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NATIONAL DAM INSPECTION PROGRAM, GRAHAMVILLE RESERVOIR DAM (NDI--ETC(U)
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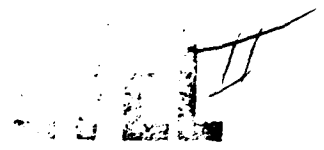
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SIXTEEN MILE CREEK, ERIE COUNTY
PENNSYLVANIA



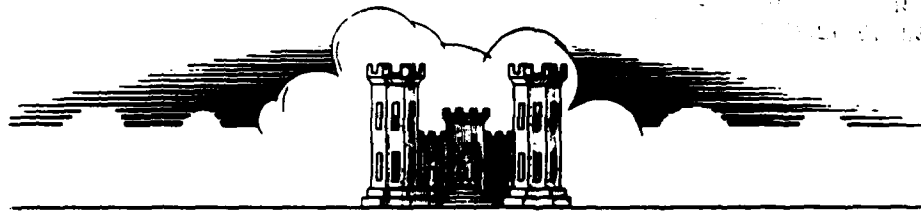
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GRAHAMVILLE RESERVOIR DAM

NDI No. PA 00020
PennDER No. 25-2



PHASE I INSPECTION REPORT NATIONAL DAM INSPECTION PROGRAM



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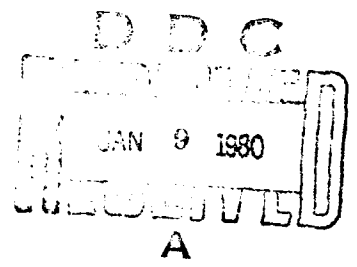
prepared for

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

prepared by

MICHAEL BAKER, JR., INC.

Consulting Engineers
4301 Dutch Ridge Road
Beaver, Pennsylvania 15009



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AUGUST 1979

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LAKE ERIE BASIN

GRAHAMVILLE RESERVOIR DAM
ERIE COUNTY, COMMONWEALTH OF PENNSYLVANIA
NDI No. PA 00020
PennDER No. 25-2

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Grahamville Reservoir Dam (NDI PA-00020)
(PennDER 25-2) Lake Erie Basin
Sixteen Mile Creek, Erie County,
Pennsylvania.

Prepared for: DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

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Prepared by: MICHAEL BAKER, JR., INC.
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4301 Dutch Ridge Road
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PREFACE

This report was prepared under guidance contained in the "Recommended Guidelines for Safety Inspection of Dams," for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Grahamville Reservoir Dam, Erie County, Pennsylvania
NDI No. 00020, PennDER No. 25-2
Sixteen Mile Creek
Inspected 16 November 1978 and 5 June 1979

ASSESSMENT OF
GENERAL CONDITIONS

Grahamville Reservoir Dam is classified as a "Small" size-
"Significant" hazard dam. The structure consists of a zoned,
earthfill embankment approximately 29 feet high and 400 feet
long.

Based on observations made during the visual inspection, data
available from the Pennsylvania Department of Environmental
Resources' (PennDER) files, and information obtained from
interviewing North East Borough personnel and representatives
from Hill and Hill Engineers, North East; the dam is considered
to be in poor overall condition.

Hydraulic/hydrologic evaluations, performed in accordance with
procedures established by the Baltimore District of the U.S.
Army Corps of Engineers for Phase I Inspection Reports, revealed
that the spillway will pass the 100-year flood without
overtopping the dam. Therefore, the spillway is considered
"adequate".

It is recommended that the owner initiate a feasibility study to
determine if the reservoir is necessary for meeting the water
requirements of the borough or whether the effort could be
better spent upgrading one of its other reservoirs to meet the
requirement for potable water.

If the study reveals the necessity for the continued use of the
Grahamville Reservoir, the following recommendations should be
undertaken by the owner without delay:

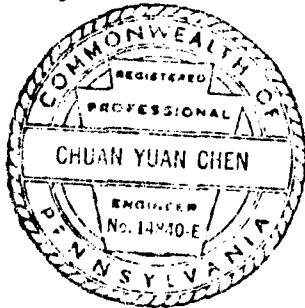
- 1) Engage the services of a qualified engineer to
evaluate the seepage and its effects on the structural
stability of the dam. The study should include
recommendations for remedial action.
- 2) Begin clearing the trees and brush from the downstream
slope, including 10 feet beyond the toe.
- 3) Place riprap or other protection on the upstream face.

- 4) Regrade and reseed the rutted areas, erosion ditches, and rodent holes.
- 5) Repair concrete on the gate valve house and repair the head wall for the 12 inch outlet pipes.
- 6) Clear the debris from the emergency spillway and diversion channels.
- 7) A plan for rapid closure of the upstream end of the pipes through the embankment should be developed and implemented in the event of a pipe rupture.

In addition, the following operational measures are recommended to be undertaken by the owner:

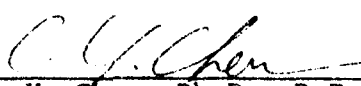
- 1) Develop a detailed emergency operation and warning system.
- 2) During periods of unusually heavy rain, provide around-the-clock surveillance of the dam.
- 3) When warning of a storm of major proportions is given by the National Weather Service, the owner should activate the emergency operation and warning system.

In the future, the owner should keep a record of the inspections and repair work done on the dam and concrete appurtenances.



Submitted by:

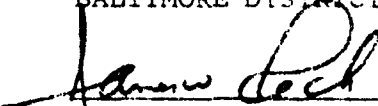
MICHAEL BAKER, JR., INC.


C. Y. Chen, Ph.D., P.E.
Engineering Manager-Geotechnical

Date: 24 August 1979

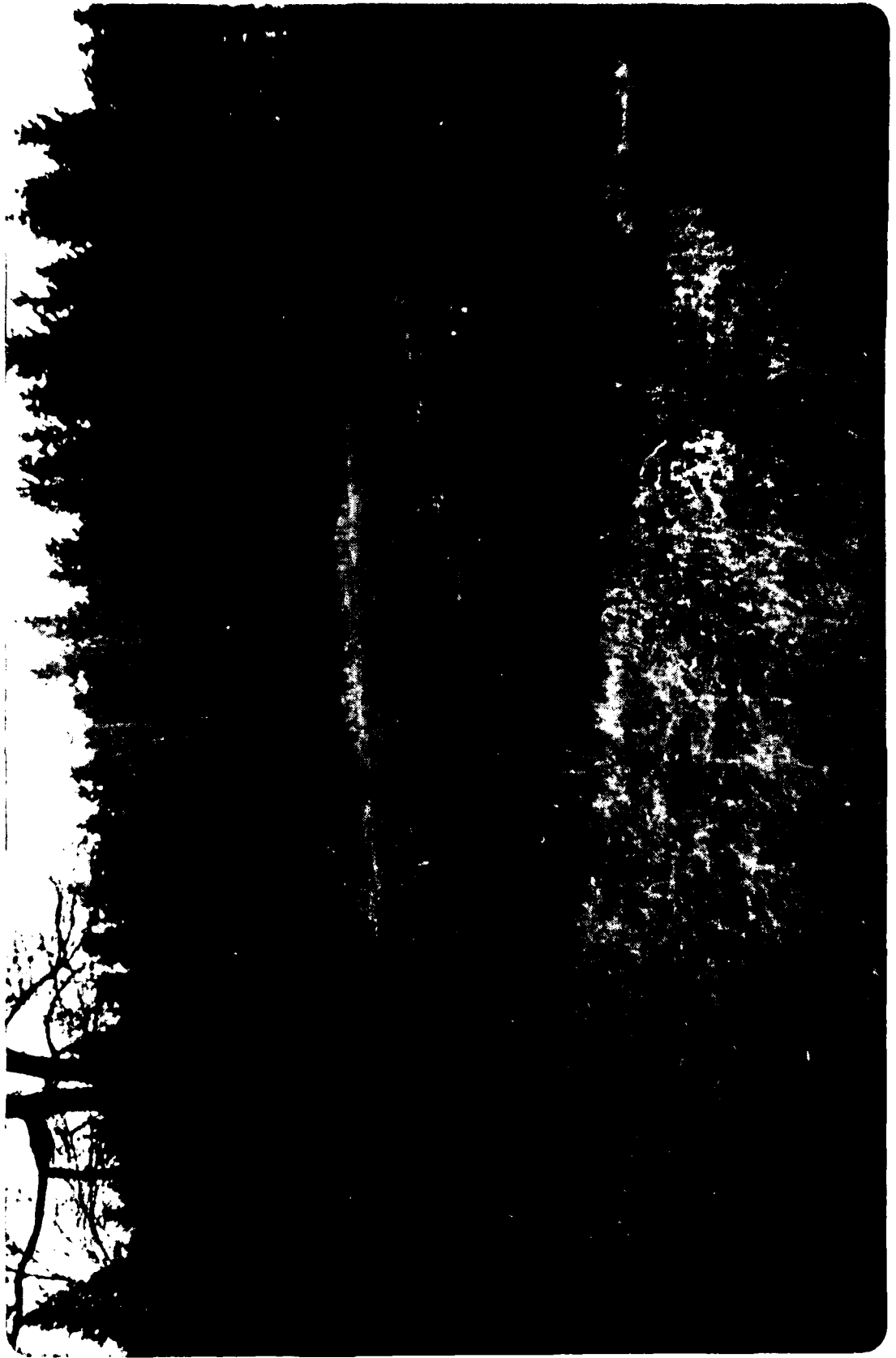
Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS


JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

Date: 12 Sep 79

GRAHAMVILLE RESERVOIR DAM



Overall View

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
GRAHAMVILLE RESERVOIR DAM
NDI No. PA 00020, PennDER No. 25-2

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

- a. Authority - The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.
- b. Purpose of Inspection - The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

- a. Description of Dam and Appurtenances - Grahamville Reservoir Dam is a zoned, earth embankment approximately 29 feet high and 400 feet long. The upstream slope is 3H:1V (Horizontal to Vertical); the downstream slope is 2H:1V and the crest is 16 feet wide. The principal outlet for the dam is two 12 inch cast-iron pipes which pass through the embankment at right angles to the axis of the dam, change direction in the gate vault, and discharge into the creek channel approximately 16 feet from the chamber. The pipe on the right has a 12 inch by 12 inch by 6 inch "Y" with the water supply line being connected to the smaller branch. All three branches are provided with valves below the junction.

A diversion channel, approximately 2550 feet long, is provided from the upstream right side of the reservoir, circling around the left end of the reservoir, and exiting below the dam into the downstream channel. The crest of the dike on the reservoir side of the channel is at approximately the same elevation as the main embankment.

The inflow to the dam is from two 18 inch cast-iron pipes that collect runoff from the drainage area to the left of the reservoir and from a 14 inch gravity line from the East Branch of Sixteen Mile Creek.

Upstream of the two 18 inch cast-iron pipes, a gate was placed to control the inflow to the reservoir; however, the gate is no longer in operating condition and is not used.

The emergency spillway, located along the left side approximately 175 feet upstream from the dam, includes three 8 inch cast-iron pipes. These pipes empty into a narrow channel which outlets into the diversion channel. The emergency spillway channel is 6 feet wide with 1H:1V side slopes on the left side and 1H:1V slopes on the right side to a height of 3 feet with a subsequent flattening to 10H:1V.

- b. Location - Grahamville Reservoir Dam is located on Sixteen Mile Creek 3.75 miles southeast of North East Borough in North East Township, Erie County, Pennsylvania. The reservoir can be located on the USGS 7.5 minute quadrangle, North East, Pennsylvania at coordinates N 42° 11' - W 79° 47'. The location of Grahamville Reservoir Dam is shown on Plate 1.
- c. Size Classification - The maximum height of the dam is 29 feet. The reservoir volume to the top of dam is 200 acre-feet. Therefore, the dam is in the "Small" size category.
- d. Hazard Classification - Grahamville Dam is located several miles upstream from the Borough of Northeast. Since the stream valley downstream from the dam is relatively steep and narrow, some damages could occur as the result of an overtopping failure of the Grahamville Dam. Loss of life resulting from such an event, however, would be very improbable. The loss of water supply resulting from failure of the dam could be a significant economic loss to the Borough of Northeast. The dam is therefore considered to be in the "Significant" hazard category.
- e. Ownership - The dam is owned by North East Borough, 58 East Main Street, North East, Pennsylvania 16428.
- f. Purpose of Dam - Grahamville Reservoir is primarily used as an auxiliary water supply for North East Borough.
- g. Design and Construction History - The original structure was designed by Hill and Hill Engineers, North East, Pennsylvania and constructed by Simpson and Willis Contractors, Erie, Pennsylvania in 1906.

- h. Normal Operational Procedures - The reservoir is typically maintained at a level corresponding to the amount of flow into the pond. The 6 inch water supply line is continuously left open at the dam and the water either feeds to or bypasses the water treatment plant, depending upon the control valve settings at the plant. Since the reservoir is not a primary source of potable water for the borough, the water bypasses the plant unless a severe shortage exists. The excess inflow passes through the emergency spillway and into the bypass canal.

1.3 PERTINENT DATA

- a. Drainage Area (square miles) - 1.64
- b. Discharge at Dam Site (c.f.s.) -
 Spillway Capacity at Maximum Pool
 (El. 1242.6 ft.) - 230
- c. Elevation (feet above Mean Sea Level [M.S.L.]) -
 Average Top of Dam - 1243.1
 Minimum Top of Dam - 1242.6
 Normal Pool - 1237.3
 Invert of Low Flow Pipes - 1237.3
 Top of Roadway Across Spillway - 1238.5
 Streambed at Centerline of Dam - 1214+
 Maximum Tailwater - Unknown
- d. Reservoir (feet) -
 Length of Pool at Top of Dam - 1300
 Length of Normal Pool - 1300
- e. Storage (acre-feet) -
 At Normal Pool (El. 1237.28 ft.) - 140+
 At Top of Dam (El. 1242.57 ft.) - 200+
- f. Reservoir Surface (acres) -
 At Normal Pool - 18+
 At Maximum Pool - 22+
- g. Dam -
 Type - Zoned earth embankment
 Length (feet) - 400
 Height (feet) - 29
 Top Width (feet) - 16

Side Slopes - Upstream - 3H:1V
 Downstream - 2H:1V
 Zoning - The embankment contains two zones. The upstream and downstream slopes are constructed of clay and gravel with a center zone of clay only.

Impervious Core - Clay
 Cut-off - Consists of clay puddle through the center of dam, 18 feet wide and 4 feet above original ground. The depth of the cut-off varies from 6 to 10 feet and was placed by cutting a trench in the shale foundation and filling it with clay puddle.

h. Dike -

Type - Zoned earthfill
 Length (feet) - 2550
 Height (feet) - 22
 Top width (feet) - 10
 Side Slopes - 3H:1V
 Zoning - Consists of clay and gravel on both sides with a clay impervious zone in the center.
 Impervious Core - Clay
 Cut-off - Consists of a clay puddle approximately 14 feet high and 25 feet wide running the entire length of the dike.

i. Diversion and Regulating Tunnel - None

j. Spillway (Emergency) -

Type - Vegetated open channel spillway with three 8 inch cast-iron pipes for low flows
 Invert Elevation of Low Flow Pipes (feet M.S.L.) - 1237.3
 Elevation of Top of Roadway Across Spillway (feet M.S.L.) - 1238.5
 Base Width (feet) - 6.0
 Side Slopes - 1H:1V
 Gates - None
 Downstream Channel - The emergency spillway empties into the diversion channel.

k. Regulating Outlets - Consists of three valves, two 12 inch and one 6 inch, located in the gate vault on the downstream toe.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Pertinent design data were not available for the inspection report. Information that was available came from the Pennsylvania Department of Environmental Resources' (PennDER) files. The files contained the following information:

- 1) Dam inspection reports from the following years: 1915, 1916, 1917, 1920, and 1967.
- 2) Application dated 5 November 1923 for permission to raise the main embankment 8 feet. Further correspondence indicated that the project was abandoned.
- 3) Various correspondence dating from 1915 to 1936.

Along with the material contained in PennDER's files, information concerning the reservoir was obtained from interviewing North East Borough personnel and representatives of Hill and Hill Engineers, North East, the original design engineers.

Plates 3 and 4 were the only available drawings of the embankment. These drawings were submitted as part of the proposal for an addition to the embankment. Since the addition was never done, the crest elevation and normal pool elevation shown on the plans are not representative of actual conditions; however, since the drawings were submitted by the original design engineers, any other information is believed to be accurate.

2.2 CONSTRUCTION

The original dam was built in 1906 by Simpson and Willis, Contractors, Erie, Pennsylvania. Hill and Hill Engineers, North East, Pennsylvania, the designers of the dam, also provided full time inspection.

The dam, when first constructed, was only 25 feet high and had a storage capacity to the top of the dam of 160 acre-feet. An inspection and study of the embankment and reservoir area made by the Water Supply Commission, Harrisburg, Pennsylvania in January 1920 indicated that the diversion dike around the reservoir was too low and could be susceptible to overtopping, which would fill the reservoir and cause the dam to overtop also. In

1923, North East Borough applied for and received a permit to: 1) increase the height of the embankment 8 feet, 2) increase the height of the dike, and 3) construct an ogee spillway at the site of the present emergency spillway. Although the permit was received and the plans accepted, no work was done and the project was abandoned. However, some time during the late 1920's, the dike size was increased and the dam received an additional height of approximately 3.5 feet of fill. No documentation was available concerning this work in PennDER's file and therefore it is not known by whom the work was done.

In the early 1930's, a 14 inch line was installed as a gravity feed into the reservoir from the East Branch of Sixteen Mile Creek.

The only other changes made to the reservoir were the replacement of the flume across the diversion channel with two 18 inch cast-iron pipes and the placement of three 8 inch cast-iron pipes in the emergency spillway channel below the dirt road around the reservoir.

PennDER's files (formerly the Department of Forests and Waters) contain no correspondence between 1936 and 1967. This fact, along with information obtained from North East Borough personnel, indicates that the dam has received very little attention.

2.3 OPERATION

Operational procedures discussed in paragraphs 1.2.h., 4.2, and 4.3 were obtained from interviewing Mr. Herb Mallick, Borough Engineer for North East. No operation or pool level records are currently recorded by the borough personnel.

2.4 EVALUATION

- a. Availability - The information reviewed consisted of PennDER's file on the dam along with information received from interviewing North East Borough personnel and the Hill and Hill Engineers' representative.
- b. Adequacy - The information available is adequate for a Phase I Inspection.
- c. Validity - There is no indication at the present time to doubt the validity of the available data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

- a. General - The dam and its appurtenant structures were found to be in poor overall condition at the time of the inspection. The noteworthy deficiencies observed are described briefly in the following paragraphs. The complete visual inspection check list and field sketches are given in Appendix A.
- b. Dam - Both the upstream and downstream faces of the embankment are covered with high grasses, bushes, and small trees. The upstream face has a 3 to 4 foot, near vertical drop-off at the normal pool elevation due to erosion of the embankment. Erosion was also noted approximately 200 feet from the right abutment on the downstream face. Some seepage was noted at the right abutment on the downstream side; however, due to the dense vegetative growth, an accurate assessment of the severity of the seepage could not be made, although no signs of piping were evident. Two large ruts have formed across the crest of the embankment due to vehicular traffic.

On 6 June 1979, a second inspection was made of the dam. At this time, the small trees and brush had been cut down. Although the debris had not been cleared, the inspectors were able to observe significant seepage (approximately 2 g.p.m.) at the toe of the embankment near the right abutment. Two rodent holes were observed on the downstream face approximately 75 feet from the left abutment.

- c. Appurtenant Structures - The concrete is severely spalled and cracked on the outside of the control gate house located at the downstream toe of the embankment. The head wall for the two 12 inch outlet pipes has fallen over and the three 8 inch pipes at the auxiliary spillway channel are blocked with debris.
- d. Reservoir Area - The reservoir area is a rolling, cultivated countryside. The greater percentage of land is used for growing fruit and the tops of the hills are mostly wooded.

- e. Downstream Channel - Below the dam, the valley becomes a narrow gorge, the floor of which is shale, with well defined, steep side slopes covered with second growth timber and shrubs. A few miles beyond the mouth, the gorge gradually widens out, with the valley changing to rolling country covered with vineyards, fruit orchards, and berry patches. Approximately 2 miles below the dam, the stream is crossed by the tracks of the Conrail and the Norfolk and Western Railroads. The stream does not flow through the Borough of North East but passes around it on the west side in a semicircular channel.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no formal emergency procedures in the event of impending catastrophe for the dam. According to North East Borough personnel, the dam is visited every day and the blow-off pipe is operated on a semiannual basis. No records of the visits or valve operations are kept.

It is recommended that a formal emergency procedure be prepared, prominently displayed, and furnished to all operating personnel.

4.2 MAINTENANCE OF DAM

The North East Borough Municipal Water Authority is responsible for maintenance of the dam.

4.3 MAINTENANCE OF OPERATING FACILITIES

The only operating facilities are the three gate valves located in the gate valve house on the downstream slope of the dam. These valves are operated twice a year by borough personnel.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system or procedure in the event of a dam failure. An emergency warning procedure should be developed.

4.5 EVALUATION OF OPERATIONAL ADEQUACY

The nature of Grahamville Reservoir Dam and its location are such that the dam is classified as a "Significant" hazard structure. The operational procedures appear to be adequate; however, a more conscientious maintenance program should be established. It is suggested that a system be established whereby all visits to the dam and maintenance items performed be documented. It is recommended that a plan for rapid closure of the upstream end of the pipes through the embankment be developed and implemented in the event of a pipe rupture.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

- a. Design Data - Design plans and correspondence for Grahamville Dam were obtained from PennDER's files.
- b. Experience Data - No rainfall or reservoir stage records are maintained for Grahamville Dam.
- c. Visual Observations - A diversion channel and dike are located on the east and south sides of the reservoir which serve to divert most of the runoff from the watershed to the stream channel downstream from the dam. Some vegetation and debris are located in this channel which could cause an obstruction to flood discharges leading to overtopping of the dike. The spillway channel is also heavily vegetated. All vegetation and debris should be periodically removed from the spillway and diversion channels.
- d. Overtopping Potential - Grahamville Dam is classified as a "Significant" hazard - "Small" size dam requiring evaluation for a spillway design flood (SDF) in the range of the 100-year flood to the 1/2 Probable Maximum Flood (1/2 PMF). Since the dam and reservoir are on the low end of the small size category, the 100-year flood was chosen as the appropriate SDF. The peak discharge for the 100-year flood was calculated in accordance with procedures outlined in the Soil Conservation Service Technical Release No. 55. The maximum discharge from the 1.64 square mile drainage basin, according to this analysis, is 580 c.f.s. The diversion channel was then analyzed to determine its ability to adequately convey the 100-year flood flows around the reservoir and dam. This analysis indicated that the upper end of the dike could experience minor overtopping of approximately 25 c.f.s. which would be discharged into the reservoir. Since this overtopping of the dike would be of relatively short duration and would produce flows of low velocity, it is not considered to be so serious as to cause any substantial damage or failure of the dike. In addition, approximately 40 c.f.s. could enter the reservoir through the three inlet pipes. This total inflow to the reservoir of 65 c.f.s. is, however, well below the spillway capacity of 230 c.f.s.

Ratios of the Probable Maximum Flood (PMF) hydrograph were also developed and routed through the reservoir with the aid of the U.S. Army Corps of Engineers' Flood Hydrograph Package, HEC-1. The inflow hydrographs, used in the analysis, were reduced by an appropriate amount to account for discharges routed around the reservoir by the diversion channel. The results indicate that the spillway and reservoir are capable of passing approximately 15 percent of the PMF without overtopping the dam.

- e. Spillway Adequacy - The spillway diversion channel, as outlined in the above analysis, is capable of passing the 100-year flood which is approximately 10 percent of the PMF with no overtopping of the dam. Therefore, the spillway is "adequate" according to the recommended criteria.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

- a. Visual Observations - Due to the existence of several seepage areas on the downstream side of the dam, it is almost impossible to accurately assess the structural integrity of the dam. Although piping conditions were not visibly evident during either inspection, the hydraulic gradient present at the seepage location indicates that piping could occur. As recommended in Section 7, North East Borough should seek engineering assistance in performing a more detailed investigation of the seepage and its effects on the structural stability of the dam.
- b. Design and Construction Data - No design or construction data were available for this Phase I Inspection.
- c. Operating Records - No operating records were available for Grahamville Reservoir Dam. Operational procedures obtained from interviewing the borough engineer do not indicate cause for concern relative to the structural stability of the dam.
- d. Post-Construction Changes - It is not believed that any of the post-construction changes have had any adverse effects on the dam.
- e. Seismic Stability - The dam is located in Zone 2 of the "Seismic Zone Map of the Contiguous United States," Figure 1, page D-30, "Recommended Guidelines for Safety Inspection of Dams." Since this is a zone of moderate seismic activity, no further investigation as to the seismic stability is necessary if the dam can be shown to meet the requirements of static stability. As stated in paragraph 6.1.a., the existence of a significant amount of seepage could have adverse affects on both the static and seismic stability of the dam. However, there will be no need for further considerations for seismic stability if the recommended engineering investigation shows the dam (with remedial measures, as necessary) has adequate structural stability.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

- a. Safety - The dam and its appurtenant structures were found to be in poor overall condition at the time of inspection. Grahamville Reservoir Dam is evaluated as being a "Significant" hazard - "Small" size dam in accordance with the "Recommended Guidelines for Safety Inspection of Dams" and should have a spillway capacity equal to the 100-year flood. As presented in Section 5, the spillway and reservoir were determined to have a capacity greater than the 100-year flood and are therefore assessed as being "adequate."
- b. Adequacy of Information - The information available and the observations made during the field inspections are considered adequate for this Phase I Inspection.
- c. Urgency - The owner should initiate the action discussed in paragraph 7.2 without delay.
- d. Necessity for Additional Data/Evaluation - As discussed in Section 6.1 and paragraph 7.2, an investigation of the seepage and its effects on the structural stability should be initiated by the owner.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

It is recommended that the owner initiate a feasibility study as to whether or not Grahamville Reservoir is necessary for the water supply of North East Borough. The time and money that will be exhausted in performing the following recommendations and remedial measures may not be justifiable in terms of the potable water used from the reservoir. If the owner decides not to repair the structure, the reservoir should be drawn-down and the embankment breached. However, if the owner feels that the reservoir is an integral part of the water supply system of the borough and should remain intact, the following items should be performed by the owner without delay:

- 1) Engage the services of a qualified engineer to assess the seepage problems and their long-term effects on the structural stability of the dam. The study should include recommendations for remedial action.
- 2) The downstream slope, including 10 feet beyond the toe, should be cleared to facilitate future inspections.
- 3) Place riprap or other types of erosion control on the upstream slope to prevent erosion.
- 4) Regrade and reseed the large ruts along the crest with an appropriate mixture to prevent erosion.
- 5) Repair the concrete on the outside of the gate valve house. Also, repair the head wall for the two 12 inch outlet pipes.
- 6) Fill and reseed the rodent holes along the downstream slope.
- 7) Remove all debris and excess vegetation from the emergency spillway and diversion channels.
- 8) A plan for rapid closure of the upstream end of the pipes through the embankment should be developed and implemented in the event of a pipe rupture.

In addition, the following operational measures are recommended to be undertaken by the owner:

- 1) Develop a detailed emergency operation and warning system.
- 2) During periods of unusually heavy rain, provide around-the-clock surveillance of the dam.
- 3) When warning of a storm of major proportions is given by the National Weather Service, the owner should activate the emergency operation and warning system.

In the future, the owner should keep a record of the inspections and repair work done on the dam and concrete appurtenances.

PLATES

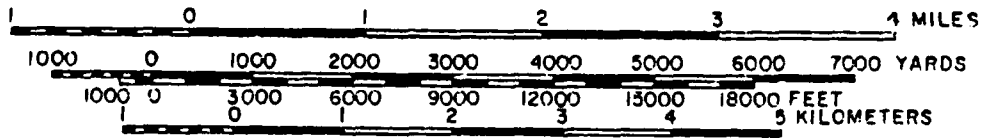
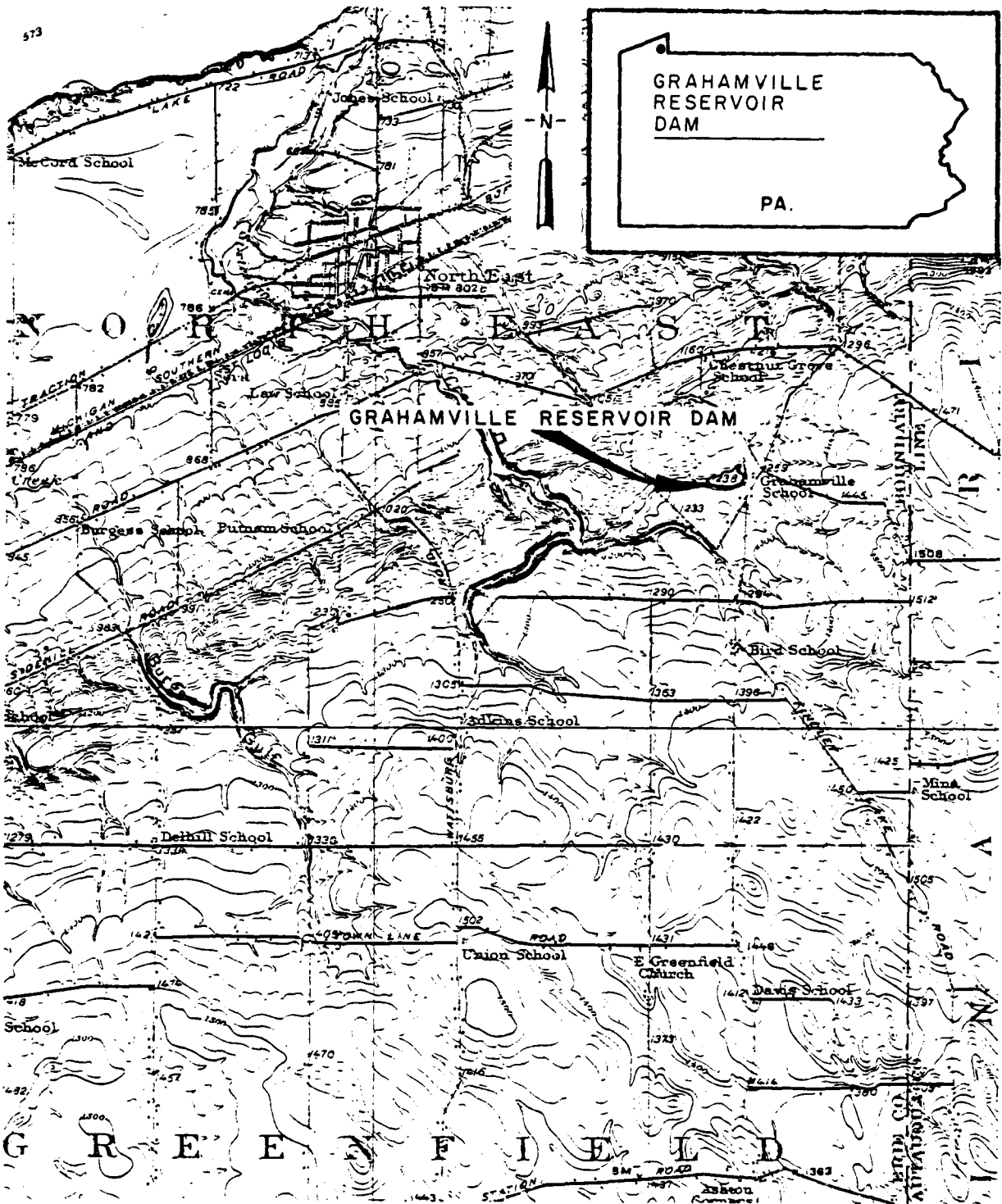
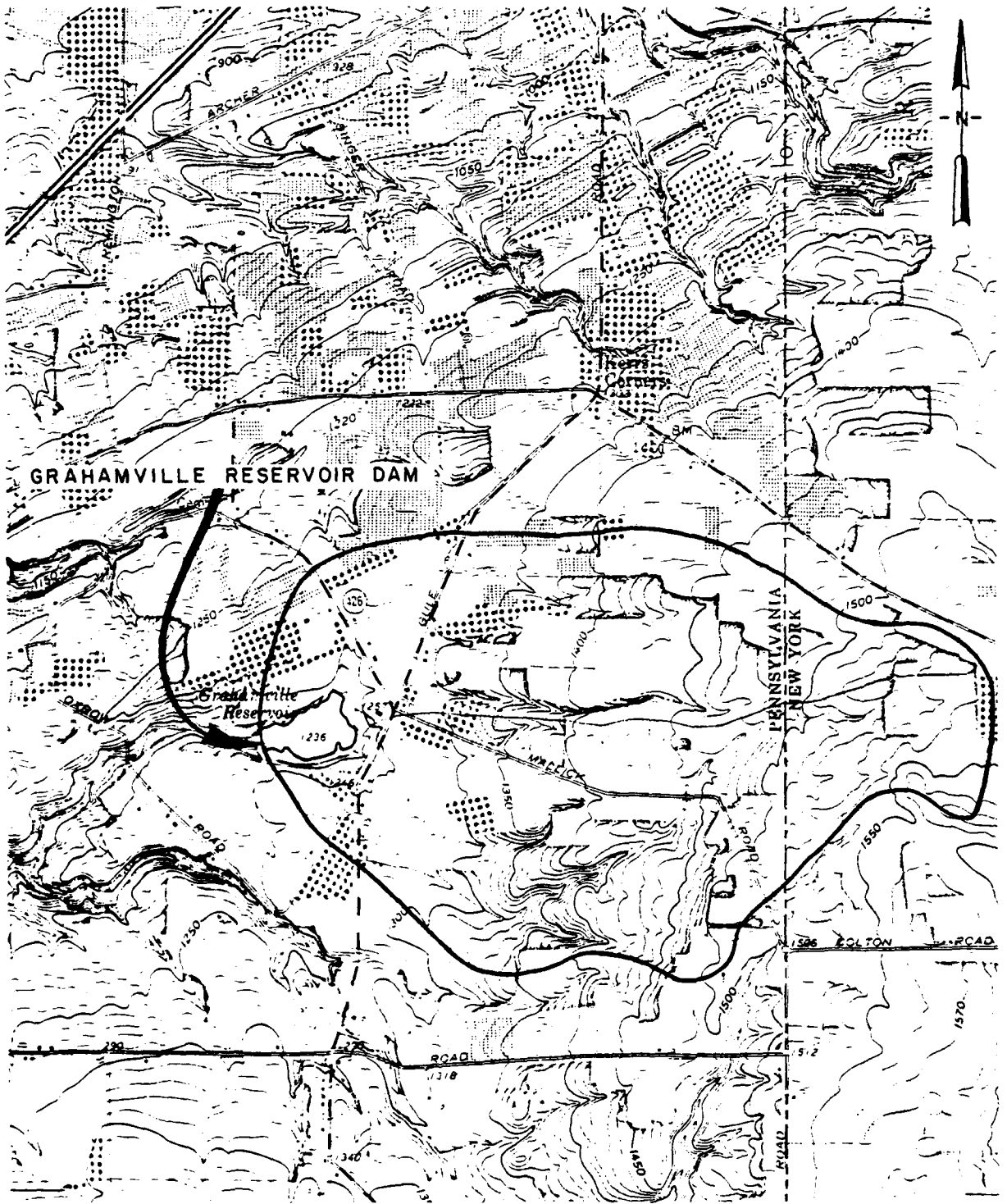


PLATE I LOCATION PLAN
GRAHAMVILLE RESERVOIR DAM



SCALE 1:24000

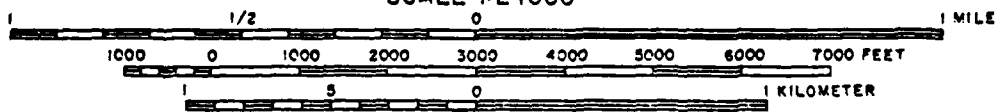
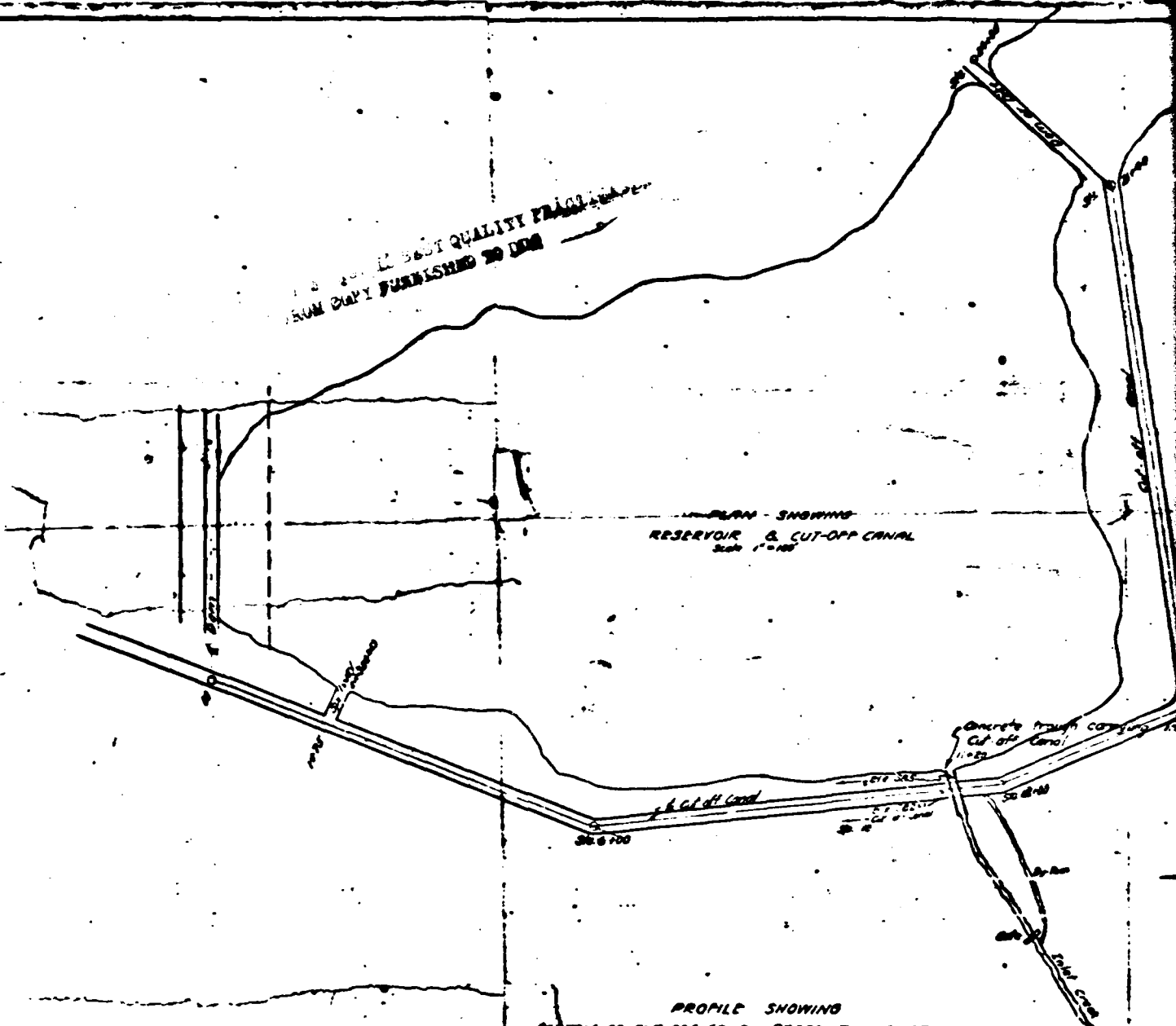


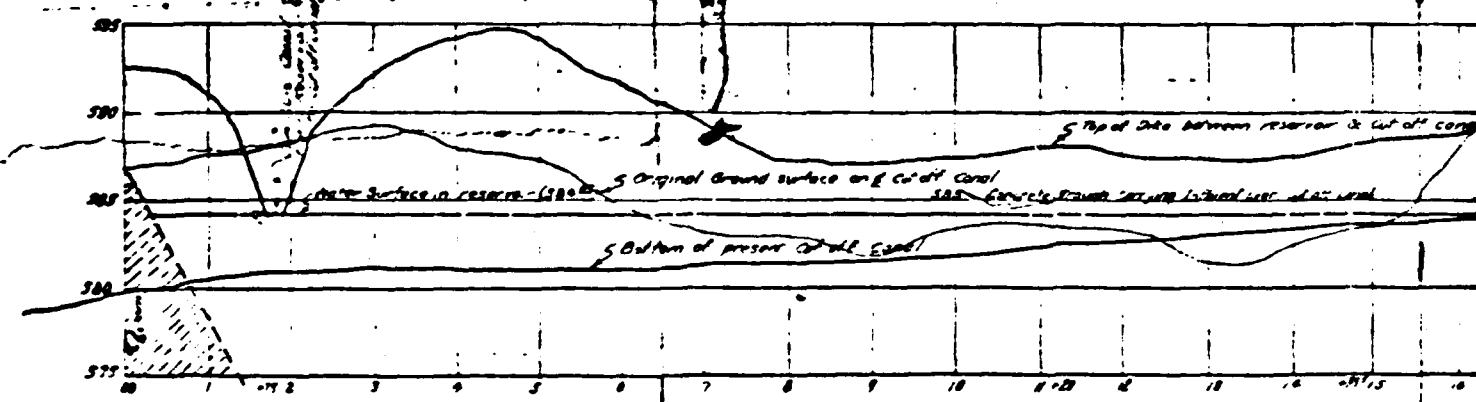
PLATE 2 WATERSHED MAP
GRAHAMVILLE RESERVOIR DAM

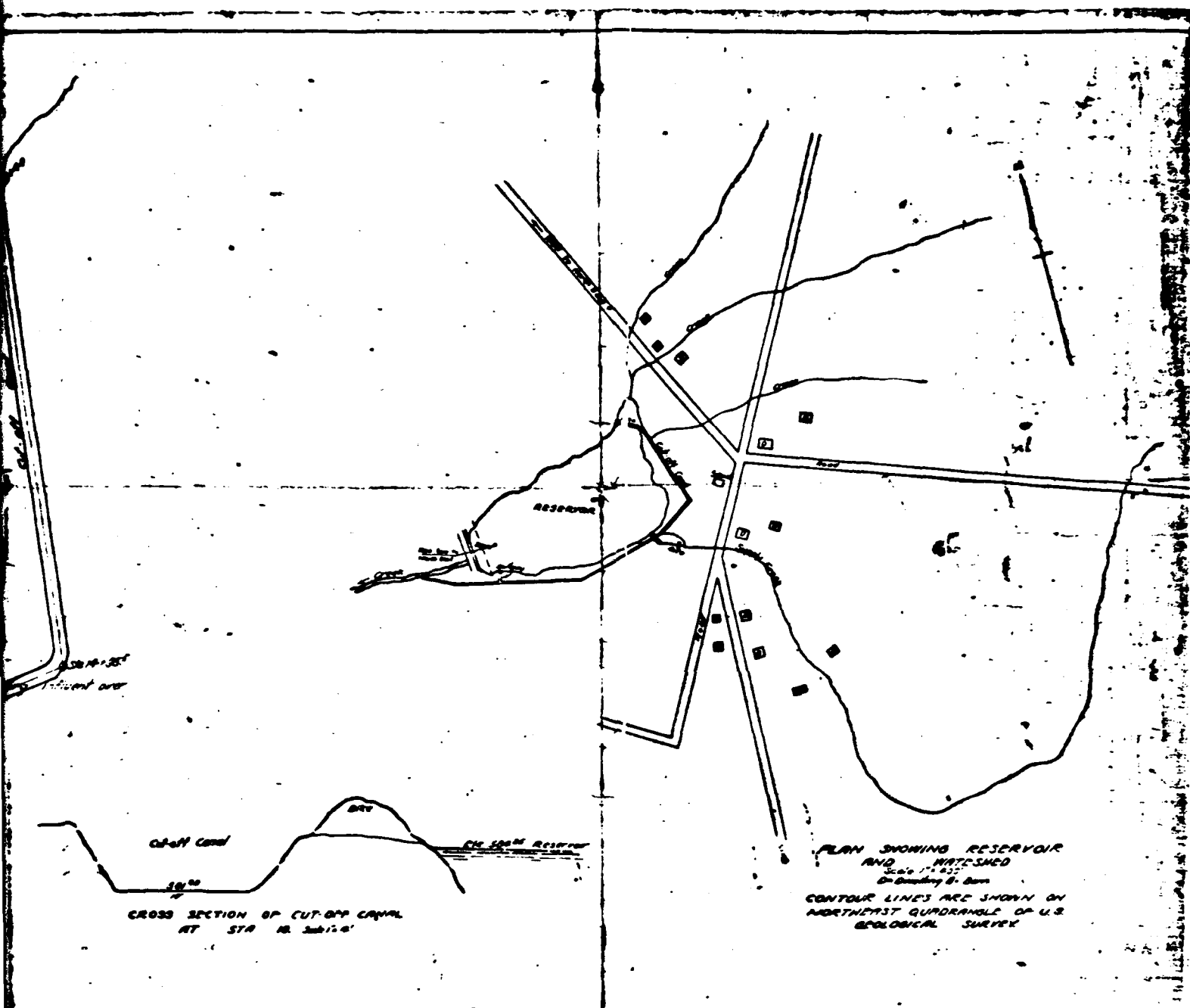
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FROM COPY FURNISHED TO DDD

PLAN - SHOWING
RESERVOIR & CUT-OFF CANAL
Scale 1" = 100'

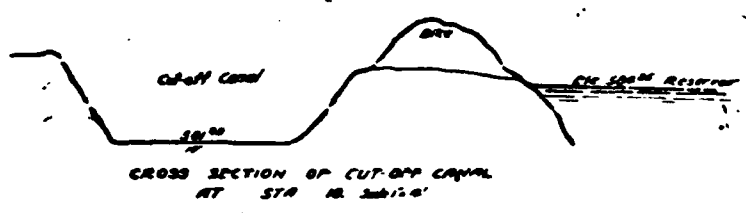


PROFILE SHOWING
ELEVATION OF CUT-OFF CANAL, PRESENT ELEVATION
OF FLOOR ON RESERVOIR SIDE OF CANAL &
SURFACE OF WATER IN RESERVOIR
Scale 1" = 100' (VERT SCALE 1" = 5')

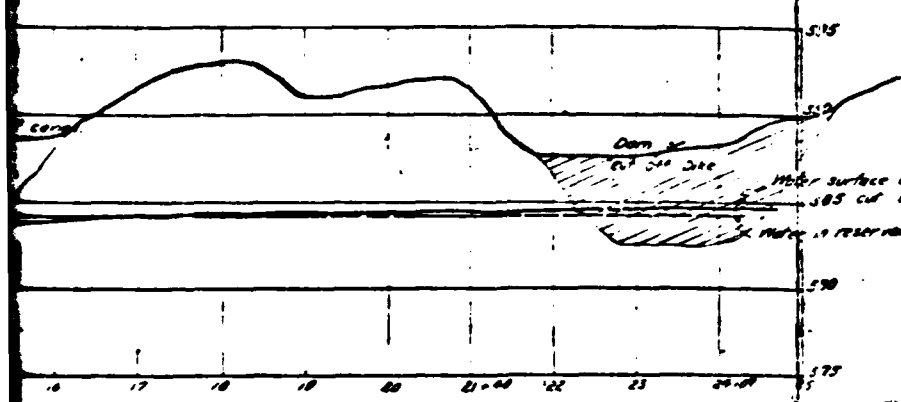




PLAN SHOWING RESERVOIR AND WATERSHED
 Scale 1" = 400'
 On Boundary of Dam
 CONTOUR LINES ARE SHOWN ON NORTHEAST QUADRANGLE OF U.S. GEOLOGICAL SURVEY



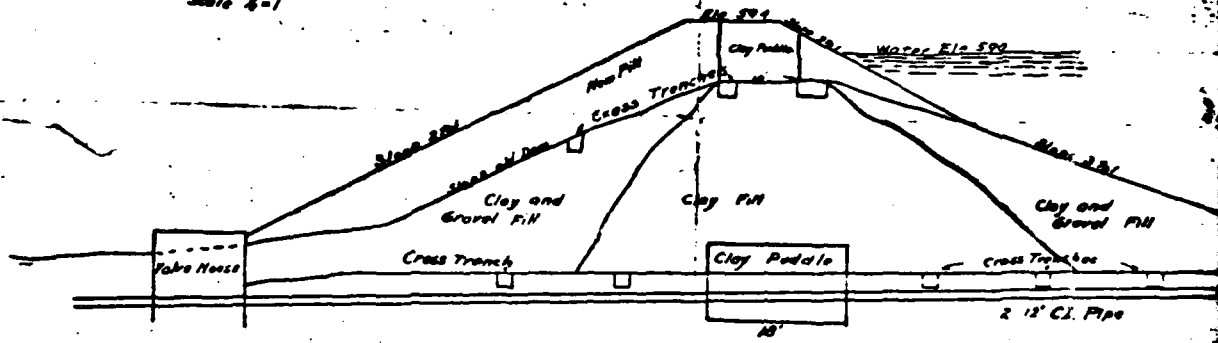
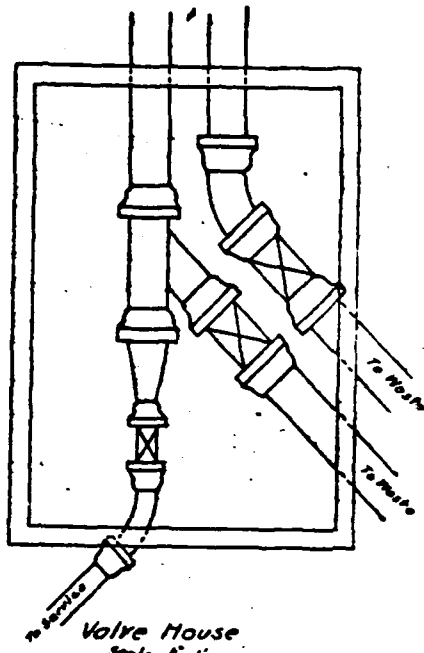
CROSS SECTION OF CUT-OFF CANAL AT STA. NO. 2015.0'



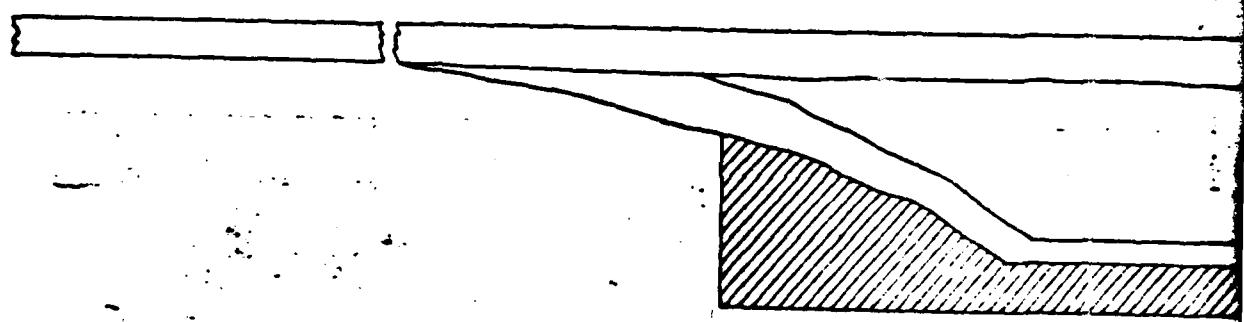
Water surface above dike of 585 cut off Canal (80442)
 Reservoir (80442)

PLATE 3
 NORTH EAST WATER SYSTEM
 NORTH EAST PENN.
 MAY 1, 1918

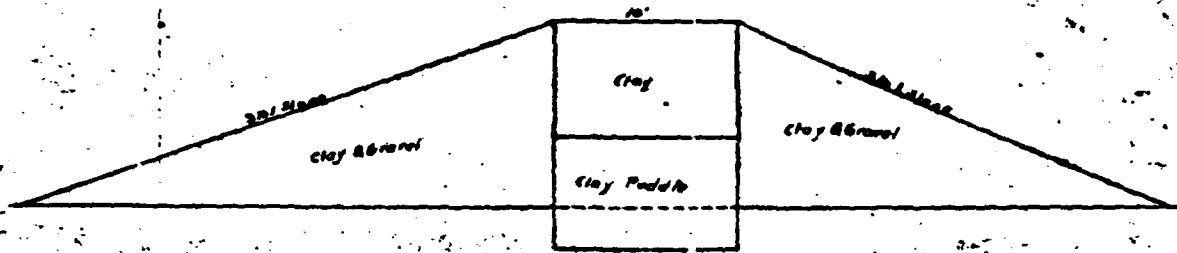
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Cross Section of Dam
Scale 1"=10'



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SPECIFICATIONS AND DIMENSIONS BY DDD

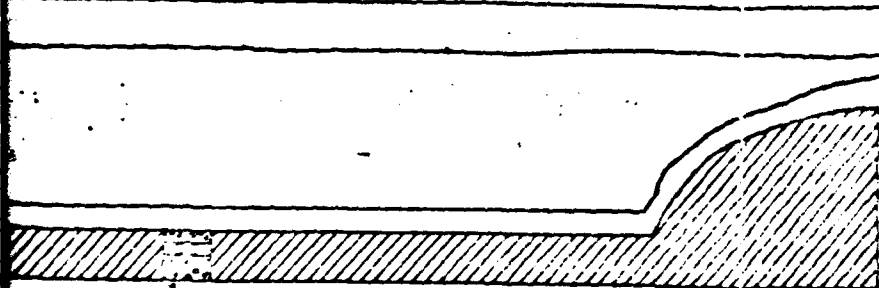
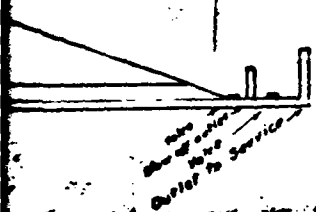


Cross Section of Canal Fill



Longitudinal Section of Canal Fill

Scale 1"=8'



Outlet Piers Constructed in place

Longitudinal Section of Dam

Scale 1"=10'

PLATE 4
NORTH EAST BORO
Water Department
 Grahamville Reservoir Extension
 October 1923
 Scales as Noted
 Hill & Hill Engs.

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 REPRODUCTION OF ORIGINAL DRAWING

APPENDIX A

CHECK LIST - VISUAL INSPECTION
AND FIELD SKETCHES

Check List
Visual Inspection
Phase 1

Name of Dam Grahamville Reservoir Dam County Erie State PA Coordinates Lat. N 42° 11.0'
NDI # PA 00020 Pennder # 25-2 Long. W 79° 47.3'

Date of Inspection 16 November 1978 Weather Partly cloudy Temperature 50°F.

Pool Elevation at Time of Inspection 1235.28 ft.* M.S.L.
Tailwater at Time of Inspection 1204.78 ft.* M.S.L.

*Elevations are based on invert elevation of emergency spillway from plans and correction of +653.03 ft. to convert from plan datum based on North East Borough datum and USGS elevations.

Inspection Personnel:

Michael Baker, Jr., Inc.:

Rodney E. Holderbaum
David Johns
James G. Ulinski

Site Visit - 5 June 1979

C. Y. Chen
James G. Ulinski

Owner's Representatives
North East Borough, PA:

Herb Mallick, Engineer

David Johns Recorder

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS		
DRAINS		
WATER PASSAGES		
FOUNDATION		

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES		
STRUCTURAL CRACKING		
VERTICAL AND HORIZONTAL ALIGNMENT		
MONOLITH JOINTS		
CONSTRUCTION JOINTS		

EMBANKMENT

A-4

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	<ol style="list-style-type: none"><li data-bbox="722 803 799 971">1. Erosion has cut into the upstream face creating a 3-4 ft. near vertical drop-off at normal pool.<li data-bbox="859 803 935 971">2. Erosion was also noted at approximately 200 ft. from the right abutment on the downstream face.<li data-bbox="995 803 1072 971">3. The crest has two large ruts across the top due to vehicular traffic.	<ol style="list-style-type: none"><li data-bbox="722 1098 833 1491">1. The upstream face should be regraded to a flatter slope and riprap should be placed to prevent erosion.<li data-bbox="859 1098 970 1491">2. The eroded areas should be regraded, treated and seeded with an appropriate mixture to prevent erosion.<li data-bbox="995 1098 1166 1491">3. The crest should be regraded, treated and seeded with an appropriate mixture to prevent erosion. Vehicular traffic should be prohibited on the crest on the embankment.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	No misalignment of the crest was noted.	
RIPRAP FAILURES	Very little riprap was noted on the upstream face. The majority of the area is covered with weeds and bushes.	It is recommended that the upstream face be cleared of all vegetation, the slope regraded to a flatter slope and riprap be placed to prevent erosion.

EMBANKMENT

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No problems were observed.	
ANY NOTICEABLE SEEPAGE	Along the right abutment, a significant (1-2 p.m.) amount of seepage was noted; however, due to the dense vegetative growth along the downstream face, no assessment could be made as to the severity of the seepage.	The downstream face should be cleared and grubbed for a distance of 10 ft. beyond the toe and another inspection should be scheduled at a later date. A qualified engineer should be engaged to determine the severity of the seepage and its effects on the structural stability of the dam.
STAFF GAGE AND RECORDER	None installed	
DRAINS	None installed	

OUTLET WORKS

Name of Dam: GRAHAMVILLE RESERVOIR DAM
DOI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT		
INTAKE STRUCTURE	The intake structure was completely submerged; therefore, no assessment could be made.	
OUTLET STRUCTURE	1. The concrete structure around the outlet pipes has collapsed. 2. The concrete gate valve house is badly cracked and spalled.	1. The outlet head wall structure should be repaired. 2. The concrete should be repaired.
OUTLET CHANNEL	The valley below the dam becomes a narrow gorge; the floor of which is composed of slate. The side slopes are steep and covered with second growth timber and shrubs.	
EMERGENCY GATE		None installed

UNGATED SPILLWAY

A-7

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Not Applicable	
APPROACH CHANNEL	<ol style="list-style-type: none">1. The approach channel flows through the left bank of the reservoir, approximately 175 ft. upstream of the dam. The typical cross-section would be 6 ft. bottom width, 10 ft. deep with 1H:1V side slope.2. At the beginning of the channel, three 8-in. C.I.P. are installed beneath the access road for low flows. Debris has collected in front of these pipes.3. The approach channel between the access road and discharge channel is overgrown with brush.	<ol style="list-style-type: none">2. The pipe entrances should be cleared.3. The channel should be cleared.
DISCHARGE CHANNEL	The spillway empties into the diversion or cutoff channel around the dam. The channel is overgrown with brush and has extensively eroded the underlying rock formation.	All brush should be removed from the channel.
BRIDGE AND PIERS	None	
DIVERSION CHANNEL	The diversion channel is overgrown with brush and small trees. Some debris is obstructing the channel at several locations.	All vegetation and debris should be periodically removed from the channel.

GATED SPILLWAY - Not Applicable

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

CONCRETE SILL

APPROACH CHANNEL

DISCHARGE CHANNEL

BRIDGE AND PIERS

GATES AND OPERATION
EQUIPMENT

INSTRUMENTATION - None Installed

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS		
OBSERVATION WELLS		
WEIRS		
PIEZOMETERS		
OTHER		

RESERVOIR

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

SLOPES

The upstream area is a cultivated rolling countryside; the greater percentage of which is used for growing fruit. The remaining areas (the tops of hills) are wooded.

SEDIMENTATION

Since inflows to the reservoir are limited by the three conduits, it is doubtful that any extensive sedimentation has occurred.

DOWNSTREAM CHANNEL

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

CONDITION
(OBSTRUCTIONS,
DEBRIS, ETC.)

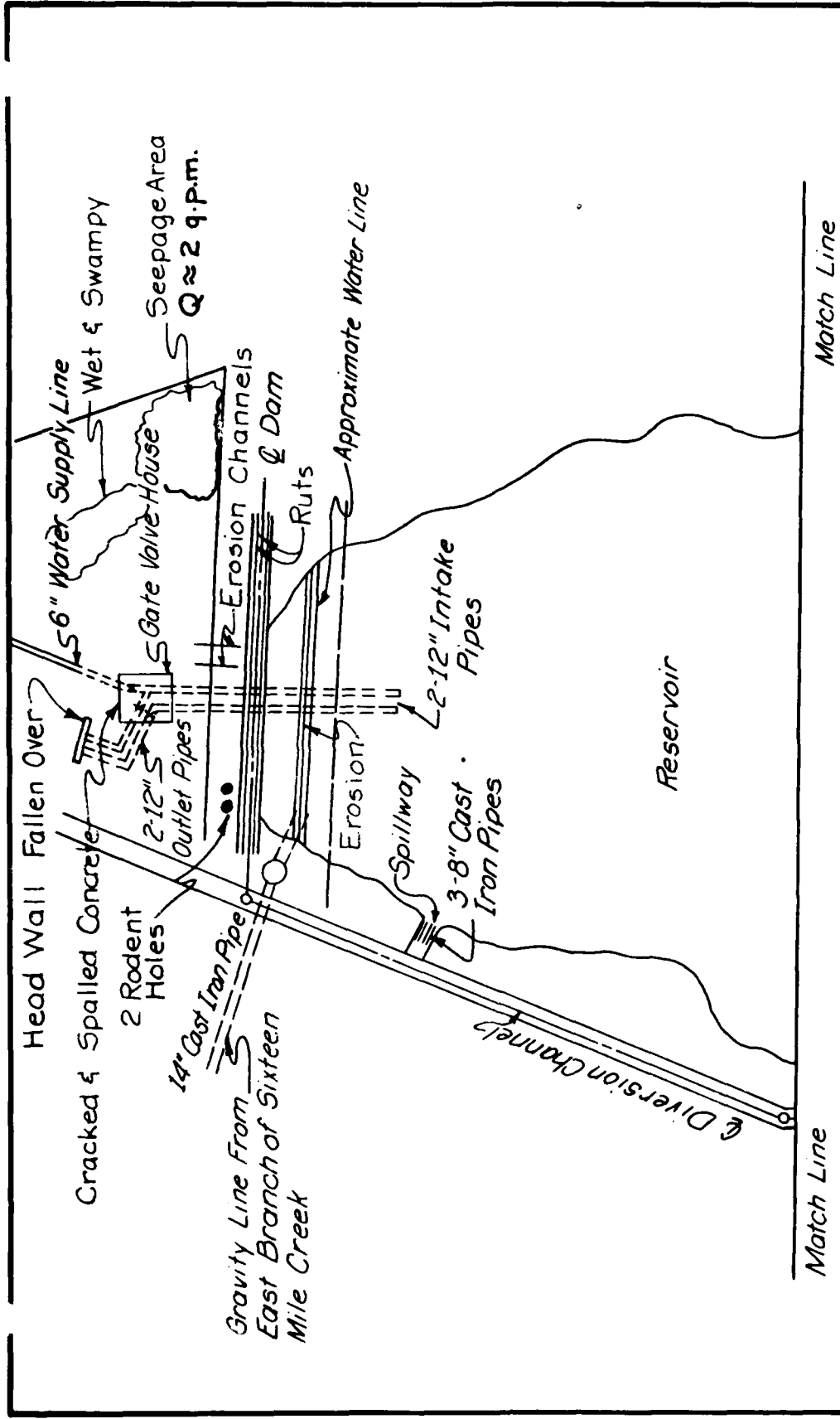
Sixteen Mile Creek flows through a forested area downstream from the dam. No major obstructions are located in the floodplain.

SLOPES

The slopes of the downstream channel is relatively steep, averaging approximately 2%. The slopes adjacent to the stream channel are steep and primarily forested.

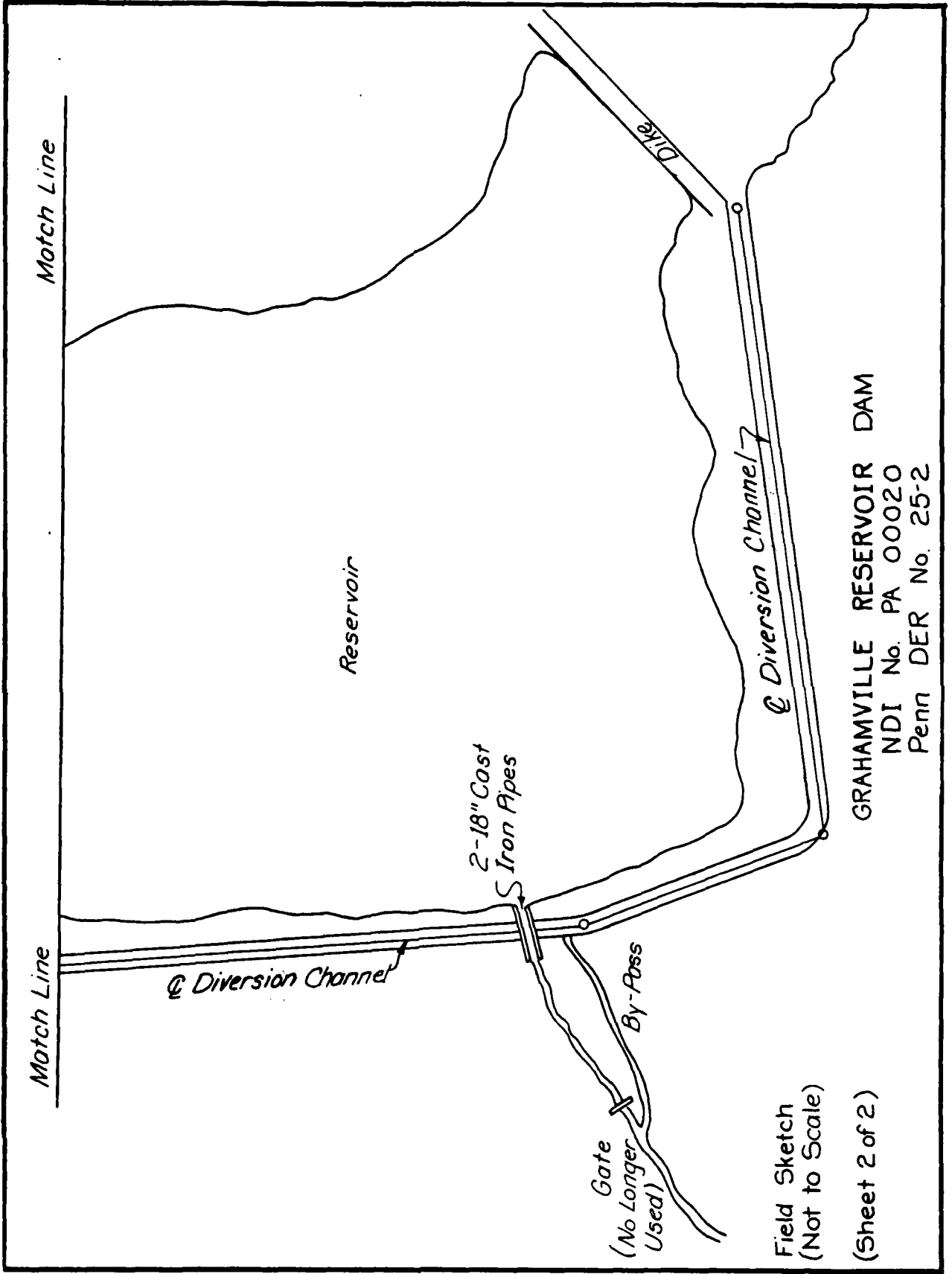
APPROXIMATE NO.
OF HOMES AND
POPULATION

The nearest homes are located about 4 mi. downstream from the dam in North East, Pennsylvania.



Field Sketch
 (Not to Scale)
 (Sheet 1 of 2)

GRAHAMVILLE RESERVOIR DAM
 NDI No. PA 00020
 Penn DER No. 25-2



GRAHAMVILLE RESERVOIR DAM
NDI No. PA 00020
Penn DER No. 25-2

Field Sketch
(Not to Scale)
(Sheet 2 of 2)

APPENDIX B

CHECK LIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

ITEM REMARKS

PLAN OF DAM See Plate 3.

REGIONAL VICINITY MAP A portion of the North East, Pennsylvania 7.5 minute quadrangle map showing the location of the dam with state location inset is enclosed in this report as Plate 1.

CONSTRUCTION HISTORY None available

TYPICAL SECTIONS OF DAM See Plate 4.

HYDROLOGIC/HYDRAULIC DATA See Check List - Engineering Data, page B-4, and also Appendix D.

OUTLETS - PLAN See Plate 4.

- DETAILS None available

- CONSTRAINTS Two-12 in. C.I.P.

- DISCHARGE RATINGS None available

RAINFALL/RESERVOIR RECORDS None available

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

B-2

ITEM REMARKS

DESIGN REPORTS None available

GEOLOGY REPORTS See Appendix E, Regional Geology

DESIGN COMPUTATIONS None available
HYDROLOGY & HYDRAULICS
DAM STABILITY
SEEPAGE STUDIES

MATERIALS INVESTIGATIONS None available
BORING RECORDS
LABORATORY
FIELD

POST-CONSTRUCTION SURVEYS OF DAM Information received from Hill and Hill Engineers of North East, Pa., indicates the existence of bench mark located at the base of the control gate. The gate is located approximately 850 ft. upstream of the main embankment. This information was not verified in the field due to the fact that it was not obtained until after the field inspection.

BORROW SOURCES None available

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

B-3

ITEM	REMARKS
------	---------

MONITORING SYSTEMS	None installed
--------------------	----------------

MODIFICATIONS	Additional material was placed on both the diversion dike and embankment in the late 1920's. In the early 1930's a 14 in. C.I.P. was installed as a gravity feed into the reservoir from the East Branch of Sixteen Mile Creek. The flume across the bypass canal was replaced by two 18 in. C.I.P. and three 8 in. C.I.P. were placed in the emergency spillway channel to permit vehicular traffic across the channel.
---------------	--

HIGH POOL RECORDS	None available
-------------------	----------------

POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None available
---	----------------

PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None reported
---	---------------

MAINTENANCE OPERATION RECORDS	None available
-------------------------------	----------------

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

B-4

ITEM

REMARKS

SPILLWAY PLAN,

SECTIONS,
and
DETAILS

None available

OPERATING EQUIPMENT
PLANS & DETAILS

None installed

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

B-5

DRAINAGE AREA CHARACTERISTICS: 1.64 sq.mi. (primarily farmland)

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1237.28 ft. (140 ac.-ft.)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1242.57 ft.
(209 ac.-ft.)

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 1242.57 ft.

CREST: Emergency Spillway

- a. Elevation 1237.28 ft.
- b. Type Three 8-in. C.I.P. under road to earth channel
- c. Width Approximately 6 ft.
- d. Length 162 ft.
- e. Location Spillover 175 ft. upstream from dam
- f. Number and Type of Gates None

OUTLET WORKS: Principal Spillway

- a. Type Two 12 in. C.I.P.
- b. Location Submerged above upstream toe
- c. Entrance inverts 12 in. blow-off pipe - El. 1218.03 ft.
12 in. service - El. 1220.53 ft.
- d. Exit inverts El. 1204.78± ft.
- e. Emergency draindown facilities Two 12 in. gate valves located in
gate house on downstream slope

HYDROMETEOROLOGICAL GAGES: None

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE Unknown

APPENDIX C

PHOTOGRAPHS

DETAILED PHOTOGRAPH DESCRIPTIONS

Overall View of Dam Looking Left to Right along Upstream Slope

- Photo 1 - Approach Channel of Emergency Spillway
- Photo 2 - Three 8 inch Pipes that Carry Emergency Spillway Flow under Dirt Road
(Note Debris Obscuring Middle Pipe.)
- Photo 3 - Outlet Channel of Emergency Spillway Looking from Diversion Channel Back Toward Reservoir
- Photo 4 - Main Embankment from Right Abutment
(Note Ruts and Standing Water on Crest.)
- Photo 5 - Downstream Side of Dam
(Note Fallen Head Wall over 12 inch Outlet Pipes. Gate Valve House is Shown in Background.)
- Photo 6 - Close up of Gate Valve House
(Note Deteriorated Condition of Concrete.)
- Photo 7 - View of Reservoir from Crest
- Photo 8 - Diversion Channel around Left End of Reservoir
- Photo 9 - Inlet to Reservoir
(Two 18 inch Cast-Iron Pipes.)
- Photo 10 - Reservoir End of Two 18 inch Cast-Iron Pipes
- Photo 11 - Seepage Area along Downstream Right Abutment of Dam

Note: Photos 1-10 were taken on 16 November 1978 and Photo 11 was taken on 5 June 1979.

GRAHAMVILLE RESERVOIR DAM



PHOTO 1. Approach Channel of Emergency Spillway

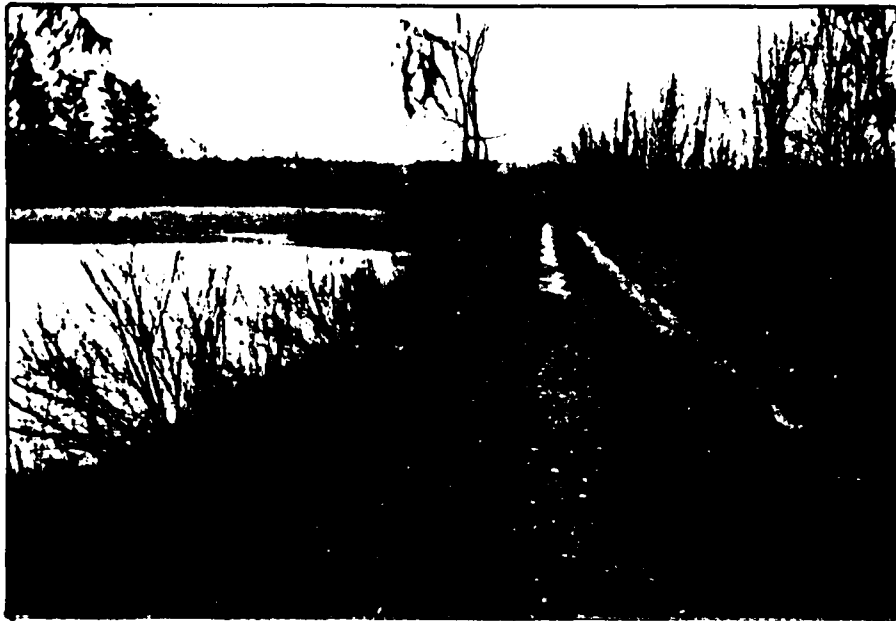


**PHOTO 2. Three 8 inch Pipes that Carry Emergency Spillway Flow under Dirt Road
(Note Debris Obscuring Middle Pipe)**

GRAHAMVILLE RESERVOIR DAM



**PHOTO 3. Outlet Channel of Emergency Spillway Looking from
Diversion Channel Back Toward Reservoir**



**PHOTO 4. Main Embankment from Right Abutment
(Note Ruts and Standing Water on Crest)**

GRAHAMVILLE RESERVOIR DAM



**PHOTO 5. Downstream Side of Dam
(Note Fallen Head Wall over 12 inch Outlet Pipes.
Gate Valve House is Shown in Background)**



**PHOTO 6. Close-up of Gate Valve House
(Note Deteriorated Condition of Concrete)**

GRAHAMVILLE RESERVOIR DAM

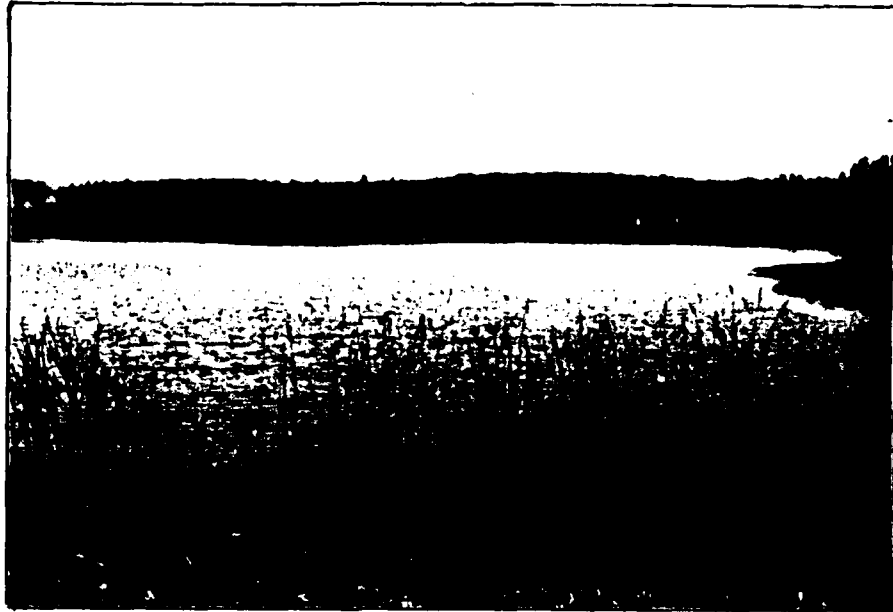


PHOTO 7. View of Reservoir from Crest



PHOTO 8. Diversion Channel around Left End of Reservoir

GRAHAMVILLE RESERVOIR DAM



PHOTO 9. Inlet to Reservoir (Two 19 Inch Cast-Iron Pipes)



PHOTO 10. Reservoir End of Two 18 inch Cast-Iron Pipes

GRAHAMVILLE RESERVOIR DAM



PHOTO 11. Seepage Area along Downstream Right Abutment of Dam

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Irakonville Dam S.O. No. _____
Hydrology and Hydraulics Sheet No. _____ of _____
Drawing No. _____
Computed by REH Checked by _____ Date _____

Table of Contents

Introduction	1
Watershed Plan	3
Reservoir Plan	4
Hydrology	5
Hydraulics	8
Conclusions	13
Spillway Rating	14
Rainfall & Hydrograph data	15
Hydrograph development	16
0.50 PMF Routing	22
0.25 PMF Routing	27
Overtopping potential	32

Grahamville Dam is a small-size significant hazard dam requiring evaluation for a 100-year flood. A dyke has been constructed around the entire reservoir thus cutting off most of the drainage area. Inflows to the reservoir could include:

1. Flows entering the reservoir through the three inlet pipes. (see page 4)
2. Flows overtopping the dyke in the event that the diversion channel capacity is exceeded by the 100-year flood.

The methods used to hydrologically and hydraulically evaluate the dam are as follows.

1. The peak flows for the 100-year storm were estimated using the SCS method for agricultural (non-urbanized) areas as outlined in Technical Release No. 55.
2. Possible inflows to the reservoir were evaluated by calculating the capacities of the diversion channel and pipes entering the reservoir.
3. The capacity of the spillway was calculated to determine if it is of

MICHAEL BAKER, JR., INC.

THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam

Introduction

S.O. No. _____

Sheet No. 2 of 32

Drawing No. _____

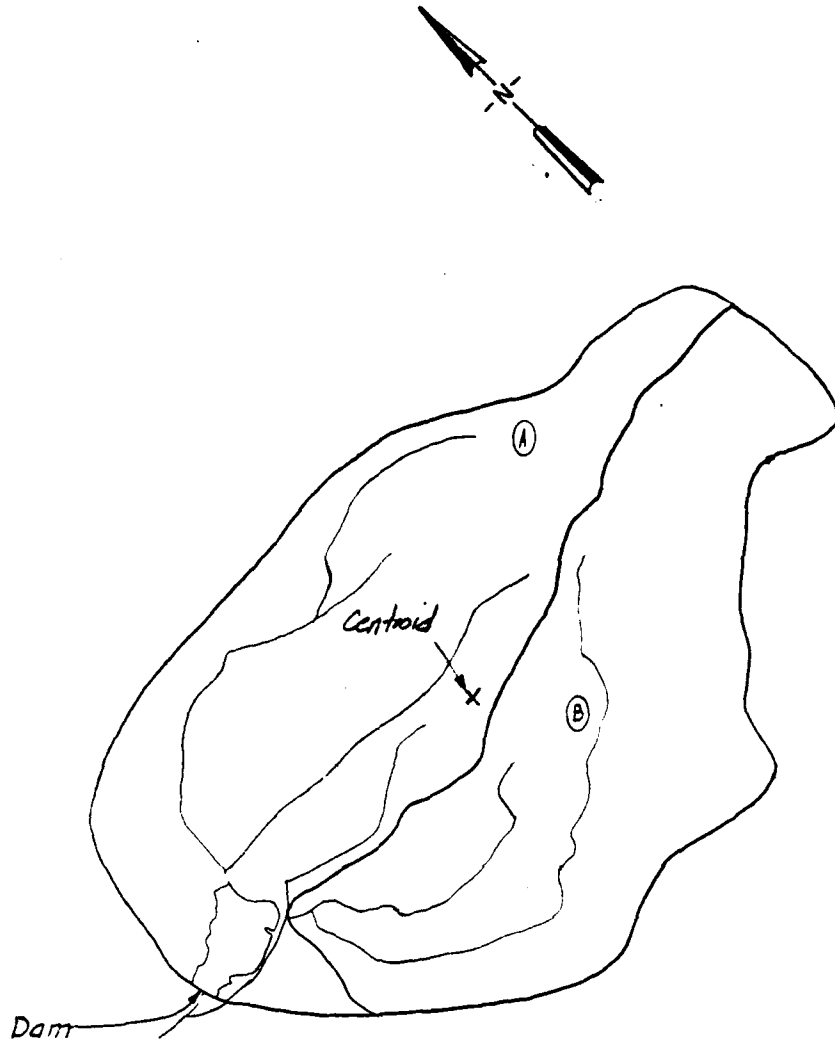
Computed by REH

Checked by _____

Date _____

sufficient size to adequately convey
all inflows to the reservoir to the
downstream channel.

Dimensions of the diversion channel,
inflow pipes, and spillway were determined
from design plans and approximate field
surveys taken during the field inspection.

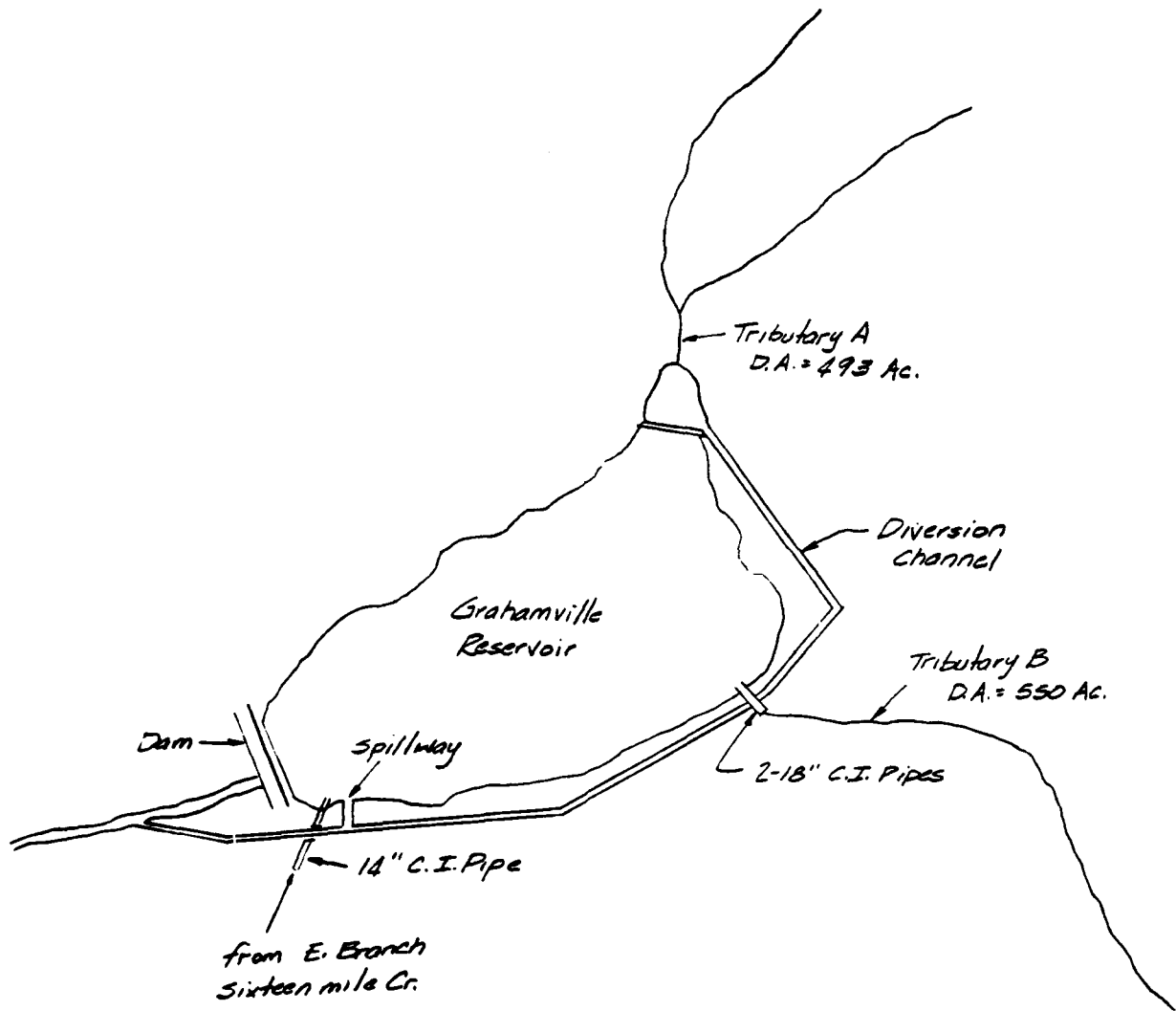


Quad: North East
A. Drainage Area = 0.77 mi.²
L = 2.22 mi. s = 2.56%
B. Drainage Area = 0.87 mi.²
L = 2.12 mi. s = 2.68%
Total Drainage Area = 1.64 mi.²

SCALE: 1" = 2000'
DATE: 3-29-79 *SES*

Grahamville Reservoir Watershed

MICHAEL BAKER JR. INC.
Consulting Engineers & Surveyors



GRAHAMVILLE DAM
AND RESERVOIR

Estimate 100-year storm runoff:

This analysis was taken from Technical Release 55 published by the Soil Conservation Service.

See Chapter 4 and App. D and E.

This method is applicable to non-urbanized watershed less than 2000 acres in size. A type II rainfall distribution is assumed.

Sub-basin A:

D.A. = 493 ac.

Watershed slope = 2.6 %

100 year rainfall = 4.8 inches (pg. C-5)

Curve No:

soils in the area are primarily in hydrologic group C (soil name - volusia)

The land use in the watershed is estimated from the Northeast quad. map (7 1/2 min.) as follows:

<u>Land use</u>	<u>Percent</u>	<u>CN*</u>
Meadows	50	71
Wooded	40	74
Cultivated	10	83

* From table 2-2

The weighted CN for sub-basin A
 $= 0.5(71) + 0.4(74) + 0.1(83) \approx \underline{73}$

From figure D-2 (Peak rates of discharge
for small watersheds)

$$Q = 95 \text{ cfs/inch runoff (1\% w/s slope)}$$

The adjustment factor for a w/s with a
2.6% slope = 1.4 (Table E-1)

$$Q = 95(1.4) \approx 135 \text{ cfs/inch runoff}$$

Total runoff from 4.8 inches rainfall
 $= 2.1 \text{ inches (Table 2-1 with CN = 73)}$

$$\text{Therefore } Q_{100} = 135(2.1) = 285 \text{ cfs.}$$

Sub-basin B:

D.A. = 550 ac.

Watershed slope = 2.7%

100-year rainfall = 4.8 inches

Curve Number: (Hydrologic Soil Group C)

<u>Land Use</u>	<u>Percent</u>	<u>CN</u>
Meadows	35	71
Wooded	60	74
Cultivated	5	83

MICHAEL BAKER, JR., INC.

THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam S.O. No. _____
Hydrology and Hydraulics Sheet No. 7 of 32
Drawing No. _____
Computed by REH Checked by _____ Date 6-16-79

$$\begin{aligned} \text{The weighted CN for sub-basin B} \\ = 0.35(71) + 0.6(74) + 0.05(83) = \underline{73} \end{aligned}$$

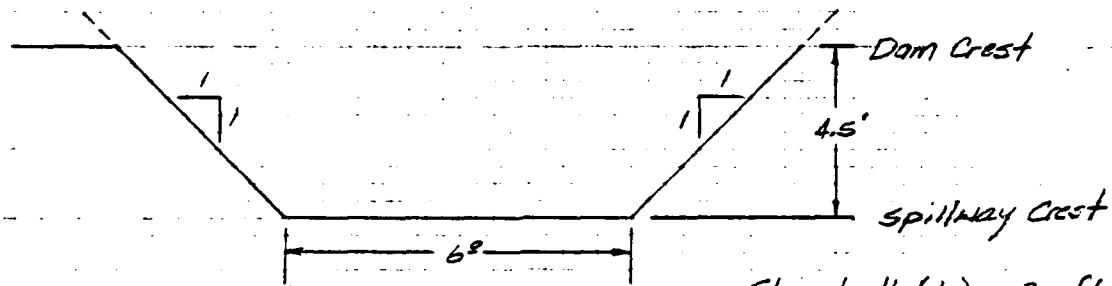
From figure D-2:

$$Q = 100 \text{ cfs/in. runoff (1\% w/s slope)}$$

The adjustment factor for a 2.7%
w/s slope = 1.4 (Table E-1)

$$Q = 100(1.4) = 140 \text{ cfs/in. runoff}$$

$$\text{Therefore } Q_{100} = 140(2.1) = 295 \text{ cfs.}$$



Flow depth (d_c) = 3.0 ft.
Head velocity = 1.5 ft
Total head = 4.5 ft.

Maximum spillway capacity:
(assume critical depth)

$$Z \text{ (section factor)} = A \sqrt{A/T}$$

A = flow area
T = top width

$$Z = 27.0 \sqrt{27.0/12} = 40.5$$

$$Q = Z \sqrt{g} = 40.5 \sqrt{32.2} = 230 \text{ cfs.} \leftarrow \text{Maximum Spillway Capacity}$$

(Source: Open channel Hydraulics - Ven Te Chow)

Diversion Ditch Capacity:

a. capacity at confluence with tributary A



$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

Assuming uniform flow conditions

$n = 0.05$ (Brush lined channel - relatively straight
and uniform in cross-section)

$$A = 75 \text{ ft}^2$$

$$s \approx 0.003$$

$$Q = \frac{1.49}{0.05} \left(\frac{75}{24.1} \right)^{2/3} (0.003)^{1/2} 75 = 260 \text{ cfs}$$

b. Capacity at confluence with Tributary B

depth = 8.5 ft. side slopes = 1:1

bottom width = 10 ft.

$$Q = \frac{1.49}{0.05} \left(\frac{157.2}{34.0} \right)^{2/3} (0.003)^{1/2} 157.2 = 710 \text{ cfs.}$$

c. Capacity at confluence with spillway

depth = 12 ft. side slopes = 1:1

bottom width = 10 ft.

$$Q = \frac{1.49}{0.05} \left(\frac{264}{44} \right)^{2/3} (0.003)^{1/2} 264 = 1420 \text{ cfs.}$$

Inflow to Grahamville Reservoir through inlet pipes:

(1) 14 inch cast iron pipe

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

assuming uniform flow and full flow condition.

$$\text{slope} = 0.02 \text{ ft/ft.}$$

$$Q = \frac{1.49}{0.012} \left(\frac{1.07}{3.67} \right)^{2/3} (0.02)^{1/2} (1.07) = 8 \text{ cfs.}$$

(2) 2- 18 inch cast iron pipes

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

$$\text{Slope} = 0.02 \text{ ft/ft.}$$

$$Q = 2 \left(\frac{1.49}{0.012} \right) \left(\frac{1.77}{4.71} \right)^{2/3} (0.02)^{1/2} (1.77) = 32 \text{ cfs.}$$

Total inflow from three pipes = 40 cfs.

The potential for overtopping the dyke adjacent to the diversion channel should be evaluated at three locations. Inflows to the reservoir through the three inlet pipes will also be considered.

(1) At confluence of Tributary A and diversion channel.

Runoff from sub-basin A = 285 cfs.
 Diversion channel capacity = 260 cfs.
 Therefore approximately 25 cfs. will overtop the dyke and flow into the reservoir at this point.

(2) At confluence of Tributary B and diversion channel.

Discharge from sub-basin A = 260 cfs.
 (diversion channel capacity at (1) above)
 Runoff from sub-basin B = 295 cfs.
 Total = 555 cfs.
 Diversion channel capacity = 710 cfs.

Since the diversion channel capacity exceeds the total expected discharge at this location the dyke should not be overtopped. However, approximately 32 cfs. will enter the reservoir through the

two 18" C.I. pipes.

- (3) At the confluence of the spillway and diversion channel.

Total inflow to reservoir from
(1) & (2) on previous page = 57 cfs.
Inflow through 14" C.I. pipe = 8 cfs.
Total inflow to reservoir = 65 cfs.
Spillwall Capacity = 230 cfs.

The spillway, therefore, has sufficient capacity to pass the 100-year flood. Since the capacity of the diversion channel (at the spillway) is 1420 cfs. no overtopping of the dyke or restriction of flows from the spillway would be expected.

Effects of overtopping of dyke at the confluence of tributary A and diversion channel.

Length of dyke subject to overtopping \approx 150 ft.
Assume, however, that only 20 ft. of the dyke is overtopped.

$$\therefore Q = 25 \text{ cfs.} = CLH^{3/2}$$

$$25 = 2.65(20)H^{3/2} \Rightarrow H \approx 0.6 \text{ ft.}$$

(Not sufficient to cause failure of the dyke)

The results of this evaluation indicate that the dam would not be overtopped by the 100-year flood. Several conditions or assumptions used in the analysis are as follows:

1. The crest of the diversion dyke is at approximately the same elevation as the crest of the dam.
2. The storage capacity of the reservoir was neglected. (In reality, the storage will be affected slightly by rainfall directly on the reservoir.)
3. All discharges in excess of the capacity of the diversion channel will enter the reservoir.

These assumptions are, overall, probably somewhat conservative and therefore support the conclusion that the dam is capable of passing the 100-year flood without overtopping.

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam
Spillway Rating

S.O. No. _____

Sheet No. 14 of 32

Drawing No. _____

Computed by REH Checked by _____

Date 8-15-79

W.S. Elev. (ft.)	Area (ft ²)	T (ft.)	Z	Q (cfs.)	Res. Elev. (ft.)
1238.6		6.0		0	1238.6
1239.0	2.56	6.8	1.57	9	1239.2
1240.0	10.36	8.8	11.24	64	1240.7
1241.0	20.16	10.8	27.54	156	1242.2
1242.0	31.96	12.8	50.50	287	1243.7
1243.0	45.76	14.8	80.46	457	1245.2

Also see pg. of this appendix

Rainfall Data:

From HMR 33: Zone 2

$$P(24 \text{ hr.} - 200 \text{ sq. mi.}) = 22.9 \text{ in.}$$

$$P_6 = 117\% \quad P_{24-200}$$

$$P_{12} = 127\% \quad P_{24-200}$$

$$P_{24} = 141\% \quad P_{24-200}$$

$$P_{48} = 151\% \quad P_{24-200}$$

Hydrograph Data: (Snyder's unit hydrograph)

The following average values were determined from the two major watercourses tributary to the reservoir.

$$L = 2.17 \text{ mi.} \quad L_{ca} = 0.99 \text{ mi.}$$

$$\text{The wfs is in zone 26} \Rightarrow C_p = 0.78$$

$$C_t = 1.16$$

$$\therefore t_p = 1.16 [(2.17)(0.99)]^{0.3}$$

$$t_p = 1.46 \text{ hours}$$

$$t_r = 1.46 / 5.5 = 0.27 \text{ hr.} \quad \text{use } t_r = 0.5 \text{ hr.}$$

$$\therefore t_{pR} = 1.46 + 0.25(0.5 - 0.27)$$

$$t_{pR} = 1.52 \text{ hours}$$

 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79
 MAJ UPDATE 04 JUN 79

1 A1 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
 2 A2 HYDROLOGIC AND HYDRAULIC ANALYSIS OF GRAHAMVILLE RES. MHJ Ub
 3 A3 PROBABLE MAXIMUM FLOOD PHF/UNIT GRAPH BY SNYDERS METHOD
 4 B 200 0 30 0 0 0 0 0
 5 B1 5
 6 J 1 1 1
 7 J1 0.5
 8 K 0
 9 K1 STORM HYDROGRAPH DEVELOPMENT BY SNYDERS UNIT HYDROGRAPH
 10 M 1 1.64
 11 P 22.9 117 127 141 151
 12 T 1.0 0.05
 13 W 1.52 0.78
 14 X -1.5 -0.05 2.0
 15 K 99

Sheet 16 of 32

 FLOOD PROGRAPH PACKAGE (HEC-1)
 DAM 54 Y VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79
 MBL UPDATE 04 JUN 79

RUN DATE 08/16/79
 TIME 09.54

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
 HYDROLOGIC AND HYDRAULIC ANALYSIS OF GRAHAMVILLE RES. MBL 06
 PROBABLE MAXIMUM FLOOD PMF/UNIT GRAPH BY SNYDERS METHOD

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
200	0	30	0	0	0	0	0	0	0

JOPER	NHT	LROPI	IRACE
5	0	0	0

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

RTIOS= 0.50

SUB-AREA RUNOFF COMPUTATION

STORM HYDROGRAPH DEVELOPMENT BY SNYDERS UNIT HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRI	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	1.64	0.0	1.64	0.0	0.0	0	0	0

PRECIP DATA

SPEE	PMS	R6	R12	R24	R48	R72	R96
0.0	22.90	117.00	127.00	141.00	151.00	0.0	0.0

TRSPC COMPUTED BY THE PROGRAM IS 0.800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRS	RTIOK	STRTL	CNSTL	ALSHX	RTIMP
0	0.0	0.0	1.00	0.0	0.0	1.00	1.00	0.05	0.0	0.0

UNIT HYDROGRAPH DATA

IP= 1.52 CP=0.78 NIA= 0

RECESSION DATA

SRTIO= -1.50 ORCSN= -0.05 RTIOR= 2.00
 APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 4.29 AND R= 1.36 INTERVALS

UNIT HYDROGRAPH 10 END-OF-PERIOD ORDINATES, LAG= 1.51 HOURS, CP= 0.77 VOL= 1.00
 91. 298. 483. 522. 374. 187. 86. 40. 18. 8.

END-OF-PERIOD FLOW

0

Sheet 17 of 32

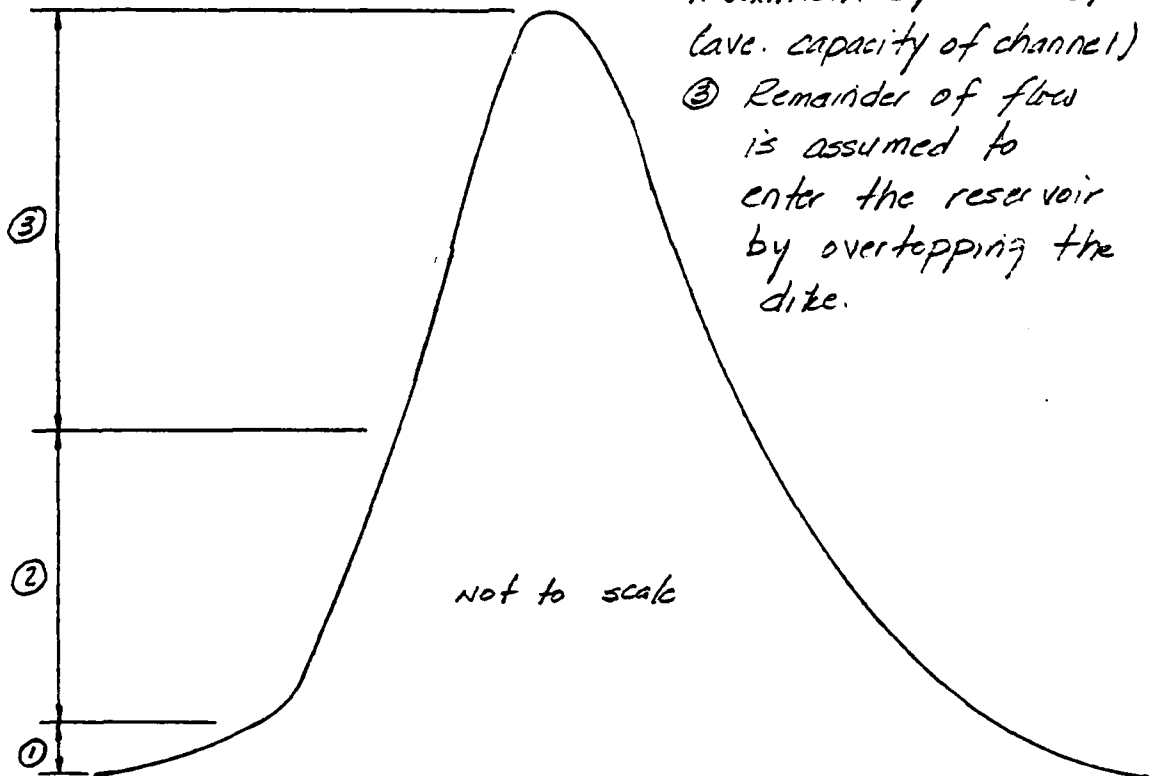
MO-DA HR-MN PERIOD RAIN EXCS LOSS COMP Q MO-DA HR-MN PERIOD RAIN EXCS LOSS COMP U

1.01	0.30	1	0.01	0.00	0.01	2.	1.03	2.30	101	0.0	0.0	0.0	158.
1.01	1.00	2	0.01	0.00	0.01	2.	1.03	3.00	102	0.0	0.0	0.0	147.
1.01	1.30	3	0.01	0.00	0.01	2.	1.03	3.30	103	0.0	0.0	0.0	137.
1.01	2.00	4	0.01	0.00	0.01	2.	1.03	4.00	104	0.0	0.0	0.0	128.
1.01	2.30	5	0.01	0.00	0.01	2.	1.03	4.30	105	0.0	0.0	0.0	120.
1.01	3.00	6	0.01	0.00	0.01	2.	1.03	5.00	106	0.0	0.0	0.0	112.
1.01	3.30	7	0.01	0.00	0.01	2.	1.03	5.30	107	0.0	0.0	0.0	104.
1.01	4.00	8	0.01	0.00	0.01	1.	1.03	6.00	108	0.0	0.0	0.0	97.
1.01	4.30	9	0.01	0.00	0.01	1.	1.03	6.30	109	0.0	0.0	0.0	91.
1.01	5.00	10	0.01	0.00	0.01	1.	1.03	7.00	110	0.0	0.0	0.0	82.
1.01	5.30	11	0.01	0.00	0.01	1.	1.03	7.30	111	0.0	0.0	0.0	79.
1.01	6.00	12	0.01	0.00	0.01	1.	1.03	8.00	112	0.0	0.0	0.0	74.
1.01	6.30	13	0.01	0.00	0.01	1.	1.03	8.30	113	0.0	0.0	0.0	69.
1.01	7.00	14	0.01	0.00	0.01	1.	1.03	9.00	114	0.0	0.0	0.0	64.
1.01	7.30	15	0.01	0.00	0.01	1.	1.03	9.30	115	0.0	0.0	0.0	60.
1.01	8.00	16	0.01	0.00	0.01	1.	1.03	10.00	116	0.0	0.0	0.0	56.
1.01	8.30	17	0.01	0.00	0.01	1.	1.03	10.30	117	0.0	0.0	0.0	52.
1.01	9.00	18	0.01	0.00	0.01	1.	1.03	11.00	118	0.0	0.0	0.0	49.
1.01	9.30	19	0.01	0.00	0.01	1.	1.03	11.30	119	0.0	0.0	0.0	45.
1.01	10.00	20	0.01	0.00	0.01	1.	1.03	12.00	120	0.0	0.0	0.0	42.
1.01	10.30	21	0.01	0.00	0.01	1.	1.03	12.30	121	0.0	0.0	0.0	39.
1.01	11.00	22	0.01	0.00	0.01	1.	1.03	13.00	122	0.0	0.0	0.0	37.
1.01	11.30	23	0.01	0.00	0.01	0.	1.03	13.30	123	0.0	0.0	0.0	34.
1.01	12.00	24	0.01	0.00	0.01	0.	1.03	14.00	124	0.0	0.0	0.0	32.
1.01	12.30	25	0.08	0.00	0.08	0.	1.03	14.30	125	0.0	0.0	0.0	30.
1.01	13.00	26	0.08	0.00	0.08	0.	1.03	15.00	126	0.0	0.0	0.0	28.
1.01	13.30	27	0.09	0.00	0.09	0.	1.03	15.30	127	0.0	0.0	0.0	26.
1.01	14.00	28	0.09	0.00	0.09	0.	1.03	16.00	128	0.0	0.0	0.0	24.
1.01	14.30	29	0.11	0.00	0.11	0.	1.03	16.30	129	0.0	0.0	0.0	23.
1.01	15.00	30	0.11	0.00	0.11	0.	1.03	17.00	130	0.0	0.0	0.0	21.
1.01	15.30	31	0.14	0.00	0.14	0.	1.03	17.30	131	0.0	0.0	0.0	20.
1.01	16.00	32	0.44	0.32	0.12	30.	1.03	18.00	132	0.0	0.0	0.0	18.
1.01	16.30	33	0.11	0.08	0.03	104.	1.03	18.30	133	0.0	0.0	0.0	17.
1.01	17.00	34	0.11	0.08	0.03	188.	1.03	19.00	134	0.0	0.0	0.0	16.
1.01	17.30	35	0.08	0.06	0.02	238.	1.03	19.30	135	0.0	0.0	0.0	15.
1.01	18.00	36	0.08	0.06	0.02	226.	1.03	20.00	136	0.0	0.0	0.0	14.
1.01	18.30	37	0.01	0.00	0.01	179.	1.03	20.30	137	0.0	0.0	0.0	13.
1.01	19.00	38	0.01	0.00	0.01	133.	1.03	21.00	138	0.0	0.0	0.0	12.
1.01	19.30	39	0.01	0.00	0.01	88.	1.03	21.30	139	0.0	0.0	0.0	11.
1.01	20.00	40	0.01	0.00	0.01	69.	1.03	22.00	140	0.0	0.0	0.0	11.
1.01	20.30	41	0.01	0.00	0.01	24.	1.03	22.30	141	0.0	0.0	0.0	10.
1.01	21.00	42	0.01	0.00	0.01	12.	1.03	23.00	142	0.0	0.0	0.0	9.
1.01	21.30	43	0.01	0.00	0.01	11.	1.03	23.30	143	0.0	0.0	0.0	9.
1.01	22.00	44	0.01	0.00	0.01	10.	1.04	0.0	144	0.0	0.0	0.0	8.
1.01	22.30	45	0.01	0.00	0.01	10.	1.04	0.30	145	0.0	0.0	0.0	7.
1.01	23.00	46	0.01	0.00	0.01	9.	1.04	1.00	146	0.0	0.0	0.0	7.
1.01	23.30	47	0.01	0.00	0.01	8.	1.04	1.30	147	0.0	0.0	0.0	7.
1.02	0.0	48	0.01	0.00	0.01	8.	1.04	2.00	148	0.0	0.0	0.0	6.
1.02	0.30	49	0.09	0.06	0.02	7.	1.04	2.30	149	0.0	0.0	0.0	6.
1.02	1.00	50	0.09	0.06	0.02	24.	1.04	3.00	150	0.0	0.0	0.0	5.
1.02	1.30	51	0.09	0.06	0.02	53.	1.04	3.30	151	0.0	0.0	0.0	5.
1.02	2.00	52	0.09	0.06	0.02	84.	1.04	4.00	152	0.0	0.0	0.0	5.
1.02	2.30	53	0.09	0.06	0.02	107.	1.04	4.30	153	0.0	0.0	0.0	4.
1.02	3.00	54	0.09	0.06	0.02	118.	1.04	5.00	154	0.0	0.0	0.0	4.
1.02	3.30	55	0.09	0.06	0.02	124.	1.04	5.30	155	0.0	0.0	0.0	4.
1.02	4.00	56	0.09	0.06	0.02	126.	1.04	6.00	156	0.0	0.0	0.0	3.
1.02	4.30	57	0.09	0.06	0.02	127.	1.04	6.30	157	0.0	0.0	0.0	3.
1.02	5.00	58	0.09	0.06	0.02	128.	1.04	7.00	158	0.0	0.0	0.0	3.
1.02	5.30	59	0.09	0.06	0.02	128.	1.04	7.30	159	0.0	0.0	0.0	3.
1.02	6.00	60	0.09	0.06	0.02	128.	1.04	8.00	160	0.0	0.0	0.0	3.
1.02	6.30	61	0.15	0.13	0.03	134.	1.04	8.30	161	0.0	0.0	0.0	2.
1.02	7.00	62	0.15	0.13	0.03	154.	1.04	9.00	162	0.0	0.0	0.0	2.
1.02	7.30	63	0.15	0.13	0.03	186.	1.04	9.30	163	0.0	0.0	0.0	2.
1.02	8.00	64	0.15	0.13	0.03	221.	1.04	10.00	164	0.0	0.0	0.0	2.

2.	1.	1.	1.	0.	0.	2.	1.	1.	2.	2.	1.	2.	1.	2.	1.	2.	1.	2.	1.
2857.	81.	1727.	49.	9.80	248.81	12.30	13.10	334.80	1152.	1326.	1075.	1375.	1421.	1421.	1421.	1421.	1421.	1421.	1421.
CFS																			
CMS																			
INCHES																			
MM																			
AC-FT																			
THOUS CU M																			
TOTAL VOLUME										TOTAL VOLUME									
27900.										27900.									

The storm hydrographs were adjusted to account for discharges entering the inlet pipes and discharges diverted around the reservoir through the diversion channel.

- ① Flow through 2-18" inlet pipes up to a maximum of 32 cfs.
- ② Flow diverted by diversion channel to a maximum of 485 cfs. (ave. capacity of channel)
- ③ Remainder of flow is assumed to enter the reservoir by overtopping the dike.



 FL110 HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION, JULY 1978
 LAST MODIFICATION, 26 FEB 79
 MAJ UPDATE 04 JUN 79

RUN DATE 08/17/79
 TIME 11.03

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
 HYDROLOGIC AND HYDRAULIC ANALYSIS OF GRAHAMVILLE RES. MDJ 00
 PROBABLE MAXIMUM FLOOD PMF/UNIT GRAPH BY SNYDERS METHOD

JOB SPECIFICATION

RU	NHR	NMIN	IDAY	IHK	IMIN	MFTRC	IPLT	IPKT	NSTAN
130	0	30	0	0	0	0	0	0	0
	JOPER	NWT	LROPT	TRACE					
	5	0	0	0					

MULTI-PLAN ANALYSES TO BE PERFORMED
 NPLAN= 1 NRTI2= 1 LKTI0= 1

PTIOS= 1.00

SUB-AREA RUNOFF COMPUTATION

STORM HYDROGRAPH DEVELOPMENT BY SNYDERS UNIT HYDROGRAPH

ISTAU	ICOMP	IECON	ITAPE	JPLT	JPKT	INAME	ISTAGE	IAUTO
1	0	0	0	0	2	1	0	0

HYDROGRAPH DATA

IHYDG	IUNG	IAREA	SNAP	IRSDA	TRSPC	KAJIO	ISNDW	ISAME	LOCAL
-1	0	1.64	0.0	1.64	0.0	0.0	0	0	0

HYDROGRAPH ROUTING

FLOOD ROUTING FOR GRAHAMVILLE DAM

ISTAU	ICOMP	IECON	ITAPE	JPLT	JPKT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IKES	ISAME	IUPT	IPMP	LSTR
0.0	0.0	0.0	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STJKA	ISPRAT
1	0	0	0.0	0.0	0.0	-12.7	-1

STA 1237.30 1239.20 1240.70 1242.20 1243.70 1245.20

FL 1% 0.0 9.00 64.00 130.00 267.00 457.00
 CAPACITY= 140. 200. 216.
 ELEVATION= 1237. 1243. 1244.

CREL	SPWID	COBW	EXPM	ELEVEL	COJL	CAREA	EXPL
1237.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COJD	EXPD	DAMWID
1243.1	2.0	1.2	400.

PEAK OUTFLOW IS 2400. AT TIME 26.50 HOURS

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

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

STATION PLAN RATIO - 1.00
 RATIO APPLIED TO FLOWS

STATION	AREA	PLAN RATIO	1.00
1	1.64	1	2372.0
(4.25)	(67.17)(
2	1.64	1	2400.0
(4.25)	(67.96)(

SUMMARY OF DAM SAFETY ANALYSIS

1	PLAN 1	ELEVATION	INITIAL VALUE	SPILLWAY REST	TOP OF DAM	AVERAGE				
2		STORAGE	1237.30	1237.50	1243.10					
3		OUTFLOW	140.	140.	206.					
4			0.	0.	232.					
5										
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Sheet 26 of 32

 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79
 MBJ UPDATE 04 JUN 79

1 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
 2 HYDROLOGIC AND HYDRAULIC ANALYSIS OF GRAHAMVILLE D.S. MBI 06
 3 A3 025 POSSIBLE MAXIMUM FLOOD PWF/UNIT GRAPH BY SNYDERS METHOD
 4 9 130 0 30 0 0 0 0 0
 5 81 5
 6 J 1 1 1
 7 J1 1.0
 8 K 0
 9 K1 1

STORM HYDROGRAPH DEVELOPMENT BY SNYDERS UNIT HYDROGRAPH

	1	2	3	24	30	29	22	16	11	6
N	-1	1.64								
N	3	2	2	2	1	1	1	1	1	1
N	7	10	13	15	15	16	16	16	16	16
N	17	20	23	28	31	32	32	32	32	32
N	32	32	32	32	32	32	43	137	224	407
N	697	924	943	723	429	185	32	32	32	32
N	32	31	31	29	27	27	26	24	23	21
N	20	17	17	16	15	14	13	12	11	10
N	10	9	8	8	7	7	6	6	6	5
N	5	5	5	4	4	3	2	2	2	2
N	2	2	2	2	2	2	2	2	2	2
N	1	1	1	1	1	1	1	1	1	1
N	1	0	0	0	0	0	0	0	0	0
K	1									

FLOOD ROUTING FOR GRAHAMVILLE DAM

V	1									
V1	1									
V41237.3	1230.2	1240.7	1242.2	1243.7	1245.2					
V5	0	9	64	156	287					
V5	140	200	216							
V1237.3	1242.6	1244								
V1237.3										
V1243.1	2.65	1.5	400							
K	90									

CAPACITY= 140. 200. 216.
 ELEVATION= 1227. 1243. 1244.

CFFL 1237.3 SPKID 0.0 CQWD 0.0 EYDWH 0.0 FLVCL 0.0 CQZL 0.0 CARFA 0.0 EYPL 0.0
 1237.3 0.0 0.0 0.0 0.0 0.0 0.0 0.0

DAM DATA
 TYPEL 1243.1 CQZD 2.6 EYDQ 1.5 DAMKD 400.

PEAK OUTFLOW IS 983. AT TIME 26.50 HOURS

Sheet 29 of 32

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 FEET (SQUARE METERS)

RATIOS APPLIED TO FLOWS

OPERATION STATION AREA PLAN RATIO 1
 1.00

HYDROGRAPH AT 1 1.64 1 942
 (4.25) (26.70)

ROUTED TO 2 1.64 1 983
 (4.25) (27.84)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN I	ELEVATION STORAGE		INITIAL VALUE		SPILLWAY CREST		AVERAGE TOP OF DAM		TIME OF FAILURE HOURS
	OUTFLOW	0.	140.	1237.30	1237.30	143.	206.	235.	
RATIO OF PVE	MAXIMUM RESERVOIR W.S. ELEV	DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAY OUTFLOW HOURS			
1.00 0.75	1243.84	0.74	214.	983.	2.50	26.50	2.2		

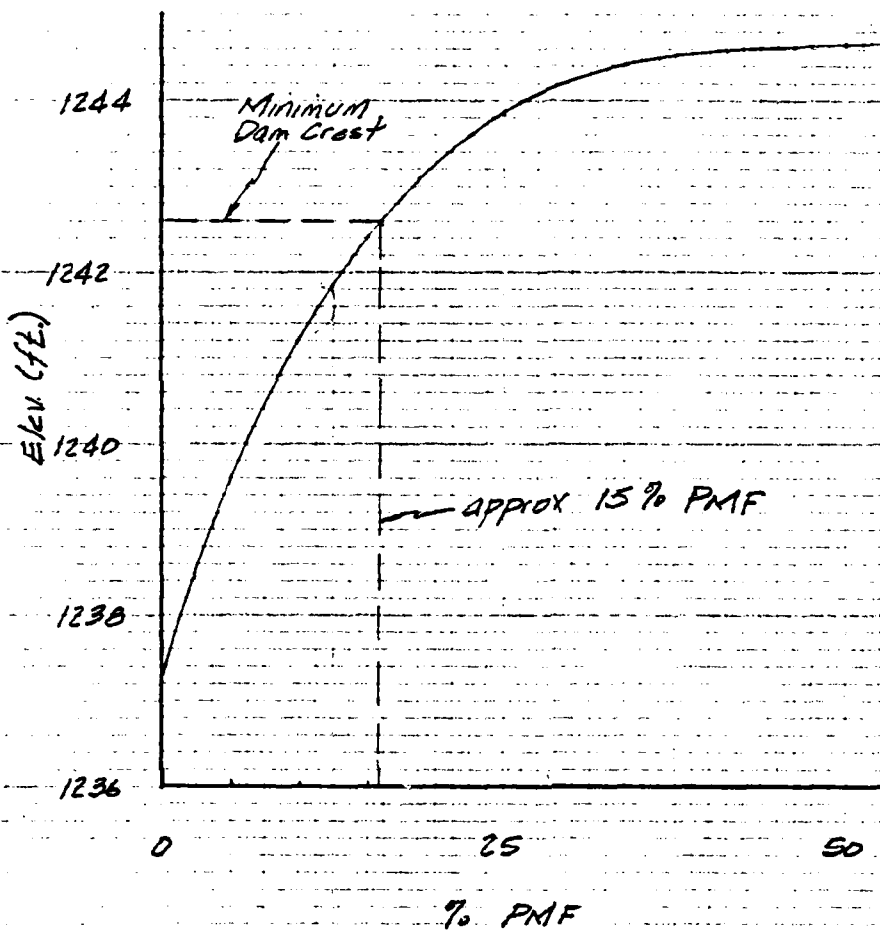
MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Subject Grahamville Dam
Overtopping Potential

S.O. No. _____
Sheet No. 32 of 32

Box 280
Beaver, Pa. 15009

Computed by REH Checked by _____
Drawing No. _____
Date 8-16-79



APPENDIX E
REGIONAL GEOLOGY

GRAHAMVILLE RESERVOIR DAM
NDI No. PA 00020, PennDER 25-2

GENERAL GEOLOGY

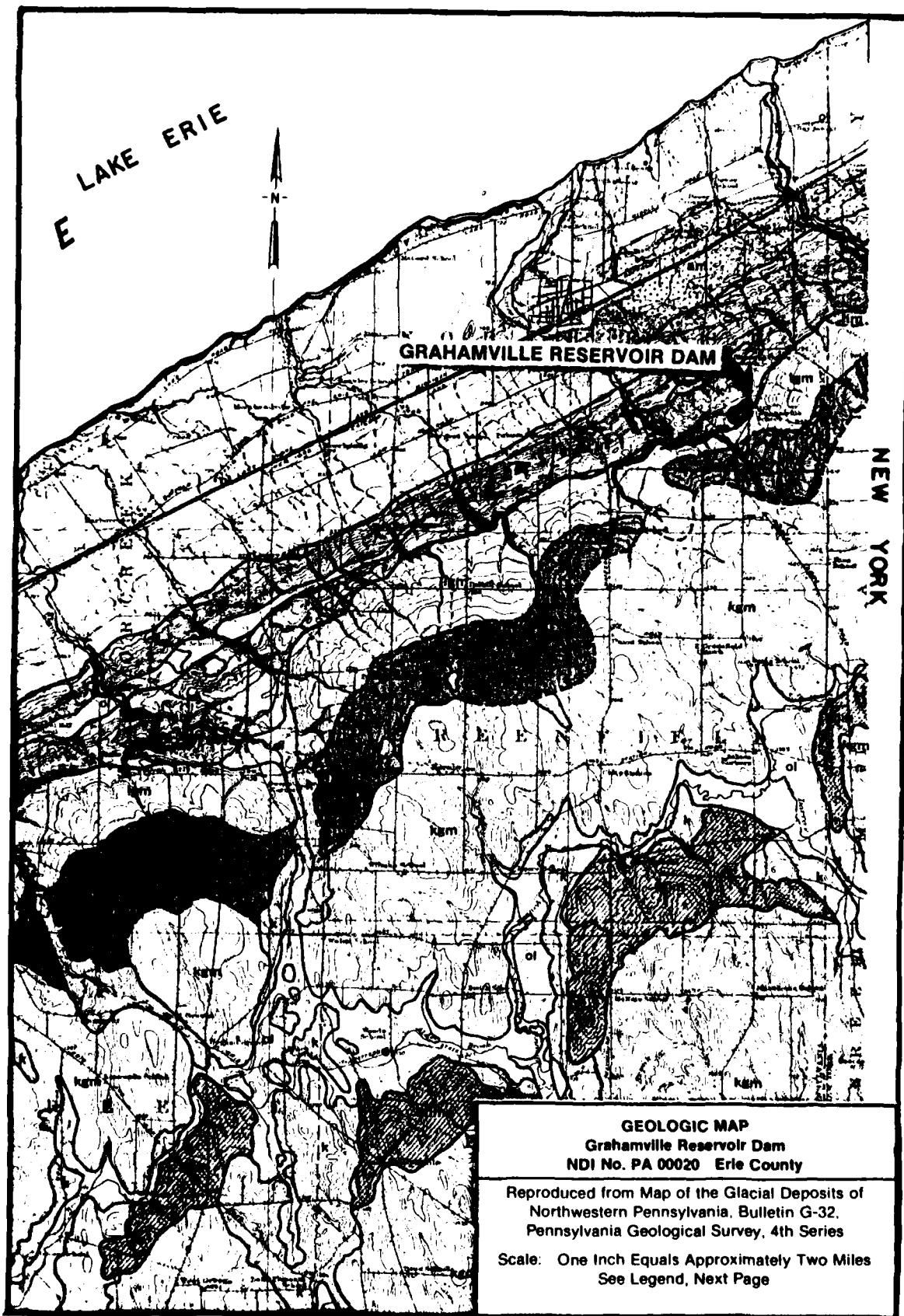
Grahamville Reservoir is located in the glaciated section of the Appalachian Plateaus physiographic province, approximately 4 miles southeast of Lake Erie. The normal pool of the reservoir is approximately 665 feet above mean lake level.

No design information is available describing geologic and soil conditions at the dam site. However, a 1916 inspection report of the Water Supply Commission of Pennsylvania describes the site geology as layers of sand and clay of variable depth overlying a gray slate formation. [The term "slate" is frequently misused as a synonym for shale.]


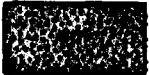








According to the geologic map on the following page, bedrock units in the general area of the dam and reservoir are members of the Conneaut group, Devonian system. These units are described on the accompanying legend as typically being shales and siltstones.

Although little specific data are available relative to the thickness and gradation of glacial till beneath the dam, some insight into its character can be obtained from the descriptions given for materials penetrated by a nearby water well. According to the well log, the area is mantled by glacial gravels approximately 19 feet thick. This information, however, can only be considered indicative of general conditions since high variability of materials can be expected.

The geologic map and legend are given on the following pages.



LEGEND

PLEISTOCENE WISCONSIN CARY	Ashtabula Till		Ashtabula morainic system (end moraines) Till (silt)
			Ashtabula moraine under thin beach sands
	Hiram Till		Defiance end moraine Till (silty clay to clay)
			ground moraine Till (silty clay)
	Lavery Till		Lavery end moraine Till (silt)
			ground moraine Till (silt)
			Kent end moraine Till (sandy loam)
	Kent Till		Findley Lake recessional moraine Till (loam)
			Clymer recessional moraine Till (loam)
			ground moraine Till (loam becoming sandy loam toward the east and south-east)