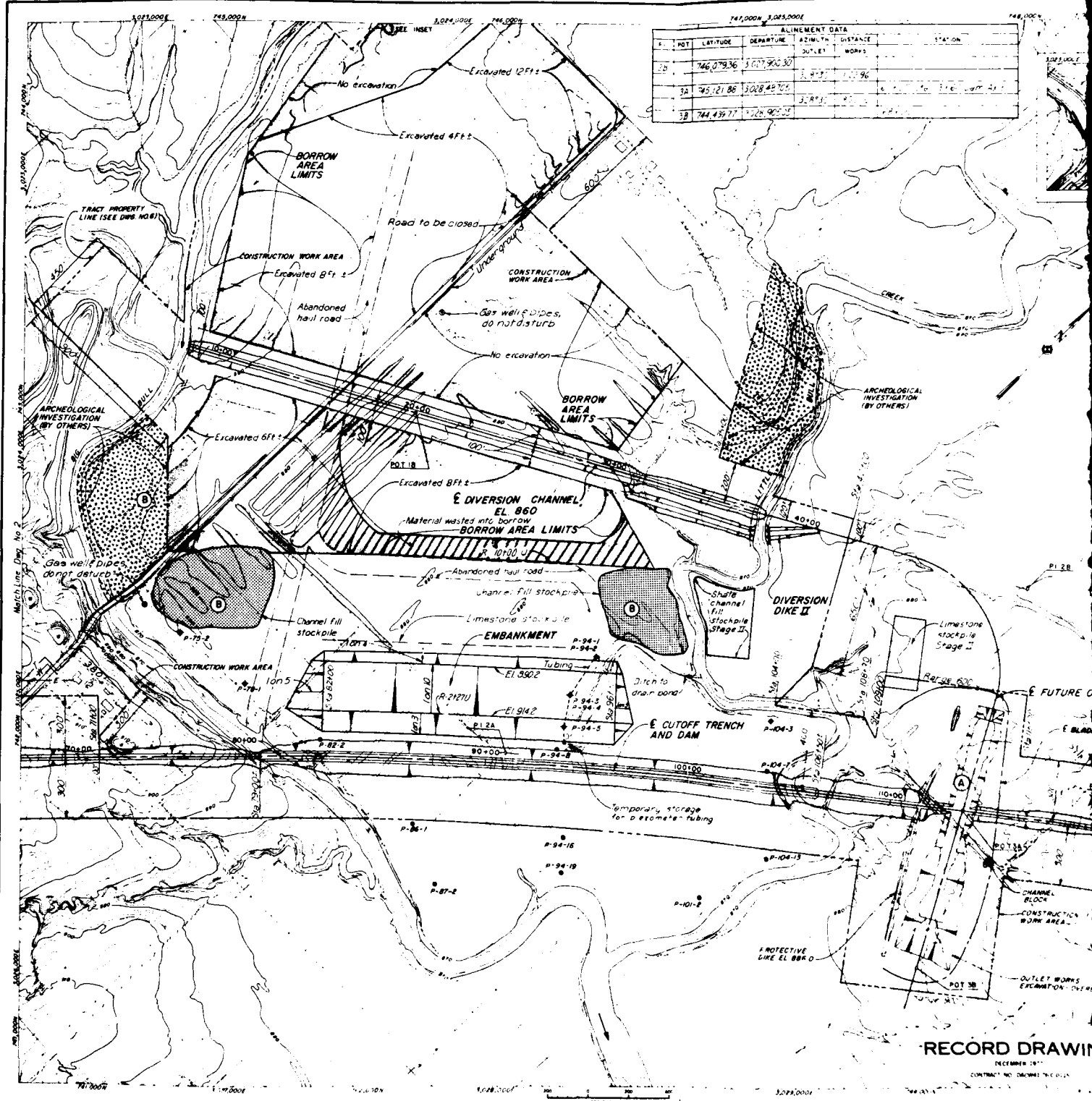


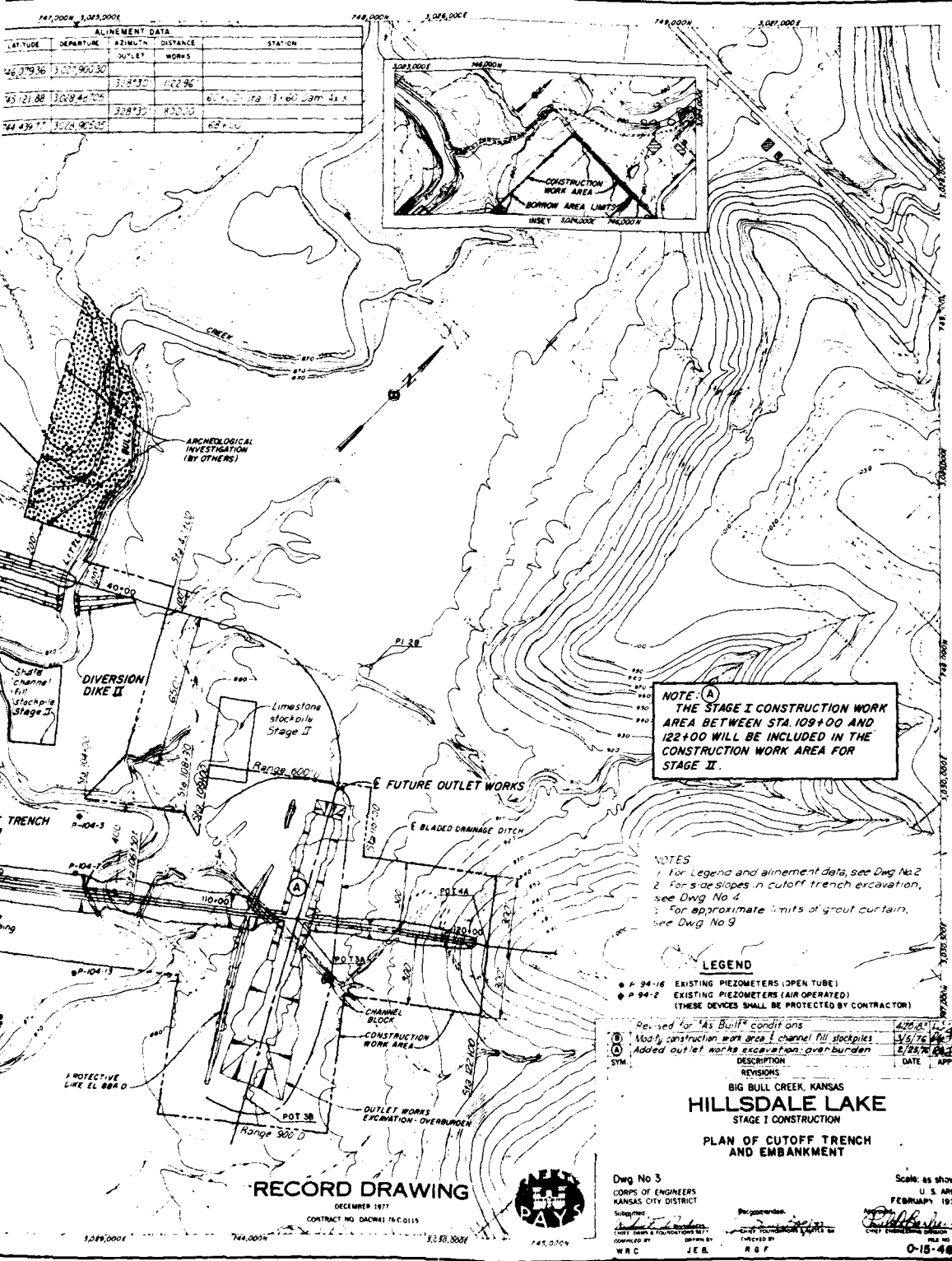
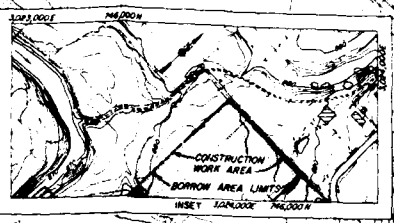
PLATE NO. 2

ALIGNMENT DATA						
P	POT	LATITUDE	DEPARTURE	AZIMUTH	DISTANCE	STATION
1B	746,079.36	3,017,900.30				
2A	745,121.88	3,028,487.05				
3B	744,439.77	3,028,900.00				



**RECORD DRAWING**  
 DECEMBER 1971  
 CONTRACT NO. 100-100-100

ALIGNMENT DATA				
LATITUDE	DEPARTURE	AZIMUTH	DISTANCE	STATION
46 279.36	13 027.900.30	307.15		
		328.30	122.96	
43 121.88	13 028.40.70	328.30	800.00	612.00 Sta 113+00 Dam 41 s
44 430.77	13 028.905.05		627.00	



NOTE: (A)  
 THE STAGE I CONSTRUCTION WORK AREA BETWEEN STA. 109+00 AND 122+00 WILL BE INCLUDED IN THE CONSTRUCTION WORK AREA FOR STAGE II.

NOTES  
 1. For Legend and alignment data, see Dwg No 2  
 2. For side slopes in cutoff trench excavation, see Dwg No 4  
 3. For approximate limits of grout curtain, see Dwg No 9

- LEGEND**
- P-94-16 EXISTING PIEZOMETERS (OPEN TUBE)
  - P-94-2 EXISTING PIEZOMETERS (AIR OPERATED)  
 (THESE DEVICES SHALL BE PROTECTED BY CONTRACTOR)

SYMBOL	DESCRIPTION	DATE	APP'D.
○	Revised for "As Built" conditions	4/29/78	
○	Modify construction work area I channel fill stockpiles	3/1/78	
○	Added outlet works excavation overburden	2/25/78	

**BIG BULL CREEK, KANSAS**  
**HILLSDALE LAKE**  
 STAGE I CONSTRUCTION  
**PLAN OF CUTOFF TRENCH AND EMBANKMENT**

**RECORD DRAWING**

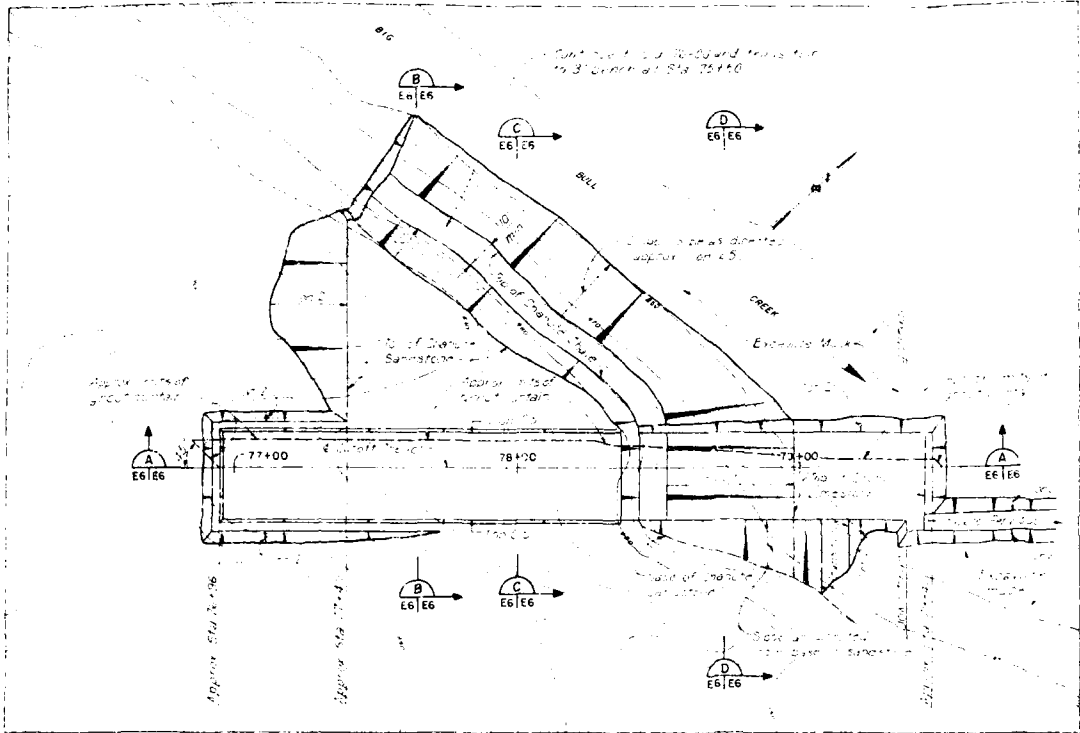
DECEMBER 1977  
 CONTRACT NO. DACW4176-0115

Dwg No 3  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 Subproject  
 COMPILED BY  
 WRC

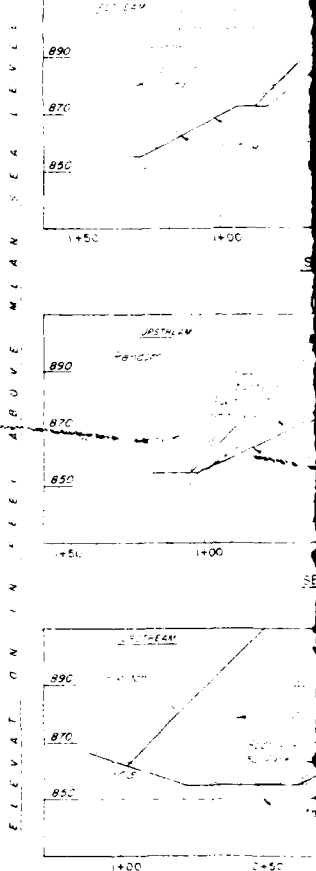
Prepared by  
 CHECKED BY  
 R G F

Scale: as shown  
 U. S. ARMY  
 FEBRUARY 1978  
 FILE NO.  
**0-15-463**

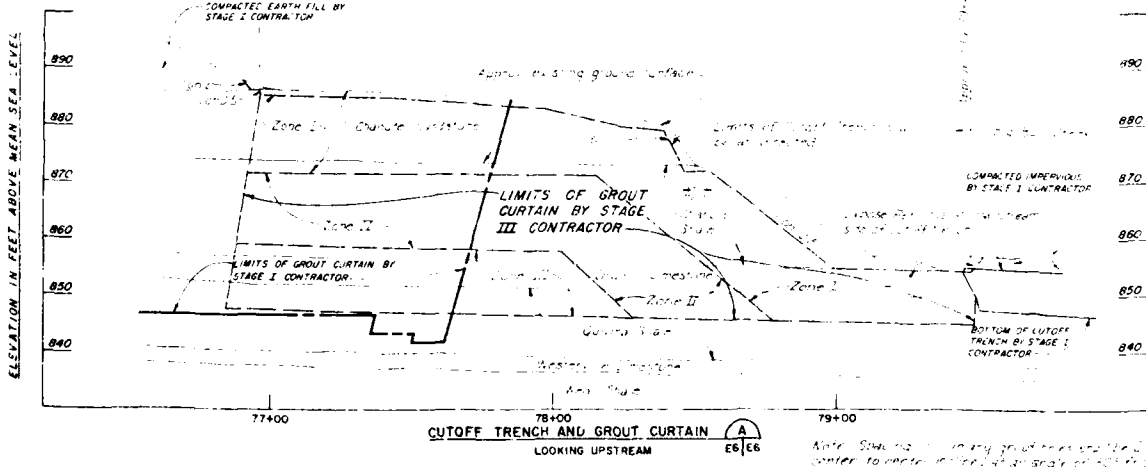
PLATE NO. 7



RIGHT ABUTMENT AND CUTOFF TRENCH EXCAVATION PLAN



ELEVATION IN FEET ABOVE MEAN SEA LEVEL



CUTOFF TRENCH AND GROUT CURTAIN  
LOOKING UPSTREAM

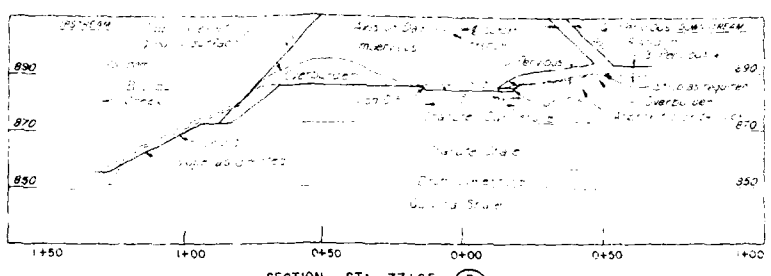
Note: Sawing in any grout lines and the center to center distance of grout lines shall be vertical and spaced upstream with a limit of 20' from the last grout line.

EXCA

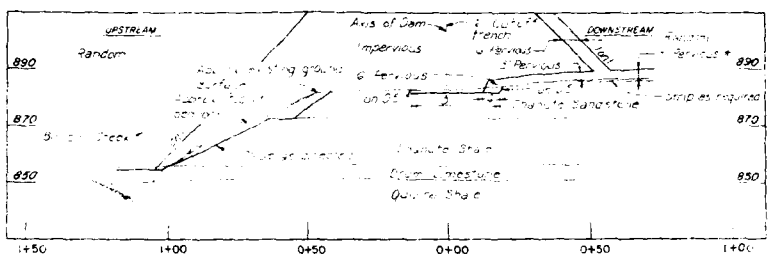
SECTION



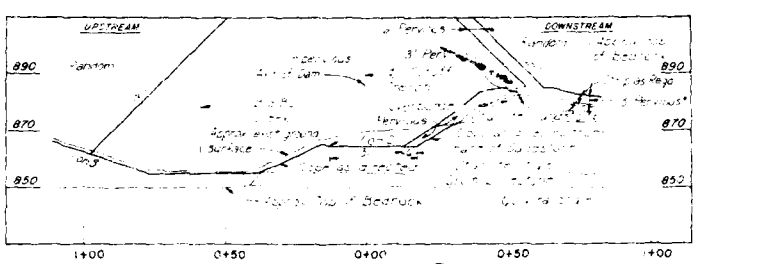
ELEVATION IN FEET ABOVE MEAN SEA LEVEL



SECTION - STA 77+65  
E6/E6



SECTION - STA 78+00  
C/E6



SECTION - STA 78+73  
D/E6

**EXCAVATION AND EMBANKMENT DETAILS**  
TYPICAL FROM STA 77+00± TO 79+50± (P)

- 1. The maximum extent of the grout curtain is shown in Dwg No. 8.
- 2. For excavation and embankment section see Section on Dwg No. 8.

**RECORD DRAWING**

SYM	DESCRIPTION	DATE	APPD
	REVISIONS		

**HILLSDALE LAKE**  
STAGE III CONSTRUCTION

**RIGHT ABUTMENT AND CUTOFF TRENCH EXCAVATION PLAN AND SECTIONS AND GROUT CURTAIN PROFILE**

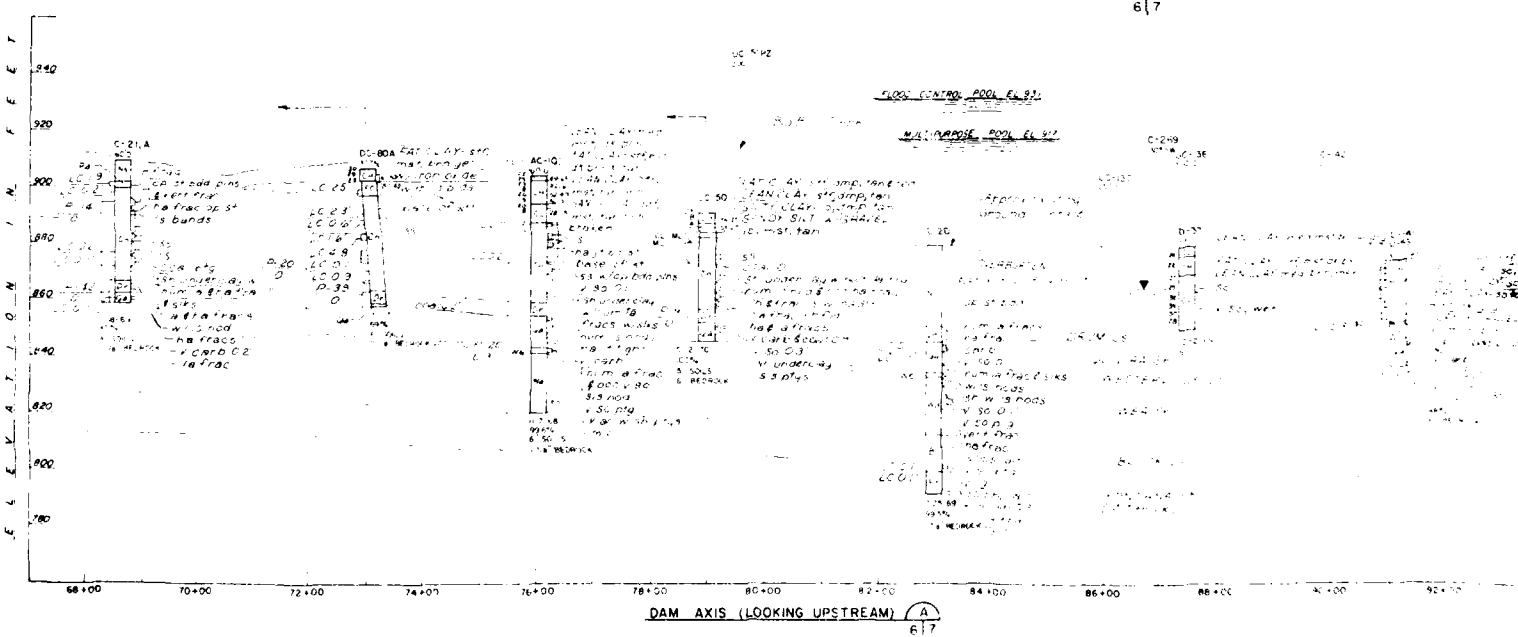
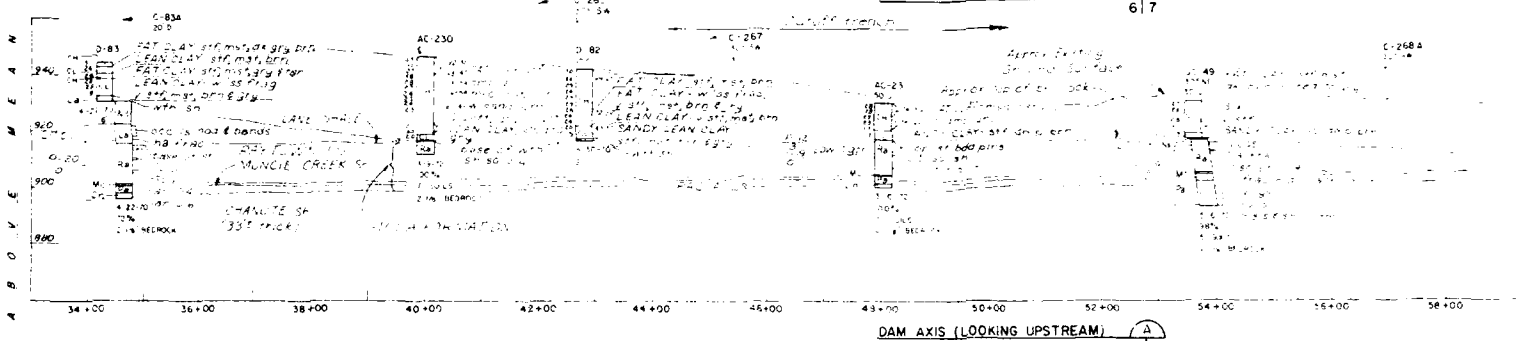
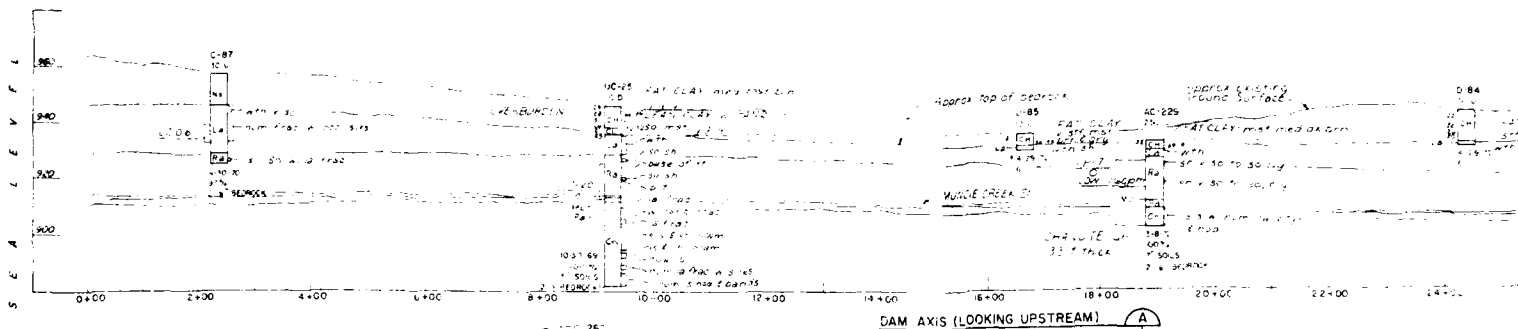
Notes:  
1. Drawings on this sheet are a guide only and are not to be used for excavation and grading purposes. Final construction of the right abutment foundation shall be in accordance with the contract specifications and shall be as directed by the Contracting Officer.  
2. Blasting for the right abutment foundation shall be in accordance with the contract specifications and shall be as directed by the Contracting Officer.

Dwg No. E6  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

Scale as shown  
U.S. ARMY  
APRIL 1978

0-15-731





AD-A169 863

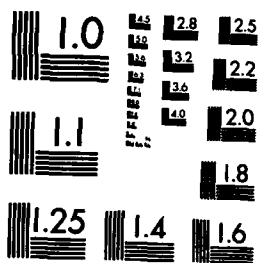
MULTIPLE-PURPOSE PROJECT OSAGE RIVER BASIN BIG BULL  
CREEK KANSAS HILLSDALE (U) CORPS OF ENGINEERS KANSAS  
CITY MO KANSAS CITY DISTRICT F C WALBERG ET AL. SEP 84  
F/G 13/2

24

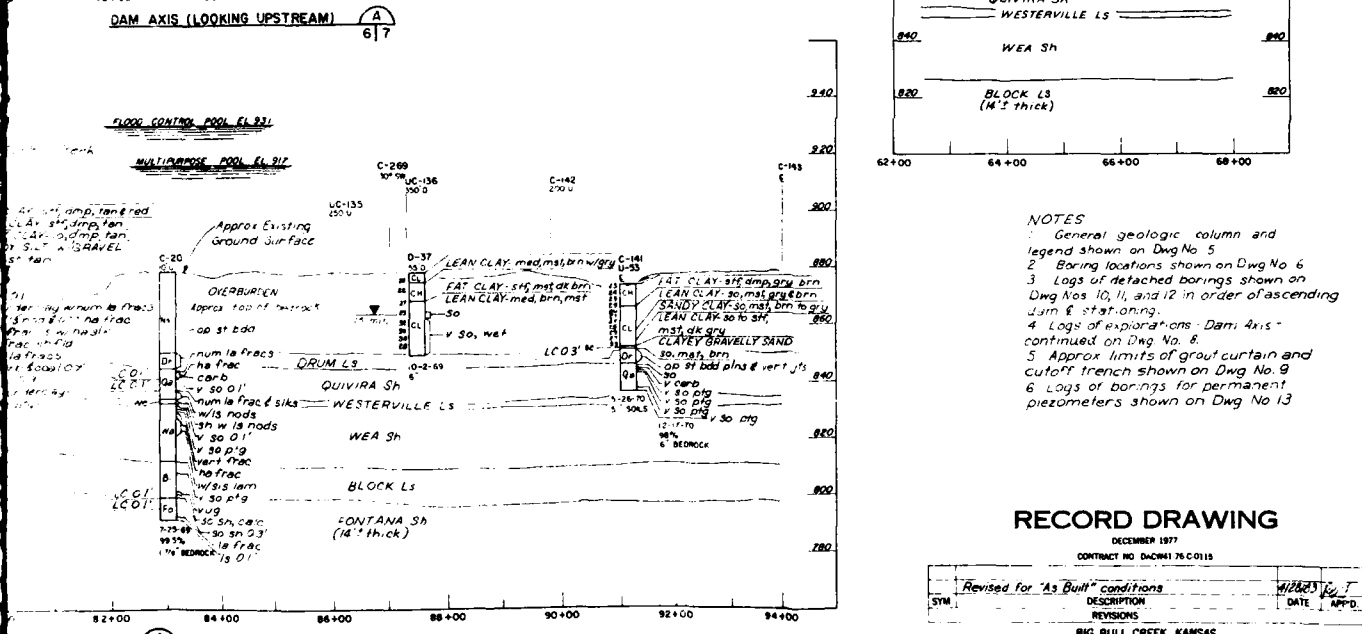
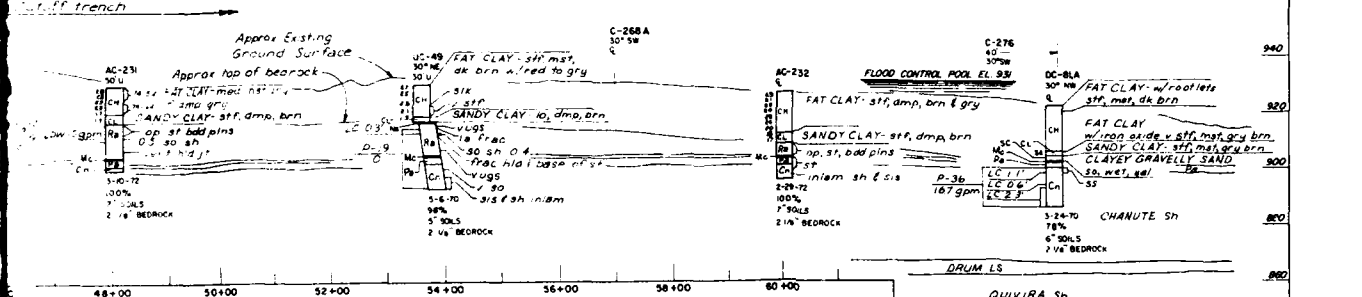
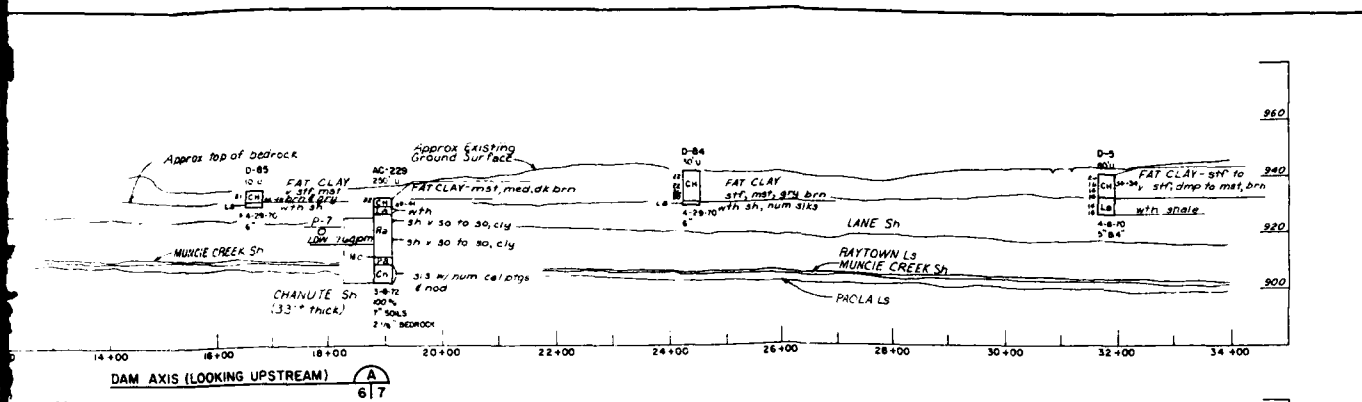
UNCLASSIFIED

NL





MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A



- NOTES**
1. General geologic column and legend shown on Dwg No 5
  2. Boring locations shown on Dwg No 6
  3. Logs of detached borings shown on Dwg Nos 10, 11, and 12 in order of ascending Dam E stationing.
  4. Logs of explorations - Dam Axis - continued on Dwg No. 8
  5. Approx limits of grout curtain and cutoff trench shown on Dwg No. 9
  6. Logs of borings for permanent piezometers shown on Dwg No 13

**RECORD DRAWING**

DECEMBER 1977  
CONTRACT NO. DACR6176 C-0115

SYN	Revised for "As Built" conditions	DATE	1/28/83
	DESCRIPTION		APP'D
	REVISIONS		

**HILLSDALE LAKE**  
STAGE I CONSTRUCTION

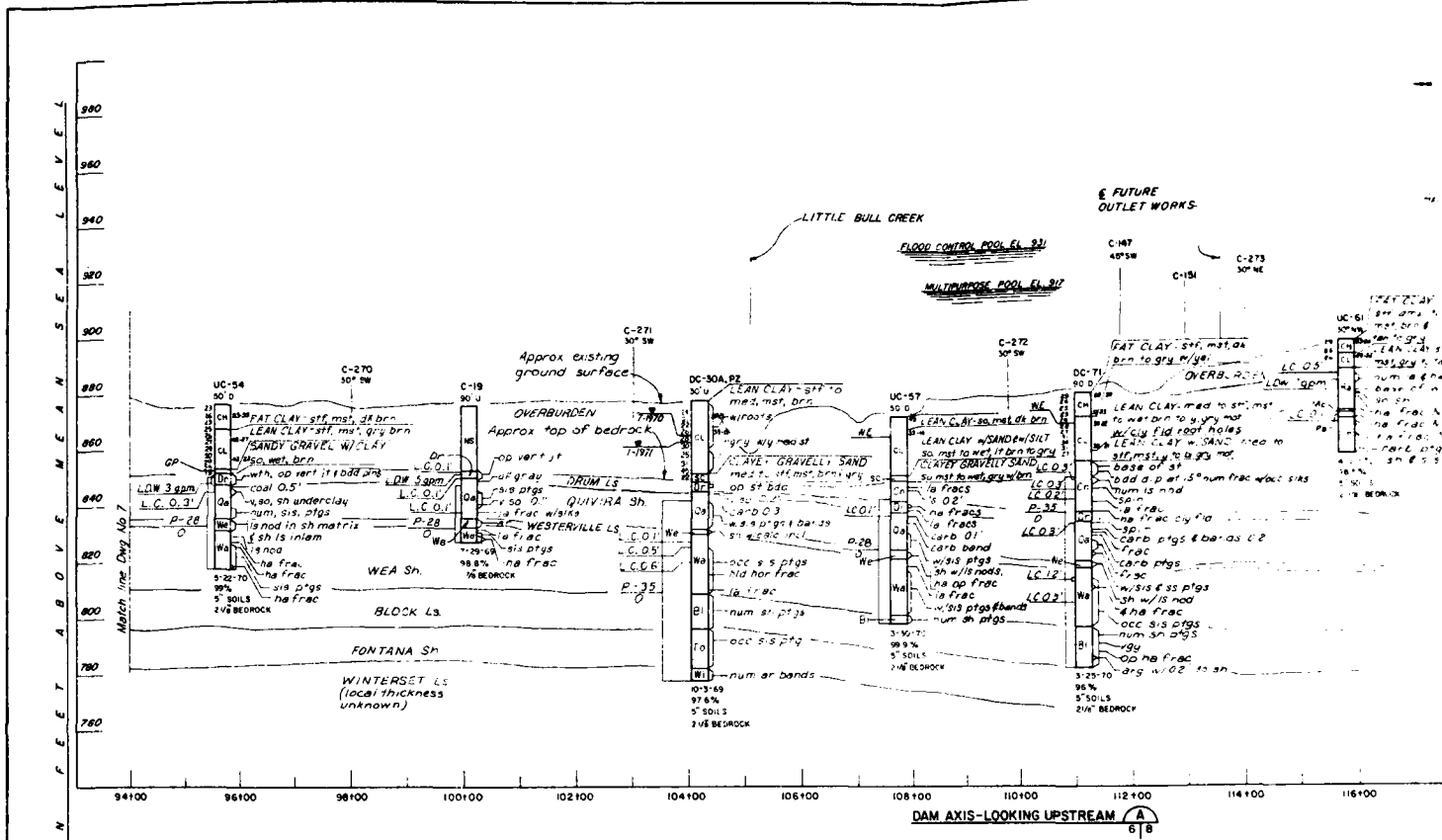
**LOGS OF EXPLORATIONS**  
DAM AXIS

Dwg. No. 7  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

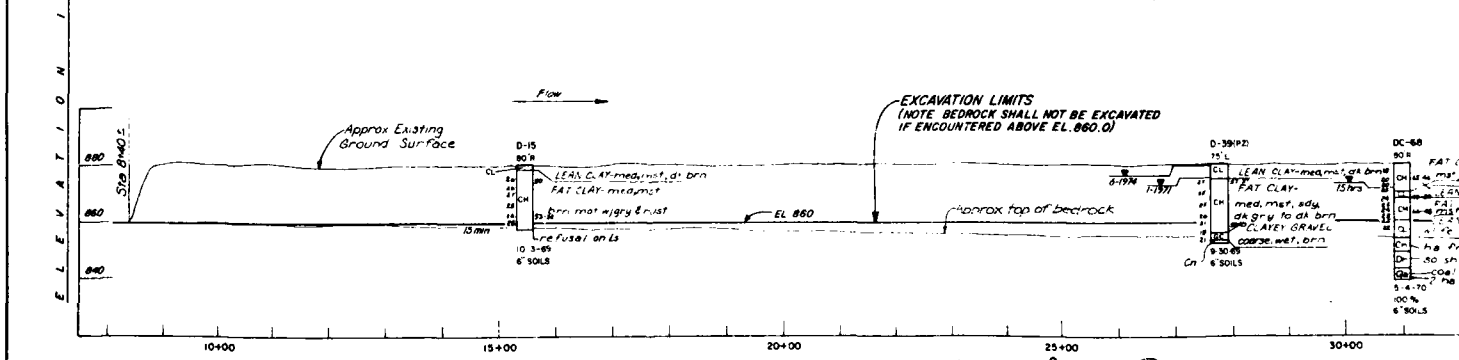
Scale as shown  
U. S. ARMY  
FEBRUARY 1976



DATE: 1/28/83  
FILE NO: 0-15-487

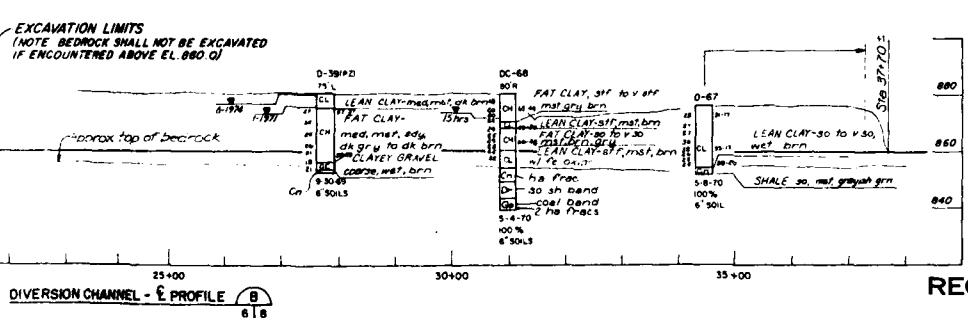
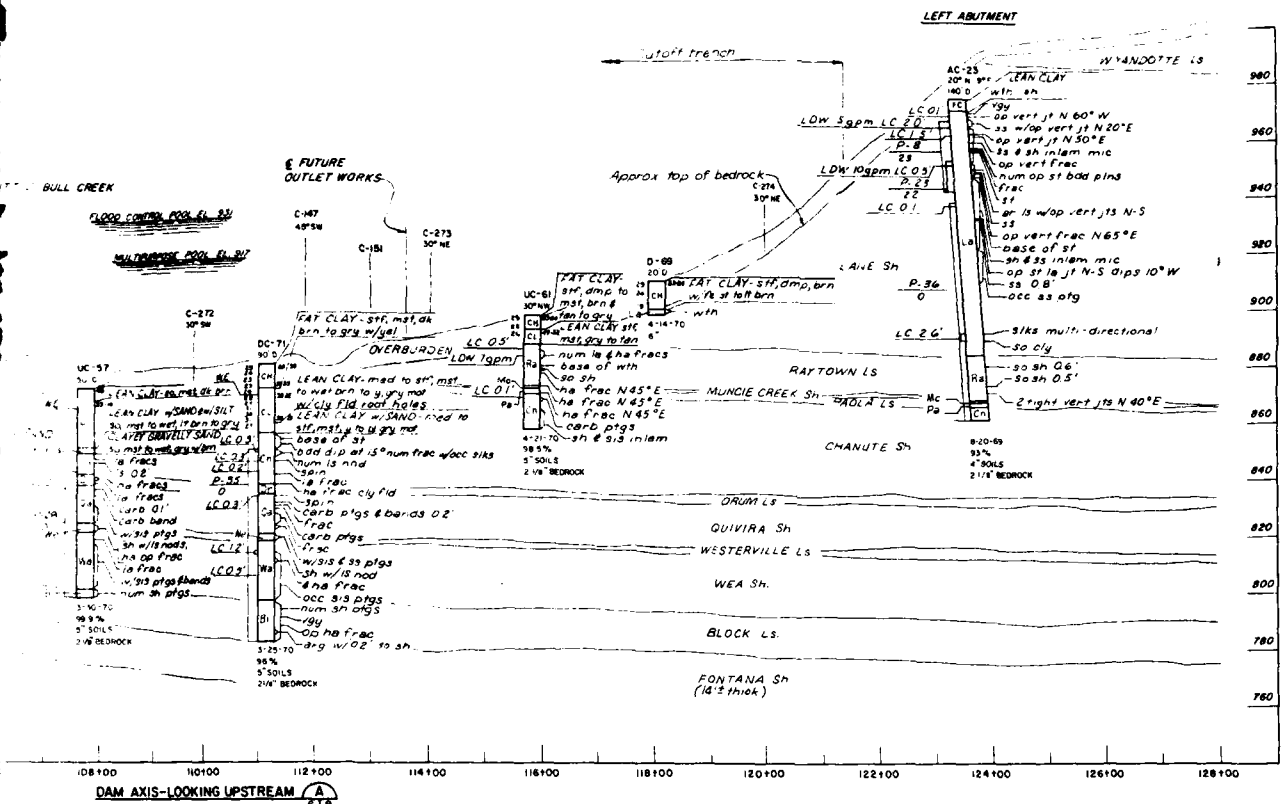


DAM AXIS - LOOKING UPSTREAM A  
6/8



DIVERSION CHANNEL - B PROFILE B  
6/8

- NOTES
1. General Geologic Column Legend shown on Dwg No. 1
  2. Boring locations shown on Dwg No. 1
  3. Logs of detached boring shown on Dwg No. 1
  4. Logs of exploration - Dam continued on Dwg No. 7
  5. Approximate limits of ground cutoff trench are shown on Dwg No. 1
  6. Logs of borings for permeability shown on Dwg No. 1



- NOTES:
1. General Geologic Column and Legend shown on Dwg. No. 5.
  2. Boring locations shown on Dwg. No. 6.
  3. Logs of detached borings shown on Dwg. Nos. 10, 11 and 12 in order of ascending dam & stationing.
  4. Logs of exploration - Dam Axis are continued on Dwg. No. 7.
  5. Approximate limits of grout curtain cutoff trench are shown on Dwg. No. 9.
  6. Logs of borings for permanent piezometers shown on Dwg. No. 13.

**RECORD DRAWING**

DECEMBER 1977  
CONTRACT NO. DACW4176C0115

SYN.	Revised for "As Built" conditions	DATE	APP'D.
	DESCRIPTION		
	REVISIONS		

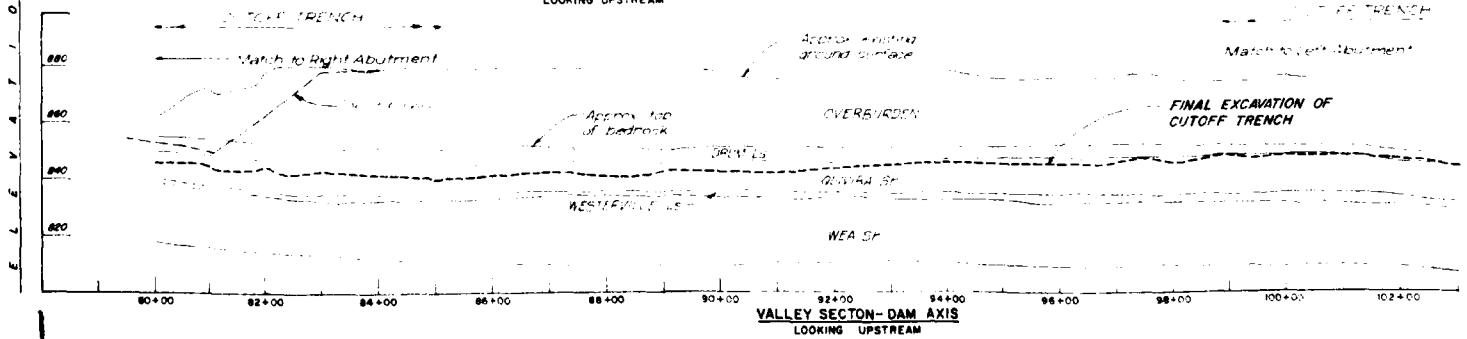
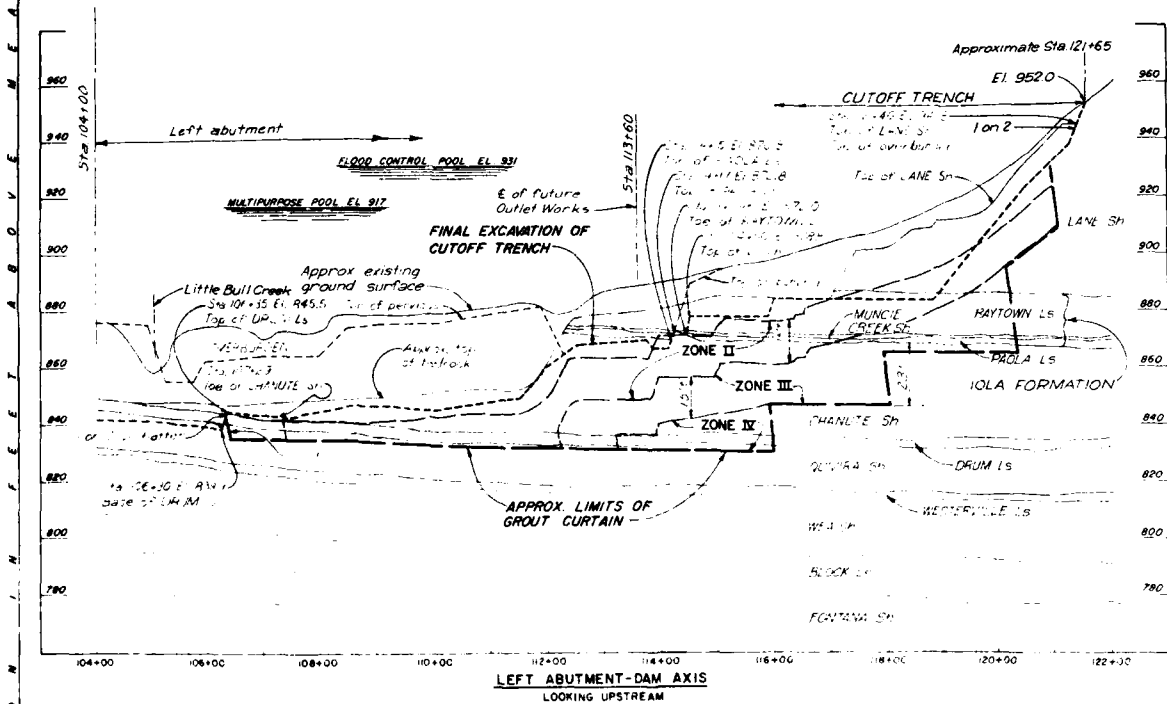
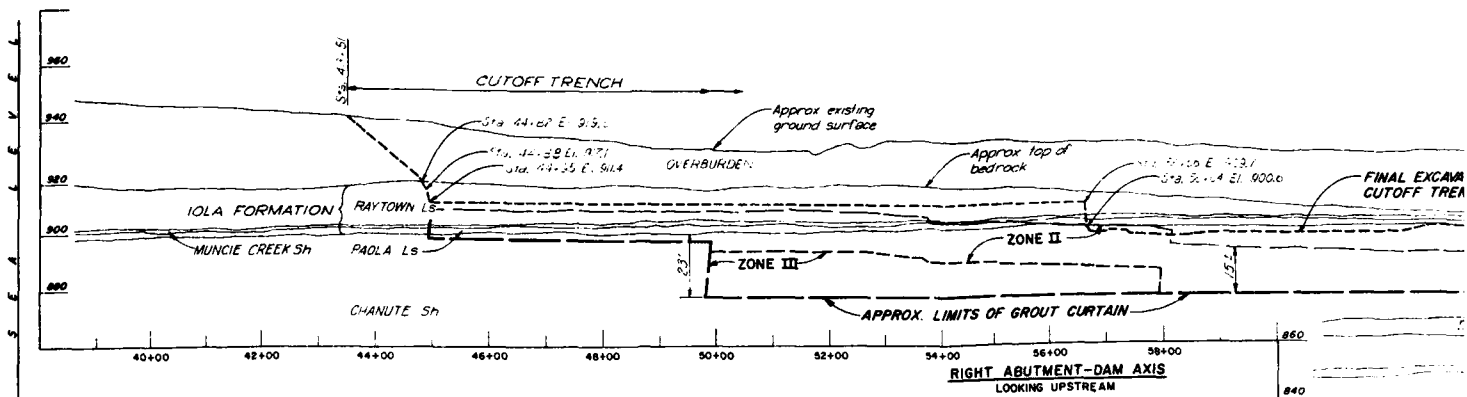
**HILLSDALE LAKE**  
STAGE I CONSTRUCTION  
LOGS OF EXPLORATIONS  
DAM AXIS AND DIVERSION CHANNEL

Dwg. No. 8  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

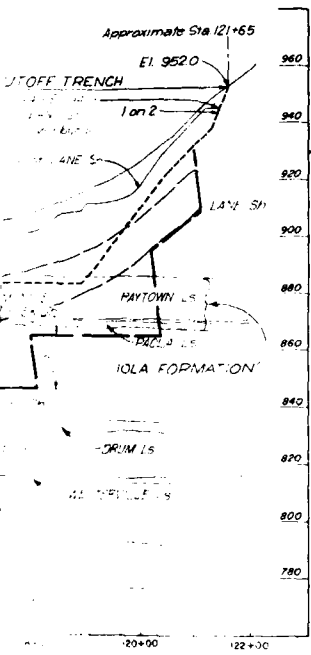
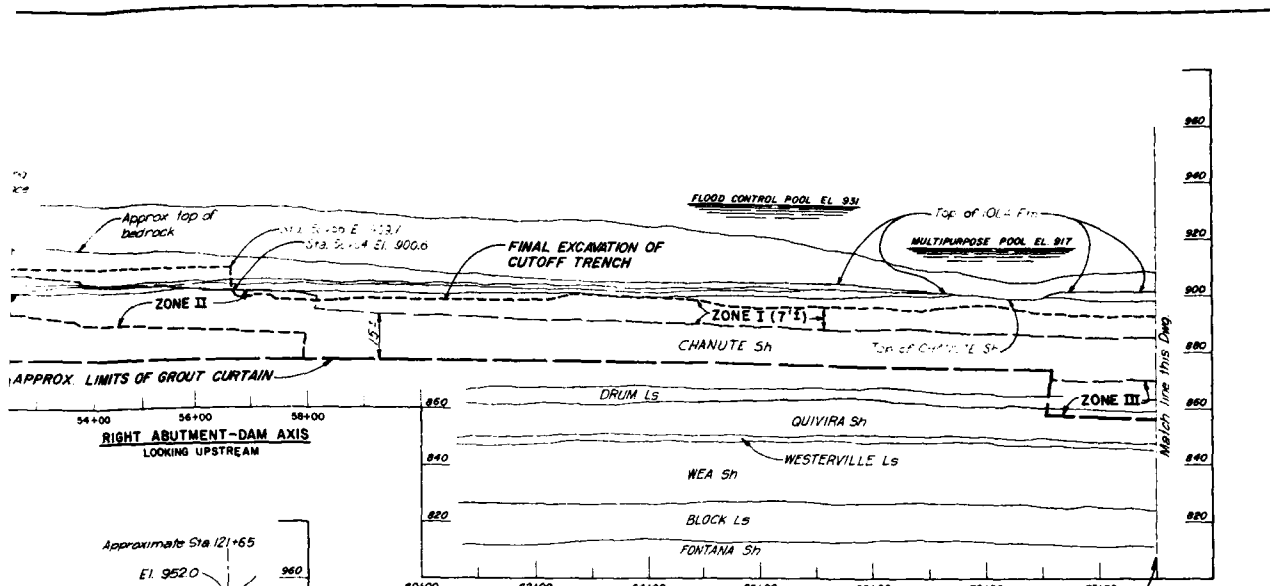
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U. S. ARMY  
FEBRUARY 1978



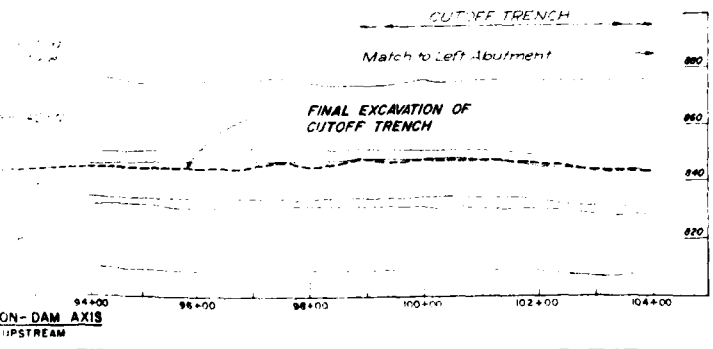
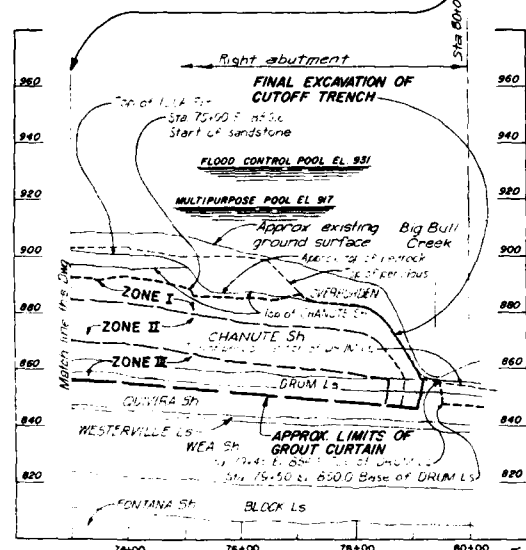
0-15-468







- NOTES
1. For description of geologic units, see General Geology Column and Legend Dwg No 5.
  2. For foundation conditions, see Logs of Exploration-Dam Axis Dwg No's 7 & 8 and Detailed Logs of Explorations Dwg No's 10 thru 13.
  3. Drilling and grouting shall be from the bedrock surface at the bottom, existing at the time when grouting required, of the cutoff trench as a result.
  4. All grout holes shall be inclined landward at a 30° L from vertical and parallel to the Dam E as directed. Spacing of primary grout holes shall be on 20' centers.
  5. All grout hole locations at the ground surface shall be determined by projector from a single horizontal datum plane.
  6. For excavation of sides slopes of cutoff trench, see Dwg No 4.



**RIGHT ABUTMENT-DAM AXIS  
LOOKING UPSTREAM**

**RECORD DRAWING**

DECEMBER 1977  
CONTRACT NO. DACW4176C 0115

Revised for "As Built" conditions  
DESCRIPTION REVISIONS

BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
STAGE I CONSTRUCTION  
**GROUT CURTAIN  
AND CUTOFF TRENCH**

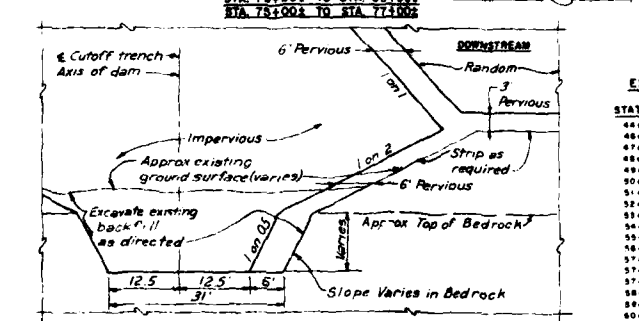
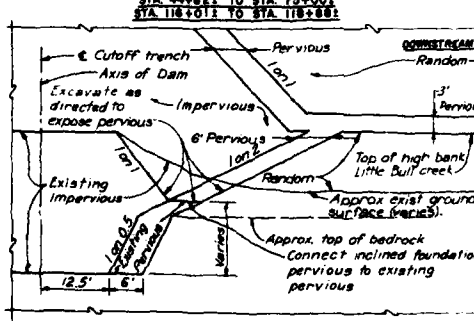
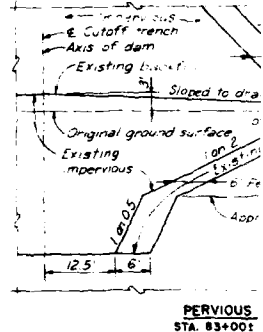
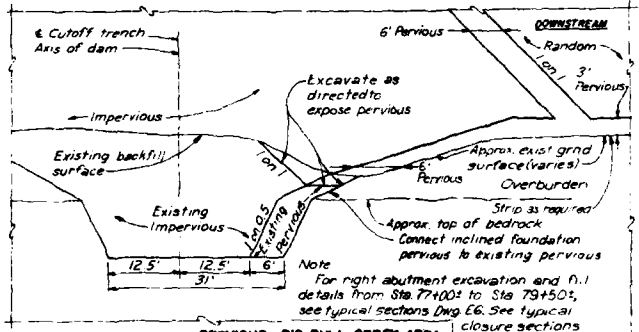
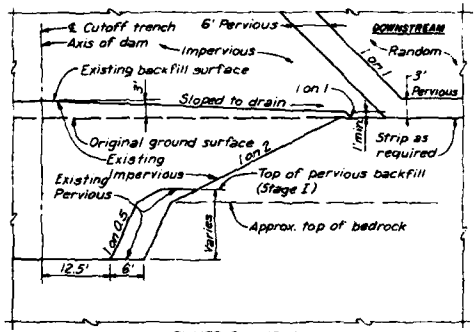
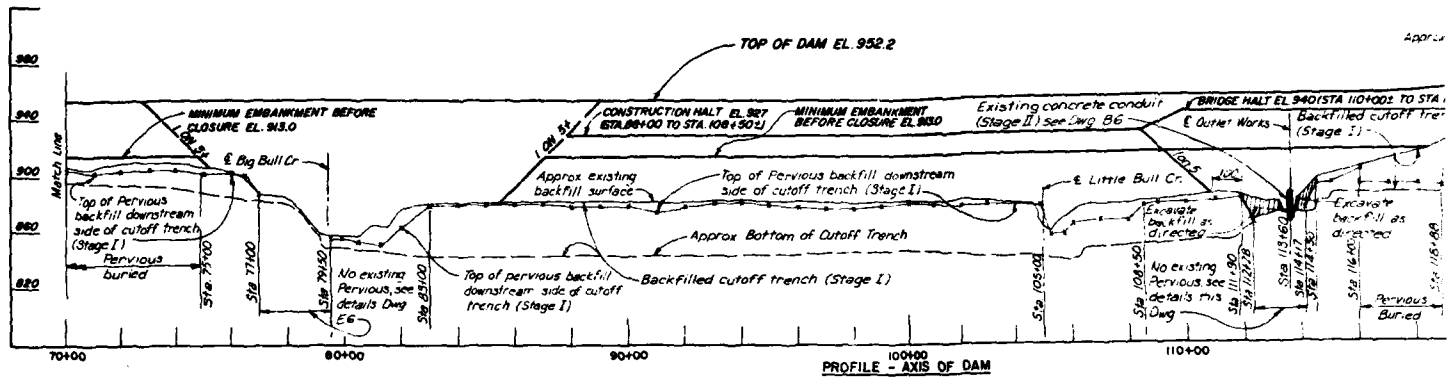
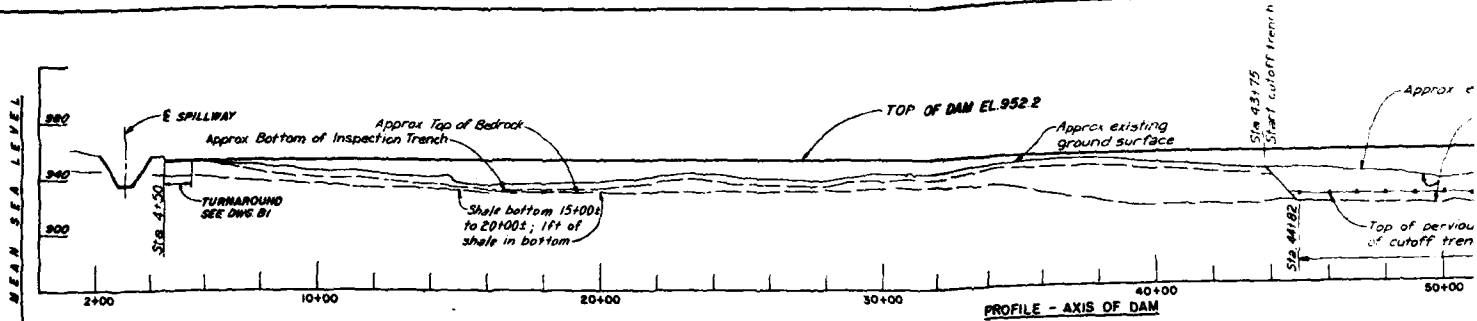
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CORPS OF ENGINEERS  
KANSAS CITY DISTRICT  
Checked by: [Signature]  
Compiled by: RGS  
Drawn by: QWD  
Checked by: [Signature]  
Designed by: RGS



DATE: 12/20/77  
APPD: [Signature]

Scale: as shown  
U.S. ARMY  
FEBRUARY 1978

0-15-469  
PLATE NO 11

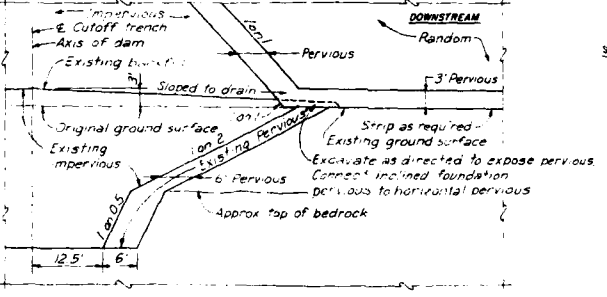
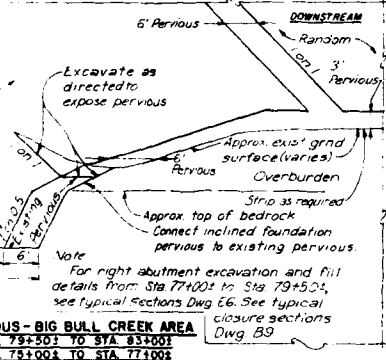
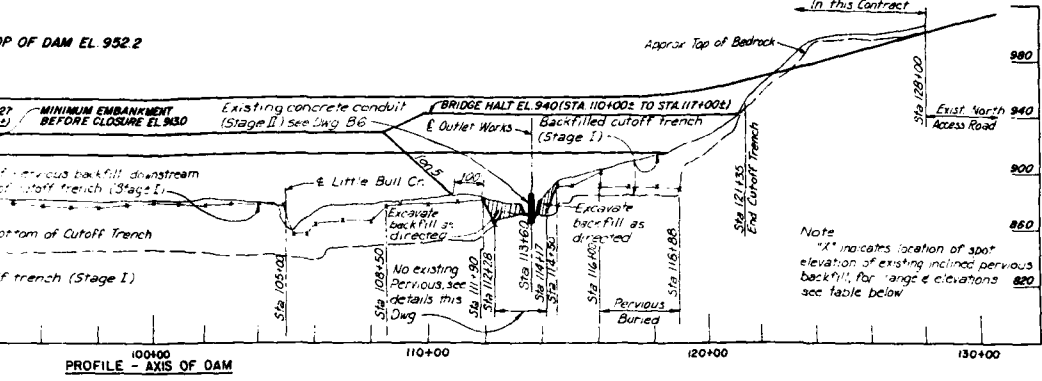
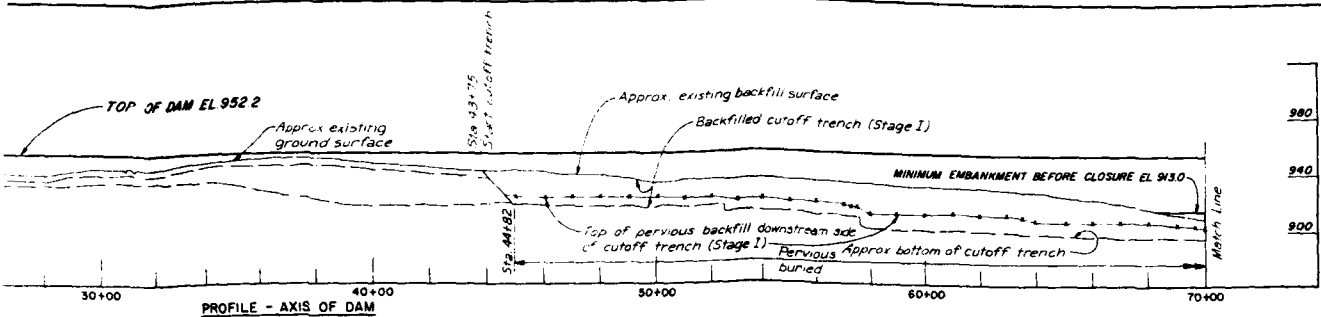


**TABLE A**  
 EXISTING INCLINED PERVIOUS EXIS'

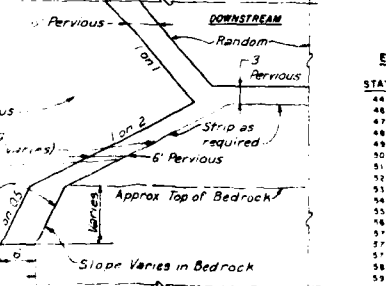
STATION	RANGE	EXISTING INCLINED PERVIOUS	ELEV. TOP OF PERVIOUS	EXIS'
44+82			92.6	88+00
48+00			92.7	88+00
67+00			92.8	89+5
88+00			92.8	70+30
88+00			92.7	7+00
90+00			92.8	72+30
91+00			92.1	73+00
92+00			92.0	74+30
93+00			91.9	75+00
94+00			91.8	76+00
95+00			91.8	76+30
96+00			91.8	77+30
97+00			91.7	78+3
97+24			91.5	78+82
97+30			91.6	80+00
98+00			91.6	81+5
98+00			91.6	82+00
99+00			91.6	83+00
99+00			91.1	84+00
99+00			90.8	87+00
99+00			91.0	88+00
99+00			90.9	89+00
99+00			90.7	89+00
99+00			90.6	90+00
99+00			90.6	90+00
99+00			90.6	91+00

Note:  
 The stream banks of Little Bull Creek beneath the embankment shall be excavated to 1 on 3 slopes or as directed.

Note:  
 For backfill details in outlet works area, see Dwg No. 86.



**PERVIOUS - MAIN VALLEY**  
 STA 83+00 TO STA 105+00  
 STA 108+50 TO STA 114+00  
 STA 114+50 TO STA 116+00



**OUTLET WORKS AREA**  
 STA 114+90 TO STA 114+90

**TABLE A**  
 EXISTING INCLINED PERVIOUS

STATION	RANGE DOWNSTREAM	ELEV TOP OF PERVIOUS
44+00		921.9
46+00		921.7
47+00		921.9
48+50		921.8
49+00		921.1
50+00		921.4
51+00		921.1
52+00		921.0
53+00		919.9
54+00		919.8
55+00		919.8
56+00		918.1
57+00		917.0
57+24		915.4
57+50		914.8
58+00		910.4
59+00		909.9
60+00		910.6
61+00		911.1
62+00		909.8
63+00		910.0
64+00		907.9
64+00		907.6
65+00		908.2
66+00		908.2
67+00		908.8

**TABLE A (CONT.)**  
 EXISTING INCLINED PERVIOUS

STATION	RANGE DOWNSTREAM	ELEV TOP OF PERVIOUS
68+00		906.1
69+00		907.2
69+65		903.2
70+30		902.3
71+00		900.9
72+00		902.8
73+00		901.9
74+00		900.0
75+00		900.0
76+00		900.0
76+50	40 9-46.9	898.2
77+00	12 5-18.5	898.2
78+00	17 0-23.0	895.0
78+82		893.9
80+50		892.5
81+25	75 8-31.8	889.8
82+00		886.0
83+00	78 2-84.2	878.9
84+00		878.9
85+00	78 2-84.0	878.8
86+00		878.4
87+00		877.7
88+00		878.1
89+00		877.1
91+00	71 8-77.4	873.4

**TABLE A (CONT.)**  
 EXISTING INCLINED PERVIOUS

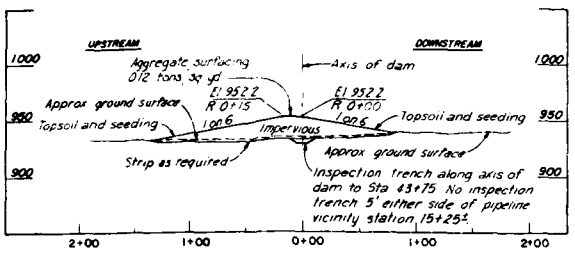
STATION	RANGE DOWNSTREAM	ELEV TOP OF PERVIOUS
92+00		877.8
93+00		879.1
94+00		878.9
95+00	75 0-81.0	878.1
96+00		876.2
97+00		875.6
98+00		876.0
99+00		877.8
100+00	68 5-75.5	876.9
101+00		877.8
102+00		876.2
103+00		877.7
104+00		877.1
104+95	79 0-89.0	876.8
105+24	36 5-42.5	856.0
105+75	40 2-46.2	856.0
106+00	32 5-36.2	862.0
107+00	48 8-51.8	865.0
108+00		865.0
108+50	67 7-73.7	875.0
109+00		876.2
110+00	67 1-73.1	876.4
111+00		876.8
111+89	59 0-65.0	882.1
112+28	4 0-20.0	865.7
112+77	15 0-21.0	875.0
113+50	35 2-38.2	889.5
115+00	40 9-46.9	894.3
116+00	44 0-50.0	899.5
116+01		899.4
117+00		888.5
118+00		888.2
119+00		888.1

**RECORD DRAWING**

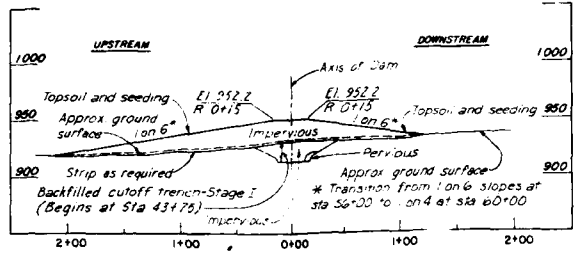
JULY 1982  
 CONTRACT NO. DACW3178C0115  
 Revised for "As Built" conditions  
 DESCRIPTION: REVISIONS  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION  
**DAM AXIS PROFILE AND DETAILS**  
 EXISTING CUTOFF TRENCH

Scale as shown  
 U.S. SURVEY  
 APRIL 1978  
 Dwg No. 83  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 Submitted: *[Signature]*  
 Checked by: *[Signature]*  
 RGF CRT RGF  
 O-15-688

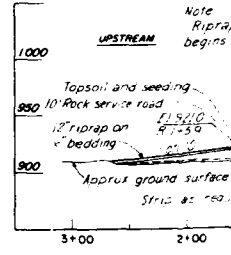
ELEVATION ABOVE MEAN SEA LEVEL



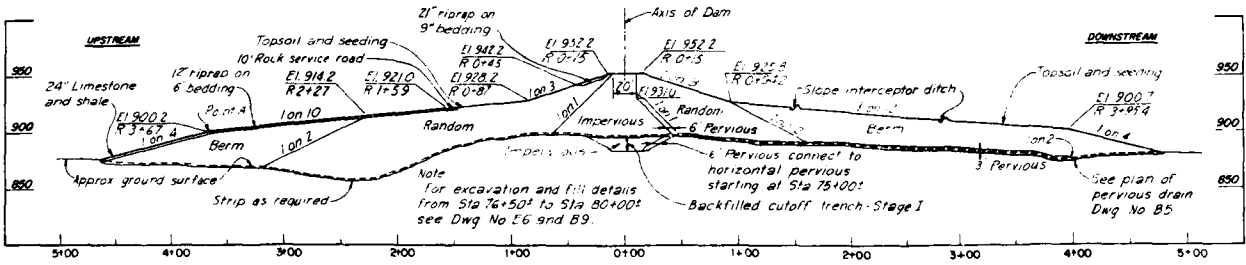
**STA 18+00**  
TYPICAL FROM STA 6+10E TO STA 36+00E



**STA 52+00**  
TYPICAL FROM STA 36+00E TO STA 60+00E

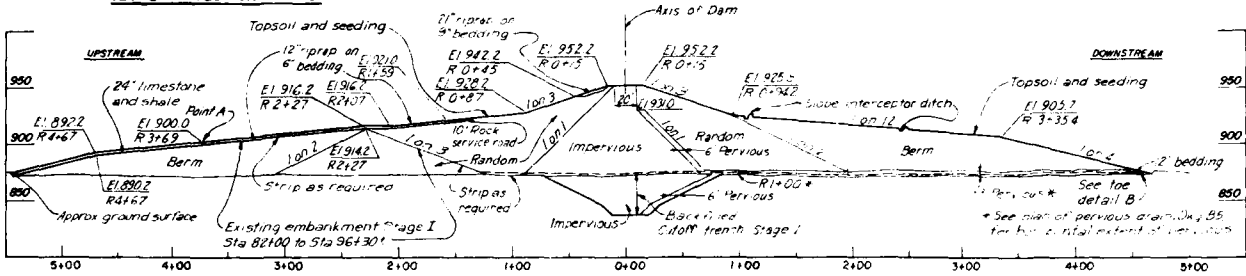


TYPICAL UPSTREAM TOE DETAIL

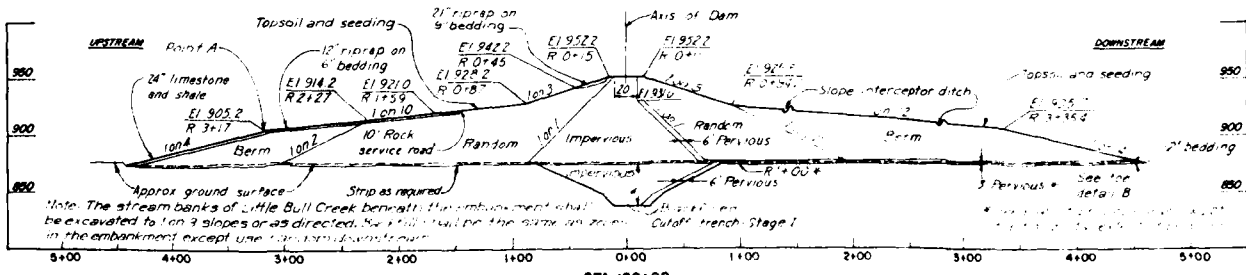


**STA 76+50**  
TYPICAL FROM STA 73+00 TO STA 81+00 UPSTREAM  
TYPICAL FROM STA 73+00 TO STA 87+00 DOWNSTREAM

SLOPE PROTECTION DETAIL



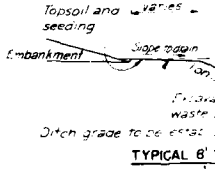
**STA 90+00**  
TYPICAL FROM STA 82+00 TO STA 96+30 UPSTREAM  
TYPICAL FROM STA 88+00 TO STA 96+00 DOWNSTREAM



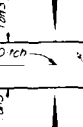
**STA 100+00**  
TYPICAL FROM STA 97+30 TO STA 111+70 UPSTREAM  
TYPICAL FROM STA 96+00 TO STA 111+70 DOWNSTREAM

Note  
10' Rock service road starts at E Station 54+80. see plan on Dwg No B1

Note  
Use type 2 bedding in stream bank



TYPICAL B'1



TOE GU

UPSTREAM

DOWNSTREAM

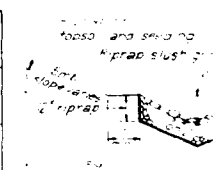
Strip as required

See toe detail B'

See plan of pervious drain Dwg No B5

See toe detail B'

TYPICAL



TYPICAL TOE GU

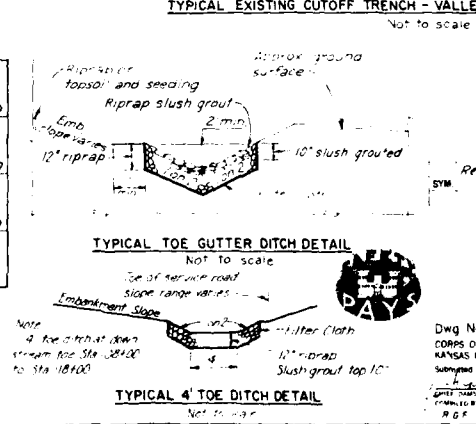
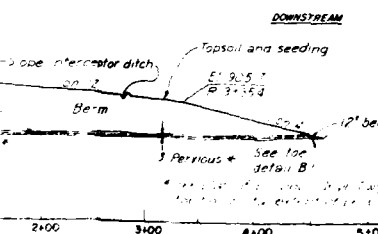
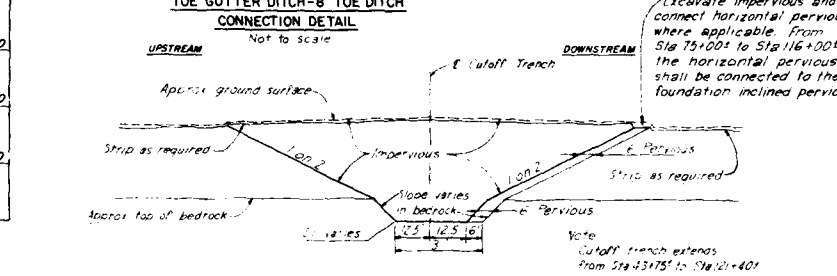
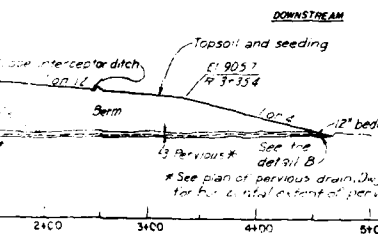
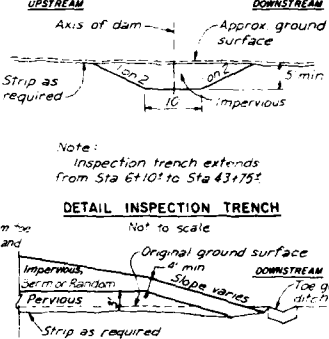
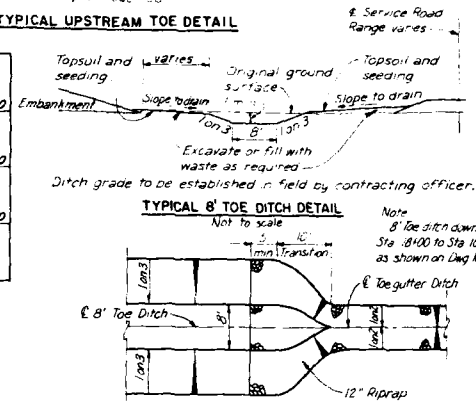
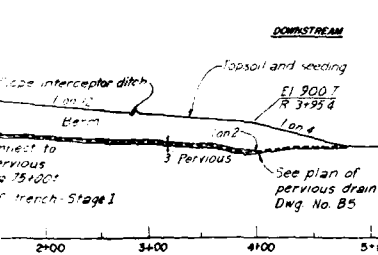
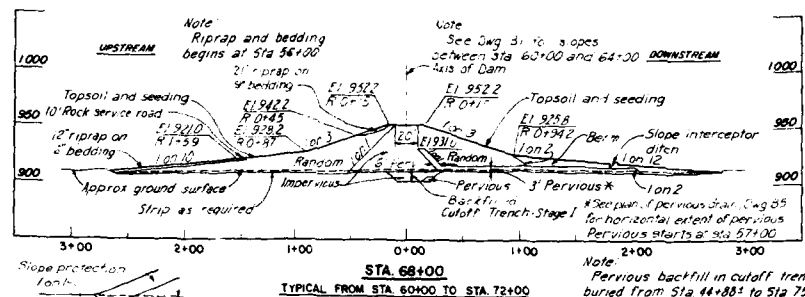
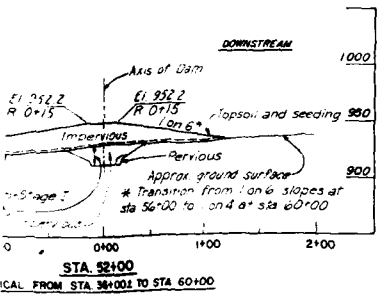
UPSTREAM

DOWNSTREAM

Strip as required

See toe detail B'

TYPICAL 4 TO



**RECORD DRAWING**  
JULY 1982  
CONTRACT NO. DAM4178C013  
Note: The gutter ditch at downstream toe Sta 64+00 to Sta 70+00 and Sta 124+00 to 124+50, upstream toe Sta 119+00 to Sta 124+00.

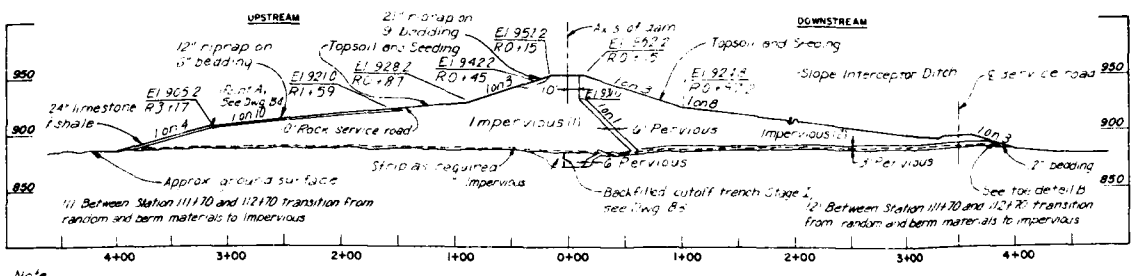
SYMBOL	DESCRIPTION	DATE	APP'D

**HILLSDALE LAKE**  
STAGE III CONSTRUCTION

EMBANKMENT SECTIONS AND DETAILS

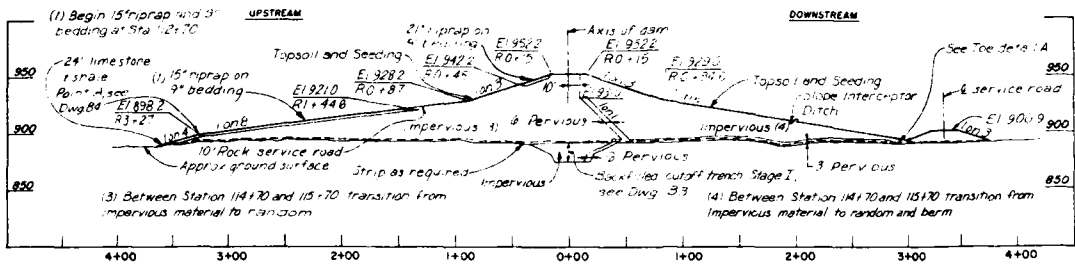
Dwg No. 84  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT  
Scale as shown  
U. S. ARMY  
APRIL 1978  
0-13-687

ELEVATION IN FEET ABOVE MEAN SEA LEVEL

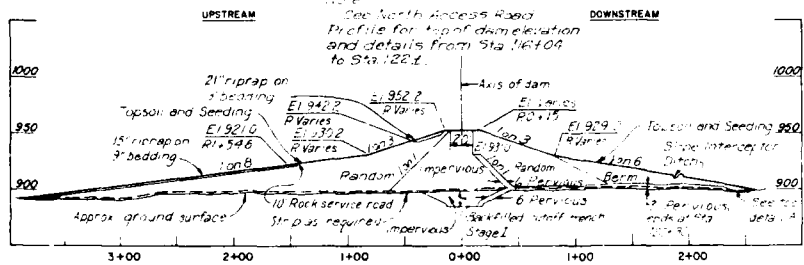


**STA. 112+70**  
TYPICAL FROM STA 112+70 TO STA 113+70 DOWNSTREAM  
TYPICAL FROM STA 111+70 TO STA 112+70 UPSTREAM

Note for embankment section 4" outlet works see Dwg No. B1

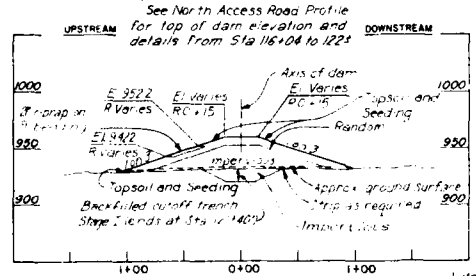


**STA. 114+70**  
TYPICAL FROM STA 113+70 TO STA 114+70 UPSTREAM  
TYPICAL FROM STA 114+70 TO STA 115+70 DOWNSTREAM



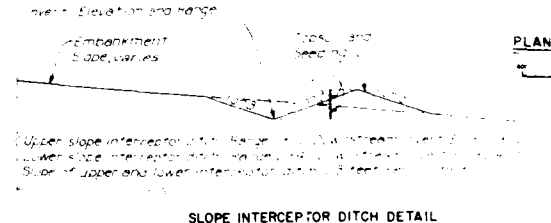
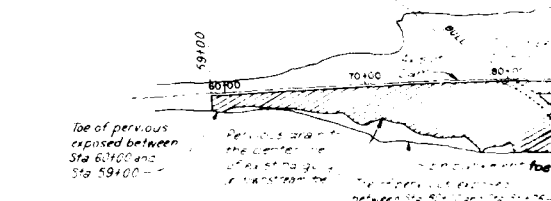
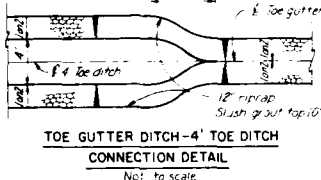
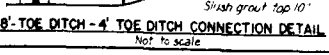
**LEFT ABUTMENT SECTION AT STA. 116+00**  
TYPICAL FROM STA 115+70 TO STA 120+35 UPSTREAM  
TYPICAL FROM STA 115+70 TO STA 120+35 DOWNSTREAM

Note: Pervious backfill in cutoff trench buried from Sta 116+00 to 118+88 See Dwg No. B3



**LEFT ABUTMENT SECTION AT STA 120+50**  
TYPICAL FROM STA 120+35 TO STA 122+50

Note: See North Access Road Details see Road Dwg D1 and D13

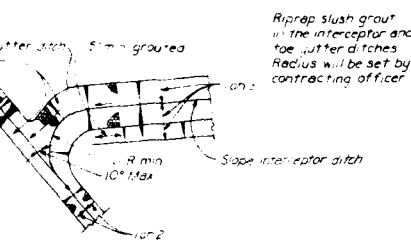
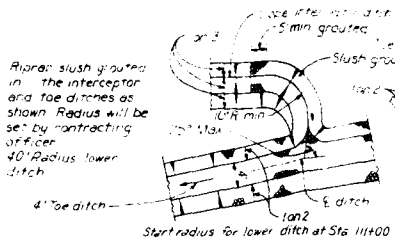
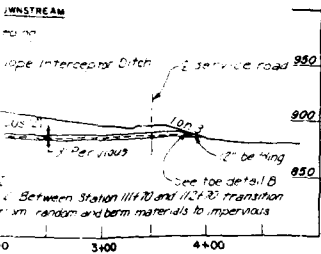


**TYPICAL SECTION A**

**TYPICAL SECTION B**

Riprap slush grout in the interceptor and toe ditches as shown. Radius will be set by contractor. 40' Radius lower ditch.

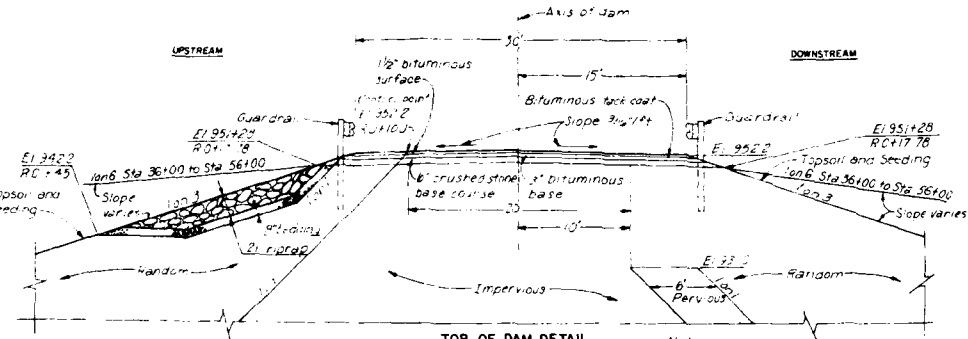
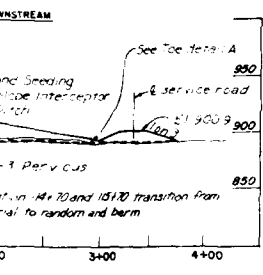
**TYPICAL SLOPE INTERCEPTOR TOE DITCH CONNECTION**  
Not to scale



**TYPICAL SLOPE INTERCEPTOR DITCH TOE DITCH CONNECTION DETAIL**  
Not to scale

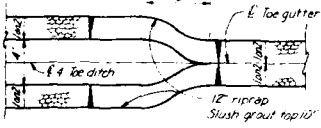
**TYPICAL SLOPE INTERCEPTOR DITCH TOE GUTTER CONNECTION DETAIL**  
Not to scale

Note: For embankment section at outlet works see Dwg No. 88

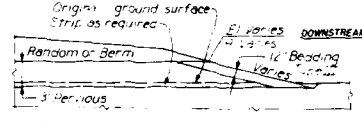


**TOP OF DAM DETAIL**

Note: Top of dam width from turnaround to Sta 36+00 is 5' with aggregate surface

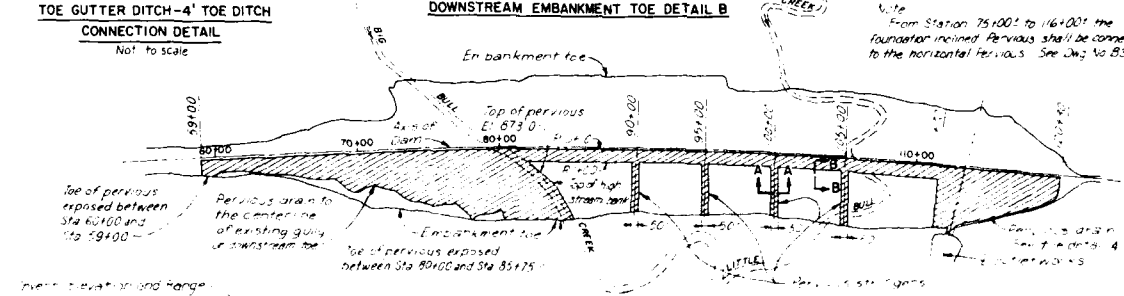
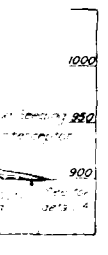


**TOE GUTTER DITCH - 4' TOE DITCH CONNECTION DETAIL**  
Not to scale



**DOWNSTREAM EMBANKMENT TOE DETAIL B**

Note: Use Detail B where Pervious drain extends to embankment toe



**PLAN OF PEROUS DRAIN**

**RECORD DRAWING**

CONTRACT NO. DALW4678-C-011

SYMBOL DESCRIPTION REVISIONS DATE APP'D

**HILLSDALE LAKE**  
STAGE 1<sup>st</sup> CONSTRUCTION

EMBANKMENT, SECTIONS AND DETAILS

**SLOPE INTERCEPTOR DITCH DETAIL**



**TYPICAL SECTION A**

**TYPICAL SECTION B**

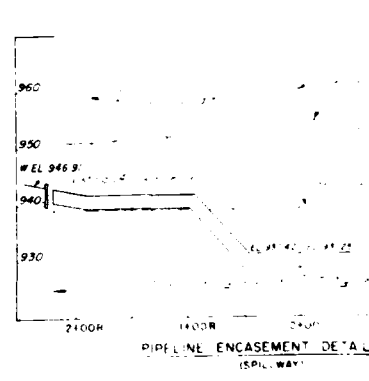
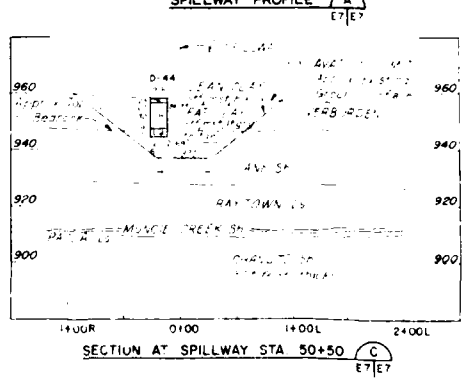
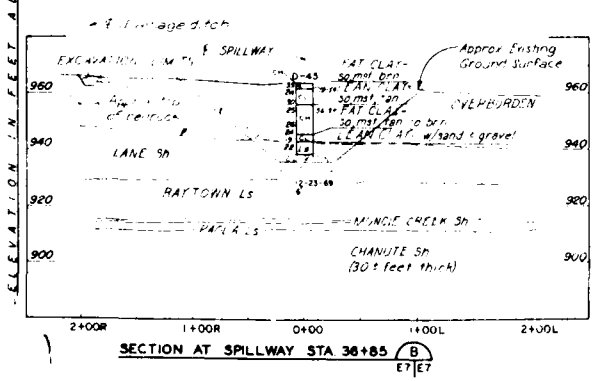
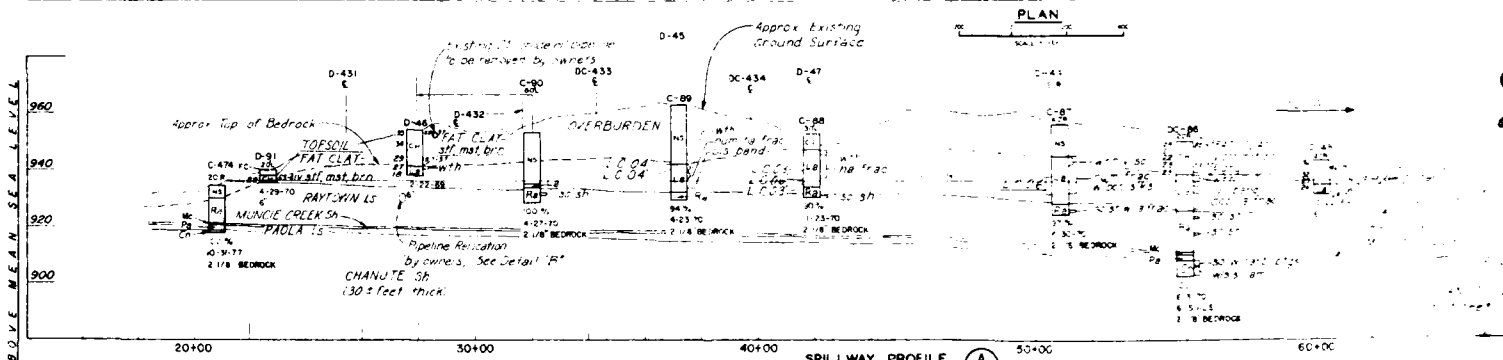
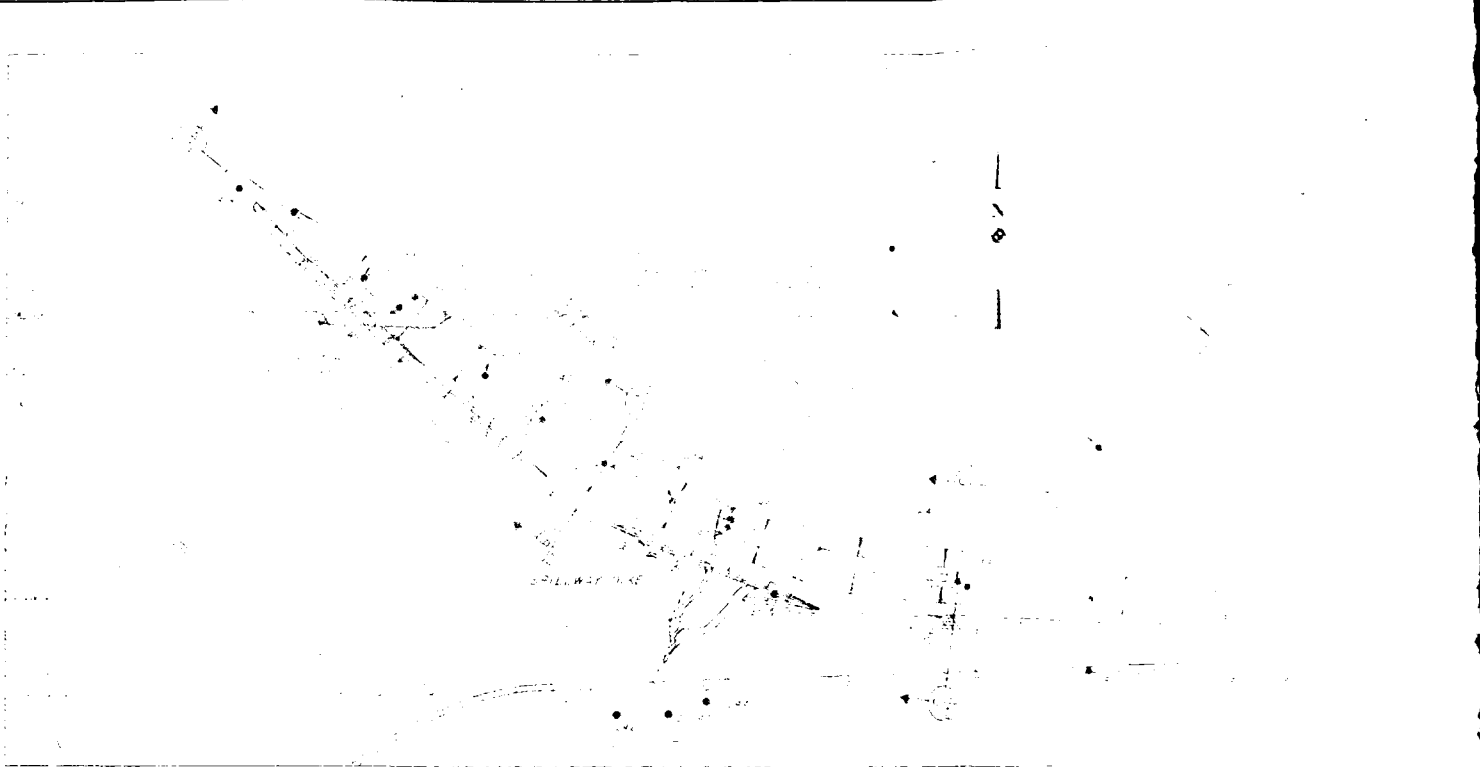


Dwg No 85  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

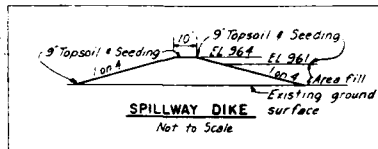
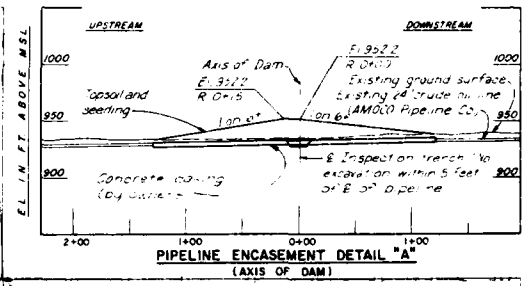
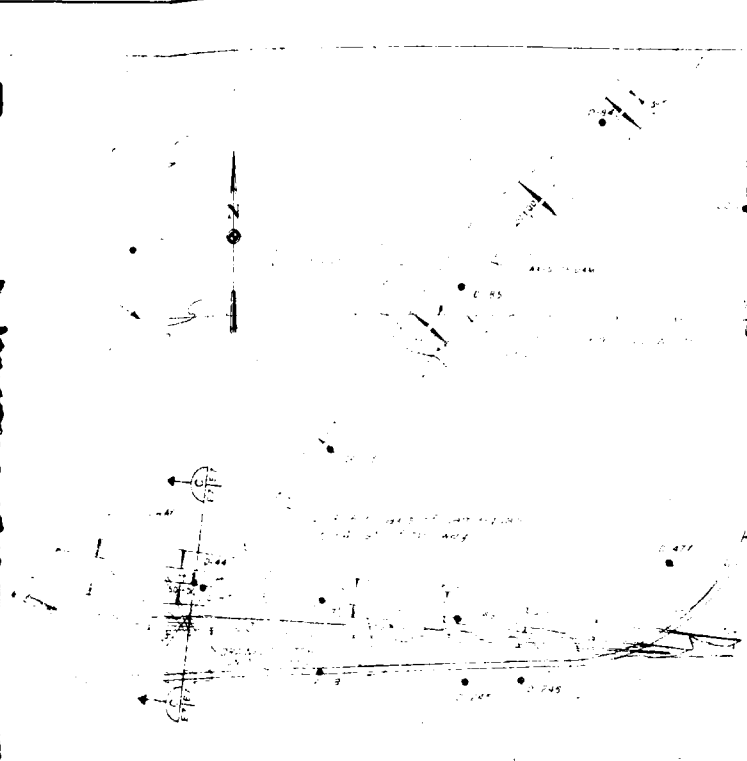
Scale as shown  
U.S. ARMY  
APRIL 1978

0-15-688

PLATE NO 14





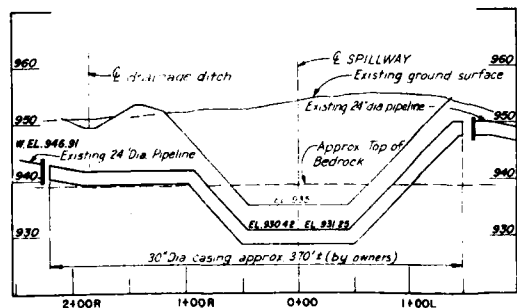
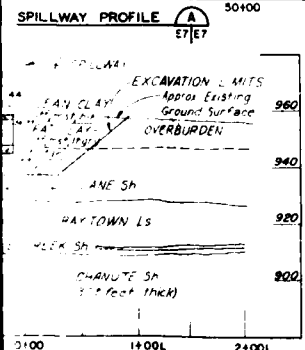
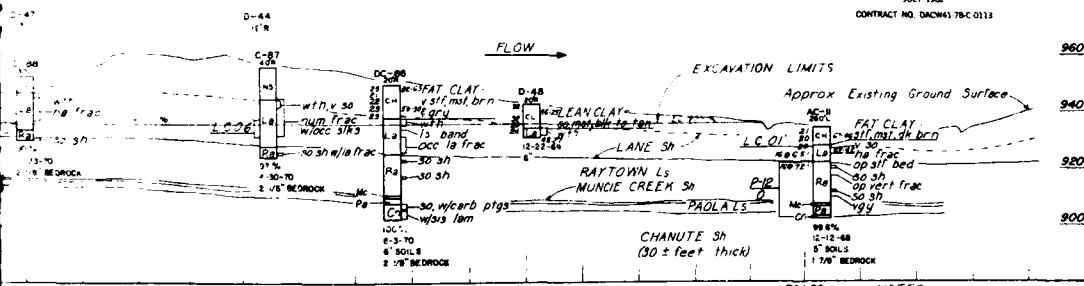


### RECORD DRAWING

JULY 1982  
CONTRACT NO. DACW6178C-0113

FT. LARAMIE-FREEMAN 24" PIPELINE  
RELOCATION FOR HILLSDALE LAKE  
TOP OF 24" LINE UNDER SPILLWAY

STA	BS	HI	FS	ELEV.
BM	5.41	959.22		953.81
*3m	5.03	948.72	15.53	943.69
<b>TOP OF 24"</b>				
E. BEND			17.47	931.23
+45'			17.53	934.19
+34'			17.72	931.00
+50'			18.16	930.66
+49'			18.16	930.56
+50' W BEND			18.30	930.42
TOP OF PIPE AT THE IN			1.81	941.91
TOP OF PIPE AT NEW LINE			0.86	948.36



NOTES  
For General Geologic Column and Legend, see Dwg E1  
For detached borings, see Dwg Nos E2 thru E12  
For plan of South Access Road, see Dwg Nos D6 thru D10  
For alignment data, see Dwg Nos A3 & B1  
For detached borings for South Access Road see Dwg No. D-18



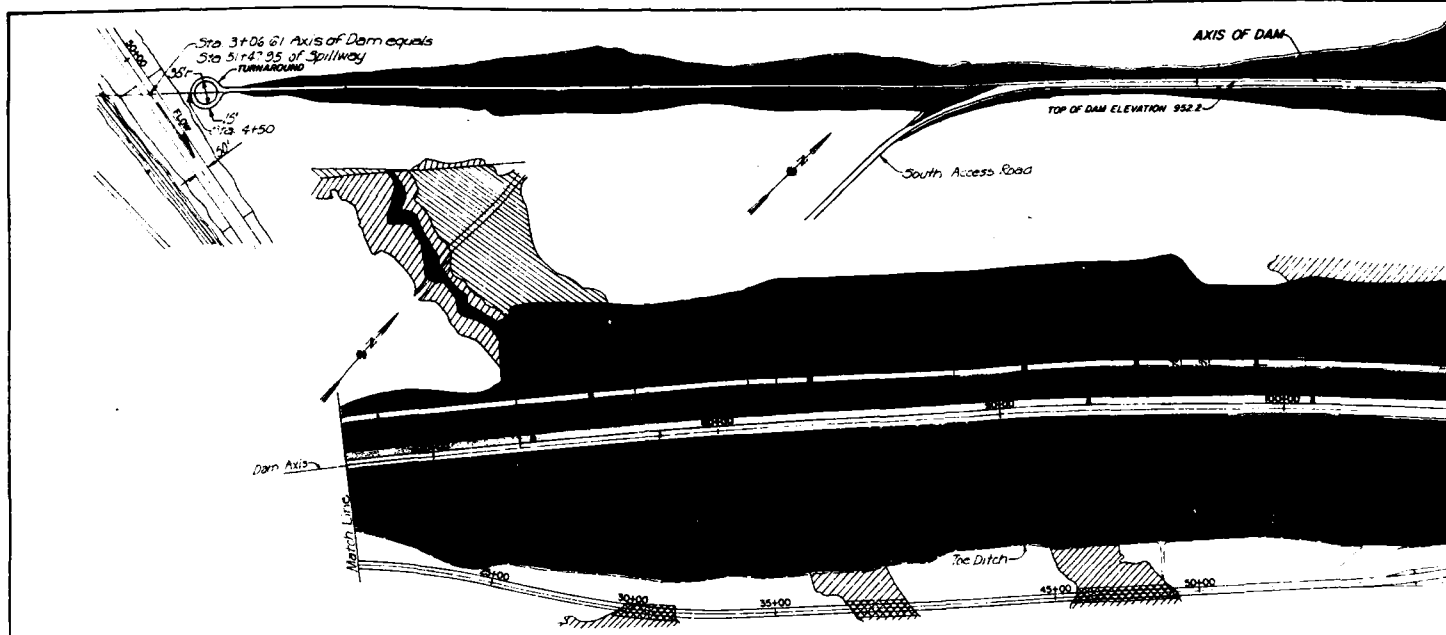
Revised for "As-Built" conditions  
DESCRIPTION  
REVISIONS  
DATE  
APPROVED

BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
STAGE III CONSTRUCTION  
SPILLWAY PLAN, PROFILE AND SECTIONS

Dwg No. [ ]  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

Scale: as shown  
U. S. ARMY  
APRIL 1978

0-15-732



**BEDDING, SPALLS, AND RIPRAP**

SOURCE	LOCATION	GEOLOGIC UNIT
Killough, Inc. Oy. No. 04 (Bones) See Note 1	SW 1/4, Sec. 27, T. 18 S., R. 22 E., Miami Co., Kans.	Spring Hill limestone

Note 1: Only the upper 14 feet acceptable for riprap.

Except for 12-inch riprap, stone for all other riprap shall not be placed during the period 1 November to 1 April unless supplied from free draining stockpiles constructed at least 60 days prior to placement. Said stockpile material shall be tested for gradation and re-processed as necessary prior to delivery to the job site.

**MATERIALS:** Stone for riprap and bedding, except 24-inch, shall be sound, durable limestone free from cracks, seams, shale partings, and overburden spoil. The existing stockpiles of limestone in addition to materials from required excavation may be used for 24-inch limestone-shale slope protection and rock fill.

**ELONGATION:**

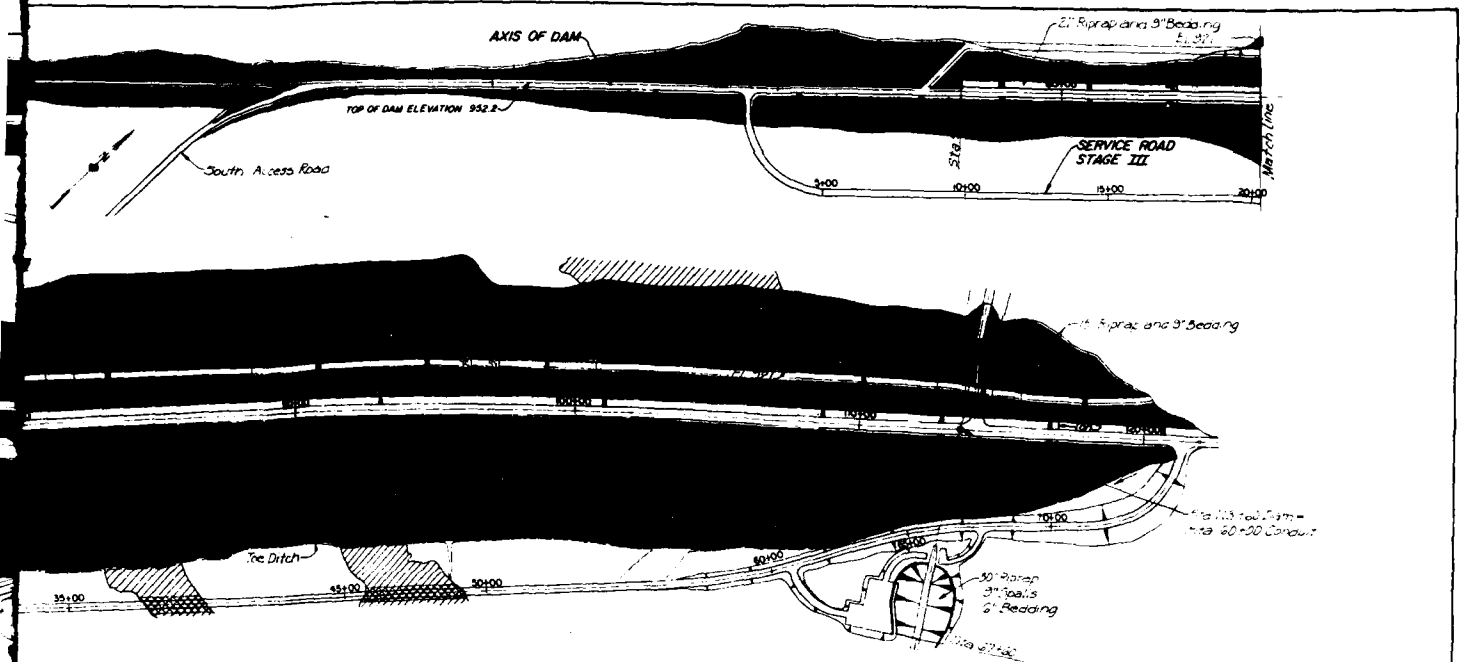
**RIPRAP:** Stone for riprap shall be approximately rectangular in cross section and be relatively free from thin slabby pieces having an elongation ratio greater than 3, except stone for 24-inch limestone-shale and rock fill. In no case shall the quantity of stone having an elongation ratio greater than 3 exceed 5 percent by weight of any one load or area.

**BEDDING AND SPALLS** larger than the 1-inch standard sieve shall be reasonably free from flat, elongated particles.

**DELETERIOUS SUBSTANCES** which include soft friable particles, shale, objectionable materials, and other foreign matter shall not exceed 10 percent by weight.

**WASHING:** Type III bedding that is placed over the downstream end of the pervious drain shall be washed with either a log washer or a screw washer at the Contractor's option.

SIEVE SIZE	PERCENT BY WEIGHT PASSING	WEIGHT IN POUNDS PER STONE	PERCENT OF TOTAL WEIGHT LIGHTER THAN
<b>BEDDING (TYPE I)</b>			
5-inch	Maximum Allowable		<b>12-INCH RIPRAP</b>
3-inch	75-95	1200	100
1-inch	40-60	800	60-90
1/2-inch	20-40	300	30-50
#4	0-20	50	0-15
<b>BEDDING (TYPE II)</b>			
1-inch	Maximum Allowable	2000	100
3/8-inch	75-95	1500	60-90
#8	35-55	500	30-50
#16	20-40	150	0-10
#40	0-20		
<b>BEDDING (TYPE III)</b>			
6-inch	Maximum Allowable	6000	100
3-inch	70-90	3000	60-90
1 1/2-inch	55-75	1500	30-50
1/2-inch	35-55	500	0-15
#4	15-35		
#10	0-20	1200	100
#20	0-5	900	85-95
<b>SPALLS</b>			
6-inch	Maximum Allowable	3500	30-50
8-inch	75-95	750	0-15
2-inch	40-60		
1-inch	20-40		
1/2-inch	0-20		



PERCENT BY WEIGHT PASSING	WEIGHT IN POUNDS PER STONE	PERCENT OF TOTAL WEIGHT LIGHTER THAN
<b>G (TYPE I)</b>		
Maximum Allowable	<b>12-INCH RIPRAP</b>	
75-95	1200	100
40-60	600	60-90
20-40	300	30-50
0-20	50	0-15
<b>G (TYPE II)</b>		
Maximum Allowable	<b>15-INCH RIPRAP</b>	
75-95	2000	100
35-55	1500	60-90
20-40	500	30-50
0-20	150	0-10
<b>G (TYPE III)</b>		
Maximum Allowable	<b>21-INCH RIPRAP</b>	
70-90	8000	100
55-75	3000	60-90
35-55	1500	30-50
15-35	500	0-15
<b>30-INCH RIPRAP</b>		
0-20	12000	100
0-5	9000	85-95
<b>ALLS</b>		
Maximum Allowable	<b>3500</b>	
75-95	9000	85-95
40-60	3500	30-50
20-40	750	0-15
0-20		

**LEGEND**

24" LIMESTONE AND SHALE	---
12" RIPRAP AND 6" BEDDING	---
15" RIPRAP AND 9" BEDDING	---
21" RIPRAP AND 9" BEDDING	---
30" RIPRAP, 9" SPALLS, AND 6" BEDDING	---
STONE PROTECTION FOR CLAY BLANKET, REMEDIAL WORK	---
SEEDED	---

Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI

Designed by: **2**

Drawn by:

Checked by:

Submitted by:

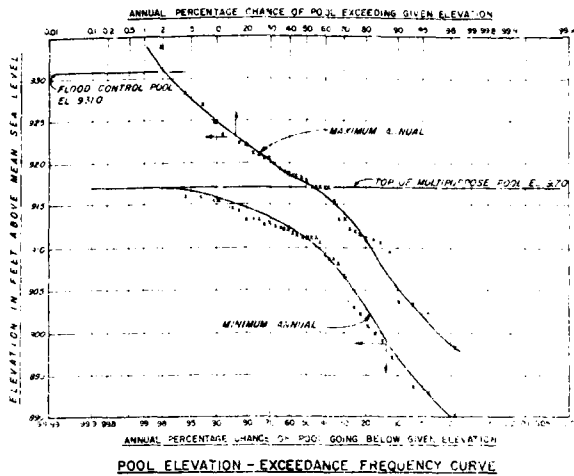
**BIG BULL CREEK, KANSAS  
HILLSDALE LAKE  
EMBANKMENT CRITERIA REPORT**

**SLOPE PROTECTION PLAN**

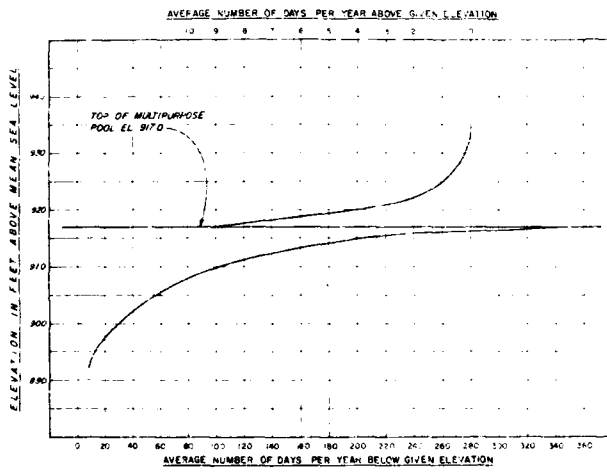
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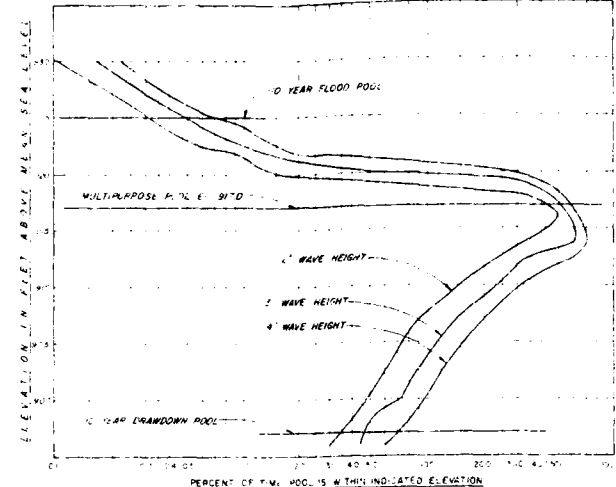
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ANNUAL PERCENTAGE CHANCE OF POOL EXCEEDING GIVEN ELEVATION  
 ANNUAL PERCENTAGE CHANCE OF POOL GOING BELOW GIVEN ELEVATION  
**POOL ELEVATION - EXCEEDANCE FREQUENCY CURVE**



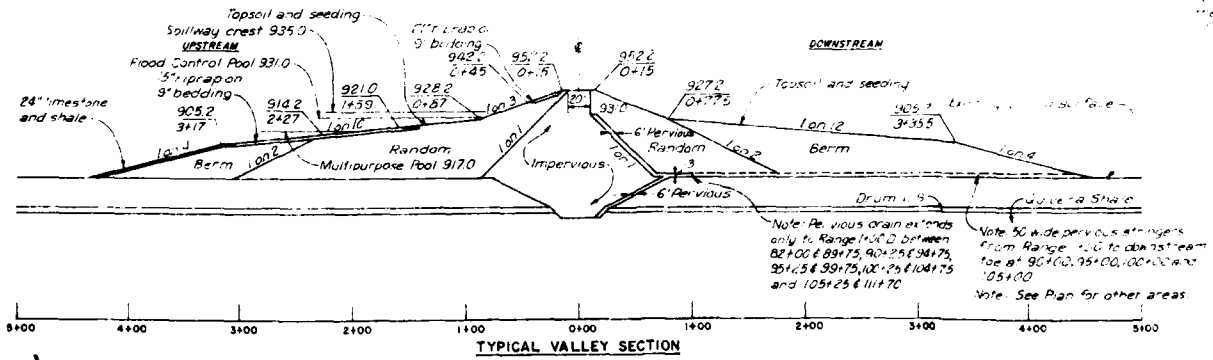
**POOL ELEVATION - DURATION CURVE**



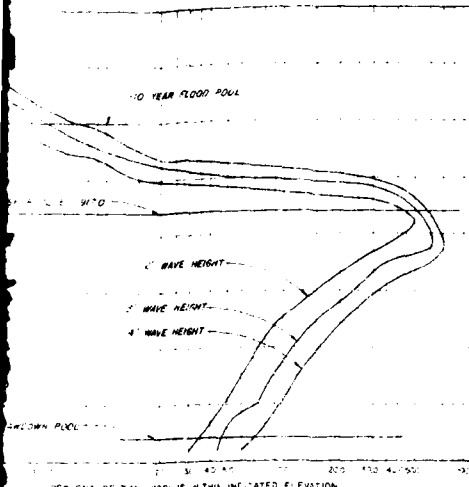
**WIND VELOCITY - FREQUENCY CHART**

DIRECTION	FREQUENCY IN YEARS	TOPEKA, KS M.P.H.	COLUMBIA, MO M.P.H.	KANSAS CITY, MO M.P.H.	DESIGN WIND M.P.H.
N	100	51	36	28	36
NW	100	36	49	31	49
NNW	100	40	45	3	45
WNW	100	46	49	34	49
W	100	40	43	33	43
NE	100	37	32	25	32
N	50	57	35	27	35
NW	50	44	47	30	47
NNW	50	40	43	30	43
WNW	50	44	47	33	47
W	50	47	41	32	41
NE	50	36	32	24	32
N	10	45	31	25	31
NW	10	40	41	28	41
NNW	10	40	38	27	38
WNW	10	40	41	29	41
W	10	40	36	29	36
NE	10	33	28	22	28

\* AVERAGE HOURLY WIND



STA.	EL.
90+00	91.7
91+00	91.7
92+00	91.7
93+00	91.7
94+00	91.7
95+00	91.7
96+00	91.7
97+00	91.7
98+00	91.7
99+00	91.7
100+00	91.7
101+00	91.7
102+00	91.7
103+00	91.7
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110+00	91.7
111+00	91.7
112+00	91.7
113+00	91.7
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117+00	91.7
118+00	91.7
119+00	91.7
120+00	91.7

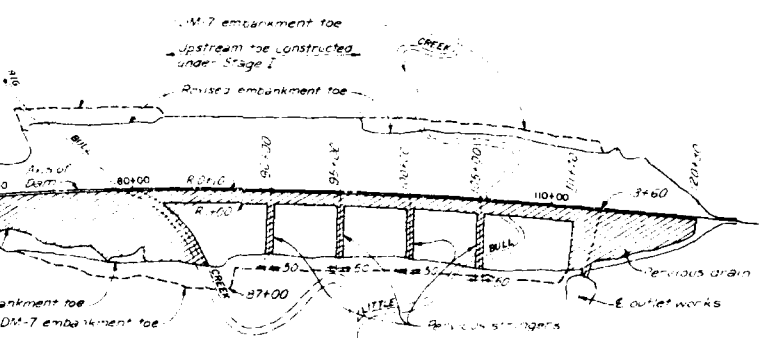
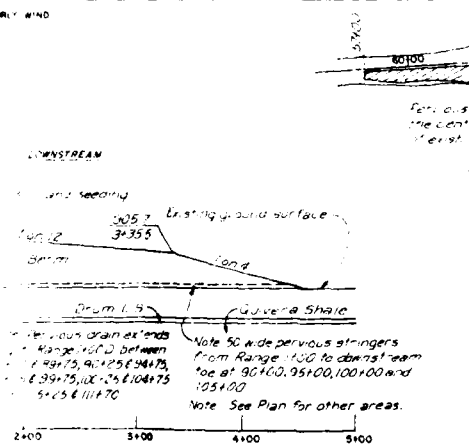


**RIPRAP STUDY** (SPECIFIC GRAVITY = 2.60)

STATION	ELEV.	SLOPE	LENGTH	DIRECTION	FREQ. (CY)	WIND		WAVE			RIPRAP				
						MPH	DIR	H <sub>s</sub>	H <sub>m</sub>	L (ft)	TYP	W <sub>s</sub> (ft)	W <sub>d</sub> (ft)	THICK	S.F.
POINT 'A'															
70+00	931	1:0N 3	254	NW	100	49	31	49	64	DW	200	446	200	24"	100
70+00	917	1:0N 10	85	NW	100	49	30	42	55	DW	14	50	30	15"	3
70+00	917	1:0N 3	85	NW	100	49	30	42	55	DW	126	283	150	21"	106
70+00	931	1:0N 3	254	NW	50	47	30	42	55	DW	122	274	150	21"	107
70+00	917	1:0N 2	85	NW	50	47	27	38	49	DW	10	46	30	15"	3
70+00	917	1:0N 3	85	NW	50	47	27	38	49	DW	91	194	100	18"	103
70+00	931	1:0N 3	254	NW	0	41	24	34	44	DW	77	171	100	18"	109
70+00	917	1:0N 2	85	NW	0	41	24	34	44	DW	14	30	30	12"	3
70+00	917	1:0N 3	85	NW	0	41	24	34	44	DW	65	141	100	18"	115
POINT 'B'															
90+00	931	1:0N 3	258	NW	100	49	35	49	64	DW	200	446	200	24"	100
90+00	917	1:0N 2	82	NW	100	49	30	42	55	DW	24	52	30	15"	3
90+00	917	1:0N 3	82	NW	100	49	30	42	55	DW	26	283	150	21"	106
90+00	931	1:0N 3	258	NW	50	47	30	42	55	DW	122	274	150	21"	107
90+00	917	1:0N 2	82	NW	50	47	27	38	49	DW	20	47	30	15"	3
90+00	917	1:0N 3	82	NW	50	47	27	38	49	DW	91	194	100	18"	103
90+00	931	1:0N 3	258	NW	0	41	26	36	47	DW	77	171	100	18"	109
90+00	917	1:0N 2	82	NW	0	41	24	34	44	DW	14	30	30	12"	3
90+00	917	1:0N 3	82	NW	0	41	24	34	44	DW	65	141	100	18"	115
POINT 'C'															
115+00	931	1:0N 3	240	WNW	100	49	35	49	64	DW	200	446	200	24"	100
115+00	917	1:0N 3	93	WNW	100	49	30	42	55	DW	26	58	30	15"	12
115+00	917	1:0N 3	93	WNW	100	49	30	42	55	DW	126	283	150	21"	106
115+00	931	1:0N 3	240	WNW	50	47	30	42	55	DW	122	274	150	21"	107
115+00	917	1:0N 3	93	WNW	50	47	27	38	49	DW	9	41	30	15"	14
115+00	917	1:0N 3	93	WNW	50	47	27	38	49	DW	91	194	100	18"	103
115+00	931	1:0N 3	240	WNW	0	41	26	36	47	DW	77	171	100	18"	109
115+00	917	1:0N 3	93	WNW	0	41	24	34	44	DW	14	30	30	12"	3
115+00	917	1:0N 3	93	WNW	0	41	24	34	44	DW	65	141	100	18"	115

**WIND VELOCITY - FREQUENCY CHART**

FREQUENCY IN YEARS	TOPEKA, KS M.P.H.	COLUMBIA, MO M.P.H.	KANSAS CITY, MO M.P.H.	DESIGN WIND M.P.H.
1	57	36	28	36
100	16	49	31	49
100	45	45	3	45
100	46	49	34	49
100	49	43	33	43
100	37	32	25	32
50	49	35	27	35
50	44	47	30	47
50	43	43	30	43
50	44	47	33	47
50	47	41	32	41
50	36	32	24	32
10	45	31	25	31
10	40	41	28	41
10	38	38	27	38
10	40	41	29	41
10	40	36	29	36
10	33	28	22	28



**HILLSDALE LAKE**  
EMBANKMENT CRITERIA REPORT

**RIPRAP DESIGN, TYPICAL VALLEY EMBANKMENT AND PLAN OF PEROVIOUS DRAIN**

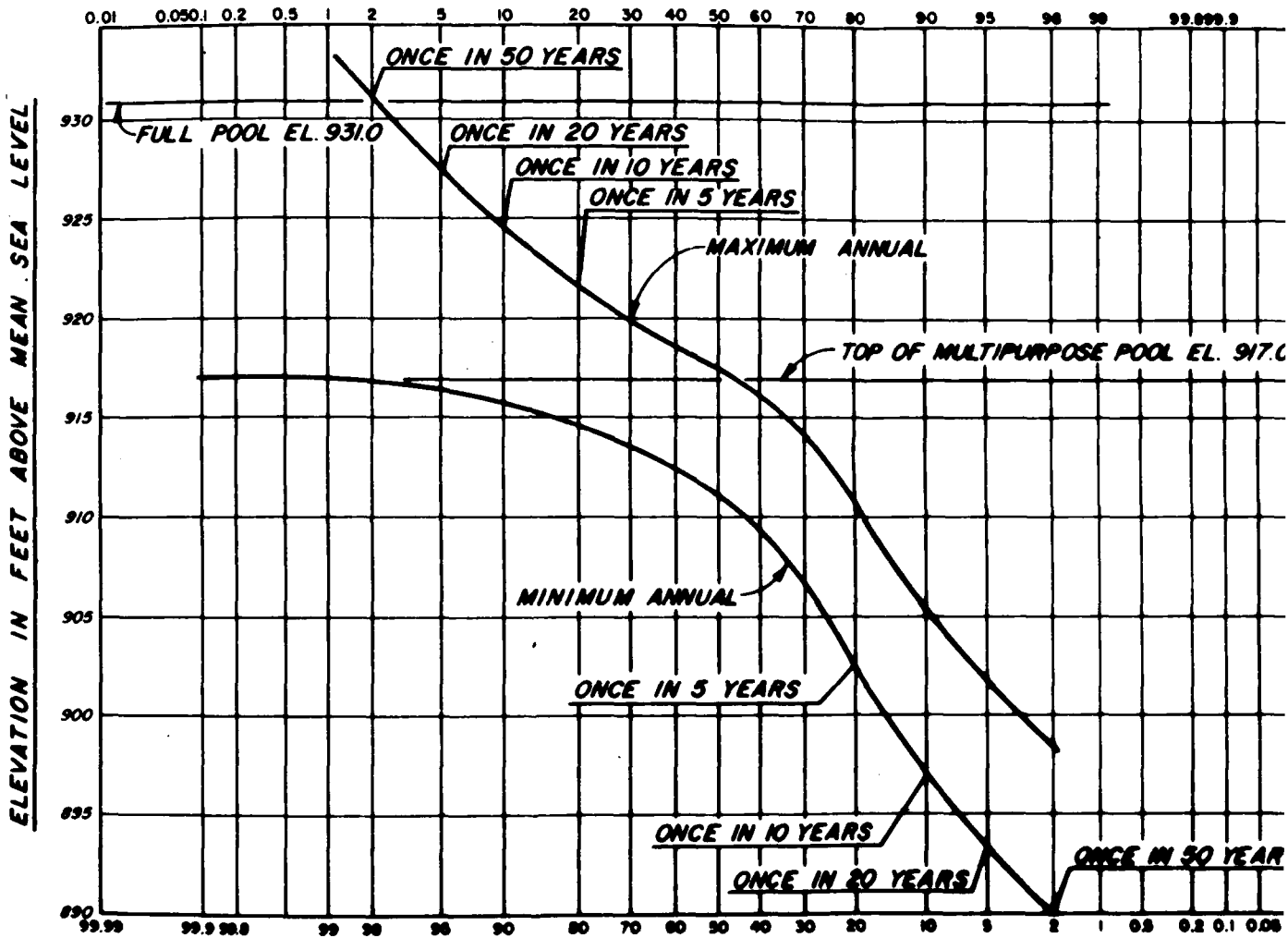
In 1 sheet      Sheet No. 1      Scale: as shown

CORPS OF ENGINEERS      U. S. ARMY  
KANSAS CITY DISTRICT      JANUARY 1978

Submitted by: [Signature]      Recommended by: [Signature]      Approved by: [Signature]

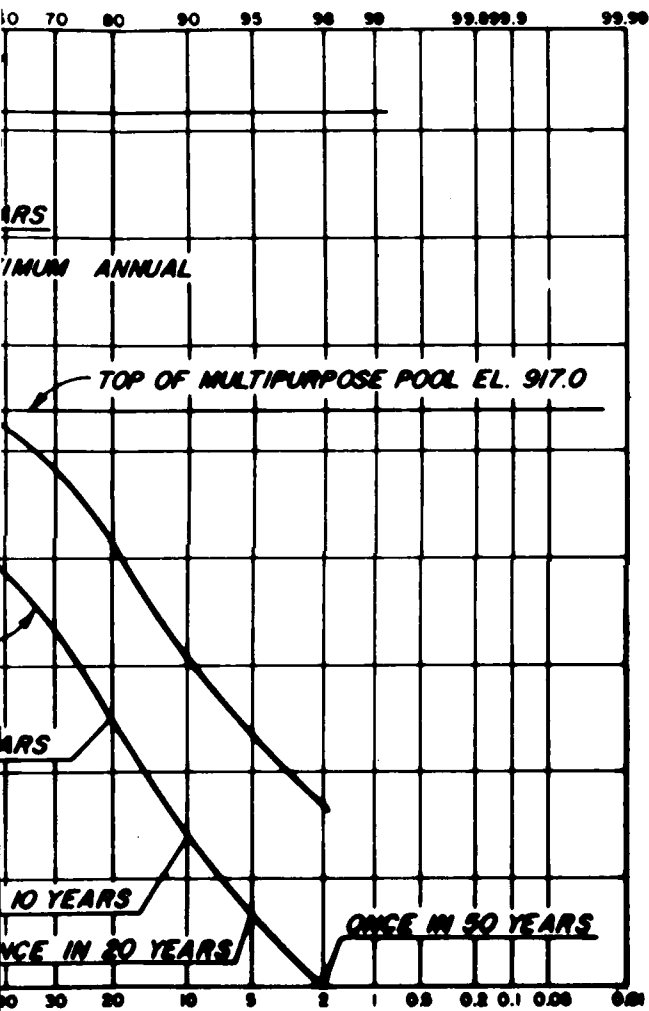
Checked by: GAD      JPM      RGF      DM-7      O-15-678

**ANNUAL PERCENT CHANCE OF POOL EXCEEDING GIVEN ELEVATION  
(MAXIMUM ANNUAL)**



**ANNUAL PERCENT CHANCE OF POOL GOING BELOW GIVEN ELEVATION  
(MINIMUM ANNUAL)**

EXCEEDING GIVEN ELEVATION  
(ANNUAL)



GOING BELOW GIVEN ELEVATION  
(ANNUAL)

SYMBOL	DESCRIPTION	DATE	APP'D.
	REVISION		

DNS BALL CREEK, KANSAS  
**HILLSDALE LAKE**  
MASTER PLAN

**LAKE STAGE FREQUENCY CURVES**

In 1 sheet  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

Sheet No. 1

Scale: as shown  
U. S. ARMY  
FEBRUARY 1978

Approved:  
*William M. Linden*  
CHIEF, HILLSDALE LAKE DISTRICT  
COMPILED BY: DRAWN BY: CHECKED BY:

FILE NO.

R.L.T. J.P.R. J.P.R. 00-15 0-15-013

2

PLATE NO. 17A

**GENERALIZED GEOLOGIC COLUMN**

SYSTEM	GROUP	FORMATION	MEMBER	SYMBOL	APPROXIMATE THICKNESS	GENERAL DESCRIPTION
PENNSYLVANIAN	PLATYFORM	Spring Hill	H <sub>1</sub>	S <sub>1</sub>	14'	SHALE moderate to hard dense to occasional very fine grained with occasional pits thin bedded to wavy bedded light grey.
			H <sub>2</sub>	S <sub>2</sub>	0.5'	SHALE soft to platy calcareous dark grey.
			H <sub>3</sub>	S <sub>3</sub>	2.5'	SHALE moderate to hard dense to occasional very fine grained with occasional pits thin bedded light grey.
			H <sub>4</sub>	S <sub>4</sub>	19'	SHALE soft to very soft platy calcareous with occasional pits with margin zone in center part moderate to hard very fine grained sandstone at bottom.
			H <sub>5</sub>	S <sub>5</sub>	14'	SHALE moderate to hard dense thin bedded with many shaly partings light grey to buff with light blue mottling.
			H <sub>6</sub>	S <sub>6</sub>	100'	SHALE soft to occasional very soft to very sandy platy blue to dark grey with occasional sandstones partings and limestone (see upper half of formation) in lower sandstone moderate to hard fine grained calcareous occasional calcareous thin bedded grey.
			H <sub>7</sub>	S <sub>7</sub>	75'	SHALE moderate to hard dense to fine grained thin bedded and fine to coarse thin bedded grey bedded with calcareous partings with occasional shaly partings.
			H <sub>8</sub>	S <sub>8</sub>	0.1'	SHALE soft to very platy calcareous occasional dense to cherty nodular grey.
	LOBE	Ravine	P <sub>1</sub>	S <sub>1</sub>	2.5'	SHALE moderate to hard dense to very dense thin bedded light grey.
			P <sub>2</sub>	S <sub>2</sub>	10'	SHALE SANDSTONE and SANDSTONE also some calcareous sandstone in the gray with sandstone and limestone (see upper half of formation) in the lower part of the member. The upper part is calcareous with occasional pits and sandstone nodules in the lower part of the member. The lower part is very fine grained with occasional pits and sandstone nodules.
			P <sub>3</sub>	S <sub>3</sub>	4'	SHALE moderate to hard dense to very dense thin bedded light grey.
	UPPERVALLEY	Canaan	C <sub>1</sub>	S <sub>1</sub>	14'	SHALE moderate to hard thin bedded dense arg. to black sandstone with occasional very dark grey partings and bands with a nodular texture in a green shaly matrix.
			C <sub>2</sub>	S <sub>2</sub>	75'	SHALE soft to moderate to hard dense to very dense to occasional pits and shaly partings dark grey to green grey.
			C <sub>3</sub>	S <sub>3</sub>	14'	SHALE moderate to hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
			C <sub>4</sub>	S <sub>4</sub>	14'	SHALE moderate to hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
			C <sub>5</sub>	S <sub>5</sub>	14'	SHALE moderate to hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
			C <sub>6</sub>	S <sub>6</sub>	14'	SHALE moderate to hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
			C <sub>7</sub>	S <sub>7</sub>	14'	SHALE moderate to hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
			C <sub>8</sub>	S <sub>8</sub>	14'	SHALE moderate to hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.

NOTE: A vertical joint system consisting of fine shaly partings commonly occurring in the rock, is found in all upper parts of the group. Where the rock surface consists of limestone, these joints have been observed in varying degrees of unroofing and unroofing processes. These processes have also been active along bedding planes in non-surface rocks. The resulting solution cavities are partially or completely filled with fine grained sand and occasional calc fragments. In the case of shales, this weathering activity may be traced some distance back from the surface into even though the limestone is overlain by them.

**ABBREVIATIONS**

Symbol	Formation Name	Member Name	Symbol	Formation Name	Member Name
S <sub>1</sub>	Spring Hill	H <sub>1</sub>	S <sub>1</sub>	Spring Hill	H <sub>1</sub>
S <sub>2</sub>	Spring Hill	H <sub>2</sub>	S <sub>2</sub>	Spring Hill	H <sub>2</sub>
S <sub>3</sub>	Spring Hill	H <sub>3</sub>	S <sub>3</sub>	Spring Hill	H <sub>3</sub>
S <sub>4</sub>	Spring Hill	H <sub>4</sub>	S <sub>4</sub>	Spring Hill	H <sub>4</sub>
S <sub>5</sub>	Spring Hill	H <sub>5</sub>	S <sub>5</sub>	Spring Hill	H <sub>5</sub>
S <sub>6</sub>	Spring Hill	H <sub>6</sub>	S <sub>6</sub>	Spring Hill	H <sub>6</sub>
S <sub>7</sub>	Spring Hill	H <sub>7</sub>	S <sub>7</sub>	Spring Hill	H <sub>7</sub>
S <sub>8</sub>	Spring Hill	H <sub>8</sub>	S <sub>8</sub>	Spring Hill	H <sub>8</sub>
P <sub>1</sub>	Ravine	P <sub>1</sub>	P <sub>1</sub>	Ravine	P <sub>1</sub>
P <sub>2</sub>	Ravine	P <sub>2</sub>	P <sub>2</sub>	Ravine	P <sub>2</sub>
P <sub>3</sub>	Ravine	P <sub>3</sub>	P <sub>3</sub>	Ravine	P <sub>3</sub>
C <sub>1</sub>	Canaan	C <sub>1</sub>	C <sub>1</sub>	Canaan	C <sub>1</sub>
C <sub>2</sub>	Canaan	C <sub>2</sub>	C <sub>2</sub>	Canaan	C <sub>2</sub>
C <sub>3</sub>	Canaan	C <sub>3</sub>	C <sub>3</sub>	Canaan	C <sub>3</sub>
C <sub>4</sub>	Canaan	C <sub>4</sub>	C <sub>4</sub>	Canaan	C <sub>4</sub>
C <sub>5</sub>	Canaan	C <sub>5</sub>	C <sub>5</sub>	Canaan	C <sub>5</sub>
C <sub>6</sub>	Canaan	C <sub>6</sub>	C <sub>6</sub>	Canaan	C <sub>6</sub>
C <sub>7</sub>	Canaan	C <sub>7</sub>	C <sub>7</sub>	Canaan	C <sub>7</sub>
C <sub>8</sub>	Canaan	C <sub>8</sub>	C <sub>8</sub>	Canaan	C <sub>8</sub>

**CLASSIFICATION SYSTEM**

Q1	Very soft green to buff	Q2	Soft to moderate to hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
Q3	Moderate to hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.	Q4	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
Q5	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.	Q6	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
Q7	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.	Q8	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
Q9	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.	Q10	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
Q11	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.	Q12	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
Q13	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.	Q14	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
Q15	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.	Q16	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
Q17	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.	Q18	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.
Q19	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.	Q20	Very hard dense to very dense thin bedded with occasional pits and shaly partings light grey to buff with light blue mottling.

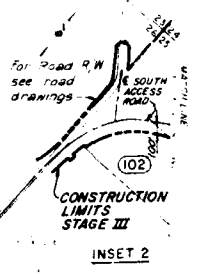
**MEMBER UNIT THICKNESS**

Symbol	Thickness
H <sub>1</sub>	14'
H <sub>2</sub>	0.5'
H <sub>3</sub>	2.5'
H <sub>4</sub>	19'
H <sub>5</sub>	14'
H <sub>6</sub>	100'
H <sub>7</sub>	75'
H <sub>8</sub>	0.1'
P <sub>1</sub>	2.5'
P <sub>2</sub>	10'
P <sub>3</sub>	4'
C <sub>1</sub>	14'
C <sub>2</sub>	75'
C <sub>3</sub>	14'
C <sub>4</sub>	14'
C <sub>5</sub>	14'
C <sub>6</sub>	14'
C <sub>7</sub>	14'
C <sub>8</sub>	14'





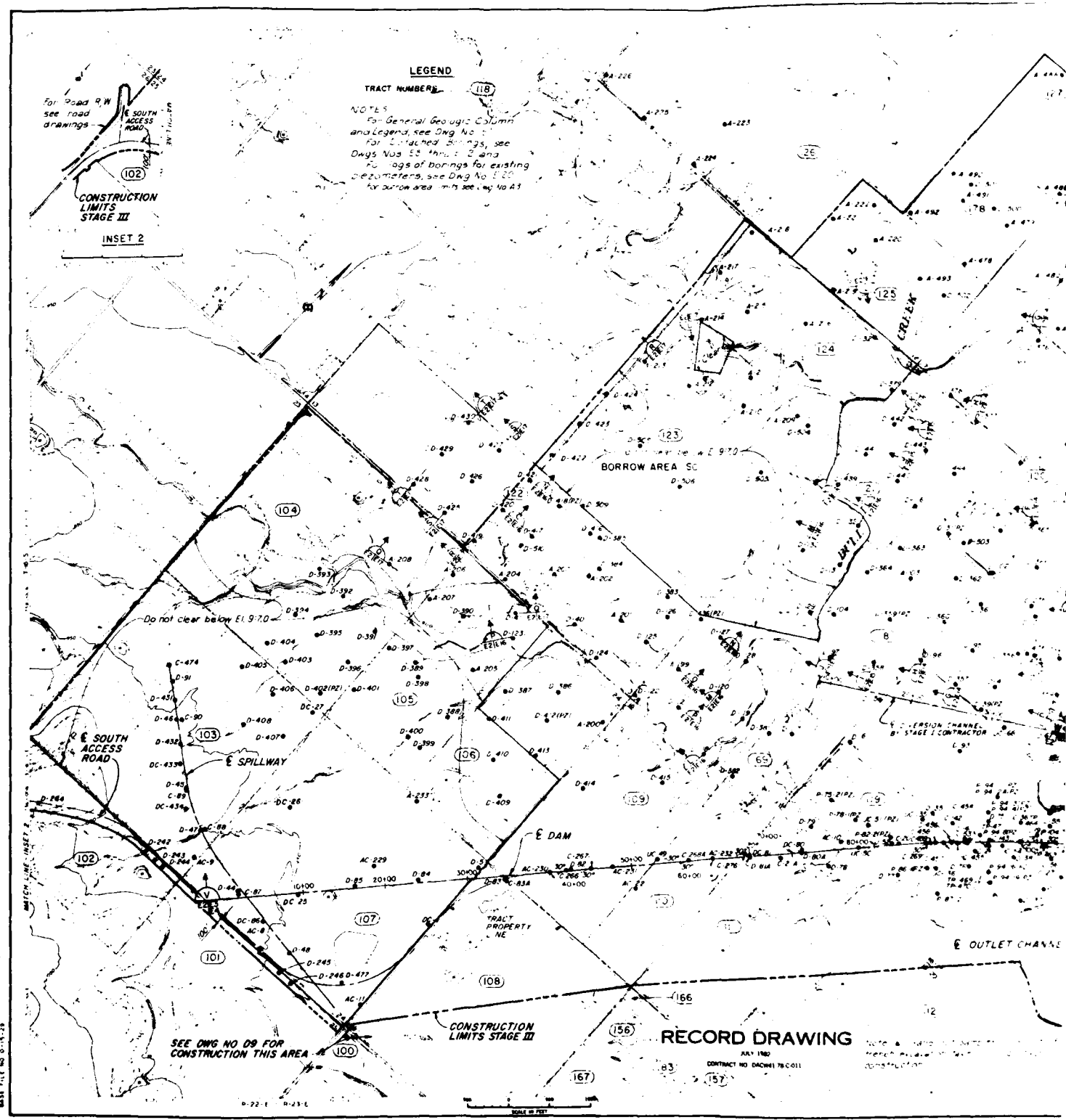




**LEGEND**

**TRACT NUMBERS** (118)

**NOTES**  
 For General Geologic Column and Legend, see Dwg. No. 1  
 For Attached Borings, see Dwg. Nos. 55 thru 72 and logs of borings for existing borings, see Dwg. No. 100  
 For borrow area limits see Dwg. No. A3



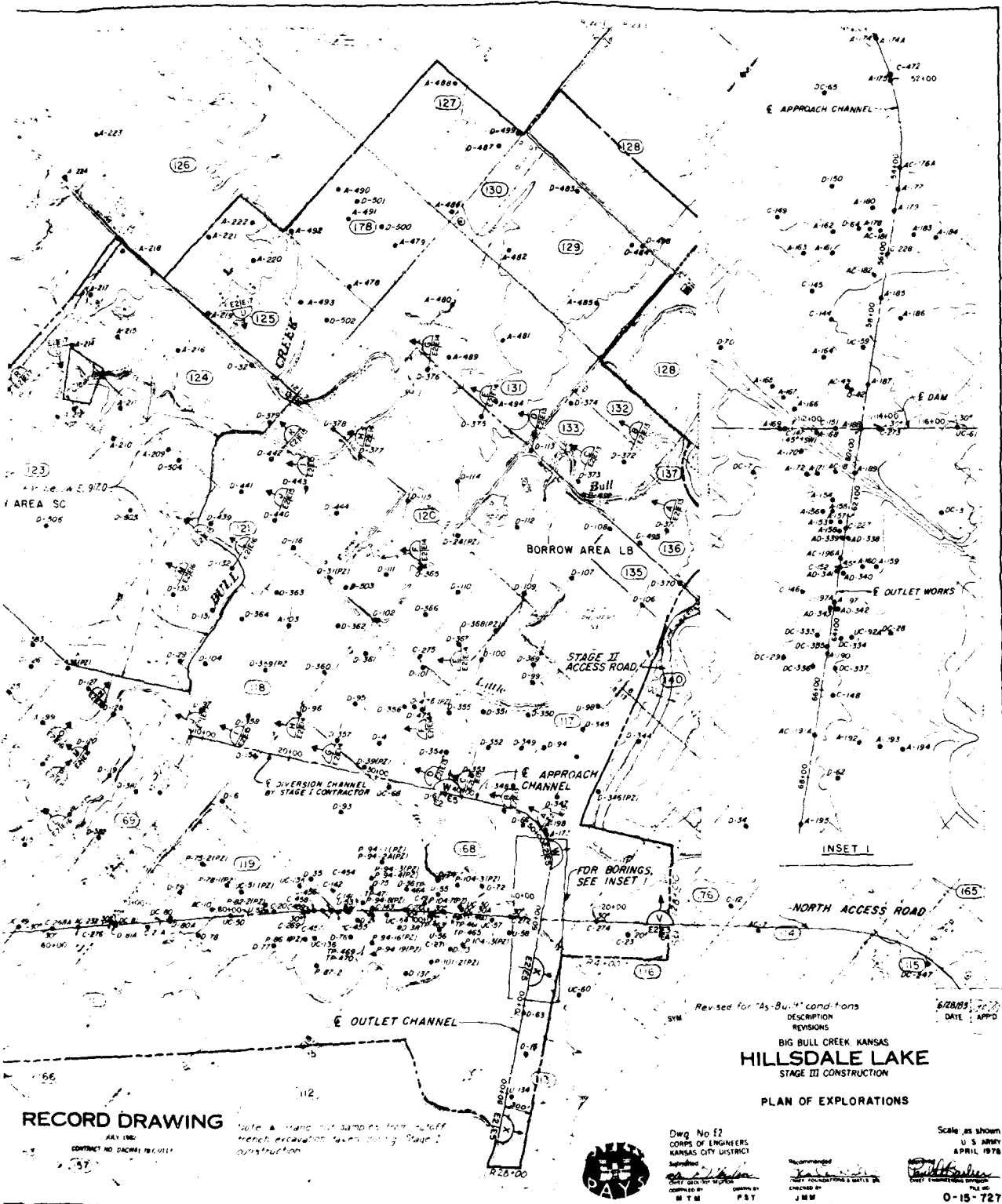
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 MATCH LINE - INSET 99  
 MATCH LINE - INSET 100

SEE DWG NO. D9 FOR CONSTRUCTION THIS AREA

**RECORD DRAWING**

CONTRACT NO. DACW178C-011

SCALE 1" = 200'



**RECORD DRAWING**

DATE: MAY 1961  
 CONTRACT NO. DACW41-70-0111

Note: All hand-drawn samples from staff trench excavations were during Stage I construction.

**HILLDALE LAKE**  
 STAGE III CONSTRUCTION

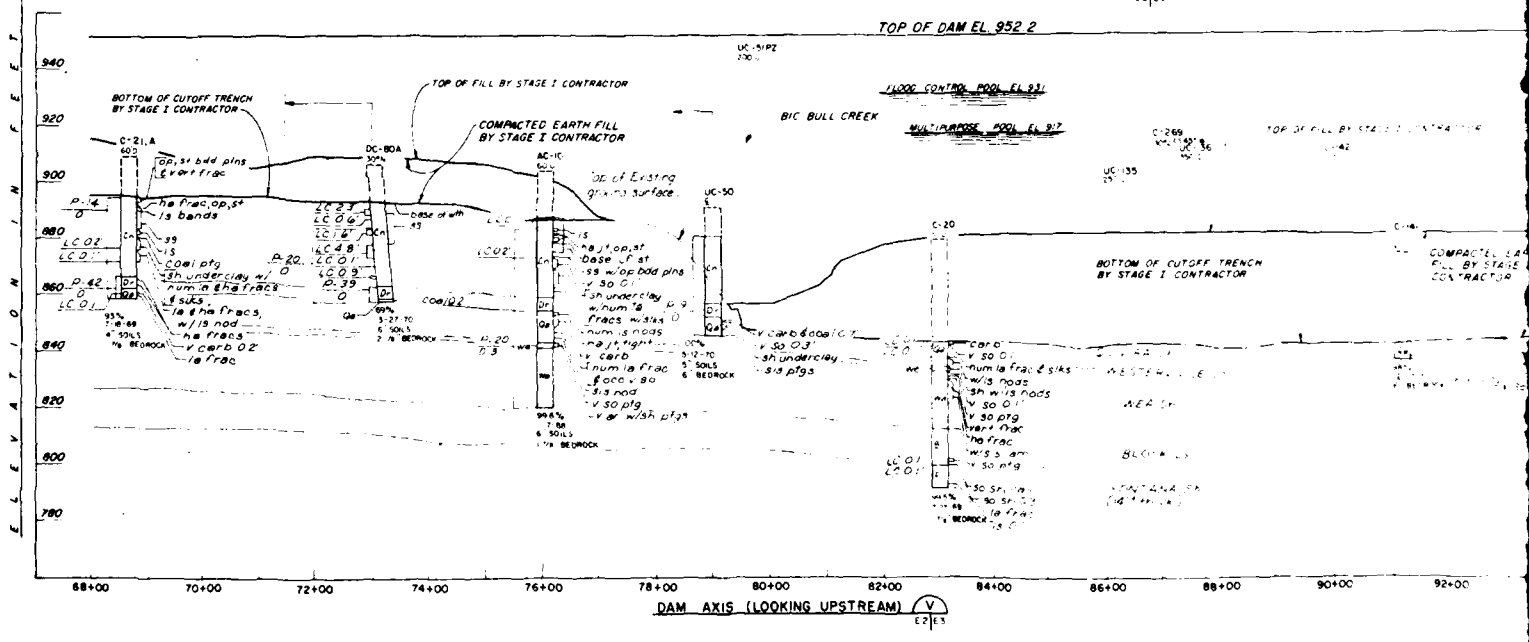
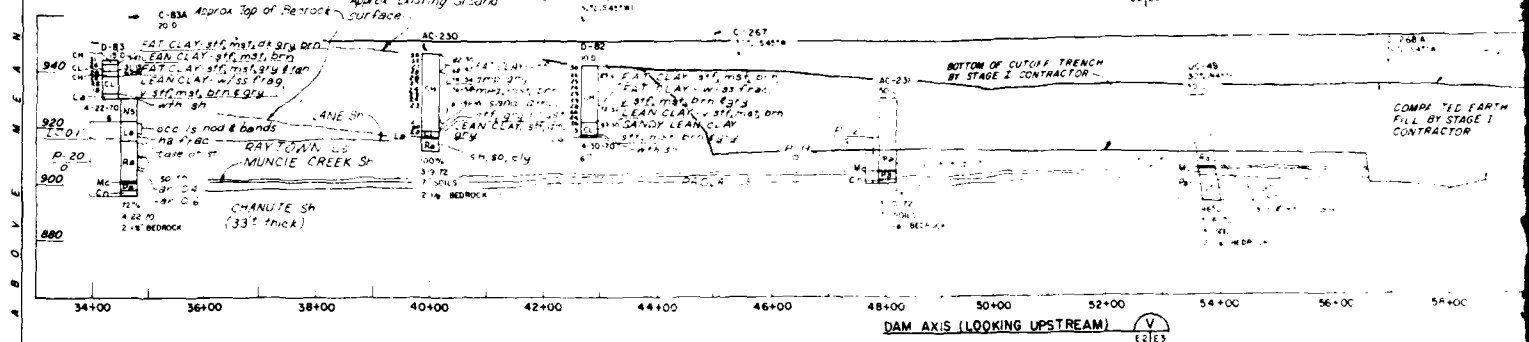
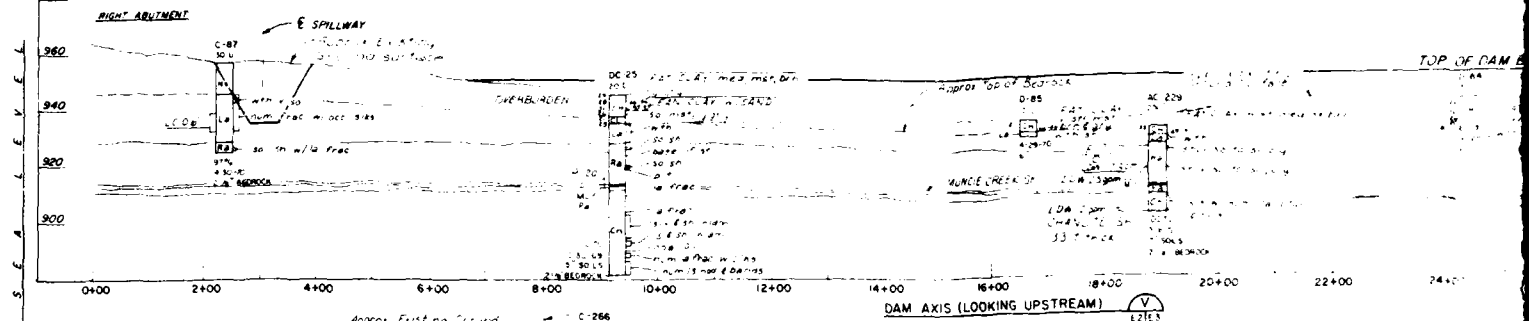
**PLAN OF EXPLORATIONS**

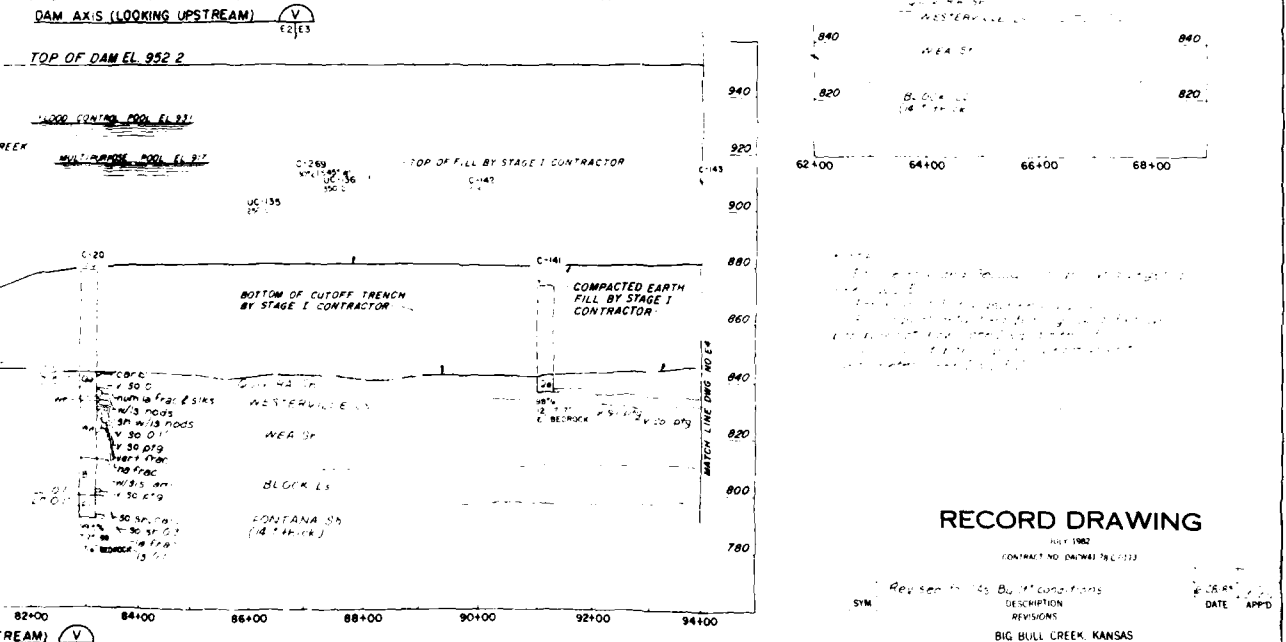
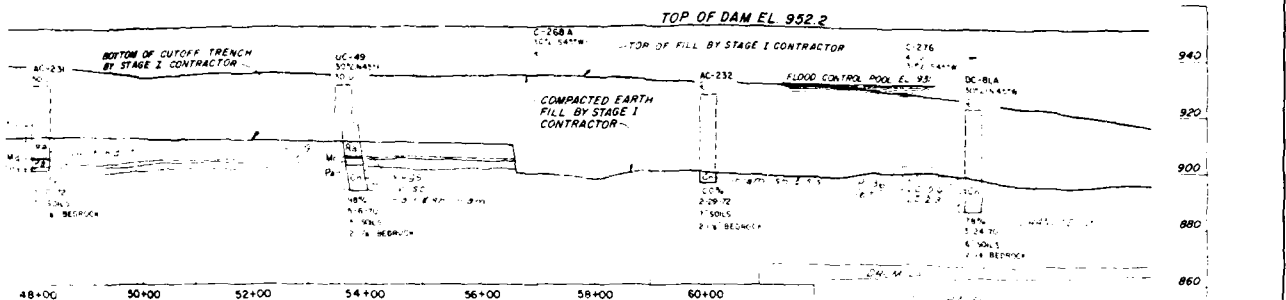
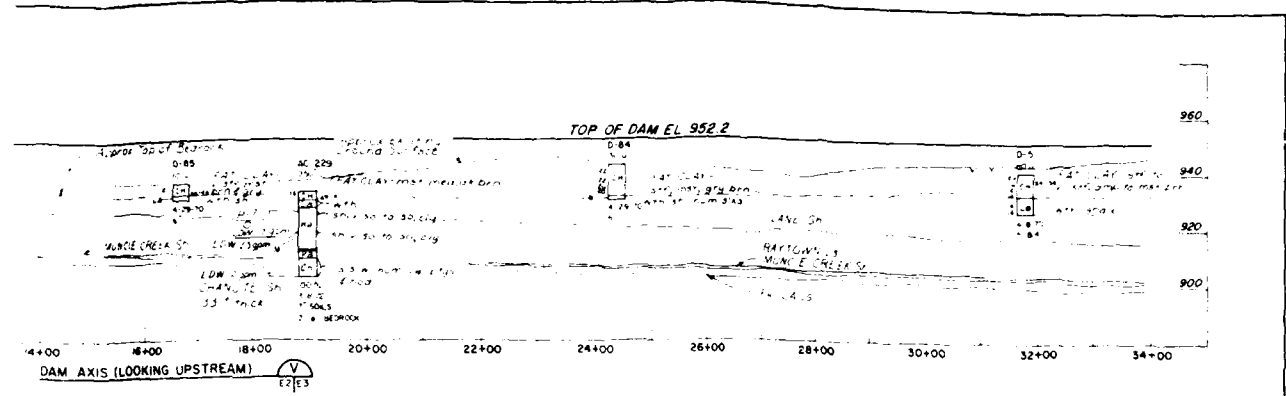
Dwg No E2  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 Recommended  
 Checked by  
 M T M P S T J M B

Scale as shown  
 U.S. ARMY  
 APRIL 1978

0-15-727

PLATE NO 19





**RECORD DRAWING**

CONTRACT NO. (DAW) 72-1-133  
 REVISIONS  
 DATE APP'D

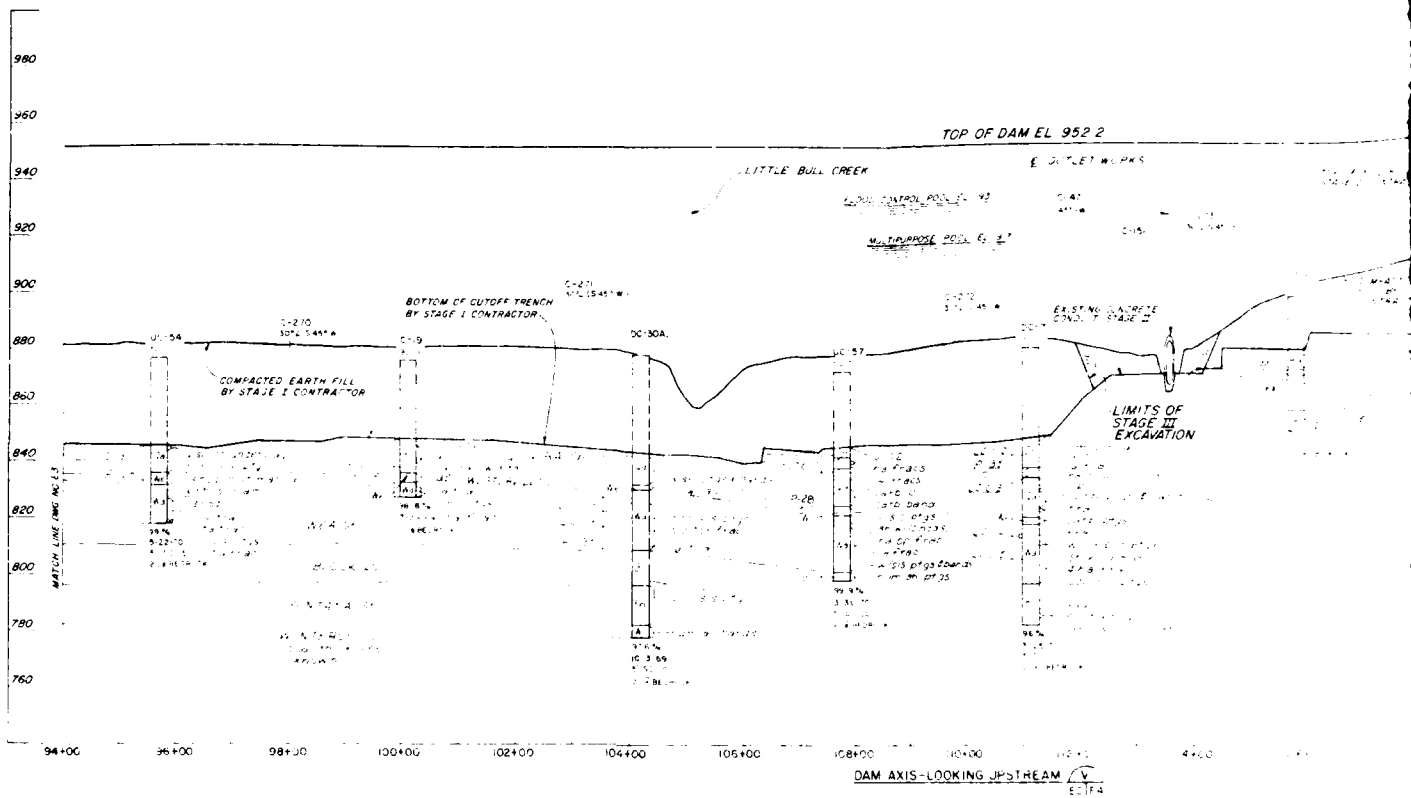
**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION

LOGS OF SELECTED EXPLORATIONS  
 DAM AXIS

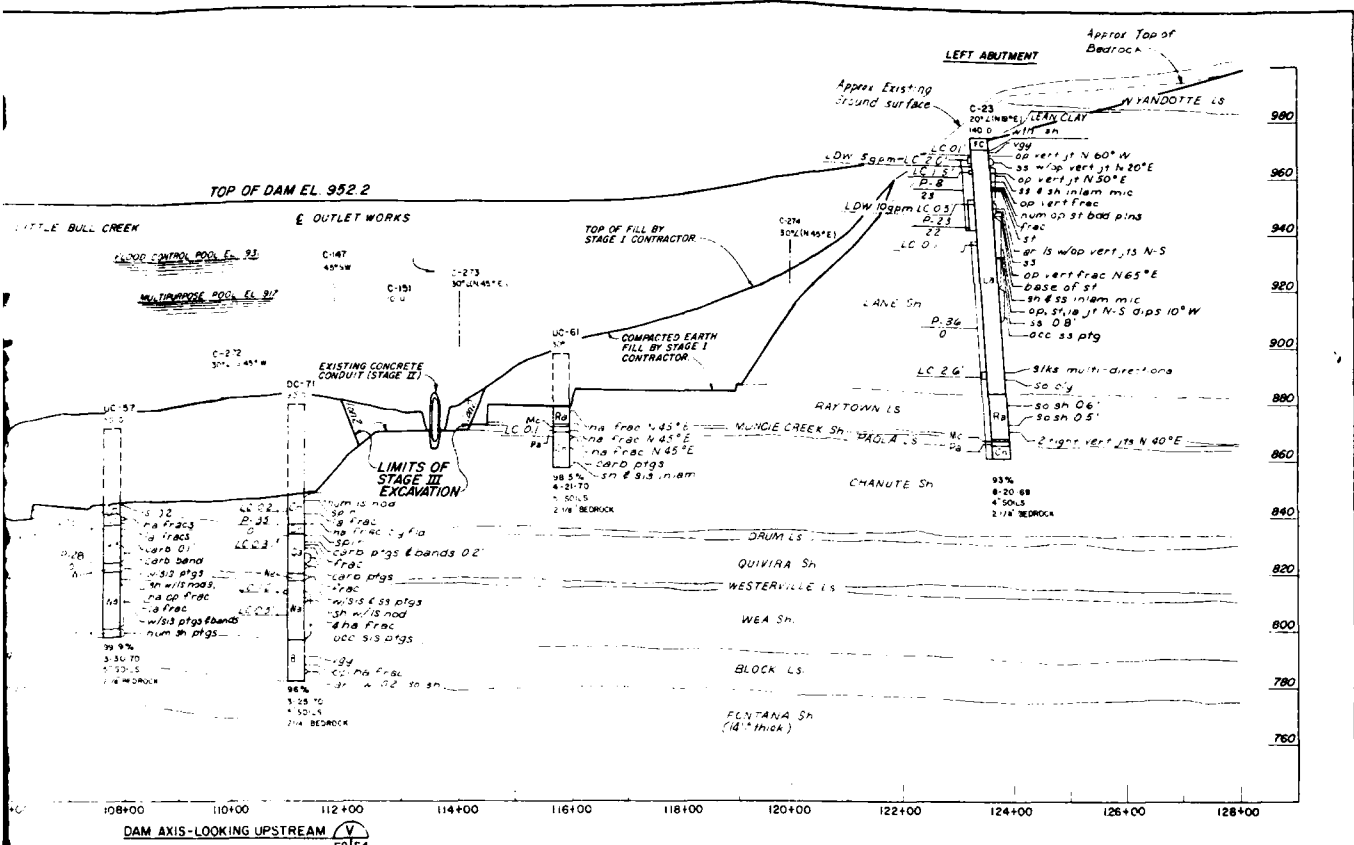
DWG No. E3  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 SCALE AS SHOWN  
 U.S. ARMY  
 APRIL 1978  
 0-15-728



ELEVATION IN FEET ABOVE MEAN SEA LEVEL



1



Notes:  
 For General Geologic Column and Legend, see Dwg. E1.  
 For plan of borings see Dwg. E2.  
 For logs of borings for permanent piezometers, see Dwg. E20.  
 For logs of detached borings and dam axis borings, not shown see Dwgs. E6 thru E9.

**RECORD DRAWING**

JULY 1967  
 CONTRACT NO. DACW4178C0113

SYM	Revised for 'As Built' conditions	DESCRIPTION	DATE	APP'D
		REVISIONS		

2

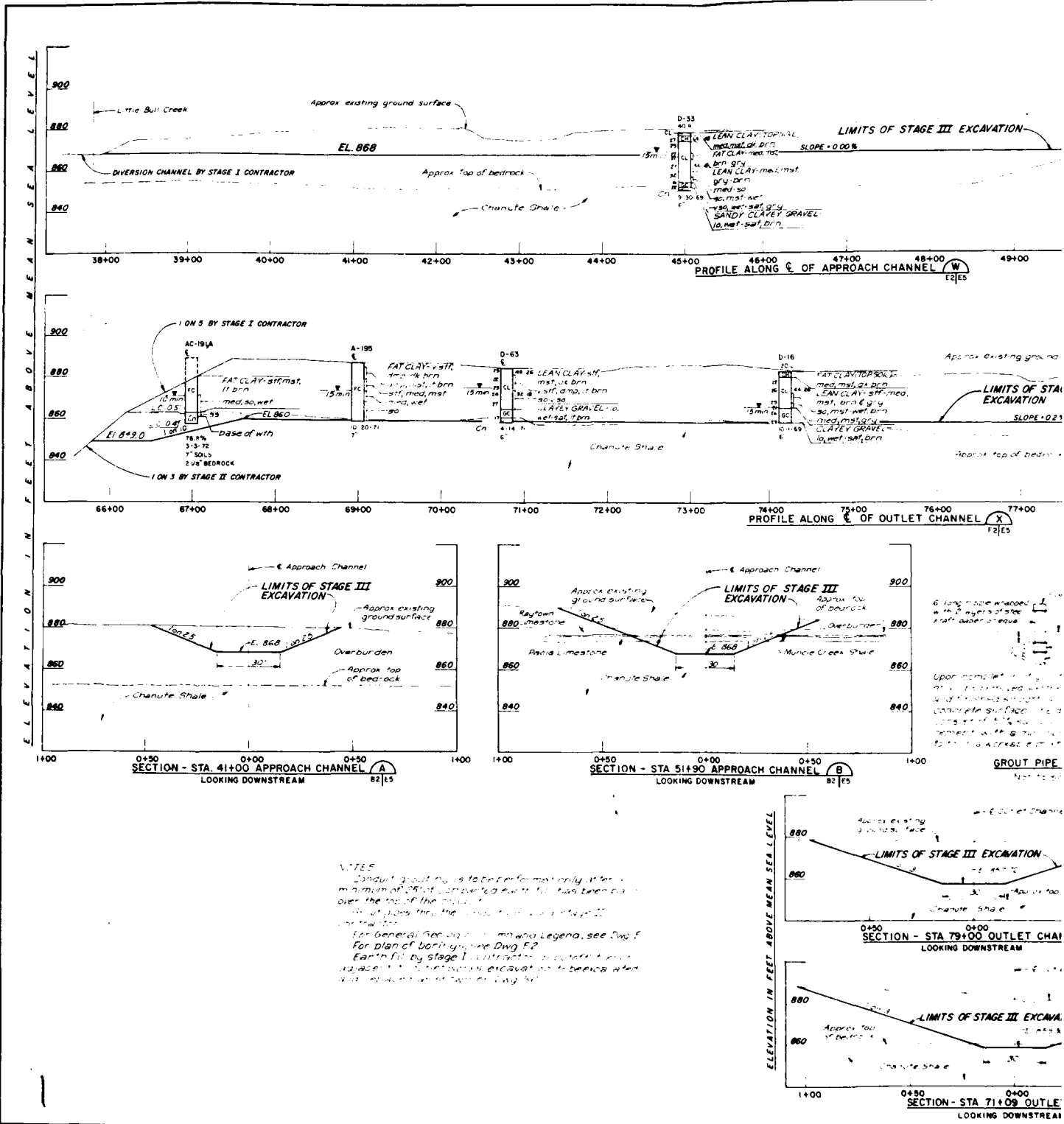
**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION  
 LOGS OF SELECTED EXPLORATIONS  
 DAM AXIS

Dwg No E4  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 SUPERVISOR  
 CHECKED BY  
 DRAWN BY  
 R.S. R.L.D.

Recommended  
 CHECKED BY  
 J.M.M.

Scale as shown  
 U.S. ARMY  
 APRIL 1978  
 FILE NO.  
 O-15-729





**NOTES**

1. Grout pipes to be perforated only at a maximum of 2 ft. in depth from the top of the concrete surface.

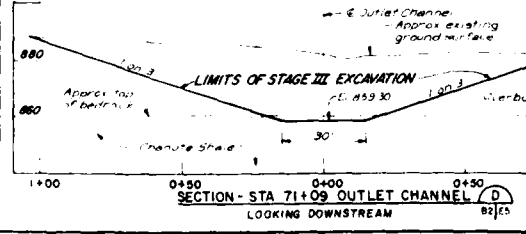
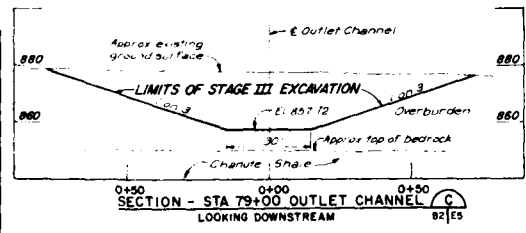
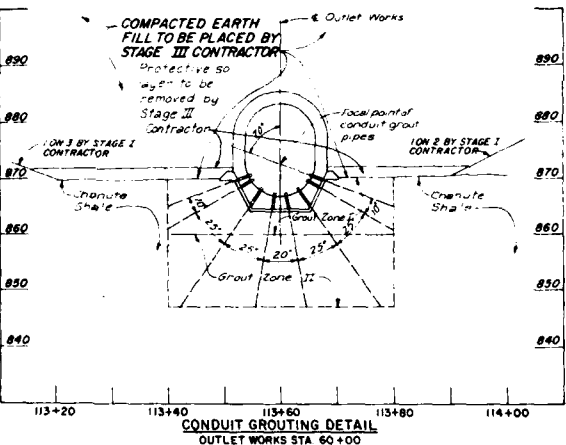
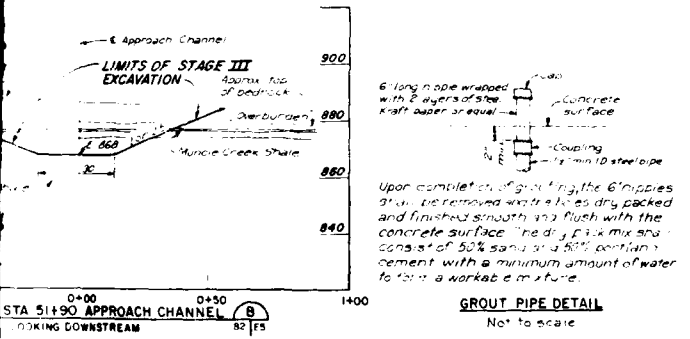
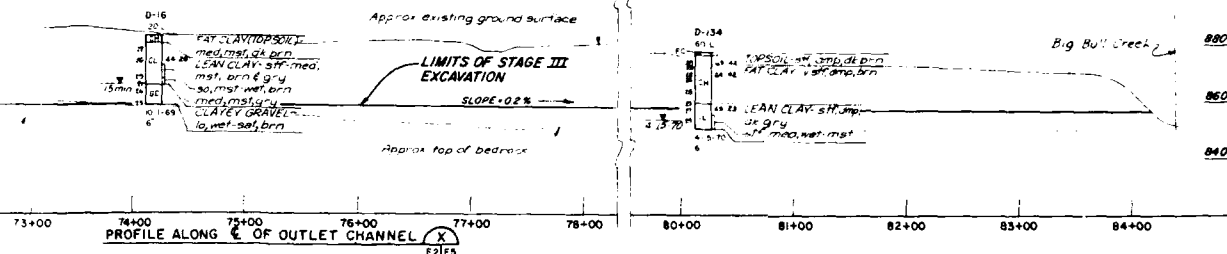
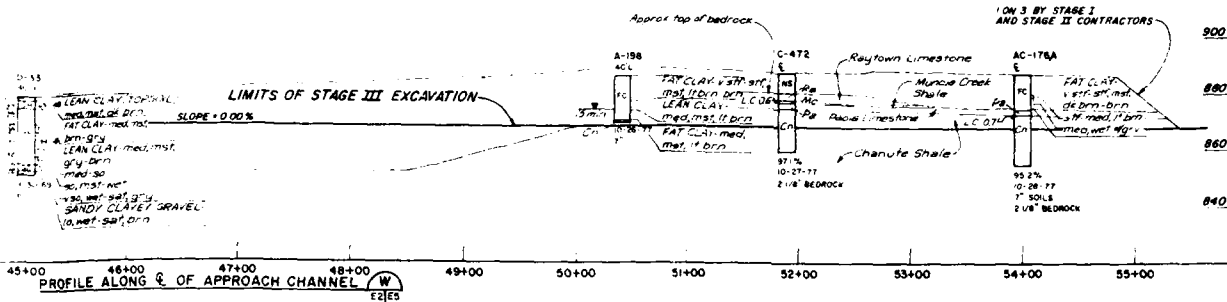
2. For General Notes, Symbols and Legend, see Dwg. F-2.

3. Earth fill by Stage I contractor to be placed in place of the excavation to be backfilled with the surface of the Dwg. F-2.

6" long pipe wrapped with 2 layers of steel mesh water stop.

Upon completion of excavation, concrete surface to be placed with grout pipe in place with a grout pipe.





**RECORD DRAWING**

JULY 1962  
 CONTRACT NO. DACW4178 C0111

Revised for "As-Built" conditions

SYN. DESCRIPTION REVISIONS DATE APPD.

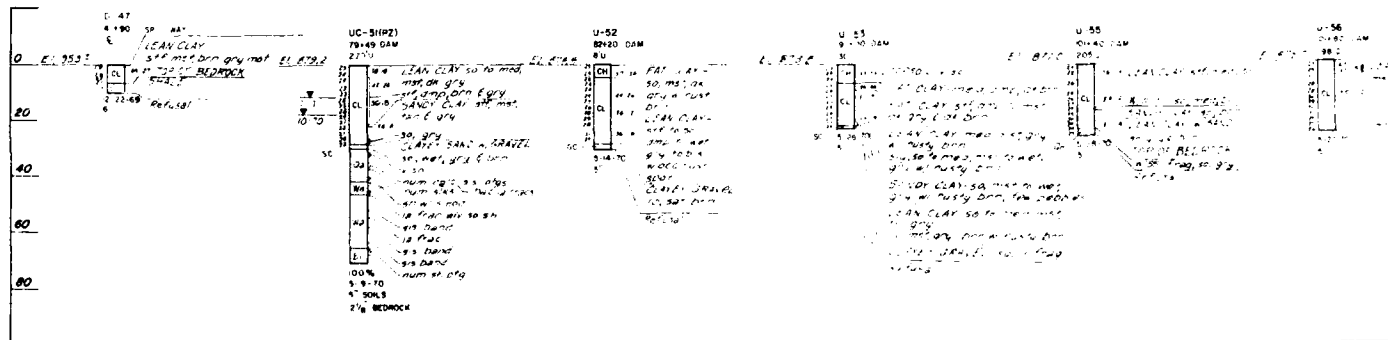
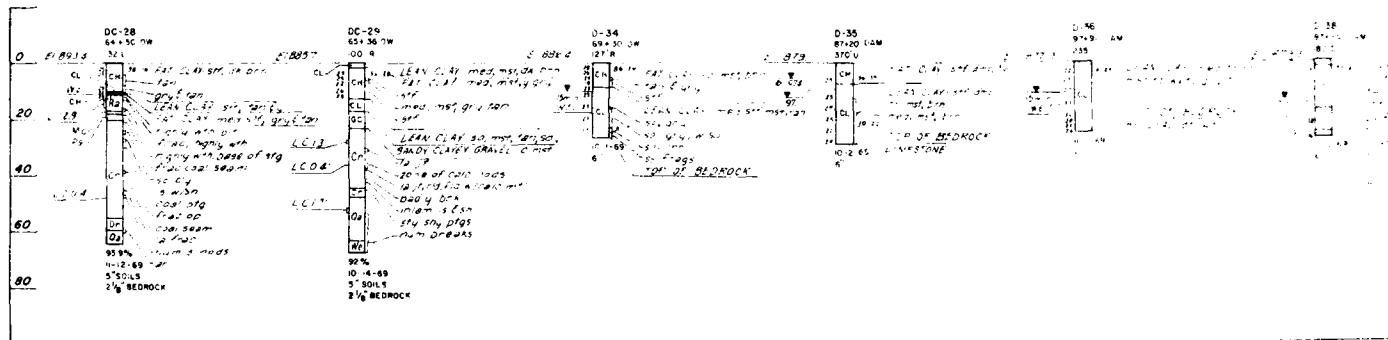
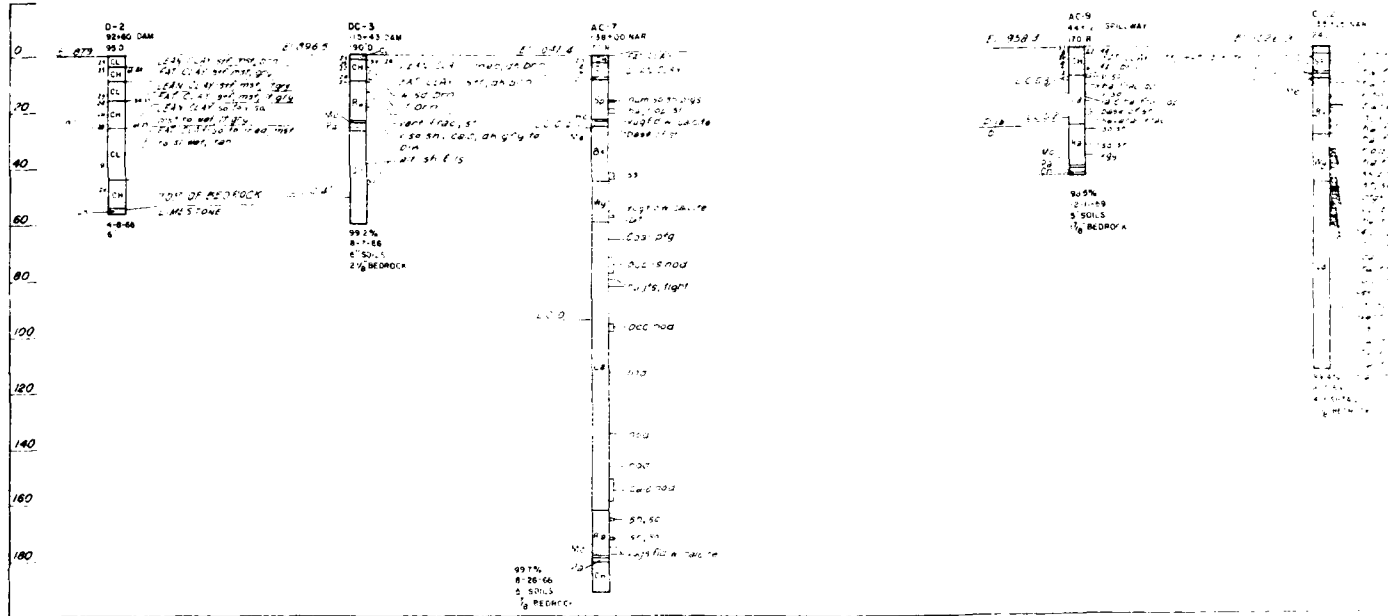
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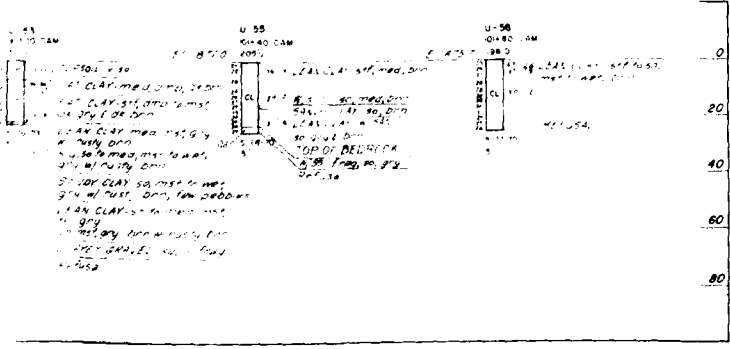
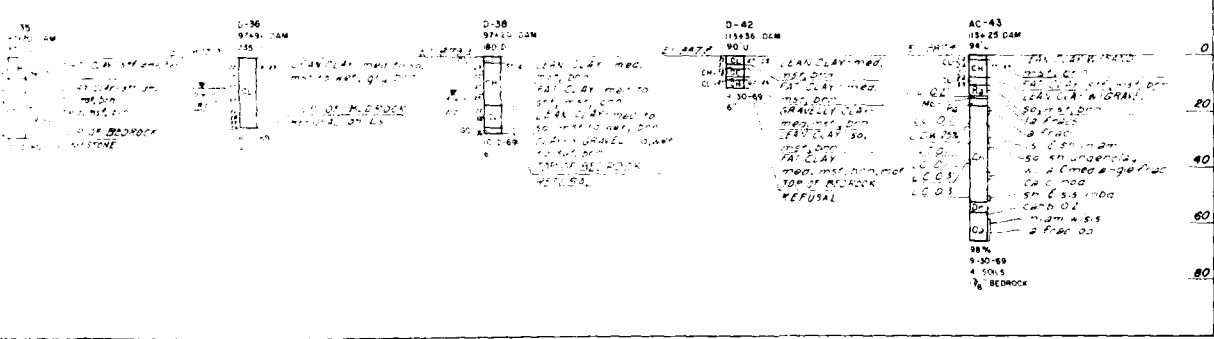
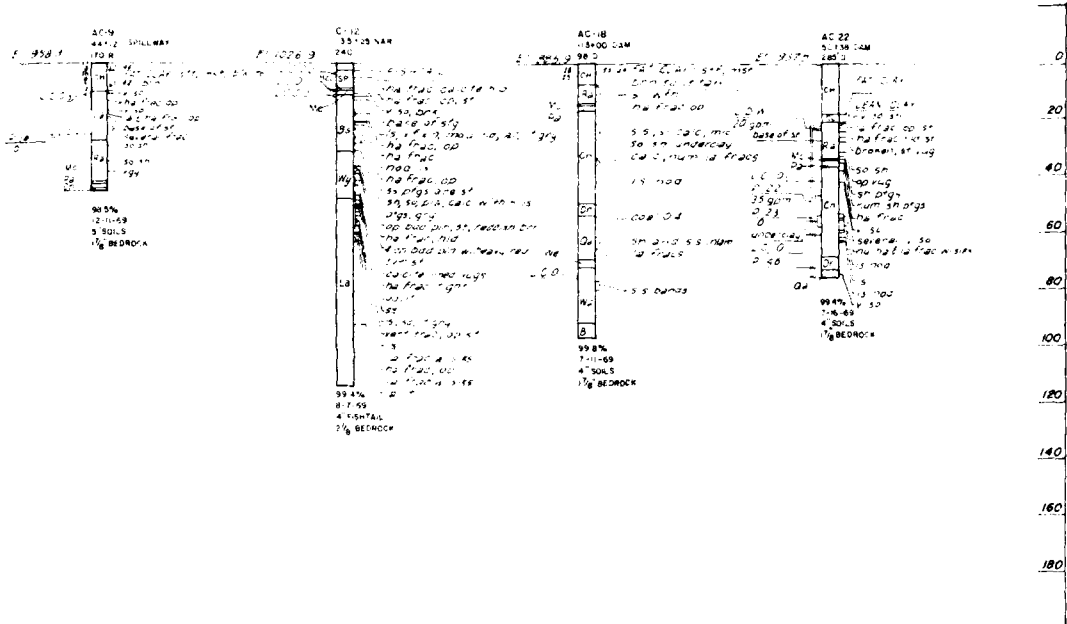
BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION  
 APPROACH AND OUTLET CHANNEL  
 PROFILES AND SECTIONS  
 AND CONDUIT GROUTING DETAIL

Dwg No E5  
 CORPUS OF ENGINEERS  
 KANSAS CITY DISTRICT

Scale: as shown  
 U. S. ARMY  
 APRIL 1978

0-15-730





NOTES  
 For General See Typo Column and Legend, see Dwg No. 1  
 for Plan of Borings. See Dwg No. 2.

OW - OUTLET WORKS  
 NAN-NORTH ACCESS ROAD  
**RECORD DRAWING**

JULY 1962  
 CONTRACT NO. DACW4178C0113

Revised for "As Built" conditions  
 SYM. DESCRIPTION REVISIONS DATE APPD

BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION

LOGS OF EXPLORATIONS  
 DETACHED BORINGS

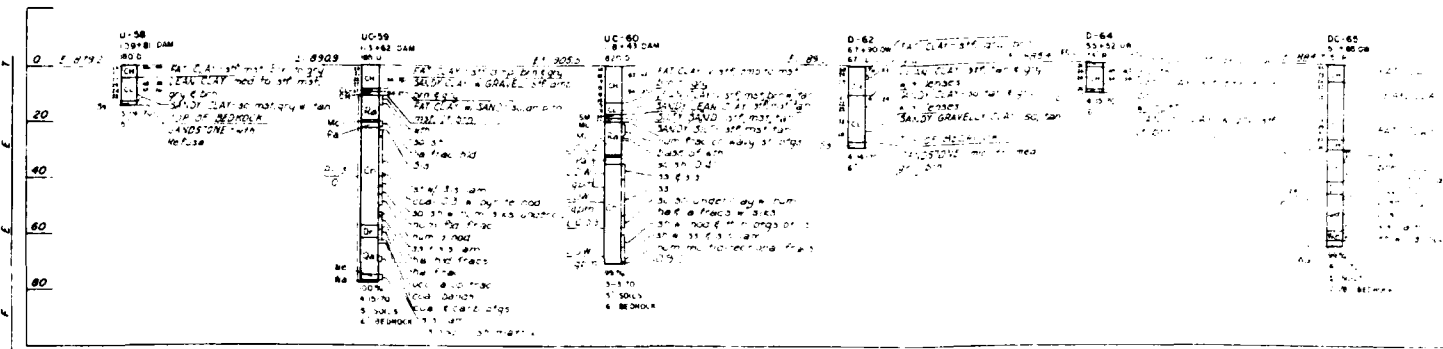


Dwg. No. E8  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 SUBMITTED BY  
 CHECKED BY  
 J. M. M. R. L. O.

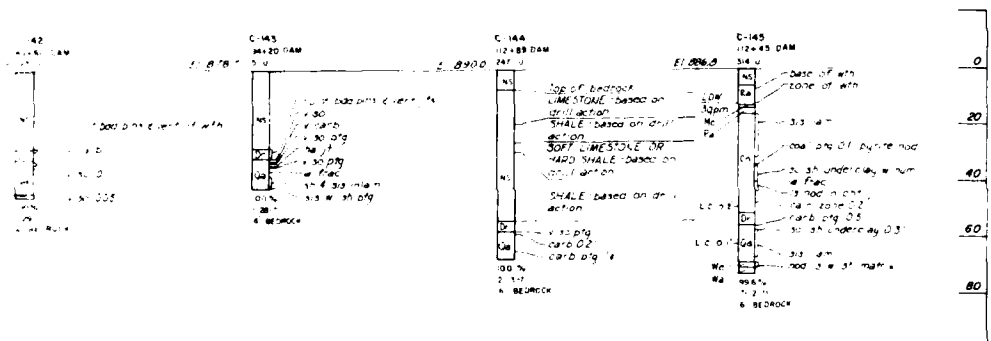
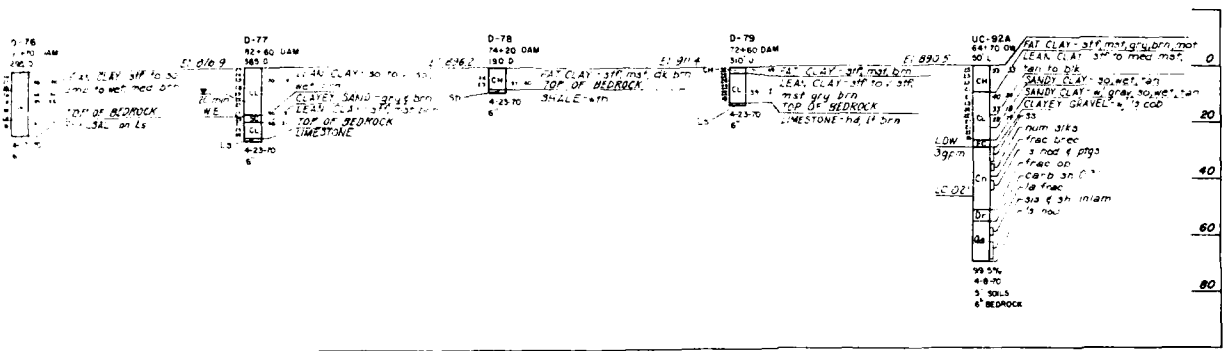
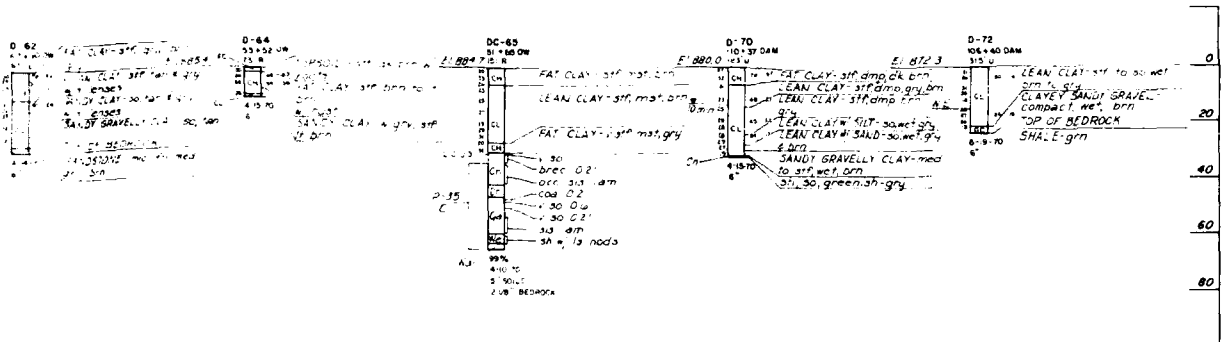
Recommended by  
 CHECKED BY  
 J. M. M.

Scale as shown  
 U. S. ARMY  
 APRIL 1978  
 FILE NO.  
 0-15-733

PLATE NO. 23



1



**RECORD DRAWING**

JULY 1987  
CONTRACT NO. DACW4178C0113

NOTES  
1. General Geologic Column and Legend see Dwg No. 1  
2. Plan of Borings, see Dwg No. 52

Revised for "As Built" conditions  
SYMBOL DESCRIPTION REVISIONS  
DATE 1 APPD

OW - OUTLET WORKS

**HILLSDALE LAKE**  
STAGE III CONSTRUCTION  
LOGS OF EXPLORATIONS  
DETACHED BORINGS

Scale as shown  
U.S. ARMY  
APRIL 1978

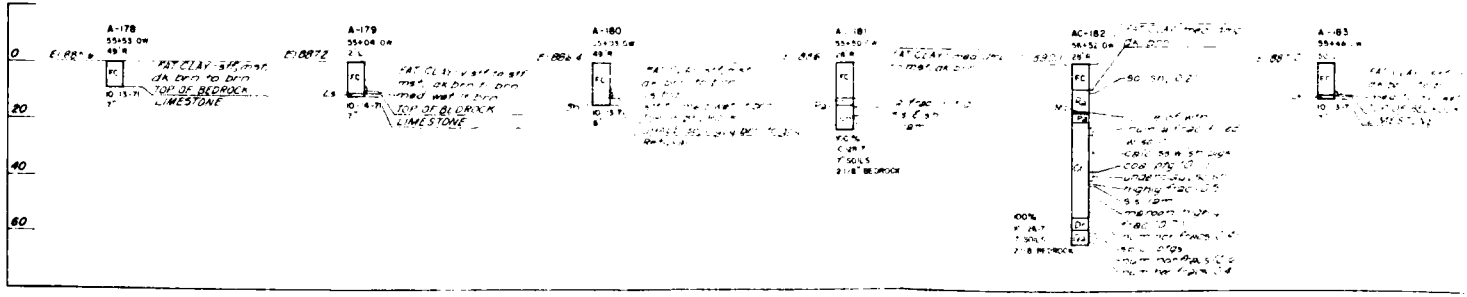
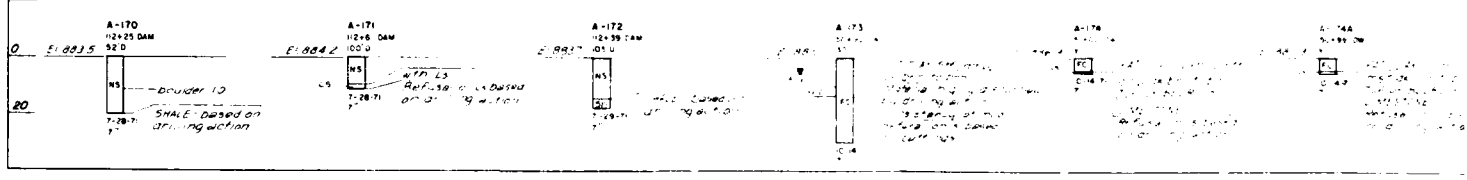
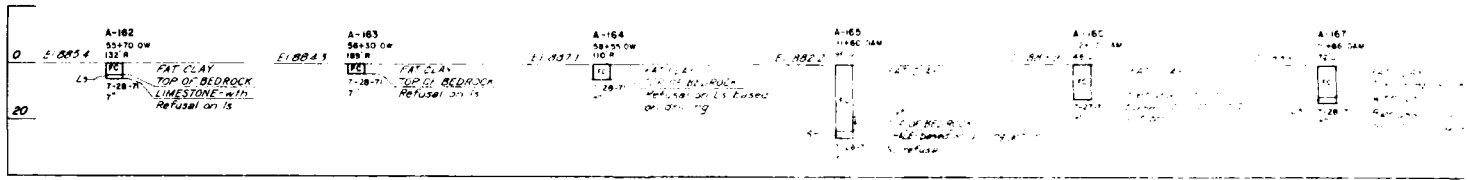
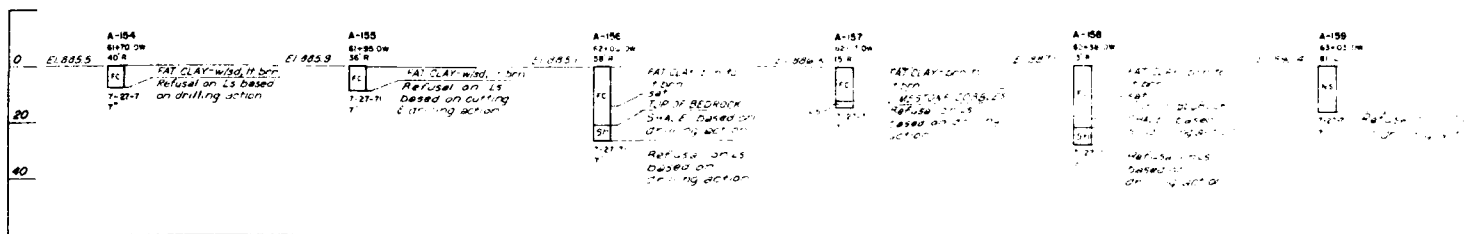
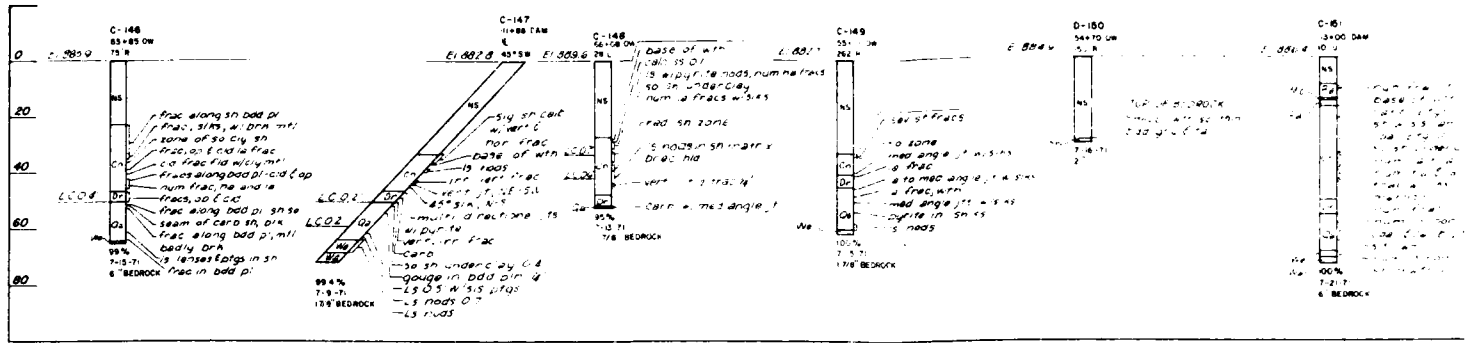
Dwg No. E9  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

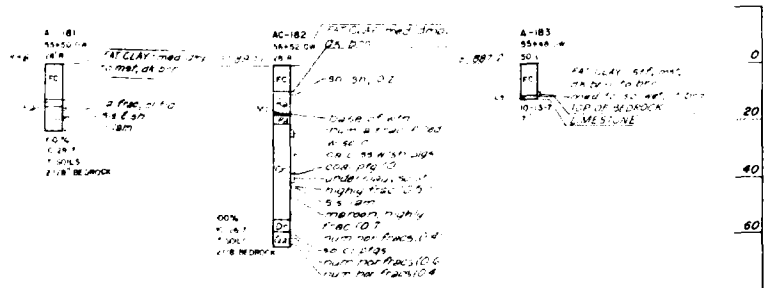
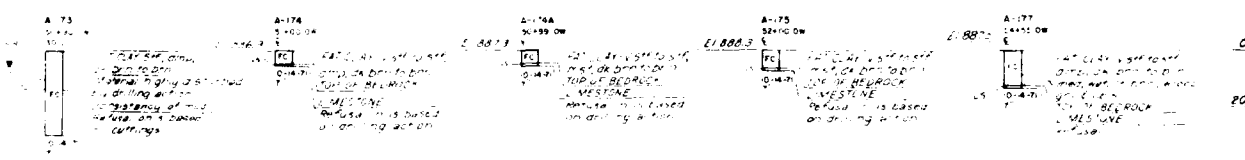
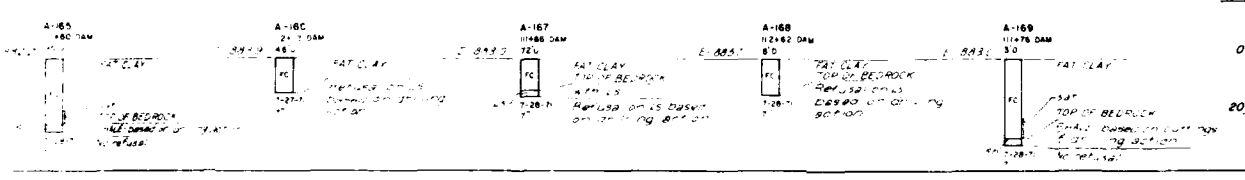
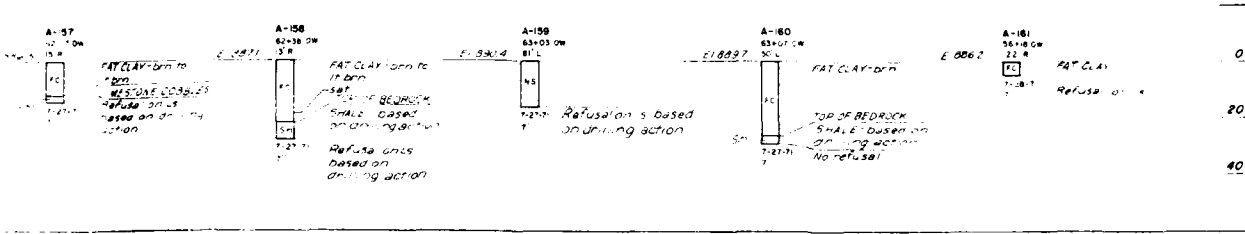
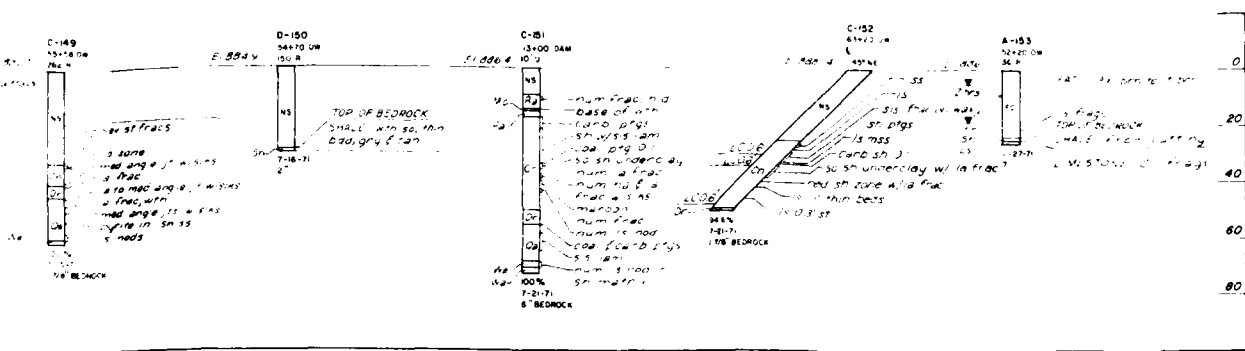


Recommended by  
Checked by  
J. M. B.

Checked by  
J. M. B.

0-15-734





Notes:  
 1. See general notes on page 1 and legend.  
 2. See Dwg No. 10 for plan of borings.  
 3. See Dwg No. 10 for plan of borings.

### RECORD DRAWING

CONTRACT NO. DACW 17-69-011  
 JULY 1970  
 Revised for 14.3.11 conditions  
 SYM DESCRIPTION DATE APPD

### HILLSDALE LAKE

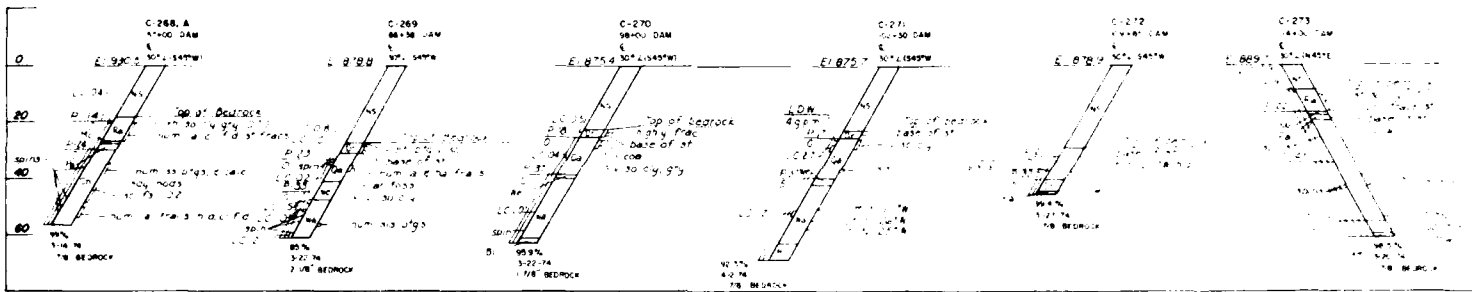
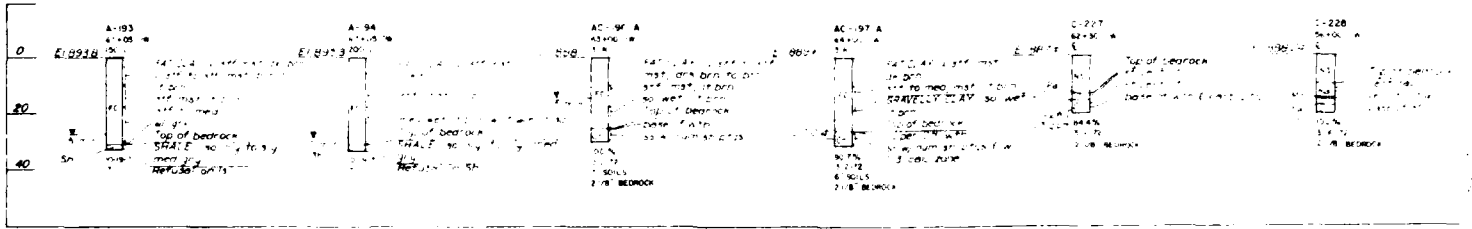
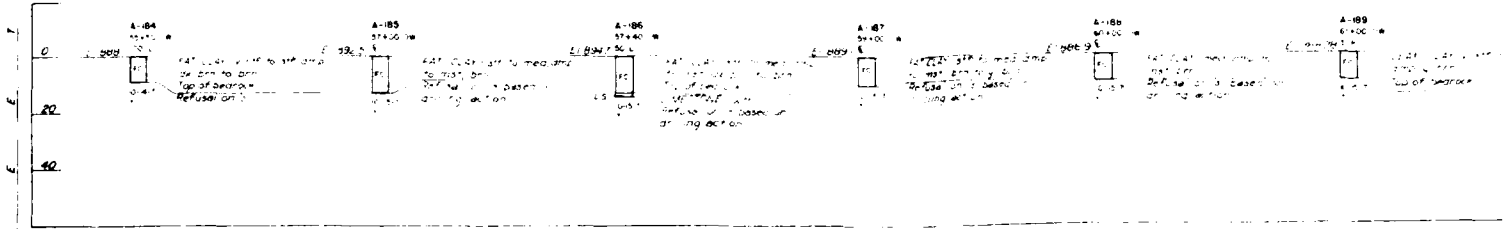
STAGE III CONSTRUCTION  
 LOGS OF EXPLORATIONS  
 DETACHED BORINGS

Dwg No. E10  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 SCALE AS SHOWN  
 U. S. ARMY  
 APRIL 1978  
 O-15-735

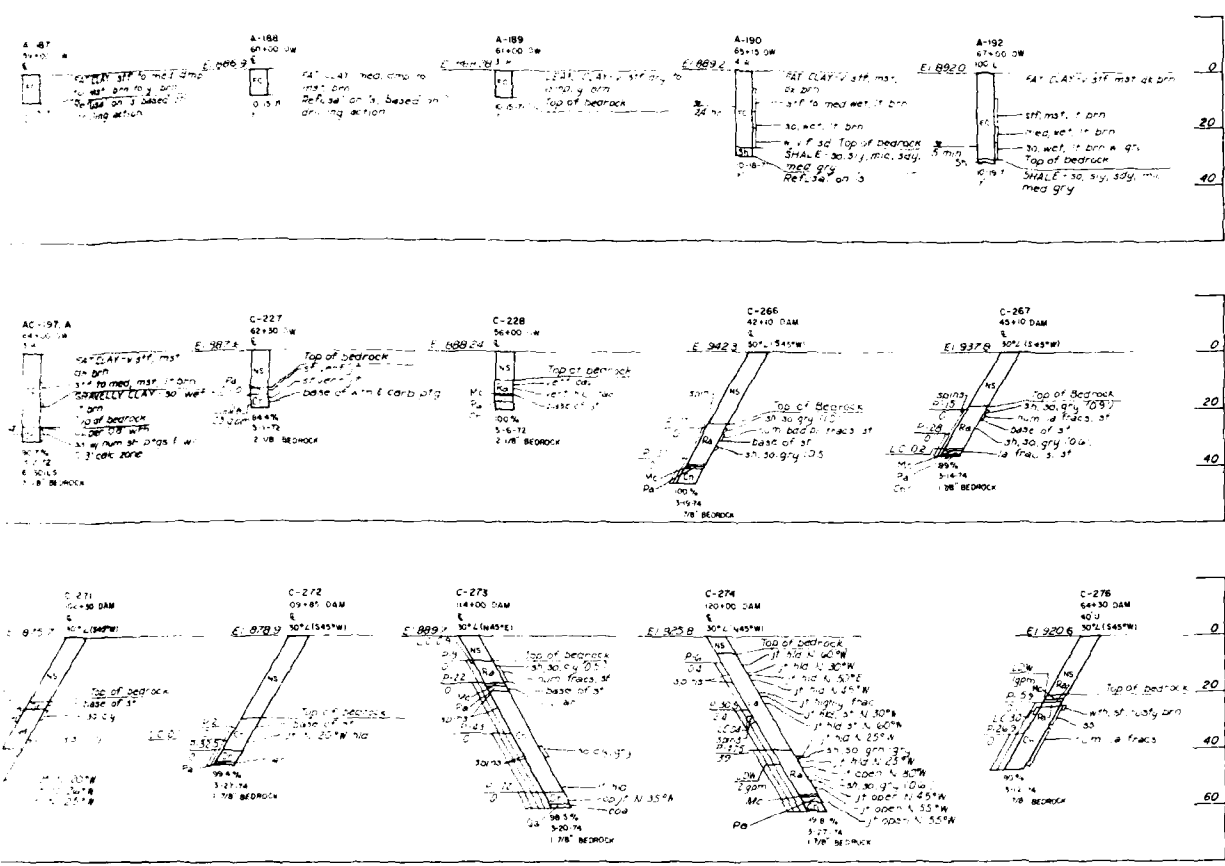


APPROVED  
 J. M. M.  
 R. L. D.

OW - OUTLET WORKS







OW/OUTLET WORKS

Notes  
 For General Geologic Column and Legend, see Dwg No. E-1  
 For Part of Borings, see Dwg No. E-2

RECORD DRAWING

JULY 1980  
 CONTRACT NO. DACW4176C0113

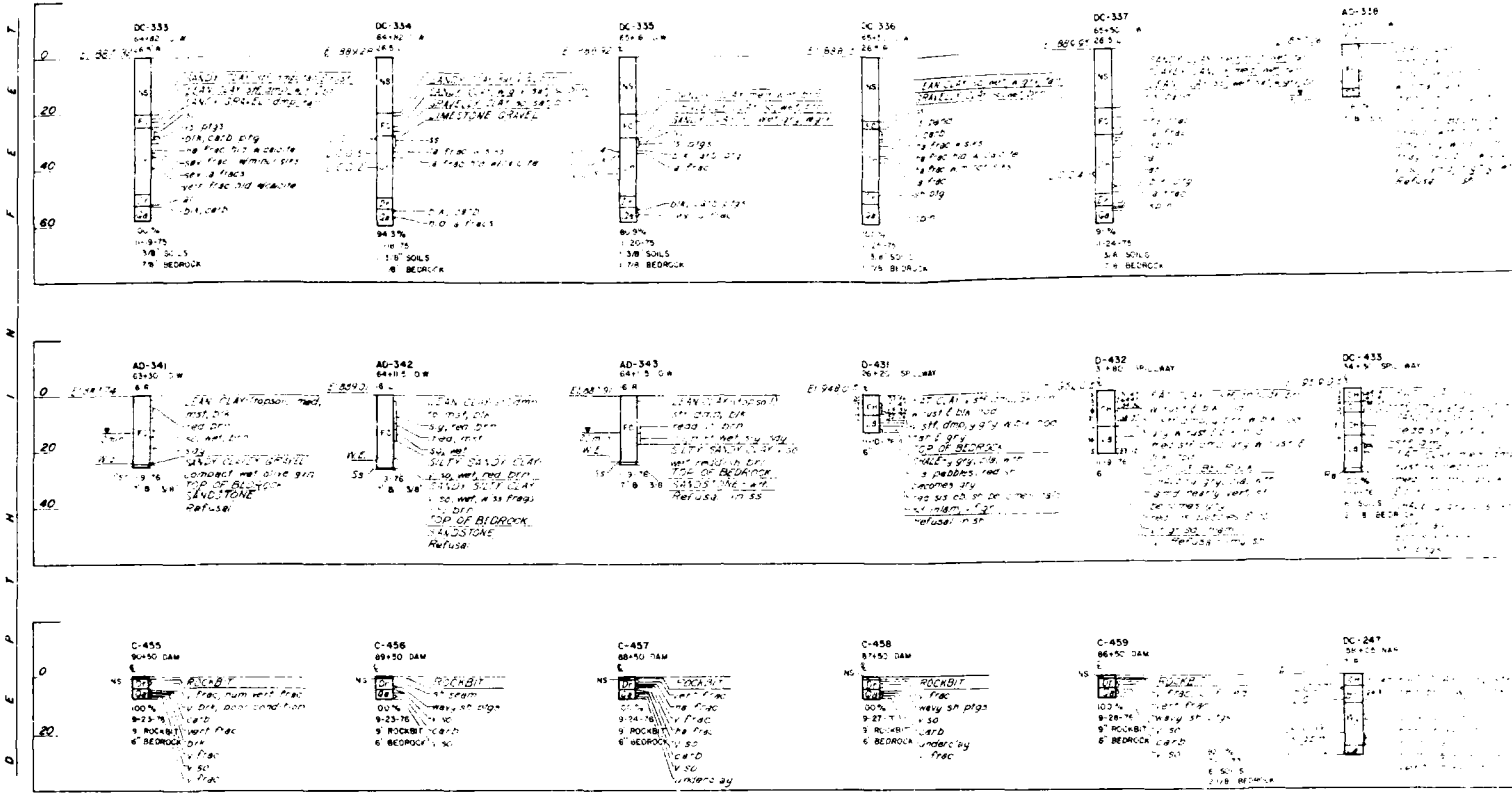
SYM.	DESCRIPTION	DATE	APP'D.
	Revised for "As Built" conditions		
	REVISIONS		

BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION  
 LOGS OF EXPLORATIONS  
 DETACHED BORINGS

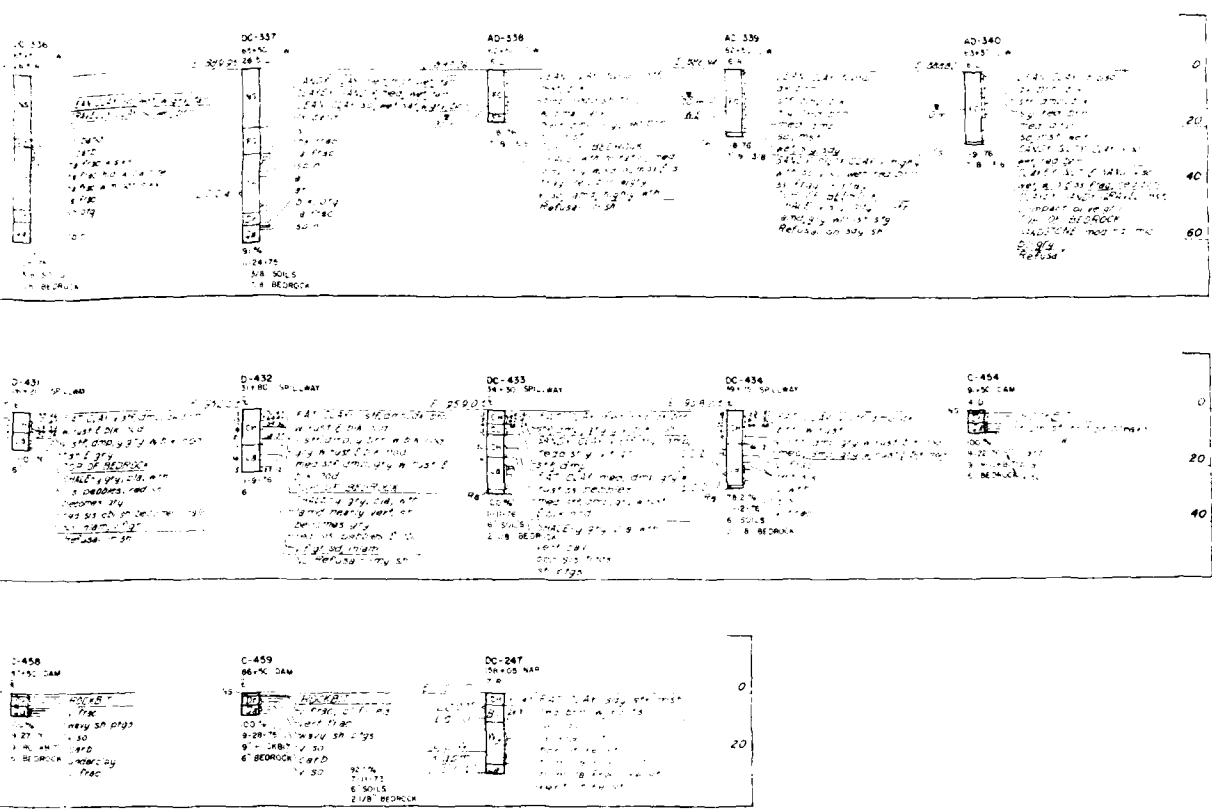
Dwg No. E11  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 JMM

Scale as shown  
 U. S. ARMY  
 APRIL 1978  
 0-15-736





OW = OUTLET WORKS  
 NAR = NORTH ACCESS ROAD



OW = OUTLET WORKS  
 NAR = NORTH ACCESS ROAD

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**RECORD DRAWING**

SYM	DESCRIPTION	DATE	APPRO
	REVISIONS		

**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION

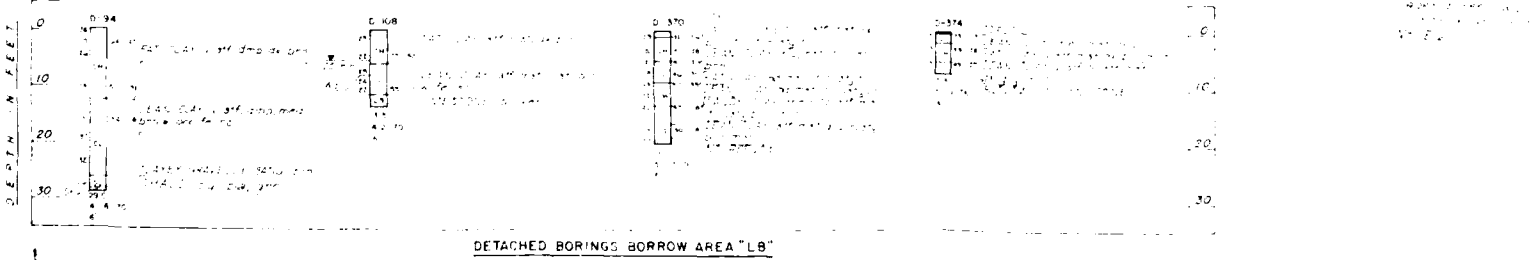
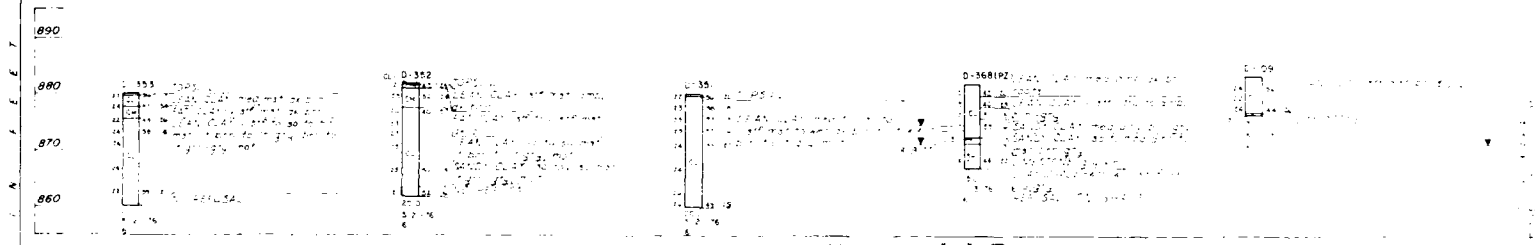
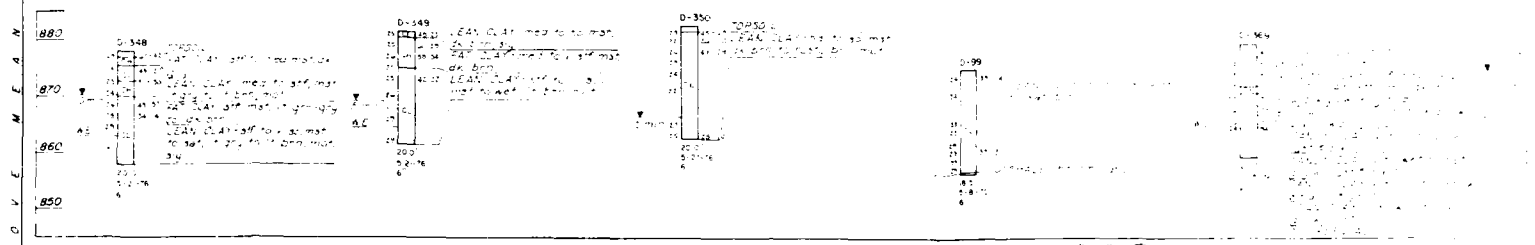
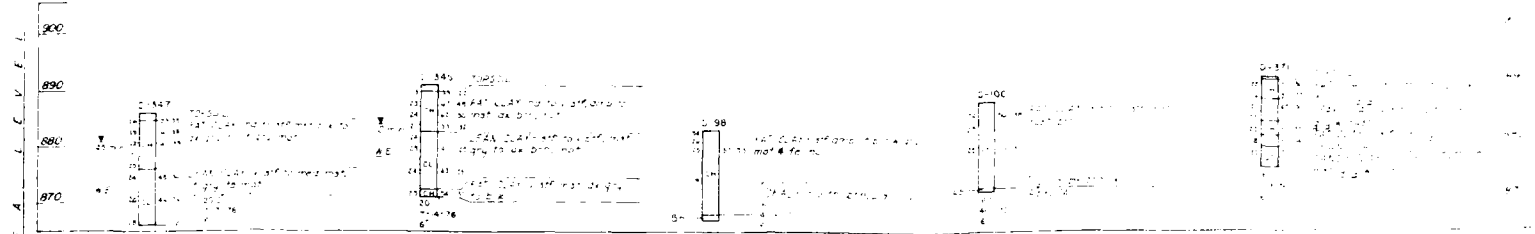
**LOGS OF EXPLORATIONS**  
 DETACHED BORINGS



Dwg No E12  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 J. M. M.  
 R. C. D.

Revised  
 J. M. M.  
 R. C. D.

Scale as shown:  
 U. S. ARMY  
 APRIL 1978  
 0-15-737



DEPTH IN FEET

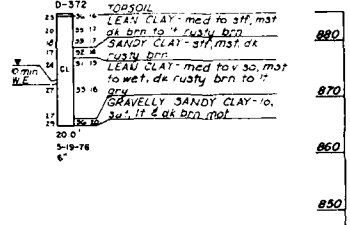
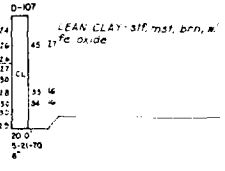
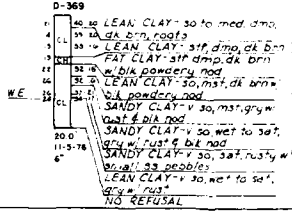
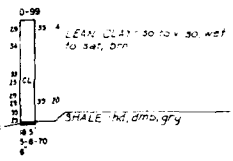
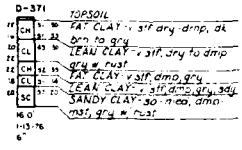
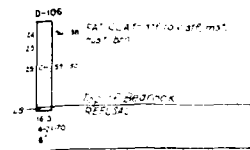
0  
10  
20  
30

D-144

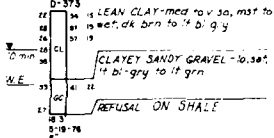
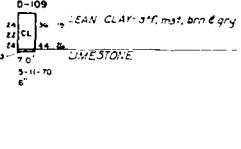
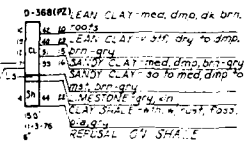
Soil profile data for D-144, showing depth intervals and soil descriptions.

DET

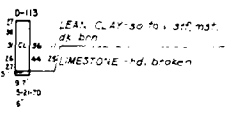
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890  
880  
870



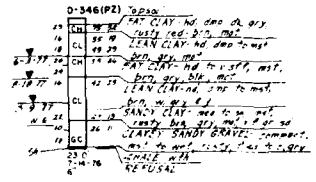
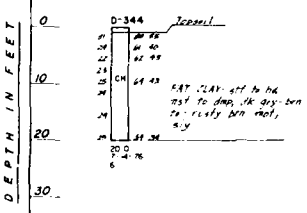
BORROW AREA "LB" B  
E2/E13



BORROW AREA "LB" C  
E2/E13



890  
880  
870  
860



0  
10  
20  
30

DETACHED BORINGS BORROW AREA "LB"

NOTES  
For General Geologic Column and legend, See Dwg No E1  
For Plan of borings, See Dwg No E2

RECORD DRAWING

JULY 1982  
CONTRACT NO DACW6178 C0113

Table with columns: SYM, DESCRIPTION, REVISIONS, DATE, APP'D

HILLSDALE LAKE  
STAGE III CONSTRUCTION

BORROW AREA  
LOGS OF EXPLORATIONS

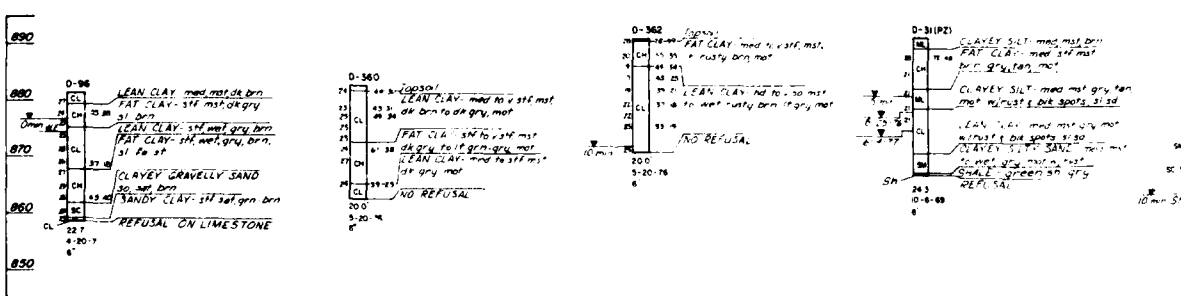
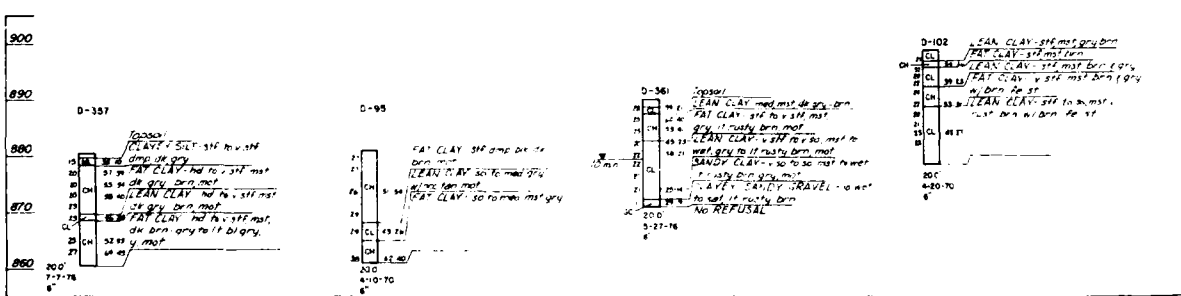
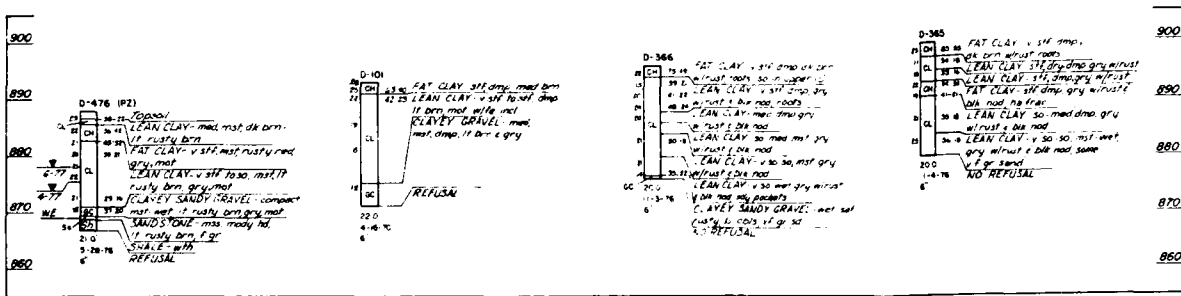
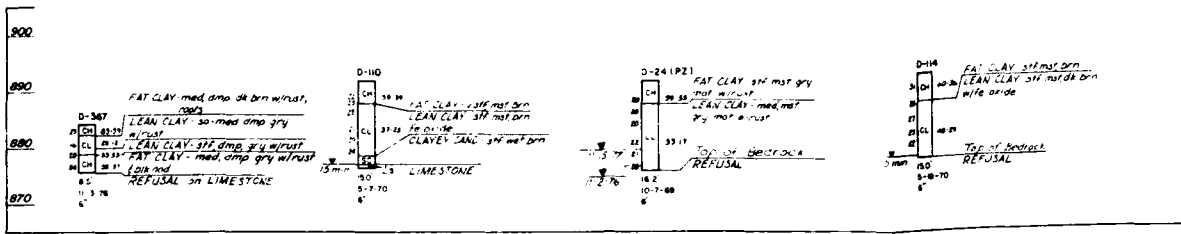
Dwg No E15  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

Scale: as shown  
U S ARMY  
APRIL 1978

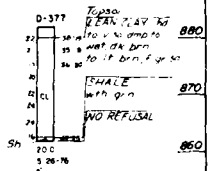
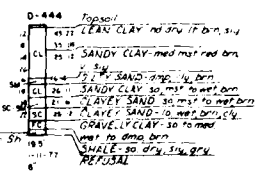
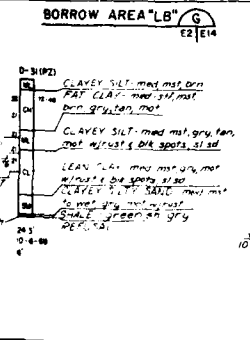
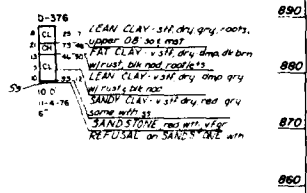
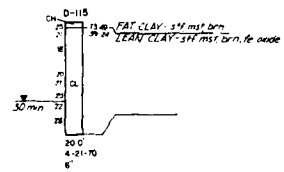
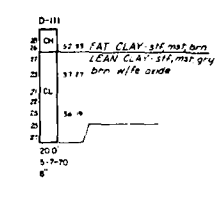
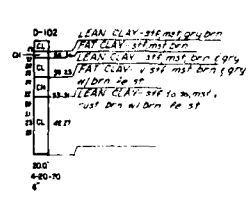
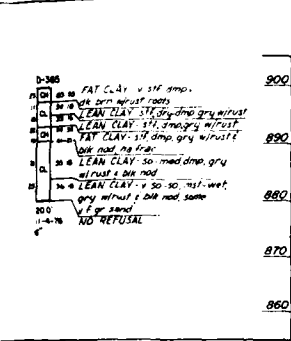
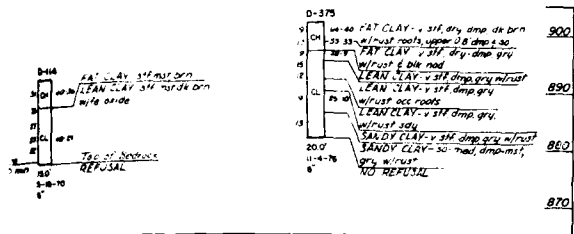


COMPLETED BY: M.T.M. J.R.M. R.G.F.  
CHECKED BY: R.G.F.  
DATE: APRIL 1978  
FILE NO: D-15-738

LEVEL  
E  
S  
E  
A  
B  
O  
R  
R  
O  
W  
A  
R  
E  
A  
F  
E  
E  
T  
I  
N  
F  
O  
N  
T  
A  
I  
N  
S  
L  
E  
V  
E  
L  
S



1



NOTES  
For General Geologic column and  
Legenda See Dwg No E1  
For Plan of borings See Dwg No E2

**RECORD DRAWING**

MAY 1982  
CONTRACT NO. DACW4378C0111

Revised for "As Built" Conditions  
DESCRIPTION  
REVISIONS  
DATE APPD

**HILLSDALE LAKE**  
STAGE III CONSTRUCTION

**BORROW AREAS**  
LOGS OF EXPLORATIONS

Dwg No E14  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

Scale as shown  
U. S. ARMY  
APRIL 1978



Submitted by  
Checked by  
M. T. W.

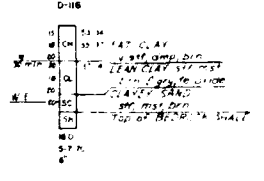
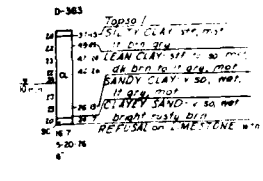
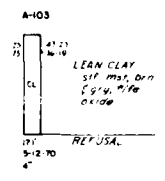
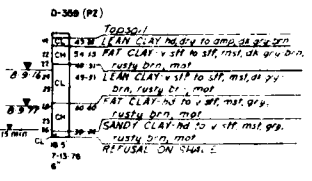
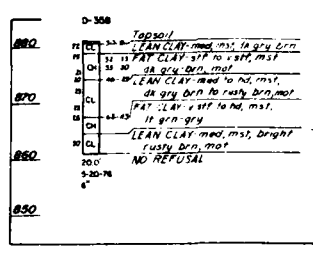
Recommended by  
Checked by  
R. G. P.

Checked by  
Checked by  
Checked by

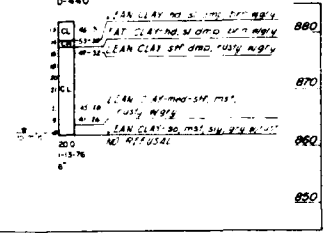
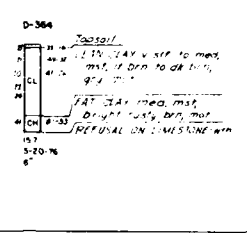
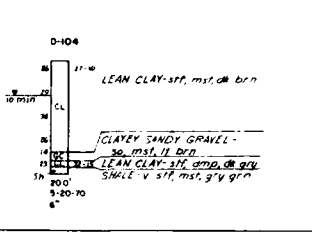
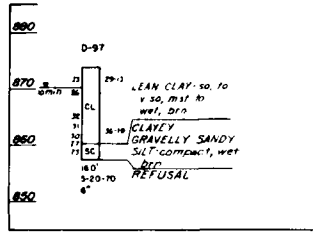
C-15-739

PLATE NO 29

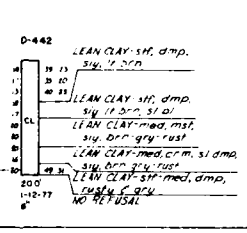
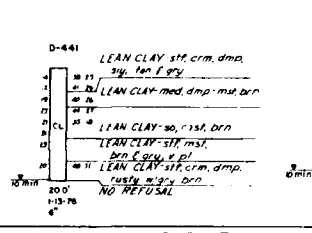
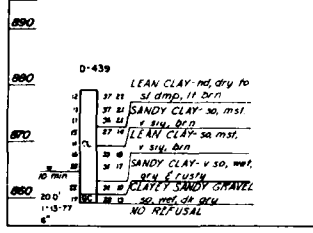
ELEVATION IN FEET ABOVE MEAN SEA LEVEL



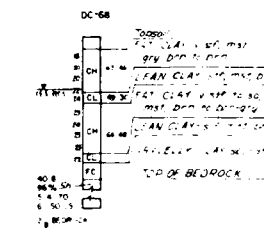
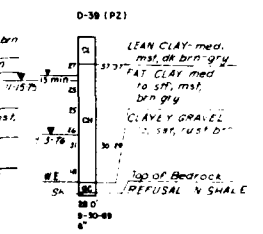
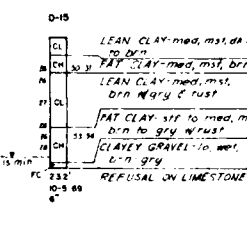
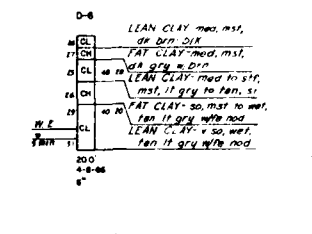
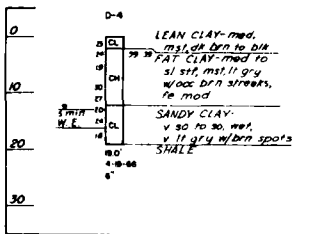
BORROW AREA "LB"



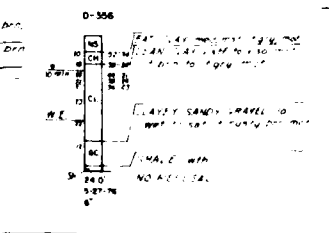
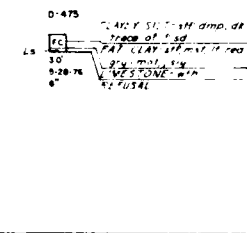
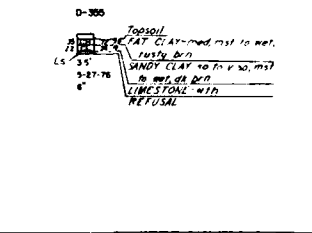
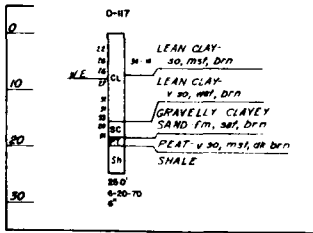
BORROW AREA "LB"



BORROW AREA "LB"



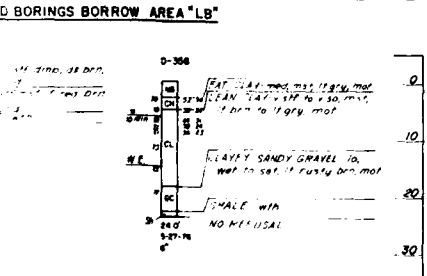
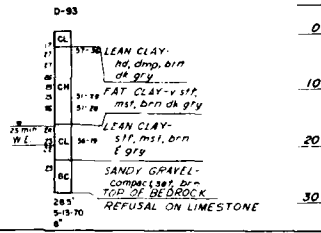
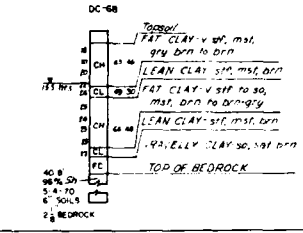
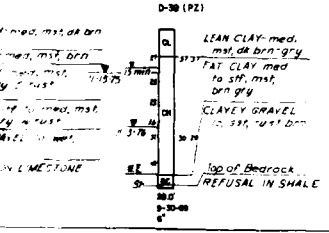
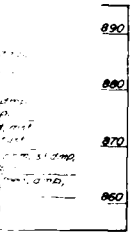
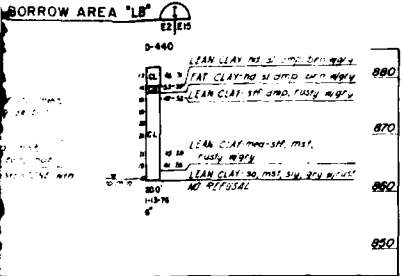
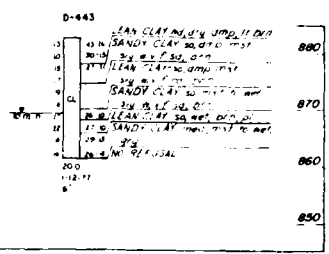
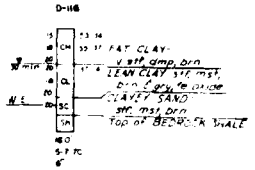
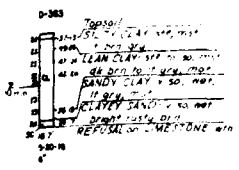
DETACHED BORINGS BORROW AREA "LB"



DETACHED BORINGS BORROW AREA "LB"

Notes for general section legend the July 4, 1964 Plan of Borrow





**NOTES**  
 For General Geologic Column and Legend See Dwg No E1  
 For Plan of Borings See Dwg No E2

**RECORD DRAWING**

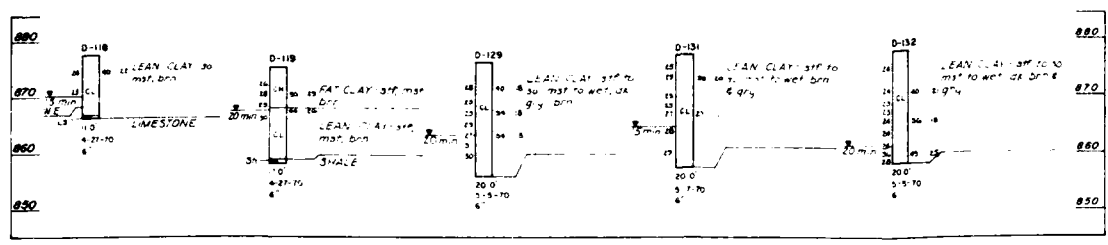
JULY 1982  
 CONTRACT NO. DACW178C0113  
 Revised for "As Built" conditions  
 DESCRIPTION  
 REVISIONS  
 DATE APPD.

**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION

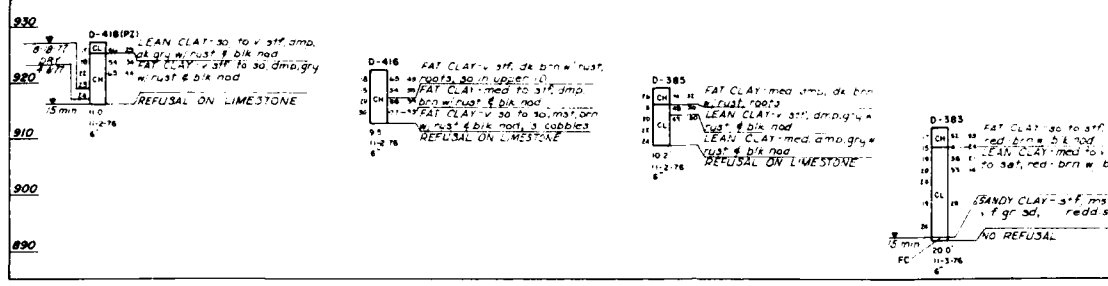
**BORROW AREA**  
 LOGS OF EXPLORATIONS

Dwg No E15  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 Scale as shown  
 U. S. ARMY  
 APRIL 1978  
 FILE NO  
 0-15-740

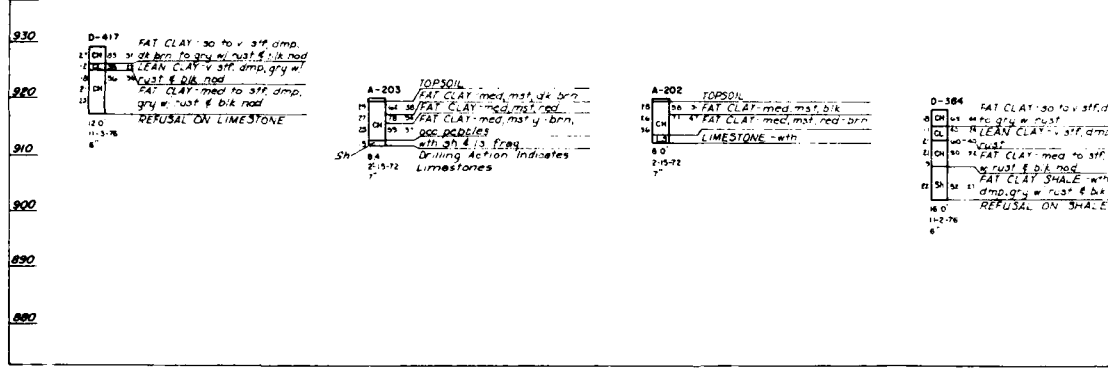
ELEVATION  
 890  
 870  
 860  
 850  
 830  
 820  
 810  
 900  
 890  
 880  
 870  
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 850  
 830  
 820  
 810  
 900  
 890  
 880  
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 850  
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 820  
 810  
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 890  
 880  
 870  
 860  
 850



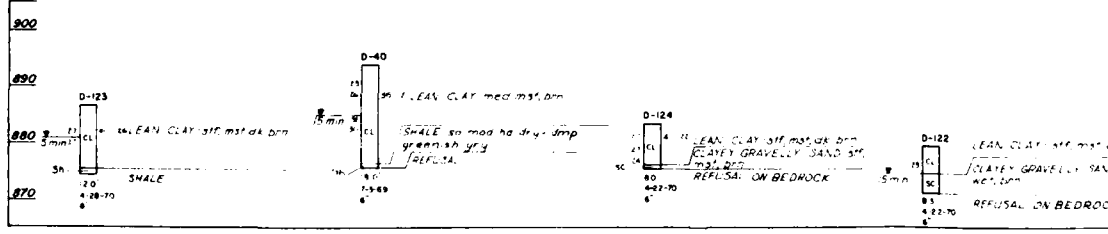
BORROW AREA "SC" L  
E2/E16



BORROW AREA "SC" N  
E2/E16

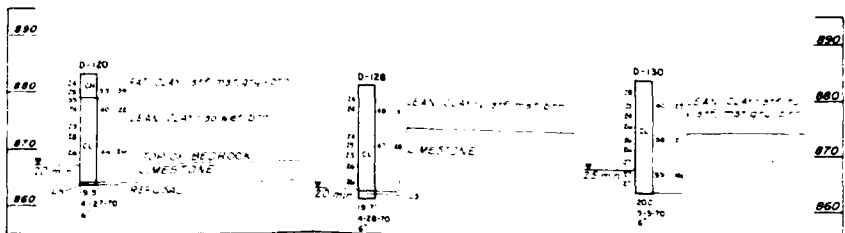
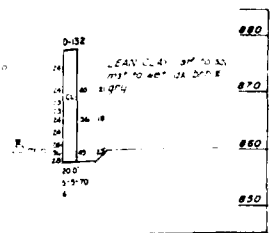


BORROW AREA "SC" O  
E2/E16

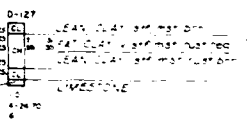
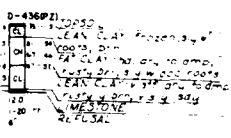
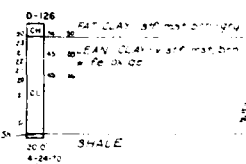
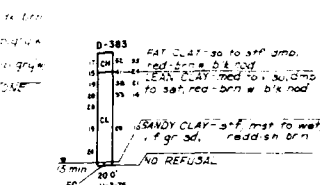


BORROW AREA "SC" P  
E2/E16

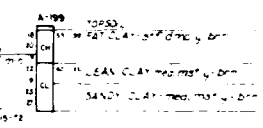
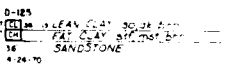
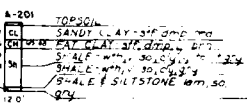
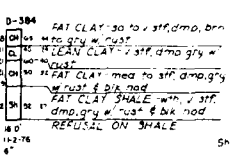
RECORD DRAWING  
 DATE: 1962  
 CONTRACT NO. DAWKINS 78C-1111



BORROW AREA "SC" M  
E2[E16



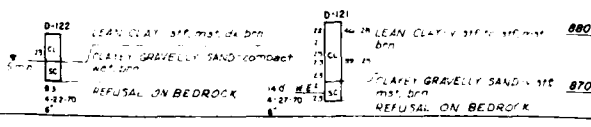
BORROW AREA "SC" N  
E2[E16



BORROW AREA "SC" O  
E2[E16

900  
890

NOTES  
For General Geologic column and  
Legend See Dwg No E1  
For Plan of Borings See Dwg No E2



Revised for the Built conditions  
SYM DESCRIPTION REVISIONS  
DATE APPD

BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
STAGE III CONSTRUCTION  
BORROW AREA  
LOGS OF EXPLORATIONS

**RECORD DRAWING**

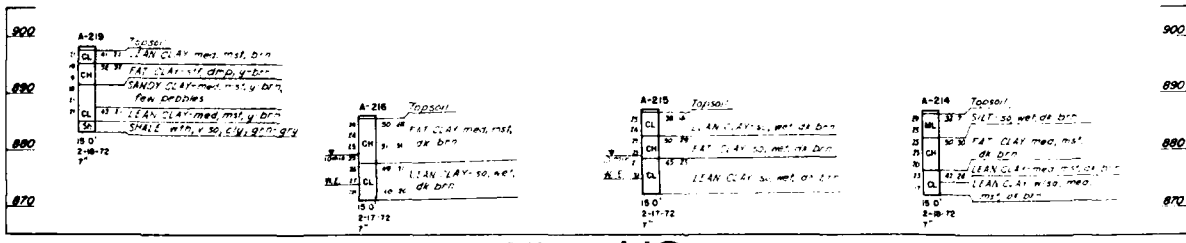
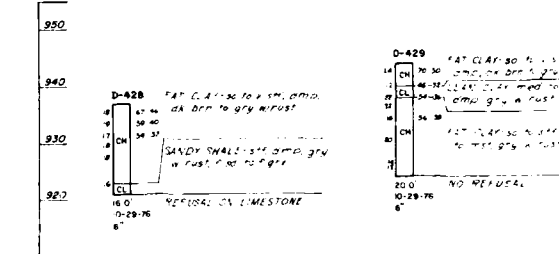
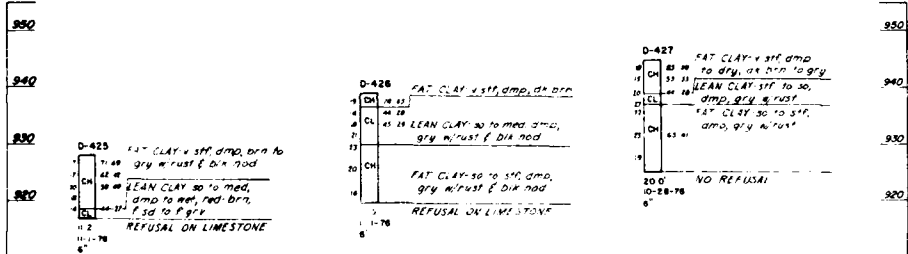
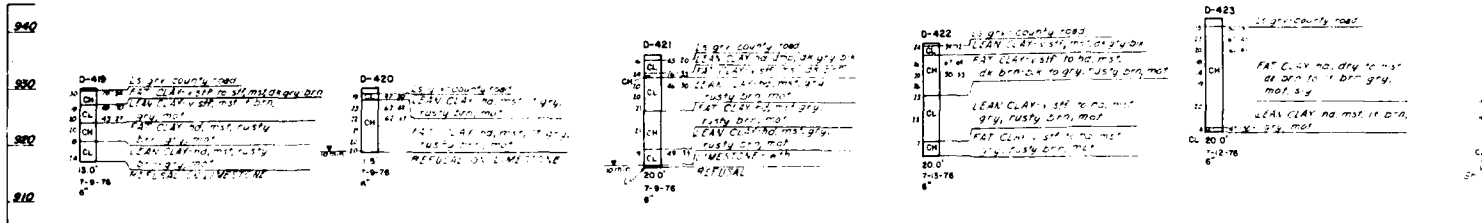
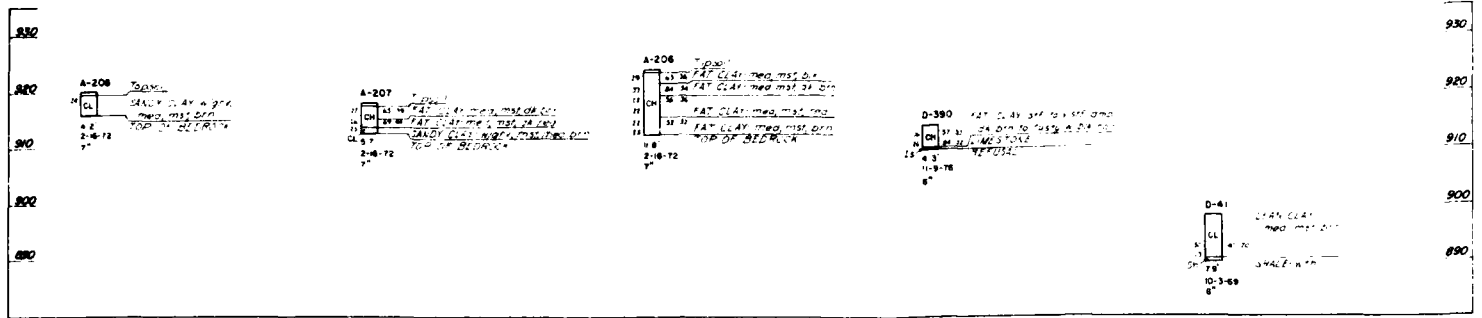


Dwg No E16  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT  
DESIGNED BY  
CHECKED BY  
DATE

Scale as shown  
U.S. APPD  
APRIL 1978  
DATE  
APPD

0-15-741

E L E V A T I O N I N F E E T A B O V E M E A N S E A L E V E L



D-380  
 11-8-76  
 6'

D-41  
 10-3-49  
 6'

930  
 920  
 910  
 900  
 890

D-422  
 7-5-76  
 6'

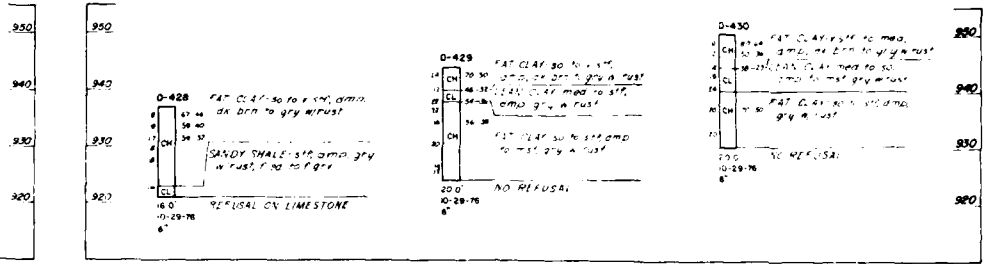
D-423  
 7-12-76  
 6'

D-424  
 7-3-76  
 6'

A-213  
 2-25-72  
 7'

940  
 930  
 920  
 910

BORROW AREA "SC" R  
 E2 | E17



BORROW AREA "SC" E1 | E17

NOTES  
 For General Geologic column and  
 Legend See Dwg No E1  
 For Plan of Borings see Dwg No E2

A-214  
 2-25-72  
 7'

RECORD DRAWING

JULY 1982  
 CONTRACT NO. DACW4178C0113

Revised for "As Built" conditions  
 SYM DESCRIPTION REVISIONS DATE APP'D

BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION

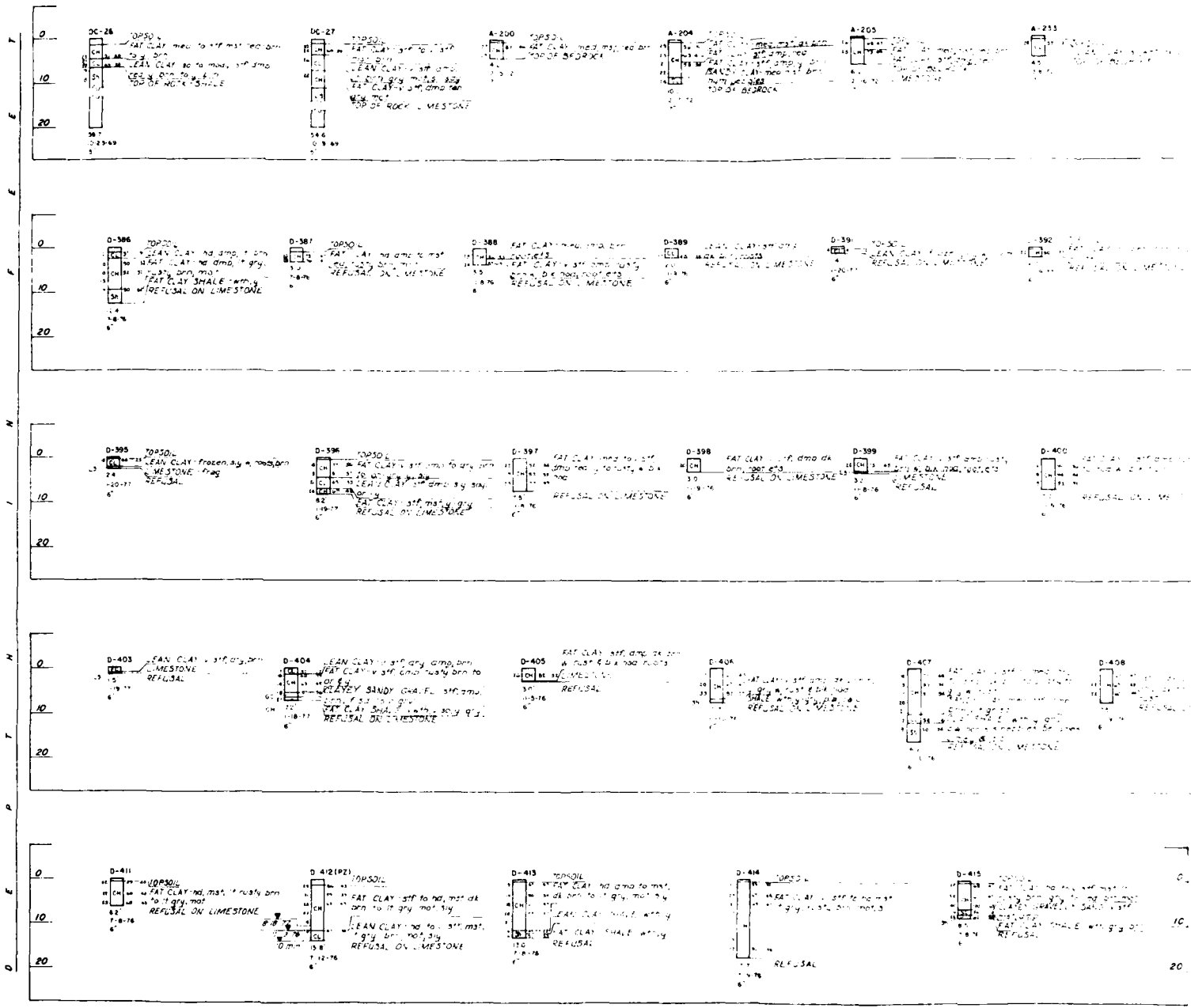
BORROW AREA  
 LOSS OF EXPLORATIONS

Dwg No E-7  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT

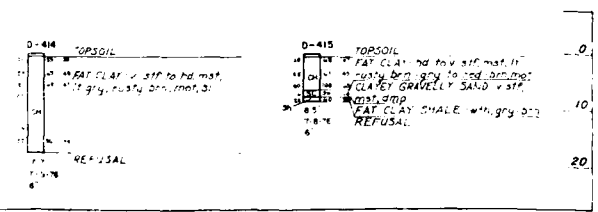
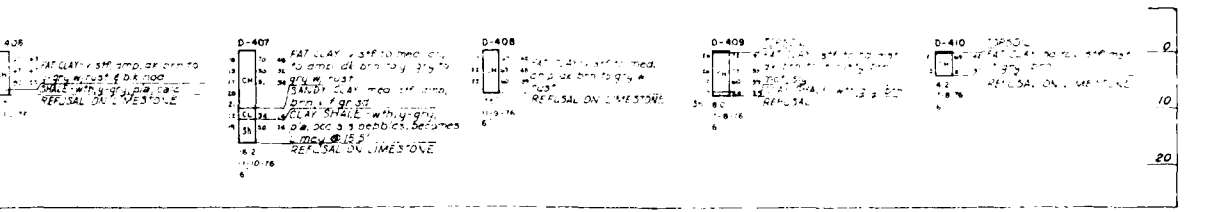
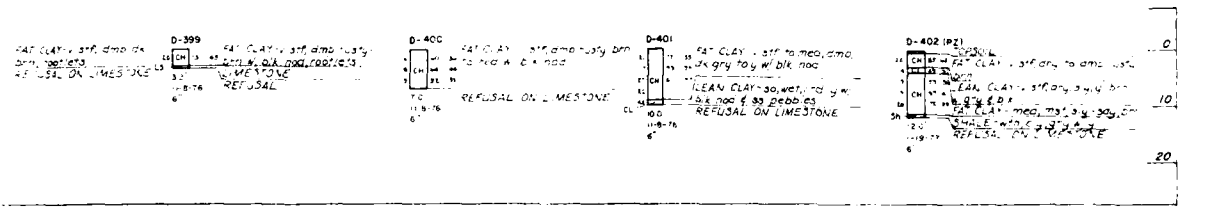
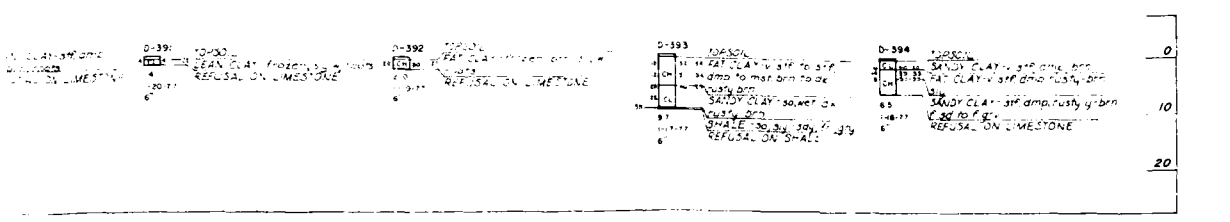
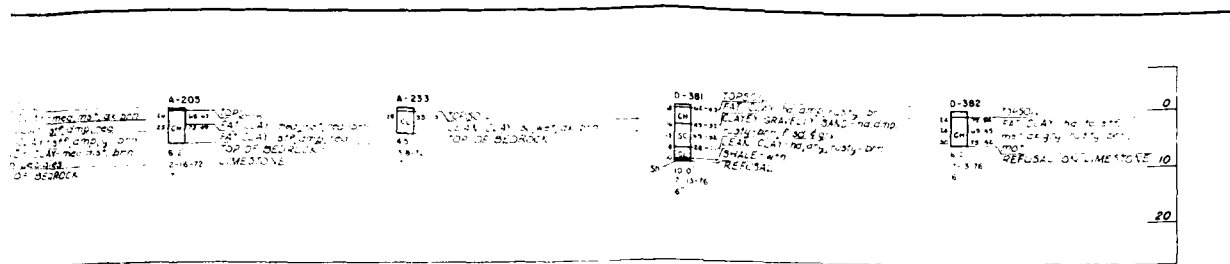
Scale as shown  
 U. S. ARMY  
 APRIL 1978



COMPILED BY W. T. M. W. L. C. R. G. P.  
 CHECKED BY  
 0-15-742



RECORD DRAW  
 JULY 1962  
 (CONTRACT NO. DACW 17-62-0001)



Rev. per '45 Bu. II conditions  
 Log No. 1  
 For Plot of Borings see Plate No. 12

STM: \_\_\_\_\_  
 DESCRIPTION: \_\_\_\_\_  
 REVISIONS: \_\_\_\_\_  
 DATE: \_\_\_\_\_ APPD: \_\_\_\_\_

BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION  
 BORROW AREA  
 LOGS OF EXPLORATIONS

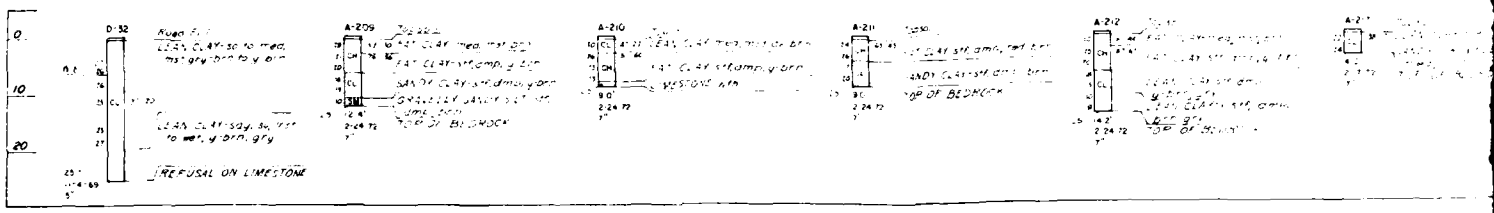
**RECORD DRAWING**



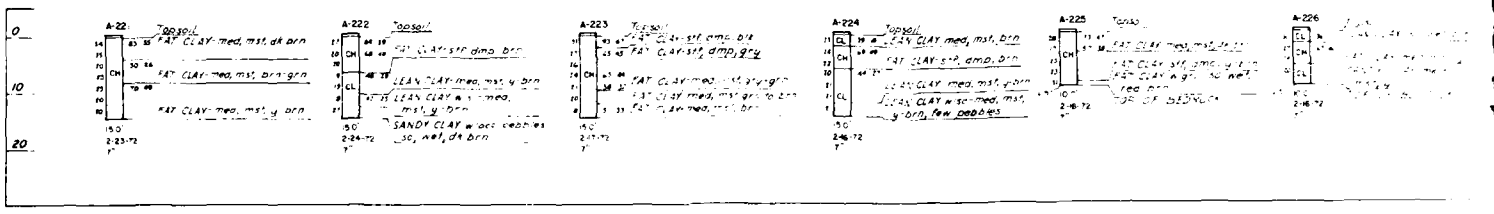
Dwg No 618  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 Checked by: \_\_\_\_\_  
 Drawn by: \_\_\_\_\_  
 M.T.M. J.P.M. M.T.M.

Scale as shown  
 U.S. ARMY  
 APRIL 1978  
 CIVIL ENGINEERING DIVISION  
 15-743

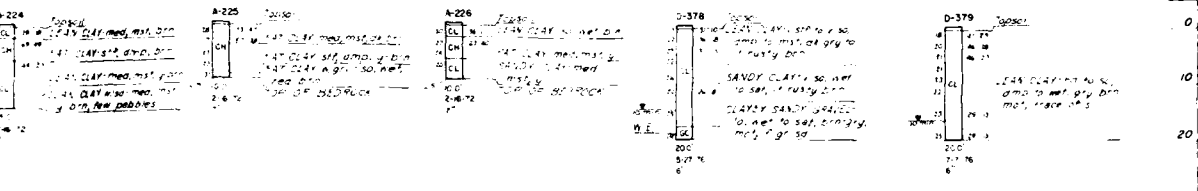
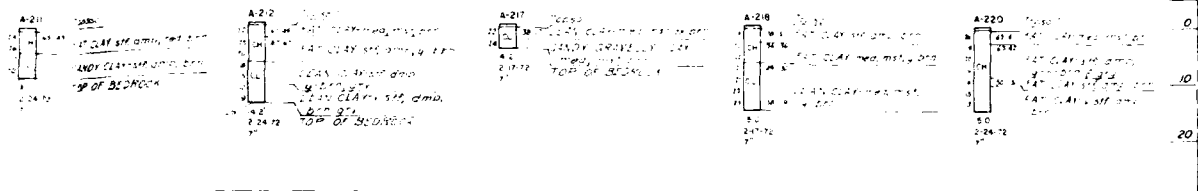
DEPTH IN FEET



DEPTH IN FEET







NOTES  
 For General Geologic column and  
 Legend See Dwg. No. E1  
 For Plan of Borings See Dwg. No. E2

**RECORD DRAWING**

JULY 1961  
 CONTRACT NO. DACW4178-0111  
 Revised for site conditions  
 DESCRIPTION  
 REVISIONS  
 DATE APPD.

**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION

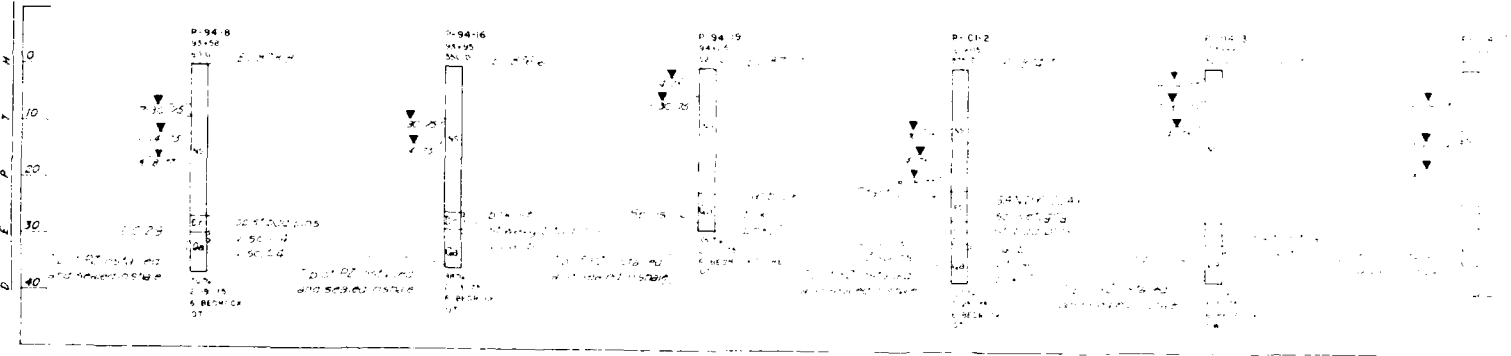
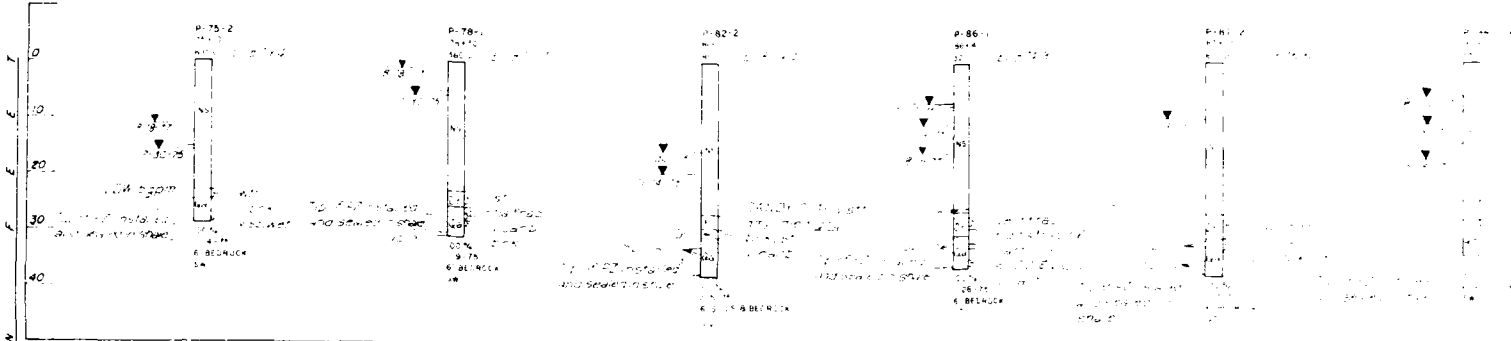
BORROW AREA  
 LOGS OF EXPLORATIONS



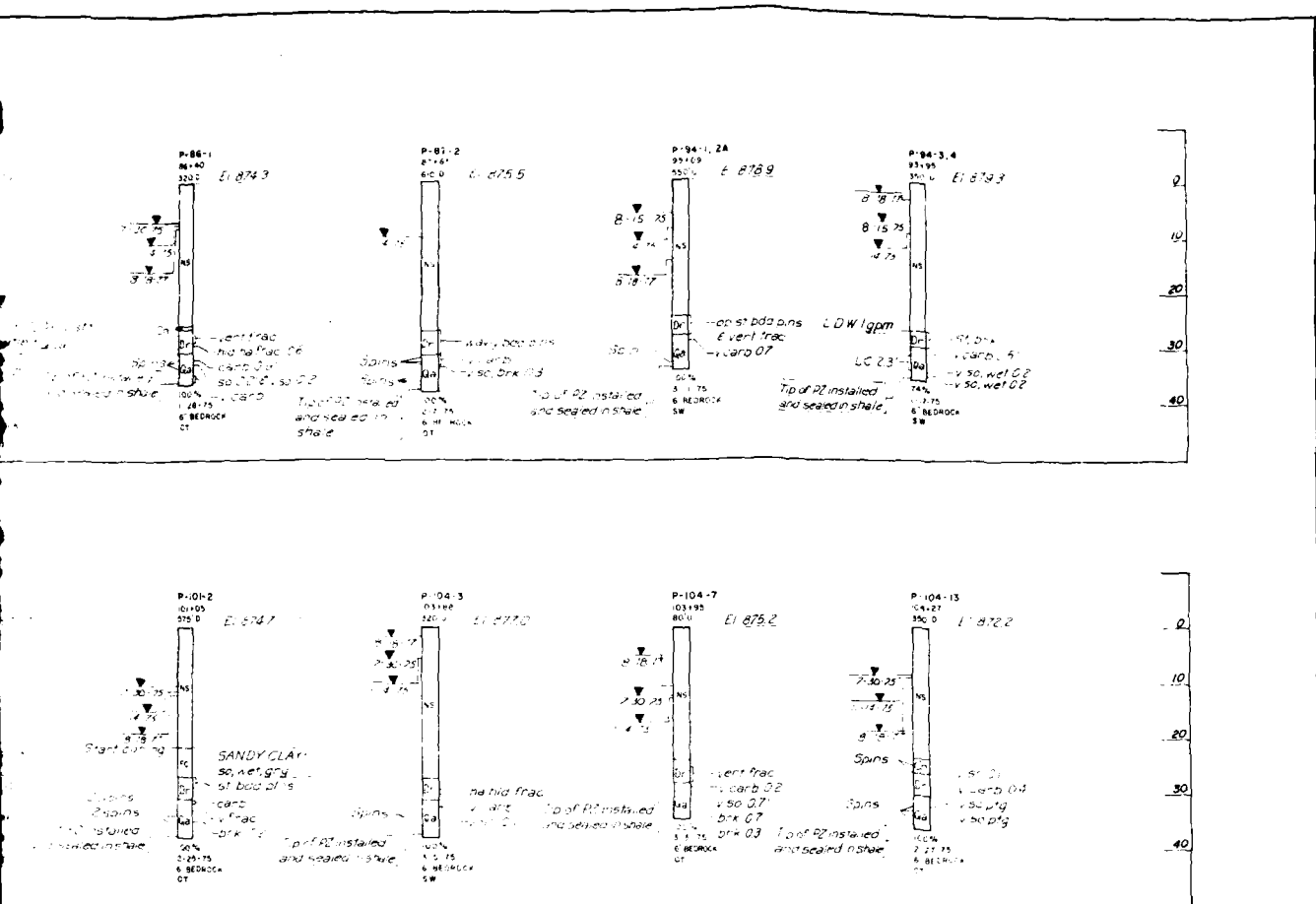
Dwg No. E19  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT

Scale as shown  
 U. S. ARMY  
 APRIL 1978

Submitted by: [Signature]  
 Recommended by: [Signature]  
 Checked by: [Signature]  
 FILE NO. 0-15-744



45252  
 1000  
 1000



**LEGEND**  
 SANDY CLAY AND SILTY CLAY 56  
 OPEN - 85

Notes  
 1. See boring logs for Town and  
 Legend. See DWG No. F  
 for Plan of Boring, see DWG No. E2

**RECORD DRAWING**

JULY 1982  
 CONTRACT NO. DAOR11787-0111

SYMBOL	DESCRIPTION	DATE	APPROVED
	REVISIONS		

BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 STAGE III CONSTRUCTION

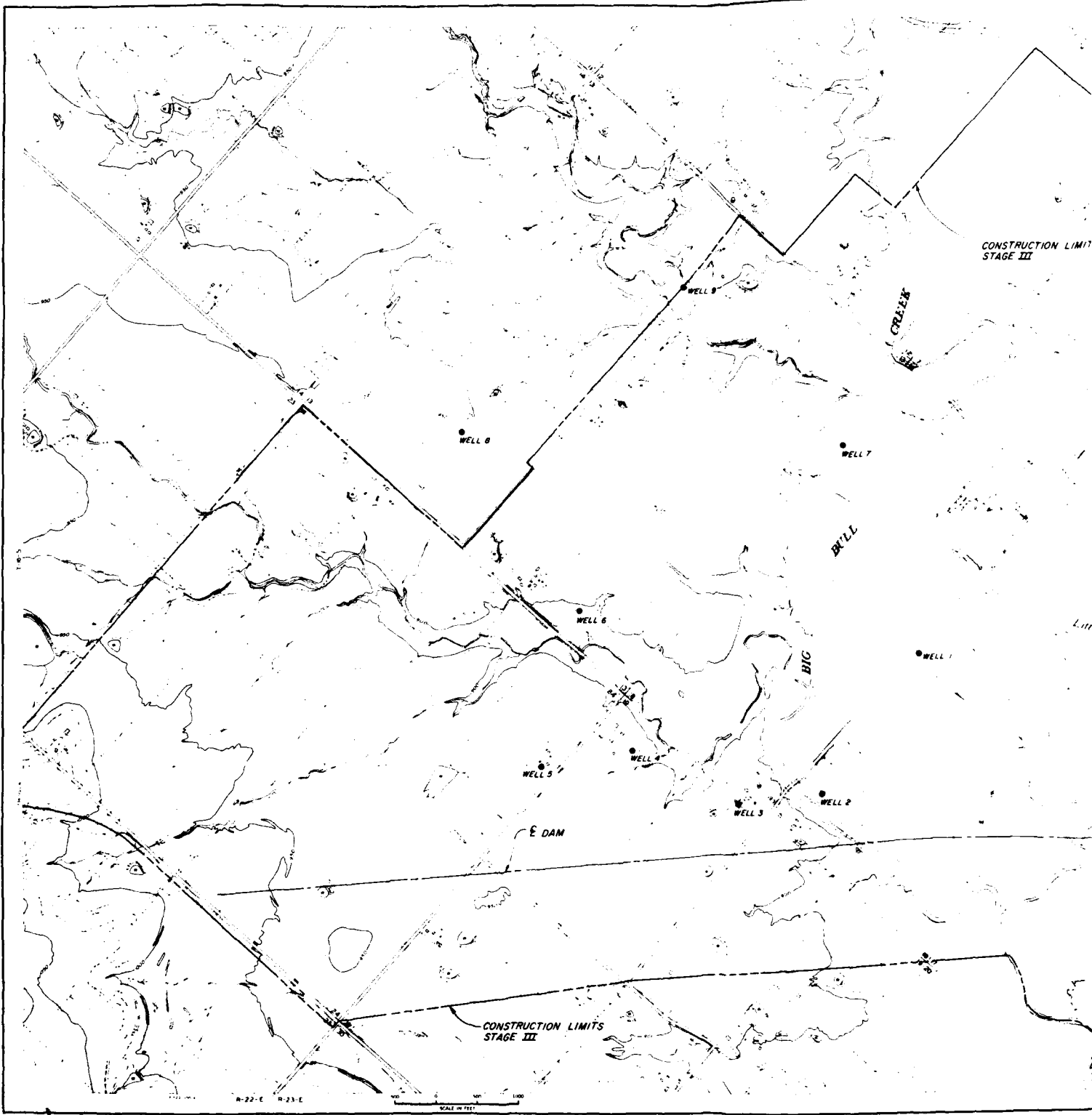
**LOGS OF BORING FOR EXISTING PIEZOMETERS**

Dwg No E20  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 SUBMITTED BY  
 CHECKED BY  
 R G C

RECOMMENDED BY  
 CHECKED BY  
 R S R G F

Scale: as shown  
 U.S. ARMY  
 APRIL 1978  
 FILE NO.  
**0-15-745**





BASE FILE NO. 01-91-03  
CONSTRUCTION LIMIT STAGE III

R-22-E R-23-E

CONSTRUCTION LIMITS  
STAGE III

WELL 6

BIG BULL CREEK

Creek

WELL 7

Bull

BULL

Little

WELL 1

BIG

WELL 3

WELL 2

### RECORD DRAWING

JULY 1982  
CONTRACT NO. DACW4178 C 0113

SYMBOL	Revised for "As Built" conditions	DATE	4/28/83
DESCRIPTION		APP'D	
REVISIONS			

### BIG BULL CREEK, KANSAS HILLSDALE LAKE STAGE III CONSTRUCTION

#### PLAN OF KNOWN GAS AND OIL WELLS

Dwg No E 21  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

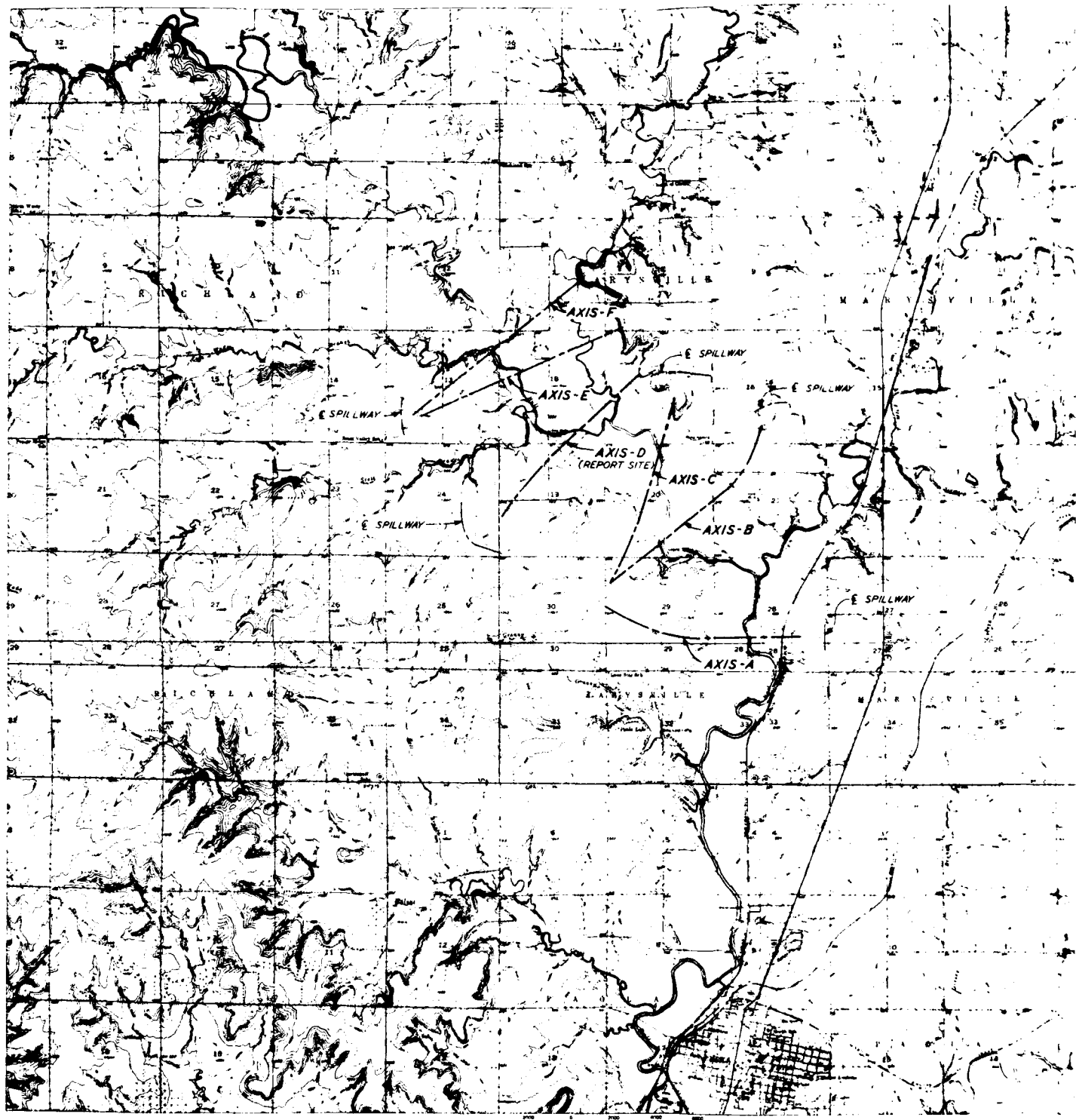
Scale: as shown  
U. S. ARMY  
APRIL 1978

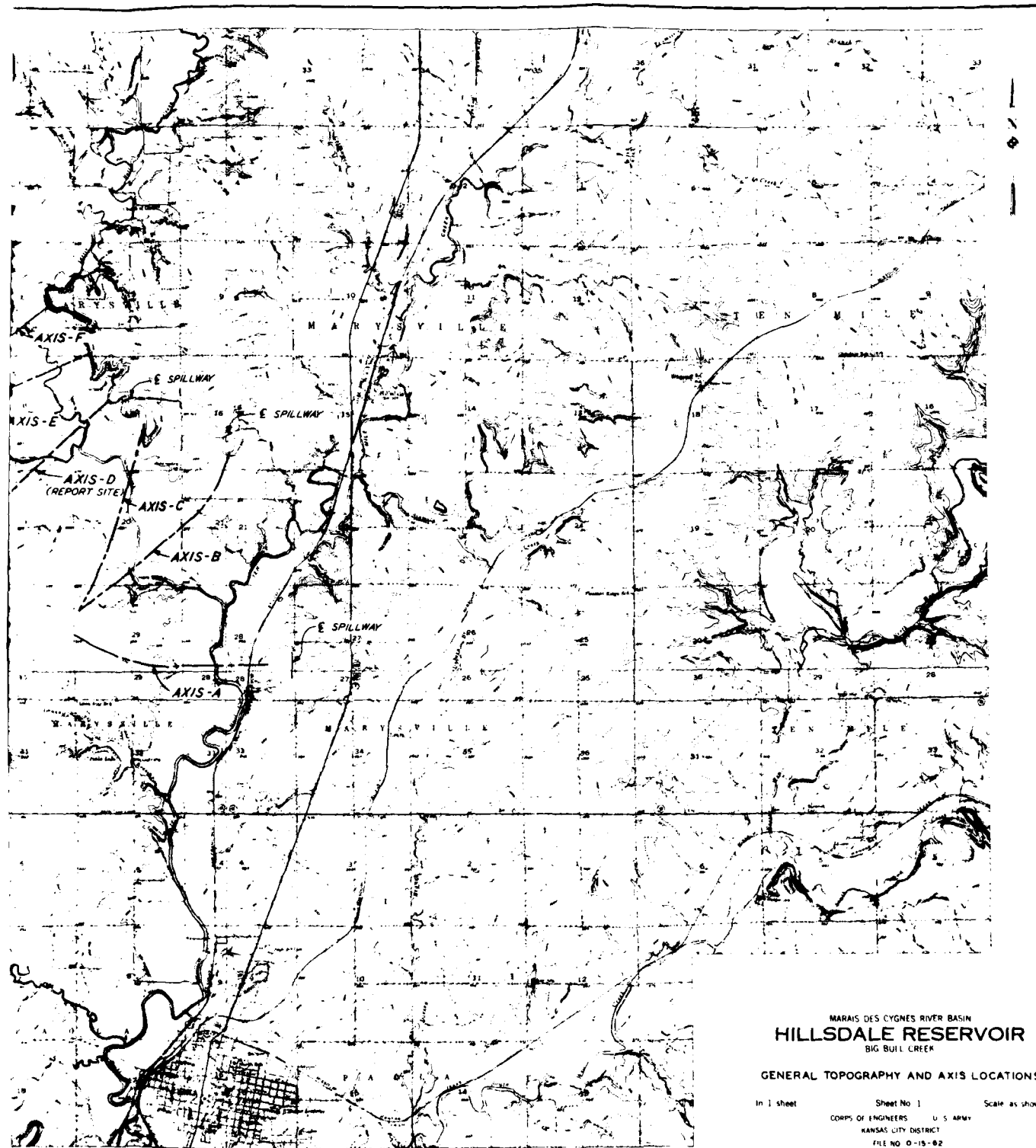


DESIGNED BY: [Signature]  
CHECKED BY: [Signature]  
DATE: [Signature]

RECOMMENDED BY: [Signature]  
DATE: [Signature]

0-15-746  
PLATE NO. 36

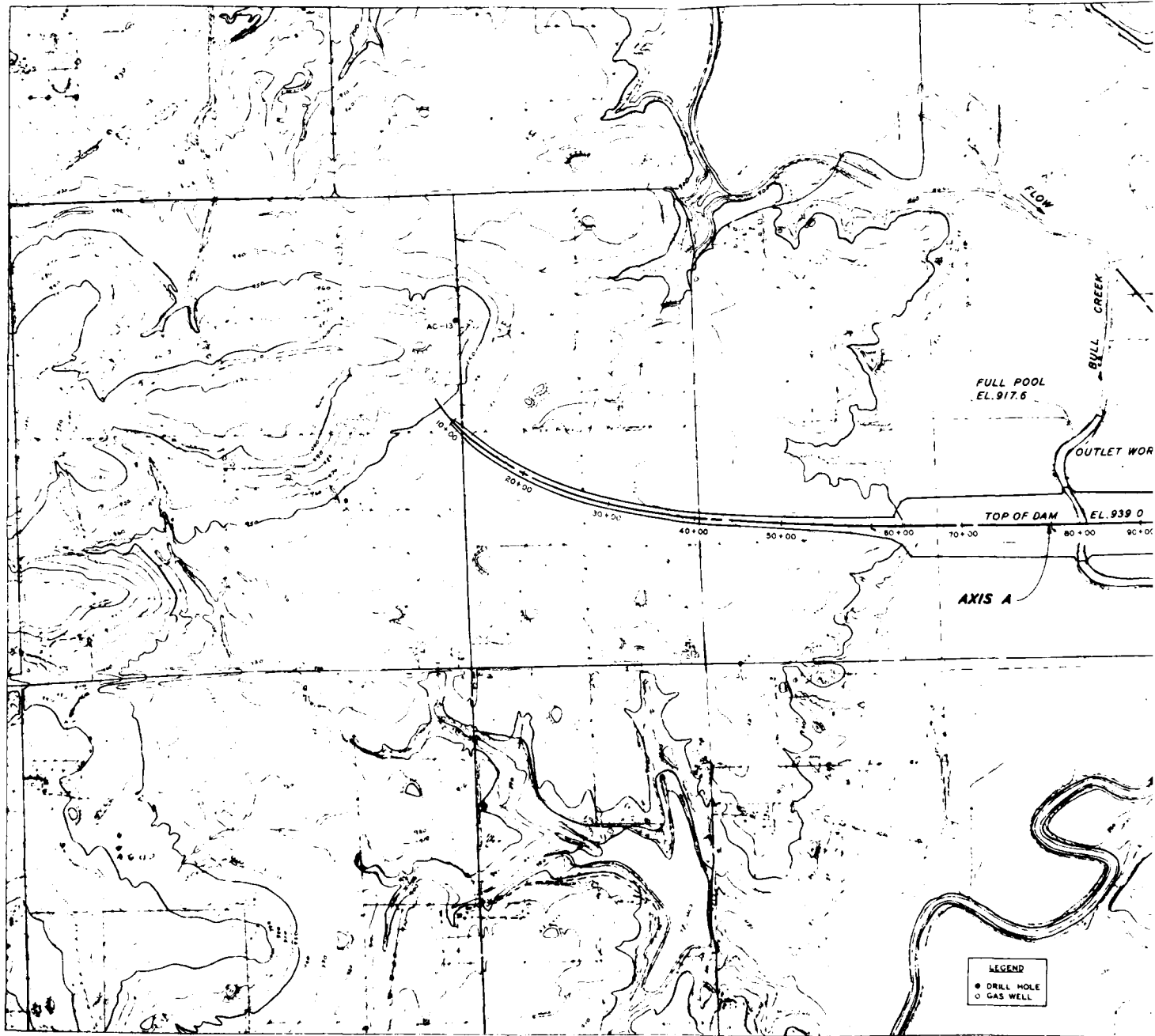




MARIS DES CYGNES RIVER BASIN  
**HILLSDALE RESERVOIR**  
 BIG BULL CREEK

**GENERAL TOPOGRAPHY AND AXIS LOCATIONS**

In 1 sheet      Sheet No 1      Scale as shown  
 CORPS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-02  
 FEBRUARY 1969

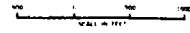


FULL POOL  
EL. 917.6

TOP OF DAM  
EL. 939.0

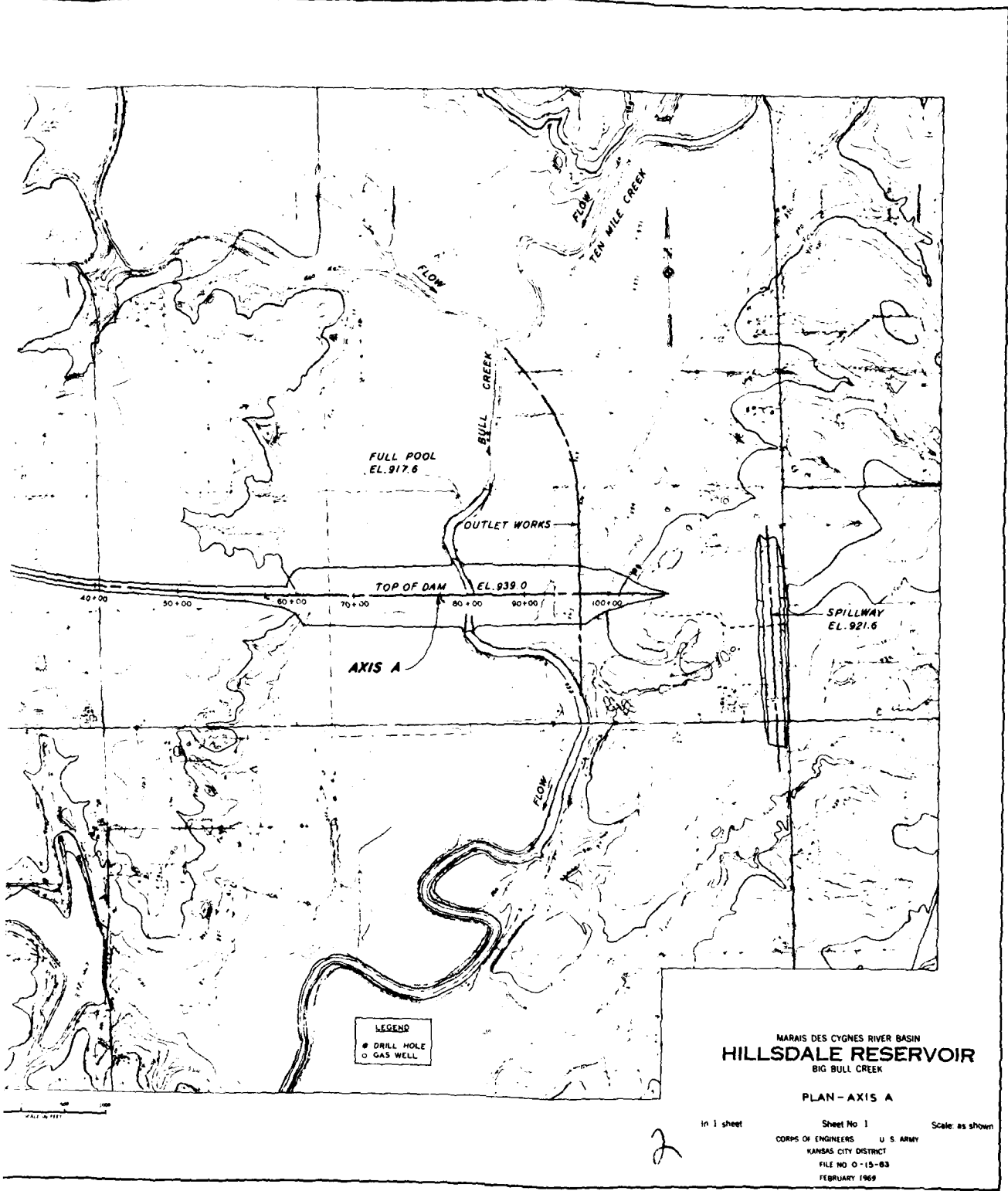
AXIS A

LEGEND  
● DRILL HOLE  
○ GAS WELL



1

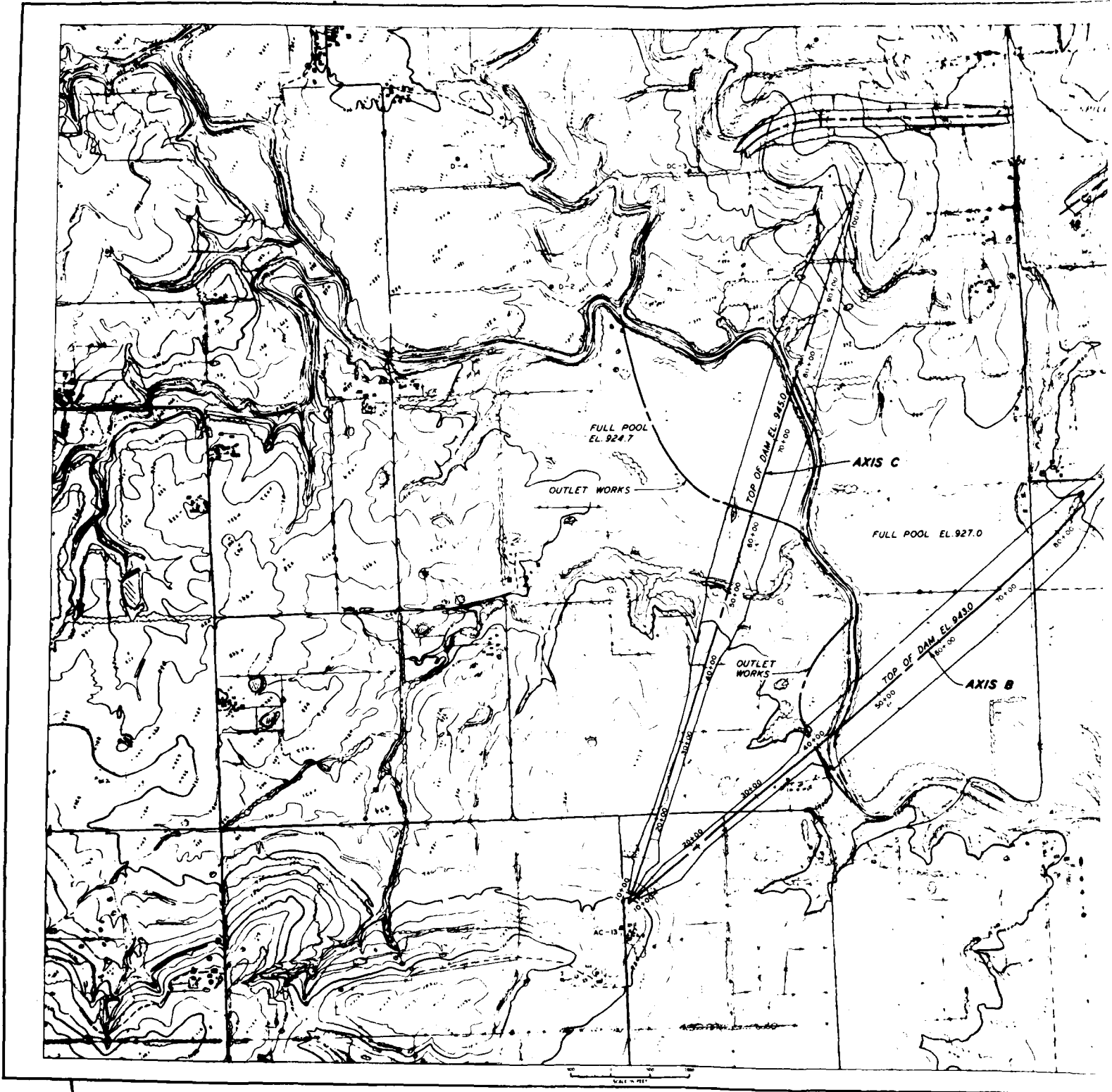


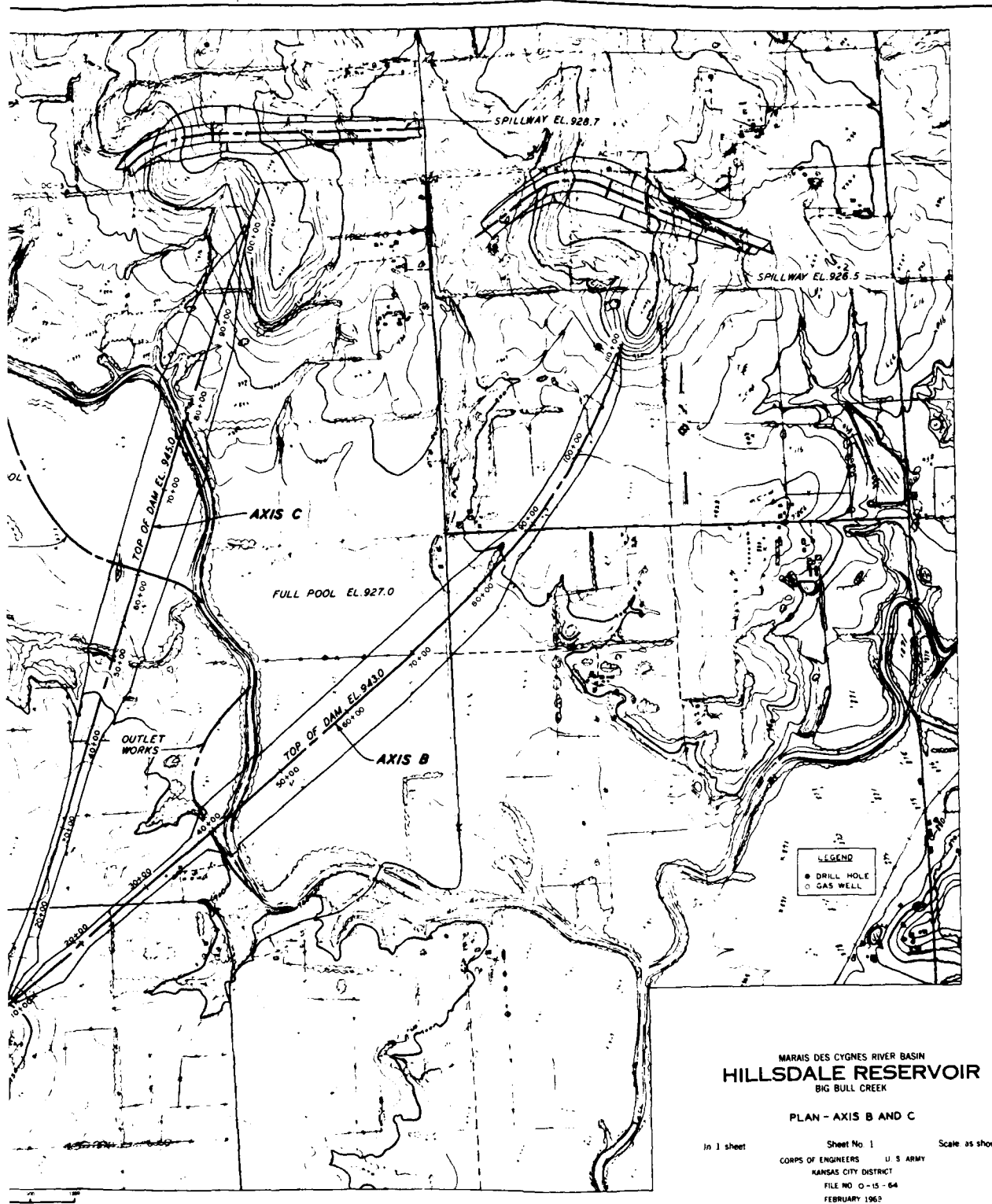


MARIS DES CYGNES RIVER BASIN  
**HILLSDALE RESERVOIR**  
 BIG BULL CREEK

PLAN - AXIS A

In 1 sheet      Sheet No 1      Scale: as shown  
 CORPS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO O-15-83  
 FEBRUARY 1969

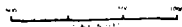
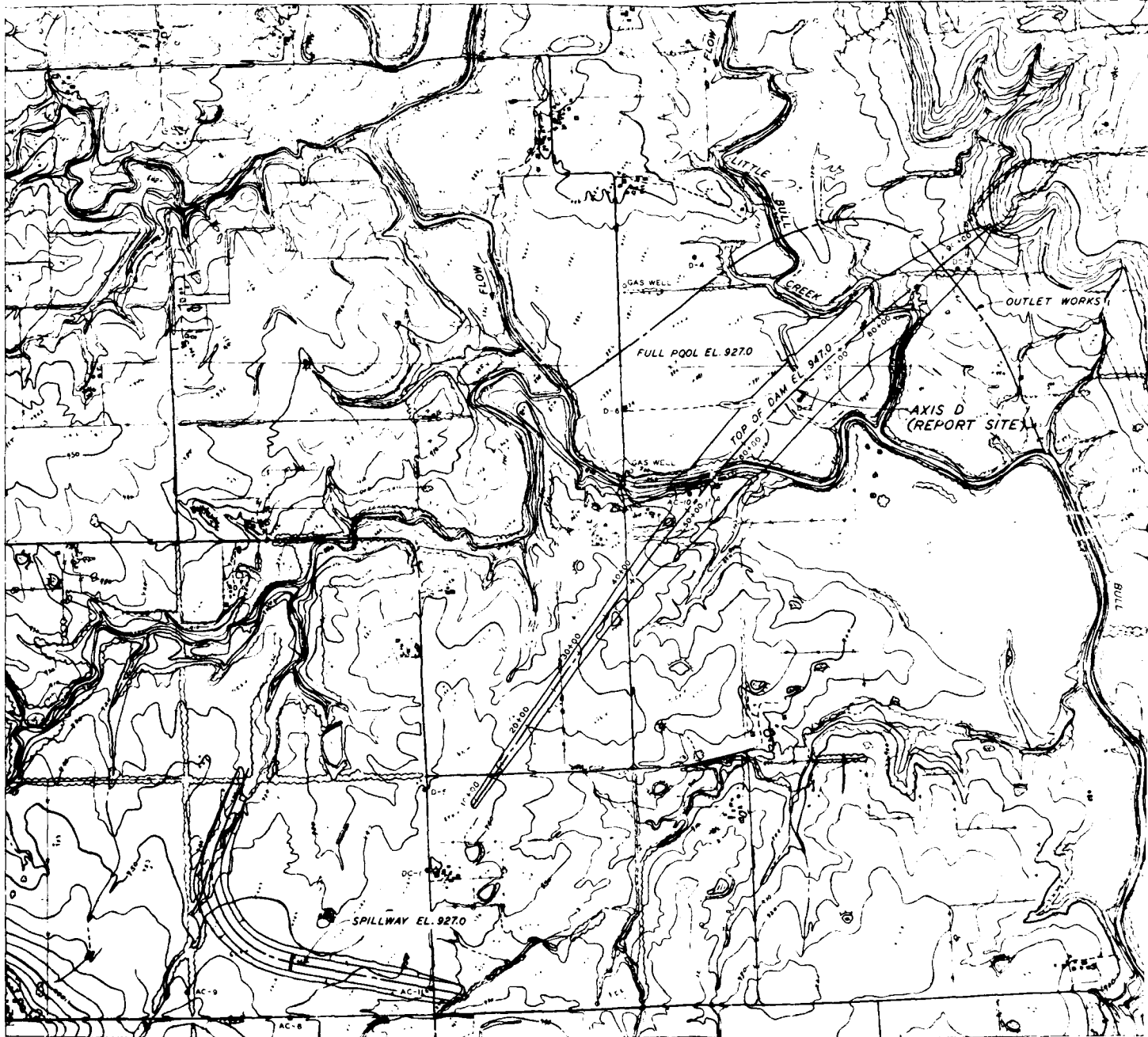


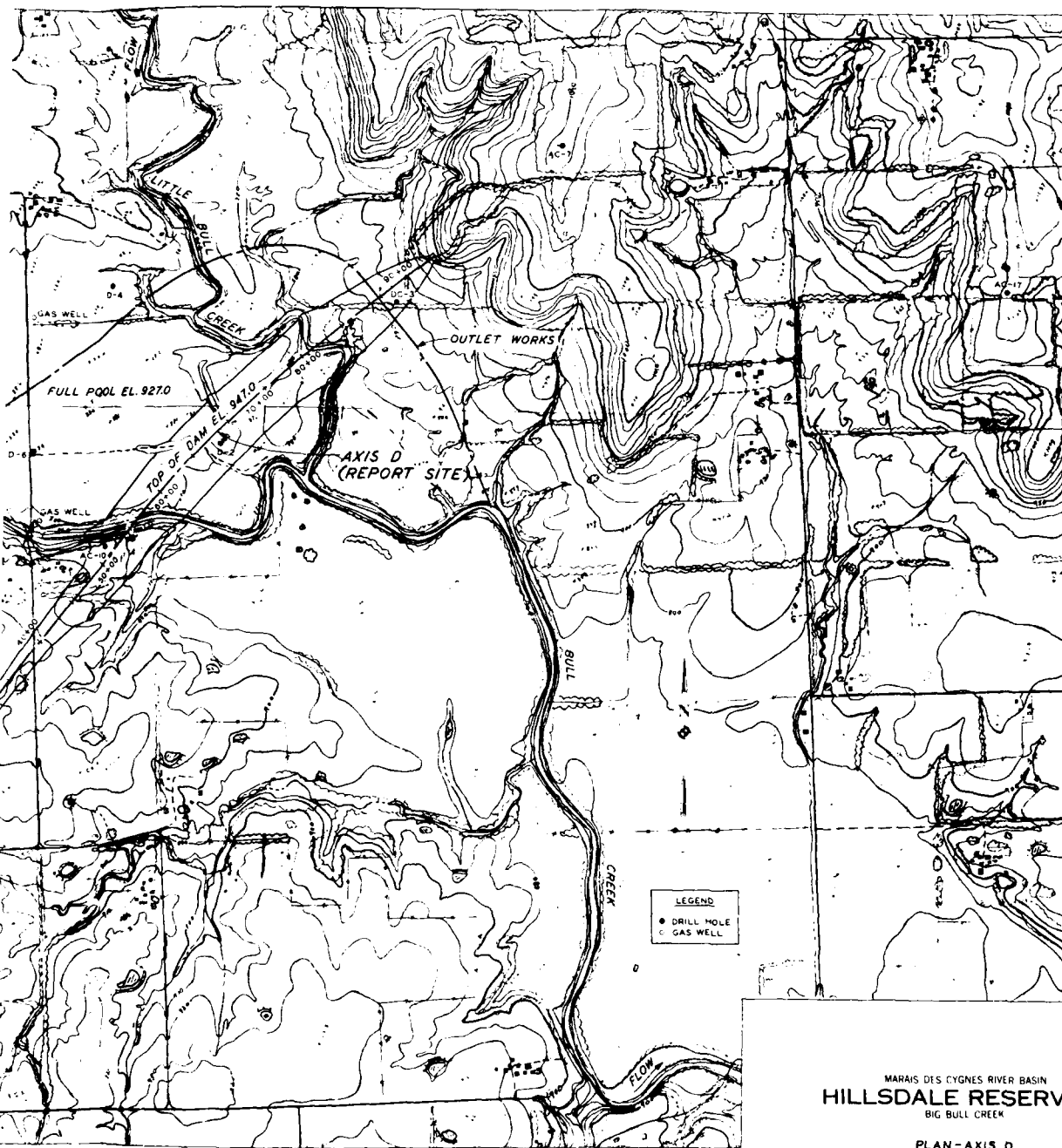


MARAI DES CYGNES RIVER BASIN  
**HILLSDALE RESERVOIR**  
 BIG BULL CREEK

PLAN - AXIS B AND C

In 1 sheet      Sheet No 1      Scale as shown  
 CORPS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO O-15-64  
 FEBRUARY 1962





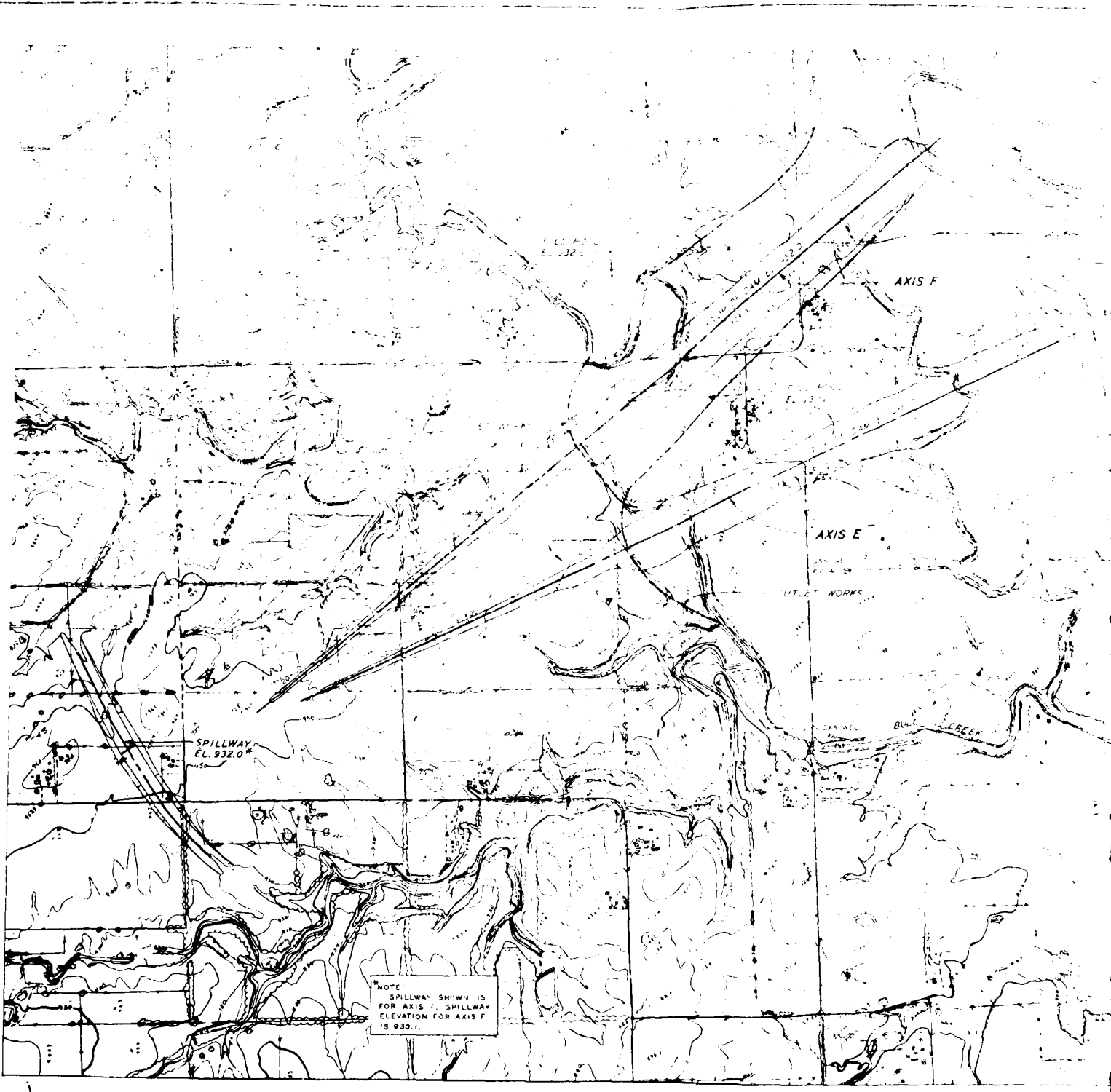
MARAI DES CYGNES RIVER BASIN  
**HILLSDALE RESERVOIR**  
 BIG BULL CREEK

PLAN-AXIS D

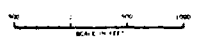
In 1 sheet      Sheet No 1      Scale as shown  
 CORPS OF ENGINEERS      U S ARMY  
 KANSAS CITY DISTRICT  
 FILE NO O-15-85  
 FEBRUARY 1969

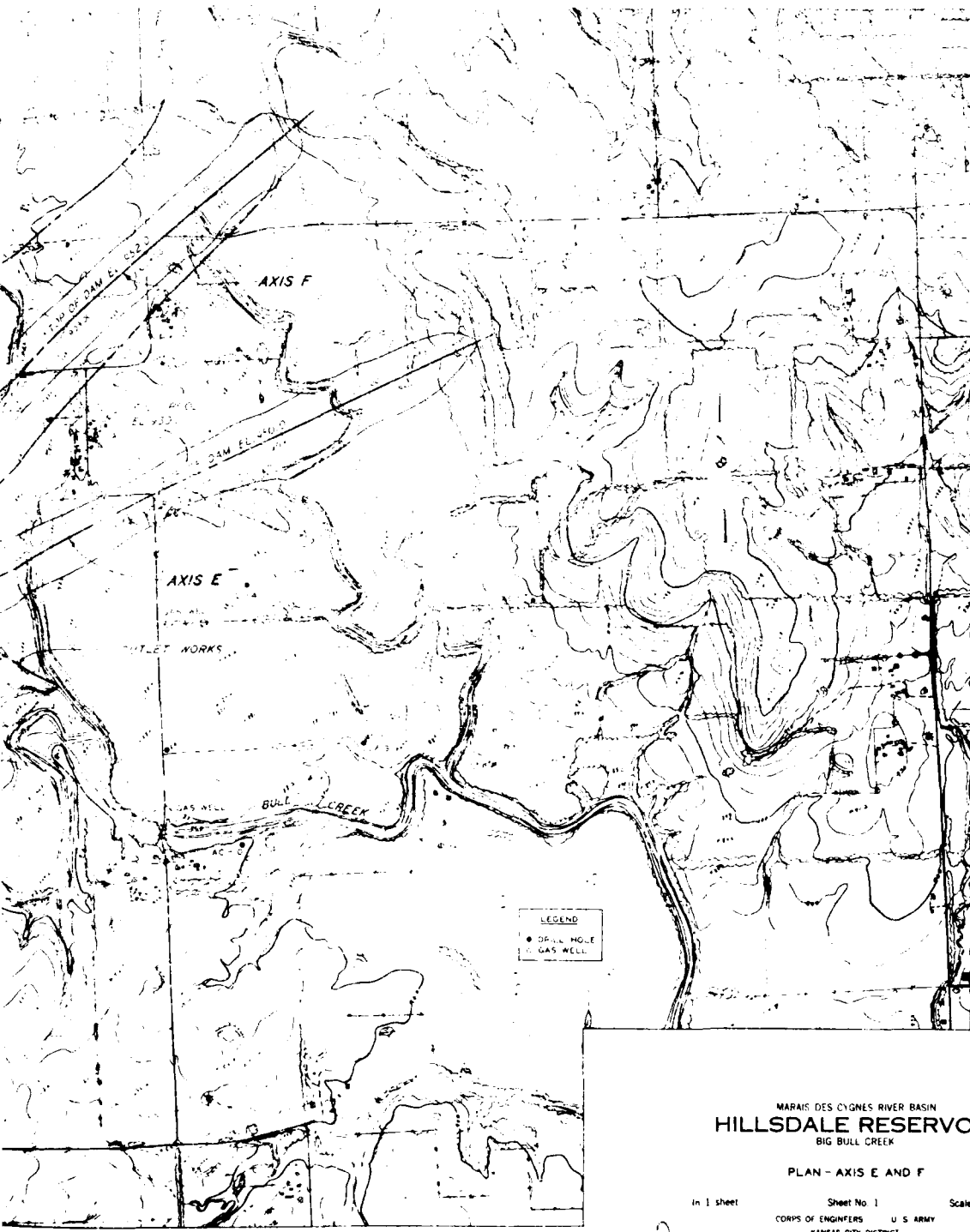
PLATE NO 40

2



NOTE:  
SPILLWAY SHOWN IS  
FOR AXIS E. SPILLWAY  
ELEVATION FOR AXIS F  
IS 930.7.

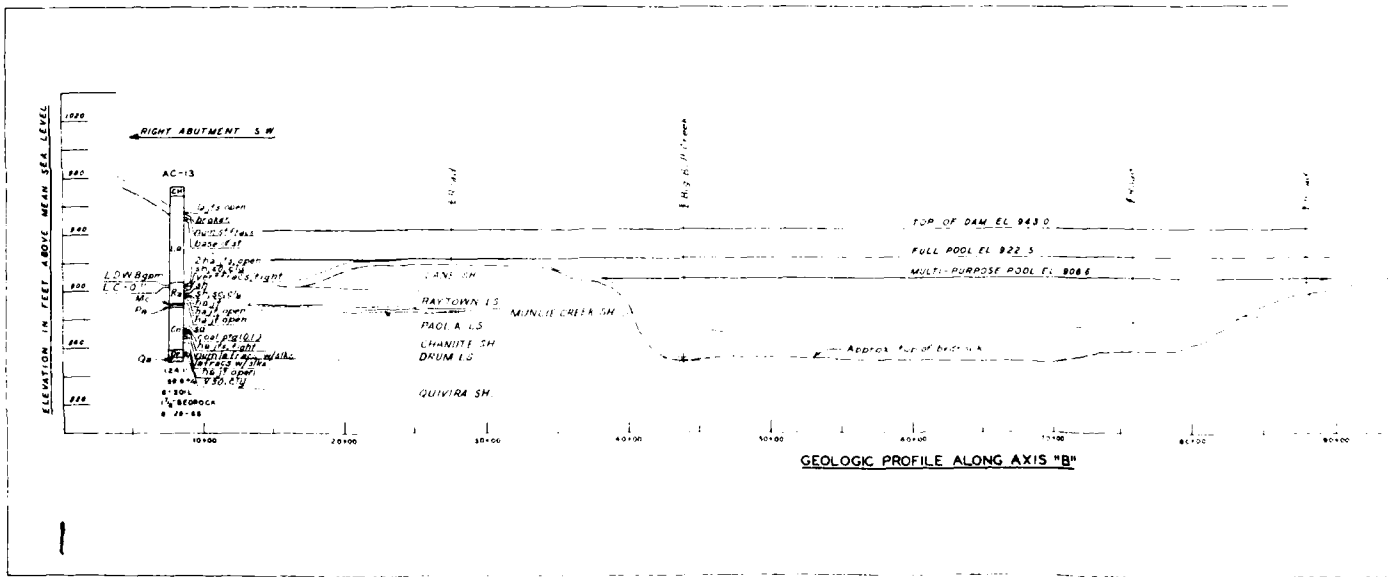




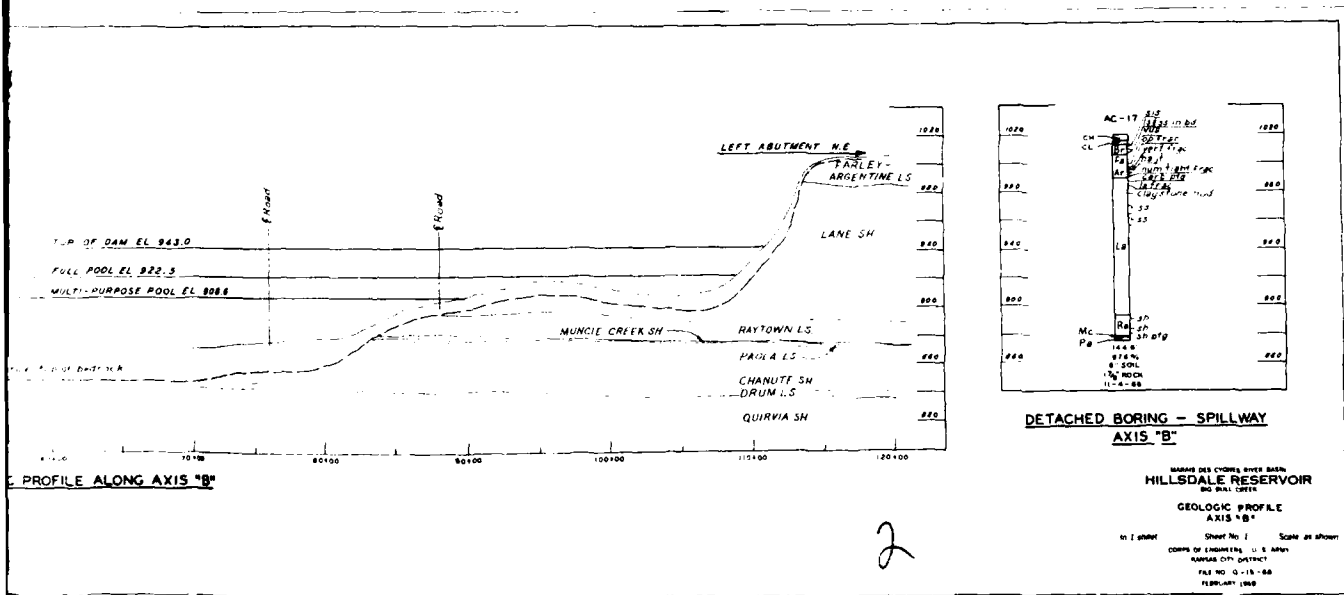
MARAI DES CYGNES RIVER BASIN  
**HILLSDALE RESERVOIR**  
 BIG BULL CREEK

PLAN - AXIS E AND F

In 1 sheet      Sheet No 1      Scale: as shown  
 CORPS OF ENGINEERS      U S ARMY  
 KANSAS CITY DISTRICT  
 FILE NO 0-15-86  
 FEBRUARY 1969

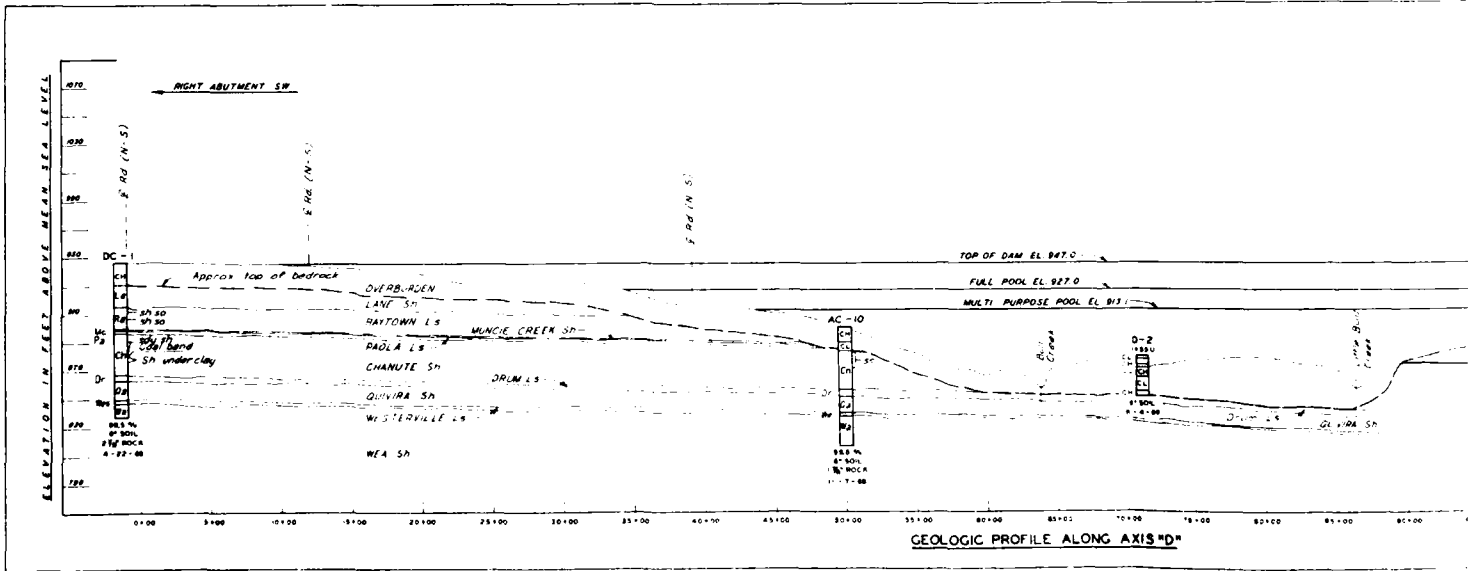






2

BARABAS DES CYGNES RIVER BASIN  
**HILLSDALE RESERVOIR**  
 GEOLOGIC PROFILE  
 AXIS "B"  
 SHEET NO. 1 SCALE AS SHOWN  
 CORPS OF ENGINEERS U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. 3-15-66  
 FEBRUARY 1966  
 PLATE NO 42



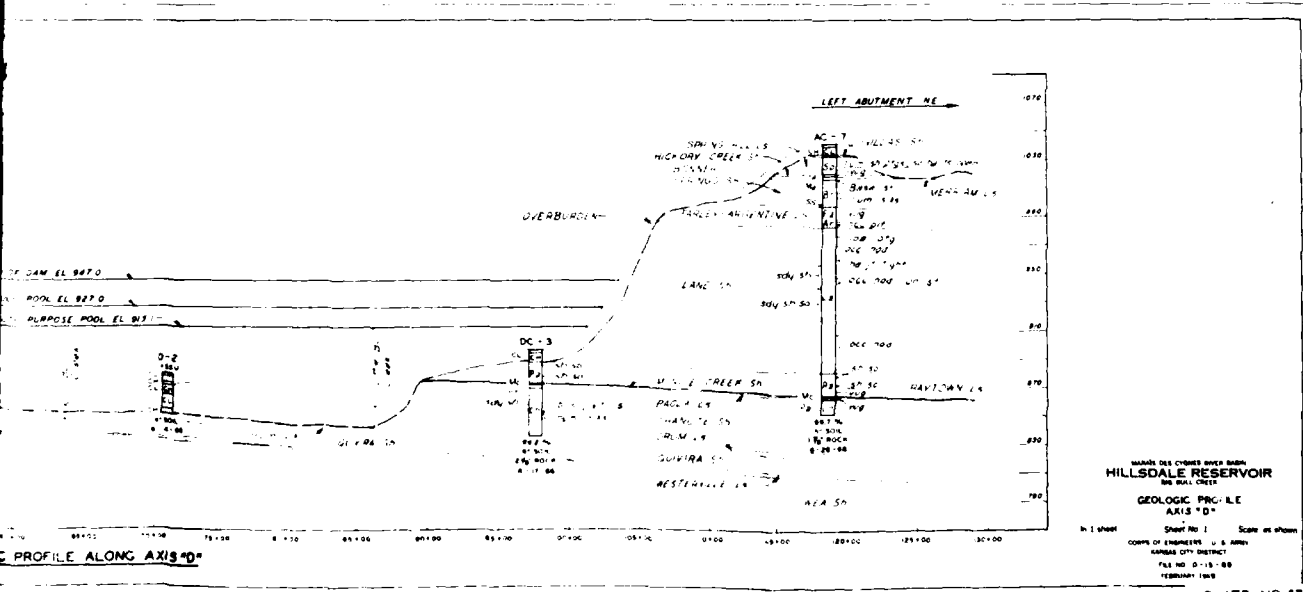
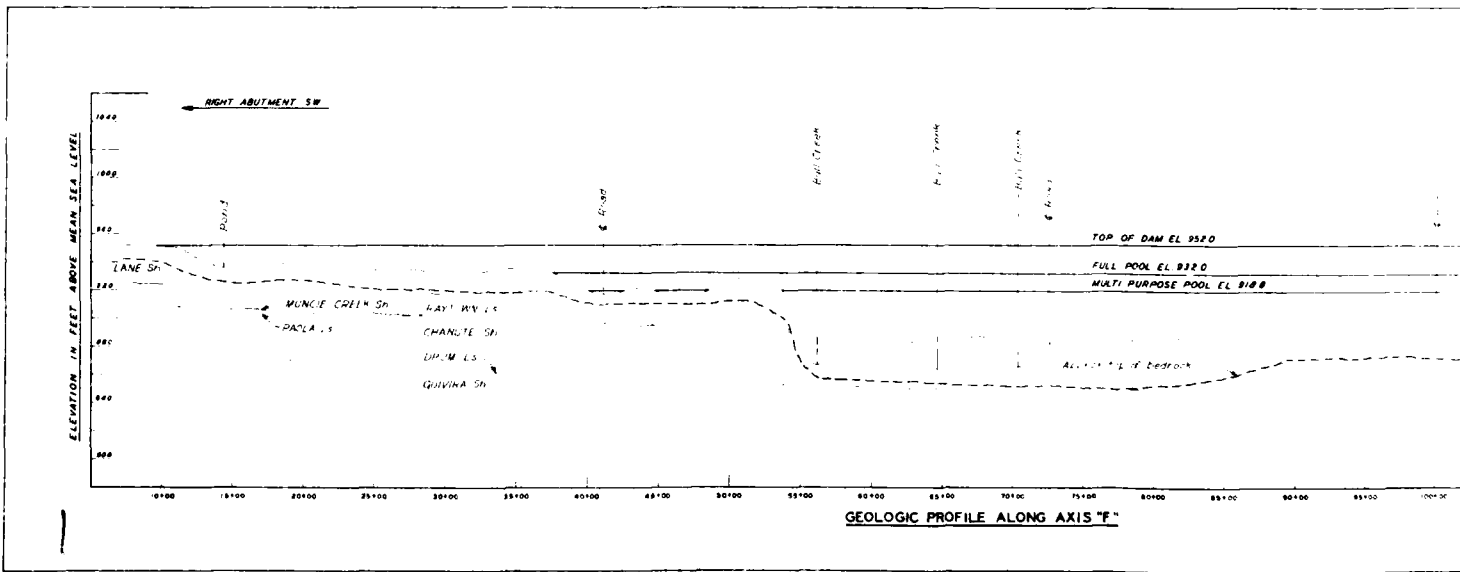
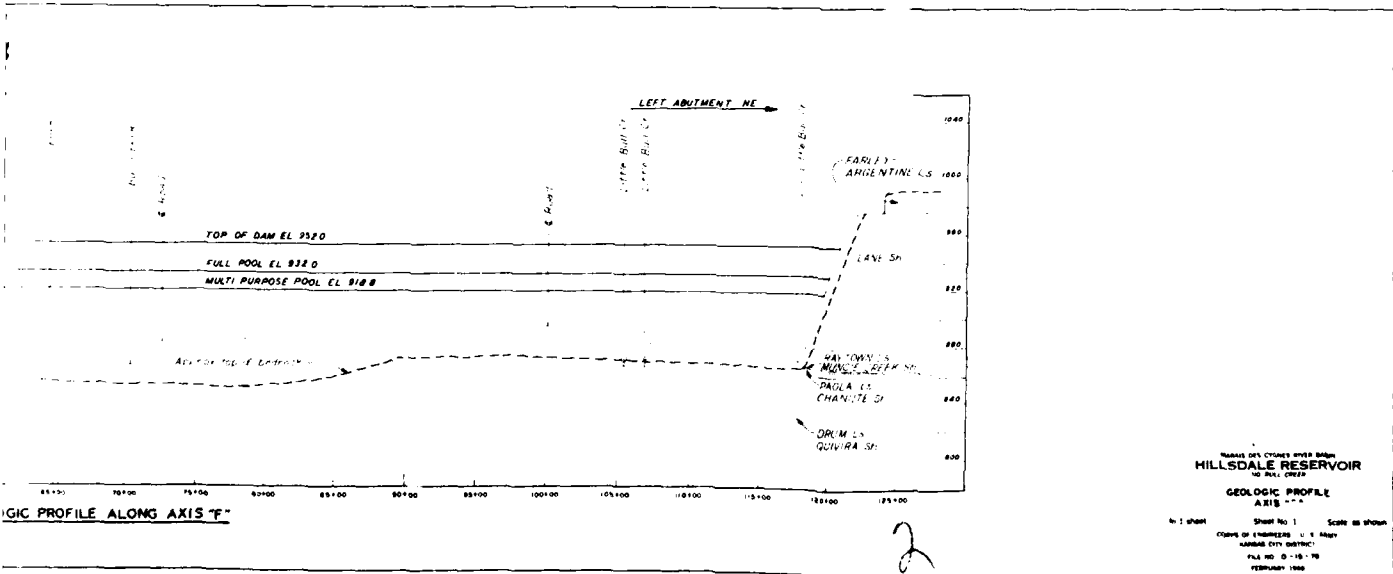
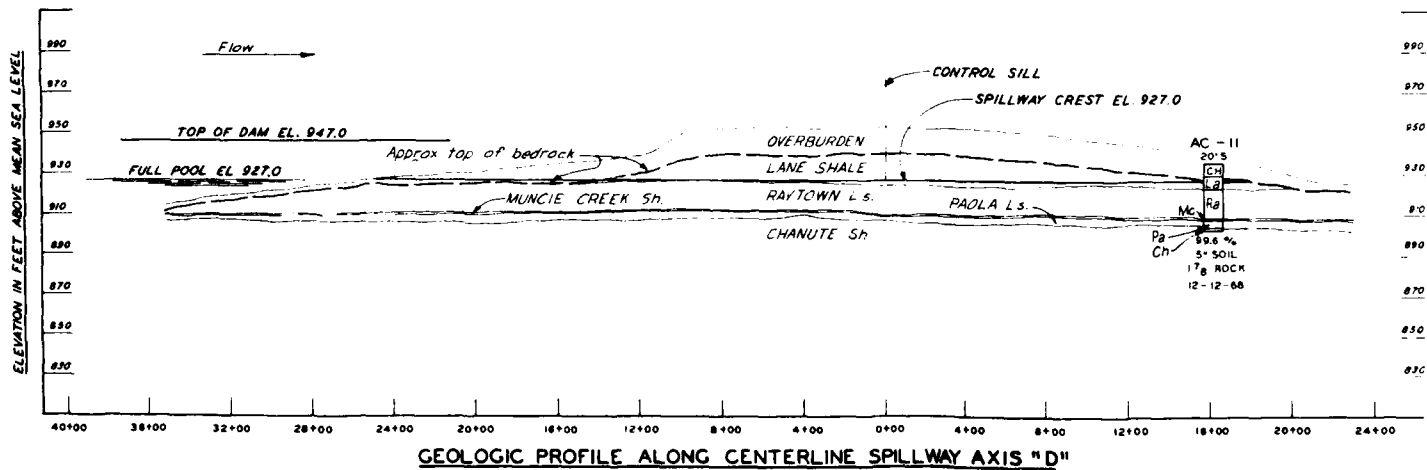
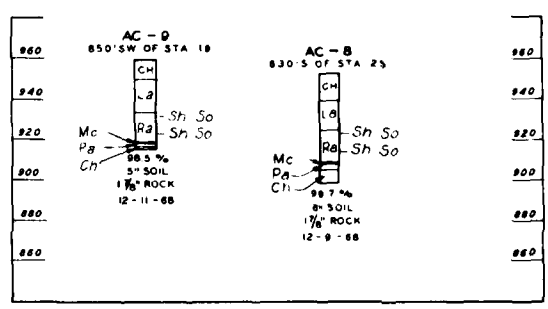
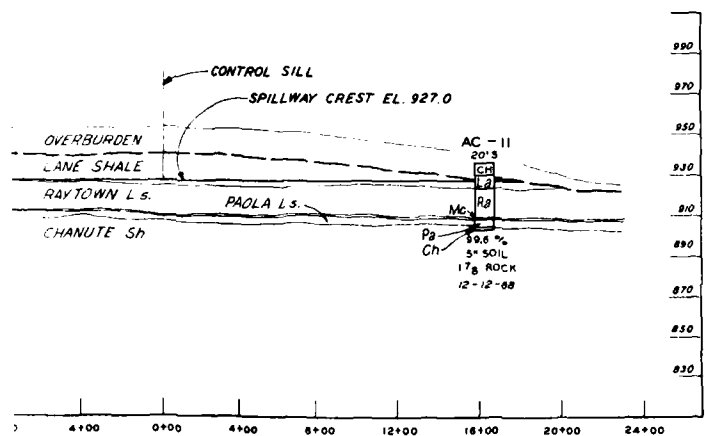


PLATE NO 43









DETACHED BORINGS - SPILLWAY

ENTERLINE SPILLWAY AXIS "D"

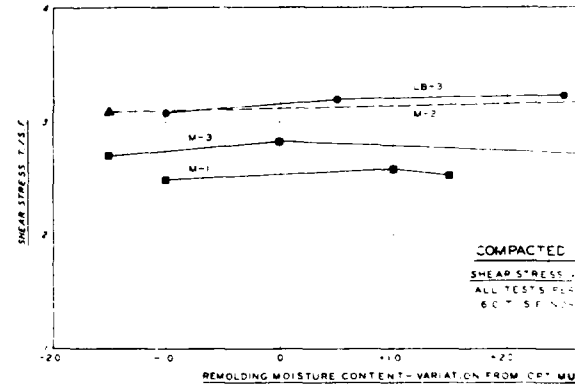
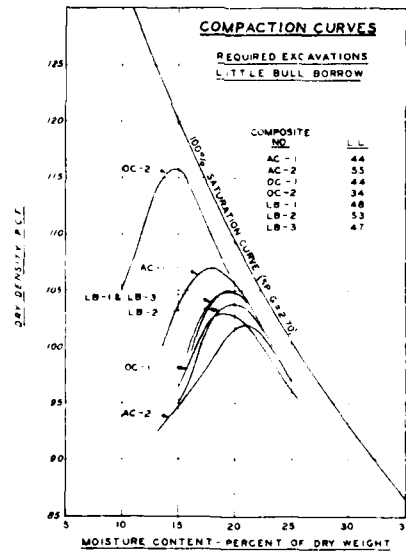
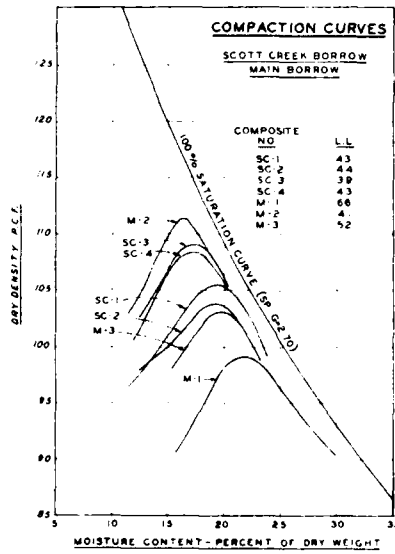
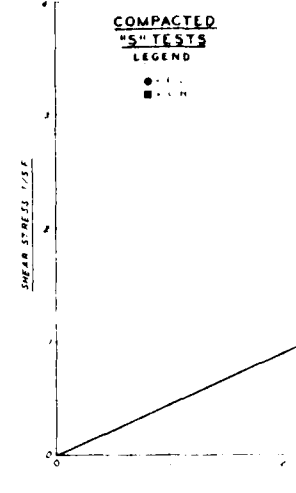
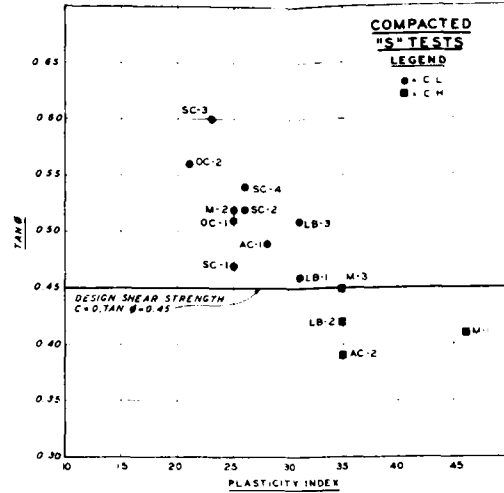
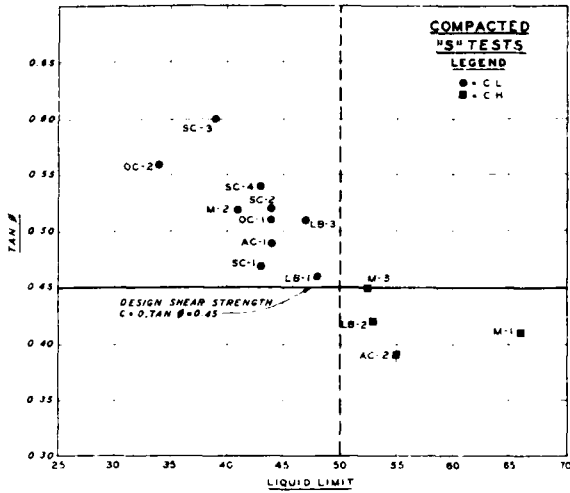
2

MARAS DES CYGNES RIVER BASIN  
**HILLSDALE RESERVOIR**  
 BIG BULL CREEK

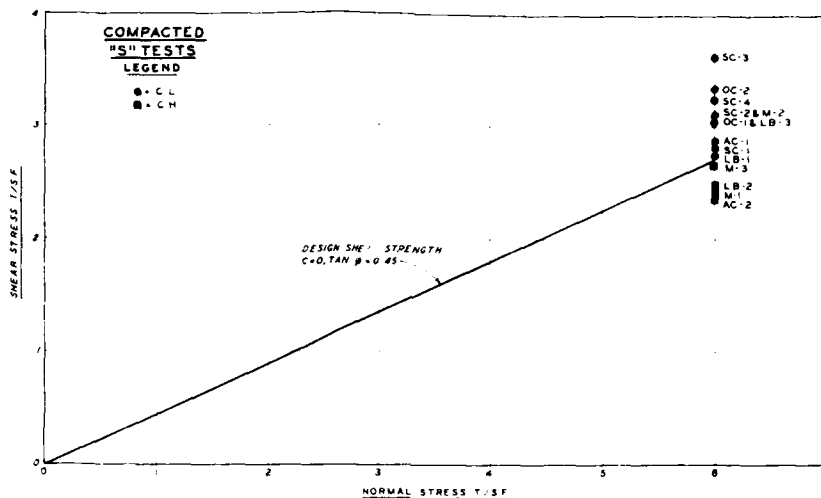
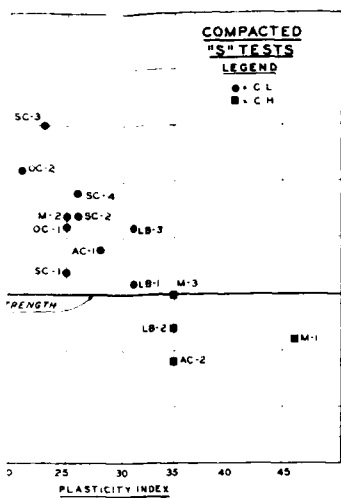
**GEOLOGIC PROFILE**  
 SPILLWAY FOR AXIS "D"

In 1 sheet Sheet No. 1 Scale as shown  
 CORPS OF ENGINEERS U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-71  
 FEBRUARY 1968

PLATE NO. 45



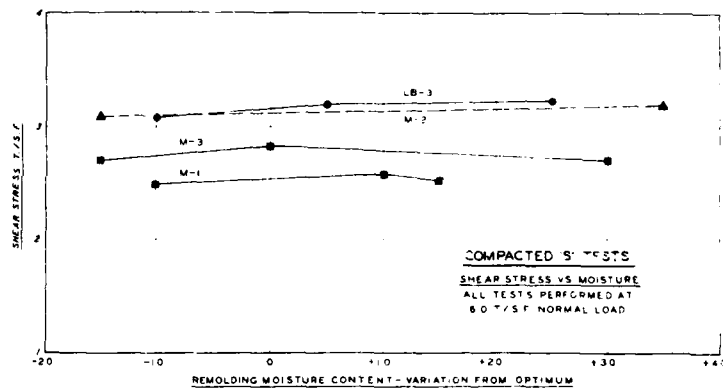




VES  
ONS  
OW

44  
53  
44  
34  
48  
53  
47

10 35  
WEIGHT



SYM: \_\_\_\_\_ DESCRIPTION: OSAGE RIVER BASIN  
REVISIONS: \_\_\_\_\_ DATE: \_\_\_\_\_ APP'D: \_\_\_\_\_

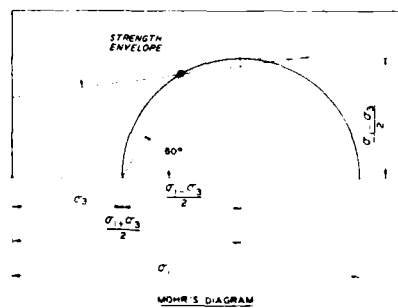
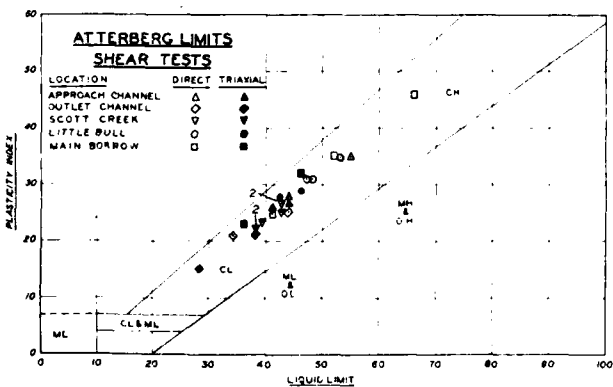
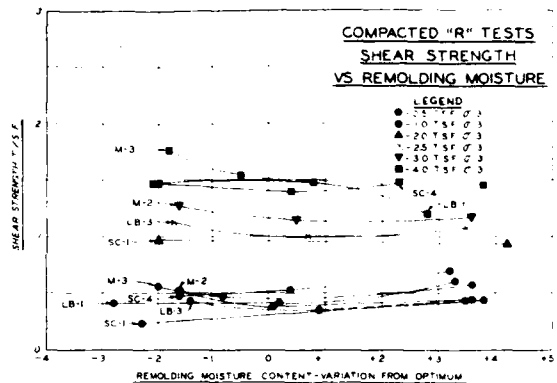
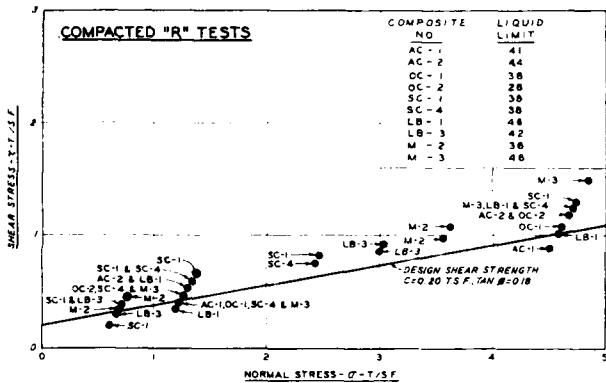
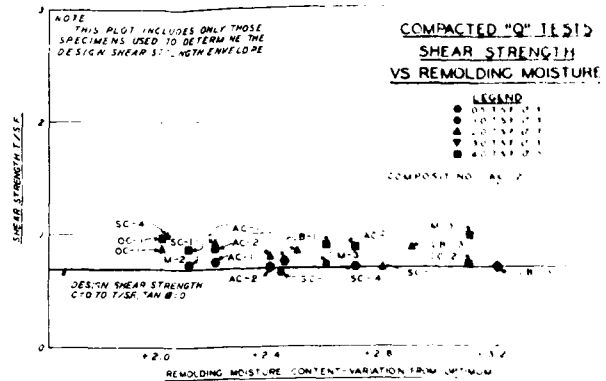
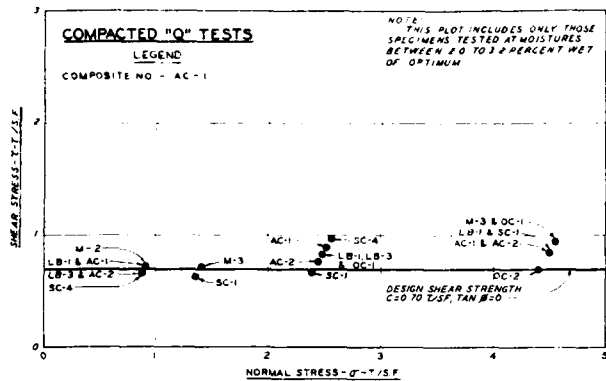
**HILLSDALE LAKE**  
BIG BULL CREEK

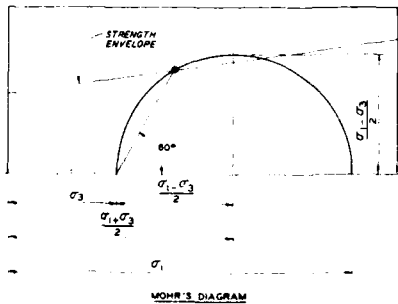
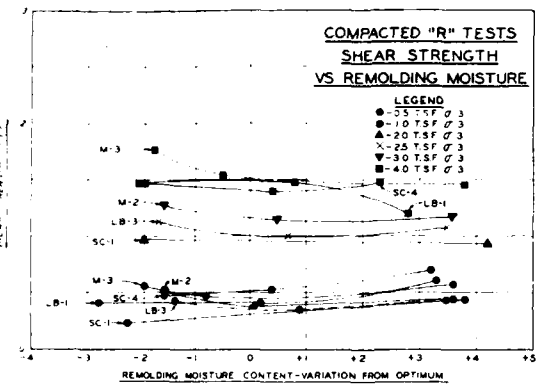
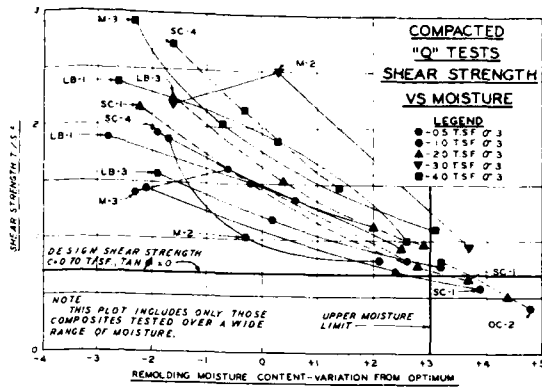
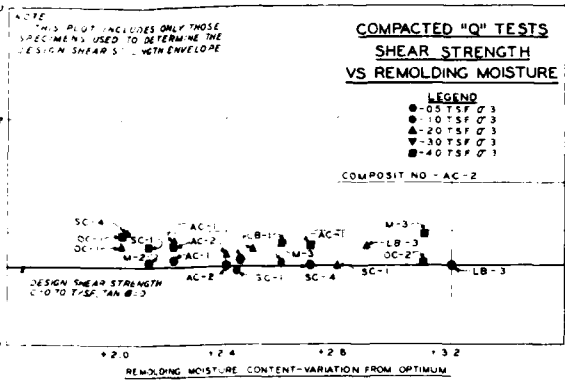
TEST DATA SUMMARY  
COMPACTED EMBANKMENT MATERIAL  
"S" AND COMPACTION TESTS

In 80 sheets Sheet No 1 Scale as shown  
CORPS OF ENGINEERS U.S. ARMY  
KANSAS CITY DISTRICT MARCH 1971

Submitted: \_\_\_\_\_ Recommended: \_\_\_\_\_ Approval: \_\_\_\_\_

PREPARED BY: R.W.B. CHECKED BY: L.E.M.-C.P.W. DRAWN BY: R.F.D. FILE NO: DM-7 O-15-185





SYM.	DESCRIPTION REVISIONS	DATE	APP'D.
2	OSAGE RIVER BASIN <b>HILLSDALE LAKE</b> BIG BULL CREEK TEST DATA SUMMARY COMPACTED EMBANKMENT MATERIAL "Q", "R" AND ATTERBERG LIMIT TESTS		
In 80 sheets CORPS OF ENGINEERS KANSAS CITY DISTRICT	Submitted by RKB	Checked by PST-CPW	Scale as shown U.S. ARMY MARCH 1971
	Recommended by RFB	Checked by RFD	DM-*
			FILE NO 0-15-188

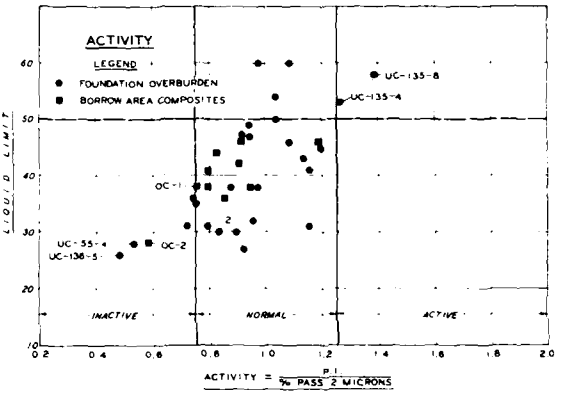
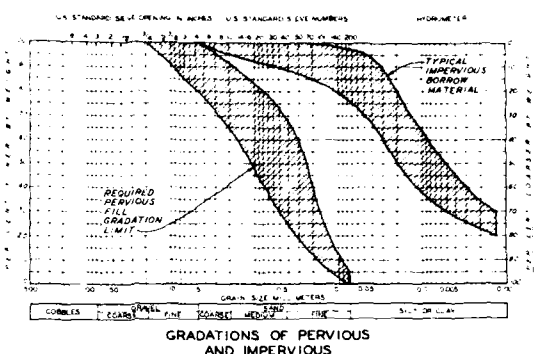
PLATE NO 47

DATA ON COMPOSITE SAMPLES  
COMPACTED EMBANKMENT MATERIAL

COMPOSITE NO.	HOLE NO.	SAMPLE DEPTH	CLASSIFICATION				DRY DENSITY		WATER CONTENT			100 TEST		200 TEST		REMARKS
			SYM	L.L.	P.L.	P.I.	MAX	AT TEST INITIAL	DPT	AT TEST INITIAL	PERCENT SATURATION	TAN $\phi$	C	TAN $\phi$	C	
101	1187	11.0	42	55	27		121.0	10.5	121.0	10.5						
102	1187	12.0	44	57	27		121.5	10.5	121.5	10.5						
103	1187	13.0	46	59	27		122.0	10.5	122.0	10.5						
104	1187	14.0	48	61	27		122.5	10.5	122.5	10.5						
105	1187	15.0	50	63	27		123.0	10.5	123.0	10.5						
106	1187	16.0	52	65	27		123.5	10.5	123.5	10.5						
107	1187	17.0	54	67	27		124.0	10.5	124.0	10.5						
108	1187	18.0	56	69	27		124.5	10.5	124.5	10.5						
109	1187	19.0	58	71	27		125.0	10.5	125.0	10.5						
110	1187	20.0	60	73	27		125.5	10.5	125.5	10.5						
111	1187	21.0	62	75	27		126.0	10.5	126.0	10.5						
112	1187	22.0	64	77	27		126.5	10.5	126.5	10.5						
113	1187	23.0	66	79	27		127.0	10.5	127.0	10.5						
114	1187	24.0	68	81	27		127.5	10.5	127.5	10.5						
115	1187	25.0	70	83	27		128.0	10.5	128.0	10.5						
116	1187	26.0	72	85	27		128.5	10.5	128.5	10.5						
117	1187	27.0	74	87	27		129.0	10.5	129.0	10.5						
118	1187	28.0	76	89	27		129.5	10.5	129.5	10.5						
119	1187	29.0	78	91	27		130.0	10.5	130.0	10.5						
120	1187	30.0	80	93	27		130.5	10.5	130.5	10.5						
121	1187	31.0	82	95	27		131.0	10.5	131.0	10.5						
122	1187	32.0	84	97	27		131.5	10.5	131.5	10.5						
123	1187	33.0	86	99	27		132.0	10.5	132.0	10.5						
124	1187	34.0	88	101	27		132.5	10.5	132.5	10.5						
125	1187	35.0	90	103	27		133.0	10.5	133.0	10.5						
126	1187	36.0	92	105	27		133.5	10.5	133.5	10.5						
127	1187	37.0	94	107	27		134.0	10.5	134.0	10.5						
128	1187	38.0	96	109	27		134.5	10.5	134.5	10.5						
129	1187	39.0	98	111	27		135.0	10.5	135.0	10.5						
130	1187	40.0	100	113	27		135.5	10.5	135.5	10.5						
131	1187	41.0	102	115	27		136.0	10.5	136.0	10.5						
132	1187	42.0	104	117	27		136.5	10.5	136.5	10.5						
133	1187	43.0	106	119	27		137.0	10.5	137.0	10.5						
134	1187	44.0	108	121	27		137.5	10.5	137.5	10.5						
135	1187	45.0	110	123	27		138.0	10.5	138.0	10.5						
136	1187	46.0	112	125	27		138.5	10.5	138.5	10.5						
137	1187	47.0	114	127	27		139.0	10.5	139.0	10.5						
138	1187	48.0	116	129	27		139.5	10.5	139.5	10.5						
139	1187	49.0	118	131	27		140.0	10.5	140.0	10.5						
140	1187	50.0	120	133	27		140.5	10.5	140.5	10.5						
141	1187	51.0	122	135	27		141.0	10.5	141.0	10.5						
142	1187	52.0	124	137	27		141.5	10.5	141.5	10.5						
143	1187	53.0	126	139	27		142.0	10.5	142.0	10.5						
144	1187	54.0	128	141	27		142.5	10.5	142.5	10.5						
145	1187	55.0	130	143	27		143.0	10.5	143.0	10.5						
146	1187	56.0	132	145	27		143.5	10.5	143.5	10.5						
147	1187	57.0	134	147	27		144.0	10.5	144.0	10.5						
148	1187	58.0	136	149	27		144.5	10.5	144.5	10.5						
149	1187	59.0	138	151	27		145.0	10.5	145.0	10.5						
150	1187	60.0	140	153	27		145.5	10.5	145.5	10.5						

**SAMPLES  
AT MATERIAL**

NO.	"U" TEST		"R" TEST		"S" TEST		LOCATION
	TAN	C	TAN	C	TAN	C	
PERCENT SATURATION	#	T.S.F.	D	T.S.F.	#	T.S.F.	
1							WATER HOLLOW
2							WATER HOLLOW
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44							WATER HOLLOW
45							WATER HOLLOW
46							WATER HOLLOW
47							WATER HOLLOW
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49							WATER HOLLOW
50							WATER HOLLOW
51							WATER HOLLOW
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78							WATER HOLLOW
79							WATER HOLLOW
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88							WATER HOLLOW
89							WATER HOLLOW
90							WATER HOLLOW
91							WATER HOLLOW
92							WATER HOLLOW
93							WATER HOLLOW
94							WATER HOLLOW
95							WATER HOLLOW
96							WATER HOLLOW
97							WATER HOLLOW
98							WATER HOLLOW
99							WATER HOLLOW
100							WATER HOLLOW



DESCRIPTION  
REVISIONS

OSAGE RIVER BASIN  
**HILLSDALE LAKE**  
BIG BULL CREEK

TEST DATA SUMMARY  
COMPACTED EMBANKMENT MATERIAL  
ACTIVITY, GRADATIONS AND TABULATED DATA

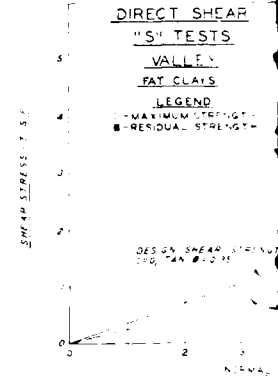
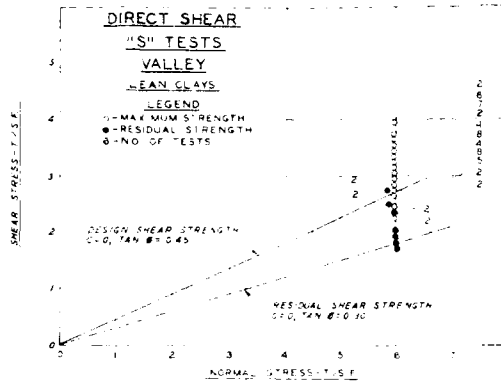
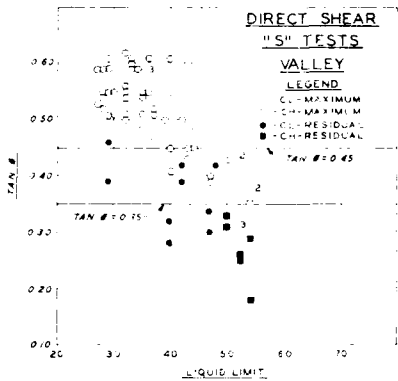
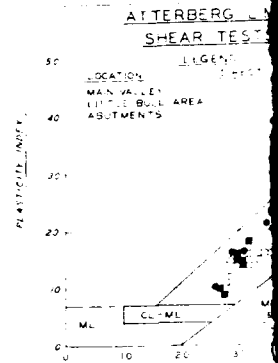
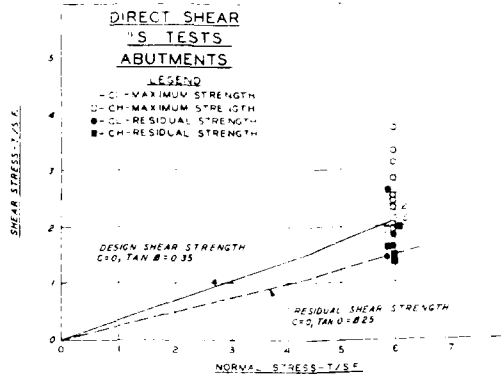
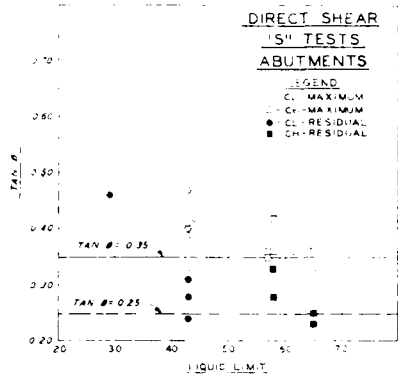
In 60 sheets Sheet No. 3 Scale as shown  
U.S. ARMY  
KANSAS DISTRICT  
MARCH 1971

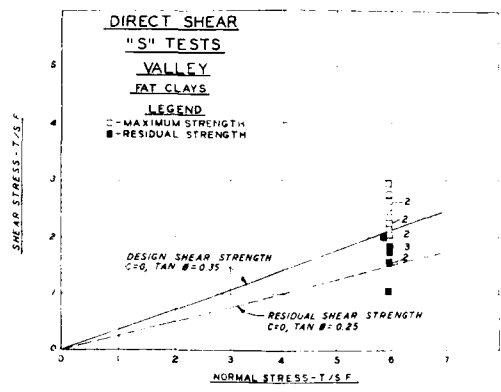
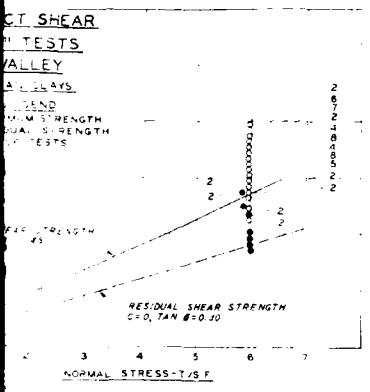
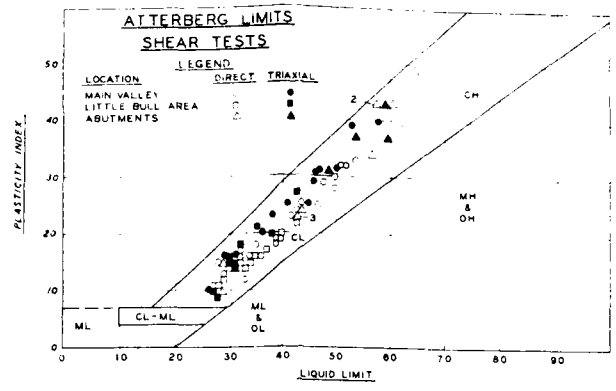
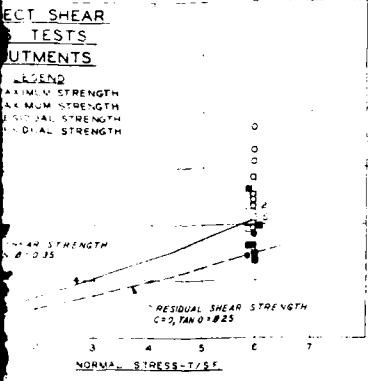
Submitted: \_\_\_\_\_ Recommended: \_\_\_\_\_ Approved: \_\_\_\_\_

Checked: \_\_\_\_\_

RKB PST PWB RFD DM-T O-15-187

PLATE NO. 49





Note:  
 This data is for design purposes only and should not be used for foundation design.

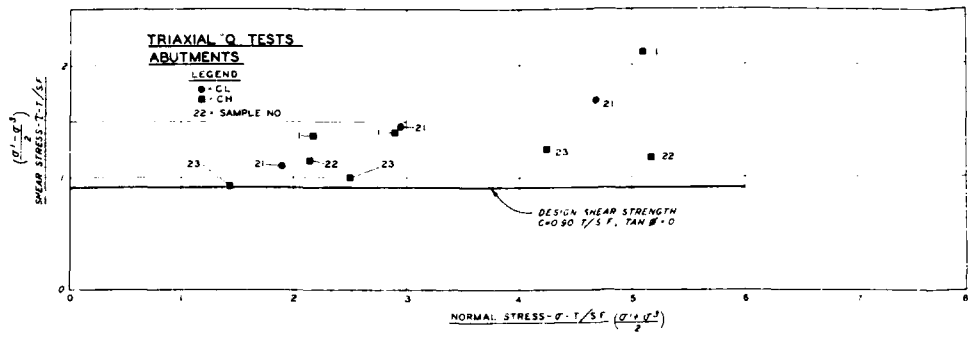
DESCRIPTION: USAGE RIV. R. BASIN  
**HILLSDALE LAKE**  
 BIG BULL CREEK

TEST DATA SUMMARY  
 FOUNDATION OVERBURDEN  
 "S" AND ATTERBERG LIMIT TESTS

In 60 sheets. Sheet No. 4. Scale as shown.

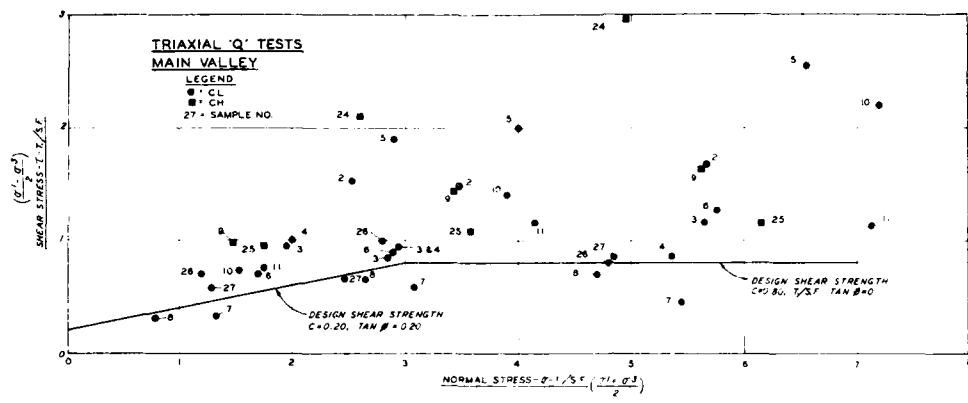
ENGINEERS: R.K.B. J.A.M. R.F.D. DM-7 O-15-188

DATE: MARCH 1971



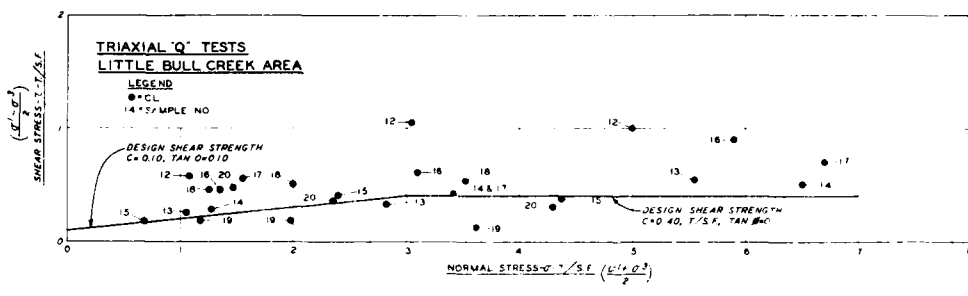
### Q TEST DATA ABUTMENTS

SAMPLE NO.	DEPTH	CLASSIFICATION	RANGE OF STRESS
1			
2			
3			
4			
5			
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21			
22			
23			



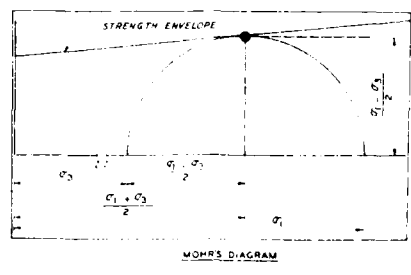
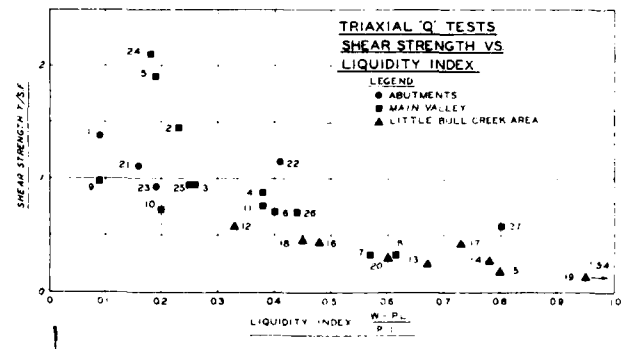
### Q TEST DATA MAIN VALLEY

SAMPLE NO.	DEPTH	CLASSIFICATION	RANGE OF STRESS
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
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16			
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24			
25			
26			
27			



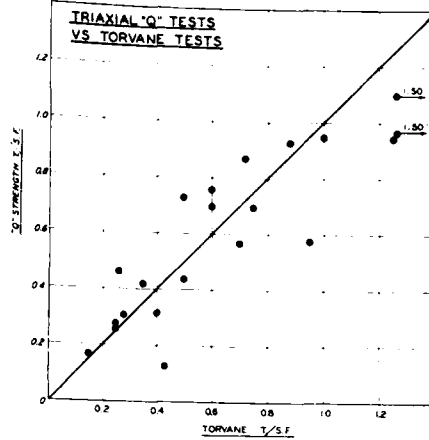
### Q TEST DATA LITTLE BULL CREEK AREA

SAMPLE NO.	DEPTH	CLASSIFICATION	RANGE OF STRESS
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

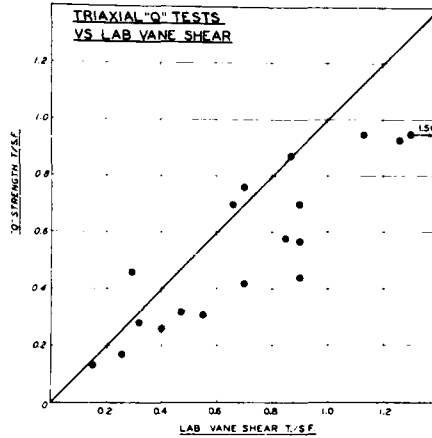




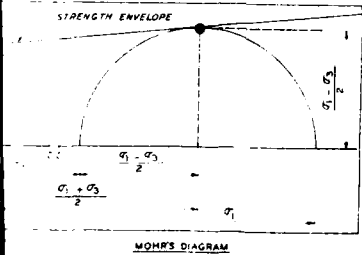
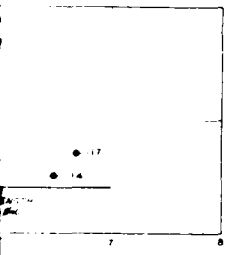
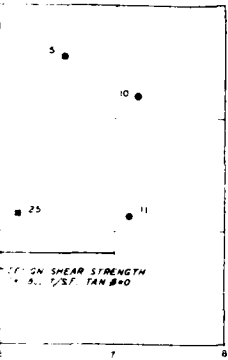
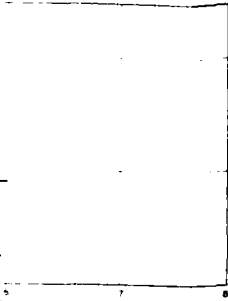
"Q" TEST DATA ABUTMENTS								
SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION			RANGE OF INITIAL CONDITIONS		
			SW	LL	PI	DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
1	1	1.0	10	20	15	100	10	100
2	1	2.0	10	20	15	100	10	100
3	1	3.0	10	20	15	100	10	100
4	1	4.0	10	20	15	100	10	100
5	1	5.0	10	20	15	100	10	100
6	1	6.0	10	20	15	100	10	100
7	1	7.0	10	20	15	100	10	100
8	1	8.0	10	20	15	100	10	100
9	1	9.0	10	20	15	100	10	100
10	1	10.0	10	20	15	100	10	100



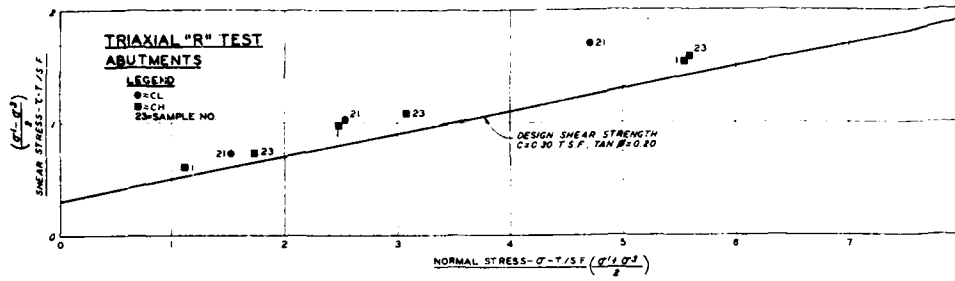
"Q" TEST DATA MAIN VALLEY								
SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION			RANGE OF INITIAL CONDITIONS		
			SW	LL	PI	DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
1	1	1.0	10	20	15	100	10	100
2	1	2.0	10	20	15	100	10	100
3	1	3.0	10	20	15	100	10	100
4	1	4.0	10	20	15	100	10	100
5	1	5.0	10	20	15	100	10	100
6	1	6.0	10	20	15	100	10	100
7	1	7.0	10	20	15	100	10	100
8	1	8.0	10	20	15	100	10	100
9	1	9.0	10	20	15	100	10	100
10	1	10.0	10	20	15	100	10	100



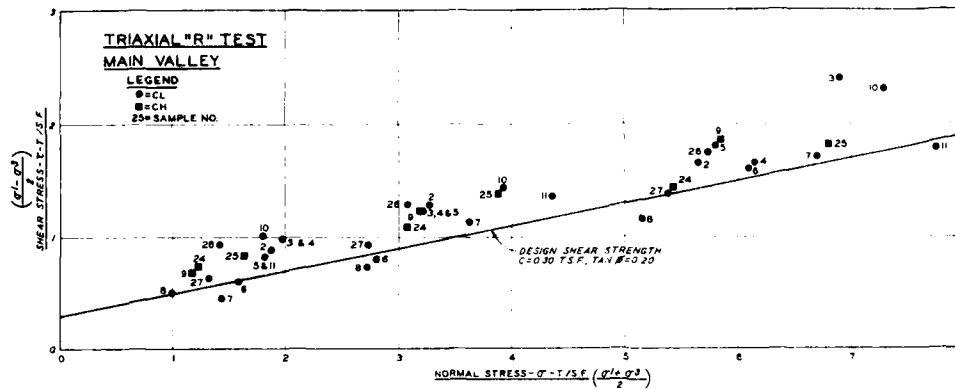
"Q" TEST DATA LITTLE BULL CREEK AREA								
SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION			RANGE OF INITIAL CONDITIONS		
			SW	LL	PI	DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
1	1	1.0	10	20	15	100	10	100
2	1	2.0	10	20	15	100	10	100
3	1	3.0	10	20	15	100	10	100
4	1	4.0	10	20	15	100	10	100
5	1	5.0	10	20	15	100	10	100
6	1	6.0	10	20	15	100	10	100
7	1	7.0	10	20	15	100	10	100
8	1	8.0	10	20	15	100	10	100
9	1	9.0	10	20	15	100	10	100
10	1	10.0	10	20	15	100	10	100



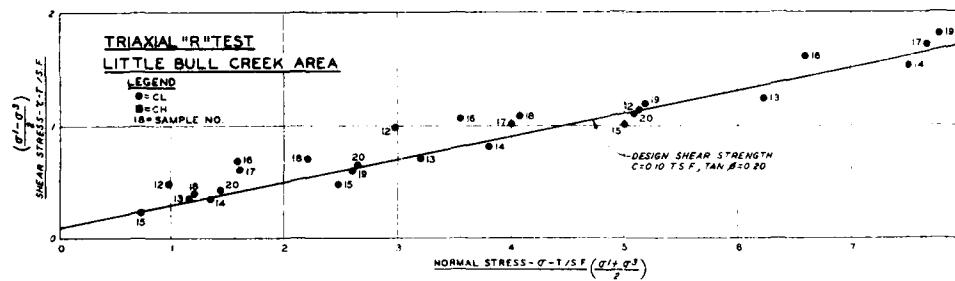
SYMBOL: \_\_\_\_\_ DESCRIPTION: OSAGE RIVER BASIN  
 REVISIONS: \_\_\_\_\_ DATE: \_\_\_\_\_ APP'D: \_\_\_\_\_  
**HILLSDALE LAKE**  
 BIG BULL CREEK  
 TEST DATA SUMMARY  
 FOUNDATION OVERBURDEN  
 "Q" TESTS  
 Sheet No 5  
 Scale as shown  
 U. S. ARMY  
 MARCH 1971  
 In 60 sheets  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 Submitted by: \_\_\_\_\_ Recommended by: *R. D. Radtke*  
 Checked by: RKB P.S.T. Reviewed by: RFD  
 DRAWING NUMBER: DM-7  
 O-15-188  
 PLATE NO 50



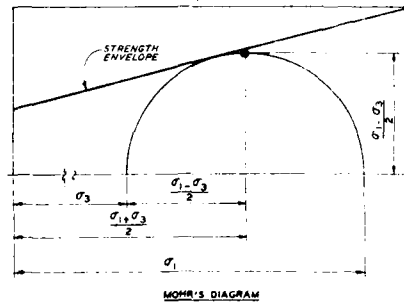
SYMBOL	HOLE NUMBER	SAMPLE DEPTH
21	05-18	4.0' - 9"
22	05-19	8.7' - 9"
23	05-07	4.0' - 9"

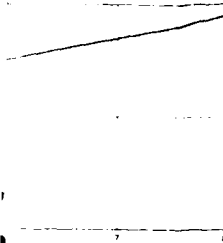


SYMBOL	HOLE NUMBER	SAMPLE DEPTH
10	05-11	2.0' - 9"
11	05-11	15.0' - 9"
24	05-11	18.0' - 9"
25	05-11	9.0' - 9"
26	05-11	12.0' - 9"
27	05-11	12.0' - 9"
28	05-11	12.0' - 9"
10	05-12	1.0' - 9"
11	05-12	15.0' - 9"
24	05-12	18.0' - 9"
25	05-12	9.0' - 9"
26	05-12	12.0' - 9"
27	05-12	12.0' - 9"
28	05-12	12.0' - 9"
10	05-13	1.0' - 9"
11	05-13	15.0' - 9"
24	05-13	18.0' - 9"
25	05-13	9.0' - 9"
26	05-13	12.0' - 9"
27	05-13	12.0' - 9"
28	05-13	12.0' - 9"



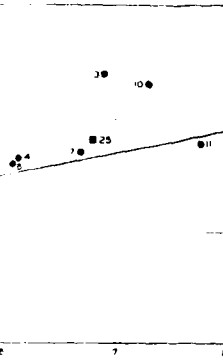
SYMBOL	HOLE NUMBER	SAMPLE DEPTH
12	05-14	1.0' - 9"
13	05-14	1.0' - 9"
14	05-14	1.0' - 9"
15	05-14	1.0' - 9"
16	05-14	1.0' - 9"
17	05-14	1.0' - 9"
18	05-14	1.0' - 9"
19	05-14	1.0' - 9"
20	05-14	1.0' - 9"





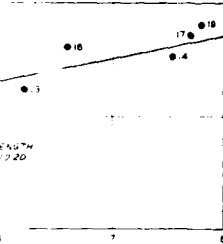
"R" TEST DATA  
ADJUTANTS

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION			RANGE OF INITIAL CONDITIONS			
			SYM	LL	PL	P	DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
1	UC-49	7.5-8.3	CH	60	17	43	98.1-100.8	22.7-25.0	89-93
21	UC-58	4.0-5.9	CL	49	18	31	99.1-99.5	23.9-24.5	96-98
22	UC-59	8.7-9.3	CH	60	23	37			
23	UC-61	4.0-5.9	CH	54	17	37	99.2-99.3	25.4-25.6	99-100



"R" TEST DATA  
MAIN VALLEY

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION			RANGE OF INITIAL CONDITIONS			
			SYM	LL	PL	P	DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
2	UC-51	7.0-8.4	CL	47	16	31	99.9-101.6	22.3-22.8	89-93
3	UC-51	15.0-8.4	CL	41	16	25	100.2-100.7	24.0-24.2	96-97
4	UC-51	19.0-21.9	CL	35	14	21	104.6-106.3	21.1-21.6	95-97
5	UC-52	9.0-10.9	CL	47	16	31	100.0-101.2	21.9-22.7	91
6	UC-52	17.0-18.9	CL	36	16	20	96.0-98.3	23.7-25.4	91-93
7	UC-52	21.0-22.9	CL	38	15	23	92.7-96.4	27.2-28.5	96-100
8	UC-53	10.0-11.9	CL	31	16	15	94.2-95.3	26.4-26.6	93-95
9	UC-54	7.0-8.9	CH	50	19	31	97.1-97.4	24.3-24.6	92-94
10	UC-54	13.0-14.9	CL	45	20	25	95.6-97.9	25.4-25.9	92-95
11	UC-54	21.0-22.9	CL	46	17	29	93.0-93.7	27.4-27.8	93-96
24	UC-135	6.3-8.4	CH	53	14	39	98.8-102.3	20.2-21.7	85-88
25	UC-135	14.5-16.4	CH	58	18	40	93.9-95.7	28.1-28.5	99
26	UC-136	5.7-7.9	CL	50	14	16	124.2-105.6	21.4-21.9	93-96
27	UC-136	10.0-11.9	CL	26	16	10	101.2-101.5	23.1-23.9	98-100



"R" TEST DATA  
LITTLE BULL CREEK AREA

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	CLASSIFICATION			RANGE OF INITIAL CONDITIONS			
			SYM	LL	PL	P	DRY DENSITY	PERCENT MOISTURE	PERCENT SATURATION
12	UC-55	7.0-8.9	CL	28	19	9	97.0-100.5	23.9-23.1	89-90
13	UC-55	13.0-14.9	CL	30	15	5	94.7-95.5	25.9-25.6	89
14	UC-55	21.0-22.9	CL	15	14	18	91.5-92.6	28.0-28.3	93-95
15	UC-56	7.0-10.4	CL	37	16	15	90.2-90.4	27.1-27.6	86-87
16	UC-56	17.0-18.9	CL	42	16	27	92.8-93.1	27.1-28.3	89-91
17	UC-56	21.0-22.9	CL	35	15	15	93.2-95.5	26.8-28.6	96
18	UC-57	2.0-5.4	CL	38	18	20	91.4-92.3	28.2-28.6	94-96
19	UC-57	11.0-13.9	CL	27	16	11	87.4-93.1	31.3-34.1	100
20	UC-57	15.0-15.9	CL	37	16	15	93.2-94.3	29.0-30.0	100

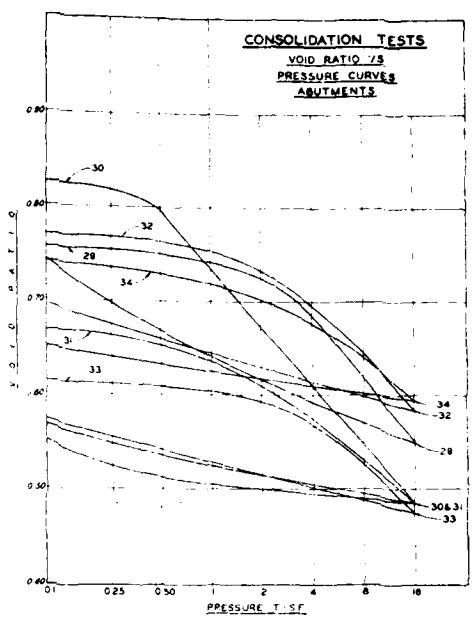
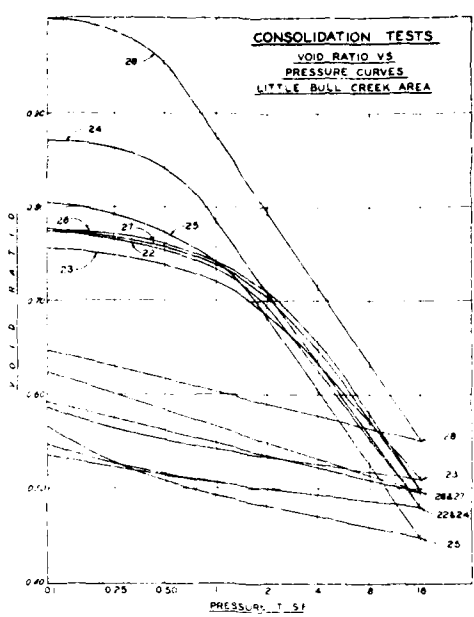
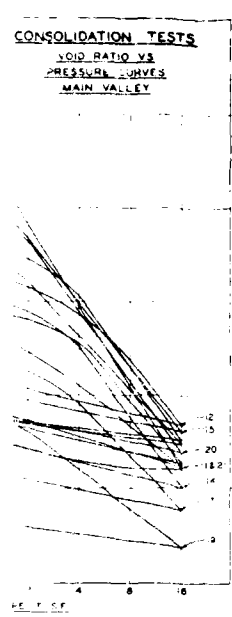
SYM	DESCRIPTION	DATE	APPD.
	REVISIONS		

OSAGE RIVER BASIN  
**HILLSDALE LAKE**  
BIG BULL CREEK  
TEST DATA SUMMARY  
FOUNDATION OVERBURDEN  
"R" TESTS

In 60 sheets  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT  
Submitted  
Checked  
Compiled by  
R. H. B.

Sheet No. 6  
Scale: as shown  
U. S. ARMY  
MARCH 1971  
Reviewed by  
Checked  
Ordered by  
R. F. D.  
DW-7  
FILE NO.  
0-15-190





### CONSOLIDATION TEST DATA

MAIN VALLEY

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	LL	P <sub>u</sub>	E	E <sub>s</sub>	C <sub>c</sub>	C <sub>u</sub>	C <sub>v</sub> (IN <sup>2</sup> /MIN)		
									A	B	T
12	12	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
14	14	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
16	16	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
18	18	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
20	20	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
22	22	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
24	24	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
26	26	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05

### CONSOLIDATION TEST DATA

LITTLE BULL CREEK AREA

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	LL	P <sub>u</sub>	E	E <sub>s</sub>	C <sub>c</sub>	C <sub>u</sub>	C <sub>v</sub> (IN <sup>2</sup> /MIN)		
									A	B	T
20	20	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
24	24	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
26	26	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
27	27	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
25	25	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
23	23	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
22	22	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
25	25	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05

### CONSOLIDATION TEST DATA

ABUTMENTS

SYMBOL	HOLE NUMBER	SAMPLE DEPTH	LL	P <sub>u</sub>	E	E <sub>s</sub>	C <sub>c</sub>	C <sub>u</sub>	C <sub>v</sub> (IN <sup>2</sup> /MIN)		
									A	B	T
30	30	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
32	32	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
28	28	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
34	34	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
31	31	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
33	33	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
34	34	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
32	32	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
28	28	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
30	30	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
31	31	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05
33	33	1.0	20.0	0.85	1.5	1.5	0.05	0.05	0.05	0.05	0.05

SYM	DESCRIPTION	DATE	APP'D.
	REVISIONS		

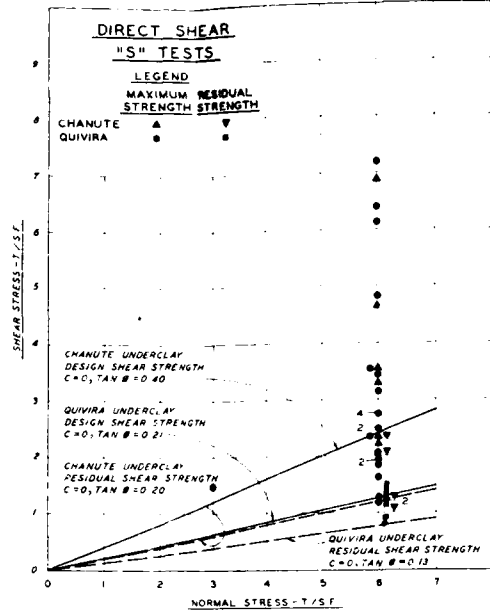
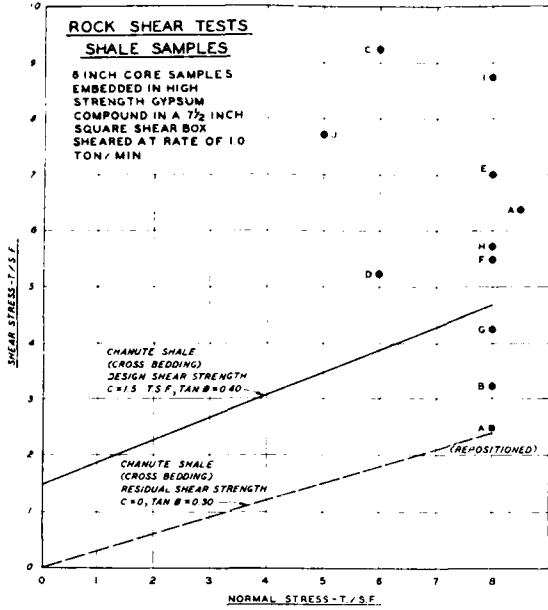
OSAGE RIVER BASIN  
**HILLSDALE LAKE**  
BIG BULL CREEK  
TEST DATA SUMMARY  
FOUNDATION OVERBURDEN  
CONSOLIDATION TESTS

In 60 sheets      Sheet No. 7      Scale: as shown  
CORPS OF ENGINEERS      U. S. ARMY  
KANSAS CITY DISTRICT      MARCH 1971

Submitted by: *AD*      Prepared by: *AD*  
Checked by: *AD*      Checked by: *AD*  
Compiled by: *AD*      Compiled by: *AD*  
R. K. B.      L. R. M.      R. F. D.

DM-1      0-15-101

PLATE NO 52



SYMBOL	SAMPLE NO	SAMPLE DEPTH	DRY DENSITY	MOISTURE	HORIZONTAL DEFORMATION AT FAILURE	GEOLOGIC MEMBER
A*	UC-50-3	19.2-20.5	93.5	17.5	0.017	Chanute Underclay
B	UC-59-1	23.3-24.8	131.0	10.5	0.014	Chanute
C	UC-59-2	26.7-28.1	132.5	13.0	0.034	Chanute
D	UC-59-2	26.7-28.1	134.0	8.0	0.030	Chanute
E	UC-59-5	41.6-43.1	119.5	14.5	0.016	Chanute Underclay
F	UC-59-6	43.1-44.8	122.5	13.0	0.027	Chanute
G	UC-59-7	47.5-49.2	139.9	8.0	0.009	Chanute
H	UC-59-9	62.3-63.8	138.0	8.5	0.015	Quivira
I	UC-92-2	37.8-39.0	127.0	14.5	0.050	Chanute
J	UC-92-3	41.0-42.4	132.0	17.0	0.052	Chanute

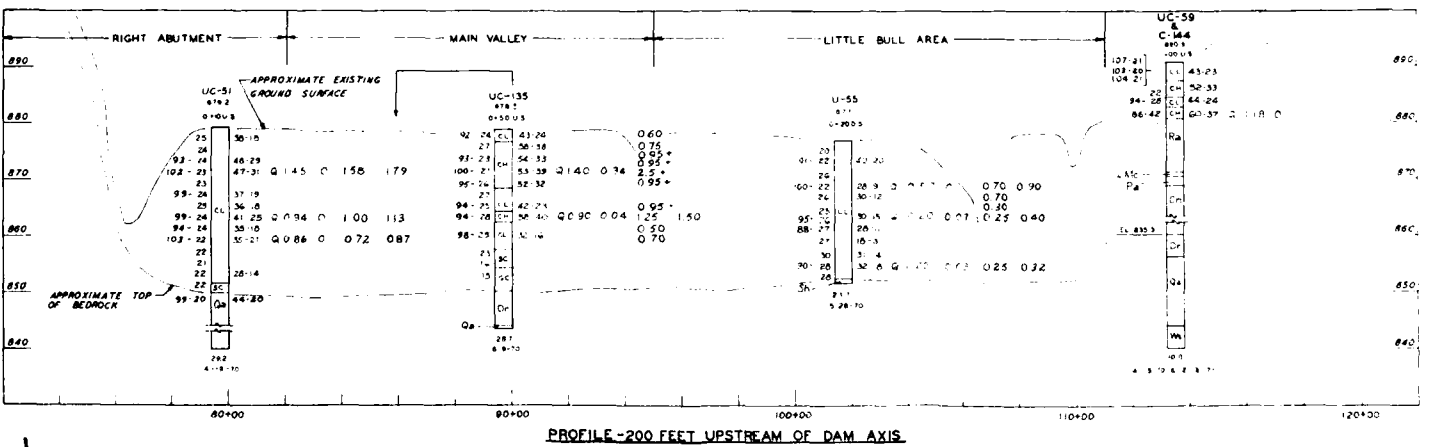
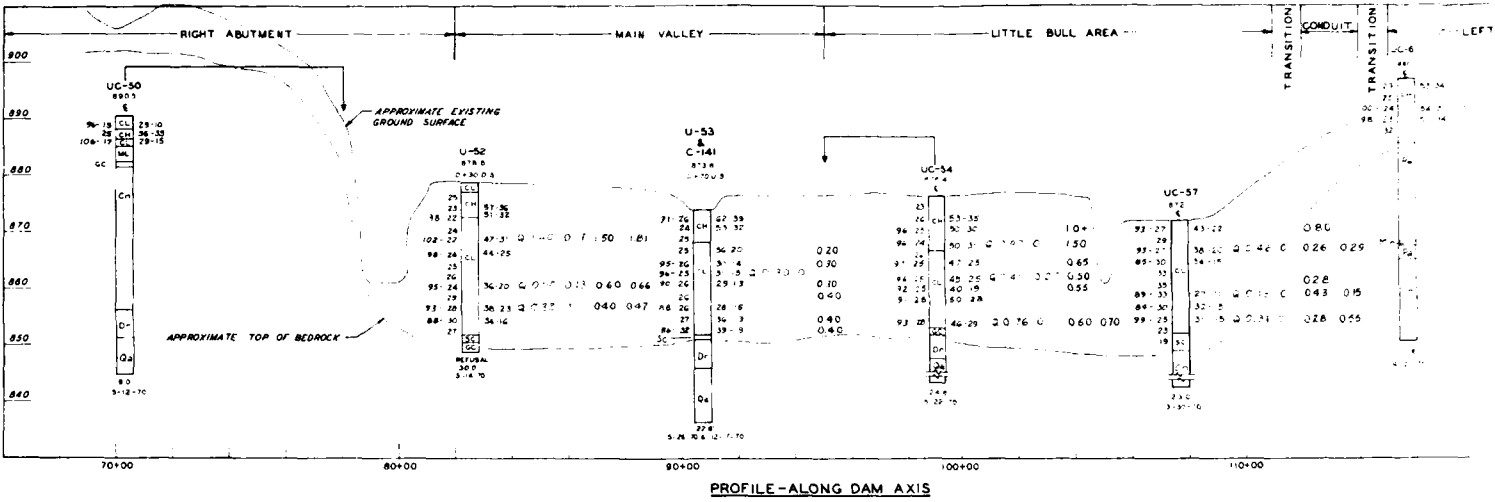
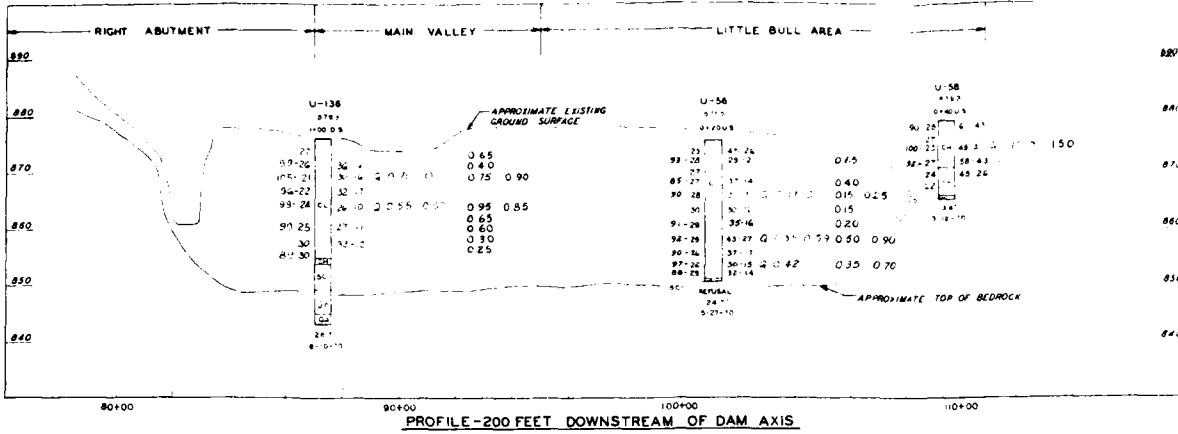
\* Note Hole No UC-50 located on right abutment of dam

HOLE NO	SAMPLE DEPTH	INITIAL CONDITIONS			GEOLOGIC MEMBER
		DRY DENSITY	MOISTURE CONTENT	SATURATION	
UC-50	19.2-20.5	93.5	17.5	74	Chanute
UC-59-1	23.3-24.8	131.0	10.5	100	Chanute
UC-59-2	26.7-28.1	132.5	13.0	63	Chanute
UC-59-2	26.7-28.1	134.0	8.0	51	Chanute
UC-59-5	41.6-43.1	119.5	14.5	85	Quivira
UC-59-6	43.1-44.8	122.5	13.0	100	Quivira
UC-59-7	47.5-49.2	139.9	8.0	82	Quivira
UC-59-9	62.3-63.8	138.0	8.5	97	Quivira
UC-92-2	37.8-39.0	127.0	14.5	96	Quivira
UC-92-3	41.0-42.4	132.0	17.0	75	Quivira
UC-40	26.0-26.3	117.0	14.0	85	Quivira
UC-41	26.7-28.8	116.0	11.0	100	Quivira
UC-42	27.1-28.6	115.0	9.5	82	Quivira
UC-43	28.1-29.3	114.0	9.5	78	Quivira
UC-44	31.3-32.0	113.0	7.0	97	Quivira
UC-45	32.0-32.5	112.0	6.0	96	Quivira
UC-46	34.9-35.9	111.0	9.0	75	Quivira
UC-47	34.9-35.4	110.0	8.0	75	Quivira
UC-48	37.2-37.9	109.0	2.0	10	Quivira
UC-49	37.2-37.9	109.0	16.5	89	Quivira
UC-50	34.0-34.9	125.0	15.0	99	Quivira
UC-51	34.9-35.3	125.0	13.5	99	Quivira
UC-43	36.0-36.7	115.0	7.0	99	Quivira
UC-43	33.1-33.2	114.0	15.5	34	Quivira
UC-44	37.3-37.4	113.0	11.5	100	Quivira
UC-44	37.4-37.5	113.0	11.0	100	Quivira
UC-44	39.5-40.3	114.0	10.0	95	Quivira

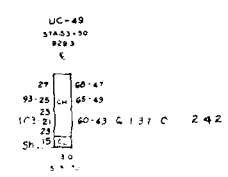
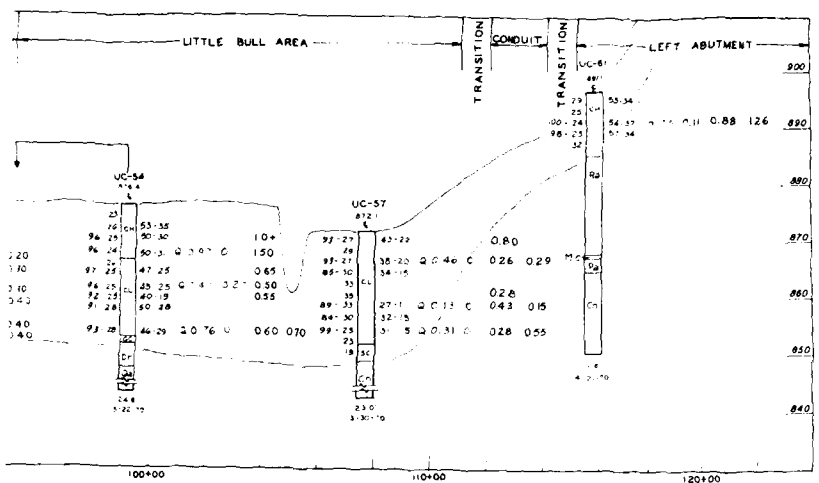
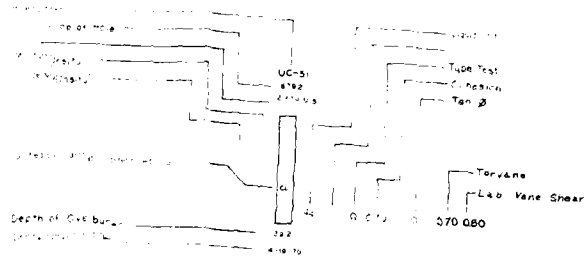
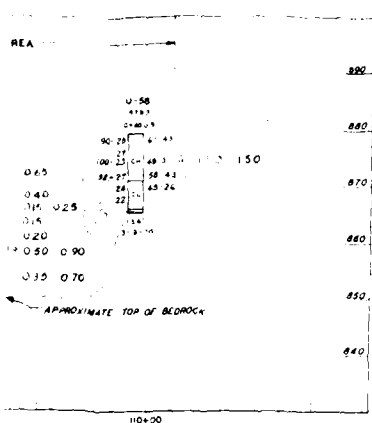
BEDROCK UNIT NAME	RESIDUAL SHEAR STRENGTH
Chanute Shale	0.20
Chanute Underclay	0.20
Quivira Underclay	0.13
Chanute Shale	0.30
Chanute Underclay	0.40
Quivira Underclay	0.20
Chanute Shale	0.30
Chanute Underclay	0.40
Quivira Underclay	0.13
Chanute Shale	0.30
Chanute Underclay	0.40
Quivira Underclay	0.13

\* Test procedure used for residual shear strength testing is based on ASTM D 5821-97 (1998) with modifications.

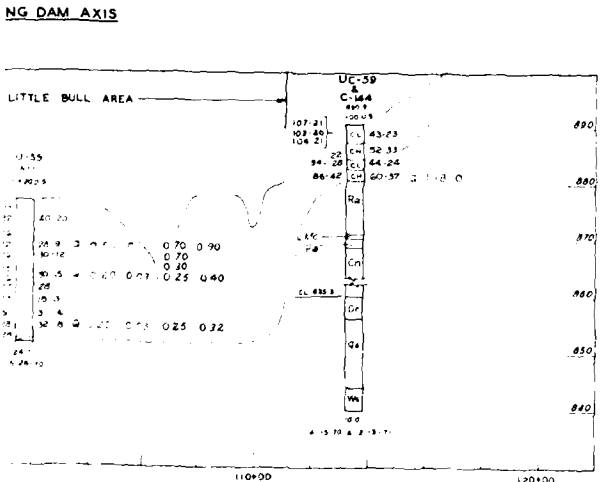








DETACHED BORING



DAM AXIS

DESCRIPTION REVISIONS DATE APP'D

OSAGE RIVER BASIN

**HILLSDALE LAKE**

BIG BULL CREEK

2 FOUNDATION STRENGTH PROFILES "Q" TESTS

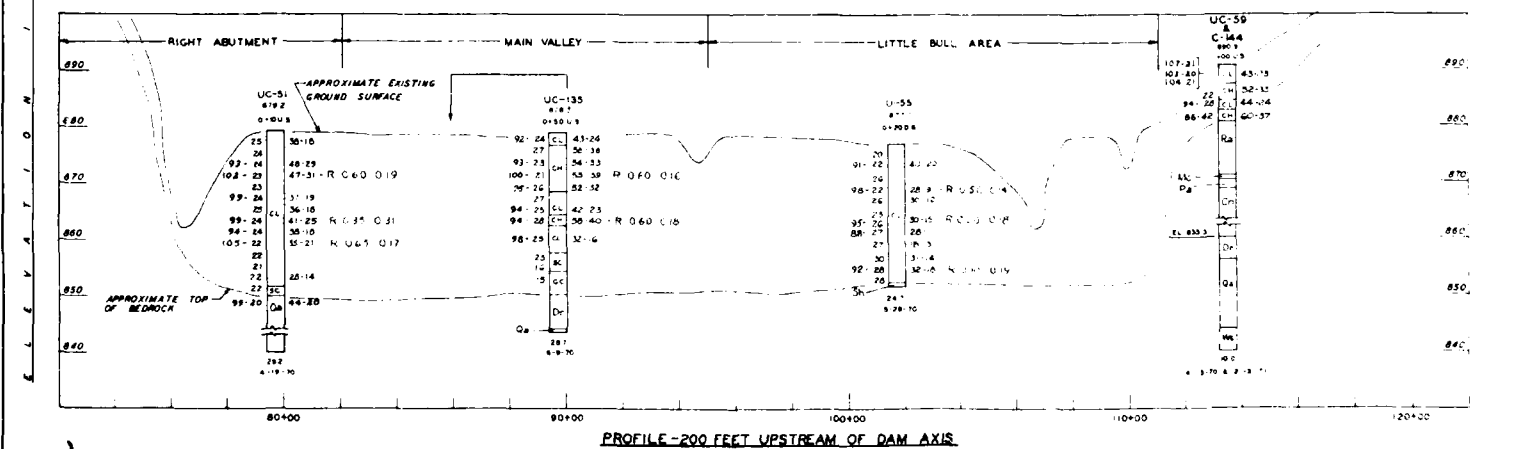
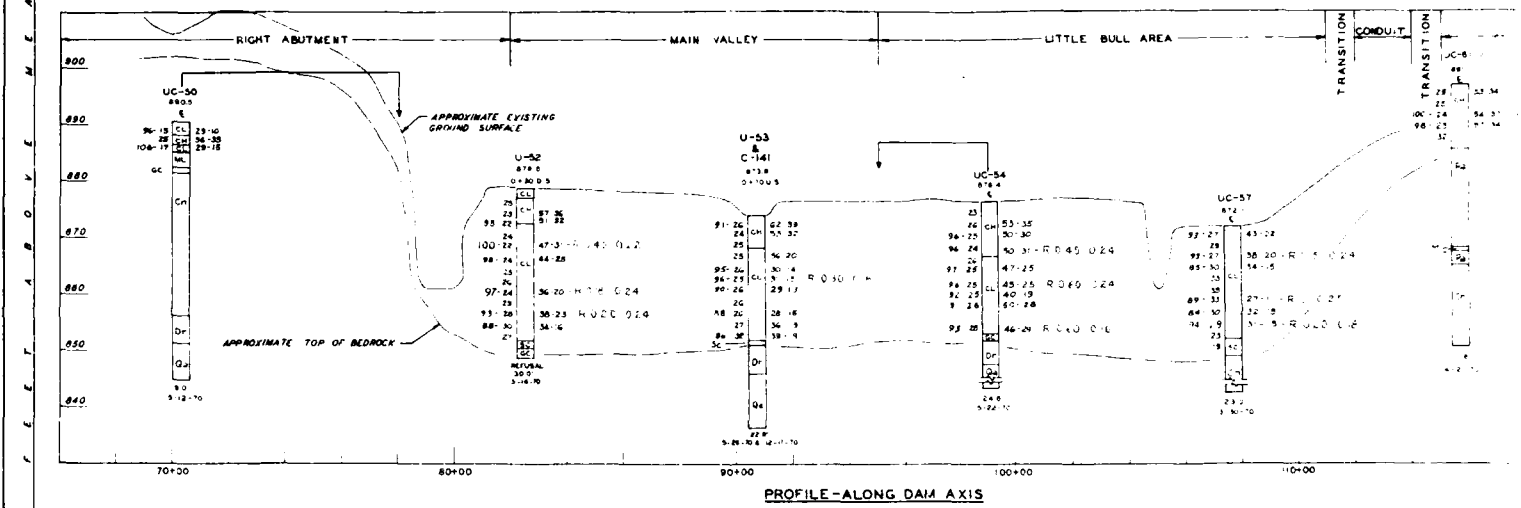
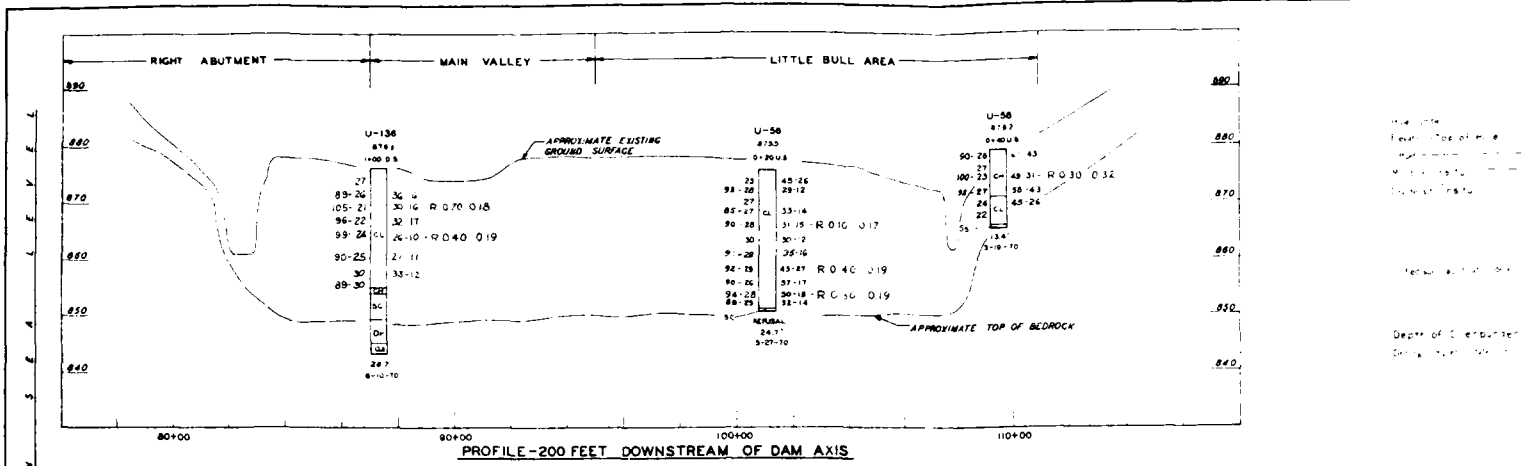
in 60 sheets Sheet No 9 Scale as shown U. S. ARMY MARCH 1971

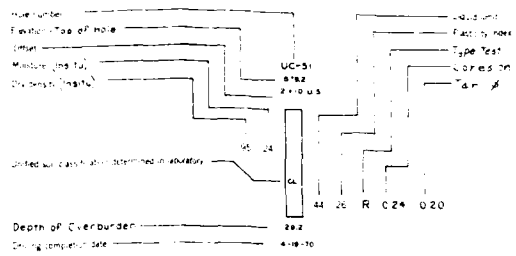
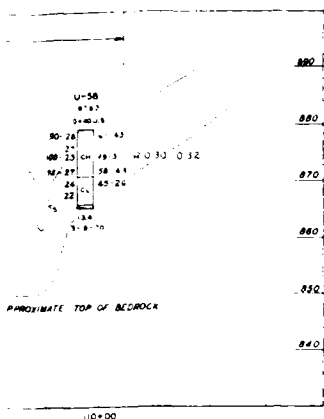
COMPS OF ENGINEERS KANSAS CITY DISTRICT

Submitted: [Signature] Recommended: [Signature] Approved: [Signature]

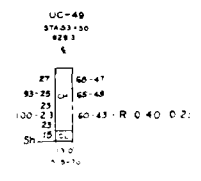
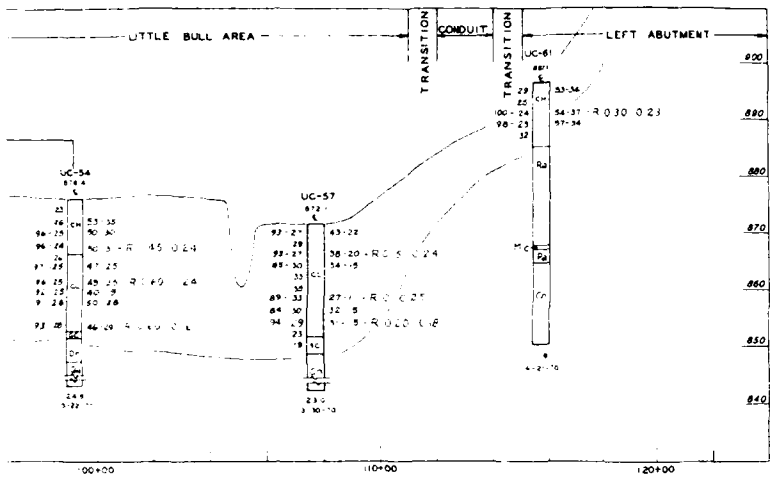
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PLATE NO 54

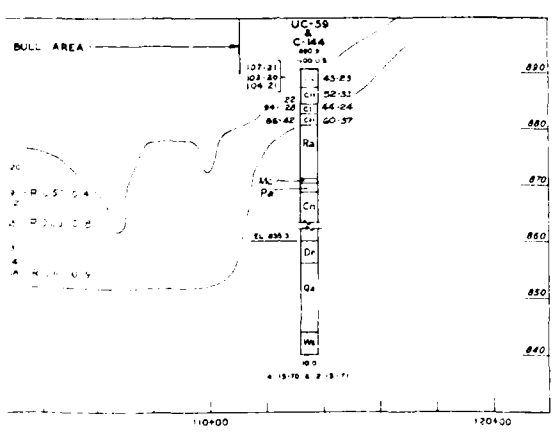




LEGEND



DETACHED BORING



DESCRIPTION  
REVISIONS  
DATE APR 0

OSAGE RIVER BASIN  
**HILLSDALE LAKE**  
BIG BULL CREEK

FOUNDATION STRENGTH PROFILES  
"R" TESTS

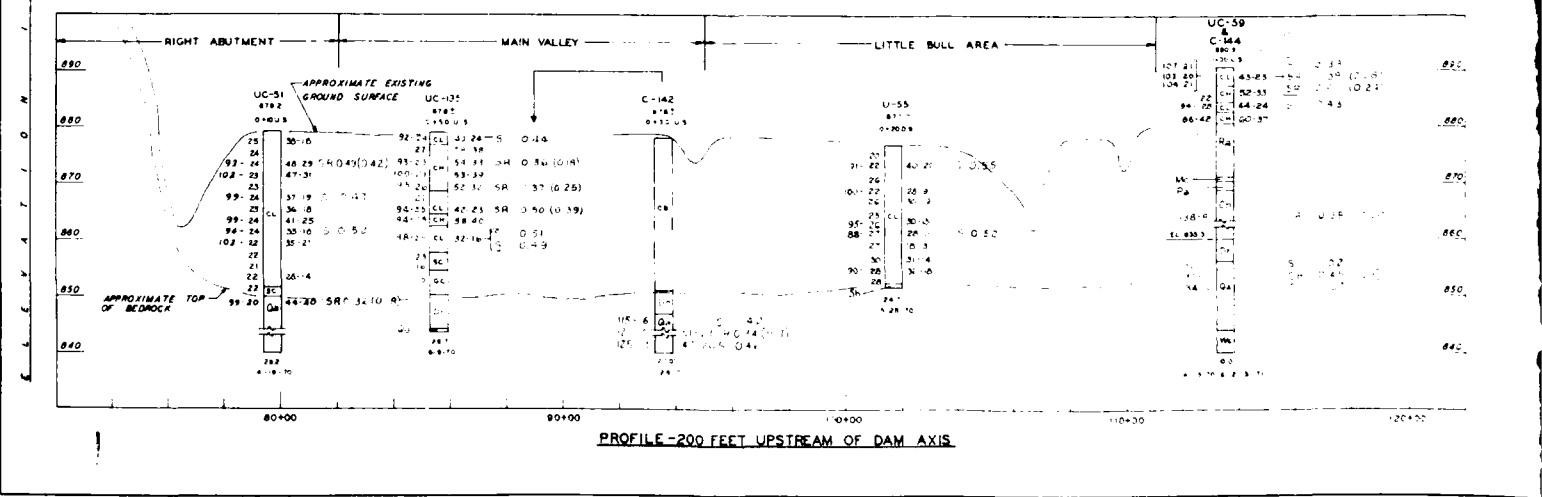
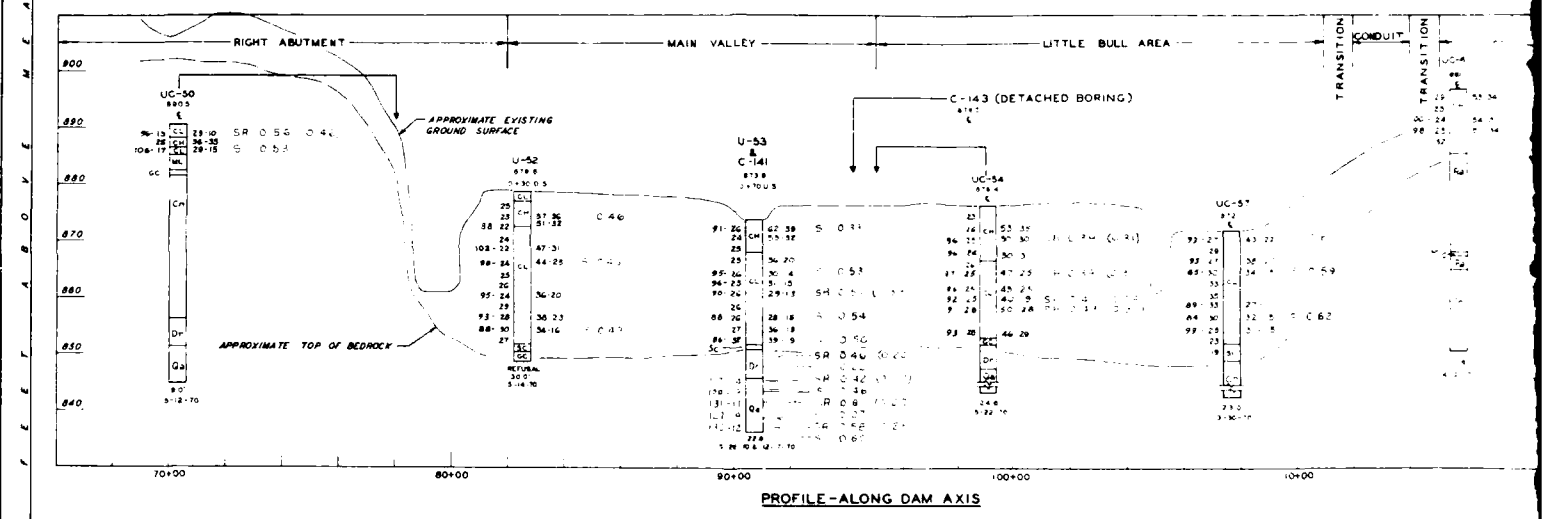
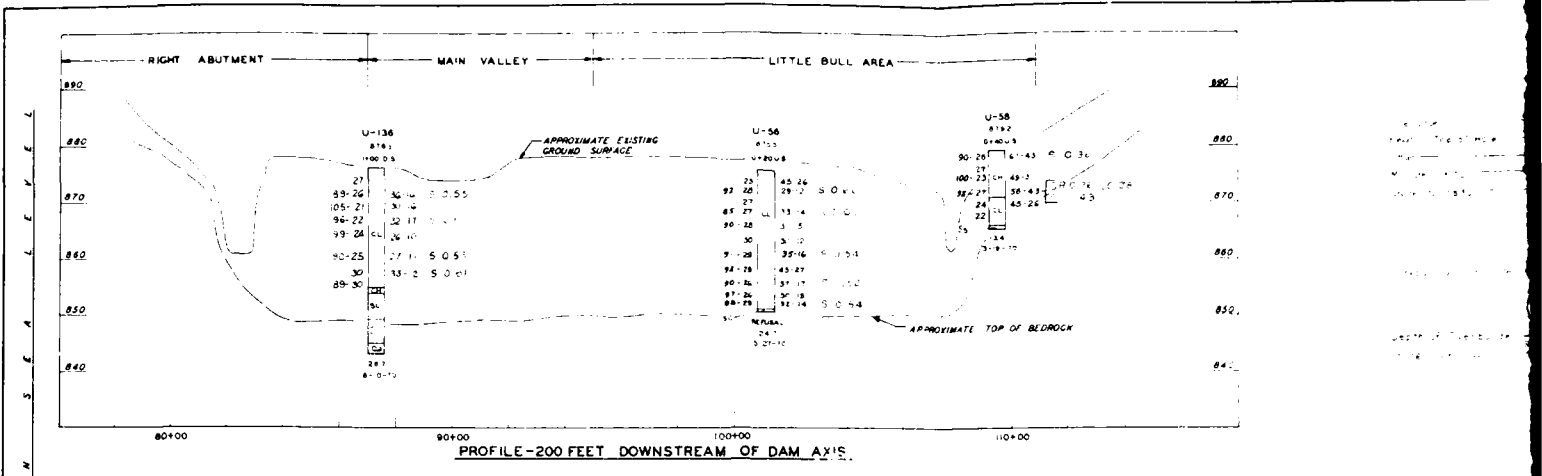
In 60 sheets  
ENGINEER  
KANSAS DISTRICT

Scale as shown  
S. ARMY  
MARCH 97

Sheet No 10

DM-7 0-15-194

PLATE NO 55



AD-A169 863

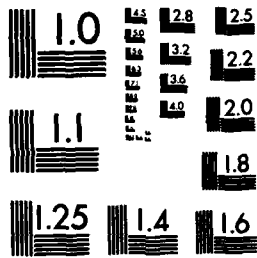
MULTIPLE-PURPOSE PROJECT OSAGE RIVER BASIN BIG BULL  
CREEK KANSAS HILLSDALE (U) CORPS OF ENGINEERS KANSAS  
CITY MO KANSAS CITY DISTRICT F C WALBERG ET AL. SEP 84  
F/G 1372

3/84

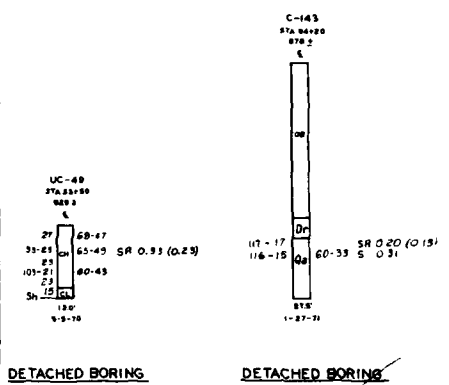
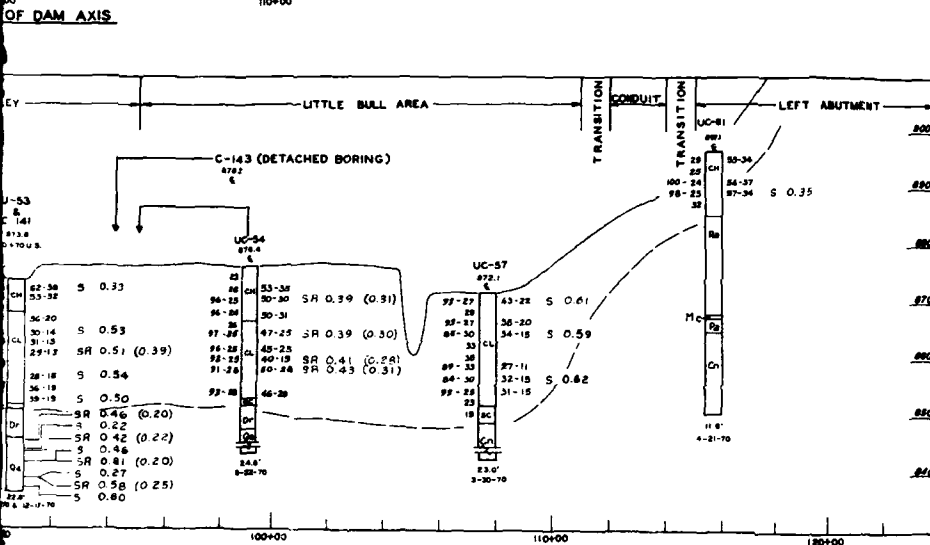
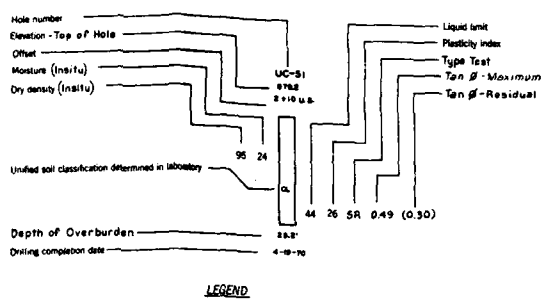
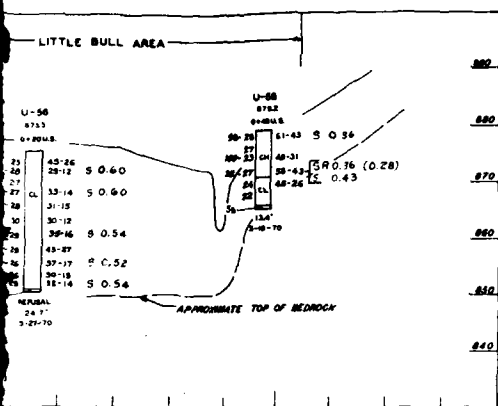
UNCLASSIFIED

NL

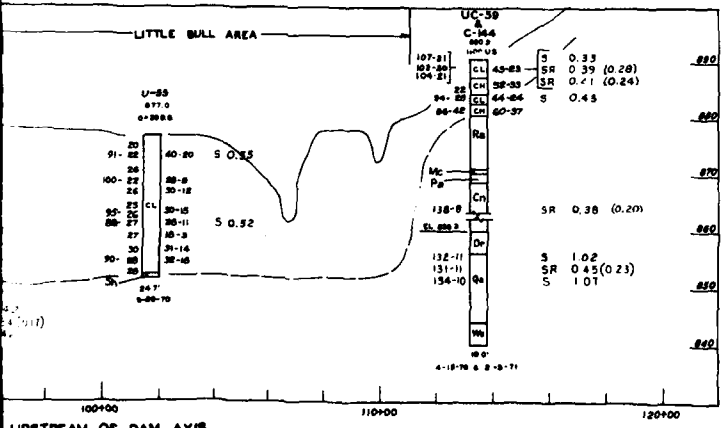




MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A



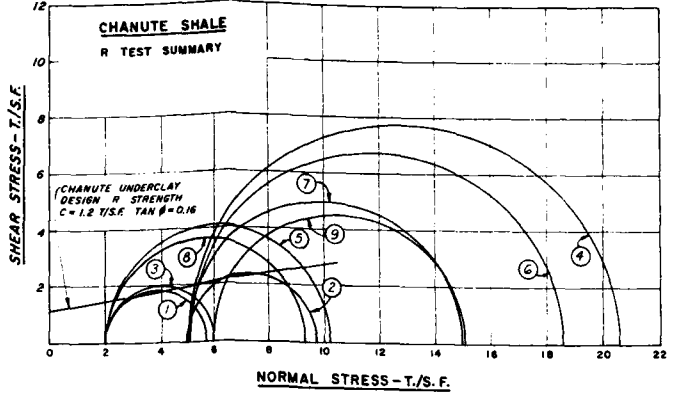
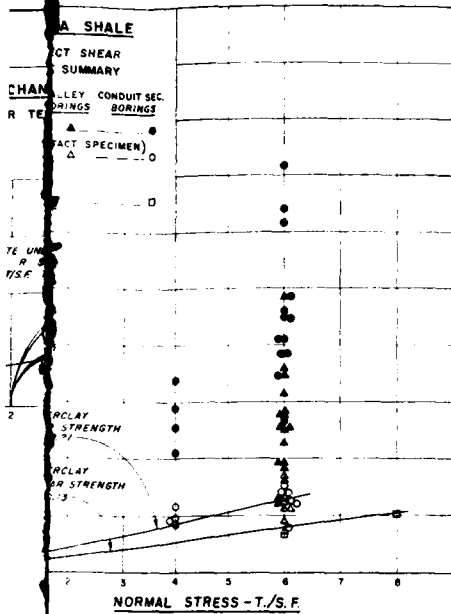
NOTE:  
Direct Shear tests run under normal strains to 0.50 inch are denoted by the symbol -S. Tests run at large strains to 2.5 or 3.0 inches are denoted by the symbol -SR.



SYMBOL	DESCRIPTION	DATE	APP'D.
	REVISIONS		
OSAGE RIVER BASIN			
<b>HILLSDALE LAKE</b>			
BIG BULL CREEK			
FOUNDATION STRENGTH PROFILES			
"S" TESTS			
In 60 sheets		Sheet No. 11	Scale as shown
CORPS OF ENGINEERS			U. S. ARMY
KANSAS CITY DISTRICT			MARCH 1971
Submitted by R. K. B.	Checked by J. A. M.	Reviewed by R. F. D.	Approved by DM-7
DESIGNED BY R. K. B.		DRAWN BY J. A. M.	
CHECKED BY R. F. D.		FILE NO. O-15-195	





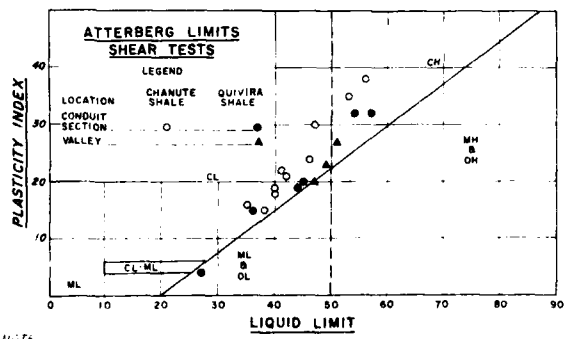


**CHANUTE SHALE R TEST SUMMARY**

TEST NO.	HOLE NO.	LOCATION	SAMPLE NO.	SAMPLE DEPTH	INITIAL CONDITIONS		
					DRY DENSITY	MOISTURE CONTENT	SATURATION
1	C-145	CONDUIT SEC	21 & 22	48.0	133.1	11.2	100
2					137.6	9.8	93
3	E-152	" "	1	48.0-50.0	121.0	13.5	93
4					124.9	13.9	100
5			3	52.5-54.7	117.1	10.9	65
6					124.2	11.7	85
7			6	58.2-60.5	128.4	10.4	84
8			7	60.5-62.7	142.9	7.1	97
9					145.5	6.8	92

**QUIVIRA SHALE TEST SUMMARY**

LOCATION	SAMPLE NO.	SAMPLE DEPTH	TYPE OF TEST	INITIAL CONDITIONS			NORMAL STRESS	PEAK TAN $\phi$	RESIDUAL TAN $\phi$	COMMENTS
				DRY DENSITY	MOISTURE CONTENT	% SATURATION				
VALLEY	15	29.0-30.2	DIRECT SHEAR	99.5	20.0	75	6.0	0.37	0.18	
	1	28.0-28.3	"	117.0	14.0	85	6.0	0.46	0.21	
	2	28.7-28.8	"	130.0	11.0	100	6.0	0.38		
VALLEY	2	29.7-29.8	"	130.0	9.5	82	6.0	0.22		SHEAR ON SOFT SEAM
	2	30.1-30.3	"	128.0	9.5	78	6.0	0.42	0.22	
	3	31.3-32.0	"	130.0	12.0	97	6.0	0.46		
VALLEY	5	34.9-35.3	"	131.0	11.0	96	6.0	0.81	0.18	
	6	37.2-37.3	"	127.0	9.0	75	6.0	0.27		SHEAR ON OPEN JOINT
	8	37.2-37.3	"	130.0	17.0	100	6.0	0.60	0.28	
VALLEY	2	31.2-31.9	"	115.0	16.5	89	6.0	0.43		
	2	34.0-34.3	"	110.0	15.0	89	3.0	0.50	0.24	
			"	120.0	15.0	95	6.0	0.34	0.16	
VALLEY	3	34.9-35.3	"	125.0	13.5	89	6.0	0.88		
		32.0-32.5	"	117.0	17.0	100	6.0	0.21	0.12	SHEAR ON SOFT SEAM
	2	31.2-35.5	"	116.0	15.5	96	6.0	0.31		
CONDUIT SEC.			"	116.0	15.3	94	6.0	0.37		
	3	33.9-34.7	"	114.0	14.5	79	6.0	0.42	0.20	
		57.3-57.4	"	132.0	11.5	100	6.0	1.03	0.23	
CONDUIT SEC.	1	57.4-57.5	"	131.0	11.0	100	6.0	0.45	0.23	
	3	59.5-60.3	"	134.0	10.0	95	6.0	1.20		
			"	135.0	9.0	92	6.0	1.07		
CONDUIT SEC.	28	54.7-56.1	"	133.5	11.0	100	6.0		0.11	PRE-SAWED SHEAR PLANE
			"	135.1	5.5	92	6.0	0.76		
			"	149.7	12.2	100	6.0	0.89	0.13	
CONDUIT SEC.	18	52.9-53.4	"	130.5	10.0	81	4.0	0.53	0.24	
			"	113.5	10.0	81	4.0	0.64	0.21	
			"	129.0	11.0	87	6.0	0.75	0.18	
CONDUIT SEC.	18	53.6-53.8	"	129.0	11.0	87	6.0	0.69	0.20	
			"	136.0	9.0	80	6.0	0.75	0.25	
			"	136.0	9.0	80	6.0	0.81	0.20	
CONDUIT SEC.	19	55.6-55.9	"	136.0	9.0	80	6.0	0.84	0.22	
			"	136.0	9.0	80	6.0	0.84	0.22	
			"	136.0	9.0	80	6.0	0.73	0.18	
CONDUIT SEC.	29	54.7-55.0	"	129.5	12.0	93	6.0	0.64		
			"	128.5	12.0	93	6.0	0.64		
			"	133.0	10.0	93	6.0	0.58		
CONDUIT SEC.	30	54.9-56.1	"	132.0	10.0	93	6.0	0.75		
			"	132.0	10.0	93	6.0	0.75		



NOTE: Test results shown on this plate include those presented in DM-7. Additional testing not supplemental to DM-7.

**HILLSDALE LAKE**  
TEST DATA SUMMARY  
FOUNDATION SHALES

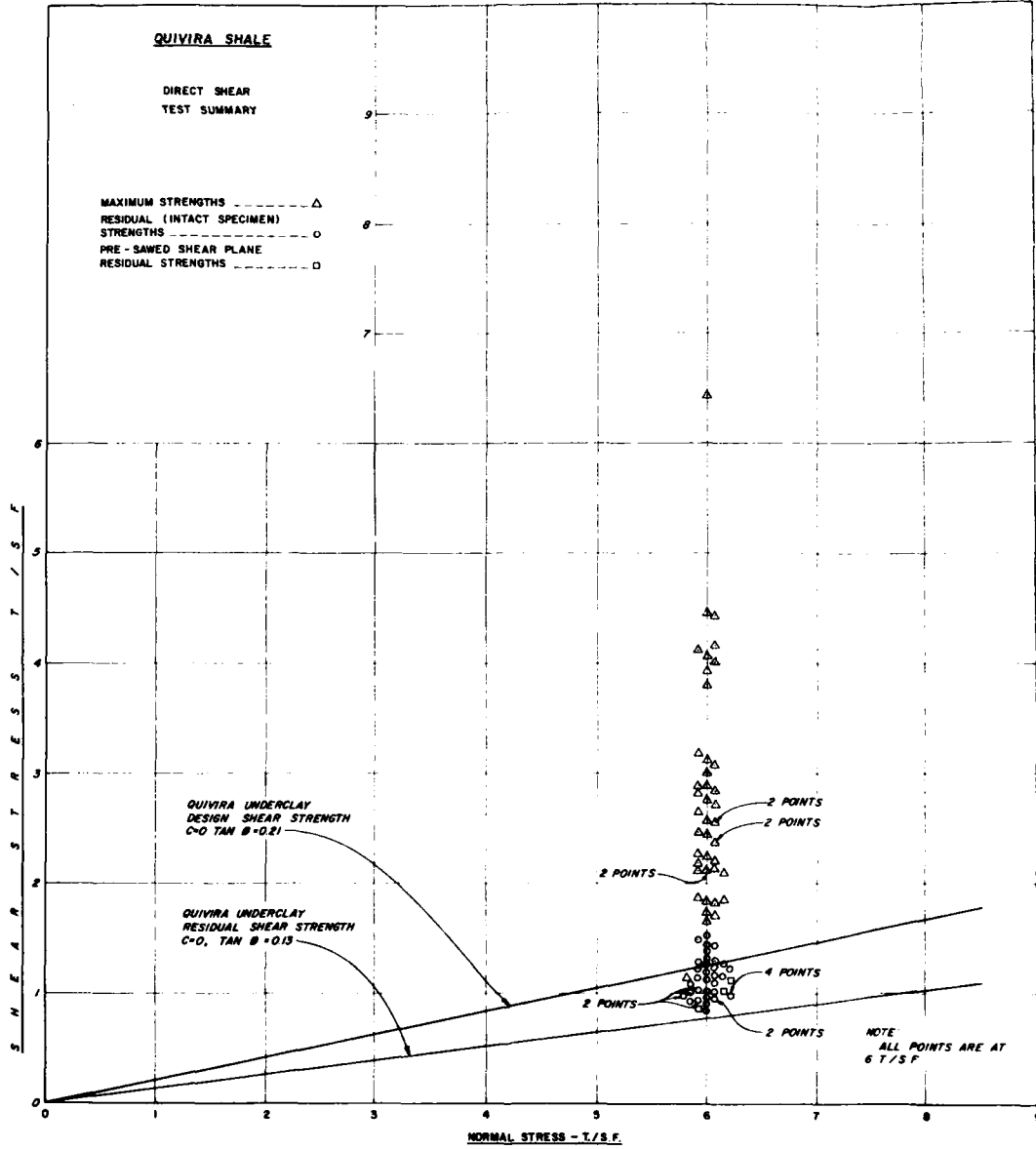
Scale as shown  
U.S. ARMY  
DECEMBER 1971

DM-7 0-15-307  
PLATE NO. 57

**QUIVIRA SHALE**

**DIRECT SHEAR  
TEST SUMMARY**

MAXIMUM STRENGTHS -----  $\Delta$   
 RESIDUAL (INTACT SPECIMEN)  
 STRENGTHS -----  $\circ$   
 PRE-SAWED SHEAR PLANE  
 RESIDUAL STRENGTHS -----  $\square$



HOLE NUMBER	STATION	DEPTH
P-76-1	76+30	18.00'
P-86-1	86+40	34.20'
P-87-2	87+65	44.00'
P-94-2	94+09	54.50'
P-94-3	93+95	34.50'
P-94-8	93+58	04.80'
P-94-16	93+95	3+50'
P-104-7	103+95	04.80'
P-104-13	104+27	3+50'
C-454	91+50	04.04'
C-457	88+50	5'
TP-460	104+15	04.05'
TP-461	102+80	04.05'
TP-463	100+70	04.82'
TP-464	100+67	04.8'
TP-465	103+91	04.82'
TP-469	94+22	04.82'
TP-470	94+24	04.8'
TP-471	94+18	04.82'

QUIVIRA SHALE DIRECT SHEAR TEST SUMMARY

HOLE NUMBER	STATION	RANGE	SAMPLE NUMBER	SAMPLE DEPTH	DRY DENSITY	INITIAL CONDITIONS			LIQUID LIMIT	PEAK TAN $\phi$	RESIDUAL TAN $\phi$	COMMENTS
						MOISTURE CONTENT	% SATURATION	URATION				
P-75-2	75+10	6+10U	1	241-246	102.8	23.3	94	56	0.40			
			1	241-246	100.7	23.8	91	56	0.35			
			1	241-246	104.8	21.0	89	56		0.14		Pre-sawed shear plane
P-78-1	78+30	3+60U	2	241-246	107.2	21.3	95	56	0.41	0.16		
			2	270-272	115.2	17.3	93	54	0.35	0.18		
			2	270-272	115.7	17.0	92	54	0.41	0.16		
			2	274-276	117.0	17.7	99	54	0.38	0.16		No peak on $\phi$
P-86-1	86+40	3+20D	2	275-277	123.1	14.2	93	54		0.21		Equipment malfunction
			2	270-272	117.0	17.3	97	54				
			1	308-313	121.6	14.0	92	42	0.66			
			1	308-313	123.9	12.9	90	42	0.69			
			1	308-313	123.4	12.9	89	42	0.68	0.24		
P-87-2	87+65	6+10D	3	308-313	124.4	13.8	98	42	0.67	0.22		
			3	332-334	118.8	17.8	100*	47	0.74	0.20		
			3	332-334	127.2	13.9	100	47	0.74	0.16		
P-94-2	94+09	5+50U	1	31.8	110.2	14.8	73	44	0.44	0.20		
			1	31.8	120.8	15.3	99	44	1.07	0.25		
			2	33.6	117.3	15.4	89	50	0.43	0.17		
			2	33.6	112.8	17.6	90	50	0.38	0.17		
P-94-3	94+95	3+50U	2	33.4	106.2	20.8	91	50		0.17		No peak on $\phi$ - Equipment malfunction
			1	28.8-293	110.6	15.4	74	42		0.19		Pre-sawed shear plane
			2	28.8-293	115.8	16.1	89	42		0.17		
P-94-4	94+95	3+50U	2	29.4	116.2	15.6	84	52	0.35	0.16		
			2	29.4	115.8	15.9	85	52	0.31	0.16		
			1	29.5-29.7	114.3	16.2	86	46	0.40			
P-94-5	94+95	3+50U	1	29.5-29.7	116.9	16.9	95	46	0.51	0.20		
			1	29.5-29.7	118.4	16.4	96	46	0.48	0.19		
			2	30.9-31.2	105.8	20.0	89	54	0.35	0.23		
P-94-6	94+95	3+50U	2	30.9-31.2	117.0	17.2	100*	54	0.36	0.16		
			1	30.6	117.2	16.7	98	44	0.70	0.25		
P-94-16	94+95	3+50U	1	30.6	114.5	15.8	86	44	0.53	0.22		
			2	29.8	117.1	17.4	100*	55	0.46	0.20		
P-104-7	104+95	0+80U	2	29.8	119.4	15.7	97	55	0.46	0.16		
			1	28.8	114.4	18.2	100	52	0.28	0.14		
P-104-13	104+27	3+50U	1	28.8	113.9	17.3	94	52	0.30	0.16		
			2	30.8	116.4	15.8	90	58		0.17		No peak on $\phi$ - Equipment malfunction
C-454	91+50	0+04D	1	410-560	112.5	18.0	90	52	0.47	0.19	6" was drilled from top of	
C-457	88+50	E	2	600-770	113.9	16.5	88	57	0.20	0.16	Drum Limestone	
TP-460	104+15	0+05D	1	0.87-1.33	114.5	18.0	94	51	0.29	0.15	6" cylinder handcut from bottom of cutoff trench	
TP-461	102+80	0+05U	1	0.83-1.11	113.5	17.7	91	52	0.28	0.18		
TP-463	100+70	0+18.5D	1	1.11-1.39	115.6	16.1	87	52	0.47			12" block handcut from bottom of cutoff trench
			1	1.39-1.67	120.6	15.0	92	49	0.43			
TP-464	100+67	0+18.5D	1	0.30	111.3	17.2	87	48	0.43	0.21		
			1	0.50	114.2	17.6	95	57	0.50	0.18		
TP-465	103+91	0+18.5D	1	0.10	114.0	15.6	84	45	0.52			
			1	0.30	116.4	16.0	91	49	0.37	0.19		6" cylinders handcut from sidewall of cutoff trench
			1	0.25	109.1	19.7	92	44	0.83	0.24		
TP-469	94+22	0+18.5D	1	0.40	105.9	20.9	90	55	0.48	0.21		
			1	0.40	109.9	19.8	92	65	0.31	0.17		
TP-470	94+24	0+18.5D	1	0.40	110.7	19.9	95	63	0.36	0.17		
TP-471	94+18	0+18.5D	1	0.50	106.7	19.9	87	64	0.31	0.16		

NOTE  
ALL TESTS WERE RUN WITH  
A NORMAL STRESS OF 6 T/S.F

2 POINTS  
2 POINTS

4 POINTS

2 POINTS  
NOTE:  
ALL POINTS ARE AT  
6 T/S.F

7 8 9

SYM

DESCRIPTION

DATE APPD

REVISIONS  
BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**

TEST DATA SUMMARY  
QUIVIRA SHALE (1977 TESTS)

In 1 sheet  
CORPUS OF ENGINEERS  
KANSAS CITY DISTRICT  
Submitted

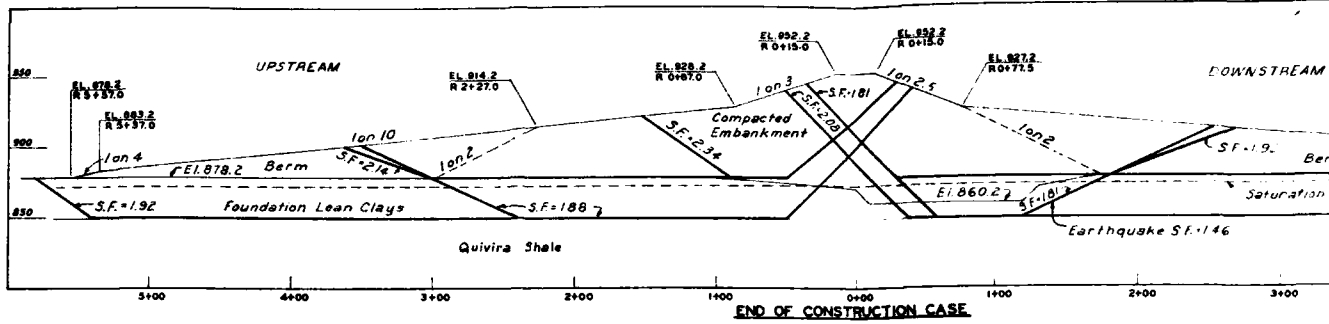
Recommended

Scale as shown  
JANUARY 1978

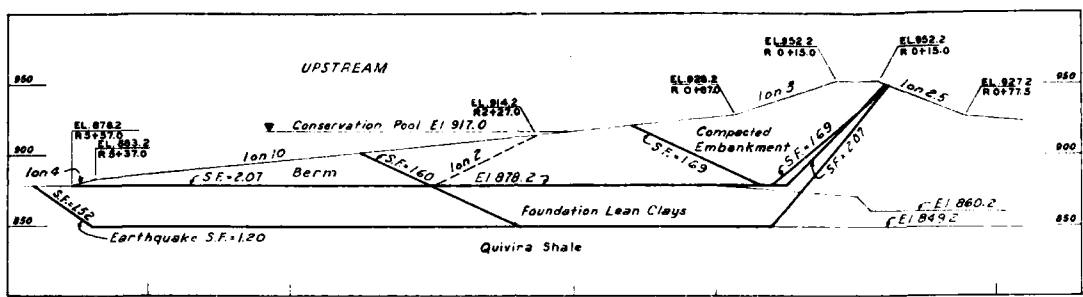
Checked by  
SAD JPM

Checked by  
RGP

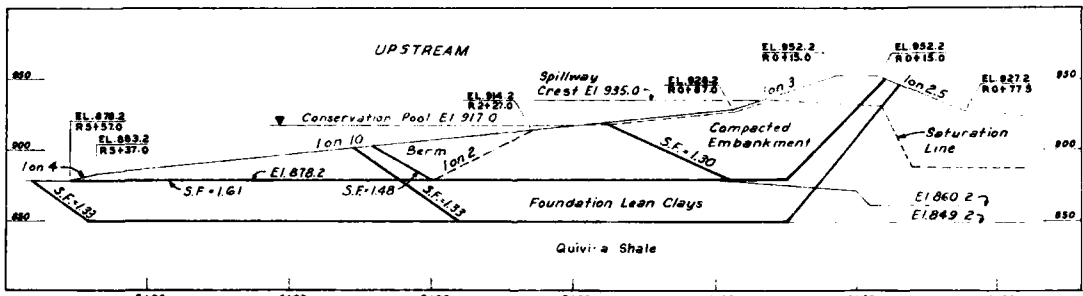
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DATE MA 80



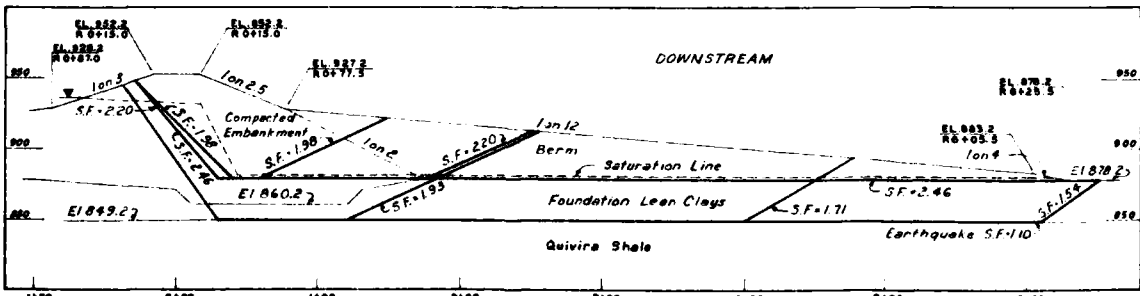
END OF CONSTRUCTION CASE



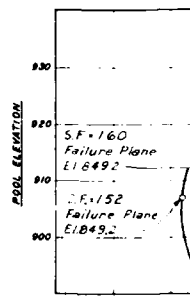
PARTIAL POOL CASE



RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)

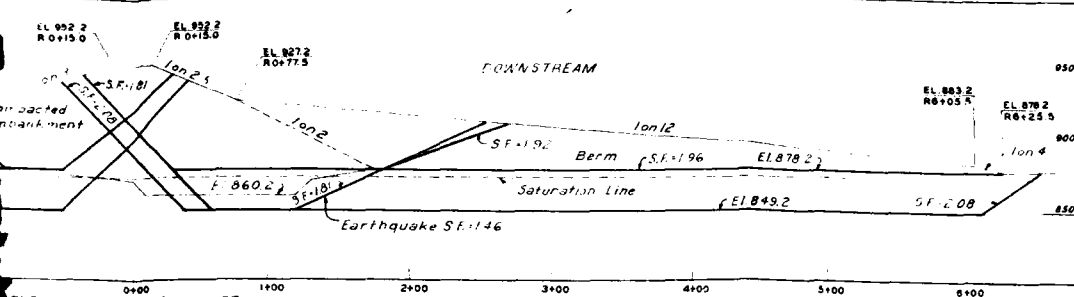


STEADY SEEPAGE CASE

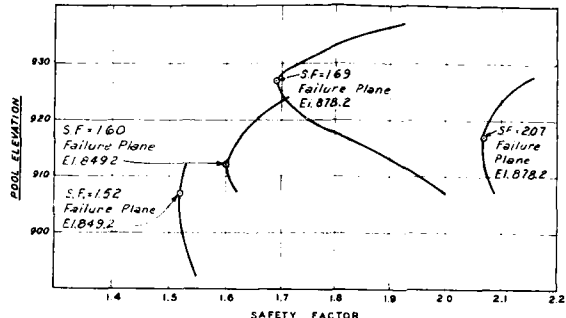
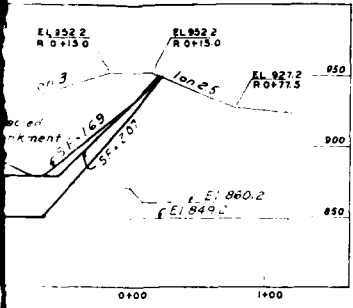


RAPID DRAWDOWN	
EL OF FAILURE PLANE	SAFETY FROM SPILLWAY CREST
878	1.30
849	1.33

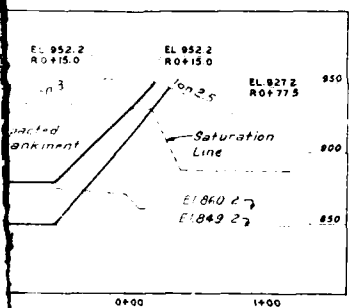
- End of Cons
- Rapid Draw From Spillway
- Rapid Draw From Maximum
- Partial Pool
- Steady Seepage
- Earthquake
- W For Steady Seepage



END OF CONSTRUCTION CASE



PARTIAL POOL CASE



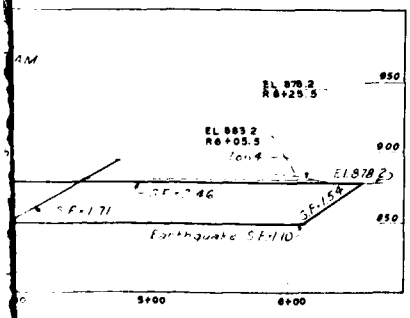
EL OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
878	1.30	1.21
849	1.33	1.28

MATERIAL	PHYSICAL SOIL CONSTANTS							
	UNIT WEIGHT				DESIGN SHEAR STRENGTHS			
	SAT	DRAINED	C (TSF)	TAN $\phi$	C (TSF)	TAN $\phi$	C (TSF)	TAN $\phi$
Compacted Embankment	125	100	700	0.00	200	180	0.00	45.0
Berm Fill	115	110	100	0.01	100	00	0.00	25.0
Fdn Lean Clays	115	110	200	0.00	300	240	0.00	45.0
Quivira Underclay	140						0.00	2.0

CASE	SAFETY FACTORS	
	REQUIRED	ACTUAL
End of Construction	1.4	1.81
Rapid Drawdown From Spillway Crest	1.2	1.30
Rapid Drawdown From Maximum Surcharge	1.0	1.21
Partial Pool	1.5	1.52
Steady Seepage	1.5	1.54
Earthquake	1.0	1.10*

\* For Steady Seepage Case

STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN AND SHALES	
CASE	SAFETY FACTOR
Steady Seepage	1.06
Partial Pool	1.09
Rapid Drawdown From Spillway Crest	0.94
Rapid Drawdown From Max Surcharge	0.90



SYMBOL	DESCRIPTION	DATE	APP'D
	REVISIONS		

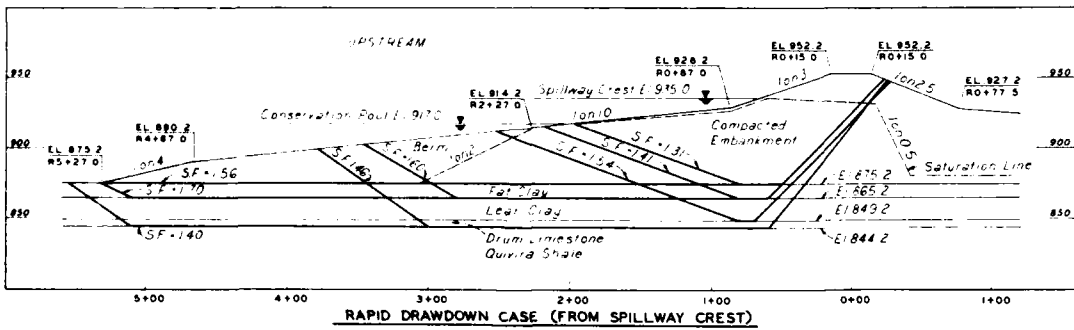
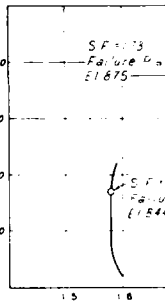
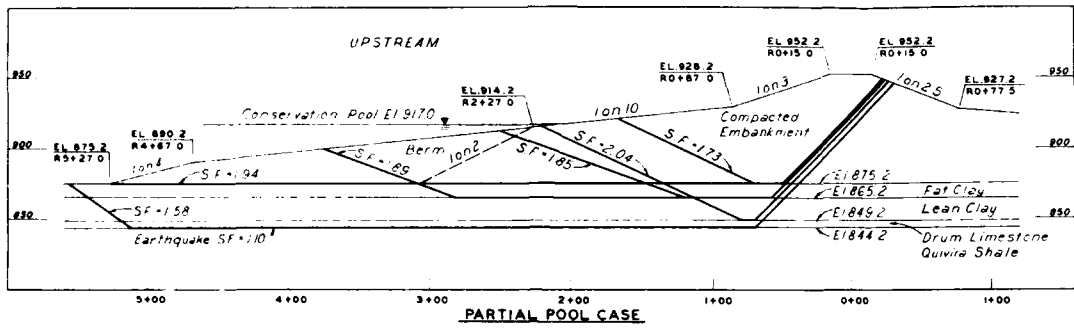
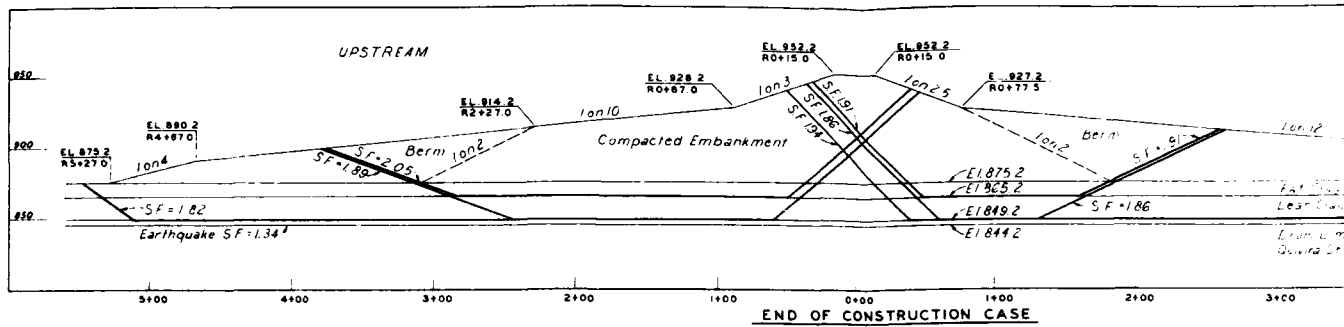
OSAGE RIVER BASIN  
**HILLSDALE LAKE**  
 BIG BULL CREEK

EMBANKMENT STABILITY ANALYSIS SUMMARY  
 LOWER RIGHT ABUTMENT-STA 81+00

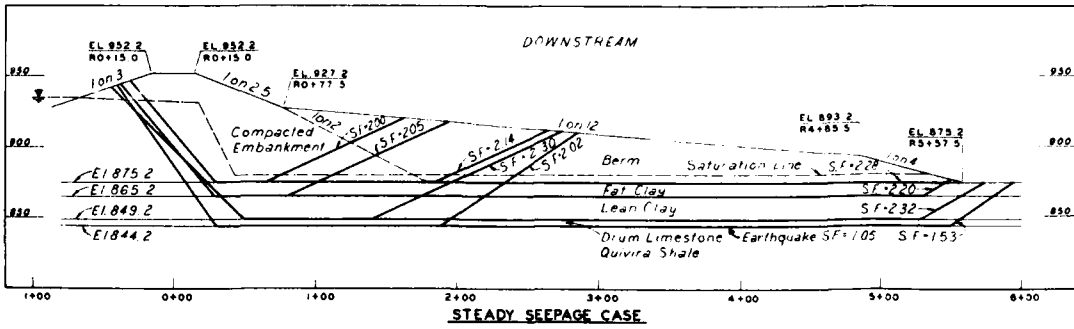
In 5 sheets      Sheet No. 1      Scale as shown  
 CORPS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT      MARCH 1971

Submitted: \_\_\_\_\_ Recommended: \_\_\_\_\_ Approved: \_\_\_\_\_

DESIGNED BY: RRB-WGA      CHECKED BY: J.A.M.      DRAWN BY: R.F.      DATE: JUNE 7      FILE NO: C-15-247

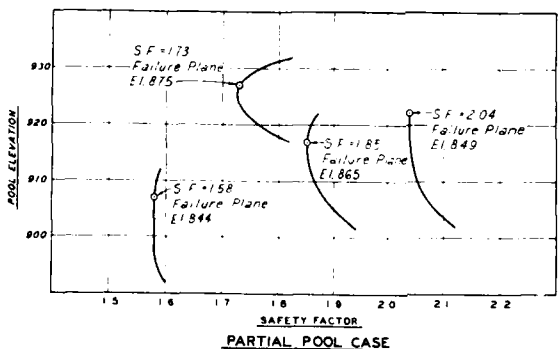
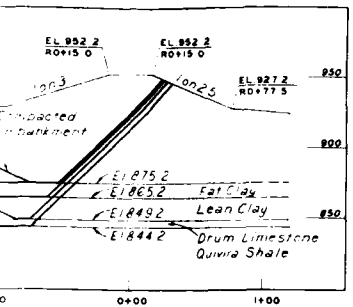
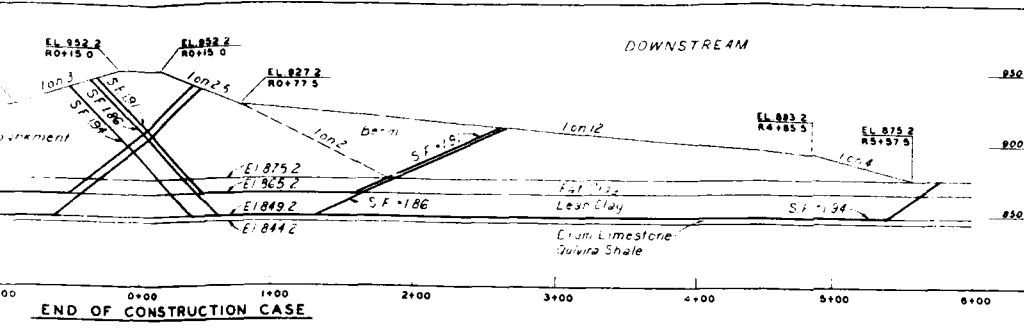


RAPID DRAWDOWN	
EL. OF FAILURE PLANE	FROM SPILLWAY CREST
875	3'
865	4'
849	5.4'
844	4'



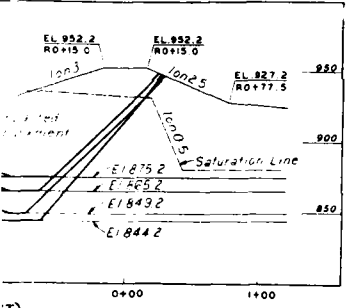
CASE	
End of Construction	
Rapid Drawdown	
Rapid Drawdown + Surge	
Partial Pool	
Steady Seepage	
Earthquake	

\* For Steady Seepage



**STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN AND SHALES**

CASE	SAFETY FACTOR
Steady Seepage	1.05
Partial Pool	1.6
Rapid Drawdown from Spillway Crest	1.02
Rapid Drawdown from Maximum Surcharge	0.98

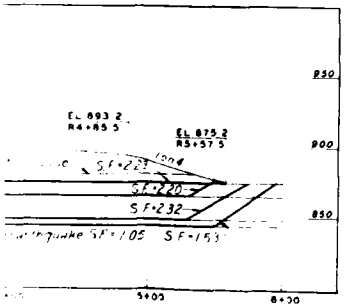


**RAPID DRAWDOWN**

EL. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
875	1.31	1.23
865	1.41	1.34
849	1.54	1.46
844	1.40	1.36

**PHYSICAL SOIL CONSTANTS**

MATERIAL	UNIT WEIGHT		DESIGN SHEAR STRENGTHS								
	SAT.	DRAINED	c (PSF)				tan φ				
			φ <sup>0</sup>	φ <sup>15</sup>	φ <sup>30</sup>	φ <sup>45</sup>	φ <sup>0</sup>	φ <sup>15</sup>	φ <sup>30</sup>	φ <sup>45</sup>	
Compacted Embankment	125	120	0.70	0.00	0.20	0.18	0.00	0.45			
Berm Fill	115	110	0.70	0.00	0.10	0.20	0.00	0.35			
Fdn. Fat. Clays	115	110	0.60	0.00	0.30	0.20	0.00	0.35			
Fdn. Lean Clays	115	110	0.60	0.00	0.30	0.20	0.00	0.45			
Drum Limestone	165						0.00	0.70			
Quivira Underclay	140						0.00	0.21			



**SAFETY FACTORS**

CASE	REQUIRED	ACTUAL
End of Construction	1.4	1.82
Rapid Drawdown from Spillway Crest	1.2	1.31
Rapid Drawdown from Maximum Surcharge	1.0	1.23
Partial Pool	1.5	1.58
Steady Seepage	1.5	1.53
Earthquake	1.6	1.05

\* For Steady Seepage Case

SYMBOL    DESCRIPTION    REVISIONS    DATE    APP'D

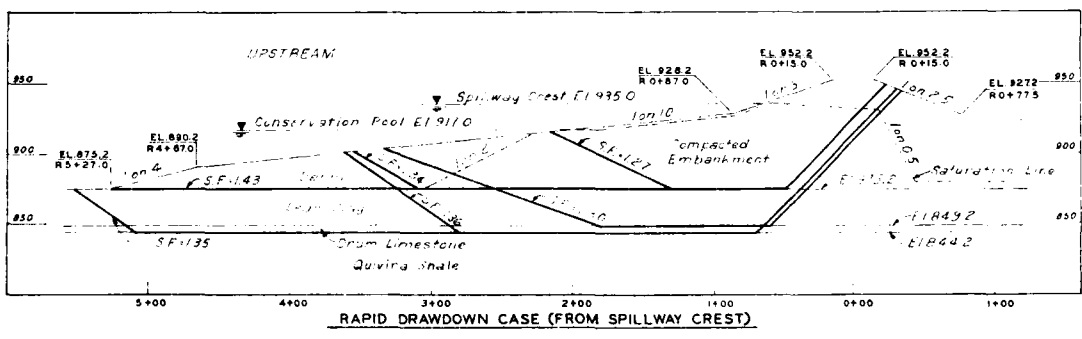
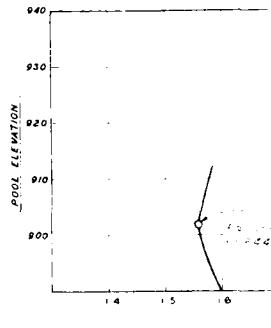
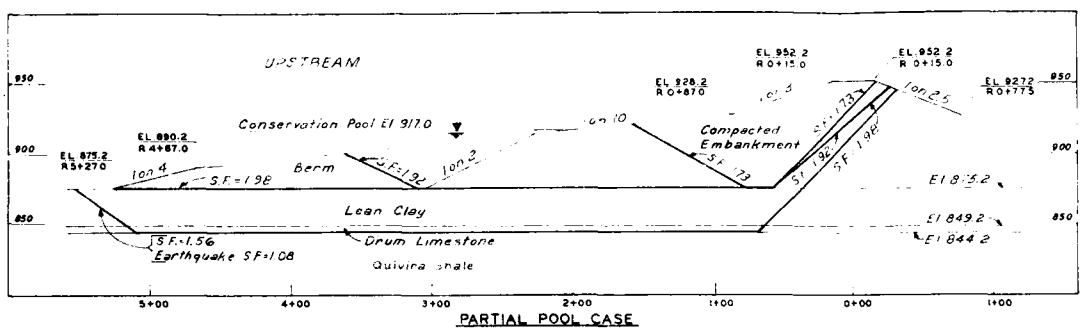
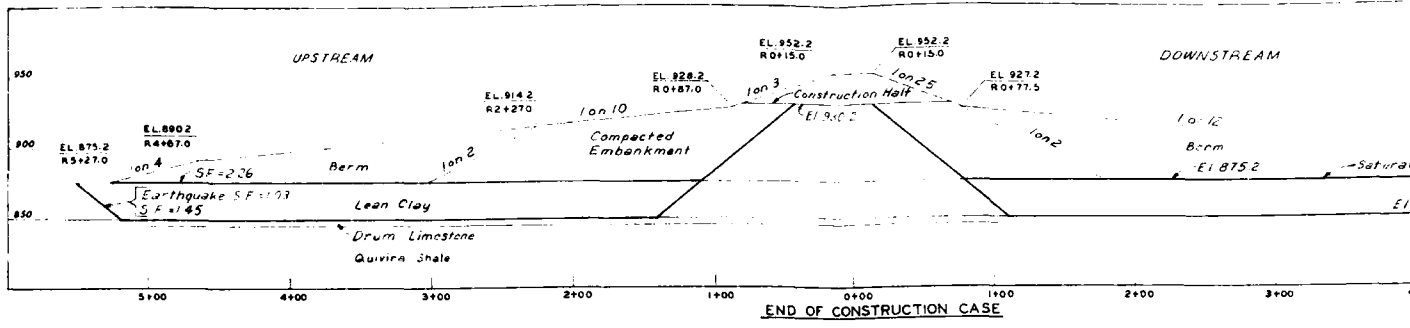
**HILLSDALE LAKE**  
OSAGE RIVER BASIN  
BIG BULL CREEK

**EMBANKMENT STABILITY ANALYSIS SUMMARY**  
MAIN VALLEY STA 90+00

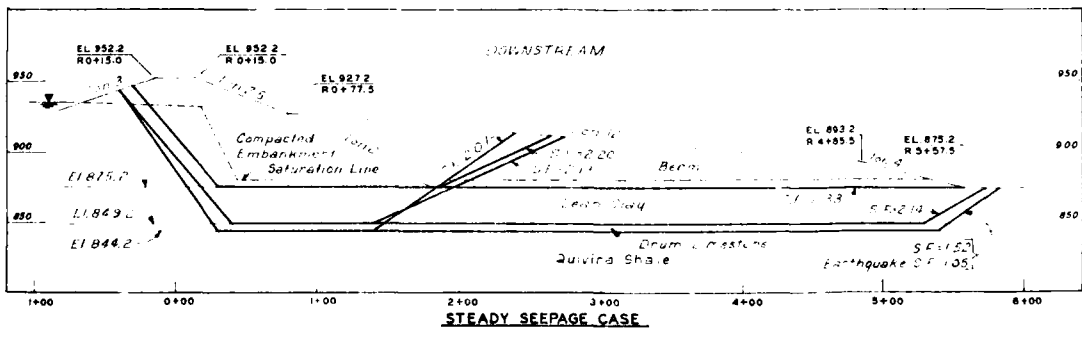
In 5 sheets    Sheet No 2    Scale as shown  
CORPS OF ENGINEERS    U. S. ARMY  
KANSAS CITY DISTRICT    MARCH 1971

Submitted    Recommended    Approved

COMPILED BY: R. K. B. - W.G.A.    CHECKED BY: P.W.M.    R.F.D.    DM-7    0-15-248    LATE NO 60



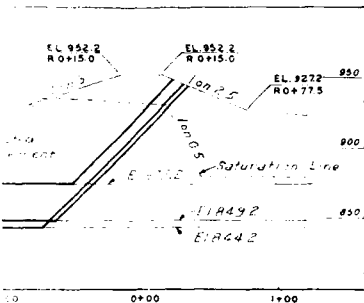
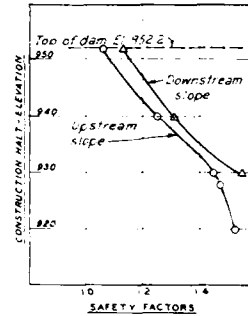
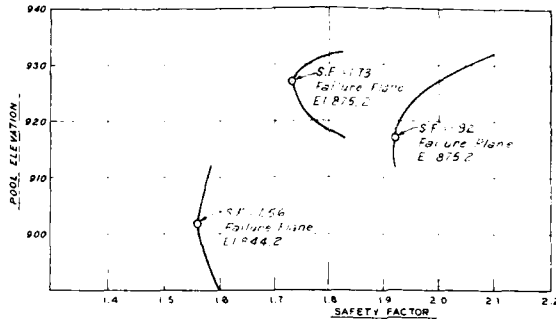
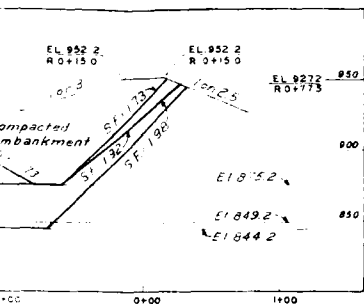
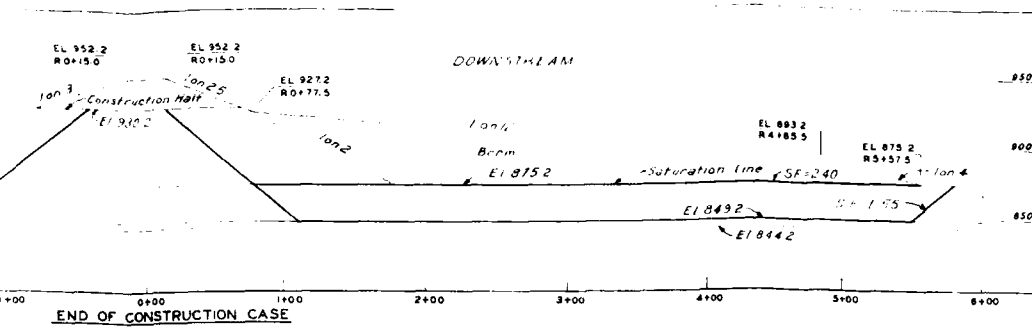
SAFETY FACTOR		
EL. OF FAILURE PLANE	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
928	1.27	1.27
849	1.30	1.30
844	1.31	1.31



SAFETY FACTOR	
CASE	
Construction Case EL 935	1.31
Partial Pool Case EL 917	1.30
Rapid Drawdown From Maximum Surcharge	1.30
Steady Seepage	1.30
Earthquake	1.03

\* For Steady Seepage Case

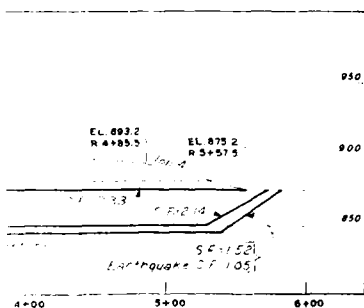




RAPID DRAWDOWN		
EL OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
875	1.27	1.00
849	1.30	1.00
844	1.56	1.00

PHYSICAL SOIL CONSTANTS							
MATERIAL	UNIT WEIGHT P.C.F.	DESIGN SHEAR STRENGTHS					
		15°	20°	25°	30°	35°	40°
Compacted embankment	120	100	100	100	100	100	100
Spillway crest	120	100	100	100	100	100	100
Little Bull Creek	120	100	100	100	100	100	100
Foundation	120	100	100	100	100	100	100
Quality Underway	40						

STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN AND SHALES	
CASE	SAFETY FACTOR
Steady seepage	1.05
Partial pool	1.05
Rapid drawdown from spillway crest	1.05
Rapid drawdown from maximum surcharge	1.05



SAFETY FACTORS		
CASE	REQ'D	ACTUAL
Construction half at E 844.2	1.1	1.45
Rapid drawdown from spillway crest	1.0	1.27
Rapid drawdown from maximum surcharge	1.0	1.00
Partial pool	1.1	1.56
Steady seepage	1.1	1.52
Earthquake	1.1	1.52

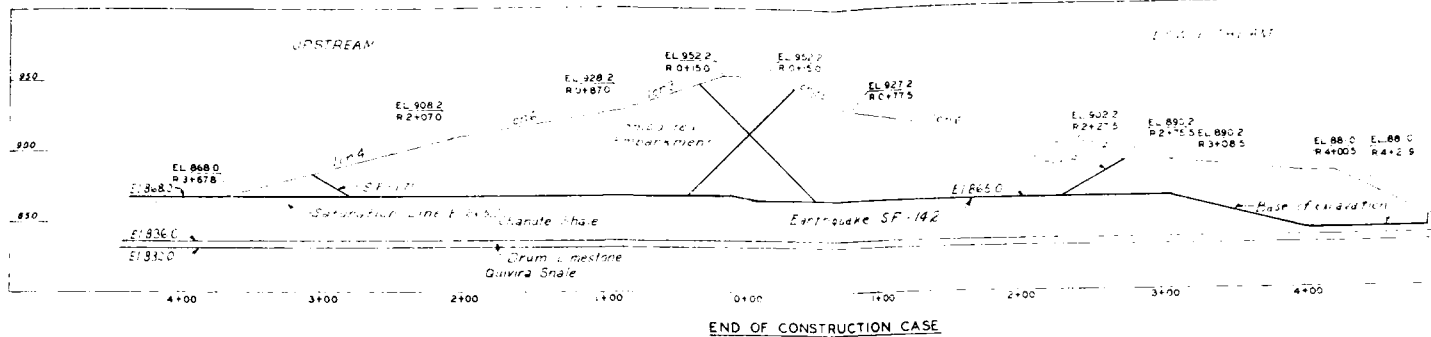
\*For Steady Seepage Case

SYN. DESCRIPTION. DATE: APR 1971

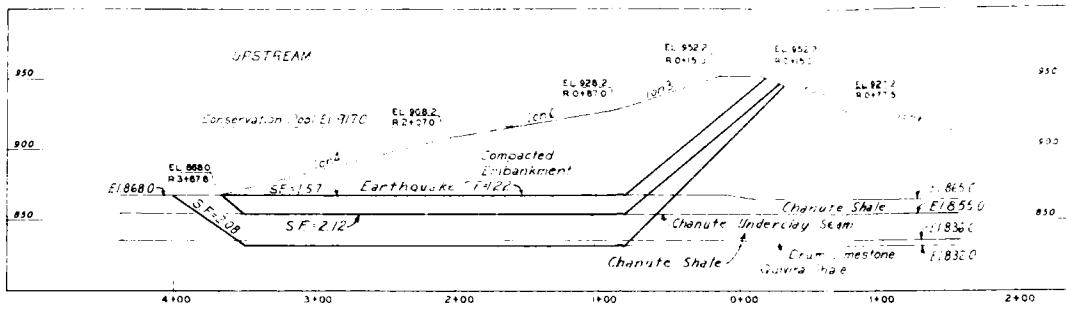
### HILLSDALE LAKE

OSAGE RIVER BASIN  
BIG BULL CREEK  
EMBANKMENT STABILITY ANALYSIS SUMMARY  
LITTLE BULL AREA - STA 104+00

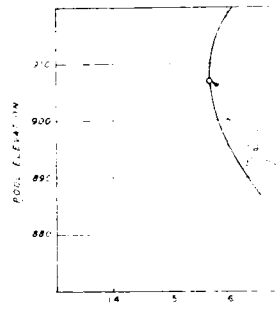
In 5 sheets. Sheet No 3. Scale as shown.  
 COMPS OF ENGINEERS  
 RANSAS CITY, MO.  
 MARCH 1971  
 RRB-WGA JAM RFD DM-1 0-15-249



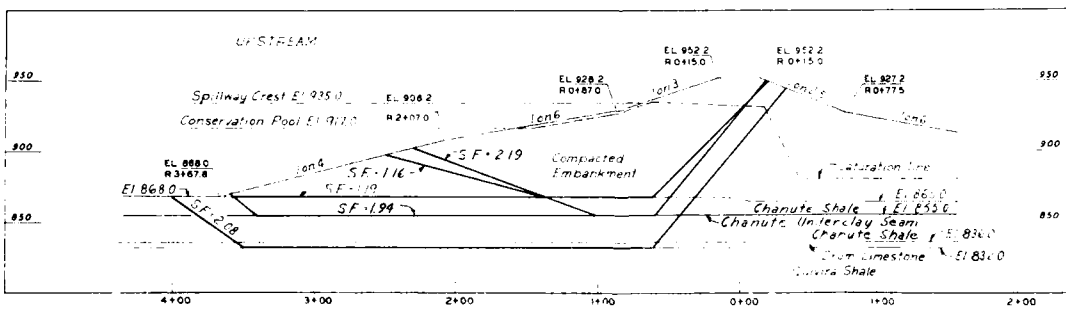
END OF CONSTRUCTION CASE



PARTIAL POOL CASE

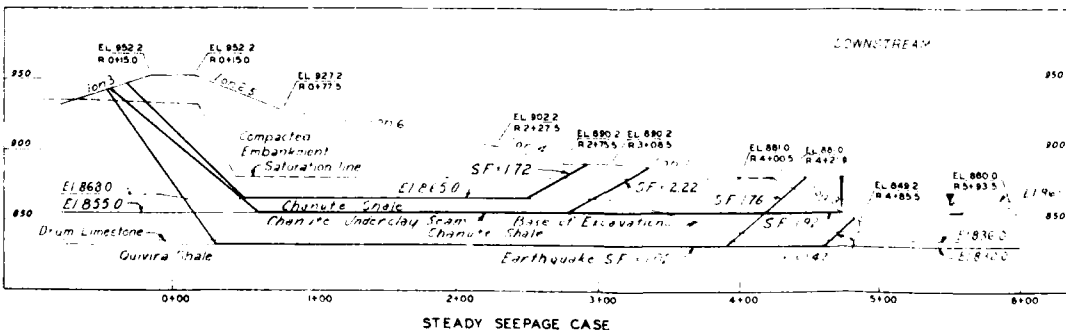


PAF



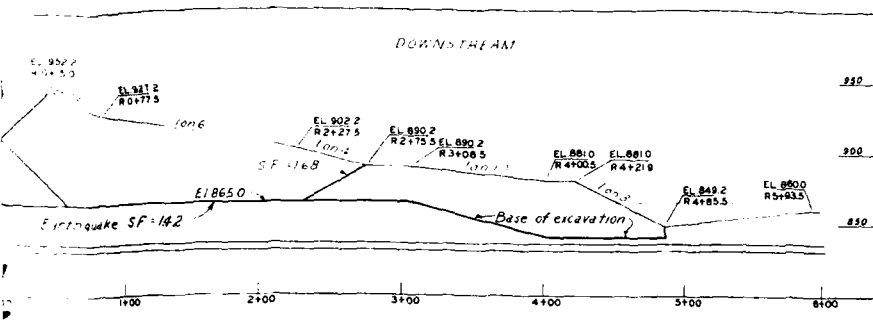
RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)

RAPID DRAWDOWN			
ELEV. OF FAILURE PLANE	SAFETY FACTOR		
	FROM SPILLWAY CREST	FROM CONSERVATION POOL	FROM MAXIMUM SURCHARGE
868	1.76	1.77	1.77
855	1.94	1.89	1.89
837	2.08	2.04	2.04



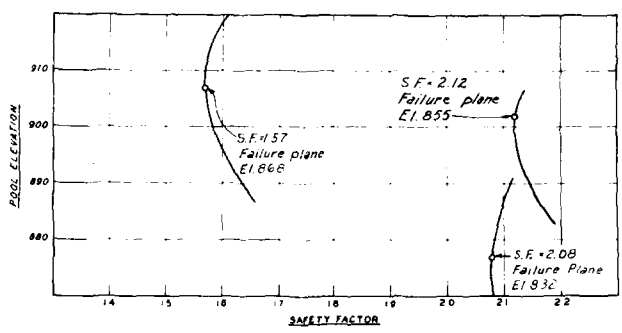
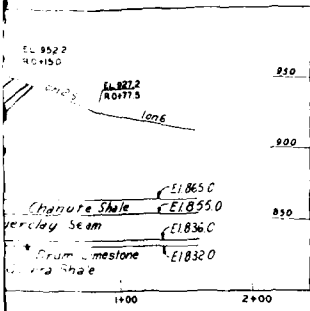
STEADY SEEPAGE CASE

SAFETY FACTORS	
CASE	
End of construction	1.42
Rapid drawdown from spillway crest	1.94
Rapid drawdown from maximum surcharge	1.89
Partial pool	1.57
Steady seepage	1.72
Earthquake	1.42
For steady seepage use	1.42

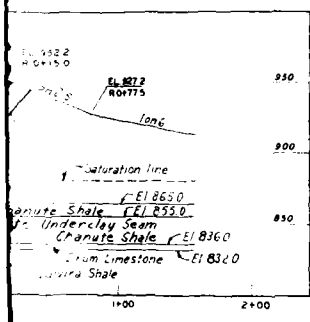


CASE	SAFETY FACTOR	
	857 PLANE	855 PLANE
Steady Seepage	0.82-1.05	1.15
Partial Pool	1.12	1.09
Rapid Drawdown From Spillway Crest	1.00	0.92
Rapid Drawdown From Max. Surcharge	0.92	0.89

OF CONSTRUCTION CASE



PARTIAL POOL CASE

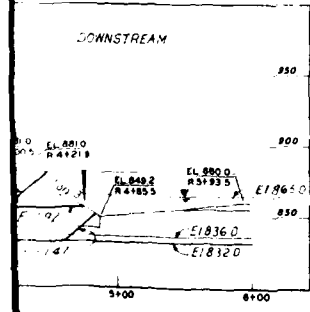


L. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
868	1.16	1.11
855	1.94	1.89
832	2.08	2.03

MATERIAL	UNIT WEIGHT P.C.F.		DESIGN SHEAR STRENGTH							
	SAT	DRAINED	"G"				"B"			
			C (TSF)	TAN B	C (TSF)	TAN B	C (TSF)	TAN B		
Compacted embankment	125	120	0.70	0.00	0.20	0.18	0.00	0.45		
Embankment-Shale Contact Plane			0.70	0.00	0.20	0.18	0.00	0.45		
Chanute Shale Cross Bed	135	130					1.50	0.40		
Chanute Underclay Seam							0.00	0.40		
Drum Limestone	165						1.50	0.50		
Quivira Underclay	140						0.00	0.21		

CASE	SAFETY FACTORS	
	REQUIRED	ACTUAL
End of construction	1.4	1.68
Rapid drawdown from spillway crest	1.2	1.16
Rapid drawdown from maximum surcharge	1.0	1.11
Partial pool	1.5	1.57
Steady seepage	1.5	1.47-1.72
Earthquake	1.0	1.02

\* For steady seepage case



SYM	DESCRIPTION	DATE	APP'D
	REVISIONS		
	OSAGE RIVER BASIN		
	<b>HILLSDALE LAKE</b>		
	BIG BULL CREEK		
	<b>EMBANKMENT STABILITY ANALYSIS SUMMARY</b>		
	OUTLET WORKS-STA. 112+86		

In 5 sheets  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT

Submitted by: [Signature]  
Checked by: RFB-WGA C.H.L.

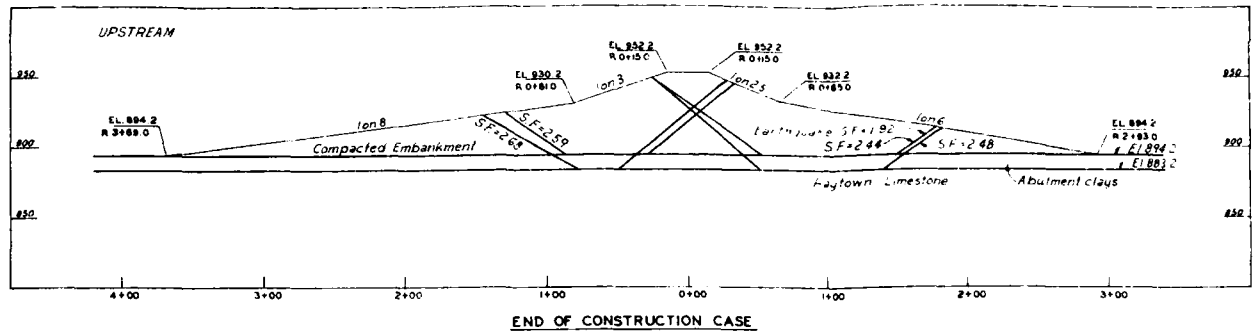
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Checked by: R.F.C. D.M.

Scale as shown  
U. S. ARMY  
MARCH 1971

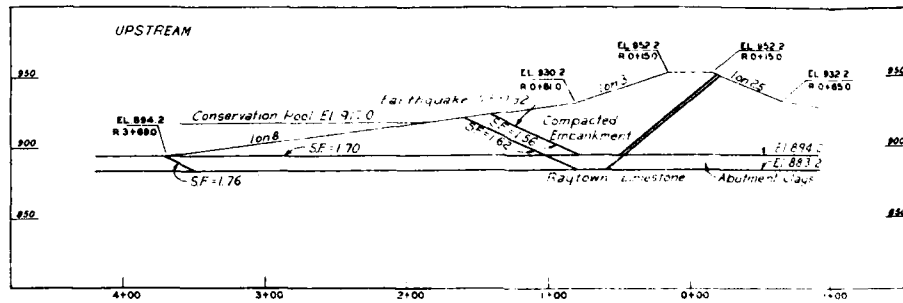
Sheet No. 4

0-15-230

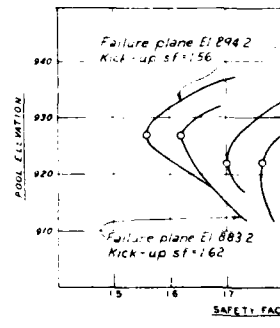
PLATE NO. 6.



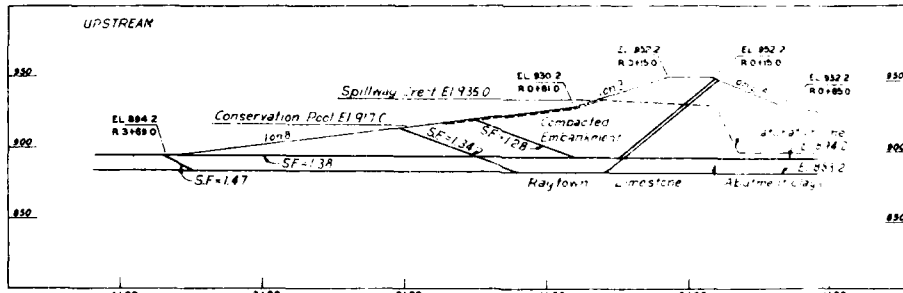
END OF CONSTRUCTION CASE



PARTIAL POOL CASE

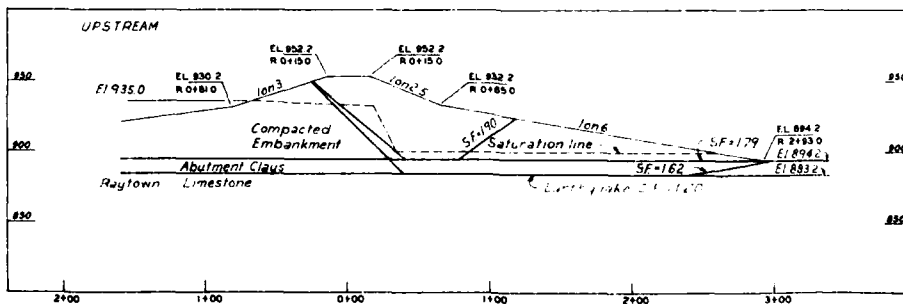


PARTIAL POOL



RAPID DRAWDOWN CASE (FROM SPILLWAY CREST)

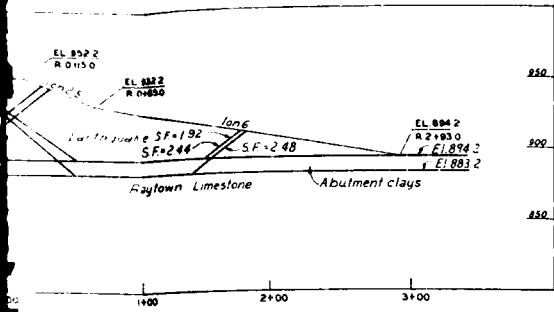
EL. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
894.2	1.28	1.18
883.2	1.34	1.26



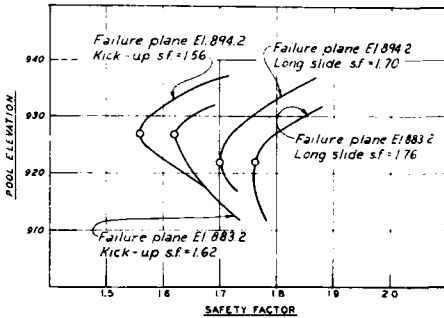
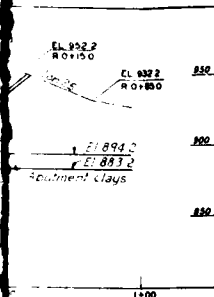
STEADY SEEPAGE CASE

CASE	SAFETY FACTOR
	End of construction
Rapid drawdown from spillway crest	
Rapid drawdown from maximum surcharge	
Partial pool	
Steady seepage	
Earthquake	

\* For Steady Seepage Case

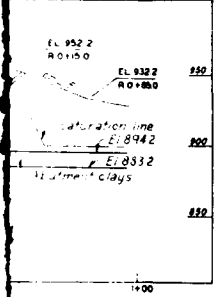


CASE



PARTIAL POOL CASE

CASE	SAFETY FACTOR
Steady seepage	1.27
Partial pool	1.37
Rapid drawdown from spillway crest	1.10
Rapid drawdown from max surcharge	1.03



EL. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST*	FROM MAXIMUM SURCHARGE
894.2	1.28	1.18
883.2	1.34	1.26

MATERIAL	UNIT WEIGHT		DESIGN SHEAR STRENGTH					
	SAT	DRAINED	C (TSP)	TAN Ø	C (TSP)	TAN Ø	C (TSP)	TAN Ø
Compacted embankment	125	120	700	300	200	180	000	450
Abutment clays	120	115	900	000	300	200	000	350
Raytown Ls	165						000	700

CASE	REQUIRED	ACTUAL
End of construction	1.4	2.44
Rapid drawdown from spillway crest	1.2	1.78
Rapid drawdown from maximum surcharge	1.0	1.18
Partial pool	1.5	1.56
Steady seepage	1.5	1.60
Earthquake	1.0	1.20*

\* For Steady Seepage Case

SYM

DESCRIPTION: OSAGE RIVER BASIN  
**HILLSDALE LAKE**  
 BIG BULL CREEK

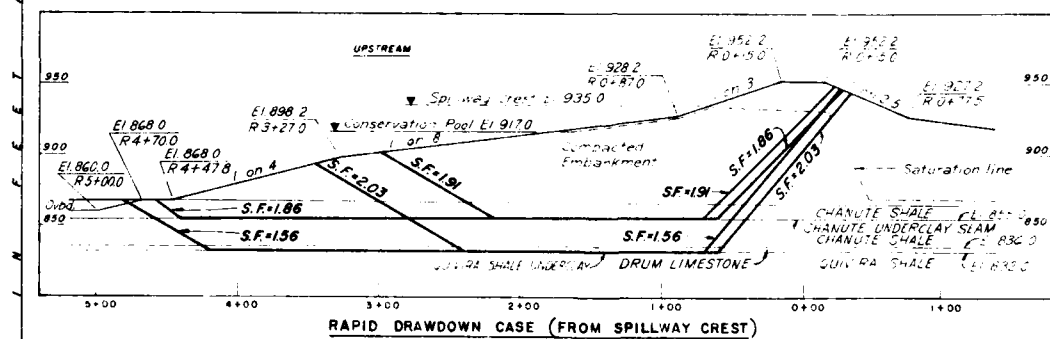
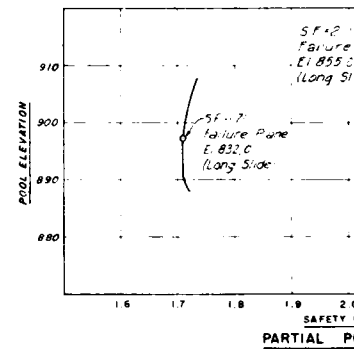
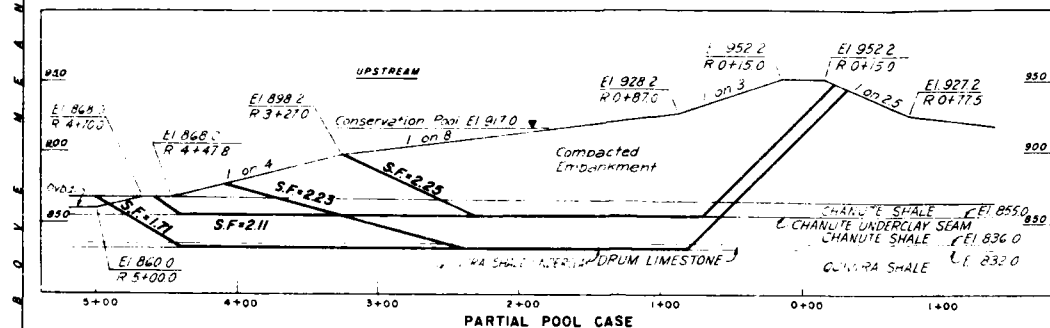
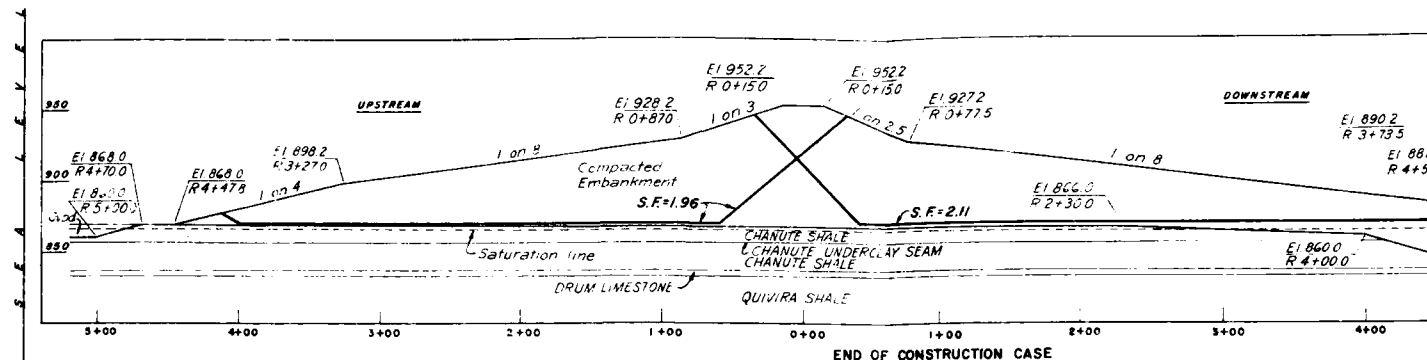
EMBAKMENT STABILITY ANALYSIS SUMMARY  
 LEFT ABUTMENT- STA. 115+00

In 5 sheets      Sheet No 5      Scale as shown  
 CORPS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT      MARCH 1971

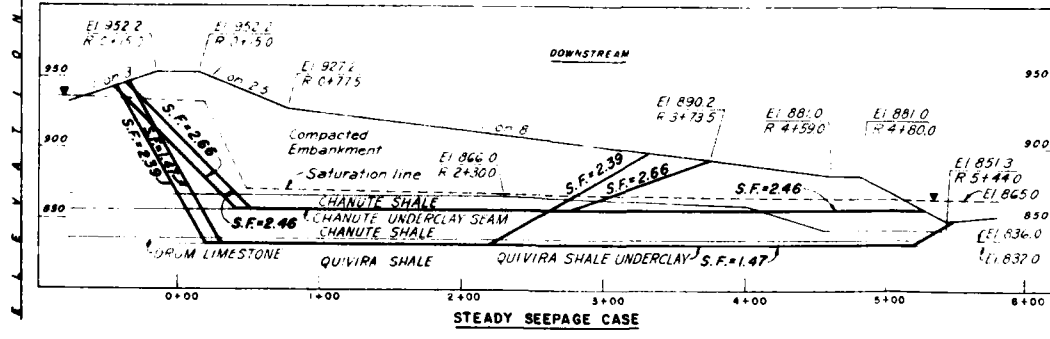
Submitted: \_\_\_\_\_ Recommended: \_\_\_\_\_ Approved: \_\_\_\_\_

CHIEF ENGINEERING SECTION      FILE NO. 0-15-251

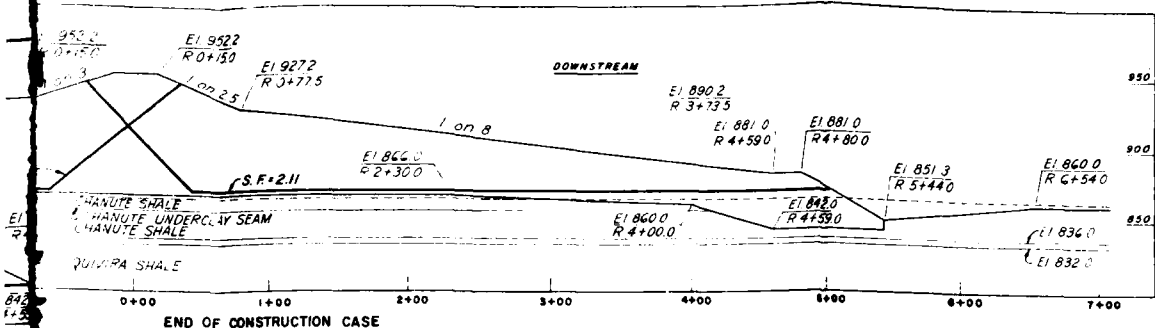
LATE NO 63



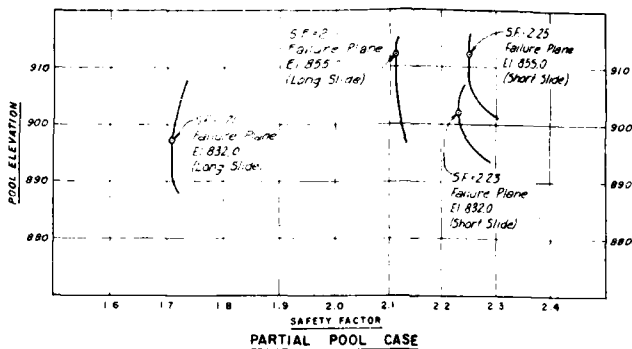
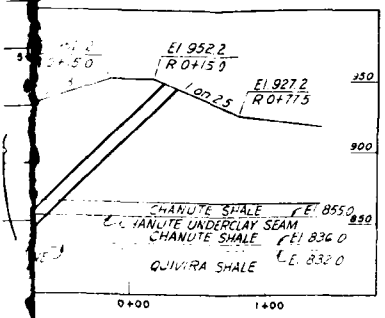
RAPID DRAWDOWN		
EL. OF FAILURE PLANE	FROM SPILLWAY CREST	SAFETY FACTOR FROM MAXIMUM SURCHARGE
832.0	5.0	2.11
832.0	5.0	2.11



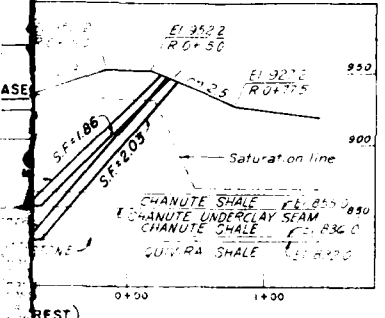
REQUIRED SAFETY FACTORS	
CASE	
END OF CONSTRUCTION	2.11
RAPID DRAWDOWN FROM SPILLWAY CREST	2.11
RAPID DRAWDOWN FROM MAXIMUM SURCHARGE	2.11
PARTIAL POOL	2.11
STEADY SEEPAGE	2.11
EARTHQUAKE	2.11



END OF CONSTRUCTION CASE

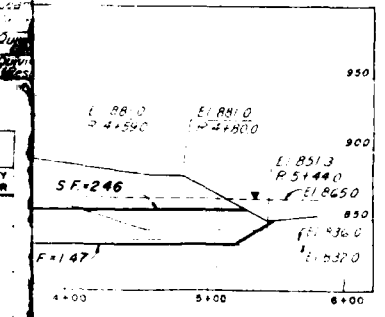


CASE AND FAILURE PLANE	SAFETY FACTOR	
	PEAK STRENGTH	RESIDUAL STRENGTHS
PARTIAL POOL Failure plane along Chanute underclay	2.11	0.99
PARTIAL POOL Failure plane along Quivira underclay	1.71	1.17
STEADY SEEPAGE Failure plane along Chanute underclay	2.46	1.11
STEADY SEEPAGE Failure plane along Quivira underclay	1.47	0.96



EL. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
855	1.86	2.03
832	1.50	1.81

MATERIAL	PHYSICAL SOIL CONSTANTS					
	UNIT WEIGHT		DESIGN SHEAR STRENGTHS			
	SAT	DRAINED	C (TSF)	TAN Ø	C (TSF)	TAN Ø
Impacted Embankment						1.15
Overburden	15					1.42
Chanute Shale	135					1.00
Chanute Shale (Residual)	135					0.92
Chanute Underclay	140					0.40
Quivira Shale	140	165				0.49
Quivira Underclay (Peak)	140	140				0.21
Quivira Underclay (Residual)	140	140				0.13

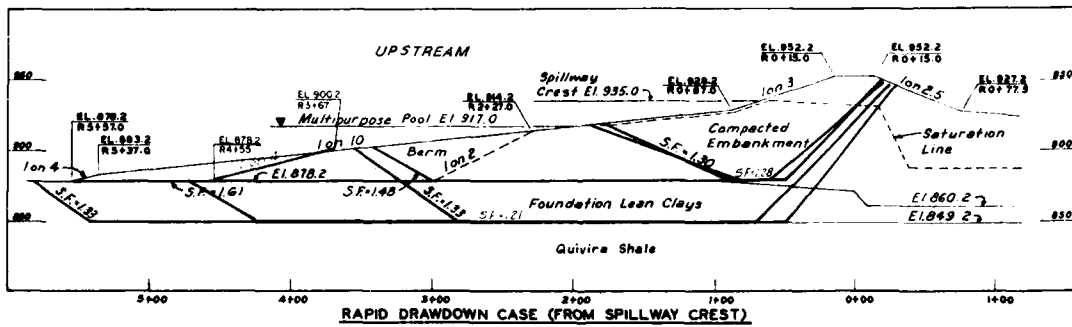
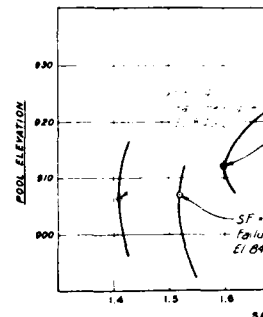
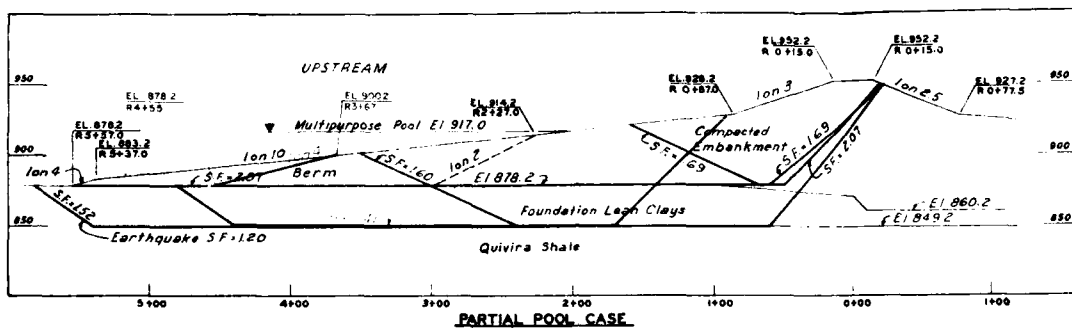
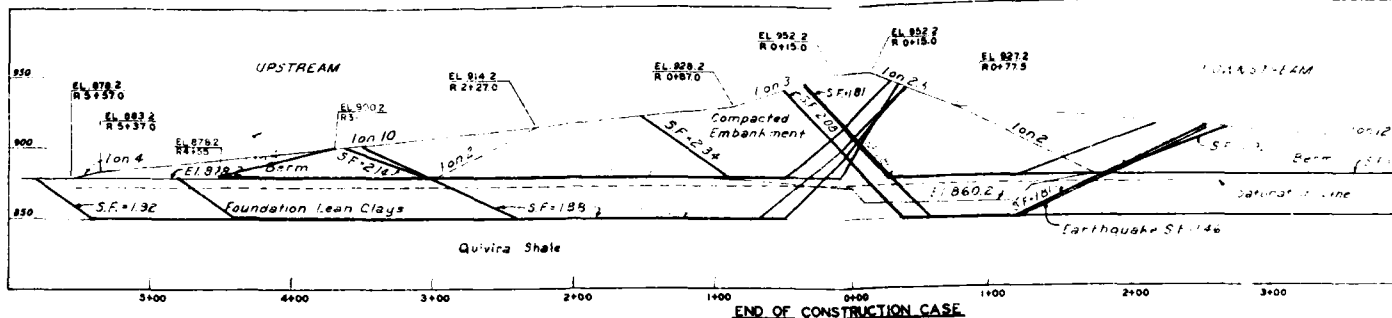


CASE	SAFETY FACTOR
END OF CONSTRUCTION	1.4
RAPID DRAWDOWN FROM SPILLWAY CREST	1.2
RAPID DRAWDOWN FROM MAXIMUM SURCHARGE	1.0
PARTIAL POOL	1.5
STEADY SEEPAGE	1.5
EARTHQUAKE	1.0

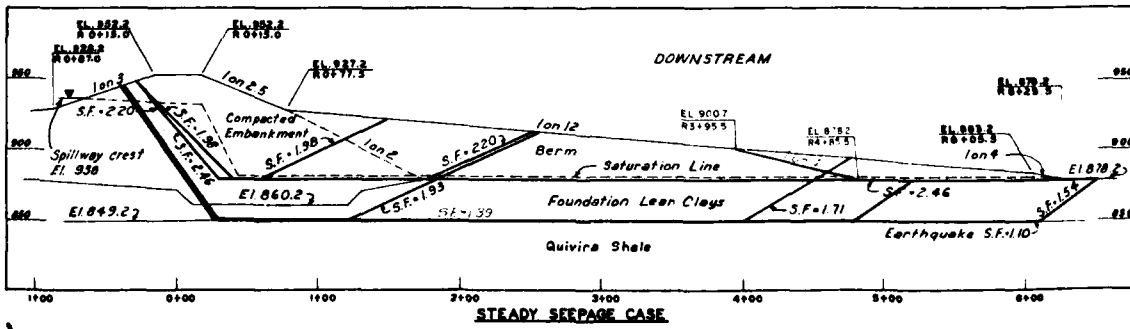
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 BIG BULL CREEK KANSAS  
**HILLSDALE LAKE**

**EMBANKMENT STABILITY ANALYSIS SUMMARY: OUTLET WORKS**

In 1 sheet Sheet No. 1 Scale as shown U.S. ARMY DECEMBER 1971  
 CORPS OF ENGINEERS KANSAS CITY DISTRICT  
 Chief: DAVID B. FOUNDRON, 1011  
 Designer: W. B. A. F. C. L. R. P. DM-7 0-15-30J  
 Checker: J. B. G. L. R. P. DM-7 0-15-30J  
 Draftsman: J. B. G. L. R. P. DM-7 0-15-30J  
 Title No. 0-15-30J  
 DATE: APP'D.



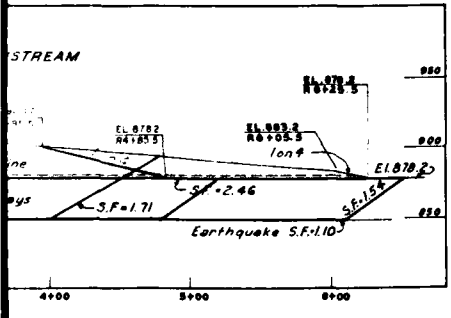
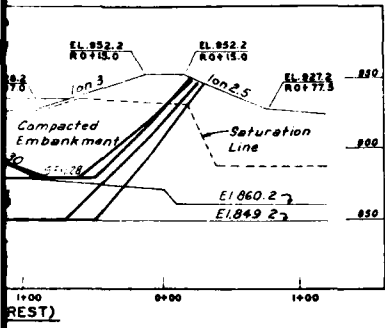
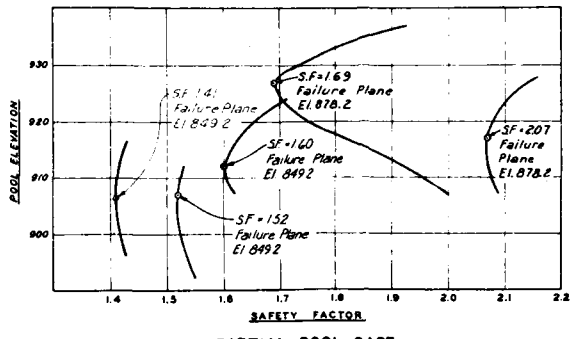
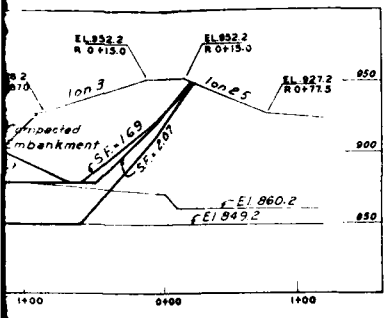
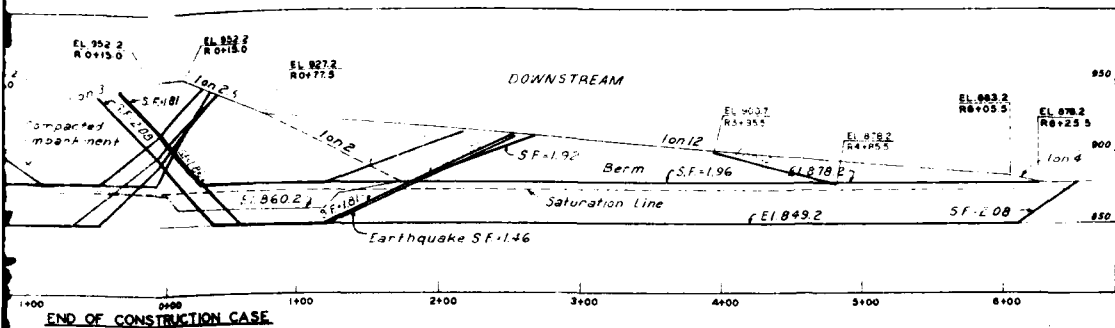
SAFETY FACTOR		
EL. OF FAILURE PLANE	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
878	1.30	1.21
849	1.33	1.28
878		
849		



CASE	SAFETY FACTOR
End of Construction	
Rapid Drawdown From Spillway Crest	
Rapid Drawdown From Maximum surcharge	
Partial Pool	
Steady Seepage	
Earthquake	

\* For Steady Seepage Case





EL. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
	878	1.30
849	1.33	1.28
878	1.28	1.21
849	1.21	1.17

MATERIAL	UNIT WEIGHT P.C.F.	DESIGN SHEAR STRENGTH						
		c=0		c=100		c=200		
		TAN 0	C (TSP)	TAN 0	C (TSP)	TAN 0	C (TSP)	
Compacted Embankment	125	120	700	000	200	180	000	450
Berm Fill	115	110	100	100	100	200	000	350
Fan Lean Clays	115	110	200	200	300	200	000	450
Quivira Underclay (Peak)	140	—	—	—	—	—	000	210
Quivira Underclay (Residual)	140	—	—	—	—	—	000	130

CASE	SAFETY FACTORS		
	REQUIRED	ACTUAL	REVISED SECTION
End of Construction	1.4	1.81	1.81
Rapid Drawdown From Spillway Crest	1.2	1.30	1.30
Rapid Drawdown From Maximum surcharge	1.0	1.21	1.21
Partial Pool	1.5	1.52	1.52
Steady Seepage	1.5	1.54	1.54
Earthquake	1.0	1.10	1.10

CASE	SAFETY FACTOR	REVISED SECTION
Partial Pool	1.09	1.09
Rapid Drawdown From Spillway Crest	0.94	0.94
Rapid Drawdown From Max Surcharge	0.90	0.90

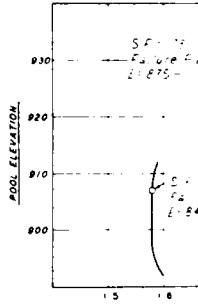
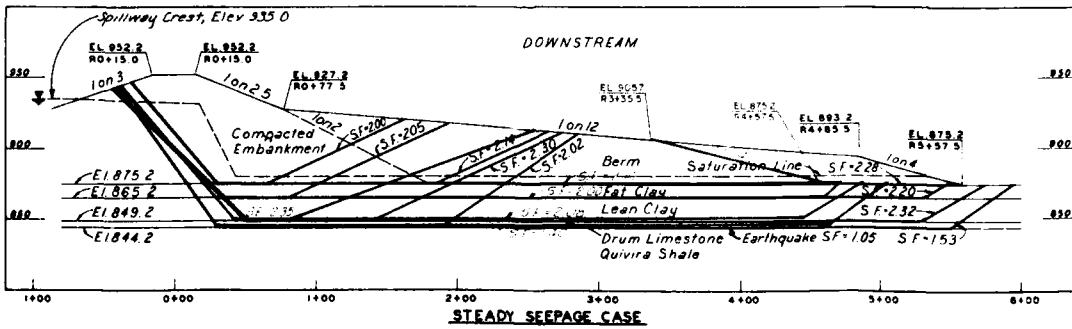
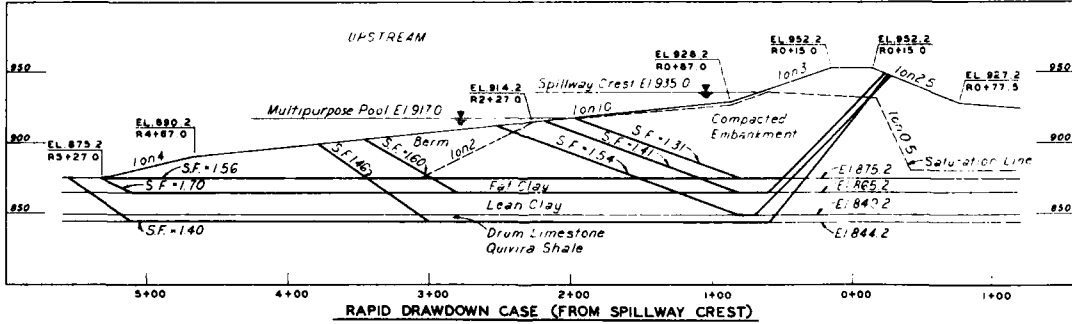
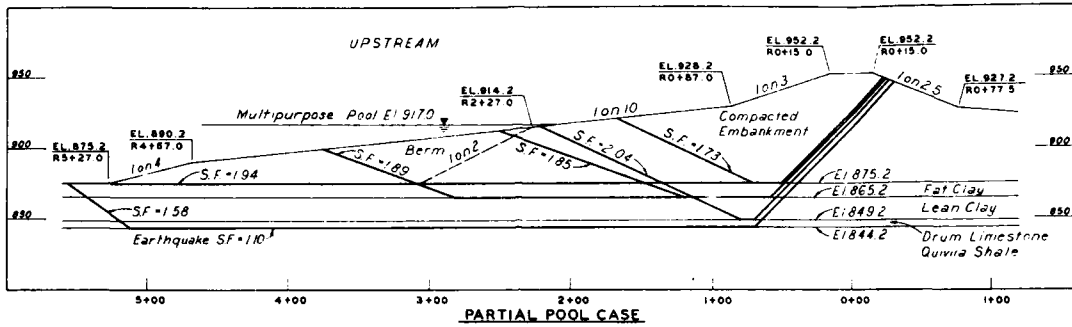
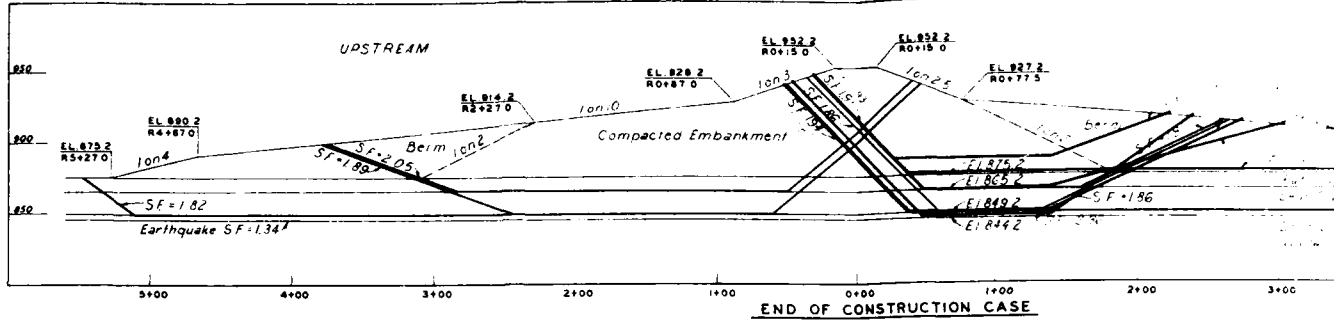
(1) RESIDUAL STRENGTHS WERE NOT USED FOR OVERBURDEN IN REVISED SECTION.

SYM.	DESCRIPTION REVISIONS	DATE	APPD.

**HILLSDALE LAKE**

**EMBANKMENT STABILITY ANALYSIS SUMMARY STATION 81+00**

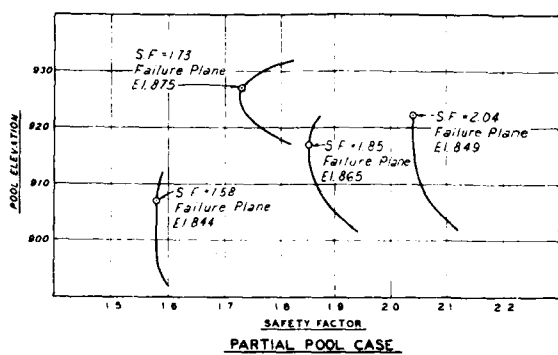
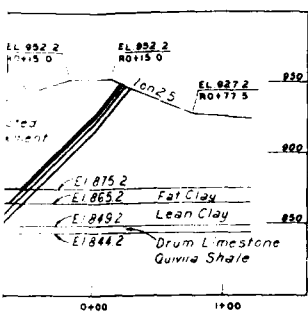
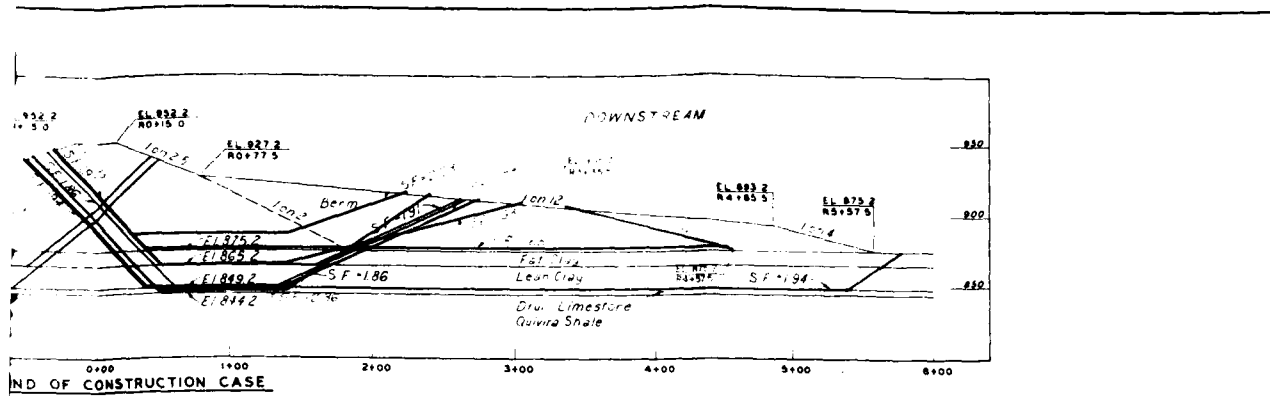
In 1 sheet  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT  
 2  
 Scale: as shown  
 U. S. ARMY  
 JANUARY 1978  
 GAD R.L.D. R.G.F. DM-7 O-15-678



RAPID DRAWDOWN		SAFETY	
EL. OF FAILURE PLANE	FROM SPILLWAY CREST		
875			
865	4		
849	54		
844	4		

CASE		SAFETY	
End of Construction			
Rapid Drawdown from Spillway Crest			
Rapid Drawdown from Max. Surge			
Partial Pool			
Steady Seepage			
Earthquake			

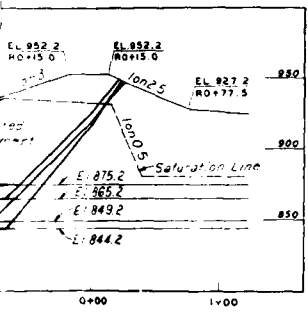
\* For Steady Seepage Case



STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN (1) AND SHALES

CASE	SAFETY FACTOR
Steady Seepage	1.05 (2)
Partial Pool	1.16
Rapid Drawdown from Spillway Crest	1.02
Rapid Drawdown from Maximum Surcharge	0.98

(1) RESIDUAL STRENGTHS WERE NOT USED FOR OVERBURDEN IN REVISED SECTION  
 (2) FOR REVISED SECTION, WHICH IS SAME AS STA 104+00, THE S.F. = 1.02

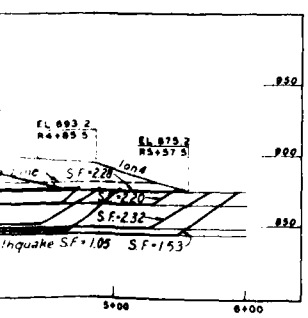


RAPID DRAWDOWN

EL. OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
875	1.31	1.23
865	1.41	1.34
849	1.54	1.48
844	1.40	1.36

PHYSICAL SOIL CONSTANTS

MATERIAL	UNIT WEIGHT P.C.F.		DESIGN SHEAR STRENGTHS							
	SAT.	DRAINED	TOP				B.P.			
			C (TSF)	TAN Ø	C (TSF)	TAN Ø	C (TSF)	TAN Ø		
Compacted Embankment	125	120	0.70	0.00	0.20	0.18	0.00	0.45		
Berm Fill	115	110	0.10	0.10	0.10	0.20	0.00	0.35		
Fdn Fat Clays	115	110	0.20	0.20	0.30	0.20	0.00	0.35		
Fdn Lean Clays	115	110	0.20	0.20	0.30	0.20	0.00	0.45		
Drum Limestone	165	—	—	—	—	—	0.00	0.70		
Quivira Underclay (Peak)	140	—	—	—	—	—	0.00	0.21		
Quivira Underclay (Residual)	140	—	—	—	—	—	0.00	0.13		



SAFETY FACTORS

CASE	REQUIRED	ACTUAL	REVISED SECTION
End of Construction	1.4	1.82	1.69
Rapid Drawdown from Spillway Crest	1.2	1.31	
Rapid Drawdown from Maximum Surcharge	1.0	1.23	
Partial Pool	1.5	1.58	
Steady Seepage	1.5	1.53	
Earthquake	1.0	1.05 *	

\* For Steady Seepage Case

SYM.	DESCRIPTION	DATE	APP'D.
	REVISIONS		

BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT STABILITY ANALYSIS SUMMARY  
 STATION 90+00

In 1 sheet  
 CORPS OF ENGINEERS  
 KANSAS CITY DISTRICT

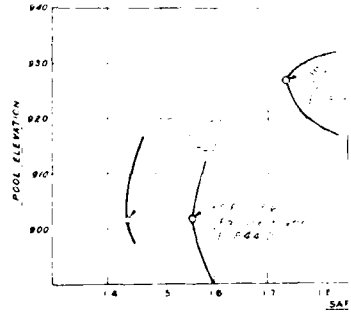
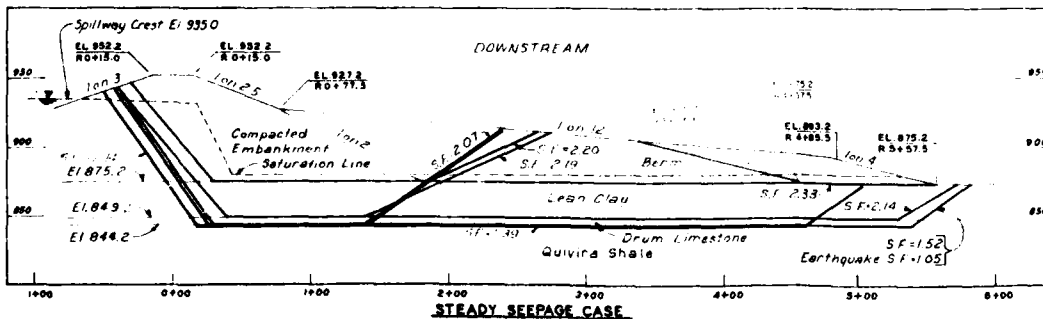
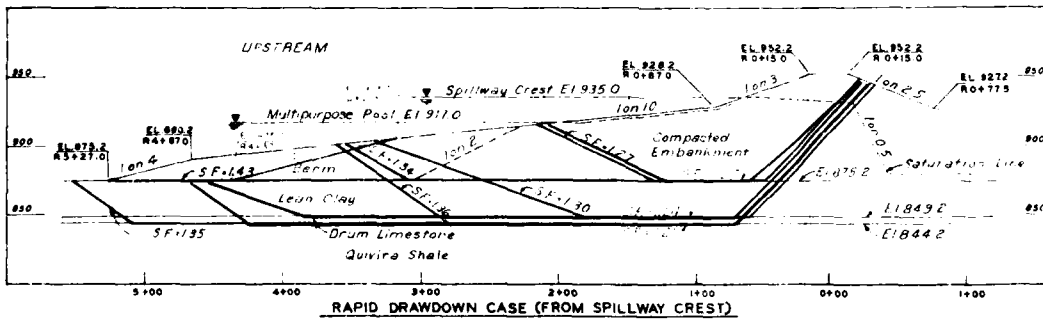
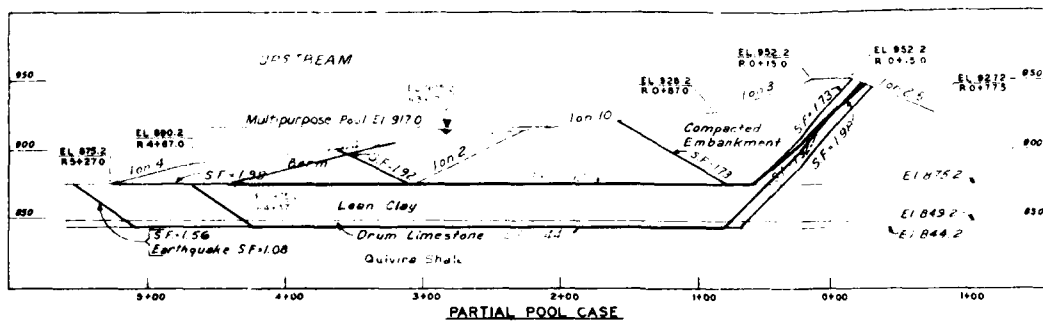
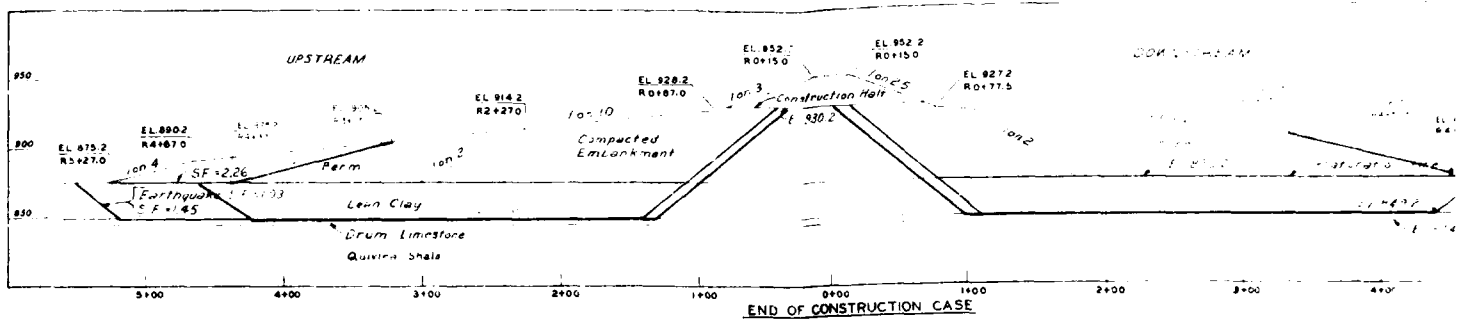
Supervised by: *[Signature]*  
 G.A.D.

Recommended by: *[Signature]*  
 R.L.D.

Approved by: *[Signature]*  
 R.G.F.

Scale: as shown  
 U.S. ARMY  
 JANUARY 1978

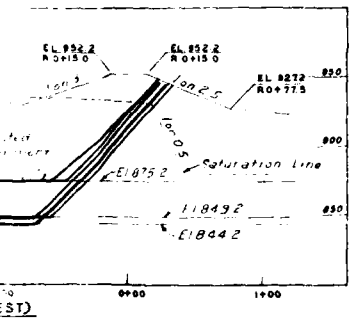
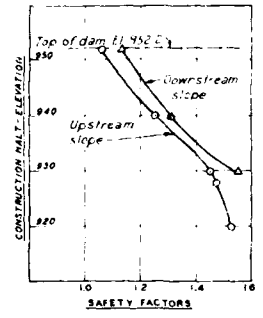
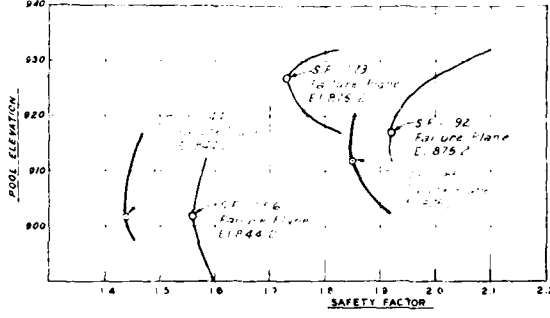
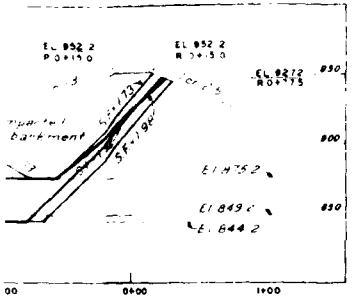
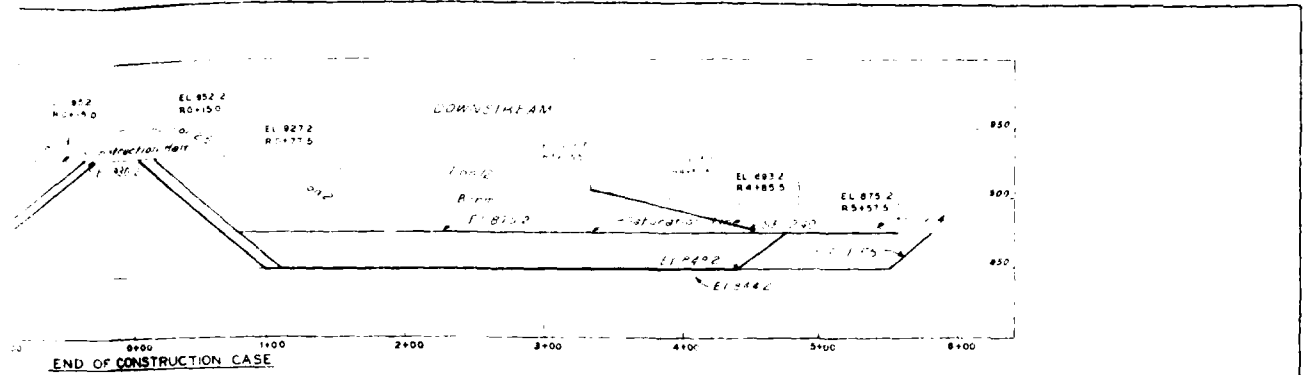
DM-7 O-15-676



EL. OF PA. OF PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MULTIPURPOSE POOL
875	1.43	1.05
849	1.30	1.05
844	1.31	1.05
817	1.43	1.05
812	1.43	1.05

CASE	SAFETY FACTORS	
	REQUIRED	ACTUAL
Construction from E. 935.0	1.4	1.43
Full pool drawdown from Spillway Crest	1.4	1.43
Rapid drawdown from Spillway Crest	1.4	1.43
Steady seepage	1.4	1.43
Earthquake	1.0	1.05

\* For Steady Seepage only



RAPID DRAWDOWN		
EL OF FAILURE PLANE	SAFETY FACTOR	
	FROM SPILLWAY CREST	FROM MAXIMUM SURCHARGE
875	1.27	1.23
849	1.30	
844	1.35	1.32
827		
821		
815		

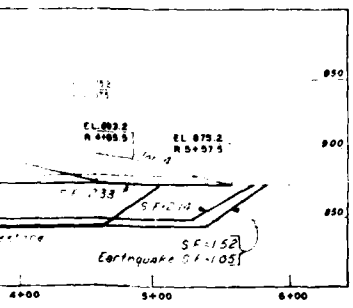
MATERIAL	UNIT WEIGHT P.C.F.	DESIGN SHEAR STRENGTHS							
		1/4"				1/8"			
		SAT	UNDRAINED	C (LBS/FT <sup>2</sup> )	TAN $\phi$	C (LBS/FT <sup>2</sup> )	TAN $\phi$	C (LBS/FT <sup>2</sup> )	TAN $\phi$
Compacted Embankment	125	120	700	000	200	180	000	450	
Barren Fill	115	110	100	000	100	200	000	350	
Little Bull Ebn Clays	115	110	100	100	100	200	000	450	
Drum Limestone	165							700	
Quivira Underclay (Peak)	140						000	210	
Quivira Underclay (Residual)	140						000		

STABILITY STUDIES USING RESIDUAL STRENGTHS FOR FOUNDATION OVERBURDEN AND SHALES		
CASE	SAFETY FACTOR	REVISED SECTION
Steady seepage	1.05	
Partial pool	1.13	
Rapid drawdown from spillway crest	1.01	
Rapid drawdown from maximum surcharge	0.97	

RESIDUAL STRENGTHS WERE NOT USED FOR OVERBURDEN IN REVISED SECTION

SAFETY FACTORS			
CASE	REQUIRED	ACTUAL	REVISED SECTION
Condition from Hilt F 9302	4	1.45	1.39
Rapid Drawdown from Spillway Crest	1.1	1.17	1.17
Rapid Drawdown from Maximum Surcharge	1.0	1.07	1.04
Partial Pool	1.5	1.46	1.50
Steady seepage	1.5	1.52	1.49
Earthquake	1.0	1.05	1.00

\* For Steady Seepage Case



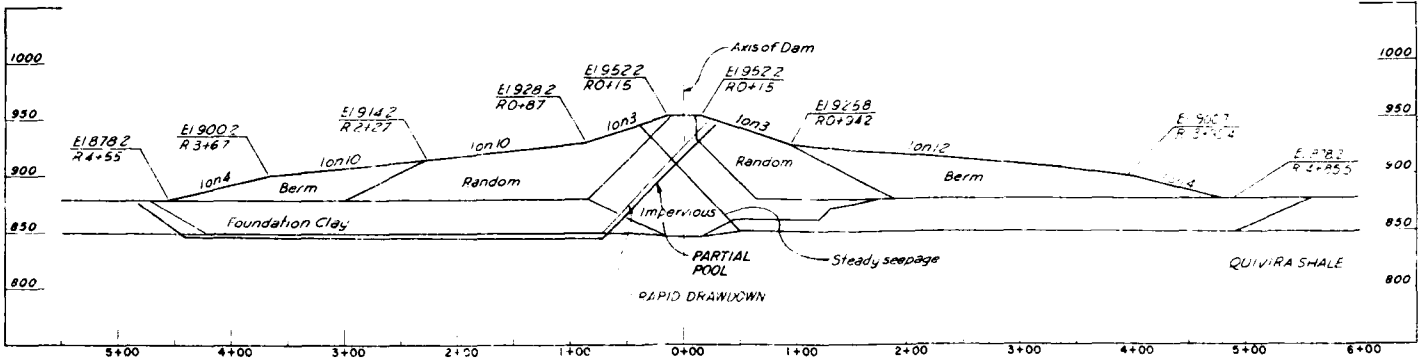
SYM DESCRIPTION REVISIONS DATE APP'D

### HILLSDALE LAKE

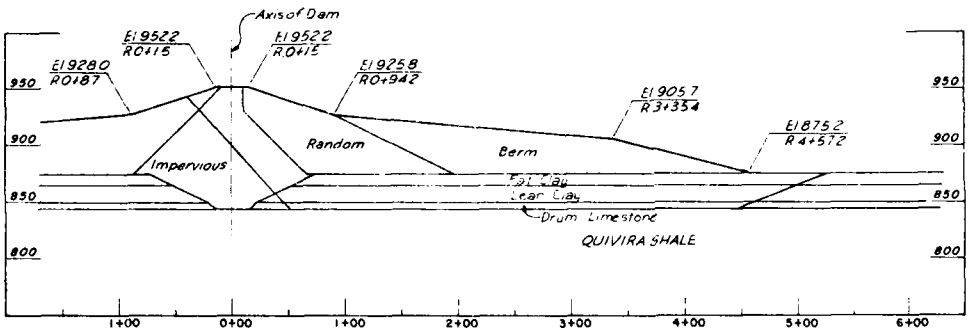
#### EMBANKMENT STABILITY ANALYSIS SUMMARY STATION 104+00

In 1 sheet  
CORPS OF ENGINEERS  
KANSAS CITY DISTRICT  
Submitted: [Signature]  
Reviewed: [Signature]  
Approved: [Signature]  
Checked by: GAD RLD RGF  
Scale: as shown  
U. S. ARMY  
JANUARY, 1978  
DM-7 O-15-677

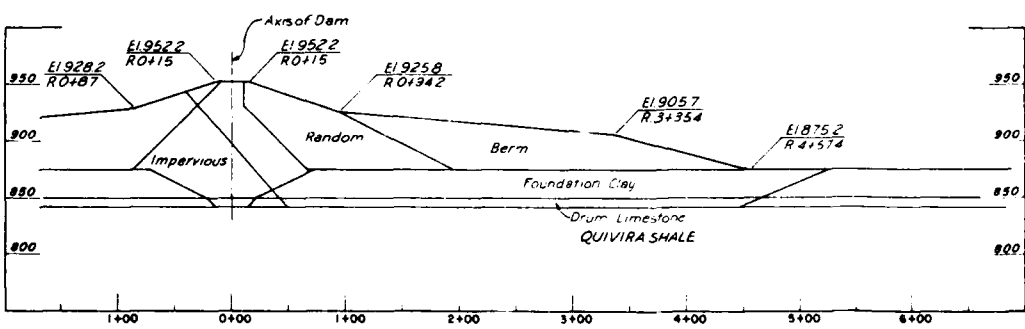
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929



STATION - 81+00  
LOWER RIGHT ABUTMENT



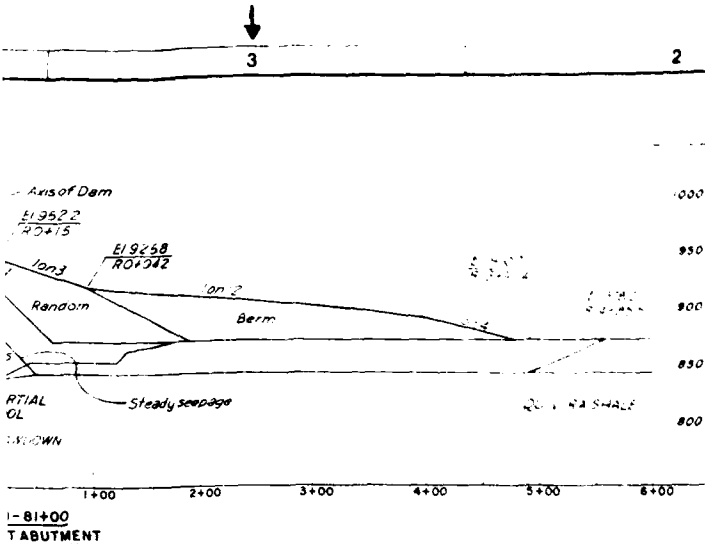
STATION - 90+00  
MAIN VALLEY



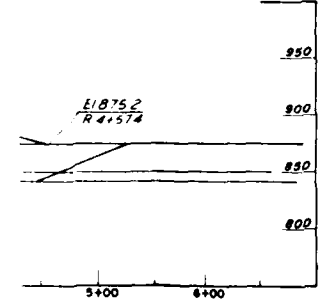
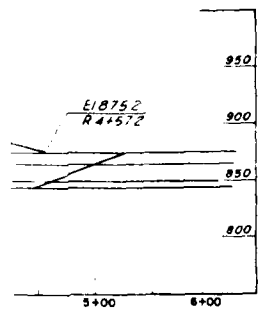
STATION - 104+00  
LITTLE BULL AREA

STABILITY STUDIES USING EMBANKMENT STRENGTHS FROM RECORD CONTROL TESTS AND DESIGN FOUNDATION STRENGTHS

CASE STUDY	SAFETY FACTOR REQUIRED	SAFETY FACTOR FROM STUDIES
RAPID DRAWDOWN FROM SPILLWAY CREST	1.2	1.39
RAPID DRAWDOWN FROM MAXIMUM SURCHARGE	1.0	1.30
PARTIAL POOL (STA 81+00)	1.5	1.54
STEADY SEEPAGE (STA 81+00)	1.5	1.13
STEADY SEEPAGE (STA 90+00)	1.5	1.15
STEADY SEEPAGE (STA 104+00)	1.5	1.15



1-81+00  
TABUTMENT



PHYSICAL SOIL CONSTANTS										
LOWER RIGHT ABUTMENT (STA 81+00)										
MATERIALS	UNIT WEIGHT		C		Tan $\phi$		C		Tan $\phi$	
	SAT	DRAINER	C	Tan $\phi$	C	Tan $\phi$	C	Tan $\phi$	C	Tan $\phi$
BERM	115	101	0.40	0.33	0.40	0.20	0.00	0.38		
RANDOM	125	120	0.45	0.00	0.48	0.22	0.00	0.48		
IMPERVIOUS	120	120	0.45	0.00	0.65	0.24	0.00	0.48		
FOUNDATION CLAY	115	110	0.25	0.20	0.30	0.20	0.00	0.48		
QUINIRA SHALE SEAM	140		0.90	0.00			0.00	0.2		
MAIN VALLEY (STA 90+00)										
BERM	115	110	0.40	0.33	0.40	0.20	0.00	0.38		
RANDOM	125	120	0.45	0.00	0.48	0.22	0.00	0.48		
IMPERVIOUS	120	120	0.45	0.00	0.65	0.22	0.00	0.48		
FOUNDATION CLAY (CH)	115	110	0.25	0.20	0.30	0.20	0.00	0.38		
FOUNDATION CLAY (CL)	115	110	0.20	0.20	0.30	0.20	0.00	0.48		
DRUM LIMESTONE	165						0.00	0.70		
QUINIRA SHALE SEAM	140						0.00	0.21		
LITTLE BULL AREA (STA 104+00)										
BERM	115	110	0.40	0.33	0.40	0.20	0.00	0.38		
RANDOM	125	120	0.45	0.00	0.48	0.22	0.00	0.47		
IMPERVIOUS	120	120	0.45	0.00	0.65	0.22	0.00	0.51		
FOUNDATION CLAY (CL)	115	110	0.20	0.20	0.30	0.20	0.00	0.48		
DRUM LIMESTONE	165						0.00	0.70		
QUINIRA SHALE SEAM	140						0.00	0.21		

\* QUINIRA SHALE STRENGTH REVISED TO C=0.00TSF AND TAN  $\phi$ =0.37 REPRESENTING A STRENGTH ENVELOPE EXCEEDED BY TWO-THIRDS OF THE DIRECT SHEAR TESTS

STABILITY STUDIES USING EMBANKMENT STRENGTHS FROM RECORD CONTROL TESTS AND DESIGN FOUNDATION STRENGTHS

CASE STUDY	SAFETY FACTOR REQUIRED	SAFETY FACTOR FROM STUDIES
RAPID DRAINDOWN FROM SPILLWAY CREST	1.2	1.39
RAPID DRAINDOWN FROM MAXIMUM SURCHARGE	1.0	1.30
PARTIAL POOL (STA. 81+00)	1.5	1.54
STEADY SEEPAGE (STA. 81+00)	1.5	1.13
STEADY SEEPAGE (STA. 90+00)	1.5	1.15
STEADY SEEPAGE (STA. 104+00)	1.5	1.15

STABILITY STUDIES USING EMBANKMENT STRENGTHS FROM RECORD CONTROL TESTS AND REVISED FOUNDATION STRENGTHS

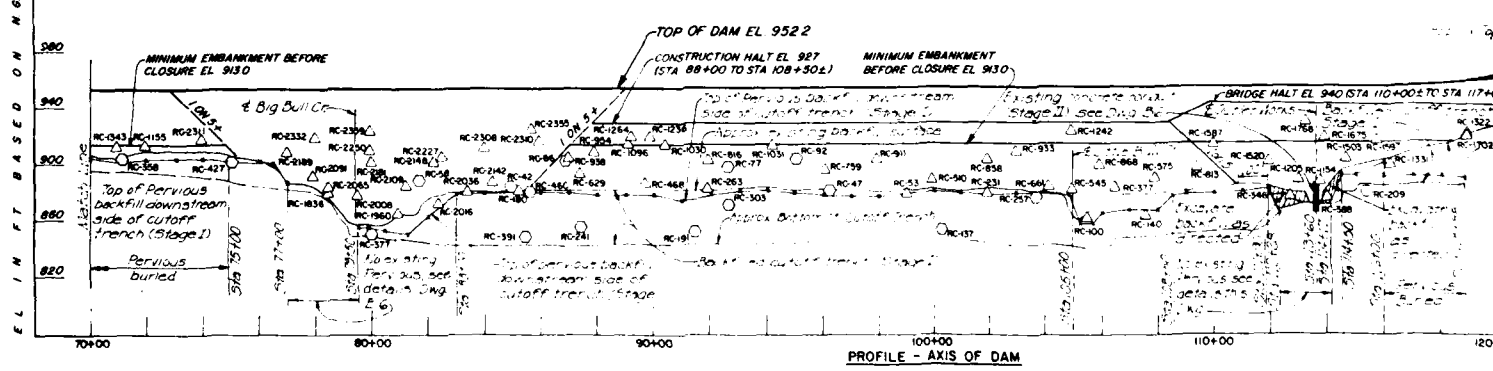
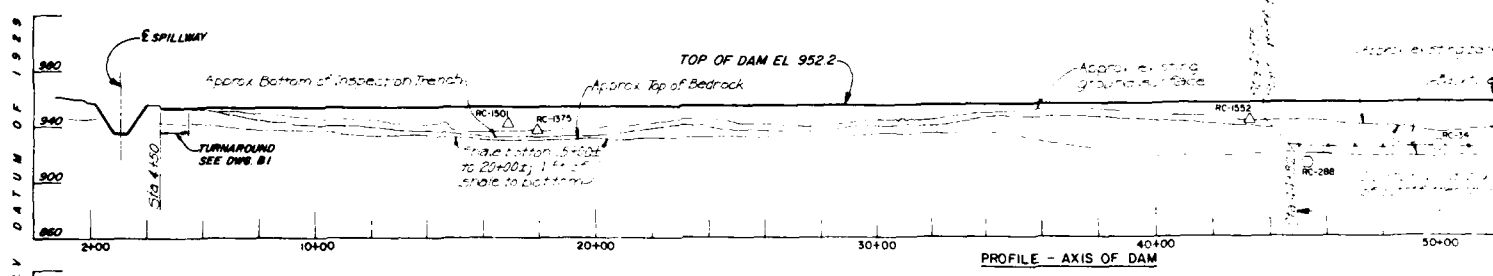
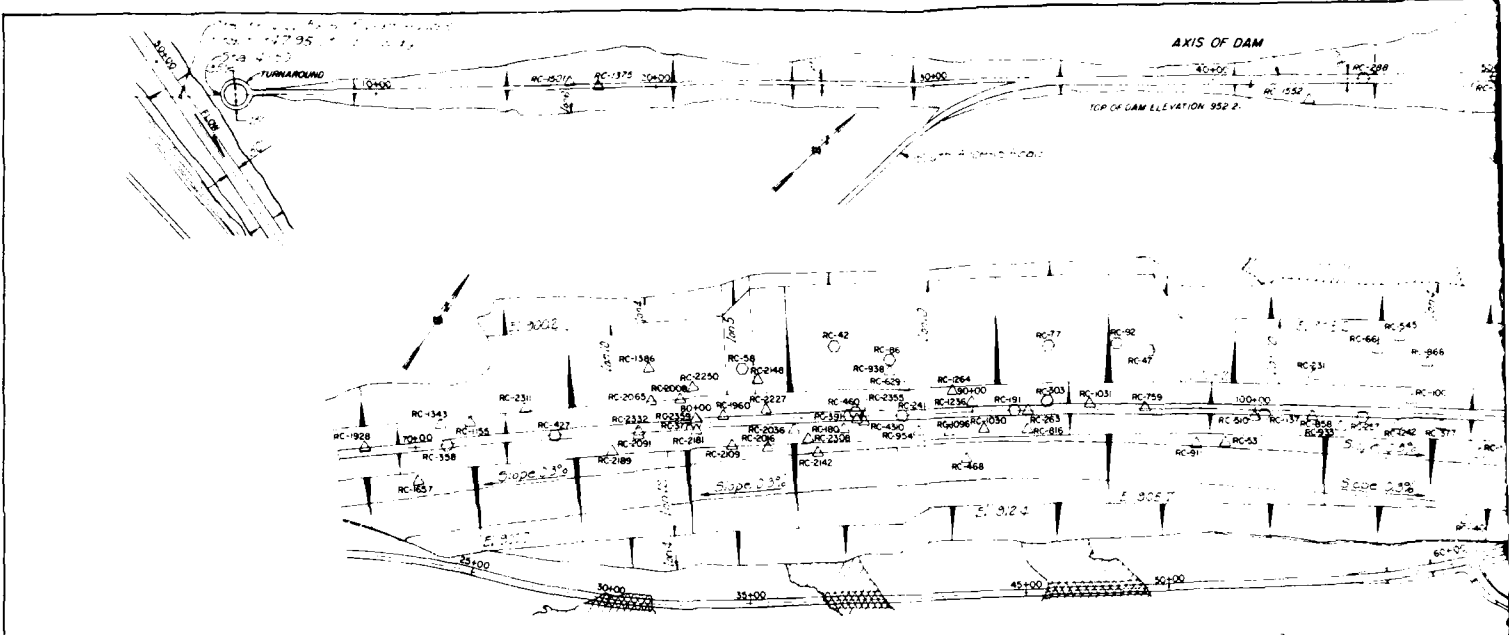
CASE STUDY	SAFETY FACTOR REQUIRED	SAFETY FACTOR FROM STUDIES
RAPID DRAINDOWN FROM SPILLWAY CREST	1.2	2.00
RAPID DRAINDOWN FROM MAXIMUM SURCHARGE	1.0	1.90
PARTIAL POOL (STA. 81+00)	1.5	2.17
STEADY SEEPAGE (STA. 81+00)	1.5	1.63
STEADY SEEPAGE (STA. 90+00)	1.5	1.64
STEADY SEEPAGE (STA. 104+00)	1.5	1.64

Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI

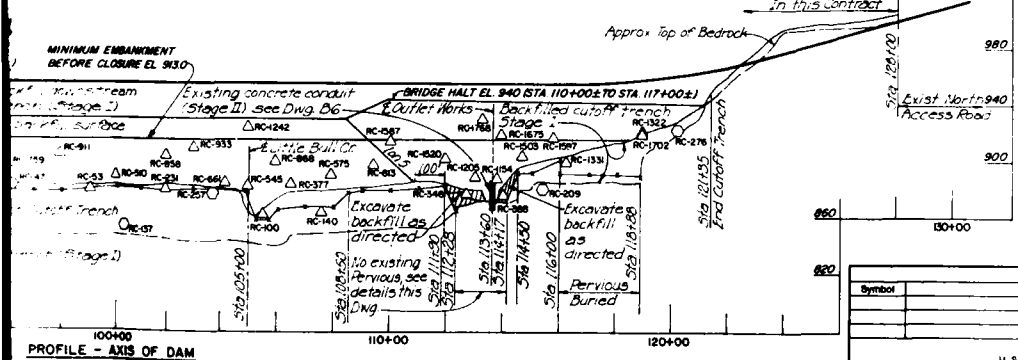
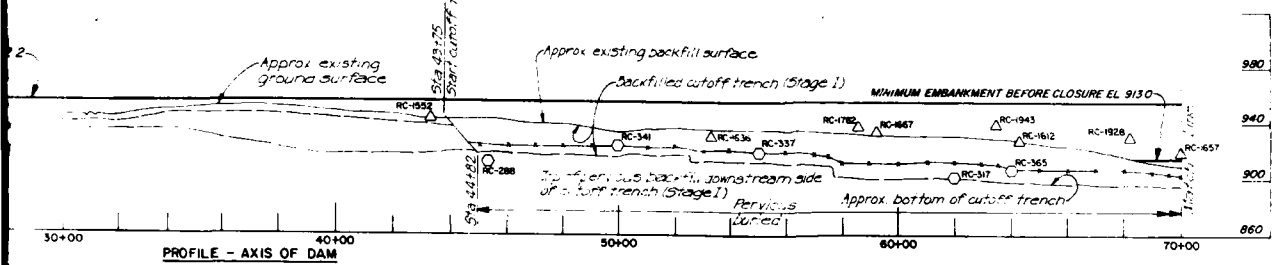
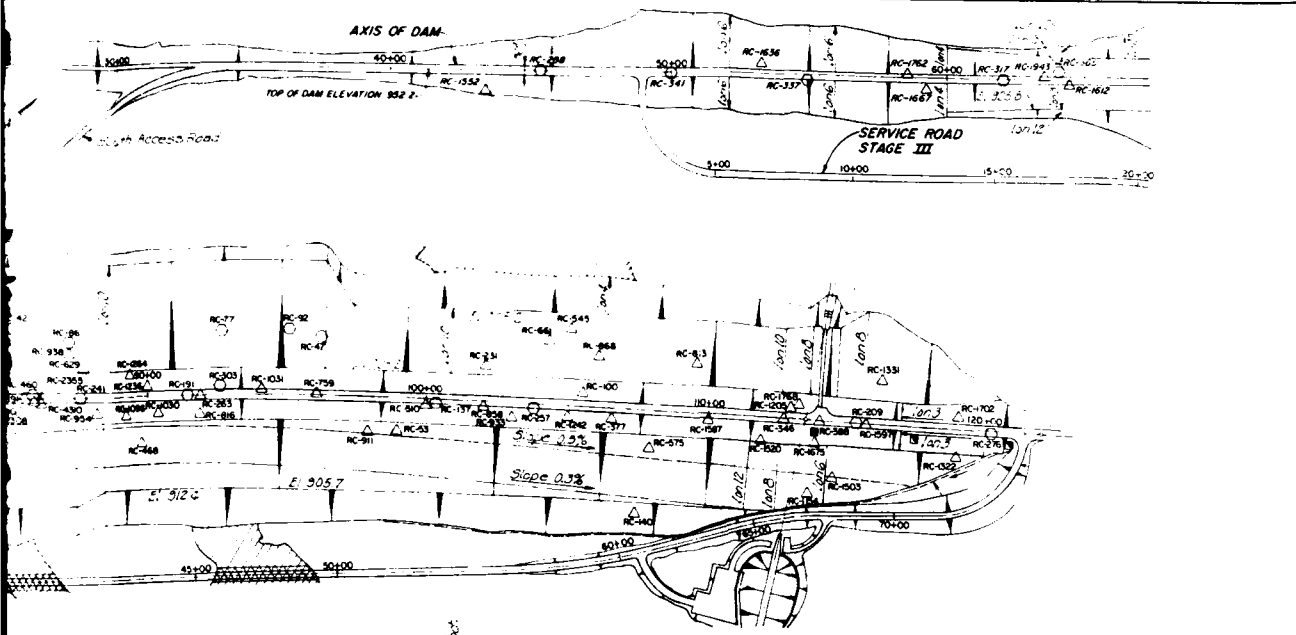
Designed by: BIG BULL CREEK, KANSAS  
HILLSDALE LAKE  
EMBANKMENT CRITERIA REPORT

Drawn by:   
Checked by:   
Submitted by:   
Date: SEPTEMBER 1964  
Sheet number: 1 of 1  
File No. 0-15-1062



**LEGEND**  
 ○ - STAGE I RECORD CONTROL POINT  
 △ - STAGE III RECORD CONTROL POINT





**LEGEND**  
 ○ - STAGE I RECORD CONTROL SAMPLE LOCATION  
 △ - STAGE III RECORD CONTROL SAMPLE LOCATION

Revisions

Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT  
 CORPS OF ENGINEERS  
 KANSAS CITY, MISSOURI

Designed by: \_\_\_\_\_  
 Drawn by: \_\_\_\_\_  
 Checked by: \_\_\_\_\_  
 Submitted by: \_\_\_\_\_

**BIG BULL CREEK, KANSAS  
 HILLSDALE LAKE  
 EMBANKMENT CRITERIA REPORT**

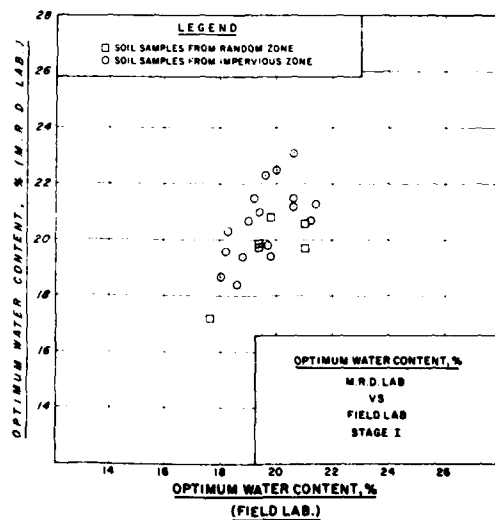
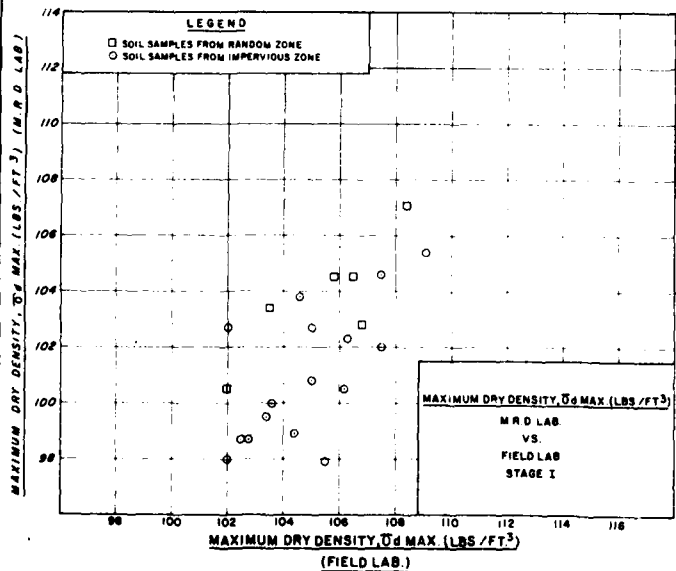
EMBANKMENT CRITERIA AND PERFORMANCE  
 REPORT EMBANKMENT PLAN AND PROFILE  
 RECORD CONTROL SAMPLE LOCATIONS

Scale: \_\_\_\_\_ Sheet number: \_\_\_\_\_  
 Date: SEPTEMBER 1964 1 of 1  
 Draw no: \_\_\_\_\_ File no: 0-15-1063

RECORD CONTROL SAMPLE					SOIL CLASSIFICATION DATA									STANDARD COMPACTION TEST				DENSITY AND MO			
					FIELD			M. R. D. LABORATORY						FIELD		M. R. D. LAB.		SAND CONE DATA			
					NUMBER	STATION	RANGE	ELEVATION	ZONE	LL	PI	CLASS	TRIAxIAL TEST SPECIMEN			COMPACTION TEST SPECIMEN			MAX DRY DENSITY (PCF)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (PCF)
RC-42	85+00	2+55U/S	884.0	RANDOM	46	28	CL	52	34	CH	45	30	CL	106.8	19.8	102.8	20.8	107.2	100.4	20.8	+1.0
RC-47	96+30	2+06U/S	881.0	RANDOM	44	26	CL	45	23	CL	42	26	CL	105.8	21.0	104.5	19.7	103.3	97.6	21.6	+0.6
RC-58	80+10	1+85U/S	888.0	RANDOM	48	30	CL	46	31	CL	45	29	CL	104.5	19.4	104.5	19.9	105.9	101.3	20.5	+1.1
RC-77	92+70	2+30U/S	898.0	RANDOM	40	22	CL	48	26	CL	39	23	CL	108.4	17.6	107.1	17.2	107.5	99.2	17.3	-0.3
RC-86	86+95	2+00U/S	902.0	RANDOM	54	34	CH	54	31	CH	49	32	CL	102.0	21.0	100.5	20.6	105.8	103.7	18.6	-2.4
RC-92	95+10	2+35U/S	904.0	RANDOM	51	34	CH	51	30	CH	48	30	CL	103.5	19.4	103.4	19.8	103.0	99.5	22.1	+2.7
RC-137	100+30	0+13D/S	853.0	IMP.	41	22	CL	44	26	CL	41	23	CL	104.6	19.7	103.8	19.8	103.4	98.9	22.1	+2.4
RC-191	91+50	0+06U/S	852.0	IMP.	46	31	CL	49	31	CL	43	26	CL	106.4	18.8	105.1	19.4	103.5	97.3	21.5	+2.7
RC-209	115+40	℄	880.0	IMP.	58	40	CH	59	39	CH	50	35	CH	102.0	21.2	98.0	20.7	98.4	96.5	24.5	+3.3
RC-241	87+40	0+50U/S	855.0	IMP.	43	28	CL				38	27	CL	109.1	18.0	105.4	18.7	107.3	98.4	15.9	-2.1
RC-257	103+75	0+15D/S	876.0	IMP.	43	27	CL	45	26	CL	36	24	CL	107.5	18.2	102.0	19.6	107.1	99.6	19.5	+1.3
RC-276	120+20	0+06D/S	922.0	IMP.	51	34	CH	61	43	CH	47	30	CL	102.0	21.4	102.7	21.3	97.6	95.7	21.8	+0.4
RC-288	45+35	0+05U/S	913.0	IMP.	48	31	CL	51	33	CH	50	33	CH	103.4	20.6	99.5	21.2	102.5	99.1	18.8	-1.8
RC-303	92+68	0+30U/S	871.0	IMP.	51	33	CH	60	44	CH	51	35	CH	105.0	19.2	100.8	21.5	103.3	98.4	19.9	+0.7
RC-317	62+00	℄	902.0	IMP.	45	26	CL	54	37	CH	45	28	CL	105.0	19.8	102.7	19.4	101.8	97.0	19.6	-0.2
RC-337	55+00	0+12D/S	920.0	IMP.	54	36	CH	70	52	CH	61	44	CH	104.4	20.6	98.9	23.1	103.1	98.7	22.6	+2.0
RC-341	50+00	℄	925.0	IMP.	53	34	CH	65	48	CH	55	38	CH	105.5	19.4	97.9	21.0	104.4	98.9	22.4	+3.0
RC-358	71+10	℄	904.0	IMP.	44	25	CL	54	37	CH	39	26	CL	106.3	18.3	102.3	20.3	105.3	99.1	20.9	+2.6
RC-365	64+00	0+30U/S	908.0	IMP.	53	33	CH	58	41	CH	56	39	CH	102.8	20.0	98.7	22.5	104.8	101.9	21.8	+1.8
RC-377	80+00	0+06U/S	850.0	IMP.	50	31	CL	59	44	CH	52	35	CH	103.6	20.6	100.0	21.5	101.2	97.7	22.2	+1.6
RC-391	85+50	℄	849.0	IMP.	49		CL	59	43	CH	53	35	CH	102.5	19.6	98.7	22.3	103.0	100.5	20.0	+0.4
RC-427	75+00	℄	903.0	IMP.	50		CH	61	45	CH	51	34	CH	106.2	19.0	100.5	20.7	107.0	100.8	20.9	+1.9
RC-460	85+67	0+14U/S	881.0	IMP.	45	30	CL	51	34	CH	47	32	CL	107.5	18.6	104.6	18.4	109.1	101.4	19.7	+1.7

\* UNDISTURBED DATA OBTAINED BY AVERAGING MOISTURE AND DENSITY VALUES OF TRIAXIAL TEST SPECIMENS

### STAGE I RECORD CONTROL SUMMARY





RECORD CONTROL SAMPLE					SOIL CLASSIFICATION DATA									STANDARD COMPACTION TEST				DENSITY AND MO			
					FIELD			M.R.D. LABORATORY						FIELD		M.R.D. LAB		SAND CONE DATA			
NUMBER	STATION	RANGE	ELEVATION	ZONE	TRIAXIAL TEST SPECIMEN			COMPACTION TEST SPECIMEN			MAX. DRY DENSITY (PCF)	OPT. MOIST CONTENT (%)	MAX. DRY DENSITY (PCF)	OPT. MOIST CONTENT (%)	DRY DENSITY (PCF)	COM. PACTION (%)	WATER CONTENT (%)	WATER CONTENT (% OPT)			
					LL	PI	CLASS	LL	PI	CLASS									LL	PI	CLASS
RC-1501	17+00	0+15U/S	941.0	IMP	74	52	CH	70	50	CH	83	65	CH	95.0	24.8	93.3	24.8	98.8	104.0	25.2	+0.4
RC-1503	114+65	2+00D/S	901.5	IMP	37	21	CL	36	20	CL	35	18	CL	112.2	15.5	111.7	15.3	110.8	98.7	17.4	+1.9
RC-1520	112+00	0+80D/S	901.0	IMP	35	21	CL	36	21	CL	40	28	CL	112.2	15.6	112.5	15.6	110.6	98.6	17.6	+2.0
RC-1552	43+40	0+70D/S	943.0	IMP	57	36	CH	64	50	CH	62	47	CH	101.0	21.2	101.8	20.2	102.2	101.1	21.8	+0.6
RC-1587	110+00	0+20D/S	912.6	IMP	30	15	CL	29	15	CL	30	16	CL	116.3	13.4	114.8	13.7	116.8	100.4	14.8	+1.4
RC-1597	115+75	0+50D/S	914.5	IMP	28	14	CL	31	15	CL	30	16	CL	116.7	13.7	117.4	12.7	103.7	97.4	14.2	+0.5
RC-1612	64+30	0+18D/S	927.5	IMP	46	29	CL	52	37	CH	54	37	CH	104.2	18.8	104.8	19.5	106.9	102.6	20.1	+1.3
RC-1636	53+30	0+35U/S	930.0	IMP	54	33	CH	59	44	CH	62	46	CH	101.6	21.1	101.5	21.1	103.2	101.6	21.4	+0.3
RC-1657	70+00	1+20D/S	920.0	RANDOM	49	31	CL	56	42	CH	55	41	CH	103.5	19.9	101.4	20.7	100.8	97.4	23.4	+3.5
RC-1667	59+30	0+40D/S	934.0	IMP	46	29	CL	59	45	CH	49	36	CL	107.3	18.0	107.1	18.2	111.8	104.2	16.6	-1.4
RC-1675	114+00	0+80D/S	917.0	IMP	43	28	CL	51	38	CH	47	35	CL	109.4	16.0	109.5	16.3	108.4	99.0	18.6	+2.6
RC-1702	119+00	0+45U/S	920.0	RANDOM	41	23	CL	52	38	CH	43	29	CL	106.9	17.3	106.7	19.4	110.0	102.8	17.2	-0.1
RC-1762	58+60	0+15U/S	937.0	IMP	40	25	CL	42	30	CL	36	21	CL	110.7	16.2	113.2	14.6	114.0	103.0	15.2	-1.0
RC-1768	113+30	0+55U/S	929.5	IMP	39	20	CL	42	28	CL	36	18	CL	107.1	16.8	109.2	16.3	106.8	99.8	18.3	+1.5
RC-1836	78+50	2+10U/S	879.0	IMP	56	38	CH	67	53	CH	57	43	CH	104.0	20.2	102.0	20.1	106.4	101.4	19.6	-0.6
RC-1928	68+20	0+20U/S	931.0	IMP	32	18	CL	38	28	CL	33	22	CL	114.3	14.4	114.7	14.7	120.0	105.0	12.0	-2.4
RC-1943	63+50	0+12U/S	940.0	IMP	54	35	CH	66	51	CH	55	40	CH	103.2	20.4	101.4	22.7	107.2	104.0	19.7	+0.7
RC-1960	81+00	0+20U/S	864.6	IMP	40	23	CL	53	38	CH	39	25	CL	108.6	17.5	107.7	17.8	108.0	99.5	18.6	+1.1
RC-2008	79+50	0+90U/S	877.8	RANDOM	41	25	CL	54	40	CH	45	31	CL	108.3	17.2	107.3	18.7	110.2	101.8	18.7	+1.5
RC-2016	82+50	1+00D/S	871.5	RANDOM	43	28	CL	54	43	CH	44	30	CL	111.0	16.1	108.4	18.0	110.2	99.3	17.2	+1.1
RC-2036	83+45	0+37D/S	880.0	IMP	37	21	CL	37	21	CL	36	22	CL	110.1	16.1	109.1	17.0	111.4	101.1	17.9	+1.8
RC-2065	78+50	0+90U/S	884.0	RANDOM	50	33	CH	60	47	CH	51	37	CH	105.0	19.0	106.3	18.5	111.4	106.0	17.2	-1.8
RC-2091	78+00	0+30D/S	891.5	IMP	34	20	CL	30	17	CL	33	22	CL	113.0	15.5	112.3	15.7	113.1	100.0	15.4	-0.1
RC-2109	81+25	0+85D/S	884.0	RANDOM	49	32	CL	47	32	CL	48	34	CL	107.0	18.8	104.3	20.0	107.6	100.6	20.1	+1.3
RC-2142	84+30	1+25D/S	887.5	RANDOM	70	50	CH	75	58	CH	75	58	CH	96.6	23.7	92.8	24.2	99.0	102.6	23.8	+0.1
RC-2148	82+25	1+45U/S	901.0	RANDOM	46	30	CL	51	38	CH	49	34	CL	105.9	19.0	103.9	19.3	104.5	98.7	21.0	+2.0
RC-2181	80+00	0+25D/S	902.0	IMP	50	34	CL	53	35	CH	53	39	CH	106.8	18.9	106.3	19.4	101.4	94.9	19.0	+0.1
RC-2189	77+00	0+75D/S	908.0	RANDOM	57	41	CH	61	41	CH	32	14	CL	103.8	20.7	100.3	22.0	106.0	102.1	21.0	+0.3
RC-2227	82+50	0+35U/S	905.0	IMP	57	40	CH	48	33	CL	59	46	CH	102.6	20.3	100.8	20.8	101.5	98.9	19.2	-1.1
RC-2250	80+00	1+25U/S	910.0	RANDOM	59	41	CH	53	37	CH	59	45	CH	100.0	21.8	102.3	22.2	103.5	103.5	19.7	-2.1

**STAGE III RECORD CONTROL SUMMARY**

		STANDARD COMPACTION TEST				DENSITY AND MOISTURE CONTENT								
LABORATORY		FIELD		M.R.D. LAB		SAND CONE DATA				UNDISTURBED DATA				
NO.	COMPACTION TEST SPECIMEN	CLASS	MAX. DRY DENSITY (PCF)	OPT. MOIST CONTENT (%)	MAX DRY DENSITY (PCF)	OPT. MOIST CONTENT (%)	DRY DENSITY (PCF)	COM-PACTION (%)	WATER CONTENT (%)	WATER CONTENT (% OPT)	DRY DENSITY (PCF)	COM-PACTION (%)	WATER CONTENT (%)	WATER CONTENT (% OPT)
3	65	CH	95.0	24.8	93.3	24.8	98.8	104.0	25.2	+0.4	96.8	101.9	25.8	+1.0
9	18	CL	112.2	15.5	111.7	15.3	110.8	98.7	17.4	+1.9	108.8	97.0	17.7	+2.2
0	28	CL	112.2	15.6	112.5	15.6	110.6	98.6	17.6	+2.0	110.6	98.6	15.9	+0.3
2	47	CH	101.0	21.2	101.8	20.2	102.2	101.1	21.8	+0.6	100.4	99.4	22.4	+1.2
3	16	CL	116.3	13.4	114.8	13.7	116.8	100.4	14.8	+1.4	115.1	99.0	15.5	+2.1
4	16	CL	116.7	13.7	117.4	12.7	103.7	97.4	14.2	+0.5	112.7	96.6	15.6	+1.9
5	37	CH	104.2	18.8	104.8	19.5	106.9	102.6	20.1	+1.3	102.9	98.8	21.3	+2.5
6	46	CH	101.6	21.1	101.5	21.1	103.2	101.6	21.4	+0.3	105.5	103.8	21.6	+0.5
7	41	CH	103.5	19.9	101.4	20.7	100.8	97.4	23.4	+3.5	100.0	96.3	22.2	+2.3
8	36	CL	107.3	18.0	107.1	18.2	111.8	104.2	16.6	-1.4	107.4	100.0	21.1	+3.1
9	35	CL	109.4	16.0	109.5	16.3	108.4	99.0	18.6	+2.6	105.3	96.3	19.8	+3.8
0	29	CL	106.9	17.3	106.7	19.4	110.0	102.8	17.2	-0.1	111.3	104.1	17.0	-0.3
1	21	CL	110.7	16.2	113.2	14.6	114.0	103.0	15.2	-1.0	110.0	99.4	14.8	-1.4
2	18	CL	107.1	16.8	109.2	16.3	106.8	99.8	18.3	+1.5	105.4	98.4	18.7	+1.9
3	43	CH	104.0	20.2	102.0	20.1	106.4	101.4	19.6	-0.6	102.8	98.8	21.3	+1.1
4	22	CL	114.3	14.4	114.7	14.7	120.0	105.0	12.0	-2.4	116.6	102.0	12.6	-1.8
5	40	CH	103.2	20.4	101.4	22.7	107.2	104.0	19.7	+0.7	103.4	100.2	21.4	+1.0
6	25	CL	108.6	17.5	107.7	17.8	108.0	99.5	18.6	+1.1	103.1	94.9	20.2	+2.7
7	31	CL	108.3	17.2	107.3	18.7	110.2	101.8	18.7	+1.5	107.5	99.3	19.8	+2.6
8	30	CL	111.0	16.1	108.4	18.0	110.2	99.3	17.2	+1.1	107.2	96.6	19.6	+3.5
9	22	CL	110.1	16.1	109.1	17.0	111.4	101.1	17.9	+1.8	109.8	99.7	18.3	+2.2
0	37	CH	105.0	19.0	106.3	18.5	111.4	106.0	17.2	-1.8	107.4	102.3	19.0	+0.0
1	22	CL	113.0	15.5	112.3	15.7	113.1	100.0	15.4	-0.1	113.4	100.4	15.0	-0.5
2	34	CL	107.0	18.8	104.3	20.0	107.6	100.6	20.1	+1.3	110.7	103.5	20.4	+1.6
3	58	CH	96.6	23.7	92.8	24.2	99.0	102.6	23.8	+0.1	96.8	100.2	24.9	+1.2
4	34	CL	105.9	19.0	103.9	19.3	104.5	98.7	21.0	+2.0	100.8	95.2	21.6	+2.6
5	39	CH	106.8	18.9	106.3	19.4	101.4	94.9	19.0	+0.1	103.3	96.7	20.9	+2.0
6	14	CL	103.8	20.7	100.3	22.0	106.0	102.1	21.0	+0.3	101.1	97.4	22.7	+2.0
7	46	CH	102.6	20.3	100.8	20.8	101.5	98.9	19.2	-1.1	101.6	99.0	21.6	+1.3
8	45	CH	100.0	21.8	102.3	22.2	103.5	103.5	19.7	-2.1	102.8	102.8	18.7	-3.1

**RECORD CONTROL SUMMARY**


Revisions		Date		Approved	
Symbol	Descriptions				
U S ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI					
Designed by:	BIG BULL CREEK, KANSAS HILLSDALE LAKE EMBANKMENT CRITERIA REPORT				
Drawn by:	RECORD CONTROL DATA - STAGE III STANDARD COMPACTION TEST LABORATORY VS FIELD				
Checked by:	Date	Sheet number			
Submitted by:	SEPTEMBER 1964	1 of 5	FORM NO. 0-15-1065		
PLATE NO 71					

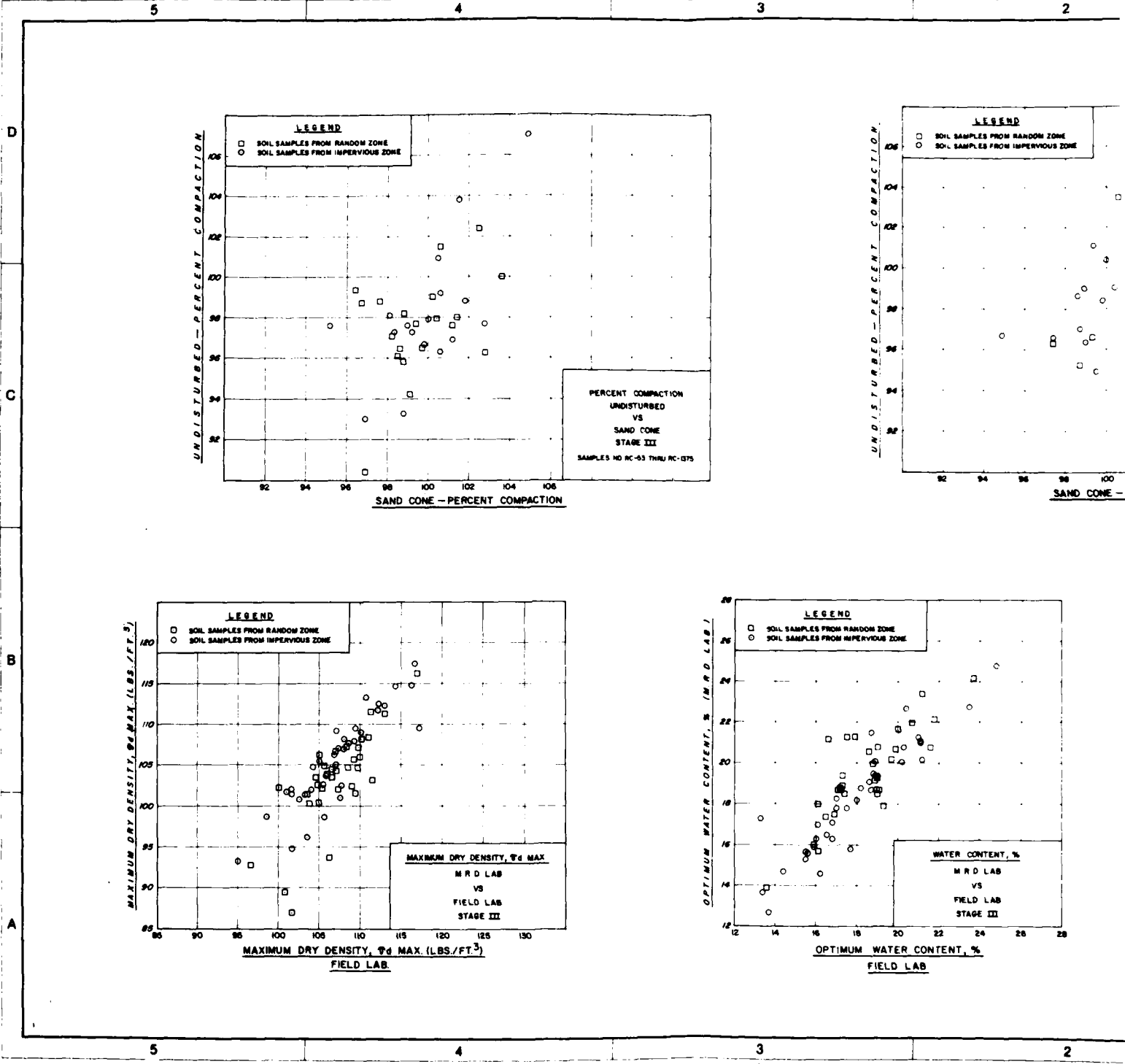
RECORD CONTROL SAMPLE					SOIL CLASSIFICATION DATA									STANDARD COMPACTION TEST				DENSITY AND MOISTURE					
NUMBER	STATION	RANGE	ELEVATION	ZONE	FIELD			M.R.D. LABORATORY						FIELD		M.R.D. LAB.		SAND CONE DATA					
					LL	PI	CLASS	TRIAxIAL TEST SPECIMEN			COMPACTION TEST SPECIMEN			MAX DRY DENSITY (PCF)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (PCF)	OPT MOIST CONTENT (%)	DRY DENSITY (PCF)	COMPACTION (%)	WATER CONTENT (%)	WATER CONTENT (%OPT)	DRY DENSITY (PCF)	
								LL	PI	CLASS	LL	PI	CLASS										LL
RC-53	99+00	1+150/S	878.0	RANDOM	53	32	CH	53	35	CH	51	32	CH	105.0	20.0	100.4	21.7	103.8	98.8	19.7	-0.3	100.6	
RC-100	105+30	0+80U/S	862.0	IMP	53	31	CH	58	38	CH	51	34	CH	101.6	21.1	102.1	21.0	102.1	100.5	23.1	+2.0	102.1	
RC-140	107+60	3+70D/S	863.0	RANDOM	44	24	CL	49	32	CL	44	26	CL	105.3	19.7	102.2	19.7	107.9	102.5	20.4	+0.7	107.8	
RC-180	85+25	0+45D/S	881.0	IMP	47	28	CL	52	34	CH	49	30	CL	105.0	19.0	105.5	19.0	104.9	104.8	18.2	-0.8	112.3	
RC-231	102+00	1+25D/S	879.0	RANDOM	49	30	CL	53	37	CH	44	28	CL	104.5	19.7	103.5	19.7	104.9	100.4	21.3	+1.6	102.1	
RC-263	92+00	ε	882.0	IMP	48	28	CL	54	37	CH	45	27	CL	105.8	18.9	103.7	18.9	110.1	100.6	20.7	+1.8	101.9	
RC-346	112+75	ε	876.7	IMP	43	26	CL	53	37	CH	51	34	CH	105.5	18.2	102.7	18.2	103.7	99.2	19.8	+1.6	102.7	
RC-377	106+60	0+35D/S	883.0	IMP	56	37	CH	52	36	CH	55	36	CH	101.6	21.0	94.8	21.0	101.4	99.8	23.4	+2.4	98.2	
RC-388	114+50	ε	875.0	IMP	38	18	CL	36	20	CL	37	20	CL	107.6	17.0	101.0	17.0	105.9	101.8	18.6	+1.6	106.1	
RC-468	89+80	1+70D/S	886.0	RANDOM	53	33	CH	55	38	CH	54	36	CH	101.6	21.6	87.0	21.6	100.7	99.1	24.9	+3.3	95.7	
RC-510	100+00	0+26D/S	888.0	IMP	42	26	CL	39	25	CL	46	33	CL	107.0	18.7	105.1	18.7	107.7	100.6	18.8	+0.1	106.1	
RC-545	108+00	2+75U/S	881.3	RANDOM	41	24	CL	40	26	CL	42	30	CL	109.8	16.9	107.2	16.9	113.8	103.6	18.5	+1.6	109.8	
RC-575	108+00	1+35D/S	890.0	RANDOM	42	25	CL	42	27	CL	50	35	CH	105.6	18.9	105.0	18.9	107.0	101.4	19.3	+0.4	103.5	
RC-629	87+50	1+00D/S	893.0	RANDOM	47	30	CL	52	36	CH	52	36	CH	106.2	19.1	93.7	19.1	104.2	98.2	19.0	-0.1	103.1	
RC-661	104+20	2+25U/S	884.0	RANDOM	43	27	CL	50	35	CH	46	30	CL	109.4	17.9	101.6	17.9	109.6	100.2	18.5	+0.6	108.3	
RC-759	96+15	0+05U/S	896.0	IMP	42	26	CL	48	31	CL	43	27	CL	107.7	18.7	102.5	18.7	108.9	101.2	19.3	+0.6	104.4	
RC-813	109+40	1+75U/S	896.6	RANDOM	45	27	CL	41	25	CL	40	24	CL	109.2	17.1	105.7	17.1	110.6	101.2	19.0	+1.9	108.8	
RC-816	92+00	0+70D/S	902.5	RANDOM	49	31	CL	45	30	CL	51	37	CH	107.3	18.6	102.1	18.6	109.0	101.5	18.1	-0.5	108.0	
RC-858	102+00	0+20D/S	903.5	IMP	31	18	CL	34	20	CL	30	16	CL	117.2	13.3	109.6	13.3	115.8	98.8	15.2	+1.9	109.3	
RC-868	106+00	1+80U/S	899.5	RANDOM	42	25	CL	46	32	CL	36	23	CL	109.7	17.3	104.7	17.3	106.1	96.7	19.9	+2.6	107.7	
RC-901	—	—	878.5	—	—	—	—	49	33	CL	44	27	CL	—	—	99.2	—	—	—	—	—	—	100.8
RC-911	98+00	1+25D/S	904.0	RANDOM	40	24	CL	44	31	CL	33	20	CL	109.9	19.3	106.0	19.3	109.2	99.4	19.3	0.0	107.4	
RC-933	103+05	0+55D/S	908.6	RANDOM	39	24	CL	43	30	CL	37	21	CL	111.4	16.6	103.2	16.6	108.7	97.6	16.8	+0.2	110.1	
RC-938	87+00	1+60U/S	904.5	RANDOM	44	28	CL	56	42	CH	52	38	CH	108.5	17.2	104.8	17.2	111.6	102.8	18.0	+0.8	104.5	
RC-954	88+00	0+60D/S	908.0	RANDOM	37	22	CL	41	28	CL	40	27	CL	112.9	15.9	111.3	15.9	111.4	98.8	15.8	-0.1	110.9	
RC-1030	90+45	0+60D/S	913.0	RANDOM	37	21	CL	37	21	CL	43	28	CL	110.1	16.5	108.2	16.5	108.6	98.6	18.3	+1.8	106.3	
RC-1031	94+20	0+15U/S	912.0	IMP	40	24	CL	42	28	CL	39	23	CL	109.2	16.8	108.0	16.8	107.3	98.3	20.2	+3.4	106.2	
RC-1096	89+15	0+70D/S	913.5	RANDOM	52	25	CH	57	40	CH	56	43	CH	104.8	19.0	102.6	19.0	104.5	99.7	21.0	+2.0	101.2	
RC-1154	113+80	2+60D/S	887.0	IMP	37	20	CL	51	34	CH	35	18	CL	108.0	17.0	108.2	17.8	109.6	101.5	18.3	+1.3	112.1	
RC-1155	72+00	0+70U/S	912.5	RANDOM	42	26	CL	48	29	CL	45	31	CL	106.4	19.0	104.5	18.7	103.1	96.9	22.6	+3.6	96.2	
RC-1205	113+00	0+40U/S	888.0	IMP	36	19	CL	52	36	CH	38	22	CL	107.9	17.7	107.0	15.8	110.9	102.8	18.8	+1.1	105.4	
RC-1236	90+00	0+35U/S	919.0	IMP	48	30	CL	54	36	CH	50	34	CH	103.4	20.4	96.2	22.7	101.4	98.1	20.8	+0.4	101.4	
RC-1242	105+00	0+40D/S	922.5	RANDOM	43	27	CL	56	43	CH	39	25	CL	108.9	17.5	102.4	21.3	108.9	100.0	19.1	+1.6	106.6	
RC-1264	89+25	0+70U/S	918.8	RANDOM	29	16	CL	35	22	CL	31	21	CL	116.9	13.6	116.3	13.9	113.3	96.9	17.0	+3.4	108.7	
RC-1322	119+00	1+02D/S	921.0	IMP	42	24	CL	52	34	CH	45	31	CL	105.6	18.6	98.7	19.1	100.5	95.2	20.0	+1.4	103.1	
RC-1331	116+20	1+60U/S	899.0	RANDOM	38	19	CL	38	18	CL	38	20	CL	106.5	17.4	103.6	18.5	104.9	98.5	19.7	+2.3	102.3	
RC-1343	70+90	0+75U/S	912.0	RANDOM	39	25	CL	32	17	CL	40	28	CL	111.2	16.1	111.5	15.7	107.2	96.4	16.1	0.0	110.5	
RC-1375	18+00	ε	938.0	IMP	63	43	CH	77	61	CH	69	53	CH	98.5	23.5	98.7	22.8	97.5	99.0	25.8	+2.3	96.1	

**STAGE III RECORD CONTROL SUMMARY**

STANDARD COMPACTION TEST					DENSITY AND MOISTURE CONTENT								
LABORATORY		FIELD		M.R.D. LAB.		SAND CONE DATA				UNDISTURBED DATA			
COMPACTION TEST SPECIMEN	CLASS	MAX DRY DENSITY (PCF)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (PCF)	OPT MOIST CONTENT (%)	DRY DENSITY (PCF)	COMPACTION (%)	WATER CONTENT (%)	WATER CONTENT (+%OPT)	DRY DENSITY (PCF)	COMPACTION (%)	WATER CONTENT (%)	WATER CONTENT (+%OPT)
32	CH	105.0	20.0	100.4	21.7	103.8	98.8	19.7	-0.3	100.6	95.8	22.1	+2.1
34	CH	101.6	21.1	102.1	21.0	102.1	100.5	23.1	+2.0	102.5	100.9	23.1	+2.0
26	CL	105.3	19.7	102.2	19.7	107.9	102.5	20.4	+0.7	107.8	102.4	20.9	+1.2
30	CL	105.0	19.0	105.5	19.0	104.9	104.8	18.2	-0.8	112.3	107.0	17.8	-1.2
28	CL	104.5	19.7	103.5	19.7	104.9	100.4	21.3	+1.6	102.3	97.9	21.5	+1.8
27	CL	105.8	18.9	103.7	18.9	110.1	100.6	20.7	+1.8	101.9	96.3	22.7	+3.8
34	CH	105.5	18.2	102.7	18.2	103.7	99.2	13.8	+1.6	102.7	97.3	20.4	+2.2
36	CH	101.6	21.0	94.8	21.0	101.4	99.8	23.4	+2.4	98.2	96.7	23.7	+2.7
20	CL	107.6	17.0	101.0	17.0	105.9	101.8	18.6	+1.6	106.3	98.8	18.7	+1.7
36	CH	101.6	21.6	87.0	21.6	100.7	99.1	24.9	+3.3	95.7	94.2	25.2	+3.6
33	CL	107.0	18.7	105.1	18.7	107.7	100.6	18.8	+0.1	106.1	99.2	18.1	-0.6
30	CL	109.8	16.9	107.2	16.9	113.8	103.6	18.5	+1.6	109.8	100.0	17.7	+0.8
35	CH	105.6	18.9	105.0	18.9	107.0	101.4	19.3	+0.4	103.5	98.0	20.1	+1.2
36	CH	106.2	19.1	93.7	19.1	104.2	98.2	19.0	-0.1	103.1	97.1	20.8	+1.7
30	CL	109.4	17.9	101.6	17.9	109.6	100.2	18.5	+0.6	108.3	99.0	18.4	+0.5
27	CL	107.7	18.7	102.5	18.7	108.9	101.2	19.3	+0.6	104.4	96.9	21.1	+2.4
24	CL	109.2	17.1	105.7	17.1	110.6	101.2	19.0	+1.9	108.8	99.6	19.3	+2.2
37	CH	107.3	18.6	102.1	18.6	109.0	101.5	18.1	-0.5	108.0	100.6	18.3	-0.3
16	CL	117.2	13.3	109.6	13.3	115.8	98.8	15.2	+1.9	109.3	93.3	15.8	+2.5
23	CL	109.7	17.3	104.7	17.3	106.1	96.7	19.9	+2.6	107.7	98.7	18.4	+1.1
27	CL	—	—	99.2	—	—	—	—	—	100.8	—	20.7	—
20	CL	109.9	19.3	106.0	19.3	109.2	99.4	19.3	0.0	107.4	97.7	20.7	+1.4
21	CL	111.4	16.6	103.2	16.6	108.7	97.6	16.8	+0.2	110.1	98.8	16.7	+0.1
38	CH	108.5	17.2	104.8	17.2	111.6	102.8	18.0	+0.8	104.5	96.3	19.6	+2.4
27	CL	112.9	15.9	111.3	15.9	111.4	98.8	15.8	-0.1	110.9	98.2	16.4	+0.5
28	CL	110.1	16.5	108.2	16.5	108.6	98.6	18.3	+1.8	106.3	96.5	18.6	+2.1
23	CL	109.2	16.8	108.0	16.8	107.3	98.3	20.2	+3.4	106.2	97.3	19.3	+2.5
43	CH	104.8	19.0	102.6	19.0	104.5	99.7	21.0	+2.0	101.2	96.5	20.8	+1.8
18	CL	108.0	17.0	108.2	17.8	109.6	101.5	18.3	+1.3	112.1	103.8	18.3	+1.3
31	CL	106.4	19.0	104.5	18.7	103.1	96.9	22.6	+3.6	96.2	90.4	25.4	+6.4
22	CL	107.9	17.7	107.0	15.8	110.9	102.8	18.8	+1.1	105.4	97.7	18.7	+1.0
34	CH	103.4	20.4	98.2	22.7	101.4	98.1	20.8	+0.4	101.4	98.1	22.6	+2.2
25	CL	108.9	17.5	102.4	21.3	108.9	100.0	19.1	+1.6	106.6	97.9	20.0	+2.5
21	CL	116.9	13.6	116.3	13.9	113.3	96.9	17.0	+3.4	108.7	93.0	17.4	+3.8
31	CL	105.6	18.6	98.7	19.1	100.5	95.2	20.0	+1.4	103.1	97.6	21.2	+2.6
20	CL	106.5	17.4	103.6	18.5	104.9	98.5	19.7	+2.3	102.3	96.1	21.9	+4.5
28	CL	111.2	16.1	111.5	15.7	107.2	96.4	16.1	0.0	110.5	99.4	15.6	-0.5
53	CH	98.5	23.5	98.7	22.8	97.5	99.0	25.8	+2.3	96.1	97.6	25.4	+1.9

**RECORD CONTROL SUMMARY**

Revisions			
Symbol	Description	Date	Approved
U. S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI			
Designed by:	 BIG BULL CREEK, KANSAS HILLSDALE LAKE EMBANKMENT CRITERIA REPORT		
Drawn by:	<b>RECORD CONTROL DATA - STAGE III</b> <b>STANDARD COMPACTION TEST</b> <b>LABORATORY VS. FIELD</b>		
Checked by:	Date:	Sheet number:	
Submitted by:	SEPT 1964	2 of 5	File No. O-15-1086



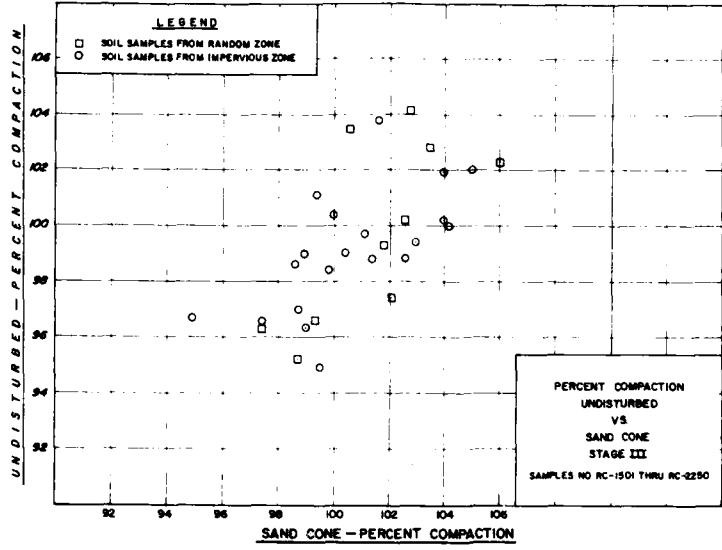


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ENT COMPACTION  
UNDISTURBED  
VS  
SAND CONE  
STAGE III  
NO RC-53 THRU RC-175

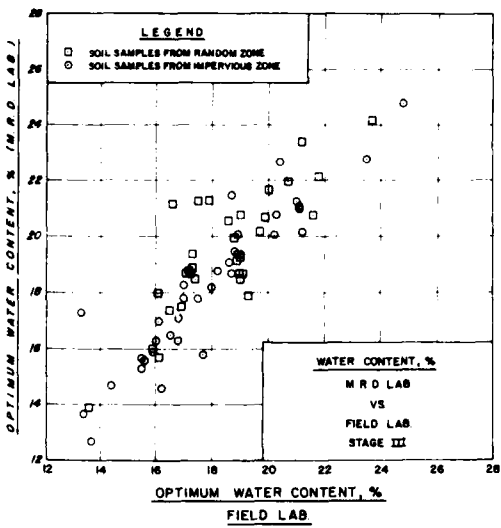


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Revisions			
Symbol	Descriptions	Date	Approved
U S ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI			
Designed by:	BIG BULL CREEK, KANSAS HILLSDALE LAKE EMBANKMENT CRITERIA REPORT		
Drawn by:	RECORD CONTROL TEST DATA - STAGE III		
Checked by:	Date:	Sheet number:	
Submitted by:	SEPTEMBER 1984	3 of 5	File No: 0-15-1067

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PLATE NO 73

2

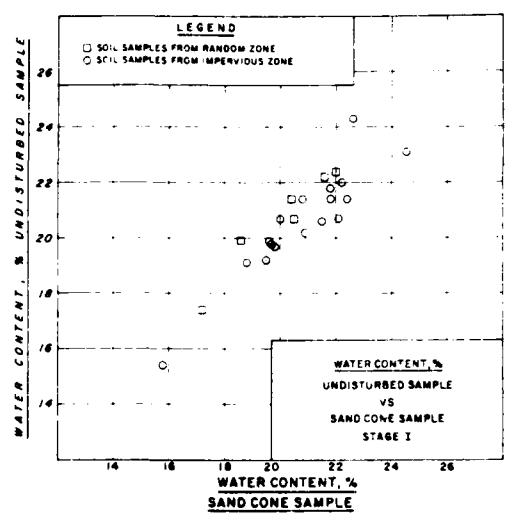
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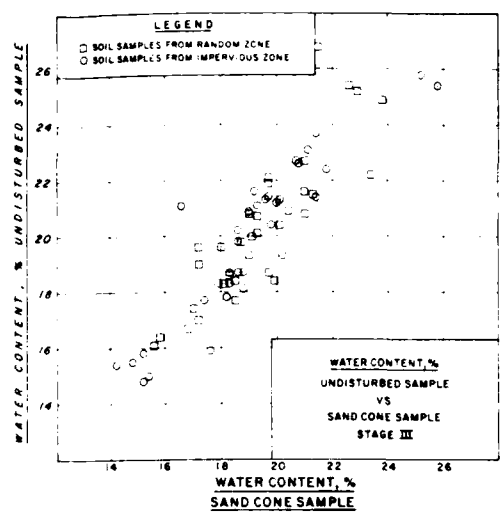


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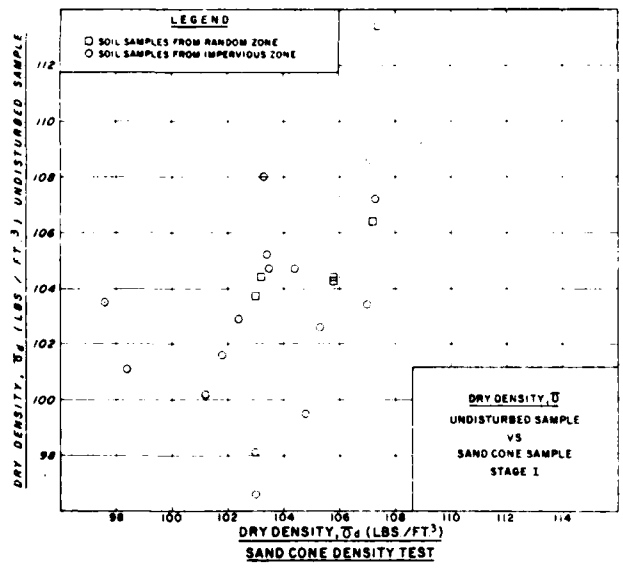
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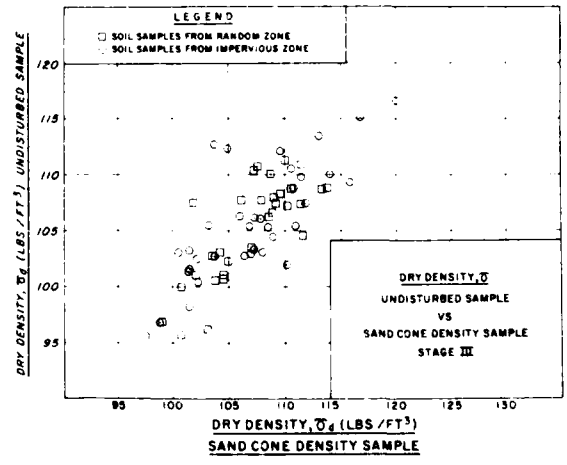
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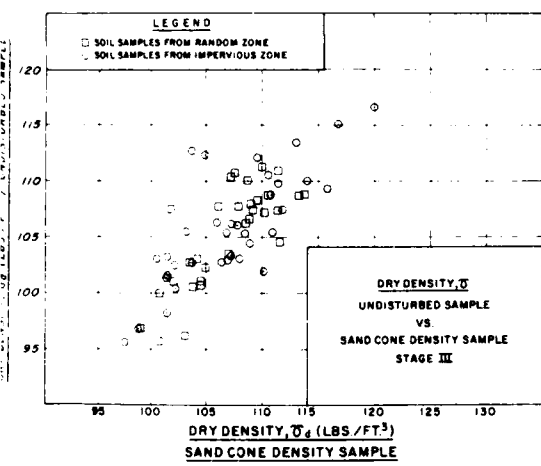
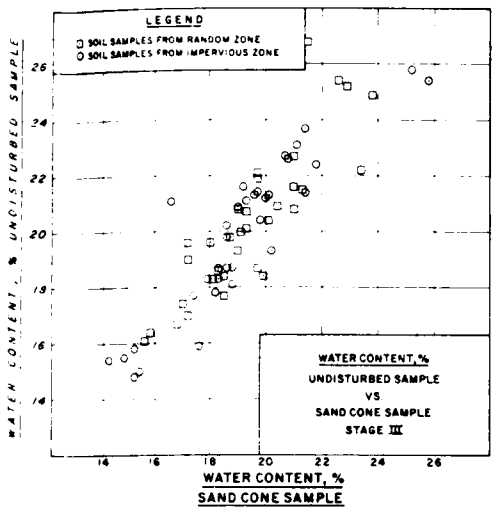


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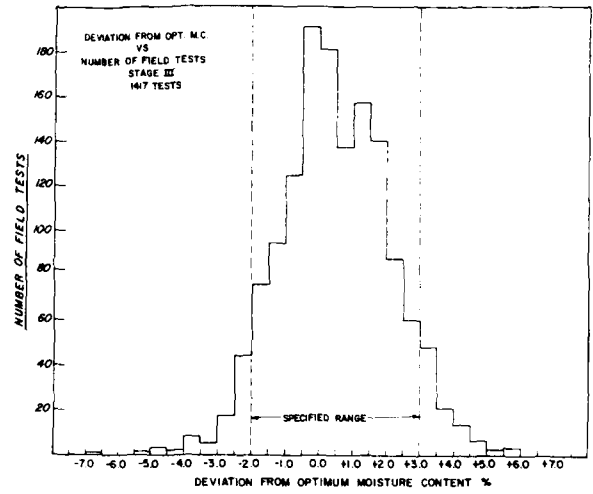
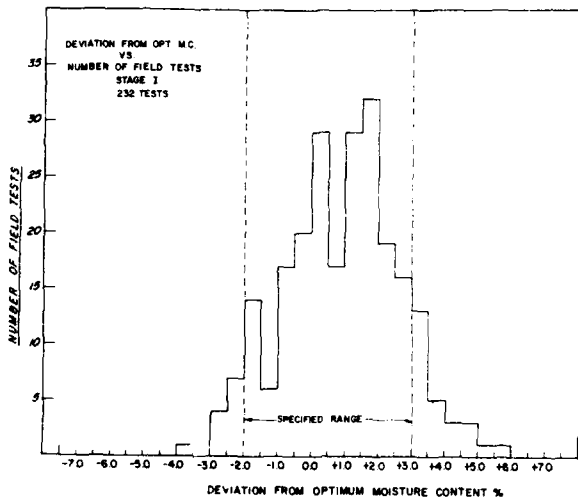
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Revisions			
Symbol	Descriptions	Date	Approved
U. S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI			
Designed by:	BIG BULL CREEK, KANSAS HILLSDALE LAKE EMBANKMENT CRITERIA REPORT		
Drawn by:	<b>RECORD CONTROL TEST DATA-STAGE I &amp; II</b>		
Checked by:	Book:	Sheet number:	
Submitted by:	Date:		
Dist. No:		4 of 5	File No. 0-15-1068



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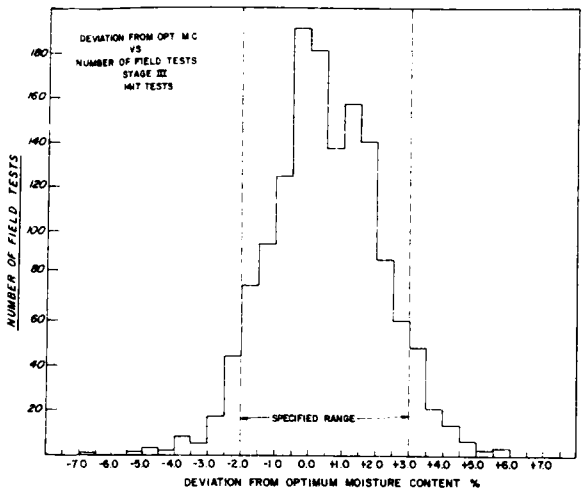
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Revisions			
Symbol	Descriptions	Date	Approved

U S ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI

Designed by: BIG BULL CREEK, KANSAS  
HILLSDALE LAKE  
EMBANKMENT CRITERIA REPORT

Drawn by: **RECORD CONTROL DATA - STAGE I & II**

Checked by: **STANDARD COMPACTION TEST**

Submitted by: **LABORATORY VS FIELD**

Scale	Sheet number
Date: SEPTEMBER 1984	5 of 5
Draw No.	File No. 0-15-1069

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PLATE NO 75

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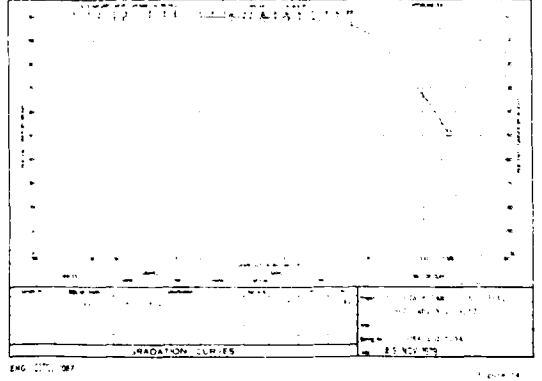
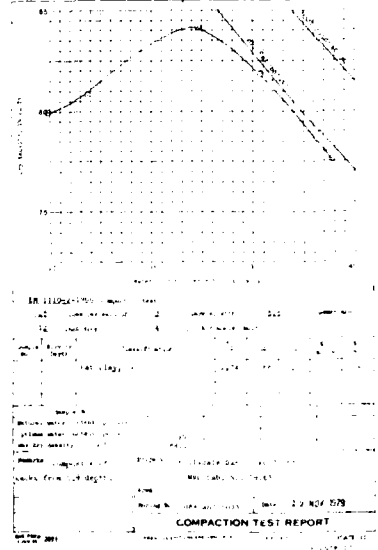
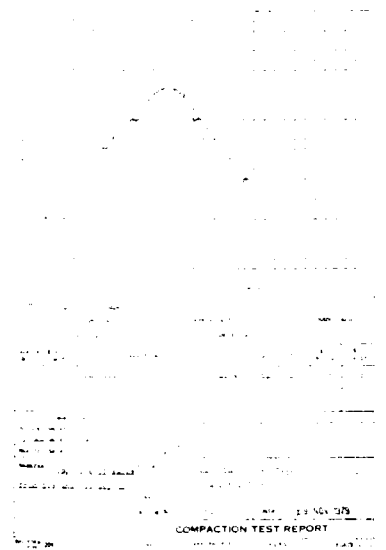
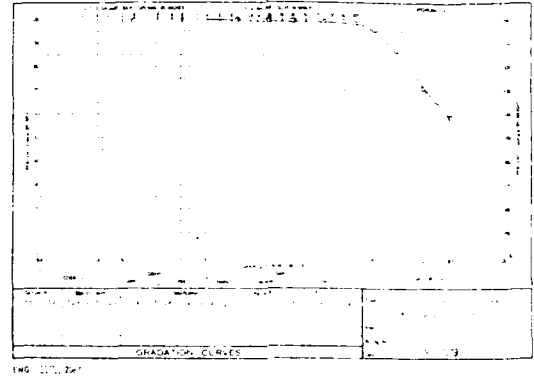
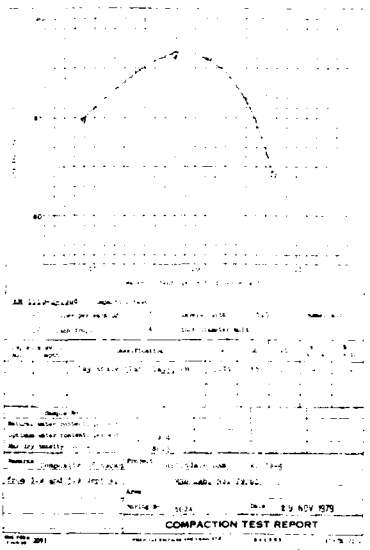
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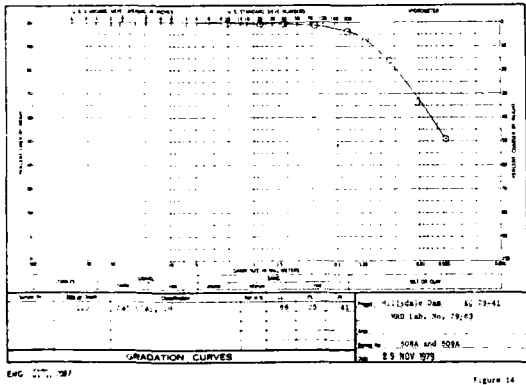
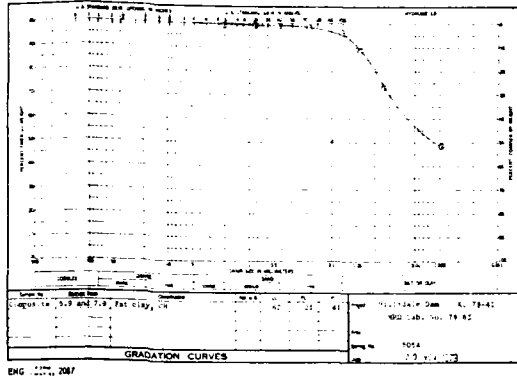
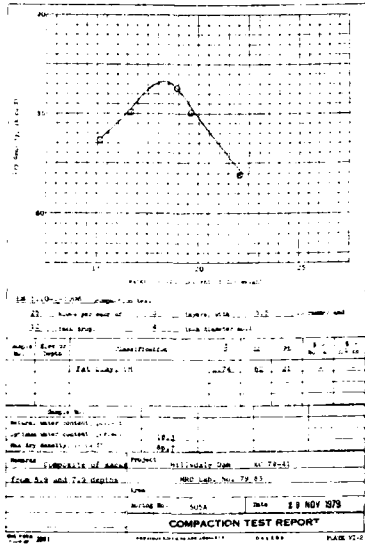
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Revisions			
Symbol	Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI

Designed by: SAC  
Drawn by: SAC  
Checked by: SAC  
Submitted by: SAC

**BIG BULL CREEK, KANSAS  
HILLSDALE LAKE  
EMBANKMENT CRITERIA REPORT**

**BORROW AREA COMPACTION TEST RESULTS**

Scale: \_\_\_\_\_ Sheet number: \_\_\_\_\_  
Date: SEPTEMBER 1964  
File No: 0-15-1070

3

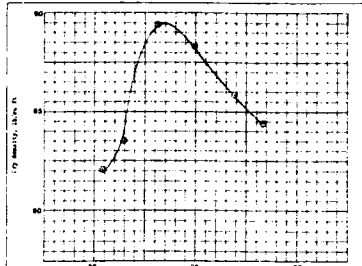
2

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PLATE NO. 76

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EN 1110-2-1908 Compaction test

15 blows per inch of 3 layers, with 5.5 lb hammer and 12 inch drop. 4 inch diameter mold

Sample No.	Layer or Depth	Classification	W	L	P	A	A'
		Clay shale (Fat clay), CH	22.1	70	22		

Report No. \_\_\_\_\_

Actual water content, percent \_\_\_\_\_

Optimum water content, percent 21.6

Max dry density, lb/cu ft 93.6

Remarks: 9.0 Depth

Project: Hillside Dam, SC 78-41

Drawn: MND Lab. No. 72-82

Checked: \_\_\_\_\_

Serial No. 288 Date: 29 NOV 57

COMPACTION TEST REPORT

Figure 1

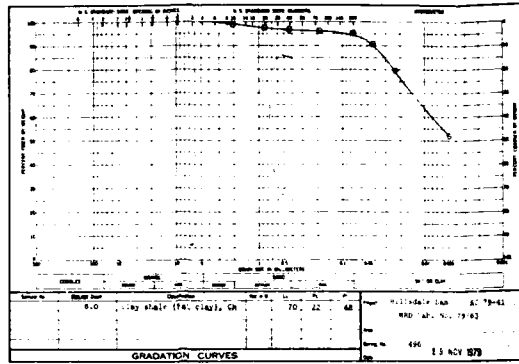
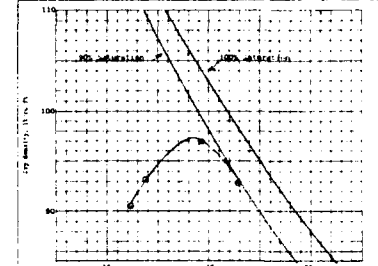


Figure 2



EN 1110-2-1908 Compaction test

15 blows per inch of 3 layers, with 5.5 lb hammer and 12 inch drop. 4 inch diameter mold

Sample No.	Layer or Depth	Classification	W	L	P	A	A'
		Fat clay, CH	22.1	63	18		

Report No. \_\_\_\_\_

Actual water content, percent \_\_\_\_\_

Optimum water content, percent 23.3

Max dry density, lb/cu ft 91.6

Remarks: Back from 72-81

Project: Hillside Dam, SC 78-41

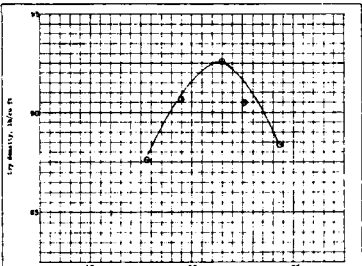
Drawn: MND Lab. No. 72-82

Checked: \_\_\_\_\_

Serial No. 300 Date: NOV 27 57

COMPACTION TEST REPORT

Figure 3



EN 1110-2-1908 Compaction test

15 blows per inch of 3 layers, with 5.5 lb hammer and 12 inch drop. 4 inch diameter mold

Sample No.	Layer or Depth	Classification	W	L	P	A	A'
		Clay shale (Fat clay), CH	22.7	68	18		

Report No. \_\_\_\_\_

Actual water content, percent \_\_\_\_\_

Optimum water content, percent 21.6

Max dry density, lb/cu ft 93.6

Remarks: Composite of

Project: Hillside Dam, SC 78-41

Drawn: MND Lab. No. 72-82

Checked: \_\_\_\_\_

Serial No. 301 Date: 29 NOV 57

COMPACTION TEST REPORT

Figure 4

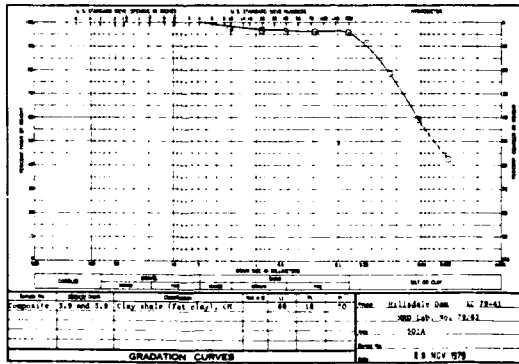
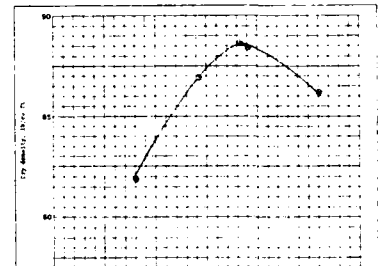


Figure 5



EN 1110-2-1908 Compaction test

15 blows per inch of 3 layers, with 5.5 lb hammer and 12 inch drop. 4 inch diameter mold

Sample No.	Layer or Depth	Classification	W	L	P	A	A'
		Fat clay, CH	22.7	72	21		

Report No. \_\_\_\_\_

Actual water content, percent \_\_\_\_\_

Optimum water content, percent 20.7

Max dry density, lb/cu ft 93.6

Remarks: Back from 5.0

Project: Hillside Dam, SC 78-41

Drawn: MND Lab. No. 72-82

Checked: \_\_\_\_\_

Serial No. 302 Date: 29 NOV 57

COMPACTION TEST REPORT

Figure 6



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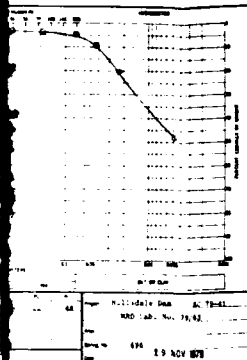


Figure 1

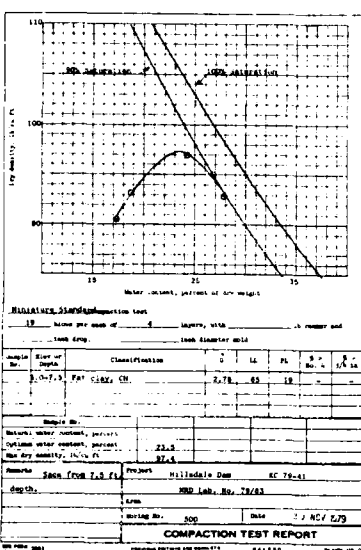


Figure 2

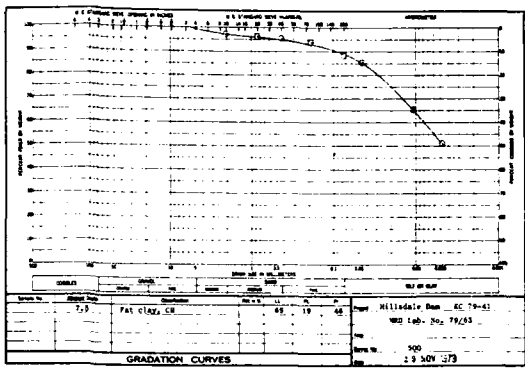


Figure 4

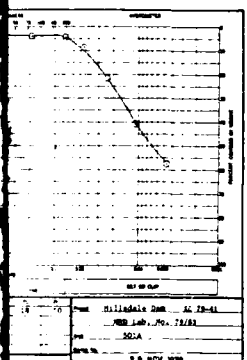


Figure 3

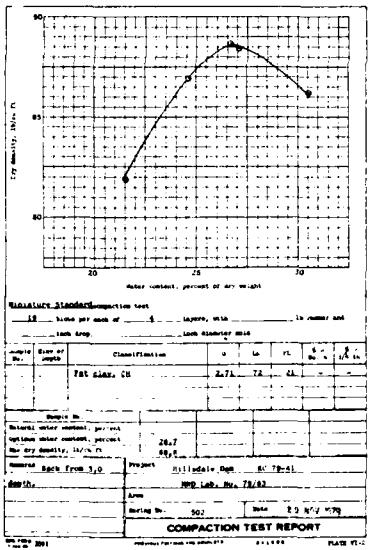


Figure 7

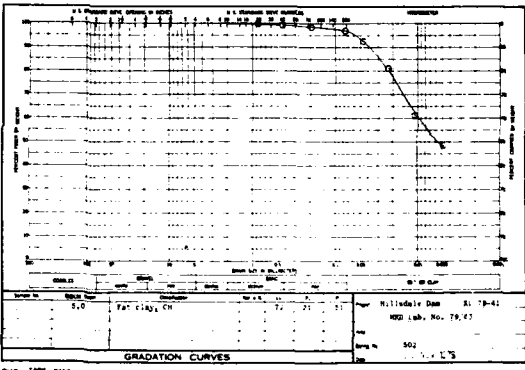


Figure 5

Revisions			
Symbol	Descriptions	Date	Approved

**U S ARMY ENGINEER DISTRICT**  
**CORPS OF ENGINEERS**  
**KANSAS CITY, MISSOURI**

Designed by: **BIG BULL CREEK, KANSAS**  
**HILLSDALE LAKE**  
**EMBANKMENT CRITERIA REPORT**

**BORROW AREA COMPACTION TEST RESULTS**

Drawn by:	Checked by:	Submitted by:	Date: <b>SEPTEMBER 1984</b>	Sheet number:

File No: **O-15-1071**

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PLATE NO 77

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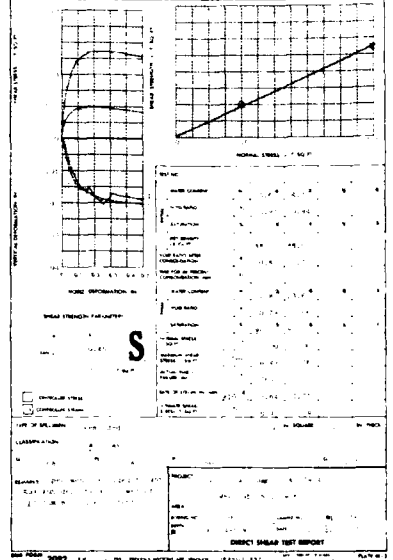
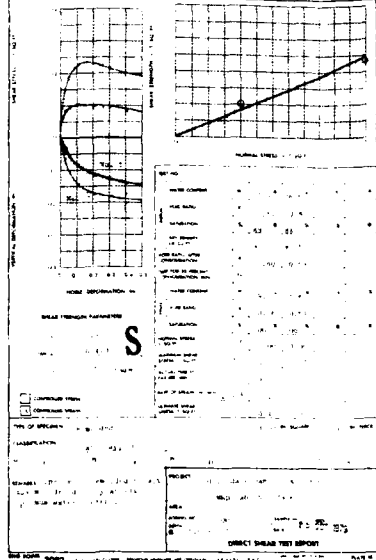
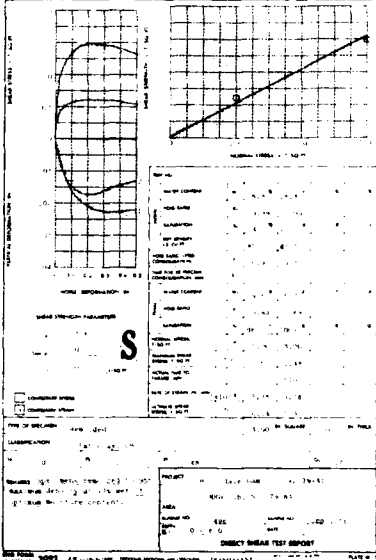
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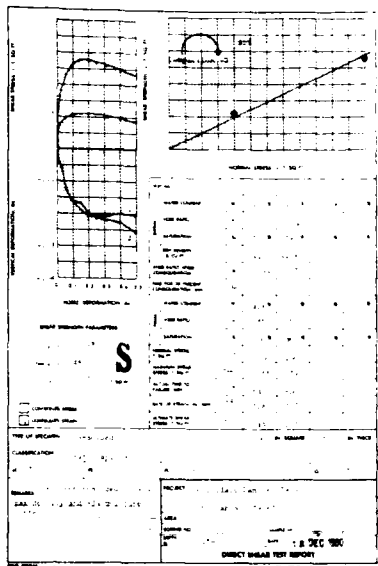
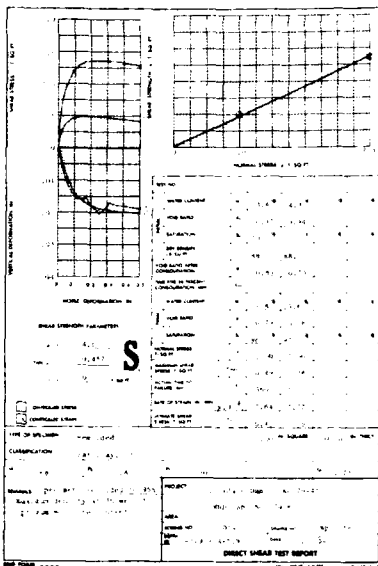
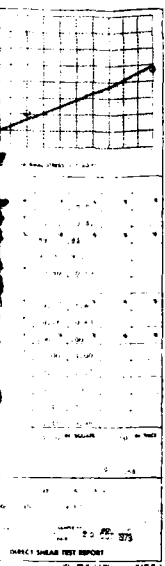


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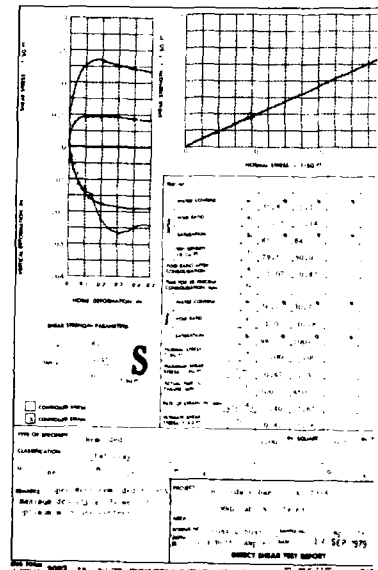
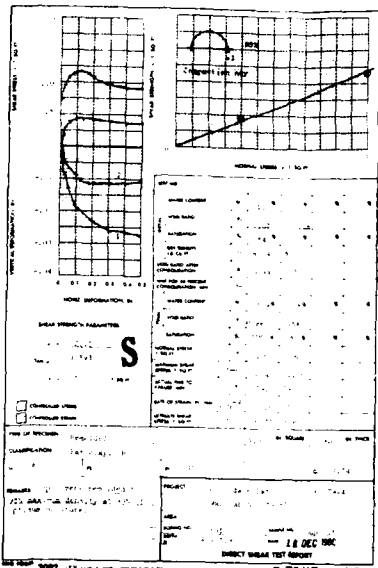
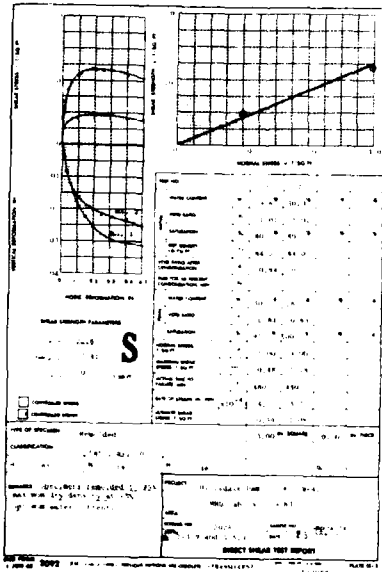
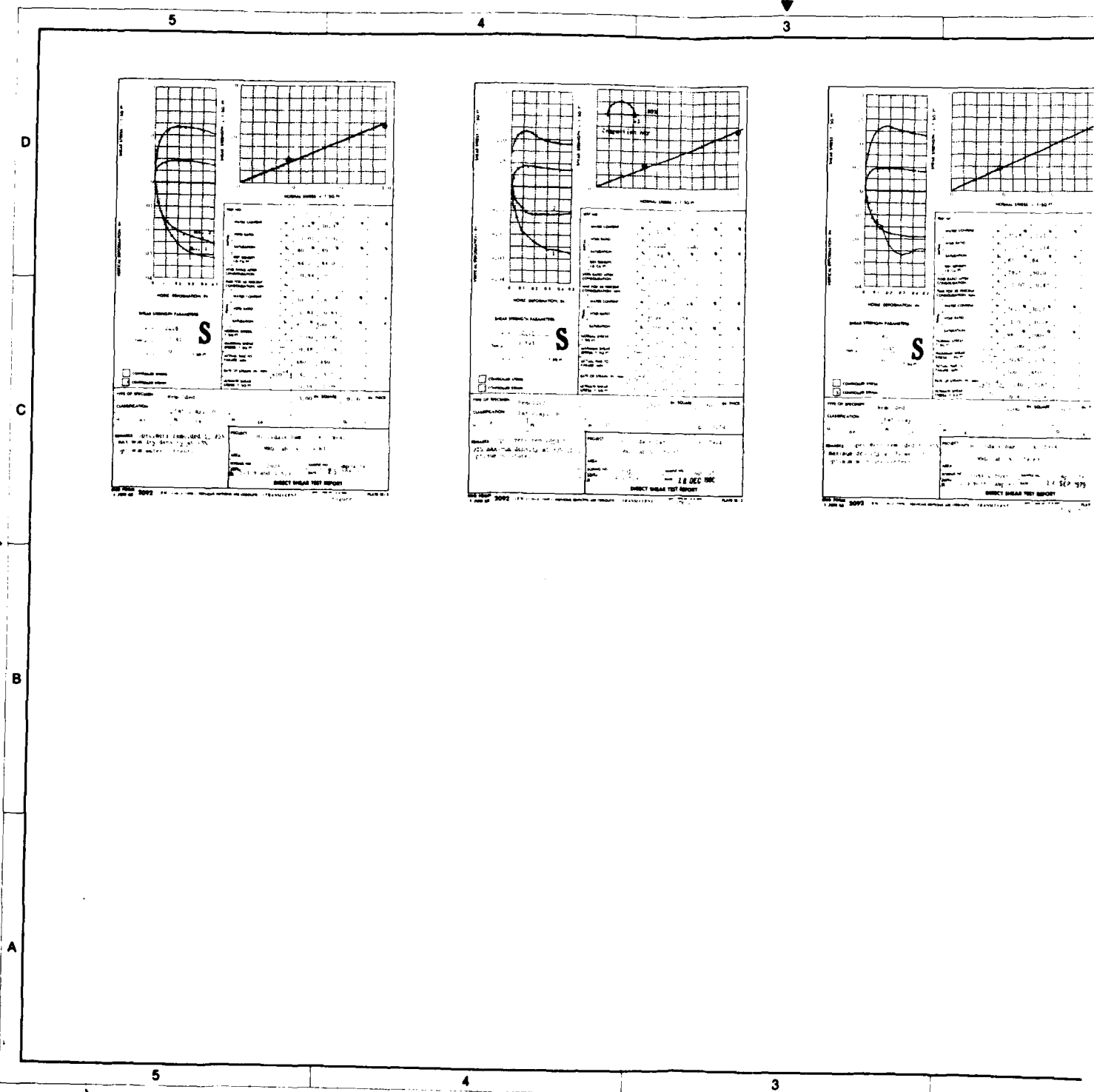
Revisions			
Symbol	Descriptions	Date	Approved

U S ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI

Designed by:		BIG BULL CREEK, KANSAS HILLSDALE LAKE EMBANKMENT CRITERIA REPORT	
Directed by:		BORROW AREA REMOLDED "S" TESTS	
Checked by:	State:	Sheet	1 of 2
Submitted by:	Date:	Number	
			File No. O-15-1072

PLATE NO 78

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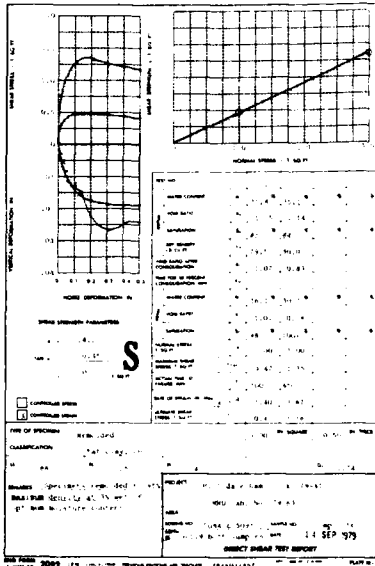
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Revisions			
Symbol	Descriptions	Date	Approved

U S ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI

**BIG BULL CREEK, KANSAS  
HILLSDALE LAKE  
EMBANKMENT CRITERIA REPORT**

**BORROW' AREA REMOLDED "S" TESTS**

Designed by:		Scale:	Sheet Number:
Drawn by:		Date:	1 of 2
Checked by:	Drawn by:	Drawn by:	Drawn by:
Submitted by:	Drawn by:	Drawn by:	Drawn by:

PLATE NO 79

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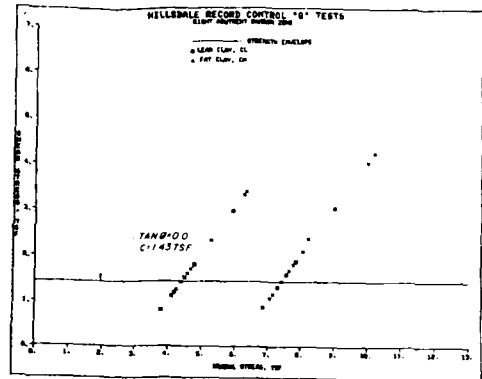
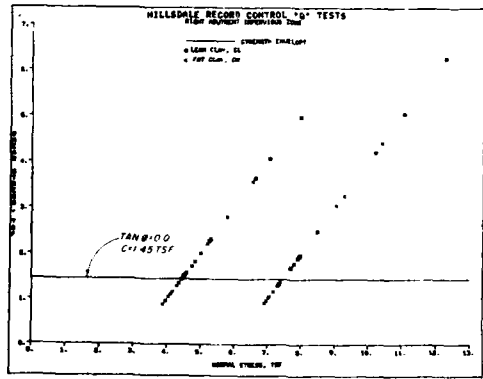
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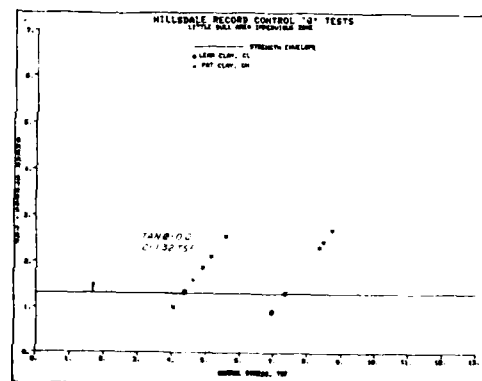
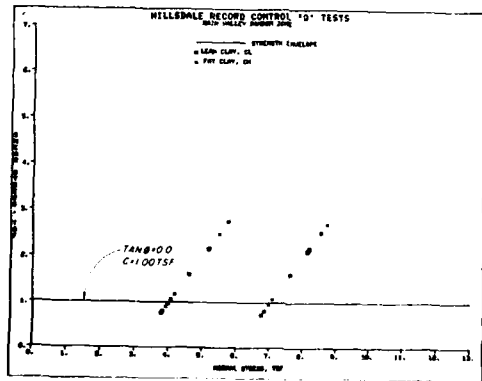
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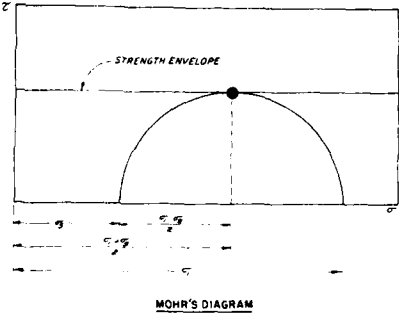
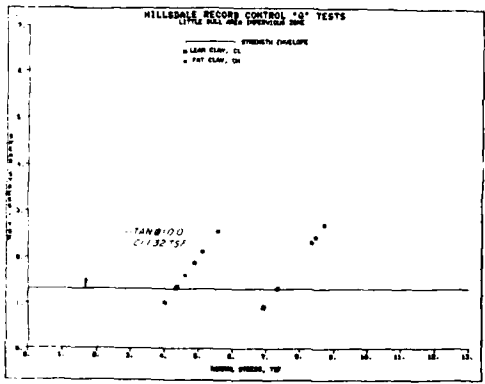
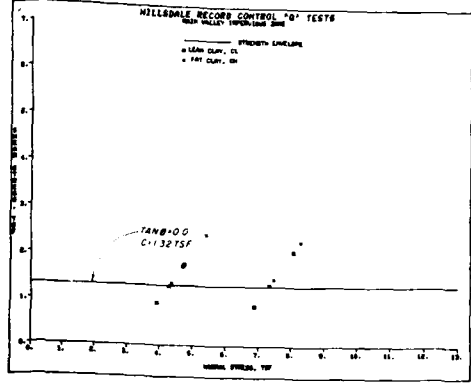
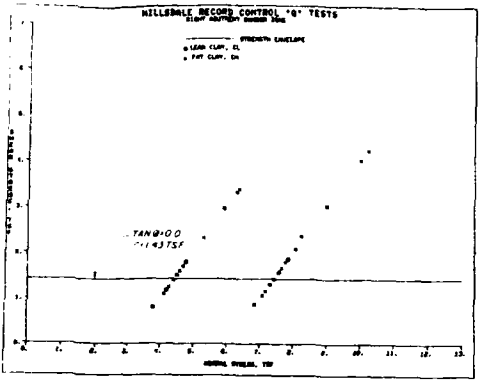
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Symbol	Revisions	Date	Approved
	Descriptions		
U. S. ARMY ENGINEER DISTRICT CORPUS OF ENGINEERS KANSAS CITY, MISSOURI			
Designed by	BIG BULL CREEK, KANSAS <b>HILLSDALE LAKE</b> EMBANKMENT CRITERIA REPORT		
Drawn by	<b>RECORD CONTROL "Q" TEST SUMMARY</b>		
Checked by			
Submitted by	Date	SEPTEMBER 1984	
	Sheet	1 of 2	
	Form No.	O-15-1074	

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PLATE NO. 80

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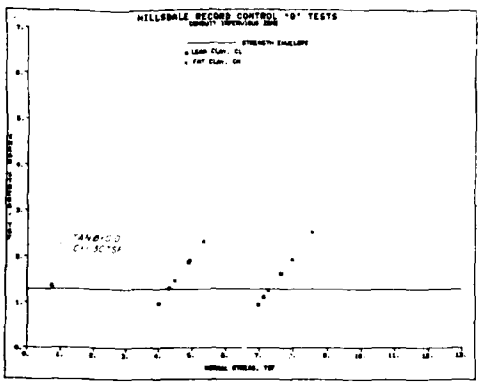
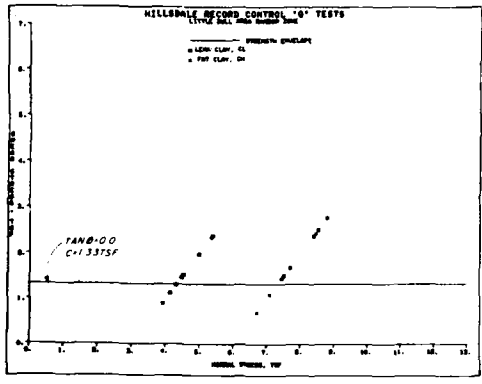
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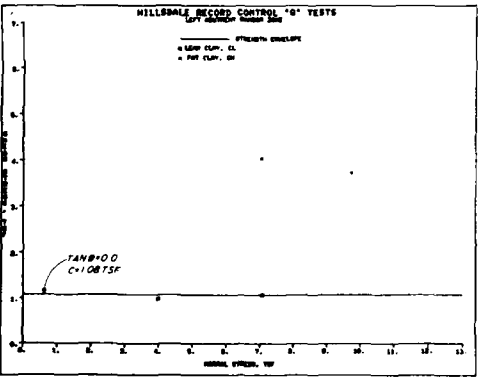
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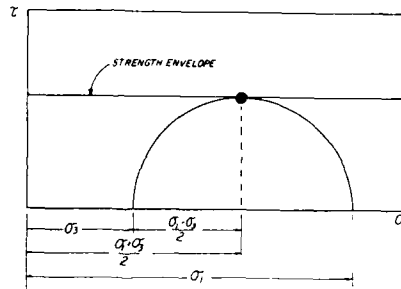
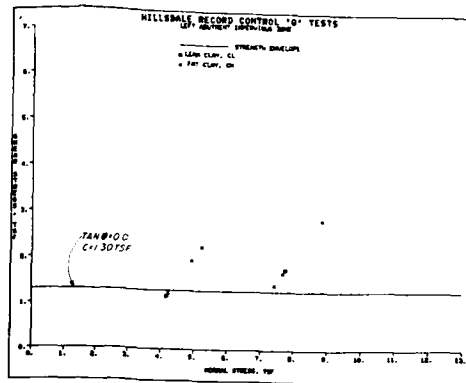
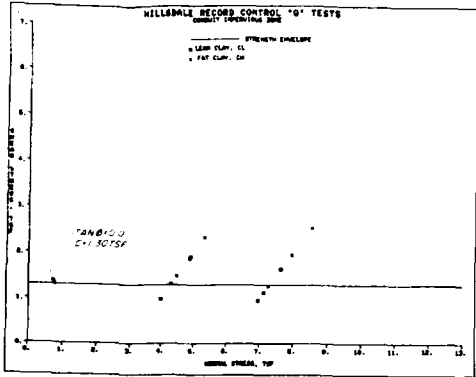




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MOHR'S DIAGRAM

Symbol	Definition	Date	Approved

U.S. ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI

Drawn by:

Project: BIG BULL CREEK, KANSAS  
HILLSDALE LAKE  
EMBANKMENT CRITERIA REPORT

RECORD CONTROL "Q" TEST SUMMARY

Date: SEPTEMBER 1984

2 of 2 O-15-1075

3

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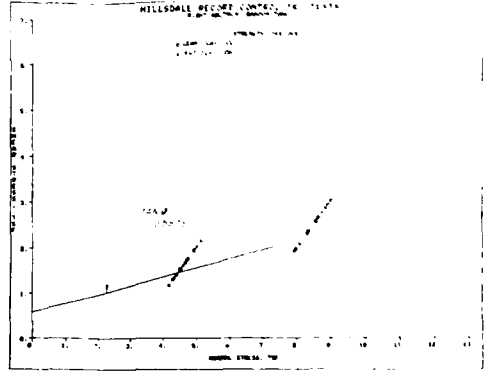
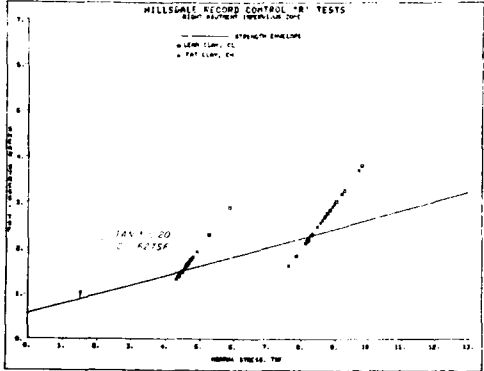
PLATE NO 81

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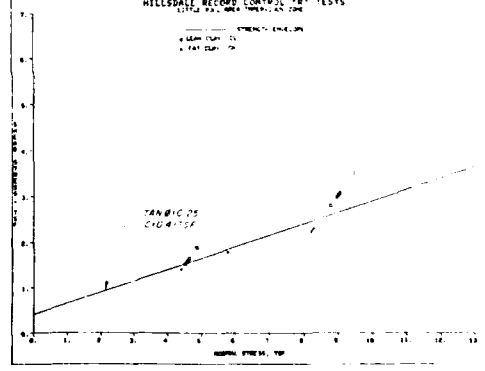
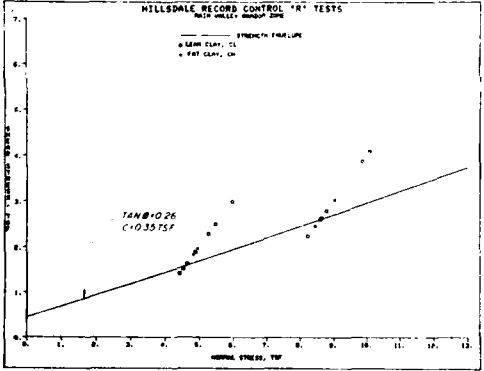
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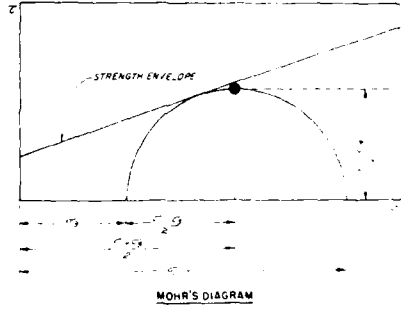
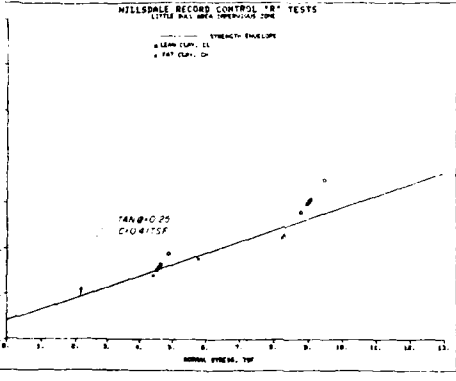
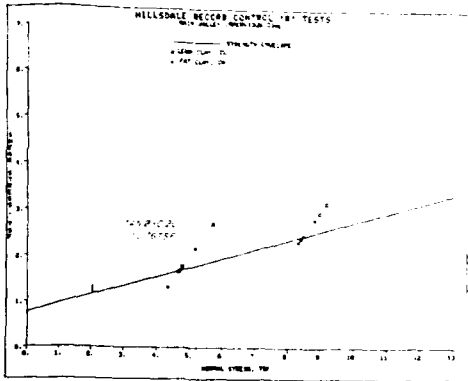
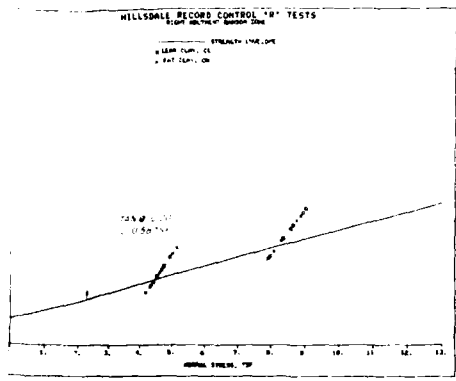
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Date: \_\_\_\_\_  
 Drawn by: \_\_\_\_\_  
 Checked by: \_\_\_\_\_  
 Approved by: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Drawn by: \_\_\_\_\_  
 Checked by: \_\_\_\_\_  
 Approved by: \_\_\_\_\_

U.S. ARMY ENGINEER CENTER  
 CIVIL ENGINEERS  
 KANSAS CITY, MISSOURI

**BIG BULL CREEK, KANSAS  
 HILLSDALE LAKE  
 EMBANKMENT CRITERIA REPORT**

**RECORD CONTROL "R" TEST SUMMARY**

SEPTEMBER 1984

1 of 4 Form No. O-15-1076

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PLATE NO 82

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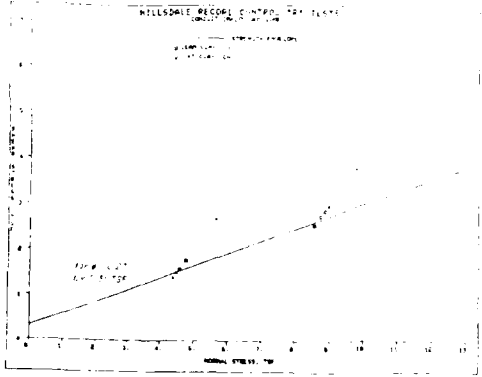
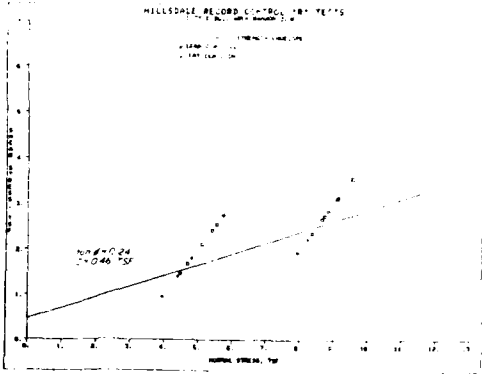
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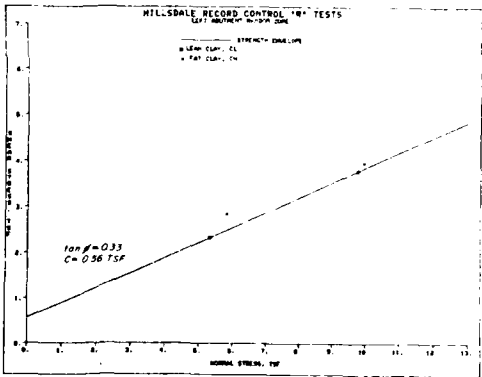
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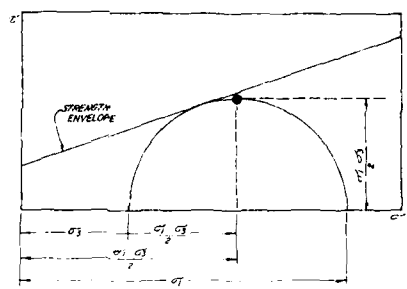
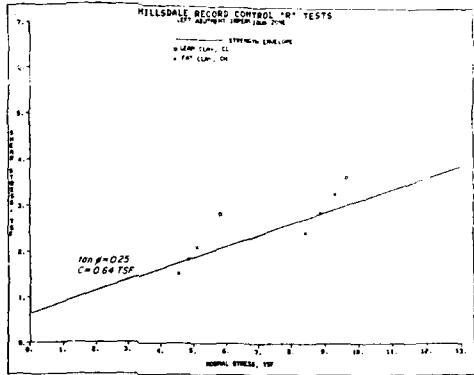
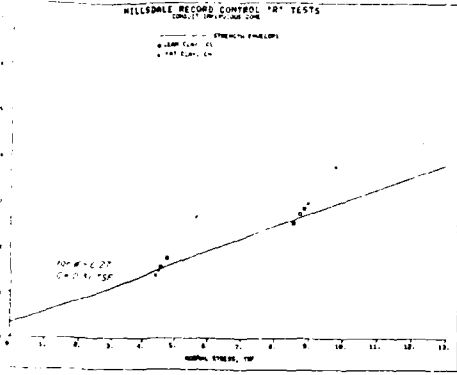
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Checked	Date	Approved
U.S. ARMY ENGINEERING CENTER CORPUS COLLEGE ENGINEERING KANSAAS CITY, MISSOURI		
<b>BIG BULL CREEK, KANSAS          HILLSDALE LAKE          EMBANKMENT CRITERIA REPORT</b>		
<b>RECORD CONTROL "R" TEST SUMMARY</b>		
Drawn by	Scale	Sheet
Checked by	Date	
	SEPTEMBER 1984	
	2 of 4	File No. O-15-1077

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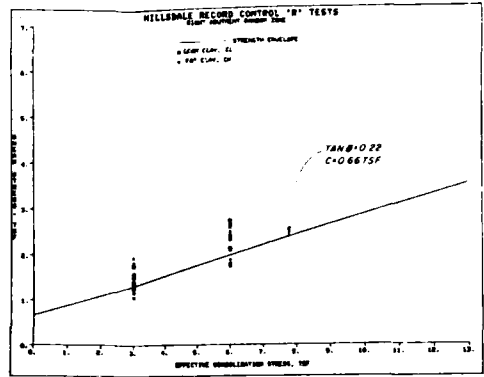
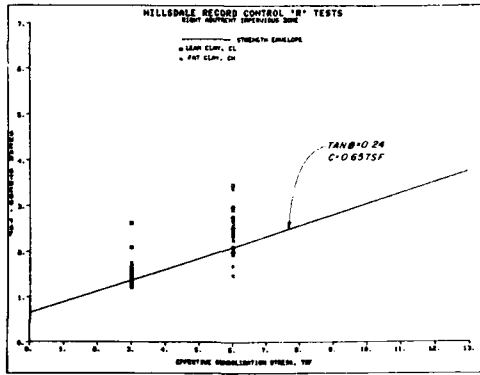
PLATE NO. 83

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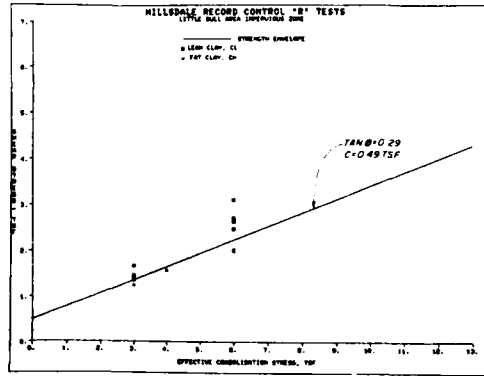
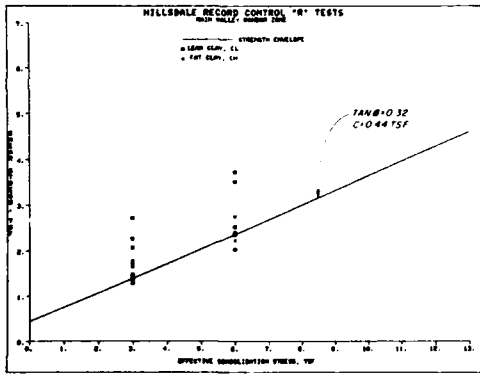
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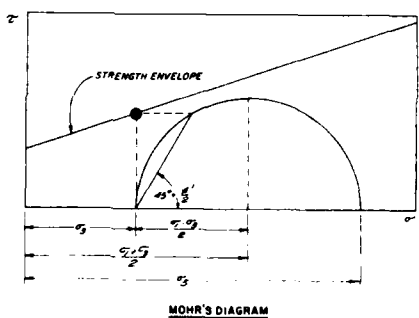
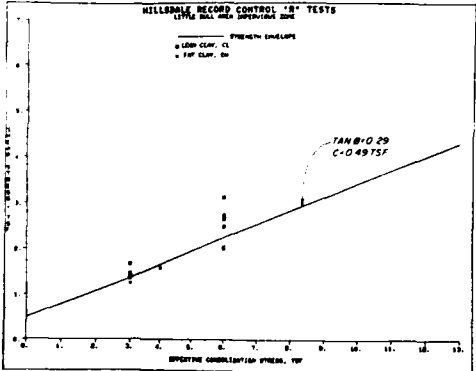
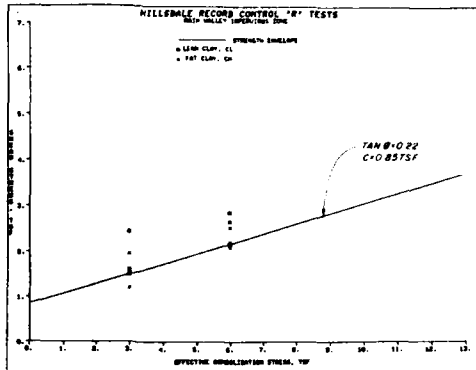
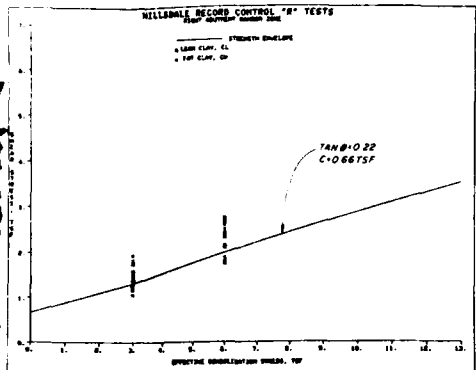
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Symbol	Revisions Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI

Designed by: [Signature]

Drawn by: [Signature]

Checked by: [Signature]

Submitted by: [Signature]

Date: SEPTEMBER 1964

Sheet Number: 3 of 4

File No: O-15-1078

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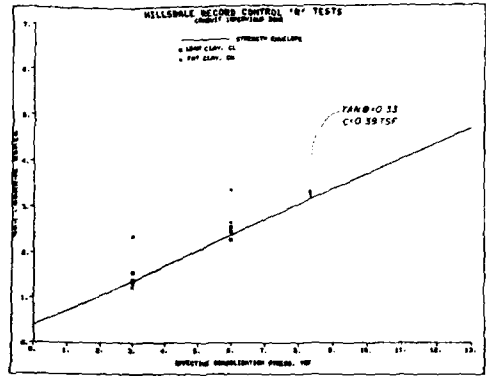
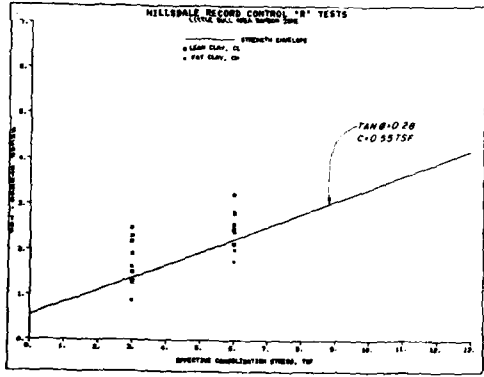
PLATE NO. 84

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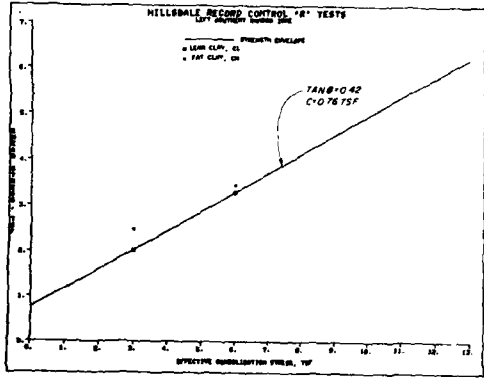
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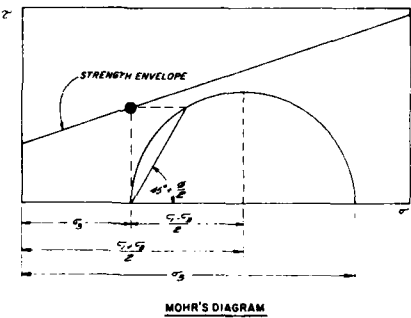
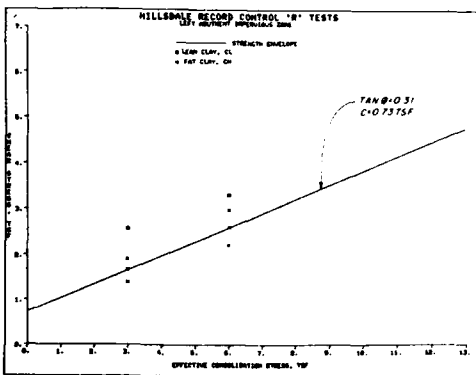
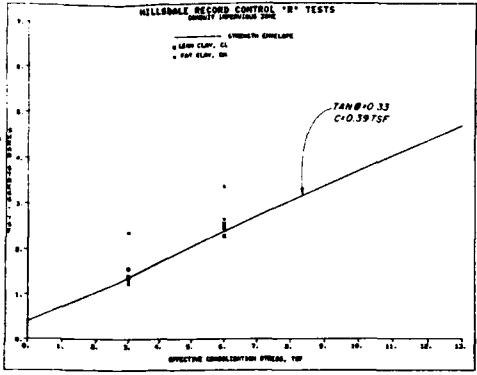
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Symbol	Revisions Descriptions	Date	Approved

U. S. ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI

Designed by: **BIG BULL CREEK, KANSAS  
HILLDALE LAKE  
EMBANKMENT CRITERIA REPORT**

Drawn by: **RECORD CONTROL "R" TEST SUMMARY**

Checked by: **U.S. Army Corps of Engineers**

Submitted by: **SEPTEMBER 1964**

Date: **4 of 4** File No: **0-15-1079**

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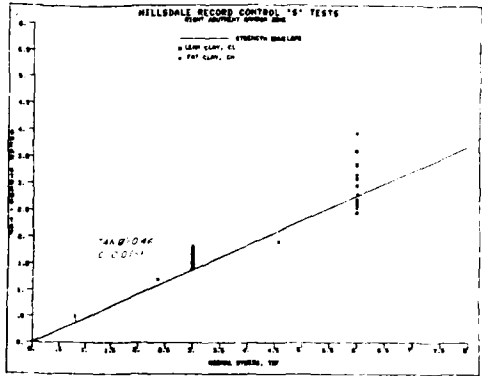
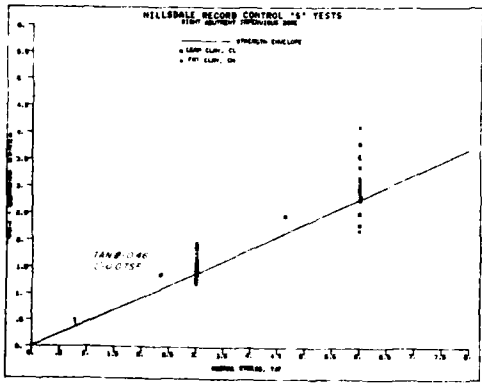
PLATE NO. 85

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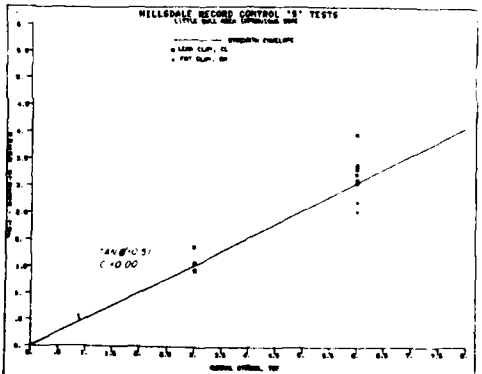
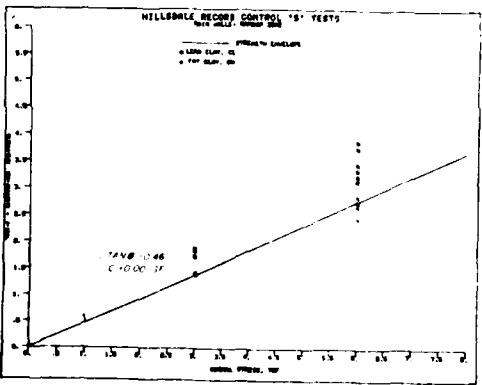
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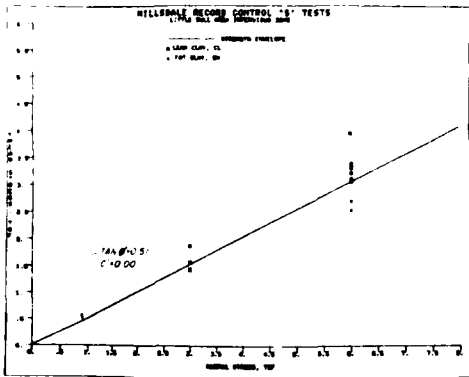
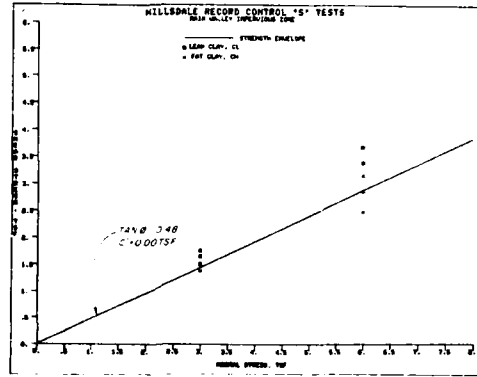
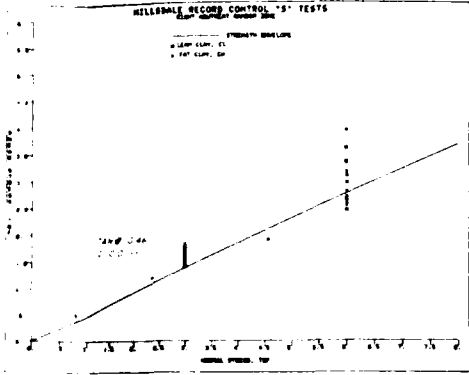
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Revisions		Date		Approved	
Symbol	Descriptions				
U. S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI					
Designed by	 <b>BIG BULL CREEK, KANSAS            HILLSDALE LAKE            EMBANKMENT CRITERIA REPORT</b>	<b>RECORD CONTROL "S" TEST SUMMARY</b>			
Drawn by					
Checked by					
Submitted by					
Scale		Sheet Number		Date	
				SEPTEMBER 1984	
Dwg No.		1 of 2		File No. 0-15-1080	

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PLATE NO. 86

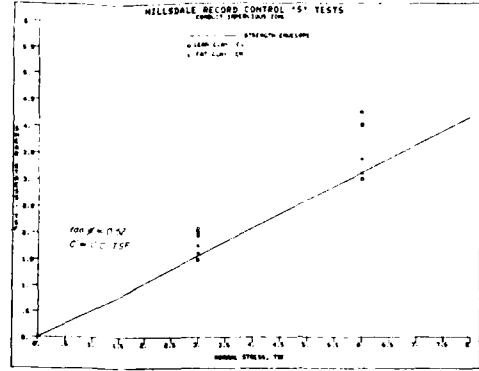
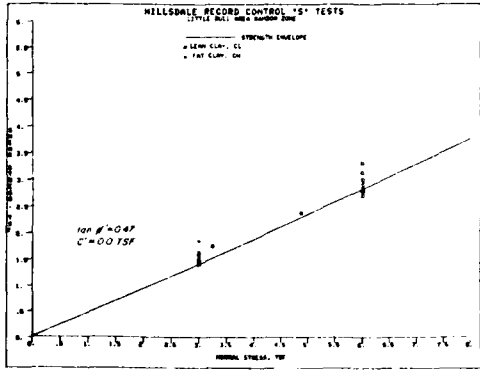
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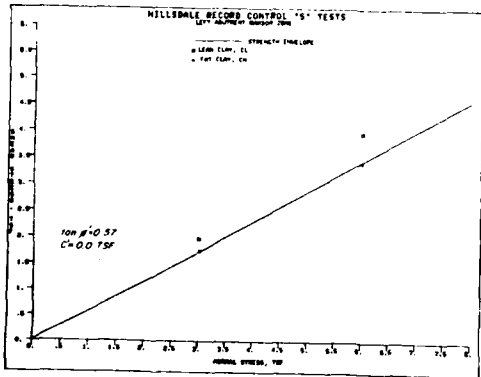
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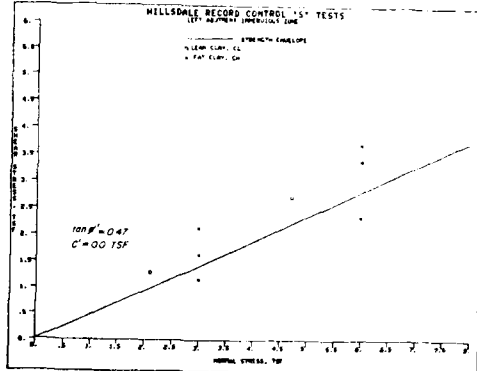
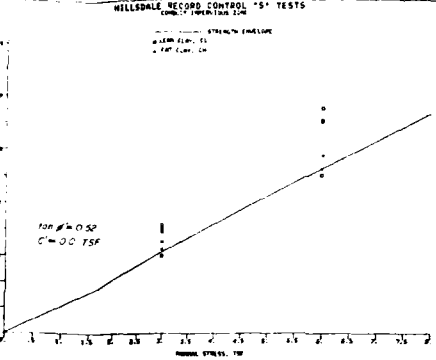
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Symbol	Revisions	Date	Approved
U. S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI			
Designed by	BIG BULL CREEK, KANSAS HILLSDALE LAKE EMBANKMENT CRITERIA REPORT		
Drawn by	<b>RECORD CONTROL "S" TEST SUMMARY</b>		
Checked by	Scale	Sheet Number	
Submitted by	Date		
	SEPTEMBER 1984		
		2 of 2	File No. 0-15-1081

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PLATE NO. 87

2

DEPARTMENT OF THE ARMY  
MISSOURI RIVER DIVISION, ENGINEER OFFICE  
DIVISION LABORATORY  
OMAHA, NEBRASKA 68102

Subject: Bridge Superstructure Double Underpinning and Deck Replacement  
Materials for Materials of Service

Project: Milldale Lake

Reference: None

Date Sample: 10/1/57 Date Received: 10/1/57

Method of Test: As Specified

References: None

Subject testing has been conducted in accordance with the above method and references. Results are presented in Tables 1 and 2 and Figures 1 through 4. All tests indicate that both samples were non-dispersive, except for soluble salts test run on Sample No. 1. Since the 100% pure water permeability has only about 80 percent reliance in predicting dispersal performance, it is felt that the other tests are sufficient to evaluate the material performance.

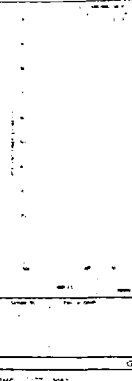
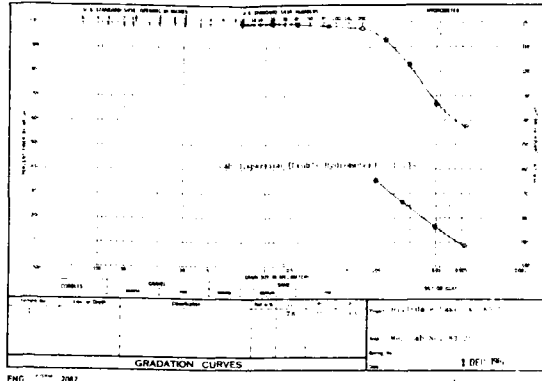
TABLE 1  
Material: Sample No. 1

1. Crumb test results: non-dispersive.  
2. Soluble salts in pure water:

Sample No.	Na	Ca	Mg	SO <sub>4</sub>
1	111	100	186	117

Filtrate from 50g dry soil and 100ml distilled water:  
Concentration of actual pure water of soil in an liquid limit (see Table 2): 100 (100) (100) (100)

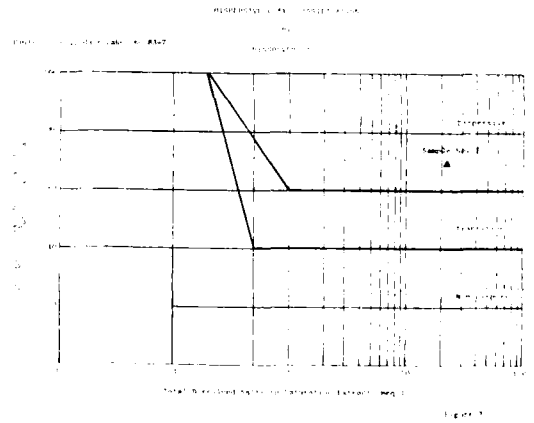
Submitted by: *[Signature]*  
K. C. [Name]  
Division Laboratory



Project: Milldale Lake, C-83-7

Product Dispersive Test Results

Sample	Depth	Hand, Inches	Test Time, Minutes	Flow Through, cc/min	Color of Flow, of Test	Note Stop Filter Test, Needle Pin.	Observation
#1	10'	40	7	1.2	100	no stop	non-dispersive
#1	15'	35	7	1.2	100	no stop	non-dispersive
#2	10'	40	7	1.2	100	no stop	non-dispersive
#2	15'	40	7	1.2	100	no stop	non-dispersive





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DEPARTMENT OF THE ARMY  
 MISSOURI FIELD DIVISION, CORPS OF ENGINEERS  
 DIVISION LABORATORY  
 WASH., DISTRICT OFFICE

18 JULY 1964

Project: Missouri Lake EC 64-8

Location: Missouri Lake

Date Sampled: 18 JULY 1964

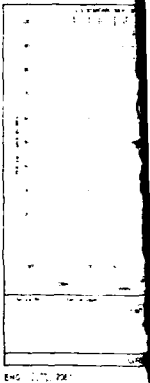
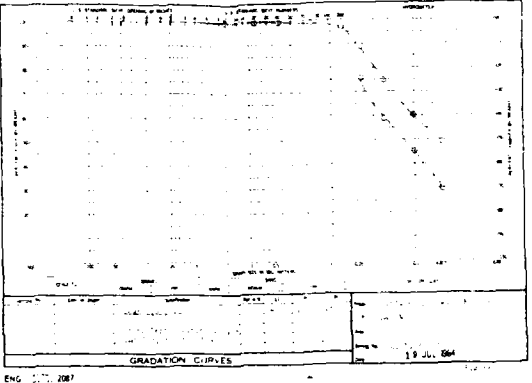
Method of Test or Specimen: DISPERSE

Reference: None

Table 1: Test Results

Sample	Depth	Head, Inches	Test Time, Minutes	Flow Through Specimen, ml/sec	Color of Flow at End of Test	Soil Size after Test, (Sieve No.)	Classification
November	2	10	2.4	Cloudy	100		Dispersive
May	2	10	2.7	Cloudy	100		Dispersive
May	2	10	2.0	Cloudy	100		Dispersive
May with 2% NaCl	2	5	0.5	Clear	100		Non-dispersive

Signature: *R. Schalk*



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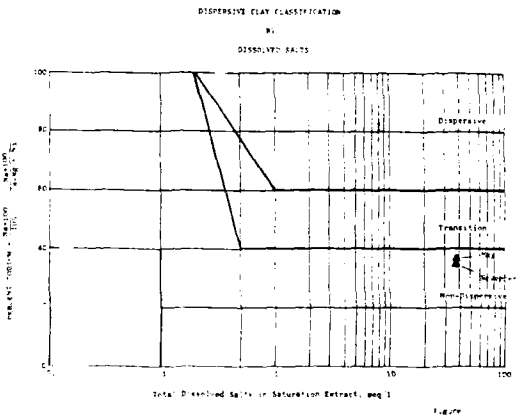
B

FINNLE TEST RESULTS

Project: Missouri Lake EC 64-8

MO Lab. No.: 64-218

Sample	Depth	Head, Inches	Test Time, Minutes	Flow Through Specimen, ml/sec	Color of Flow at End of Test	Soil Size after Test, (Sieve No.)	Classification
November	2	10	2.4	Cloudy	100		Dispersive
May	2	10	2.7	Cloudy	100		Dispersive
May	2	10	2.0	Cloudy	100		Dispersive
May with 2% NaCl	2	5	0.5	Clear	100		Non-dispersive



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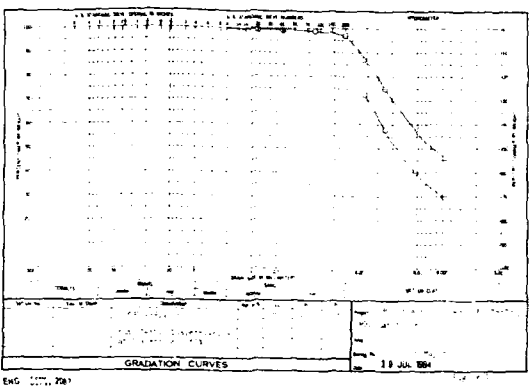
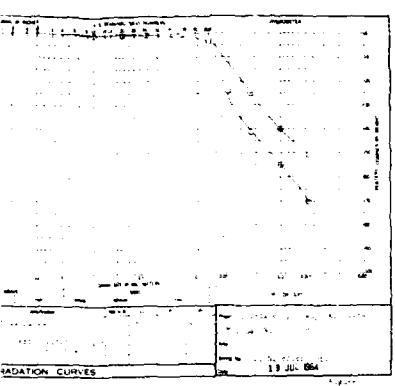
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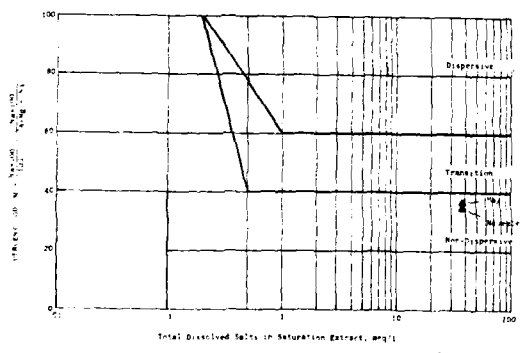
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DISPERSIVE CLAY CLASSIFICATION  
BY  
DISSOLVED SALTS



Symbol	Revisions Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
KANSAS CITY, MISSOURI

Designated by: **41**  
U.S. Army Corps of Engineers

Drawn by: **BIG BULL CREEK, KANSAS  
HILLSDALE LAKE  
EMBANKMENT CRITERIA REPORT**

Checked by:

Submitted by:

Date: **SEPTEMBER 1964**

Sheet number: **2 of 2**

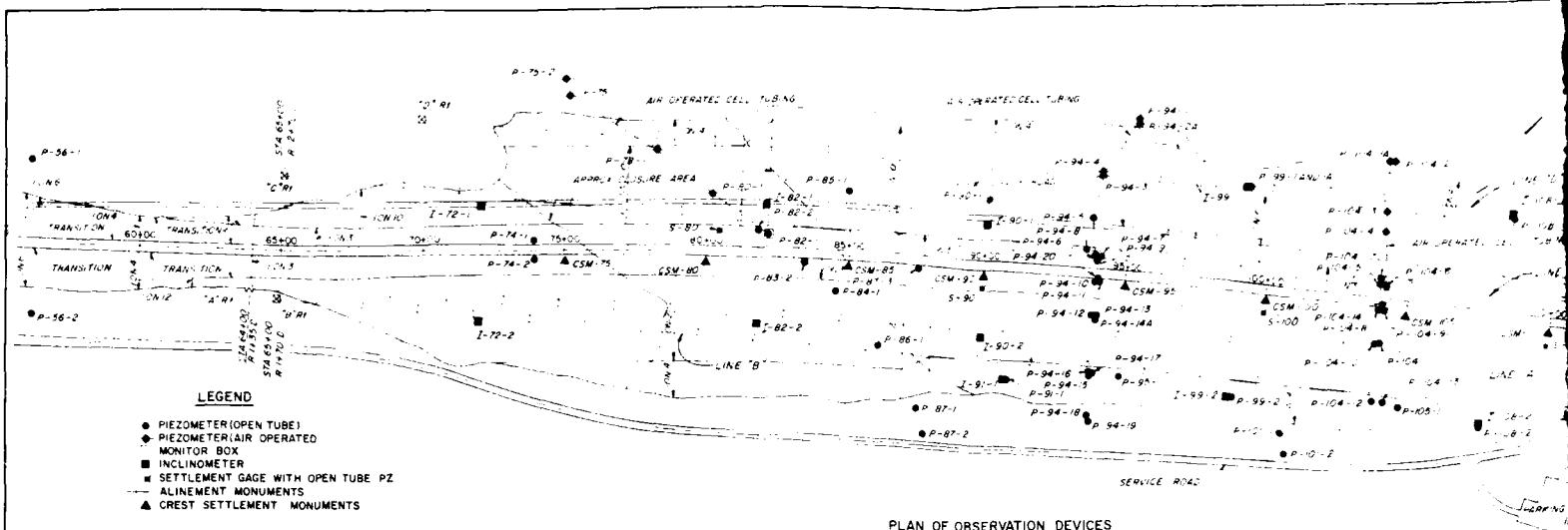
File No: **0-15-1147**

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PLATE NO. 151B



PLAN OF OBSERVATION DEVICES

OPEN TUBE PIEZOMETERS					
DEVICE NUMBER	STATION	RANGE	TIP ELEVATION	TOP OF RISER	MATERIAL
P-56-1	56+00	3+300	908.0	326.97	RAYTOWN LS
P-56-2	56+00	2+500	909.5	329.77	RAYTOWN LS
P-74-1	74+00	0+180	856.6	453.28	DRUM LS
P-74-2	74+00	0+180	855.5	453.45	DRUM LS
P-82-1	82+75	0+800	847.4	338.53	QUIVIRA SH
P-82-2	82+75	0+800	847.7	334.14	QUIVIRA SH
P-83-2	83+35	0+250	858.5	951.90	IMPERVIOUS
P-84-1	84+65	1+200	845.1	925.47	DRUM LS
P-85-1	85+00	2+350	841.2	917.30	QUIVIRA SH
P-86-1	86+40	3+200	838.2	908.93	QUIVIRA SH
P-87-1	87+75	5+200	836.3	873.71	OVERBURDEN
P-87-2	87+65	6+100	837.8	879.66	QUIVIRA SH
P-87-3	87+50	0+250	875.0	907.70	IMPERVIOUS
P-90-1	90+00	2+350	842.6	917.55	QUIVIRA SH
P-91-1	91+10	4+200	839.0	881.77	QUIVIRA SH
P-94-6	93+95	0+600	861.6	938.53	OVERBURDEN
P-94-7	94+05	0+600	847.7	938.74	DRUM LS
P-94-8	93+58	0+800	842.5	932.29	QUIVIRA SH
P-94-9	93+95	0+500	833.1	940.15	WESTERVILLE LS
P-94-10	93+95	0+250	881.67	949.53	IMPERVIOUS
P-94-11	94+05	0+250	862.4	949.90	IMPERVIOUS
P-94-12	93+95	1+450	861.1	922.92	OVERBURDEN
P-94-13	94+55	1+450	847.1	922.97	DRUM LS
P-94-14A	94+05	1+570	832.4	922.02	WESTERVILLE LS
P-94-15	93+95	3+550	809.3	902.43	OVERBURDEN
P-94-16	93+95	3+500	841.3	903.31	QUIVIRA SH
P-94-17	94+05	3+500	832.3	903.21	WESTERVILLE LS
P-94-18	93+95	5+000	852.4	877.83	OVERBURDEN
P-94-19	94+05	5+200	843.2	877.96	QUIVIRA SH
P-94-20	94+05	0+170	847.5	952.55	PERVIOUS
P-95-1	95+00	3+300	934.0	908.00	PERVIOUS
P-99-1	99+10	3+520	845.4	897.80	QUIVIRA SH
P-99-2	99+10	3+880	842.0	894.55	QUIVIRA SH
P-101-1	100+95	5+000	894.6	877.51	OVERBURDEN
P-101-2	101+05	5+750	837.2	879.21	QUIVIRA SH
P-104-5	103+95	0+600	853.0	931.1	OVERBURDEN
P-104-6	104+20	0+550	846.9	936.90	DRUM LS
P-104-7	103+95	0+800	841.2	931.27	QUIVIRA SH
P-104-8	103+95	0+250	879.8	950.90	IMPERVIOUS
P-104-9	104+05	0+250	856.8	951.10	IMPERVIOUS
P-104-10	103+95	1+450	856.6	922.87	OVERBURDEN
P-104-11	104+05	1+410	845.5	923.20	DRUM LS
P-104-12	103+95	3+500	853.8	902.1	OVERBURDEN
P-104-13	104+27	3+500	836.2	904.41	QUIVIRA SH
P-104-14	104+06	0+180	843.4	952.41	IMPERVIOUS
P-105-1	105+05	3+350	868.05	901.15	PERVIOUS
P-108-2	108+10	3+970	836.4	892.83	QUIVIRA SH
P-112-2	113+43	0+210	890.8	944.70	IMPERVIOUS
P-113-3	113+00	2+500	890.52	944.45	IMPERVIOUS
P-120-1	120+00	1+250	878.0	921.17	RAYTOWN LS
P-120-2	120+71	1+500	877.6	928.24	RAYTOWN LS
A-53	53+00	2+600	895.0	368.34	RAYTOWN LS
CSM-75-2	53+00	2+200	892.41	376.11	RAYTOWN LS

\* SUBMERGED - NO LONGER READ

AIR OPERATED PIEZOMETERS					
DEVICE NUMBER	STATION	RANGE	TIP ELEVATION	MATERIAL	TYPE
P-75-1	75+11	1+500	857.7	128.15	NET
P-75-2	75+11	1+100	857.7	128.15	S.W.
P-74-1	74+75	2+450	843.7	128.15	S.W.
P-80-1	80+70	4+100	847.0	128.15	S.W.
P-84-1A	84+04	1+450	854.1	128.15	S.W.
P-84-1	83+99	3+550	843.1	128.15	S.W.
P-84-4	84+00	3+500	846.4	128.15	S.W.
P-84-5	83+70	2+000	846.4	128.15	S.W.
P-90-1A	90+10	3+500	841.4	128.15	S.W.
P-104-1A	103+95	1+150	867.1	128.15	RETIC
P-110-3	110+00	1+700	852.0	128.15	RETIC
P-110-4	110+00	1+700	842.0	128.15	S.W.
P-106-1	104+00	5+500	851.4	128.15	S.W.
P-113-1	113+00	2+200	840.1	128.15	S.W.

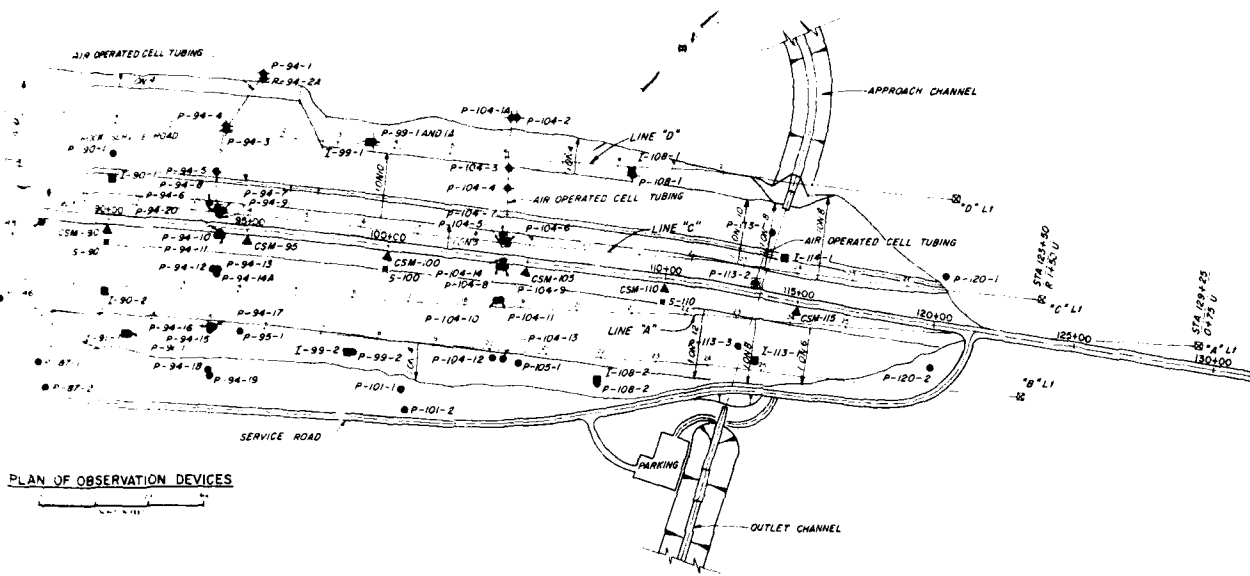
\* SUBMERGED - NO LONGER READ

FOUNDATION SETTLEMENT GAGES W/OPEN TUBE PZS					
DEVICE NUMBER	STATION	RANGE	TIP ELEVATION	RISER ELEVATION	MATERIAL
S-81	80+50	0+400	870.33	41.00	OVERBURDEN
S-95	90+00	1+400	871.43	41.00	OVERBURDEN
S-100	100+00	0+400	870.40	41.00	OVERBURDEN
S-112	113+00	0+400	871.24	94.00	OVERBURDEN

CREST SETTLEMENT MONUMENTS			
DEVICE NUMBER	STATION	RANGE	INITIAL SURVEY ELEVATION
CSM-75	75+00	0+150	902.34
CSM-80	80+00	0+150	901.84
CSM-85	85+00	0+150	901.88
CSM-90	90+00	0+150	902.03
CSM-95	95+00	0+150	902.00
CSM-100	100+00	0+150	901.55
CSM-105	105+00	0+150	902.04
CSM-110	110+00	0+150	901.96
CSM-112	113+00	0+150	902.00

INCLINOMETER SCHEDULE			
DEVICE NUMBER	STATION	RANGE	ORIG. DATA
I-72-1	72+00	0+100	128.15
I-72-2	72+00	0+100	128.15
I-74-1	74+00	0+100	128.15
I-74-2	74+00	0+100	128.15
I-82-1	82+75	0+100	128.15
I-82-2	82+75	0+100	128.15
I-83-2	83+35	0+100	128.15
I-84-1	84+65	1+100	128.15
I-85-1	85+00	2+100	128.15
I-86-1	86+40	3+100	128.15
I-87-1	87+75	5+100	128.15
I-87-2	87+65	6+100	128.15
I-87-3	87+50	0+100	128.15
I-90-1	90+00	2+100	128.15
I-91-1	91+10	4+100	128.15
I-94-6	93+95	0+100	128.15
I-94-7	94+05	0+100	128.15
I-94-8	93+58	0+100	128.15
I-94-9	93+95	0+100	128.15
I-94-10	93+95	0+250	128.15
I-94-11	94+05	0+250	128.15
I-94-12	93+95	1+450	128.15
I-94-13	94+55	1+450	128.15
I-94-14A	94+05	1+570	128.15
I-94-15	93+95	3+550	128.15
I-94-16	93+95	3+500	128.15
I-94-17	94+05	3+500	128.15
I-94-18	93+95	5+000	128.15
I-94-19	94+05	5+200	128.15
I-94-20	94+05	0+170	128.15
I-95-1	95+00	3+300	128.15
I-99-1	99+10	3+520	128.15
I-99-2	99+10	3+880	128.15
I-101-1	100+95	5+000	128.15
I-101-2	101+05	5+750	128.15
I-104-5	103+95	0+600	128.15
I-104-6	104+20	0+550	128.15
I-104-7	103+95	0+800	128.15
I-104-8	103+95	0+250	128.15
I-104-9	104+05	0+250	128.15
I-104-10	103+95	1+450	128.15
I-104-11	104+05	1+410	128.15
I-104-12	103+95	3+500	128.15
I-104-13	104+27	3+500	128.15
I-104-14	104+06	0+180	128.15
I-105-1	105+05	3+350	128.15
I-108-2	108+10	3+970	128.15
I-112-2	113+43	0+210	128.15
I-113-3	113+00	2+500	128.15
I-120-1	120+00	1+250	128.15
I-120-2	120+71	1+500	128.15
A-53	53+00	2+600	128.15
CSM-75-2	53+00	2+200	128.15

\* SUBMERGED - NO LONGER READ



PLAN OF OBSERVATION DEVICES

**PIEZOMETERS**

STATION	MATERIAL	TYPE
72+00	OVERBURDEN	PERFOR
72+00	OVERBURDEN	S.W.
82+00	OVERBURDEN	S.W.
82+00	OVERBURDEN	PERFOR
82+00	OVERBURDEN	S.W.
90+00	OVERBURDEN	S.W.
90+00	OVERBURDEN	PERFOR
90+00	OVERBURDEN	S.W.
99+00	OVERBURDEN	S.W.
99+00	OVERBURDEN	PERFOR
99+00	OVERBURDEN	S.W.
108+00	OVERBURDEN	PERFOR
108+00	OVERBURDEN	S.W.
113+64	OVERBURDEN	PERFOR
113+64	OVERBURDEN	S.W.
114+20	OVERBURDEN	PERFOR
114+20	OVERBURDEN	S.W.

**INCLINOMETER SCHEDULE**

DEVICE NUMBER	STATION	RANGE	ORIGINAL DEPTH
72-1	72+00	1+750	80.5
72-2	72+00	2+500	75.9
82-1	82+00	1+400	119.2
82-2	82+00	2+500	112.3
90-1	90+00	1+430	120.7
90-2	90+00	2+500	111.8
99-1	99+00	4+000	66.1
99-2	99+00	3+520	85.6
99-3	99+00	3+880	73.7
108-1	108+00	3+520	83.3
108-2	108+00	3+920	95.4
113-1	113+64	2+500	94.0
114-1	114+20	4+400	108.8

\* SUBMERGED - NO LONGER READ

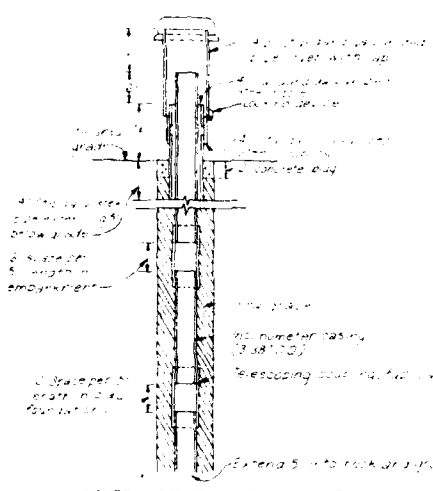
**GAGES W/OPEN TUBE PZS**

STATION	ELEVATION	RISER	MATERIAL
72+00	44.4	OVERBURDEN	OVERBURDEN
82+00	44.4	OVERBURDEN	OVERBURDEN
90+00	44.4	OVERBURDEN	OVERBURDEN
99+00	44.4	OVERBURDEN	OVERBURDEN

- DOCUMENTS**
- 1. SURVEY
  - 2. LOCATION
  - 3. PLAN
  - 4. SCHEDULE
  - 5. REPORT

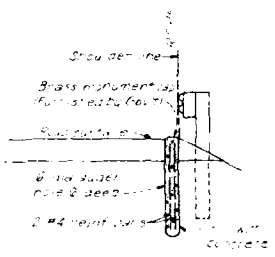
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 OBSERVATION DEVICES  
 PLAN AND SCHEDULE

In 1 sheet Sheet No. 1 Scale as shown  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-881  
 JANUARY 1983

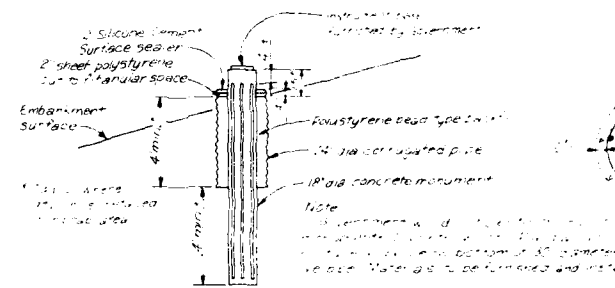


**INCLINOMETER CASING WITH SETTLEMENT COUPLINGS AND PROTECTIVE CAP**

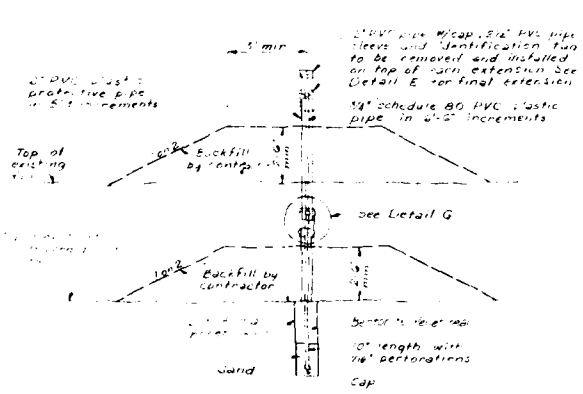
1. Settlement install complete  
 2. Government install-Contractor Extend  
 3. Settlement install complete  
 4. Contractor install complete



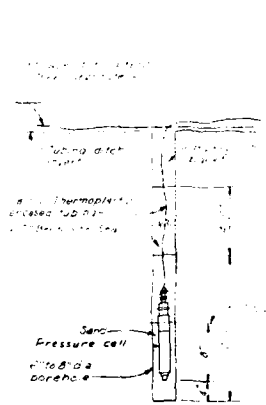
**CREST SETTLEMENT MONUMENT**



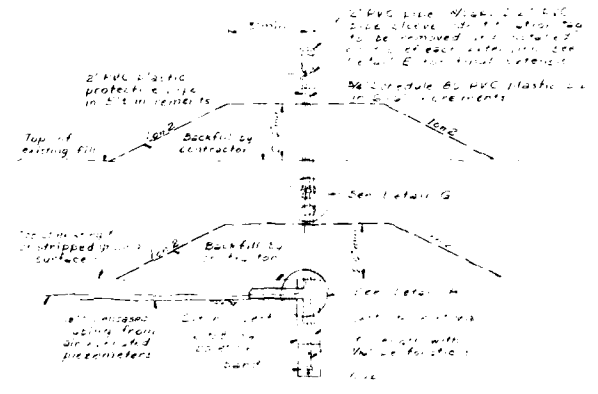
**ALIGNMENT MONUMENTS**



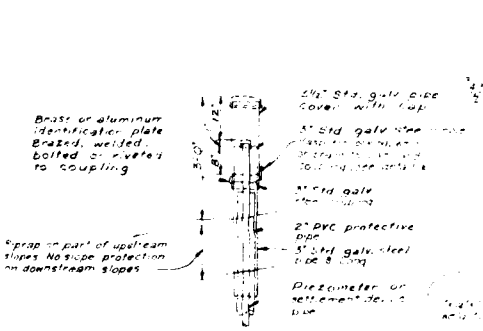
**OPEN TUBE PIEZOMETER INSTALLATION AND EXTENSION. DETAIL A**  
 Not to Scale



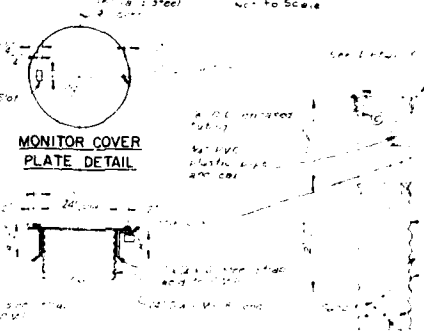
**AIR OPERATED PIEZOMETER INSTALLATION. DETAIL E**  
 Not to Scale



**OPEN TUBE PIEZOMETER WITH TUBING FROM AIR OPERATED PIEZOMETER. DETAIL C**  
 Not to Scale

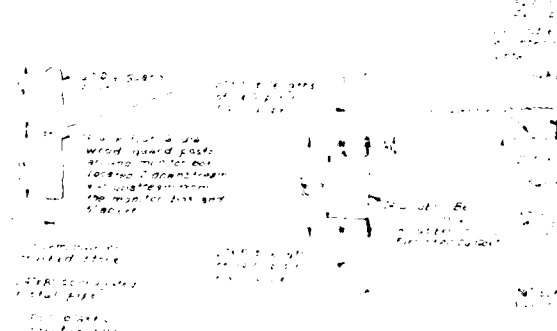


**FINAL POSITION OF PIEZOMETERS AND SETTLEMENT DEVICES. DETAIL E**  
 Not to Scale

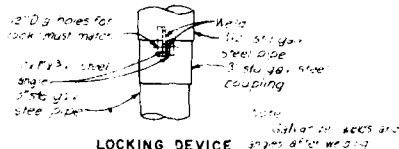


**MONITOR COVER PLATE DETAIL**

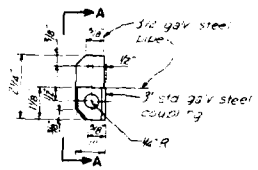
**MONITOR LOCK. DETAIL F**  
 Not to Scale



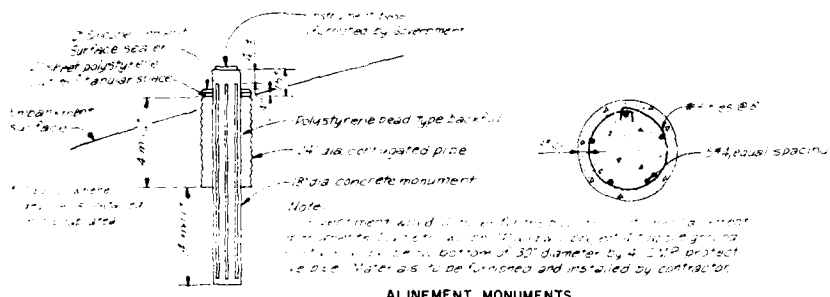
**PROTECTIVE PIPE COUPLING. DETAIL G**  
 Not to Scale



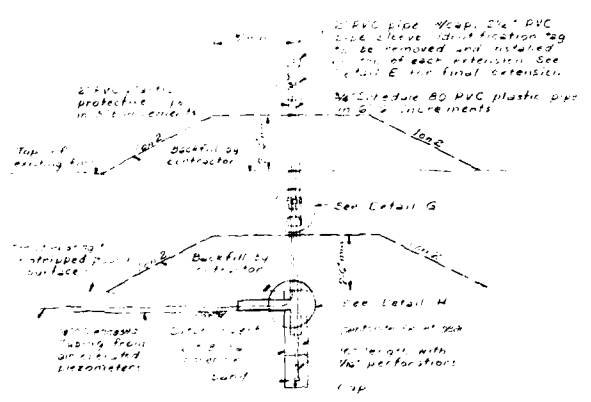
**LOCKING DEVICE SECTION A**



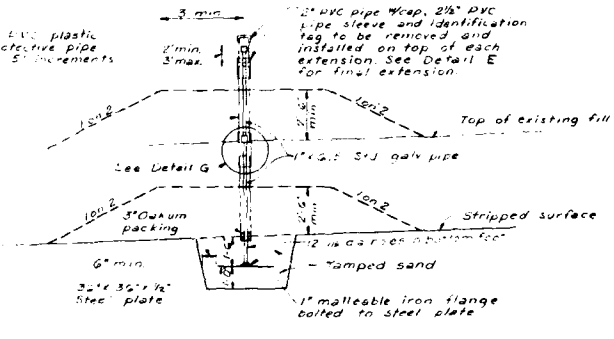
**LOCKING DEVICE DETAIL K**



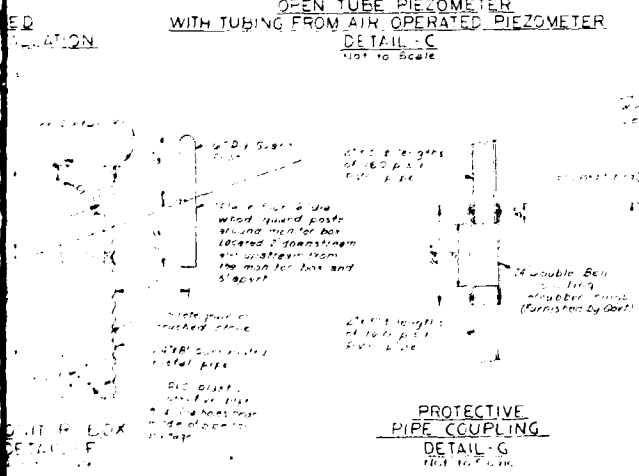
**ALIGNMENT MONUMENTS**



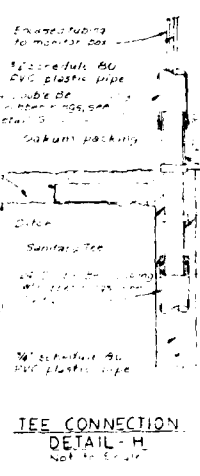
**OPEN TUBE PIEZOMETER WITH TUBING FROM AIR OPERATED PIEZOMETER DETAIL C**  
Not to Scale



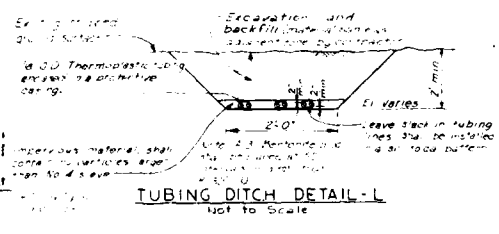
**SETTLEMENT DEVICE INSTALLATION AND EXTENSION DETAIL D**  
Not to Scale



**PROTECTIVE PIPE COUPLING DETAIL G**  
Not to Scale



**ICE CONNECTION DETAIL H**  
Not to Scale



**TUBING DITCH DETAIL L**  
Not to Scale

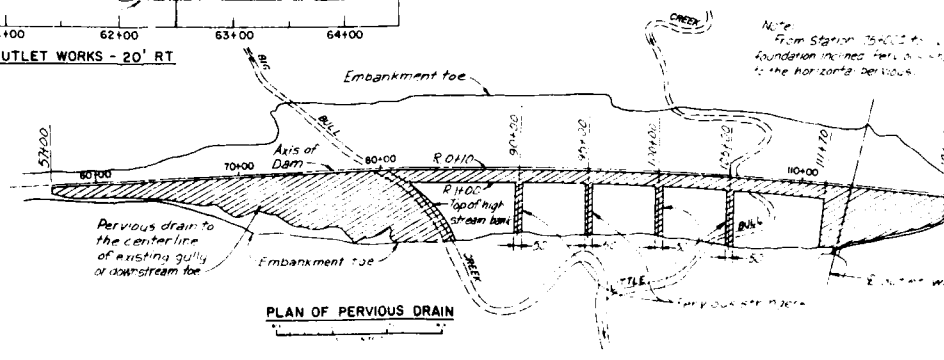
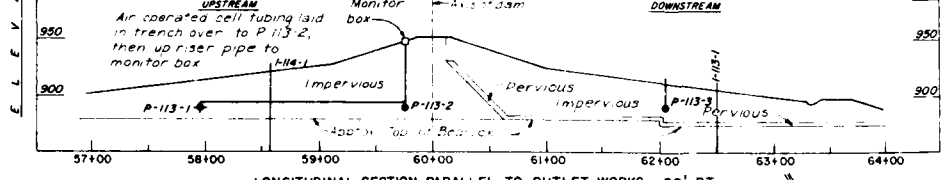
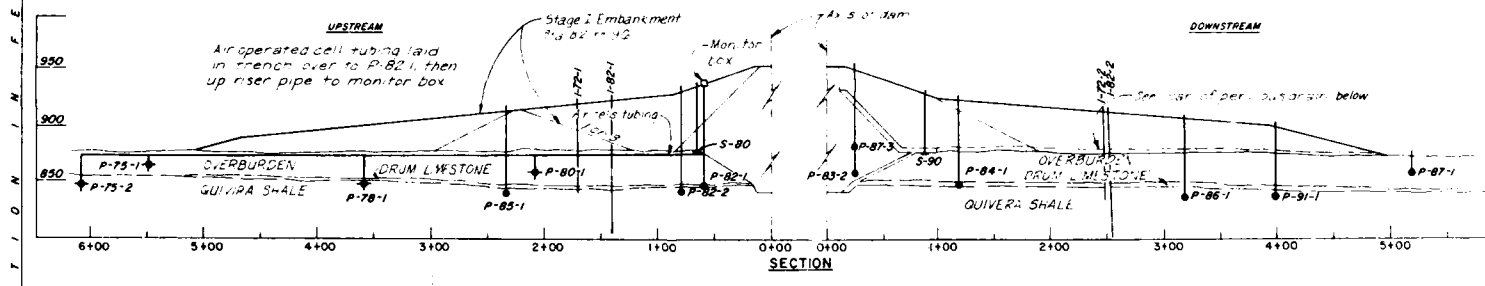
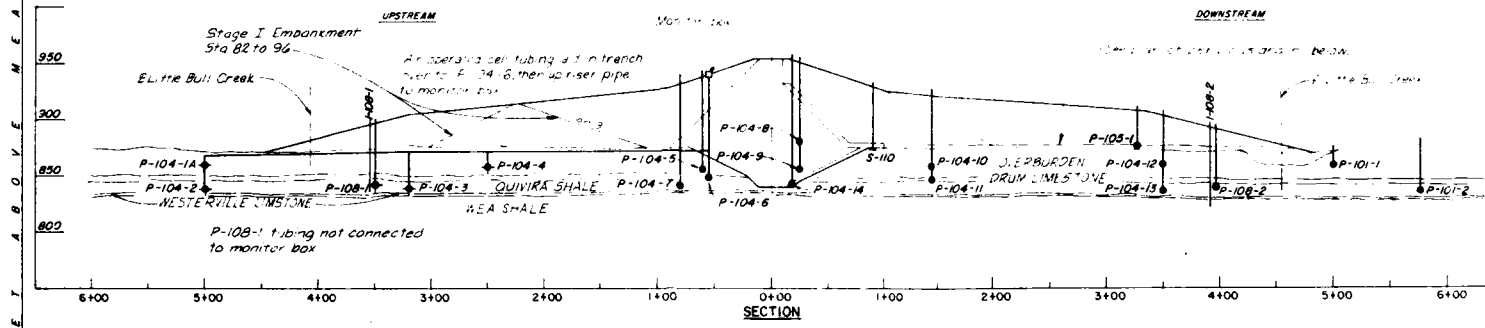
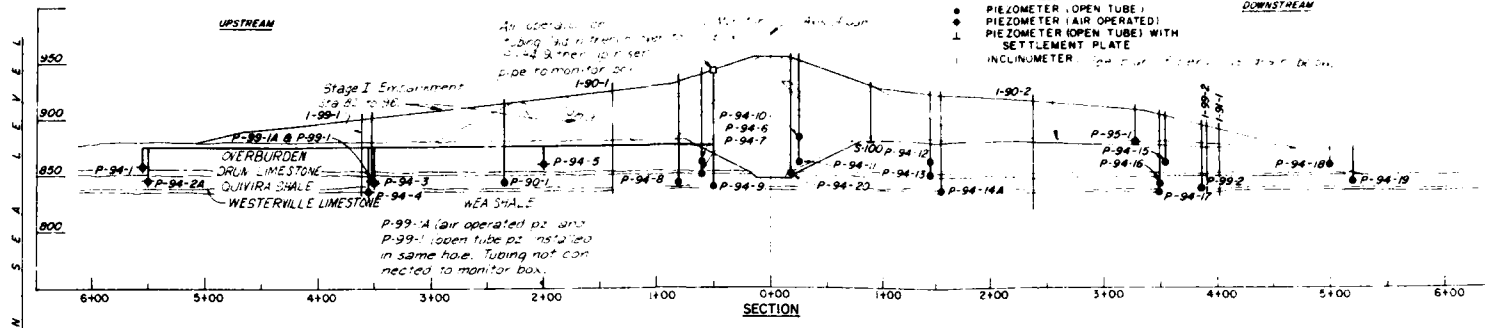
REVISED SEPTEMBER 1984  
BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
EMBANKMENT CRITERIA REPORT

**OBSERVATION DEVICES**  
DETAILS

in 1 sheet Sheet No. 1 Scale as shown  
CORPUS OF ENGINEERS U.S. ARMY  
KANSAS CITY DISTRICT  
FILE NO. O-15-882  
JANUARY 1983

**LEGEND**

- PIEZOMETER (OPEN TUBE)
- PIEZOMETER (AIR OPERATED)
- ⊥ PIEZOMETER (OPEN TUBE) WITH SETTLEMENT PLATE
- INCLINOMETER

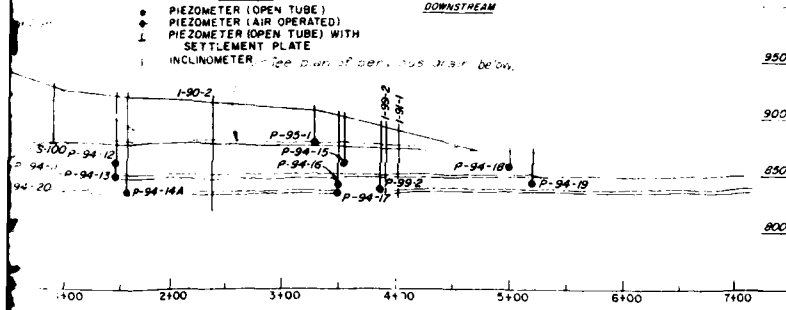


Note: From Station 70+00 to foundation inclined feet parallel to the horizontal pervious.

**LEGEND**

- PIEZOMETER (OPEN TUBE)
- ◆ PIEZOMETER (AIR OPERATED)
- L PIEZOMETER (OPEN TUBE) WITH SETTLEMENT PLATE
- I INCLINOMETER (Type mark of device shown below)

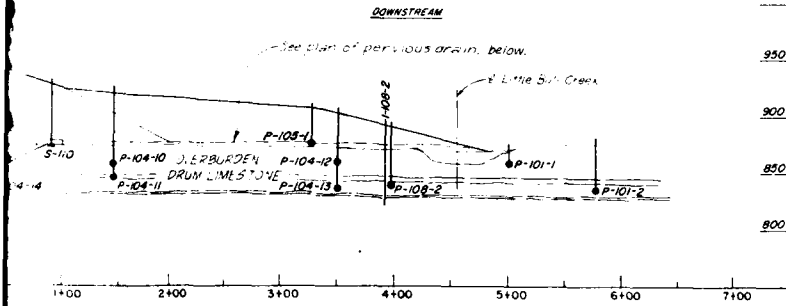
DOWNSTREAM



DOWNSTREAM

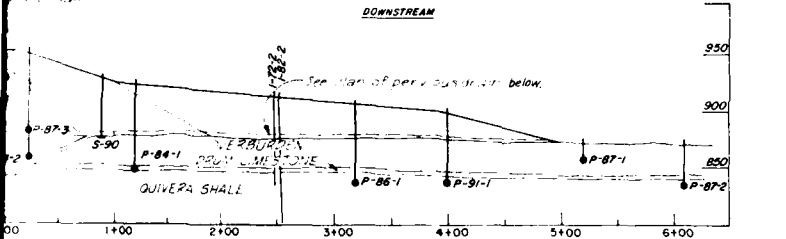
See plan of pervious drain, below.

Little Bull Creek

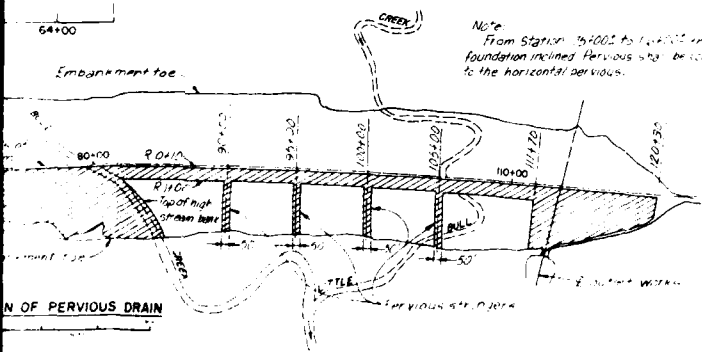


DOWNSTREAM

See plan of pervious drain, below.



Note:  
From Station 15+000 to 16+000 the foundation included pervious soil, be connected to the horizontal pervious.



REVISED SEPTEMBER 1984  
BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
EMBANKMENT CRITERIAL REPORT

OBSERVATION DEVICES  
SECTIONS

In 1 sheet

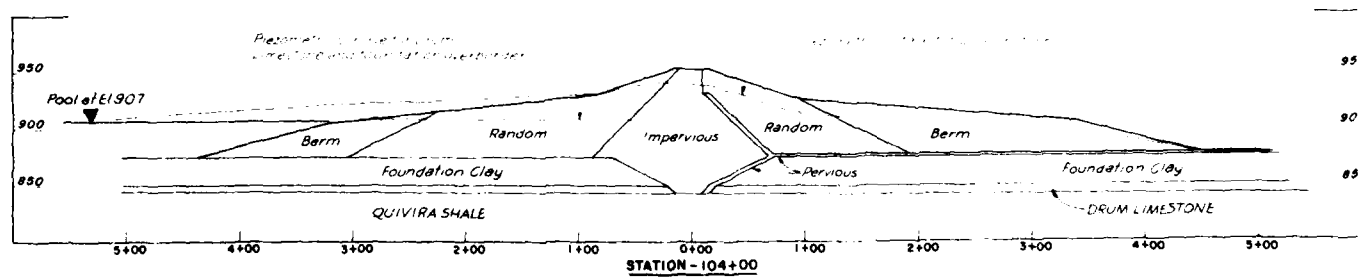
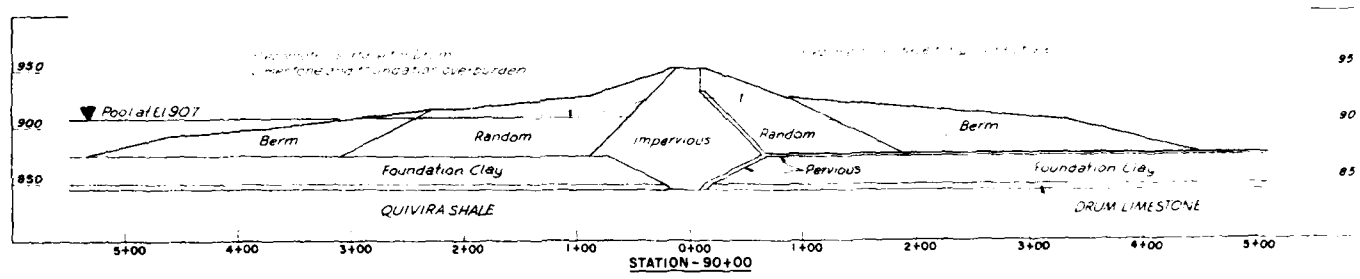
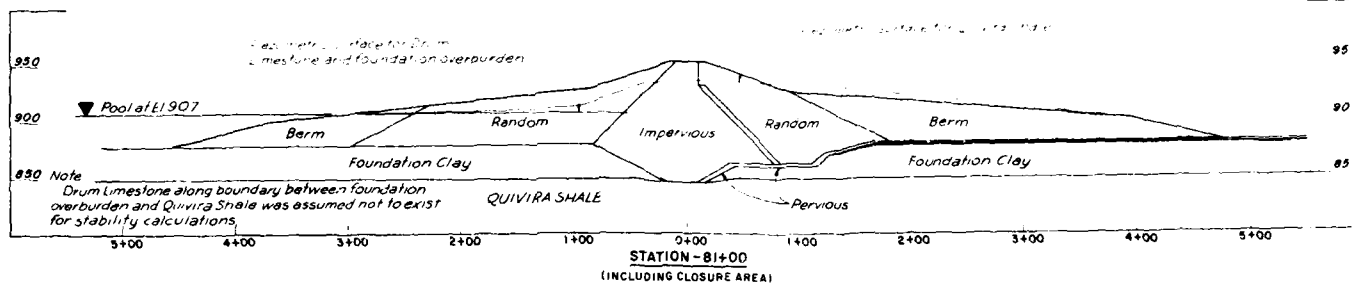
Sheet No. 1

Scale as shown

CORPS OF ENGINEERS U.S. ARMY  
KANSAS CITY DISTRICT  
FILE NO. O-15-883  
JANUARY 1983

PLATE NO 154

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929



5 4 3 2

D

C

B

A

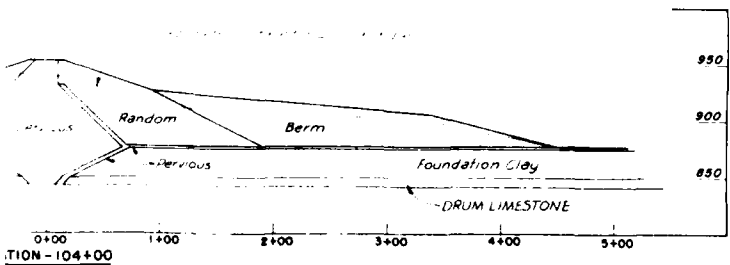
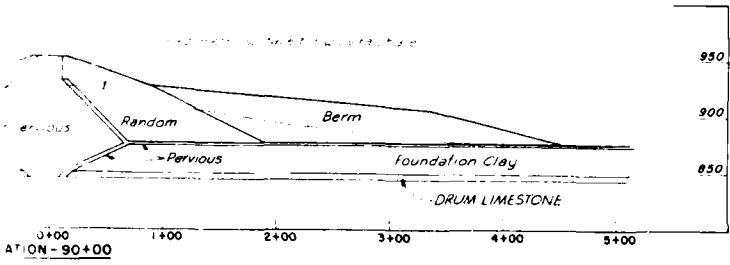
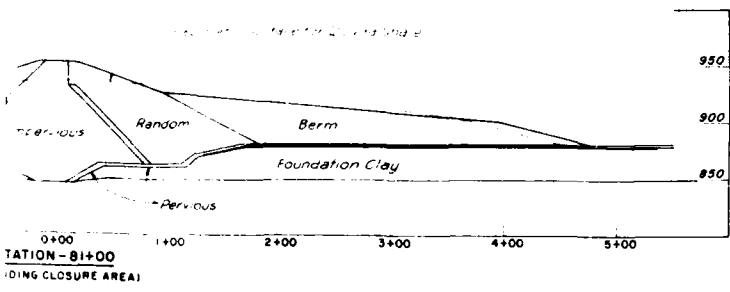
5 4 3 2



3

2

1



Note  
 All piezometric surfaces are shown  
 as they existed July 1983 with the pool  
 at El 907

Revisions			
Symbol	Descriptions	Date	Approved
U. S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI			
Designed by:	BIG BULL CREEK, KANSAS HILLSDALE LAKE EMBANKMENT CRITERIA REPORT		
Drawn by:	<b>PIEZOMETRIC SURFACES</b>		
Checked by:	Scale	Sheet number	
Submitted by:	AS SHOWN		
	Date		
	SEPTEMBER 1984		
	Dep. No.	1 of 1	File No. 0-15-1057

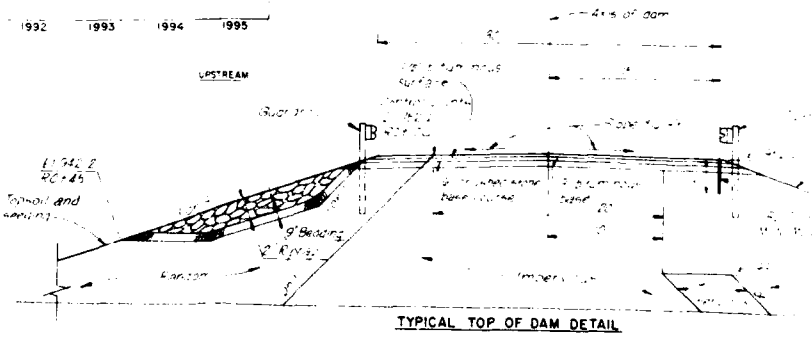
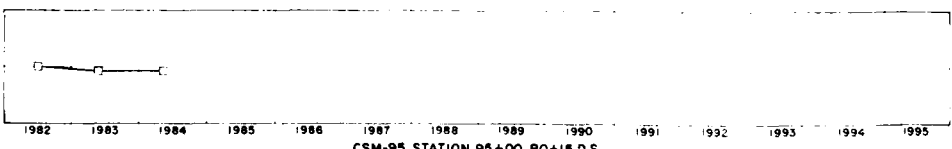
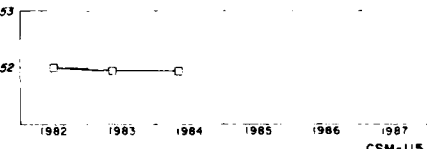
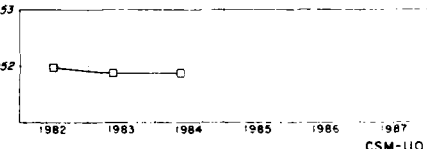
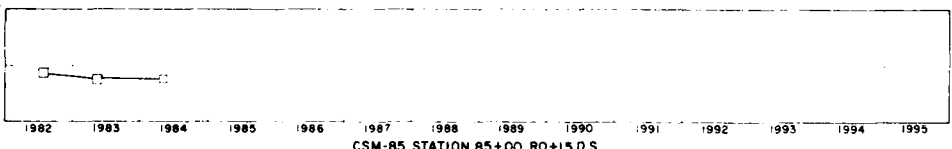
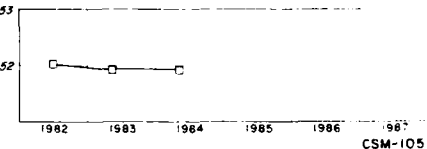
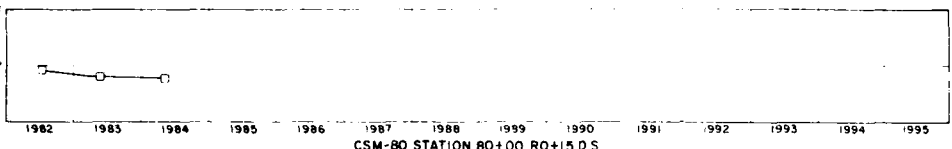
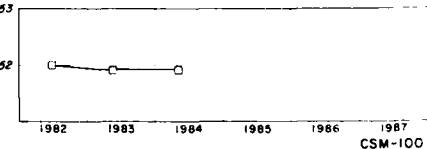
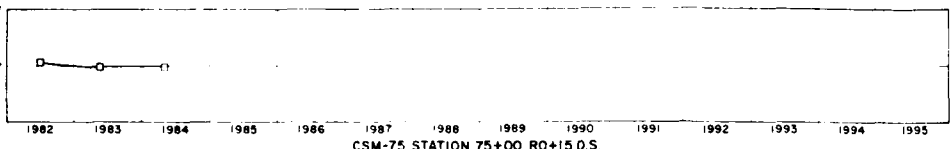
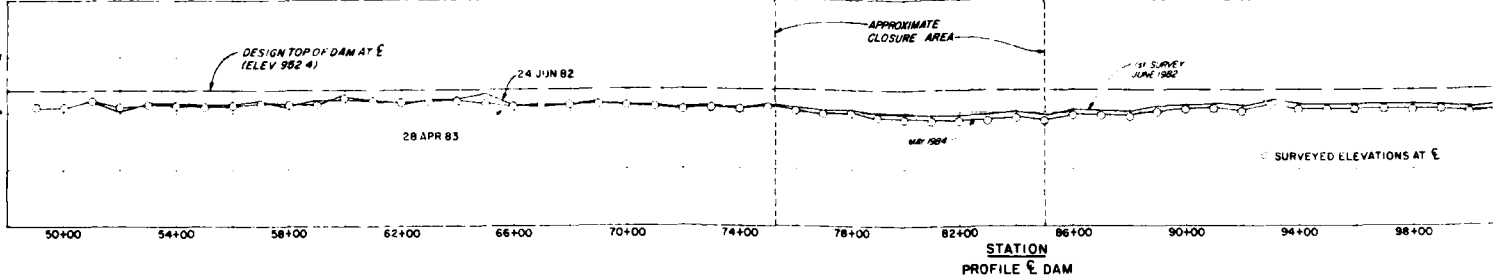
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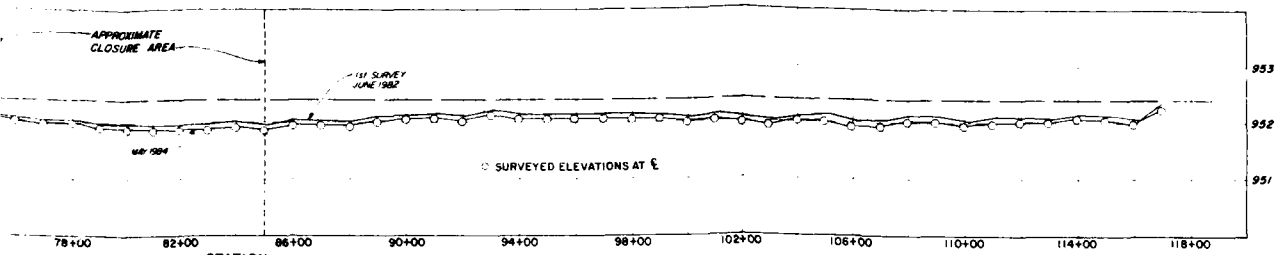
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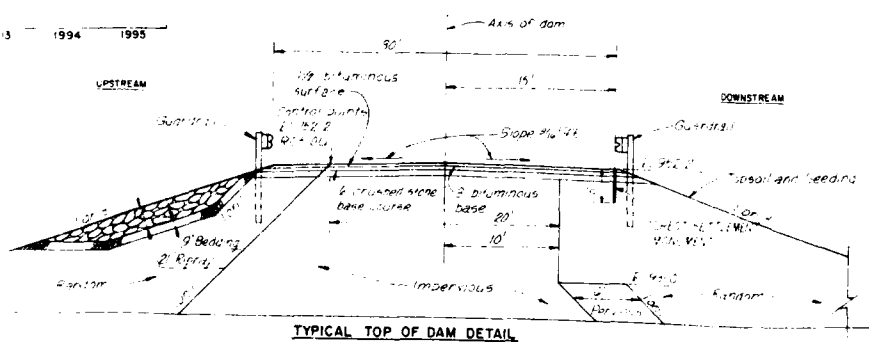
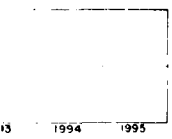
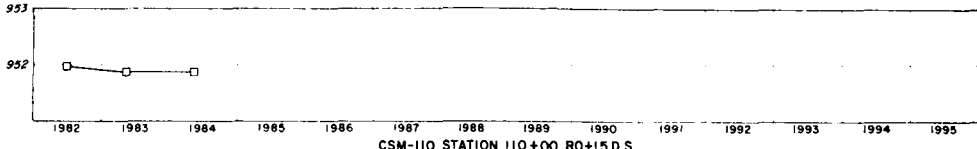
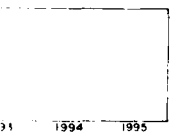
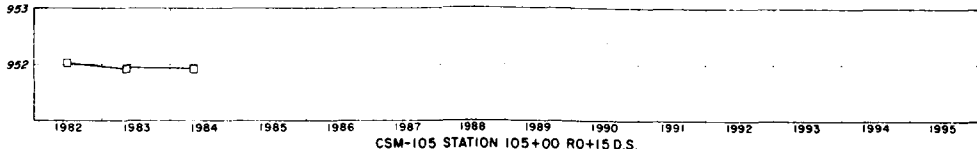
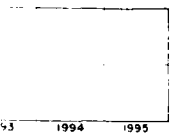
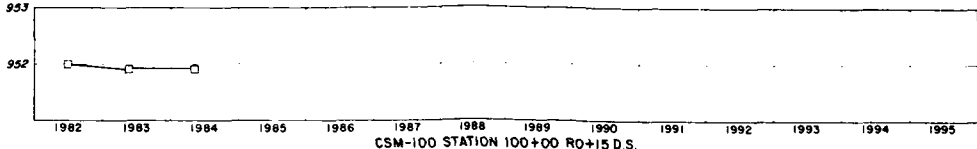
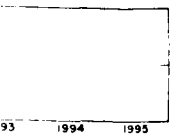
PLATE NO. 154A

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929





STATION  
PROFILE E OF DAM



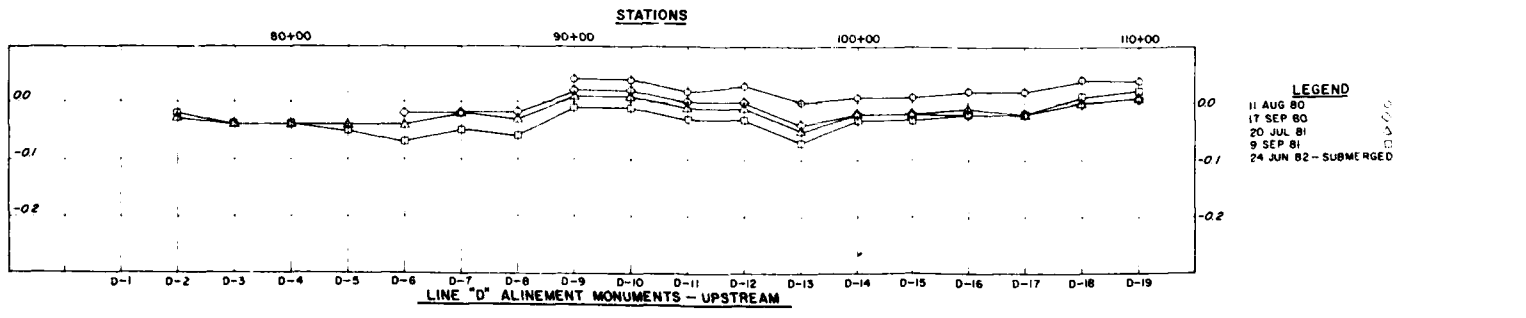
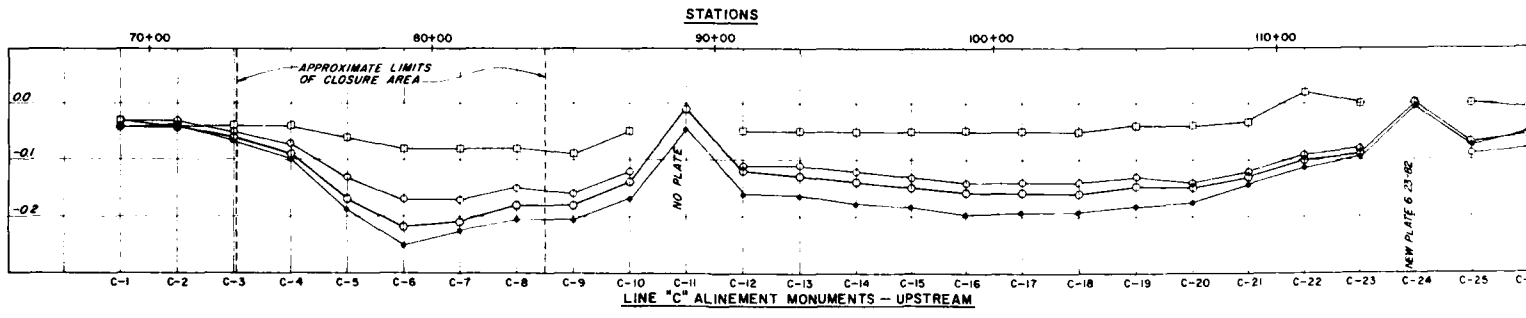
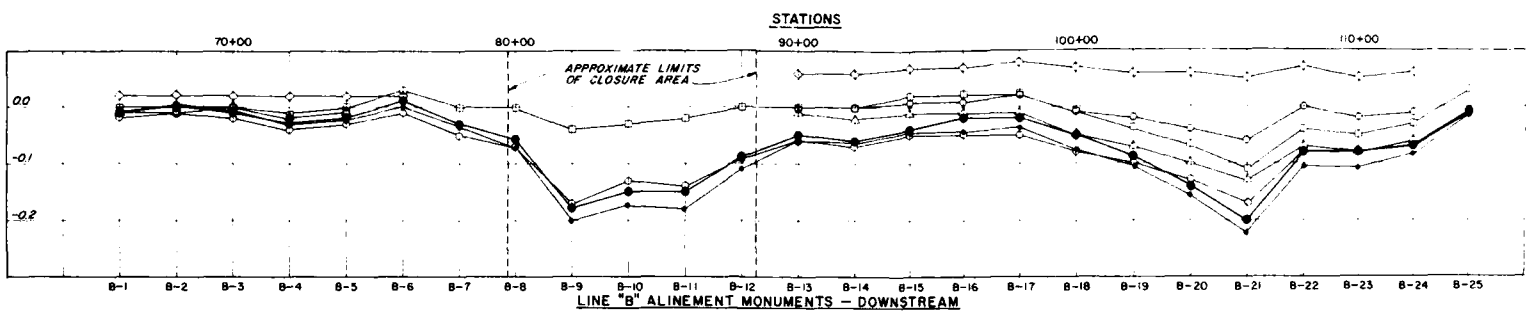
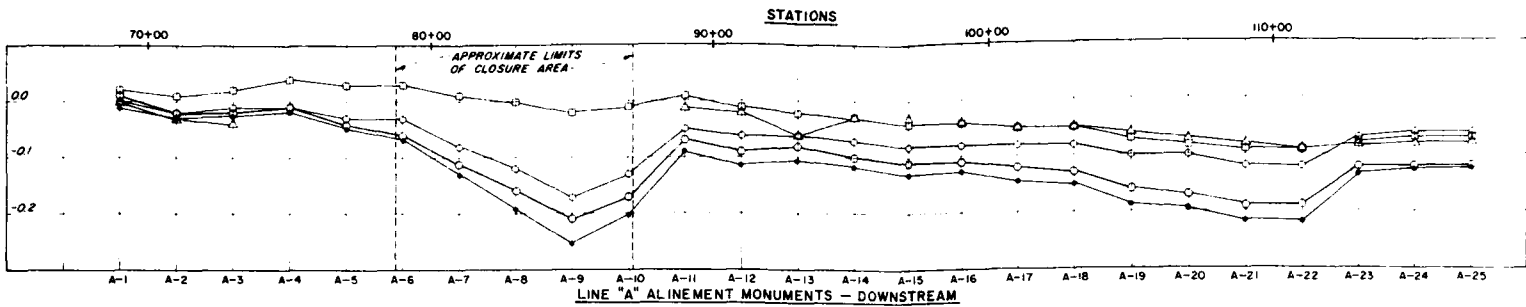
REVISED SEPTEMBER 1984  
BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
CREST SETTLEMENT MONUMENTS  
AND PROFILE ALONG E OF DAM

Sheet No. 1  
CORP. OF ENGINEERS U.S. ARMY  
KANSAS DISTRICT  
FILE NO. O-15-884  
JANUARY 1983

Scale as shown

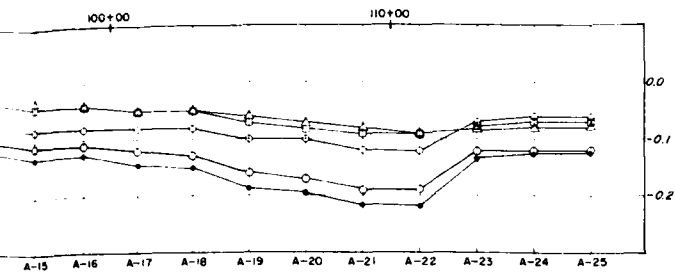
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PLATE NO 155



**LEGEND**

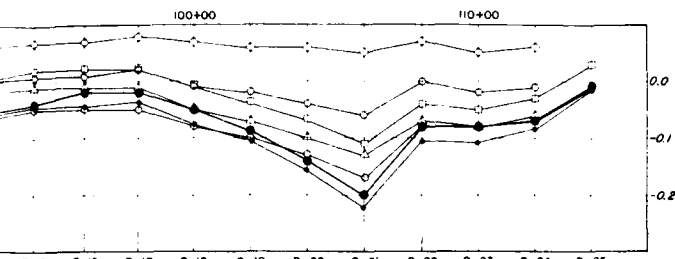
- 11 AUG 80
- 17 SEP 80
- 20 JUL 81
- 9 SEP 81
- 24 JUN 82 - SUBMERGED



**LEGEND**

- 22 JUL 81 ○
- 10 SEP 81 △
- 24 JUN 82 □
- 10 MAY 83 ●
- 9 MAY 84 •

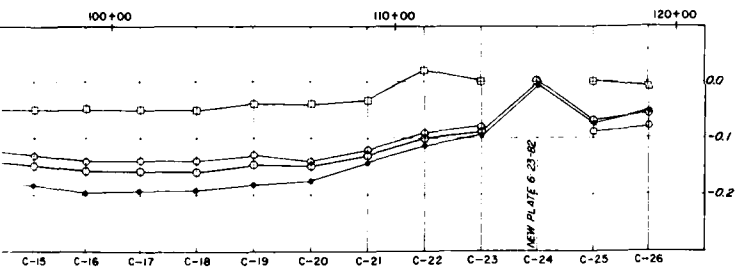
DOWNSTREAM



**LEGEND**

- 17 SEP 80 ○
- 5 MAY 81 △
- 21 JUL 81 □
- 10 SEP 81 ●
- 24 JUN 82 •
- 10 MAY 83 ○
- 9 MAY 84 △

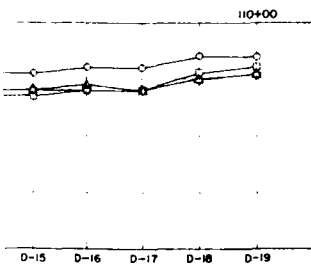
DOWNSTREAM



**LEGEND**

- 9 SEP 81 ○
- 23 JUN 82 △
- 11 MAY 83 □
- 9 MAY 84 ●

UPSTREAM



**LEGEND**

- 11 AUG 80 ○
- 17 SEP 80 △
- 20 JUL 81 □
- 9 SEP 81 ●
- 24 JUN 82 - SUBMERGED •

UPSTREAM

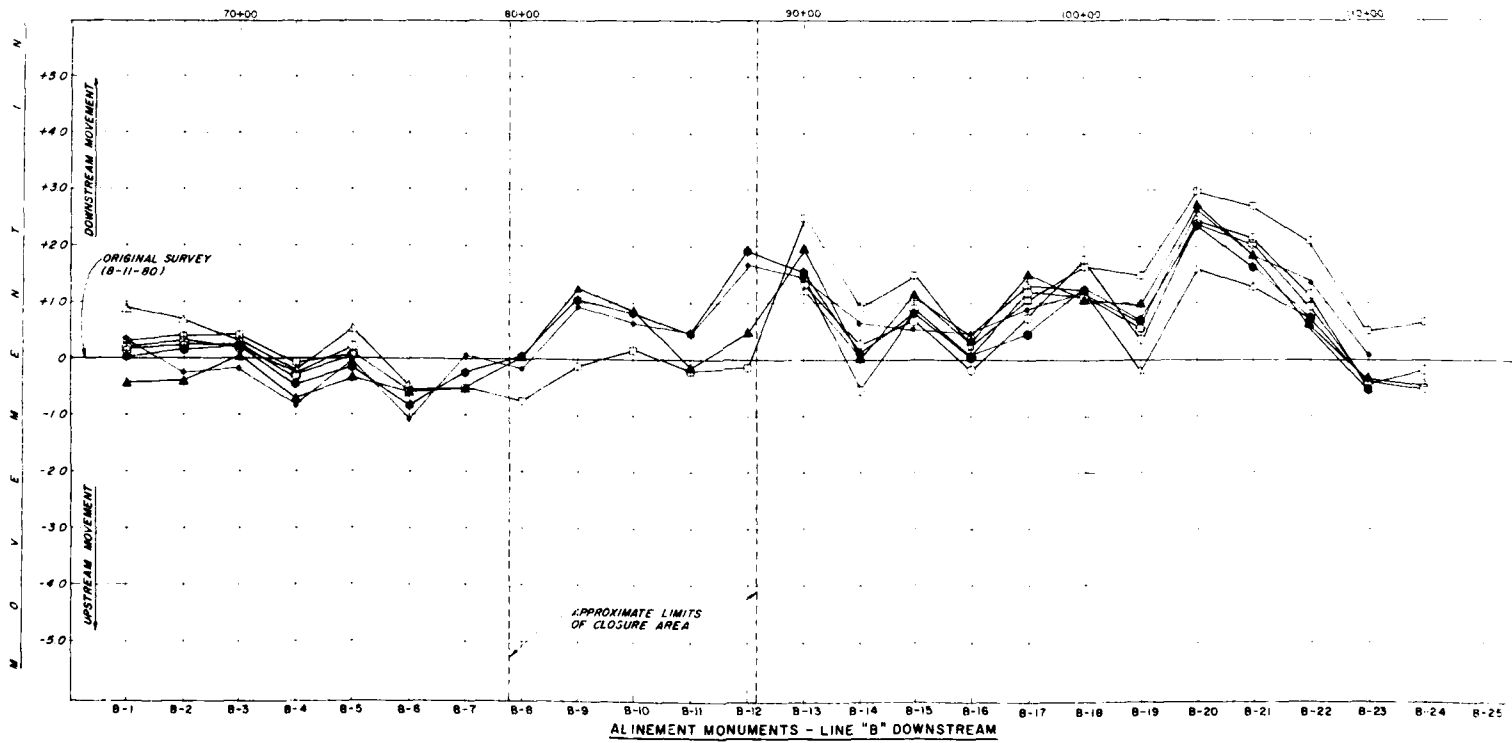
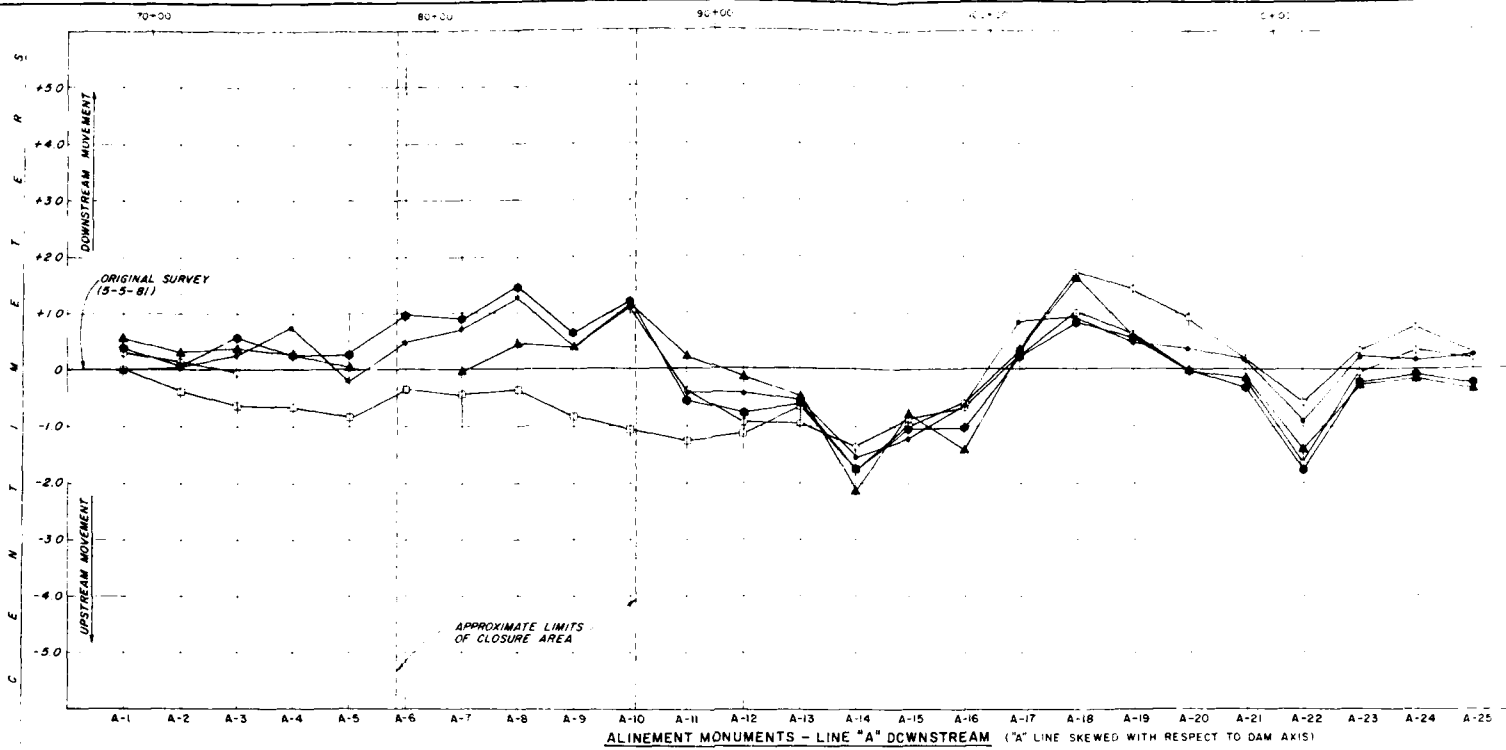
REVISED SEPTEMBER 1984  
BIG HULL CREEK, KANSAS  
**HILLSDALE LAKE**  
EMBANKMENT CRITERIA REPORT  
ALIGNMENT MONUMENTS  
LINES A, B, C AND D  
VERTICAL SUMMARIES

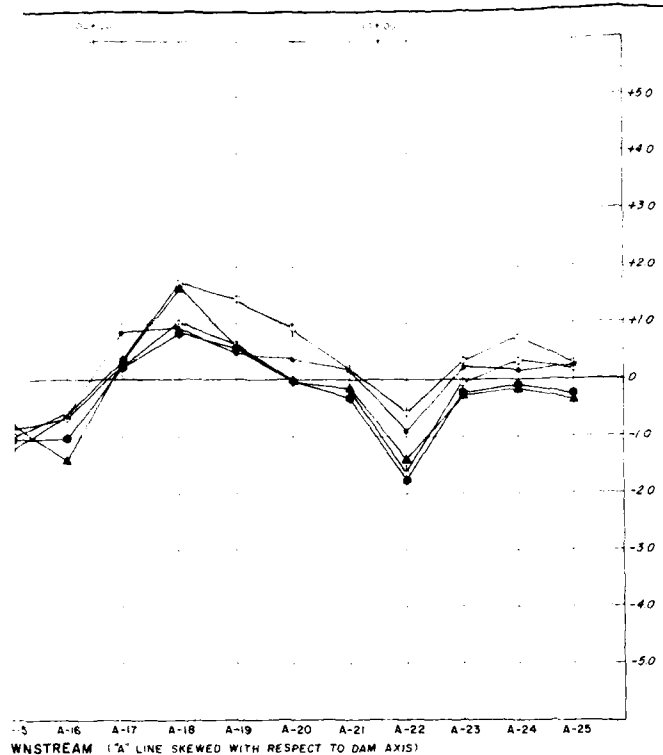
In 1 sheet

Sheet No 1

Scale as shown

CORPS OF ENGINEERS U.S. ARMY  
KANSAS CITY DISTRICT  
FILE NO O-15-885  
JANUARY 1983





**LEGEND**

ORIGINAL SURVEY 5-5-81L

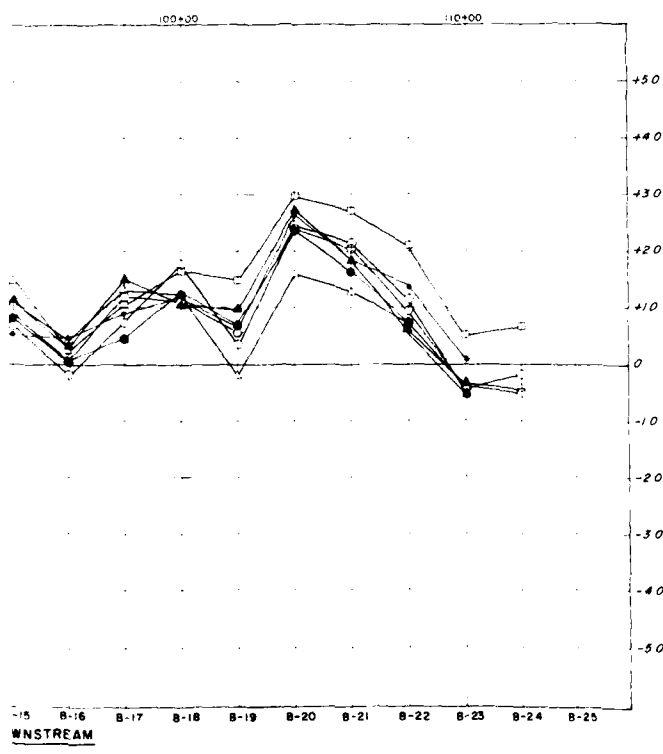
9-17-80  
5-5-81  
7-21-81  
9-10-81  
6-24-82  
5-10-83  
5-9-84

▲  
●

UPSTREAM DOWNSTREAM

V B A

INCREASE IN READING INDICATES  
DOWNSTREAM MOVEMENT



REVISED SEPTEMBER 1984  
BY BILL CREEK, KANSAS

**HILLSDALE LAKE**  
MONUMENT BROWN COUNTY

DOWNSTREAM  
ALINEMENT MONUMENTS LINES  
A AND B HORIZONTAL SUMMARY

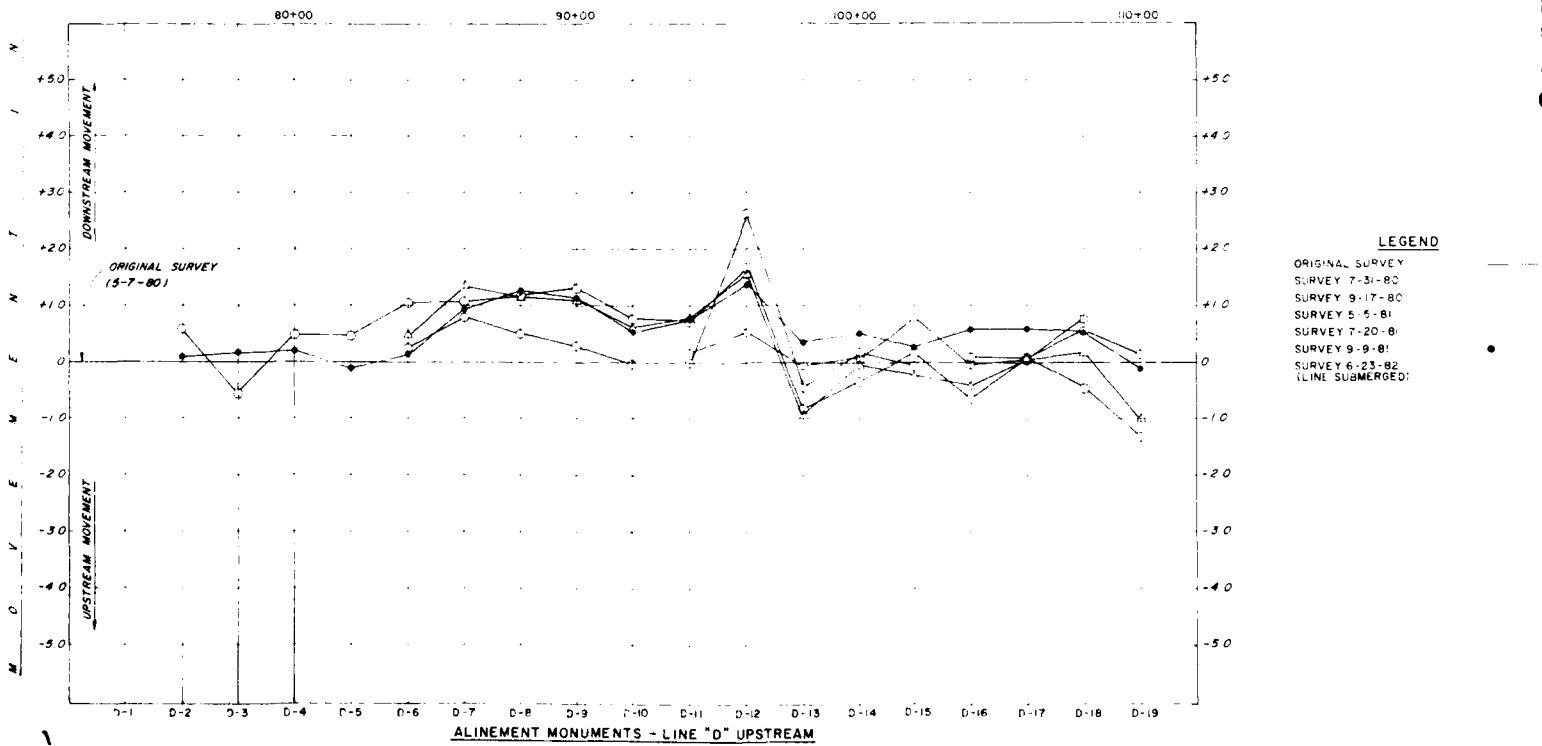
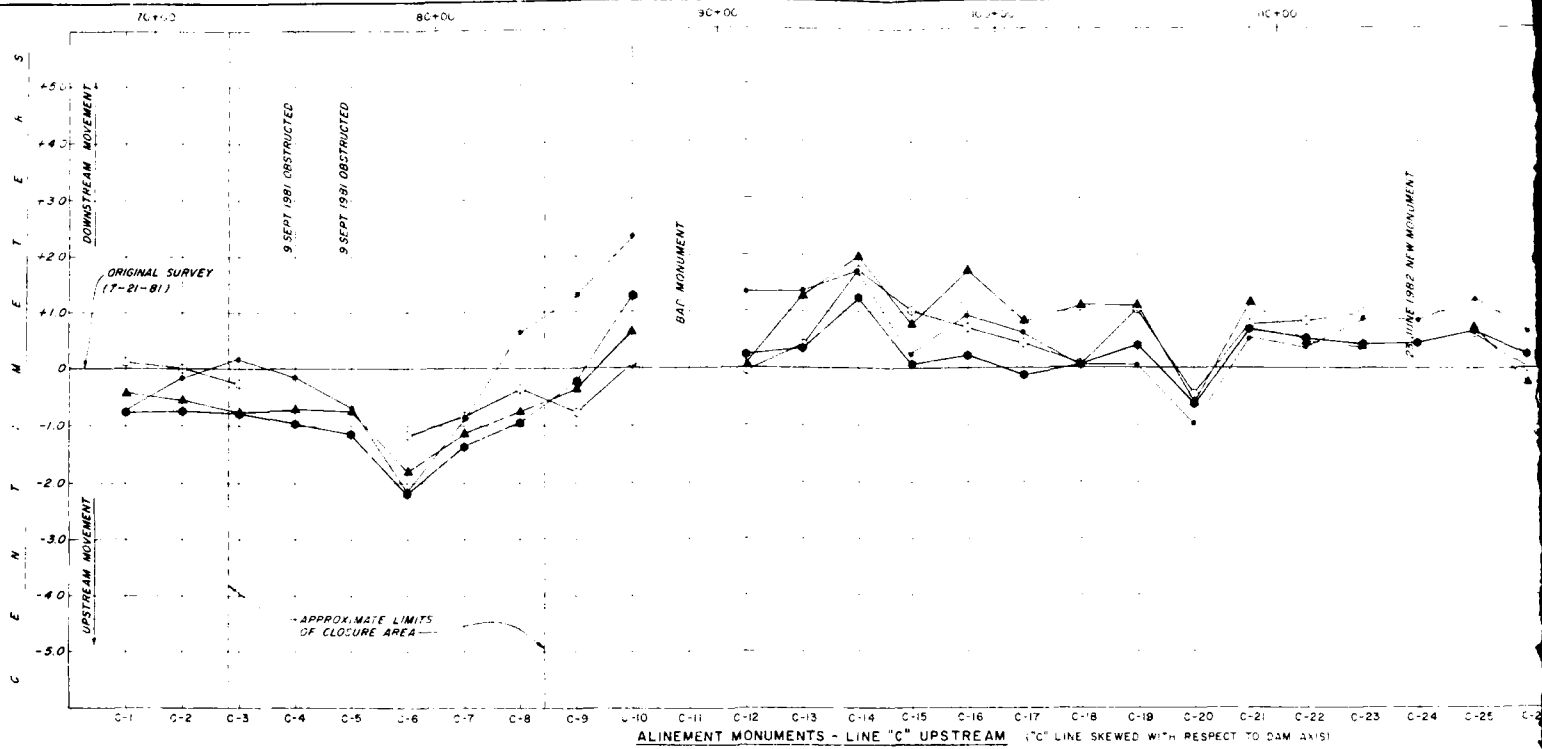
Sheet No. 1 of 1 sheet

Scale as shown

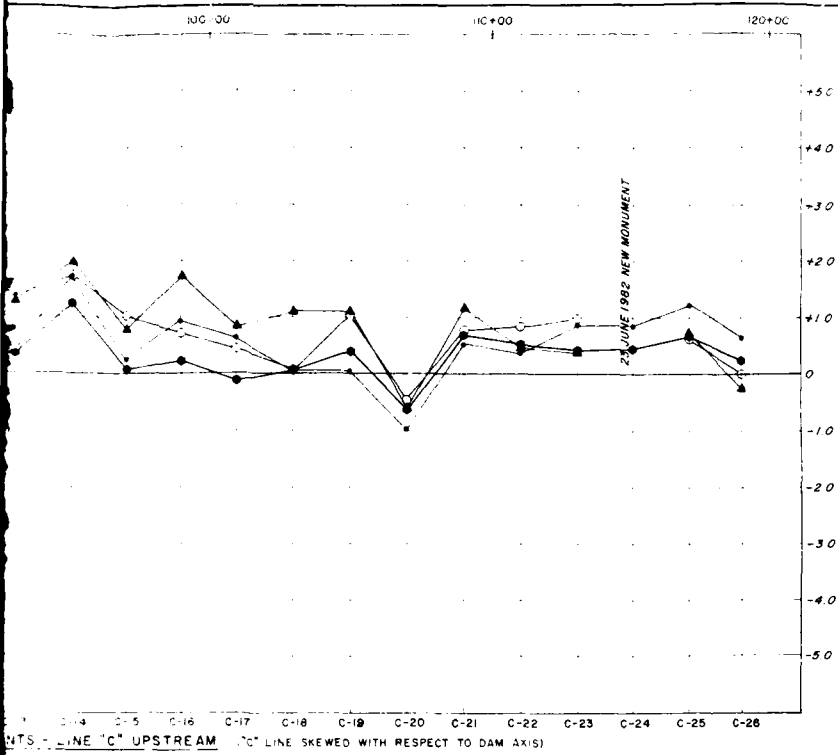
ENGINEER: [Signature]

KANSAS CITY DISTRICT

FILE NO. 0-15-886  
JANUARY 1985







**LEGEND**

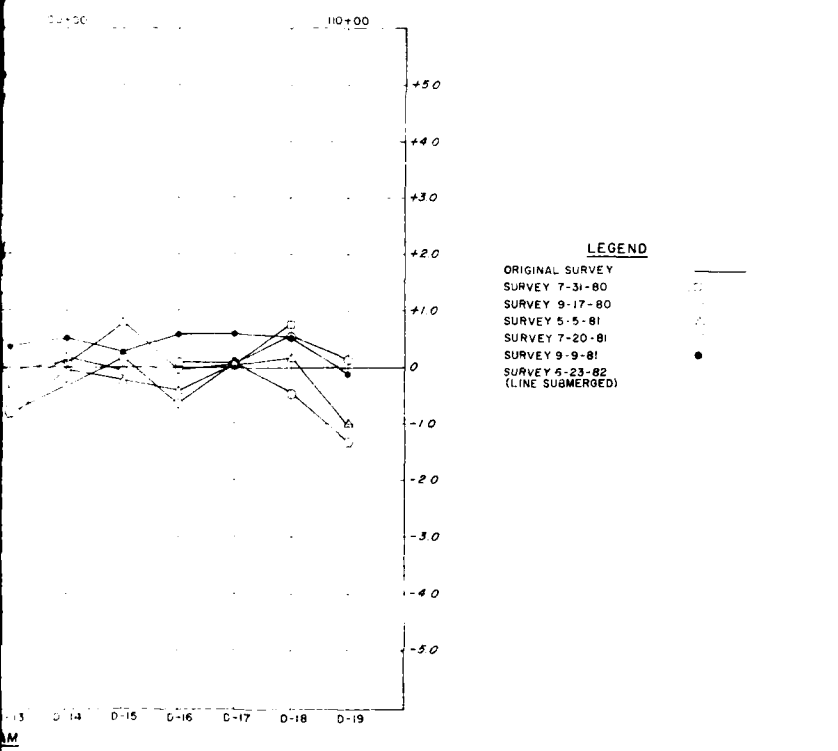
ORIGINAL SURVEY —●—

9-9-81 - -▲-

6-23-82 ···■···

5-10-83 -·-○-·-

5-9-84 - -◇-



**LEGEND**

ORIGINAL SURVEY —●—

SURVEY 7-31-80 - -▲-

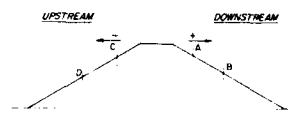
SURVEY 9-17-80 ···■···

SURVEY 5-5-81 -·-○-·-

SURVEY 7-20-81 - -◇-

SURVEY 9-9-81 - -▽-

SURVEY 6-23-82 (LINE SUBMERGED) ···■···

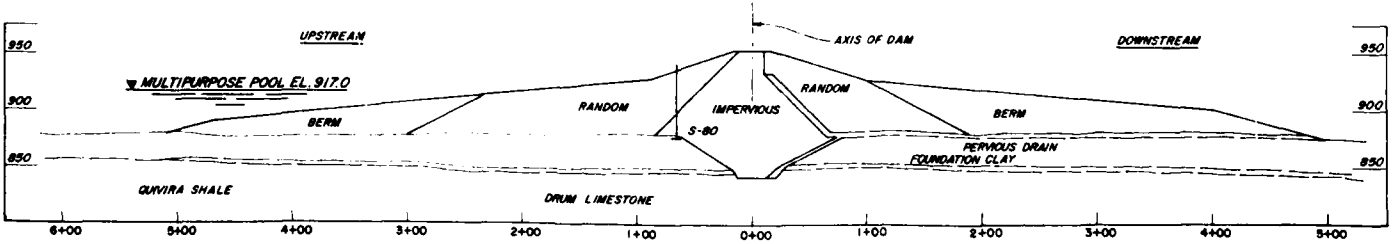
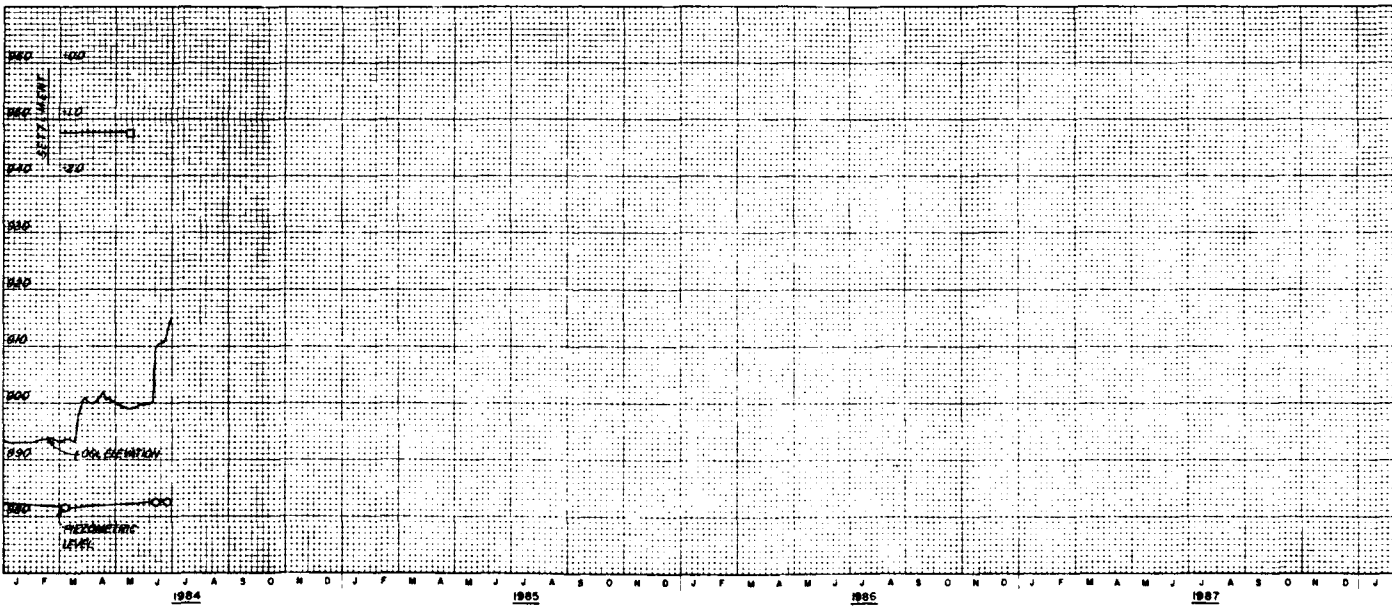
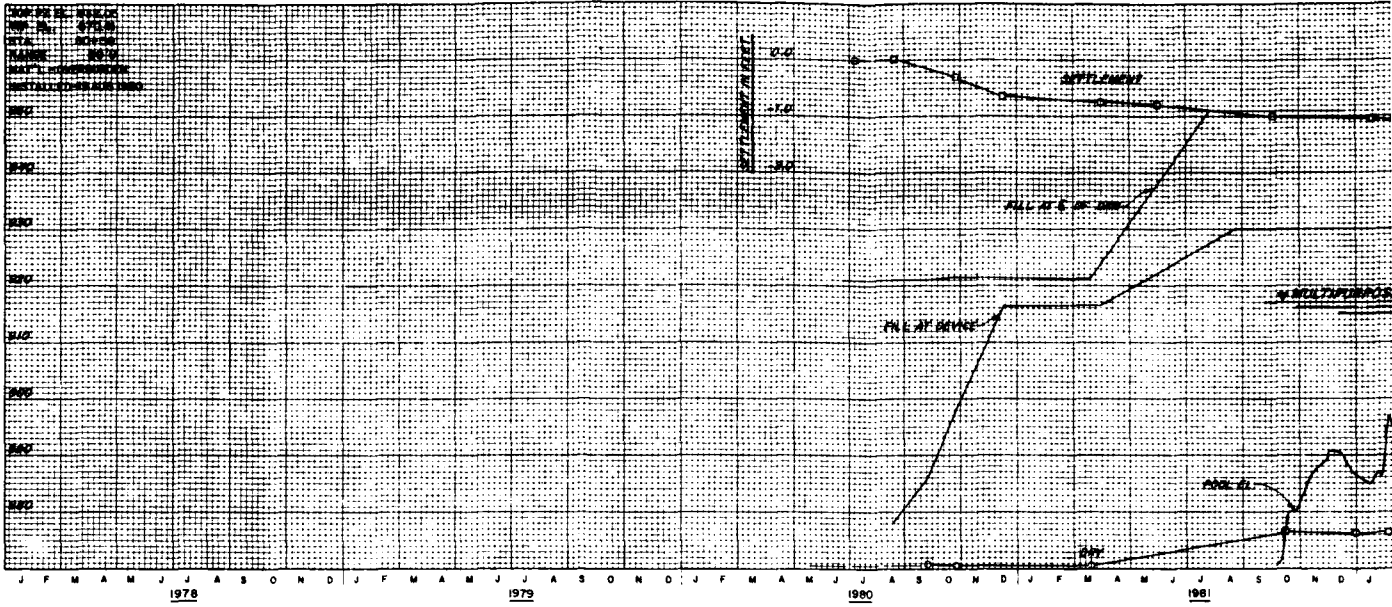


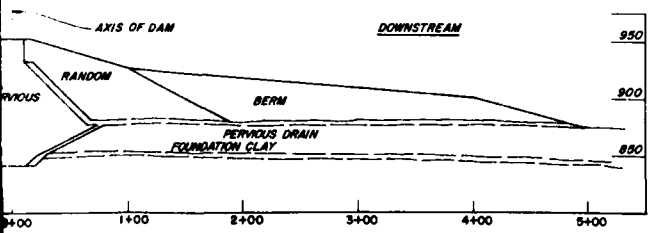
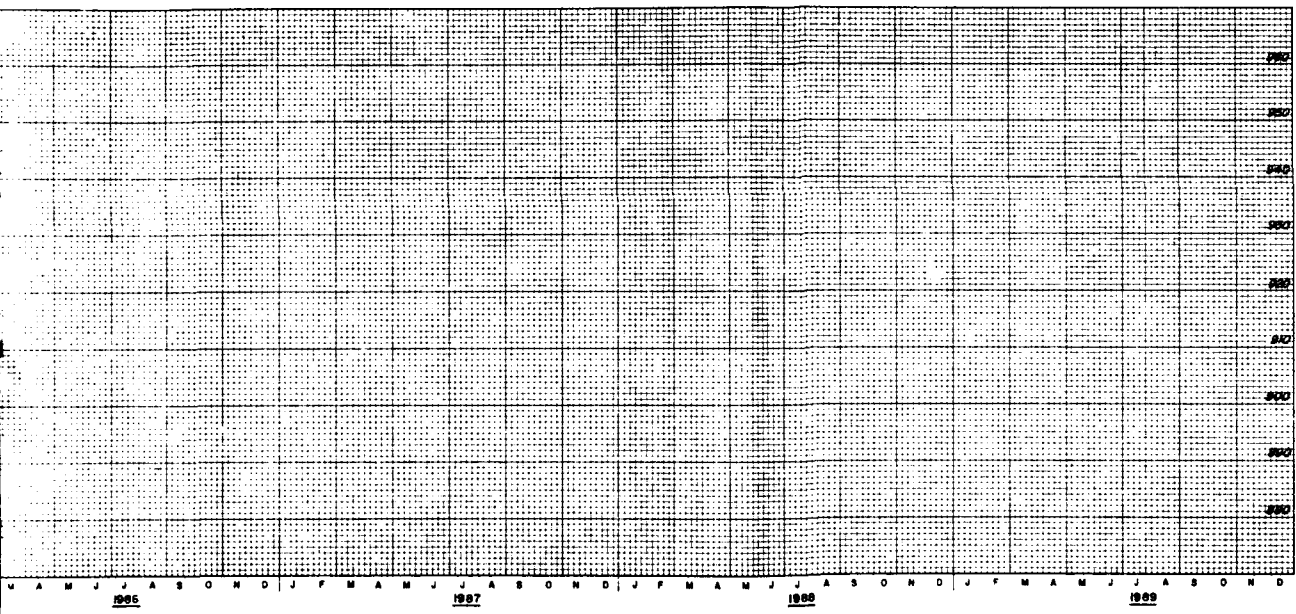
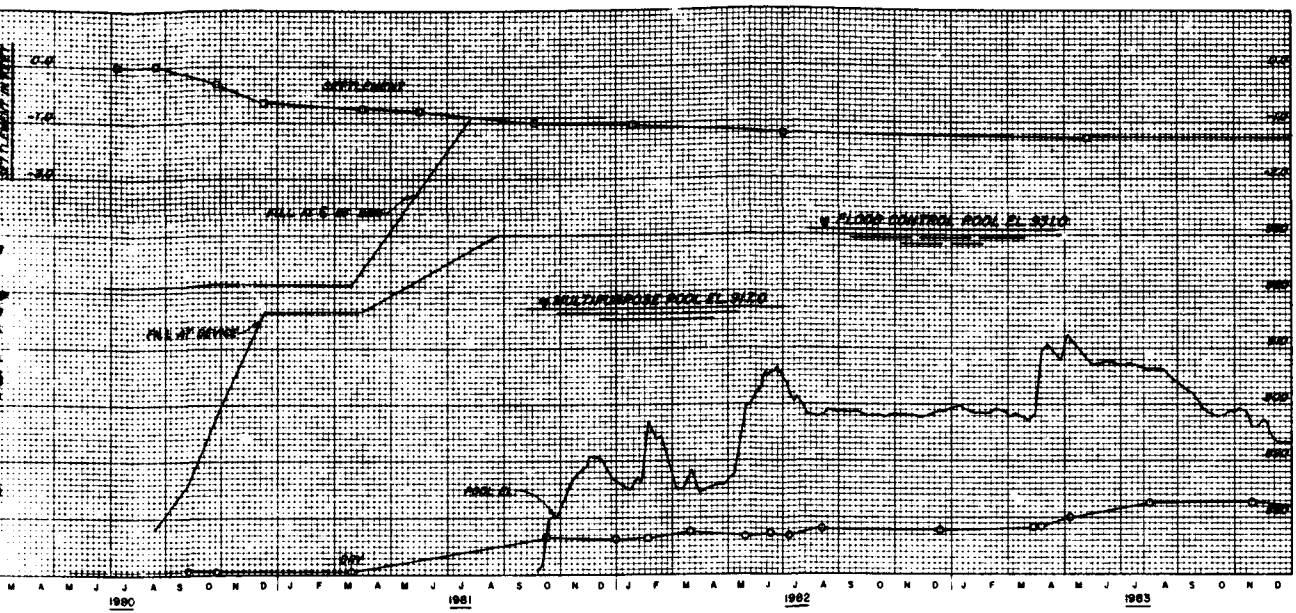
**NOTE:**  
 INCREASE IN READING INDICATES  
 DOWNSTREAM MOVEMENT  
 DECREASE IN READINGS INDICATES  
 UPSTREAM MOVEMENT.

REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 ENVIRONMENTAL CRITERIA REPORT  
 UPSTREAM  
 ALINEMENT MONUMENTS LINES  
 C AND D HORIZONTAL SUMMARY

Sheet No. 1 Scale as shown  
 CORES OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-887  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929



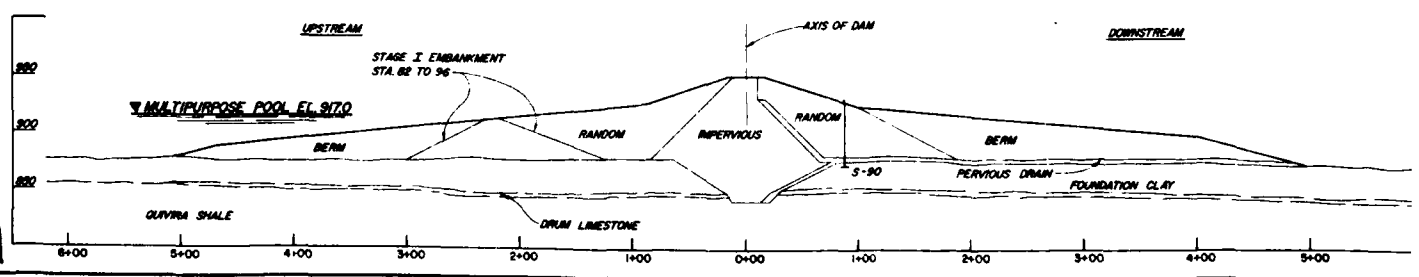
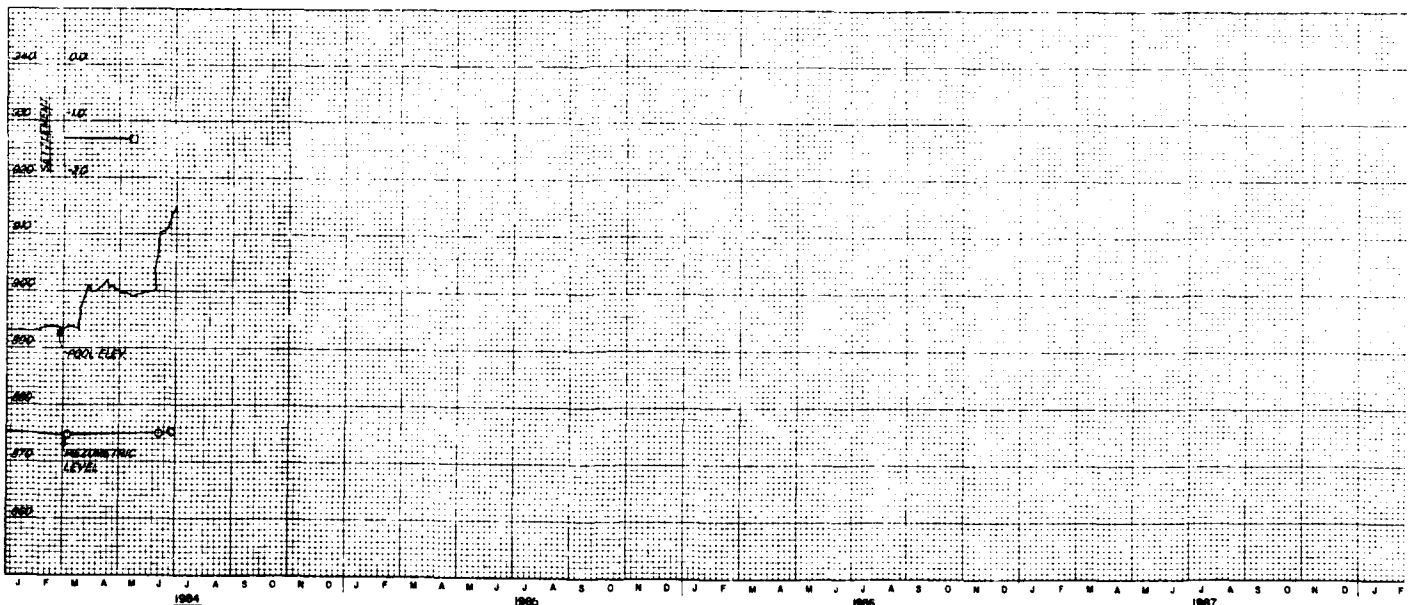
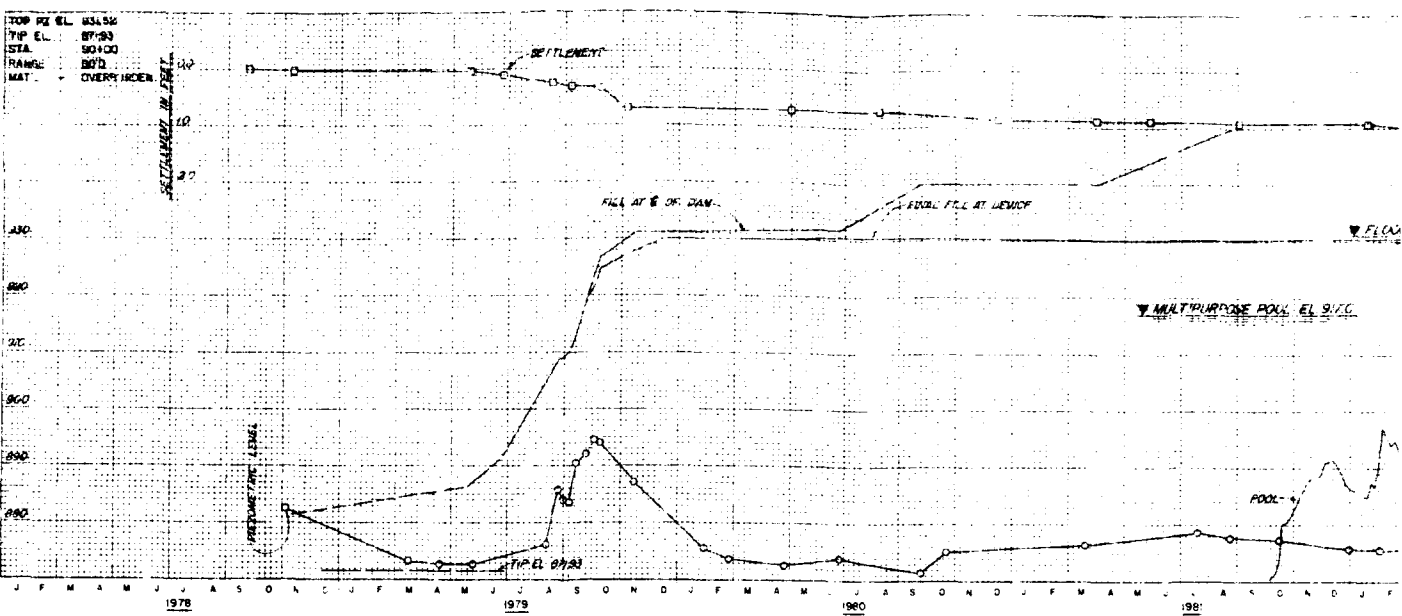


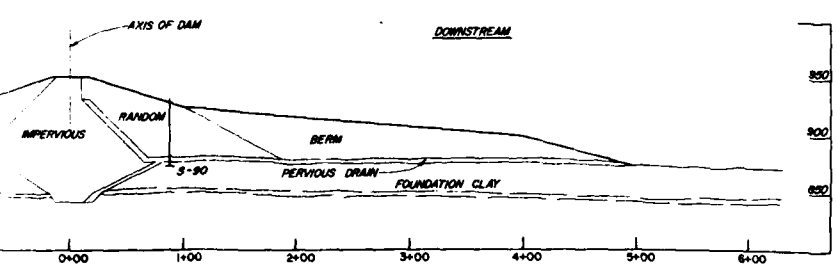
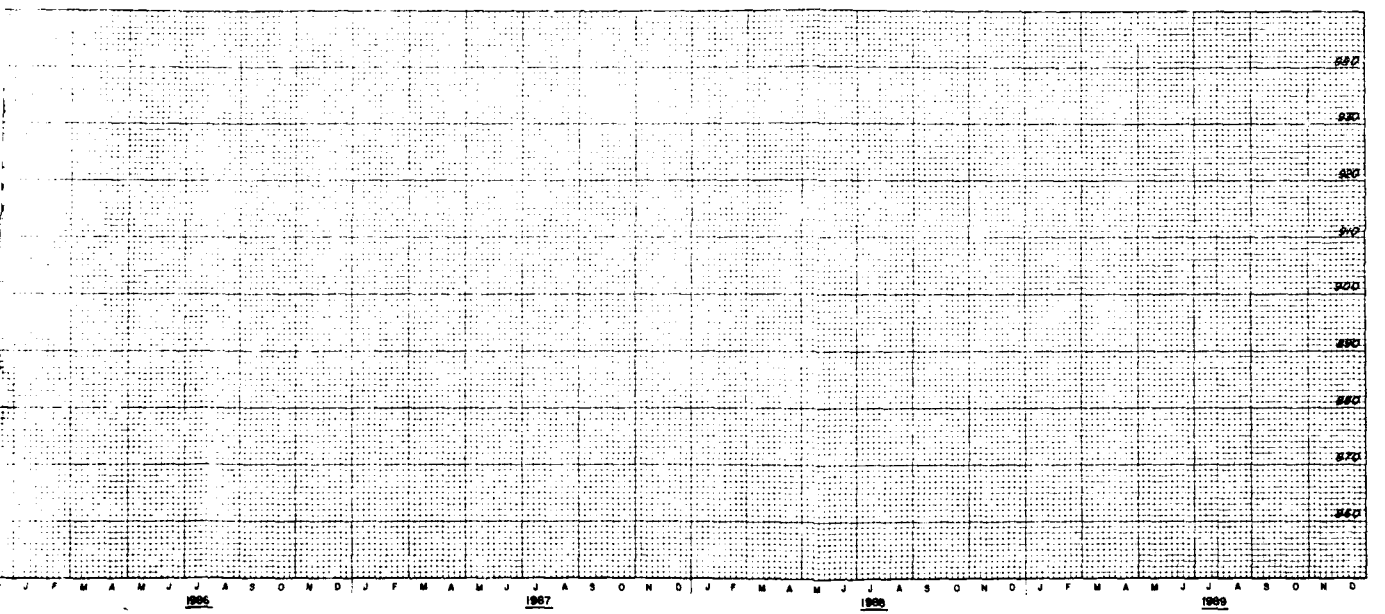
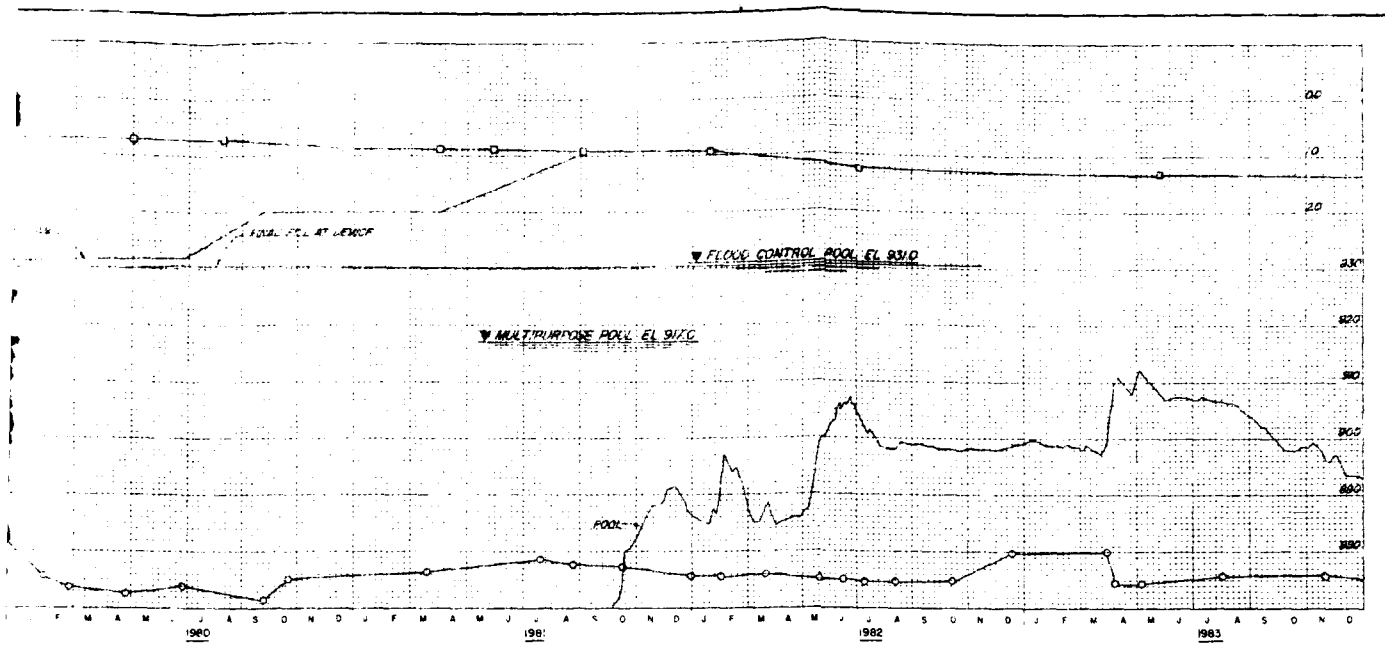
LEGEND  
 SETTLEMENT - - - - - □  
 PIEZOMETRIC LEVEL - - - - - ○

REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 FOUNDATION SETTLEMENT PLATE  
 AND OPEN TUBE PIEZOMETER  
 S-80

In 1 sheet  
 Sheet No. 1  
 Scale: as shown  
 CORPS OF ENGINEERS U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. 0-15-922  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929





REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 FOUNDATION SETTLEMENT PLATE  
 AND OPEN TUBE PIEZOMETER  
 S-90

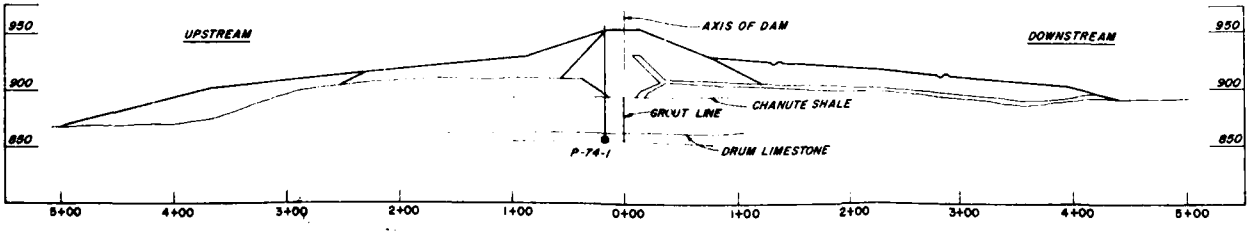
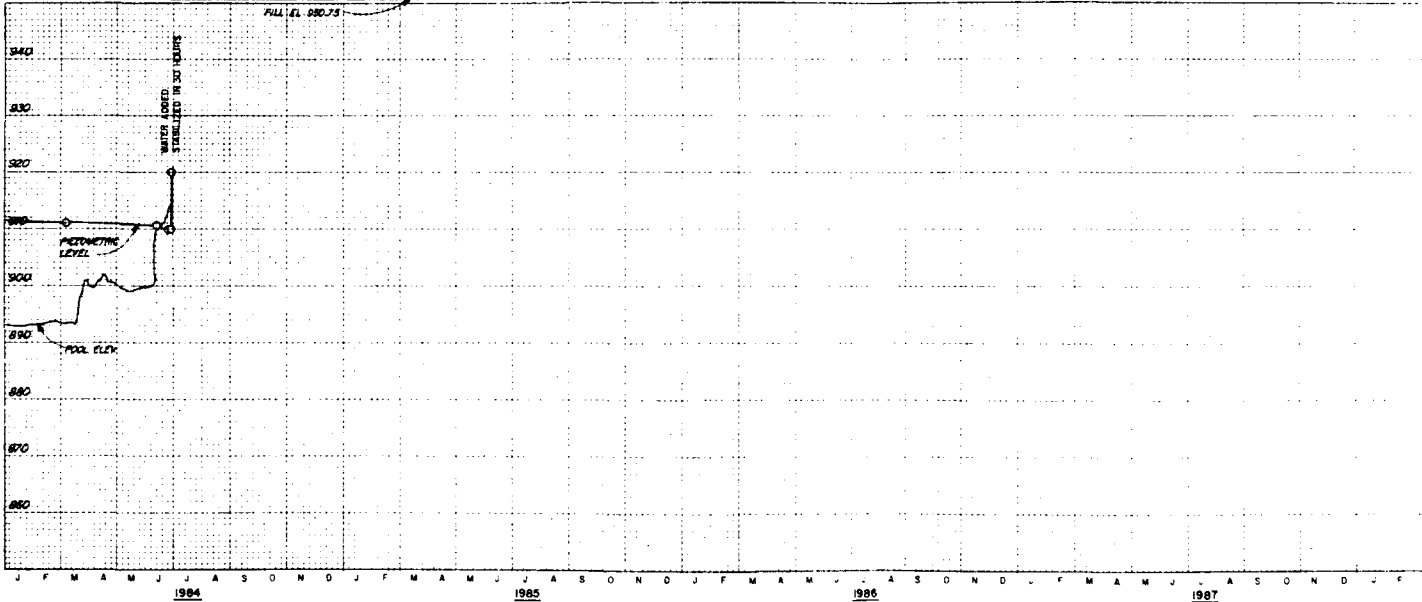
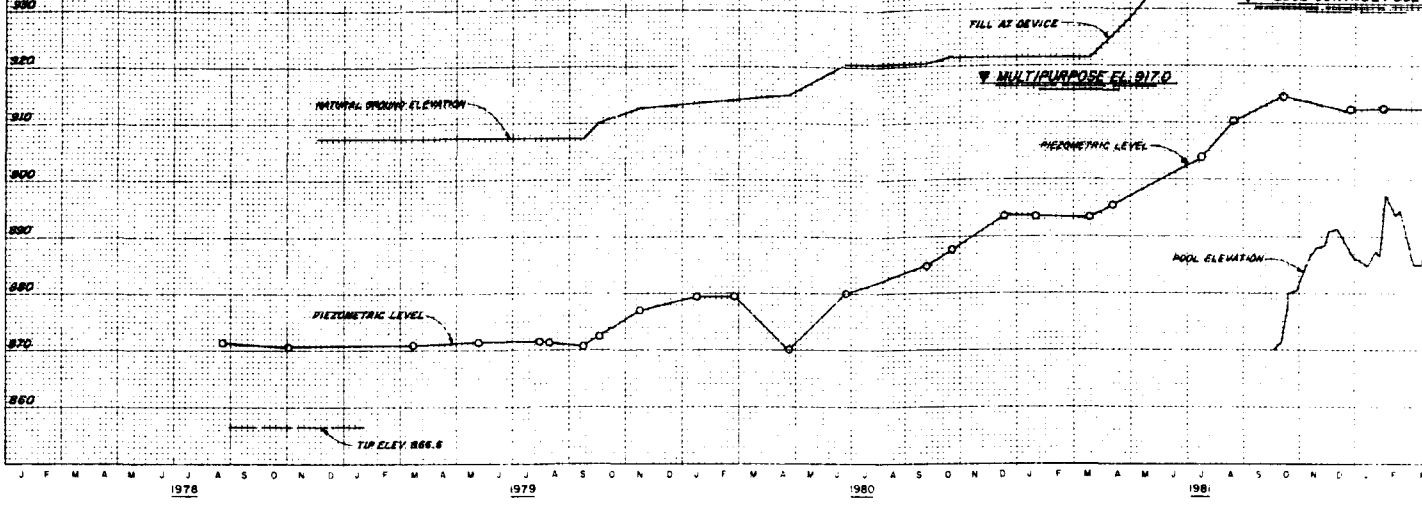
In 1 sheet Sheet No. 1 Scale: as shown

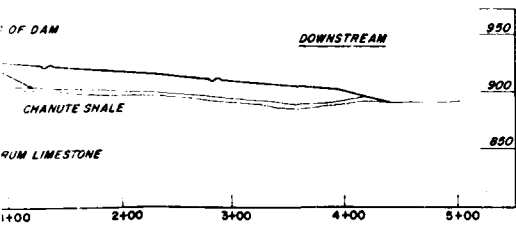
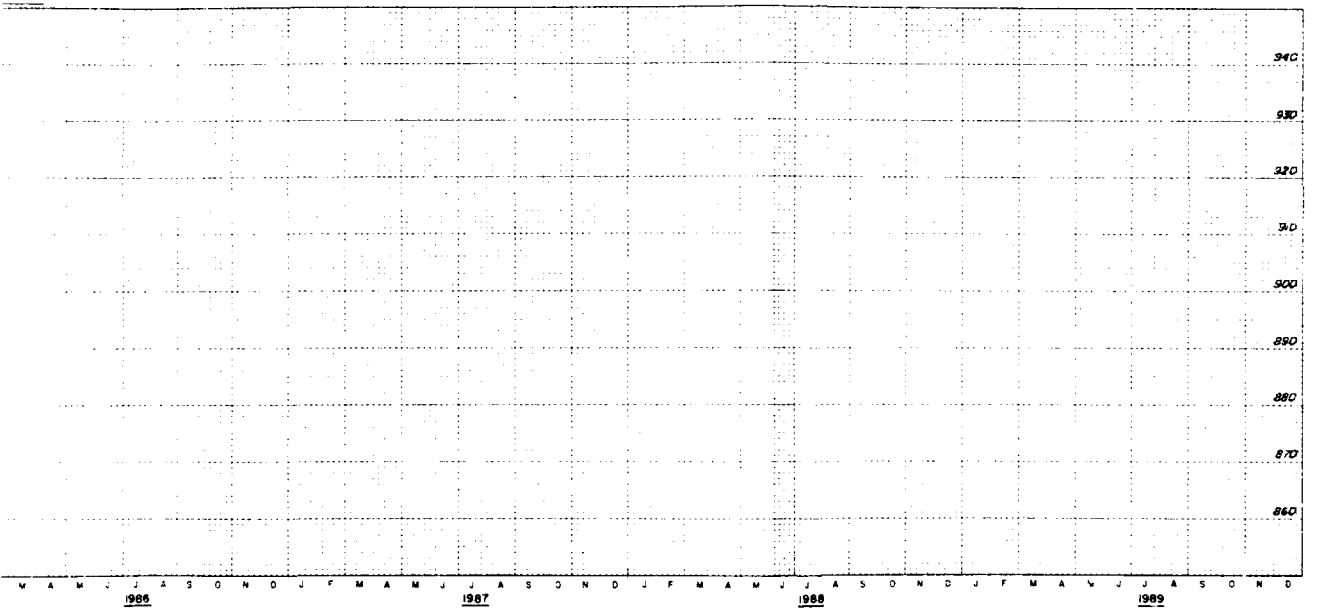
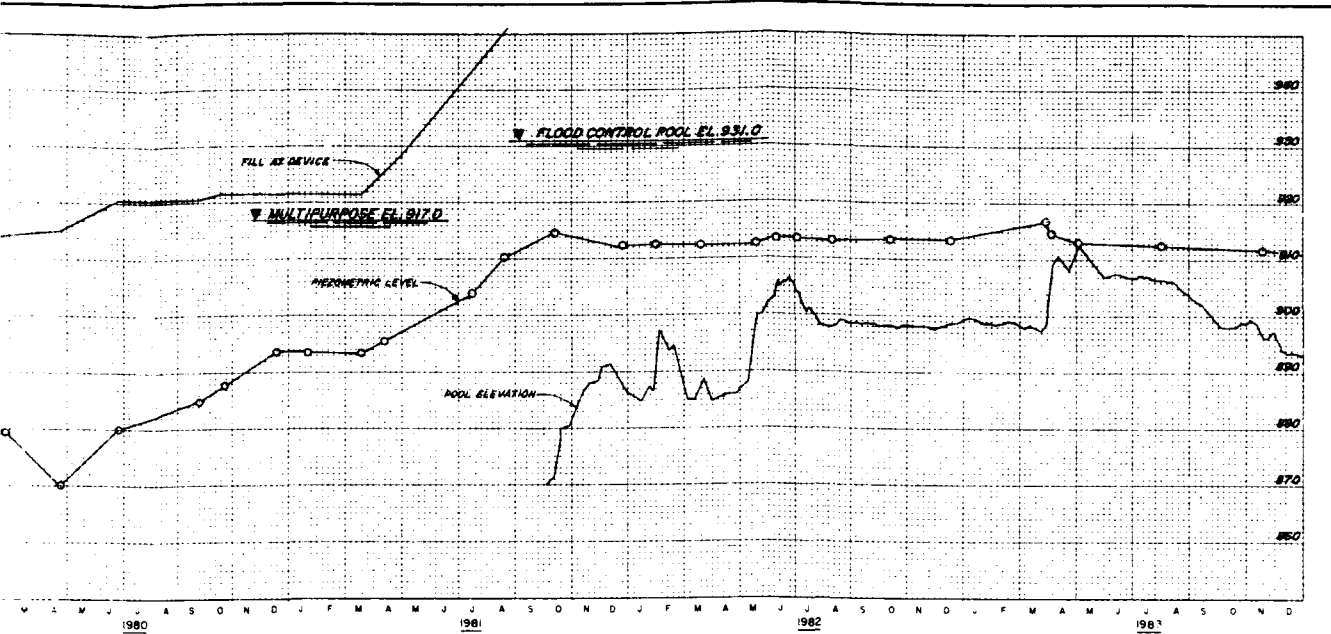
CDRAPS OF ENGINEERS U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-923  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TOP FT. 863.28  
 TIP EL. 866.8  
 STA. 74+00  
 RANGE 150  
 MAT'L. LS  
 INSTALLED 23 MAR 78





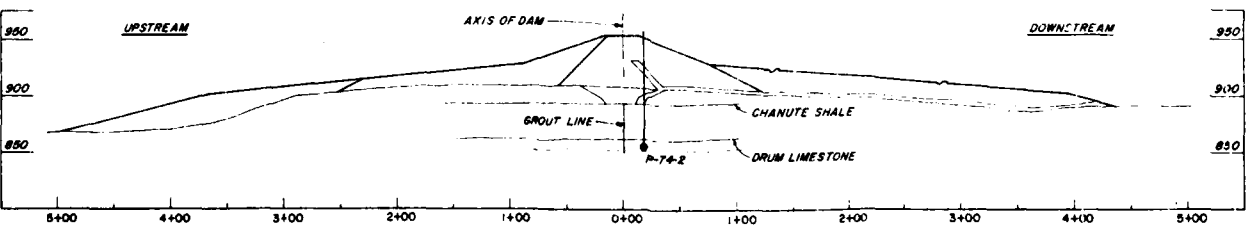
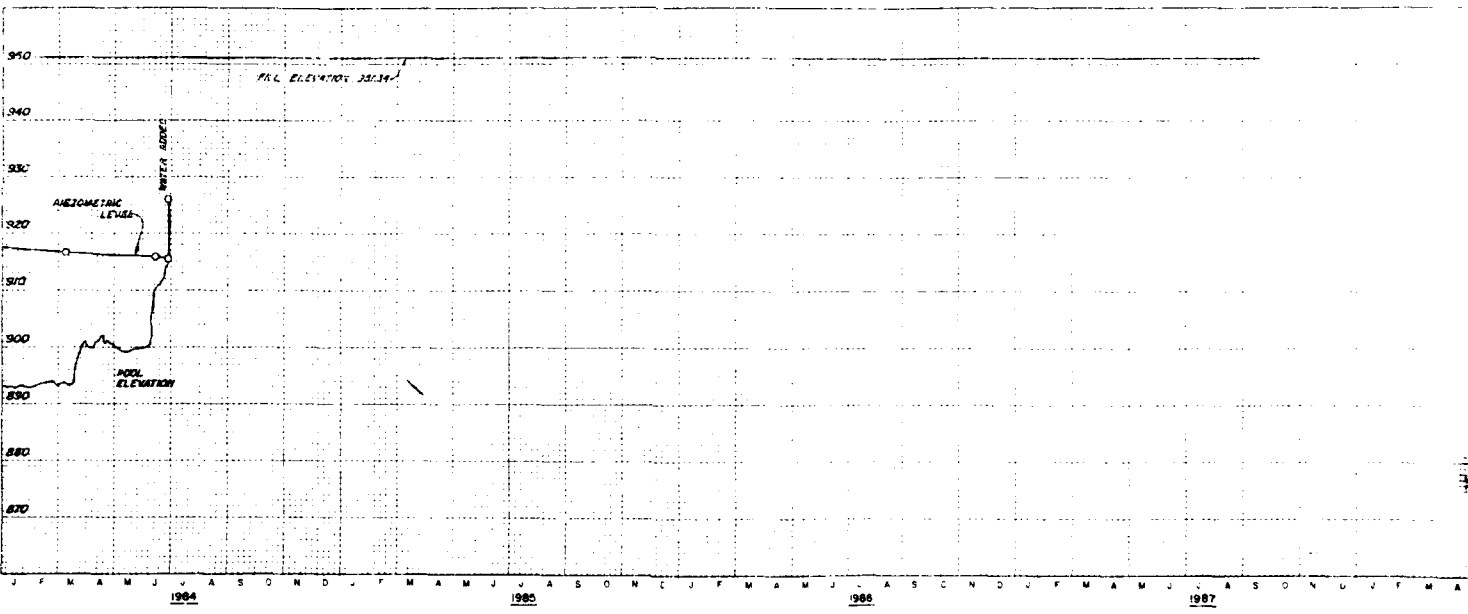
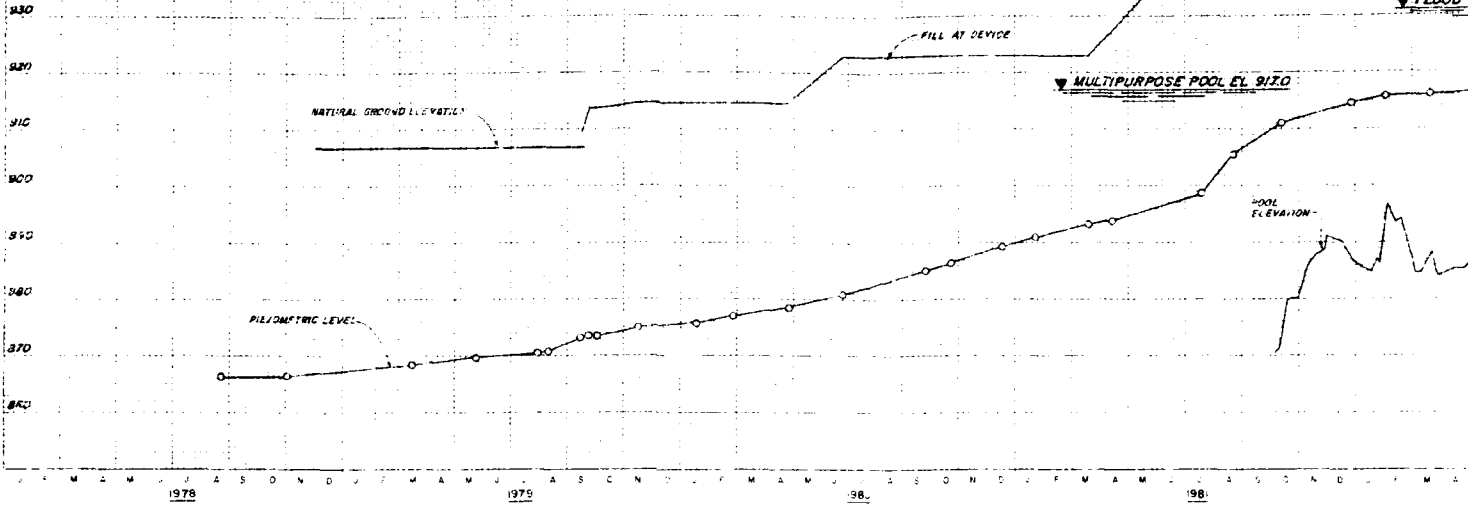
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 OPEN TUBE PIEZOMETER  
 P-74-1

In 1 sheet  
 Sheet No 1  
 Scale: as shown  
 CORPS OF ENGINEERS U S ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-928  
 JANUARY 1983

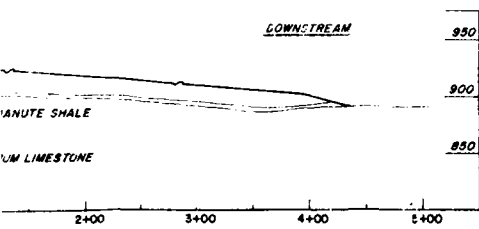
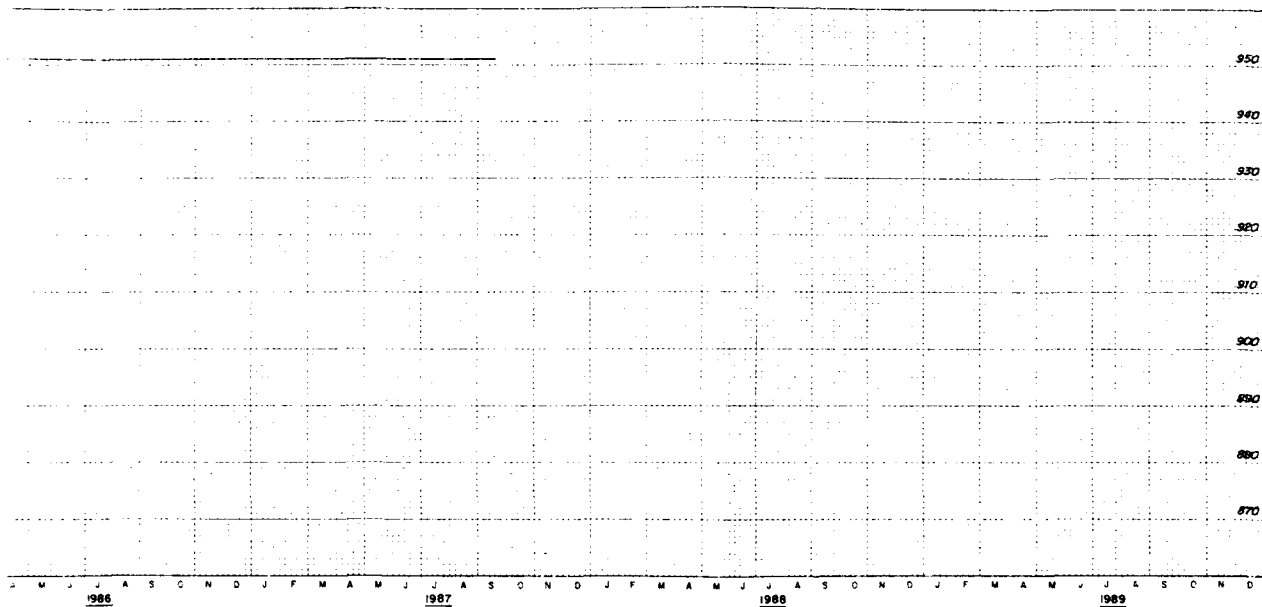
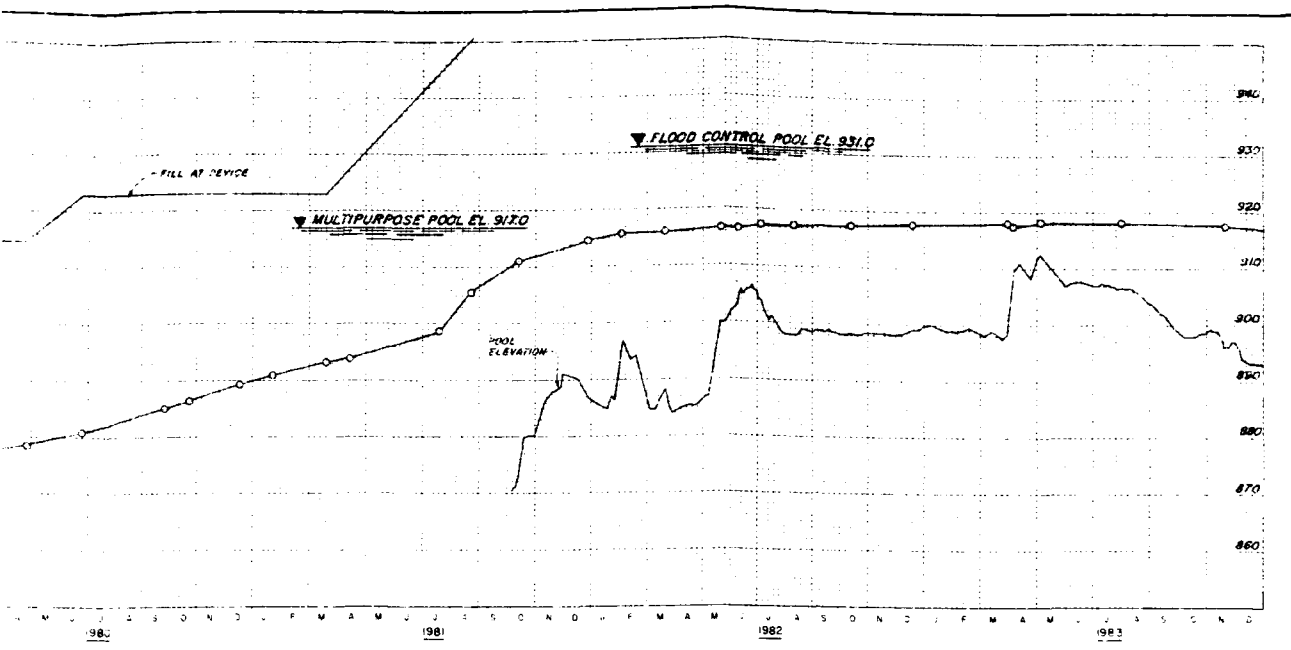
2

ELEVATION IN FEET BASED ON NATIONAL CELESTIAL VERTICAL DATUM OF 1989

TOP PZ EL. 883.85  
 TIP EL. 888.9  
 STA. 76+00  
 RANGE 18.0  
 MAT'L - L3  
 INSTALLED 24 MAY 78







REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-74-2

In 1 sheet

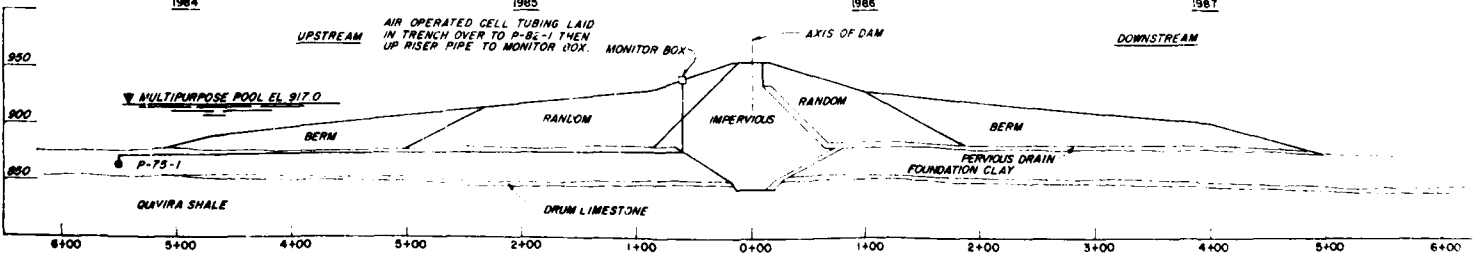
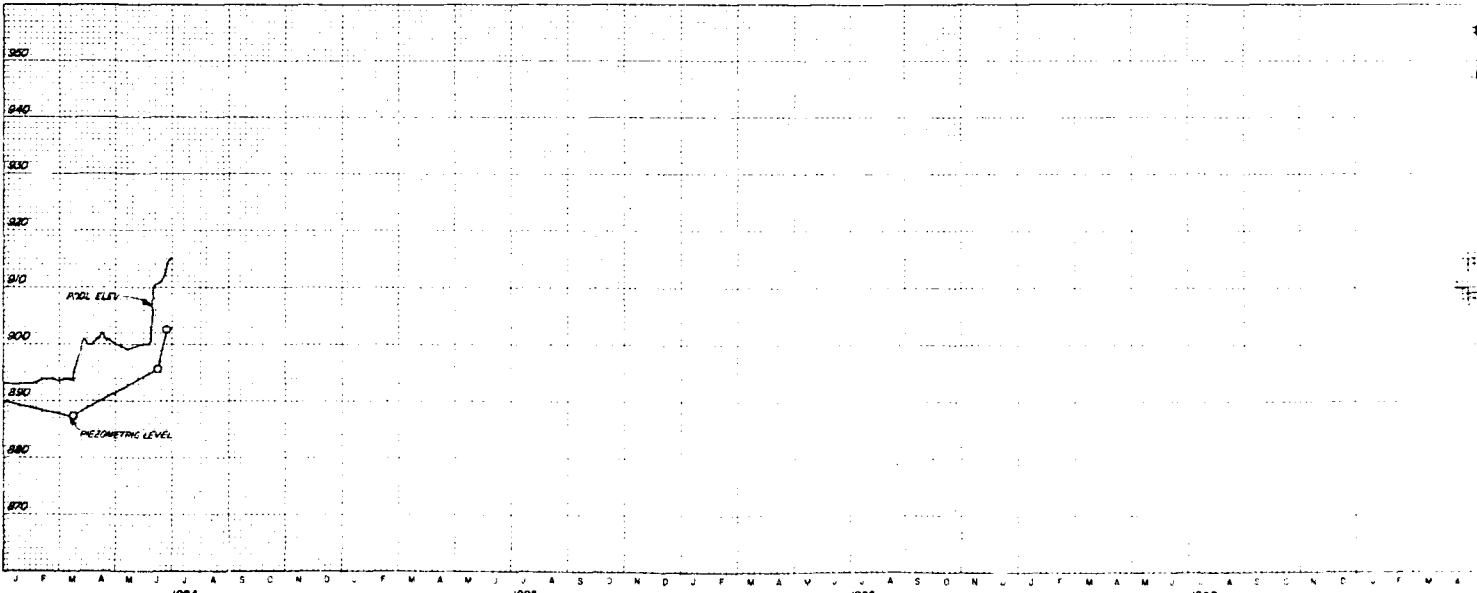
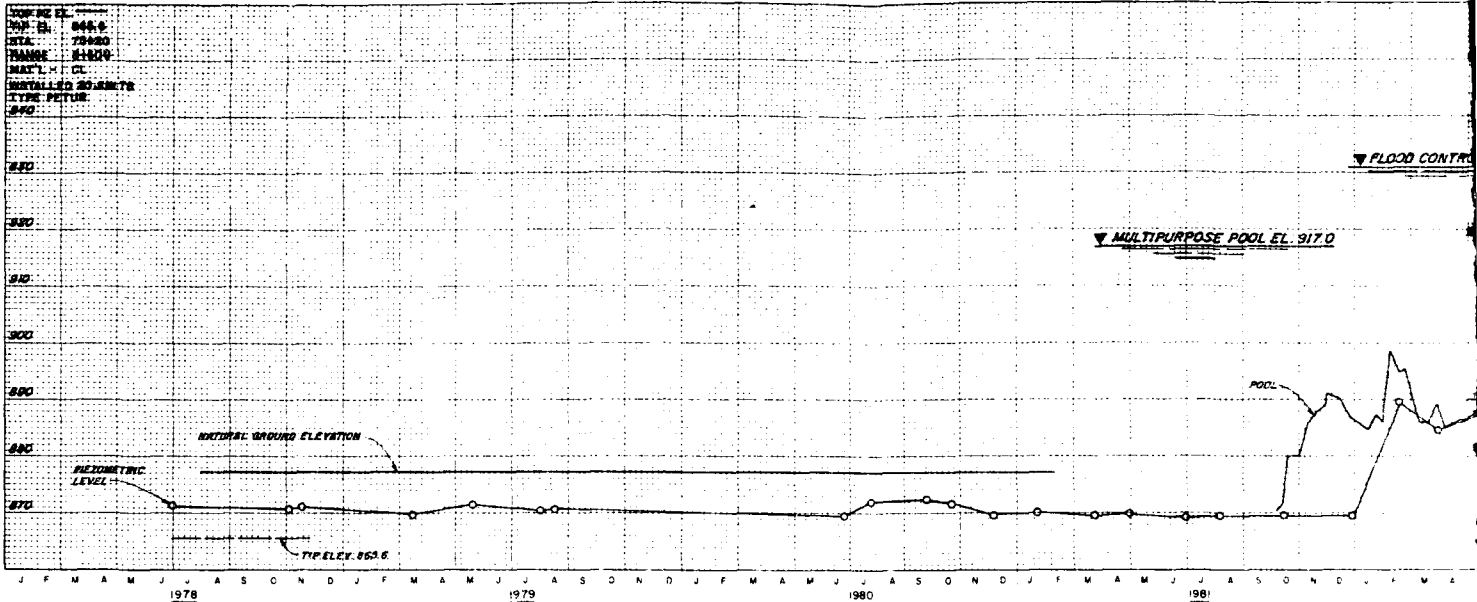
Sheet No 1

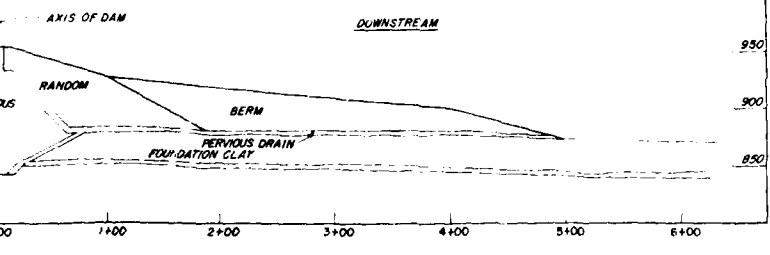
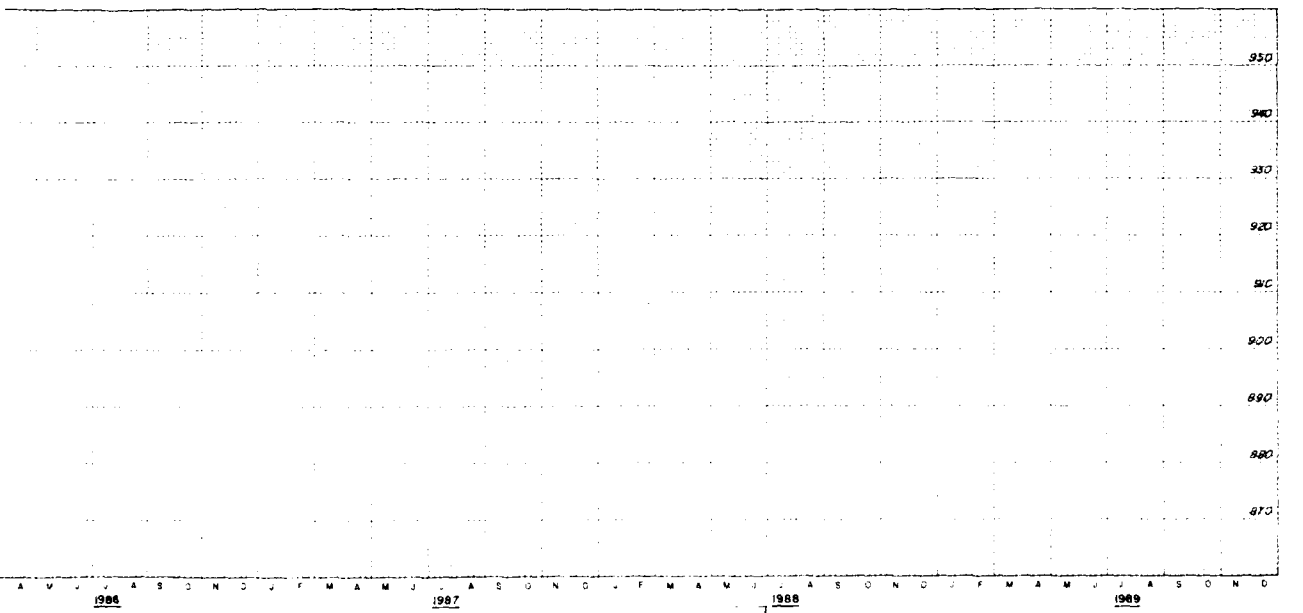
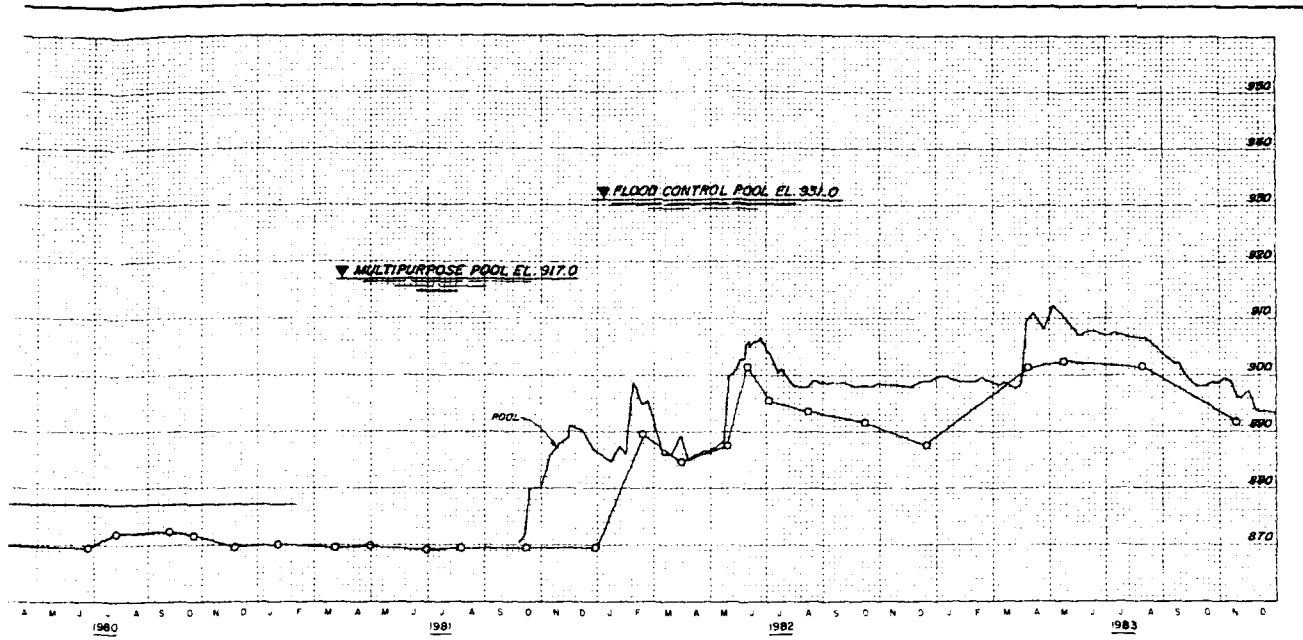
Scale: as shown

CORPS OF ENGINEERS U S ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. 0-15-929  
 JANUARY 1983

PLATE NO 200

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929





REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

AIR CELL PIEZOMETER  
 P-75-1

In 1 sheet

Sheet No. 1

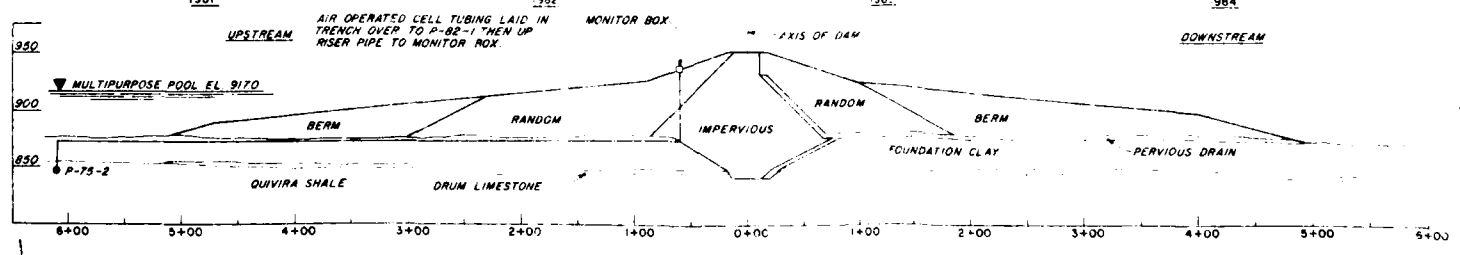
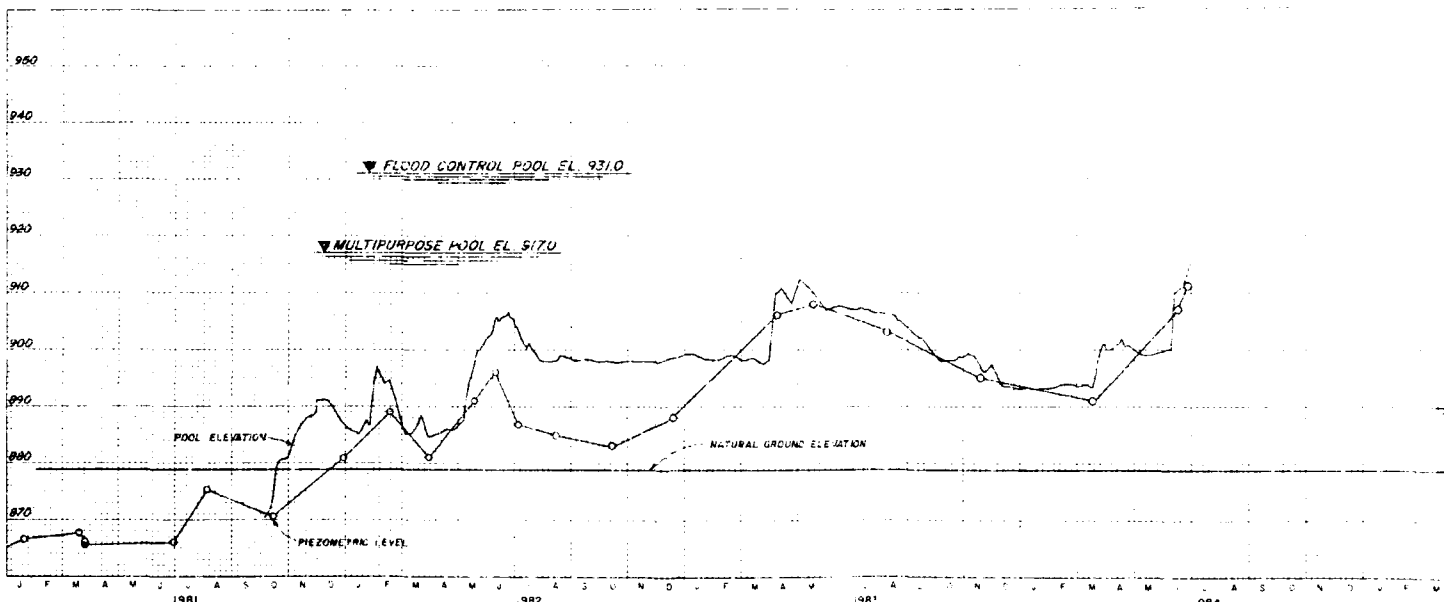
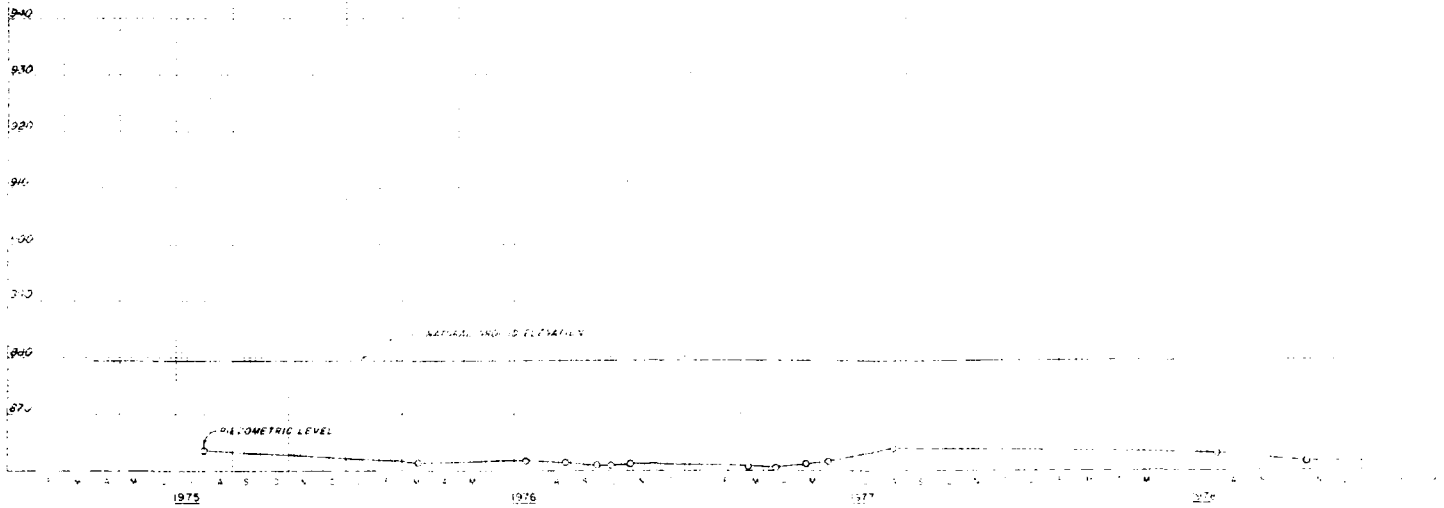
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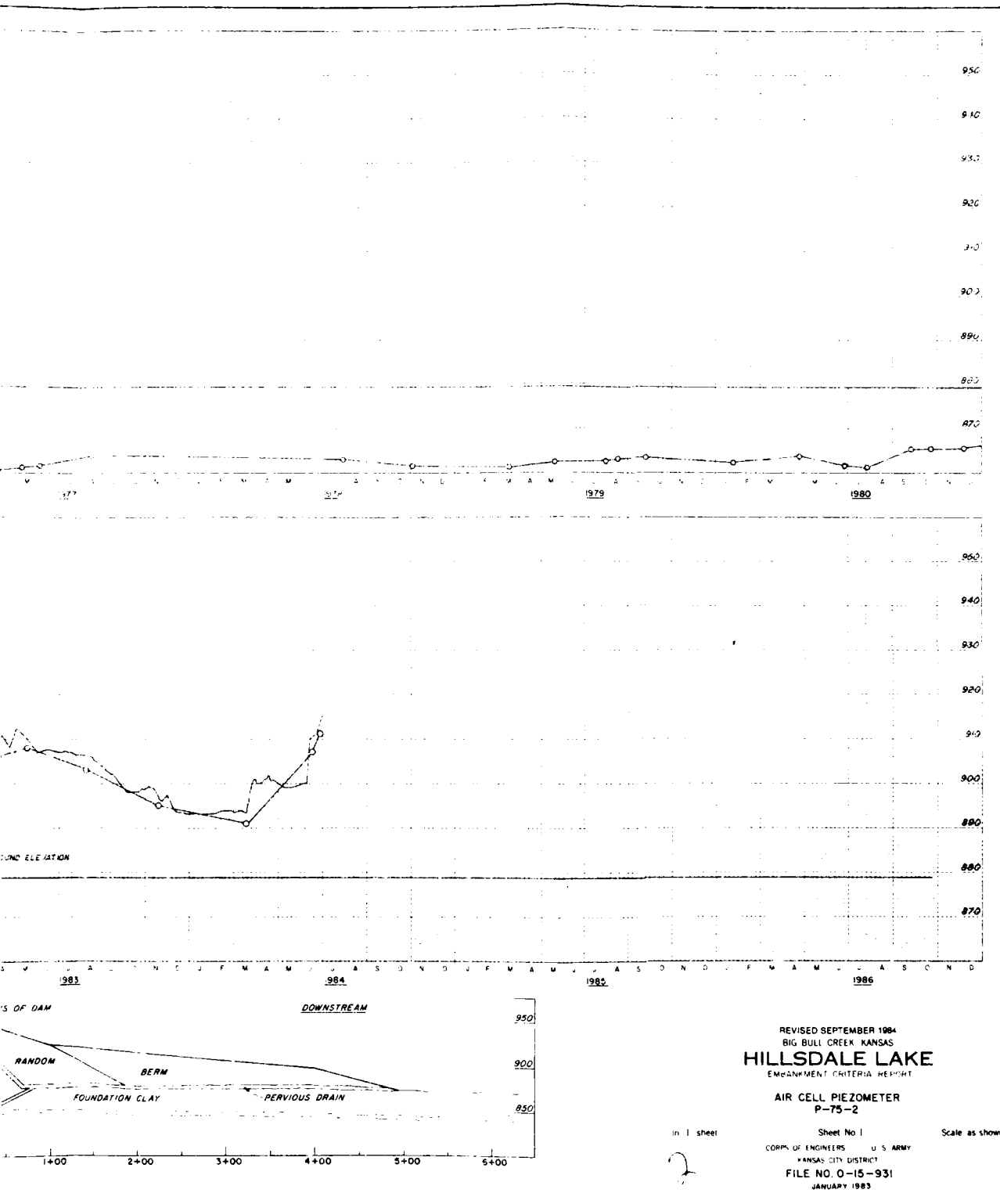
CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. 0-15-930  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TOP PI EL. 861.0  
 TIP EL. 861.0  
 STA. 75+10  
 RANGE 610.0  
 DIA. 3"  
 INSTALLED 14 JAN 75  
 TYPE 5 BW





REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMPIREMENT CRITERIA REPORT

AIR CELL PIEZOMETER  
 P-75-2

in 1 sheet

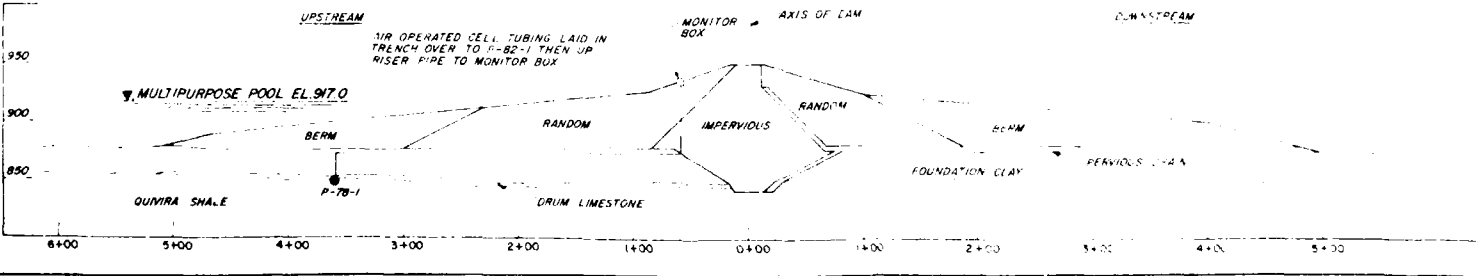
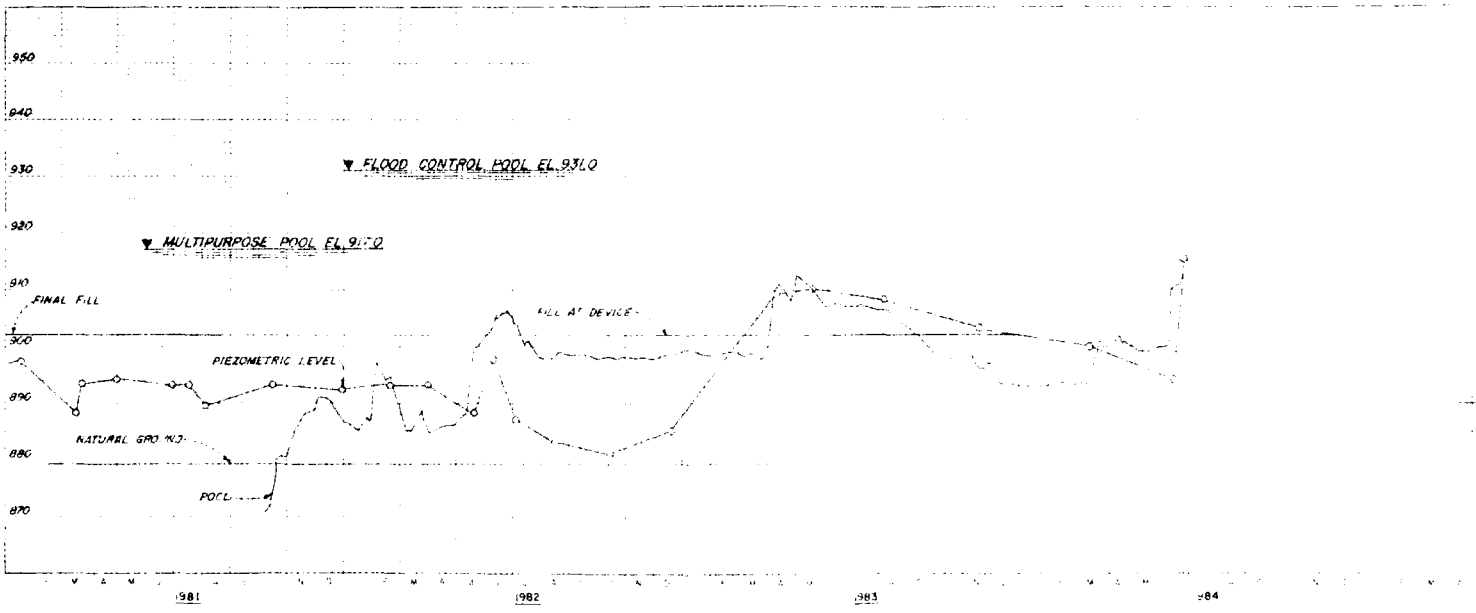
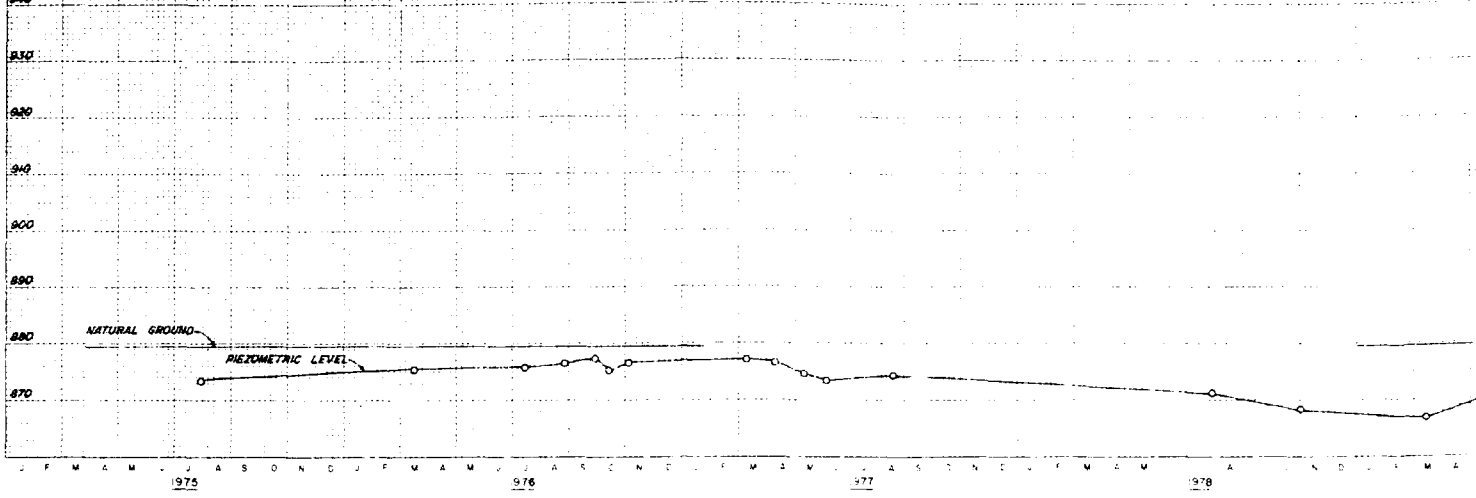
Sheet No 1

Scale as shown

CORP. OF ENGINEERS U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-931  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TOP PE EL.  
 TIP EL. 848.1  
 STA. 78+30  
 FRAME 300 LL  
 MATH. 84  
 INSTALLED 9 JAN 75  
 TYPE S & W



AD-A169 863

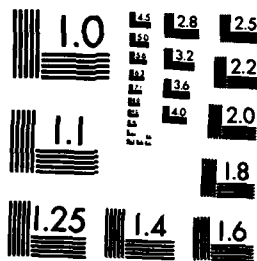
MULTIPLE-PURPOSE PROJECT OSAGE RIVER BASIN BIG BULL  
CREEK KANSAS HILLSDALE (U) CORPS OF ENGINEERS KANSAS  
CITY MO KANSAS CITY DISTRICT F C WALBERG ET AL. SEP 84  
F/G 1372

40f

UNCLASSIFIED

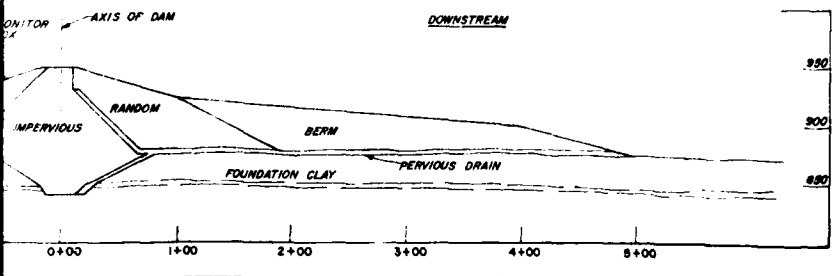
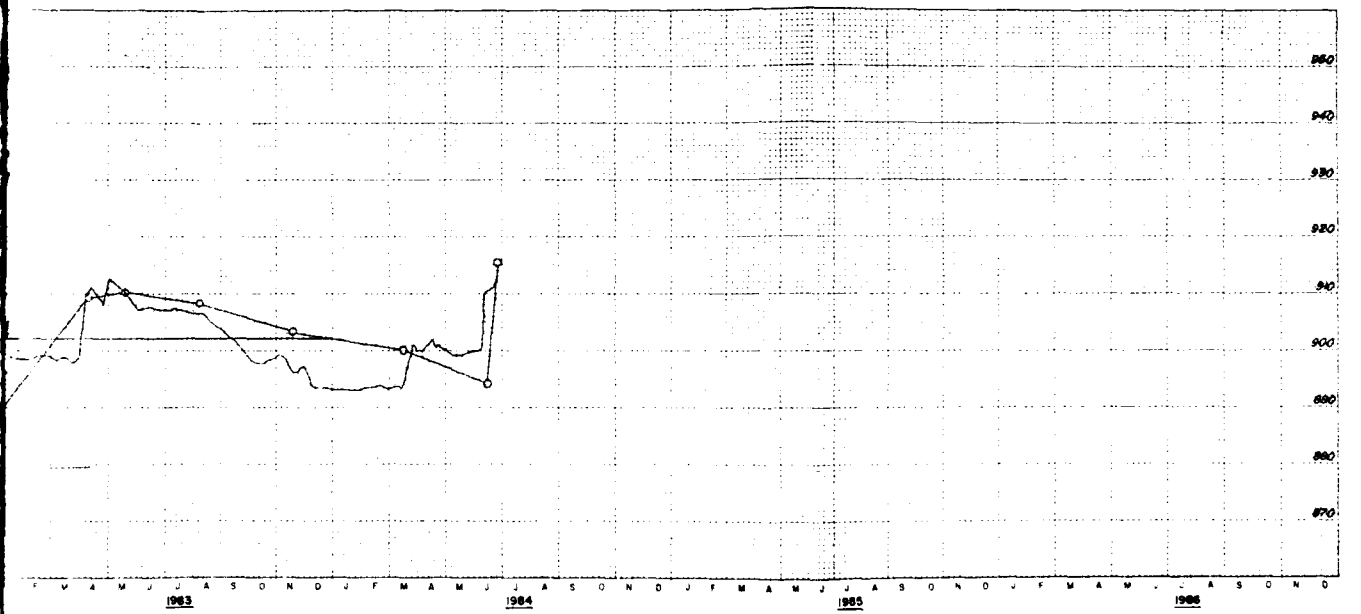
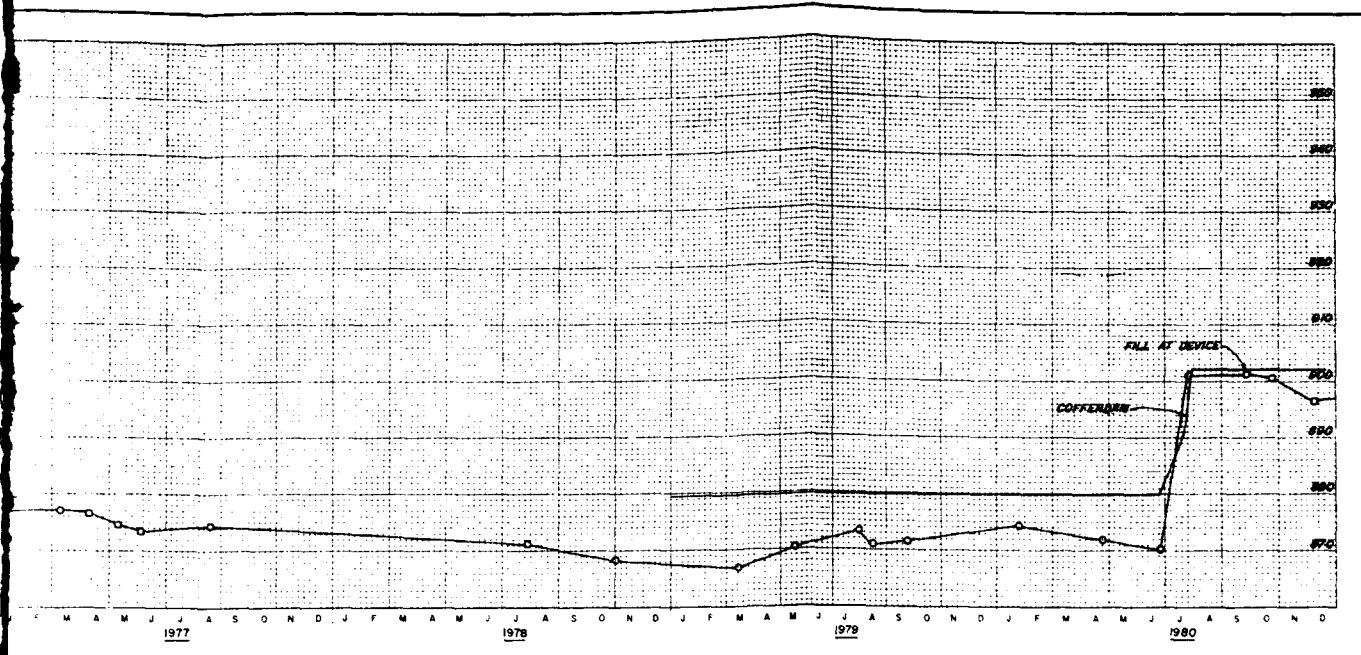
NL

END  
144  
10 1984  
B 14E



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A





REVISED SEPTEMBER 1984  
BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
EMBANKMENT CRITERIA REPORT

AIR CELL PIEZOMETER  
P-78-1

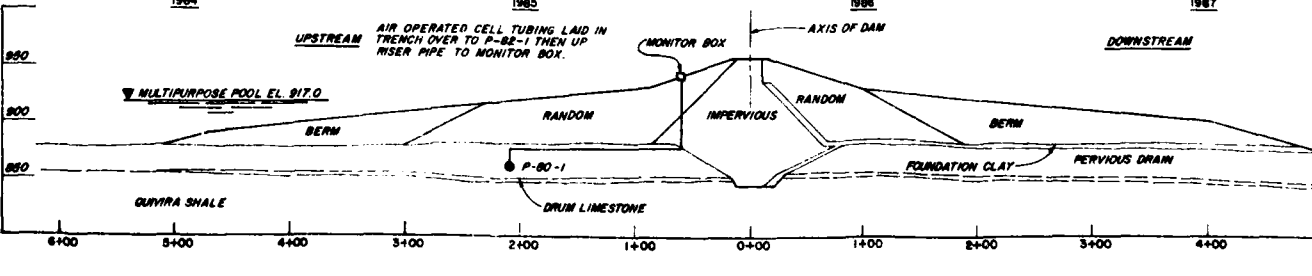
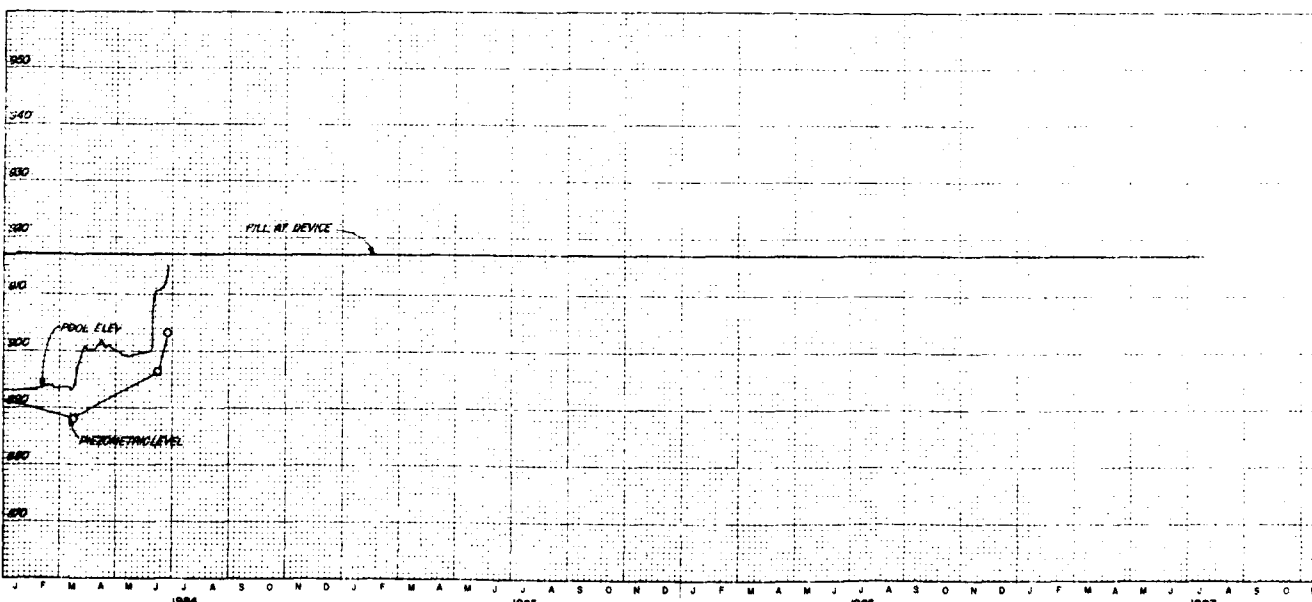
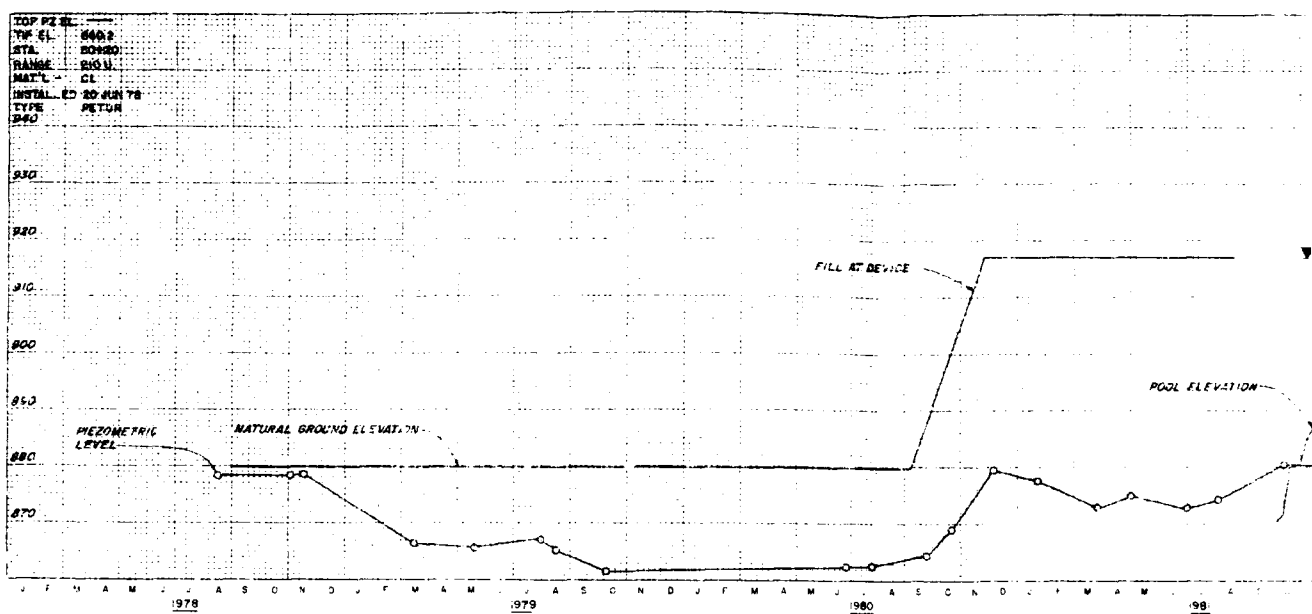
In 1 sheet

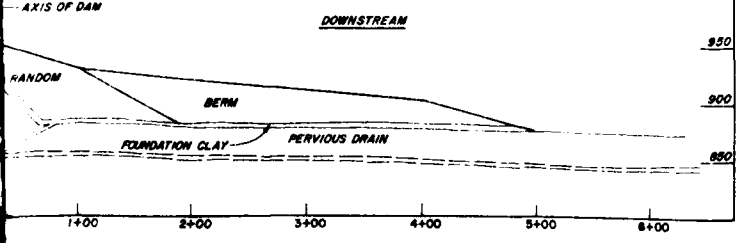
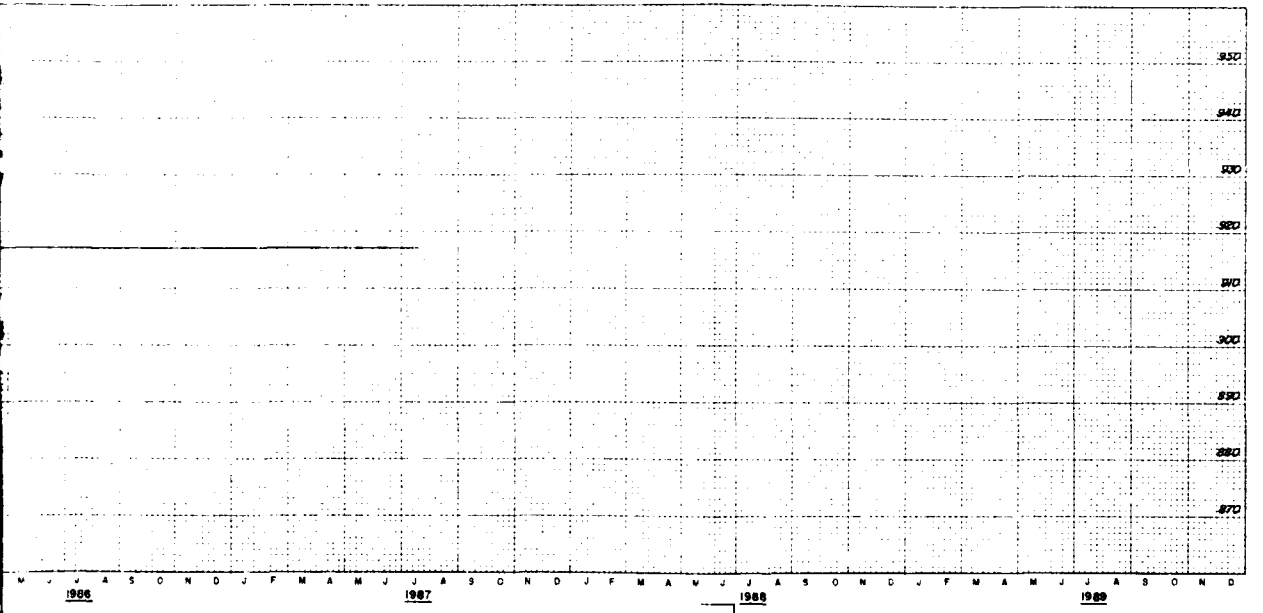
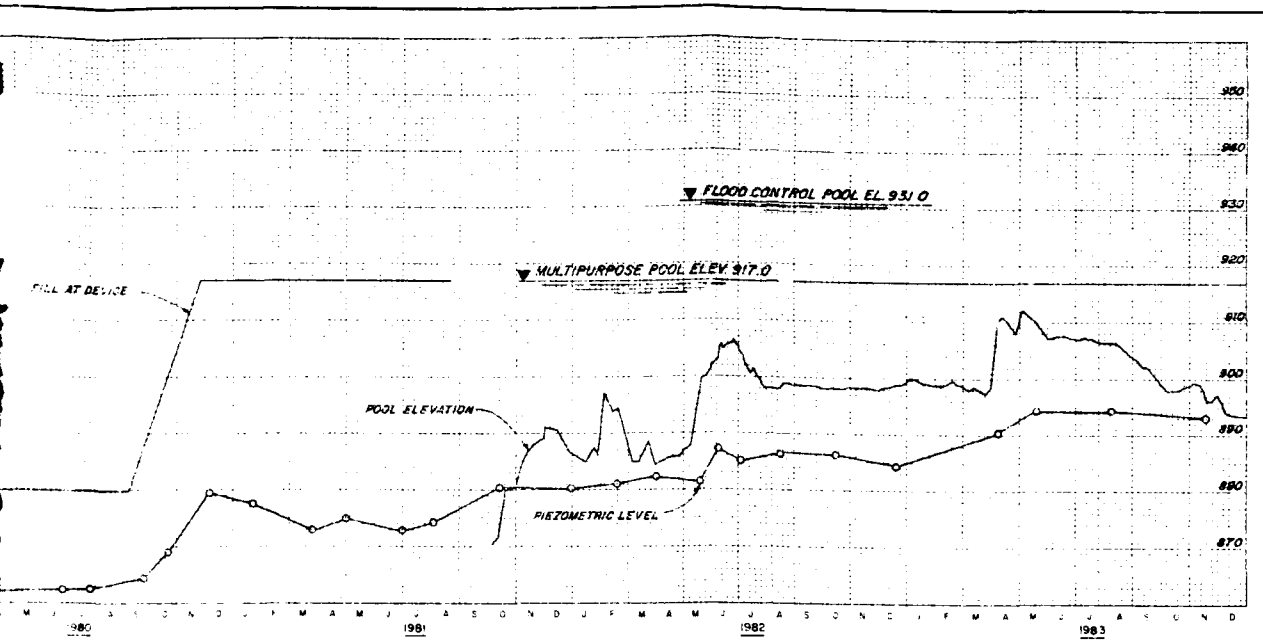
Sheet No. 1

Scale as shown

CORPS OF ENGINEERS U.S. ARMY  
KANSAS CITY DISTRICT  
FILE NO 0-15-932  
JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929





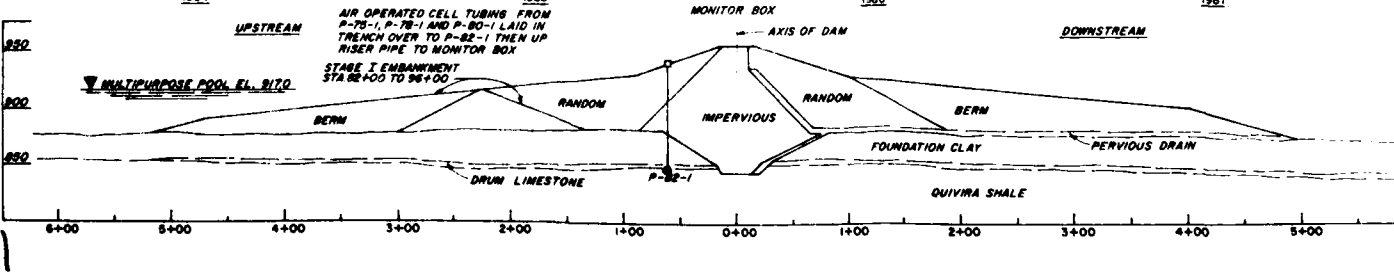
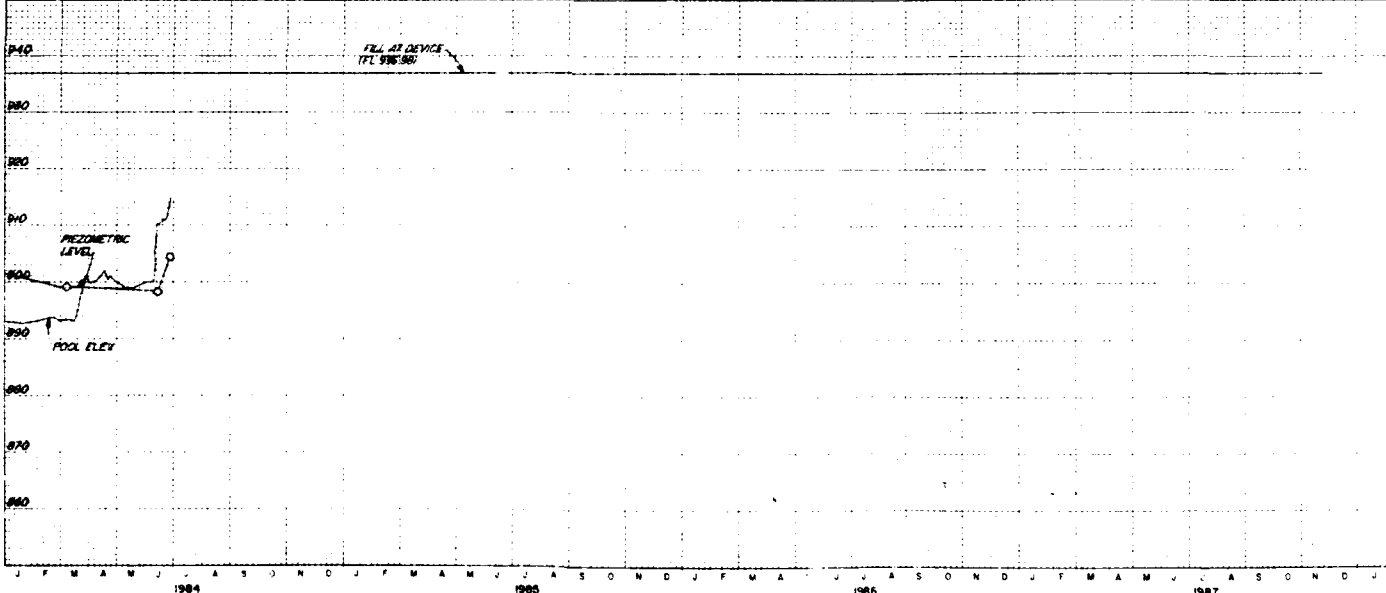
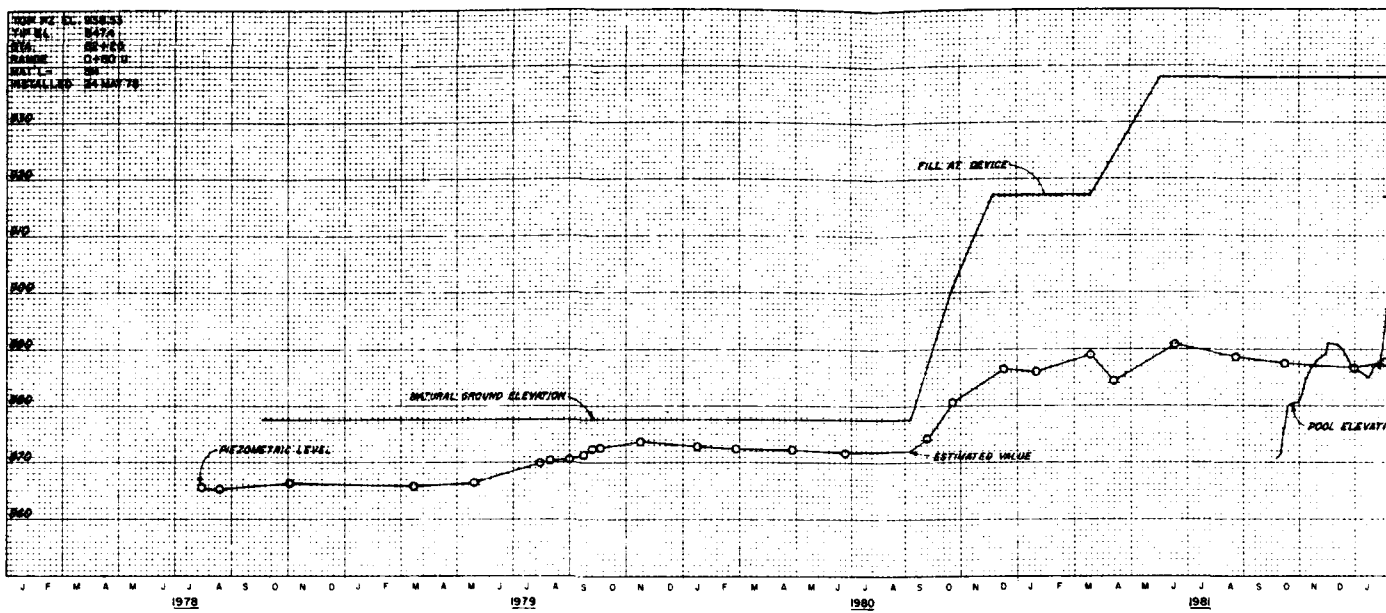
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

AIR CELL PIEZOMETER  
 P-80-1

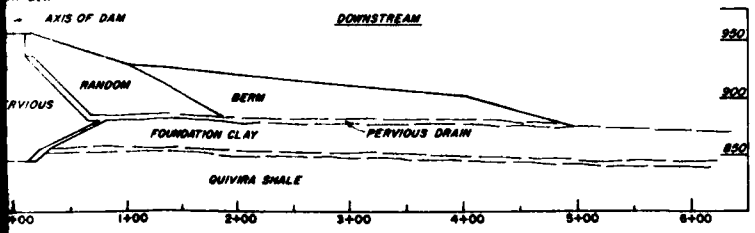
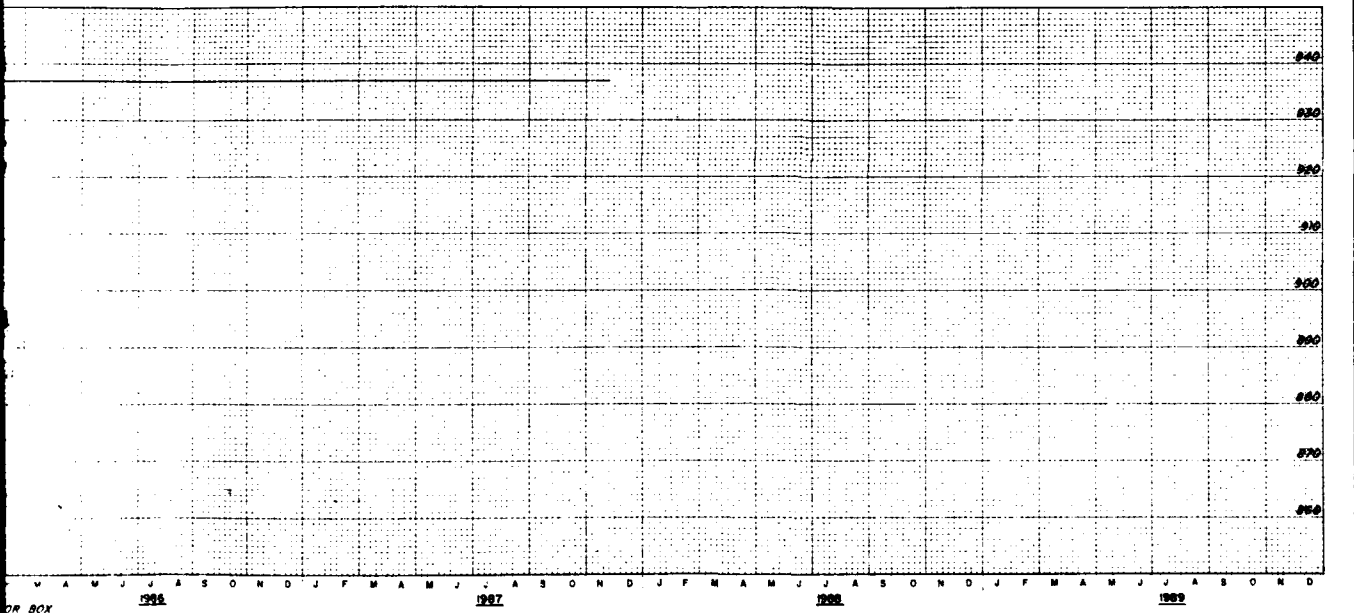
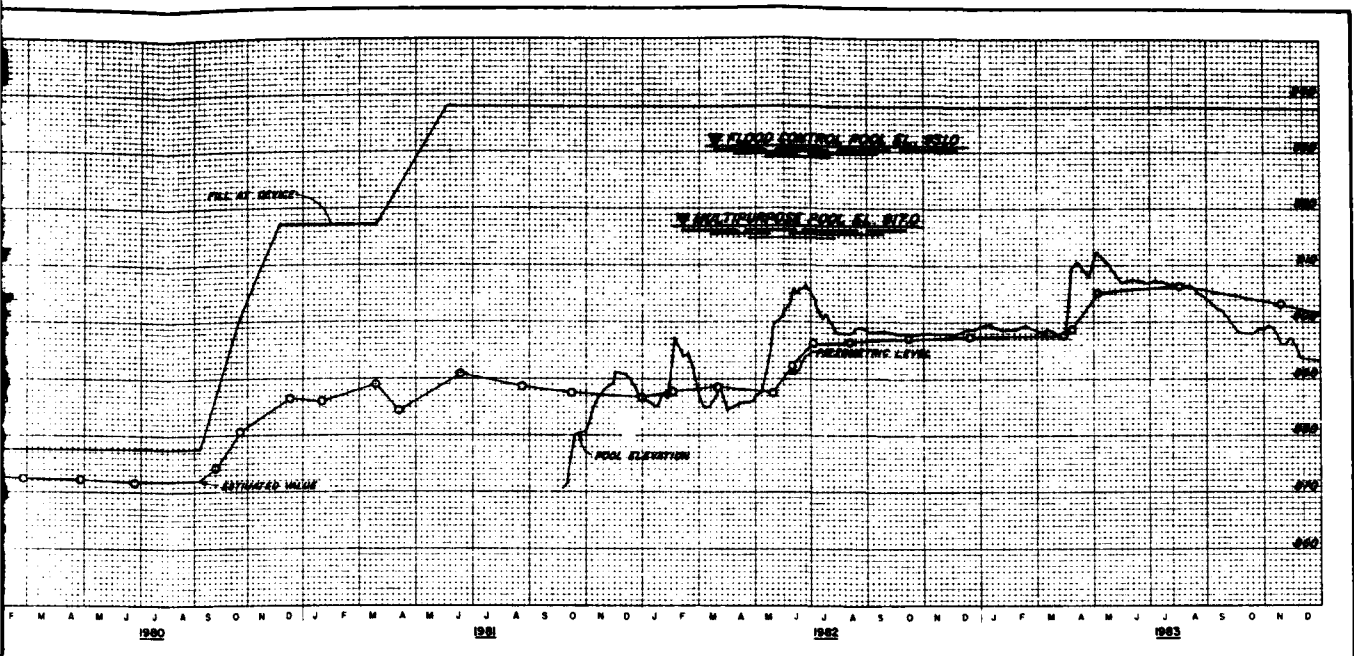
In 1 sheet  
 Sheet No. 1  
 Scale: as shown  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. 0-15-933  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1989



AIR OPERATED CELL TUBING FROM P-75-1, P-78-1 AND P-80-1 LAID IN TRENCH OVER TO P-22-1 THEN UP RISER PIPE TO MONITOR BOX



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 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-82-1

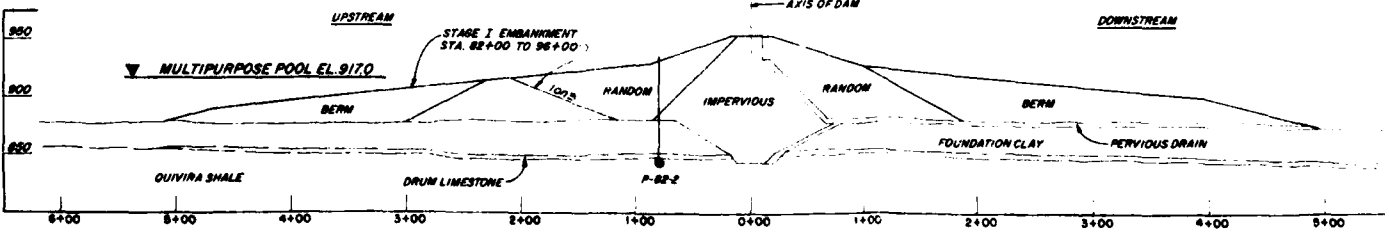
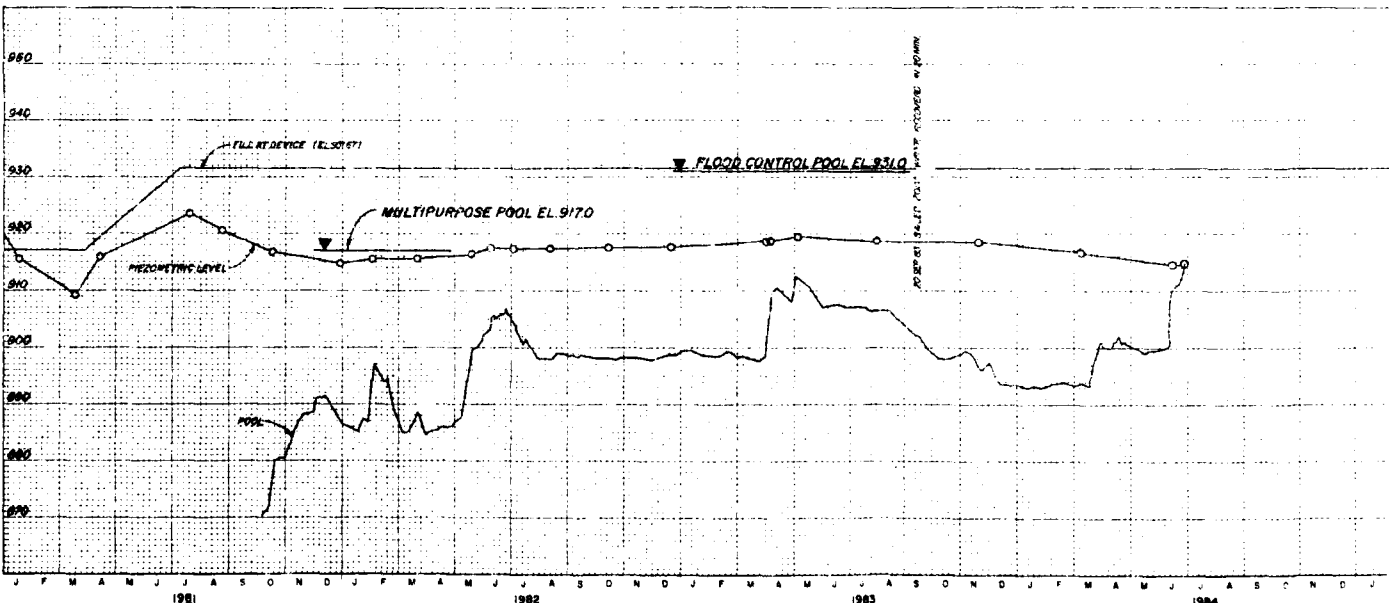
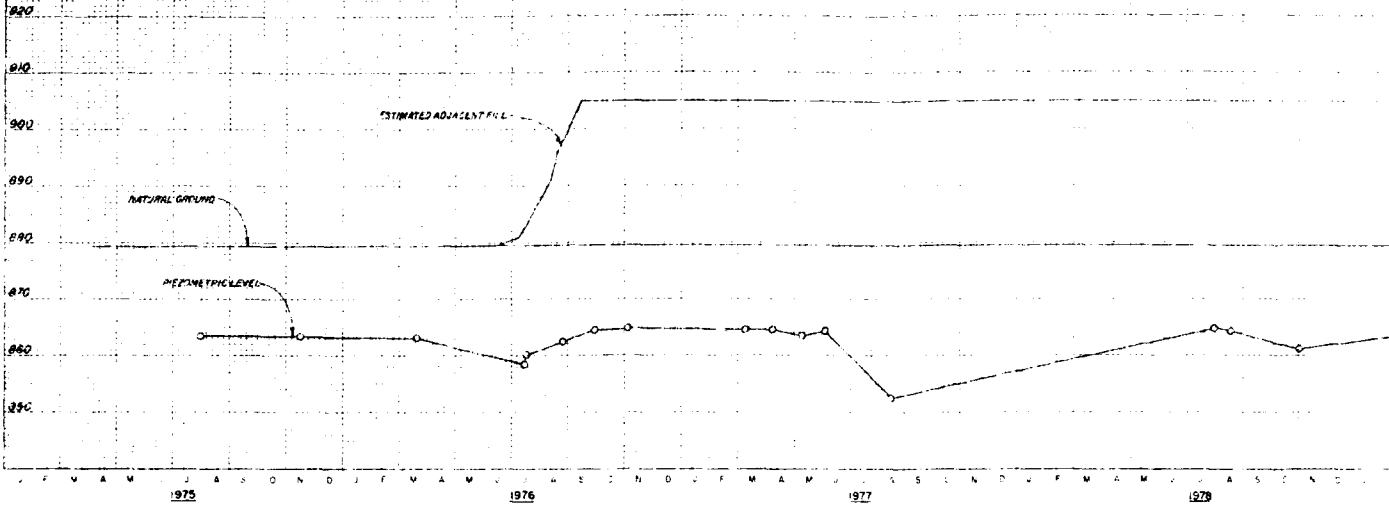
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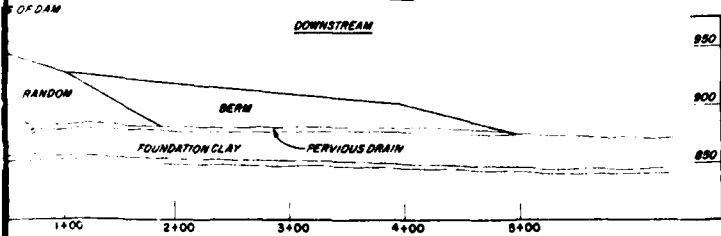
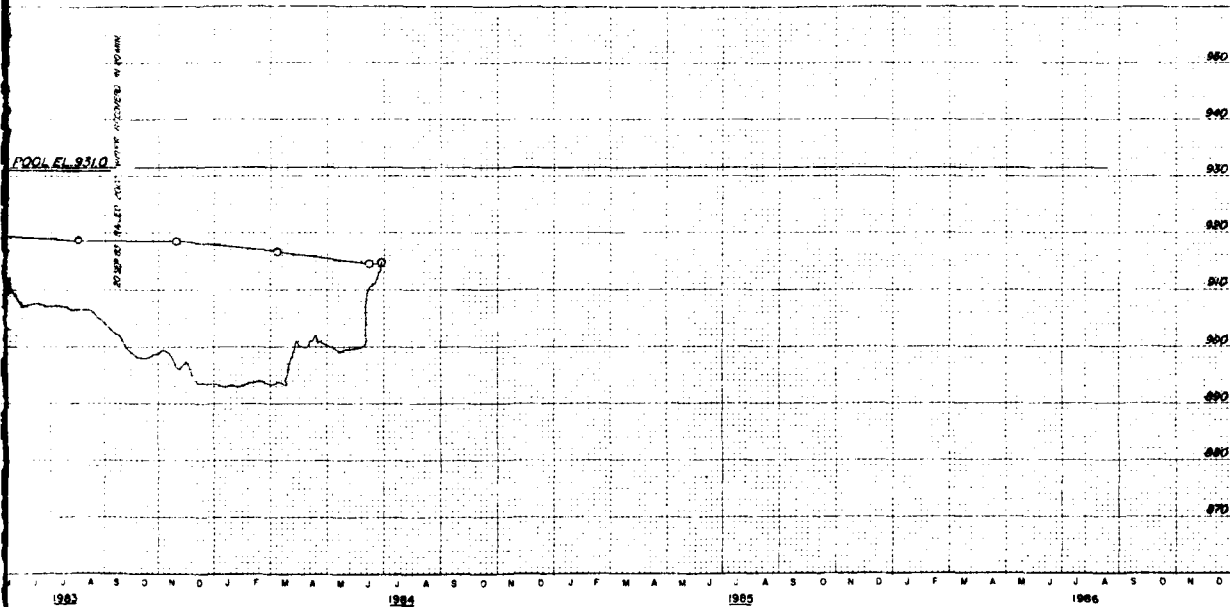
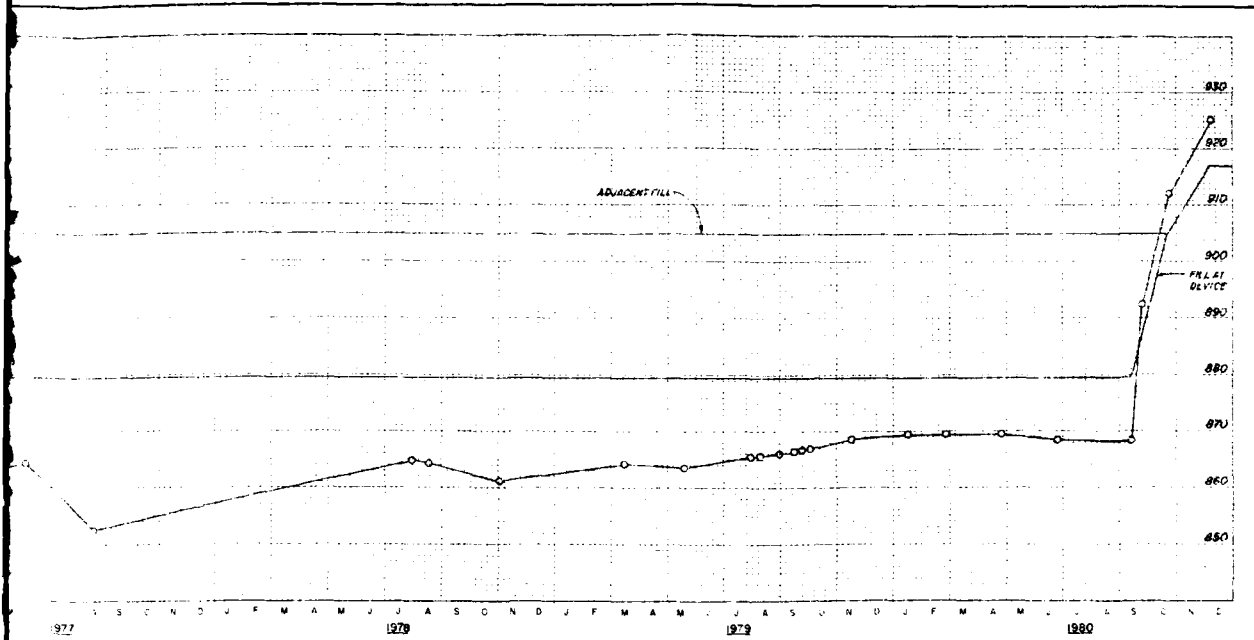
CORPS OF ENGINEERS    U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-934  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

PGP-02 EL. 834.4  
 TIP EL. 841.7  
 STA. 85+81  
 RANGE 804.1  
 MAP L. SHALE  
 INSTALLED 13 FEB 75





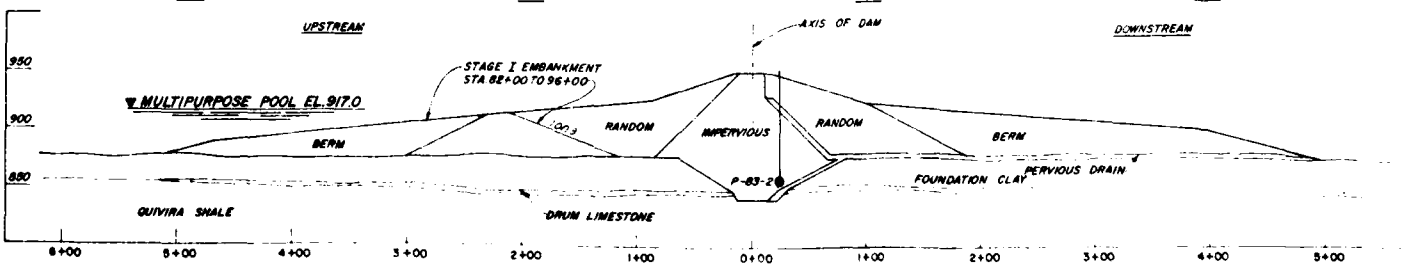
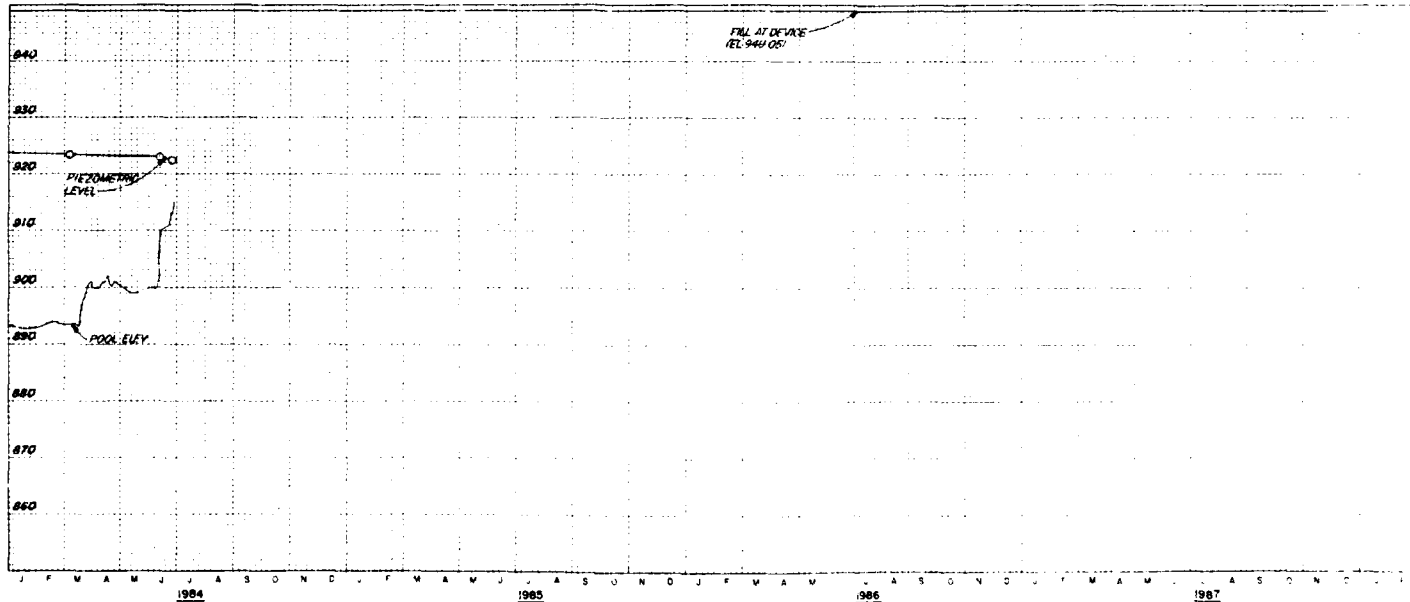
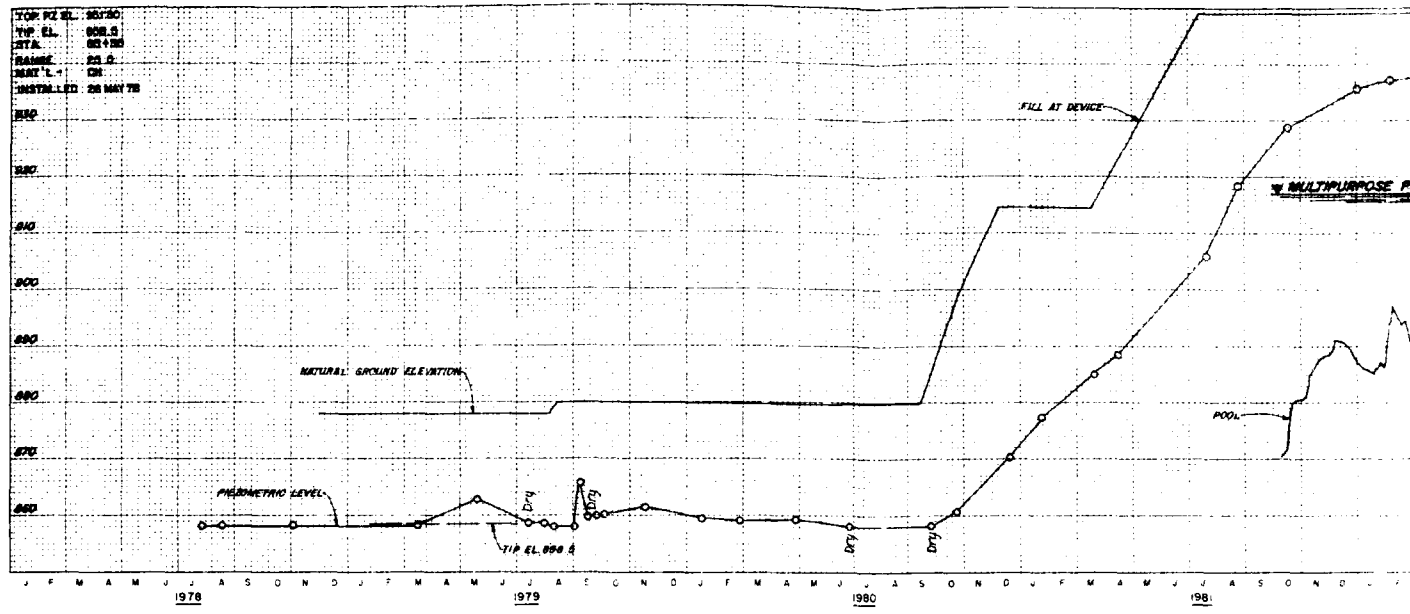
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 OPEN TUBE PIEZOMETER  
 P-82-2

In 1 sheet

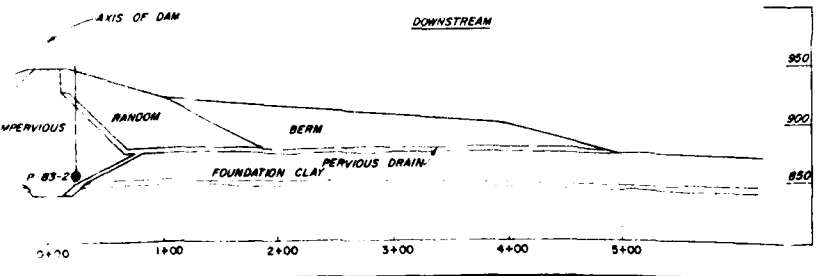
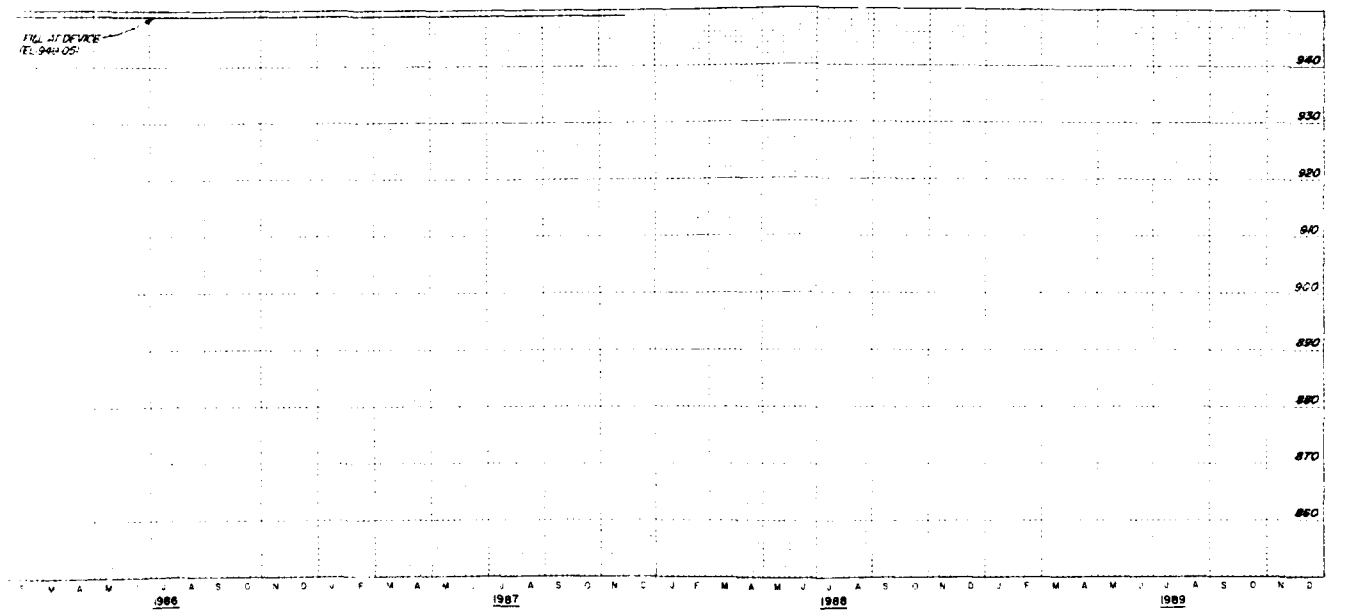
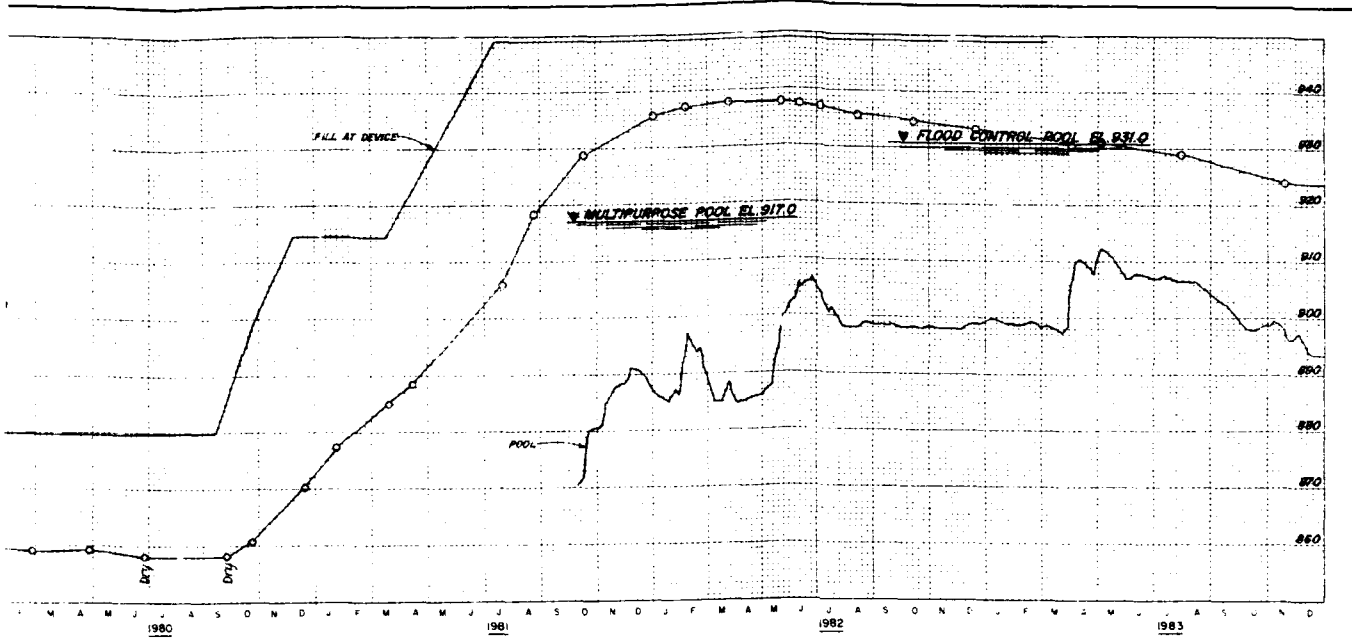
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Sheet No. 1  
 Scale as shown  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-935  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929





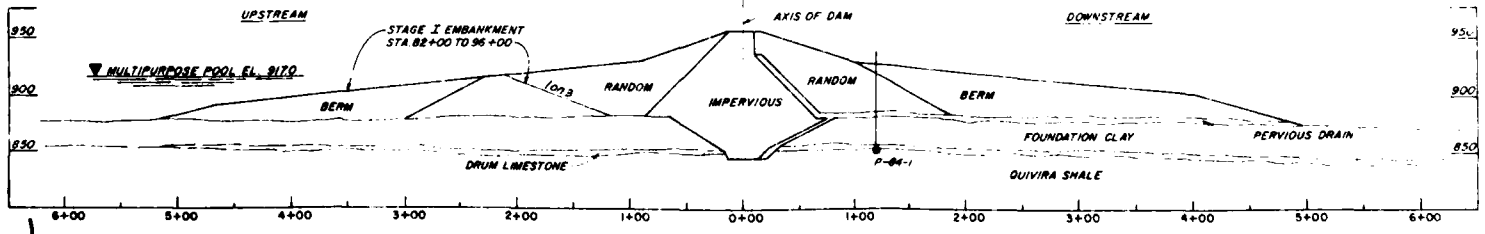
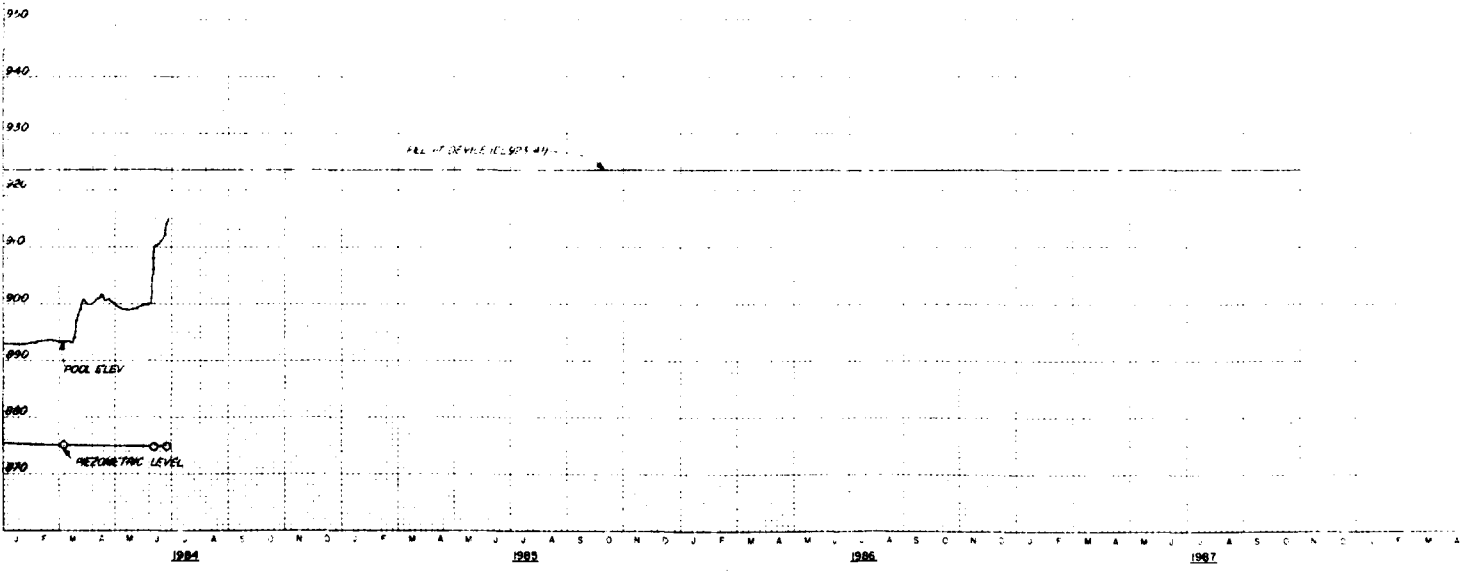
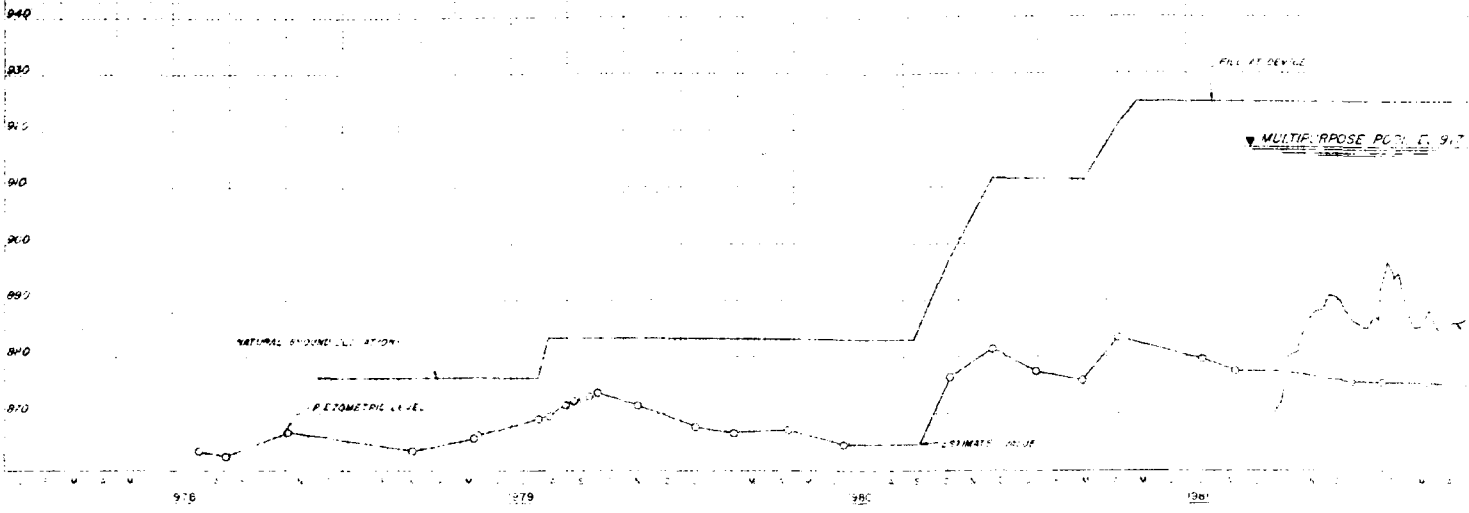


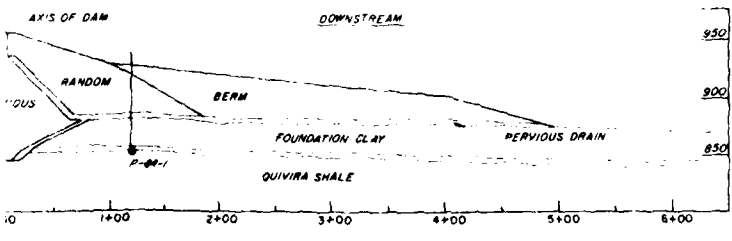
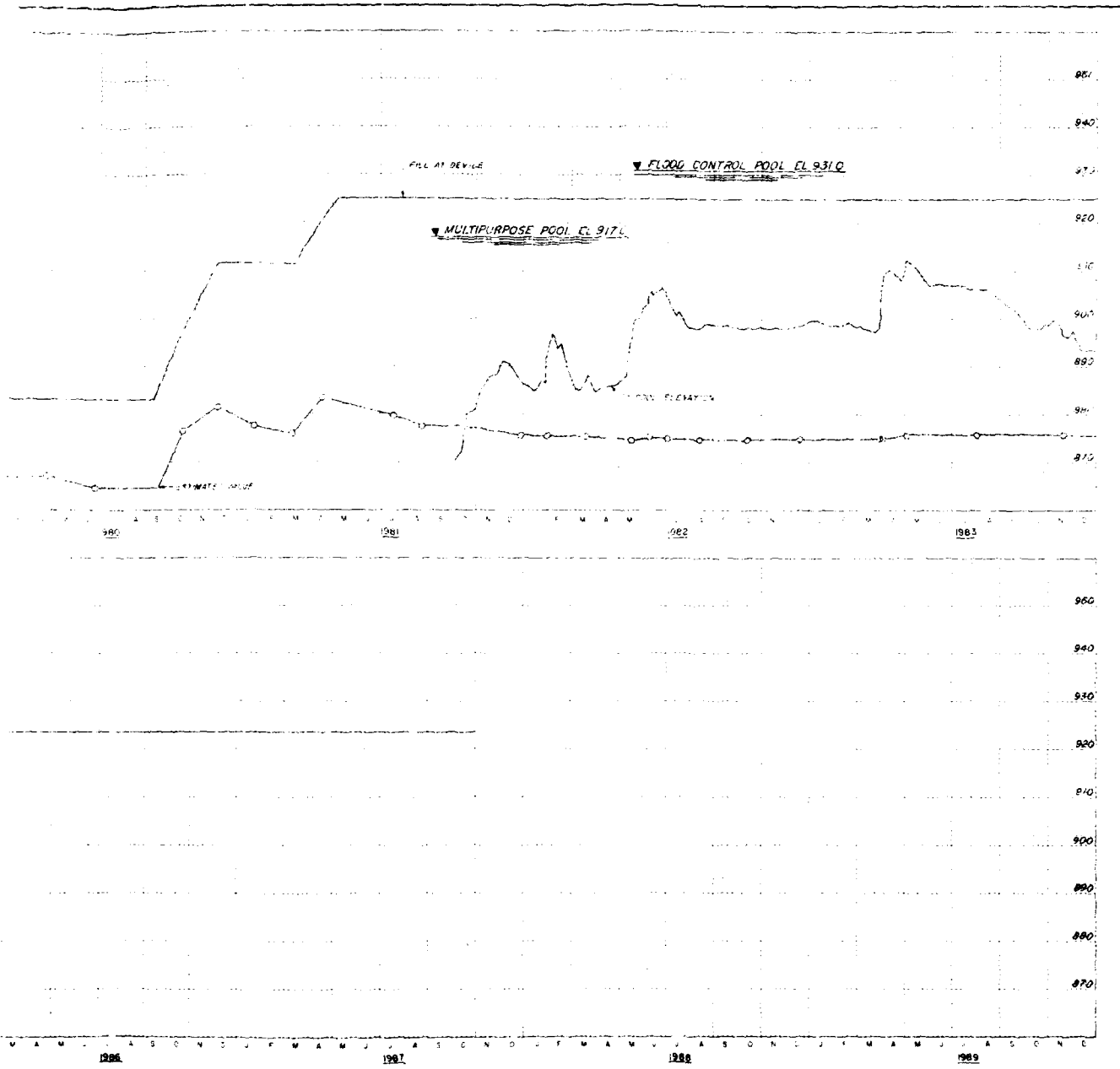
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 OPEN TUBE PIEZOMETER  
 P-83-2  
 Sheet No. 1  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-936  
 JANUARY 1983

In 1 sheet  
 Scale as shown  
 2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TOP PZ EL. 923.47  
 TOP EL. 848.1  
 STA. 84+88  
 RANGE 1+20.0  
 MAT'L. L.S.  
 INSTALLED: 30 MAY 78





REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMPLACEMENT CRITERIA REPORT

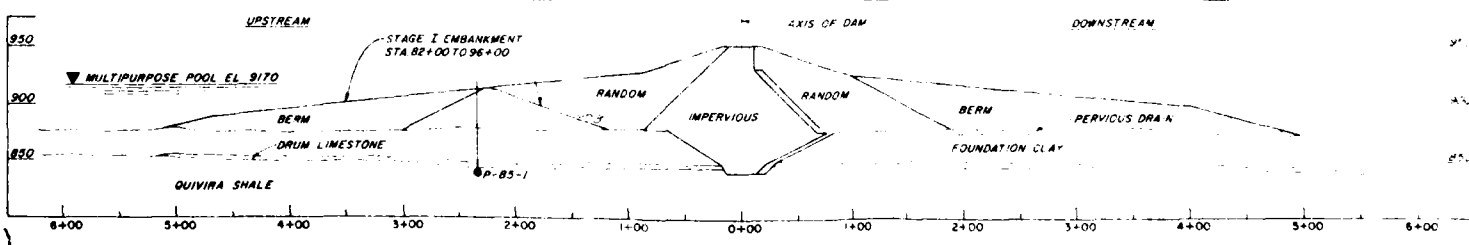
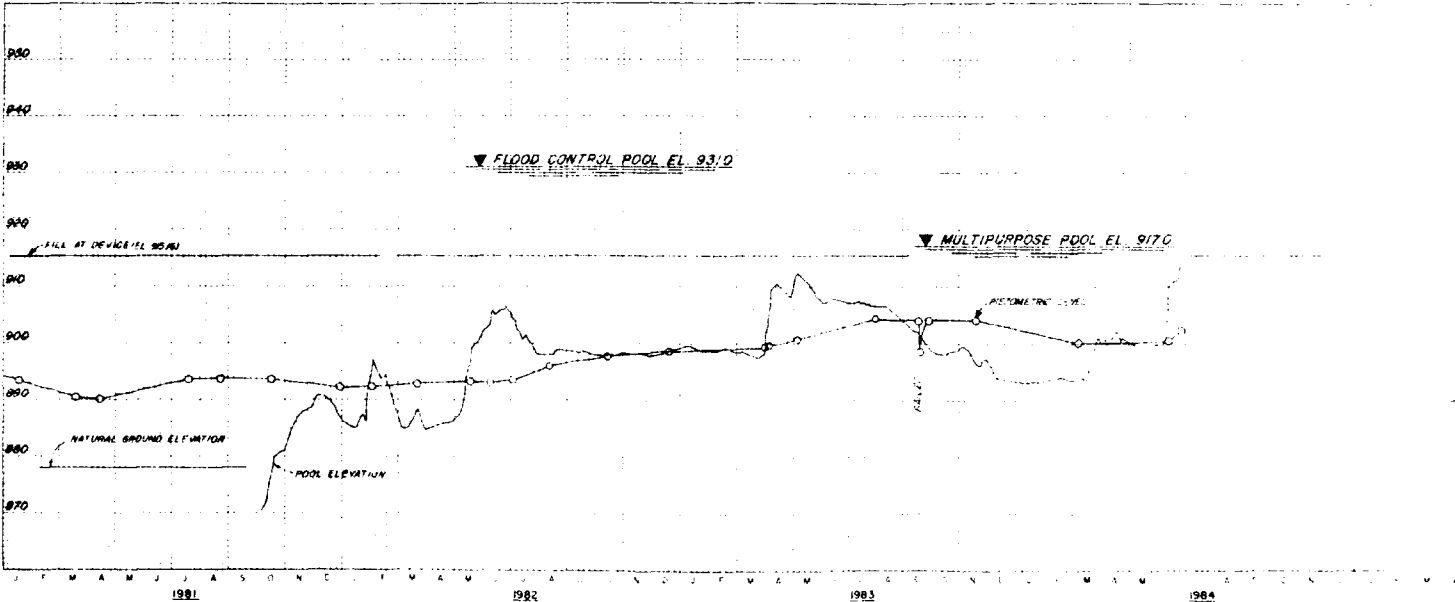
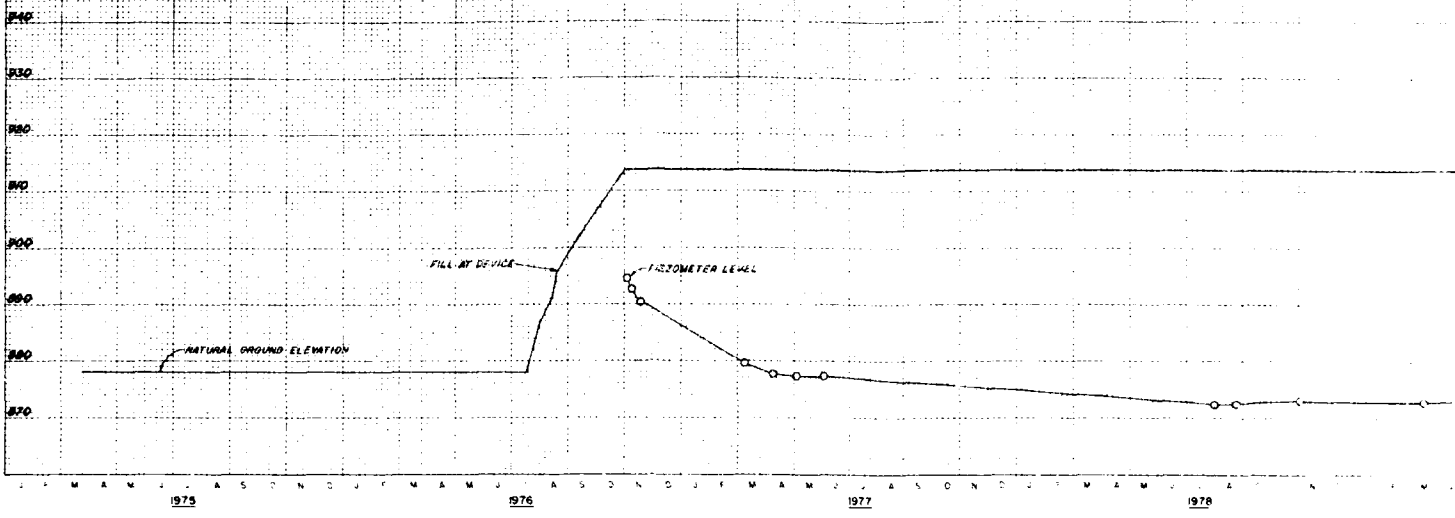
OPEN TUBE PIEZOMETER  
 P-84-1

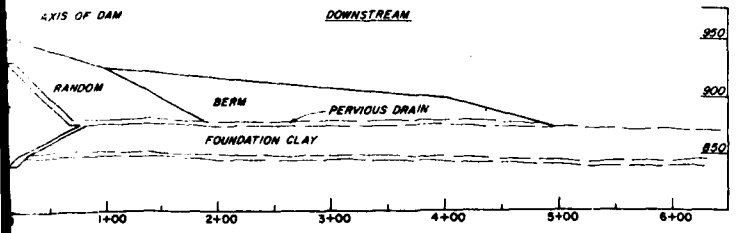
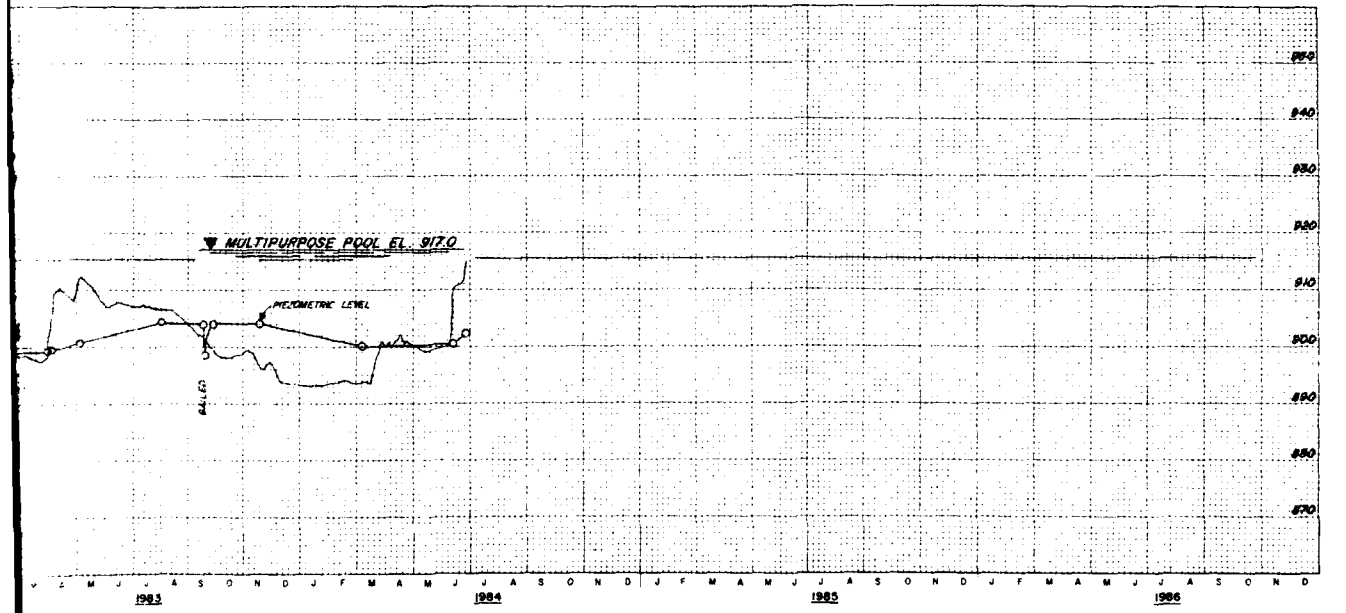
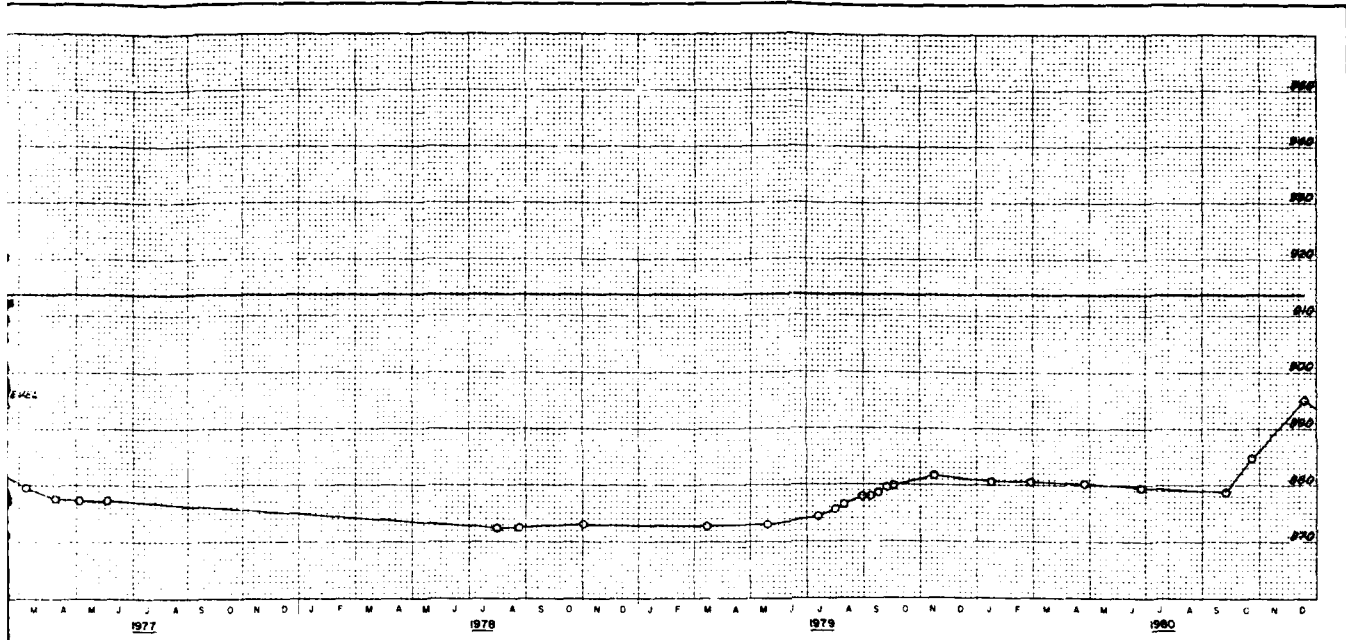
Sheet No. 1  
 Scale as shown  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. 0-15-937  
 JANUARY 1983

2

ELEVATION, IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TOP OF EL: 877.50  
 TOP EL: 841.00  
 STA: 84+00  
 RANGE: 230.0  
 INSTRUMENT: SW  
 INSTALLED: 19 OCT 74



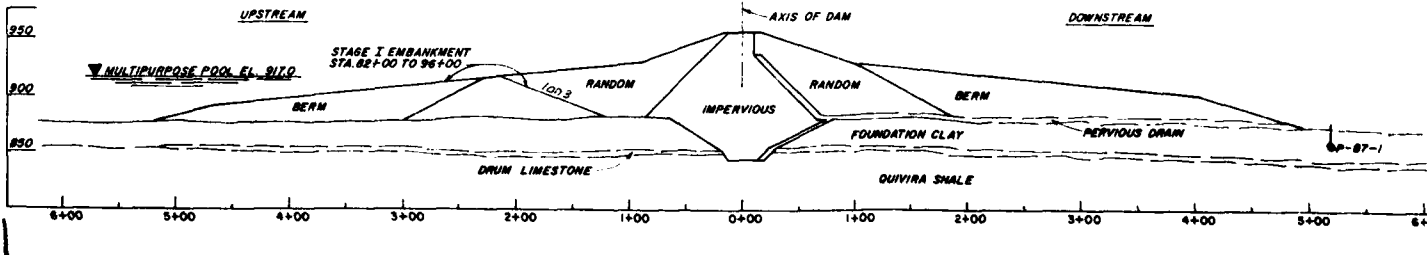
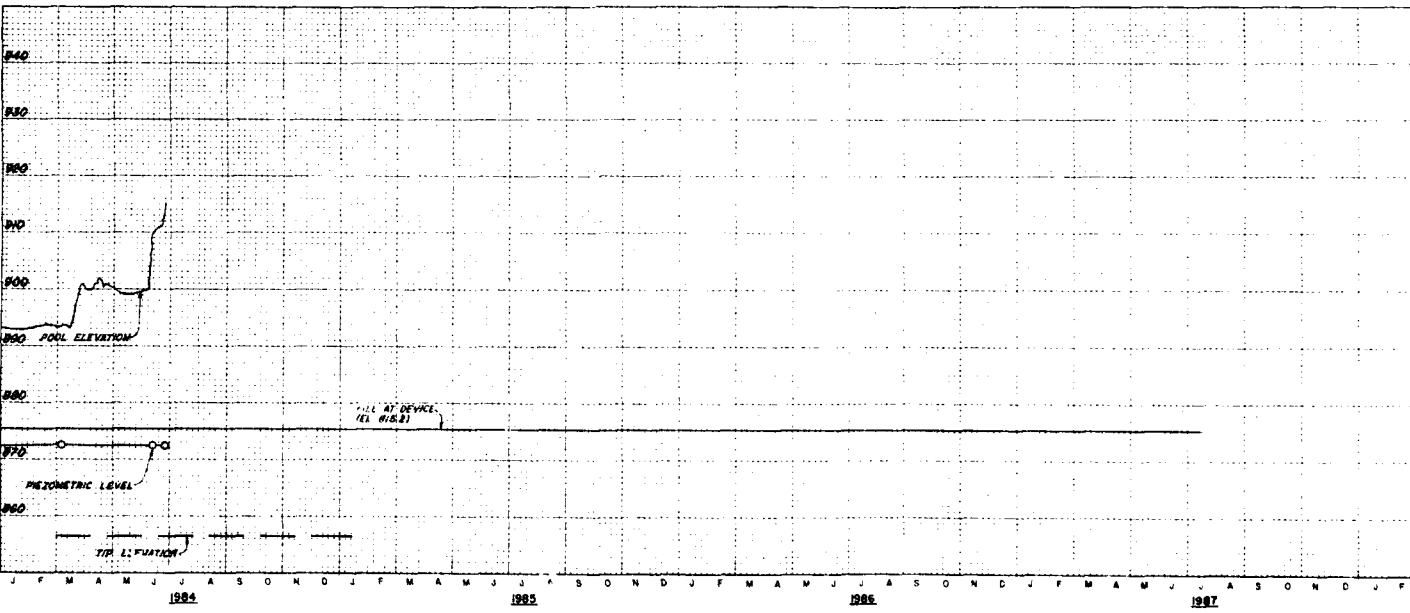
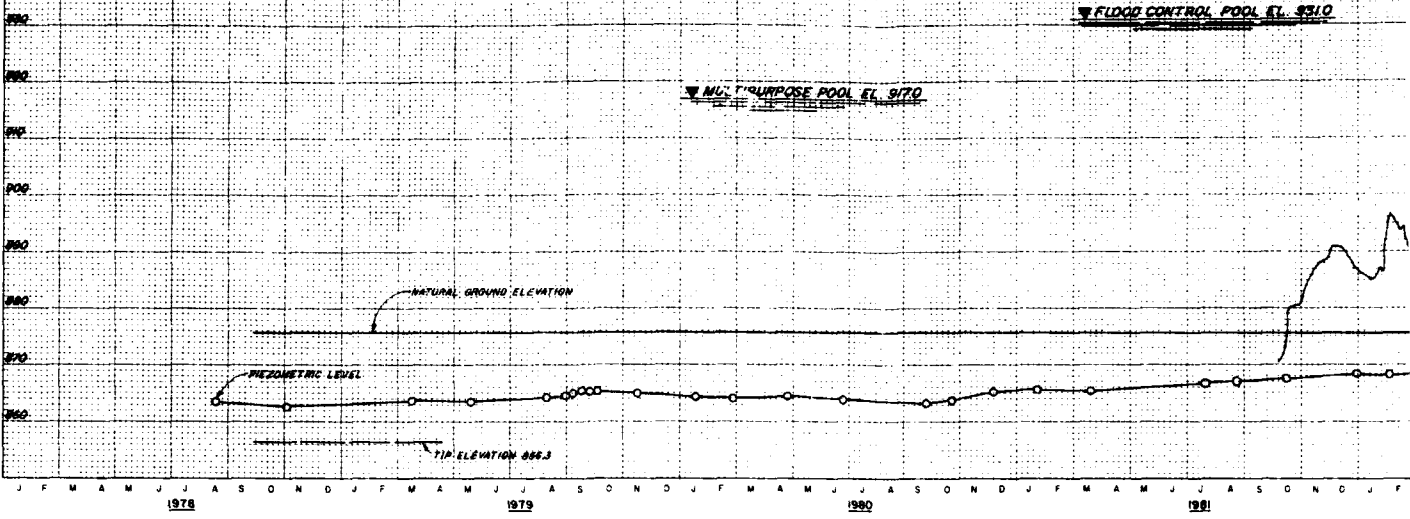


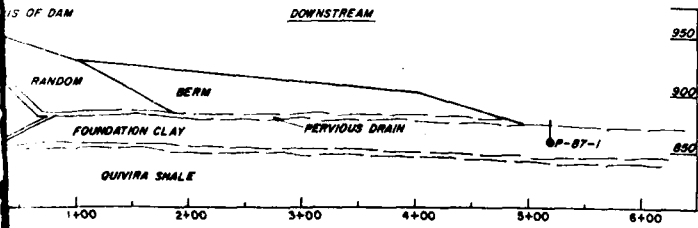
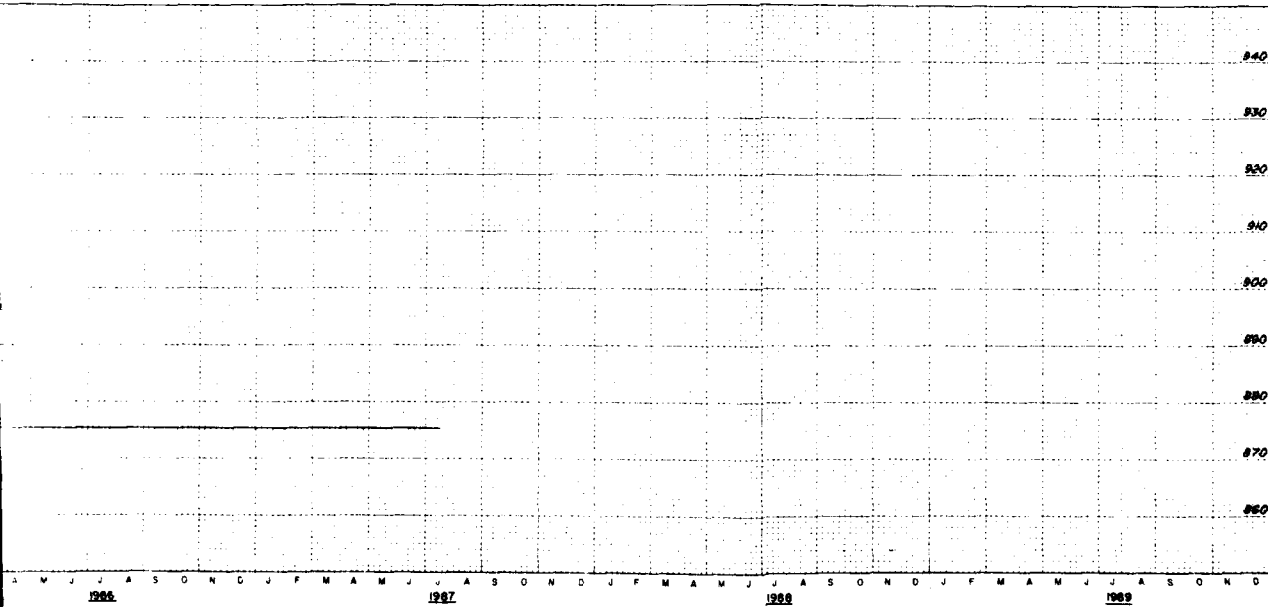
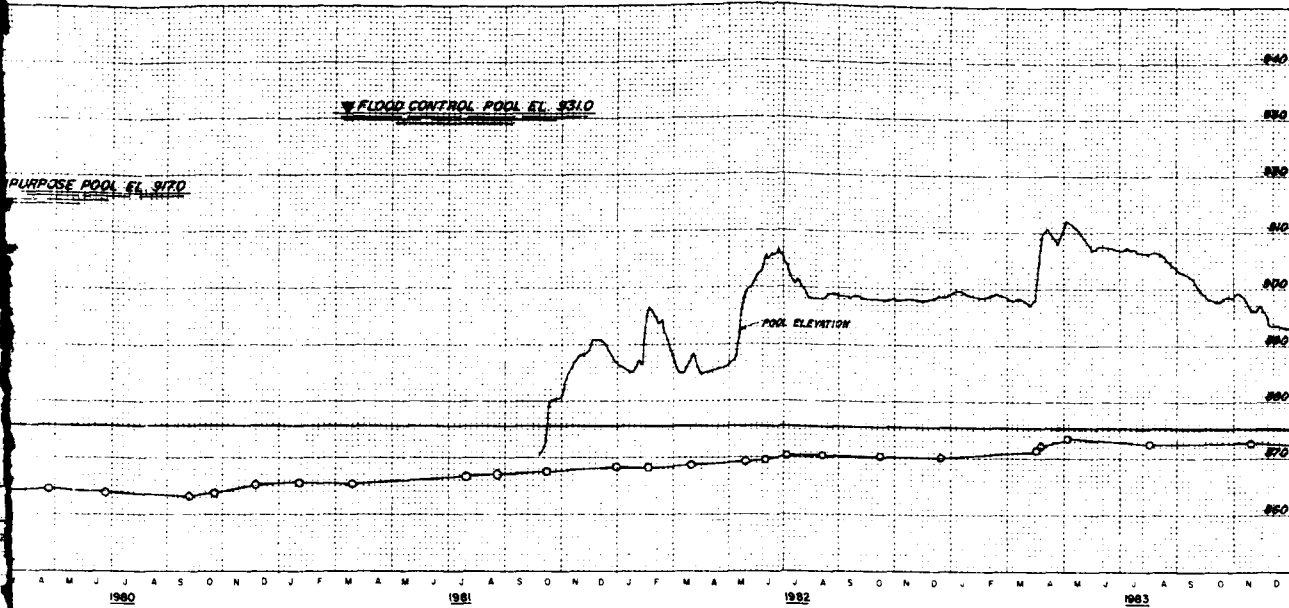
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 OPEN TUBE PIEZOMETER  
 P-85-1

In 1 sheet      Sheet No. 1      Scale, as shown  
 CORPS OF ENGINEERS    U S ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-938  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TOP EL. 878.7  
 TIP EL. 866.3  
 STA. 81+75  
 RANGE 0+00 0  
 MAY 1978  
 INSTALLED BY JVA MS





REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

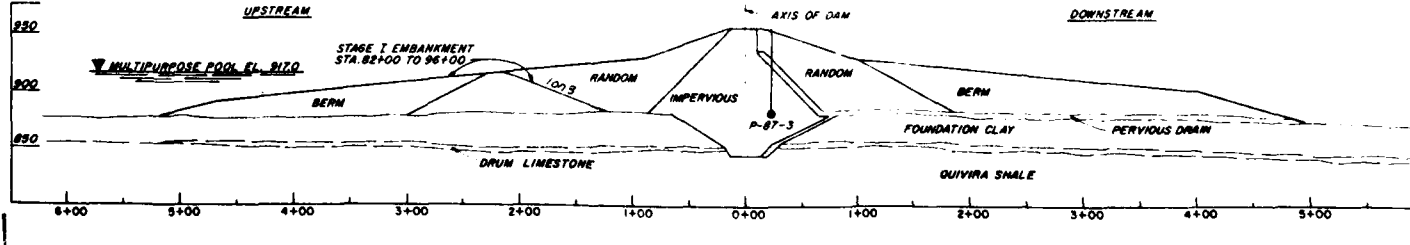
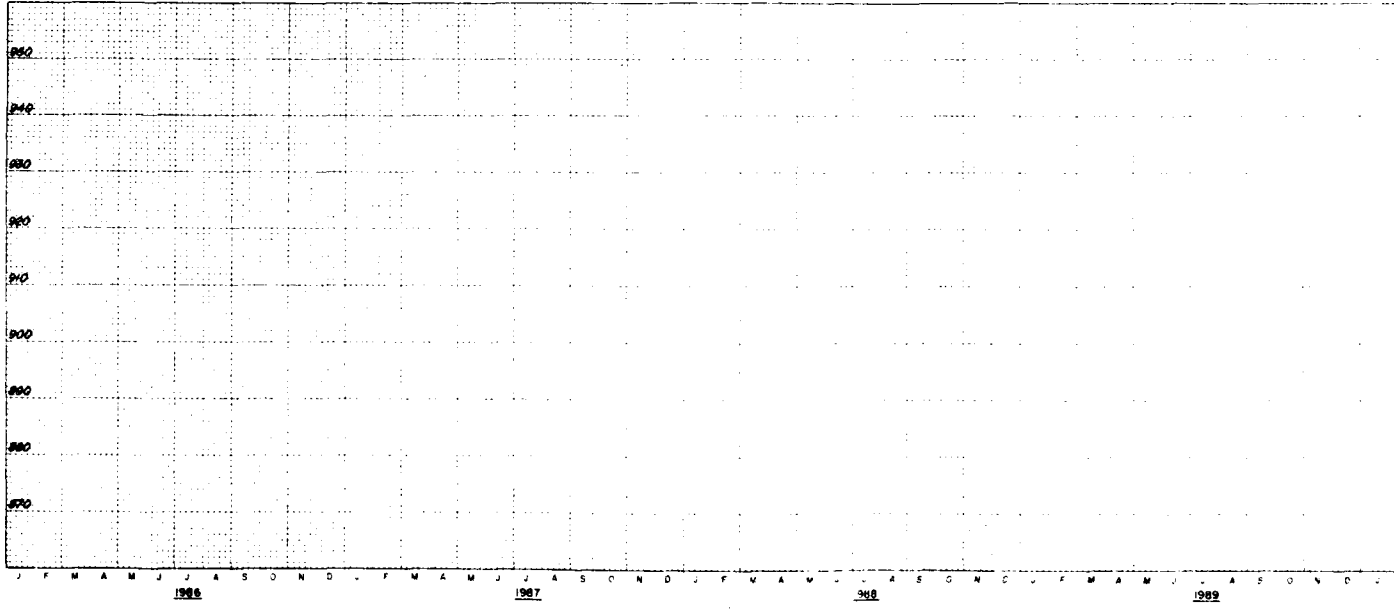
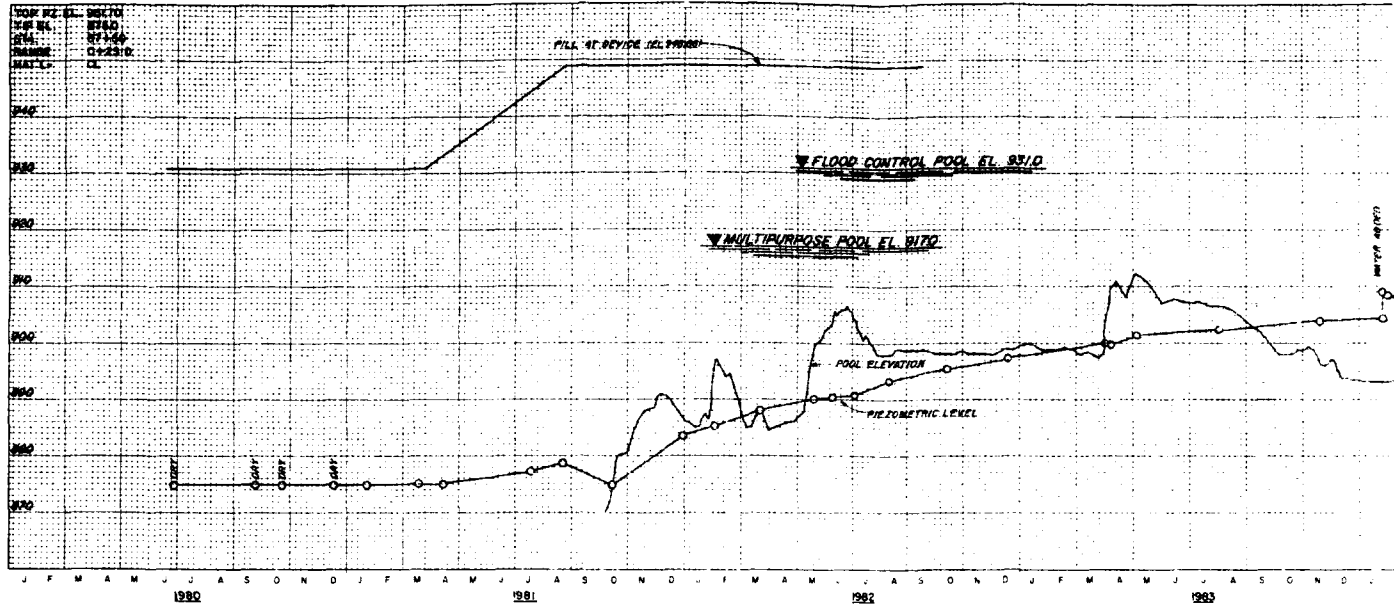
**OPEN TUBE PIEZOMETER**  
 P-87-1

In 1 sheet Sheet No. 1 Scale as shown

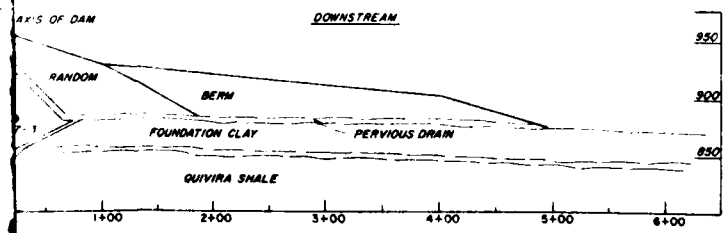
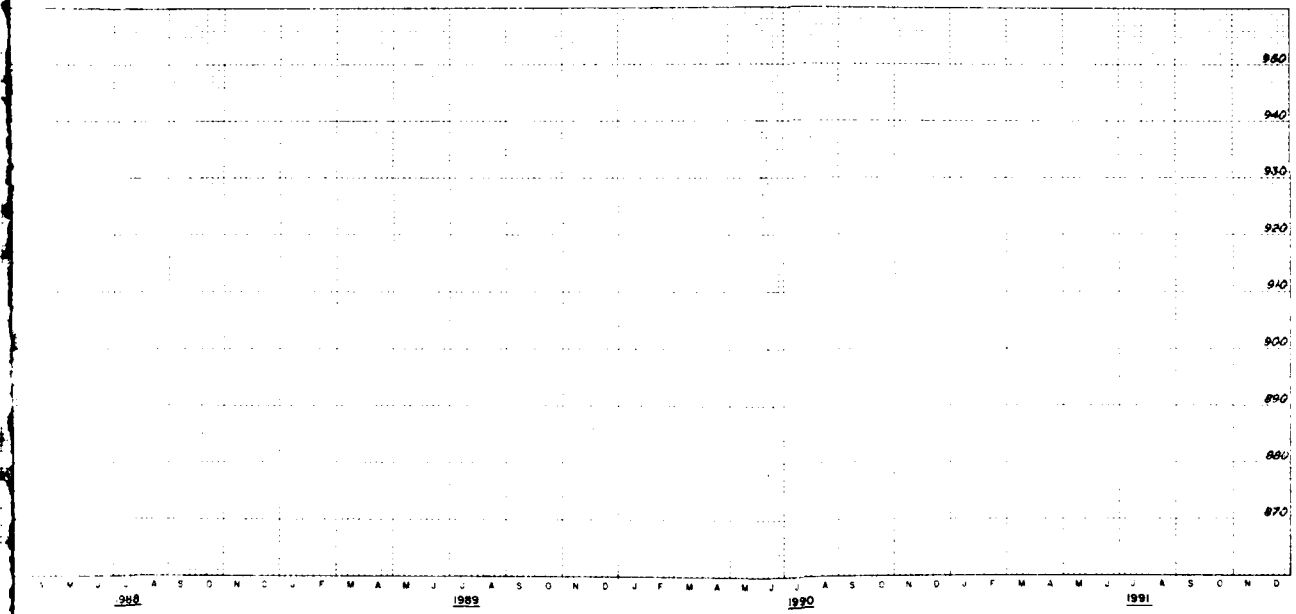
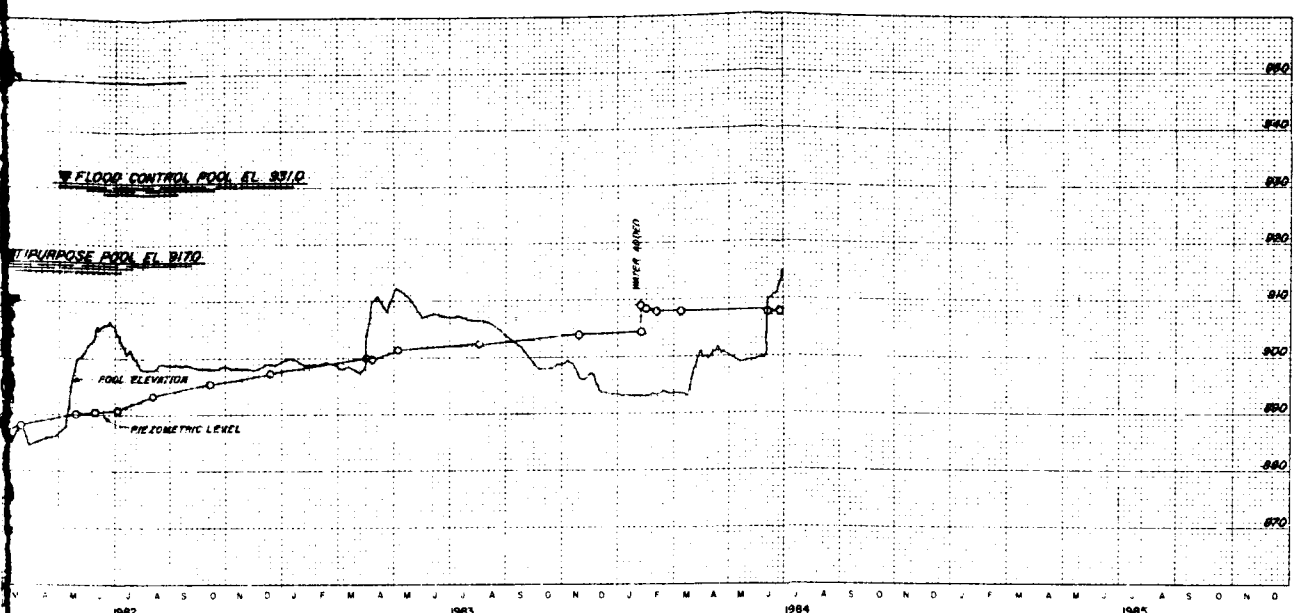
CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-940  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929







REVISED SEPTEMBER 1984  
 BIG BULL CREEK KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

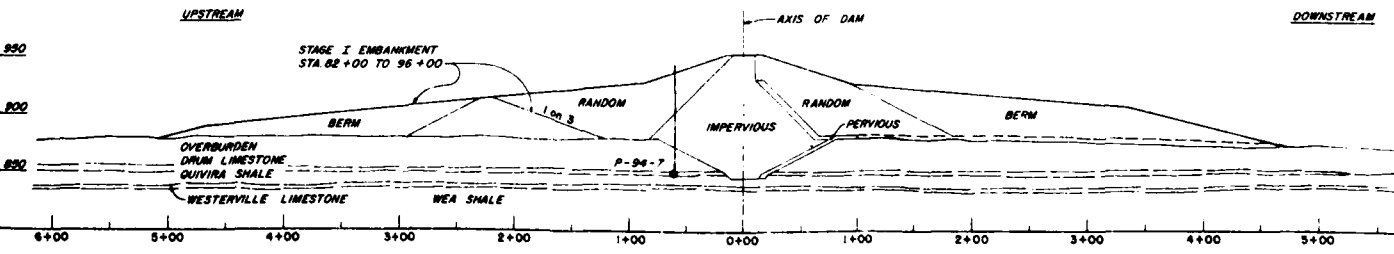
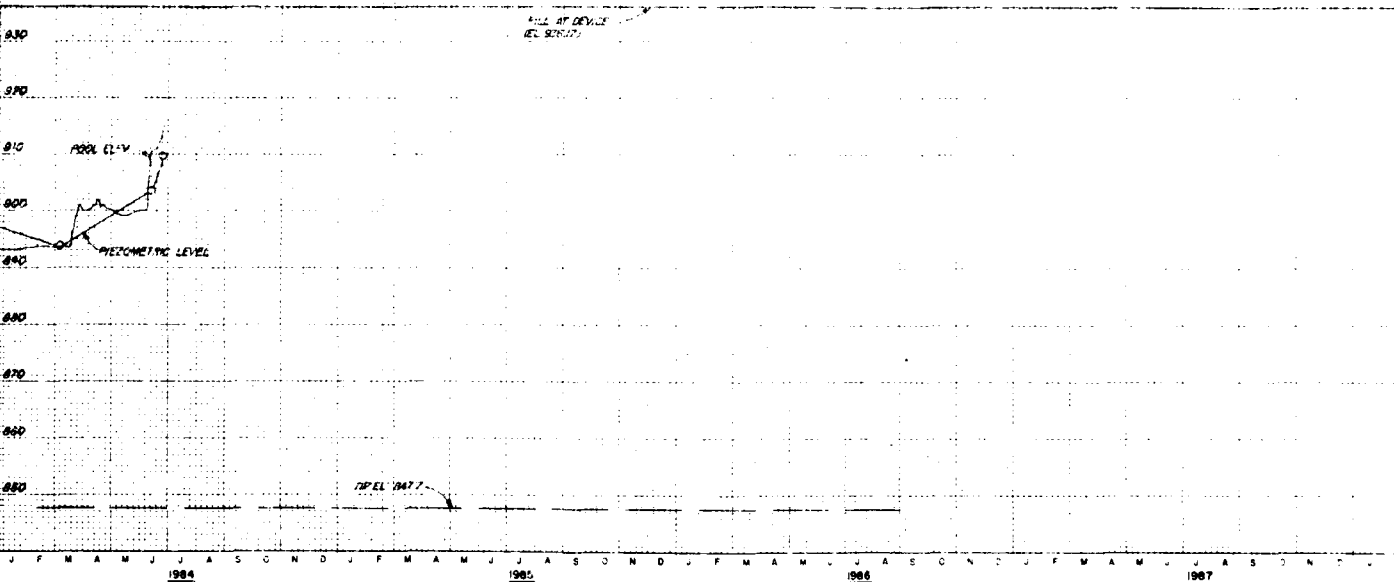
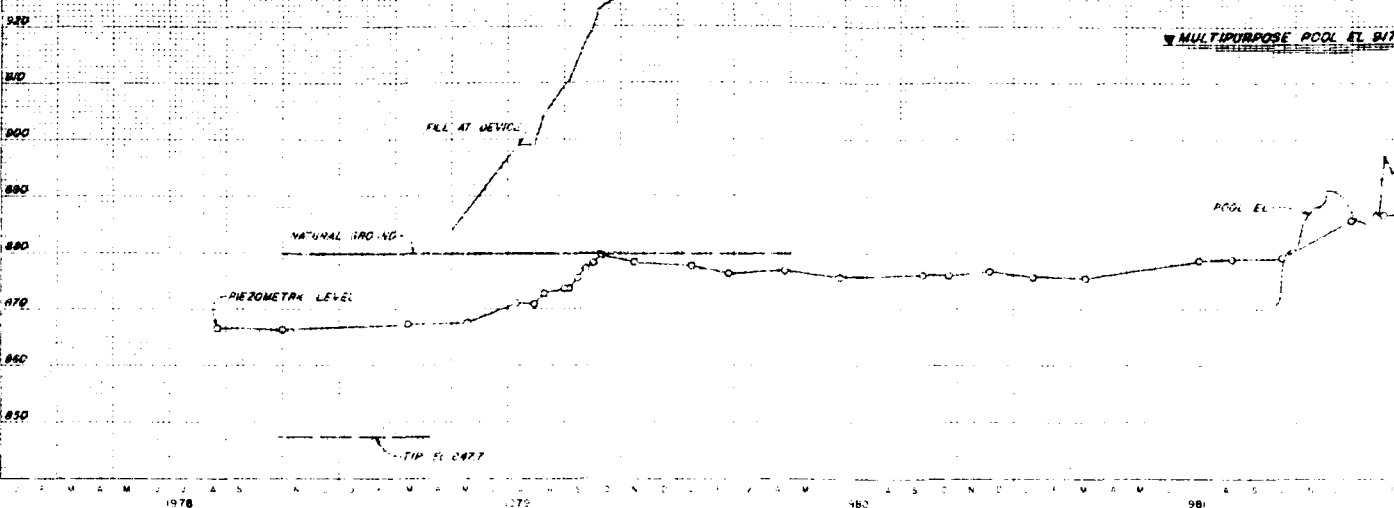
OPEN TUBE PIEZOMETER  
 P-87-3

In 1 sheet  
 Sheet No. 1  
 Scale: as shown  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-942  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

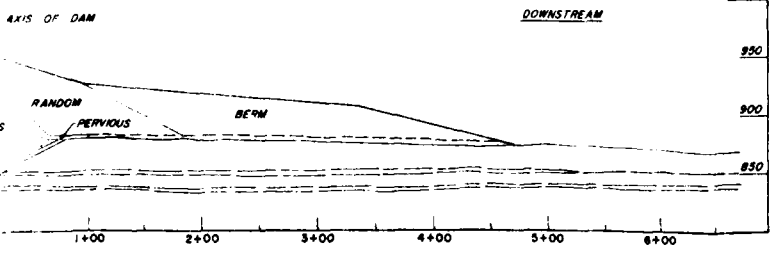
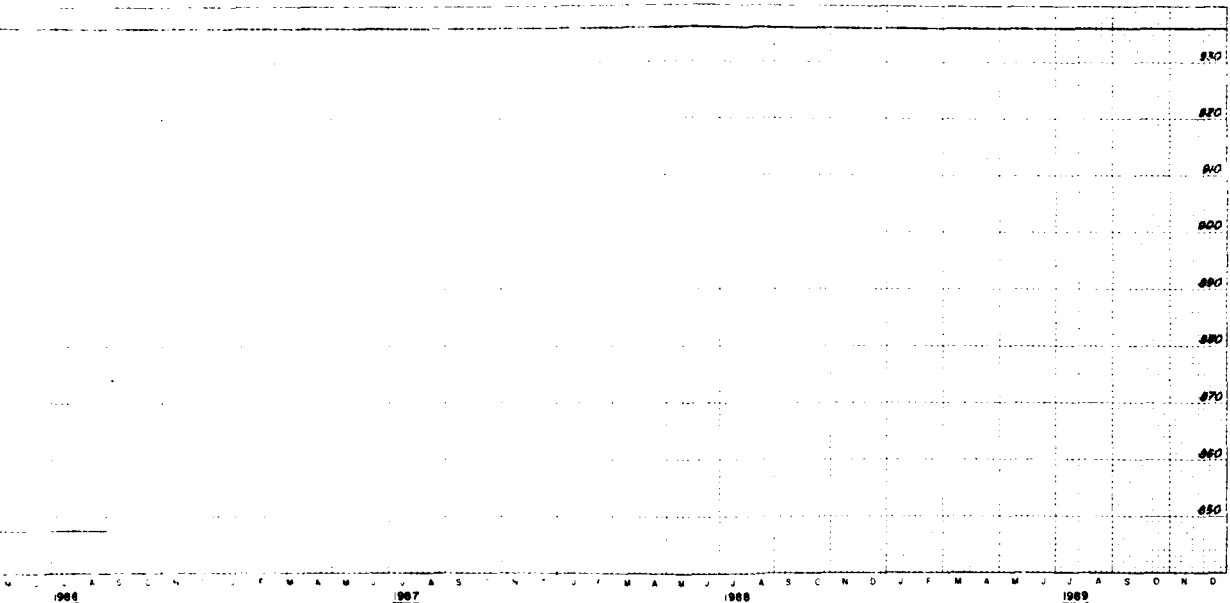
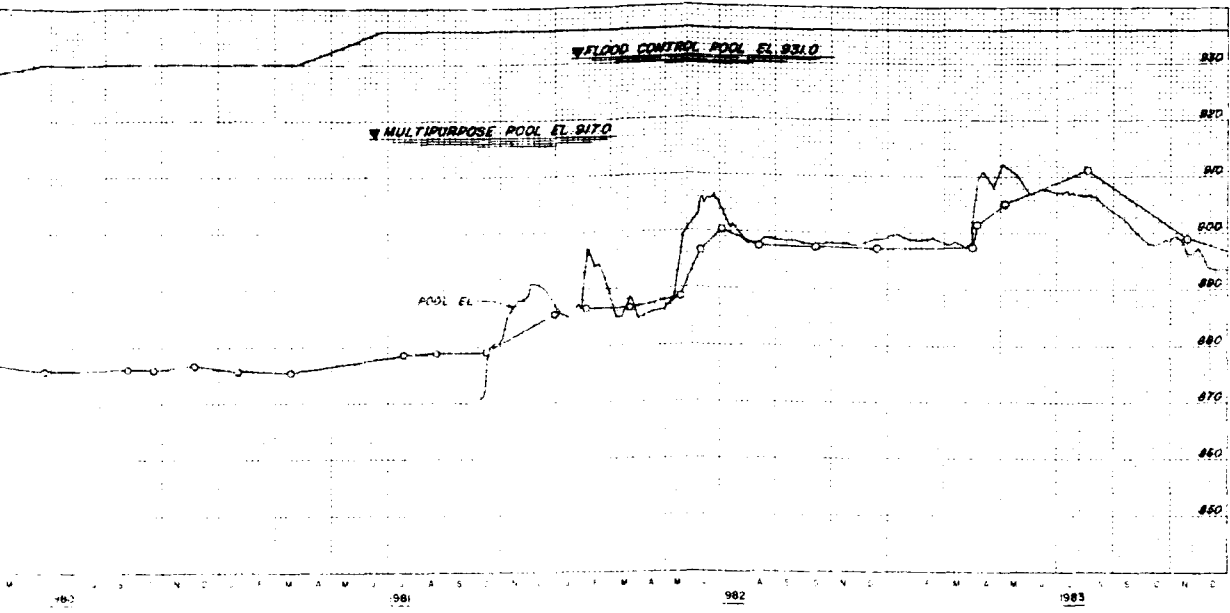
TOP OF EL. 848.4  
 TIP EL. 847.7  
 STA. 84+00  
 RANGE 01800  
 MAT. L.S.  
 INSTALLED BY MAY 78



FLOOD CONTROL POOL EL. 931.0

MULTIPURPOSE POOL EL. 817.0

POOL EL.



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 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

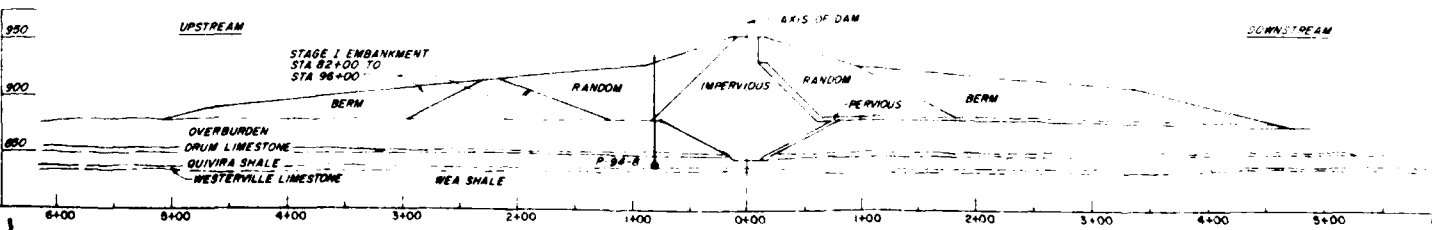
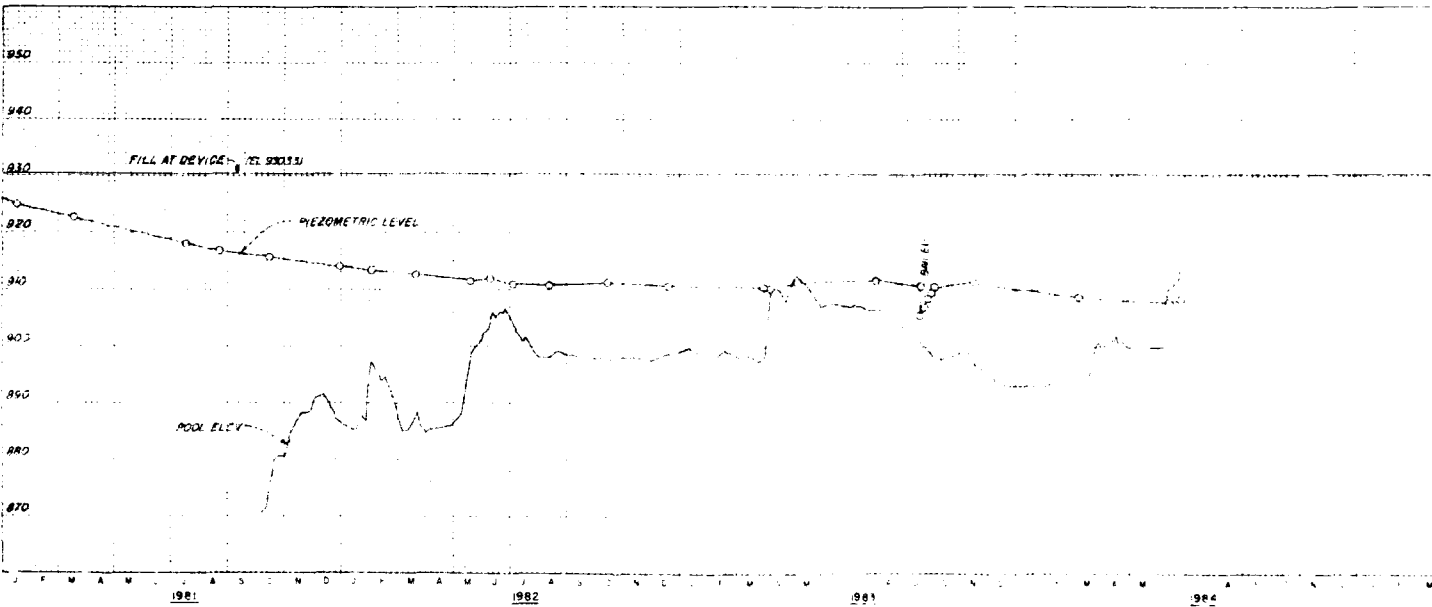
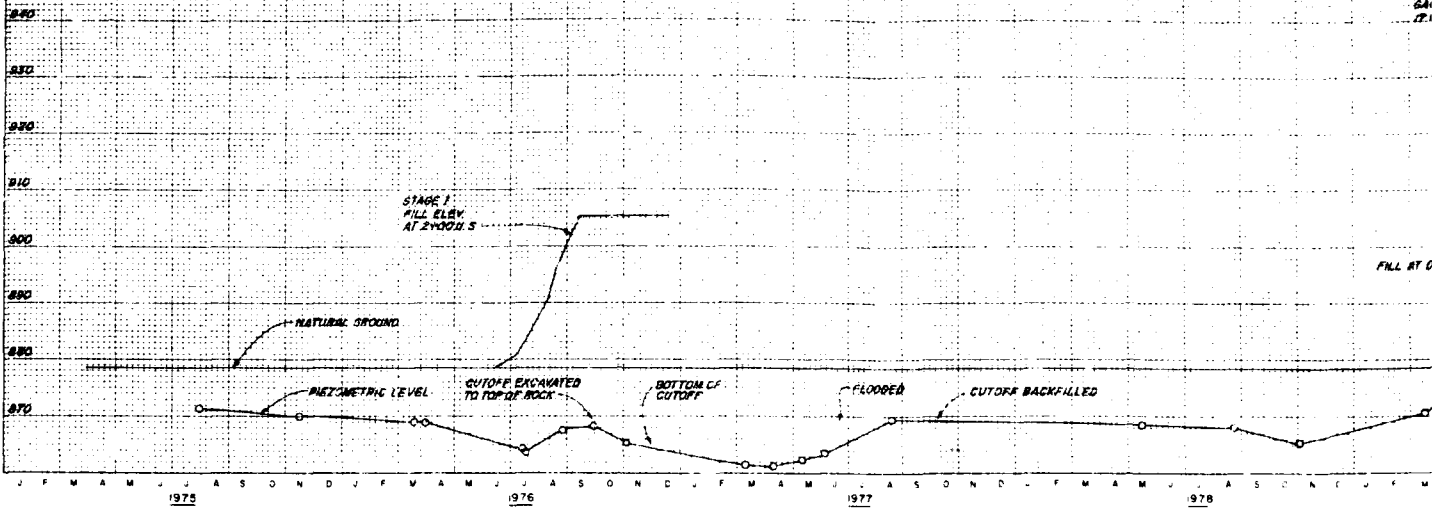
OPEN TUBE PIEZOMETER  
 P-94-7

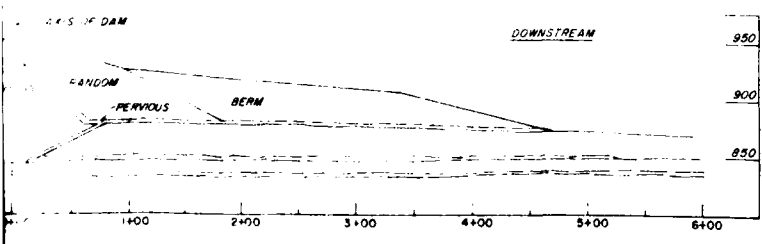
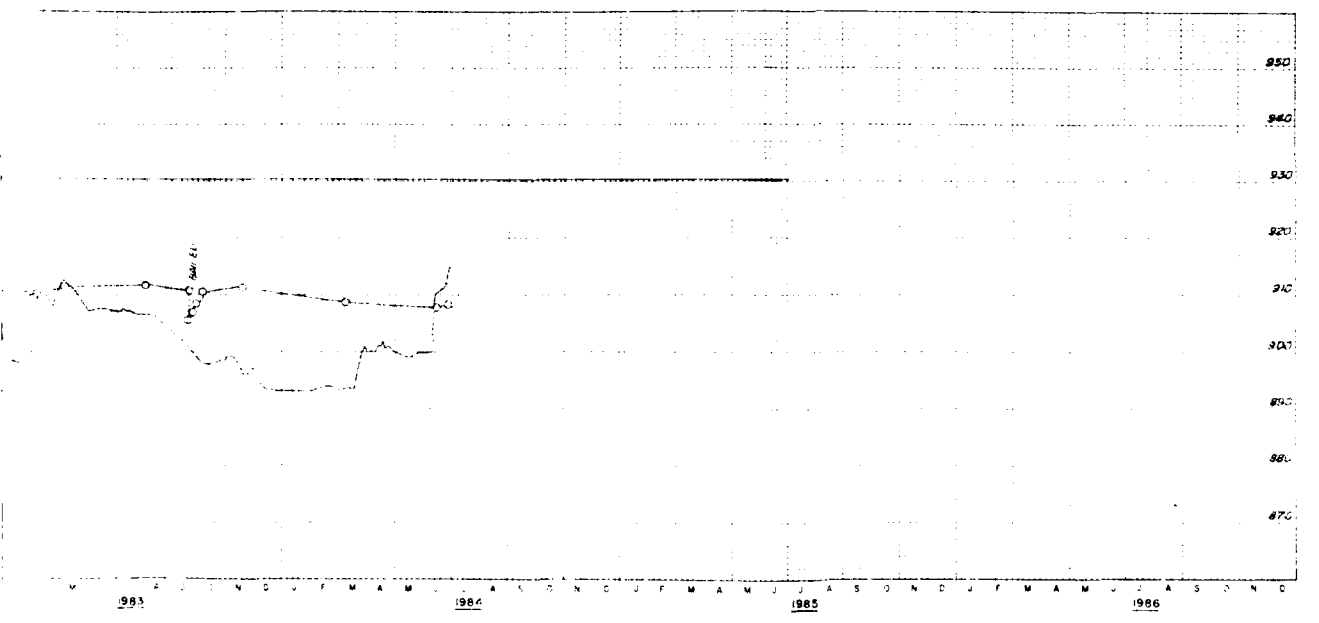
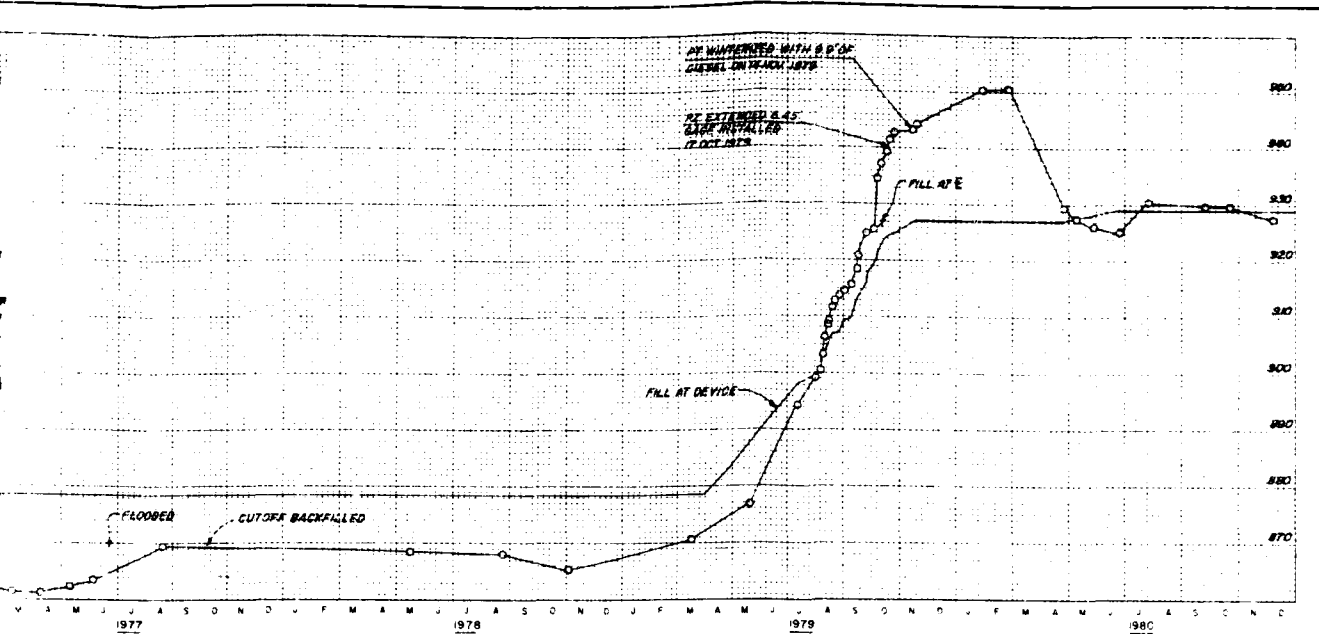
In 1 sheet  
 Sheet No. 1  
 Scale as shown  
 CORPS OF ENGINEERS U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. 0-15-951  
 JANUARY 1983

2

ELEVATION IN FEET AT 10 DAY PAUSE MONTHLY GEODETIC VERTICAL DATUM OF 1929

TOP OF SL. 822.21  
 TIP EL. 822.8  
 STA. 93+58  
 NAME: T1004  
 MAX. - 0.1  
 INSTALLED 28 FEB 75





REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-94-8

In 1 sheet Sheet No. 1 Scale as shown

CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-952  
 JANUARY 1983

TOP PZ EL. 940.15  
 TIP EL. 835.1  
 STA. 95.95  
 RANGE 0+900  
 NAT. L. LB. 85M \*  
 INSTALLED 2 JUN 78

\* NOTE 1 WESTERVILLE LS  
 CS' WEA

PZ WINTER EL. R. 10' OF  
 WHEEL IN 1 NOV 1979  
 RE. READ 5.69 TO GSE. EL.  
 TO WATER ON 6 JUL 1979

ESE.

FILL AT DEVICE

WESTERVILLE L.S.

WEA SHALE

NATURAL GROUND ELEVATION

PIEZOMETRIC LEVEL

940

940

930

920

910

900

890

880

870

FILL AT DEVICE  
 (EL. 938.66)

PIEZOMETRIC LEVEL

POOL ELEVATION

1984

1985

1986

1987

950

940

890

800

UPSTREAM

STAGE I EMBANKMENT  
 STA 82+00 TO STA 96+00

BERM

RANDOM

MONITOR BOX

AXIS OF DAM

IMPERVIOUS

RANDOM

PERVIOUS

BERM

DOWNSTREAM

OVERBURDEN

DRUM LIMESTONE

QUIVIRA SHALE

WESTERVILLE LIMESTONE

WEA SHALE

P-94-9

6+00

5+00

4+00

3+00

2+00

1+00

0+00

1+00

2+00

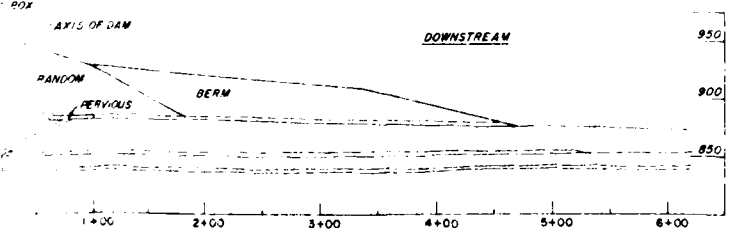
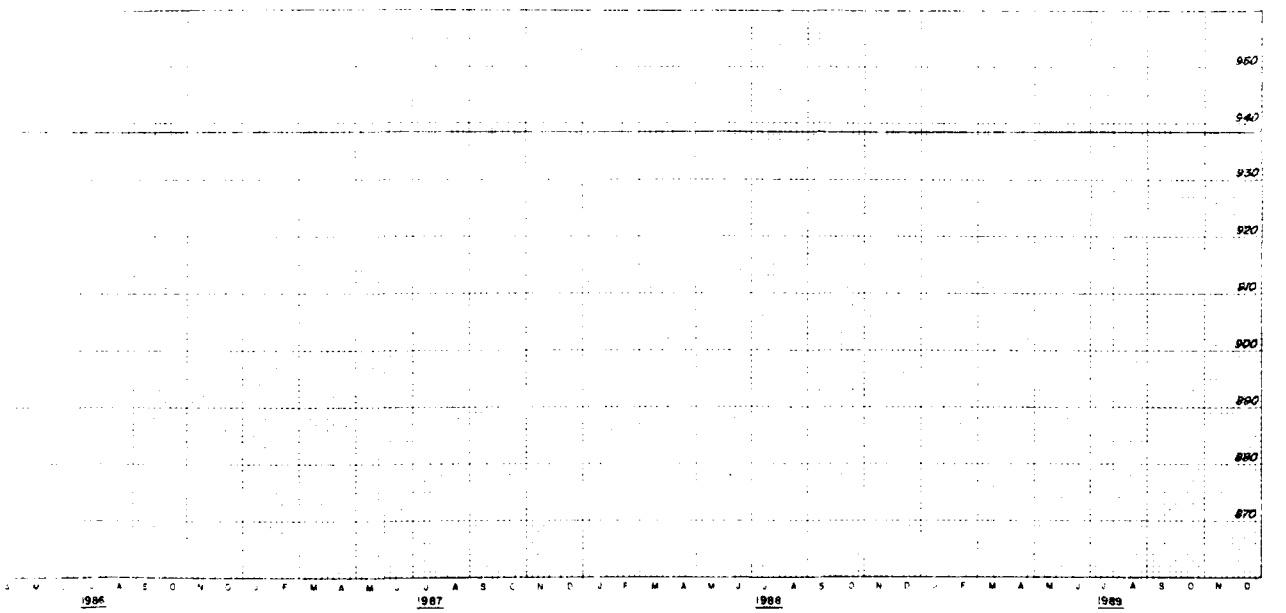
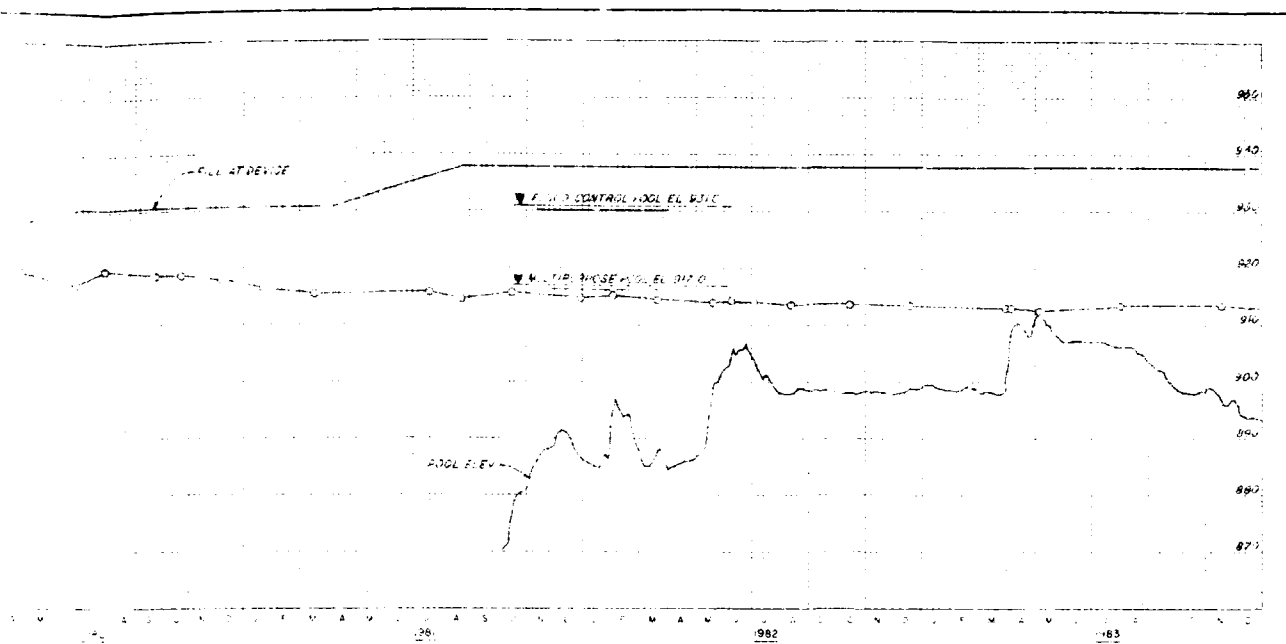
3+00

4+00

5+00

6+00

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM



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 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-94-9

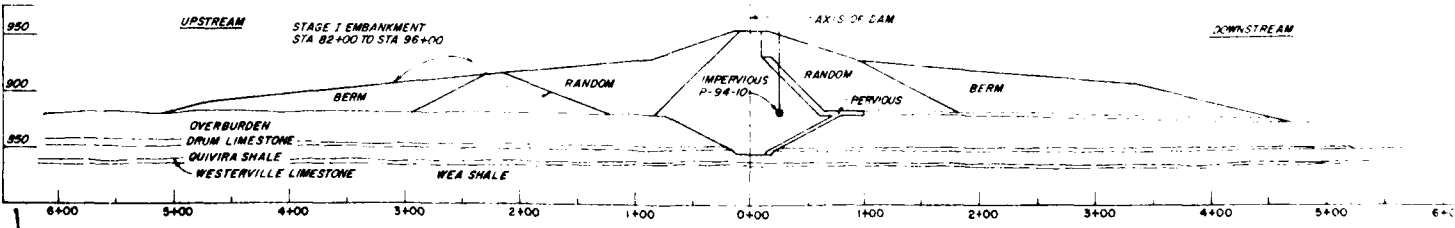
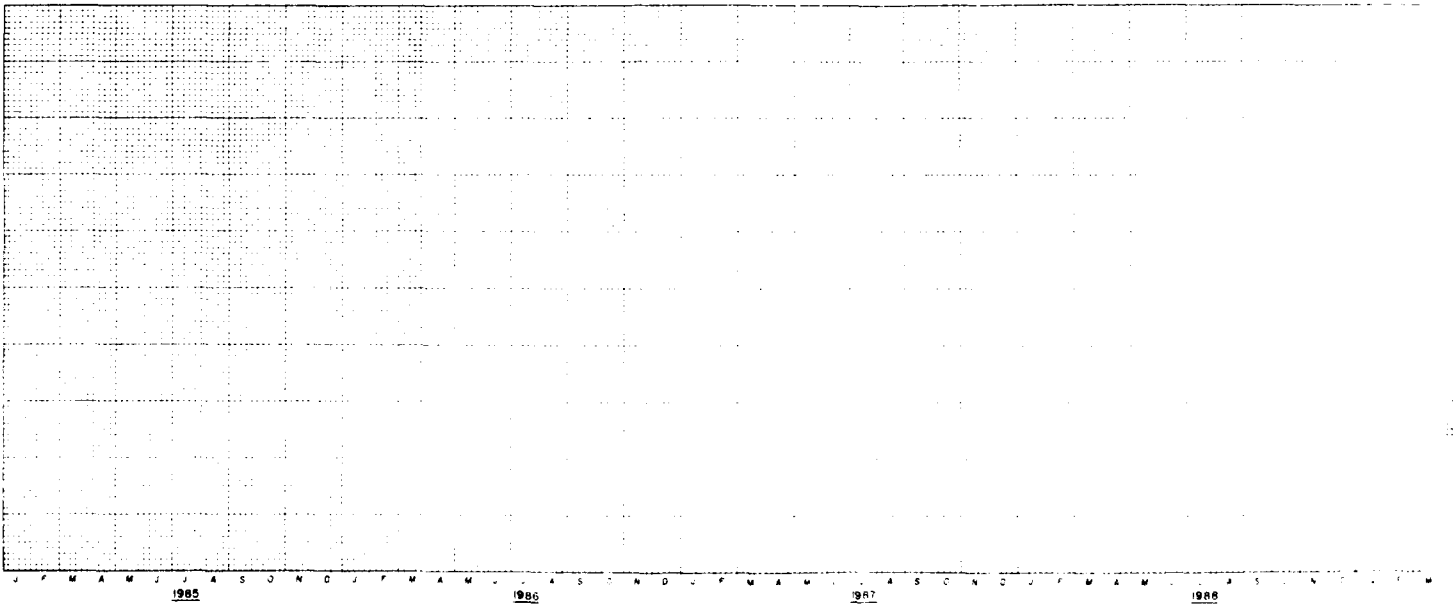
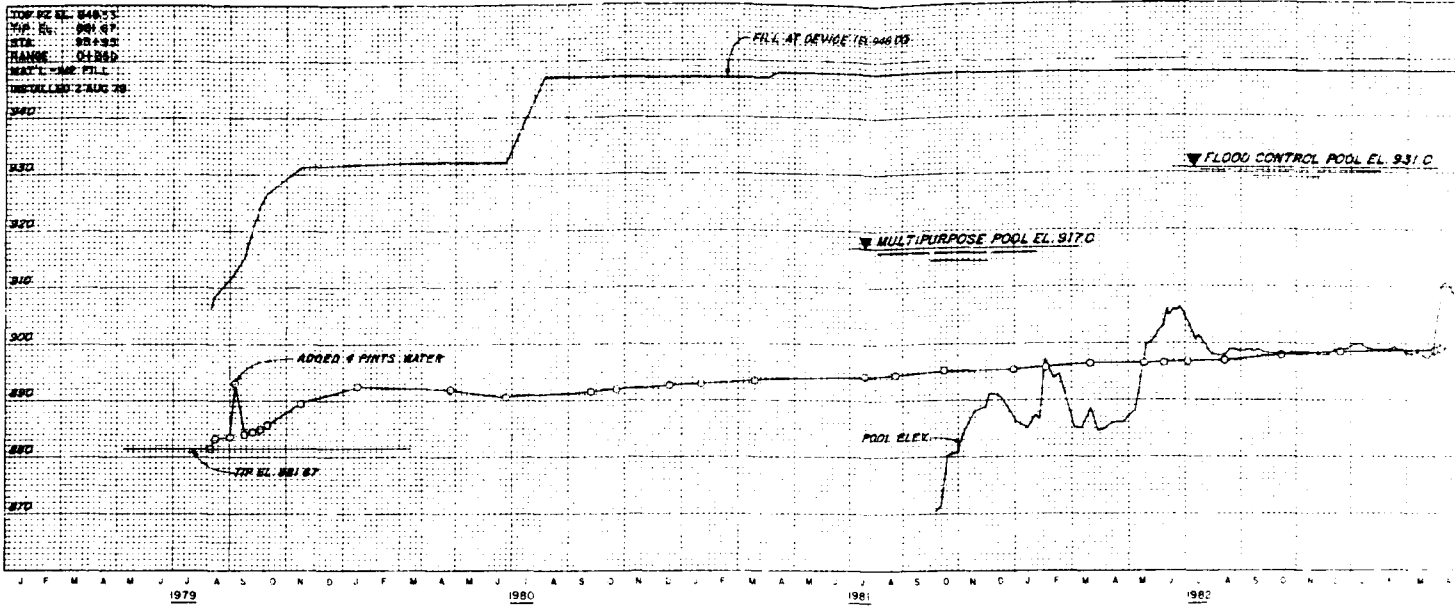
Sheet No. 1  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-953  
 JANUARY 1983

In 1 sheet

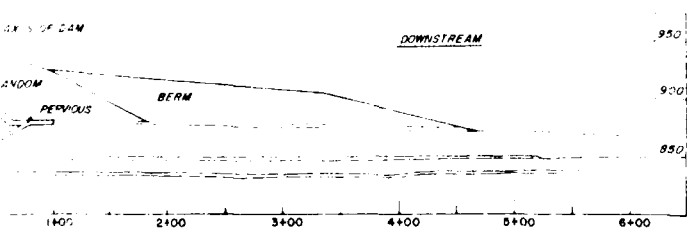
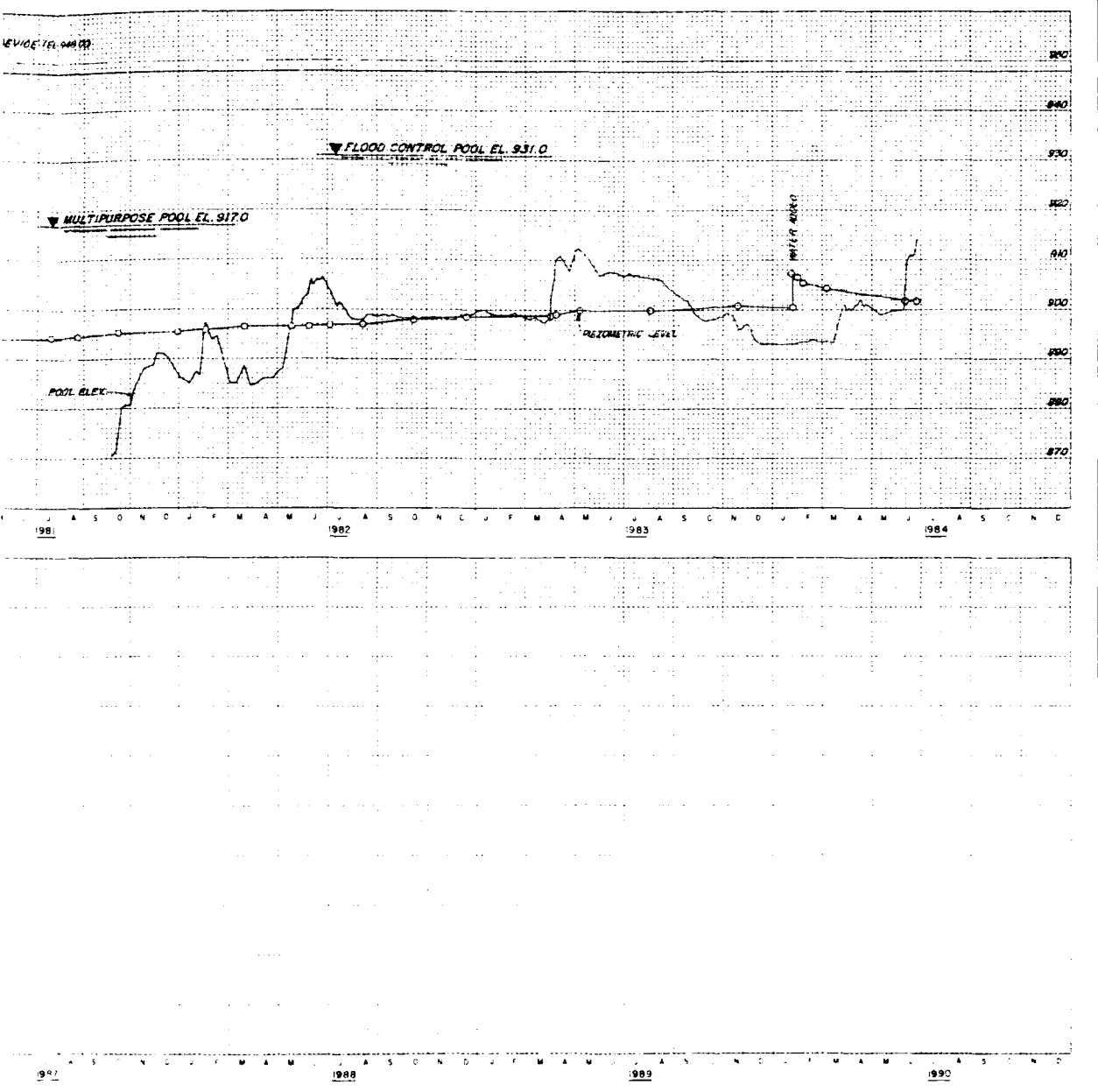
Scale as shown

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929





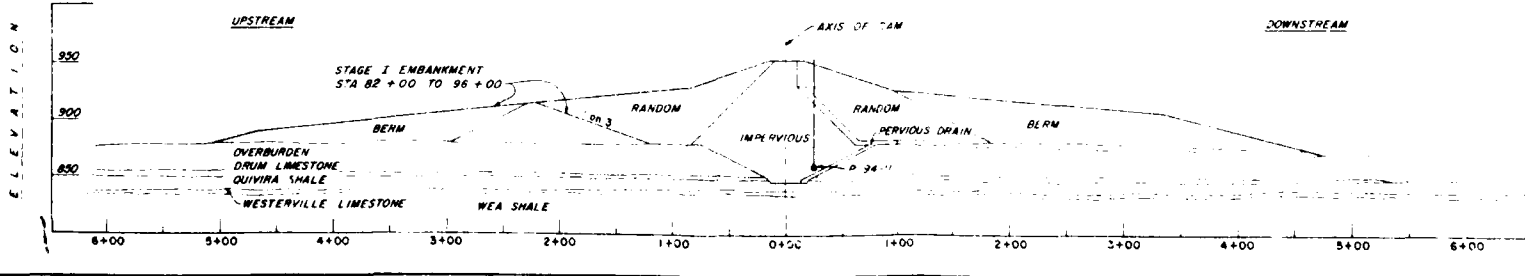
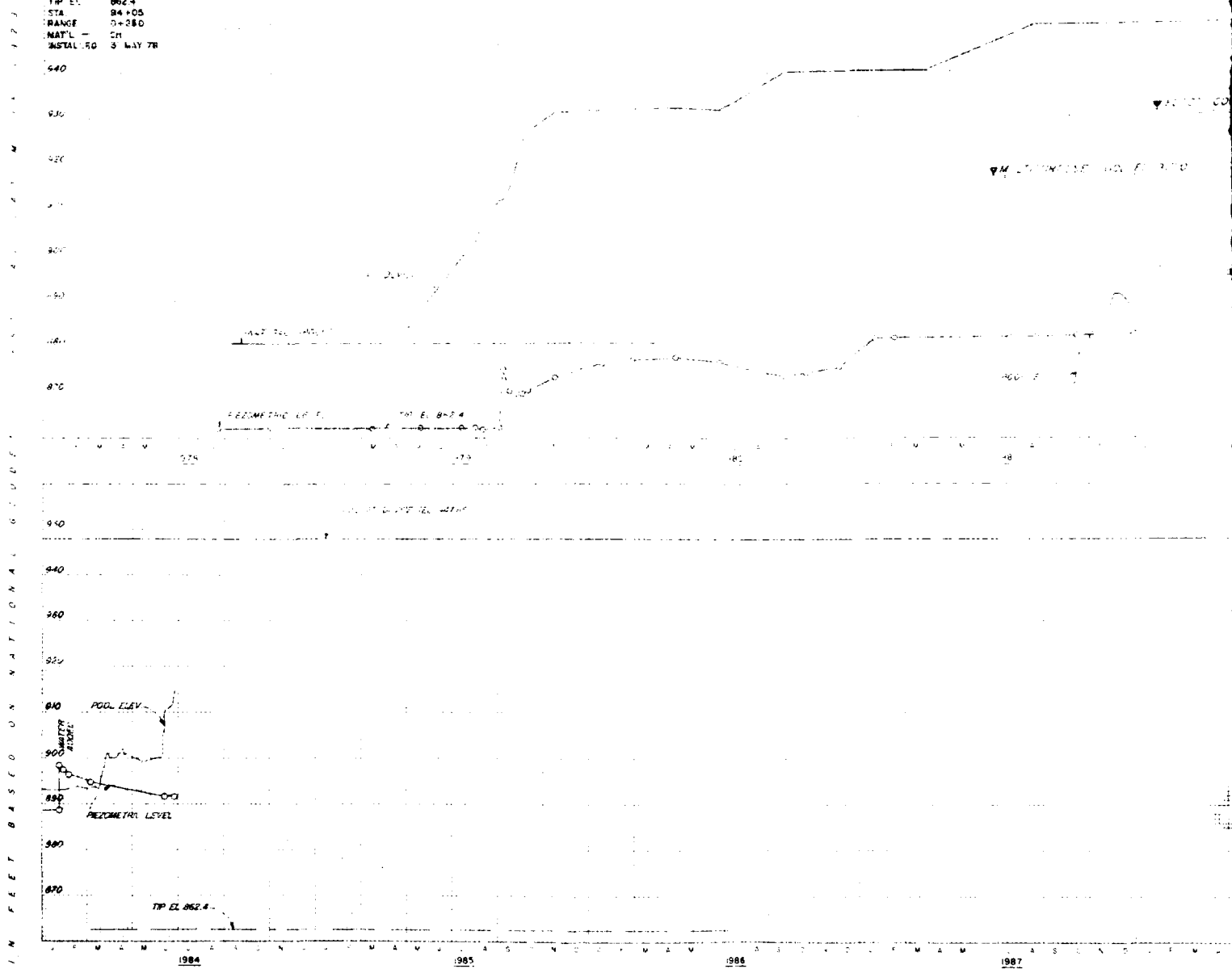


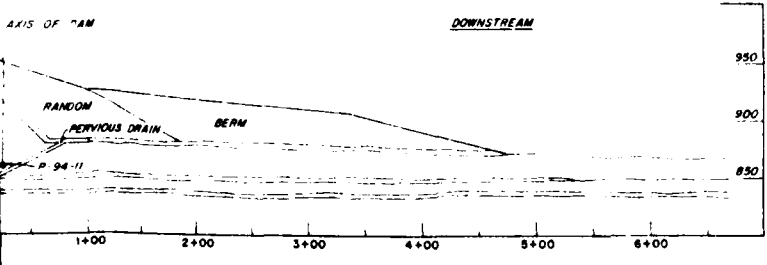
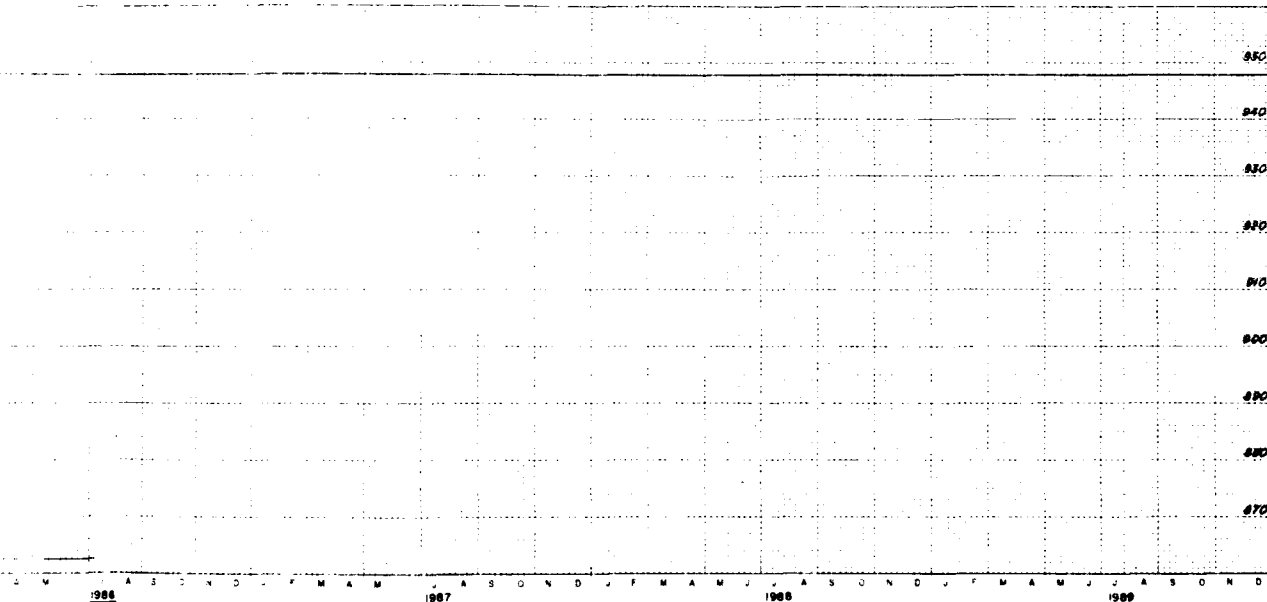
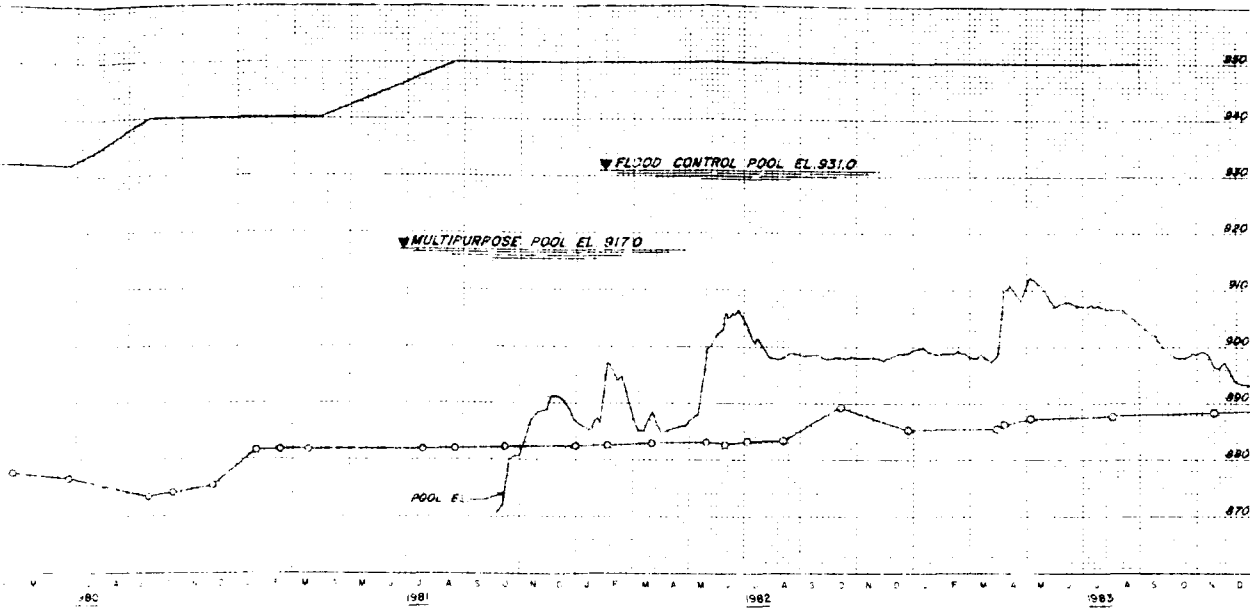
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBELEMENT, WATER & POWER

OPEN TUBE PIEZOMETER  
 P-94-10

in 1 sheet      Sheet No. 1      Scale as shown  
 CORPS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-954  
 JANUARY 1983

TOP RZ EL. 943.51  
 TIP EL. 862.4  
 STA. 84+05  
 RANGE 0+00 TO 80+00  
 MAT'L CR  
 INSTAL. 50 3 MAY 78





REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 OPEN TUBE PIEZOMETER  
 P-94-11

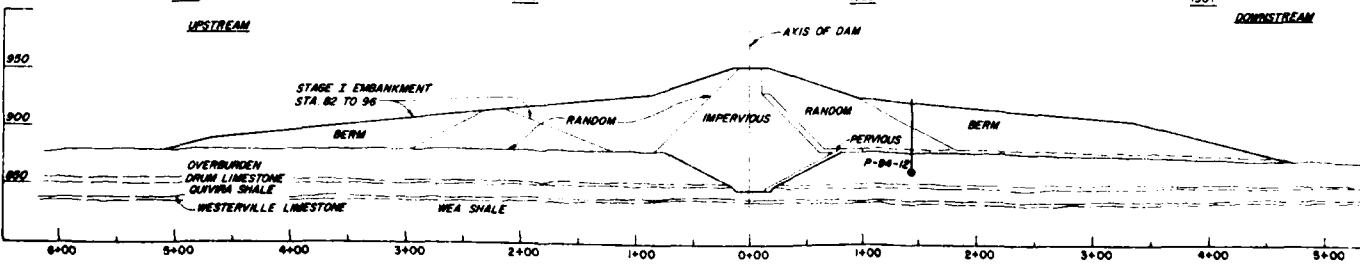
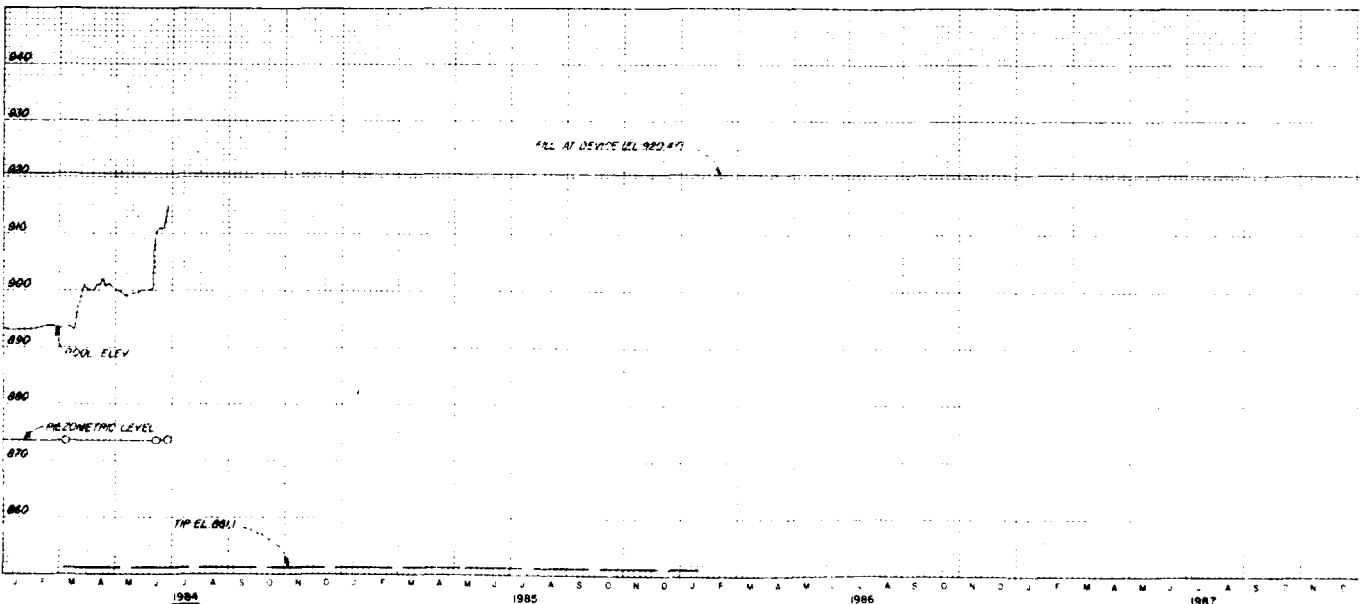
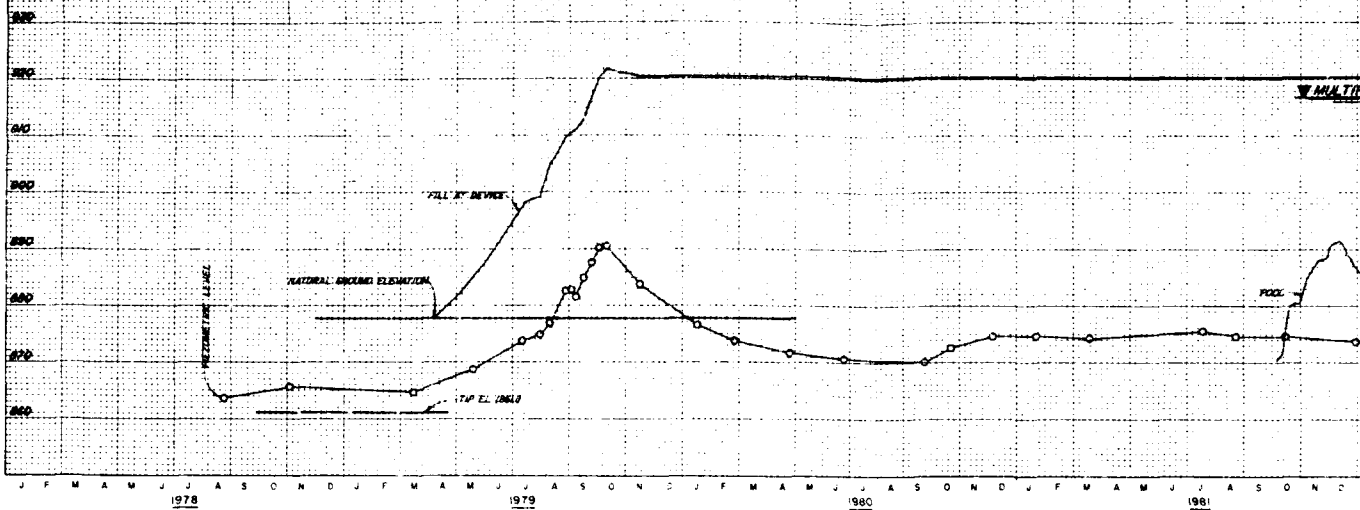
Sheet No. 1  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-955  
 JANUARY 1983

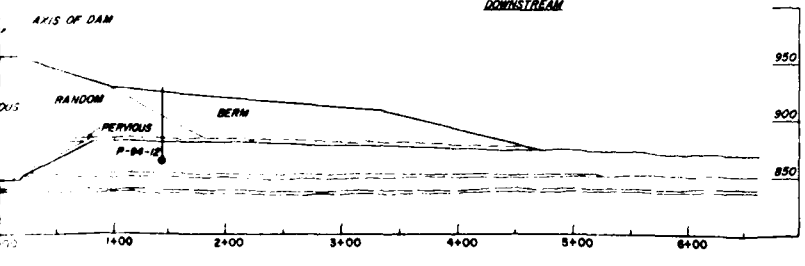
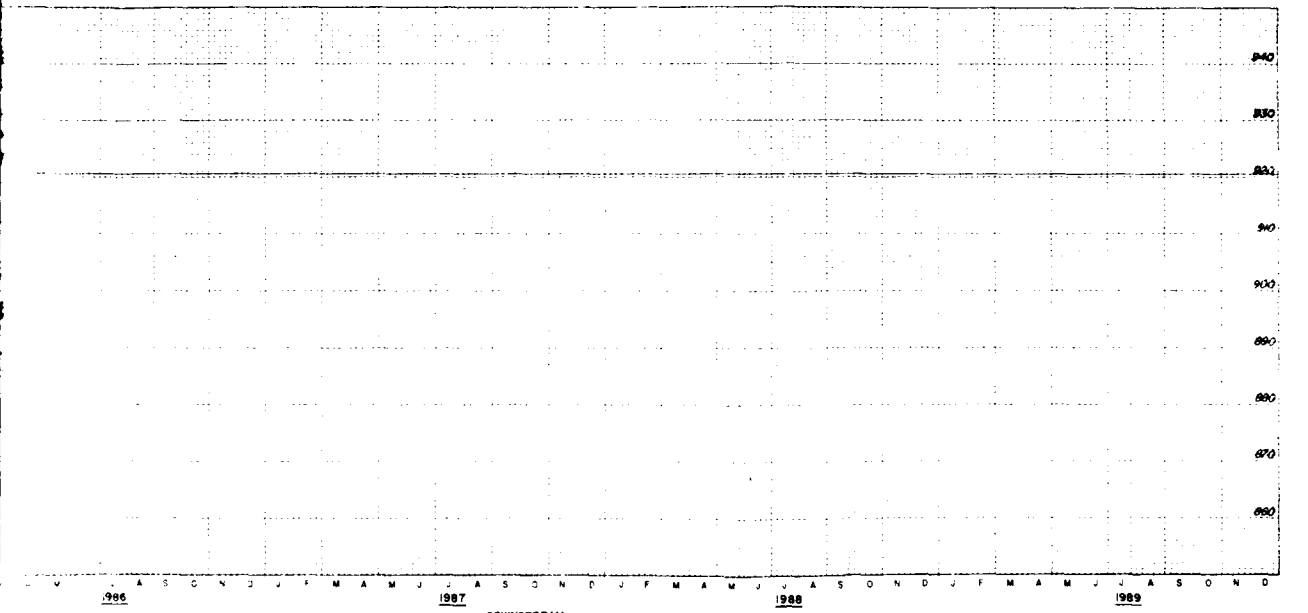
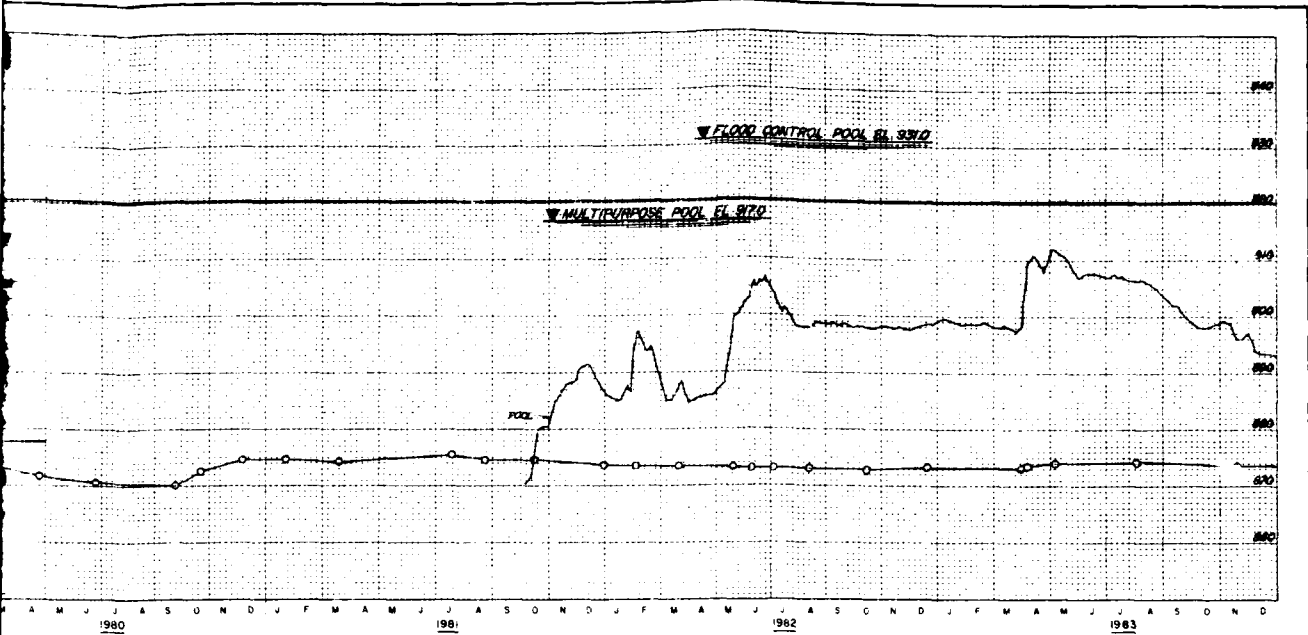
In 1 sheet Scale as shown

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

CORNER EL. 822.52  
 TOP EL. 824.7  
 STA. 82+85  
 HAIRLINE 1+96.2  
 BEARING CL  
 PARALLELED 16 JUN 78





REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-94-12

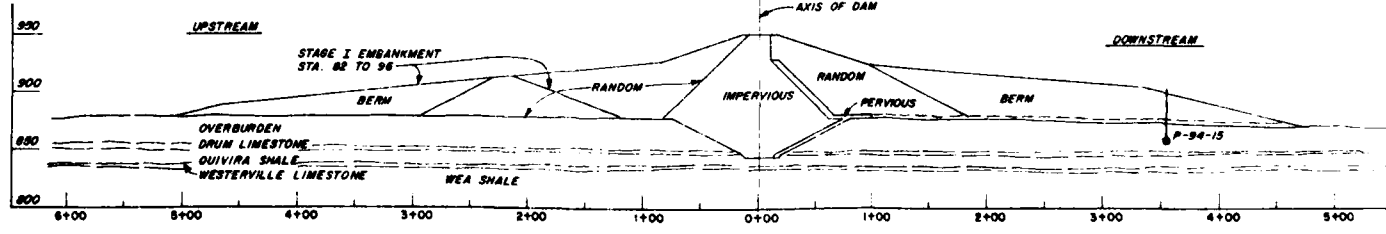
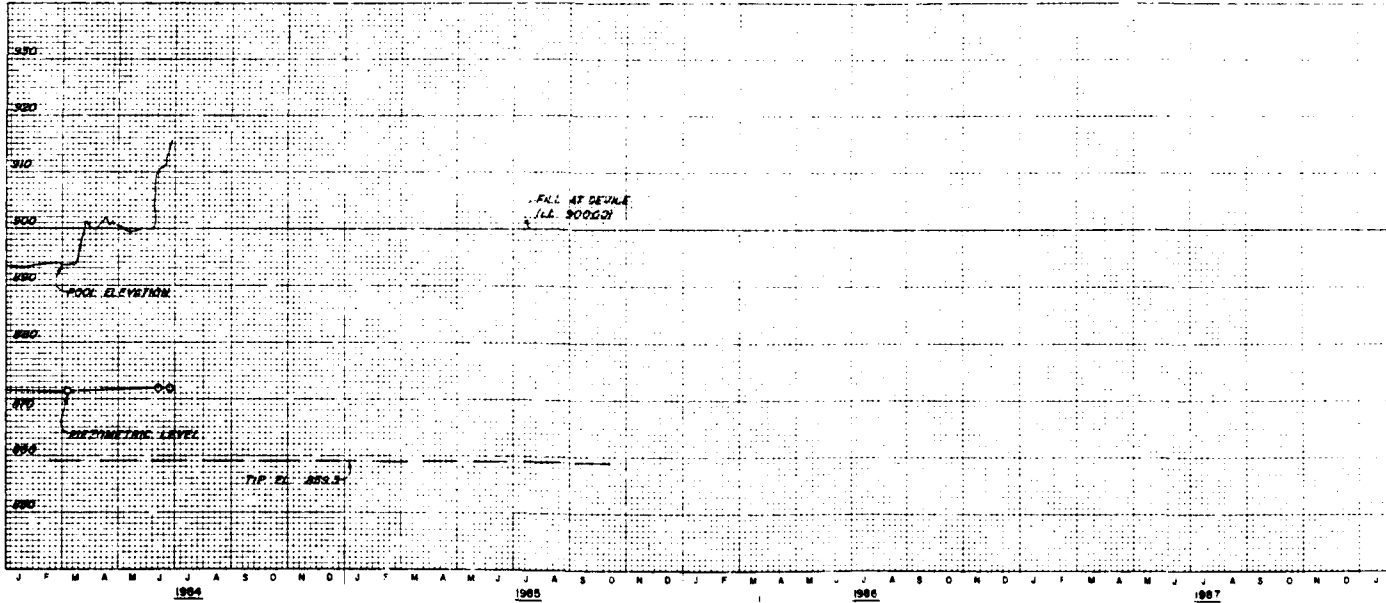
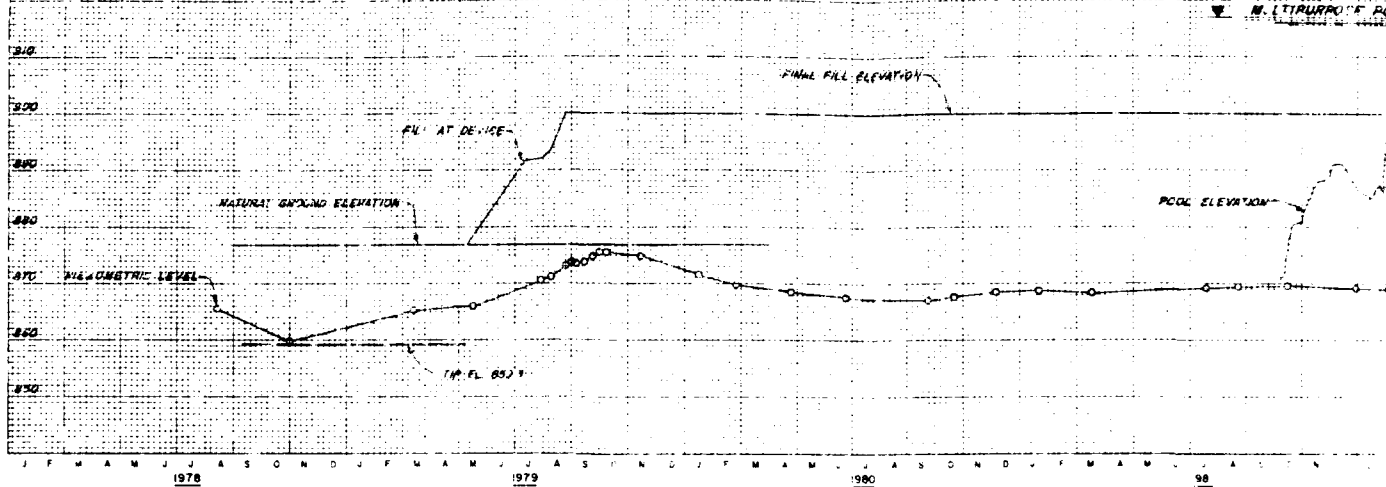
In 1 sheet      Sheet No 1      Scale: as shown

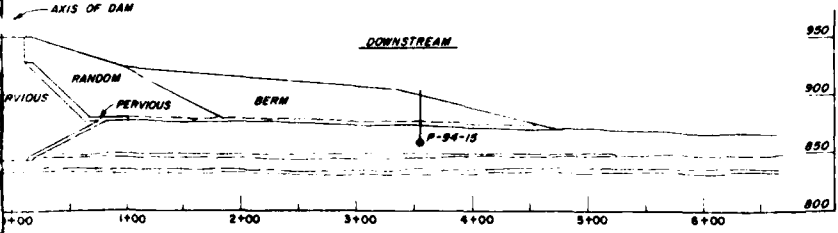
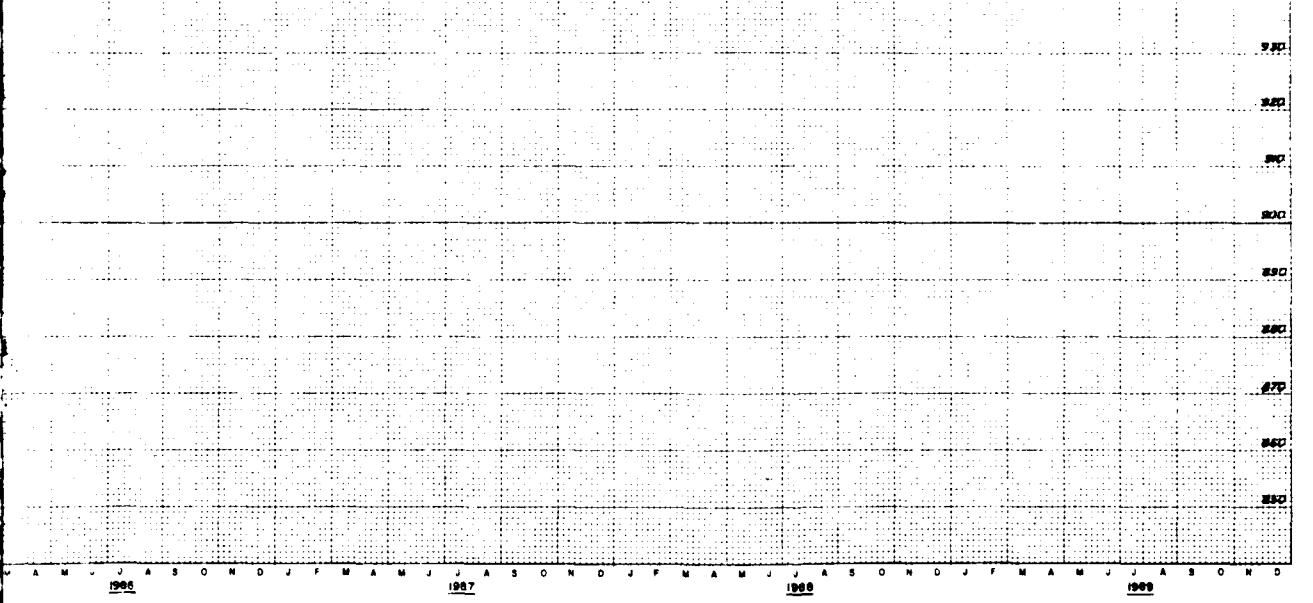
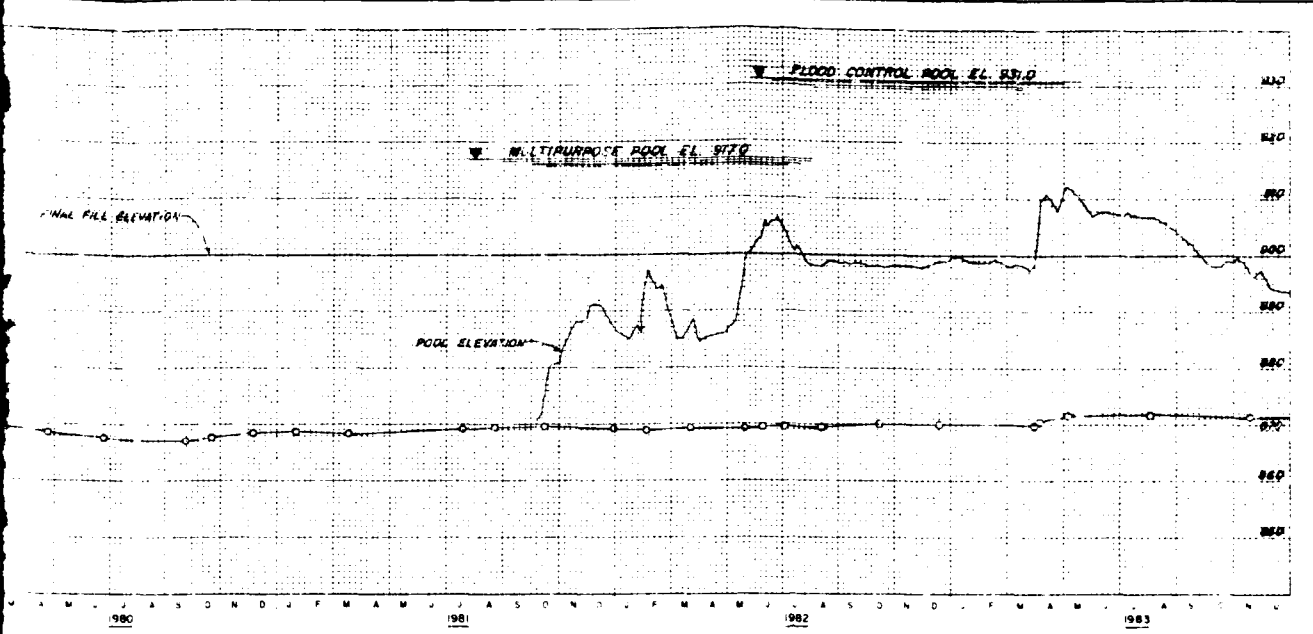
CORPS OF ENGINEERS      U S ARMY  
 KANSAS CITY DISTRICT  
 FILE NO 0-15-956  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC DATUM OF 1929

TOP OF EL. 802.43  
 TIP EL. 802.3  
 STA. 82+96  
 RANGE 1+50 0  
 MAY 61  
 INSTALLED 12 JUN 78





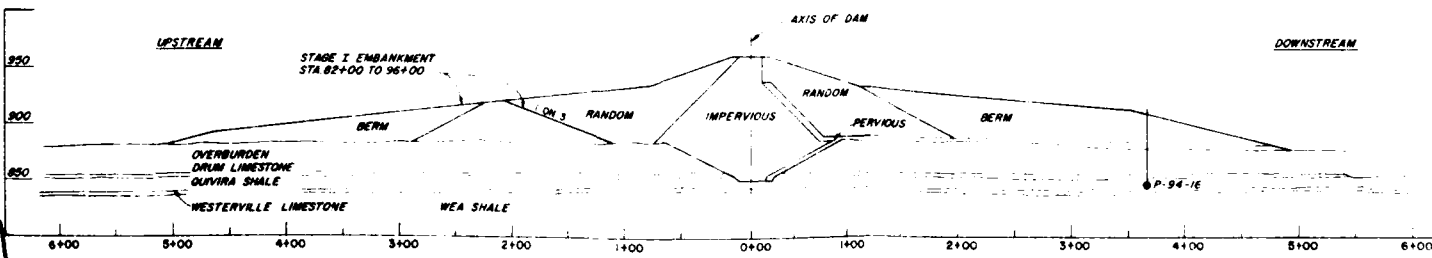
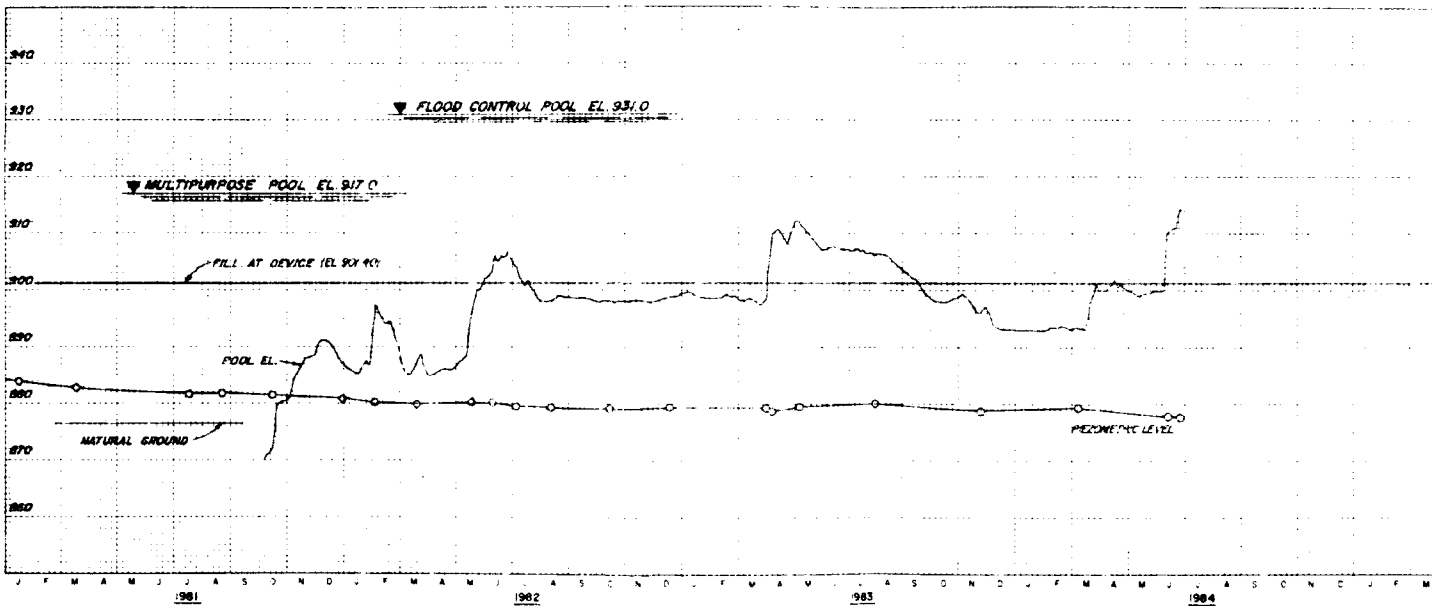
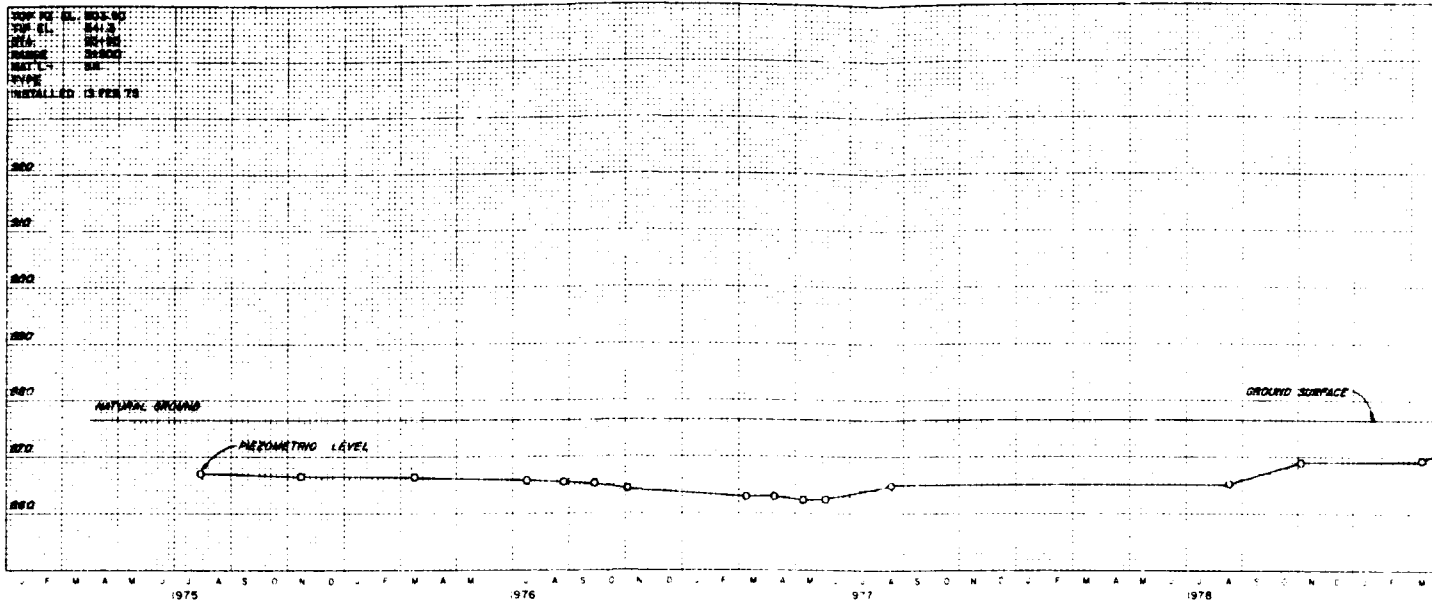
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-94-15

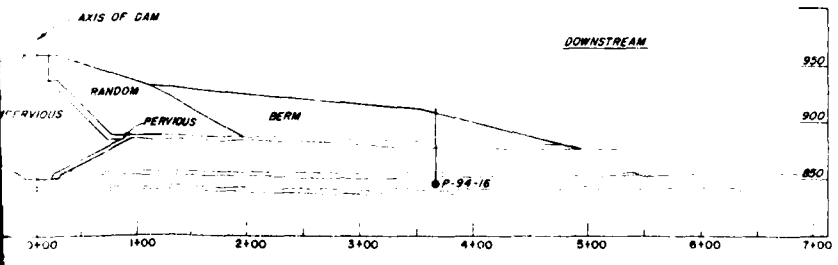
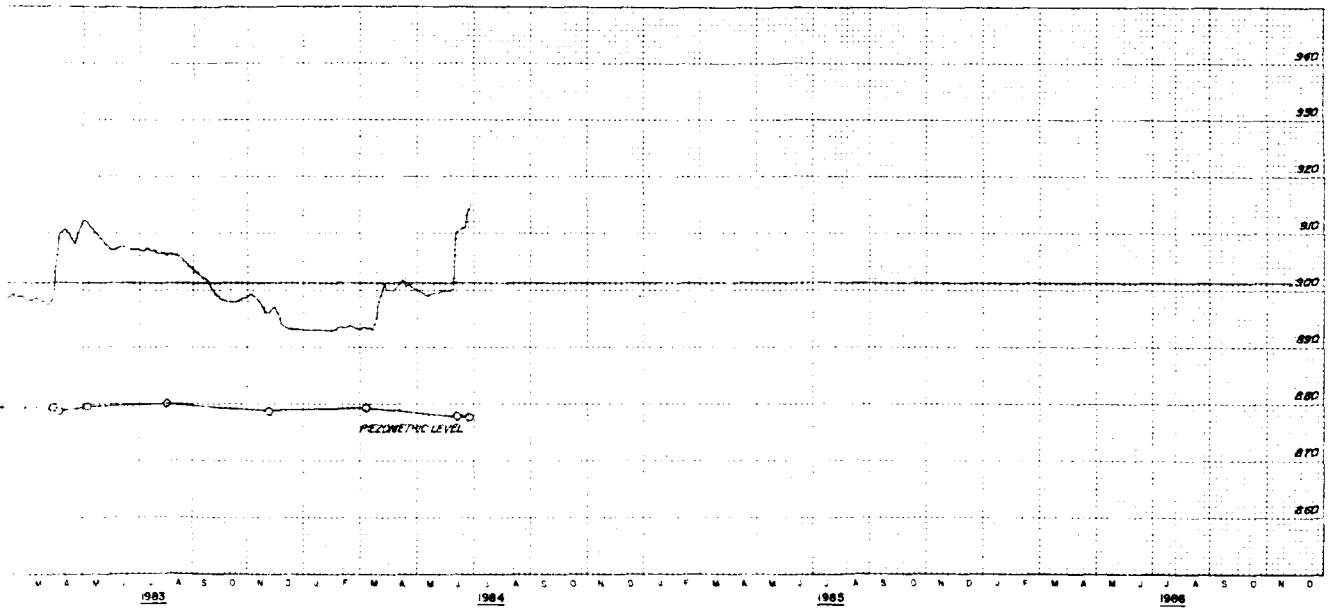
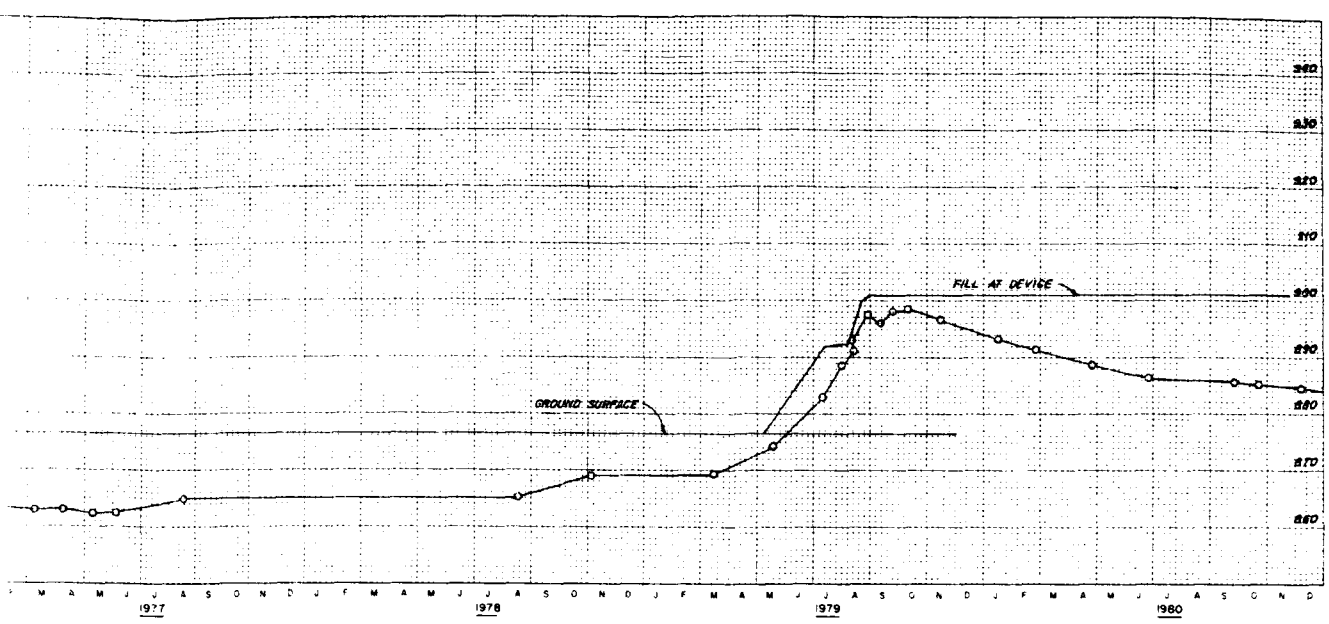
In 1 sheet      Sheet No. 1      Scale as shown  
 CORPS OF ENGINEERS      U S ARMY  
 KANSAS CITY DISTRICT  
 FILE NO O-15-959  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929







REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

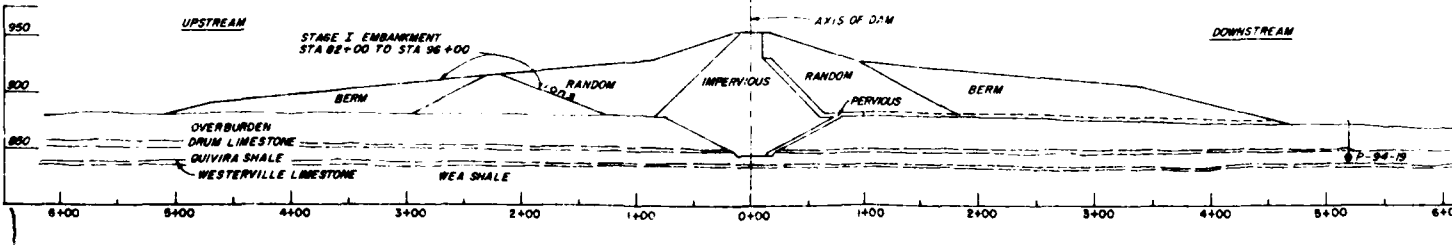
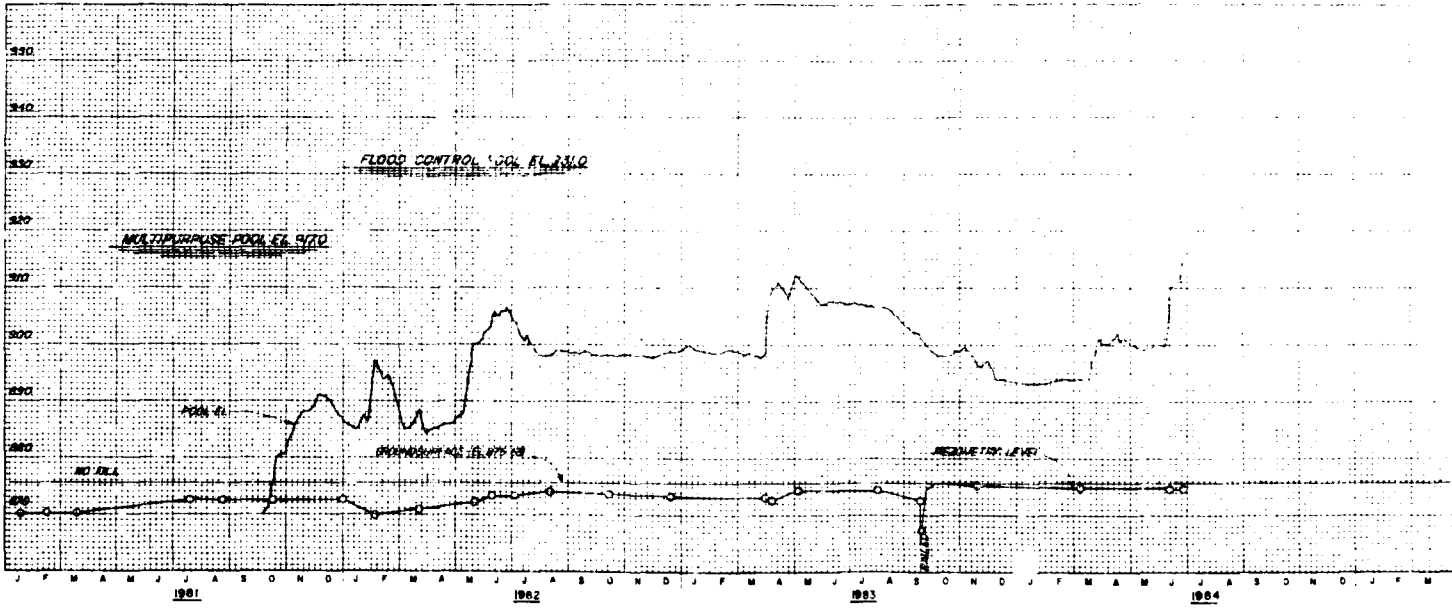
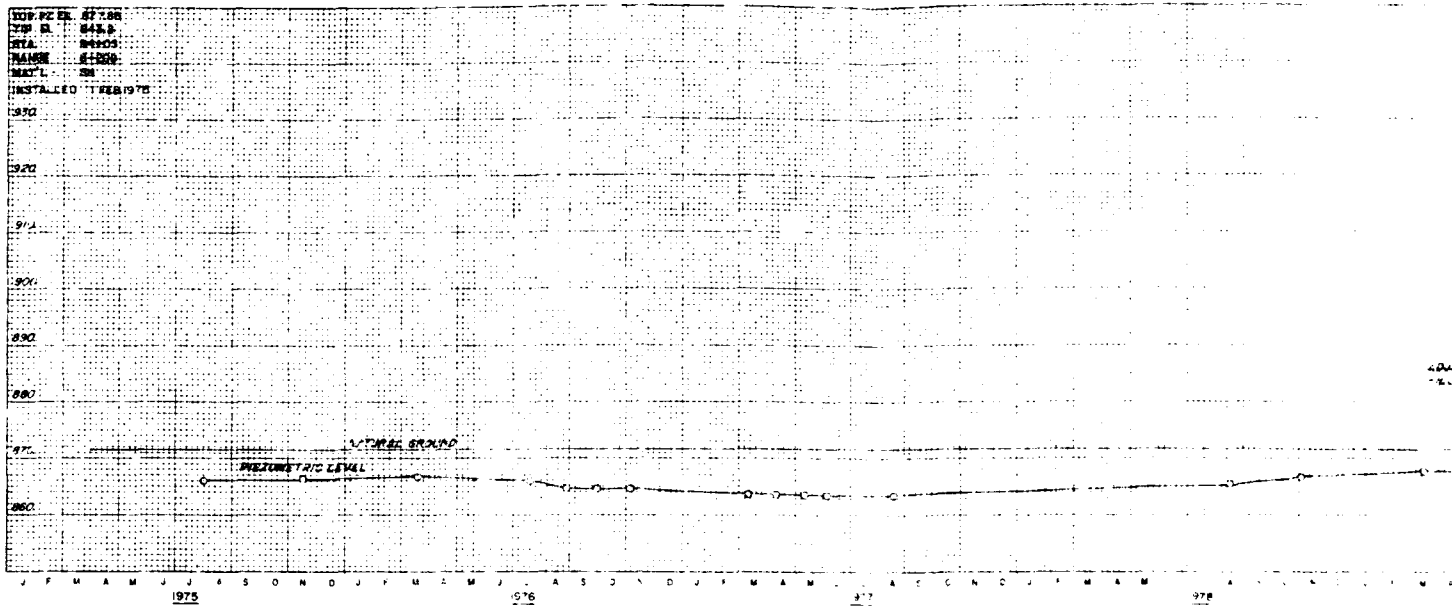
OPEN TUBE PIEZOMETER  
 P-94-16

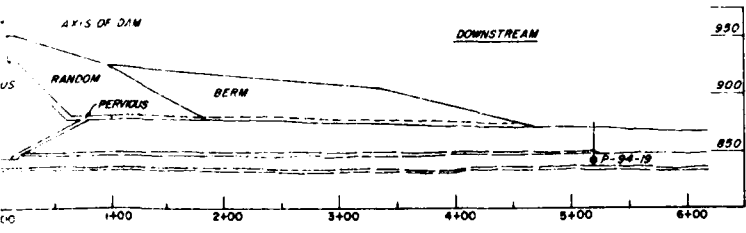
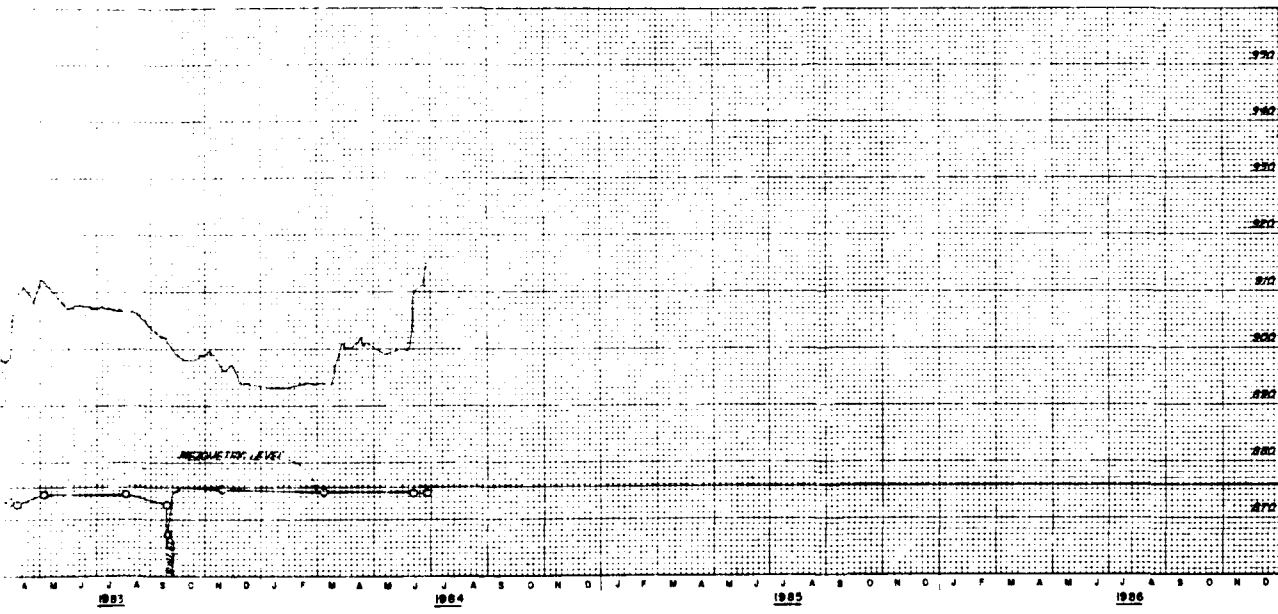
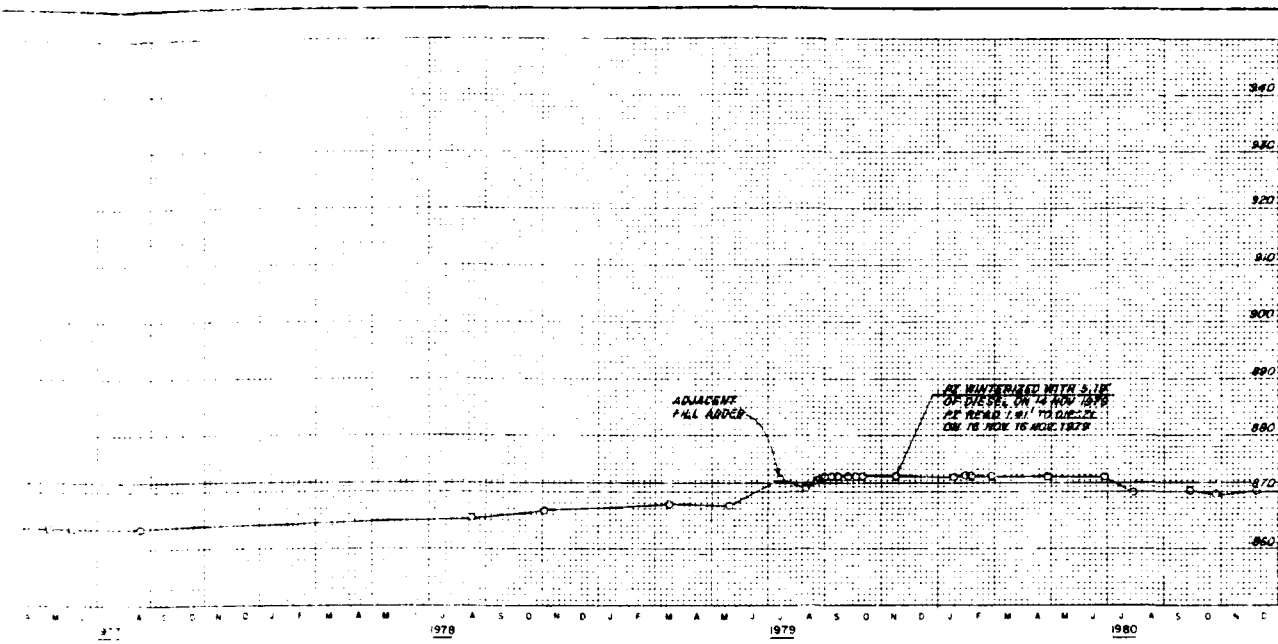
Sheet No 1  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO 0-15-960  
 JANUARY 1983

1 of 1 sheet  
 2

Scale as shown

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929



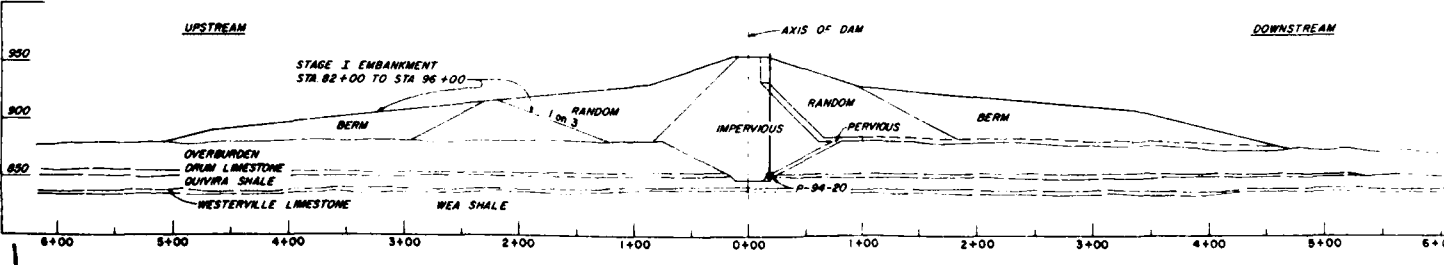
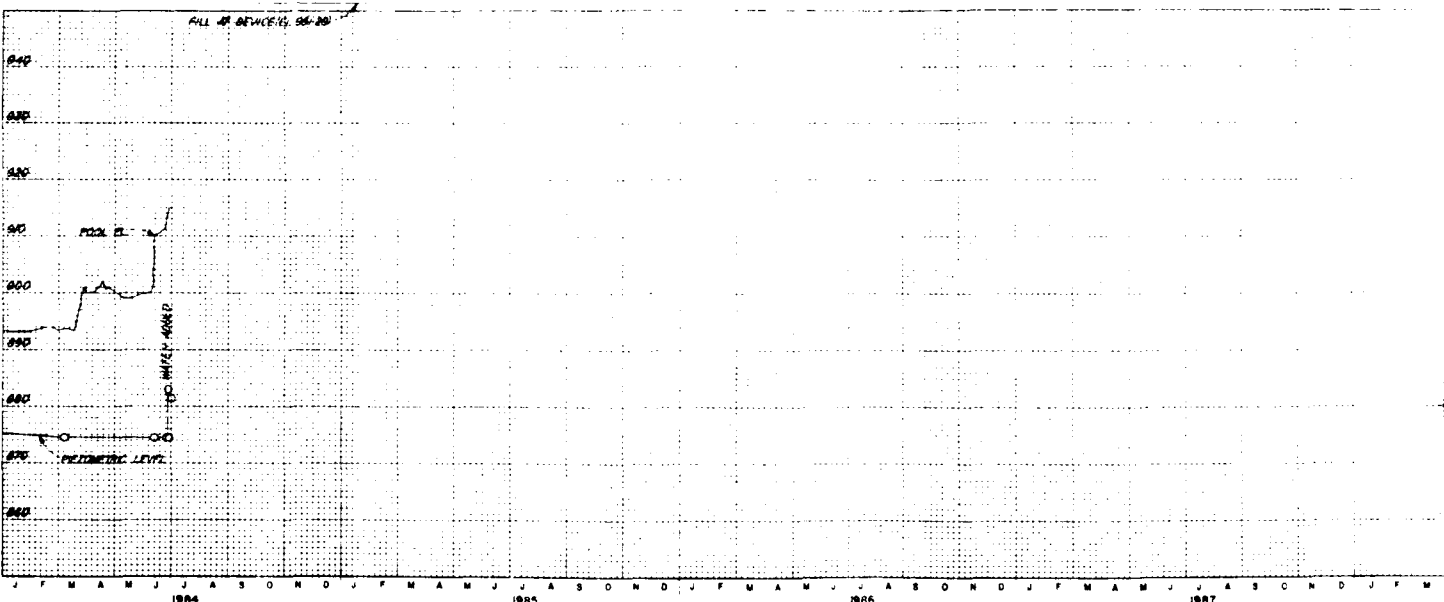
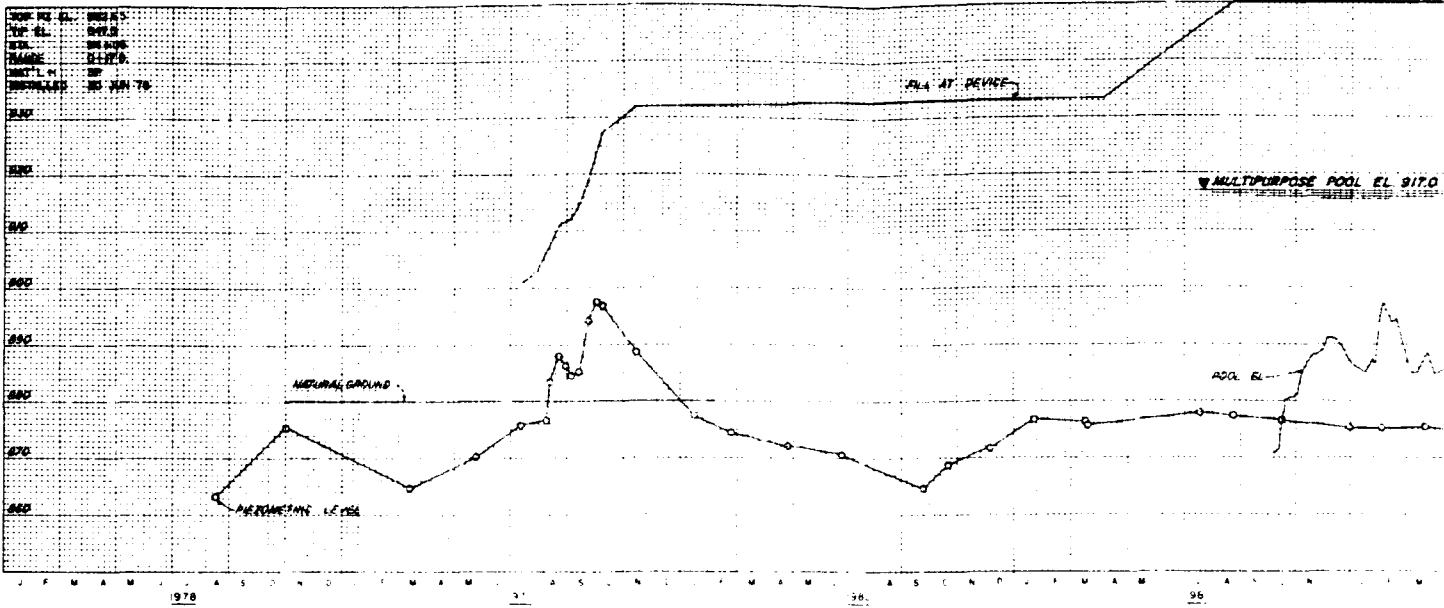


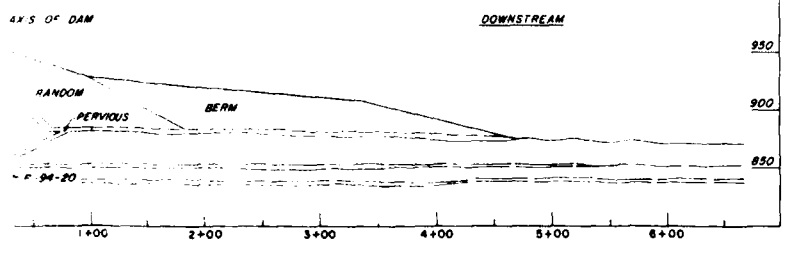
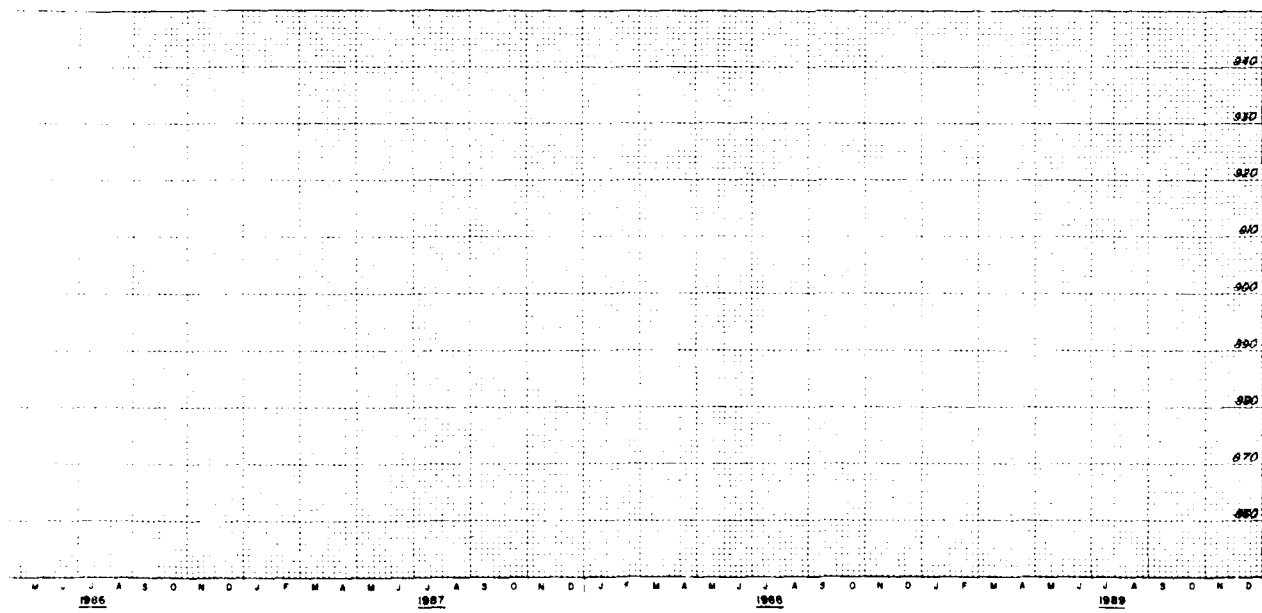
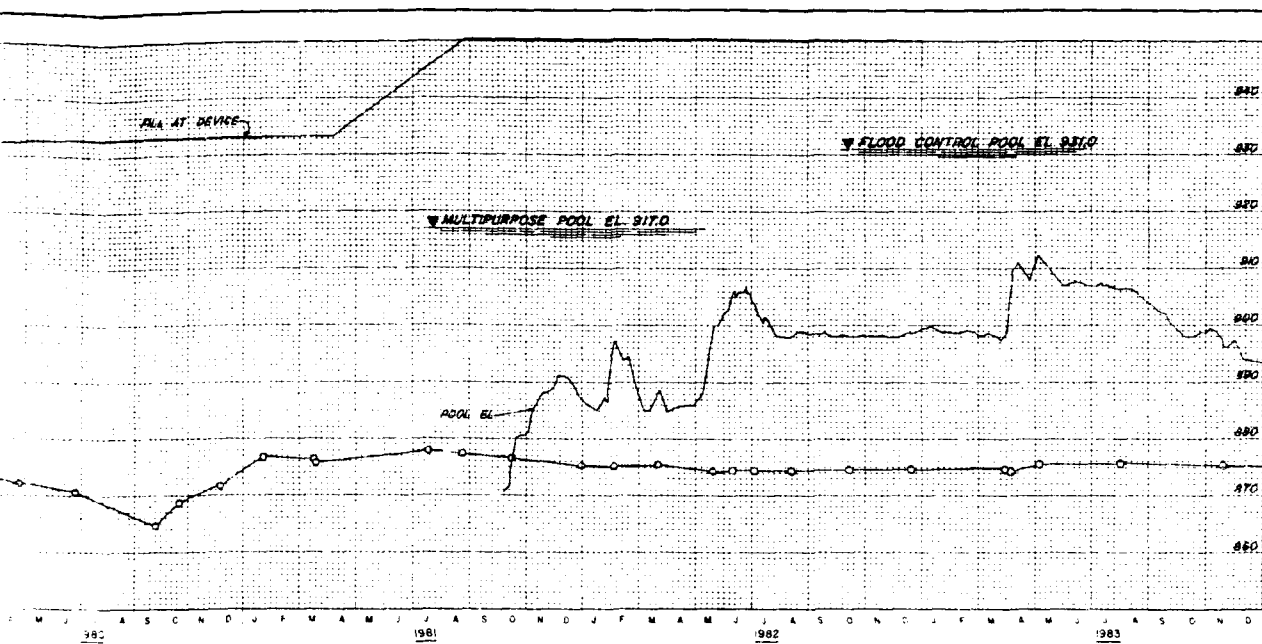
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-94-19

In 1 sheet  
 Sheet No. 1  
 Scale: as shown  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-963  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929





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 BIG BULL CREEK KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

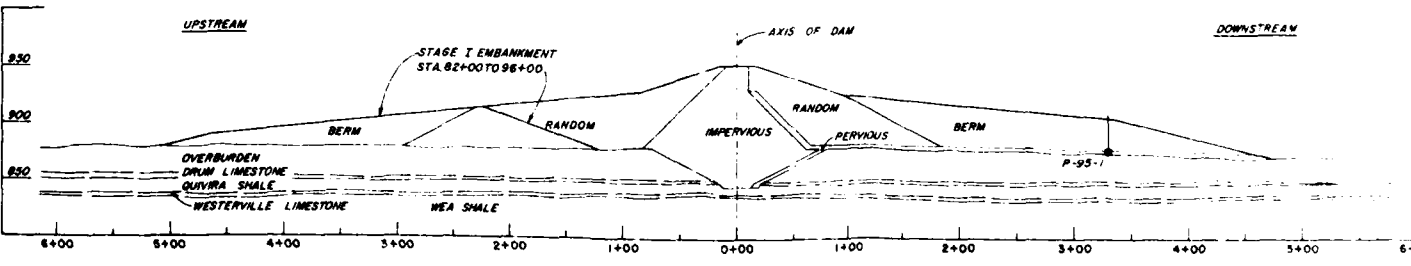
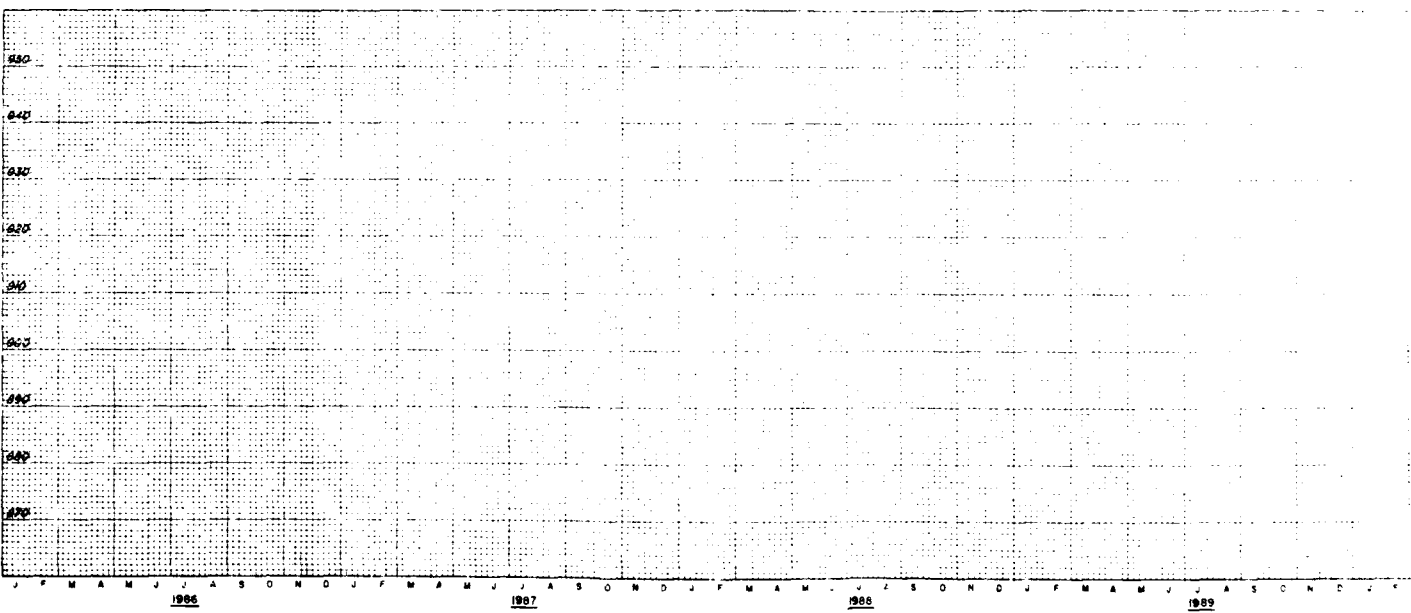
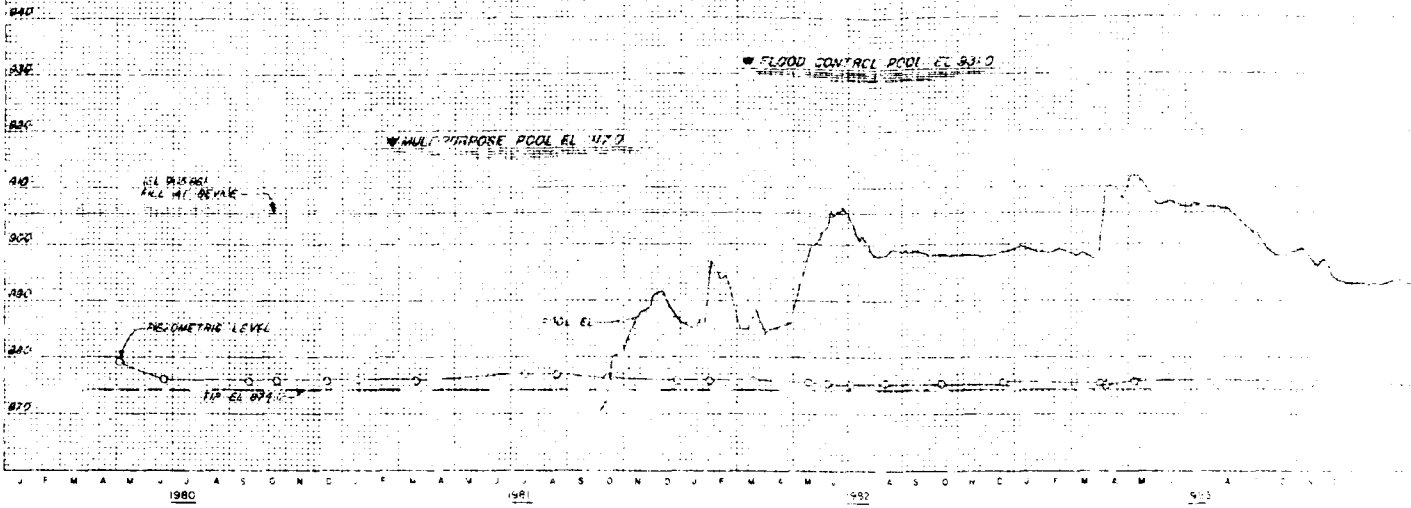
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 P-94-20

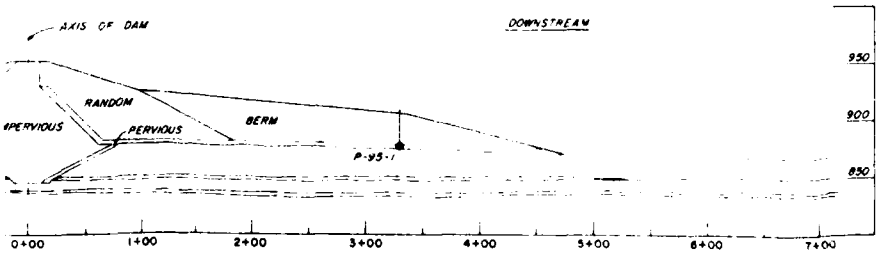
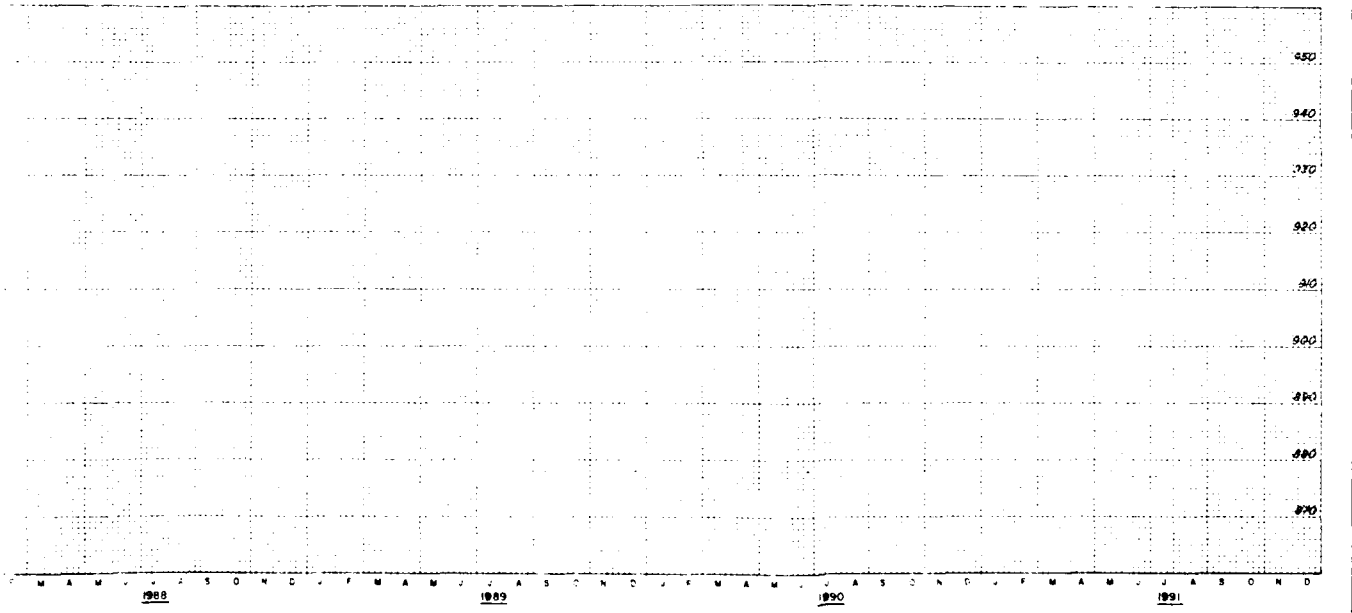
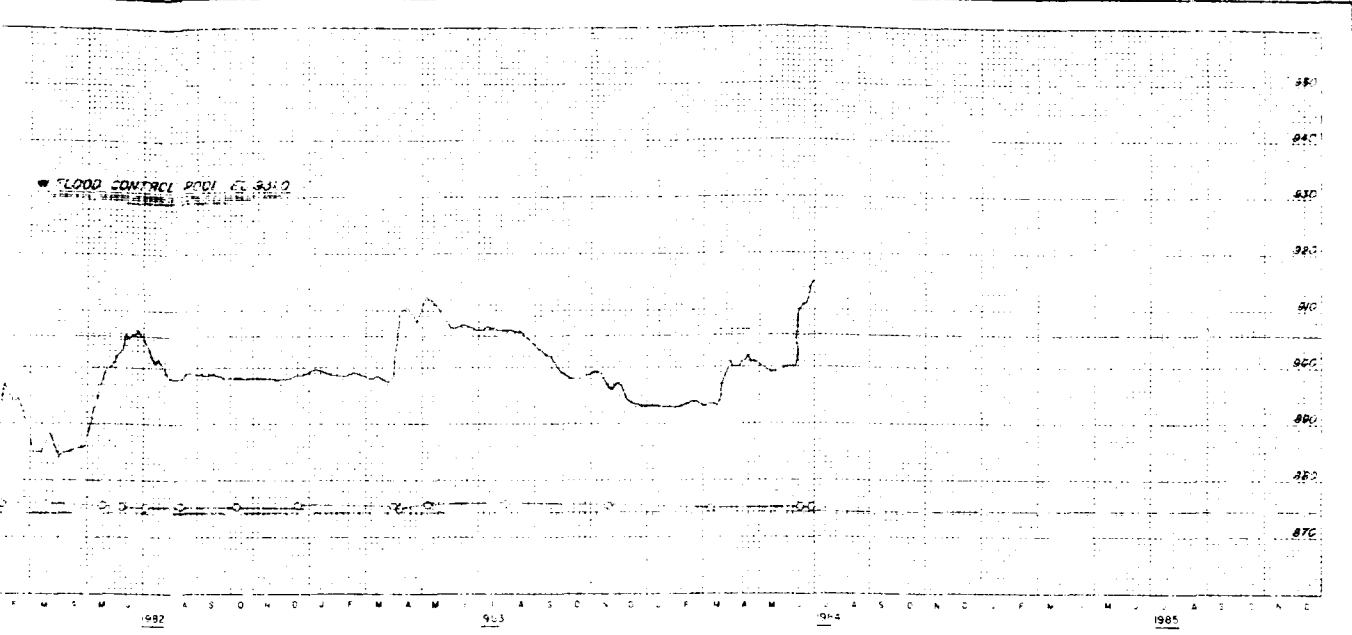
in 1 sheet  
 Sheet No. 1  
 Scale as shown  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-964  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC DATUM OF 1929

TOP OF EL: 82+00  
 TOP EL: 82+00  
 STA: 82+00  
 RANGE: 5+100.0  
 DATE: 82  
 INSTALLED: 8 MAY 82





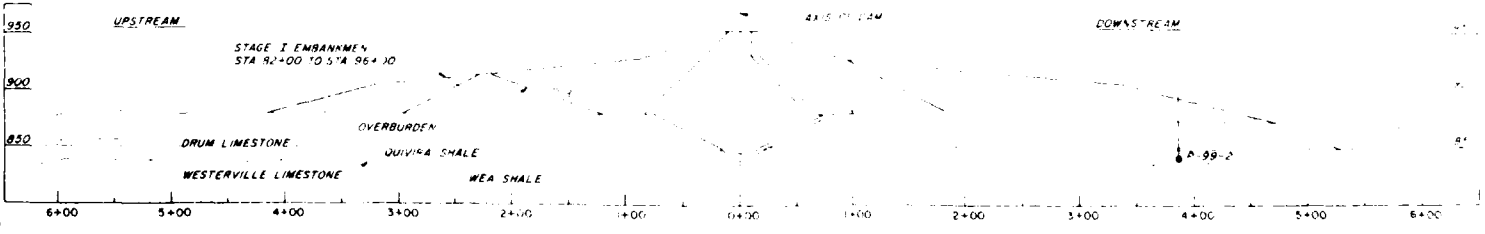
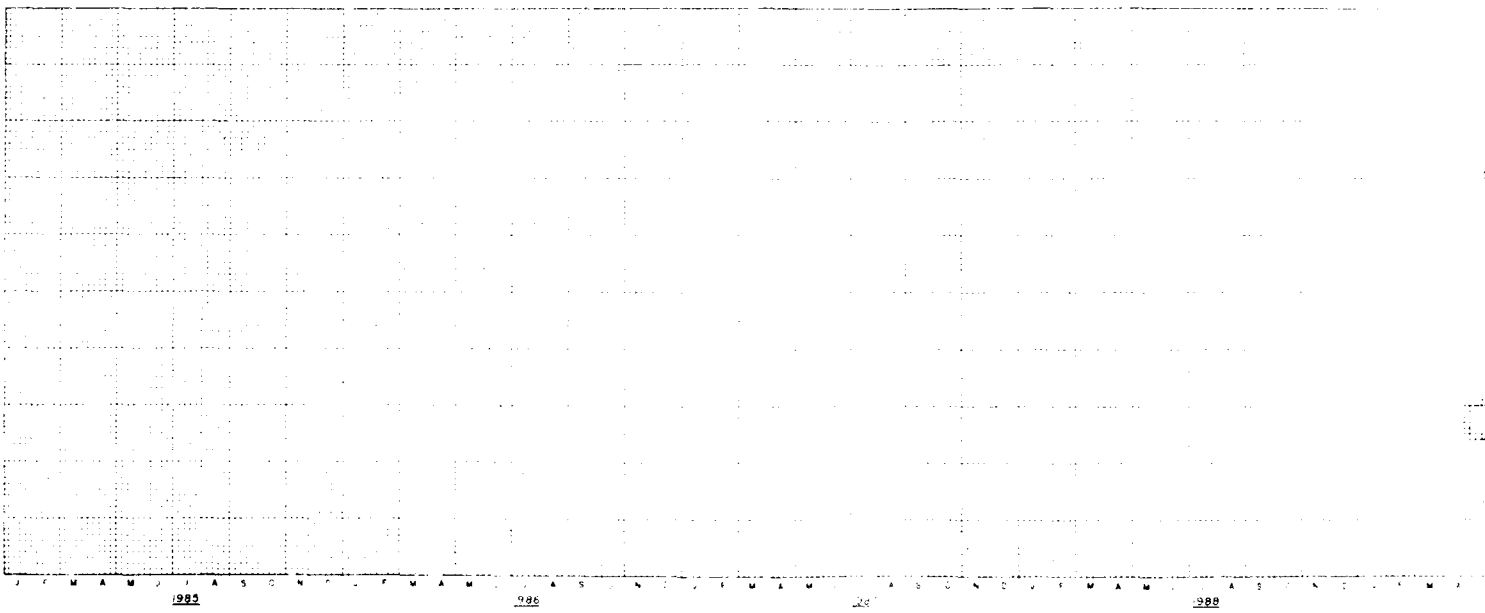
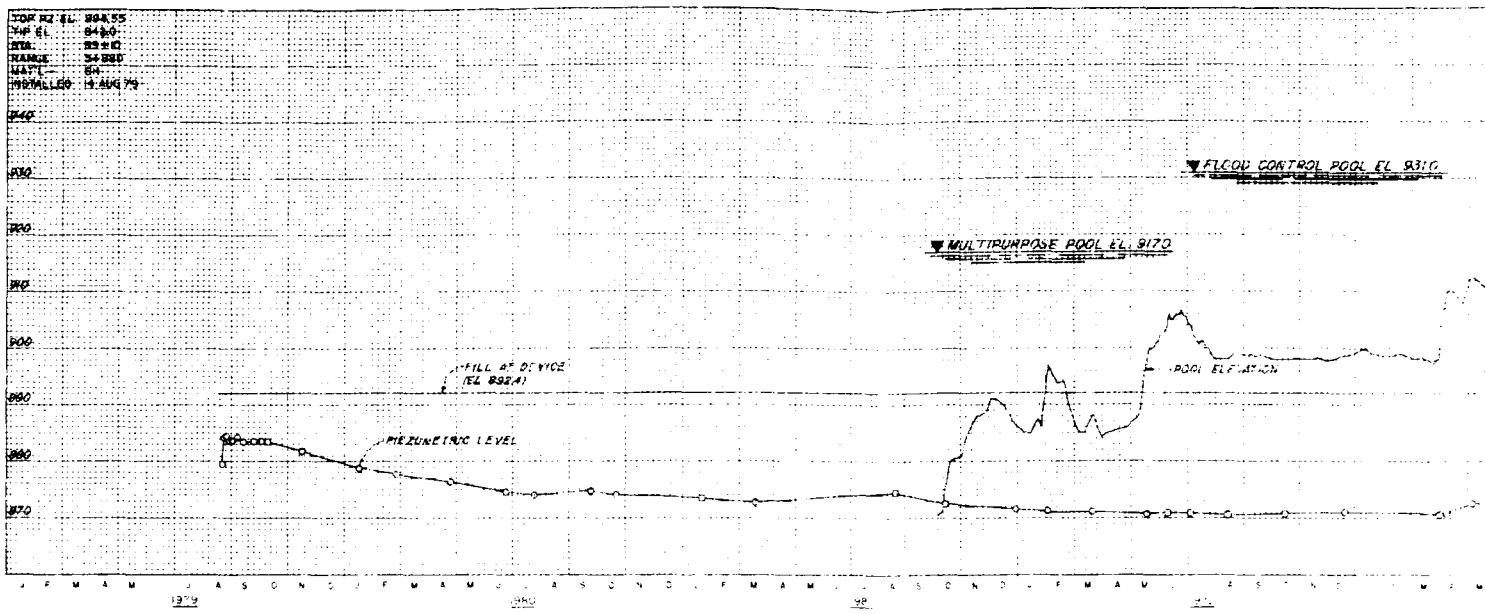
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-95-1

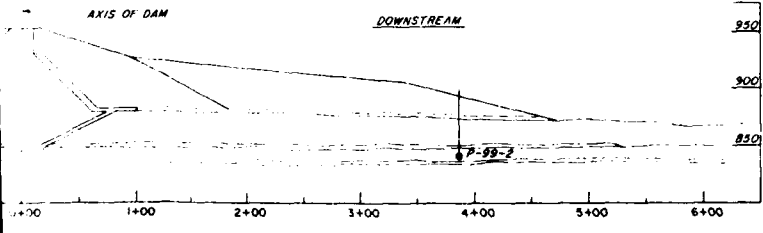
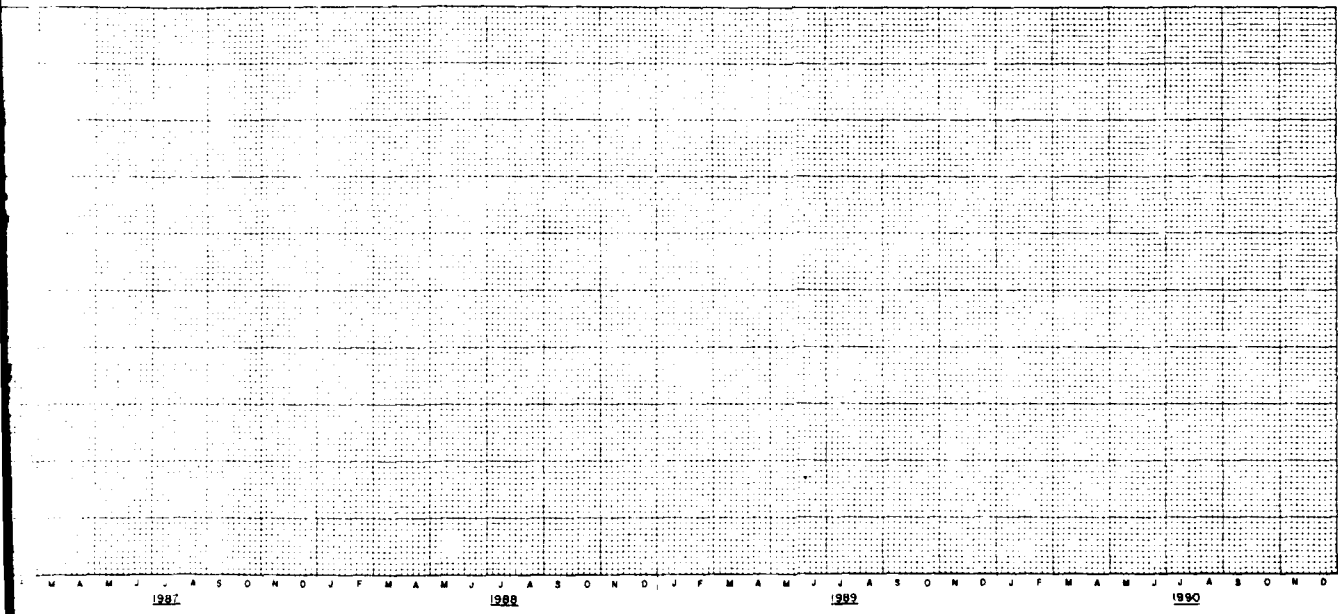
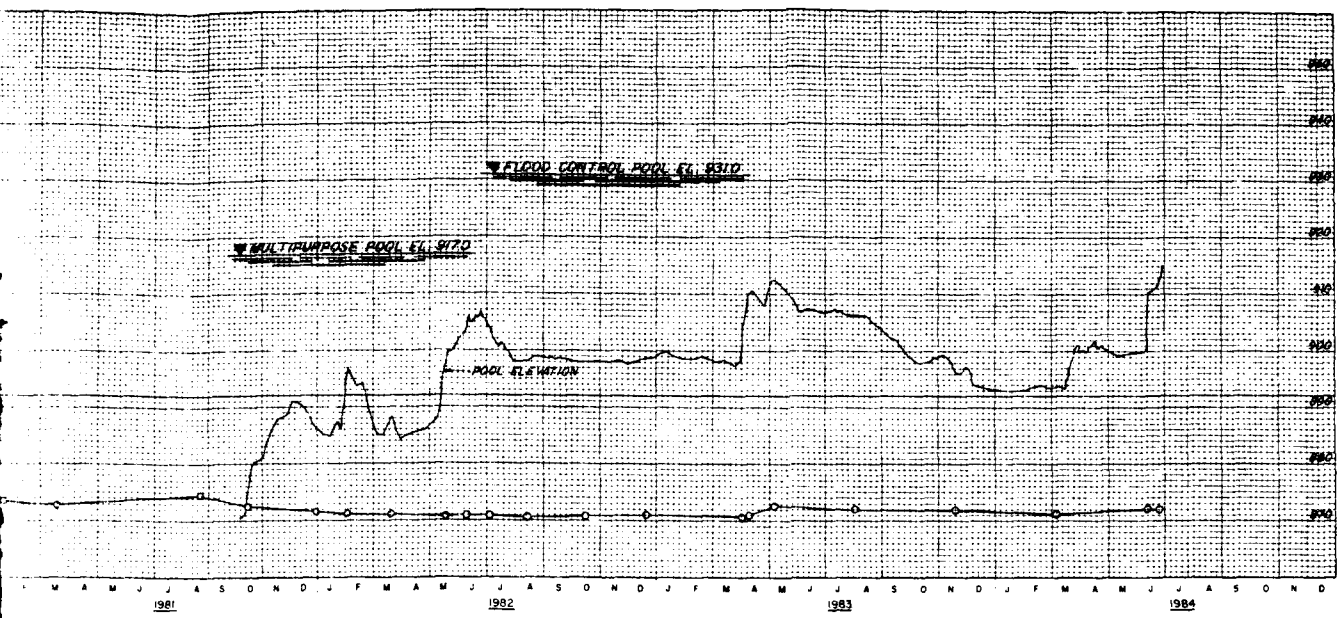
in 1 sheet      Sheet No. 1      Scale as shown

CORPS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-965  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929







REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 OPEN TUBE PIEZOMETER  
 P-99-2

In 1 sheet

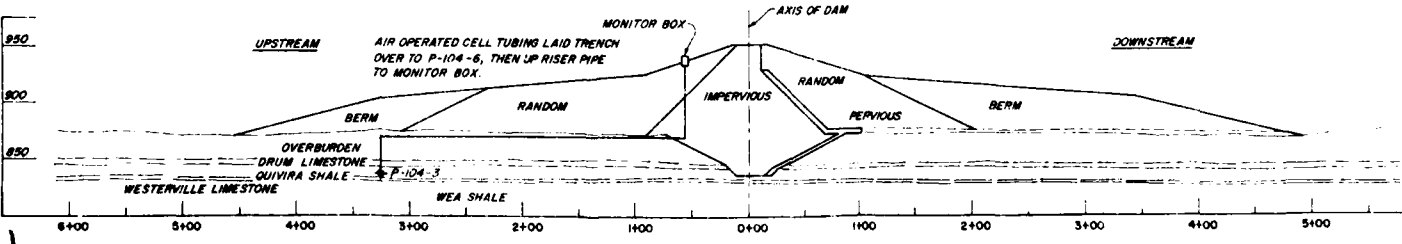
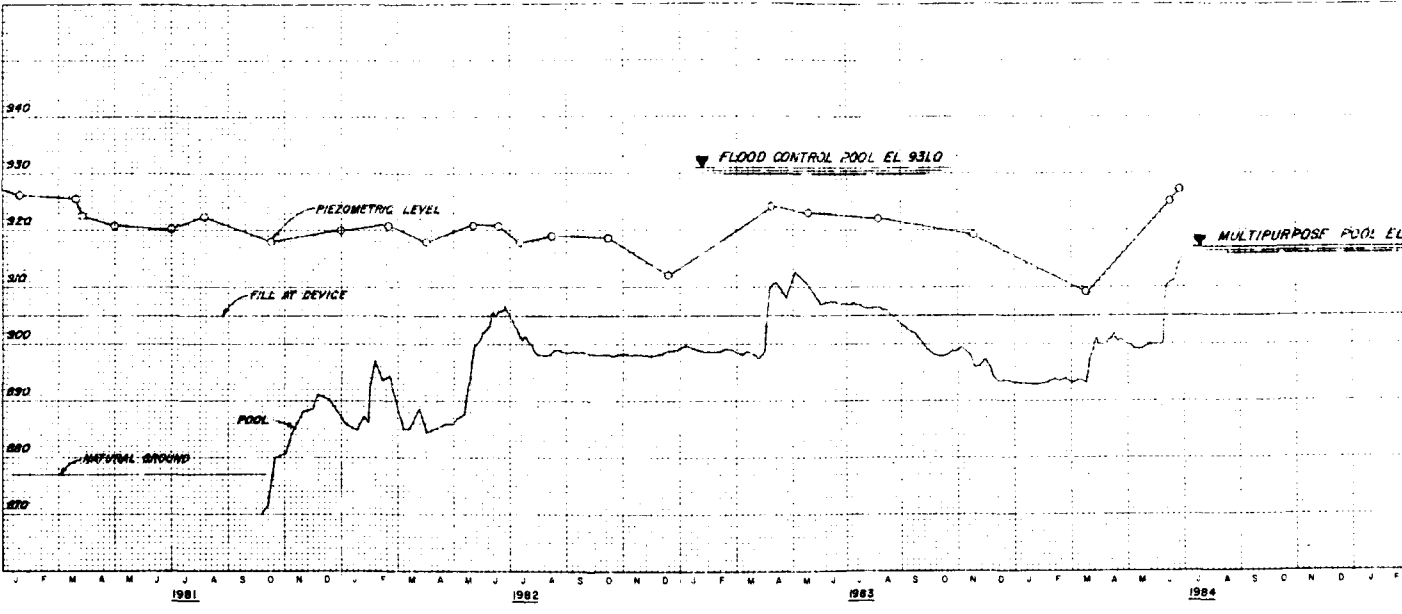
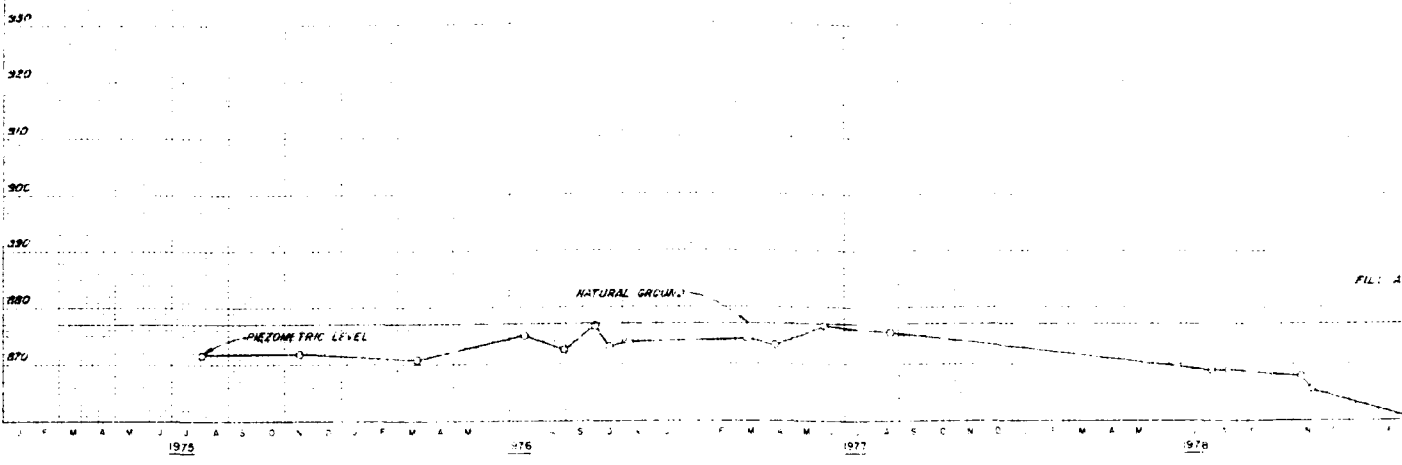
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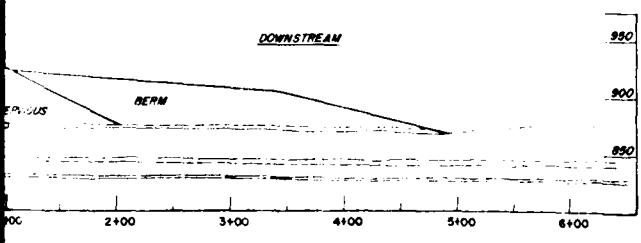
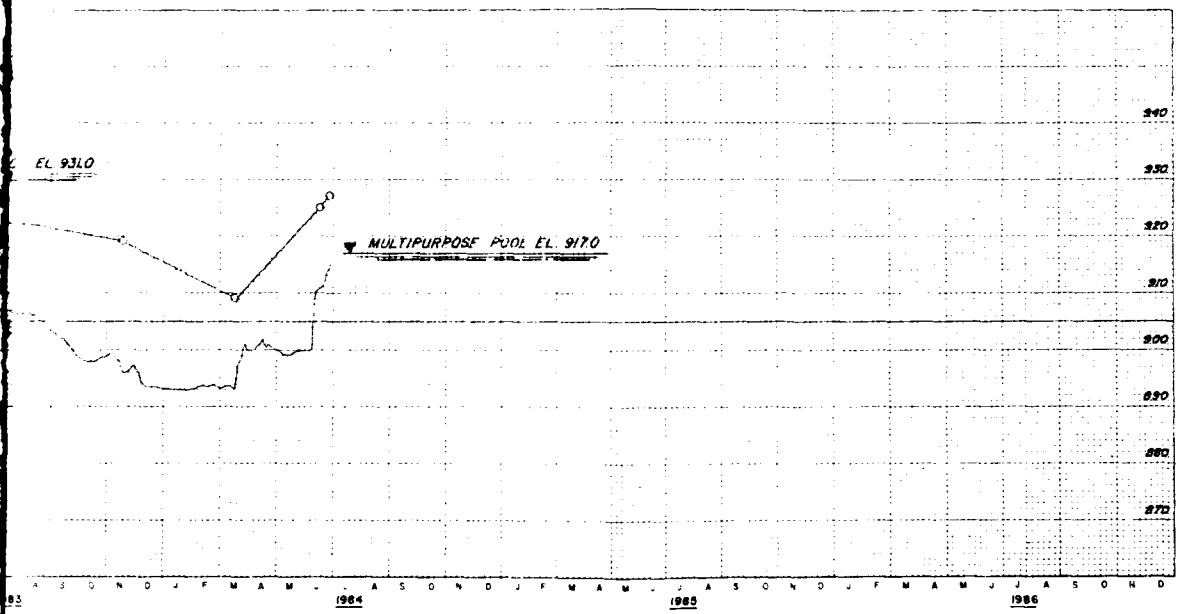
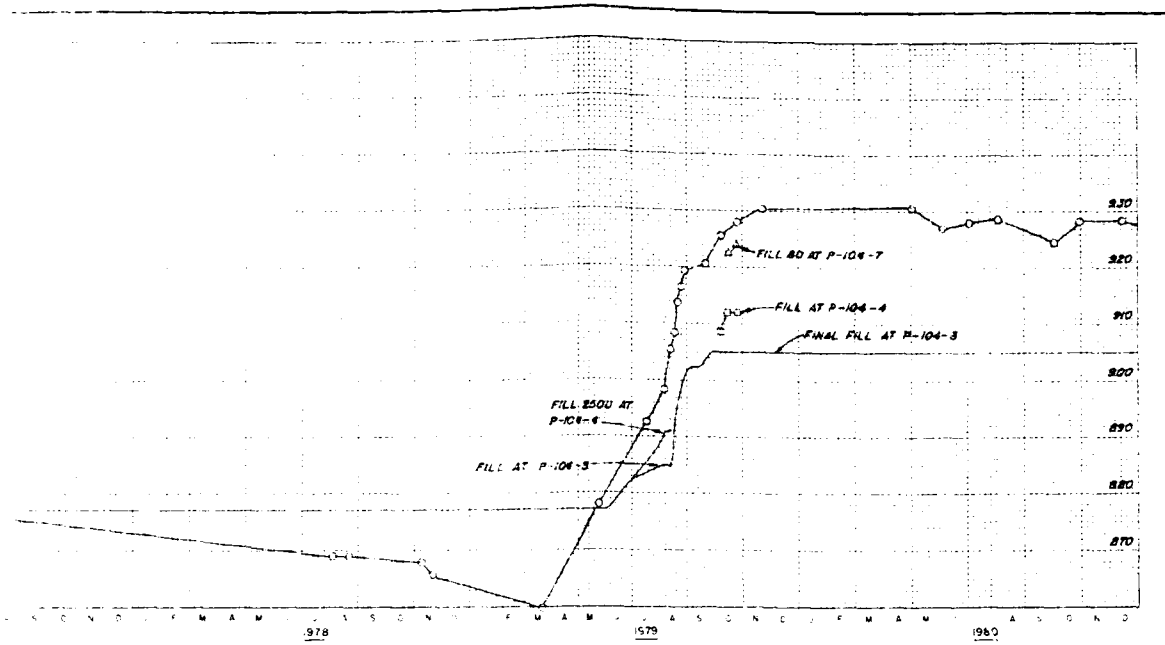
Scale as shown

CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO 0-15-967  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETTIC VERTICAL DATUM OF 1929

TOP PZ EL  
 TIP EL 840.0  
 STA 103+88  
 RANGE 2:20 V.  
 MAT'L - 3/1  
 TYPE 8 1/2 W  
 INSTALLED 8 FEB 78





REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

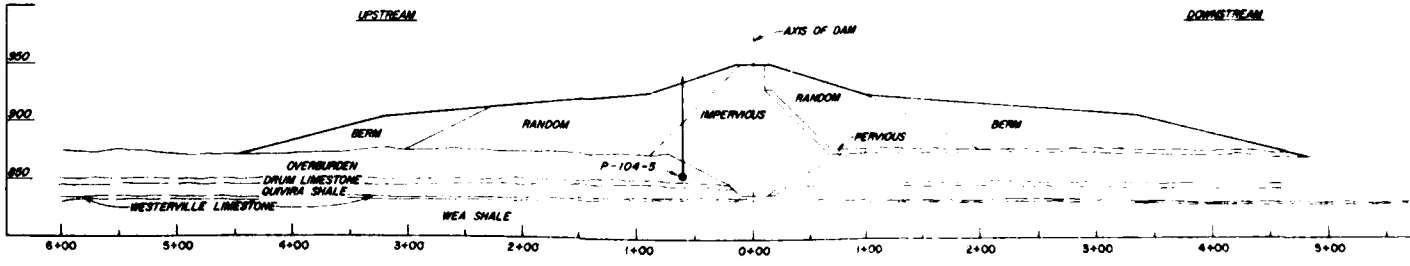
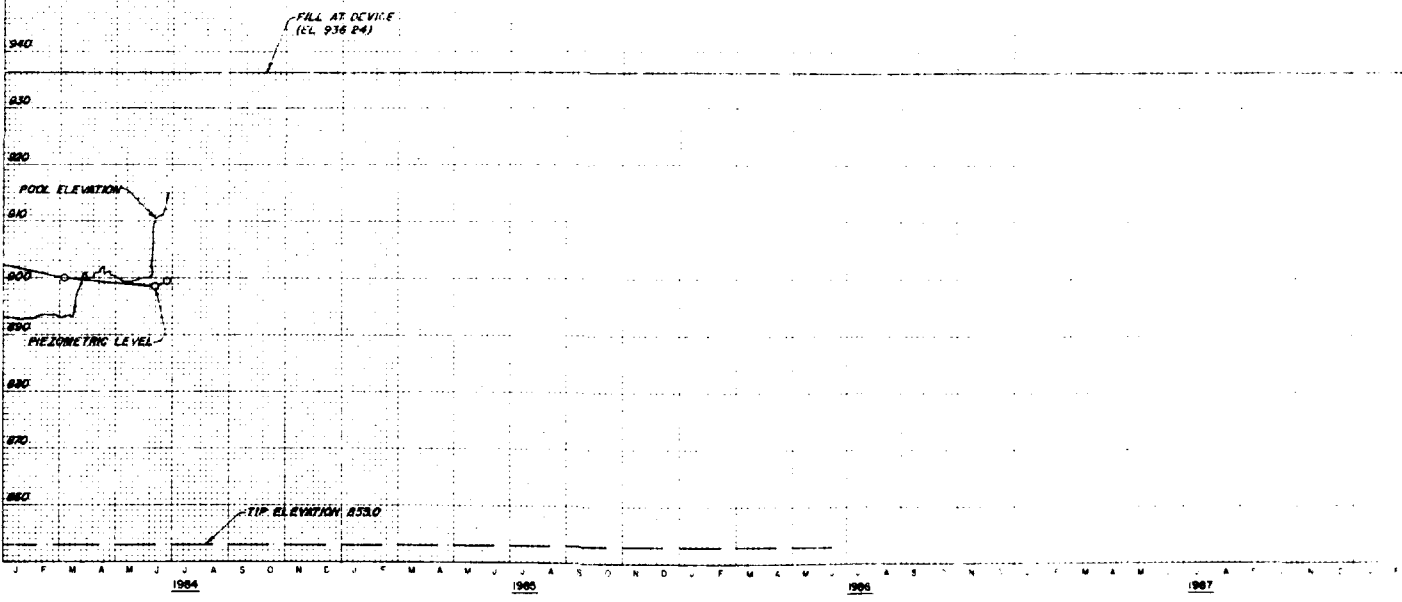
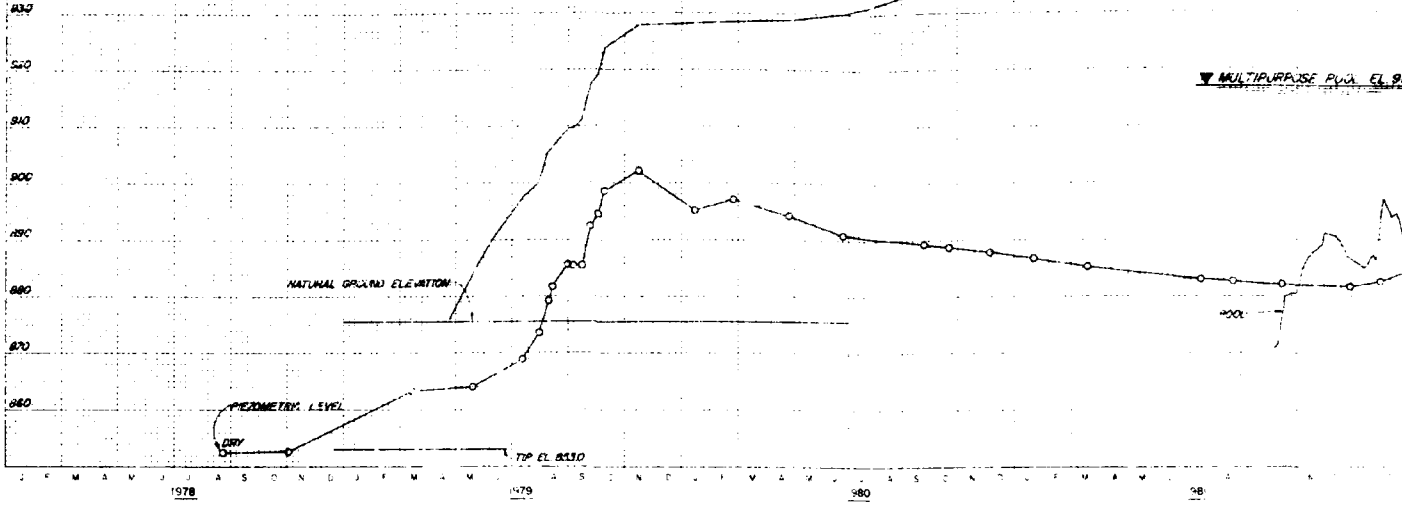
AIR CELL PIEZOMETER  
 P-104-3

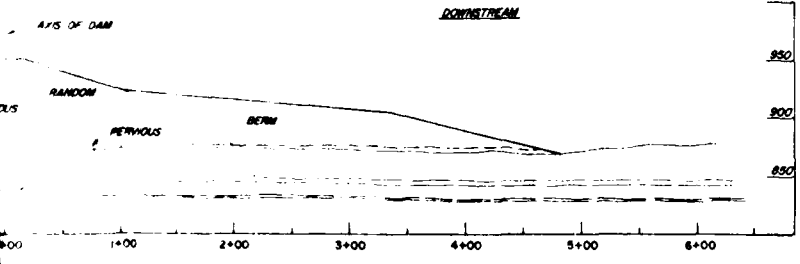
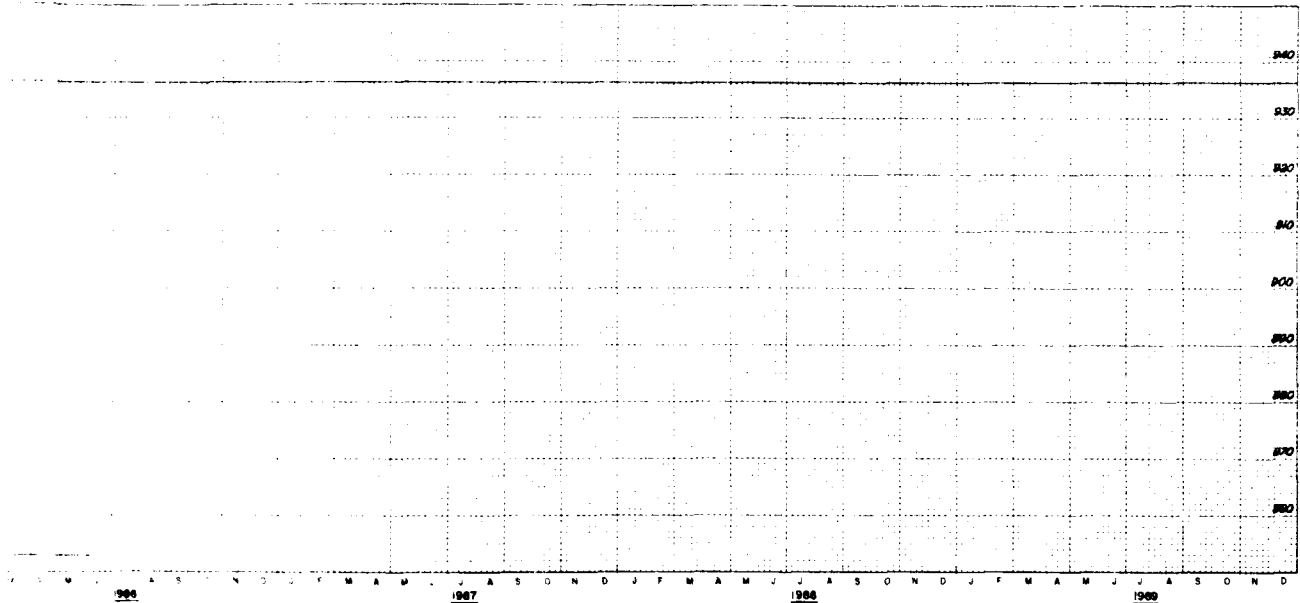
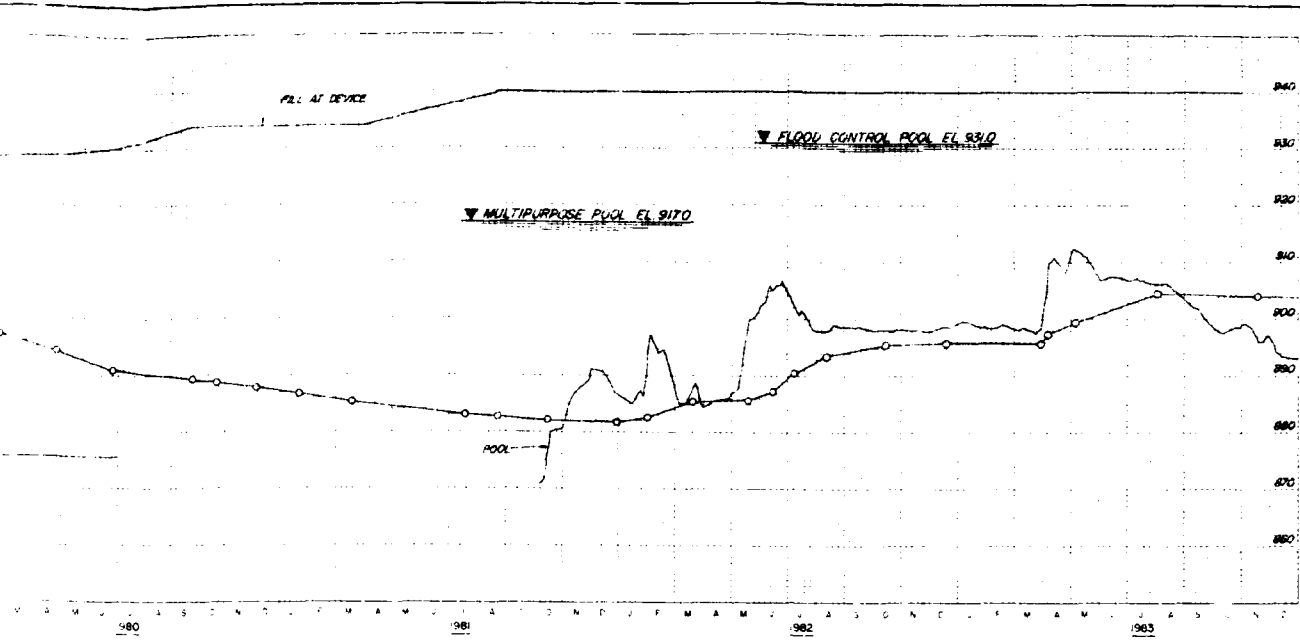
In 1 sheet  
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Sheet No. 1  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-972  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TOP PZ EL. 8330  
 TIP EL. 8330  
 STA. 103498  
 RANGE 0+80.1  
 MAT'L CL  
 INSTALLED 16 JUN 78





REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

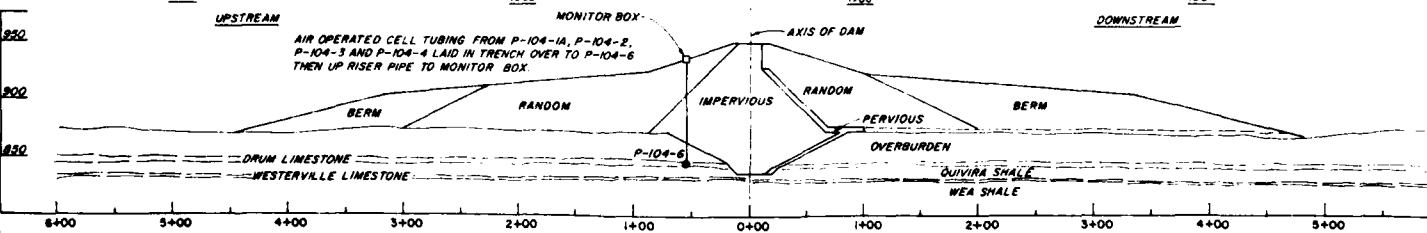
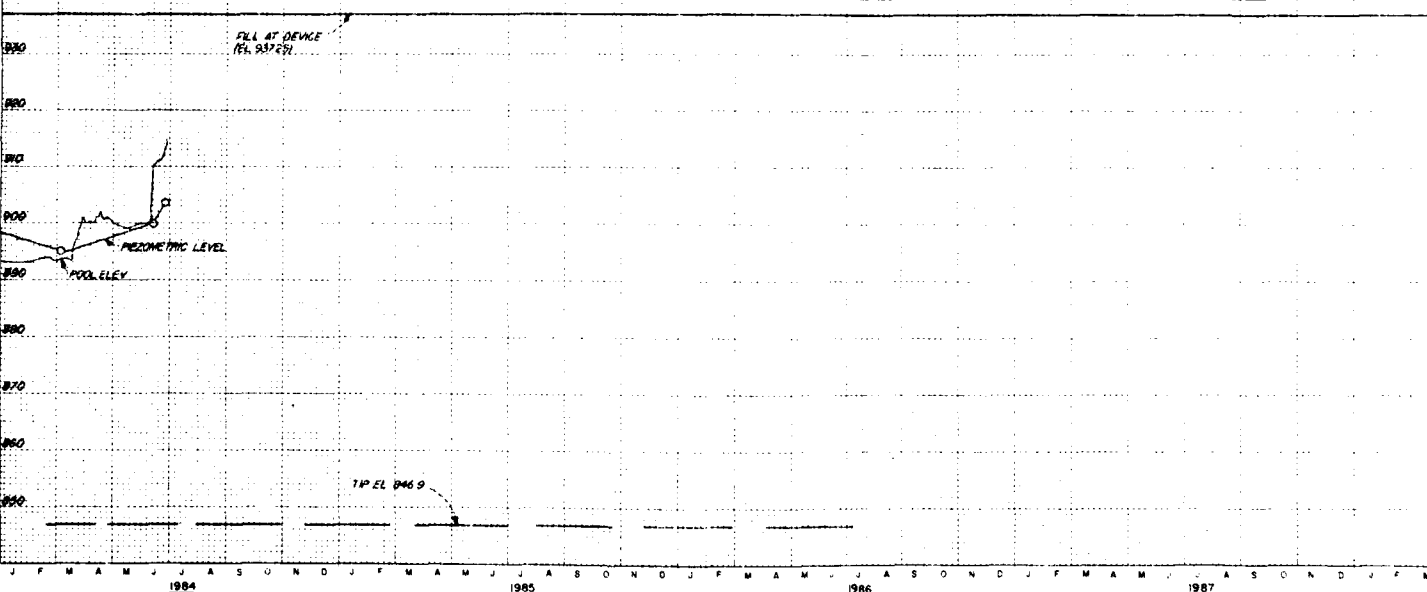
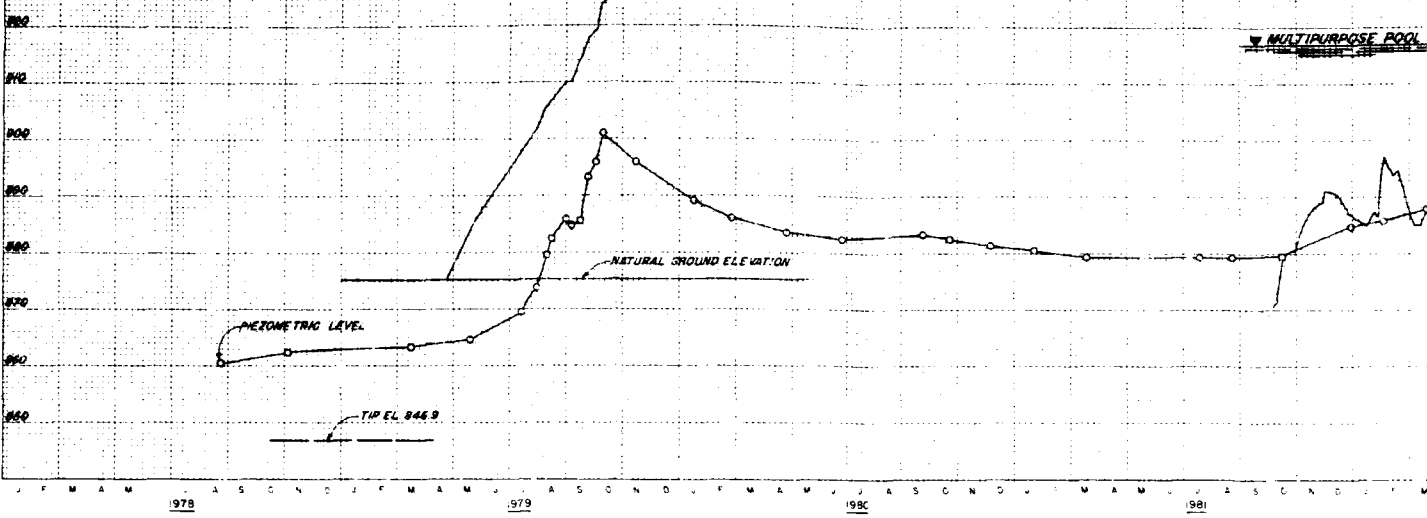
OPEN TUBE PIEZOMETER  
 P-104-5

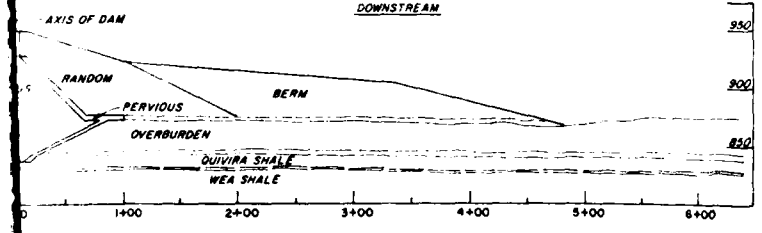
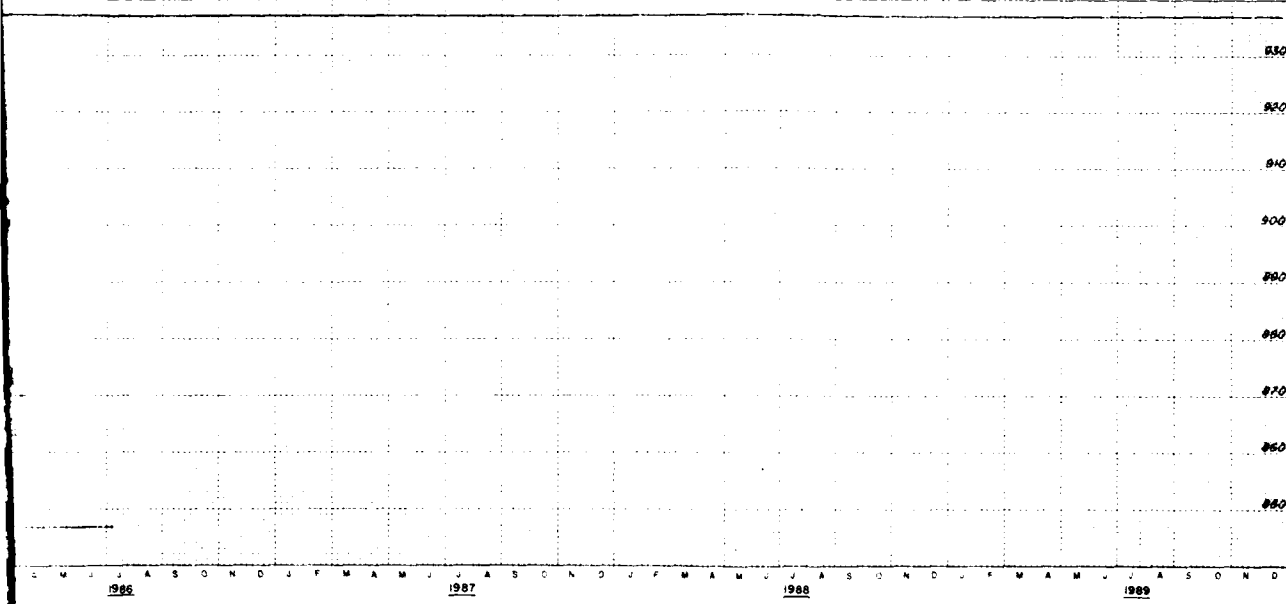
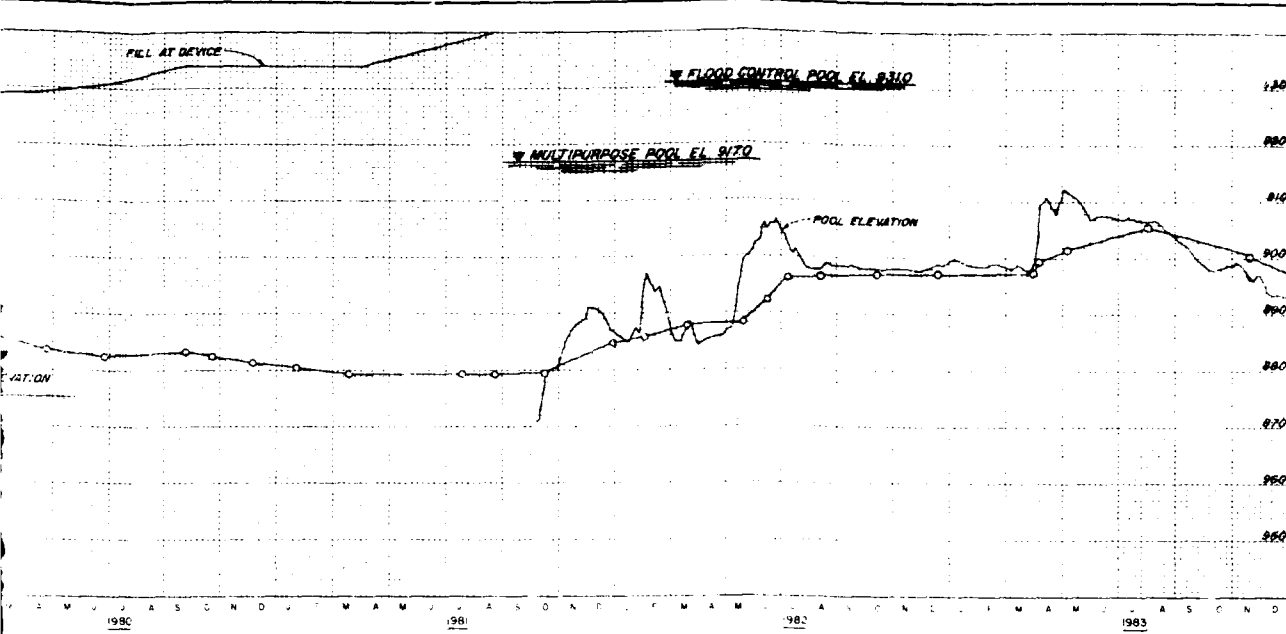
In 1 sheet      Sheet No. 1      Scale as shown  
 CORPUS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-974  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1989

TOP PI EL. 83880  
 TIP EL. 8469  
 STA. 104106  
 NAME 0+530  
 MAT'L. C  
 INSTALLED 15-JAN-78





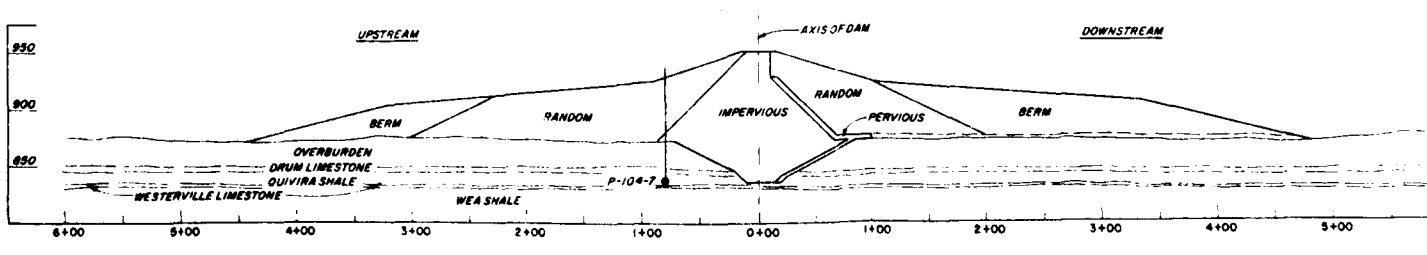
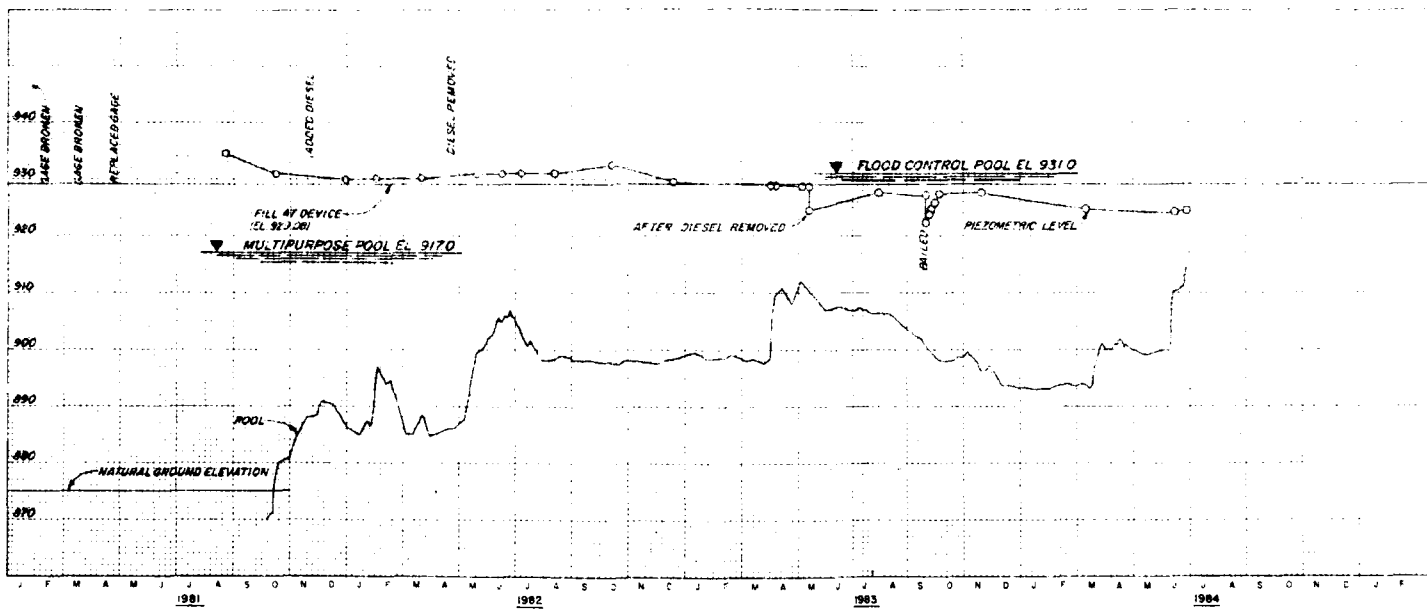
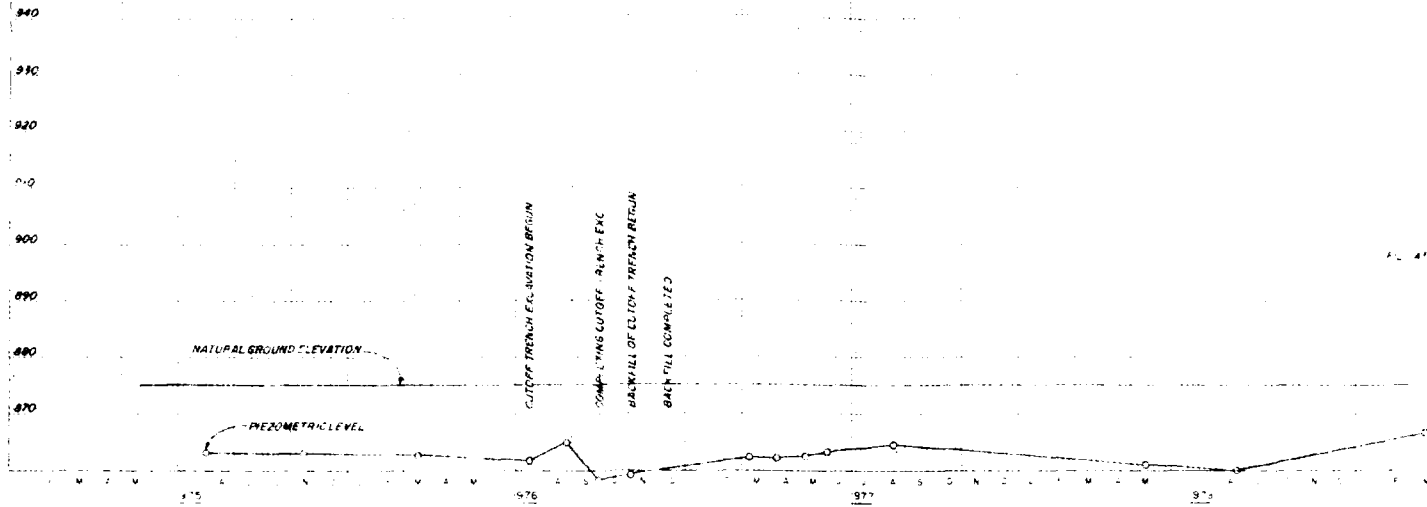
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 OPEN TUBE PIEZOMETER  
 P-104-6

in 1 sheet  
 Sheet No 1  
 Scale as shown  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. 0-15-975  
 JANUARY 1983

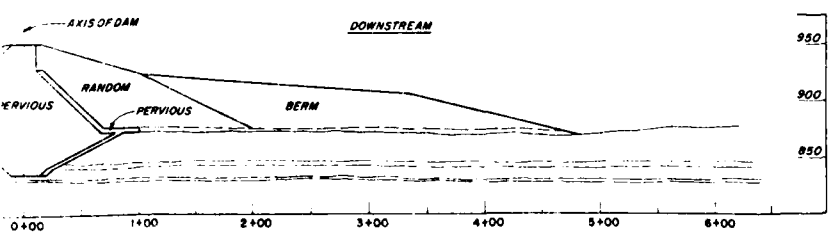
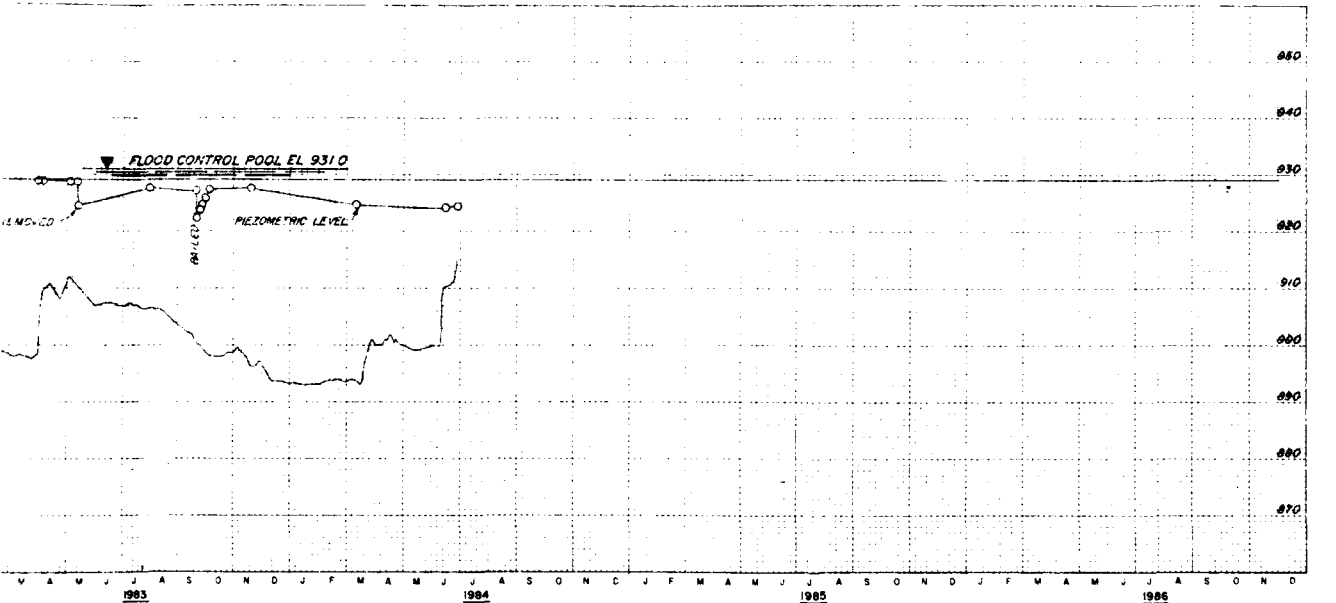
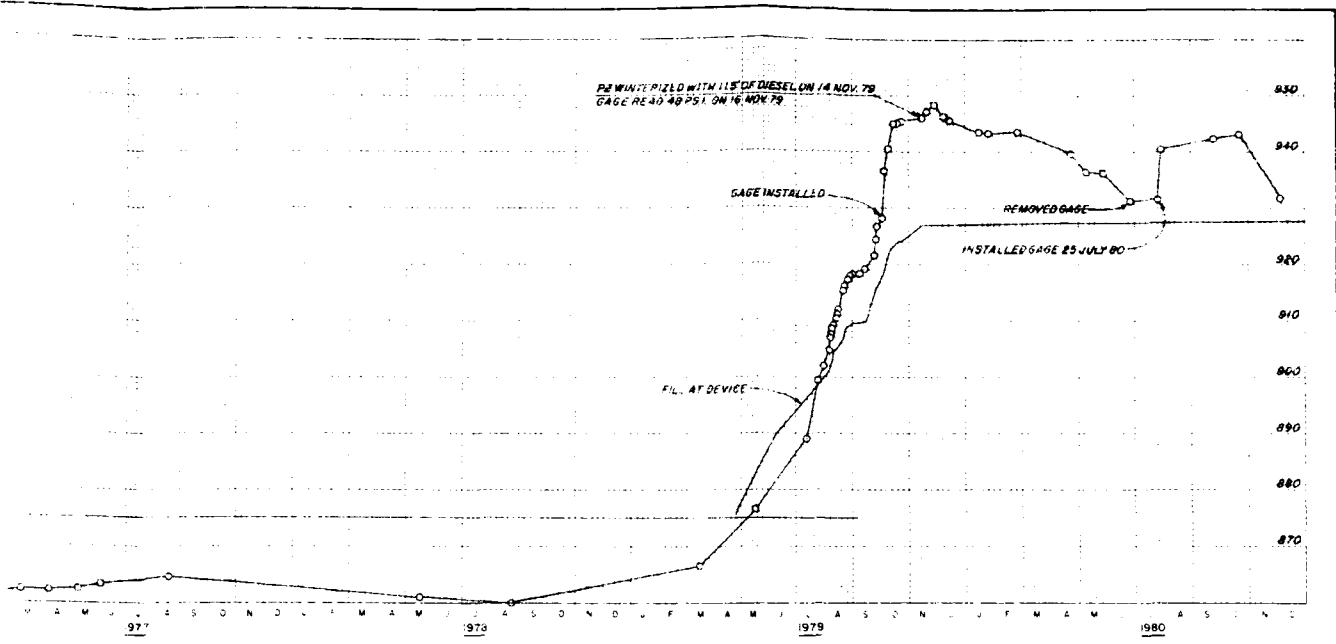
2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TOP PI EL. 931.20  
TIP EL. 841.4  
STA. 105+95  
RANGE 07+00L  
MARK 34  
INSTA. LED FEB 79







REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

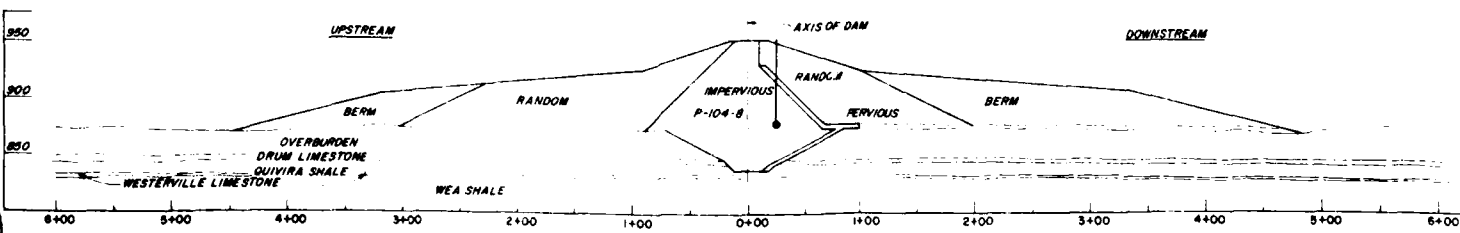
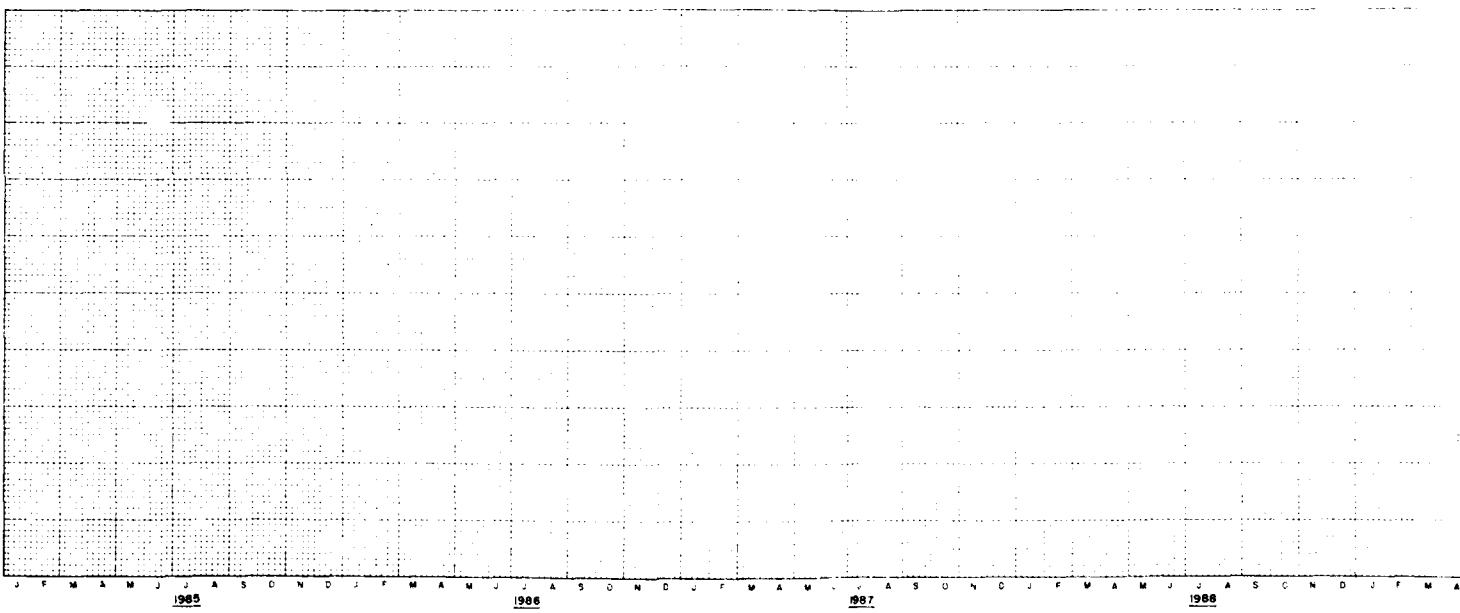
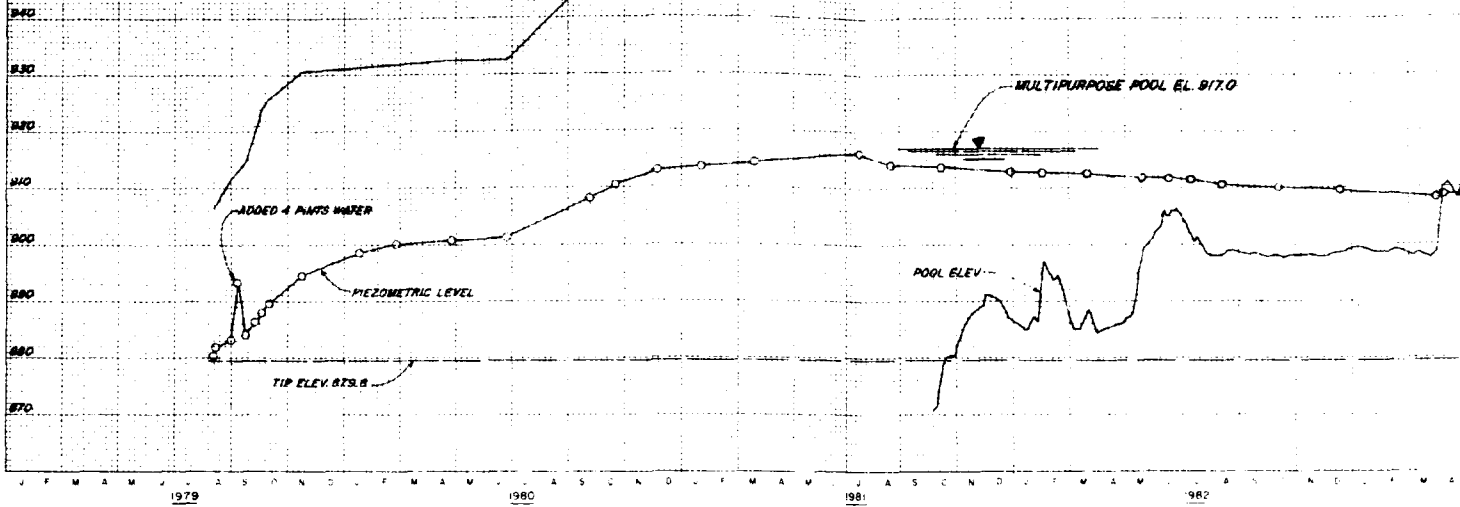
OPEN TUBE PIEZOMETER  
 P-104-7

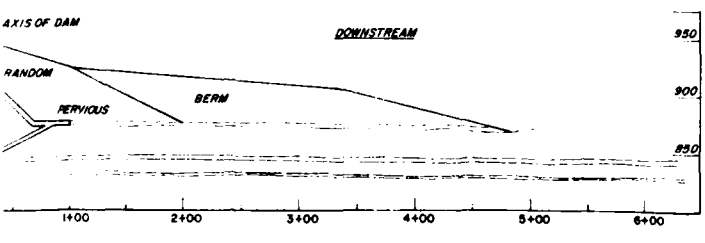
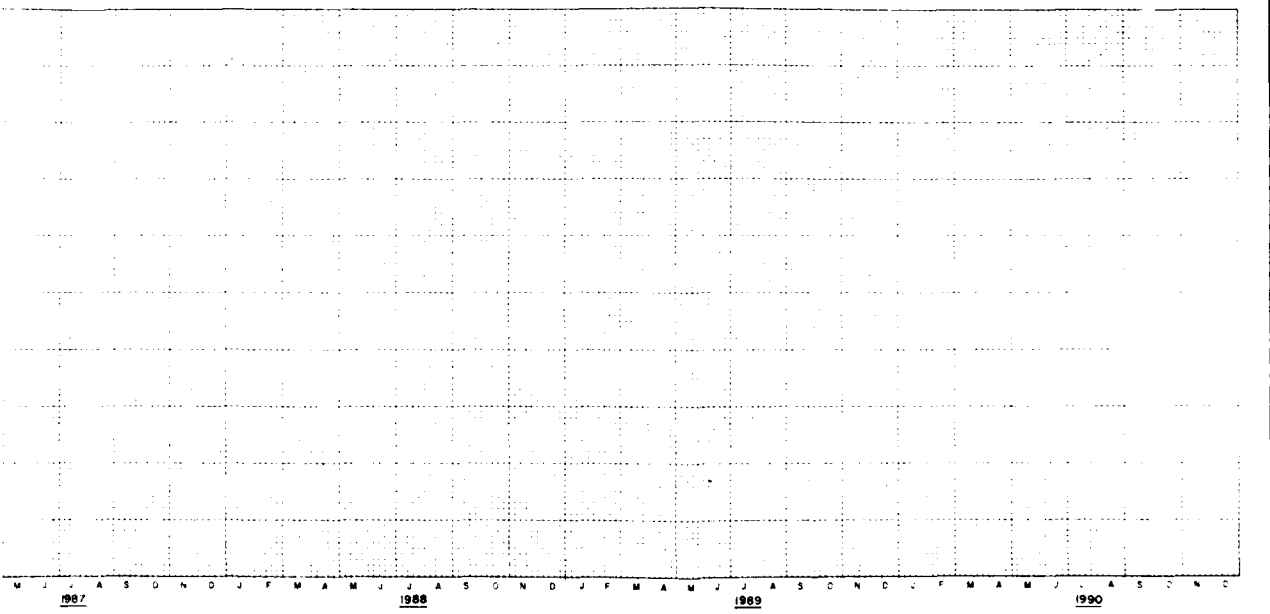
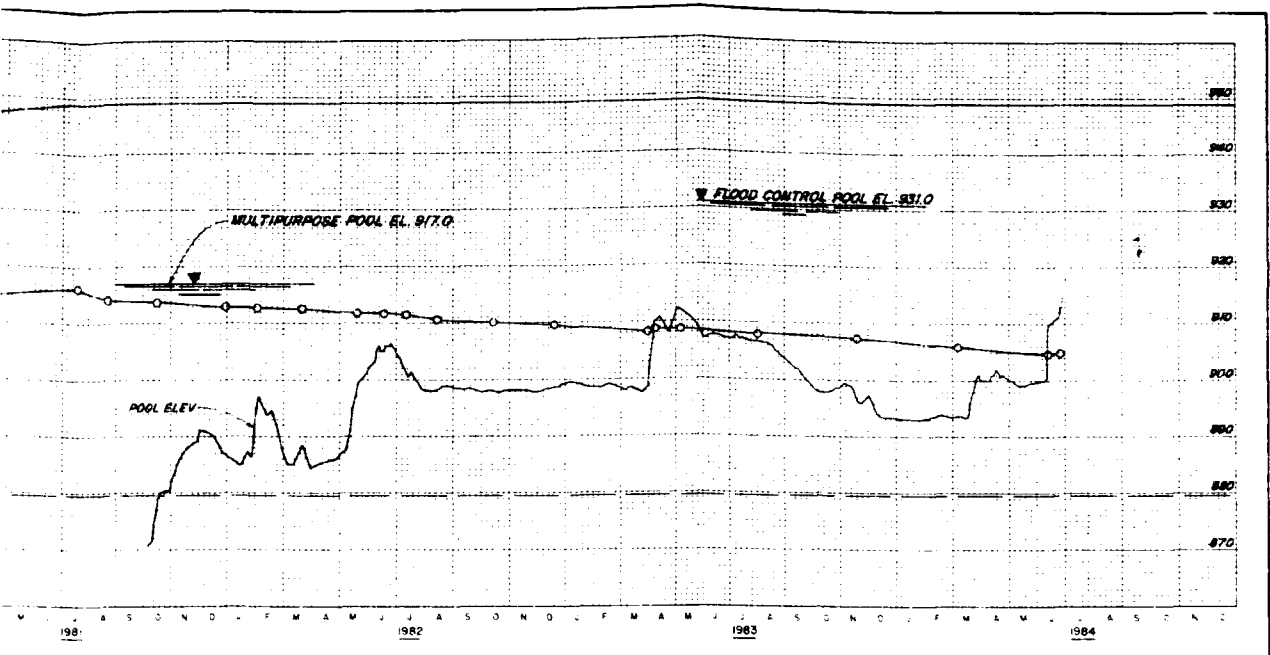
In 1 sheet Sheet No 1 Scale: as shown  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-976  
 JANUARY 1985

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TOP PE. EL. 823.6  
 TIP EL. 875.6  
 STR. 100+22  
 RANGE D. 1524  
 INST. 100-FILL  
 INSTALLED 8-1-78





REVISED SEPTEMBER 1984  
 BIG HULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-104-8

Sheet No. 1  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-977  
 JANUARY 1983

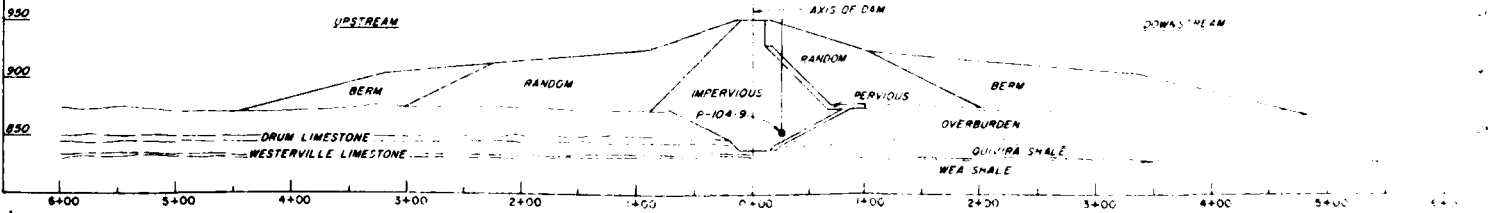
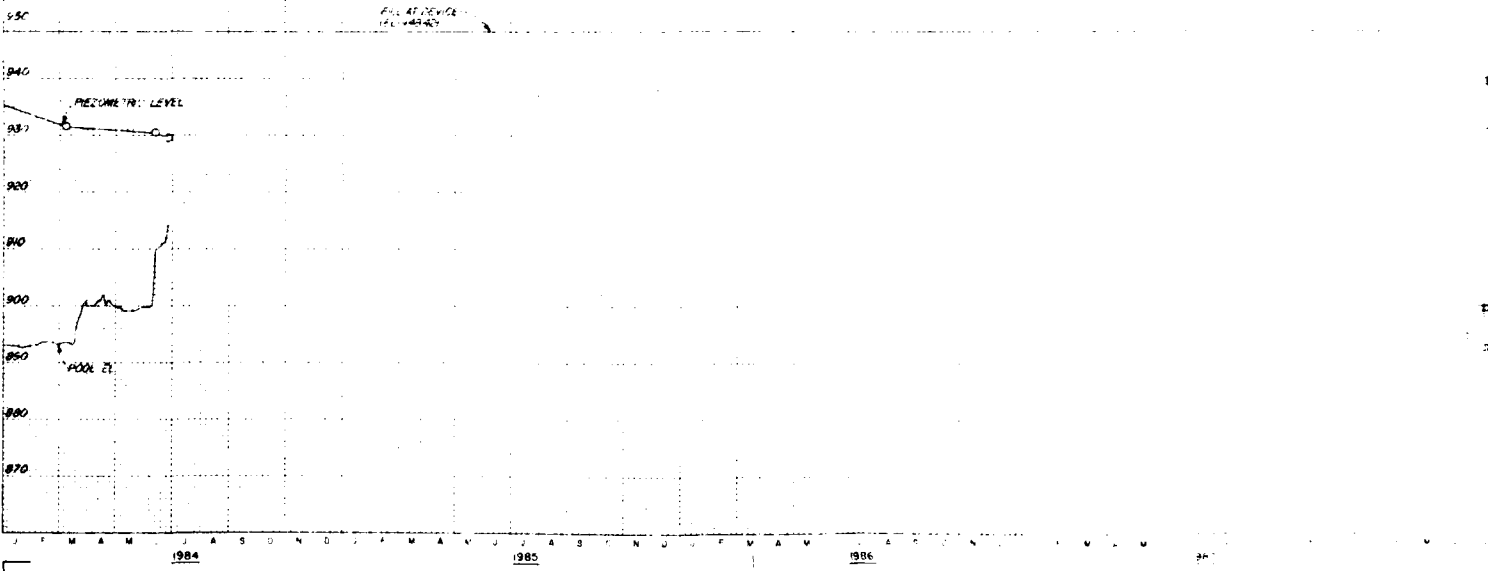
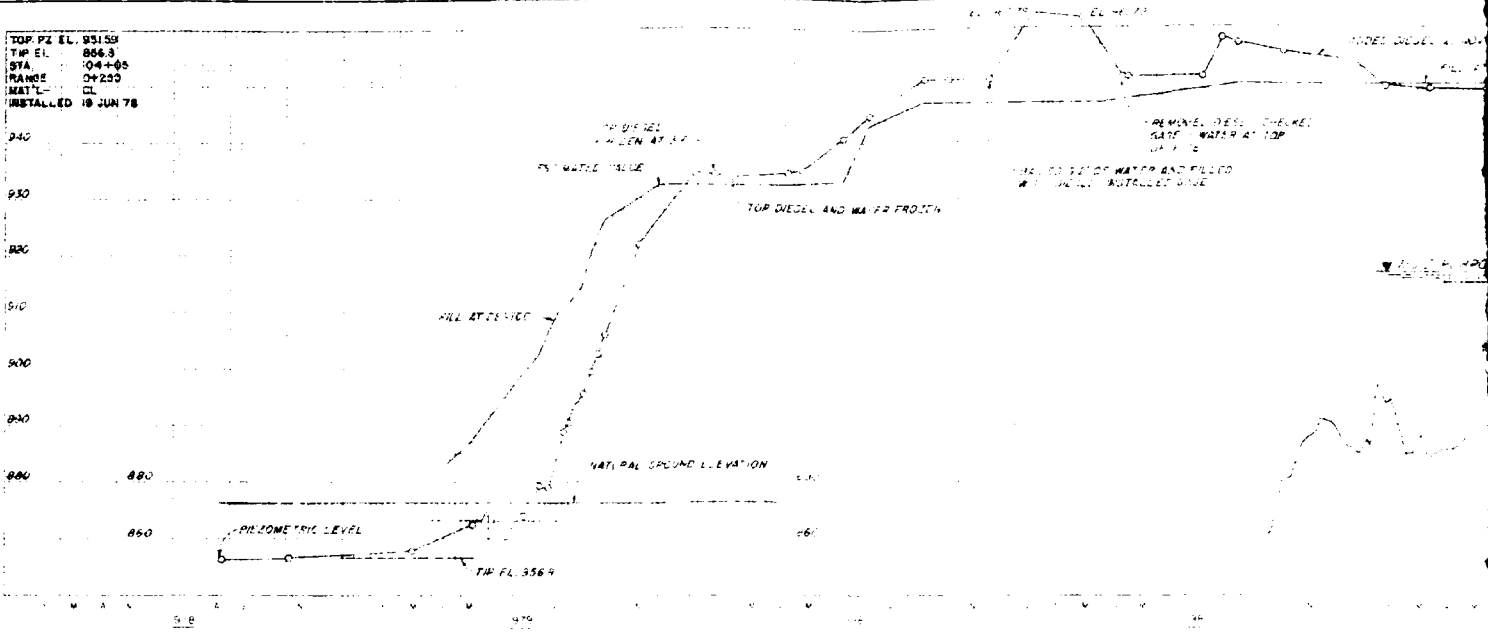
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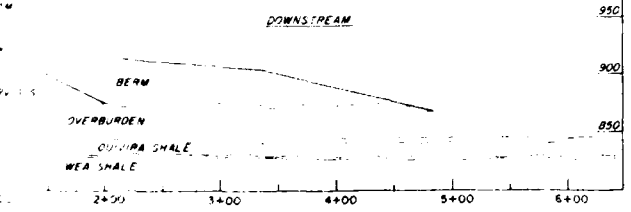
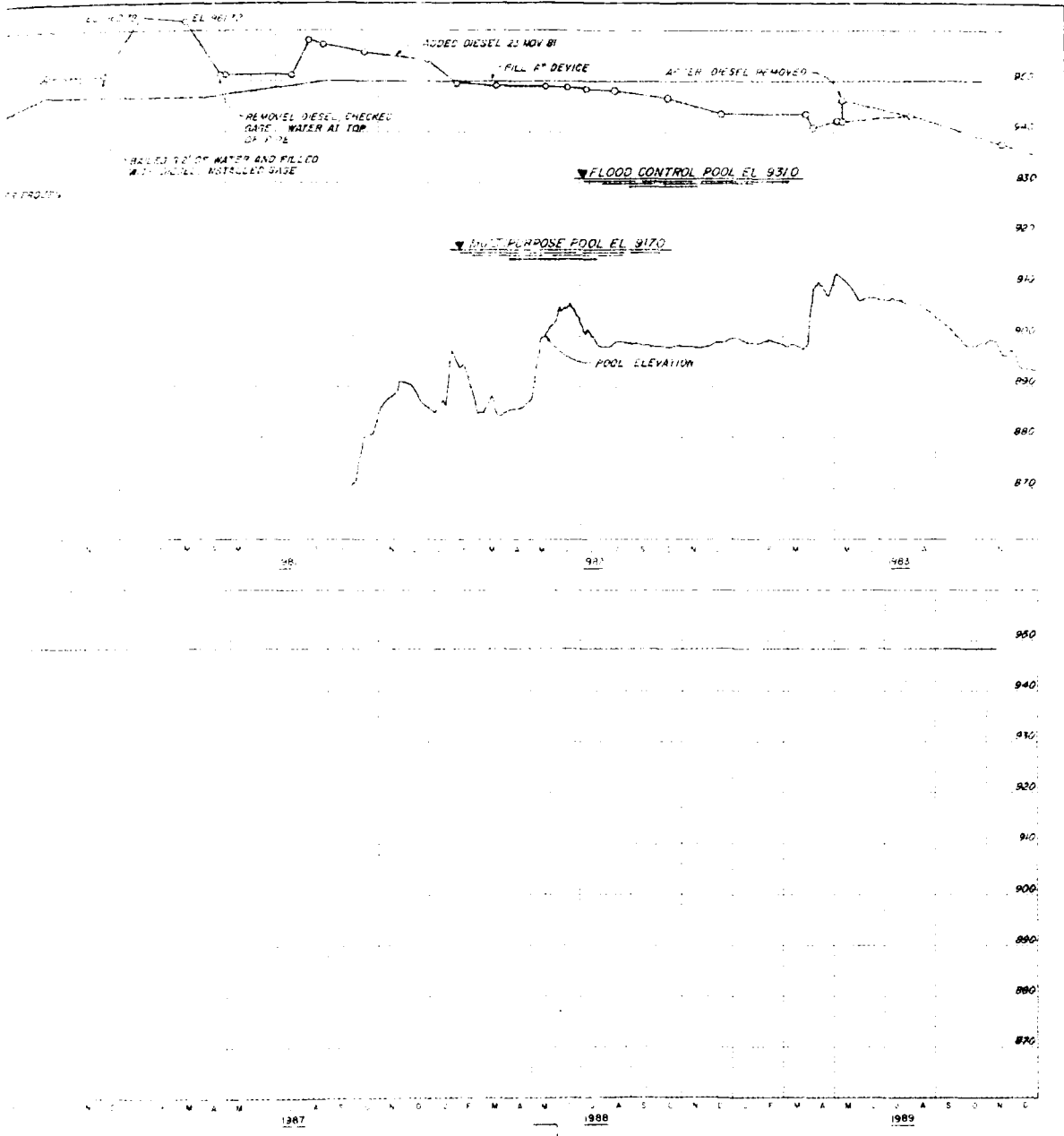
Scale as shown

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TOP PZ EL. 931.59  
 TOP EL. 886.8  
 STA. 0+230  
 RANGE 0+230  
 MAT'L CL  
 INSTALLED 19 JUN 78





REVISED SEPTEMBER 1984  
 BIG BULL CREEK KANSAS  
**HILLSDALE LAKE**  
 EMBAKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-104-9

Sheet No. 1  
 CORPS OF ENGINEERS, U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. C-15-978  
 JANUARY 1983

Scale as shown

TOP OF EL. 904.52  
 TIP EL. 834.2  
 STA. 1044.27  
 RANGE 14200  
 INST. 1001 B475  
 970

910

900

890

880

870

860

850

975

976

977

978

930

920

910

900

890

880

870

860

850

1981

1982

1983

1984

950

900

850

8+00

5+00

4+00

3+00

2+00

+00

0+00

1+00

2+00

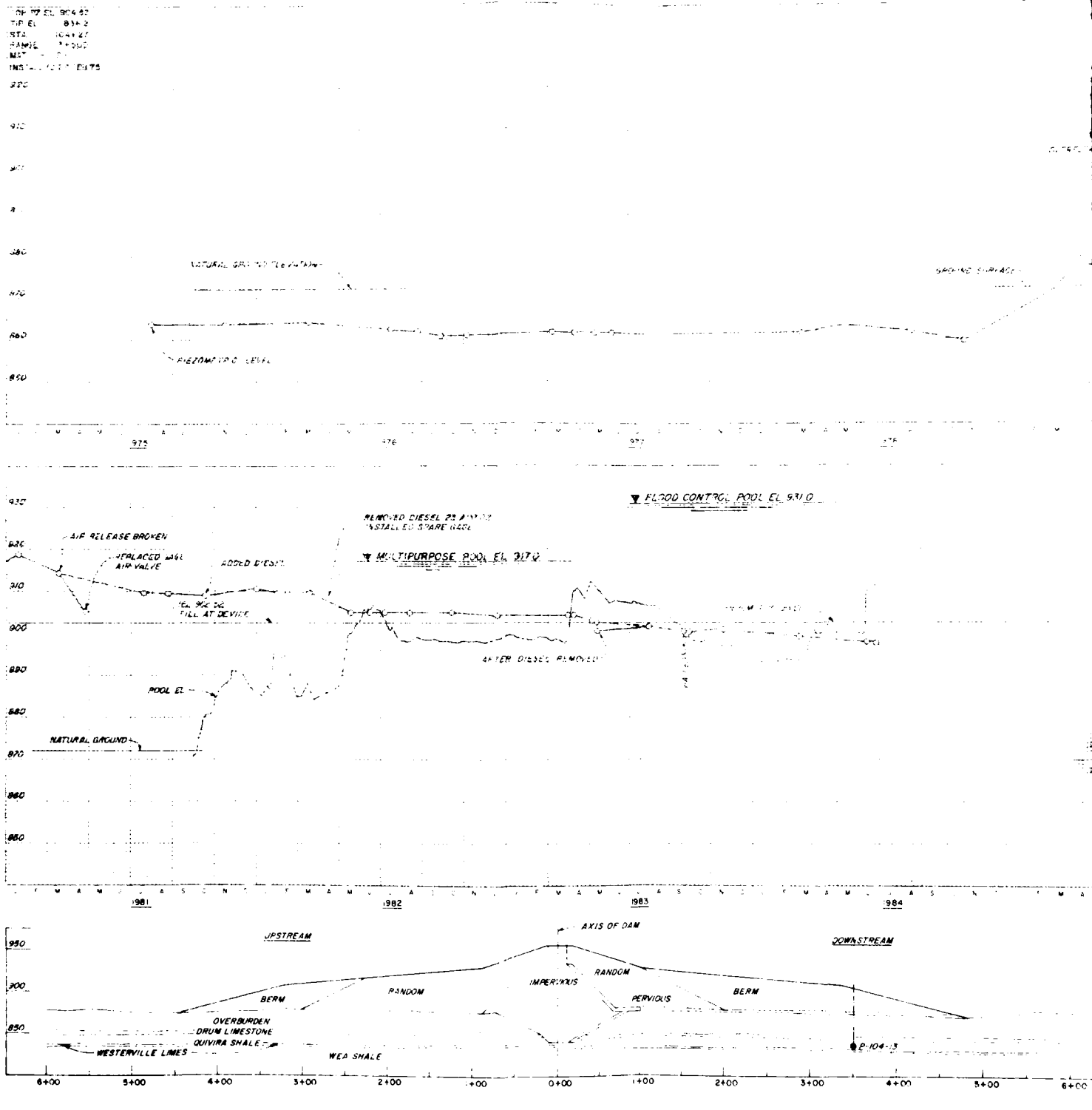
3+00

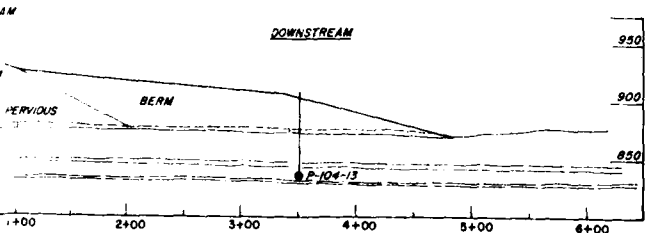
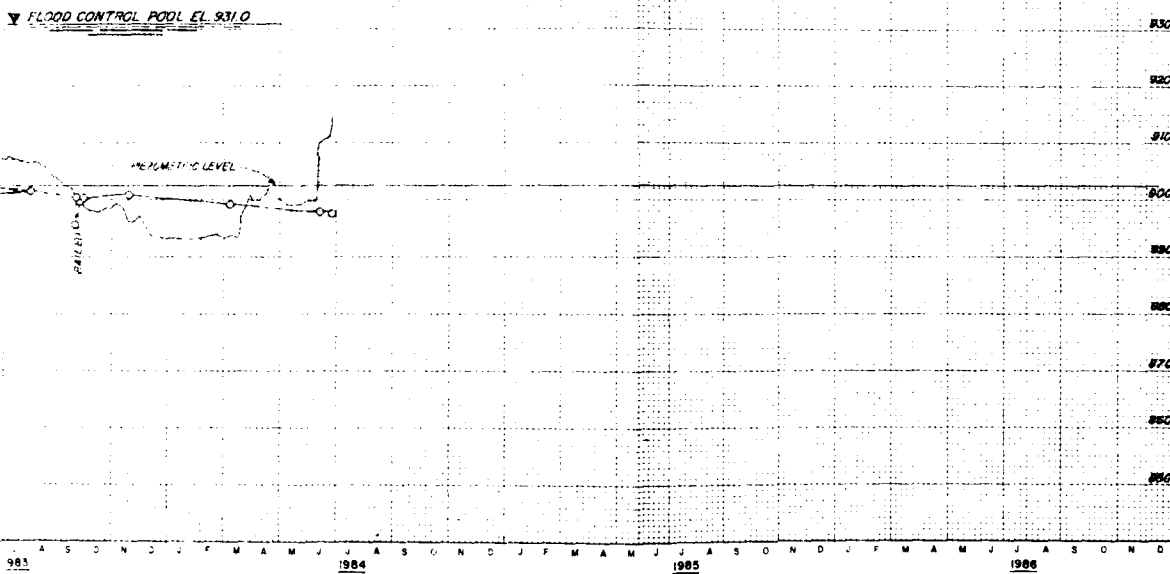
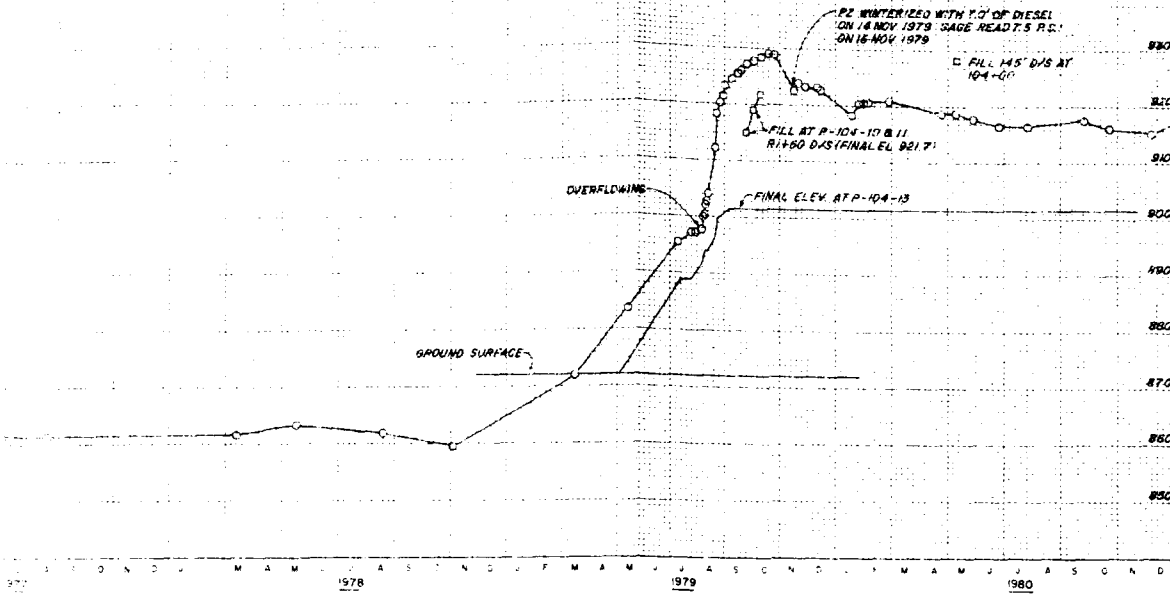
4+00

5+00

6+00

ELEVATION IN FEET BASED ON NATIONAL GEODETIC DATUM OF 1985





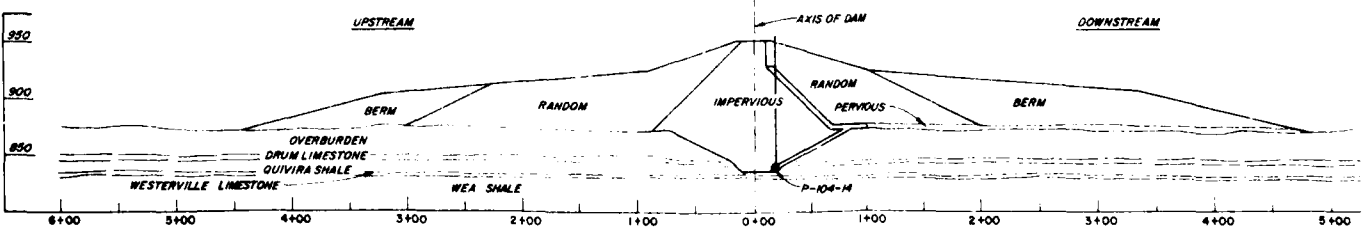
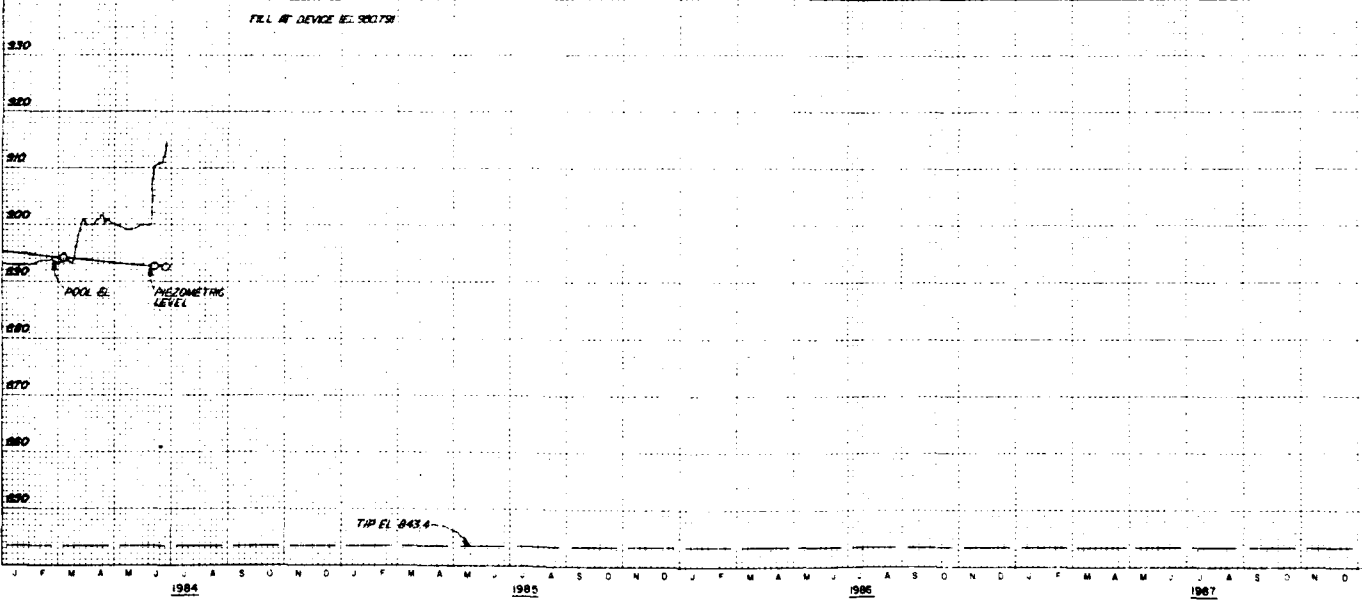
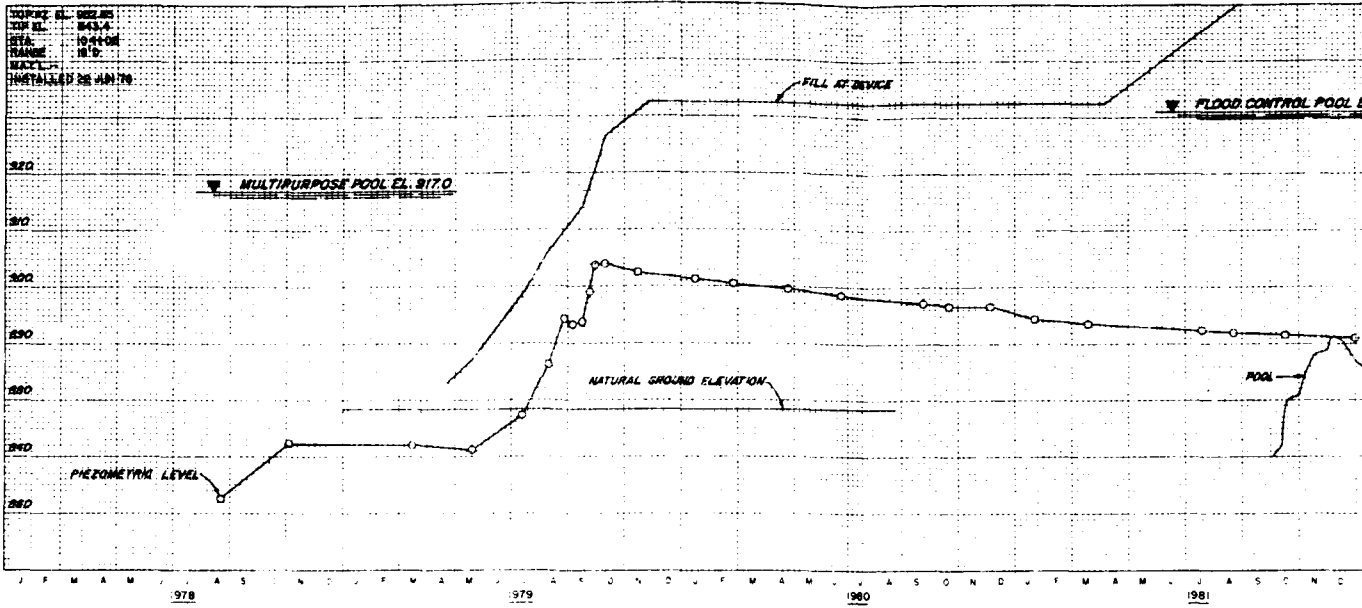
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-104-13

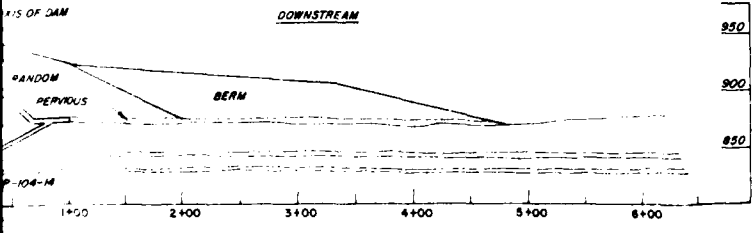
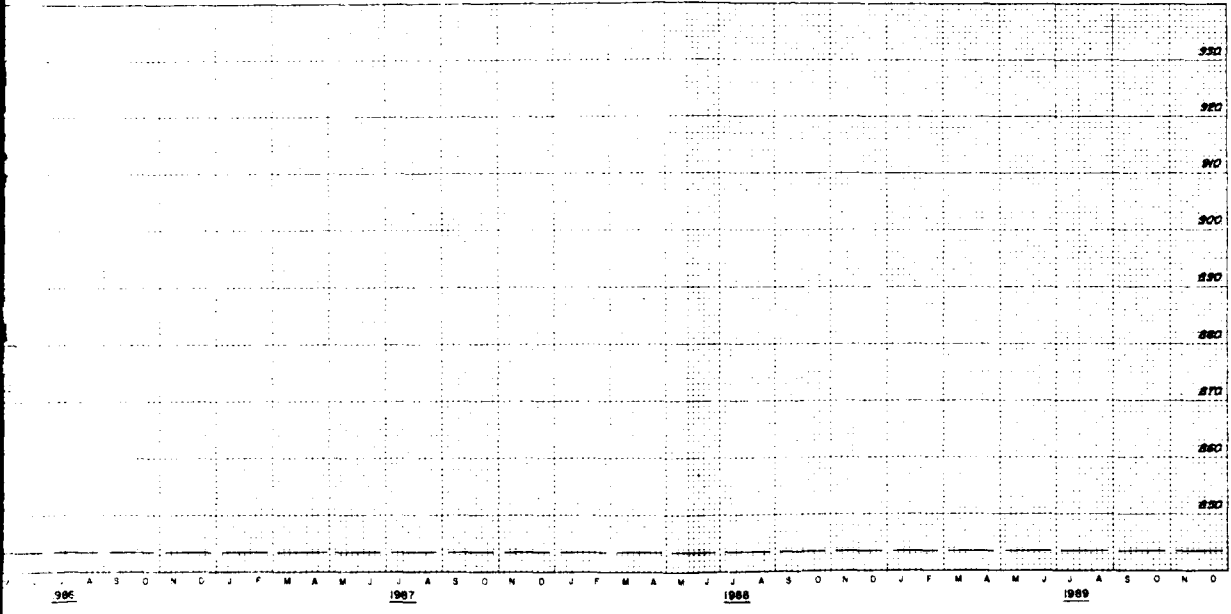
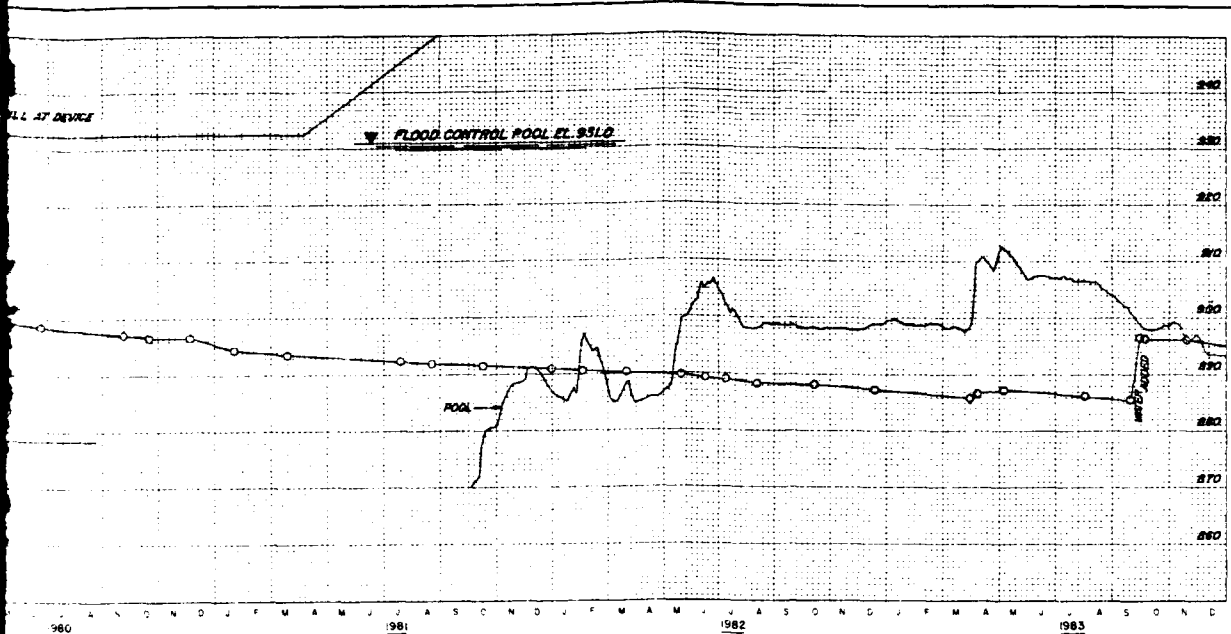
In 1 sheet  
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 Scale: as shown  
 CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-982  
 JANUARY 1983

2

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929







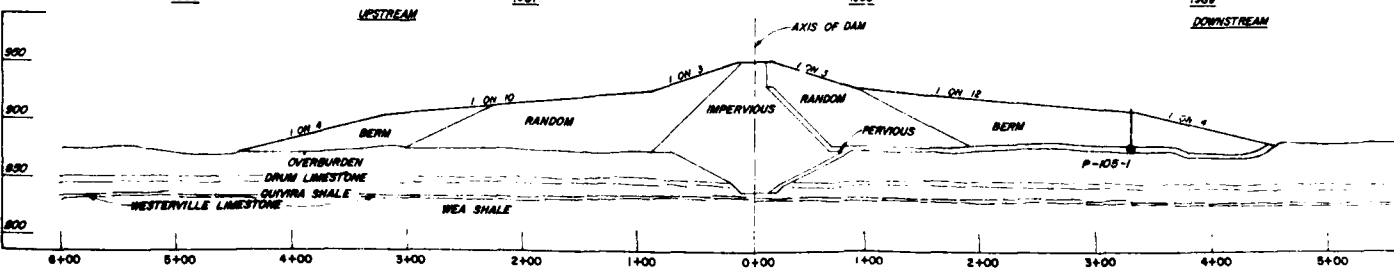
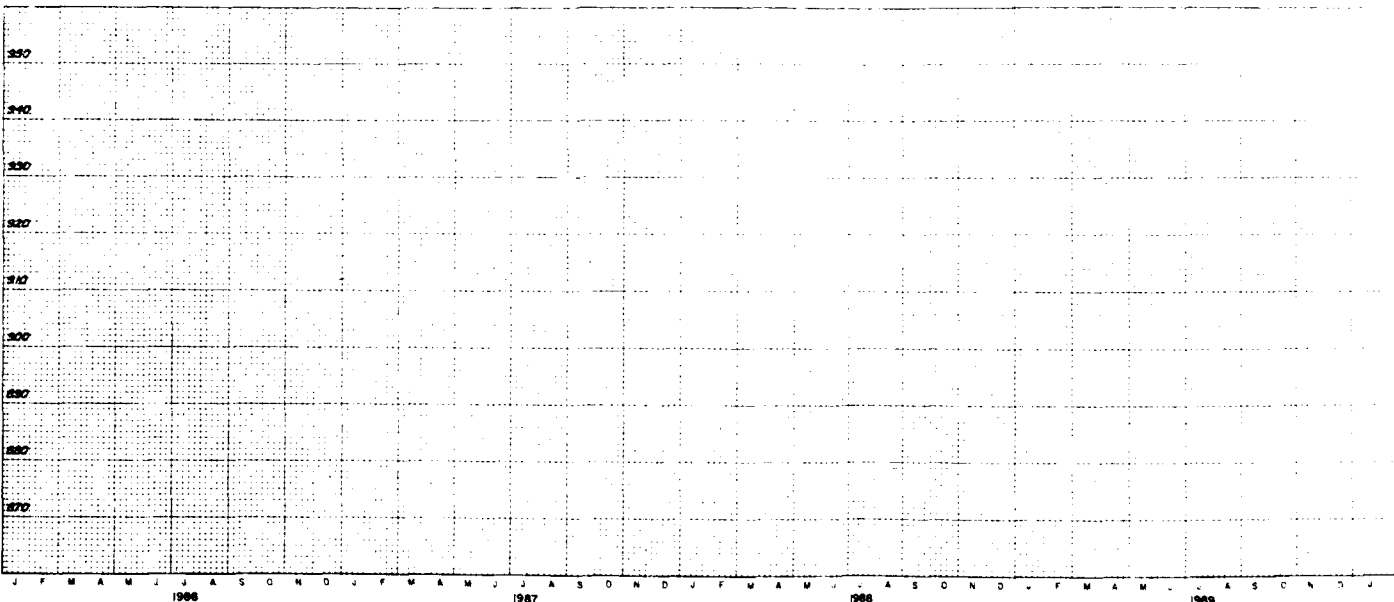
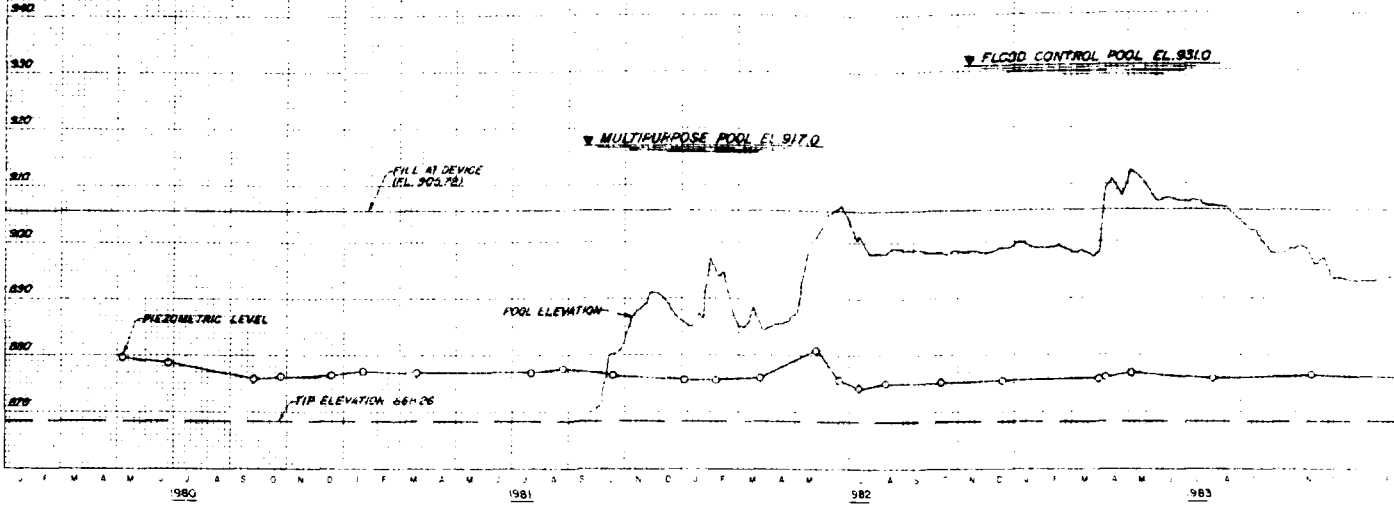
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

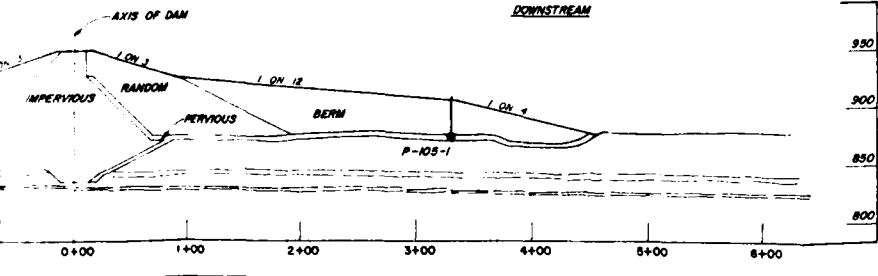
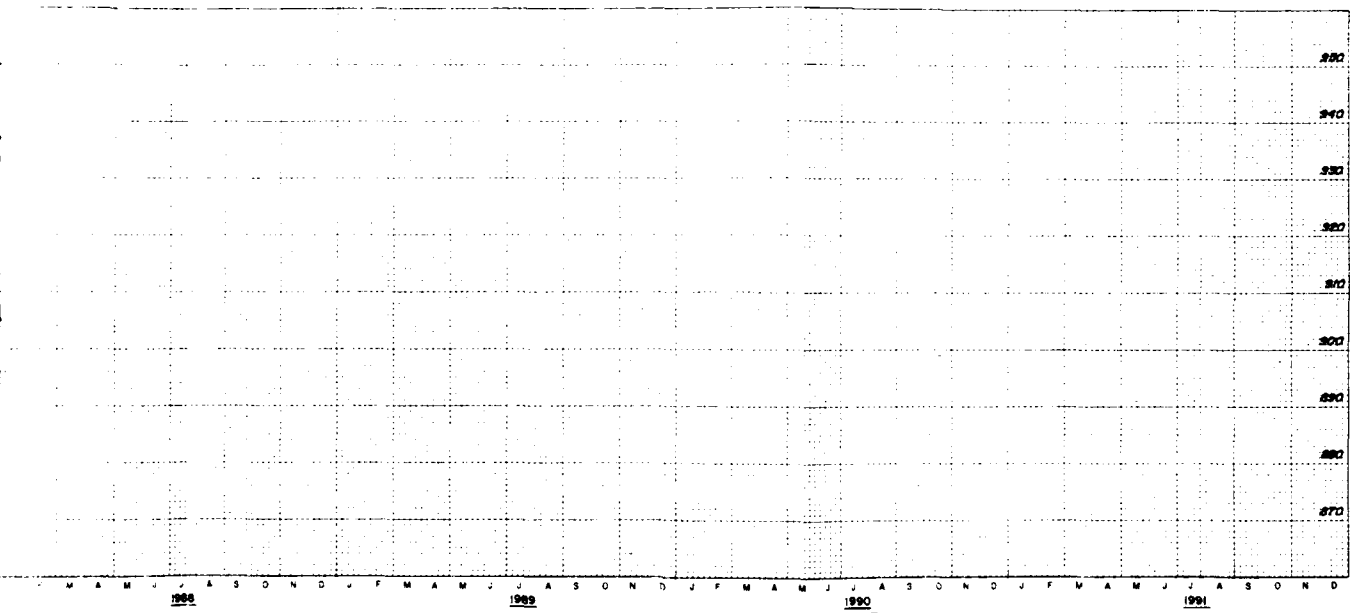
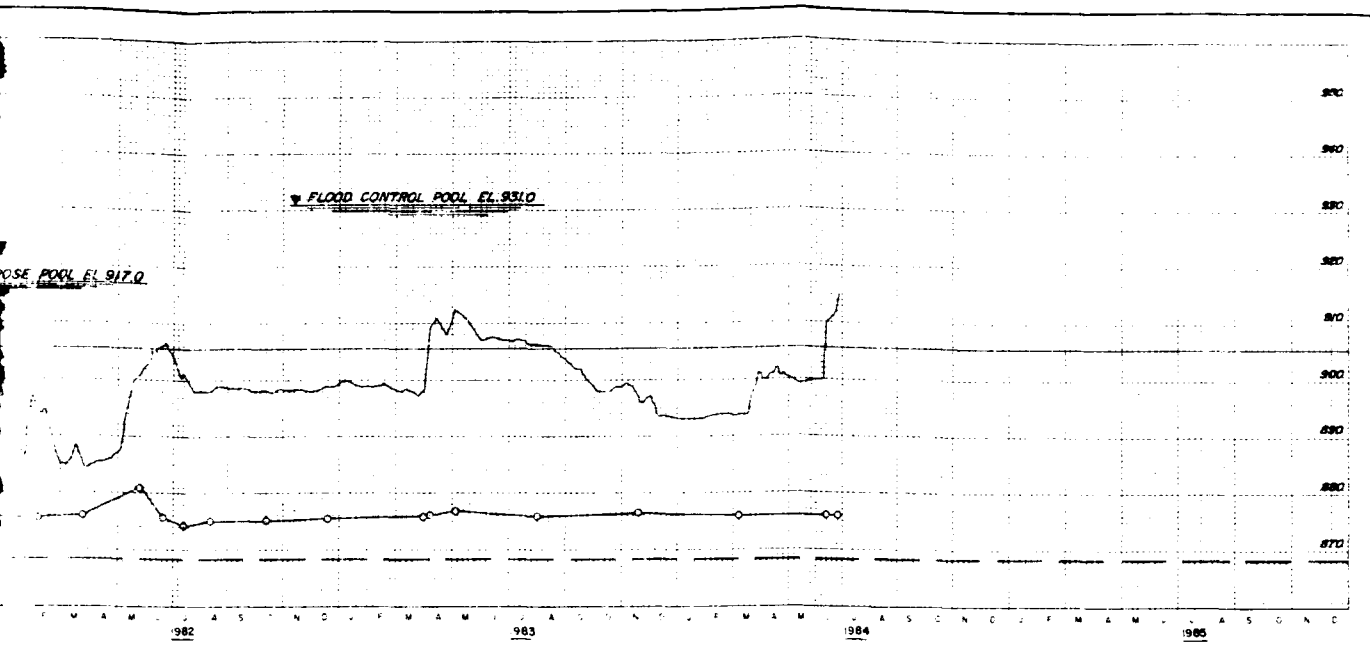
OPEN TUBE PIEZOMETER  
 P-104-14

In 1 sheet 2 Sheet No 1 Scale as shown  
 CORPS OF ENGINEERS U S ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-983  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929

TIP PE EL. 807.78  
 TIP EL. 868.26  
 STA. 10+00  
 RANGE 3+30  
 MAT'L - SAND DRUM  
 INSTALLED 8/24/80





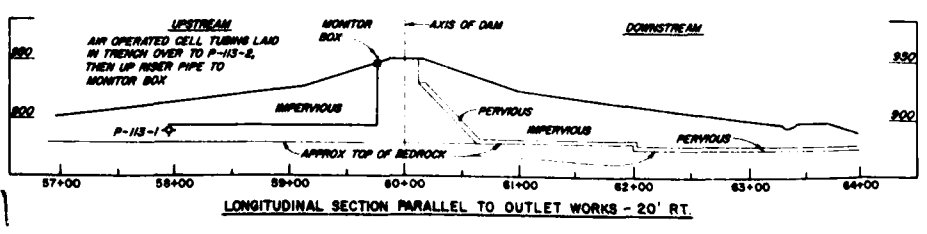
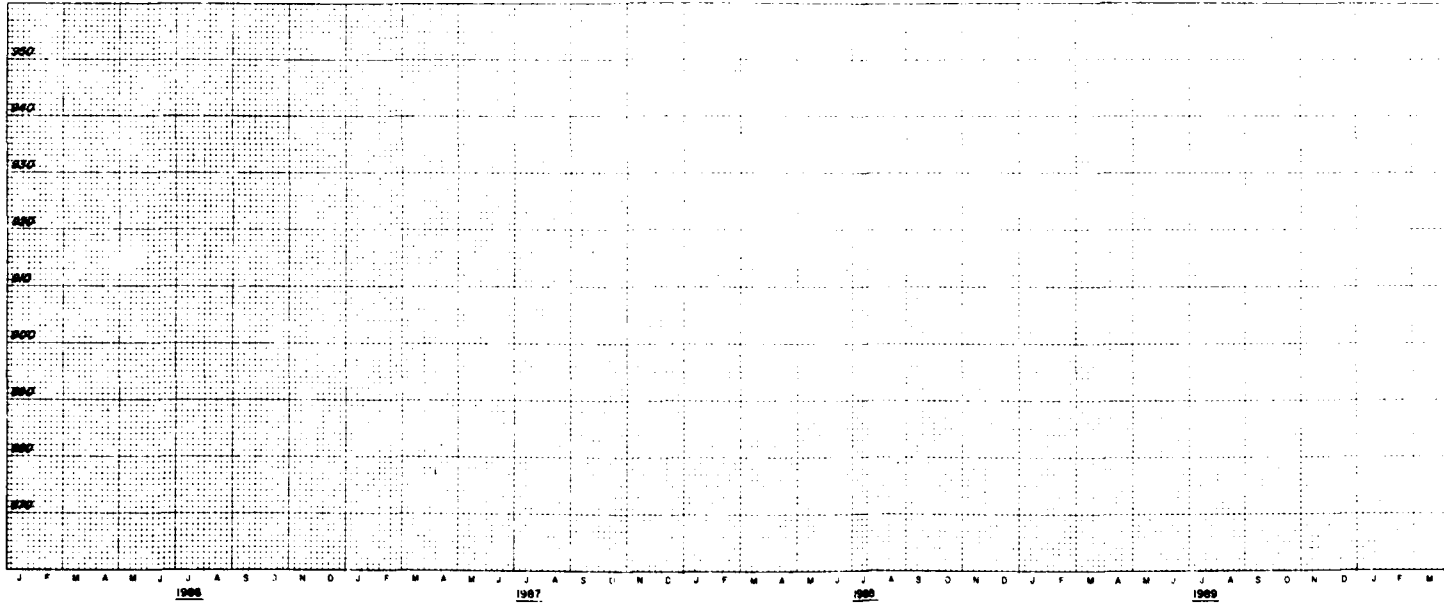
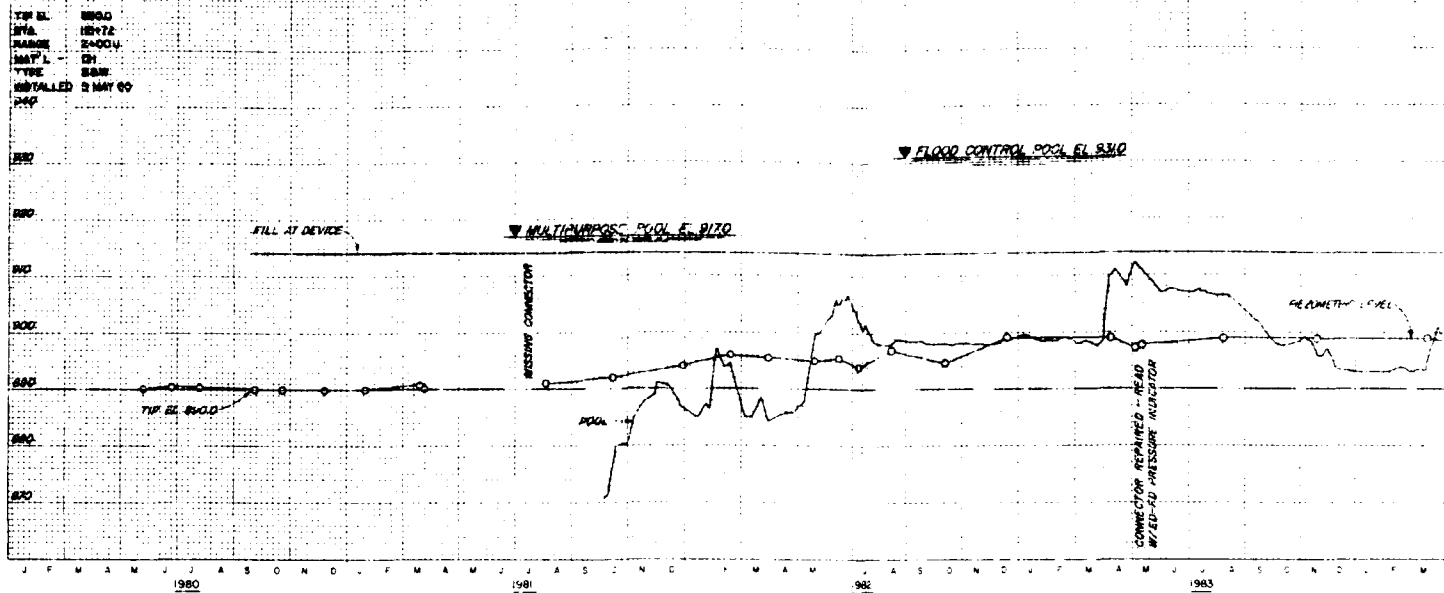
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-105-1

In 1 sheet Sheet No 1 Scale: as shown

CORPS OF ENGINEERS U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. 0-15-984  
 JANUARY 1983

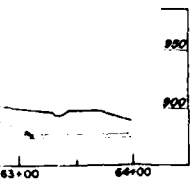
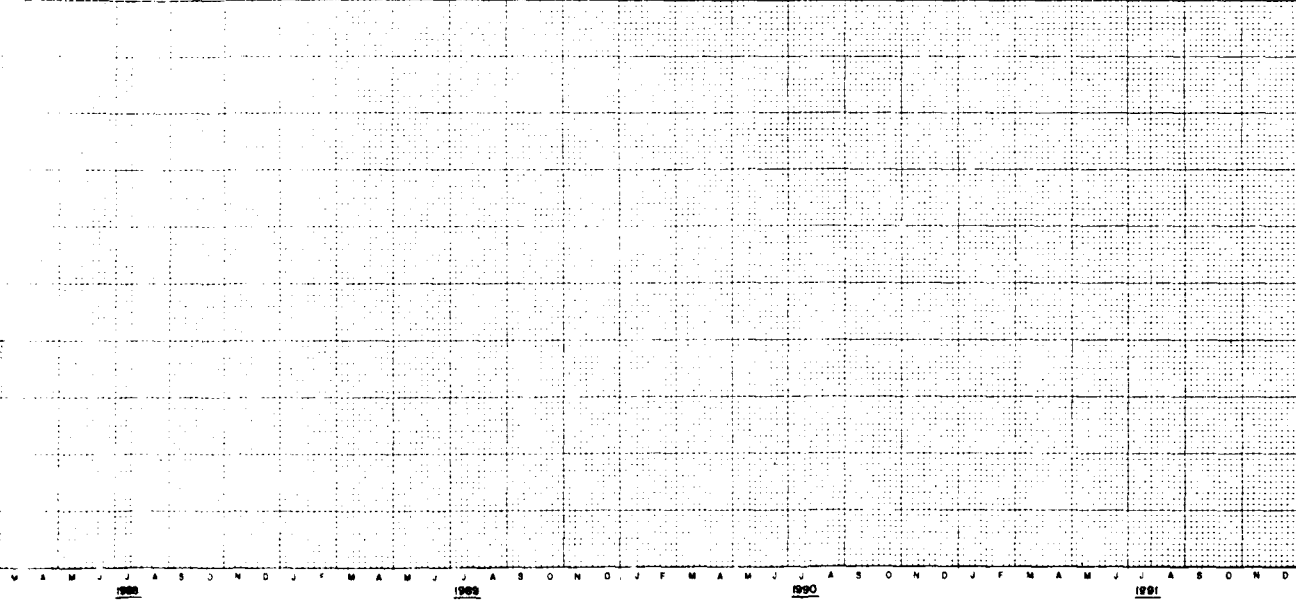
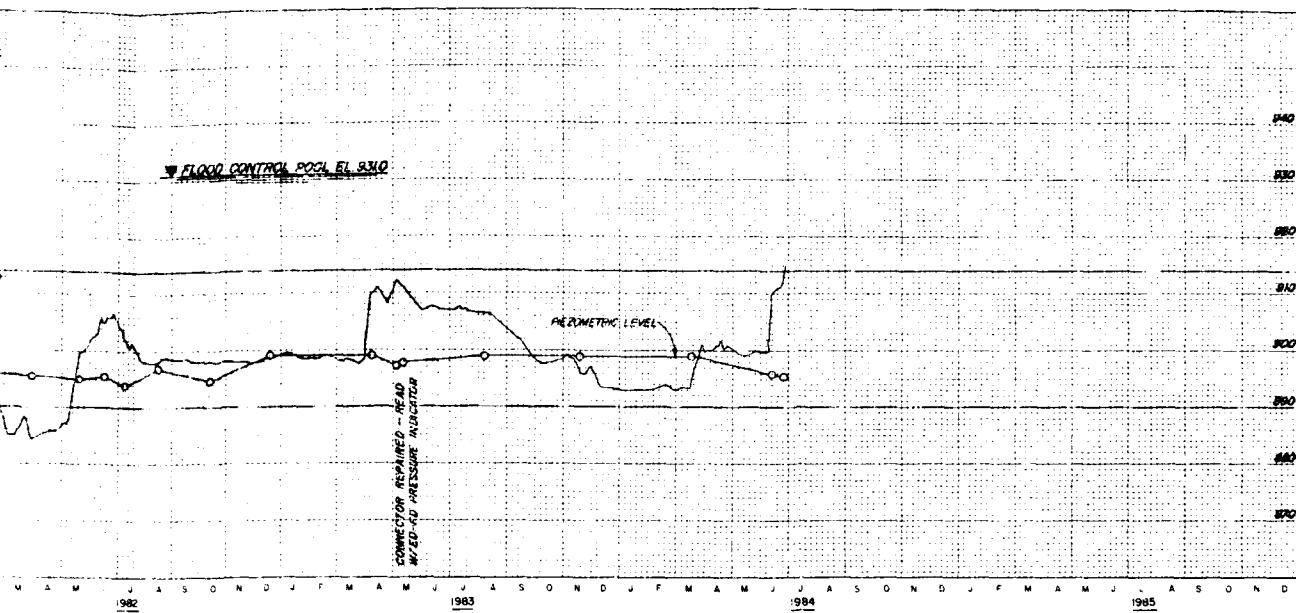
ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929



FLOOD CONTROL POOL EL. 9310

PIEZOMETRIC LEVEL

CONNECTION REPAIRED - HEAD  
W/ED-AD PRESSURE INDICATOR



REVISED SEPTEMBER 1984  
BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
EMBANKMENT CRITERIA REPORT

AIR CELL PIEZOMETER  
P-113-1

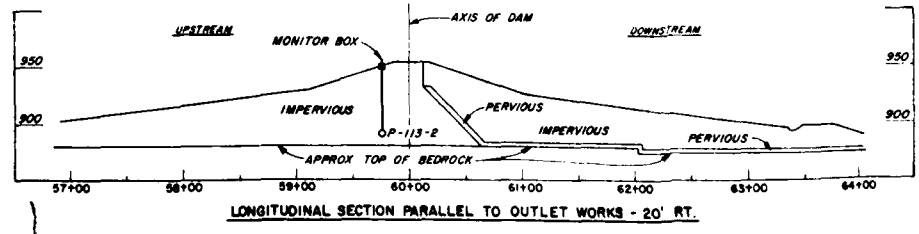
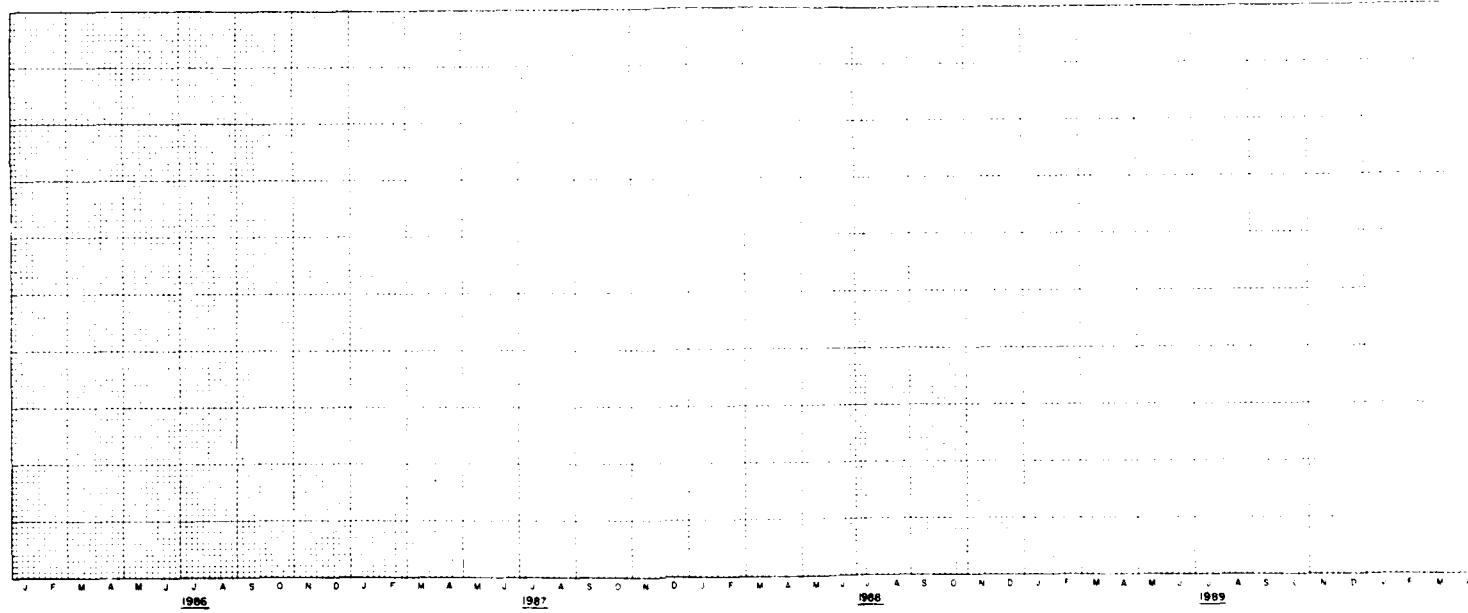
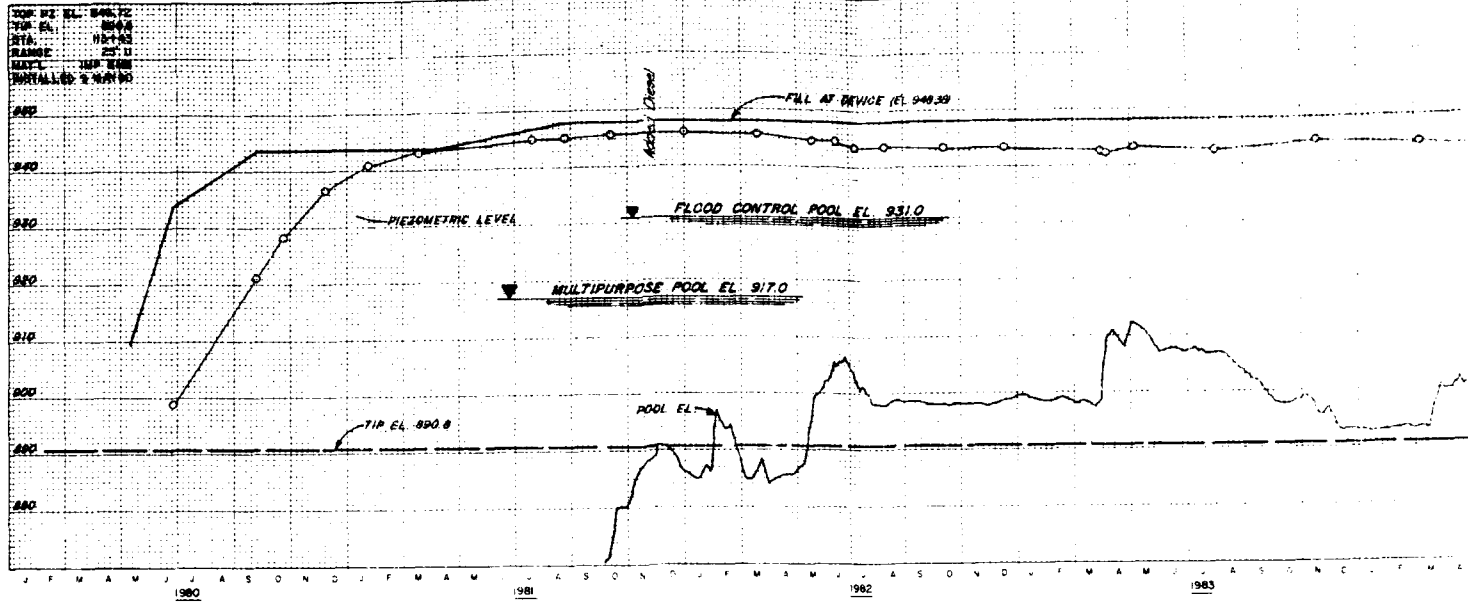
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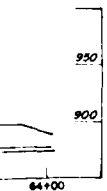
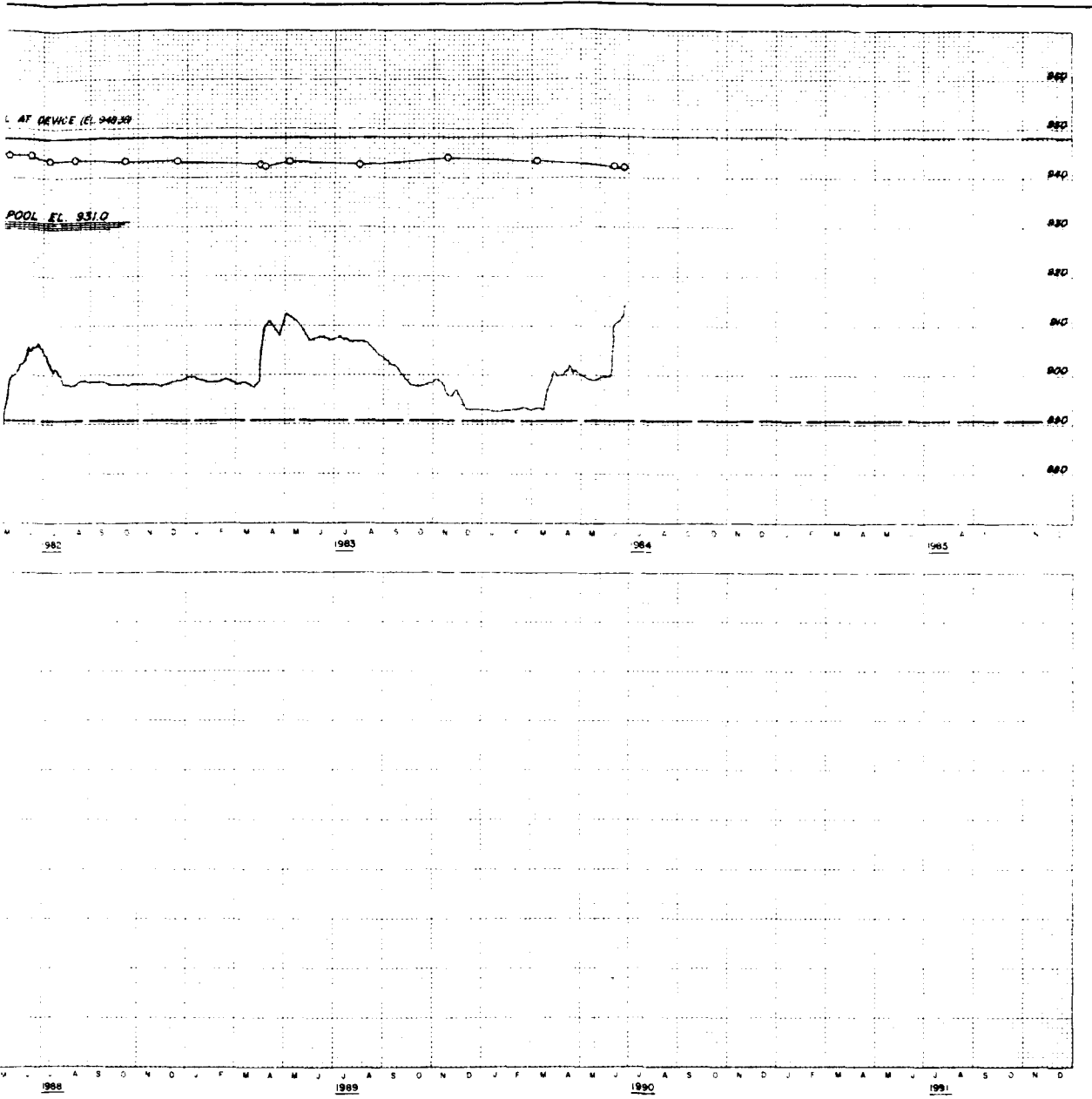
Sheet No. 1

Scale: as shown

CORPS OF ENGINEERS U. S. ARMY  
KANSAS CITY DISTRICT  
FILE NO. O-15-987  
JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929





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 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT  
 OPEN TUBE PIEZOMETER  
 P-113-2

in 1 sheet      Sheet No 1      Scale: as shown  
 CORPS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-988  
 JANUARY 1983

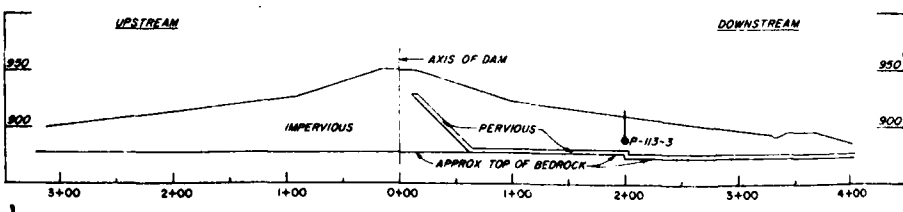
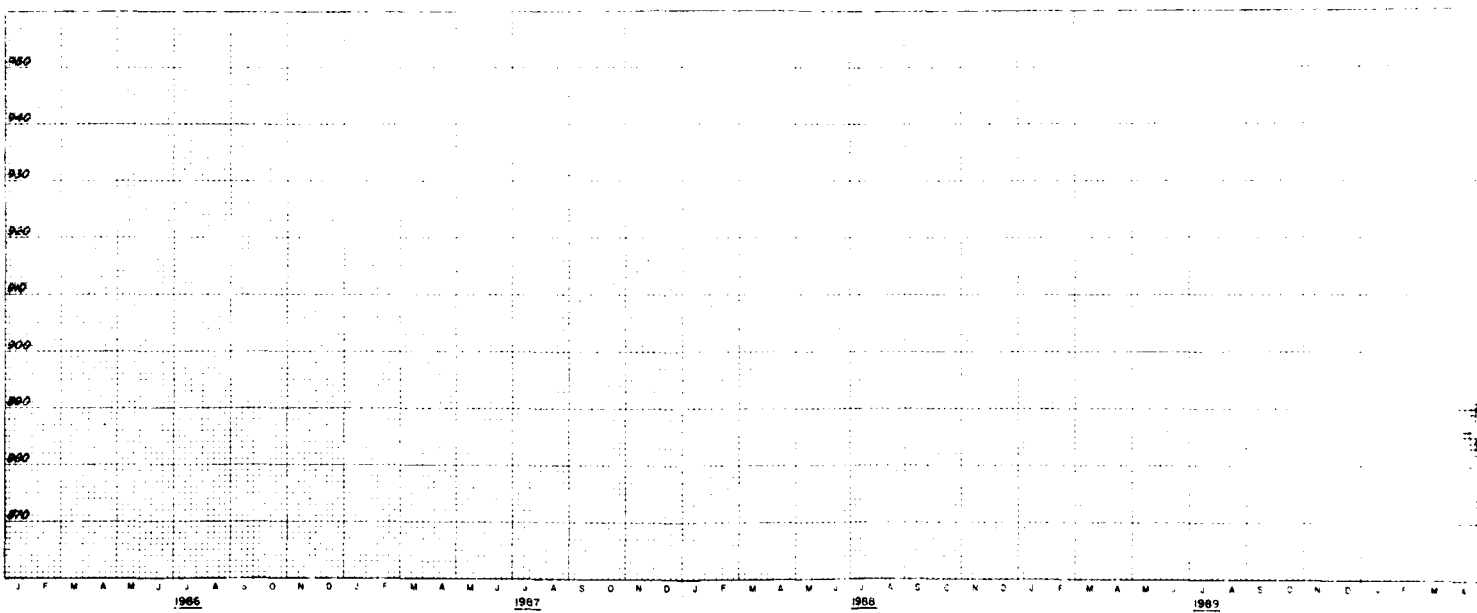
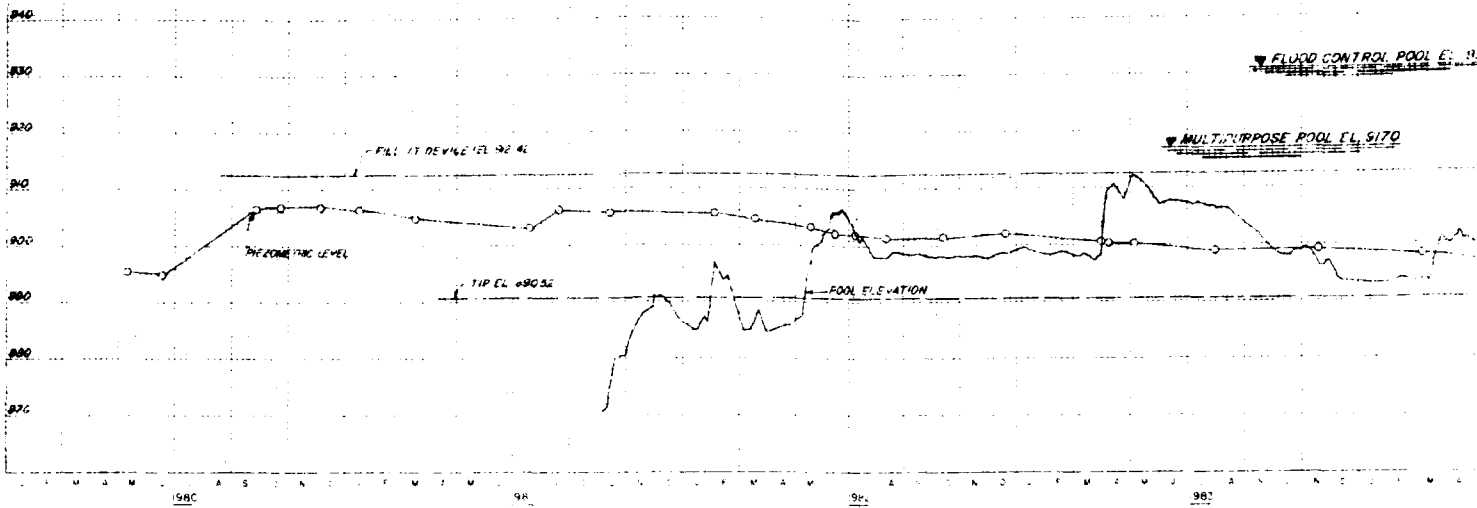
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ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1989

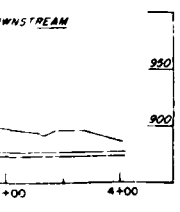
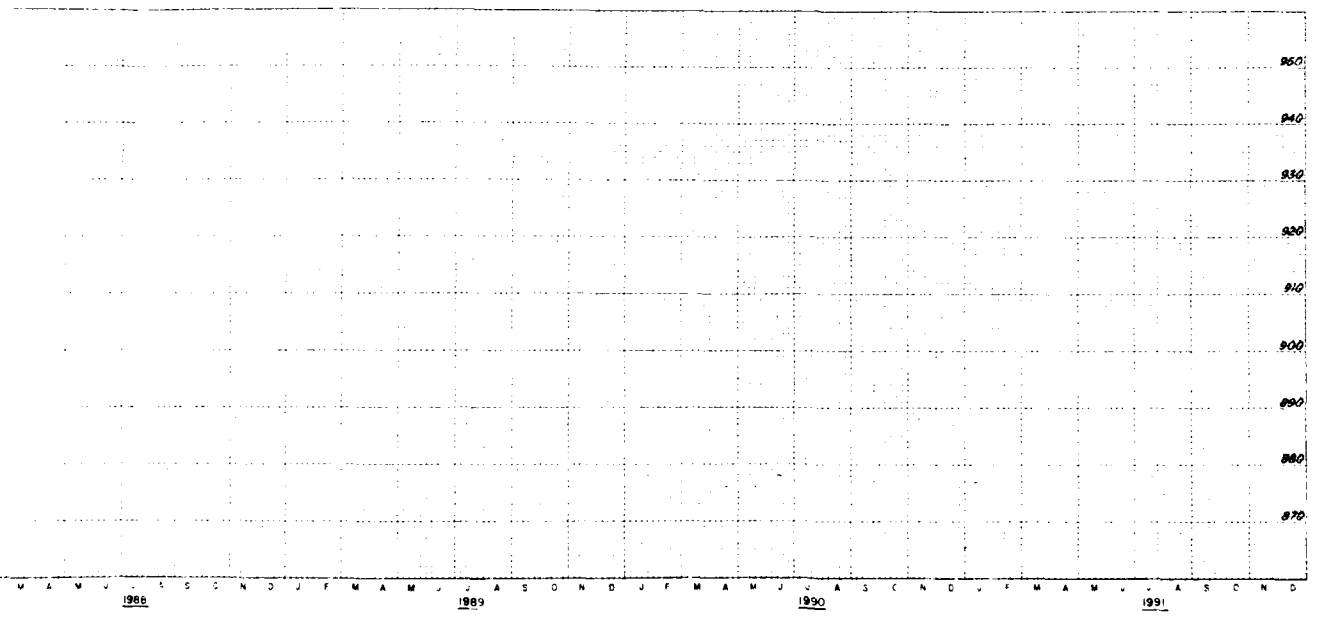
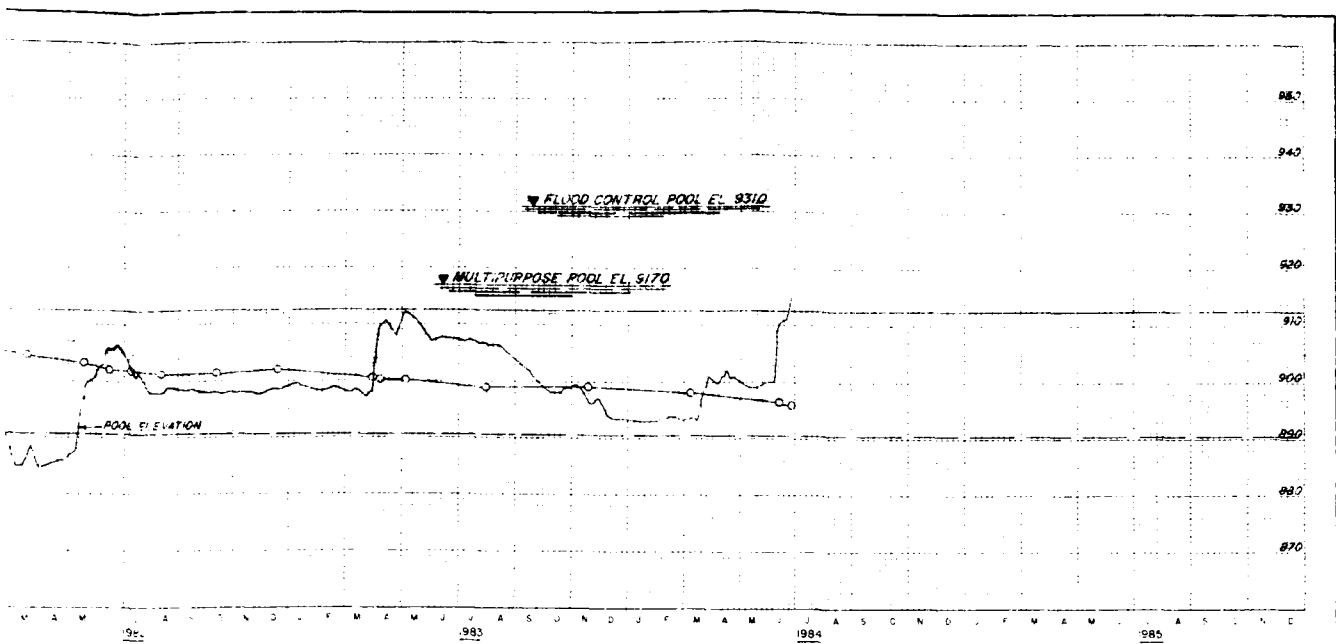
TOP PE EL. 846.45  
 TIP EL. 860.52  
 STA. 15+00  
 RANGE 2+000  
 MAT'L CL  
 INSTALLED 18 MAY 80

FLOOD CONTROL POOL CL. 8170

MULTIPURPOSE POOL CL. 8170







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 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

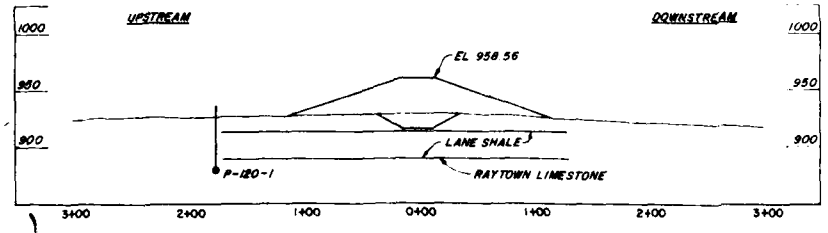
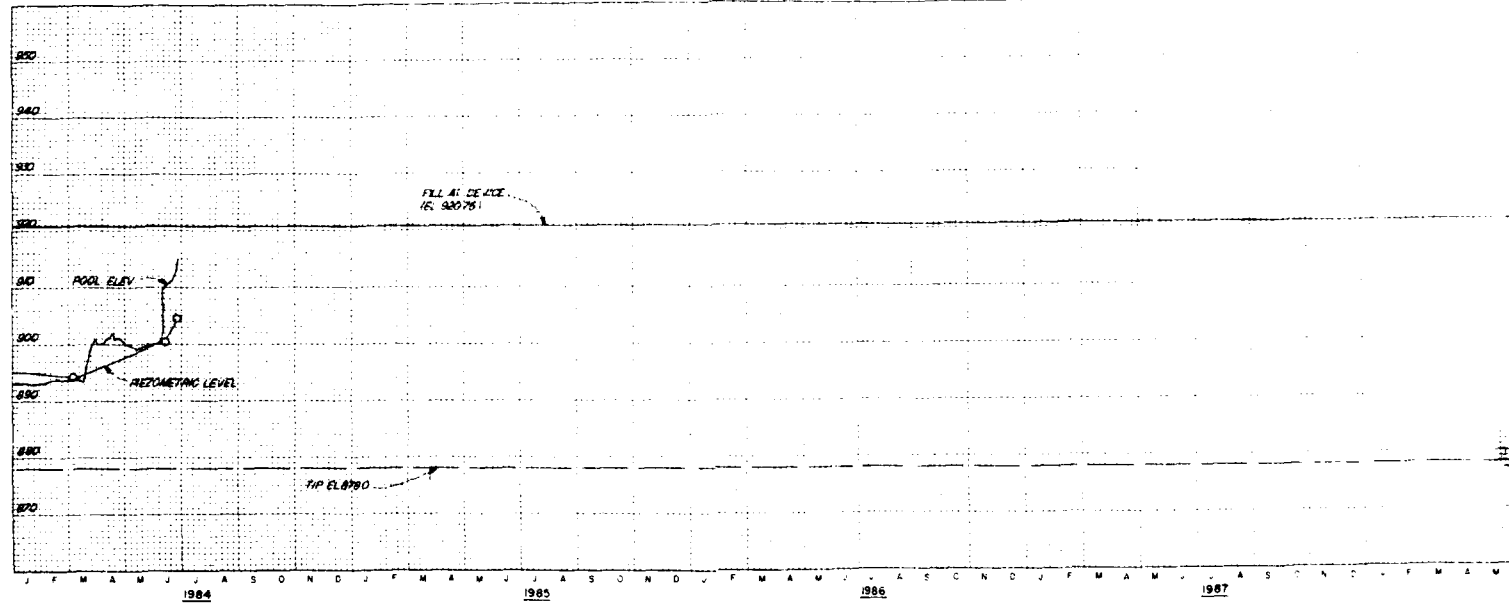
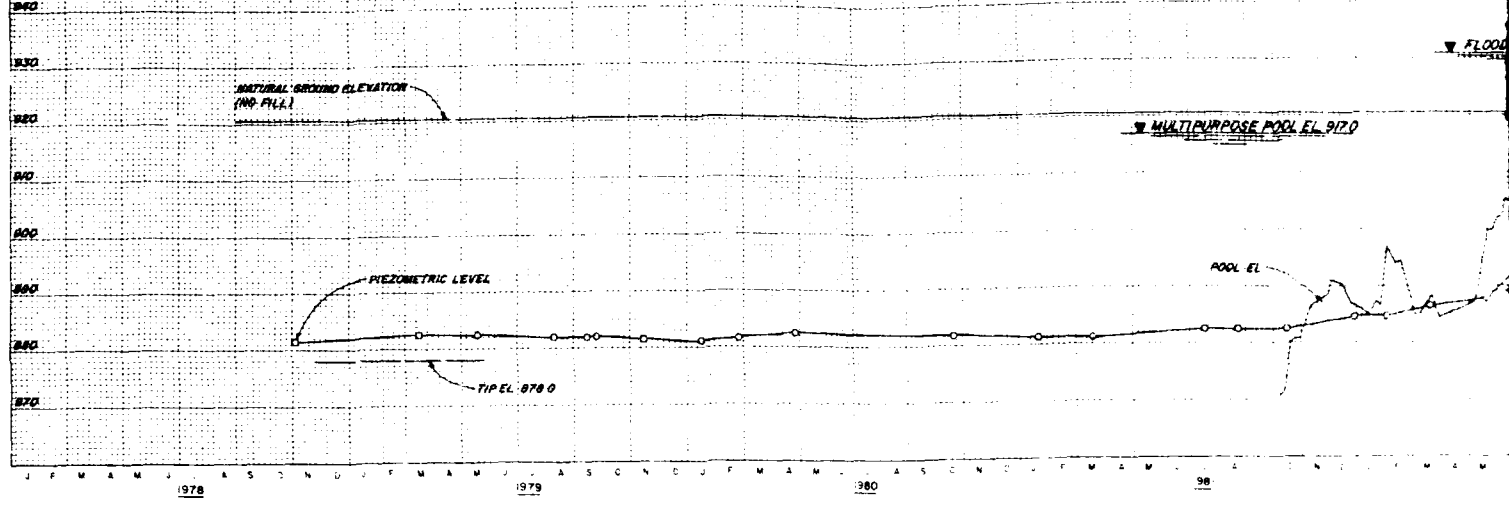
OPEN TUBE PIEZOMETER  
 P-113-3

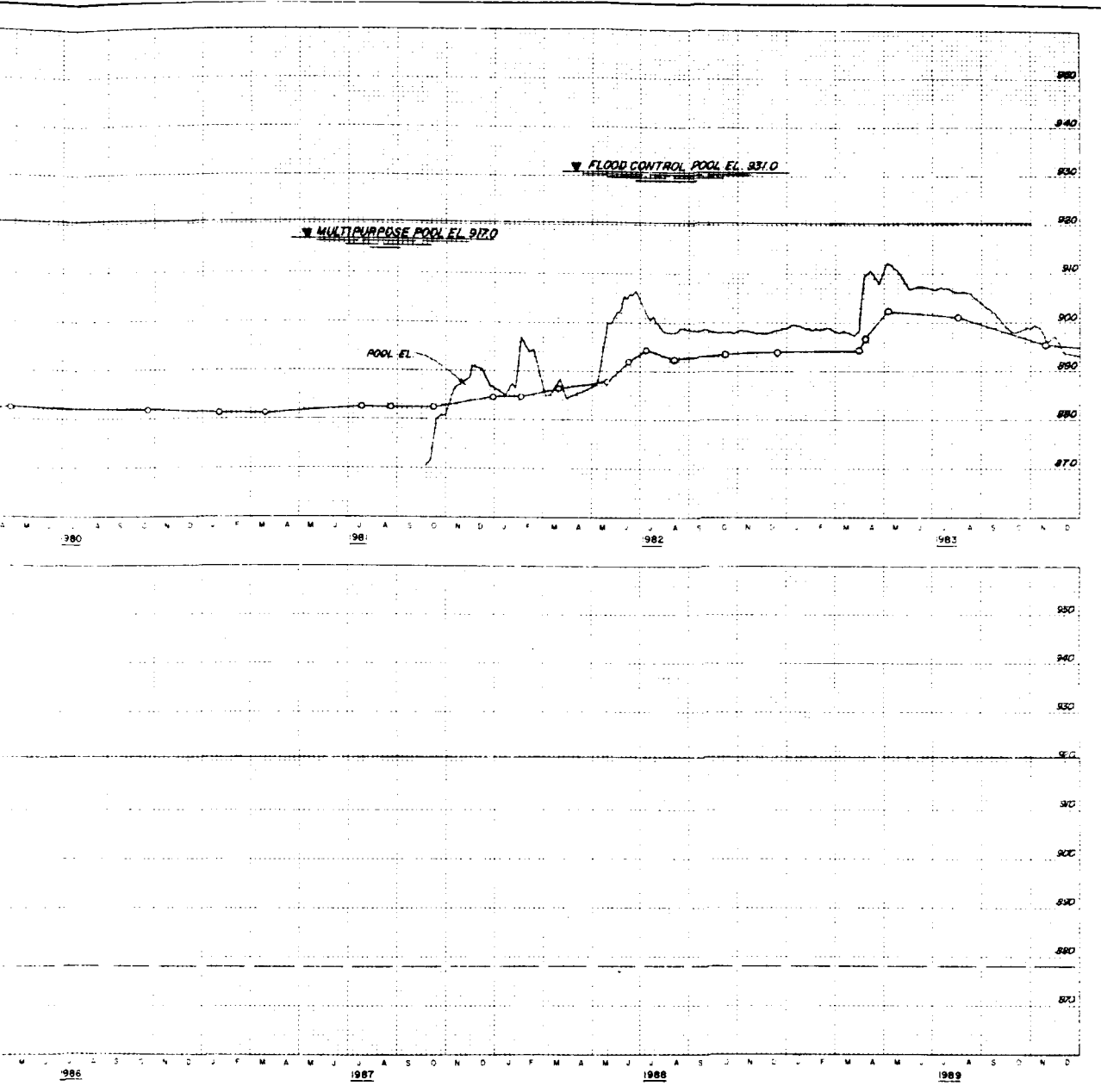
1 in 1 sheet Sheet No 1 Scale as shown

CORPS OF ENGINEERS U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-989  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1989

TOP OF EL. 983.57  
 TIP EL. 876.0  
 DATE: 12/01/00  
 RANGE: 11784  
 MAT'L: L.S.  
 INSTALLED: FEBRU 78





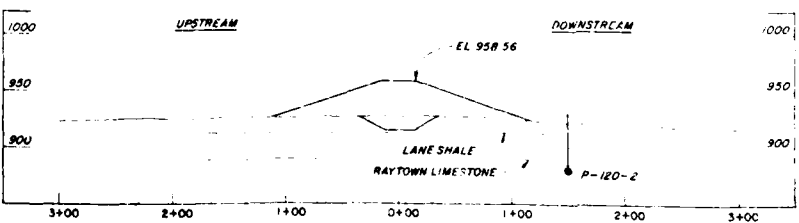
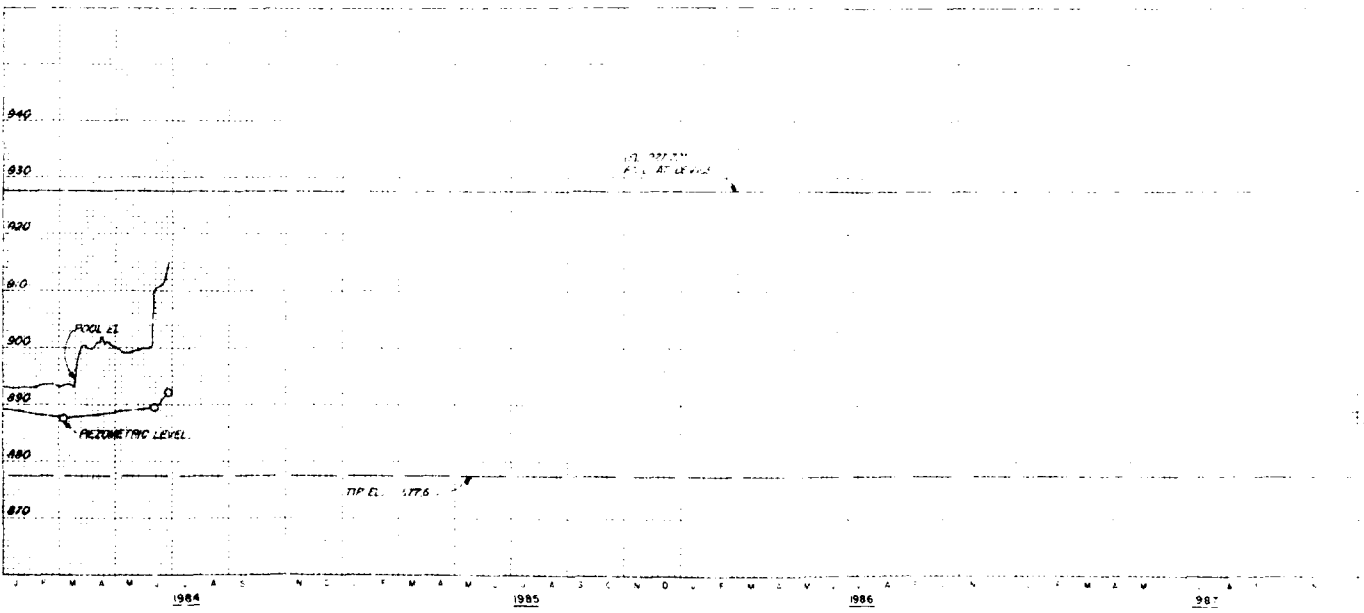
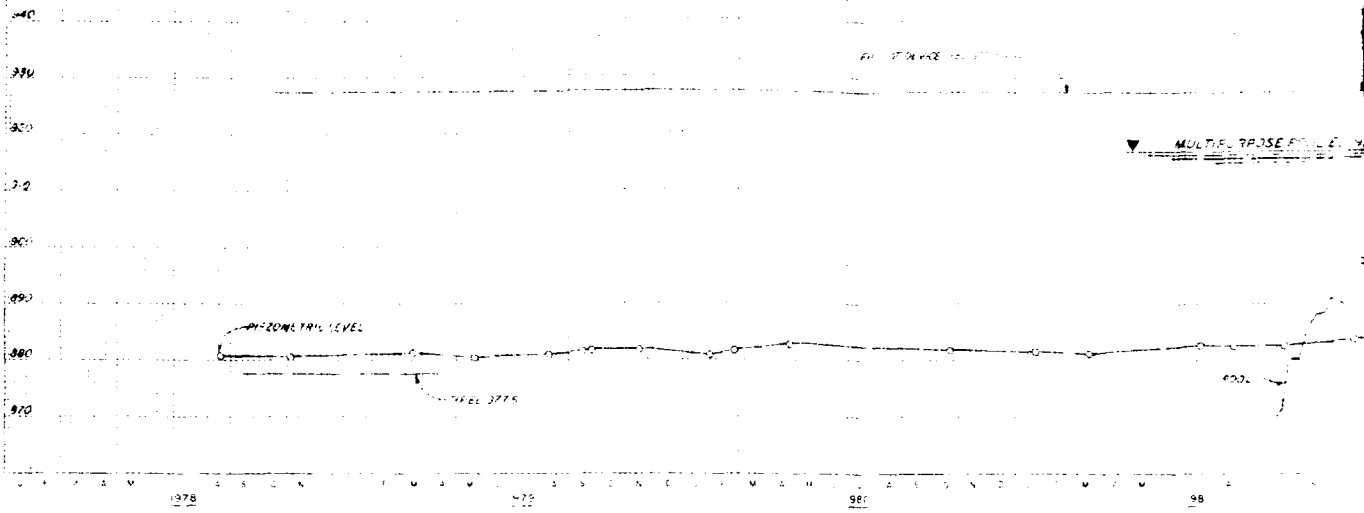
REVISED SEPTEMBER 1984  
 BIG BULL CREEK KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

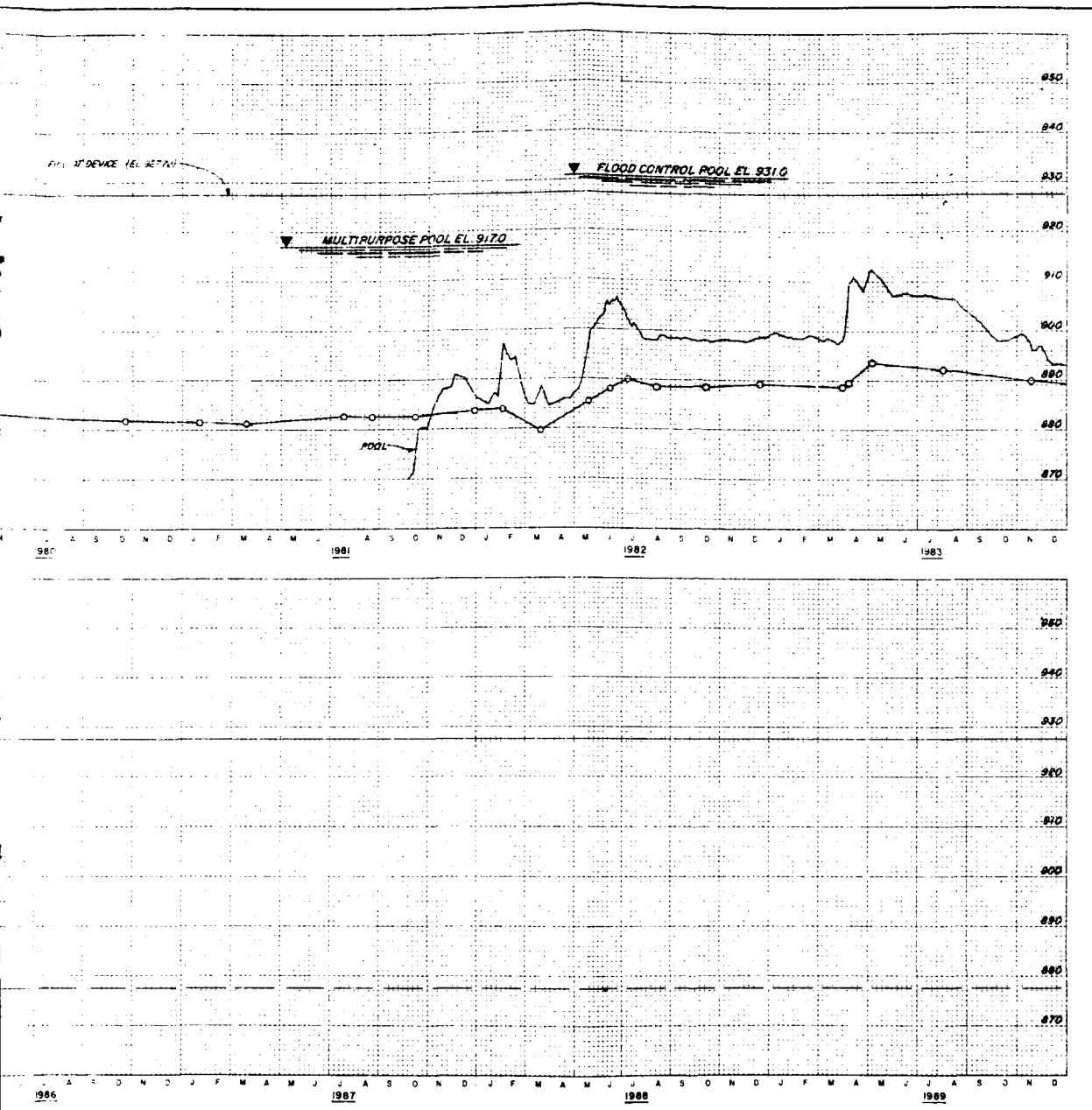
OPEN TUBE PIEZOMETER  
 P-120-1

In 1 sheet      Sheet No 1      Scale as shown  
 CORPS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO O-15-990  
 JANUARY 1983

ELEVATION IN FEET BASED ON NATIONAL GEODESIC LEVEL DATUM OF 1919

TOP PZ EL. 828.68  
 PZ EL. 877.6  
 STA. 120+00  
 RANGE 1+500  
 MAY 15  
 INSTALLED 10 MAY 78





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 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

OPEN TUBE PIEZOMETER  
 P-120-2

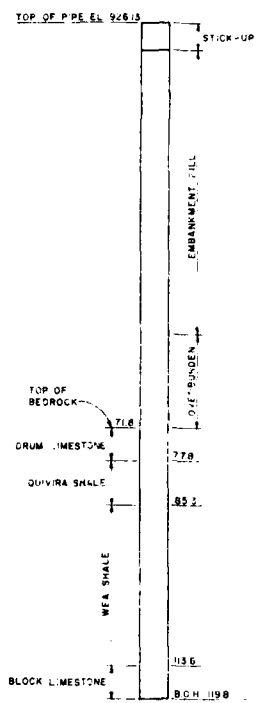
In 1 sheet

Sheet No. 1

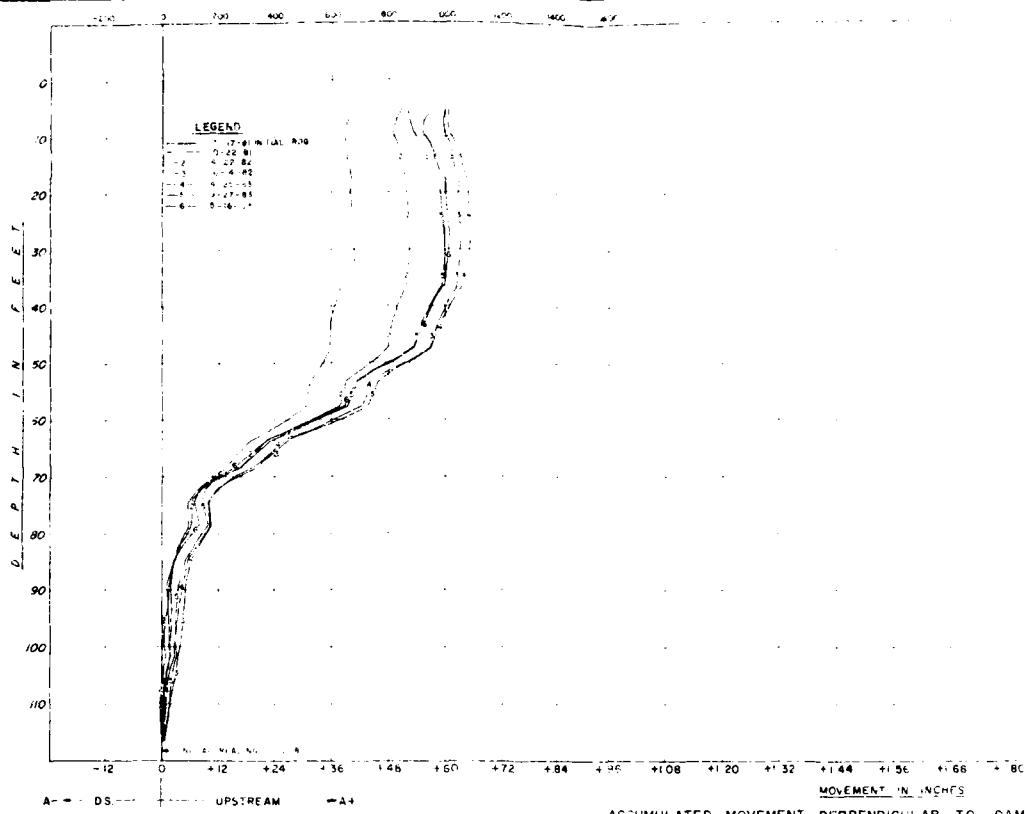
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CORPS OF ENGINEERS U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. O-15-996  
 JANUARY 1983

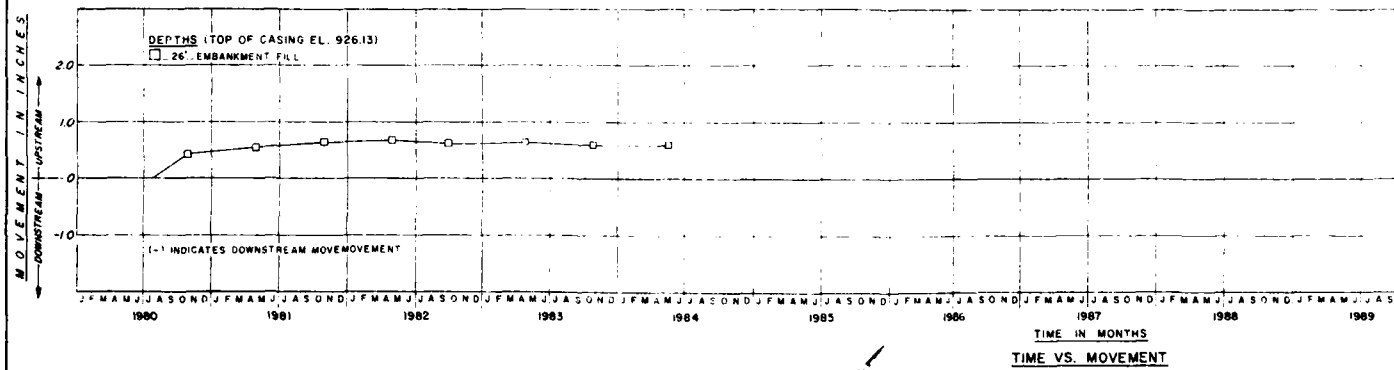
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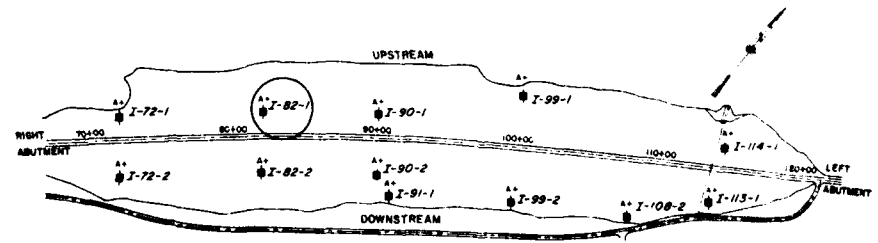
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STATION 82+00  
RANGE 1+40 U/S  
INSTALLED 6-5-81

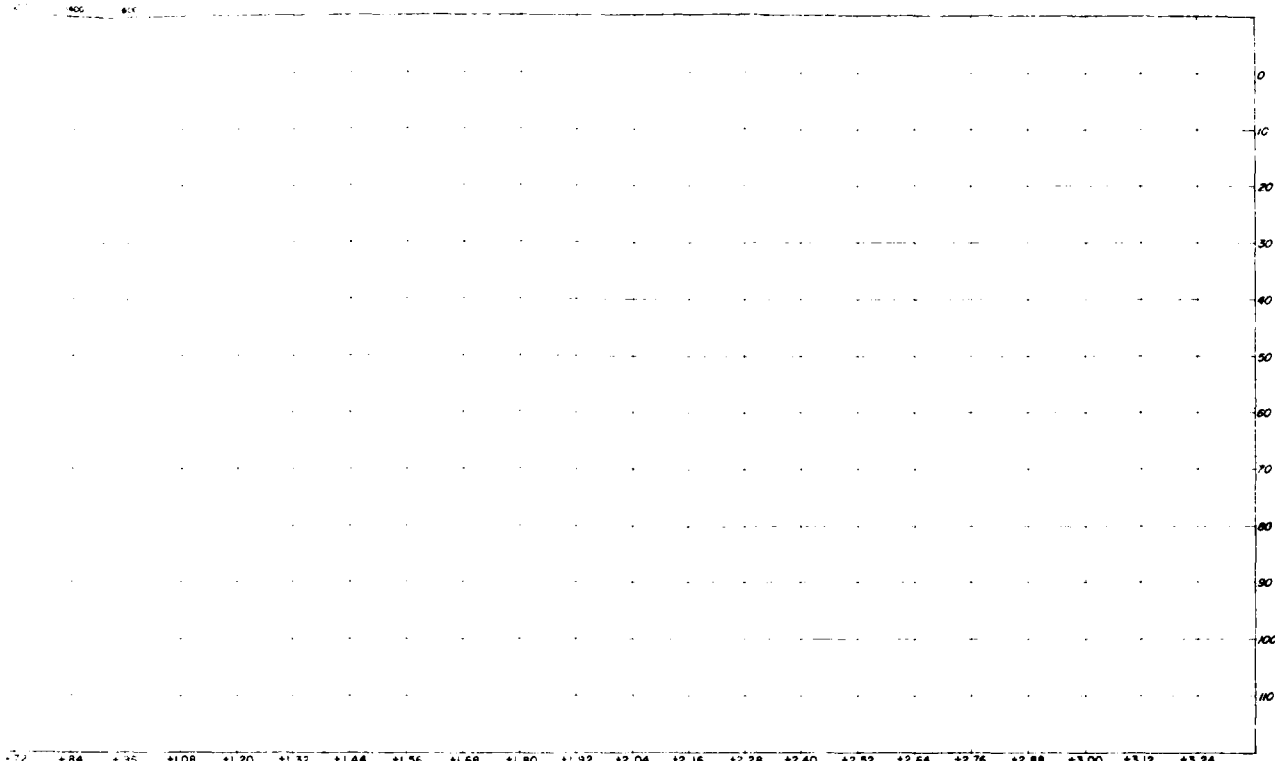


MOVEMENT IN INCHES  
ACCUMULATED MOVEMENT PERPENDICULAR TO DAM

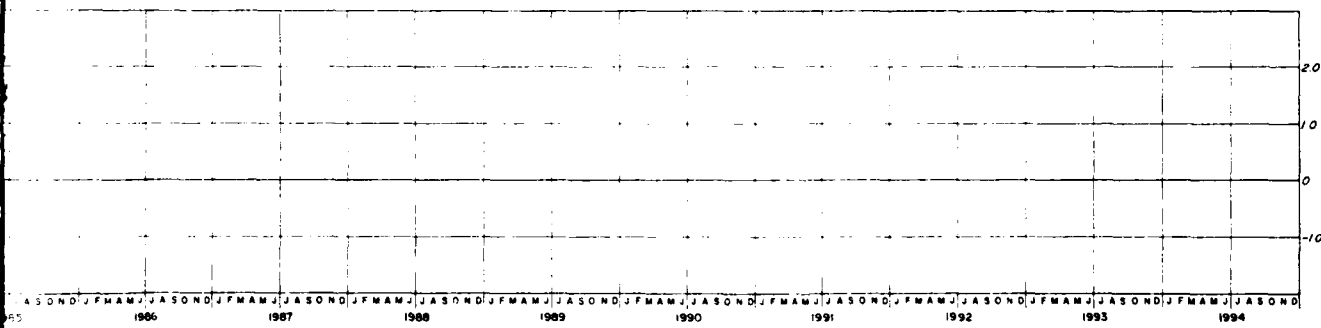


TIME VS. MOVEMENT





ACCUMULATED MOVEMENT PERPENDICULAR TO DAM AXIS VS. DEPTH



TIME VS. MOVEMENT



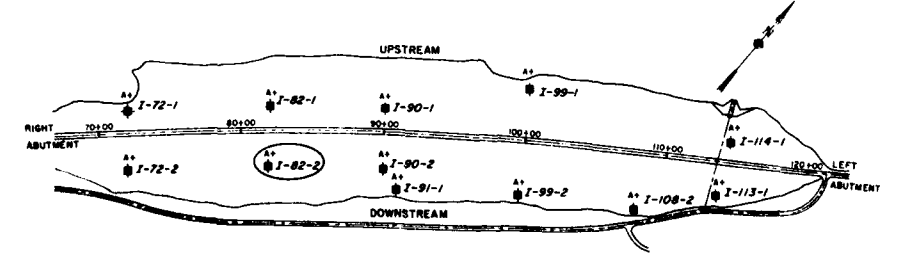
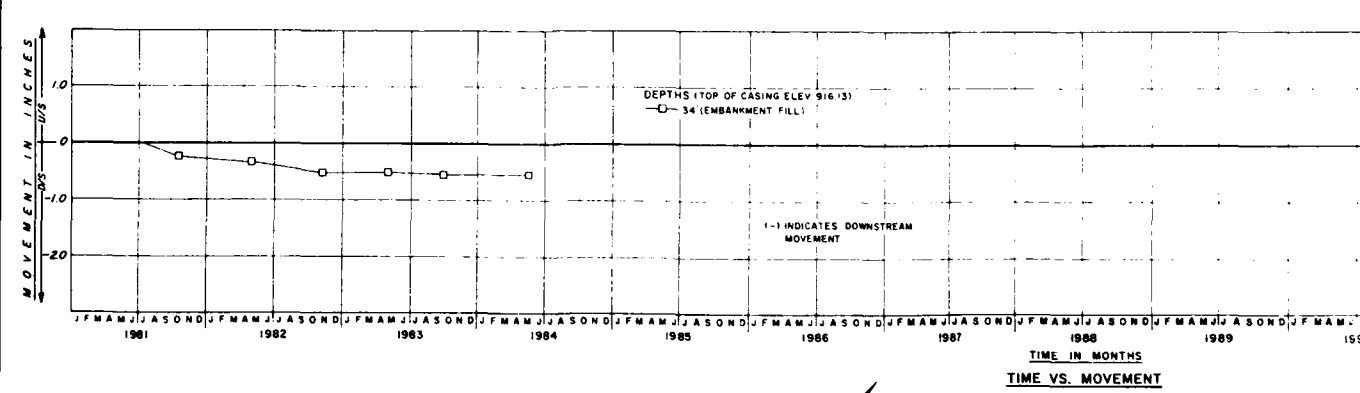
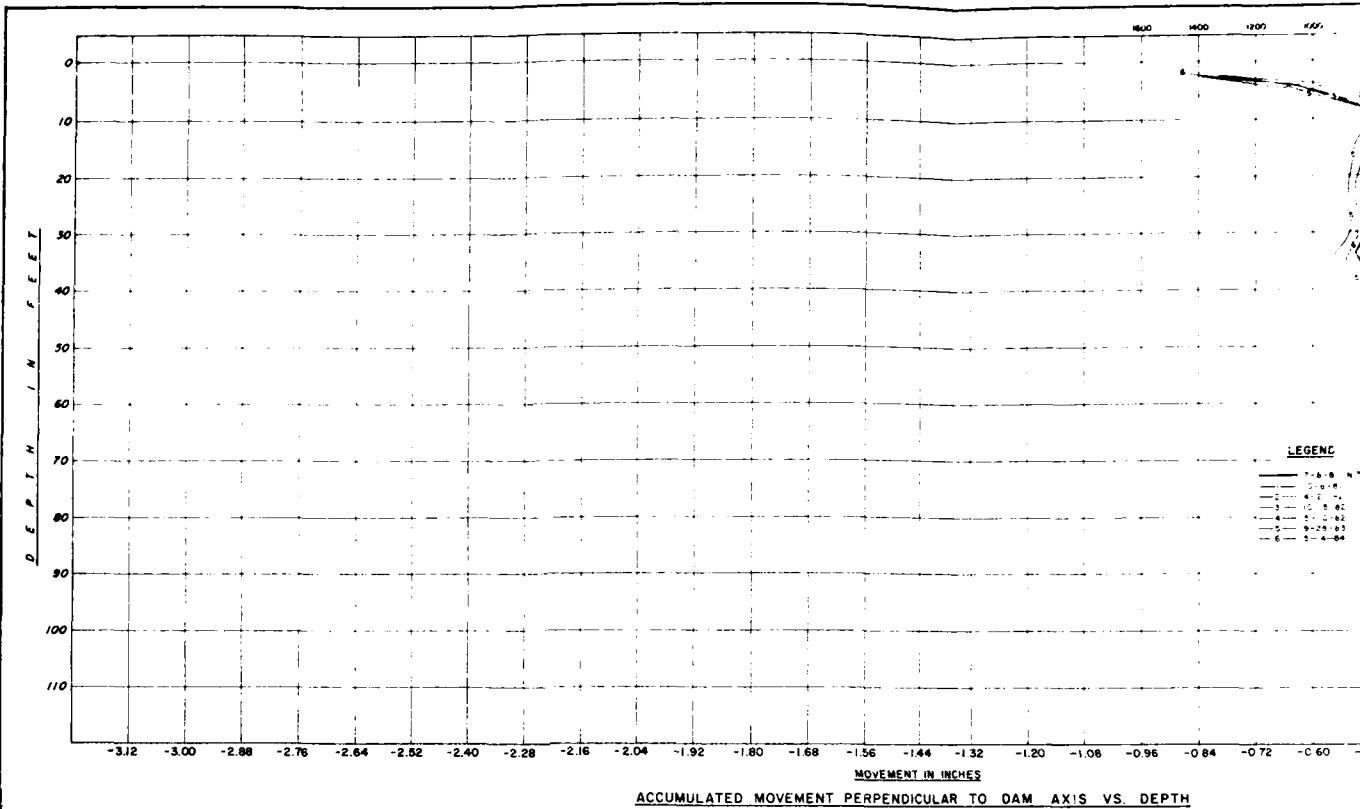
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

INCLINOMETER  
 [-82-1]

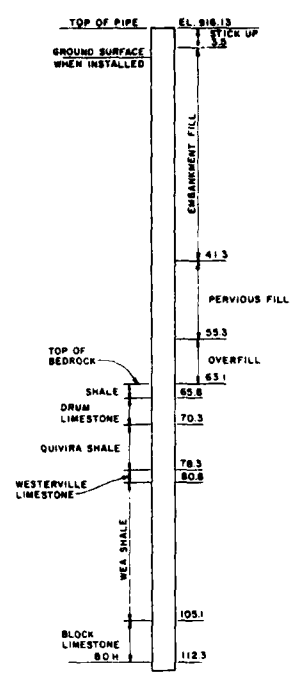
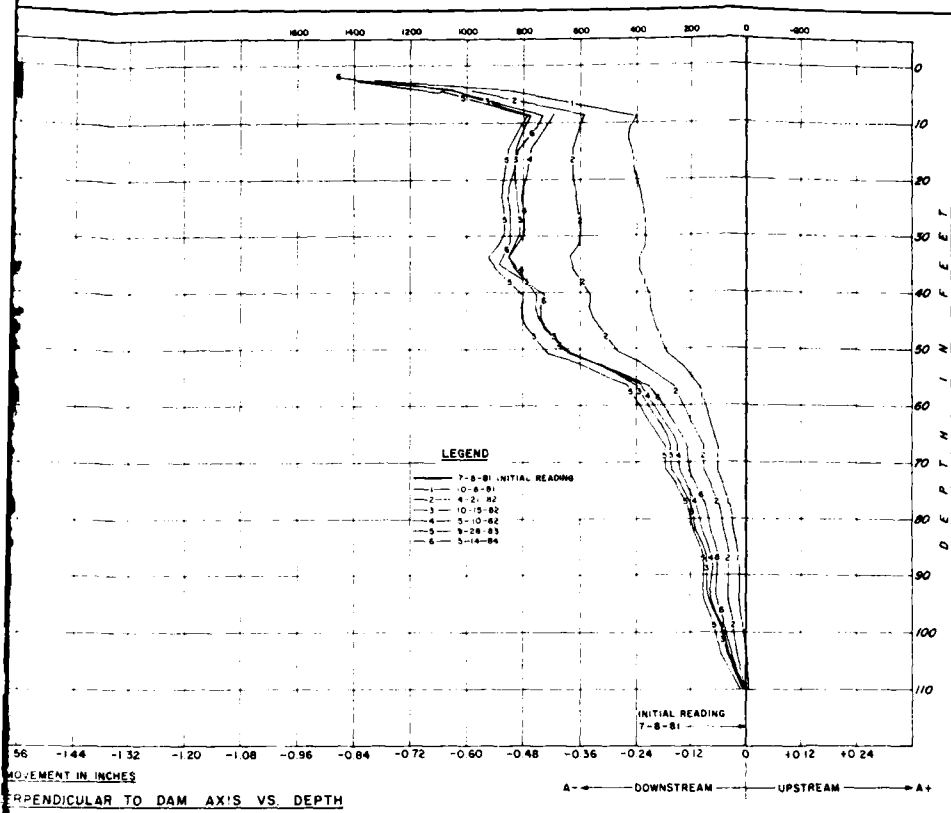
In 1 sheet      Sheet No. 1      Scale: as shown

CORPS OF ENGINEERS      U. S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. C-15-1046  
 JANUARY 1984

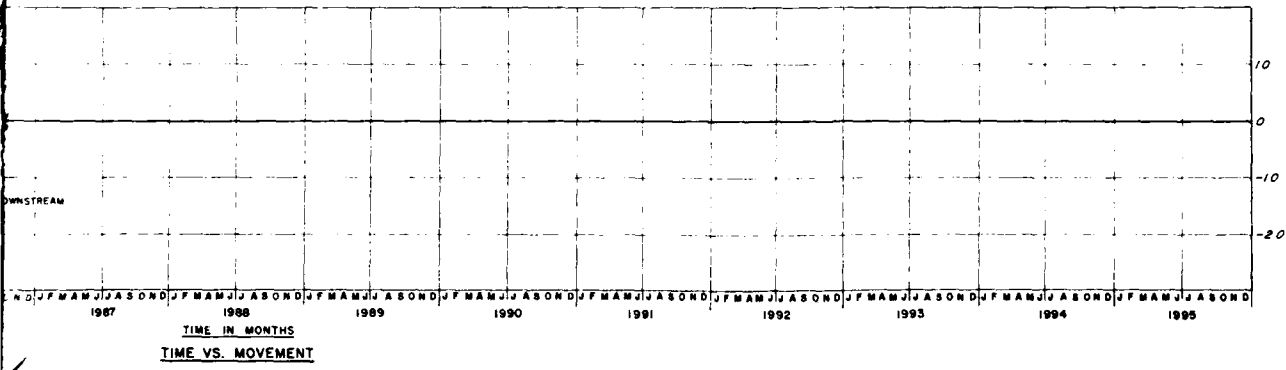
2







I-82-2  
 STA 82+00  
 RANGE 2+50 D/S  
 INSTALLED 6-3-81



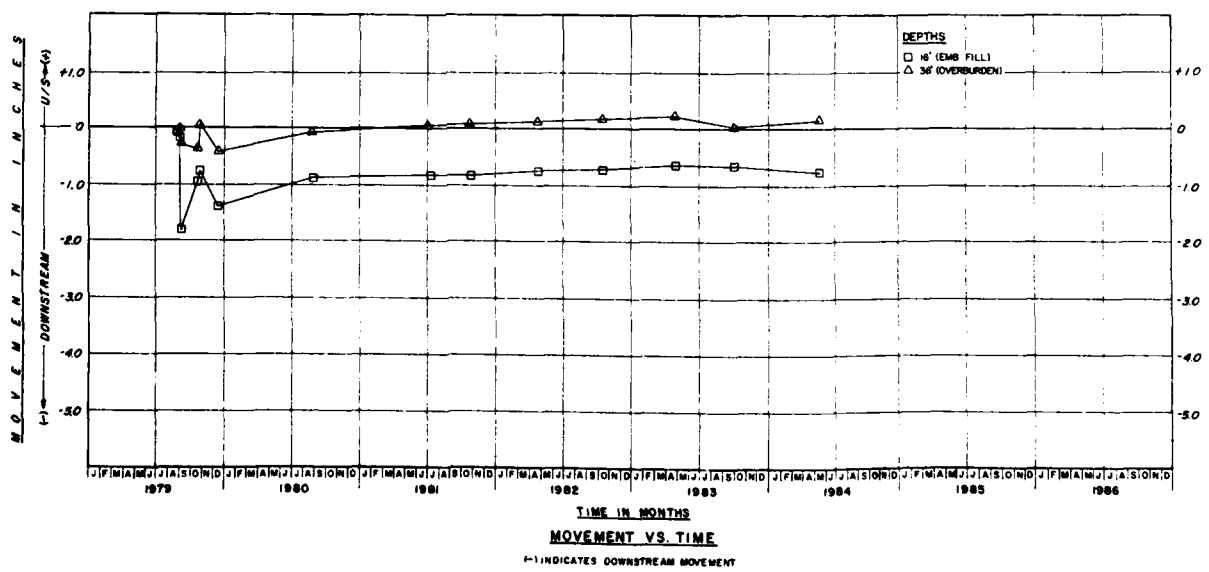
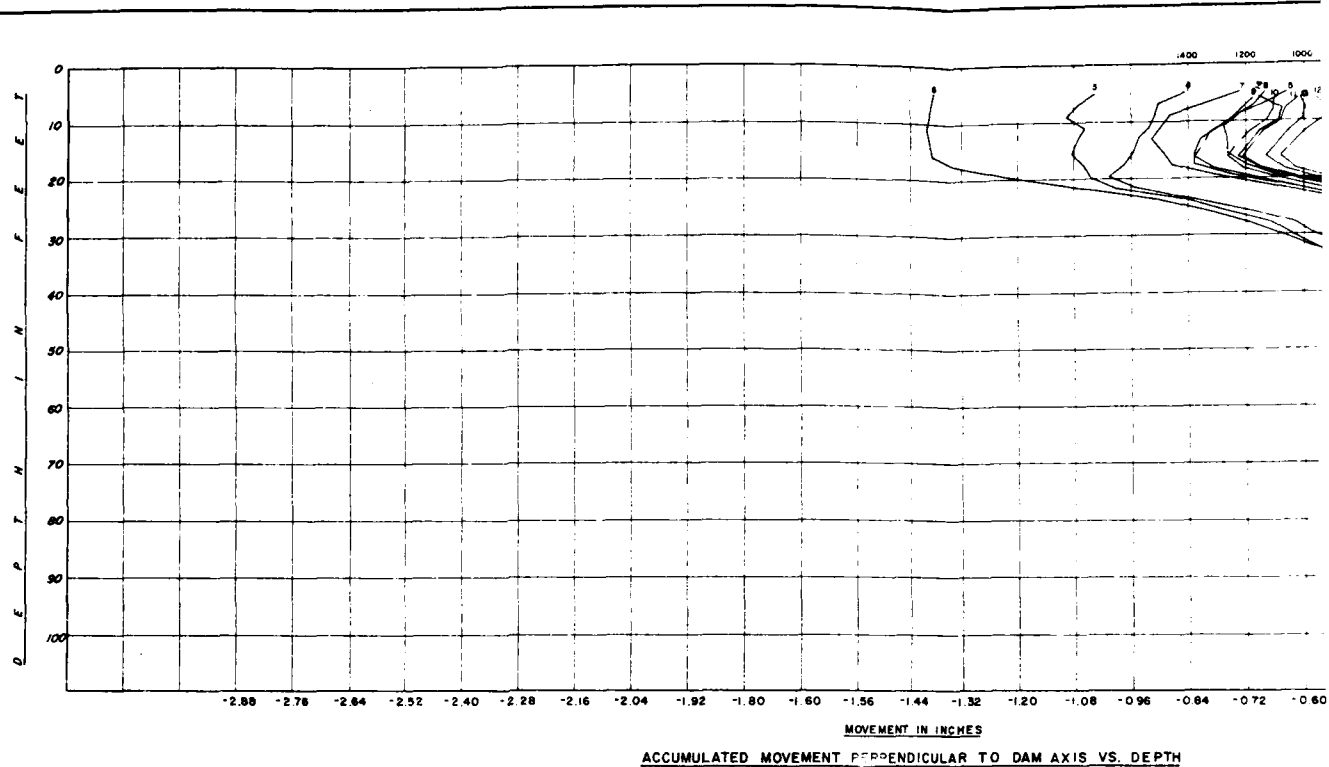
REVISED SEPTEMBER 1984  
 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EM'SANKMENT CRITERIA REPORT

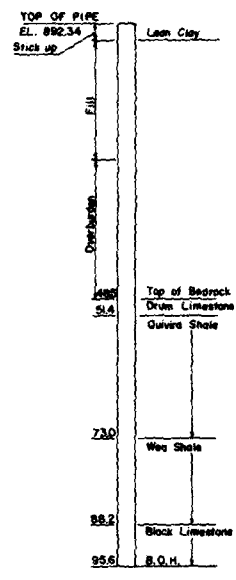
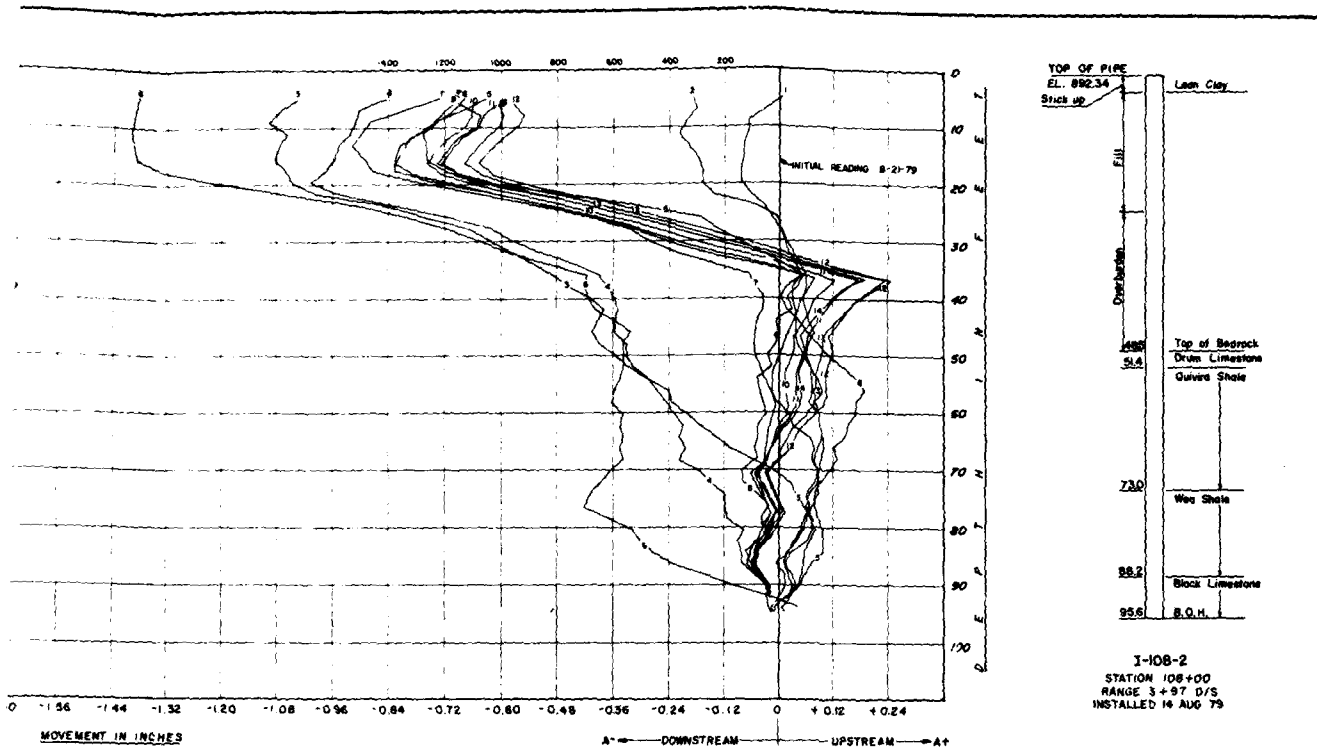
**INCLINOMETER**  
 I-82-2

In 1 sheet      Sheet No. 1      Scale: as shown

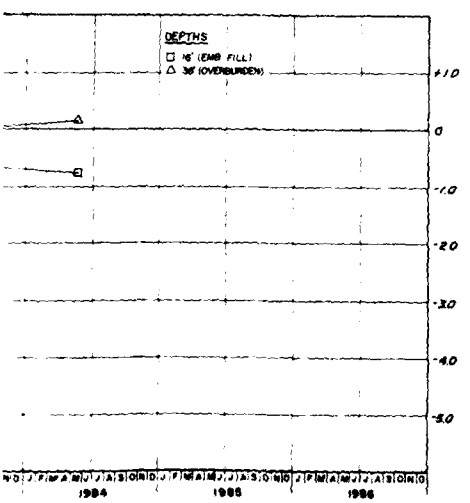
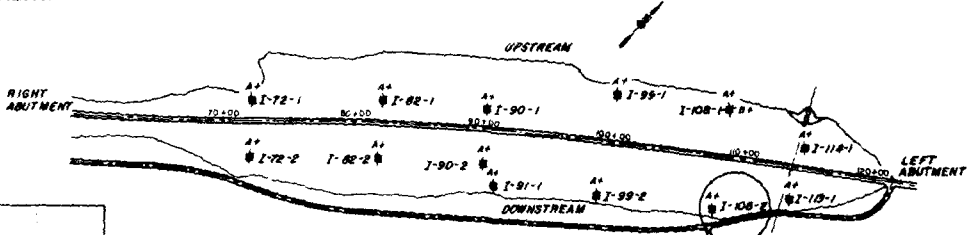
CORPS OF ENGINEERS      U.S. ARMY  
 KANSAS CITY DISTRICT  
 FILE NO. 0-15-1047  
 JANUARY 1984

2





I-108-2  
STATION 108+00  
RANGE 3+ST. D/S  
INSTALLED 14 AUG 79



- LEGEND
- 21 AUG 79 (INITIAL READING)
  - 1 - 23 AUG 79
  - 2 - 30 AUG 79
  - 3 - 15 SEP 79
  - 4 - 17 OCT 79
  - 5 - 26 OCT 79
  - 6 - 13 DEC 79
  - 7 - 18 AUG 80
  - 8 - 9 JAN 81
  - 9 - 22 OCT 81 (FIRST READING WITH DRIFT)
  - 10 - 20 APR 82
  - 11 - 13 OCT 82
  - 12 - 27 APR 83
  - 13 - 22 SEP 83
  - 14 - 15 MAY 84

REVISED SEPTEMBER 1984  
BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
EMBANKMENT CRITERIA REPORT

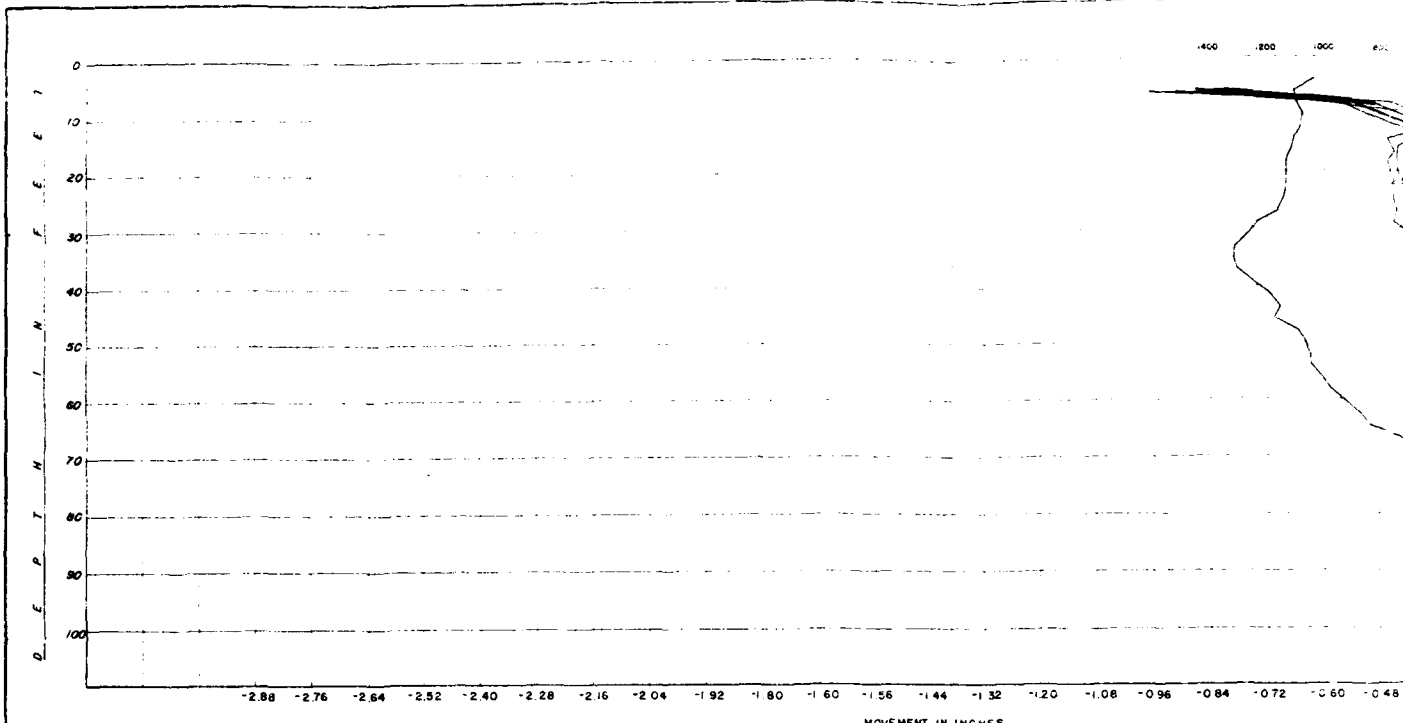
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I-108-2

In 1 sheet

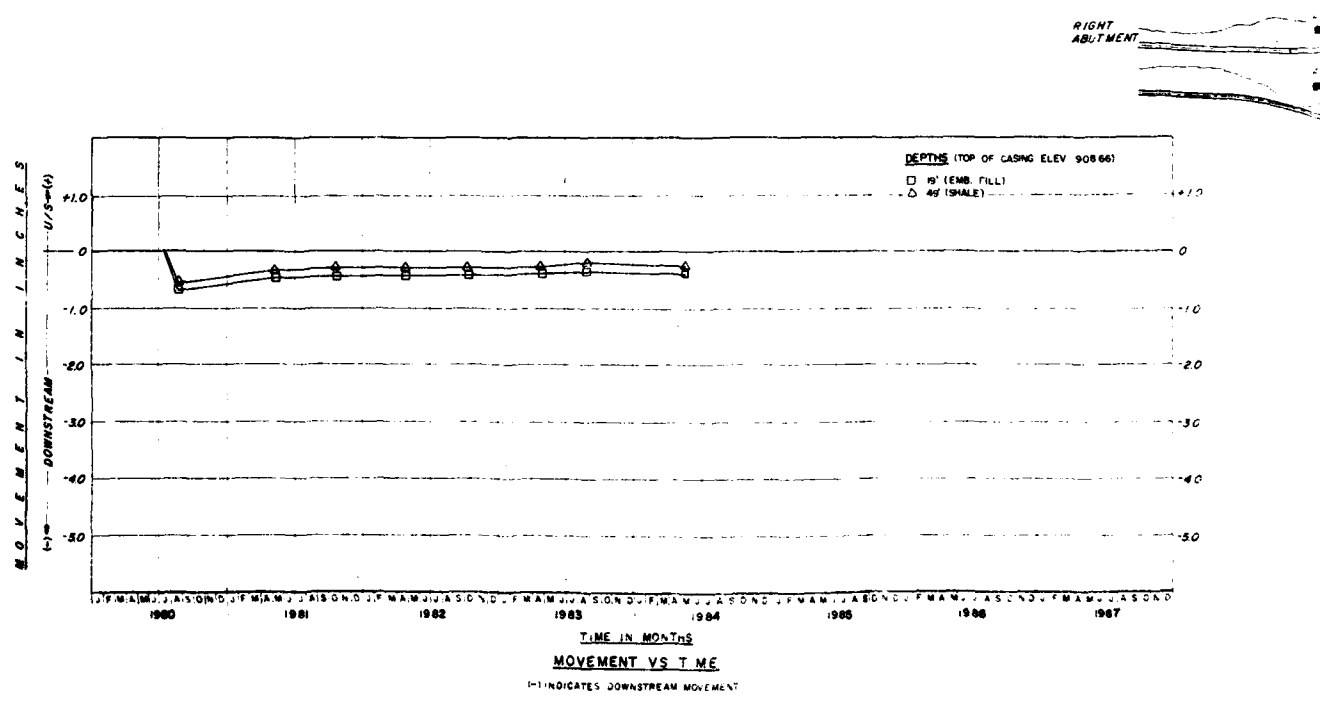
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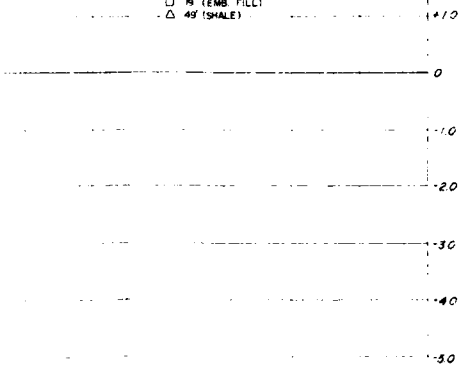
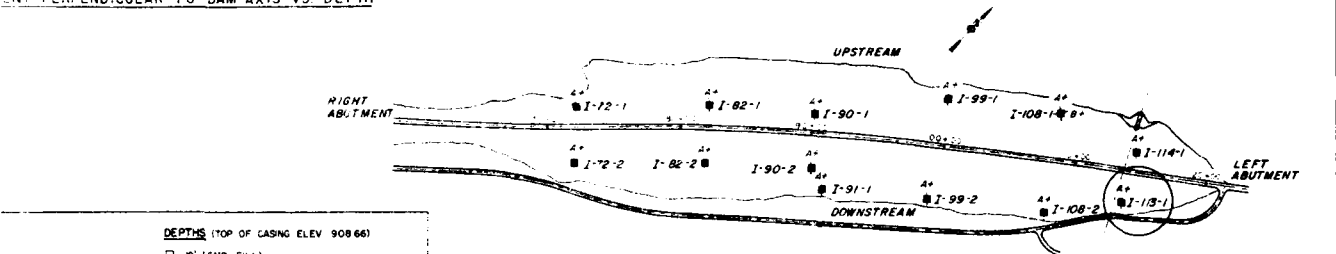
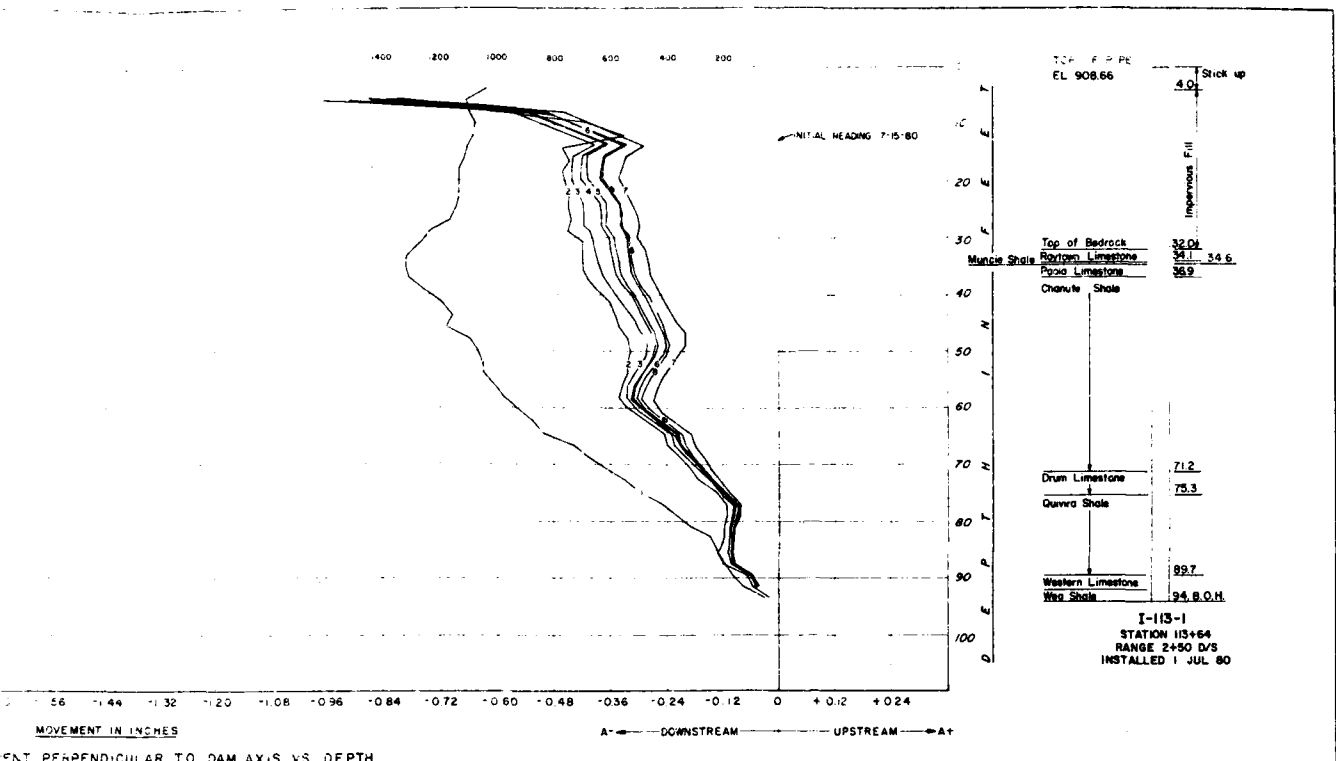
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KANSAS CITY DISTRICT  
FILE NO. 0-15-1064  
JANUARY 1984



ACCUMULATED MOVEMENT PERPENDICULAR TO DAM AXIS VS. DEPTH





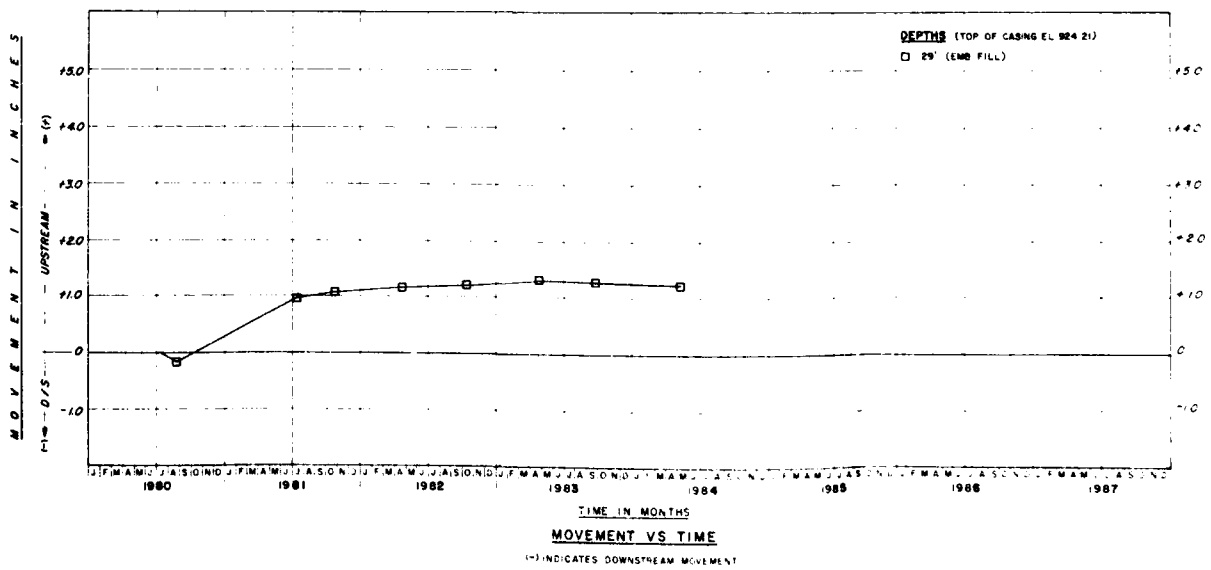
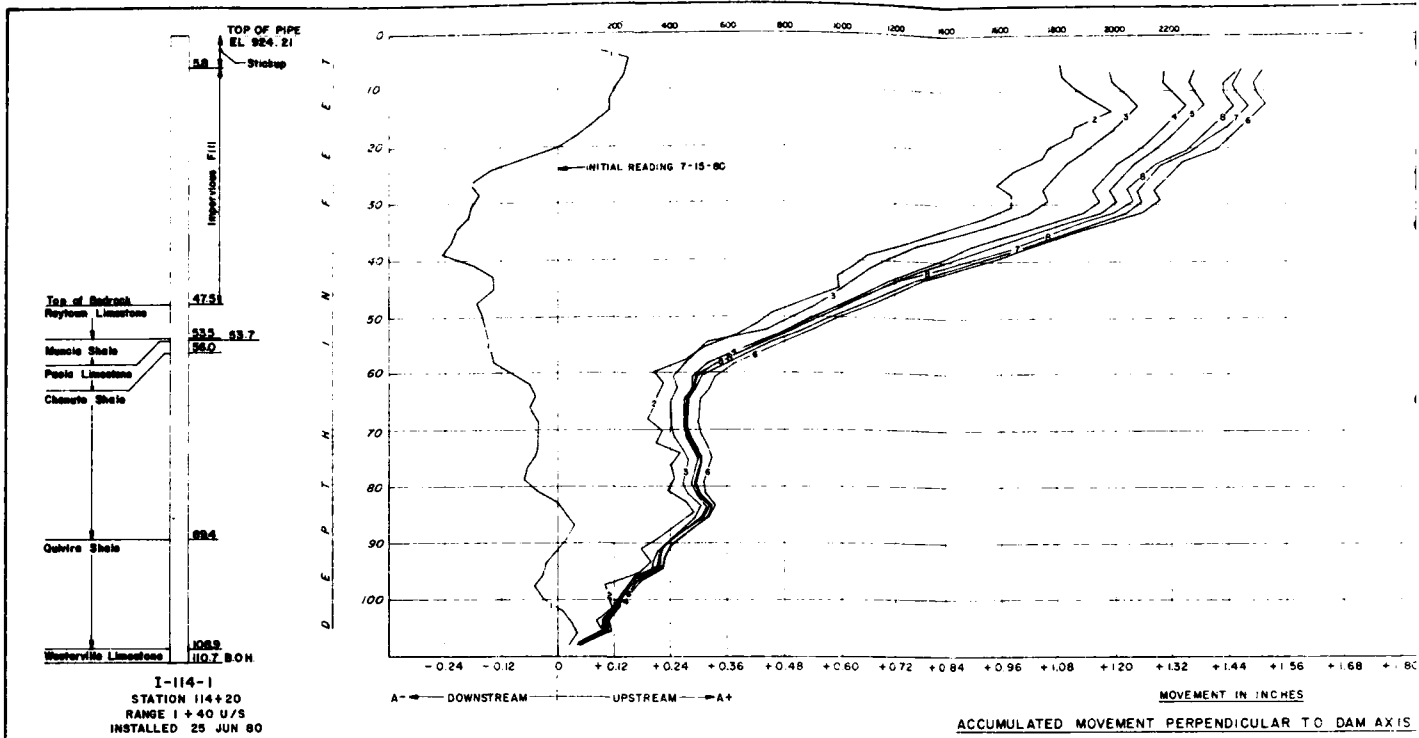
- LEGEND**
- 15 JUL 80 (INITIAL READING)
  - 1- 18 AUG 80
  - 2- 12 MAY 81
  - 3- 20 OCT 81 (FIRST READING WITH DIGIT)
  - 4- 20 APR 82
  - 5- 13 OCT 82
  - 6- 27 APR 83
  - 7- 22 SEP 83
  - 8- 15 MAY 84

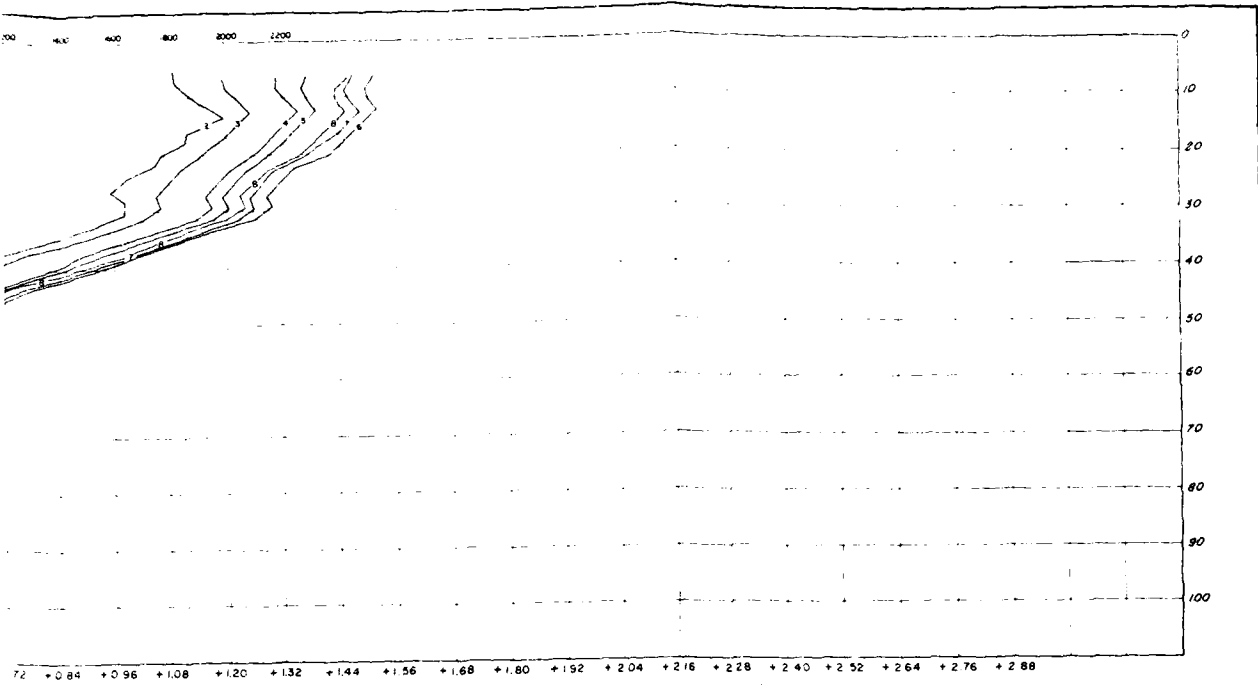
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 BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
 EMBANKMENT CRITERIA REPORT

**INCLINOMETER**  
 I-113-1

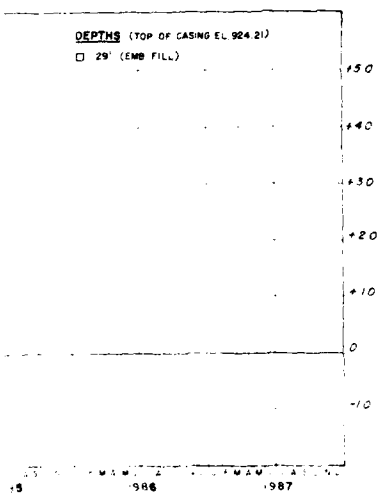
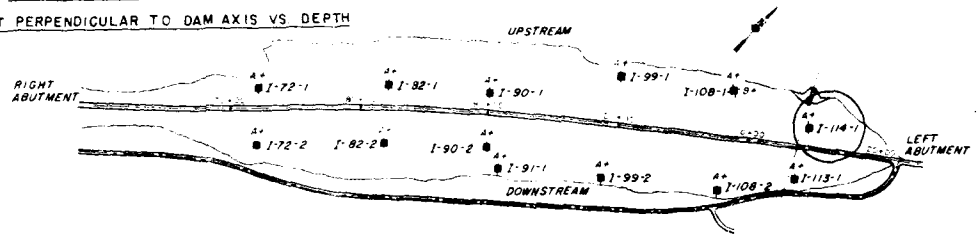
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 KANSAS CITY DISTRICT  
 FILE NO. O-15-1055  
 JANUARY 1984

2





MOVEMENT IN INCHES  
ACCUMULATED MOVEMENT PERPENDICULAR TO DAM AXIS VS. DEPTH



- LEGEND**
- 15 JUL 80 (INITIAL READING)
  - 1- 18 AUG 80
  - 2- 8 JUL 81
  - 3- 22 OCT 81 (FIRST READING W/DIGITILT)
  - 4- 20 APR 82
  - 5- 14 OCT 82
  - 6- 28 APR 83
  - 7- 27 SEP 83
  - 8- 15 MAY 84

REVISED SEPTEMBER 1984  
BIG BULL CREEK, KANSAS  
**HILLSDALE LAKE**  
EMBANKMENT CRITERIA REPORT

**INCLINOMETER**  
I-114-1

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KANSAS CITY DISTRICT  
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Scale, as shown

END

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FILMED

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