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NATIONAL DAM INSPECTION PROGRAM. DUTCH FORK DAM (NDI ID NUMBER --ETC(U)
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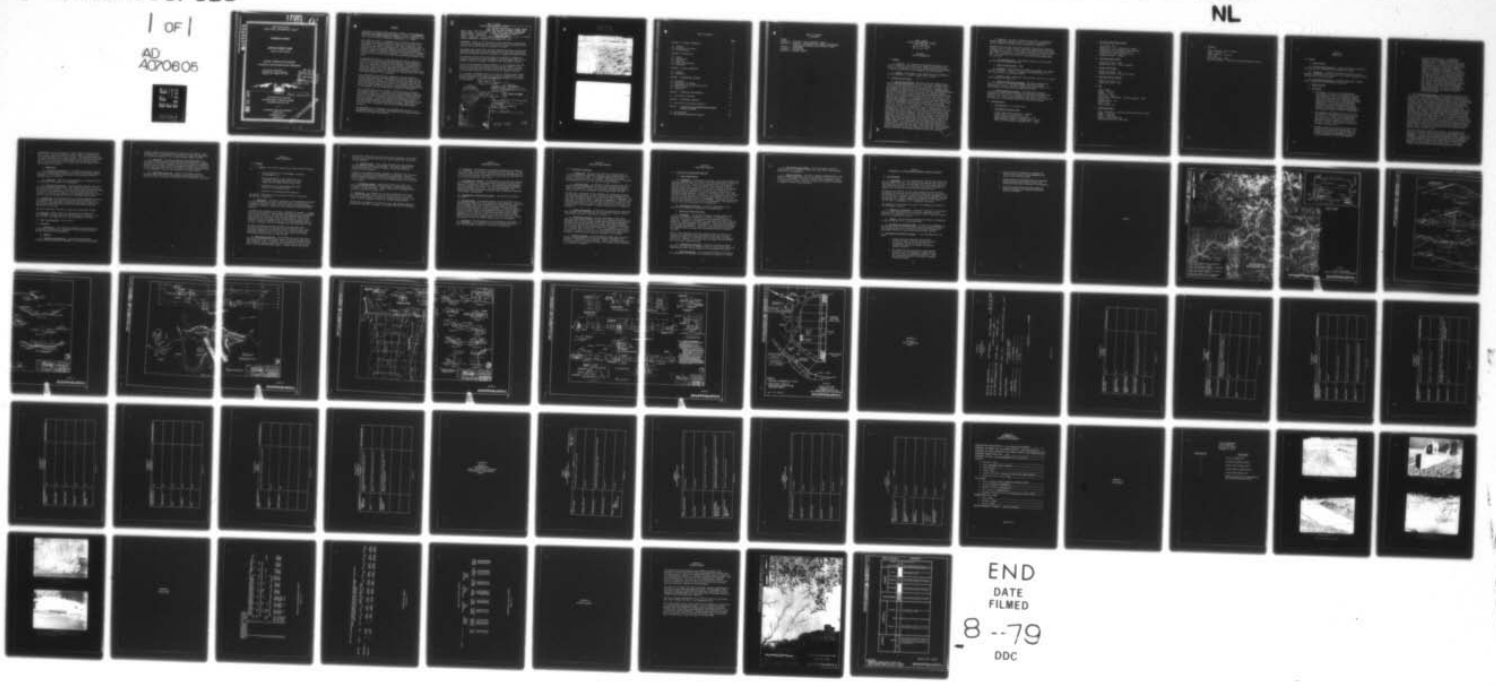

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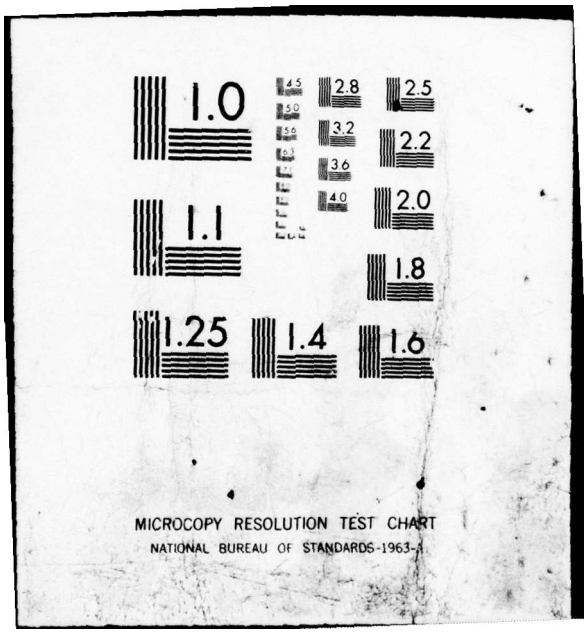
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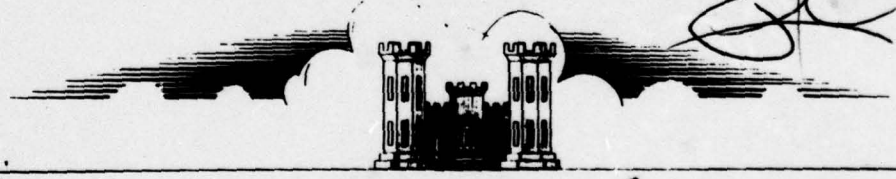
OHIO RIVER BASIN
DUTCH FORK, WASHINGTON COUNTY

PENNSYLVANIA

DUTCH FORK DAM

NDI I.D. NO: PA-490

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND 21203

BY

D'APPOLONIA CONSULTING ENGINEERS
10 DUFF ROAD
PITTSBURGH, PA. 15235
JANUARY 1979

PREFACE

This report is 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 Department of the Army, 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 visual observations and review of available data. Detailed investigation and analyses involving topographic mapping, subsurface investigations, material testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the inspection is intended to identify any need for such studies which should be performed by the owner.

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 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 the dam depends on numerous and constantly changing internal and external factors which are 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.

The assessment of the conditions and recommendations was made by the consulting engineer in accordance with generally and currently accepted engineering principles and practices.

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

(6) National Dam Inspection Program. Dutch Fork Dam (NDI ID Number PA-490), Ohio River Basin, Dutch Fork, Washington County, Pennsylvania. Phase I Inspection Report.

NAME OF DAM: Dutch Fork Dam
STATE LOCATED: Pennsylvania
COUNTY LOCATED: Washington
STREAM: Dutch Fork, a tributary of Buffalo Creek
DATE OF INSPECTION: November 30 and December 21, 1978

ASSESSMENT: Based on the evaluation of the conditions as they existed on the dates of inspection and as revealed by visual observations, the condition of Dutch Fork Dam is assessed to be good.

The swampy area located near the right abutment and the wet area on the downstream slope near the spillway should be periodically observed and necessary maintenance should be performed if seepage conditions develop.

The spillway capacity (50 percent PMF) is classified as inadequate because it will not pass the recommended spillway design flood of full probable maximum flood (PMF) according to the recommended criteria.

In view of the marginal spillway capacity, it is recommended that the owner initiate additional hydrologic and hydraulic studies to more accurately ascertain the spillway capacity and the nature and extent of improvements required to provide sufficient spillway capacity.

It is further recommended that in the event of unusually heavy runoff, an around-the-clock surveillance plan should be implemented to detect possible problems and to alert the downstream residents in the event of an emergency.

(11) Jan 79

Lawrence D. Andersen

Lawrence D. Andersen, P.E.
Vice President

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
Lawrence D. Andersen
ENGINEER
No. 17459-E

(12) 63 p.

(15) DACW31-79-C-0014

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

DATE: 1 Mar 79

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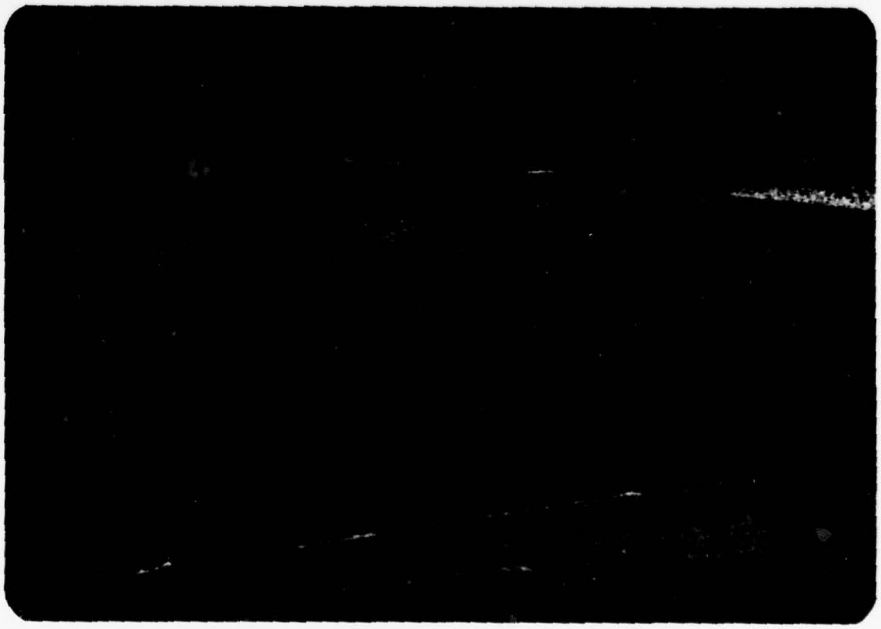
Upstream Face



Downstream Face

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(Continued)

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM
DUTCH FORK DAM
NDI I.D. NO. PA-490
DER I.D. NO. 63-67

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. The inspection was performed pursuant to the authority granted by The National Dam Inspection Act, Public Law 92-367, to the Secretary of the Army, through the Corps of Engineers, to conduct inspections of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project

ABSTRACT

a. Dam and Appurtenances. The Dutch Fork Dam consists of an earth embankment approximately 460 feet long with a maximum height of 42 feet from the downstream toe and a crest width of 12 feet. The flood discharge facilities for the dam consist of a combined primary and emergency spillway located on the left abutment (looking downstream). The spillway structures of the dam consist of a concrete overflow section, a trapezoidal concrete-lined spillway discharge channel which terminates in a concrete-lined plunge pool at the toe level of the dam near the left abutment. The overflow structure of the spillway is an 89-foot-long concrete weir, trapezoidal in cross section, located at an elevation approximately 10 feet below the dam crest. The outlet works consist of a reinforced concrete box culvert and a control tower located at the center of the embankment. The conduit is equipped with trash rack devices on the upstream end with a stilling basin at the discharge end. The flow through the conduit is controlled by stop logs located in the control tower. The stop logs divide the control tower into inflow and outflow chambers. The stop logs in the control tower extend from the invert elevation of the box culvert to the normal pool elevation. The flow entering into the intake chamber of the control tower through the upstream portion of the outlet conduit rises to the normal pool elevation, spills over the stop logs into the outflow chamber, which in turn discharges into the downstream portion of the outlet conduit. The lake can be drawn down below the normal pool elevation by removing the stop logs. The control tower is not equipped with any mechanical device for removing the stop logs. This outlet system constitutes the emergency drawdown facility for the dam.

ABSTRACT

b. Location. The dam is located on Dutch Fork, a tributary of Buffalo Creek, approximately two miles northwest of Claysville in Donegal Township, Washington County, Pennsylvania (Plate 1).

Downstream from the dam, Dutch Fork generally flows north, meandering through a 200- to 300-foot valley, and joins Buffalo Creek 3-1/2 miles downstream from the dam. In this reach, one mobile home and five permanent homes are considered to be within the flood plain of Dutch Fork Dam. It is estimated that failure of the dam would cause more than a few lives lost.

c. Size Classification. Intermediate (based on 42-foot height and 730 acre-feet storage capacity).

d. Hazard Classification. High.

e. Ownership. Pennsylvania Fish Commission (address: Mr. Edward R. Miller, Director of Bureau of Fisheries and Engineering, R.D. 3, Box 70, Bellefonte, Pennsylvania 16823).

f. Purpose of Dam. Recreation (also emergency supply for municipal water authority of Claysville).

g. Design and Construction History. The dam was designed by Mr. T. F. O'Hara, a professional engineer from State College, Pennsylvania, in 1957. The dam was constructed by the forces of the Pennsylvania Fish Commission with completion in 1959.

h. Normal Operating Procedure. The reservoir is normally maintained at Elevation 965, the level of uncontrolled spillway crest elevation, leaving 10 feet of freeboard to the top of the dam at Elevation 975. Inflow occurring when the lake level is at or above the spillway level is discharged through the uncontrolled spillway.

1.3 Pertinent Data

a. Drainage Area - 17.8 square miles

b. Discharge at Dam Site (cfs)

Maximum known flood at dam site - Unknown
Outlet conduit at maximum pool - 120
Gated spillway capacity at maximum pool - N/A
Ungated spillway capacity at maximum pool - 12,255
Total spillway capacity at maximum pool - 12,255

c. Elevation (USGS Datum) (feet)

Top of dam - 975
Maximum pool - 974.5 (low spot on crest)
Normal pool - 965 (spillway crest elevation)
Upstream invert outlet works - 934
Streambed at center line of dam - 933
Maximum tailwater - Unknown

d. Reservoir Length (feet)

Normal pool level - 9000
Maximum pool level - 9500 (estimated)

e. Storage (acre-feet)

Normal pool level - 730
Maximum pool level - 1850 (top of dam)

f. Reservoir Surface (acres)

Normal pool level - 91
Maximum pool level - 130

g. Dam

Type - Earth
Length - 460 feet
Height - 42 feet
Top Width - 12 feet
Side slopes - Downstream: 2.5H:1V; Upstream: 3H:1V
Zoning - Yes
Impervious core - No
Cutoff - Yes
Grout curtain - No

h. Regulating Outlet

Type - Four-foot by four-foot reinforced concrete culvert
Length - 215± feet
Closure - Stop logs
Access - Control structure
Regulating facilities - Stop logs

i. Spillway

Type - Concrete overflow section
Length - 89 feet
Crest elevation - 965 feet
Gate - None
Upstream channel - Lake
Downstream channel - Trapezoidal concrete discharge channel

SECTION 2
DESIGN DATA

2.1 Design

a. Data Available

(1) Hydrology and Hydraulics. Design calculations provided by Pennsylvania Fish Commission were available for review.

(2) Embankment. Available information consisted of design drawings, construction specifications, boring logs, geologist's report, and past state inspection reports.

(3) Appurtenant Structures. Available information includes design drawings and spillway design calculations.

b. Design Features

(1) Embankment

a. As designed, the dam is a zoned embankment consisting of an impervious central and upstream zone extending to top of rock through a cutoff trench and a pervious zone forming the downstream slope of the dam (Plate 2). These materials were designated as Class A and Class B materials, respectively. In the specifications, Class A material was defined as "selected impervious material," while Class B material was defined as "sufficiently pervious to drain the embankment."

b. The embankment was designed to have a 2.5 to 1 (horizontal to vertical) slope on the downstream face and a 3 to 1 slope on the upstream face. The upstream face of the dam is protected by hand-placed riprap extending from the crest of the dam to a level 3 feet below the normal pool elevation (Elevation 962).

c. As shown in Plate 3, at least five borings were drilled for the subsurface investigation. As illustrated in Plate 2, the typical subsurface profile consisted of approximately 10 feet of overburden underlain by shale and sandstone.

d. A report prepared by Mr. S. S. Philbrick, a geologist from Pittsburgh, Pennsylvania, indicates that soil samples and rock cores were examined by him. A reference to the results of the hydraulic tests in this report suggests that hydraulic permeability tests were conducted during the subsurface investigation. In this report, two concerns were raised relative to the subsurface conditions. One was the possibility of seepage around the left abutment indicated by the high water takes during the pressure tests. The other was the possibility of the consolidation of the foundation soils indicated by low blow counts. The report concluded that the need for foundation grouting should be established after filling of the lake if the dam showed significant seepage. It was also concluded that consolidation would occur mainly during the construction period.

(2) Appurtenant Structures. The appurtenant structures of the dam consist of the combined emergency and primary spillway and the outlet works. The spillway structures consist of a concrete overflow section, a trapezoidal concrete discharge channel, and a concrete-lined stilling basin. The spillway plan and profile are shown on Plate 4. The 89-foot concrete overflow section is located at Elevation 965, leaving 10 feet of freeboard as designed to the top of the dam. The approach channel is an unlined channel excavated into the left abutment. The bottom of the approach channel as designed is located at Elevation 962, leaving a 3-foot approach depth at normal pool level. The trapezoidal concrete discharge channel is approximately 140 feet long and converges uniformly from a width of 81 feet at the overflow weir to 54 feet at the downstream end. A 54-foot-wide, 40-foot-long stilling basin is also trapezoidal in cross section. The minimum depth of water in the stilling basin is maintained at 5 feet by a sill at the downstream end. The slab sections of the spillway discharge channel and the stilling basin are 10 inches thick and are underlain by 8-inch gravel filter. The gravel filter drains into the spillway channel through 4-inch cast-iron drains.

The outlet works are located at the center of the embankment and consist of a concrete intake structure at the upstream toe of the embankment, a 4-foot by 4-foot reinforced concrete conduit through the embankment, a control tower situated at mid-length of the conduit, and a concrete outlet structure at the downstream toe of the embankment. Six equally spaced concrete cutoff collars were provided along the length of the outlet conduit for seepage control. Construction drawings indicate that the conduit was constructed in a trench

excavated into the natural ground. Plate 5 shows the details of the outlet works. The flow through the outlet conduit is controlled by the stop logs located in the control tower. The stop logs extend from the invert elevation of the outlet conduit to the normal pool elevation. The lake can be lowered by removing the stop logs from the control tower. The control tower is not equipped with any mechanical device for removing the stop logs.

c. Design Data

(1) Hydrology and Hydraulics. The design calculations indicate that the provided spillway capacity was greater than spillway capacity required by the Pennsylvania Department of Environmental Resources (PennDER) Curve "C" criteria.

(2) Embankment. Other than design drawings, no engineering data are available on the design of the embankment.

(3) Appurtenant Structures. The calculations indicate that the reinforced concrete design of the outlet conduit was based on vertical and lateral earth pressures. While the vertical earth pressure was taken as the full overburden pressure, the lateral pressure was taken as one-third of the vertical pressure. The reinforcing design was based on 3000 psi concrete strength and 18,000 psi allowable steel stress.

2.2 Construction. The construction of the dam was apparently conducted in accordance with the drawings and specifications prepared by the Pennsylvania Fish Commission. No reference was found to indicate that any unusual construction difficulties were encountered during the construction of the dam.

Available information indicates no major post-construction changes.

2.3 Operation. Formal records of operation have not been kept. Correspondence indicates that after the inspection of the dam by the state in 1961, the condition of the dam was assessed to be good.

2.4 Other Investigations. None reported.

2.5 Evaluation

a. Availability. The available information was provided by the Commonwealth of Pennsylvania, Department of Environmental Resources, and the Pennsylvania Fish Commission.

b. Adequacy

(1) Hydrology and Hydraulics. The available information indicates that the spillway was designed in conformance with PennDER's

spillway design criteria applicable at the time of the design. This information is not considered to be adequate to assess the conformance of the spillway capacity to the current spillway design criteria.

(2) Embankment. The dam was apparently designed based on the evaluation of the subsurface conditions and borrow materials. However, no reference was found to indicate that any soil testing or engineering analyses, such as slope stability and seepage analyses, were conducted. It was noted that design did not incorporate an internal drainage system for the embankment, such as filter blankets or chimney drains.

(3) Appurtenant Structures. Review of the design drawings indicates that as designed no significant design deficiencies exist that should affect the overall performance of the appurtenant structures.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The on-site inspection of Dutch Fork Dam consisted of:

1. Visual inspection of the embankment, abutments, and embankment toe.

2. Visual examination of the spillway and its components, the downstream end of the outlet conduit and the outlet works control tower.

3. Observation of the factors affecting runoff potential of the drainage basin.

4. Evaluation of downstream hazard potential.

The specific observations are illustrated in Plate 6 and in the photographs in Appendix C.

b. Embankment. The general inspection of the embankment consisted of searching for indications of structural stress, such as cracks, subsidence, bulging, wet areas, seeps and boils, and observing general maintenance conditions, vegetative cover, erosion, and other surficial features.

In general, the condition of the dam is considered to be good. A swampy area was found along the right abutment approximately 50 feet downstream from the toe of the dam. The flow from the area discharged through a small stream into the outlet works discharge channel. The flow was estimated to be on the order of one to two gallons per minute (gpm). Another wet area was observed along the toe of the embankment near the spillway. However, there was no seepage associated with this wet area.

The top of the dam was surveyed relative to the spillway crest elevation and was found to have some vertical irregularities. While the design freeboard of the dam was 10 feet, the survey indicated freeboards ranging from 9.5 to 9.9 feet. The lowest area occurred approximately 50 feet from the right abutment.

c. Appurtenant Structures. The spillway and outlet works were examined for deterioration or other signs of distress and obstructions that would limit flow. In general, the structures were found to be in good condition. Several structural cracks were observed in the lower half of the spillway discharge channel. However, due to the flow in

the spillway, these cracks could not be closely examined. The visible portions of the control tower and the outlet conduit were found to be in good condition.

d. Reservoir Area. A map review indicates that the watershed is predominantly covered with woodlands. The town of Claysville is located approximately two miles southeast of the dam within the watershed of the reservoir.

A review of the regional geology (Appendix E) indicates that the slopes adjacent to the reservoir are susceptible to landslides. However, massive landslides which may affect the storage volume of the reservoir and would cause overtopping of the dam by displaced water are considered to be unlikely.

e. Downstream Channel. Downstream from the dam, Dutch Fork flows north approximately 3-1/2 miles, where it joins Buffalo Creek, a tributary of the Ohio River. Further description of downstream conditions is included in Section 1.2b.

3.2 Evaluation. The condition of the dam is considered to be good. The vertical alignment of the crest was found to be 0.1 to 0.5 foot below the design elevation relative to the spillway crest level. This condition would consequently reduce the spillway design capacity.

Seepage from the swampy area located near the right abutment should be periodically observed to document if a seepage condition is developing.

SECTION 4
OPERATIONAL FEATURES

4.1 Procedure. The reservoir is normally maintained at the spillway crest level with excess inflow discharging over the spillway. The top of the stop logs in the control tower is also set at approximately the spillway crest elevation over which flow occurs when the pool level is at or above the spillway crest level.

4.2 Maintenance of the Dam. The maintenance of the dam is considered to be satisfactory. The downstream face of the dam is covered with grass and is adequately maintained. The Pennsylvania Fish Commission personnel reported that there is no full-time dam tender responsible for the maintenance of the dam. The dam is maintained by the Pennsylvania Fish Commission, Maintenance Area 2 personnel, operating from Somerset, Pennsylvania.

4.3 Maintenance of Operating Facilities. The dam has no operable facilities.

4.4 Warning System. The warning system at the site consists of an emergency plan prepared by the Pennsylvania Fish Commission. According to the emergency plan, the Pennsylvania Fish Commission Washington County waterways patrolman or deputy patrolman shall observe this structure during periods of heavy precipitation. Should they observe any of the items listed in the emergency plan which include signs of distress, such as sliding of upstream or downstream slopes, sudden subsidence of the crest of the dam, cracks on the crest of the dam, unusual release of water from the face or the toe of the dam, they are instructed to notify the PennDER regional office in Pittsburgh.

4.5 Evaluation. The dam appears to be satisfactorily maintained. It is recommended that the emergency plan should include provisions to alert the downstream residents in the event of emergencies.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features

a. Design Data. The Dutch Fork Dam has a watershed area of 17.8 square miles and impounds a reservoir with a surface area of 91 acres at normal pool level. The combined emergency and primary spillway is located on the left abutment. The capacity of the spillway is determined to be 12,255 cfs using the design freeboard.

b. Experience Data. As previously stated, the Dutch Fork Dam is classified as an intermediate size dam in the high hazard category. Under the recommended criteria for evaluating emergency spillway discharge capacity, such impoundments are required to pass full PMF.

The PMF inflow hydrograph for the reservoir was determined utilizing the Dam Safety Version of the HEC-1 computer program developed by the Hydrologic Engineering Center of the U.S. Army, Corps of Engineers. The data used for computer input is presented in Appendix D. The PMF inflow hydrograph was found to have a peak flow of 26,605 cfs, while the half PMF inflow hydrograph was found to have a peak flow of 13,353 cfs. The computer input and the summary of computer output are also included in Appendix D.

c. Visual Observations. On the date of inspection, no conditions were observed that would indicate that the spillway capacity would be significantly reduced in the event of a flood.

d. Overtopping Potential. Various percentages of PMF inflow hydrograph were routed through the reservoir to determine the percent of PMF inflow that the dam can pass without significantly overtopping the embankment and causing breaching of the dam. The computer analyses indicate that the spillway can pass 40 percent PMF without overtopping. For 50 percent PMF, the dam would overtop for a duration of 2.67 hours with a maximum depth of 0.56 foot. It is estimated that overtopping of the dam by a maximum of 0.56 foot may cause significant erosion on the embankment; however, total failure is considered to be unlikely.

e. Spillway Adequacy. Since the spillway cannot pass the recommended spillway design flood of full PMF without overtopping, the spillway is classified to be inadequate. However, because failure due to 50 percent PMF is considered unlikely, the spillway is not considered to be seriously inadequate.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

(1) Embankment. As discussed in Section 3, the field observations did not reveal any signs of distress that would significantly affect the performance of the structure, and no unsatisfactory conditions were reported in the past. Since the design lacks a positive internal drainage system, some concern exists as to the location of the phreatic surface through the embankment as it affects the stability of the embankment and the potential for internal erosion in the event a concentrated seepage develops. However, at the present time, other than an isolated wet area near the left abutment, the remaining portion of the toe area is firm, indicating that the phreatic surface is not intersecting the downstream slope of the embankment. The swampy area located near the right abutment is attributed to underseepage. The quantity of flow at this time is assessed to be insignificant.

(2) Appurtenant Structures. Structural performance of the appurtenant structures is considered to be satisfactory.

b. Design and Construction Data

(1) Embankment. The dam was apparently designed based on the evaluation of subsurface conditions. However, no references or documents were found to indicate whether any laboratory tests were conducted. Similarly, no documents or references were found to indicate whether any seepage analyses were conducted. References were found to indicate that the subsurface conditions at the dam site were evaluated by a professional geologist. Apparently, the construction of the dam was conducted under the supervision of Pennsylvania Fish Commission personnel.

Review of the available information indicates that the dam was constructed with reasonable care, and design incorporated such basic elements as zoning of the embankment and a cutoff trench extending to top of rock. However, it was found that the design did not include a positive internal drainage system.

(2) Appurtenant Structures. Review of the design drawings indicates that there are no apparent structural deficiencies that would significantly affect the performance of the appurtenant structures.

c. Operating Records. The structural stability of the dam is not considered to be affected by the operational features of the dam.

d. Post-Construction Changes. There have been no reported modifications to the original design that would affect the structural stability of the embankment.

e. Seismic Stability. The dam is located in Seismic Zone 1, and based on visual observations the static stability of the dam is considered to be adequate. Therefore, based on the recommended criteria for evaluation of seismic stability of dams, the structure is presumed to present no hazard from earthquakes.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Assessment. The visual observations indicate that Dutch Fork Dam is in good condition. No conditions were observed that would significantly affect the overall performance of the structure, and none were reported in the past. To the extent that can be determined, it appears that the dam was constructed with reasonable care.

One swampy area observed near the right abutment and the associated seepage and the wet area on the downstream slope near the spillway are not considered to be serious relative to the overall performance of the dam at this time. However, these areas should be periodically observed to determine if a seepage condition is developing, if the extent of the wet area is increasing, or if sloughing is occurring.

The capacity of the spillway was found to be inadequate according to the recommended criteria.

b. Adequacy of Information. Available information in conjunction with the visual observations and the previous experience of the inspectors are considered to be sufficient to make a reasonable assessment of the conditions of the dam.

c. Urgency. The following recommendations should be implemented as soon as possible or on a continuing basis.

d. Necessity for Additional Data. In view of the inadequacy of the spillway capacity, the owner should initiate additional studies to more accurately ascertain the spillway capacity and the extent of improvement required to provide sufficient spillway capacity.

7.2 Recommendations/Remedial Measures

It is recommended that the owner:

1. Perform additional hydrology and hydraulic analyses to more accurately ascertain the spillway capacity and the nature and extent of improvements required to provide a sufficient spillway capacity.

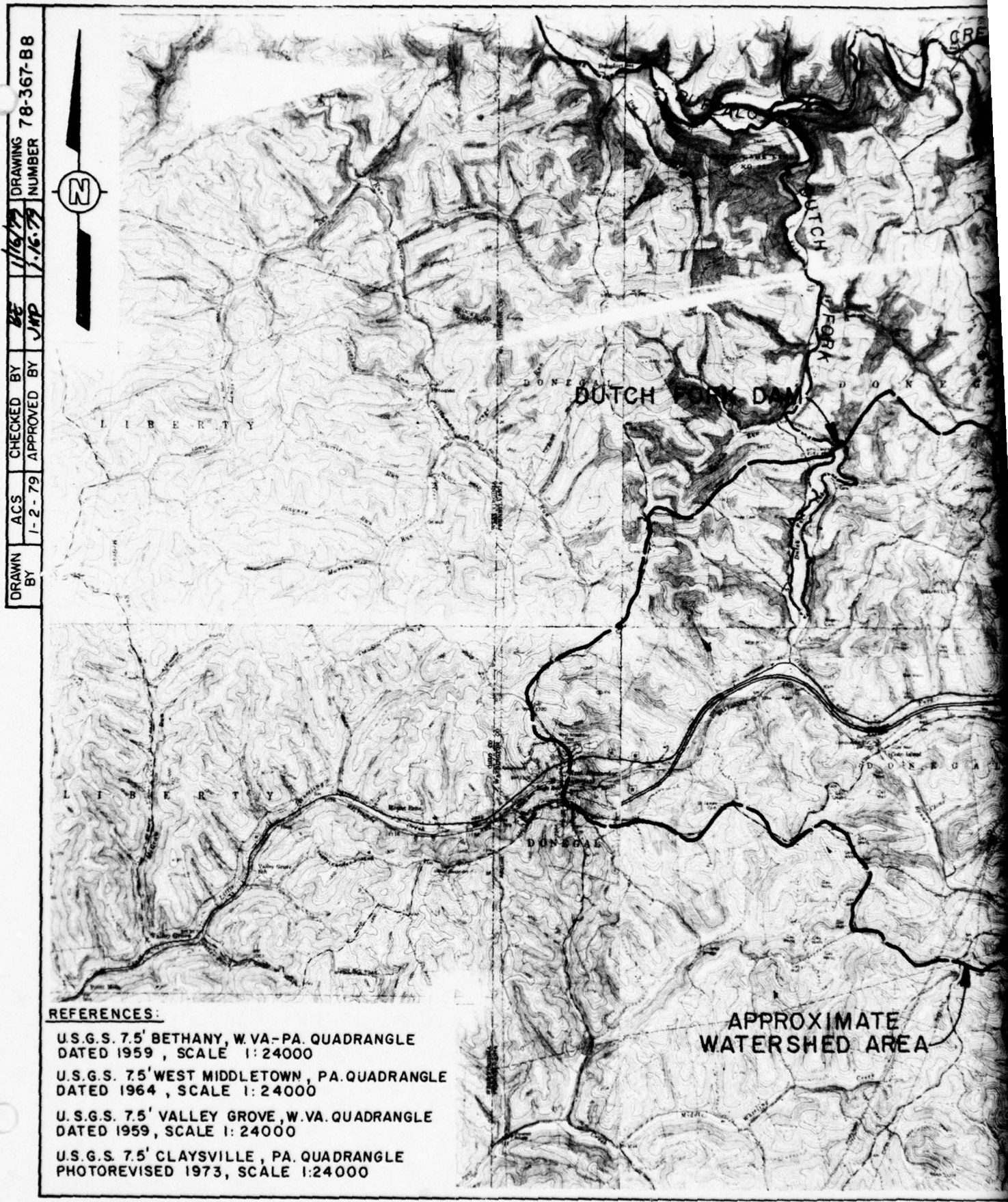
2. The swampy area located near the right abutment and wet area on the embankment located near the spillway should be periodically observed. Necessary maintenance should be performed if seepage conditions develop.

3. Surveys should be performed to establish the extent of the low areas on the embankment and the low areas filled to grade.

4. Around-the-clock surveillance should be provided during unusually heavy runoff to alert the downstream residents in the event of an emergency.

5. The dam and appurtenant structures should be inspected regularly and necessary maintenance should be performed.

PLATES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DUTCH FORK DAM
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APPROXIMATE WATERSHED AREA
REFERENCES:
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U.S.G.S. 7.5' WEST MIDDLETOWN, PA. QUADRANGLE DATED 1964, SCALE 1:24000
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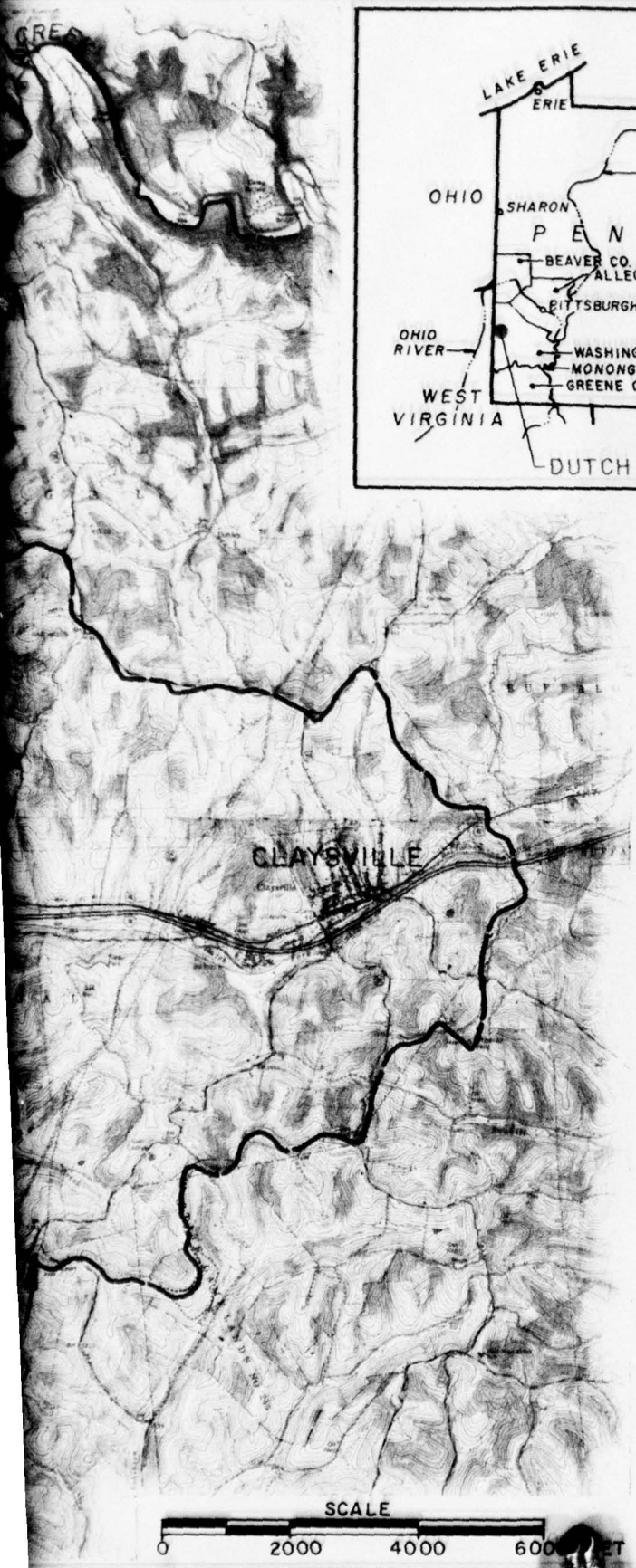

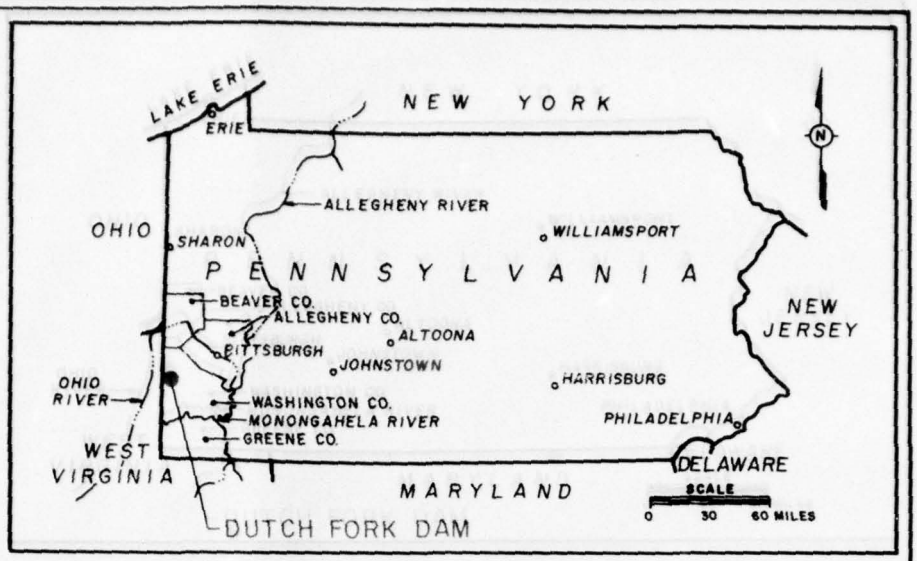

KEY PLAN

PLATE I

DUTCH FORK DAM
VICINITY, FLOOD PLAIN & WATERSHED MAP

D'APPOLONIA

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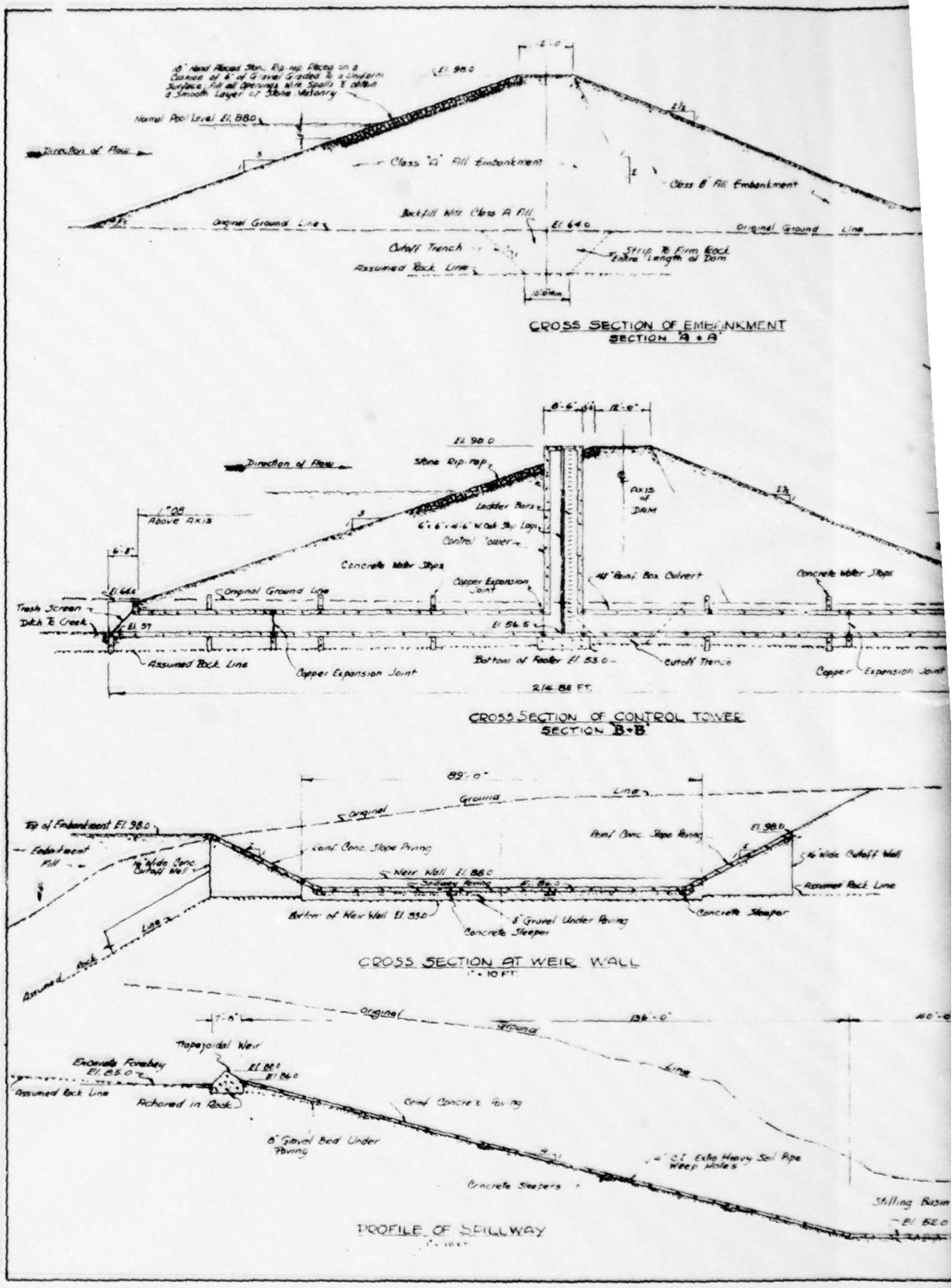
DRAWN BY	CJB	CHECKED BY	JAE	1/16/79	DRAWING
	12-20-78	APPROVED BY	JAP	1-16-79	NUMBER 78-367-B9

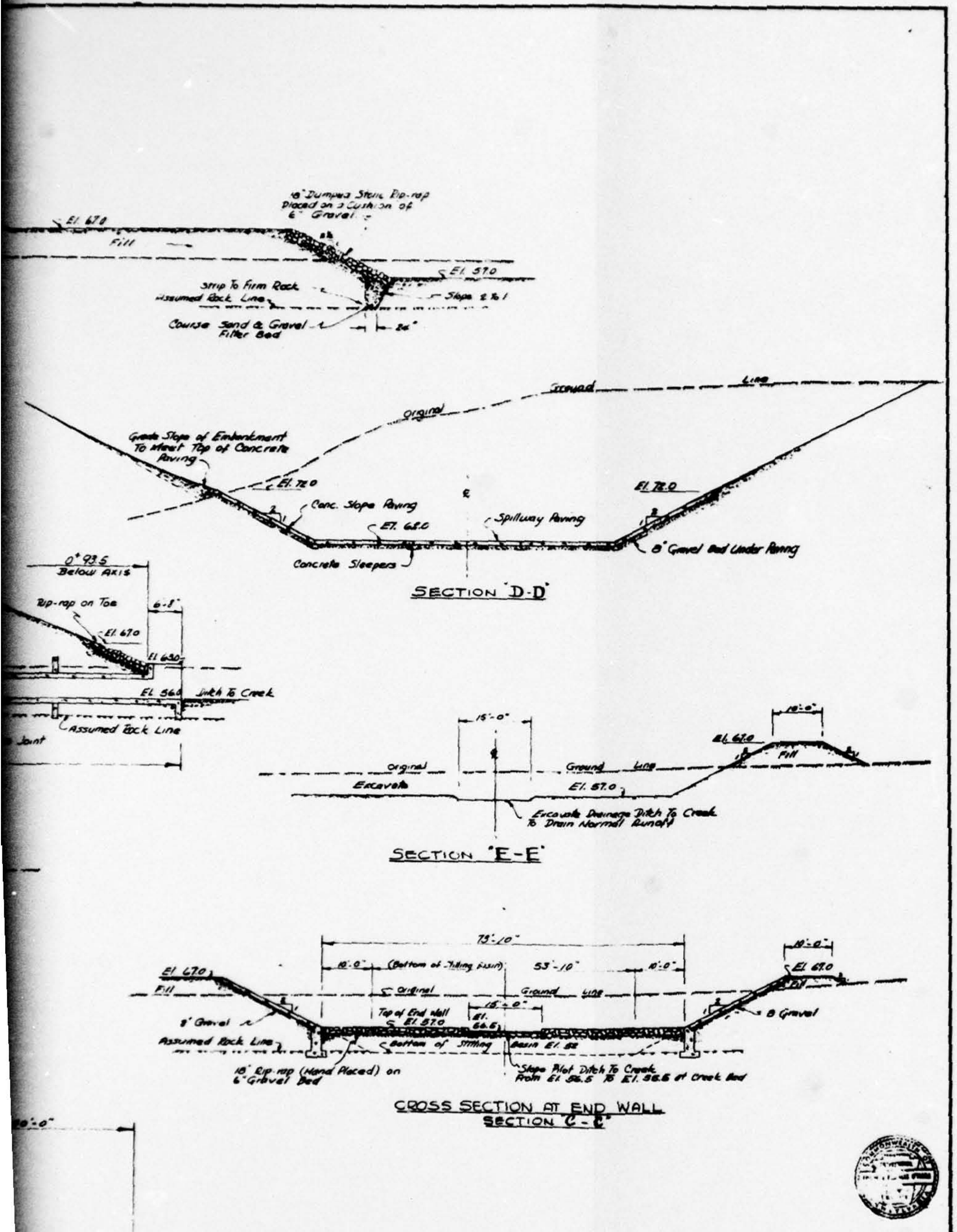


CROSS SECTION OF EMBANKMENT
SECTION A-A

CROSS SECTION OF CONTROL TOWER
SECTION B-B

CROSS SECTION AT WEIR WALL
1" = 10 FT.

PROFILE OF SPILLWAY
1" = 10 FT.



REVISED	APPROVALS	PROJECT Nº P-2101-1
	APPROVED — DIRECTOR OF ENGINEERING & CONSTRUCTION	CROSS SECTIONS
	APPROVAL RECOMMENDED — SUPERVISING ARCHITECT, BUREAU OF CONSTRUCTION	DUTCH FORK LAKE & DAM DUTCH FORK BRANCH of BUFFALO CREEK DONEGAL TOWNSHIP, WASHINGTON CO. PA.
	APPROVED FOR DEPT — PENNA FISH COMMISSION, EXEC. DIRECTOR	T. F. O'HARA – REGISTERED ENGINEER STATE COLLEGE PA.
	SUBMITTED BY — ENGINEER	
	ACCEPTED BY — CONTRACTOR BY	DATE 2/27/51 — SCALE 1" = 10 FT
	BUREAU OF ENGINEERING & CONSTRUCTION CHECKED BY: ARCH. STRUCT. MECH. ELEC.	COMMONWEALTH OF PENNSYLVANIA GEO M LEADER – GOVERNOR DEPT. OF PROPERTY & SUPPLIES JOHN S RICE – SECRETARY HARRISBURG – PENNSYLVANIA — SHEET NO 3

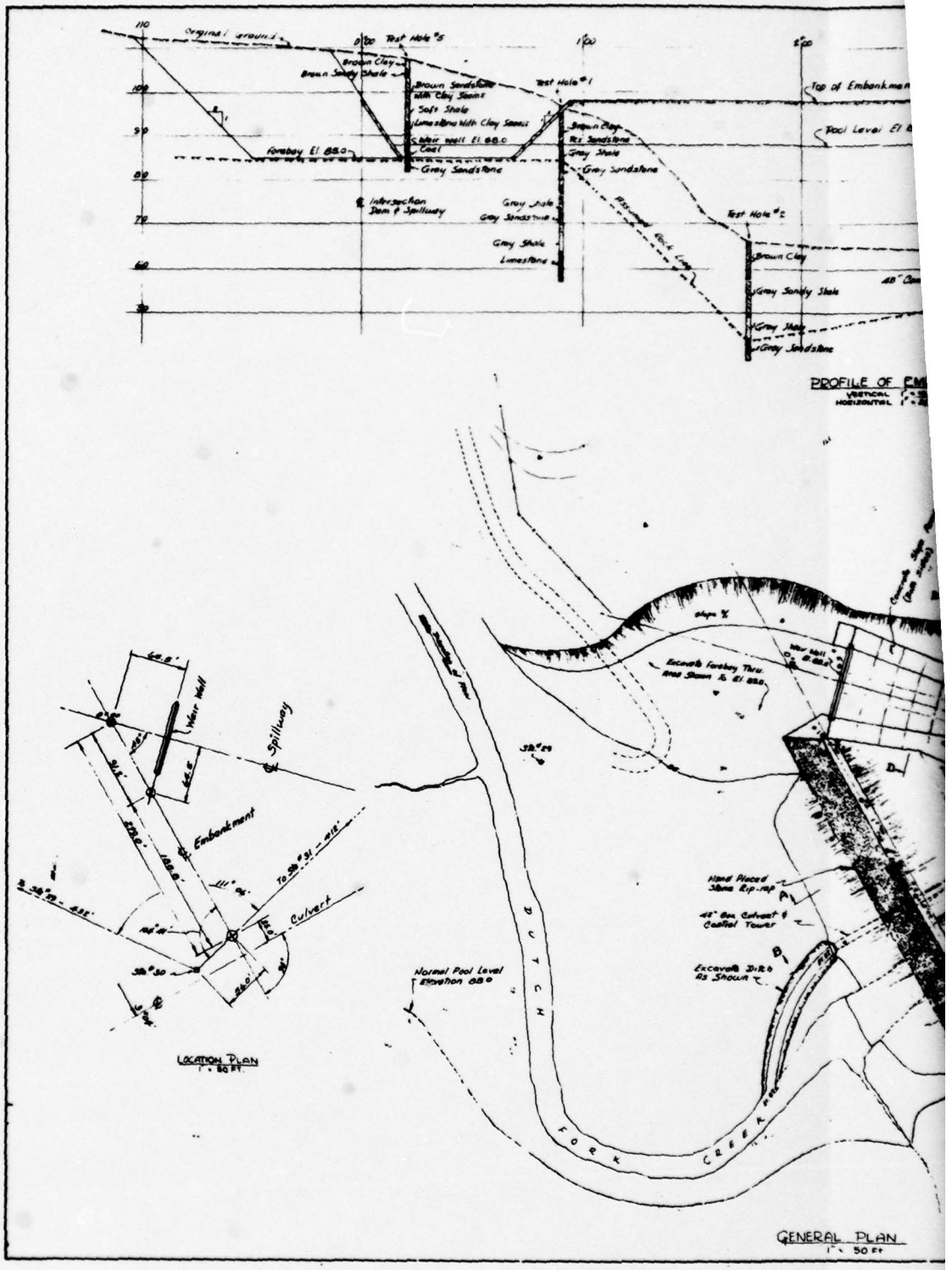
PLATE 2

D'APPOLONIA

2

DRAWN BY	c/b	CHECKED BY	DE	1/16/79
	12-20-78	APPROVED BY	JHP	1/16/79

DRAWING NUMBER 78-367-B10



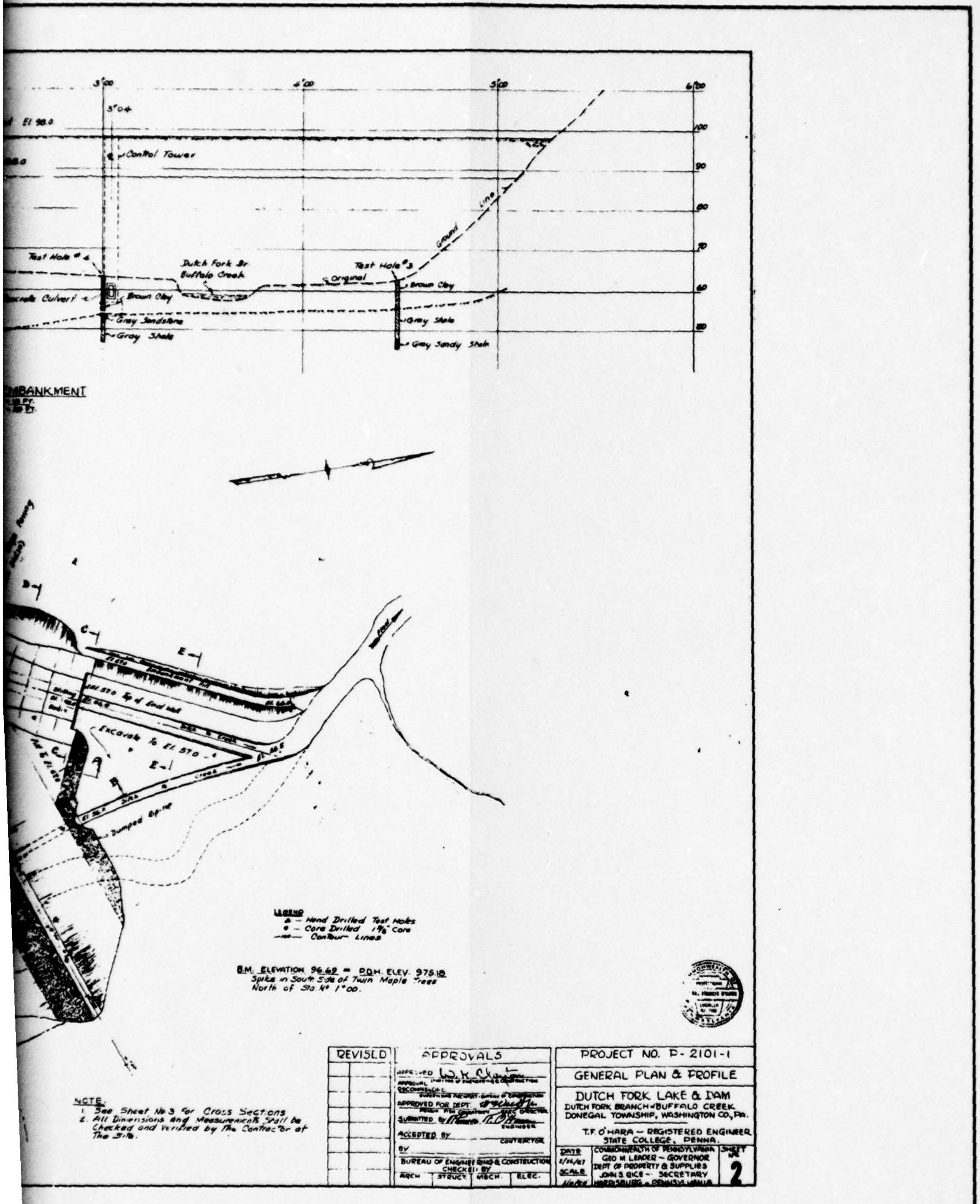
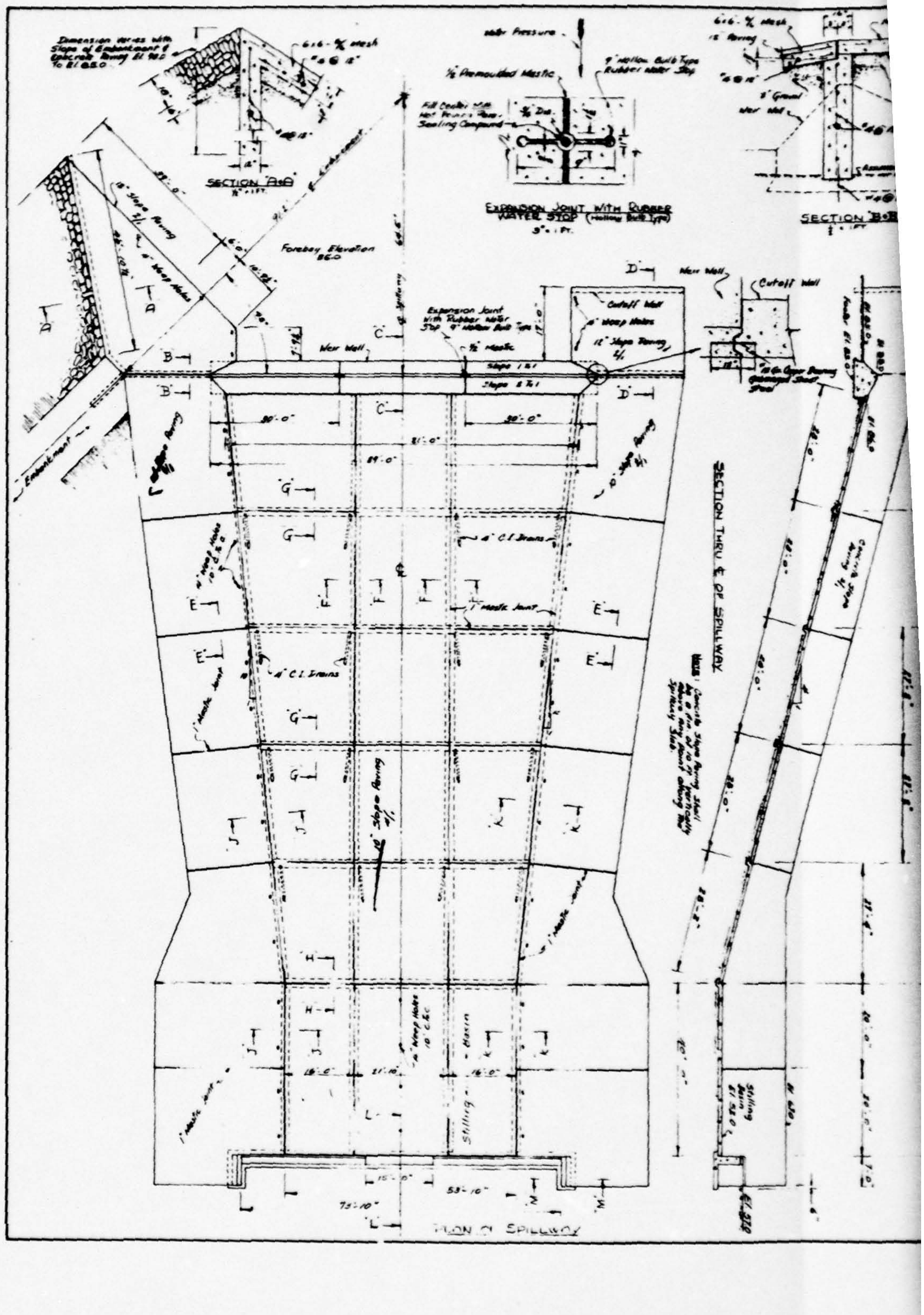
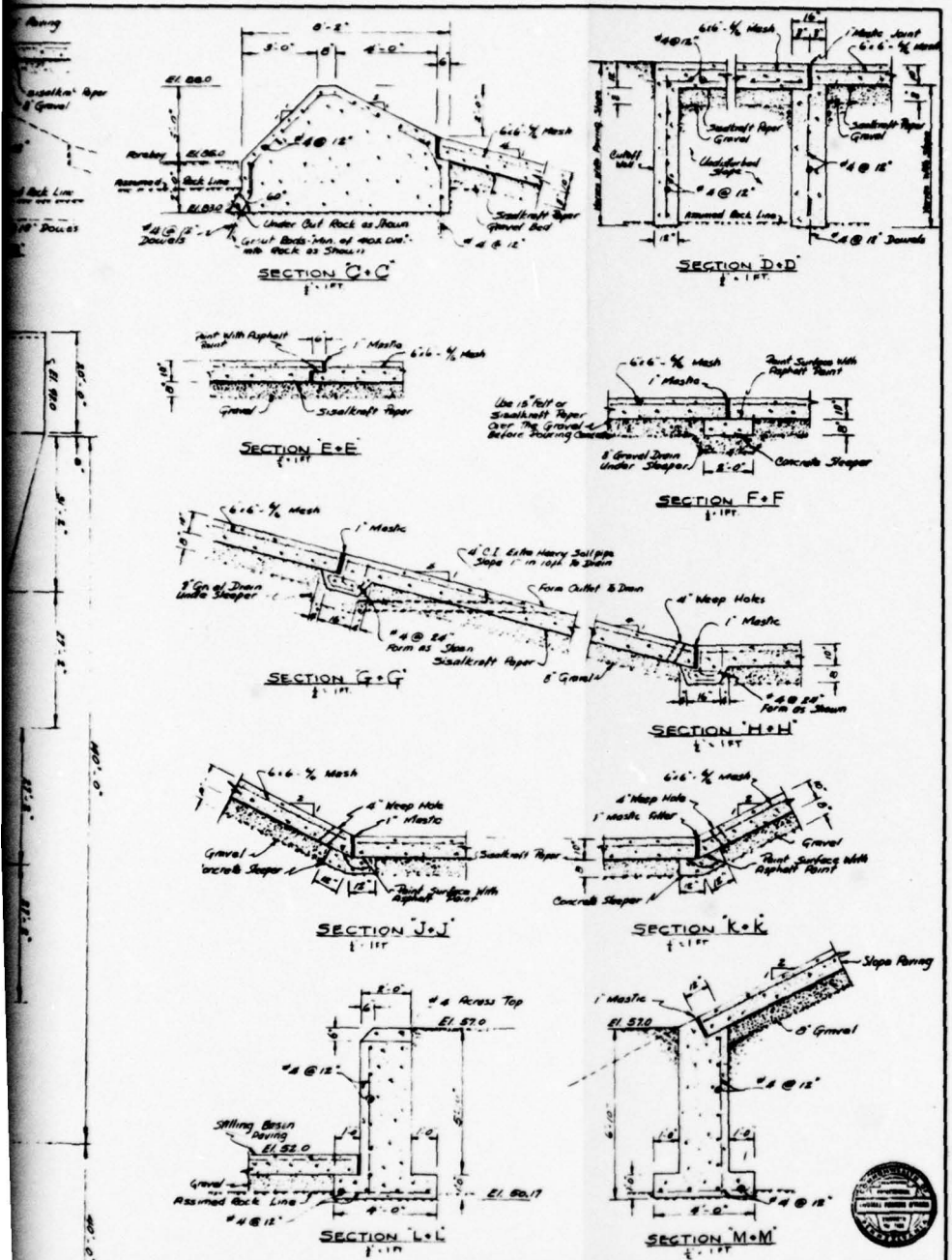


PLATE 3

D'APPOLONIA

DRAWN BY	cjb	CHECKED BY	[illegible]	1/16/79	DRAWING NUMBER	78-367-B11
	12-20-78	APPROVED BY	JHP	1-16-79		





NOTE:-
1. For Concrete and Reinforcing Steel Specifications See Sheet No. 4.
2. All Dimensions and Measurements Shall be Checked and Verified by The Contractor at The Site.

REVISED	APPROVALS
	APPROVED
	RECOMMENDED
	APPROVED FOR DRAFT
	SUBMITTED BY
	ACCEPTED BY
	BY
	BUREAU OF ENGINEERING & CONSTRUCTION CHECKED BY
	ARCH. / STRUCT. / MECH. / ELEC.

PROJECT Nº P-2101-1

SPILLWAY DETAILS

DUTCH FORK LAKE & DAM
DUTCH FORK BRANCH of BUFFALO CREEK
DONEGAL TOWNSHIP, WASHINGTON CO., PA

T. F. O'HARA - REGISTERED ENGINEER
STATE COLLEGE, PENNA.

DATE 6/1/67
SCALE 1/10 FT

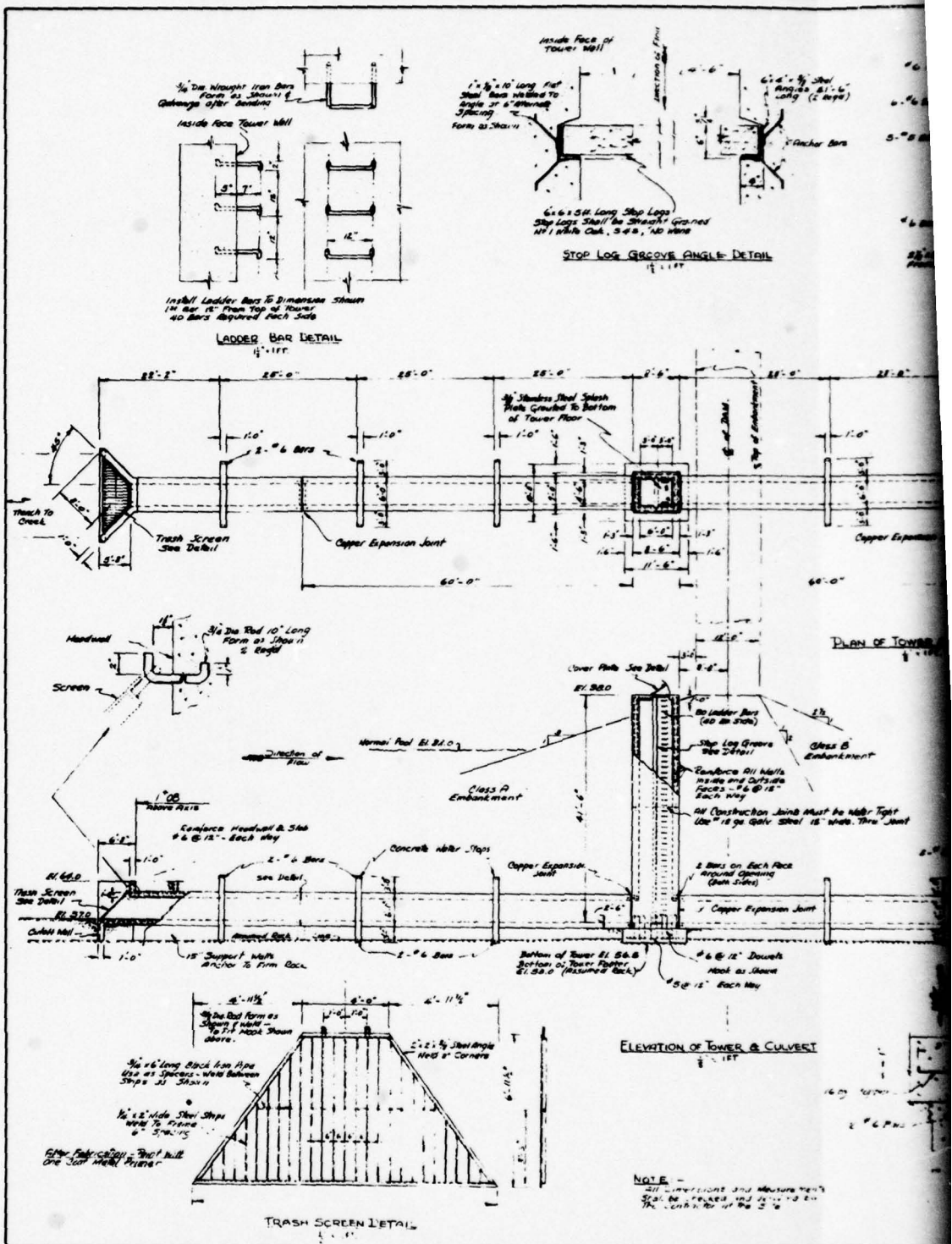
COMMONWEALTH OF PENNSYLVANIA
Geo. M. LEADER - GOVERNOR
DEPT. OF PROPERTY & SUPPLIES
JOHN S. ECE - SECRETARY
HARRISBURG - PENNSYLVANIA

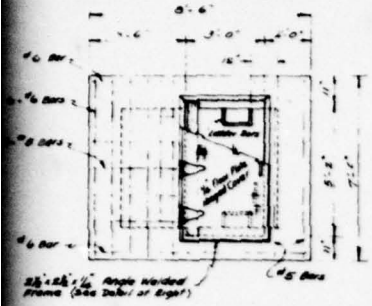
SHEET No. 4

PLATE 4

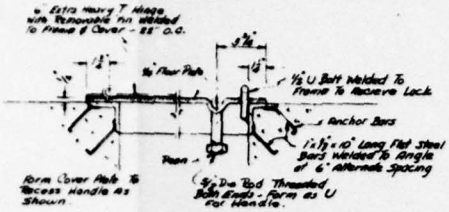
D'APPOLONIA

DRAWN BY	c/b	CHECKED BY	BJC	1/16/79	DRAWING
	12-20-78	APPROVED BY	JWP	1-16-79	NUMBER 78-367-B12

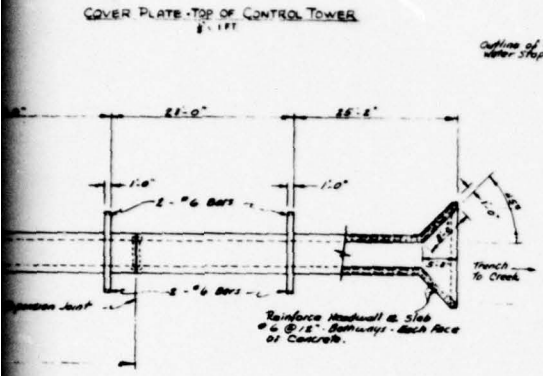


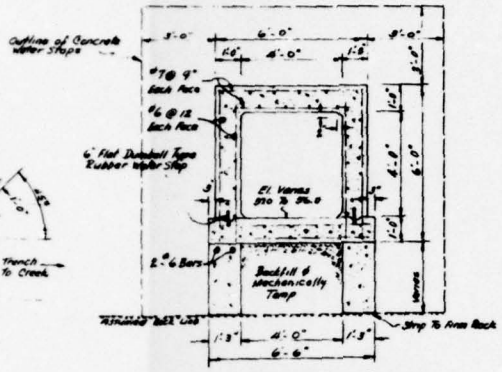


COVER PLATE - TOP OF CONTROL TOWER



HINGE & HANDLE DETAIL (COVER PLATE)



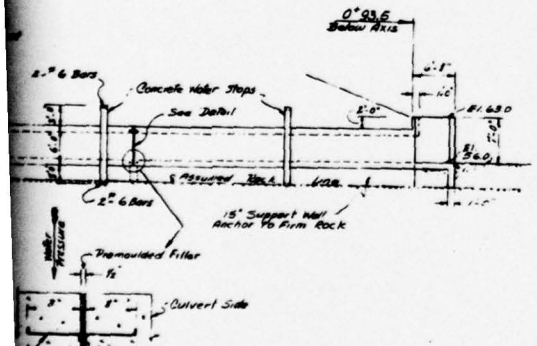


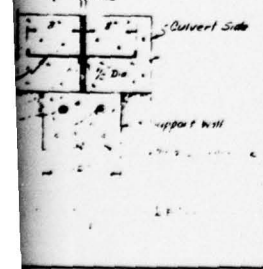
CROSS SECTION THRU CULVERT

TOWER & CULVERT

CONCRETE and REINFORCING STEEL SPECIFICATIONS

1. Keyways Shall be Provided at all Construction Joints and Unless Otherwise Noted Shall be a Minimum of 2½" Deep and ⅓ Section Width.
2. Square Bars and Spacing Noted Thus:- 1'-0 @ 14".
3. Round Bars and Spacing Noted Thus:- #6 @ 12".
4. Steel Wire Fabric Noted Thus:- 6"x6"-W4
5. Dowel Bars Shall be The Same Size as Corresponding Wall Bars Unless Otherwise Noted.
6. "Stress Steel" is Always Shown Next To The Surface of The Walls, or Slabs, and Shall Have the Following Cover From Center of Stress Bar To Surface:-
   3" where Footers or Slabs are Poured Directly on Ground.
   2" where After Removal of Forms The Concrete Will be Exposed to The Weather or in Contact With The Ground, for Bars More Than ⅝" Diameter.
   1½" where After Removal of Forms The Concrete Will be Exposed to The Weather or in Contact With The Ground, for Bars ⅝" or Less in Diameter.
7. The Amount of Steel Shown Shall be Doubled Thru Construction Joints and for a Distance Not Less Than 40 Diameter of Bar Each Side of The Joint.
8. All Bars Where Spliced Shall be Lapped 40 Diameter of Bars.
9. Splices Shall Not be Made at Points of Maximum Stress.
10. All Reinforcing Steel Shall be Bent as Noted in Compliance With A.C.I. Building Code Requirements (A.C.I. 318-47)
11. All Expansion or Contraction Joints Where Concrete Joins Concrete Surface Shall be Painted With Asphalt Paint.
12. Concrete Shall Conform To Specifications of the Pennsylvania Department of Highways Form 408, 1947 for Class A Concrete for Structures.
13. All Reinforcement Bars Shall Conform To Standard Specifications of The American Society For Testing Materials, A15-34T; A16-34T; and A305-34T
14. All Reinforcement Mesh Shall Conform To the Requirements of A.S.T.M. Designation: A185-34T.

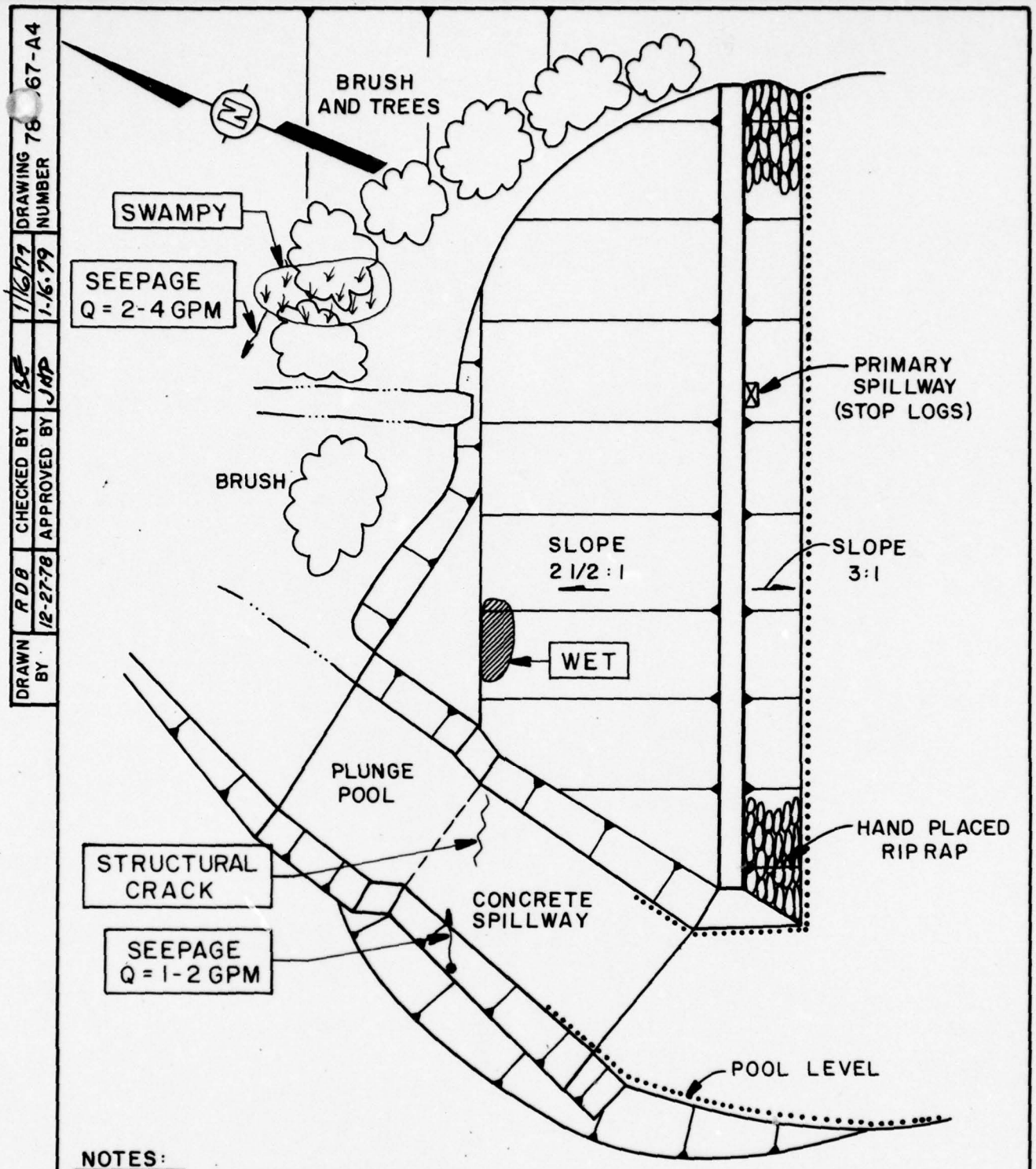




REVISED	DATES	PROJECT NO. P-2101-1
		CONTROL TOWER & CULVERT
		DUTCH FORK LAKE & DAM DUTCH FORK BRANCH of BUFFALO CREEK DONEGAL TOWNSHIP WASHINGTON CO. PA.
		T. F. SHARP — REGISTERED ENGINEER STATE COLLEGE PA.
SCALE As Noted	COMMONWEALTH OF PENNSYLVANIA GOV. W. LEADER - GOVERNOR DEPT. OF PROPERTY & SUPPLIES JOHN S. PICE - SECRETARY HARRISBURG, PENNSYLVANIA	SHEET NO. 5
DATE 3/9/5		

PLATE 5

D'APPOLONIA



DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
RDB	BE	JAP	78-67-A4
12-27-78	1/16/79	1-16-79	

NOTES:

1. SPILLWAY FREEBOARD = 9.8 FEET.
2. POOL LEVEL DATE OF INSPECTION: 0.2 FEET OVER SPILLWAY CREST.

NOT TO SCALE

PLATE 6

DUTCH FORK DAM
GENERAL PLAN
FIELD INSPECTION NOTES
FIELD INSPECTION DATE: NOV. 30, 1978

D'APPOLONIA

APPENDIX A

CHECKLIST
VISUAL INSPECTION
PHASE I

APPENDIX A

CHECKLIST
VISUAL INSPECTION
PHASE I

NAME OF DAM Dutch Fork Dam COUNTY Washington STATE Pennsylvania ID# NDI I.D. No. PA-490 DER I.D. No. 63-67

TYPE OF DAM Earth HAZARD CATEGORY High

DATE(S) INSPECTION November 30, 1978 WEATHER Sunny TEMPERATURE 40s

POOL ELEVATION AT TIME OF INSPECTION 965.2 M.S.L. TAILWATER AT TIME OF INSPECTION 935 M.S.L.

INSPECTION PERSONNEL:	REVIEW INSPECTION PERSONNEL: (December 21, 1978)
Bilgin Erel	L. D. Andersen
Wah-Tak Chan	J. H. Poellot
	B. Erel

Bilgin Erel RECORDER

VISUAL INSPECTION
PHASE I
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Crest elevation is 0.1 to 0.5 foot below design elevation relative to the spillway crest level.	
RIPRAP FAILURES	None.	

VISUAL INSPECTION
PHASE I
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No signs of distress.	
ANY NOTICEABLE SEEPAGE	Swampy area along the right abutment approximately 50 feet downstream from the toe. Seepage flow - 2 to 4 gpm. A wet area along the toe of the dam near the spillway side. No perceivable seepage.	
STAFF GAGE AND RECORDER	None.	
DRAINS	None.	

VISUAL INSPECTION
PHASE I
OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Concrete and the visible portions of the outlet works are in good condition.	
INTAKE STRUCTURE	Submerged.	
OUTLET STRUCTURE	Stilling basin. No apparent erosion.	
OUTLET CHANNEL	Earth channel. No apparent significant obstructions.	
EMERGENCY GATE	The dam has no emergency gate. The lake could be drawn down by removing the stop logs in the control tower.	

VISUAL INSPECTION
PHASE I
UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	89-foot-wide overflow weir. In good condition.	
APPROACH CHANNEL	Submerged. It appears to be free of debris.	
DISCHARGE CHANNEL	Trapezoidal concrete channel. In general, in good condition. There appears to be a structural crack in the lower half of the spillway slab.	Due to the flow in the spillway channel, the crack in the spillway slab could not be closely examined.
BRIDGE AND PIERS	None.	

VISUAL INSPECTION
PHASE I
GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

VISUAL INSPECTION
PHASE I
INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	

VISUAL INSPECTION
PHASE I
RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Steep to gentle. No signs of landslides or shore erosion.	
SEDIMENTATION	Unknown.	
UPSTREAM RESERVOIRS	None.	

VISUAL INSPECTION
PHASE I
DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	No apparent obstructions immediately downstream from the dam that would affect the discharge capacity of the spillway.	
SLOPES	No apparent instability (immediately downstream from the dam).	
APPROXIMATE NUMBER OF HOMES AND POPULATION	There are five homes within a 3-1/2-mile reach downstream from the dam on the flood plain of Dutch Fork. Population: approximately 25.	

APPENDIX B

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
AND HYDROLOGIC AND HYDRAULIC
PHASE I

APPENDIX B

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Dutch Fork Dam

ID# NDI: PA-490
DER: 63-67

ITEM	REMARKS
AS-BUILT DRAWINGS	The design drawings are available in state files.
REGIONAL VICINITY MAP	See Plate 1.
CONSTRUCTION HISTORY	The dam was designed and constructed by the Pennsylvania Fish Commission. Construction of the dam was completed in 1959.
TYPICAL SECTIONS OF DAM	See Plate 2.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	See Plate 5.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	Not available.
DESIGN REPORTS	Not available.
GEOLOGY REPORTS	Report dated October 4, 1955, signed by Mr. S. S. Philbrick.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Calculations for spillway design and structural design of outlet works were provided by the Pennsylvania Fish Commission.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	*See Plate 3 for typical subsurface profile.*

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
POST CONSTRUCTION SURVEYS OF DAM	None reported.
BORROW SOURCES	Unknown.
MONITORING SYSTEMS	None.
MODIFICATIONS	None reported.
HIGH POOL RECORDS	Not recorded.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None reported.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None reported.
MAINTENANCE OPERATION RECORDS	Not available.
SPILLWAY PLAN SECTIONS DETAILS	See Plate 4.
OPERATING EQUIPMENT PLANS AND DETAILS	See Plate 5.

CHECKLIST
ENGINEERING DATA
HYDROLOGIC AND HYDRAULIC

DRAINAGE AREA CHARACTERISTICS: 17.8 square miles (wooded)

ELEVATION; TOP NORMAL POOL AND STORAGE CAPACITY: 965 (730 acre-feet)

ELEVATION; TOP FLOOD CONTROL POOL AND STORAGE CAPACITY: 975 (1850 acre-feet)

ELEVATION; MAXIMUM DESIGN POOL: 975

ELEVATION; TOP DAM: 975 (as designed), 974.5 (low spot)

SPILLWAY:

a. Elevation 965
b. Type Concrete overflow section
c. Width 89 feet
d. Length N/A
e. Location Spillover Low spot on crest near right abutment
f. Number and Type of Gates None

OUTLET WORKS:

a. Type 4-foot by 4-foot reinforced concrete conduit
b. Location Center of embankment
c. Entrance Inverts Elevation 934
d. Exit Inverts Elevation 933
e. Emergency Draindown Facilities Stop logs in control tower

HYDROMETEOROLOGICAL GAGES:

a. Type None
b. Location None
c. Records None

MAXIMUM NONDAMAGING DISCHARGE: Spillway capacity

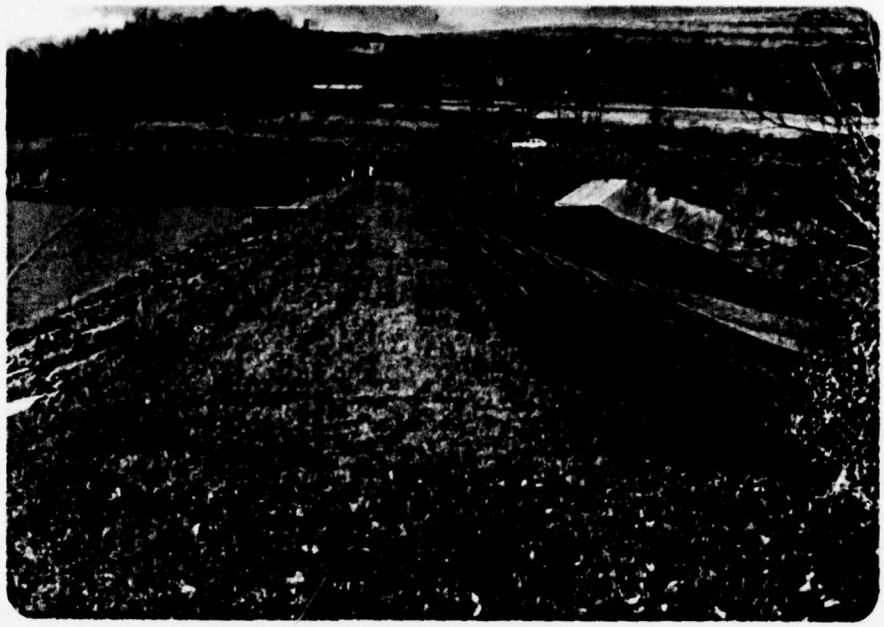
50

APPENDIX C

PHOTOGRAPHS

LIST OF PHOTOGRAPHS
DUTCH FORK DAM
NDI I.D. NO. PA-490
NOVEMBER 30, 1978

PHOTOGRAPH NO.	DESCRIPTION
1	Crest (looking east).
2	Spillway discharge channel.
3	Outlet works control tower.
4	Outlet conduit discharge end.
5	Outlet works plunge pool.
6	Homes along Dutch Fork (approximately one mile downstream from dam).

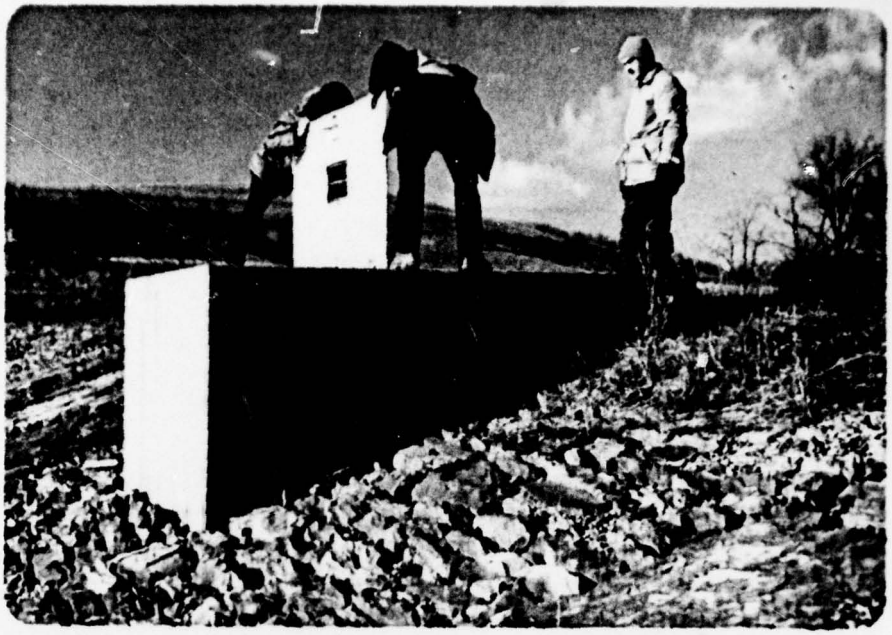


Photograph No. 1

Crest (looking east).

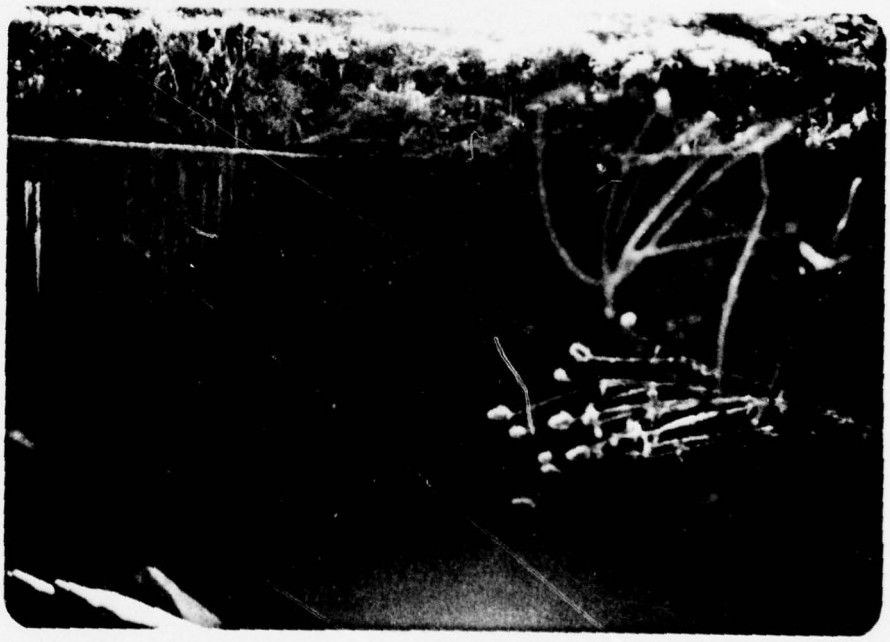
Photograph No. 2

Spillway discharge channel.



Photograph No. 3

Outlet works control tower.



Photograph No. 4

Outlet conduit discharge end.

Photograph No. 5

Outlet works plunge pool.

Photograph No. 6

Homes along Dutch Fork (approximately one mile downstream from dam).

APPENDIX D
CALCULATIONS

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
  LAST MODIFICATION  11 JAN 79
**********
    1              A1       SNYDER UNIT HYDROGRAPH,FLOOD ROUTING,AND DAM OVERTOPPING ANALYSES
    2              A2       DUTCH FORK DAM,WASHINGTON COUNTY,NDI-ID.PA490        PROJECT NO.78-367-04
    3              A3       FOR 10%,20%,30%,40%,50%,60%,70%,80%,AND 100% PMF
    4              B    300       0      10       0       0       0       0       0      -4       0
    5              B1     5
    6              J      1       9       1
    7              J1  0.10    0.20    0.30    0.40    0.50    0.60    0.70    0.80    1.00
    8              K      0       1                                       1
    9              K1       CALCULATION OF INFLOW HYDROGRAPH TO DUTCH FORK DAM,NDI-ID.PA490
   10              M      1       1    17.8            17.8                                    1
   11              P              24.2      97     116     125     136
   12              T                                                      1.0    0.12            0.0086
   13              W  4.161    0.57
   14              X   -1.0   -0.05     2.0
   15              K      1       2                                       1
   16              K1       ROUTING FLOW THROUGH DUTCH FORK DAM,NDI-ID.PA490
   17              Y                                       1       1
   18              Y1     1                                               728.0      -1
   19              Y4 965.0   966.0   967.0   968.0   969.0   970.0   971.0   972.0   973.0   974.0
   20              Y4 975.0   976.0   977.0   978.0   979.0   980.0   981.0   982.0   983.0   984.0
   21              Y5    0.     346.    992.   1847.   2880.   4076.   5425.   6922.   8561.  10339.
   22              Y512255.  14285.  16398.  18636.  21003.  23498.  26124.  28879.  31766.  34781.
   23              $S   0.0   728.0  1851.0  2602.8
   24              $E 942.0   965.0   975.0   980.0
   25              $$ 965.0
   26              $D974.54     3.1     1.5   460.0
   27              K     99
```

COMPUTER INPUT OVERTOPPING ANALYSIS

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

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1 .10	RATIO 2 .20	RATIO 3 .30	RATIO 4 .40	RATIO 5 .50	RATIO 6 .60	RATIO 7 .70	RATIO 8 .80	RATIO 9 1.00
HYDROGRAPH AT	1	17.80	1	2671.	5341.	8012.	10682.	13353.	16023.	18694.	21364.	26705.
	(	46.10)	(	75.62)(	151.24)(	226.86)(	302.48)(	378.10)(	453.72)(	529.34)(	604.97)(	756.21)
ROUTED TO	2	17.80	1	2392.	4983.	7613.	10242.	13067.	15792.	18490.	21177.	26531.
	(	46.10)	(	67.73)(	141.09)(	215.58)(	290.03)(	370.01)(	447.19)(	523.59)(	599.66)(	751.28)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	965.00	965.00	974.54
STORAGE	728.	728.	1799.
OUTFLOW	0.	0.	11374.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	968.53	0.00	1124.	2392.	0.00	44.83	0.00
.20	970.67	0.00	1365.	4983.	0.00	44.50	0.00
.30	972.42	0.00	1561.	7613.	0.00	44.33	0.00
.40	973.95	0.00	1733.	10242.	0.00	44.33	0.00
.50	975.10	.56	1867.	13067.	2.67	44.00	0.00
.60	975.78	1.24	1968.	15792.	4.50	44.00	0.00
.70	976.35	1.81	2054.	18490.	5.67	43.83	0.00
.80	976.87	2.33	2132.	21177.	6.67	43.83	0.00
1.00	977.79	3.25	2271.	26531.	8.17	43.83	0.00

OVERTOPPING ANALYSIS SUMMARY

APPENDIX E

REGIONAL GEOLOGY

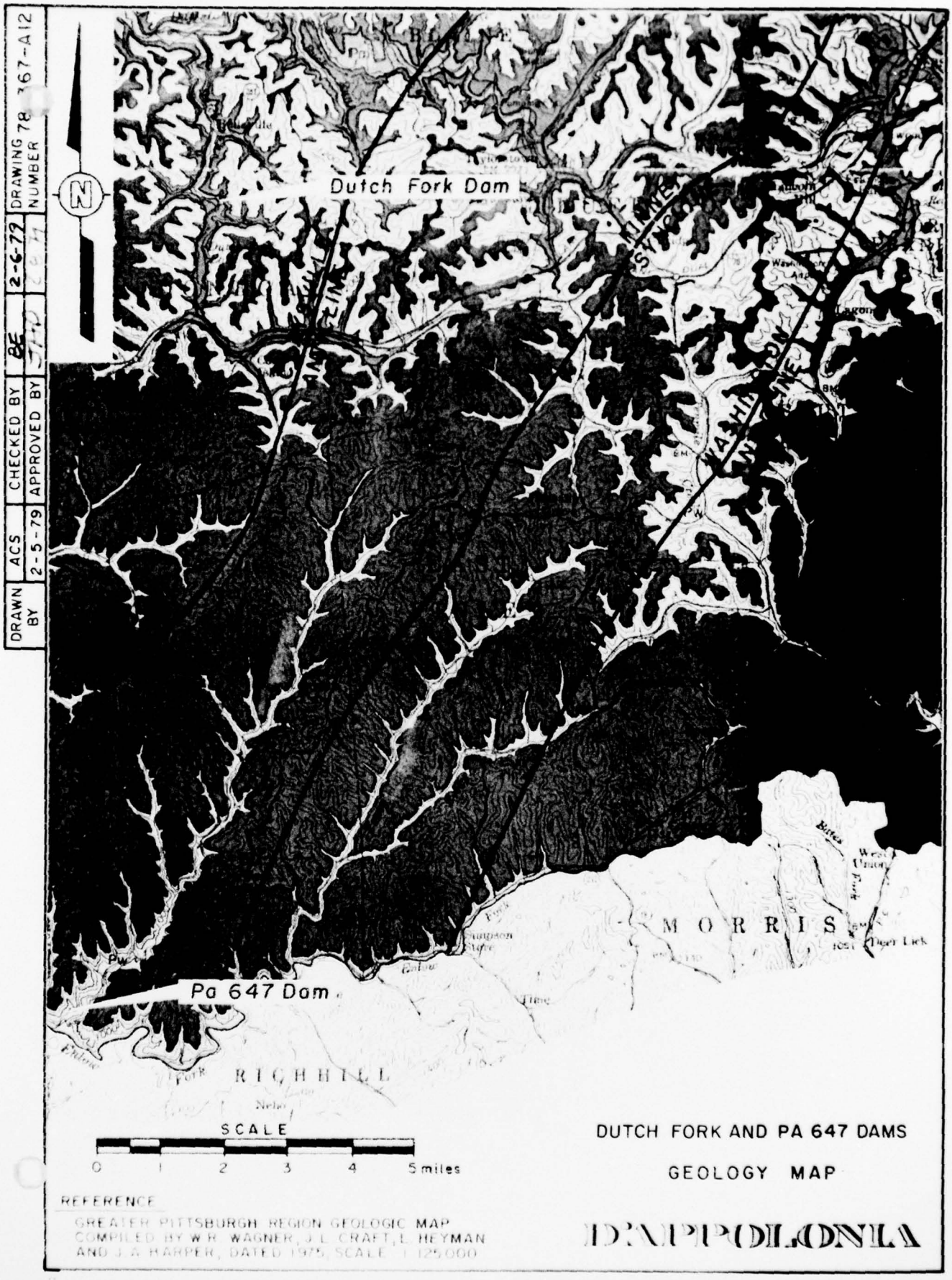
APPENDIX E
REGIONAL GEOLOGY

The Dutch Fork Dam and reservoir are located on strata of the Monongahela Group (Pennsylvanian Age) and Dunkard Group (Permian Age). The rock strata are typical for southwestern Pennsylvania, consisting of interbedded shale, claystone, sandstone, limestone, and coal seams. The dam is located on the west limb of the north-northeast trending Claysville Anticline. The regional dip is approximately 100 feet per mile in a northerly direction. This trend is due to the Claysville Anticline being very shallow and poorly defined.

The dam site is located just above the contact between the Monongahela Group and the overlying Waynesburg Formation. The Monongahela Group consists of light gray shale and siltstone seams, while the overlying Waynesburg Formation consists of gray shale with interbedded green-gray limestone and thick-bedded gray sandstone.

The dam is located approximately 420 to 430 feet above the Pittsburgh seam, which defines the base of the Monongahela Group.

The strata present in the valley slopes of the reservoir are susceptible to weathering and subsequent movement. The U.S. Geological Survey geologic map of the Waynesburg, Pennsylvania quadrangle, dated 1970, indicates that in the area, approximately 20 to 30 percent of the land is covered by landslide deposits. Although there are no recent landslides in the area, there are several old slides around the reservoir, some of which are up to 100 feet wide by 150 feet long.



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DUTCH FORK AND PA 647 DAMS

GEOLOGY MAP

REFERENCE

GREATER PITTSBURGH REGION GEOLOGIC MAP COMPILED BY W.R. WAGNER, J.L. CRAFT, E. HEYMAN AND J.A. HARPER, DATED 1975, SCALE 1:125000

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GROUP	FORMATION		DESCRIPTION
	Alluvium	Qt	Sand, gravel, clay.
	Terrace deposits		Sand, clay, gravel on terraces above present rivers; includes Carmichaels Formation.
DUNKARD	Greene		Cyclic sequences of sandstone, shale, red beds, thin limestones and coals.
	Washington	Pw	Cyclic sequences of sandstone, shale, limestone, and coal; contains Washington coal bed at base.
	Waynesburg		Cyclic sequences of sandstone, shale, limestone and coal; contains Waynesburg coal bed at base.
MONONGAHELA		Pm	Cyclic sequences of shale, limestone, sandstone and coal; contains Pittsburgh coal bed at base.
CONEMAUGH	Casselman	Pcc	Cyclic sequence of sandstone, shale, red beds and thin limestone and coal.
	Ames		
	Glenshaw	Pcg	Cyclic sequences of sandstone, shale, red beds and thin limestone and coal; several fossiliferous limestone; Ames limestone bed at top.
ALLEGHENY	Vanport	Pa	Cyclic sequences of shale, sandstone, limestone, and coal; contains Brookville coal at base and Upper Freeport coal at top; within group are the commercial Vanport limestone and Kittanning and Clarion coals.

GEOLOG MAP LEGEND

REFERENCE:

GREATER PITTSBURGH REGION GEOLOGIC MAP
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