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NATIONAL DAM SAFETY PROGRAM. HARRISONVILLE CITY LAKE DAM (MO 20--ETC(U)
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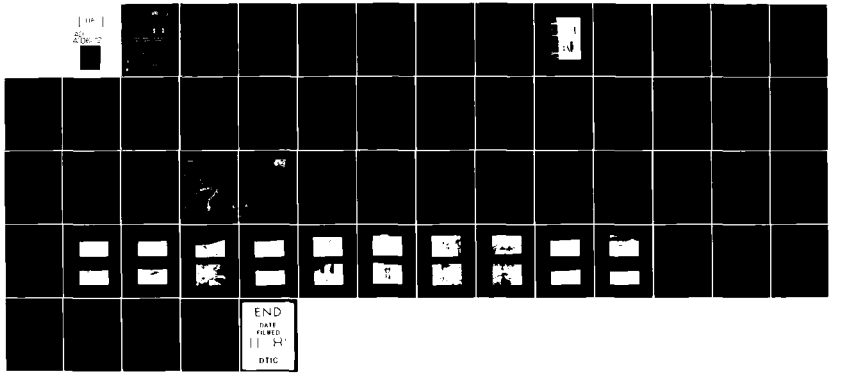

LEVEL II

1

MISSOURI-KANSAS CITY BASIN

HARRISONVILLE CITY LAKE DAM

CASS COUNTY, MISSOURI

MO 20077

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

APRIL 1979

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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Paul R. /Zaman
Edwin R. /Burton
Harry L. /Callahan

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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HARRISONVILLE CITY LAKE DAM

CASS COUNTY, MISSOURI

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FOR: STATE OF MISSOURI

APRIL 1979

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Harrisonville City Lake Dam, Missouri ID No. 20077

This report presents the results of field inspection and evaluation of the Harrisonville City Lake Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY: SIGNED
Chief, Engineering Division
20 SEP 1979
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer
20 SEP 1979
Date

HARRISONVILLE CITY LAKE DAM

CASS COUNTY, MISSOURI

MISSOURI INVENTORY NO. 20077

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

APRIL 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Harrisonville City Lake Dam
State Located	Missouri
County Located	Cass County
Stream	Tributary to Big Creek
Date of Inspection	26 April 1979

Harrisonville City Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as an intermediate size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten the life and property of approximately eleven families and six farm buildings downstream of the dam and would potentially cause appreciable damage to the Missouri Pacific Railroad, the Chicago and Rock Island Railroad, State Highway 7, and one improved road crossing within the estimated damage zone which extends approximately five miles downstream of the dam.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass the probable maximum flood without overtopping but will pass 85 percent of the probable maximum flood, which is greater than the estimated 100-year flood. The spillway design flood recommended by the guidelines is 100 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

The only significant deficiency visually observed by the inspection team was erosion of the upstream face of the embankment due to poor gradation of the riprap. Other deficiencies observed include erosion in the berm downstream of the embankment, small trees on the upstream face, minor seepage in the right abutment, spalling of concrete in the spillway

discharge structure, and erosion around the discharge structure. Seepage and complete stability analyses required by the guidelines were not readily available.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. A detailed report discussing each of these deficiencies is attached.

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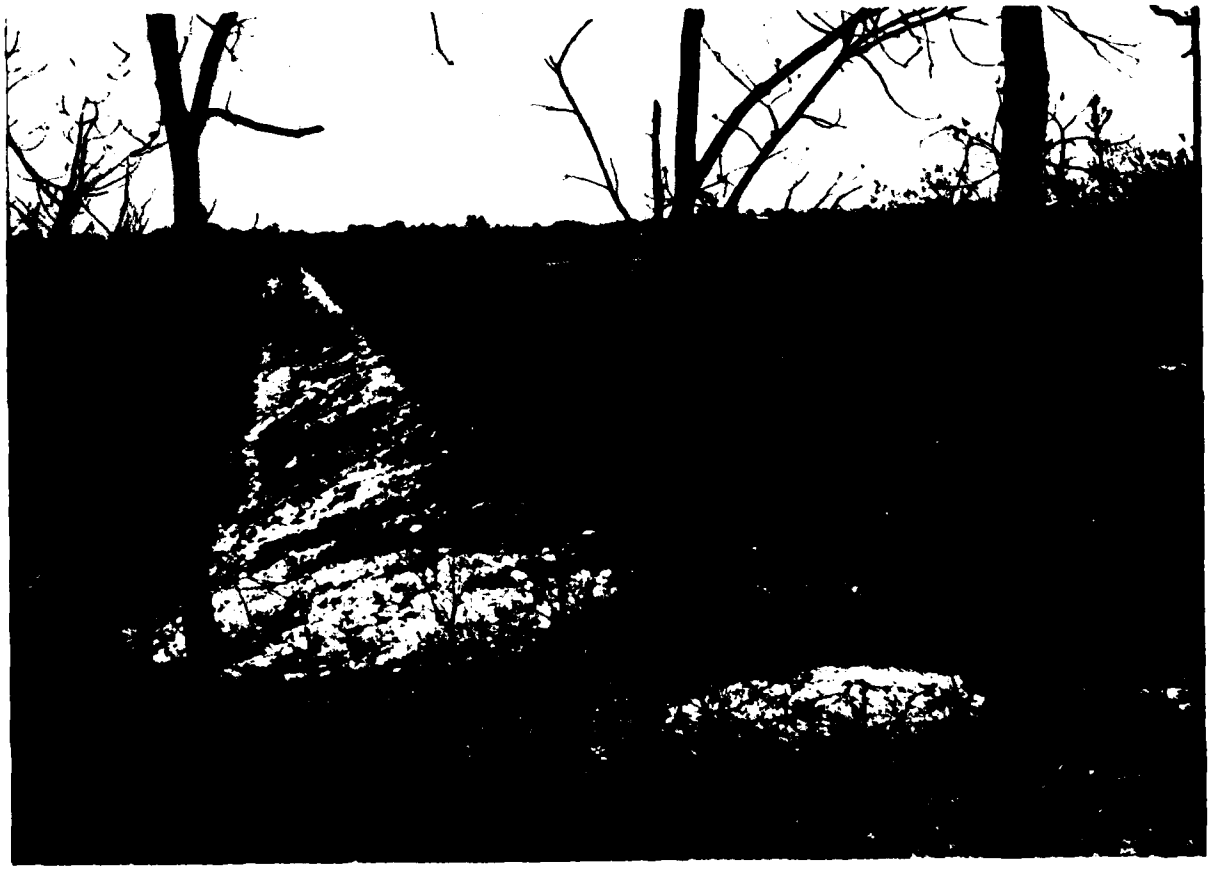

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HARRISONVILLE CITY LAKE DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Harrisonville City Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure located in the valley of a tributary to Big Creek in northcentral Cass County, Missouri (Plate 1). The dam is approximately 50 feet high from the natural stream channel at the outlet of the principal spillway to the crest, and is approximately 1,900 feet long. The axis of the dam runs from south-southwest to north-northeast. The upstream embankment of the dam is protected from erosion by riprap which is poorly graded in some areas, and the downstream slope is grass covered. The embankment from toe to crest is highest approximately 300 feet from the right abutment. The watershed is primarily comprised of farmland and grassland. Topography in the vicinity of the dam is shown on Plate 2.

(2) The principal spillway consists of a reinforced concrete morning glory shaft inlet near the right abutment of the dam. It discharges through a 96-inch diameter corrugated metal pipe passing through the dam embankment to a special concrete discharge headwall downstream of the embankment. The channel downstream of the spillway outlet is a natural stream channel with a bed of shale.

(3) An emergency broad-crested weir overflow spillway was constructed at the left abutment. The spillway consists of a rock and

earth trapezoidal overflow weir approximately 3 feet high, 170 feet long, and 19 feet wide at the top. It discharges to an excavated earthen channel which is well-covered with grass.

(4) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in northcentral Cass County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Pleasant Hill, Missouri in Section 26 of T46N, R31W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the intermediate size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Harrisonville City Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Harrisonville City Lake Dam the estimated flood damage zone extends downstream for approximately five miles. Within the damage zone are eleven homes, six farm buildings, State Highway 7, and one improved road crossing.

e. Ownership. The dam is owned by the City of Harrisonville, P.O. Box 367, Harrisonville, Missouri 64701.

f. Purpose of Dam. The dam forms a 410-acre lake for water supply and recreation.

g. Design and Construction History. The dam was designed in 1970 and built in 1971. Designers were Lankford & Collins, Consulting Engineers, Kansas City, Missouri. A set of plans and some of the design calculations were available for review during the Phase I inspection of the dam.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, withdrawals for water supply, and flow through the principal spillway all combine to maintain a relatively stable water surface elevation. Withdrawals for water supply are made from a pump station located approximately 3,500 feet upstream from the centerline of the dam on the middle arm of the lake.

1.3 PERTINENT DATA

a. Drainage Area - 9,470 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled shaft spillway.

(2) Flood discharge at the damsite is through the shaft spillway and over an uncontrolled trapezoidal shaped weir emergency spillway.

(3) Estimated experienced maximum flood at damsite - Unknown.

(4) Estimated ungated spillway capacity at maximum pool elevation 38,740 cfs (top of Dam El.909.4).

c. Elevation (Feet above m.s.l.).

(1) Top of dam - 909.4 ± (see Plate 3)

(2) Principal spillway crest - 895.0

(3) Emergency spillway crest - 896.7 ±

(4) Streambed at toe of dam - 860.0 ±

(5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 12,600 feet ±

(2) Length of normal pool - 10,300 feet ±

e. Storage (Acre-feet).

(1) Top of dam - 13,520

(2) Principal spillway crest - 6,900

(3) Emergency spillway crest - 7,650

(4) Design surcharge - Not available.

f. Reservoir Surface (Acres).

(1) Top of dam - 660

(2) Principal spillway crest - 410

(3) Emergency spillway crest - 450

g. Dam.

(1) Type - Earth embankment

(2) Length - 1,900 feet

(3) Height - 50 feet ±

(4) Top width - 20 feet

(5) Side slopes - varies (see Plate 5)

(6) Zoning - Dam plans indicate an embankment Zone 1 beginning at Elevation 875 at the central embankment Zone 2 which slopes downward at 20.0 H to 1.0 V in the upstream direction. Downstream embankment Zone 3, beginning at Elevation 875 at the central embankment zone, slopes downward at 20.0 H to 1.0 V in the downstream direction (see Plate 4). Upstream and downstream embankment zones were installed to improve dam stability.

(7) Impervious core - Plans do not indicate construction of separate impervious core within central embankment.

(8) Cutoff - Plans do not indicate construction of a cutoff beneath dam embankment.

(9) Grout curtain - Plans do not indicate use of a grout curtain.

(10) Interior drainage system - Plans indicate a 24-inch thick drainage blanket extending from 55 feet upstream of the dam centerline to 97 feet downstream and from Station 1+00 to Station 9+00, and a 20-foot wide blanket centered on the dam centerline extends from Station 9+00 to Station 11+00. Blanket is drained by a 12-inch diameter perforated corrugated metal pipe (CMP) extending for a length of 480 feet along the downstream edge of the blanket and connected to a 12-inch diameter CMP which extends 430 feet downstream of the blanket to provide gravity discharge.

h. Diversion and Regulating Tunnel - None.

i. Principal spillway.

(1) Type - Shaft with morning glory inlet.

(2) Diameter - Inlet - 12 feet; shaft - 8 feet.

(3) Crest elevation - 895.0 feet m.s.l.

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - Open channel comprised of broken shale located near the toe of the downstream embankment slope at the right abutment.

j. Emergency spillway.

(1) Type - Earth and rock overflow weir.

(2) Width of channel - 170 feet.

(3) Crest elevation - 896.7 ± feet m.s.l.

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - Open grassed waterway. This channel was excavated at the time the dam was built. The channel lies parallel with the axis of the dam downstream of the dam embankment and joins the natural stream channel downstream of the principal spillway outlet (see Plate 3).

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The following items of design data were available to members of the inspection team:

a. A copy of the report entitled "Soils Engineering Report; Final Investigation; Harrisonville Dam; Harrisonville, Missouri" by A.C. Kirkwood & Associates and Layne - Western Company, Inc. (no date given).

b. A set of plans for the water impoundment by Lankford & Collins, Consulting Engineers (dated 1970). The 25 sheets of drawings included plans of the dam, emergency spillway, pump station, and water transmission main. The pump station is located approximately 3,500 feet upstream from the centerline of the dam on the middle arm of the lake.

c. A copy of the plans for the morning glory inlet on the principal spillway and the 96-inch spillway conduit through the dam. These plans by Armco Metal Products Division were a single sheet of drawings and dated March 4, 1971.

d. Miscellaneous calculations, notes, and memorandums pertaining to the project from the files of Lankford & Collins.

2.2 CONSTRUCTION

Detailed construction records were available in the form of daily construction logs. The dam was finished in 1971.

2.3 OPERATION

The maximum recorded loading on the dam is not known. Available records indicate that the 96-inch corrugated metal pipe serving as the principal spillway conduit ruptured during a period of high inflow in early 1973. This caused some scouring of the dam embankment around the spillway conduit. Repairs were effected and no further problems are known to have occurred.

2.4 EVALUATION

a. Availability. The items mentioned in paragraph 2.1 above were available through the firm responsible for the design of the dam. This firm is Lankford & Collins, Consulting Engineers, Kansas City, Missouri.

b. Adequacy. The engineering drawings, calculations, and reports available aided in the assessment of the design, construction, and operation of the dam. However, seepage and stability calculations were

not readily available for review. Detailed seepage and stability analyses should be performed as required by the guidelines.

c. Validity. The engineering data available indicates that the dam as designed by Lankford & Collins, Consulting Engineers, and actually constructed was located downstream of the damsite investigated by Layne-Western Company, Inc. for A.C. Kirkwood & Associates. The description of subsurface conditions for the dam and foundation strength parameters provided in the Layne-Western report may not represent the foundation conditions beneath the actual constructed dam. It is anticipated that the embankment strength parameters provided in the Layne-Western report are representative of borrow materials for embankment construction available in the area.

2.5 GEOLOGY.

The Harrisonville City Lake Dam is located across a valley formed in residual soils and bedrock. The soil of the area consists of the Summit Silt Loam soil series consisting of clayey silts and silty clays derived from weathering of the underlying shale bedrock. For engineering purposes the soils are classified as ML or CL. Alluvial silty clay with pockets of sand and gravel is present along the stream channels. The bedrock consists of shales and sandstones of the Pleasanton Group and limestones and shales of the Kansas City Group of the Pennsylvanian System. The left abutment is anticipated to consist of residual soil overlying shale and sandstone bedrock. The right abutment is in shale and sandstone of the Pleasanton Group and limestone and shale of the Kansas City Group. The foundation of the dam is residual soil overlying shale of the Pleasanton Group. The natural discharge channel downstream of the principal spillway consists of shale overlain by residual shale.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Harrisonville City Lake Dam was made on 26 April 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology - hydraulic engineering, and geotechnical engineering. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following items at the dam. The riprap on the upstream face of the embankment, especially near the right abutment, is poorly graded and erosion has occurred around some of this riprap. Erosion has also occurred in the berm downstream of the dam embankment, probably as the result of local runoff following vehicle tracks. This erosion is located approximately between Stations 10+00 and 13+00 and varies in width from 4 to 6 feet and in depth from 3 to 4 feet. The upstream face above the riprap, the crest, and the downstream face are all generally well covered with grass. A few small trees (2 to 4 inches in diameter) are growing on the upstream face of the embankment. Minor seepage was observed coming from the natural shale in the right abutment near the principal spillway discharge structure. The seepage was clear and only a trickle which would be less than a gallon per minute. No sloughing, cracking, or seepage was observed on the downstream embankment. A few small animal burrows were noticed in the embankment. Seepage is collected by a blanket drain under the embankment with a 12-inch perforated collector pipe near the downstream toe of the embankment. This perforated pipe leads to a 12-inch corrugated metal pipe which discharges to the natural stream channel 400 feet downstream from the dam. When the flap gate over the outlet of this pipe was lifted, a small amount of flow came out for a period of less than a minute and then stopped. Material observed in the pipe was suspected to be from reverse flow into the pipe.

The dam does not exhibit signs of detrimental settlement, sloughing, cracking, or overstress.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The morning glory inlet to the shaft spillway near the right dam abutment appears to be in good condition, but the inspection team could only view it from a distance of about 80 feet, which was the distance from the inlet to the upstream embankment at the water surface. The 96-inch corrugated metal discharge conduit passes through the embankment and terminates at a special discharge headwall 300 feet downstream of the inlet and 180 feet

downstream of the axis of the dam. The condition of this discharge conduit is unknown, only the outlet end was accessible to inspection. The special concrete discharge headwall is generally in good condition, but there is an area of 3 feet by 4 feet on the right wall of the headwall in which the concrete has spalled to depths less than 1 inch. The channel immediately downstream of the discharge structure has eroded to a depth of 3 feet lower than the apron. Erosion probably due to surface runoff from the dam slope and downstream right abutment was also observed along the left wingwall. The earth and rock emergency overflow spillway near the left abutment of the dam is in good condition, with no significant erosion or obstructions to flow evident. The grass-lined channel downstream of the spillway also appears to be in good condition. A minor amount of rivulet erosion has occurred in the discharge channel, but it has no effect on the safety of the dam.

d. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir.

e. Downstream Channel. The natural stream channel downstream of the principal spillway discharge headwall is comprised primarily of the broken shale, with a moderate amount of vegetation in the form of medium to large trees along the channel. The channel downstream of the emergency spillway is 200 feet wide and is generally well covered by grass. The emergency spillway discharge channel leads to the natural stream channel 600 feet downstream of the principal spillway dishcarge headwall.

f. Geology. A visual inspection of the dam and abutment areas confirmed the presence of silty clay residual soil overlying shale bedrock in the area of the dam. An outcrop of the upper unnamed formation of the Pleasanton Group and the Hertha, Ladore, and Swope Formations of the Kansas City Group was observed in the right abutment. The base of the Kansas City Group was at the approximate elevation of the top of the dam. Shale of the unnamed upper formation of the Pleasanton Group was present in the right side of the downstream discharge channel just below the headwall of the outlet of the principal spillway. A minor amount of seepage (less than 1 gpm) was observed in the shale near the headwall. The material in the surface of the embankment and emergency spillway was silty clay (CL).

3.2 EVALUATION

On the basis of the visual inspection, the dam and appurtenant structures appear to be in good condition and generally operating as planned. No evidence of abnormal sloughing or settlement of the embankment is apparent. Seepage through the embankment appears to be minimal. Both the dam embankment and the emergency spillway channel appear to be sufficiently protected by grass cover to protect them from severe erosion during a period of dam overtopping and high spillway flow. Items requiring remedial action or continuing observation are:

(1) Erosion around the riprap on the upstream face of the embankment, particularly near the right abutment of the embankment.

(2) Erosion in the berm downstream of the embankment as a result of local runoff.

(3) The growth of a few small trees on the upstream face of the dam embankment. Although not presently a problem, the trees should be removed before they become one.

(4) Erosion in the stream channel immediately downstream of the discharge apron for the principal spillway.

(5) Erosion next to the left wingwall of the principal spillway discharge structure.

(6) Spalling of concrete on the right wingwall of the principal spillway discharge structure.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, withdrawals for water supply, and flow-through of the uncontrolled principal spillway.

4.2 MAINTENANCE OF DAM

Maintenance performed was unknown.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities are known to exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

4.5 EVALUATION

Erosion around the riprap on the upstream face of the embankment, particularly near the right abutment, gully erosion in the berm downstream of the dam embankment adjacent to the center of the dam, and erosion of the stream channel immediately downstream of the principal spillway discharge apron increase the potential for failure and warrant repair and regular monitoring.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Most of the hydraulic and hydrologic calculations and design data used by the firm that designed Harrisonville City Lake Dam were available for review by members of the inspection team. Included in this data were calculations on design flood inflows, spillway sizes and configurations, spillway discharges, and water surface elevations resulting from various design storms. The dam was designed to pass the probable maximum flood with freeboard for wind and wave action. The probable maximum flood inflow hydrograph was calculated by the method in Section 58 of the Design of Small Dams (2).

b. Experience Data. The drainage area and lake surface area are developed from USGS Pleasant Hill, Harrisonville, Raymore, and Peculiar Quadrangle Maps. The spillway and dam layouts are from surveys made during the inspection and construction plans.

c. Visual Observations.

(1) Both the principal spillway and the emergency spillway appear to be in good condition, but the condition of the discharge conduit for the principal spillway could not be determined by visual inspection. Some erosion has occurred in the stream channel immediately below the discharge headwall apron for the principal spillway.

(2) No facilities are available which could serve to draw down the pool.

(3) The principal spillway is a shaft spillway with morning glory inlet located near the right abutment of the dam embankment. The emergency spillway is an earth and rock overflow section near the left dam abutment. It does not appear that large spillway discharges will endanger the integrity of the dam, unless the principal spillway discharge conduit would rupture, as it has done previously.

d. Overtopping Potential. The spillways will not pass the probable maximum flood, which is the spillway design flood recommended by the guidelines, without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillways will pass 85 percent of the probable maximum flood without overtopping the dam. This flood is greater than the 100-year flood. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of intermediate size should pass 100 percent of the probable maximum flood. The portion of the estimated peak discharge of

the probable maximum flood overtopping the dam would be 12,400 cfs of the total discharge from the reservoir of 48,900 cfs. The estimated duration of overtopping is 2.0 hours with a maximum height of 1.1 feet. The grass cover on the embankment crest and back slope will provide protection from severe erosion during short periods of overtopping. Failure of upstream water impoundments shown on the 1975 revised USGS map would not have a significant impact on the hydrologic or hydraulic analysis.

The hydraulic and hydrologic calculations supplied by the firm that designed the dam indicate that the spillways would pass the probable maximum flood without overtopping the dam. Calculations performed during the Phase I report indicate that the spillways would pass 85 percent of the probable maximum flood without overtopping the dam. The difference can be attributed primarily to the rainfall distributions and the rainfall reduction factor. The design firm used the SCS rainfall distribution and an areal rainfall reduction factor. In the Phase I calculations no reduction factor was used and the Corps of Engineers rainfall distribution (as specified in the guidelines) was used, with both of these factors increasing the peak and volume of the inflow hydrograph. Minor settlement of the dam and differences in drainage area and the emergency spillway rating curve account for a minor portion of the difference in the two analyses.

According to the St. Louis District, Corps of Engineers, the estimated effect from rupture of the dam could extend approximately five miles downstream of the dam. There are eleven homes, six farm buildings, State Highway 7, the Missouri-Pacific Railroad, the Chicago and Rock Island Railroad, and one improved road crossing downstream of the dam which could be severely damaged and lives could be lost should failure of the dam occur.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. Design data relating to the structural stability of the dam were incomplete. Data describing the subsurface conditions and appropriate foundation strength parameters at the constructed location of the dam are apparently not available. Sufficient records are not available to substantiate that the data provided in the soils engineering report (Layne-Western Company, Inc. report) is appropriate for the design of the dam along the alinement where the dam was constructed.

The slopes of the dam as constructed are consistent with the design slope recommendations provided by soils engineering report Layne-Western Company, Inc. The Layne-Western Company, Inc. report selected a cohesion value of 1,500 psf and an internal friction value of zero degrees to represent the engineering properties of the embankment materials obtained from the borrow area. A value of 1,500 psf for cohesion and an internal friction value of zero degrees appears to be an appropriate design value for silty clay (CL) materials generally originating from shale (residual soil) in the site area.

Strength parameters of the foundation soils for the site investigated by Layne-Western Company, Inc. were missing from the available report.

The available soils engineering report contained design factors of safety for end-of-construction conditions only as determined by the circular arc and sliding wedge modes of failure.

Field testing data were not available to evaluate the degree and uniformity of compaction obtained during construction of the dam.

c. Operating Records. No operational records exist.

d. Post Construction Changes. In the summer of 1973, the discharge conduit of the principal spillway failed during a period of high flow. This rupture in the conduit caused some erosion of the dam embankment around the broken portion of the conduit. Shortly thereafter, the conduit and embankment were repaired and normal operation was resumed. No other post construction changes are known.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone.

The seismic stability of an earth dam is dependent upon a number of factors: The important factors being embankment and foundation material classification and shear strengths; abutment materials, conditions, and strength; embankment zoning; and embankment geometry. Adequate descriptions of foundation and abutment conditions or static stability analyses to assess the seismic stability of this embankment were not available.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Items noted during the visual inspection by the inspection team which should be monitored or controlled are erosion around the riprap on the upstream face of the embankment, particularly near the right abutment, gully erosion in the berm downstream of the dam embankment, erosion near the left wingwall of the principal spillway discharge structure, and erosion in the channel downstream of the principal spillway discharge apron. Based upon visual observations, the dam does not exhibit signs of detrimental settlement, sloughing, cracking, or overstress. The dam was constructed with an internal drainage blanket to control seepage through the embankment and relieve hydrostatic pressures in the foundation for the portion of dam where the height exceeds about 25 feet. Stabilizing berms with a slope of about 20.0 H to 1.0 V were constructed both upstream and downstream of the central embankment where the height exceeds 35 feet to provide additional foundation stability and resistance against sliding.

b. Adequacy of Information. The conclusions in this report were based only on performance history, visual conditions, and the limited engineering design data readily available. The inspection team considers that these data are sufficient to support the conclusions herein. The engineering data readily available was not sufficiently detailed to allow verification of the seepage and structural stability of the dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a serious potential of failure.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam or identify any serious dangers that would require a Phase II investigation.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of foundation design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment was not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The present spillways have the capacity to pass 85 percent of the probable maximum flood without overtopping the dam. In order to pass 100 percent of the probable maximum flood as required by the Recommended Guidelines, the spillway size and/or height of dam would need to be increased.

Stability analyses should be performed by a professonal engineer experienced in the design and construction of dams.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended:

(1) Check the upstream face of the dam periodically to assess the severity of erosion around the riprap. If this erosion becomes excessive, additional riprap will have to be placed or the existing riprap will have to be removed and replaced with properly graded riprap.

(2) The localized erosion in the berm downstream of the dam embankment should be filled and protected from further erosion by a suitable vegetative ground cover.

(3) The small trees on the upstream face of the dam embankment should be removed under the guidance of an engineer experienced in the design and construction of earthen dams, and a program should be implemented for regular removal of any new trees on the embankment.

(4) Check the stream channel immediately downstream of the principal spillway discharge apron after periods of significant discharge to determine whether erosion is undercutting the floor of the headwall. If such a situation is noted, erosion protection should be provided.

(5) A detailed inspection of the dam should be made periodically by an engineer experienced in design and construction of dams. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increases.

(6) Check the outlet of the drainage blanket discharge line after periods of significant discharge through the primary spillway and maintain the headwall structure and flap gate free of silt and debris.

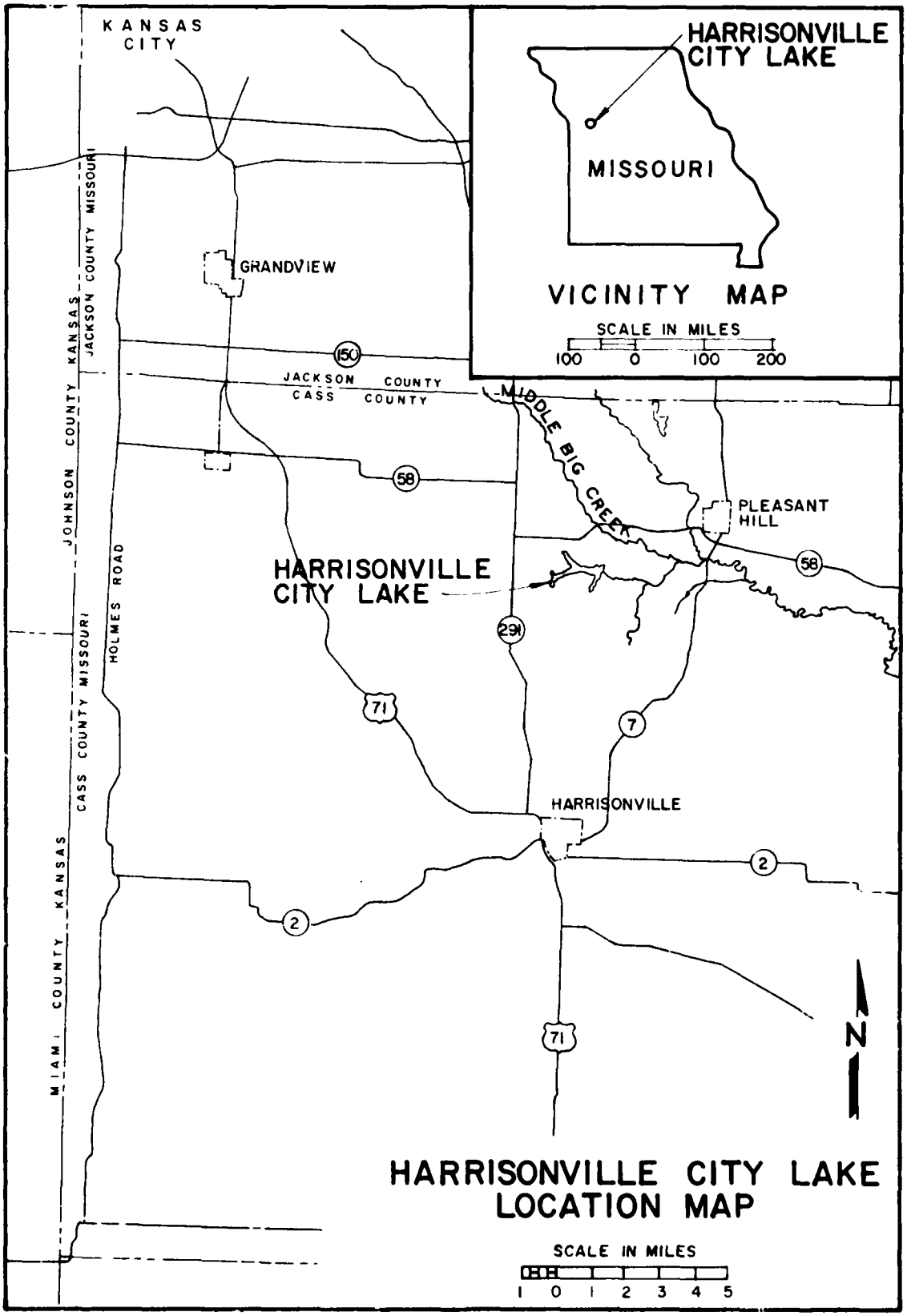
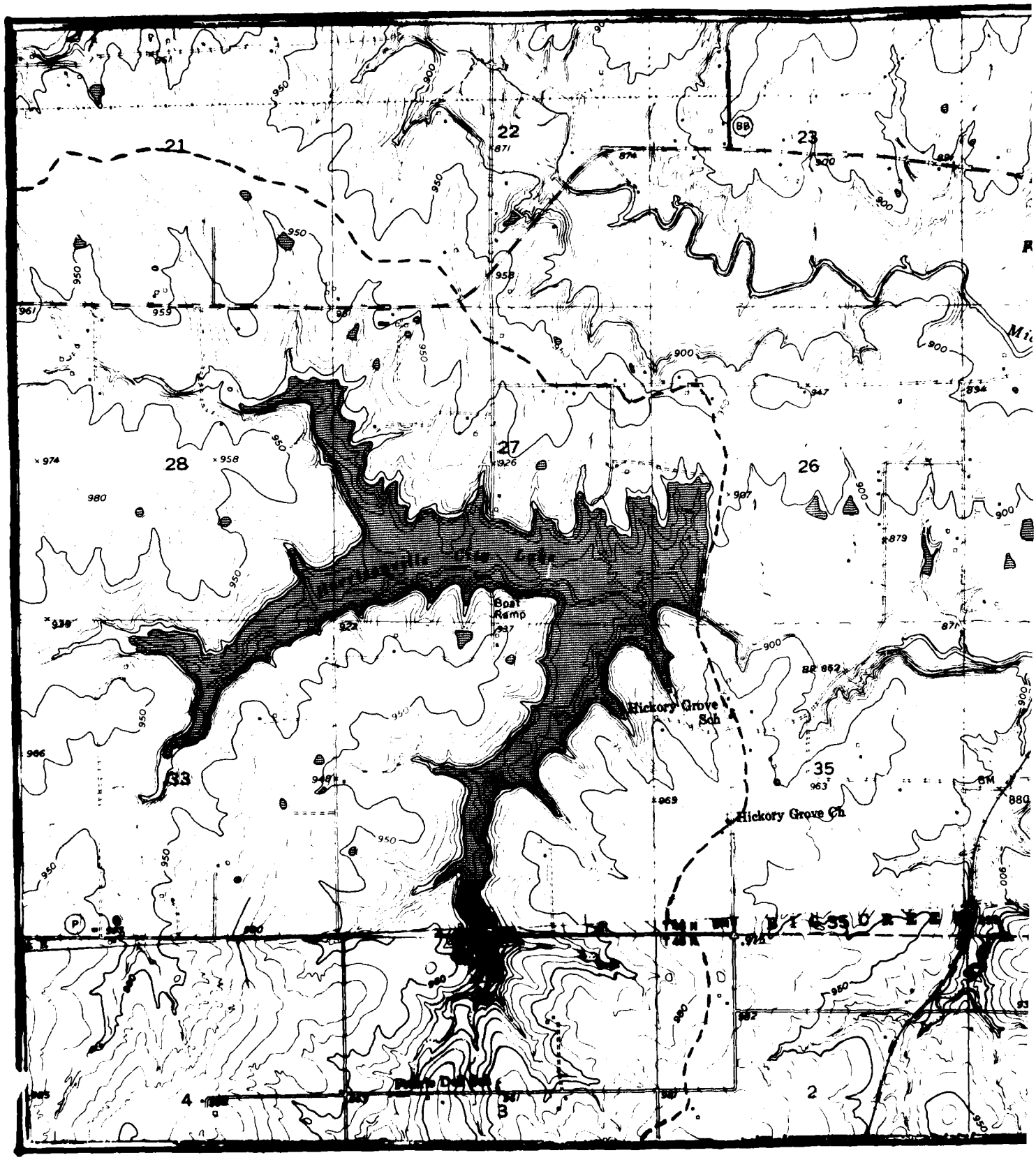

KANSAS CITY
HARRISONVILLE CITY LAKE
MISSOURI
VICINITY MAP
SCALE IN MILES
100 0 100 200
GRANDVIEW
JACKSON COUNTY MISSOURI
JOHNSON COUNTY KANSAS
150
JACKSON COUNTY
CASS COUNTY
MIDDLE BIG CREEK
58
PLEASANT HILL
HOLMES ROAD
HARRISONVILLE CITY LAKE
291
71
7
CASS COUNTY MISSOURI
MIAMI COUNTY KANSAS
HARRISONVILLE
2
N
HARRISONVILLE CITY LAKE
LOCATION MAP
SCALE IN MILES
1 0 1 2 3 4 5

PLATE 1


21
22
23
27
28
26
33
35
4
2
Boat Ramp
Hickory Grove Sch
Hickory Grove Ch
BB
BM

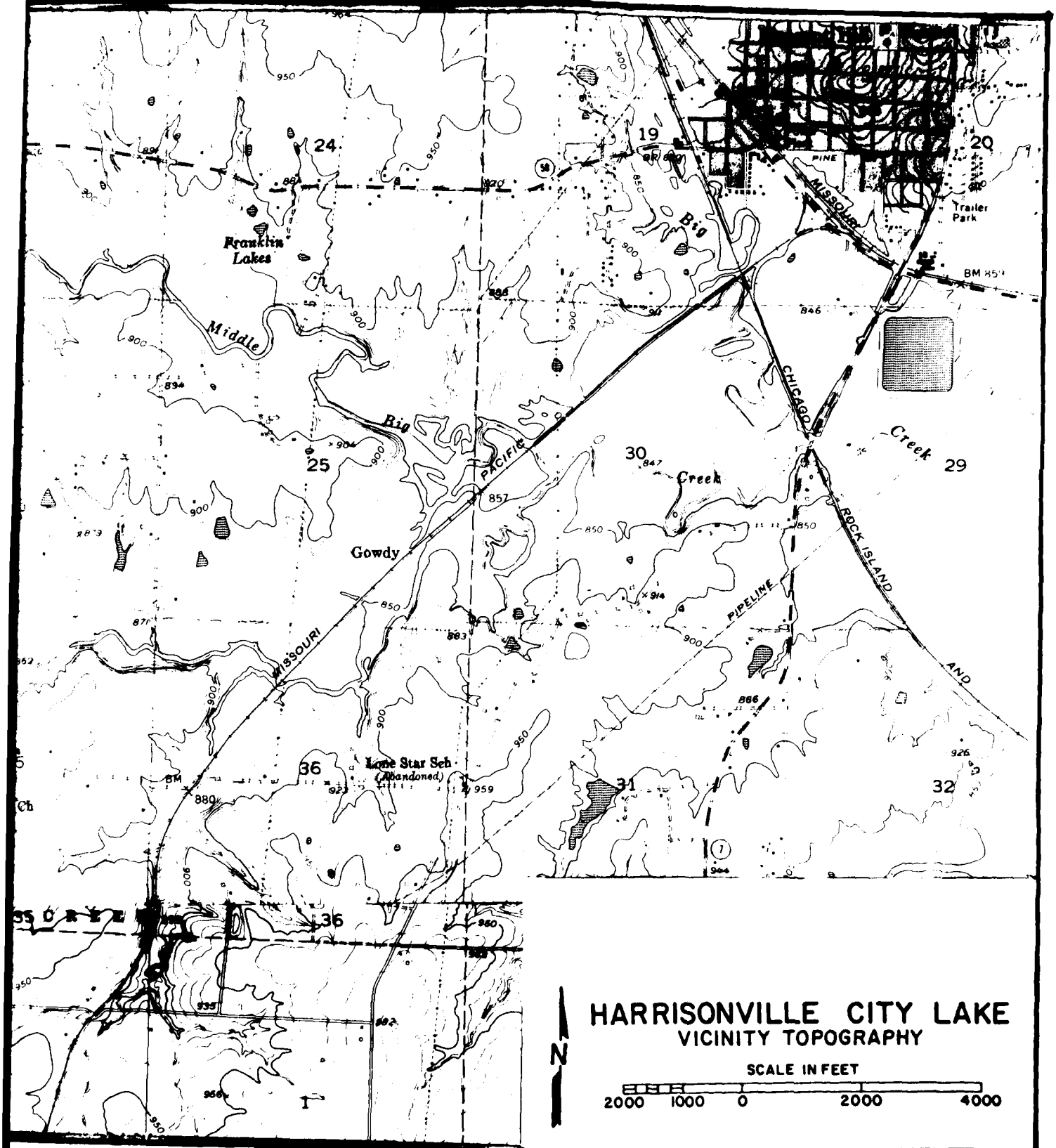
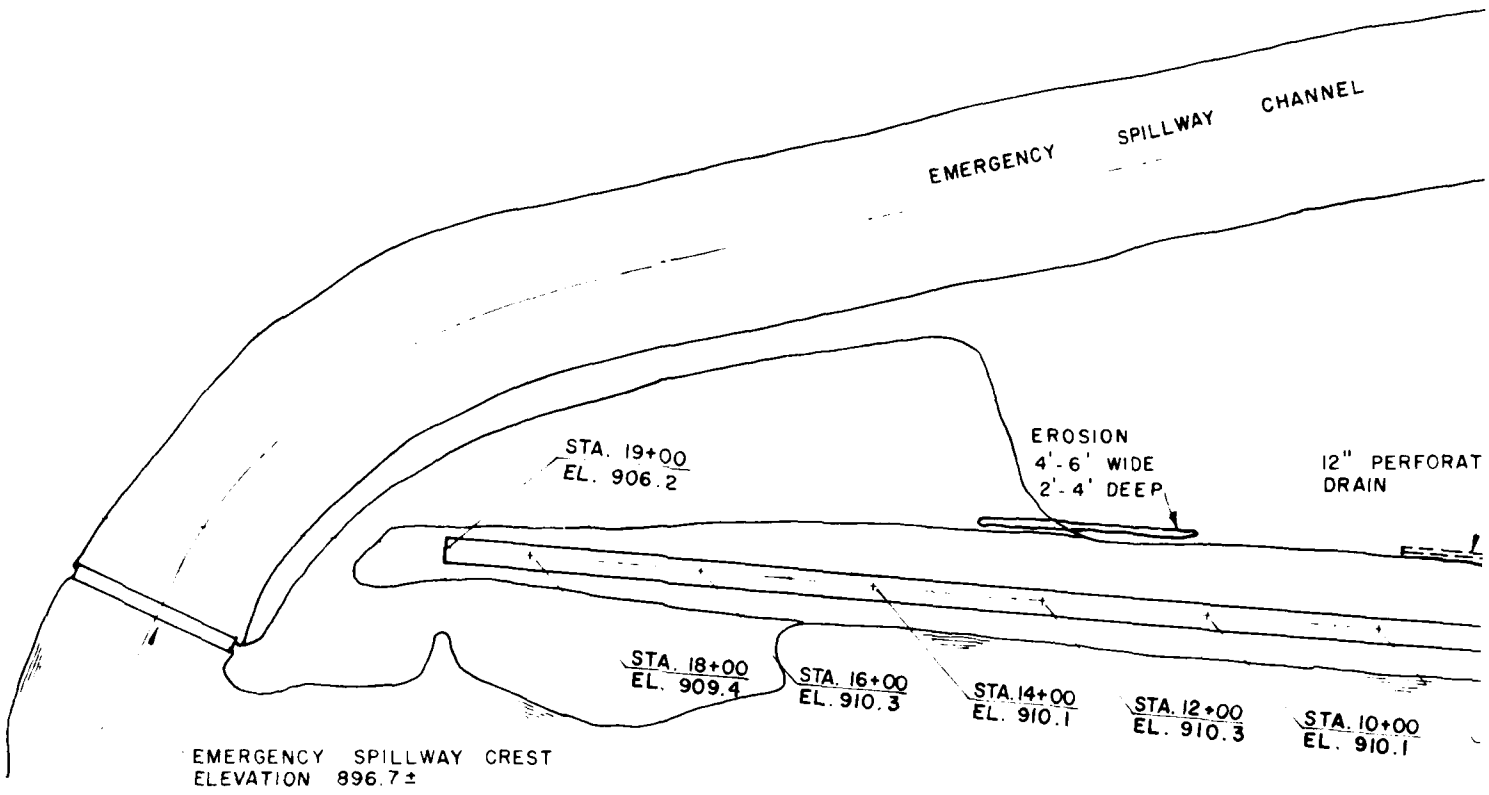
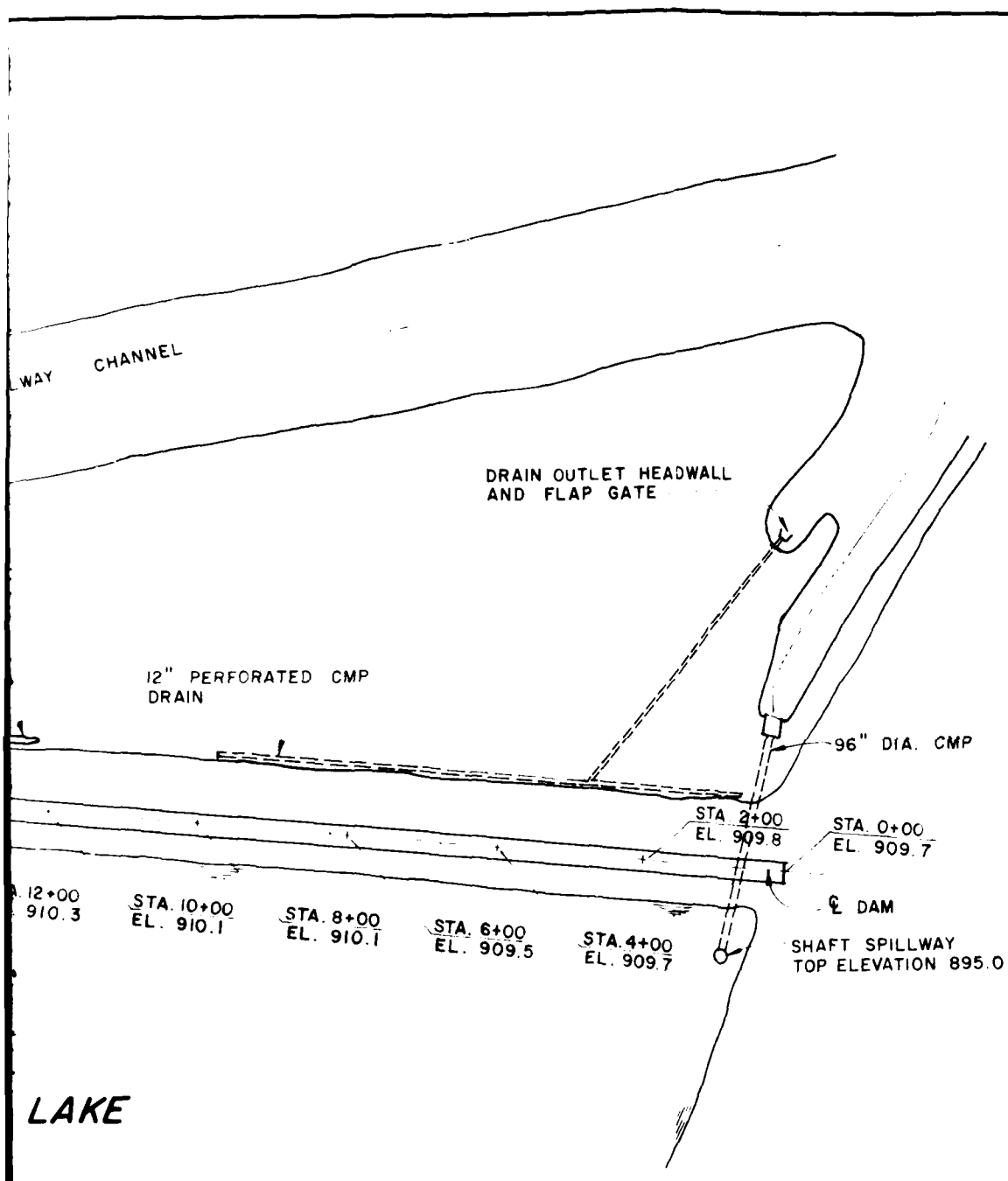

Franklin Lakes
Middle
Big
Creek
Gowdy
Lone Star Sch
(Abandoned)
Trailer Park
PINE
MISSOURI
CHICAGO
PACIFIC
ROCK ISLAND
AND
PIPELINE
19
20
24
25
29
30
31
32
36
N
HARRISONVILLE CITY LAKE
VICINITY TOPOGRAPHY
SCALE IN FEET
2000 1000 0 2000 4000

PLATE 2



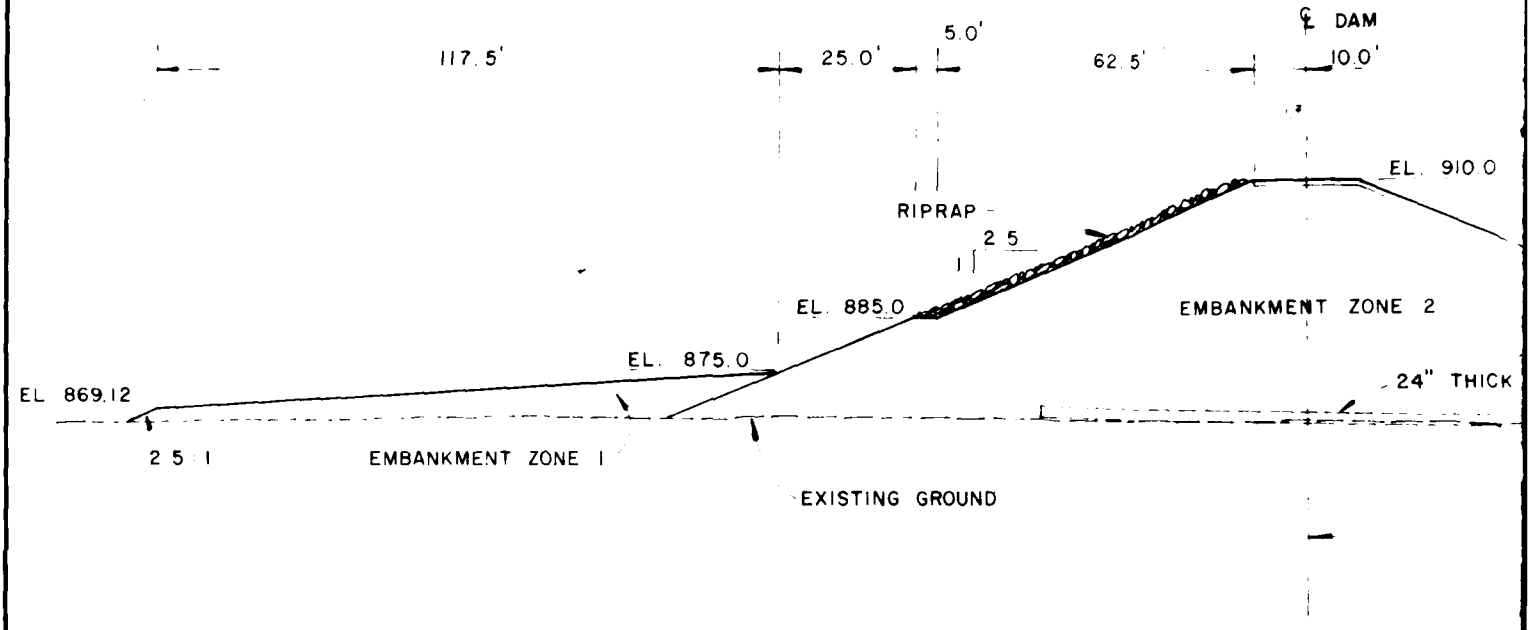
HARRISONVILLE CITY LAKE



N

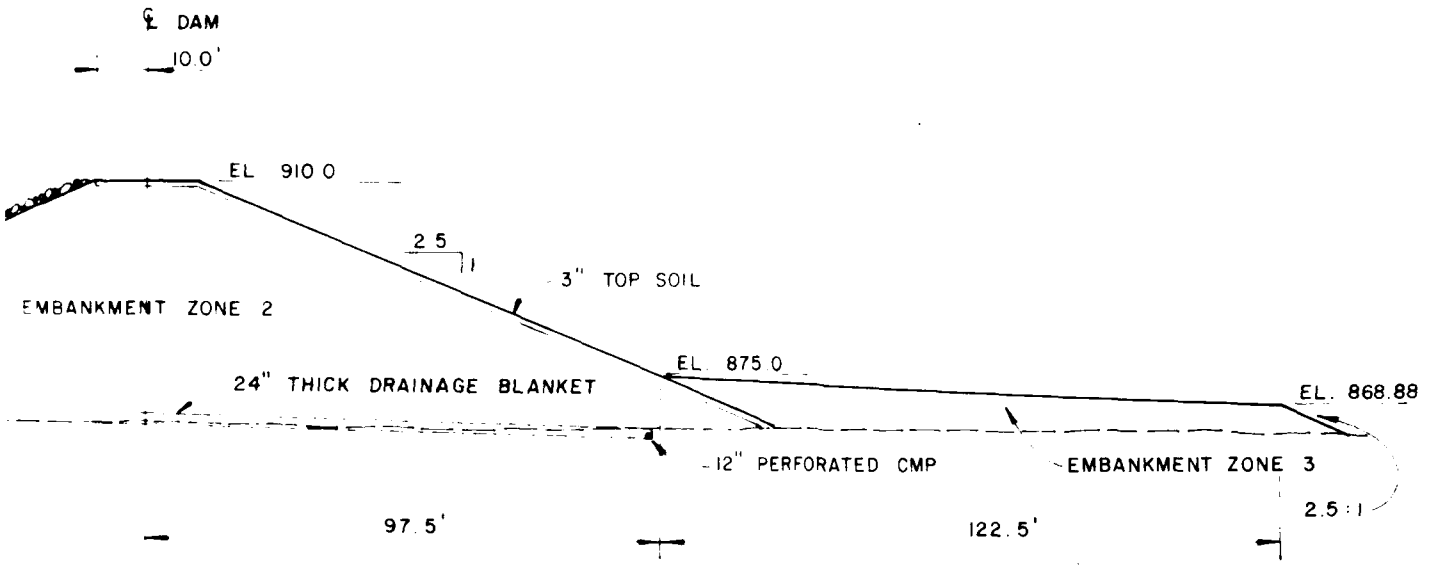
HARRISONVILLE CITY LAKE
PLAN

PLATE 3



TYPICAL CROSS SECTI

CROSS-SECTION DATA OBTAINED FROM "DESIGN



AL CROSS SECTION

ATA OBTAINED FROM "DESIGN DRAWING"

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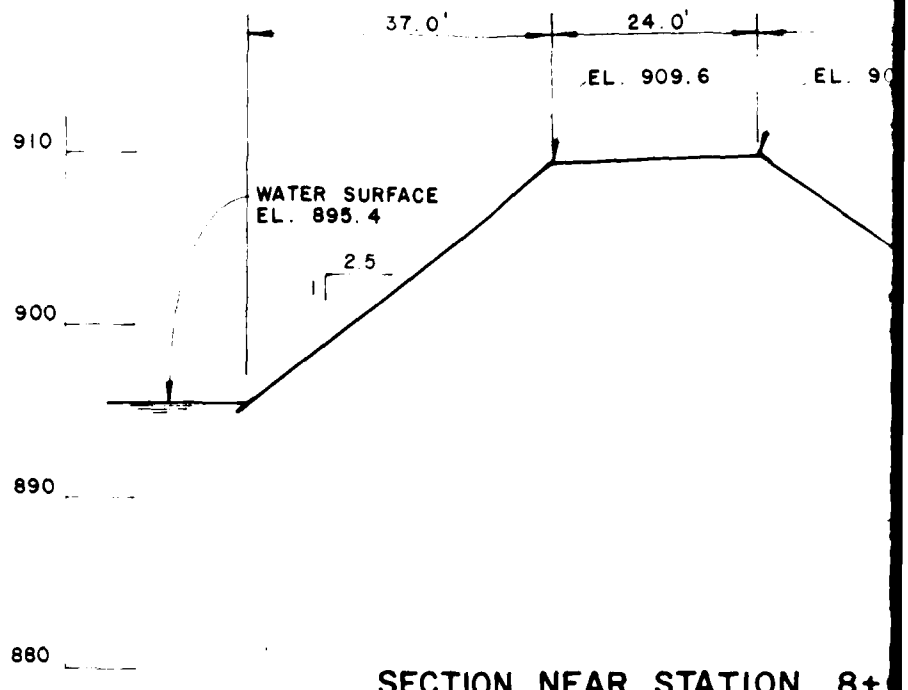
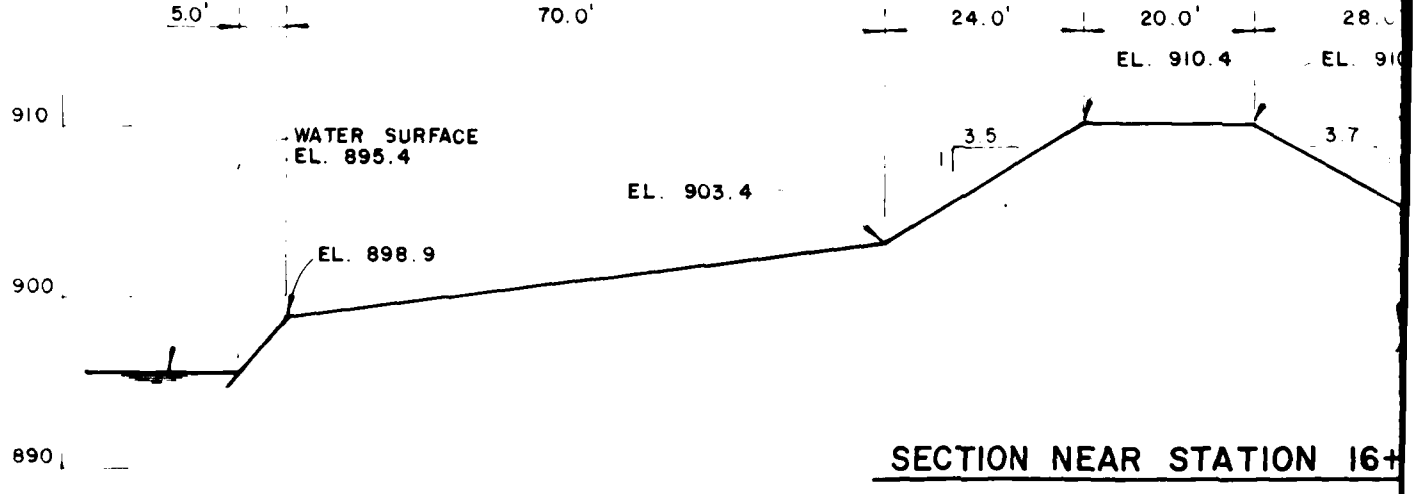
HARRISONVILLE CITY LAKE
TYPICAL CROSS SECTION

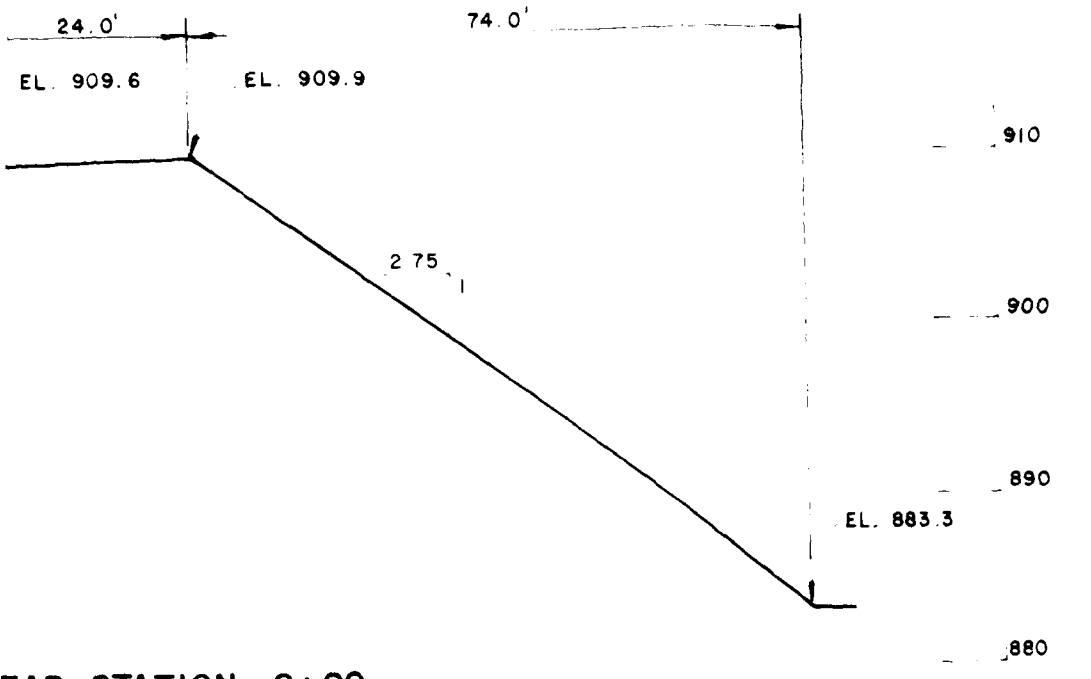
PLATE 4



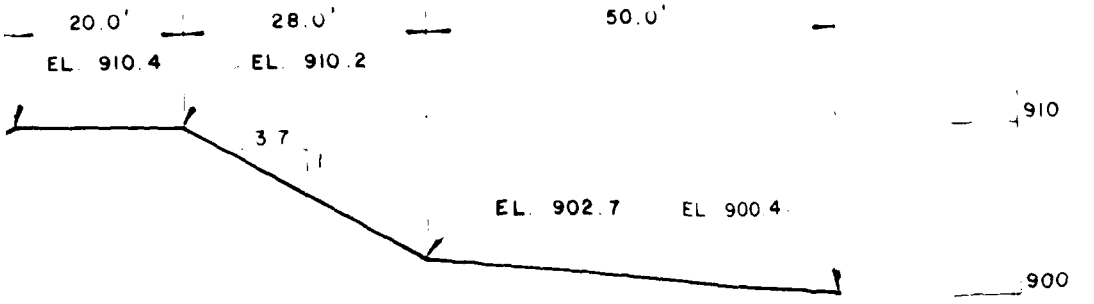
SECTION NEAR STATION 8+



SECTION NEAR STATION 16+



EAR STATION 8+00

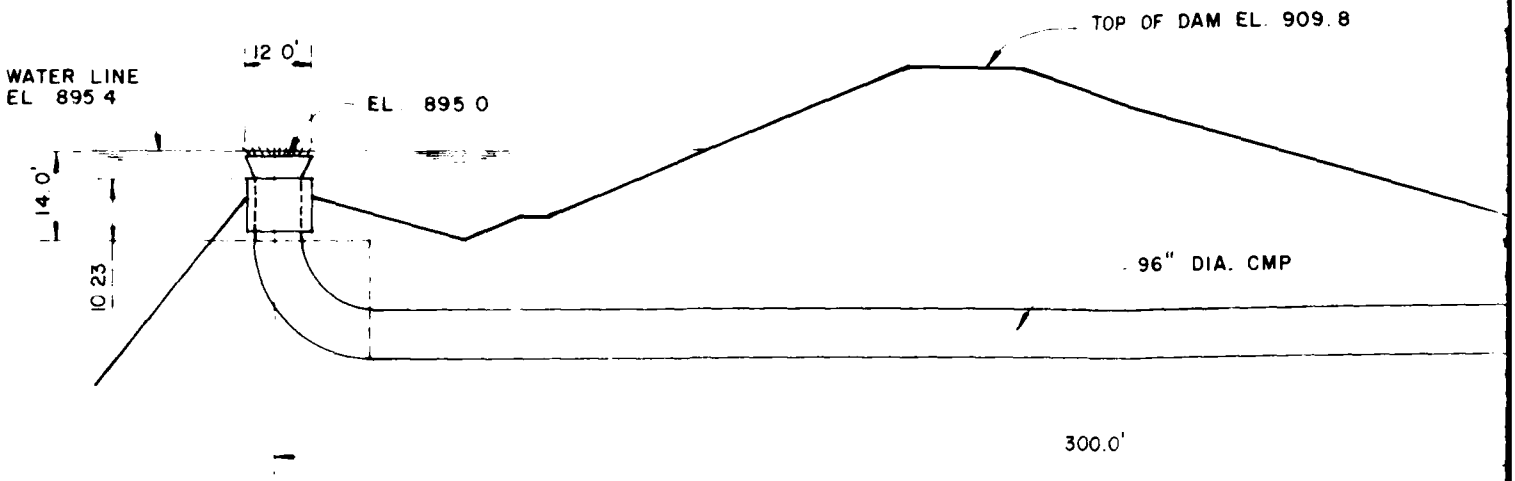


EAR STATION 16+50

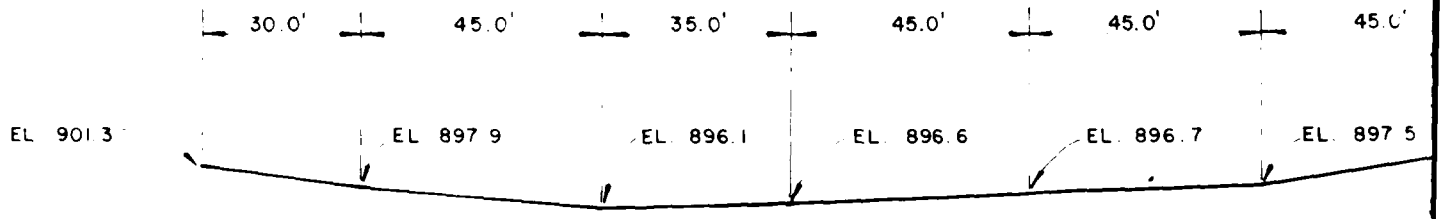
2

HARRISONVILLE CITY LAKE
TYPICAL SECTIONS

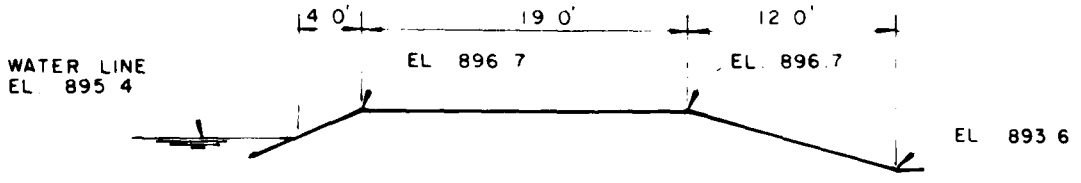
PLATE 5



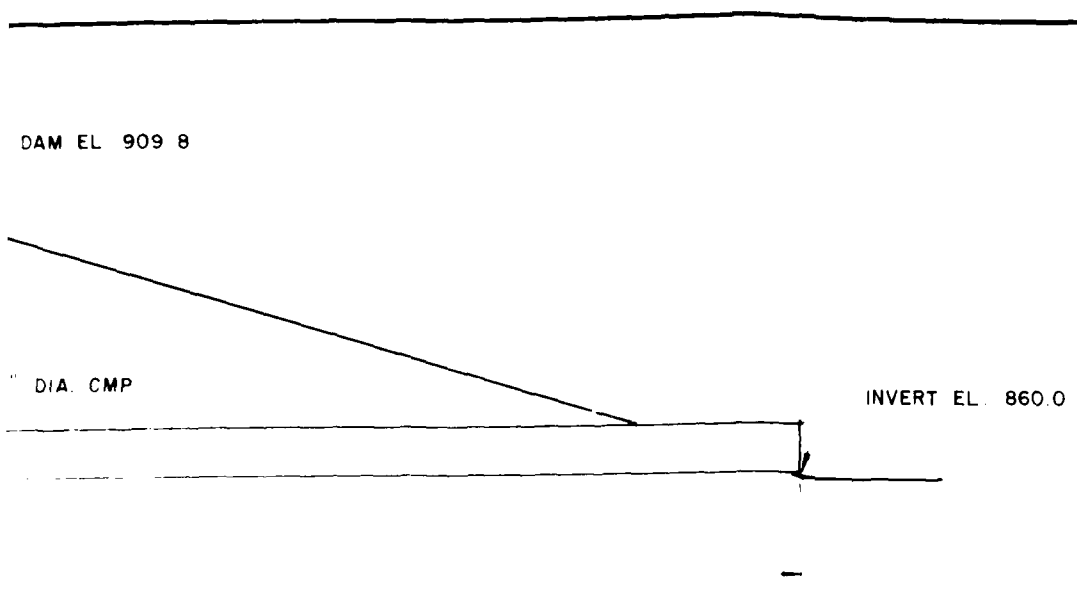
PRINCIPAL SPILLWAY - MORNING GLORY INLE



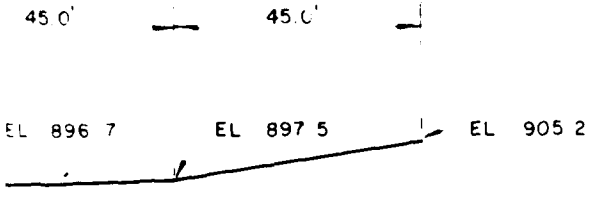
EMERGENCY SPILLWAY - LOOKING UPSTREAM



EMERGENCY SPILLWAY - CREST SECTION



ORNING GLORY INLET

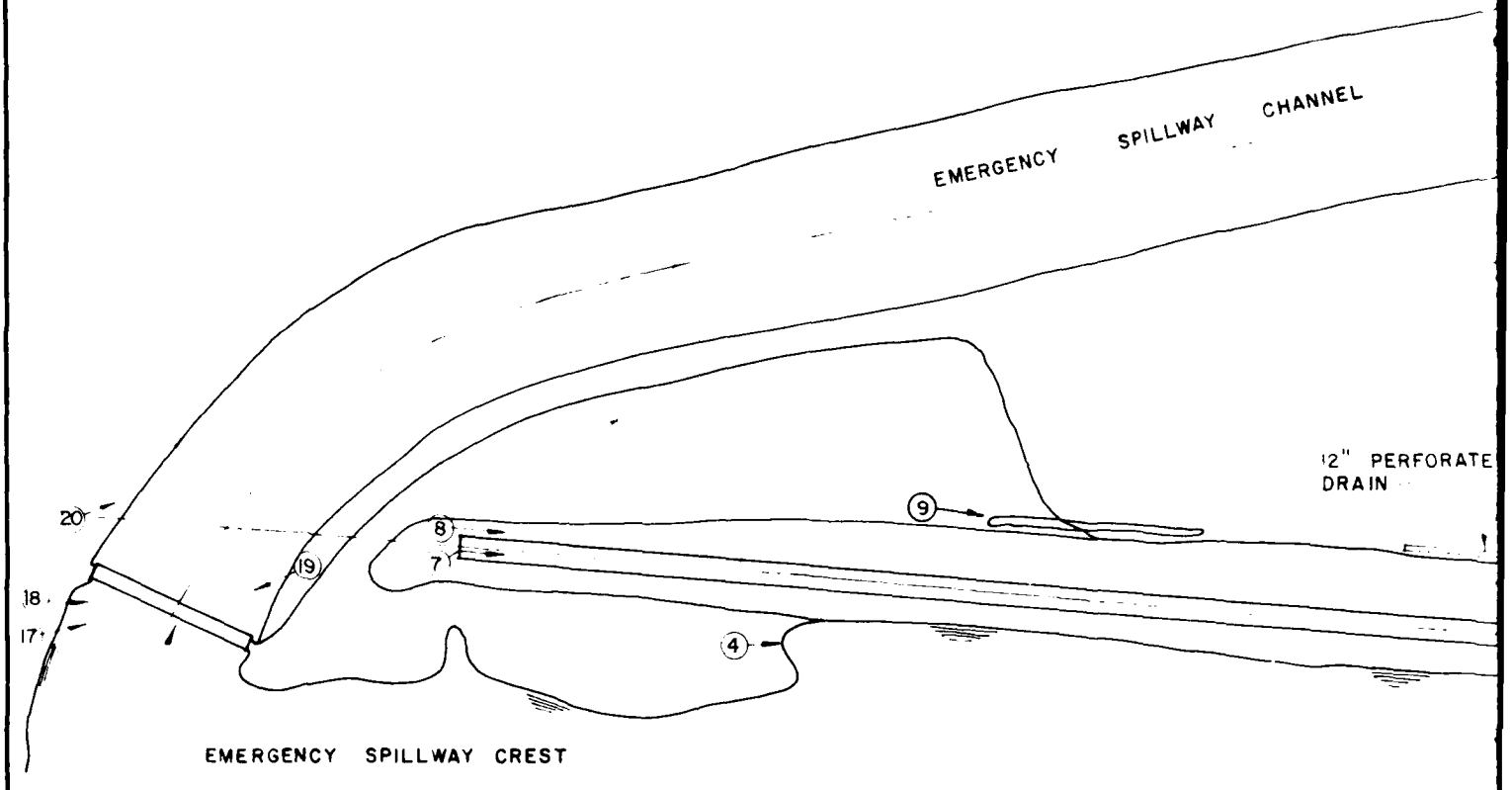


UPSTREAM

93 6

HARRISONVILLE CITY LAKE
SPILLWAY SECTIONS

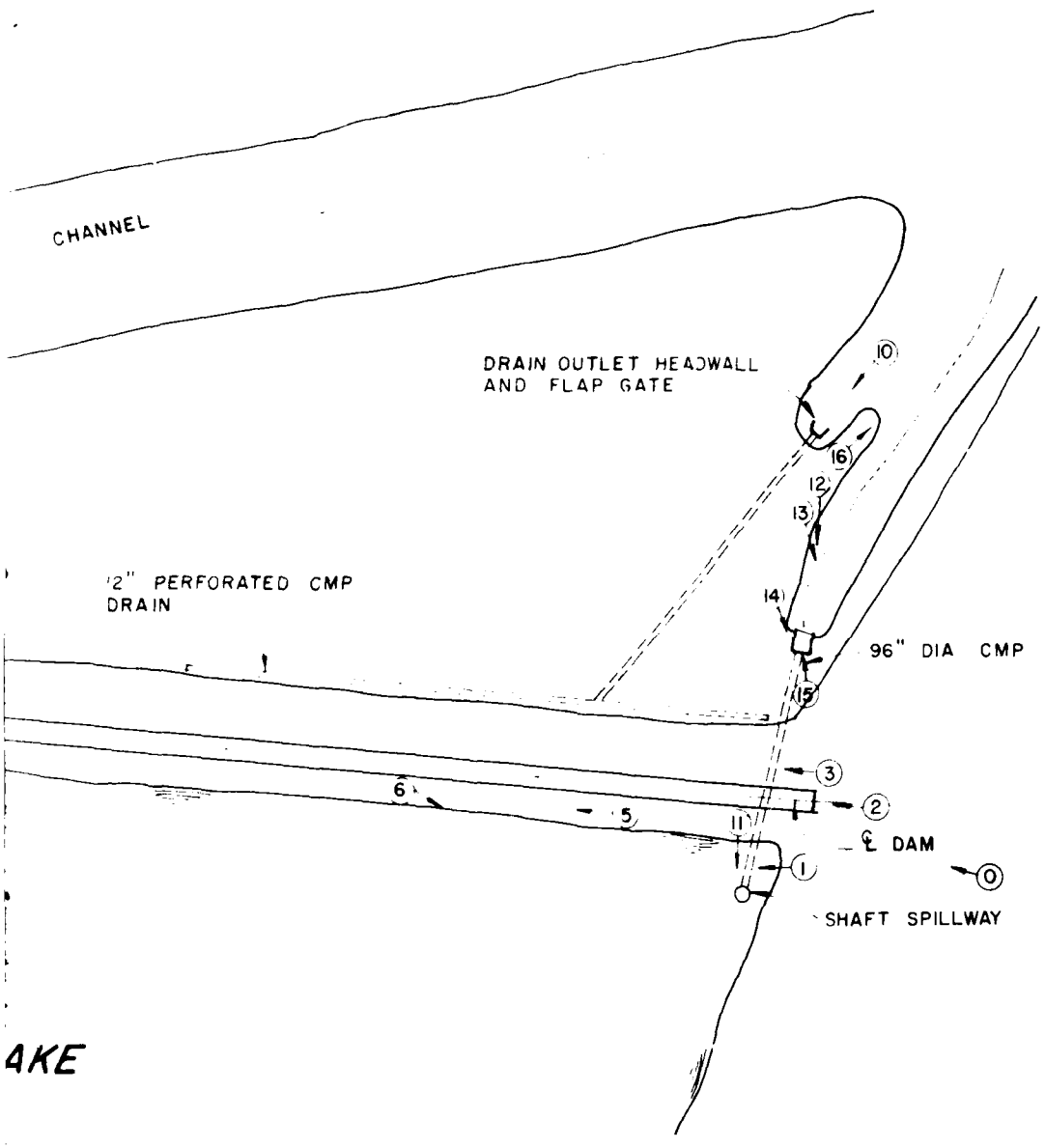
PLATE 6



HARRISONVILLE CITY LAKE

LEGEND

(1) — PHOTO LOCATION AND DIRECTION



HARRISONVILLE CITY LAKE
PHOTO INDEX

PLATE 7

PHOTO 1: UPSTREAM FACE OF DAM AND SHAFT SPILLWAY (LOOKING NORTH)

PHOTO 2: CREST OF DAM (LOOKING NORTH)

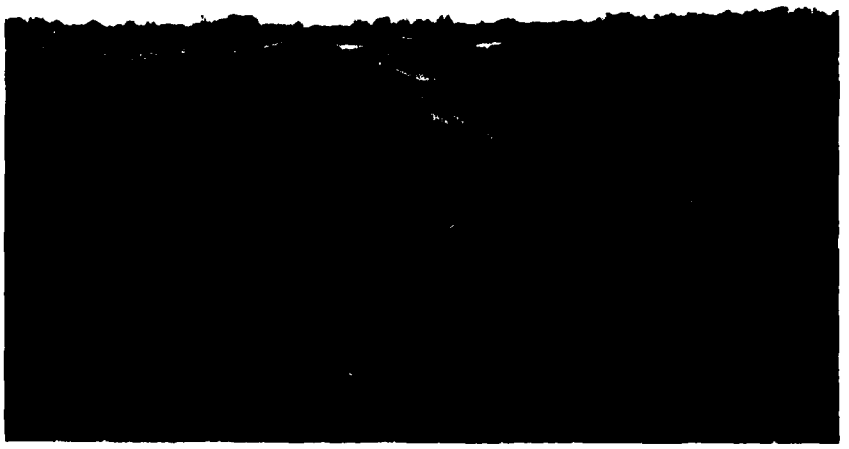


PHOTO 3: DOWNSTREAM FACE OF DAM (LOOKING NORTH)

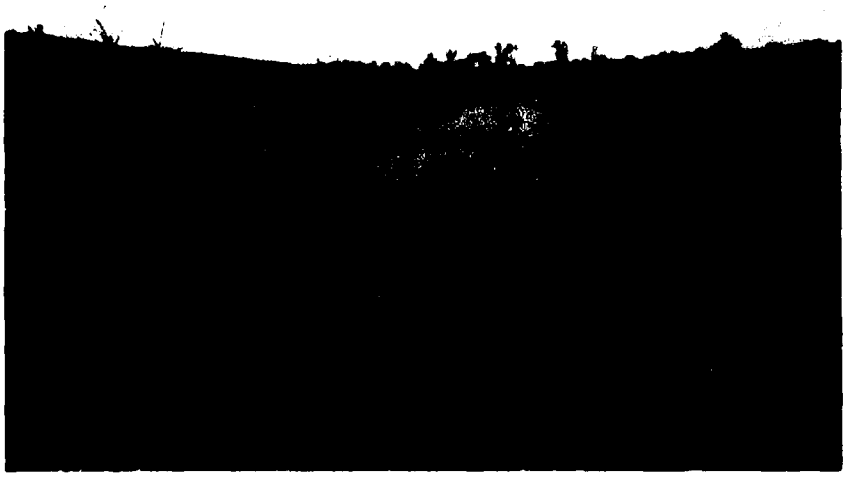


PHOTO 4: RIPRAP ON UPSTREAM FACE (LOOKING SOUTH)

PHOTO 5: EROSION OF RIPRAP ON UPSTREAM FACE (LOOKING NORTH)

PHOTO 6: EXPOSURE OF EMBANKMENT AND EROSION OF RIPRAP ON UPSTREAM FACE

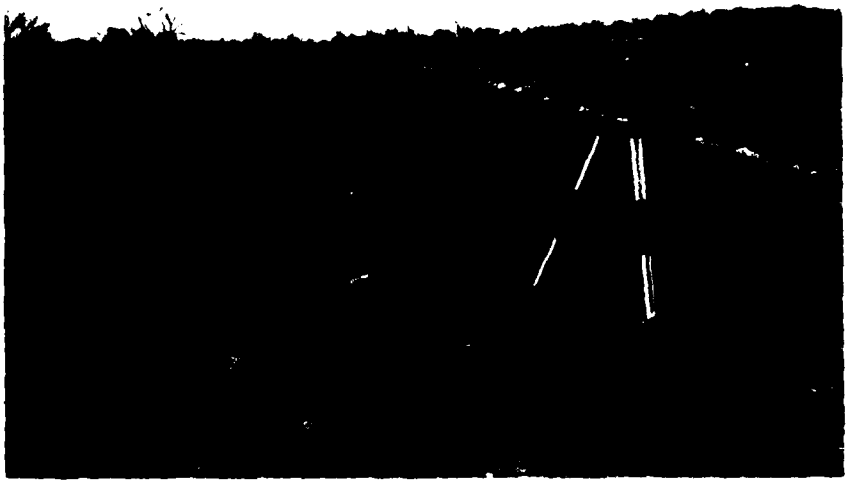


PHOTO 7: CREST OF DAM (LOOKING SOUTH)

PHOTO 8: DOWNSTREAM FACE OF DAM (LOOKING SOUTH)

PHOTO 9: EROSION ALONG TOE OF DAM (LOOKING SOUTH)

PHOTO 10: INTERIOR DRAIN OUTLET WITH FLAP GATE

PHOTO 11: SHAFT SPILLWAY STRUCTURE (LOOKING UPSTREAM)

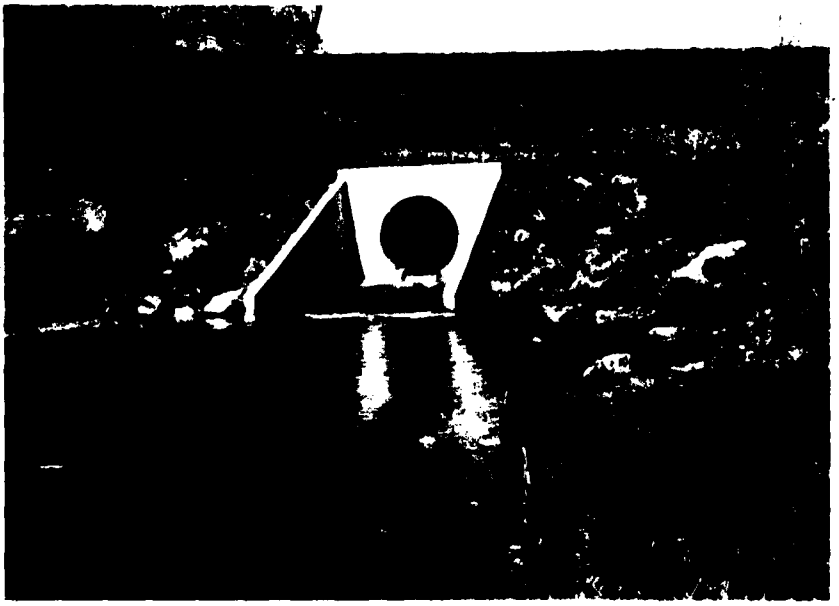


PHOTO 12: SHAFT SPILLWAY DISCHARGE STRUCTURE (LOOKING UPSTREAM)

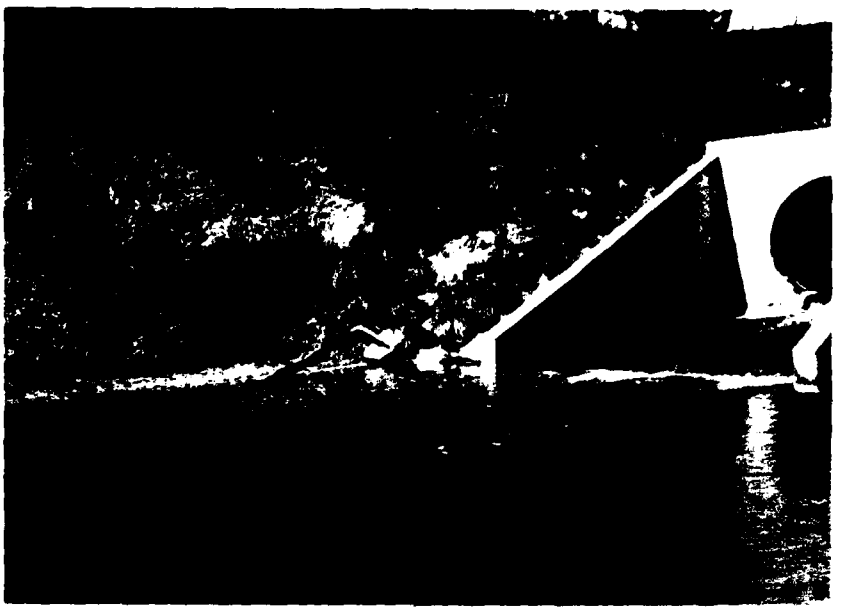


PHOTO 13: SEEPAGE FROM EMBANKMENT AND SPALLING OF CONCRETE ON WINGWALL

PHOTO 14: EROSION ALONG WINGWALL OF SPILLWAY DISCHARGE STRUCTURE

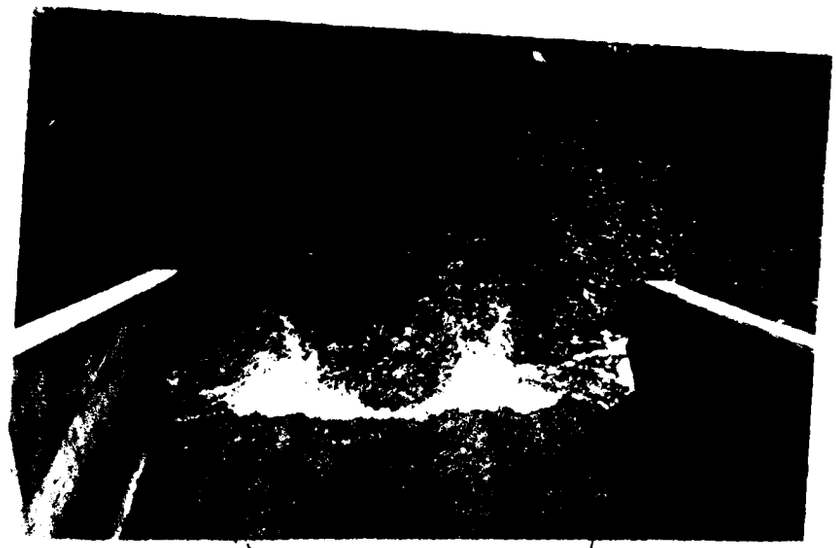


PHOTO 15: SHAFT SPILLWAY DISCHARGE STRUCTURE (LOOKING DOWNSTREAM)

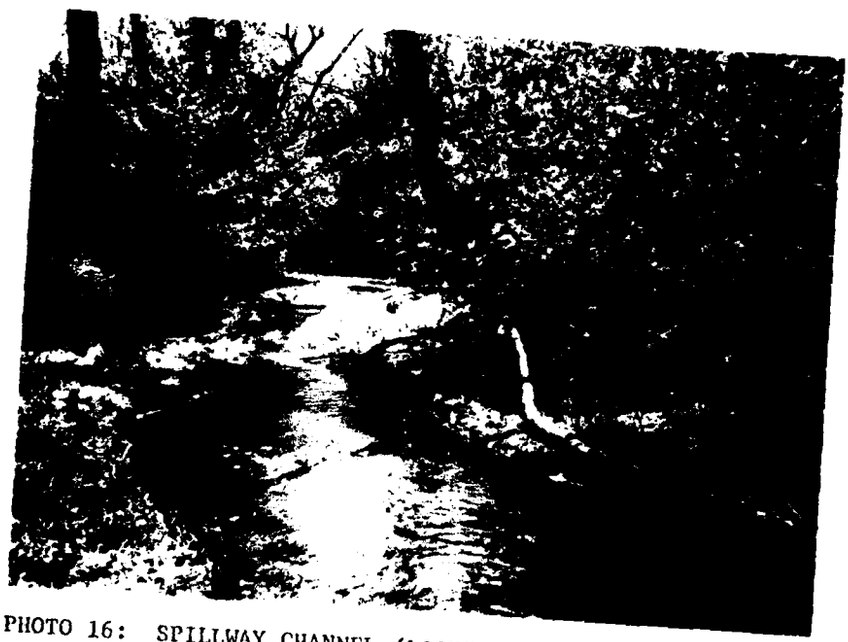


PHOTO 16: SPILLWAY CHANNEL (LOOKING DOWNSTREAM)

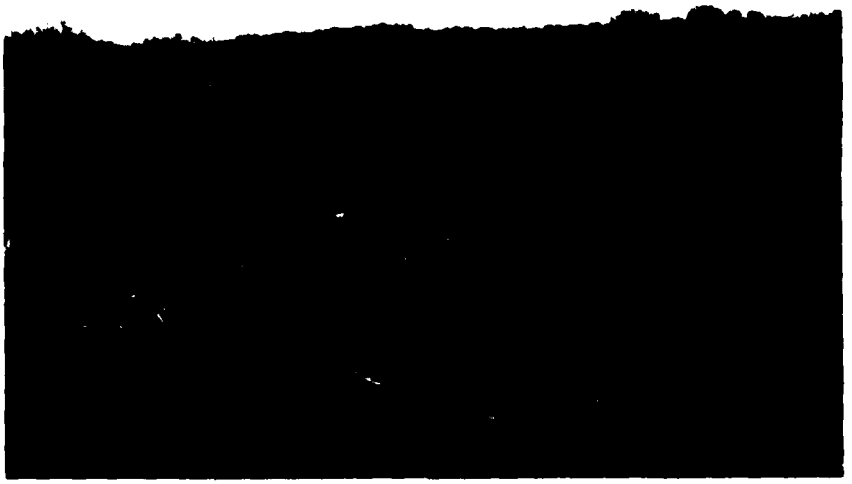


PHOTO 17: EMERGENCY SPILLWAY (LOOKING DOWNSTREAM)

PHOTO 18: EMERGENCY SPILLWAY APPROACH

PHOTO 19: EMERGENCY SPILLWAY CREST (LOOKING UPSTREAM)

PHOTO 20: EMERGENCY SPILLWAY DISCHARGE CHANNEL (LOOKING DOWNSTREAM)

APPENDIX A

HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs. Hydrologic inputs are as follows:

a. Forty-eight hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 25.0
14.79 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 97%
14.79 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 116%
14.79 square mile, 24 hour percent of 24 hour 200 square mile rainfall	- 125%
14.79 square mile, 24 hour percent of 24 hour 200 square mile rainfall	- 136%

b. Drainage area = 14.79 square miles = 9,470 acres.

c. Time of concentration: $Tc = (11.9 \times L^3/H)^{0.385}$, North Branch = 1.30 hours, West Branch = 0.84 hours, and South Branch = 0.71 hours.

d. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 88 and antecedent moisture condition III. Land usage in the watershed consists of pasture and range (55%), row crops (25%), and woods (20%). The hydrologic soil groups in the basin were B and C, with C being predominant.

2. The principal spillway is a shaft spillway with a morning glory inlet. Spillway discharge rates are based on the weir equation for low heads, and on orifice and pipe flow equations for higher heads.

Weir equation:

$Q = CLH^{1.5}$ (C = 2.43 to 3.97, L = ¶D = 37.7 feet, H is the head on the weir).

Orifice equation:

$Q = (R/0.204)^2 Ho^{0.5}$ (R = 4 feet, H_o is the head at the throat of transition).

Full pipe equation:

$$Q = A(2gH_T/K_T)^{0.5}$$ (A = 50.3 square feet, H_T is the total head, K_T is the sum of the loss coefficients).

Spillway discharge rates for the emergency spillway are based on the weir equation. The C values were chosen for broad-crested weirs of trapezoidal section:

$$Q = CLH^{1.5}$$ (C = 2.9 to 3.3, L = 105 to 245 feet, H is the head on the weir)

When the water level in the lake exceeds 904 feet, water flows over a berm between the dam and the spillway. Discharge rates over the berm are based on the weir equation:

$$Q = CLH^{1.5}$$ (C = 3.1, L = 180 feet)

Discharge rates over the top of the dam are also based on the weir equation:

$$Q = CLH^{1.5}$$ (C = 3.1, L = 1,900 feet)

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour above normal pool. The storage between two elevations was computed by multiplying the average of the areas at the two elevations by the elevation difference. The summation of these increments below a given elevation is the storage below that level.

4. Floods are routed through the spillway using HEC-1, modified Puls to determine the capability of the spillway.

(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, September 1978 Modification, Davis, California.

(2) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.

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**********
FLOOD HYDROGRA...PACKAGE (HEC-1)
DAM SAFETY VE...N     JULY 1978
  LAST MODIF. ...ION  25 SEP 78
**********
    1                A1       MISSOURI DAM INSPECTIONS
    2                A2       PMF ROUTING FOR HARRISONVILLE LAKE
    3                A3       DRAINAGE AREA = 14.79 SQ. MI.
    4                B     200         2         10         3         0         0         0         0         0         1
    5                B1       5
    6                J        1         6         1
    7                J1.5      .8        .85       .9        .95      1.0
    8                K        0   NORTH                              1         3         1
    9                K1       HARRISONVILLE LAKE 48 HOUR PMF INFLOW HYDROGRAPH - NORTH BRANCH
   10                M        1        25.53                         1.
   11                P         25.0     97.       116.      125.     136.
   12                T                                                                  -1       -88
   13                W2       1.30
   14                X                           1
   15                K        0   WEST                               1         3         1
   16                K1       HARRISONVILLE LAKE 48 HOUR PMF INFLOW HYDROGRAPH - WEST BRANCH
   17                M        1        25.47                         1.
   18                P         25.0     97.       116.      125.     136.
   19                T                                                                  -1       -88
   20                W2       0.64
   21                X                           1
   22                K        0   SOUTH                              1         3         1
   23                K1       HARRISONVILLE LAKE 48 HOUR PMF INFLOW HYDROGRAPH - SOUTH BRANCH
   24                M        1        23.79                         1.
   25                P         25.0     97.       116.      125.     136.
   26                T                                                                  -1       -88
   27                W2       0.71
   28                X                           1
   29                K        3  HEAD                                1                  1
   30                K1       COMBINE PMF INFLOW HYDROGRAPHS FROM NORTH, WEST, AND SOUTH BRANCHES
   31                K        1  DAM                                 1                  1
   32                K1       ROUTING PROBABLE MAXIMUM FLOOD THROUGH HARRISONVILLE LAKE
   33                Y                                    1         1
   34                Y1       1                                                 -895.              -1
   35                Y4895.   896.      897.      898.      899.     900.      901.      902.      903.      905.
   36                Y4910.   911.      915.
   37                Y50.     137.      506.      1520.     2660.    4160.     5850.     7920.     10240.    16230.
   38                Y542950.56050.     145430.
   39                $S0.     2325.     8190.     13000.
   40                $E895.   900.      910.      915.
   41                $$895.
   42                $D909.4
   43                K       99
```

HARRISONVILLE CITY LAKE

TRIBS MODELED SEPARATELY

PMF (85% PASS)

JUNE 14, 1979

```
**********
FLOOD HYD[illegible]APH PACKAGE (HEC-1)
DAM SAF[illegible]ERSION      JULY 1978
  LAST M[illegible]FICATION  25 SEP 78
**********

RUN  DATE= 06/14/79.
     TIME= 19.23.41.
```

MISSOURI DAM INSPECTIONS
PMF ROUTING FOR HARRISONVILLE LAKE
DRAINAGE AREA = 14.79 SQ. MI.

JOB SPECIFICATION

NQ	NMR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	10	0	0	0	0	0	0	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 6 LRTIO= 1

RTIOS= .50 .80 .85 .90 .95 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

HARRISONVILLE LAKE 48 HOUR PMF INFLOW HYDROGRAPH - NORTH BRANCH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
NORTH	0	0	0	1	5	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	5.53	0.00	5.53	1.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.00	97.00	116.00	125.00	136.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-98.00	0.00	0.00

CURVE NO = -98.00 WETNESS = -1.00 EFFECT CN = 88.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= 1.30

RECESSION DATA
STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

UNIT HYDROGRAPH 41 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= 1.30 VOL= 1.00

86.	266.	509.	852.	1282.	1632.	1846.	1924.	1914.	1789.
1621.	1417.	1159.	914.	745.	613.	507.	422.	348.	289.
234.	192.	157.	129.	104.	87.	72.	59.	49.	40.
33.	27.	22.	19.	16.	13.	11.	8.	6.	3.
1.									

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.00	0.00	.00	0.	1.02	.10	145	.03	.02	.00	64.
1.01	.20	2	.00	0.00	.00	0.	1.02	.20	146	.03	.02	.00	69.
1.01	.30	3	.00	0.00	.00	0.	1.02	.30	147	.03	.02	.00	78.
1.01	.40	4	.00	0.00	.00	0.	1.02	.40	148	.03	.02	.00	94.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS					
				RATIO 1 .50	RATIO 2 .80	RATIO 3 .85	RATIO 4 .90	RATIO 5 .95	RATIO 6 1.00
HYDROGRAPH AT	NORTH	5.53	1	11485.	18376.	19524.	20673.	21821.	22970.
		(14.32)		(325.22)(	520.34)(	552.87)(	585.39)(	617.91)(	650.43)(
HYDROGRAPH AT	WEST	5.47	1	13936.	22297.	23690.	25084.	26479.	27871.
		(14.17)		(394.61)(	631.38)(	670.84)(	710.30)(	749.76)(	789.22)(
HYDROGRAPH AT	SOUTH	3.79	1	10496.	16794.	17844.	18893.	19943.	20993.
		(9.82)		(297.22)(	475.55)(	505.28)(	535.00)(	564.72)(	594.44)(
3 COMBINED	HEAD	14.79	1	34380.	55009.	58447.	61885.	65323.	68761.
		(38.31)		(973.54)(	1557.67)(	1655.03)(	1752.38)(	1849.73)(	1947.09)(
ROUTED TO	DAM	14.79	1	19996.	36987.	39652.	42302.	45629.	48926.
		(38.31)		(566.24)(	1047.35)(	1122.82)(	1197.85)(	1292.07)(	1385.42)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	895.00	895.00	909.40
STORAGE	0.	0.	7838.
OUTFLOW	0.	0.	39744.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	905.70	0.00	5671.	19996.	0.00	41.67	0.00
.80	908.83	0.00	7536.	36987.	0.00	41.50	0.00
.85	909.38	0.00	7828.	39652.	0.00	41.33	0.00
.90	909.88	.48	8119.	42302.	1.17	41.33	0.00
.95	910.20	.80	8387.	45629.	1.67	41.33	0.00
1.00	910.46	1.06	8629.	48926.	2.00	41.33	0.00

END

DATE
FILMED

11-81

DTIC