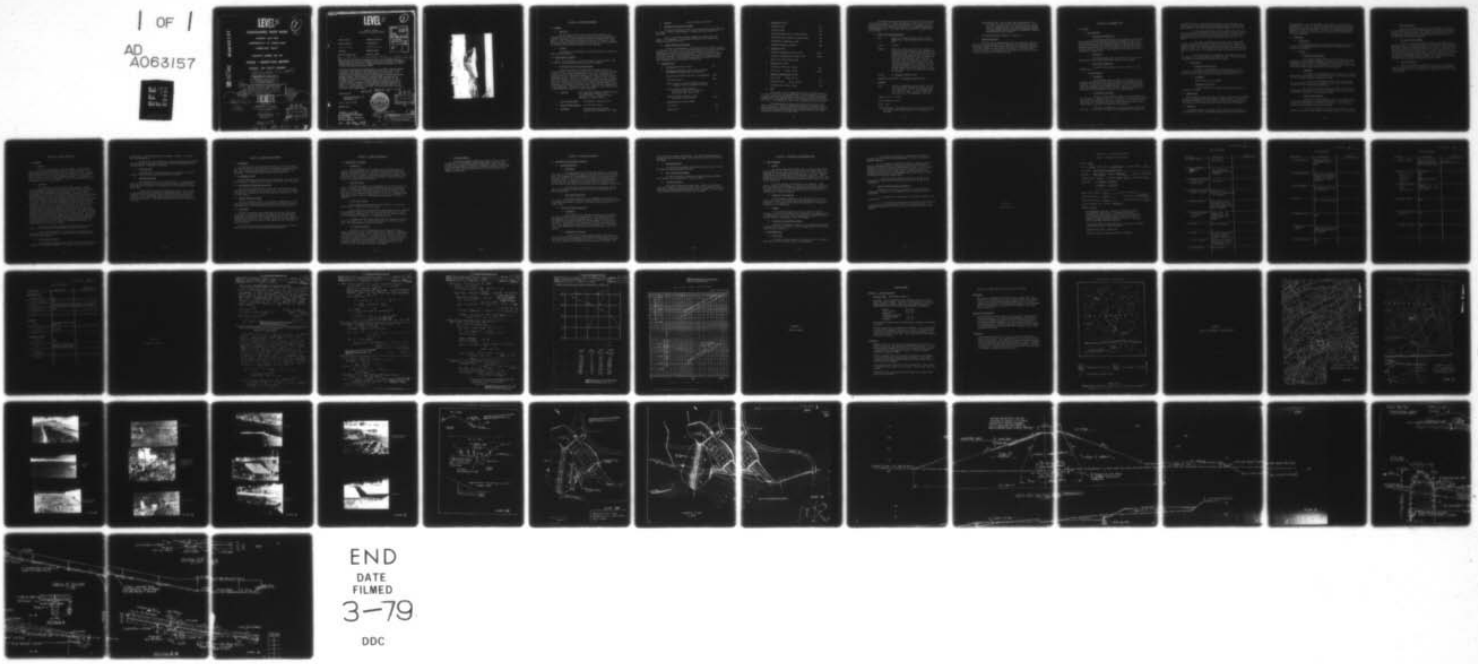
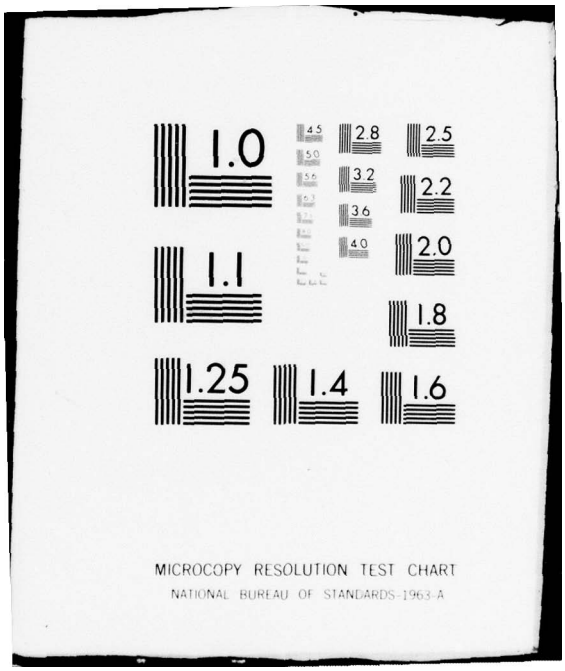
AD-A063 157 BERGER ASSOCIATES INC HARRISBURG PA F/G 13/2
NATIONAL DAM SAFETY PROGRAM. OPOSSUM LAKE DAM (INVENTORY NUMBER--ETC(U)
MAY 78 DACW31-78-C-0044
UNCLASSIFIED NL

1 OF 1
AD A063157



END
DATE FILMED
3-79
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD A063157

DDC FILE COPY

LEVEL II

SUSQUEHANNA RIVER BASIN

OPOSSUM LAKE DAM

COMMONWEALTH OF PENNSYLVANIA

CUMBERLAND COUNTY

INVENTORY NUMBER NDS 584

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

(15) DACW31-78-C-0044

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

(6) National Dam Safety Program. Opossum Lake Dam (Inventory Number NDS 584), Susquehanna River Basin, Cumberland County, Commonwealth of Pennsylvania. Phase I Inspection Report.

(11) 23 May 78

(12) 57 p.

Prepared For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland

by
BERGER ASSOCIATES, INC
CONSULTING ENGINEERS
HARRISBURG, PA.

DDC
RECEIVED
JAN 11 1979
D

411003
79 01 10 048

LEVEL II

(1)

ACCESSION for
NTIS White Section X
DDC Buff Section
UNANNOUNCED
JUSTIFICATION
Per DDC Form 50
BY on File
DISTRIBUTION/AVAILABILITY CODES
Dist. AVAIL. and/or SPECIAL
A

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	OPOSSUM LAKE DAM
State Located:	PENNSYLVANIA
County Located:	CUMBERLAND COUNTY
Stream:	OPOSSUM CREEK
Date of Inspection:	APRIL 5, 1978

Opposum Lake Dam is a zoned rolled earthfill dam with an impervious core. Construction was completed in June 1961. It was inspected 5 April 1978. This dam does not have the capacity to pass the recommended spillway design flood of one-half the Probable Maximum Flood without overtopping. The spillway capacity is not considered seriously inadequate, as the project will pass the 100-year flood.

A serious and persistent problem exists in a constant seepage passage over most of the length of the downstream slope of the dam. It is recommended that the owner maintain continual surveillance of the dam until the embankment has been rehabilitated to correct the serious seepage problem. The quantity of seepage (GPM) exiting from the drainage pipes should be measured daily and the turbidity of the discharge observed. If the seepage quantity increases by 50 percent from the initial readings, or if the observed seepage discharge is found to be cloudy, murky or containing fine soil particles; or if scarps or cracks develop on the slope, the reservoir should be drawn down until the seepage stops.

Contract DACW31-78-C-0044

Submitted By:

BERGER ASSOCIATES, INC.
HARRISBURG, PA.

Date: May 23, 1978

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
HENDRIK JONGSMA
ENGINEER
No. 5557E

DDC
RECEIVED
JAN 11 1979
D

Approved by:

G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

DATE: 30 May 1978

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

79 01 10 048

OVERVIEW

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

The Dam Inspection Act, Public Law 92-367 (Appendix III) authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspections of dams throughout the United States. Phase I Inspection and Report is limited to a review of available data, a visual inspection of the dam site and the basic calculations for determining the hydraulic adequacy of the spillway.

b. Purpose

The purpose is to determine if the dam constitutes a hazard to human life and property.

1.2 DESCRIPTION OF PROJECT

Note: All elevations in this report refer to project datum. Add 334 feet to obtain approximate mean seal level elevation.

a. Description of Dam and Appurtenances

Opossum Lake dam is a zoned rolled earthfill dam with an impervious core. Under the impervious core is a cutoff trench excavated to rock or suitable impervious material. The top of embankment is at elevation 137.0, the approximate maximum fill height is 38 feet and the embankment length is 310 feet. See Appendix D, Plate X, for a typical section of the dam. On the left abutment a concrete spillway is located with a weir elevation of 131 and a crest length of 86 feet (Appendix D, Plate IX). The emergency outlet is a 3 x 3 foot concrete conduit and is controlled by stop logs in a control tower located on the upstream side of the embankment. Appendix D, Plates III through VI, has reproductions of photographs made during the visual inspection.

b.	Location:	Lower Frankford Township, Cumberland County U.S. Quadrangle, Plainfield, Pa. Latitude 40°13.6', Longitude 77°16.8' (Appendix D, Plates I and II)
c.	Size Classification:	Intermediate (1,090 acre feet)
d.	Hazard Classification:	Low (See Section 3.e)
e.	Ownership:	Pennsylvania Fish Commission Robinson Lane, Bellefonte, Pa. 16823

f. Purpose: Public Fishing and Boating

g. Design and Construction History

The dam was designed in 1959 by the Pennsylvania Fish Commission, Mr. Thomas F. O'Hara, Chief Engineer. Construction was completed in June, 1961.

Due to a persistent seepage problem and several very soft spots on the embankment, a tile drain outletting to the minimum flow channel was installed in 1975.

h. Normal Operation Procedures

The lake is maintained at the spillway elevation 131.0, leaving a freeboard of six feet to the top of dam elevation. All inflow occurring when the pool elevation is at or above the normal pool elevation is discharged over the uncontrolled spillway. If pool elevation is below this level, minimum flow is obtained by removing one or more stop logs in the control tower. These logs are also used for drawdown purposes. Only occassional visits are made to the dam site.

1.3 PERTINENT DATA

a. Drainage Area (square miles)	4.83
b. Discharge at Dam Site (cubic feet per second) For hydraulic computations see Appendix B	
Maximum known flood at dam site - approximately	3,000
Warm water outlet	None
Outlet tunnel at low pool (maximum capacity of conduit with no stoplogs and no head)	67
Outlet tunnel at pool elevation 131 assuming that it is feasible to remove three stop logs at once	27
Maximum spillway capacity at pool elevation 137 (top of dam)	4,700
c. Elevation (Feet project datum)	
Top of dam	137
Maximum pool	137

c. Elevation (Cont'd)

Recreation pool	131
Spillway crest	131
Upstream portal invert of outlet tunnel	100
Downstream portal invert of outlet tunnel	99
Streambed at centerline of dam	99
Maximum tailwater (estimate)	108

d. Reservoir (Feet)

Length of maximum pool (Elev. 137)	6,600
Length of recreation pool (Elev. 131)	6,000

There is no flood control pool

e. Storage (acre-feet)

Recreation Pool (Elev. 131.0)	690
Top of dam (Elev. 137.0)	1,090

f. Reservoir Surface Area (acres)

Top of dam (Elev. 137.0)	73
Recreation pool (Elev. 131.0)	59
Spillway crest (Elev. 131.0)	59

g. Dam

The dam has a core of impervious material with side slopes of 1H to 1.5V on the down and upstream side. On the centerline of the dam a cutoff trench has been excavated to firm rock or suitable impervious material and a width varying from 23 feet at maximum section to a minimum of 12 feet. See Appendix D, Plate X for a typical section of the dam.

The upstream side is protected by Class "A" material with a slope of 3H to 1V. Class "A" material is described as a select impervious, structurally sound material with stones not greater than 6 inches. This material is protected by hand placed stone from three feet below normal pool elevation to the top of dam.

The downstream slope is protected by Class "B" material placed at a slope of 2.5H to 1V. Class "B" material is described as a structurally sound material and sufficiently pervious for drainage and containing stones. All material was placed in 4 inch layers and compacted by sheepsfoot rollers. The crest width of dam is 12'0". There is no grout curtain.

h. Outlet and Regulating Tunnel

Type - Tunnel is a square concrete culvert passing through dam. Inside dimensions are 3 feet by 3 feet.

Length - 204 feet.

Closure - There is a 4 feet 6 inch by 6 feet vertical access tower located about 8 feet upstream from centerline of dam. Sixty-eight stop logs, each measuring 6 inch square and 5 feet long, fit in slots on the centerline of tower and divide it into a wet well and a dry well. When the reservoir level is higher than the top of the stop logs, water will spill over and flow out through the remainder of the tunnel. The stop logs are removed and inserted manually. The maximum number that can be removed at one time is about three, due to the hydrostatic pressure on the logs.

Access - See Closure paragraph above.

Regulating Facilities - See Closure paragraph above.

i. Spillway

Type - Concrete trapezoidal weir and chute. The weir crest is 8 inches wide and the upstream face has a slope of 1H to 2V. The downstream face has a 1H to 1V slope. The weir is set three feet into rock. See Appendix D, Plate XI.

Length of Weir - 86 feet

Crest elevation - 131.0

Gates - None

Upstream channel - The Forebay area is excavated to elevation 128.0 and an unobstructed entrance to the spillway is available.

Downstream channel - The spillway chute leads directly into a 40 feet x 50 feet x 4 feet deep stilling basin. From the basin, the water flows in a natural channel about 800 feet to a highway bridge. High flows exceed the capacity of bridge opening and during Agnes a considerable (undetermined) flow was over the road.

The maximum spillway capacity is 4,700 cfs.

j. Regulating Outlets

The only way of releasing water from the reservoir, when the pool level is below spillway crest elevation, is by manually removing stop logs. Because of poor working conditions and hydrostatic pressure, it is only feasible to remove about three logs at a time (18 inches below pool level). The discharge over the height of 18 inches is about 27 cfs. Total number of stop logs is 68.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

a. Data Available

1. Hydrology and Hydraulics

An Application Permit Report was prepared by the Pennsylvania Department of Environmental Resources (PennDER) in June, 1957. This report states that the design discharge for the drainage area for this dam (4.83 square miles) should be 4,960 cfs and that the actual spillway capacity was 5,060 cfs. No mention was made at what elevation this capacity was reached. No other hydrologic or hydraulic data is available in PennDER files.

2. Embankment

The only available data was contained in a full set of design detail plans which include the results of four borings.

3. Appurtenant Structures

Structural design analyses were not available in the PennDER files.

b. Design Features

1. Embankment

The embankment section consists of an impervious core, protected and stabilized with Class "A" material on the upstream side and Class "B" material on the downstream side. No filters or rockfill drains are indicated at the downstream side. There is no indication where the embankment material came from and no description of the type of material. See Appendix D, Plate X, for a typical section.

2. Appurtenant Structures

The weir of the spillway is angled to the centerline of the dam and has a length of 86 feet. The weir is a concrete wall anchored with three feet long dowels into rock. The ends of the weir has reinforced concrete retaining walls with a maximum height of about 17 feet. Cutoff walls in the back of these walls are provided.

The chute is trapezoidal in section and has a length of 165 feet. At the end of the chute is a trapezoidal stilling basin with

a length of 40 feet. The slab of the chute is a ten inch thick reinforced concrete slab, resting on 8 inch crushed stone. Weepholes have been provided in the slab and sloping sidewalls (Appendix D, Plate XI).

The stilling basin has a width of about 50 feet and has a four foot deep bucket formed by a endsill. The chute is tapered from 86 feet at the weir to the width of the stilling basin. The chute and stilling basin walls are 10 inches thick paving slabs with a 2H to 1V slope.

The outlet consists of a 3 foot by 3 foot cast-in-place concrete conduit with an invert elevation of 100.00. The conduit has concrete collars on thirty-foot centers, but no collar is located in the impervious zone. The conduit ends at the downstream side with wingwalls and has a short apron. The downstream channel is protected by stone riprap.

The control tower is situated at the upstream side of the dam breast and is located within the impervious zone. The flow through the conduit is controlled by stop logs in the tower.

c. Design Data

1. Hydrology and Hydraulics

PennDER's Permit Application Report states that the capacity of the spillway is 5,060 cfs for a needed discharge of 4,960 cfs, but does not state available freeboard or design pool level.

2. Embankment

Design data are not available.

3. Appurtenant Structures

Design calculations or assumed design criteria were not available for review.

2.2 CONSTRUCTION

The available construction data for review included only the original contract drawings and some construction progress reports. The plans do not indicate filters or rockfill drains. A low area between the toe of fill and the stilling basin has been filled with Class "B" material.

2.3 OPERATION

No specific operation procedures exist, except that the lake is a much used fishing lake. The lake has been drawn down several times for

fish management. The only operation is the removal of stop logs for minimum flow. There is a consistent problem with seepage in the embankment slope and in the area between the toe of fill and stilling basin (Appendix D, Plate VII and VIII). In 1976, the Pennsylvania Fish Commission let a contract to place a drain in this area. The results have not been satisfactory.

2.4 EVALUATION

a. Availability

The engineering data which consists of construction plans and a report on the application permit was provided by PennDER, Office of Dams and Encroachments.

b. Adequacy

1. Hydrology and Hydraulics

The available engineering data is nonexistent, with the exception of the statement of adequacy of spillway to handle the design discharge of 4,960 cfs and the drainage area and pool surface area. No hydrographs, design storm or flood routings are available. Area capacity curve and spillway rating curves were also not available.

2. Embankment

The slopes of the embankment and the zoning of the embankment seems to be adequate, if Class "B" material is sufficiently pervious, but the following potential weaknesses do exist.

a. Due to the persistent wet spots on the embankment and on the filled in area, the conclusion could be made that the Class "B" material is not sufficiently pervious.

b. There is no filter between pervious zone and Class "B" material indicating that the type of material could be very similar. No drains are indicated in the downstream slope.

3. Appurtenant Structures

Review of the design drawings indicate an adequate design for the retaining walls of the spillway at the weir. The walls are keyed into the foundation for sliding resistance. The weir is placed on rock and anchored with dowels into the rock.

The concrete conduit has cutoff walls spaced at 30 feet. However, there are no cutoff walls in the core, except the control tower.

c. Operating Records

There are no formal operating records available. Checking with persons living in the area did not give any indication of the depth of water over the ogee section. The bridge located downstream of the stilling basin was flooded during the tropical storm Agnes (1972), but no records of flow depth were obtained.

d. Post Construction Changes

In 1976, an attempt was made to intercept the seepage in the embankment slope. A contractor excavated a trench about four feet deep, and placed stone and a perforated pipe in this trench. Some laterals were placed as sketched on Plate VII, Appendix D. The stone used was of one size and no filter action would occur. The backhoe used in the project was sinking quite deep in the mud and the scars of excavation are visible in the field (Photographs Plate IV, Appendix D). The drain pipes are discharging in the conduit outlet channel. The results of this attempt were not very successful and seepage is again occurring.

e. Seismic Stability

This dam is located in Seismic Zone 1 and it is considered that the static stability is sufficient to withstand minor earthquake-induced dynamic forces. No calculations or studies were made to confirm this statement.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

The overall appearance of the dam is good. The embankment slopes and the surrounding grassed areas are mowed regularly. Like many embankment slopes, small mole holes are present at random locations. Since these mammals do not burrow deep into the ground, their presence does not pose any threat to the embankment structure. See Appendix A for the visual checklist and Appendix D, Plates III through VI for photographs taken at time of inspection.

b. Embankment

The inspection of the downstream slope revealed a seepage condition beginning approximately thirty feet horizontally from the toe of the embankment (Appendix D, Plate VII and VIII). This condition is accompanied with what appears to be sloughing. Discussions with a representative of the owner, in charge of maintenance and repairs explained that the disturbance on the slope surface was due to measures taken during the summer of 1976, when a subsurface drainage system was installed to control an apparent annually increasing seepage from this portion of the slope. As near as can be determined, the remedial action involved trenching near the toe of the slope and parallel to the dam axis over a distance of about 150 feet. This area crosses over the outlet pipe. Several lateral trenches, perpendicular to the main trench, were cut into the slope. A four inch perforated plastic pipe and stone backfill were placed in the trench and covered with topsoil. The lateral trenches appear to be coincidental with the observed sloughing areas. The primary drain was carried to the outlet channel and day-lighted just below the outlet works end wall. The measures taken are not entirely satisfactory as water still seeps from the toe of the embankment, even though the pipe discharging to the outlet channel is continuously flowing. (No measurement of flow made at this time).

The need for further investigations and improvement is indicated. The construction of the dam did not include a toe drain.

On the left abutment some of the hand laid riprap has been disturbed and should be repaired. This was caused by vandalism, rather than structural distress.

c. Appurtenant Structures

The spillway, abutment walls, stilling basin and control tower appeared to be performing adequately and showed no signs of distress

beyond that of normal temperature and shrinkage cracking. All drains were working properly.

At the end of the stilling basin walls some erosion has occurred and some dumped riprap should be placed to prevent undercutting of the sloped sidewalls. (Appendix D, Plate VI).

d. Reservoir Area

The appearance of the reservoir area was excellent. No indications of more than the usual bank erosion was noticed.

e. Downstream Channel

The downstream channel is in good condition. A bridge located about 500 feet downstream of the stilling basin and carrying Township Road 460 over the channel is an obstruction but not considered a hazard to the dam.

Opossum Creek traverses an undeveloped area for about 1/4 of a mile and then joins the much wider Conodoguinet Creek. In the first few miles of the Conodoguinet Creek relatively little development has occurred, except a few cabins, which are located fifteen feet above normal water elevation. The Hazard Category for this dam is considered to be low.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

Mr. Ray Stichler, the maintenance foreman of the Fish Commission for this dam indicated that there are no established procedures for the dam. The reservoir has been drawn down on a regular basis for fish management. The maximum drawdown has been about eight feet.

4.2 MAINTENANCE OF DAM

The dam embankment is relatively well maintained. The grass mat is mowed regularly, although the wet areas are often too soft to be mowed.

4.3 MAINTENANCE OF OPERATING FACILITIES

The only operating facility is the control tower with stop logs. The closure of the tower is a steel plate lid. To prevent the conduit from acting as a siphon the lid is kept open with a section of 4 inch x 4 inch timber.

4.4 WARNING SYSTEMS IN EFFECT

There is no warning system. The foreman is responsible for many dams in Central Pennsylvania and during the recent tropical storms no representatives of the Fish Commission observed the dam or spillway.

4.5 EVALUATION

The dam is relatively well maintained, but is one of many dams spread over a large area owned by the Pennsylvania Fish Commission. At present the Commission has not implemented a surveillance system during high precipitation. The seepage, which has been increasing over the years, is a point of concern to the Commission, but they have no solution planned.

Due to the total lack of a warning system or inspection during heavy runoff, a monitoring system should be implemented.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data

In the application for a permit, the owner stated that the spillway would pass 5,060 cfs. Calculations made for this inspection indicate a maximum capacity of 4,700 cfs, with the water surface at the level of the top of the dam. The available files did not contain information about basic assumptions used in the design. Hydraulic computations are in Appendix B of this report.

b. Experience Data

The dam and reservoir are unattended most of the time and as a result the owner's representative was unable to furnish any experience data. It is known that the spillway safely passed the floods of 1972 and 1975. Poor quality high water marks on the left bank upstream from the spillway weir indicate a head of about 4 or 5 feet. Calculations in Appendix B indicate that the corresponding discharge would be about 3,000 cfs.

c. Visual Observations

The drainage basin upstream from the reservoir is rural and partly wooded. Perhaps 50% is state owned.

The spillway weir and chute are in good repair with the exception of considerable erosion of the left bank, just downstream from the end of the concrete retaining wall. The stilling pool is clean and appears to be performing its function in a satisfactory manner.

A highway road and bridge located 800 feet downstream from the dam form a constriction. Water has flowed over the road in the recent past. The bridge opening is 6 feet by 30 feet.

d. Overtopping Potential

The dam has a size classification of "intermediate" and a hazard potential of "low". These classifications require a recommended Spillway Design Flood (SDF) in the range between a 100-year flood (1,350 cfs) and a 1/2 PMF (7,120 cfs). Calculations made for this inspection in Appendix B indicate that the spillway will pass a 100-year flood with a 3.2 feet freeboard. The one-half PMF, however, will not pass the spillway, without overtopping the dam. The storage capacity of the reservoir is not sufficient to prevent overtopping.

e. Spillway Adequacy

The maximum spillway capacity at elevation 137 is 4,700 cfs or 33 percent of the Probable Maximum Flood (PMF). Therefore, the spillway is not adequate to pass the recommended 1/2 PMF. However, it is not considered that the spillway is seriously inadequate, since the capacity is only 1,090 acre-feet which is just over the limit for a "small" classification.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observation

1. Embankment

Of great concern was the noticeable seepage on the embankment slope over a considerable length and the wet areas in the filled-in area. The sloughage on the embankment was caused by the construction of the drain in 1976. The trench was filled with No.2 crushed stone and a perforated pipe. No graded filter was installed and the effectiveness of the drain has been reduced on the right side of the conduit and on the left side of the conduit the foundation drain is completely ineffective.

The only other points of concern are the slight disturbance in the hand laid riprap and the erosion at the downstream end of the stilling basin.

2. Appurtenant Structures

The visual inspection of the appurtenant structures did not indicate any signs of stress or unstable conditions, with the exception of possible undermining by erosion of the ends of the stilling basin sloped walls.

b. Design and Construction Data

1. Embankment

The available files and design drawings do not indicate the type of material used in the embankment. Soil classification for the different zones in the embankment are not available and no data on permeability, cohesion weight and internal angle of friction are in the files. The seepage on the slope and on the fill area between the toe of the embankment and the stilling basin indicates that the pheatic line in the embankment is relatively high and could cause a stability problem.

2. Appurtenant Structures

A review of the design drawings indicate that the abutment structures of the spillway and the spillway were designed in accordance with acceptable engineering assumptions. The drainage system under the slab is good, and the weepholes in the walls are functioning. No

signs of undue settlement were noticed. The relative high discharges during the tropical storms Agnes (1972) and Eloise (1975) did not cause any damage.

c. Operating Records

No records are available and nobody could be located to state how high the maximum discharge has been.

d. Post Construction Changes

An effort was made to reduce the seepage through the embankment slope by the installation of a drain in 1976.

e. Seismic Stability

This dam is located in Seismic Zone 1 and it is considered that static stability with normal safety factors is sufficient to withstand minor earthquake-induced dynamic forces. However, no calculations or studies have been made to confirm this conclusion.

SECTION 7 - ASSESSMENT AND RECOMMENDATIONS

7.1 DAM ASSESSMENT

a. Safety

The visual inspection indicated that a seepage problem exists. This occurred for the first time several years after construction was completed and became progressively more serious. In 1976, a drain was installed but the seepage again is becoming worse each year. Before installing the drains some attempts were made to measure the flow. This seepage could become a serious problem and affect the safety of the dam if not controlled.

The other aspects of the dam seem to be adequate. Under normal conditions the embankment is stable and the spillway capacity is more than sufficient for a 100-year discharge occurrence and will pass a maximum of 33 percent of PMF. Further erosion at the end of the stilling basin should be prevented.

b. Adequacy of Information

The information available is not considered sufficient to analyze the cause of the seepage and additional studies are in order to determine if the seepage occurs through the embankment or through the foundation of the embankment.

c. Urgency

It is considered imperative that the additional studies necessary to resolve the cause of, and a solution to the seepage problem be implemented by the owner. Other recommendations suggested in this section should be implemented as soon as feasible.

d. Necessity for Additional Studies

Additional studies by the owner or its representative should be initiated as soon as possible. Other recommendations as listed below should be given attention.

7.2 RECOMMENDATIONS

a. Facilities

To assure continued satisfactory operation of the embankment and facilities the following actions are recommended:

1. The owner should maintain a continuous surveillance of the dam until the dam has been rehabilitated to correct the serious seepage condition.

2. The quantity in gallons per minute of seepage exiting from the drainpipes should be measured and recorded daily and the turbidity of the water should be observed and recorded. If the seepage quantity increases by fifty percent from the initial readings or if the seepage is found to be cloudy, murky or containing fines; or if scarps or cracks develop on the embankment slope, the reservoir should be drawn down until the seepage stops.

3. Protective riprap should be placed at the end of the stilling basin slope walls to prevent further erosion during large discharges.

b. Operation and Maintenance Procedures

Although the dam and its facilities are in generally good maintenance condition, it is recommended that the following items be considered.

1. Installation of a staff gage on the right abutment of the spillway weir.

2. A surveillance program should be developed and implemented to observe the pool levels during periods of high precipitation. A downstream warning system in the event of an emergency should be implemented.

APPENDIX A

VISUAL CHECKLIST

CHECK LIST - DAM INSPECTION PROGRAM

PHASE I - VISUAL INSPECTION REPORT

NAD NO. 584

PA. ID # 21-176 NAME OF DAM Opossum Dam HAZARD CATEGORY Low

TYPE OF DAM: Earthfill with impervious core

LOCATION: Lower Franklin TOWNSHIP Cumberland COUNTY, PENNSYLVANIA

INSPECTION DATE 4-5-78 WEATHER Sunny - Breezy TEMPERATURE 40's

INSPECTORS: H. Jongsma R. Houseal

R. Steacy A. Bartlett

NORMAL POOL ELEVATION: 131.0 AT TIME OF INSPECTION:

BREAST ELEVATION: 137.0 POOL ELEVATION: At Spillway - Just flowing

SPILLWAY ELEVATION: 131.0 TAILWATER ELEVATION: 100.0

MAXIMUM RECORDED POOL ELEVATION: No Record

GENERAL COMMENTS:

Some sloughage areas are in evidence on downstream slope, accompanied by some seepage. Discussions with Owner's representative indicated that a drain system was constructed on the downstream during the summer of 1976, to relieve an apparent increasing seepage problem in this area. There had been some seepage observed since 1965.

The installation of the drainage pipes, etc. has not completely arrested the problem. Refer to Sketch #1.

Embankment well kept - mowed close.

Small mole holes on downstream slope of embankment.

DAM NO. NAD 584

VISUAL INSPECTION

EMBANKMENT	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. SURFACE CRACKS	None Evident	
B. UNUSUAL MOVEMENT ~~BEYOND~~ TOE ABOVE	Two slough areas seepage toward toe of embankment	
C. SLOUGHING OR EROSION OF EMBANKMENT OR ABUTMENT SLOPES	See Sketch #1.	
D. VERTICAL & HORIZONTAL ALIGNMENT OF CREST	Vertical - O.K. Horizontal - appears level no settlement	
E. RIPRAP FAILURES	None evident on main embankment (west side) Some displacement on east side of spillway	
F. JUNCTION EMBANKMENT & ABUTMENT OR SPILLWAY	Appears sound. No displacement - some slight cracks. Not serious.	
G. SEEPAGE	Yes - See Sketch #1	
H. DRAINS	Recently installed-1976 to arrest seepage problem. See Sketch #1	
J. GAGES & RECORDER	Weirs used to measure seepage flows - records at Bellefonte, Pa.	
K. COVER(GROWTH)	Grass - mowed.	

DAM NO. NAD 584

VISUAL INSPECTION

OUTLET WORKS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. INTAKE STRUCTURE	Concrete tower in embankment with stop logs.	
B. OUTLET STRUCTURE	Seepage from embankment adjacent to outlet wing (right side) looking upstream	
C. OUTLET CHANNEL	Satisfactory - grassed, no large trees	
D. GATES	None - stop log control	
E. EMERGENCY GATE	None	
F. OPERATION & CONTROL	Removal of stop logs for fish management (up to 8' removed)	
G. BRIDGE (ACCESS)	None	

DAM NO. NAD 584

VISUAL INSPECTION

SPILLWAY	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. APPROACH CHANNEL	End of wall looking downstream left side - some sloughage erosion	Not serious Should repair rip rap
B. WEIR: Crest Condition Cracks Deterioration Foundation Abutments	86' width Good Nil Nil Appears satisfactory Good	
C. DISCHARGE CHANNEL Lining Cracks Spilling Basin	Sloping Concrete Apron - good None evident	
D. BRIDGE & PIERS	None	
E. GATES & OPERATION EQUIPMENT	None	
F. CONTROL & HISTORY	None	

DAM NO. NAD 584

VISUAL INSPECTION

MISCELLANEOUS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
INSTRUMENTATION		
Monumentation	None	
Observation Wells	None	
Weirs	Previous Records-Seepage	Records at Bellefonte
Piezometers	None	
Other		
RESERVOIR		
Slopes	Some grass, pines, small trees.	
Sedimentation	No record	
DOWNSTREAM CHANNEL		
Condition	Good	
Slopes	Slight erosion adjacent to end of channel walls	
Approximate Population	5	
No. Homes	2	

APPENDIX B

HYDROLOGY/HYDRAULICS

E. H. BOURQUARD ASSOCIATES, INC. _____ of

PROJECT Dam Investigation SHEET NO. 1 OF 4

SUBJECT Spillway Dam ID #. 584

COMPUTED BY RES DATE 4-4 '78 CHECKED BY JJPJr 4-13-78

Maximum known flood at damsite

No records of flow or stage are kept by owner. Dam is unattended most of the time. Resident in house at top of left bank recalls that in 1972 flood, her husband had to wear waders to cross low point at left end of bridge 800 feet downstream from dam. Old high-water marks on left bank upstream from dam indicate head on spillway of about 4.5 feet.

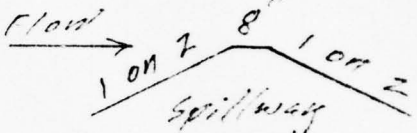
$Q = CLH^{3/2}$

$C = 3.73$, $L = 86$ ft, $H = 4.5$ ft

$Q = 3.73 \times 86 \times (4.5)^{3/2}$

$= 3067$ cfs.

Use 3,000 cfs



$C = 3.73$ for $H = 4$ ft.

THIS PAGE IS BEST QUALITY PRACTICABLE FROM COPY FURNISHED TO DDC

Diversion tunnel outlet at pool elev. 537.0 ft (project datum)

Only low-flow outlet from reservoir is a square concrete box culvert passing through dam. Inside dimensions are 3 ft x 3 ft, 34 is 204 ft long. There is a 4 ft-6 inch x 6 ft-0 inch vertical access tower about 8 ft upstream from centerline of dam. Stop logs, measuring 6 inch x 6 inch x 5 ft, set in slots on D/S of tower forming a wall that divides tower into a wet well and a dry well. Diversion tunnel discharge is controlled by inserting or removing stop logs. Stop logs are removed manually and it would be difficult to remove more than 3 at a time. If 3 stop logs are removed, discharge would be:

$Q = CLH^{3/2}$, $C = 3.32$, $L = 4.5$, $H = 1.5$

$= 3.32 \times 4.5 \times (1.5)^{3/2}$

$= 27.4$ cfs. Use 27 cfs.

Check culvert capacity. $Q = \frac{1.486}{n} a r^{2/3} s^{1/2}$

$n = 0.014$; $a = 9$ ft^2; $r = \frac{9}{9} = 1.0$; $s = \frac{4.6}{204} = 0.0049$

$Q = \frac{1.486}{0.014} \times 9 \times 1^{2/3} \times \sqrt{0.0049}$

$= 662$ cfs. Use 2[illegible] cfs.

Diversion tunnel low pool outlet at pool elevation 103.0 ft (project datum)
Upstream invert 100 ft
Downstream invert 99.0 ft. Length = 204 ft
Assume water is not touching top of culvert

$$Q = \frac{1.486}{n} a \cdot r^{2/3} \cdot s^{1/2}$$

$n = 0.014$, $a = 9\ ft^2$, $r = \frac{9}{9} = 1.0$ ft

$s = \frac{1.0}{204} = 0.0049$ ft/ft

$$Q = \frac{1.486}{0.014} \times 9 \times (1.0)^{2/3} \times (0.0049)^{1/2}$$

$= 965 \times 1 \times 0.07$

$= 66.8$ cfs (capacity of tunnel with no stop logs) Use 67 cfs

---

Spillway discharge capacity with pool at 1327 ft (top of dam)
Spillway crest is at 131 ft.

$Q = CLH^{3/2}$ $C = 3.73$ (King's Handbook of Hydraulics)
$L = 86$ ft
$H = 6$ ft

$Q = 3.73 \times 86 \times (6)^{3/2}$

$= 4,714$ cfs. (In application for permit owner stated spillway would pass 5060 cfs)

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Use 11,710 cfs

Size classification
Storage 1,090 ac. ft. (top of dam)
Height 35 ft.
Use "intermediate".
Hazard potential
Loss of life None
Economic loss - Minimal
Use "Low".
Recommended Spillway Design Flood
100-yr to ½ PMF
PMF = 2,950 cfs/sq. mi. (From curves furnished by Baltimore District Corps of Engr.)
$= 4.83 \times 2950 = 14,248$ cfs
½ PMF = 7124 cfs
Use 11,710 cfs.

E. H. BOURQUARD ASSOCIATES, INC.

PROJECT Dam Investigation SHEET NO. 3 OF 4

SUBJECT Cocalico Dam - I.D. # 588

COMPUTED BY [illegible] DATE 4-12-78 CHECKED BY JJPJr 4-13-78

Spillway routing for PMF.

PMF = 14,248 cfs.

Spillway capacity 4,710 cfs.

Spillway can pass $\frac{4710}{14248} = 33.1\%$ of PMF. (From short cut relations furnished by Balt. Dist. Corps of Eng.)

$\frac{\text{Req. Res. Storage}}{\text{Vol of Inflow}} = 0.675$

Vol of Inflow = $\frac{14248 \times \frac{24}{24}}{2} = 7124$ cfs-days

= 14,130 ac. ft.

Storage required = 14,130 × 0.675 = 9538 Ac. Ft.

Storage available 1090 - 690 = 400 Ac. Ft.

Dam will be overtopped.

Spillway routing for ½ PMF.

½ PMF = 7,124 cfs.

Spillway capacity = 4710 cfs.

$\frac{\text{Max spillway Q}}{\text{Peak Inflow}} = \frac{4710}{7124} = .661$.

$\frac{\text{Req. Storage}}{\text{Vol. of Inflow}} = 0.34$.

Vol. of Inflow = $\frac{7124}{2} = 3562$ cfs-days.

= 7065 Ac Ft.

Req. Storage = 0.34 × 7065 = 2402 Ac. Ft.

Storage Available 400 Ac. Ft.

Dam will be overtopped.

Spillway routing for 100 year flood.

100 Yr flood = 259 (4.83)$^{1.00}$

= 1,253 cfs from Balt. 13 Sq. DEC*

Spillway capacity = 4710 cfs.

At 1253 cfs reservoir elev. = 133.8 ft.

Freeboard = 137.0 − 133.8 = 3.2 ft.

(neglecting storage)

* Floods in Pennsylvania, PA DER & USGS, Oct. 1977

Using Plates 1 & 4, Model 6B, p. 5

$Q_T = CA^x$

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

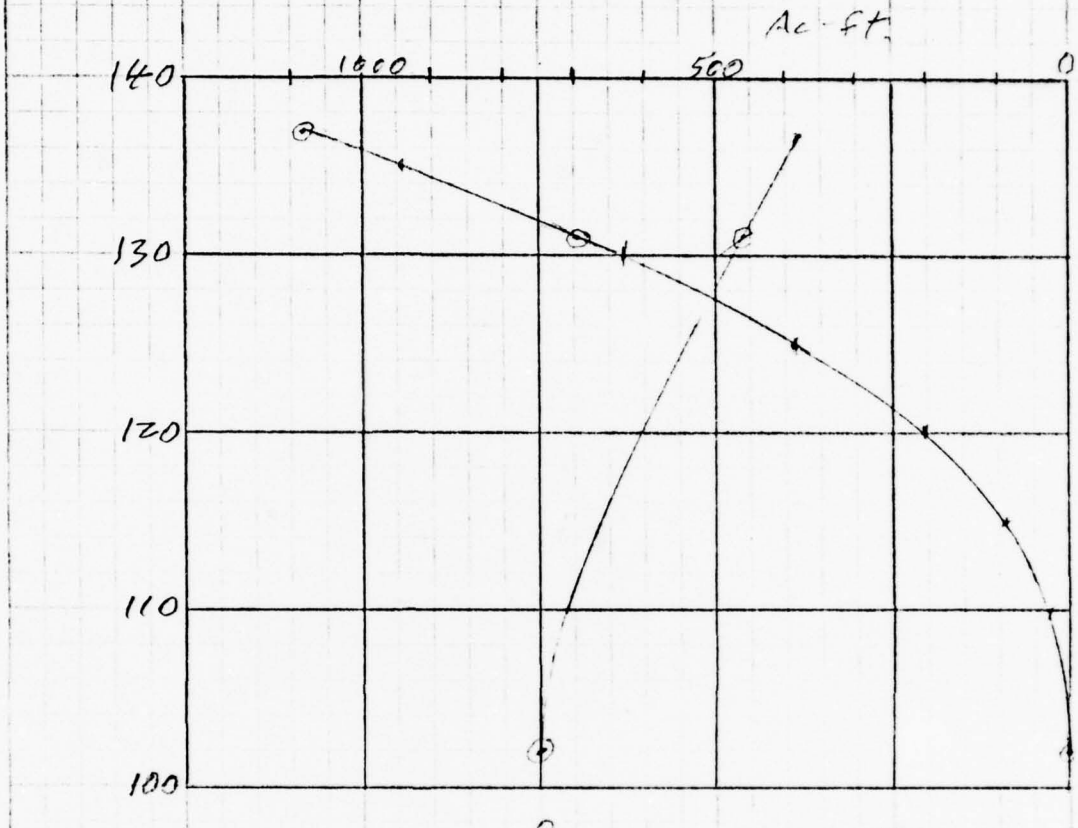
E. H. BOURQUARD ASSOCIATES, INC. _____ of

PROJECT National Dam Safety Inspection SHEET NO. 4 OF 4

SUBJECT Opossum Dam ID # 2??

COMPUTED BY KEB DATE 4-13-78 CHECKED BY _____

Recalculation of Surface Area.



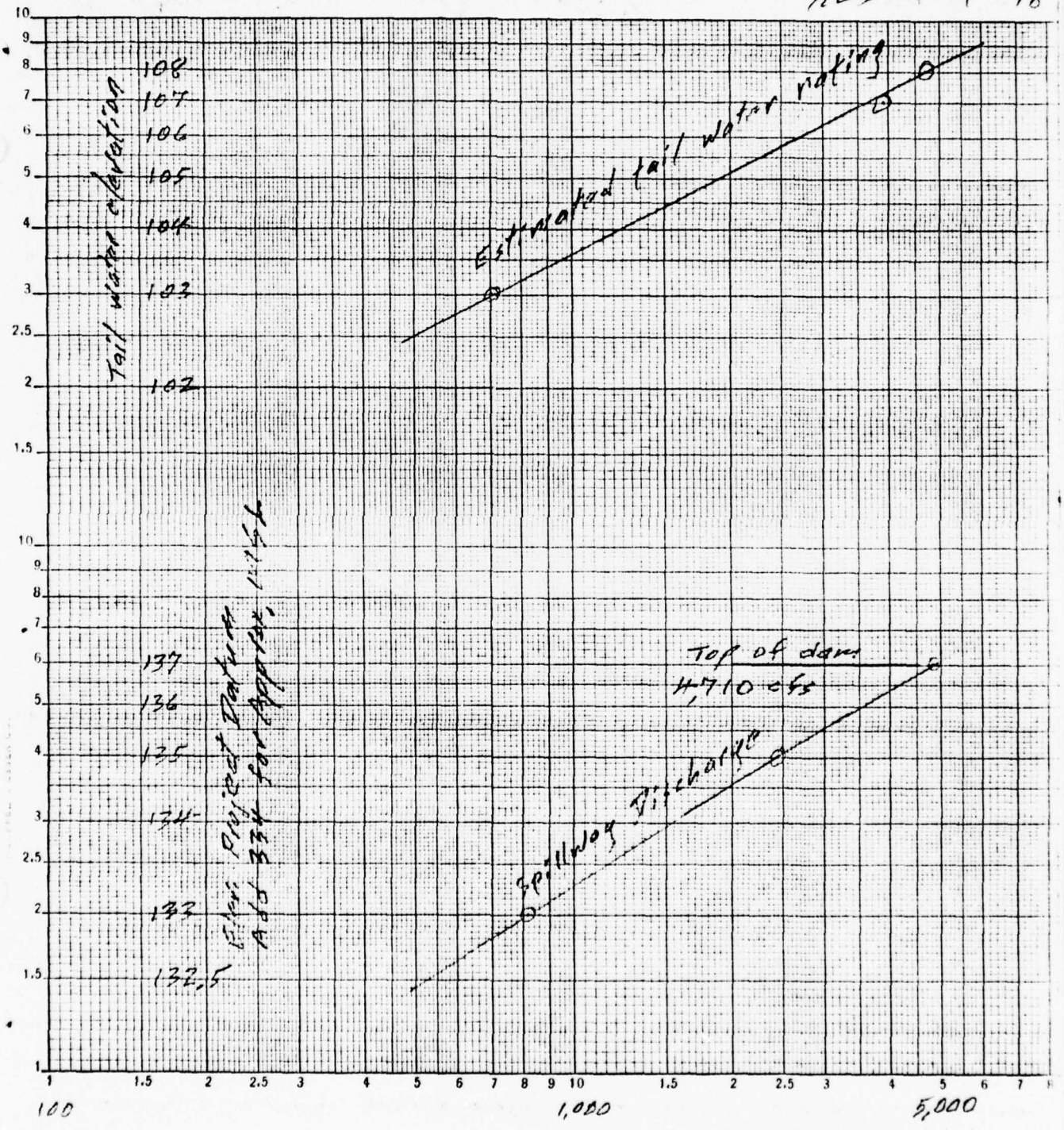
Elev.	Area Acres	Vol. Ac. Ft.	Cum. Ac. Ft.
102	0	0	0
110	7	28	28
115	17	60	88
120	30	118	206
125	43	182	388
130	55	245	633
131	59	57	690
135	69	256	946
137	73	142	1088

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Opossum Jam ID # 584

RES 4-4-78



Spillway Discharge, cubic feet per second

APPENDIX C

GEOLOGIC REPORT

GEOLOGIC REPORT

Bedrock - Dam and Reservoir

Formation Name: Martinsburg Formation.

Lithology: Gray to dark gray finely laminated shale, with some gray silt zone interbeds. Weathers to olive gray color. Mineralogical analyses of samples taken from the formation elsewhere in Cumberland County give the following approximate composition:

Quartz	30 to 37%
Mica (Illite?)	29 to 49%
Kaolinite	6 to 7%
Chlorite-Vermiculite-Montmorillionite	8 to 9%
Feldspar	2 to 11%

These figures indicate that the proportion of swelling clay minerals is small.

Drillers logs of the core borings are available. The log of Boring #2 indicates "Limestone" from 3.5 to 6.5 feet. While limestone is present in areas mapped as Martinsburg Formation elsewhere in the state there is none in this area. It is concluded that the identification was erroneous.

Structure

Bedding exposed at east end of dam strikes N90°E and dips 75°N. In borrow pit east of road bedding strikes N85°E and dips 15° to 30°S. The Martinsburg Formation in this area is tightly folded, but the structure has not been mapped in detail. The observed strike conforms to regional strike.

Fracture cleavage forms the principal parting other than bedding. In the borrow pit this cleavage strikes N70°E40°S. The intersection of this cleavage and bedding causes the weathered shale to form pencil-like fragments.

The principal joint direction is N5°E, dipping 70°W. These joints are spaced several inches to a foot apart. Joint surfaces are iron stained.

Principal air photo fracture trace directions are: N48°W, N40°W, N55°W, N17°E and N20°E.

There are no mapped faults in the vicinity of the dam.

Overburden

The bedrock is weathered to depths of ten to fifteen feet. The logs of the core holes do not clearly indicate depth of weathering, but the term "shale" probably means weathered rock, and "slate" probably is fresh rock. The longitudinal section of the dam suggests that the cutoff trench was located in the weathered zone, rather than in fresh rock.

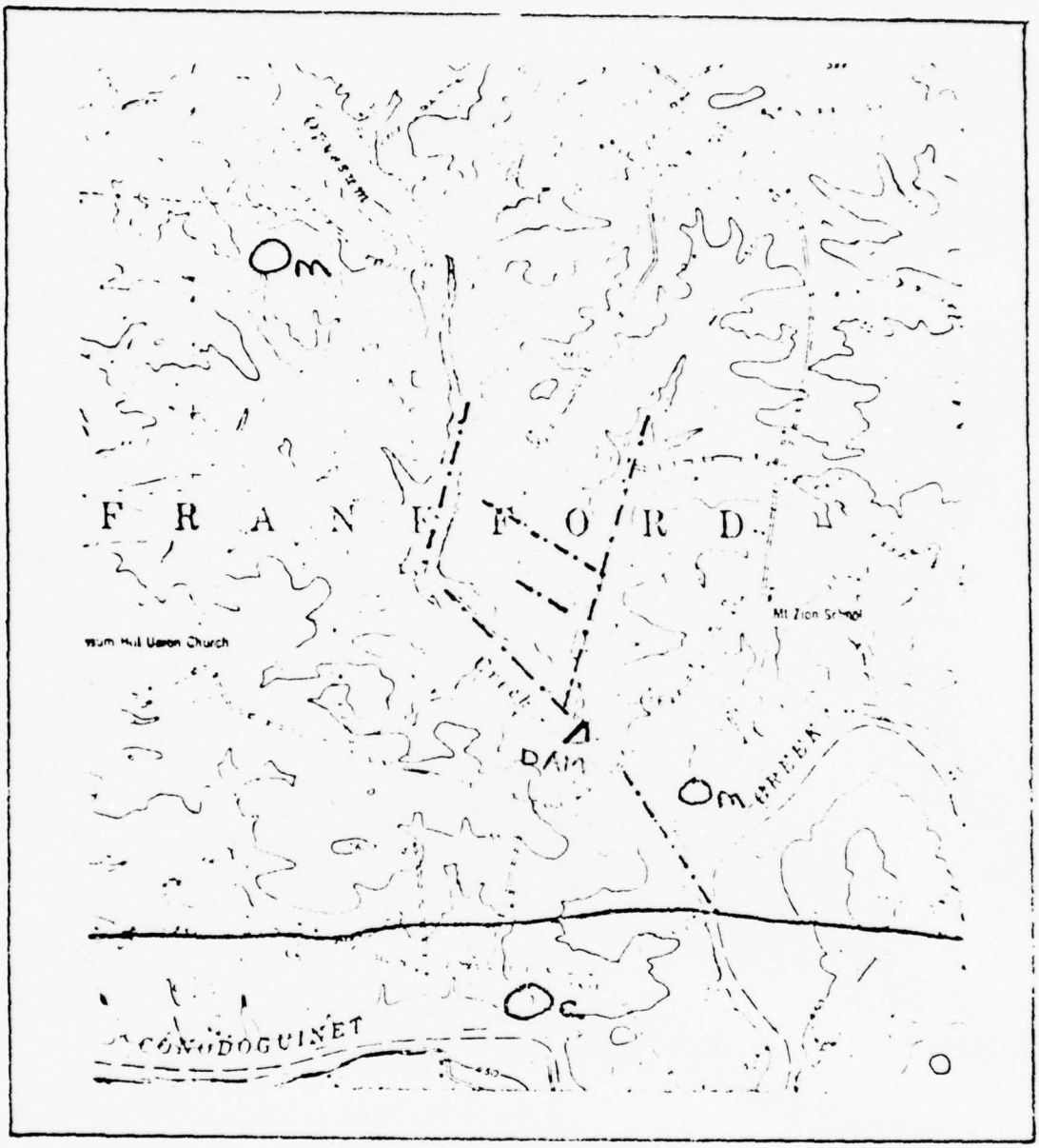
Aquifer Characteristics

The Martinsburg Formation consists of essentially impermeable rock. Below the weathered zone porosity and permeability is secondary, provided by bedding planes and fractures. The weathered zone is more porous and more permeable. Most ground water storage is in the weathered zone. Fracture traces which control straight reaches of upland streams are the principal sites of ground water movement below the water table.

Discussion

The Martinsburg Formation is a strong, relatively impermeable material where fresh. The weathered zone is more porous and permeable and would make a poor foundation, unless extensively grouted. In the unweathered zone ground water movement is largely on bedding planes and the fractures which control valley alignment. There is no limestone or other soluble material in this area, so enlargement of openings in permeable zones is unlikely.

Geologic Map - Opossum Dam



Om Martinsburg formation

Oc Chambersburg formation

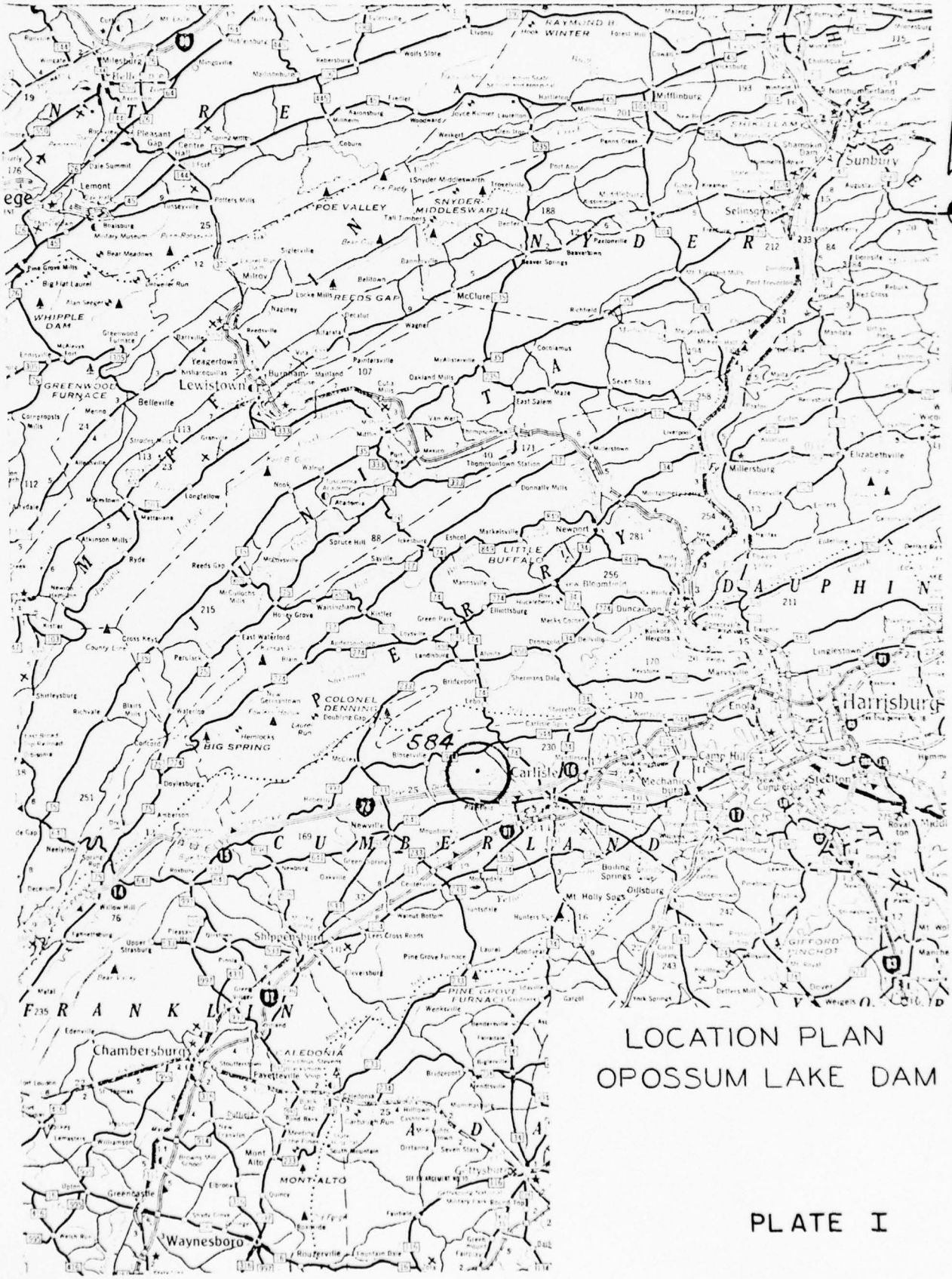
air photo fracture trace

N

SCALE 1:24000

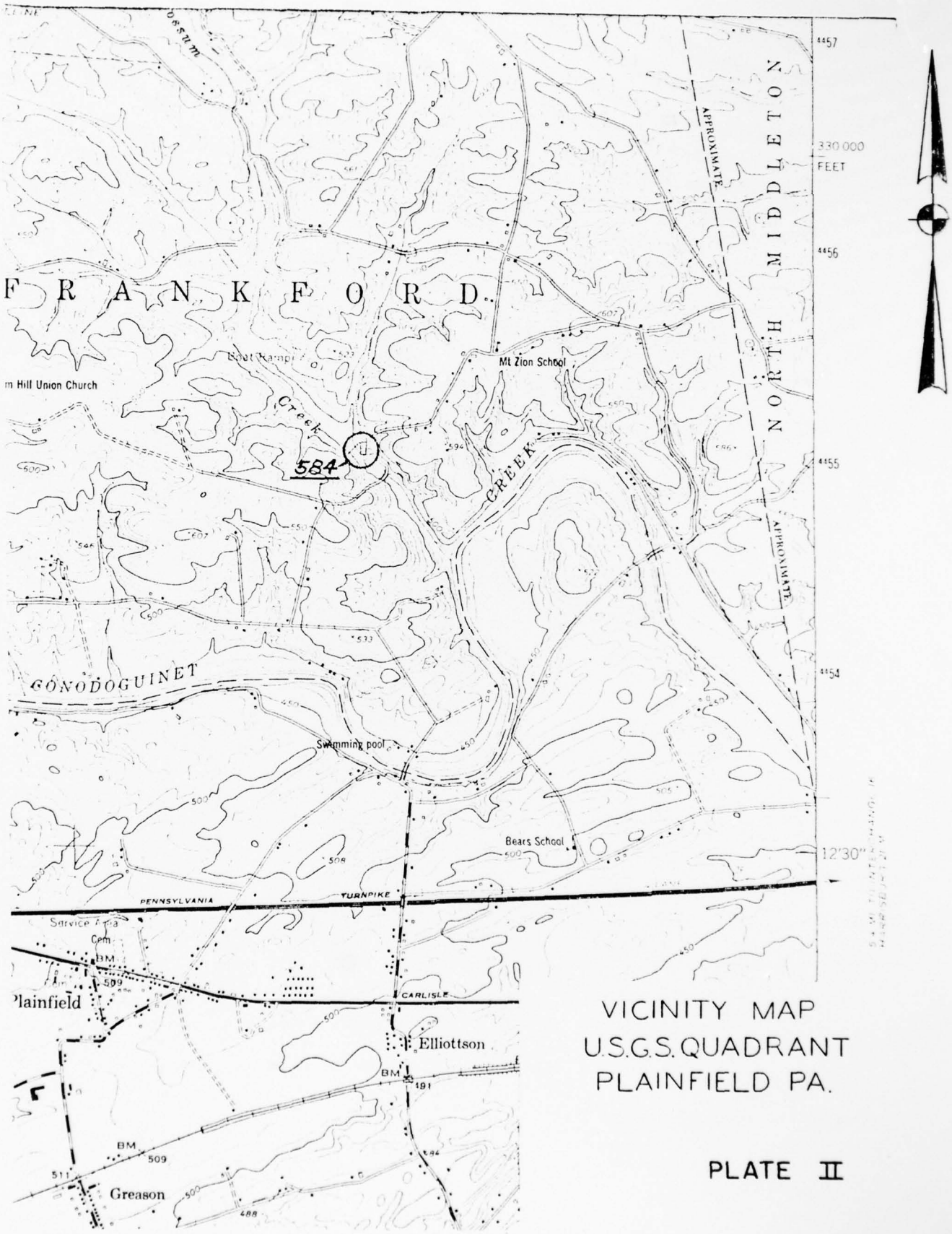
APPENDIX D

LOCATION, PHOTOGRAPHS & DESIGN DRAWINGS



LOCATION PLAN
OPOSSUM LAKE DAM

PLATE I



VICINITY MAP
U.S.G.S. QUADRANT
PLAINFIELD PA.

PLATE II

Upstream
Embankment

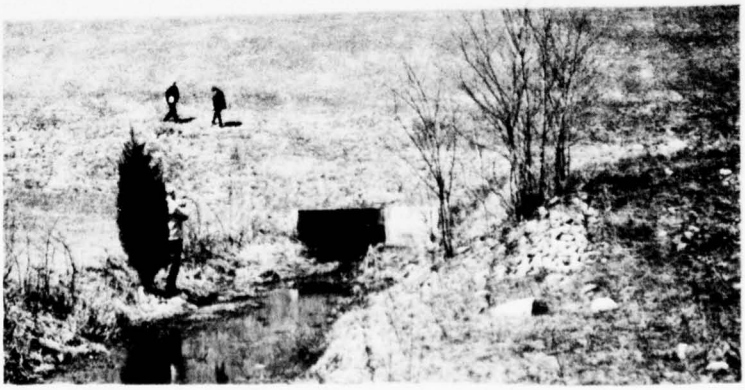
Upstream
Lake

Downstream Slope
and Outlet

PLATE III

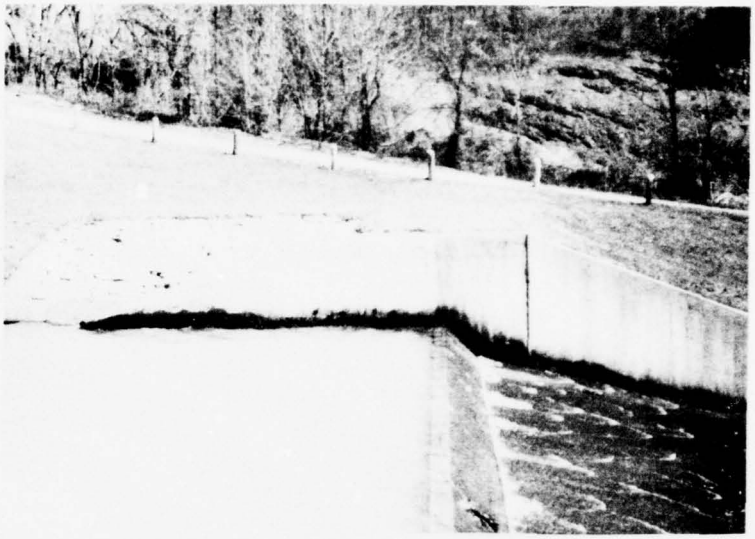
Seepage Area

"Sloughage" and Settlement due to installation of Drain



Outlet Structure

PLATE IV



Spillway

Spillway

Downstream
Channel

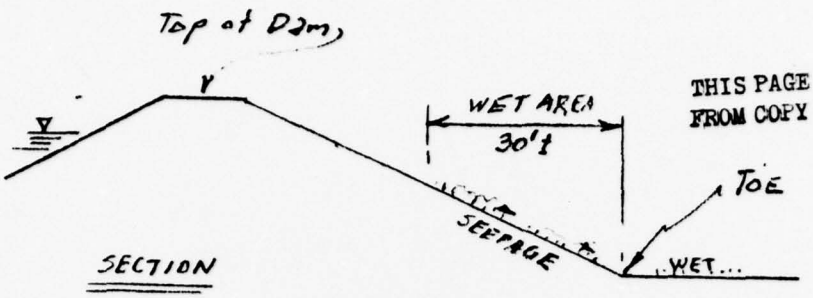
PLATE V

Downstream Channel
and Wet Area

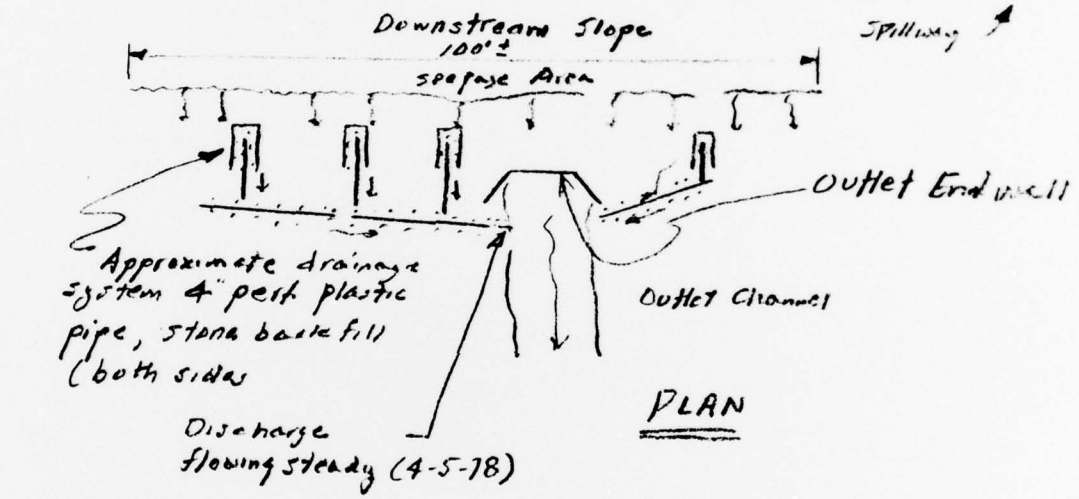
Spillway

PLATE VI

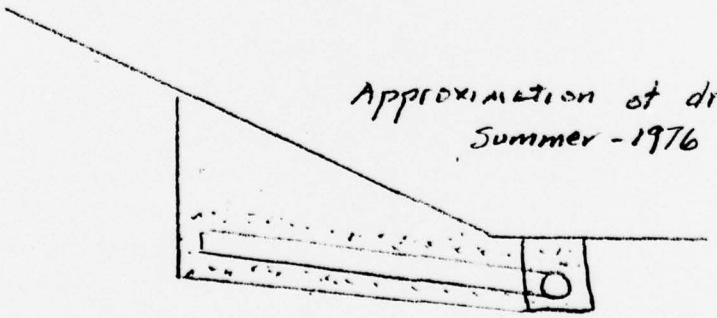
THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC



SECTION



PLAN



Approximation of drainage installed Summer - 1976

PLATE VII

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

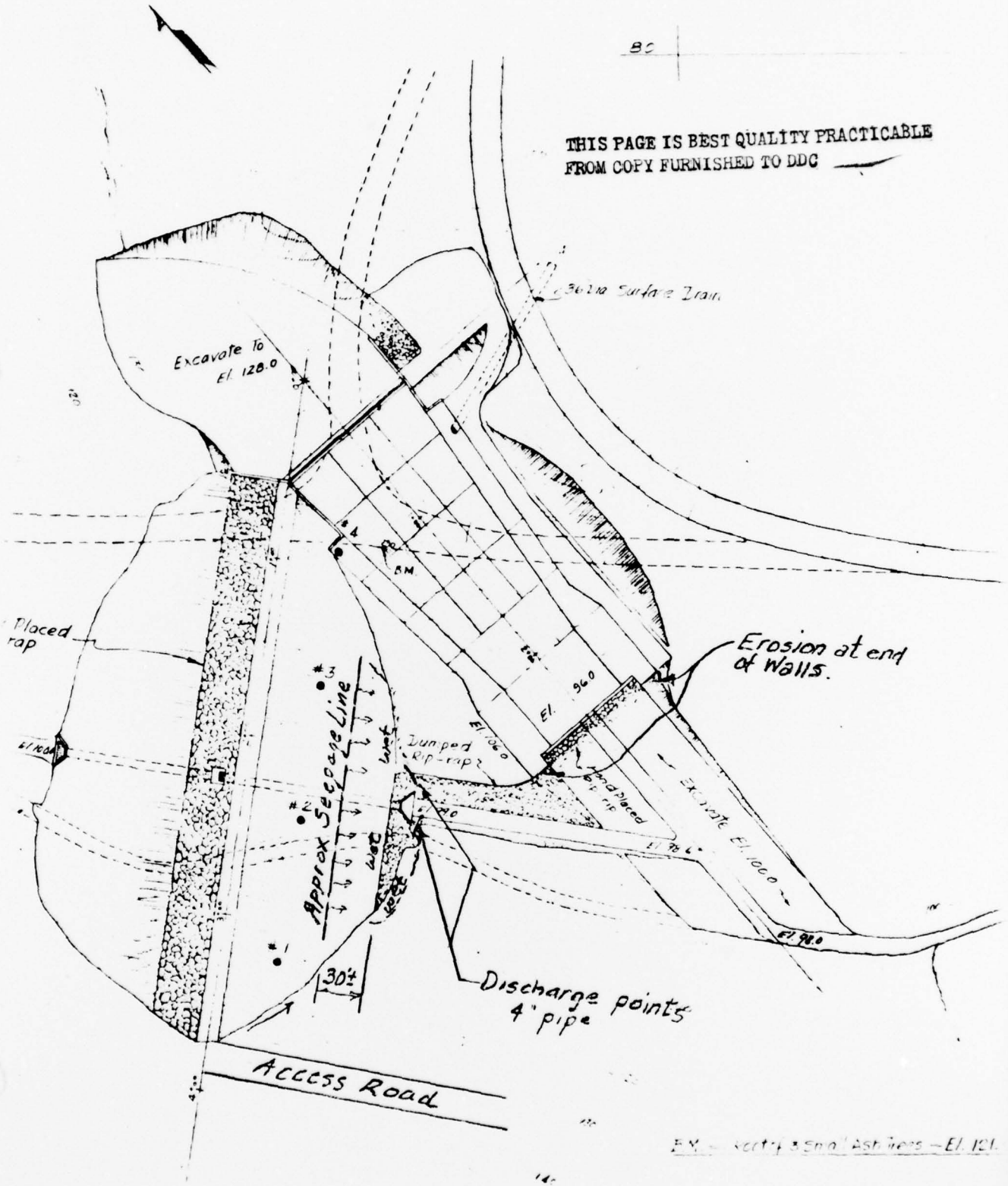
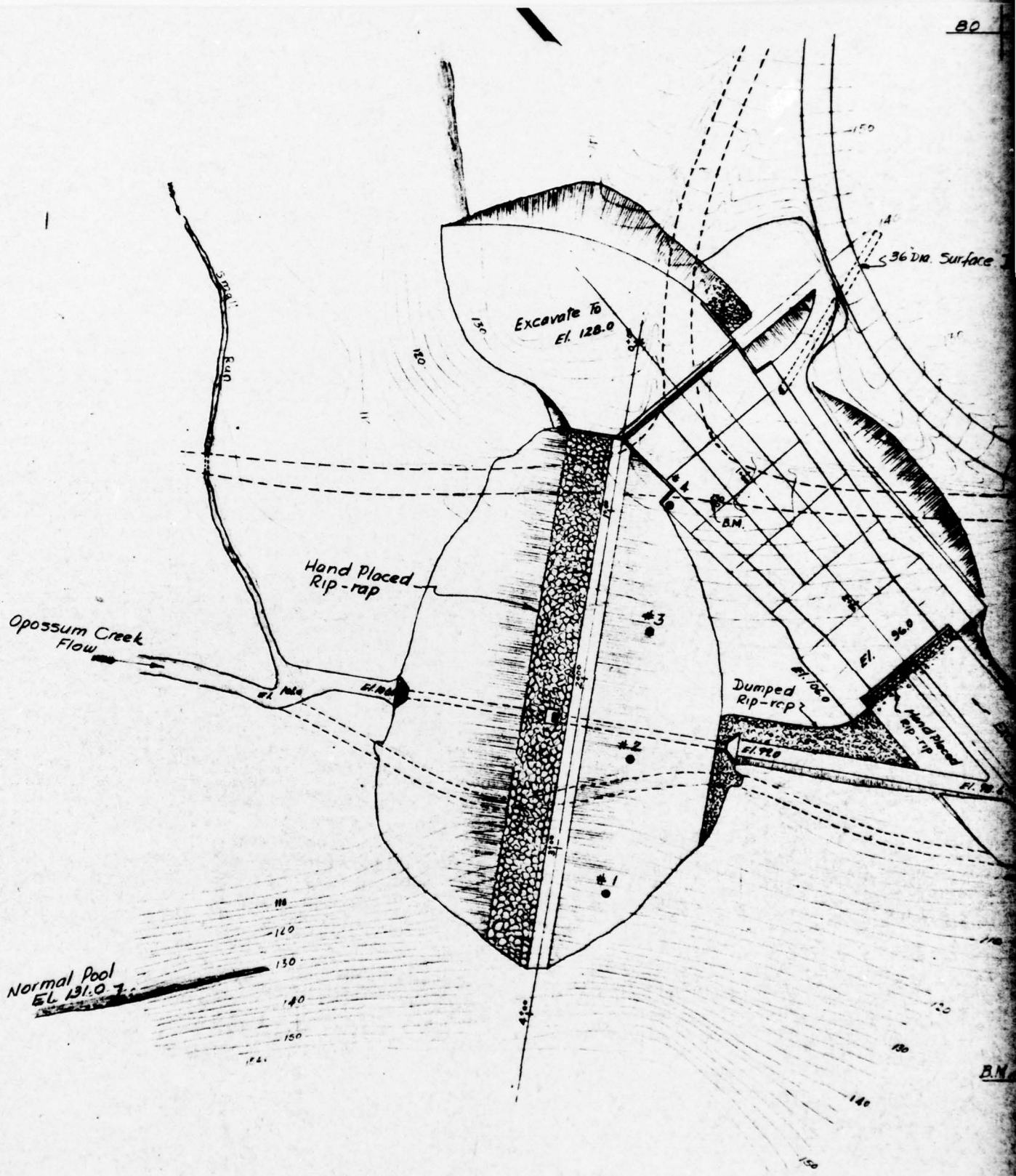


PLATE VIII

GENERAL PLAN
1" = 80 ft. ±

OPOSSUM LAKE DAM
Cumberland Co., Pennsylvania
NDS-594



GENERAL PLAN

1" = 50 ft.

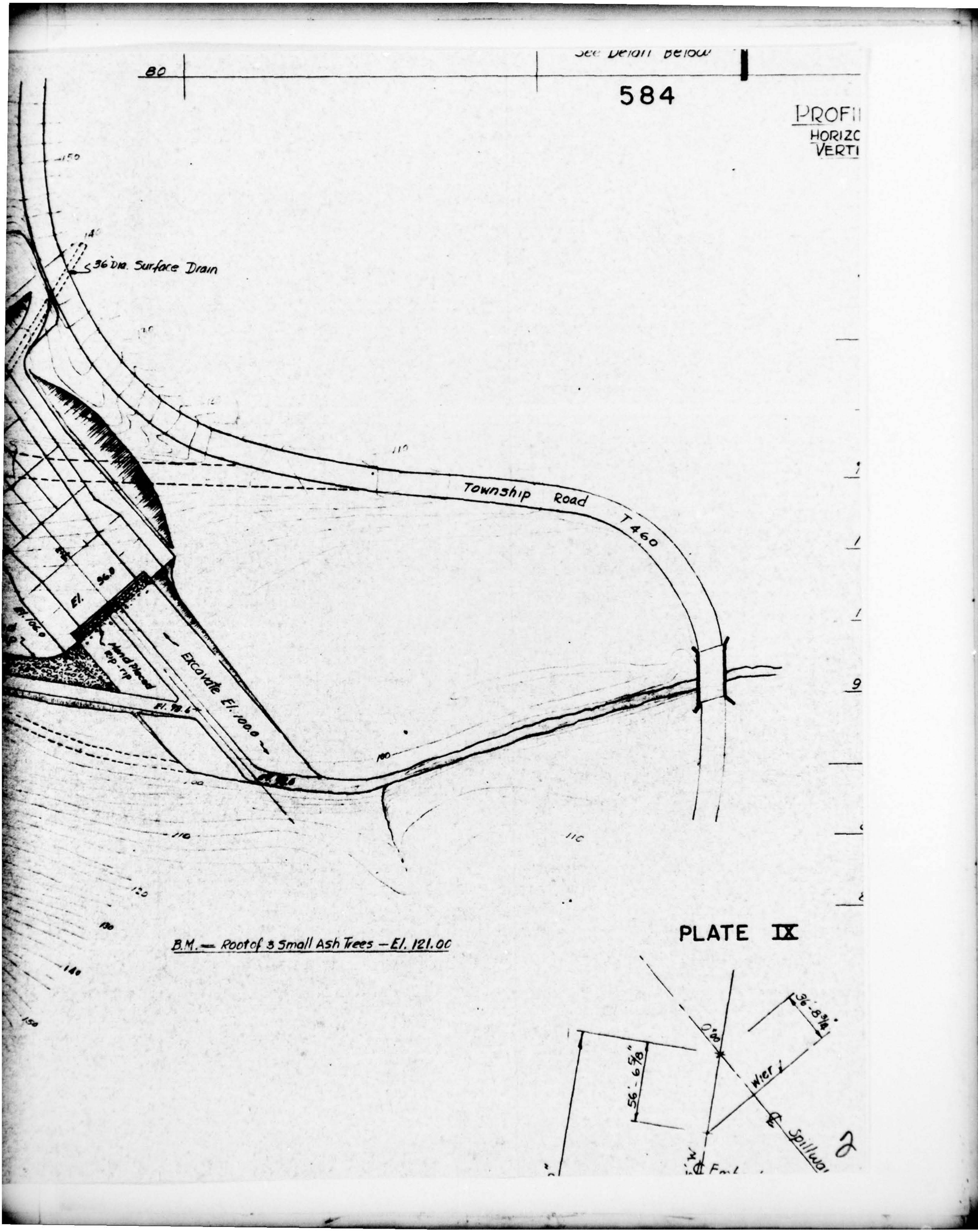
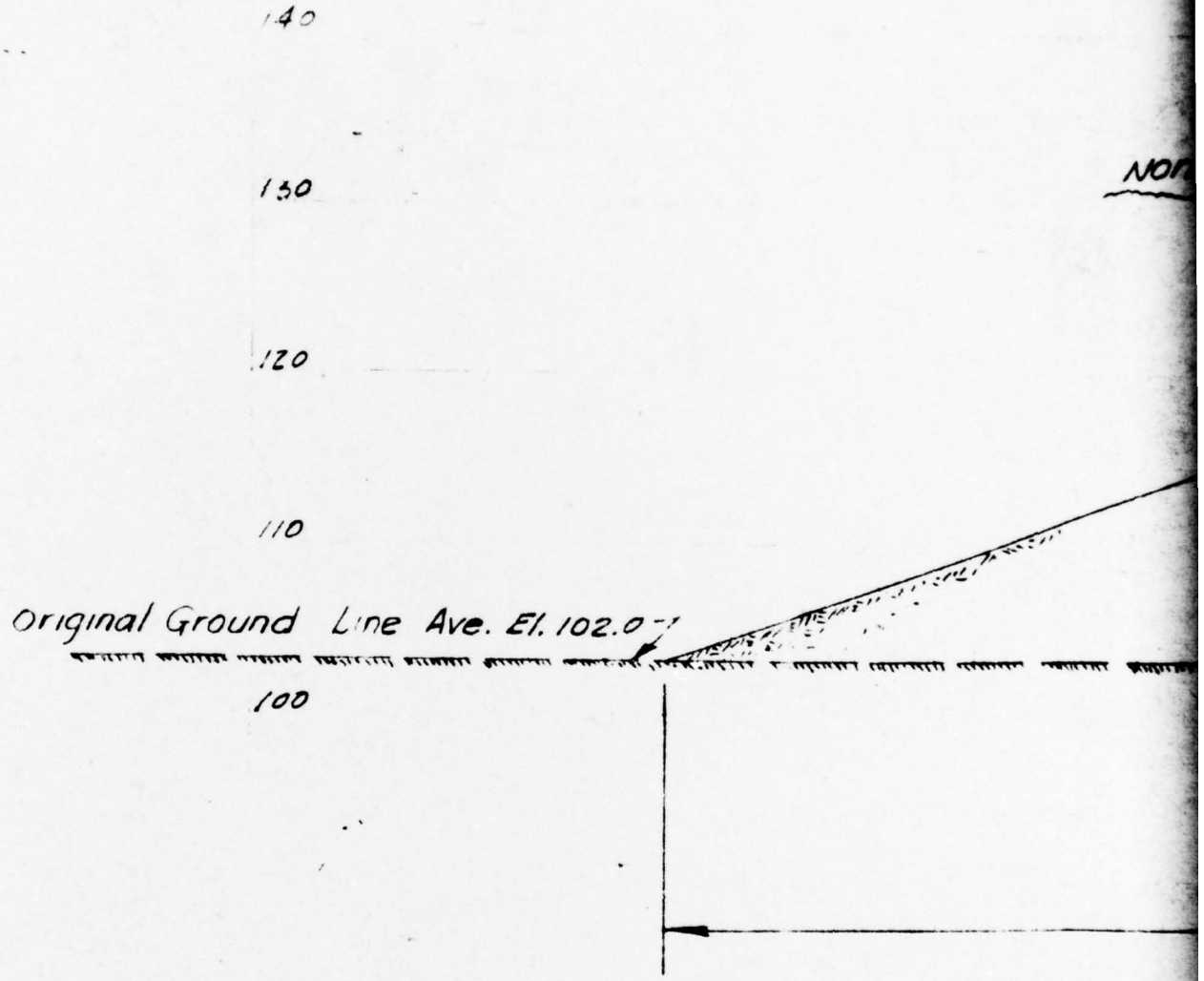
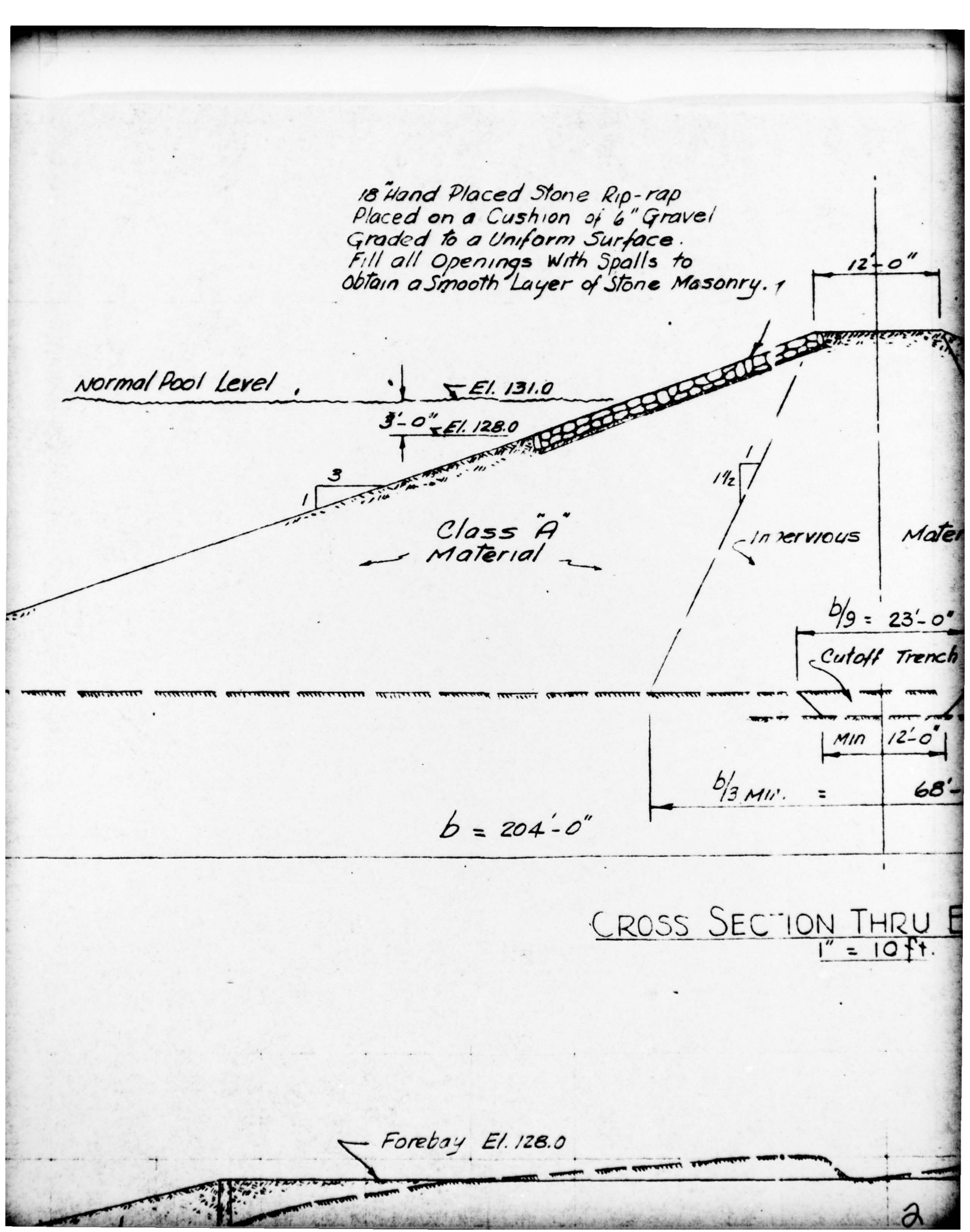

See Detail Below
80
584
PROFI
HORIZC
VERTI
36" Dia. Surface Drain
Township Road
T 460
El. 96.0
Hand Placed Rip-rap
Excavate El. 100.0
El. 98.6
B.M. — Root of 3 Small Ash Trees — El. 121.00
36'-8 3/4"
0+00
Wier
56'-6 5/8"
℄ Spillway

PLATE IX

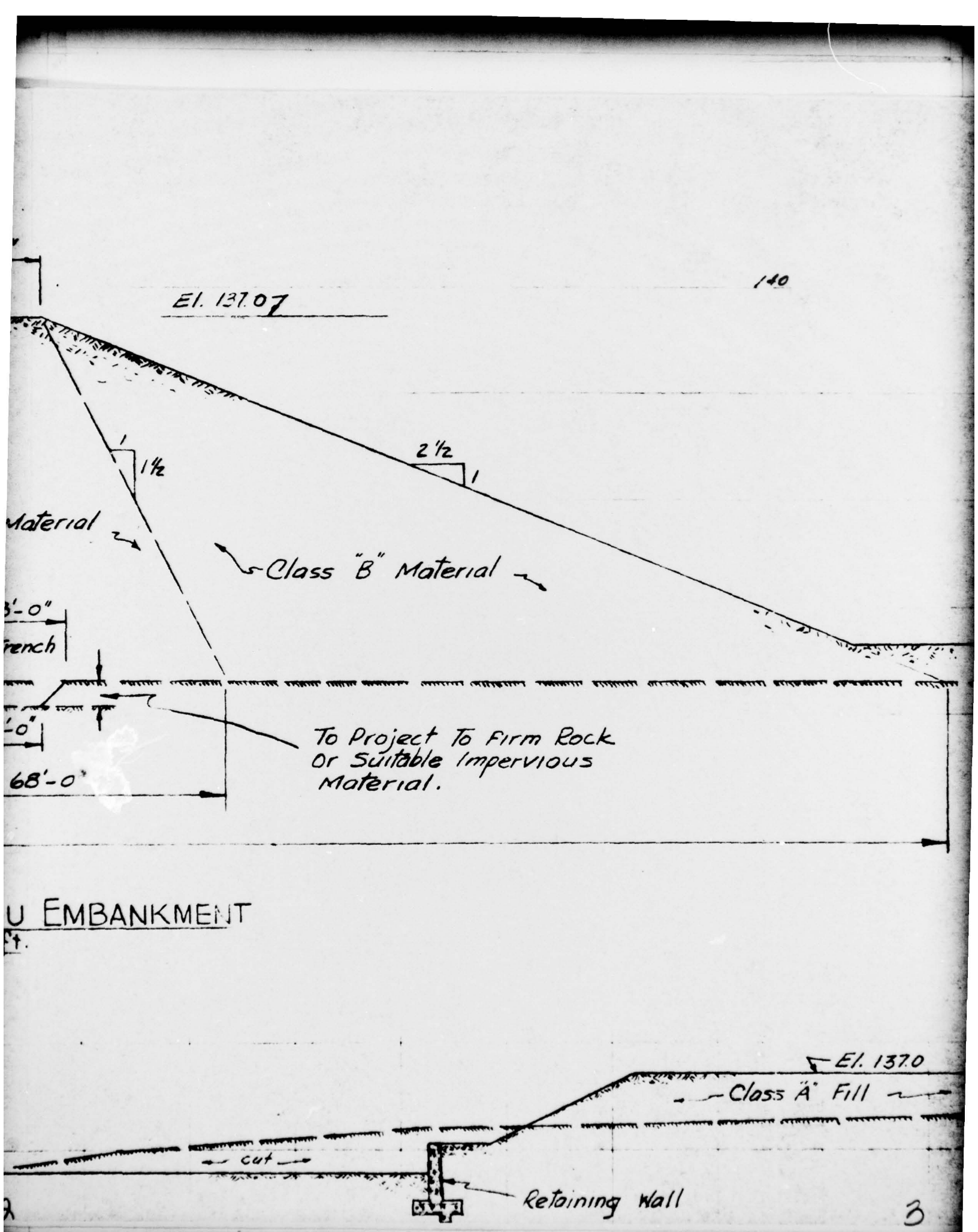


140

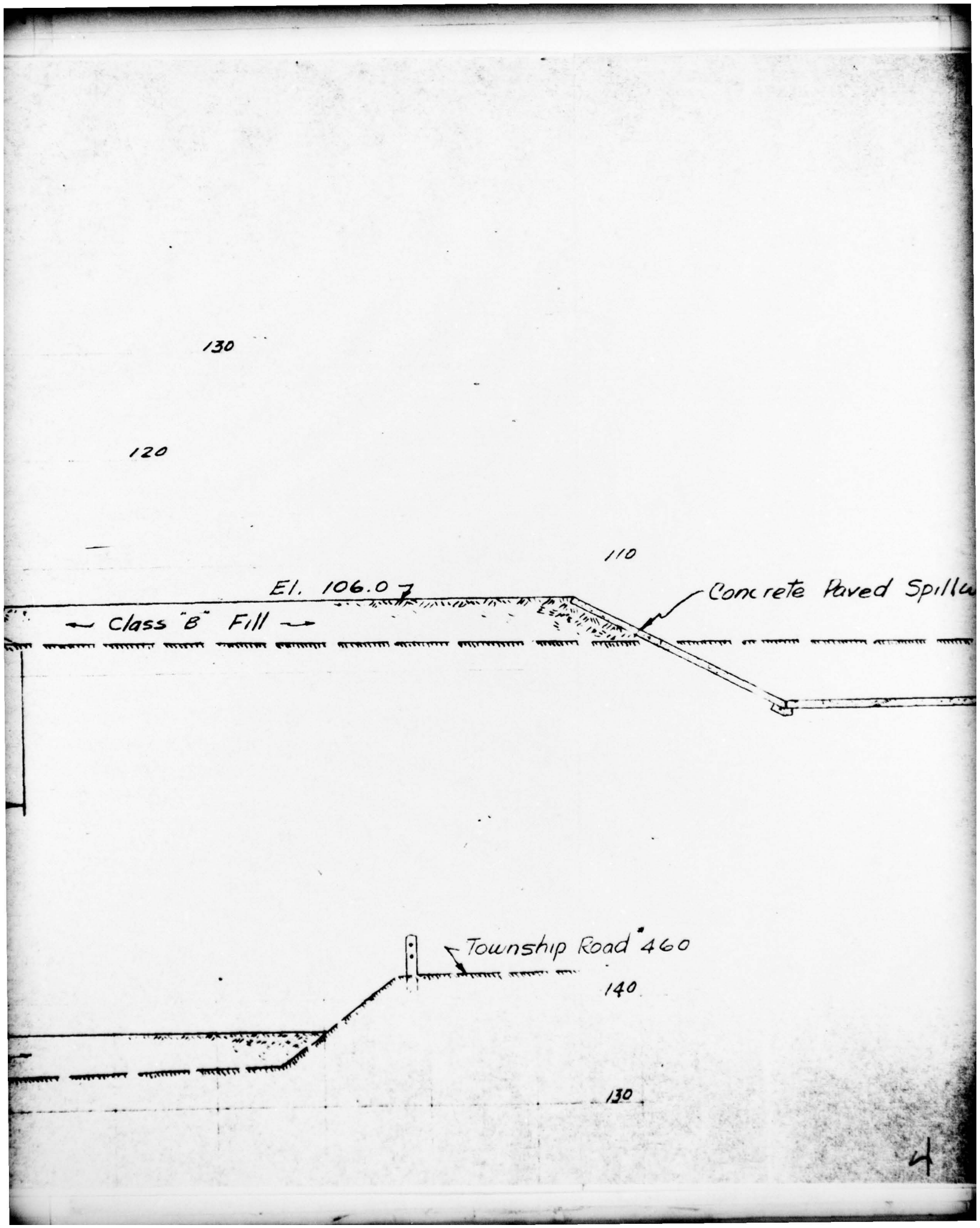
130



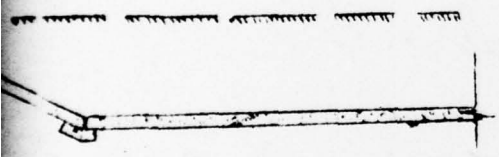
CROSS SECTION THRU E
1" = 10 ft.



U EMBANKMENT


130
120
110
El. 106.0 7
Concrete Paved Spillw
Class "B" Fill
Township Road 460
140
130

ncrete Paved Spillway

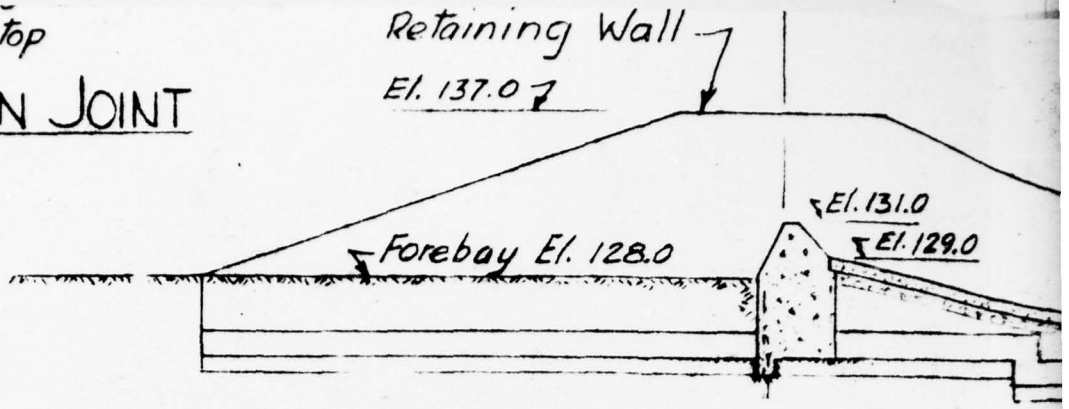


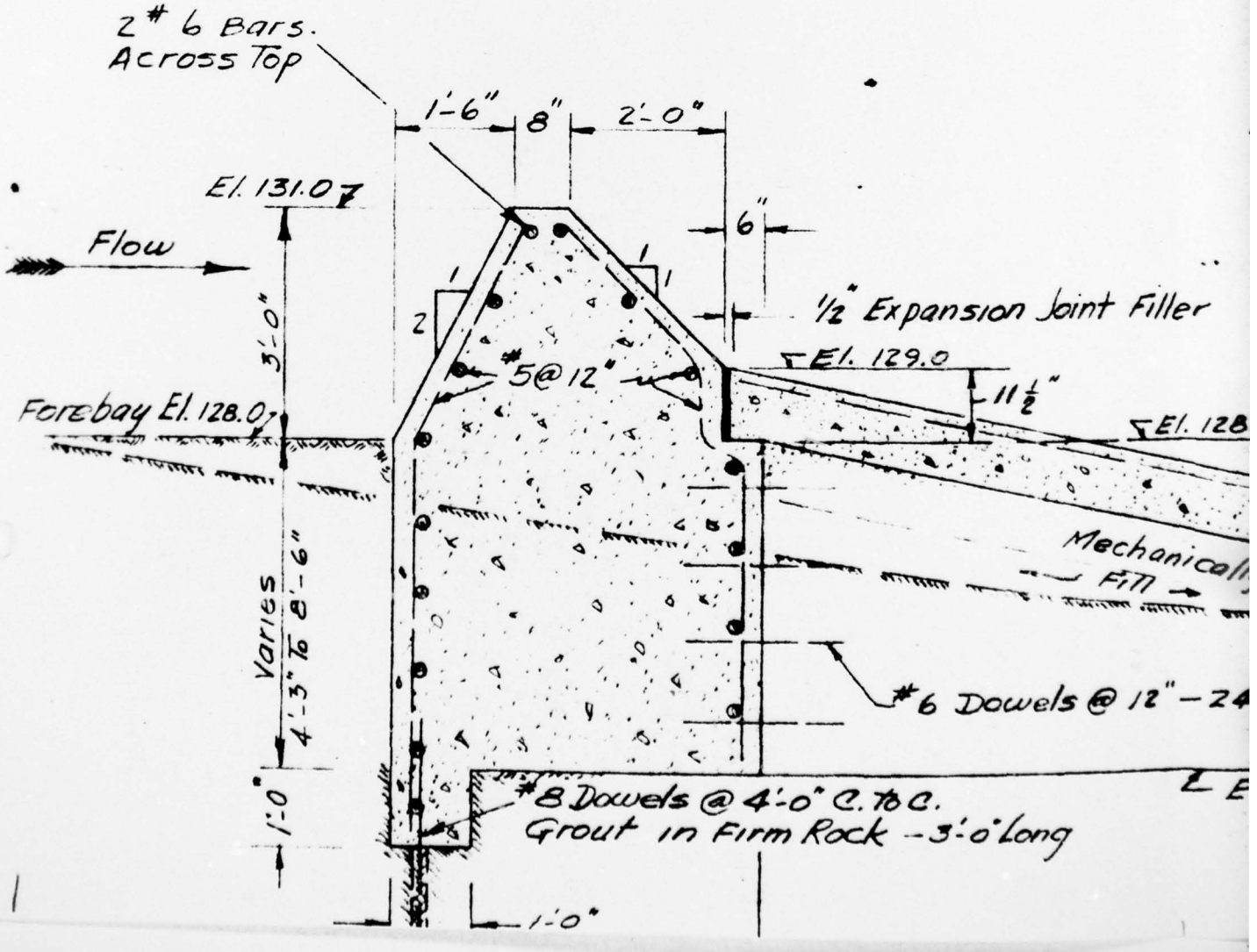
100

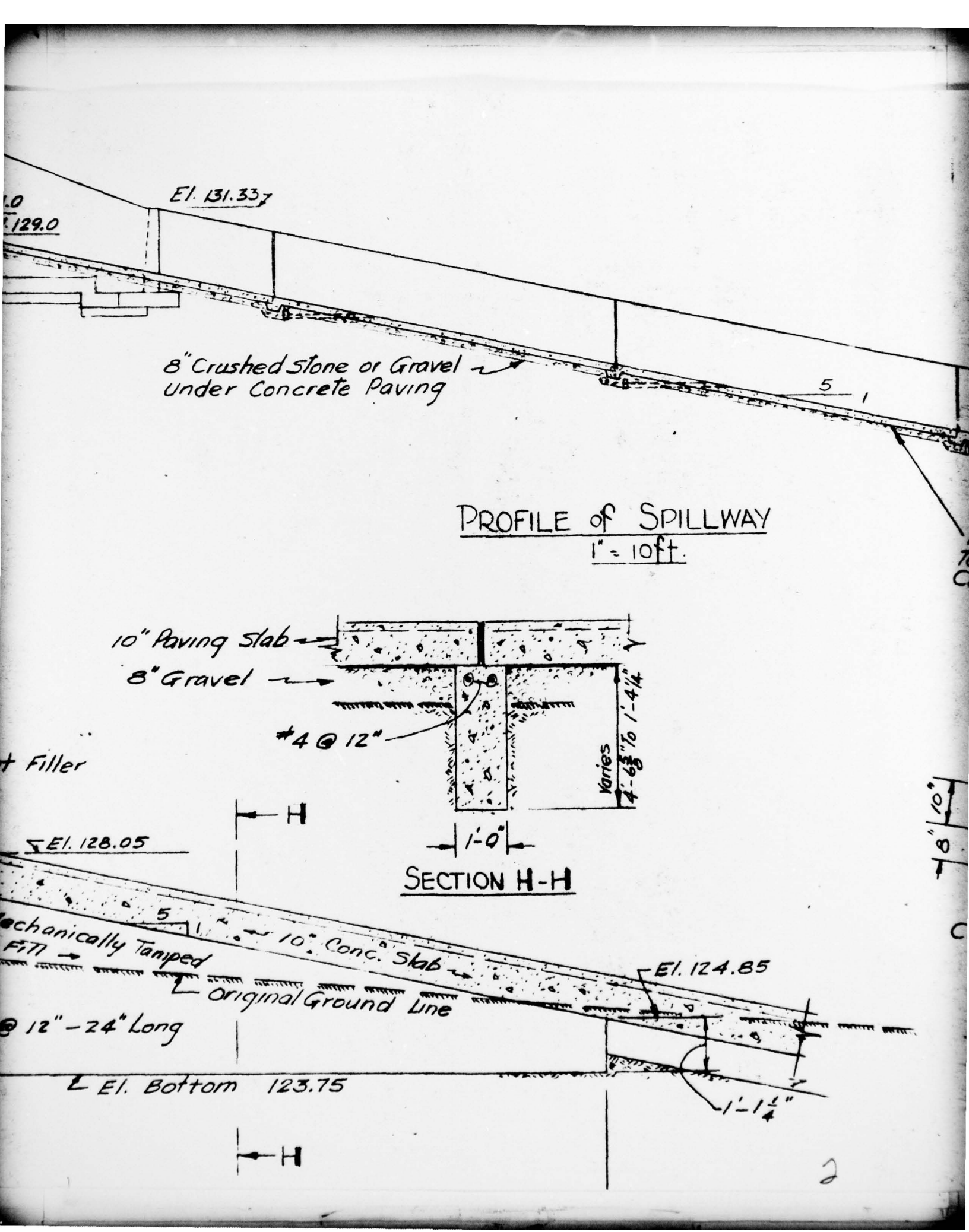
PLATE X

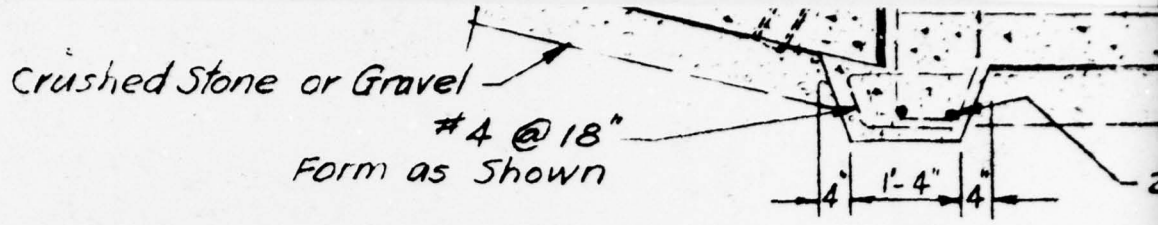
Rubber Water Stop

EXPANSION JOINT



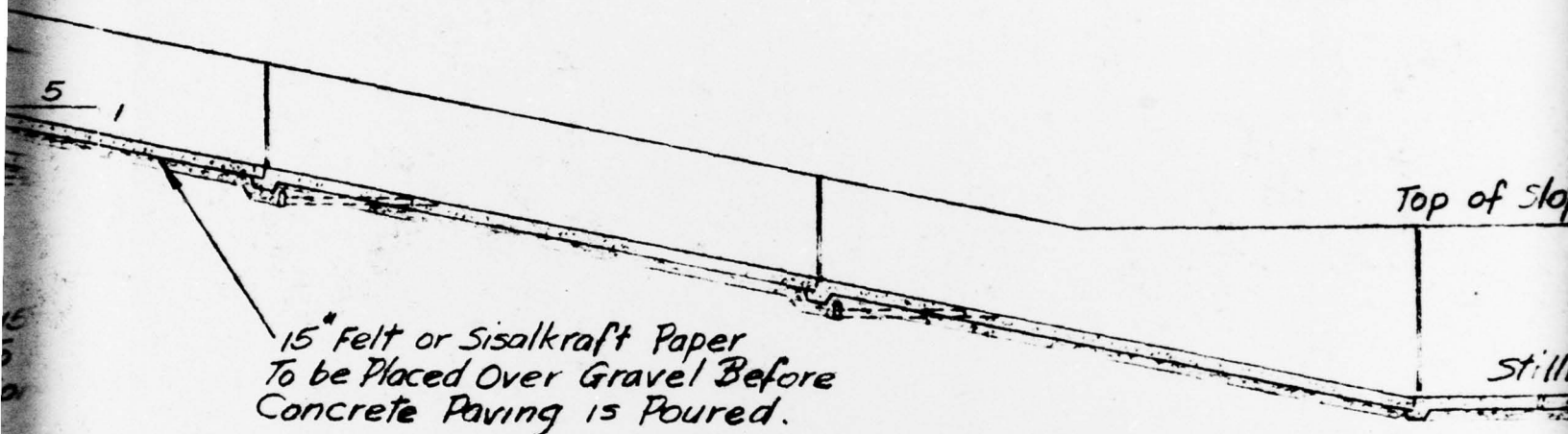


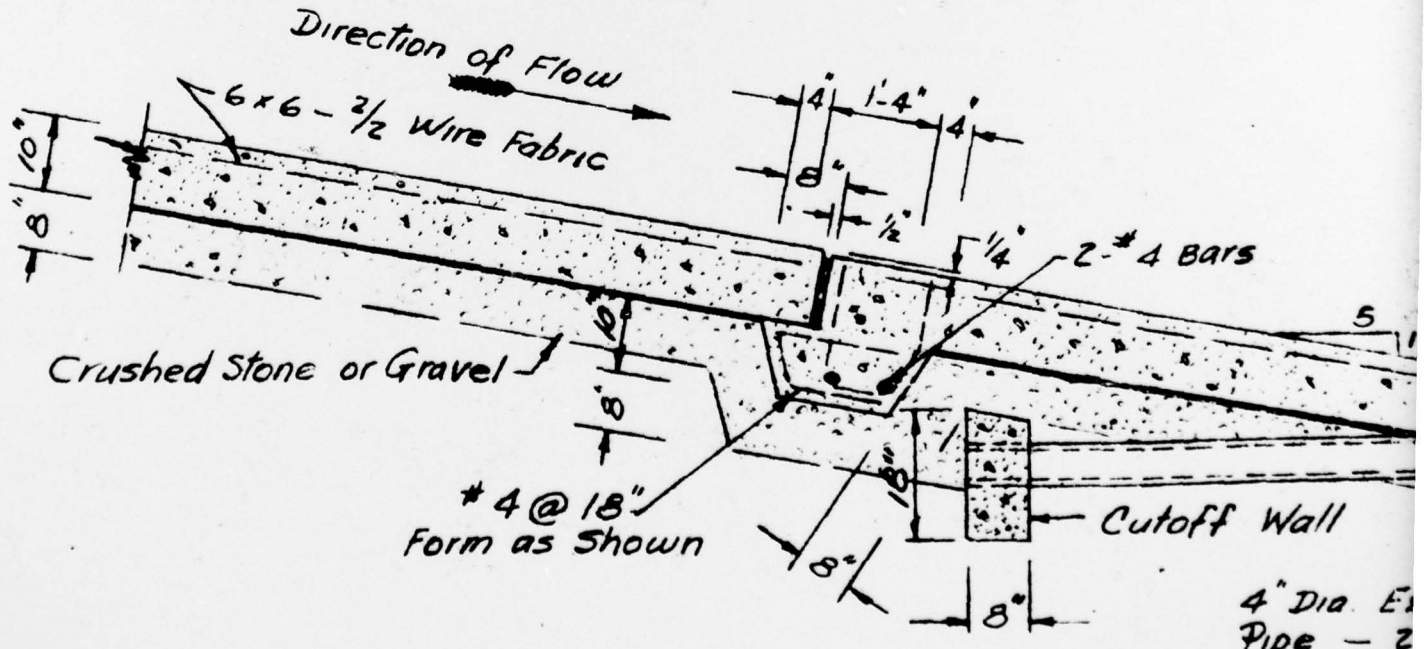

El. 131.33
8" Crushed Stone or Gravel under Concrete Paving
5
1
PROFILE of SPILLWAY
1" = 10ft.
10" Paving Slab
8" Gravel
#4 @ 12"
Varies
4'-6 3/16"
1'-4 1/4"
H
1'-0"
SECTION H-H
El. 128.05
5
1
10" Conc. Slab
El. 124.85
Original Ground Line
El. Bottom 123.75
1'-1 1/4"
H
8"
10"
2



SECTION C-C

1/2" = 1 ft.

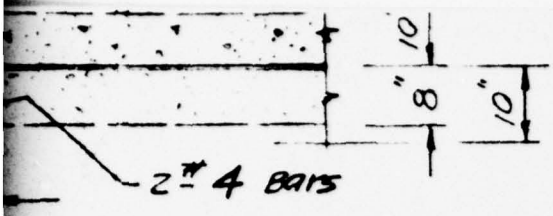




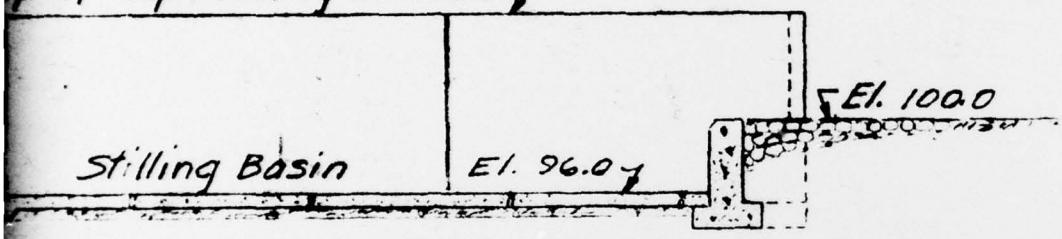
SECTION B-B

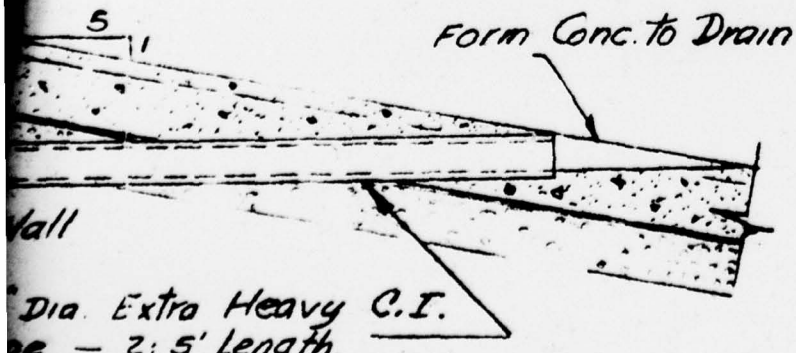
2

3



C-C
ft.





REVISE

PLATE XI

3

4