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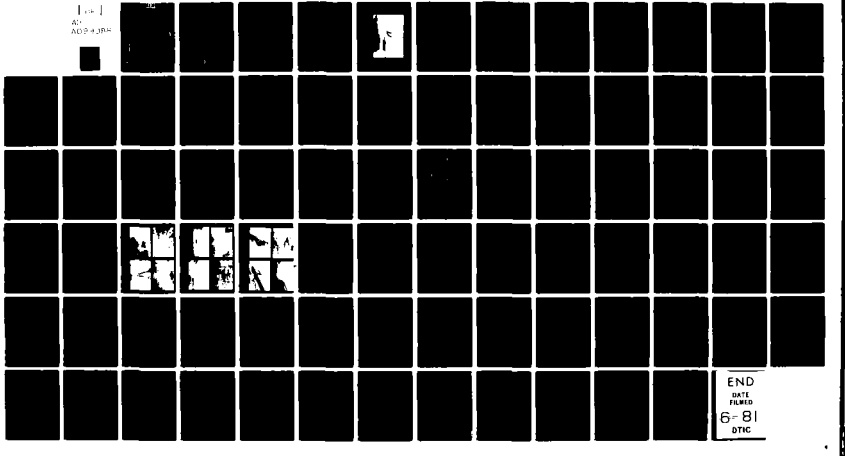

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WESTCOLANG CREEK, PIKE COUNTY

PENNSYLVANIA

WESTCOLANG LAKE DAM

NDI I.D. NO. PA-00396
PENNDER I.D. NO. 52-4

MRS. WILLIAM OTTESON

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

PREPARED FOR

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

PREPARED BY

GAI CONSULTANTS, INC.
570 BEATTY ROAD
MONROEVILLE, PENNSYLVANIA 15146

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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 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.

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 (greatest reasonably possible storm runoff) for the region, 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.

Breach analyses are performed, when necessary, to provide data to assess the potential for downstream damage and possible loss of life. The results are based on specific theoretical scenarios peculiar to the analysis of a particular dam and are not applicable to other related studies such as those conducted under the Federal Flood Insurance Program.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

ABSTRACT

Westcolang Lake Dam: NDI I.D. No. PA-00396

Owner: Mrs. William Otteson

State Located: Pennsylvania (PennDER I.D. No. 52-4)

County Located: Pike

Stream: Westcolang Creek

Inspection Dates: 21 and 22 October 1980

Inspection Team: GAI Consultants, Inc.
570 Beatty Road
Monroeville, Pennsylvania 15146

Based on a visual inspection, operational history, and hydrologic/hydraulic analysis, the dam is considered to be in fair condition.

The size classification of the facility is intermediate and its hazard classification is considered to be high. In accordance with the recommended guidelines, the Spillway Design Flood (SDF) for the facility is the PMF (Probable Maximum Flood). Results of the hydrologic and hydraulic analysis indicate the facility will pass and/or store only about 20 percent of the PMF prior to embankment overtopping. A breach analysis indicates that failure under 1/2 PMF conditions could lead to increased downstream damage and potential for loss of life. Thus, based on screening criteria provided in the recommended guidelines, the spillway is considered to be seriously inadequate and the facility unsafe, non-emergency.

It is recommended that the owner immediately:

a. Develop a formal emergency warning system to notify downstream residents in the event hazardous embankment conditions develop. Included in the plan should be provisions for around-the-clock surveillance of the facility during periods of unusually heavy precipitation.

b. Retain the services of a registered professional engineer experienced in the hydraulics and hydrology of dams to more accurately assess the adequacy of the spillway and prepare recommendations for remedial measures deemed necessary to make the facility hydraulically adequate.

c. Continue to observe the seepage encountered downstream of the embankment in all future inspections noting any turbidity and/or changes in rate of flow.

Westcolang Lake Dam: NDI I.D. No. PA-00396

d. Repair the deteriorated concrete associated with the spillway channel and its sidewalls.

e. Provide a means or develop a plan for draining the reservoir to the normal pool level of the natural lake that preceded the dam in the event emergency conditions develop within the dam.

f. Cut the thick brush along the abutment slopes immediately downstream of the embankment, on a regular routine basis, to provide a clear view of the facility.

g. Develop formal manuals of operation and maintenance to ensure the future proper care of the facility.

GAI Consultants, Inc.

Bernard M. Mihalcin, P.E.

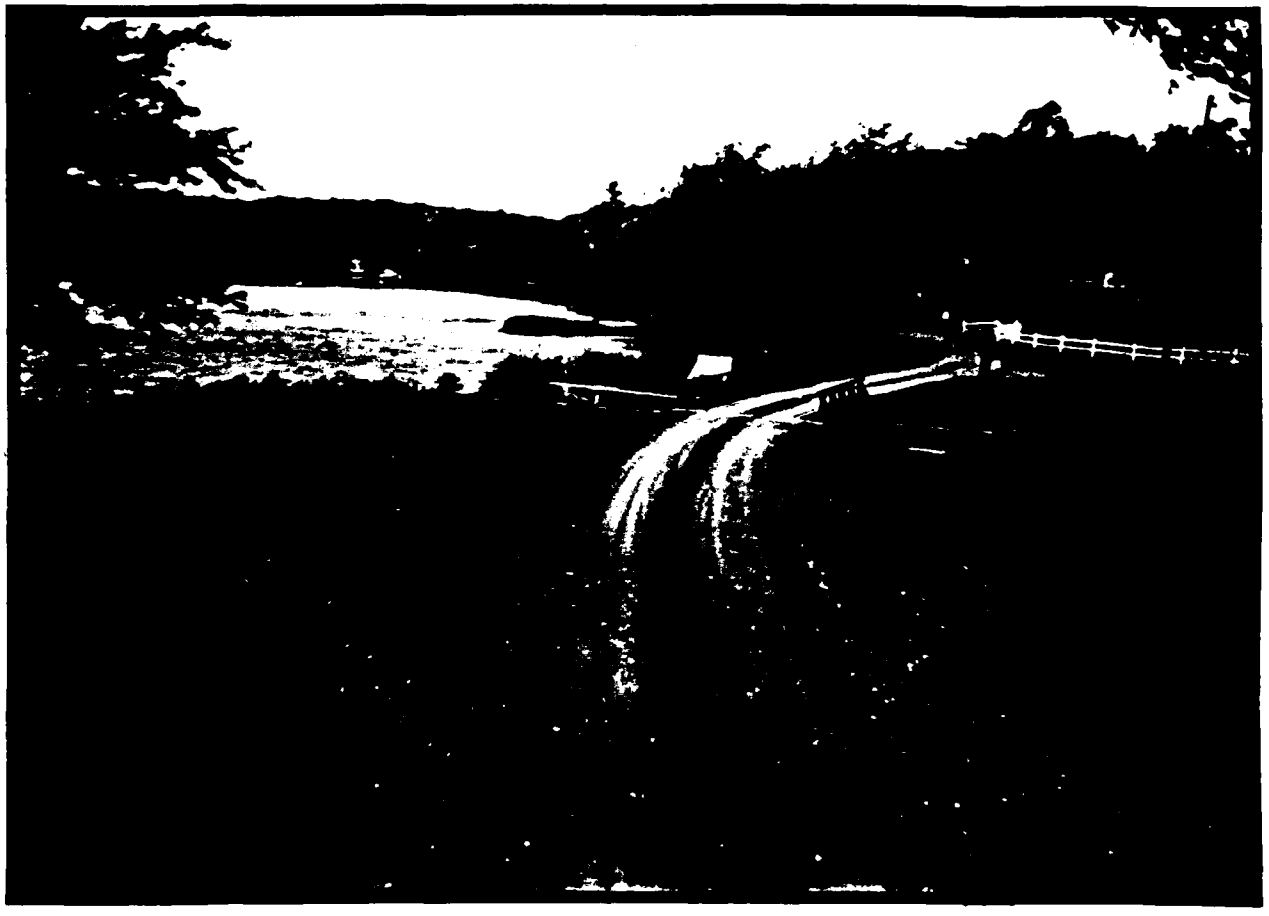
Approved by:

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
BERNARD M. MIHALCIN
ENGINEER
20371-E

Date 27 MARCH 1981

Date 15 APR 81



OVERVIEW PHOTOGRAPH

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NATIONAL DAM INSPECTION PROGRAM
WESTCOLANG LAKE DAM
NDI# PA-00396, PENNDER # 52-4

SECTION 1
GENERAL INFORMATION

1.0 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.

1.1 Purpose.

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

1.2 Description of Project.

a. Dam and Appurtenances. Westcolang Lake Dam is an eight-foot high earth embankment approximately 160 feet long, including spillway. The dam was constructed at the outlet of a natural lake. The facility is provided with an uncontrolled, rectangular shaped, concrete and masonry chute channel spillway located near the center of the embankment. No outlet conduit or means for drawing down the reservoir is available.

b. Location. Westcolang Lake Dam is located on Westcolang Creek in Lackawaxen Township, Pike County, Pennsylvania. The facility is situated about two miles from the Delaware River in the northern corner of Pike County about midway between the communities of Masthope and Bohemia, Pennsylvania. The dam, reservoir, and watershed are contained within the Narrowsburg, Pennsylvania-New York, and Rowland, Pennsylvania, 7.5 minute U.S.G.S. topographic quadrangles (see Figure 1, Appendix E). The coordinates of the dam are N41° 30.7' and W75° 2.3'.

c. Size Classification. Intermediate (eight feet high, 1,500 acre-feet effective maximum storage capacity; see Appendix D, Sheet 1).

d. Hazard Classification. High (see Section 3.1.e).

e. Ownership. Mrs. William Otteson
150 Old Army Road
Scarsdale, New York 10583

f. Purpose. Recreation.

g. Historical Data. Historical information contained in PennDER files indicates that a dam at Westcolang Lake dates back to sometime around the turn of the century. At that time, a small timber crib structure served to raise the pool level in what was formerly a natural lake in order to supply water to a small saw mill located several hundred feet downstream.

By 1912, the date of the earliest available correspondence, the saw mill had become defunct and the land encompassing the timber crib was acquired by a local farmer, W. J. Abrams. Mr. Abrams attempted to construct a more substantial structure at the site of the timber crib in 1912, but fell short in his efforts reportedly due to a lack of funds. State inspectors repeatedly cited the facility as inadequate with insufficient spillway capacity and evidence of substantial seepage.

By 1924, the facility was owned by John F. M. Detlefsen whose business address was listed as Brooklyn, New York. Mr. Detlefsen initiated modifications to the facility in 1954 resulting in the present structure. The remedial work increased the spillway capacity and reportedly eliminated the seepage problem. The last recorded state inspection occurred in 1965, at which time, the facility was reported to be in satisfactory condition with no significant deficiencies noted.

Ownership of the dam has since been transferred to the present owner, Mrs. William Otteson, a descendent of J.F.M. Detlefsen. No significant modifications have been made to the facility since 1954.

1.3 Pertinent Data.

a. Drainage Area (square miles). 2.4

b. Discharge at Dam Site.

Discharge Capacity of Outlet Conduit - facility not equipped with an outlet conduit.

Discharge Capacity of Spillway at Maximum Pool = 110 cfs (see Appendix D, Sheet 10).

c. Elevations (feet above mean sea level). The following elevations were obtained from field measurements based on the assumed elevation of normal pool as indicated on the Narrowsburg, Pennsylvania-New York, U.S.G.S. 7.5 minute topographic quadrangle (see Figure 1, Appendix E).

Top of Dam	1114.0 (field).
Maximum Design Pool	Not known.
Maximum Pool of Record	Not known.
Normal Pool	1112.0

Spillway Crest	1112.0
Upstream Inlet Invert	N/A (no outlet).
Downstream Outlet Invert	N/A.
Downstream Embankment Toe	1106.4
Streambed at Dam Centerline	Not known.
Maximum Tailwater	Not known.

d. Reservoir Length (feet).

Top of Dam	8800
Normal Pool	8400

e. Storage (acre-feet).

Top of Dam	2760
Normal Pool	2290
Effective Maximum	1500 (see Appendix D, Sheet 1).

f. Reservoir Surface (acres).

Top of Dam	223
Normal Pool	200

g. Dam.

Type	Earth.
Length	147 feet (excluding spillway, effective length).
Height	Eight feet (field measured; embankment crest to downstream base of spillway (see Sheets 1 and 6, Appendix D).
Top Width	Varies; 48 to 70 feet.
Upstream Slope	2.5H:1V.
Downstream Slope	Small, vertical, masonry wall extends from the left abutment to the spillway. Remnants of a shorter, similar wall are evident to the right of the spillway.
Zoning	Not known.
Impervious Core	Not known.

	Cutoff	Not known.
	Grout Curtain	Not known.
h.	Diversion Canal and Regulating Tunnels.	None.
i.	Spillway.	
	Type	Uncontrolled, rectangular shaped, concrete and masonry chute channel located near the center of the embankment.
	Crest Elevation	1112.0 feet.
	Crest Length	16.4 feet.
	Effective Crest Length	12.9 feet (reflects channel constriction downstream of spillway crest).
j.	Outlet Conduit.	None.

SECTION 2

ENGINEERING DATA

2.1 Design.

a. Design Data Availability and Sources. No design reports, calculations, miscellaneous design data, correspondence, design or construction drawings are available from either the owner or PennDER. PennDER maintains a correspondence file containing entries dating back to 1912 including several photographs and nine state inspection reports for various years between 1912 and 1965.

b. Design Features.

1. Embankment. Based strictly on visual observations and field measurements, general statements can be made regarding the embankment design. The dam is an eight-foot high, 160-foot long earth embankment, including spillway, constructed at the outlet to a natural lake. The crest is wide, measuring from a minimum of 48 feet along the centerline of the spillway to about 70 feet near the junction of the embankment and right abutment. Most of the crest is grass covered except for the crushed stone covered roadway which provides access between the abutments (see Photograph 1). The upstream embankment face is sloped at 2.5H:1V and protected with a riprap layer comprised of hard, durable sandstone boulders (see Photograph 11). The downstream embankment face to the left of the spillway consists of a small, vertical, masonry wall (see Photograph 12). Remnants of a similar wall are also evident to the right of the spillway; however, the downstream embankment face in this area is best described as irregular and poorly defined. No information is available relative to the internal or foundation design of this structure.

2. Appurtenant Structures.

a) Spillway. The spillway is an uncontrolled, rectangular shaped, concrete and masonry chute channel located near the center of the embankment. The original structure was apparently constructed entirely of masonry. Over the years, portions of the masonry have been covered with or completely replaced by concrete. Presently, the channel floor and sidewalls near the inlet are comprised of concrete while the sidewalls downstream of the bridge are masonry. Discharges through the spillway are regulated by a broad crested weir located at the inlet. The length of the weir is 16.4 feet at the inlet; however, because of a channel constriction downstream, its effective length is only 12.9 feet. A wood plank roadway bridge spans the spillway about 24 feet downstream of the inlet.

b) Outlet Conduit. The facility was constructed without an outlet conduit or effective means for drawing down the reservoir.

2.2 Construction Records

There are no formal records or detailed information available relative to the original construction or subsequent modifications to the facility.

2.3 Operational Records.

No records of the day-to-day operation of the facility are available.

2.4 Other Investigations.

No records of any formal investigations other than periodic state inpection reports are available. PennDER files contain nine state inspection reports performed between the years 1912 and 1965. The facility was consistantly reported as being in fair or poor condition. Repeatedly cited deficiencies included an inadequate spillway, significant seepage beyond the downstream embankment toe and settlement across the embankment crest.

2.5 Evaluation.

The available data are considered sufficient to make a reasonable Phase I evaluation of the facility.

SECTION 3

VISUAL INSPECTION

3.1 Observations.

a. General. The general appearance of the facility suggests the dam and its appurtenances are in good condition.

b. Embankment. Observations made during the visual inspection reveal the embankment is adequately maintained and presently in good condition. The left and right abutment slopes immediately downstream of the dam are covered with thick brush which partially obscures view of the facility. No evidence of seepage through the downstream embankment face, sloughing, erosion, animal burrows or excessive settlement was noted. Seepage was encountered in the rock lined discharge channel about 30 feet downstream of the embankment. The seepage, estimated at about 1/2 to 1 cfs, appeared to be emanating from the left side of the channel near an old masonry pier that previously supported a sluiceway for the old saw mill no longer in existence (see Photographs 3 and 8, Appendix C and "General Plan - Field Inspection Notes," Appendix A).

c. Appurtenant Structures.

1. Spillway. The spillway is considered to be in good condition. Minor spalling and some associated cracking were observed along the channel floor particularly at its discharge end (see Photographs 6 and 8). Cracking was also observed in the concrete portions of the channel sidewalls (see Photographs 5, 9, and 10).

d. Reservoir Area. The general area surrounding the reservoir is composed of steep slopes that are heavily forested. No signs of slope distress were observed.

e. Downstream Channel. Discharges from Westcolang Lake Dam flow into a steeply sloped channel situated in a narrow, heavily forested valley with steep confining slopes. The reach between the dam and the Delaware River is about two miles long. Several dwellings, both seasonal and permanent, are located within the reach sufficiently near the stream to possibly be affected by the floodwaters resulting from an embankment breach. It is estimated that as many as 25 persons could inhabit the valley at any given time, particularly on weekends and during the peak seasons. Consequently, the hazard classification is considered to be high.

3.2 Evaluation.

The overall appearance of the facility suggests it to be adequately maintained and in good condition. The thick brush encountered along the downstream abutment slopes should be cut back

to afford a clear view of the facility. Repairs should be made to the deteriorated portions of the concrete spillway. In addition, the seepage encountered downstream of the spillway should continue to be observed in all future inspections noting any turbidity or changes in rate of flow.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Normal Operating Procedure.

Westcoang Lake Dam is essentially a self-regulating facility. Excess inflow is automatically discharged through the uncontrolled spillway and directed downstream. The facility has no outlet conduit or operable devices associated with it. No formal operations manual is available.

4.2 Maintenance of Dam.

The owner maintains the dam on an unscheduled, as-needed basis. Typical maintenance previously performed included repairing cracks in the spillway concrete and mowing the crest regularly. No formal maintenance manual is available.

4.3 Maintenance of Operating Facilities.

No operable devices are associated with the facility.

4.4 Warning System.

No formal warning system is presently in effect.

4.5 Evaluation.

The general appearance of the facility suggests it to be adequately maintained with the exception of the brush covered slopes located immediately downstream of the embankment. No formal program of regular routine maintenance has been established. Formal manuals of operations and maintenance are recommended to ensure continued proper care of the facility. Included in these manuals should be a formal plan to effect drawdown along with a formal emergency warning system for the protection of downstream inhabitants that provides for around-the-clock surveillance of the facility during periods of unusually heavy precipitation.

SECTION 5

HYDROLOGIC/HYDRAULIC EVALUATION

5.1 Design Data.

No formal design reports, calculations, or miscellaneous design data are available for the facility.

5.2 Experience Data.

Records of reservoir levels and/or spillway discharges are not available.

5.3 Visual Observations.

On the date of the inspection, no conditions were observed that would indicate the spillway could not function satisfactorily during a flood event, within the limits of its design capacity.

5.4 Method of Analysis.

The facility has been analyzed in accordance with the procedures and guidelines established by the U. S. Army, Corps of Engineers, Baltimore District, for Phase I hydrologic and hydraulic evaluations. The analysis has been performed utilizing a modified version of the HEC-1 program developed by the U. S. Army, Corps of Engineers, Hydrologic Engineering Center, Davis, California. Analytical capabilities of the program are briefly outlined in the preface contained in Appendix D.

5.5 Summary of Analysis

a. Spillway Design Flood (SDF). In accordance with the procedures and guidelines contained in the National Guidelines for Safety Inspection of Dams for Phase I Investigations, the Spillway Design Flood (SDF) for Westcolang Lake Dam is the PMF (Probable Maximum Flood). This classification is based on the relative size of the dam (intermediate) and the potential hazard of dam failure to downstream developments (high).

b. Results of Analysis. Westcolang Lake Dam was evaluated under normal operating conditions. That is, the reservoir was initially at its normal pool or spillway elevation of approximately 1112.0 feet, with the spillway discharging freely. The spillway consists of an uncontrolled, rectangular shaped, concrete and masonry chute channel, with discharges regulated by a concrete broad-crested weir. All pertinent engineering calculations relative to the evaluation of Westcolang Lake Dam are provided in Appendix D.

Overtopping analysis (using the modified HEC-1 computer program) indicated that the discharge/storage capacity of Westcolang Lake Dam can accommodate only about 20 percent of the PMF (SDF) prior to embankment overtopping. Under PMF conditions, the dam was inundated for about 27 hours by depths of up to 3.2 feet. For the 1/2 PMF event, the dam was overtopped for about 23 hours, with a maximum depth of about 1.7 feet (Appendix D, Summary input/Output Sheets, Sheet C). Since the SDF for Westcolang Lake Dam is the PMF, it can be concluded that the dam has a high potential for overtopping, and thus, for breaching under floods of less than SDF magnitude.

As Westcolang Lake Dam cannot accommodate floods of at least 1/2 PMF magnitude, the possibility of embankment failure under floods of 1/2 PMF intensity or less was investigated (in accordance with Corps directive ETL-1110-2-234). The modified HEC-1 computer program was used for the breaching analysis, with the assumption that the downtream channel bed was dry prior to the occurrence of the dam outflows. The major concern of the breaching analysis is with the impact of the various breach discharges on increasing downstream water surface elevations above those to be expected if breaching did not occur.

The portion of Westcolang Lake Dam which is most likely to fail due to overtopping is the embankment area adjacent the spillway structure, where the downstream face of the embankment is steepest, and where the greatest depth of breach would occur. The breach was assumed to extend vertically only to the base of the dam, although the bottom of the natural lake occurs at a lower elevation. Since foundation conditions are unknown, it is possible that a breach could extend to greater depths.

Four breach models were analyzed for Westcolang Lake Dam, involving one set of breach dimensions and four possible failure times. The breach section chosen was considered to be the maximum section likely to fail near the spillway structure. The four failure times (total time for breach section to reach its final dimensions) were assumed to be a prolonged time of 12.0 hours, and three relatively rapid times of 4.0, 2.0, and 1.0 hours. The prolonged breach was assumed to commence immediately upon overtopping, while the three more rapid breaches were assumed to commence as the depth of overtopping reached about 1.0-foot or after about an hour of overtopping. All breaches were assumed to occur under 1/2 PMF conditions (see Appendix D, Sheet 12).

The peak breach outflows ranged from about 1,660 cfs for the prolonged time scheme to about 3,520 cfs for the most rapid failure, compared to the non-breach 0.50 PMF peak outflow of about 1,400 cfs (Appendix D, Sheet 13).

Three potential centers of damage were investigated in the analysis. At Section 2 (see Figure 1), located about 1.1 miles downstream from Westcolang Lake Dam, the peak water surface elevations resulting from the breaches ranged up to about 2.3 feet above

the non-breach level, or about 1.6 feet above the damage level of the nearby dwellings.

At Section 3 (see Figure 1), located about 1.4 miles downstream from the dam, all breach outflows remained below the damage level of the nearby structures.

The third potential damage center is located at Section 4, located about 1.5 miles downstream from the dam. At this section, the maximum water surface levels resulting from the breaches ranged up to about 1.8 feet above the peak non-breach level, or approximately 1.5 feet above the damage level of the residences (Appendix D, Sheet 14).

The consequences of dam failure can better be envisioned if not only the increase in the height of the floodwave is considered, but, also the great increase in the momentum of the larger and probably swifter moving volume of water. Therefore, the failure of Westcolang Lake Dam would most likely lead to increased property damage and possibly loss of life in the downstream regions.

5.6 Spillway Adequacy.

As presented previously, Westcolang Lake Dam can accommodate only about 20 percent of the PMF prior to embankment overtopping. It has been shown that should an event of 1/2 PMF magnitude occur, the dam would be overtopped and could possibly fail, endangering downstream residents and increasing the potential for loss of life in the downstream regions. Therefore, the spillway is considered to be seriously inadequate.

SECTION 6

EVALUATION OF STRUCTURAL INTEGRITY

6.1 Visual Observations.

a. Embankment. Based on visual observations, the embankment appears to be adequately maintained and in good structural condition. The only significant deficiency observed was the seepage encountered about 30 feet downstream of the embankment. The flow observed was clear and estimated at about 1/2 to 1 cfs. The facility has a history of seepage through the foundation dating back to at least 1919. Available correspondence contained in PennDER files indicates the seepage was substantially reduced as a result of the modifications to the original facility performed in 1954. The reestablishment of this seepage, by itself, is not necessarily a threat to the stability of the structure. It is important, however, to continue to observe the condition in all future inspections noting any turbidity and/or changes in rate of flow.

b. Appurtenant Structures.

1. Spillway. The spillway is considered to be in good structural condition. Concrete deterioration observed by the inspection team is considered to be minor and no threat to the stability of the structure at present. However, it can be assumed that continued decay could lead to structural instability particularly during periods of high flow and increased structural stress.

2. Outlet Conduit. The facility currently has no operable means or plan for draining the reservoir. Provisions for such action should be available particularly in light of the present seepage condition associated with the structure. The ability to lower the reservoir and reduce the hydraulic head behind the embankment can significantly reduce the risk of sudden embankment failure due to seepage and piping.

6.2 Design and Construction Techniques.

No information is available that details the methods of design and/or construction.

6.3 Past Performance.

Available information indicates the facility has performed satisfactorily throughout its history. The facility has been formally inspected nine times between the years 1912 and 1965. It was consistantly reported as being in fair or poor condition with deficiencies such as an inadequate spillway, significant seepage beyond the downstream embankment toe and settlement across the

embankment crest repeatedly cited. No verified incidences of overtopping have been recorded.

6.4 Seismic Stability.

The dam is located in Seismic Zone No. 1 and may be subject to minor earthquake induced dynamic forces. As the facility appears adequately constructed and statically stable, it is believed that it can withstand the expected dynamic forces. However, no calculations and/or investigations were performed to confirm this belief.

SECTION 7

ASSESSMENT AND RECOMMENDATIONS FOR REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The results of this investigation indicate the facility is in fair condition.

The size classification of the facility is intermediate and the hazard classification is considered to be high. In accordance with the recommended guidelines, the Spillway Design Flood (SDF) for the facility is the PMF (Probable Maximum Flood). Results of the hydrologic and hydraulic analysis indicate the facility will pass and/or store only about 20 percent of the PMF prior to embankment overtopping. A breach analysis indicates that failure under 1/2 PMF conditions could lead to increased downstream damage and potential for loss of life. Thus, based on screening criteria provided in the recommended guidelines, the spillway is considered to be seriously inadequate and the facility unsafe, non-emergency.

b. Adequacy of Information. The available data are considered sufficient to make a reasonable Phase I assessment of the facility.

c. Urgency. The recommendations listed below should be implemented immediately.

d. Necessity for Additional Investigations. Additional hydrologic/hydraulic investigations are currently deemed necessary to more accurately assess the adequacy of the spillway.

7.2 Recommendations/Remedial Measures.

It is recommended that the owner immediately:

a. Develop a formal emergency warning system to notify downstream residents should hazardous embankment conditions develop. Included in the plan should be provisions for around-the-clock surveillance of the facility during periods of unusually heavy precipitation.

b. Retain the services of a registered professional engineer experienced in the hydraulics and hydrology of dams to more accurately assess the adequacy of the spillway and prepare recommendations for remedial measures deemed necessary to make the facility hydraulically adequate.

c. Continue to observe the seepage encountered downstream of the embankment in all future inspections noting any turbidity and/or changes in rate of flow.

d. Repair the deteriorated concrete associated with the spillway channel and its sidewalls.

e. Provide a means or develop a plan for draining the reservoir to the normal pool level of the natural lake that preceded the dam in the event emergency conditions develop at the dam.

f. Cut the thick brush along the abutment slopes immediately downstream of the embankment, on a regular routine basis, to provide a clear view of the facility.

g. Develop formal manuals of operation and maintenance to ensure the future proper care of the facility.

APPENDIX A

VISUAL INSPECTION CHECKLIST AND FIELD SKETCHES

CHECK LIST
VISUAL INSPECTION
PHASE 1

NAME OF DAM Westcolang Lake Dam STATE Pennsylvania COUNTY Pike

NDI # PA — 00396 PENNDER # 52-4

TYPE OF DAM Earth SIZE Intermediate HAZARD CATEGORY High

DATE(S) INSPECTION 21 and 22 October 1980 WEATHER Overcast TEMPERATURE 40° @ 4:00 PM

POOL ELEVATION AT TIME OF INSPECTION 1111.4 feet M.S.L.

TAILWATER AT TIME OF INSPECTION N/A M.S.L.

INSPECTION PERSONNEL	OWNER REPRESENTATIVES	*OTHERS*
B. M. Mihalcin	None Present	
D. J. Spaeder		
D. L. Bonk		

RECORDED BY B. M. Mihalcin

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00396
SURFACE CRACKS	None observed.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed. Downstream abutment slopes adjacent to dam are covered with large boulders and/or high weeds.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Horizontal - good. Vertical - see "Profile of Dam Crest from Field Survey", Appendix A.
RIPRAP FAILURES	None observed. Riprap is comprised of hard, durable sandstone boulders.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good condition.

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00396
DAMP AREAS IRREGULAR VEGETATION (LUSH OR DEAD PLANTS)	None observed.
ANY NOTICEABLE SEEPAGE	Seepage (≃ 1.2 to 1 cfs) observed beneath the rocks that line the discharge channel below the spillway about 30 feet downstream of the embankment. Clear flow with no fines evident. Facility has a history of seepage problems that were reportedly corrected in 1953.
STAFF GAGE AND RECORDER	None.
DRAINS	None observed.
	Embankment is constructed at the outlet to a natural lake. Crest is very wide. The abutments slopes immediately downstream of the embankment are covered with thick brush that partially obstructs view of the facility.

OUTLET WORKS

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00396
INTAKE STRUCTURE	No outlet conduit.
OUTLET CONDUIT (CRACKING AND SPALLING OF CONCRETE SURFACES)	N/A.
OUTLET STRUCTURE	N/A.
OUTLET CHANNEL	N/A.
GATE(S) AND OPERATIONAL EQUIPMENT	N/A.

EMERGENCY SPILLWAY

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA. 00396
TYPE AND CONDITION	Uncontrolled, rectangular shaped, concrete and masonry spillway with no regulating weir. Good condition. Some concrete deterioration in the form of minor cracking and scaling of the sidewalls and channel floor was observed.
APPROACH CHANNEL	None.
SPILLWAY CHANNEL AND SIDEWALLS	Concrete channel floor is in good condition with moderate scaling and some cracking evident. Concrete sidewalls are in good condition with some visible minor cracks. Masonry sidewalls are in good condition.
STILLING BASIN PLUNGE POOL	None. The spillway discharges over large boulders immediately downstream of the spillway. Flow enters into a small pond about 200 feet downstream of the dam.
DISCHARGE CHANNEL	Natural channel.
BRIDGE AND PIERS EMERGENCY GATES	Timber roadway bridge in good condition spans spillway.

SERVICE SPILLWAY

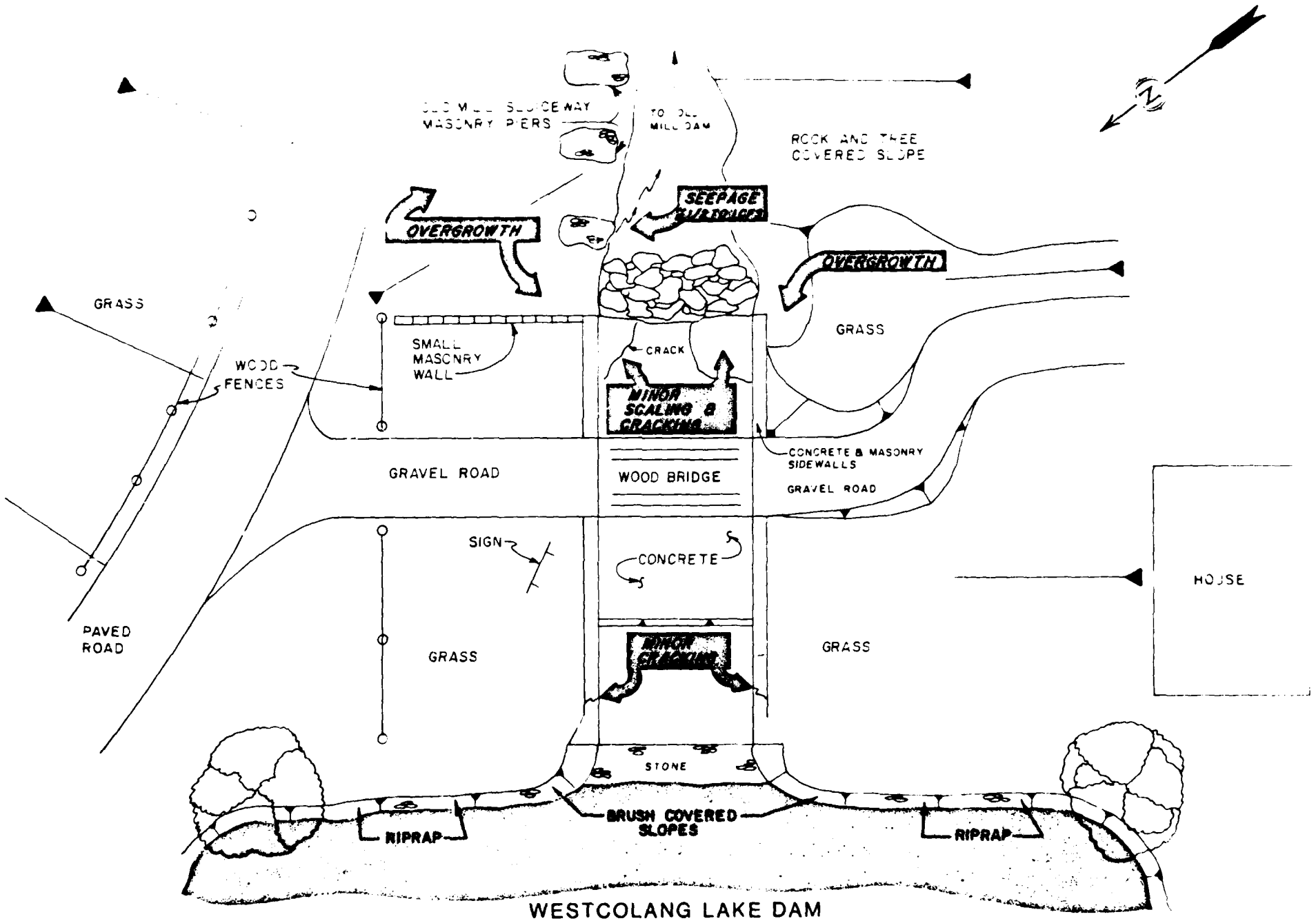
ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00396
TYPE AND CONDITION	N/A.
APPROACH CHANNEL	N/A.
OUTLET STRUCTURE	N/A.
DISCHARGE CHANNEL	N/A.

INSTRUMENTATION

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00396
MONUMENTATION SURVEYS	None.
OBSERVATION WELLS	None.
WEIRS	None.
PIEZOMETERS	None.
OTHERS	None.

RESERVOIR AREA AND DOWNSTREAM CHANNEL

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA- 00396
SLOPES: RESERVOIR	Steep slopes that are heavily forested.
SEDIMENTATION	None observed.
DOWNSTREAM CHANNEL (OBSTRUCTIONS, DEBRIS, ETC.)	Stream passes through roadway and railroad embankment culverts approximately 400 feet upstream of the inlet of Westcolang Creek to the Delaware River.
SLOPES: CHANNEL VALLEY	Discharges from Westcolang Lake Dam flow into a steeply sloped channel situated in a narrow, heavily forested valley with steep confining slopes.
APPROXIMATE NUMBER OF HOMES AND POPULATION	It is estimated that as many as 25 persons could inhabit the valley between the dam and the Delaware River, particularly on weekends and during the peak seasons, in dwellings located sufficiently near the stream to possibly be affected by an embankment breach.

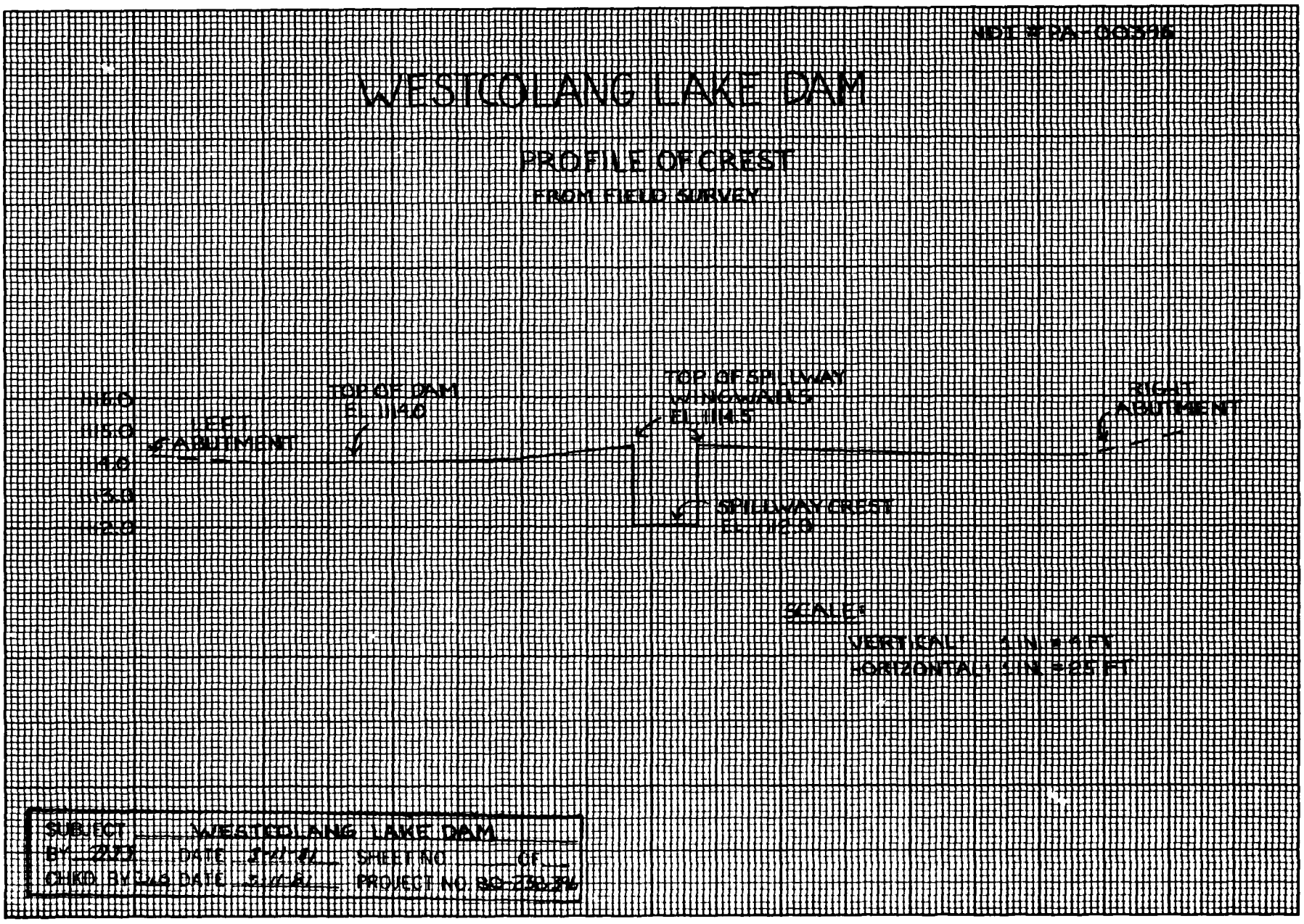


WESTCOLANG LAKE DAM
GENERAL PLAN-FIELD INSPECTION NOTES

NDI # PA-00396

WESTCOLANG LAKE DAM

PROFILE OF CREST
FROM FIELD SURVEY



SUBJECT WESTCOLANG LAKE DAM
BY JJD DATE 7/27/81 SHEET NO. ___ OF ___
CHKD. BY JJD DATE 7/27/81 PROJECT NO. 80-230-H

APPENDIX B

ENGINEERING DATA CHECKLIST

CHECK LIST
ENGINEERING DATA
PHASE I

NAME OF DAM Westcolang Lake Dam

ITEM	REMARKS NDI# PA - 00396
PERSONS INTERVIEWED AND TITLE	Clarence W. James - Resident since 1929; owns some lake front property. Mrs. William Otteson - Owner; previously contacted by letter and telephone.
REGIONAL VICINITY MAP	See Appendix E, Figure 1.
CONSTRUCTION HISTORY	Good historical report contained in PennDER files by the Pennsylvania Water Supply Commission, dated 1912. Originally a natural lake. Timber crib dam added around 1900. Construction of a more substantial structure began in 1912, but was never fully completed. Substantially renovated in 1954. See Section 1.2.g.
AVAILABLE DRAWINGS	None available.
TYPICAL DAM SECTIONS	None available.
OUTLETS: PLAN DETAILS DISCHARGE RATINGS	No outlet conduit.

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS NDI# PA - 00396
SPILLWAY: PLAN SECTION DETAILS	None available.
OPERATING EQUIP- MENT PLANS AND DETAILS	No operating appurtenances.
DESIGN REPORTS	None.
GEOLOGY REPORTS	None. 1912 report contained in PennDER files states that lake is "of glacial origin and surrounded by drift heaps,..."
DESIGN COMPUTATIONS: HYDROLOGY AND HYDRAULICS STABILITY ANALYSES SEEPAGE ANALYSES	None available.
MATERIAL INVESTIGATIONS: BORING RECORDS LABORATORY TESTING FIELD TESTING	None available.

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS	NDI# PA - 00396
BORROW SOURCES	Not known.	
POST CONSTRUCTION DAM SURVEYS	None.	
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Nine state inspection reports for the years between 1912 and 1965 are contained in PennDER files.	
HIGH POOL RECORDS	None.	
MONITORING SYSTEMS	None.	
MODIFICATIONS	The present facility is the result of renovations initiated in 1954. No subsequent modifications have been performed.	

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS NDI# PA - 00396
PRIOR ACCIDENTS OR FAILURES	None recorded. Substantial seepage through the foundation below the dam was consistently reported prior to the 1954 renovation. No seepage reported between 1954 and 1965; however, the inspection team did observe flow about 30 feet below the dam.
MAINTENANCE: RECORDS MANUAL	None available.
OPERATION: RECORDS MANUAL	None available.
OPERATIONAL PROCEDURES	Self-regulating. No operable appurtenances.
WARNING SYSTEM AND/OR COMMUNICATION FACILITIES	None.
MISCELLANEOUS	Clarence James has sounded the lake and reports it to be 24 feet at maximum depth plus 6 feet of sediment.

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

NDI ID # PA-00396
PENNDER ID # 52-4

SIZE OF DRAINAGE AREA: 2.4 square miles.

ELEVATION TOP NORMAL POOL: 1112.0 STORAGE CAPACITY: 2290 acre-feet.

ELEVATION TOP FLOOD CONTROL POOL: - STORAGE CAPACITY: -

ELEVATION MAXIMUM DESIGN POOL: - STORAGE CAPACITY: -

ELEVATION TOP DAM: 1114.0 STORAGE CAPACITY: 2760 acre-feet.

SPILLWAY DATA

CREST ELEVATION: 1112.0 feet.

TYPE: Uncontrolled, rectangular, concrete and masonry chute channel.

CREST LENGTH: 16.4 feet (actual); 12.9 feet (effective).

CHANNEL LENGTH: 48 feet.

SPILLOVER LOCATION: Near center of embankment.

NUMBER AND TYPE OF GATES: None.

OUTLET WORKS

TYPE: None.

LOCATION: -

ENTRANCE INVERTS: -

EXIT INVERTS: -

EMERGENCY DRAWDOWN FACILITIES: None.

HYDROMETEOROLOGICAL GAGES

TYPE: None.

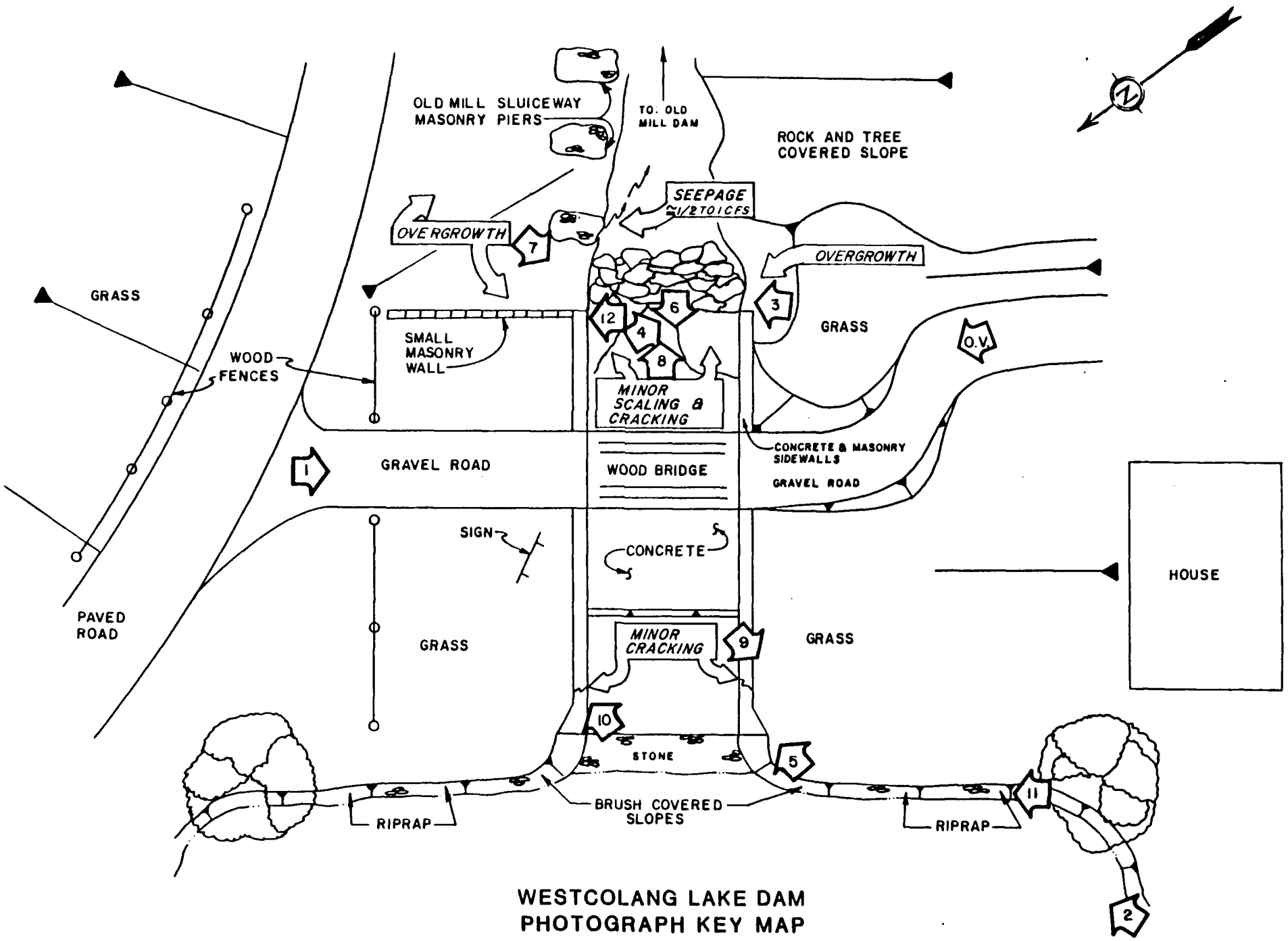
LOCATION: -

RECORDS: -

MAXIMUM NON-DAMAGING DISCHARGE: Not known.

APPENDIX C

PHOTOGRAPHS



WESTCOLANG LAKE DAM
PHOTOGRAPH KEY MAP

1

2

3

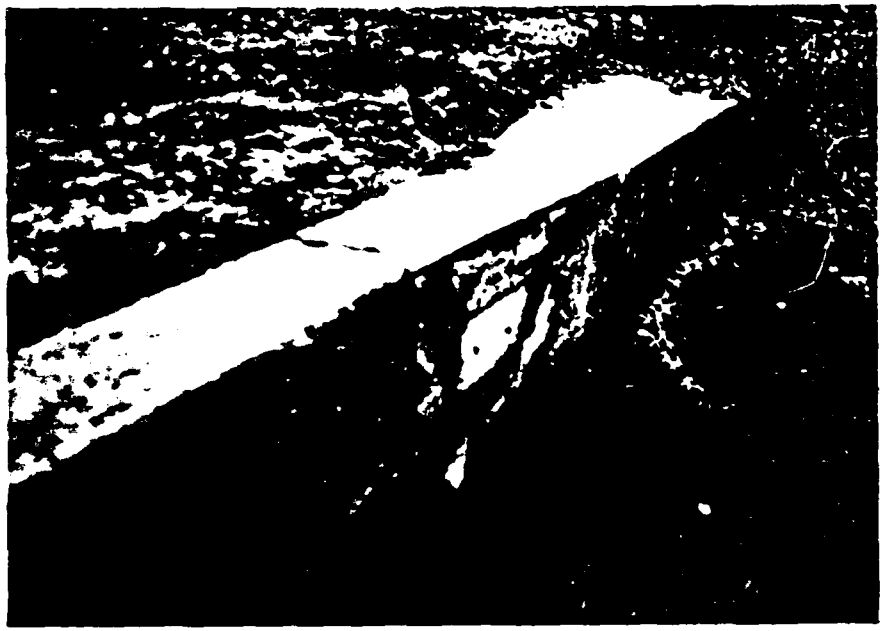
4

5

6

7

8



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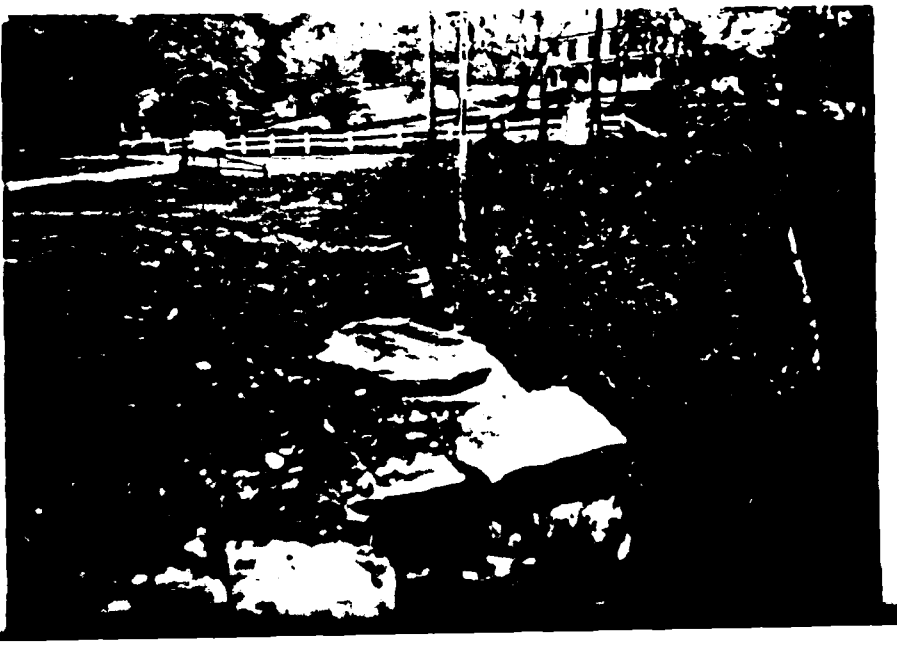

APPENDIX D

HYDROLOGIC AND HYDRAULIC ANALYSES

PREFACE

The modified HEC-1 program is capable of performing two basic types of hydrologic analyses: 1) the evaluation of the overtopping potential of the dam; and 2) the estimation of the downstream hydrologic-hydraulic consequences resulting from assumed structural failures of the dam. Briefly, the computational procedures typically used in the dam overtopping analysis are as follows:

a. Development of an inflow hydrograph(s) to the reservoir.

b. Routing of the inflow hydrograph(s) through the reservoir to determine if the event(s) analyzed would overtop the dam.

c. Routing of the outflow hydrograph(s) from the reservoir to desired downstream locations. The results provide the peak discharge(s), time(s) of occurrence the peak discharge(s), and the maximum stage(s) of each routed hydrograph at the downstream end of each reach.

The evaluation of the hydrologic-hydraulic consequences resulting from an assumed structural failure (breach) of the dam is typically performed as shown below.

a. Development of an inflow hydrograph(s) to the reservoir.

b. Routing of the inflow hydrograph(s) through the reservoir.

c. Development of a failure hydrograph(s) based on specified breach criteria and normal reservoir outflow.

d. Routing of the failure hydrograph(s) to desired downstream locations. The results provide estimates of the peak discharge(s), time(s) to peak and maximum water surface elevation(s) of failure hydrograph(s) for each location.

HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: WESTCOLANG LAKE DAM

PROBABLE MAXIMUM PRECIPITATION (PMP) = 21.0 INCHES/24 HOURS (1)

STATION	1	2	3
STATION DESCRIPTION	WESTCOLANG LAKE DAM		
DRAINAGE AREA (SQUARE MILES)	2.4		
CUMULATIVE DRAINAGE AREA (SQUARE MILES)	-		
ADJUSTMENT OF PMF FOR DRAINAGE AREA LOCATION (%) (1)	Zone 1		
6 HOURS	111		
12 HOURS	123		
24 HOURS	133		
48 HOURS	142		
72 HOURS	-		
SNYDER HYDROGRAPH PARAMETERS			
ZONE (2)	1		
C_p (3)	0.45		
C_t (3)	1.23		
L' (MILES) (4)	1.1		
$t_p = C_t (L')^{0.6}$ (HOURS)	1.30		
SPILLWAY DATA			
CREST LENGTH (FEET)	12.9		
FREEBOARD (FEET)	2.0		

(1) HYDROMETEOROLOGICAL REPORT 33, U.S. ARMY CORPS OF ENGINEERS, 1956.
(2) HYDROLOGIC ZONE DEFINED BY CORPS OF ENGINEERS, BALTIMORE DISTRICT, FOR DETERMINATION OF SNYDER COEFFICIENTS (C_p AND C_t).
(3) SNYDER COEFFICIENTS
(4) L' = LENGTH OF LONGEST WATERCOURSE FROM RESERVOIR INLET TO BASIN DIVIDE.
(5) SEE SHEETS 6, 7, OF 13.

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJS DATE 2-19-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3-10-81 SHEET NO. 1 OF 14

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DAM STATISTICS

HEIGHT OF DAM = 8 FT (FIELD MEASURED: TOP OF DAM TO BASE OF SPILLWAY (SEE SKETCH, SHEET 6); "TOP OF DAM" HERE AND ON ALL SUBSEQUENT CALCULATION SHEETS REFERS TO THE LOW AREA IN THE EMBANKMENT CREST.)

NORMAL POOL STORAGE CAPACITY = 747×10^6 GAL = 2290 AC-FT (SEE NOTE 1)
MAXIMUM POOL STORAGE CAPACITY (@ TOP OF DAM) = 2760 AC-FT (SHEET 4)
EFFECTIVE MAXIMUM STORAGE CAPACITY = 1500 AC-FT
(THE "EFFECTIVE MAXIMUM STORAGE" IS DEFINED AS THE MAXIMUM VOLUME OF WATER IMPOUNDED BY THE DAM ITSELF, OR BETWEEN THE TOP OF THE DAM (EL 1114.0) AND THE TOE OF THE EMBANKMENT (= EL. 1106; SEE SHEETS 4 AND 6). THE VOLUME BELOW THIS LEVEL IS CONSIDERED PART OF THE ORIGINAL NATURAL LAKE.)

DRAINAGE AREA = 2.4 SQ. MI. (PLANIMETERED ON USGS TOPO QUADS - NARROWSBURG AND ROWLAND, PA)

ELEVATIONS:

TOP OF DAM (DESIGN)	= UNKNOWN	
TOP OF DAM (FIELD)	= 1114.0	
NORMAL POOL	= 1112.0	(FIG. 1)
SPILLWAY CREST	= 1112.0	
UPSTREAM INLET INVERT (DESIGN)	} N/A; NO OUTLET CONDUIT OBSERVED.	
DOWNSTREAM OUTLET INVERT (DESIGN)		
DOWNSTREAM OUTLET INVERT (FIELD)		
STREAMBED AT DAM CENTERLINE	= UNKNOWN	

NOTE 1: OBTAINED FROM WATER RESOURCES INVENTORY FORM, WESTCOLANG LAKE DAM, FOUND IN DEWNDER FILES.

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJS DATE 2-19-81 PROJ. NO 80-238-396

CHKD. BY DLB DATE 3-10-81 SHEET NO. 2 OF 14

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DAM CLASSIFICATION

DAM SIZE: INTERMEDIATE (REF 1, TABLE 1)

HAZARD CLASSIFICATION: HIGH (FIELD OBSERVATION)

REQUIRED SDF: PMF (REF 1, TABLE 3)

HYDROGRAPH PARAMETERS

$C_p = 0.45$

$C_t = 1.23$

(SUPPLIED BY C.O.E., ZONE 1, DELAWARE RIVER BASIN)

L' = LENGTH OF LONGEST WATERCOURSE FROM RESERVOIR INLET TO BASIN DIVIDE = 1.1 MILES.

(USGS TOPO QUADS: NARROWSBURG AND ROWLAND, PA.)

NOTE: SINCE THE BASIN CENTROID OCCURS WITHIN THE RESERVOIR, THE SNYDER STANDARD LAG IS APPROXIMATED AS $t_p = C_t (L')^{0.6}$ HOURS [AS PER C.O.E.]. HYDROGRAPH VARIABLES USED HERE ARE DEFINED IN REF. 2, IN SECTION ENTITLED "SNYDER SYNTHETIC UNIT HYDROGRAPH."

$$t_p = C_t (L')^{0.6}$$
$$= 1.23 (1.1)^{0.6}$$
$$= 1.30 \text{ HOURS}$$

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY JTJ DATE 2-27-81 PROJ NO 80-238-196

CHKD BY [illegible] DATE [illegible] SHEET NO 3 OF 7

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RESERVOIR CAPACITY

RESERVOIR SURFACE AREAS:

SURFACE AREA (SA) @ NORMAL POOL (EL 1112.0) = 500 ACRES

SA @ EL. 1120 = 540 ACRES

(PLANIMETERED ON USGS 7.5 MIN. QUAD. SHEETS OF ARROLLTOWN AND ROWLAND, PA)

IT IS ASSUMED THAT THE MODIFIED PRISMOIDAL RELATIONSHIP ADEQUATELY MODELS THE RESERVOIR SURFACE AREA - STORAGE RELATIONSHIP:

(USACE EM 1110-2-1420)

$$\Delta V_{1-2} = \frac{h}{3}\left(A_1 + A_2 + \sqrt{A_1 A_2}\right)$$

WHERE ΔV_{1-2} = INCREMENTAL VOLUME BETWEEN ELEVATIONS 1 & 2, IN AC-FT,
h = ELEVATION 1 - ELEVATION 2, IN FT,
A_1 = SA @ ELEVATION 1, IN ACRES,
A_2 = SA @ ELEVATION 2, IN ACRES.

THE MINIMUM RESERVOIR ELEVATION IS ASSUMED TO BE AT ELEVATION 1088.0, CORRESPONDING TO A MAXIMUM RESERVOIR DEPTH (AT NORMAL POOL) OF ABOUT 24 FEET (ACCORDING TO SOUNDINGS MADE BY LOCAL RESIDENT; SEE APPENDIX B, p. 4 OF 5.)

ALSO, IT IS ASSUMED THAT RESERVOIR SURFACE AREAS AT ELEVATIONS BETWEEN 1088.0 AND 1112.0 AND BETWEEN 1112.0 AND 1120.0 CAN BE LINEARLY INTERPOLATED.

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJL DATE 24-81 PROJ NO 80-238-396

CHKD BY [illegible] DATE 3 [illegible] SHEET NO 4 OF 14

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ELEVATION - STORAGE TABLE:

RESERVOIR ELEVATION (FT)	A (ACRES)	ΔV_{1-2} (AC-FT)	INITIAL CALCULATED TOTAL VOLUME (AC-FT)	ADJUSTED ** FINAL VOLUME (AC-FT)
3980	0	0	0	0
3994	10 *	30	100	100
4030	90 *	441	541	530
4056	50 *	745	1286	1260
4112 (NORMAL POOL)	200	1046	2332	2290
4114 (TOP OF DAM)	233 *	423	2755	2760
4130	275 *	468	3223	3220
4140	288 *	513	3736	3740
4200	290	558	4294	4290

* - BY LINEAR INTERPOLATION

** - BELOW NORMAL POOL

ADJUSTED FINAL VOLUME = INITIAL CALC VOL. $\times \left(\frac{\text{KNOWN VOL @ NORMAL POOL}}{\text{INITIAL CALC VOL @ NORMAL POOL}} \right)$

$= \text{INITIAL CALC VOL} \times \left(\frac{2293}{2333} \right)$

$= 0.983 \times \text{INITIAL CALC VOLUME}$

(VALUES ROUNDED TO NEAREST 10 AC-FT)

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJS DATE 2-20-81 PROJ. NO. 80-238-396

CHKD. BY DLA DATE 3-10-81 SHEET NO. 5 OF 14

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PMP CALCULATIONS

- APPROXIMATE RAINFALL INDEX = 21 INCHES
  (CORRESPONDING TO A DURATION OF 24 HOURS AND A DRAINAGE AREA OF 200 SQUARE MILES.)

(REF. 3, FIG. 1)

- DEPTH - AREA - DURATION ZONE 1 (REF 3, FIG. 1)

- ASSUME DATA CORRESPONDING TO A 10-SQUARE MILE AREA MAY BE APPLIED TO THIS 2.4 SQUARE MILE BASIN:

DURATION (HRS)	PERCENT OF INDEX RAINFALL
6	111
12	123
24	133
48	142

(REF 3, FIG 3)

HOP BROOK FACTOR (ADJUSTMENT FOR BASIN SHAPE AND FOR THE LESSER LIKELIHOOD OF A SEVERE STORM CENTERING OVER A SMALL BASIN) FOR A DRAINAGE AREA OF 2.4 SQUARE MILES IS 0.80.

(REF. 4, p. 48)

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJS DATE 2-23-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3-10-81 SHEET NO. 6 OF 14

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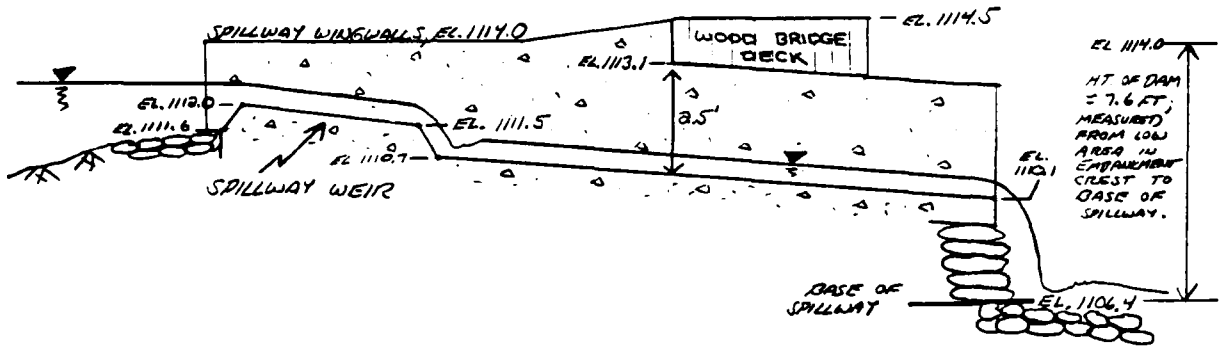
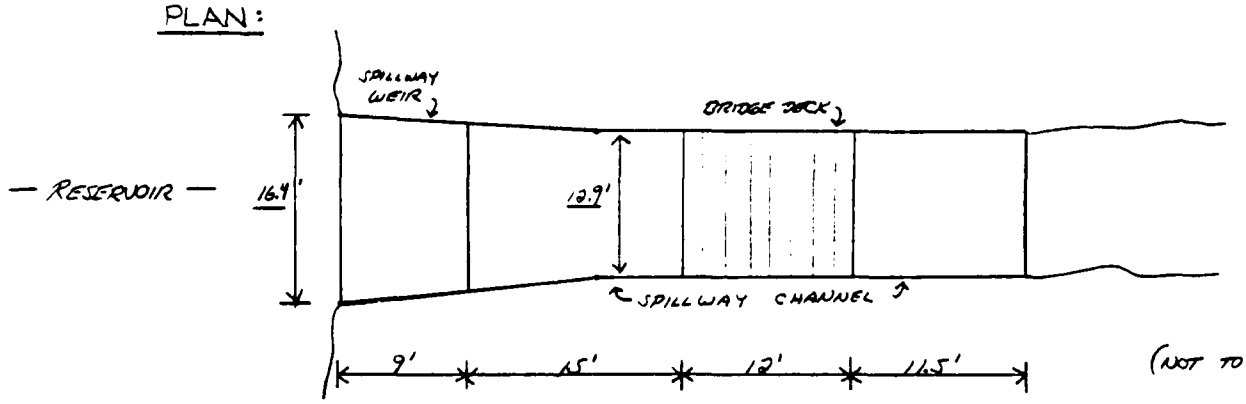
SPILLWAY CAPACITY

PROFILE:



(NOT TO SCALE)

PLAN:



(NOT TO SCALE)

(SKETCHES BASED ON FIELD MEASUREMENTS & OBSERVATIONS)

THE SPILLWAY CONSISTS OF AN UNCONTROLLED, RECTANGULAR-SHAPED CONCRETE AND MASONRY CHUTE CHANNEL, WITH DISCHARGES REGULATED BY A CONCRETE BROAD-CRESTED WEIR.

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJS DATE 2-23-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3-10-81 SHEET NO. 7 OF 14

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DISCHARGE OVER THE WEIR CAN BE ESTIMATED BY THE EQUATION

$$Q = CLH^{3/2}$$ (REF 5, p. 5-23)

WHERE Q = DISCHARGE OVER THE WEIR, IN CFS,
C = COEFFICIENT OF DISCHARGE,
L = WEIR LENGTH, IN FT,
H = HEAD, IN FT.

THE EFFECTIVE WEIR LENGTH IS ASSUMED TO BE 12.0 FT, WHICH IS THE MINIMUM WIDTH OF THE SPILLWAY CHANNEL. THE DISCHARGE COEFFICIENT IS ON THE ORDER OF 3.0 (REF 5, TABLE 5-5). ALSO, IT IS ASSUMED THAT THERE ARE NO SIGNIFICANT APPROACH LOSSES HERE.

SPILLWAY RATING TABLE:

	RESERVOIR ELEVATION (FT)	H (FT)	Q* (CFS)	RESERVOIR ELEVATION (FT)	H (FT)	Q* (CFS)
	1112.0	0	0	1116.0	4.0	310
	1113.0	1.0	40	1117.0	5.0	430
(TOP OF DAM)	1114.0	2.0	110	1118.0	6.0	570
	1114.5	2.5	150	1119.0	7.0	720
	1115.0	3.0	200	1120.0	8.0	880

* → $Q = CLH^{3/2} = (3.0)(12.9)H^{3/2} = 38.7H^{3/2}$ (TO NEAREST 10 CFS)

(NOTE: FOR THE RANGE OF ELEVATIONS CONSIDERED HERE, THE CONTROL WILL BE AT THE SPILLWAY WEIR, AND PRESSURE FLOW AT THE BRIDGE SECTION WILL NOT DICTATE TOTAL SPILLWAY OUTFLOWS.)

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJS DATE 2-23-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3-10-81 SHEET NO. 8 OF 14

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EMBANKMENT RATING CURVE

ASSUME THAT THE EMBANKMENT BEHAVES ESSENTIALLY AS A BROAD-CRESTED WEIR WHEN OVERTOPPING OCCURS. THUS, THE DISCHARGE CAN BE ESTIMATED BY THE RELATIONSHIP

$$Q = CLH^{3/2} \qquad \text{(REF 5, p. 5-23)}$$

WHERE Q = DISCHARGE OVER EMBANKMENT, IN CFS,
L = LENGTH OF EMBANKMENT OVERTOPPED, IN FT,
H = HEAD, IN FT; IN THIS CASE IT IS THE AVERAGE "FLOW AREA WEIGHTED" HEAD ABOVE THE CREST;
C = COEFFICIENT OF DISCHARGE, DEPENDENT UPON THE HEAD AND THE WEIR BREADTH.

LENGTH OF EMBANKMENT INUNDATED VS. RESERVOIR ELEVATION:

RESERVOIR ELEVATION (FT)	LENGTH (FT)	RESERVOIR ELEVATION (FT)	LENGTH (FT)
1114.00	0	1115.5	260
1114.01	25	1116.0	300
1114.1	60	1117.0	375
1114.2	80	1118.0	455
1114.3	150	1119.0	535
1114.5	200	1120.0	610
1115.0	225		

(FROM FIELD SURVEY AND USGS TOPO QUAD: NARROWSBURG, PA)

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJS DATE 2-24-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3-10-81 SHEET NO. 9 OF 14

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ASSUME THAT INCREMENTAL DISCHARGES OVER THE EMBANKMENT FOR SUCCESSIVE RESERVOIR ELEVATIONS ARE APPROXIMATELY TRAPEZOIDAL IN CROSS-SECTIONAL FLOW AREA. THEN ANY INCREMENTAL AREA OF FLOW CAN BE ESTIMATED AS $H_i [(L_1+L_2)/2]$, WHERE L_1 = LENGTH OF OVERTOPPED EMBANKMENT AT HIGHER ELEVATION, L_2 = LENGTH AT LOWER ELEVATION, H_i = DIFFERENCE IN ELEVATIONS. THUS, THE TOTAL AVERAGE "FLOW AREA WEIGHTED" HEAD CAN BE ESTIMATED AS

$H_w = (\text{TOTAL FLOW AREA}/L_1)$.

EMBANKMENT RATING CURVE

RESERVOIR ELEVATION (FT)	L_1 (FT)	L_2 (FT)	INCREMENTAL HEAD, H_i (FT)	INCREMENTAL FLOW AREA, A_i (FT²) ①	TOTAL FLOW AREA, A_T (FT²)	WEIGHTED HEAD, H_w (FT) ②	H_w/l ③	C ④	Q ⑤ (CFS)
1114.00	0	—	—	—	—	—	—	—	—
1114.01	25	0	—	—	—	—	—	—	0
1114.1	60	25	0.1	4	4	0.07	0.001	2.91	0
1114.2	80	60	0.1	7	11	0.14	0.003	2.95	10
1114.3	150	80	0.1	12	23	0.15	0.003	2.95	30
1114.5	200	150	0.2	35	58	0.29	0.01	2.99	90
1115.0	225	200	0.5	106	164	0.73	0.01	3.03	430
1115.5	260	225	0.5	121	285	1.1	0.02	3.04	910
1116.0	300	260	0.5	140	425	1.4	0.03	3.04	1510
1117.0	375	300	1.0	338	763	2.0	0.04	3.04	3220
1118.0	455	375	1.0	415	1178	2.6	0.05	3.05	5820
1119.0	535	455	1.0	495	1673	3.1	0.07	3.05	8910
1120.0	610	535	1.0	573	2246	3.7	0.07	3.05	13,240

① $A_i = H_i [(L_1+L_2)/2]$
② $H_w = A_T/L_1$
③ l = BREADTH OF CREST = 516 FT (AVG VALUE)
④ $C = f(H_w, l)$; FROM REF 12, FIG. 24.
⑤ $Q = CL_1 H_w^{3/2}$ (TO NEAREST 10 CFS)

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJS DATE 2-24-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3-10-81 SHEET NO. 10 OF 14

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TOTAL FACILITY RATING TABLE

$Q_{TOTAL} = Q_{SPILLWAY} + Q_{EMBANKMENT}$

	RESERVOIR ELEVATION (FT)	① $Q_{SPILLWAY}$ (CFS)	② $Q_{EMBANKMENT}$ (CFS)	Q_{TOTAL} (CFS)
	1112.0	0	–	0
	1113.0	40	–	40
(TOP OF DAM)	1114.0	110	0	110
	1114.2	130*	10	140
	1114.3	130*	30	160
	1114.5	150	90	240
	1115.0	200	430	630
	1115.5	260*	910	1170
	1116.0	310	1510	1820
	1117.0	430	3220	3650
	1118.0	570	5820	6390
	1119.0	720	8910	9630
	1120.0	880	13,240	14,120

* – BY LINEAR INTERPOLATION
① FROM SHEET 7.
② FROM SHEET 9.

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJS DATE 3-5-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3-10-81 SHEET NO. 11 OF 14

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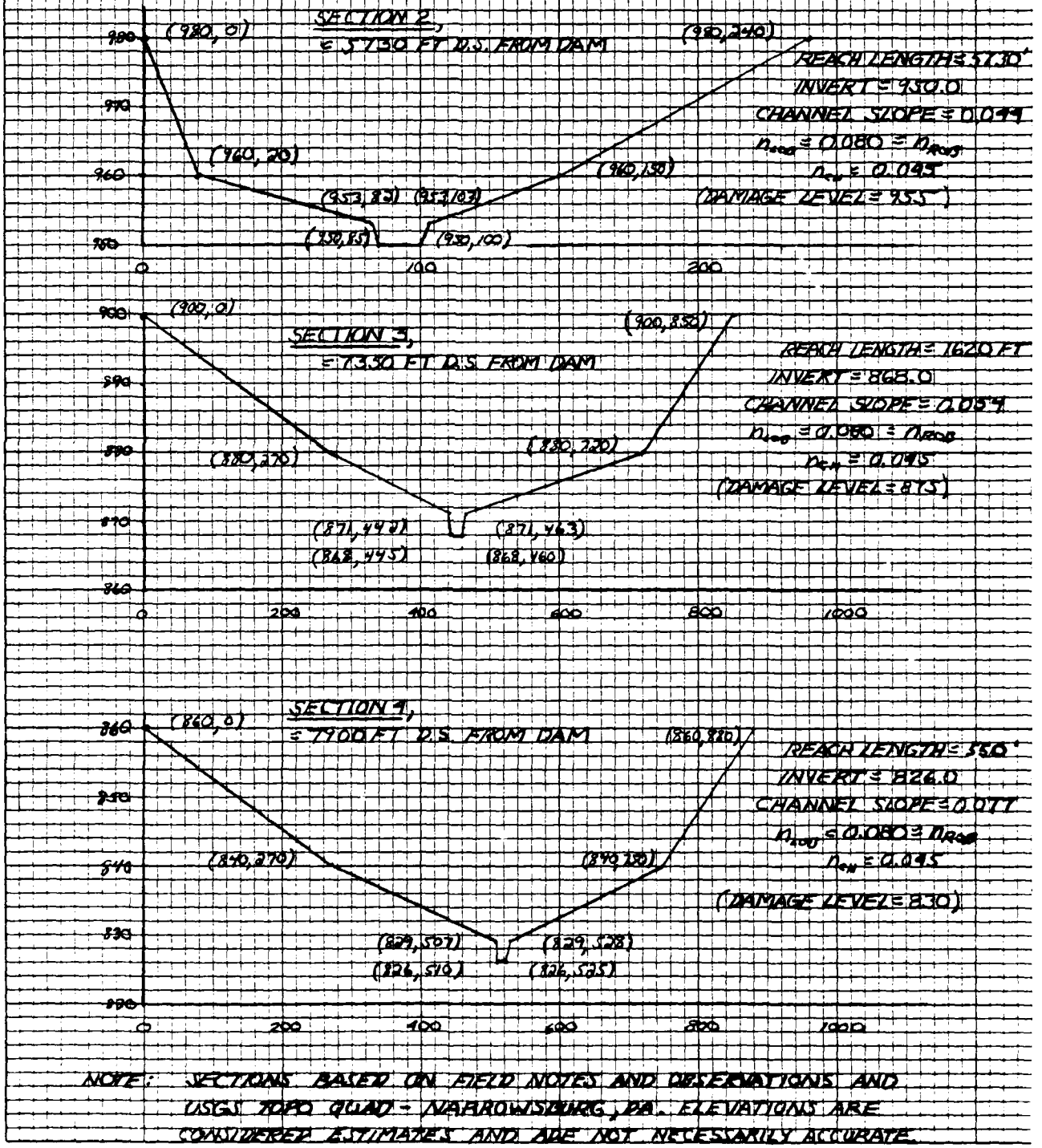
DOWNSTREAM ROUTING SECTIONS



NOTE: SECTIONS BASED ON FIELD NOTES AND OBSERVATIONS AND USGS TOPO QUAD - NARROWSBURG, PA. ELEVATIONS ARE CONSIDERED ESTIMATES AND ARE NOT NECESSARILY ACCURATE.

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY JJS DATE 3-5-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3-10-81 SHEET NO. 12 OF 14

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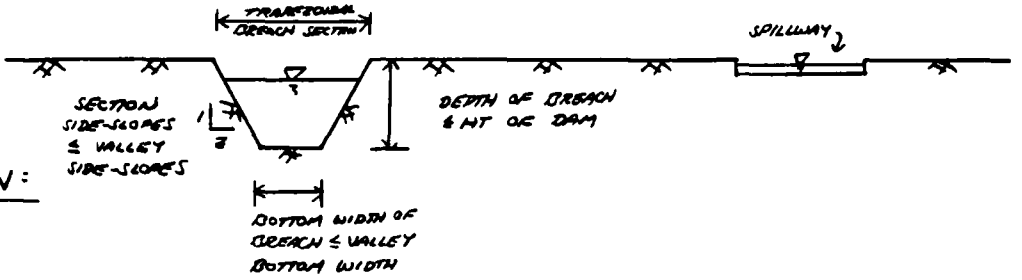
BREACH ASSUMPTIONS

TYPICAL BREACH SECTION:



HEC-1 DAM BREACHING ANALYSIS INPUT:

THE PORTION OF THE DAM WHICH WOULD MOST LIKELY FAIL FROM OVERTOPPING IS THE AREA AROUND THE SPILLWAY STRUCTURE ITSELF, WHERE THE DOWNSTREAM FACE OF THE EMBANKMENT IS STEEPEST, AND WHERE THE GREATEST DEPTH OF BREACH WOULD OCCUR.

BREACH DIMENSIONS: (MAX. LIKELY FAILURE SECTION)

DEPTH OF BREACH = 7.6 FT (HT OF DAM; SEE SHEET 6)
ASSUMED BOTTOM WIDTH OF BREACH = 30 FT (FIELD OBSERVATION)
ASSUMED TOP WIDTH OF BREACH = 50 FT,
∴ SECTION SIDE-SLOPES = 2H:1V

FOUR FAILURE TIMES (TOTAL TIME FOR BREACH SECTION TO REACH ITS FINAL DIMENSIONS) WILL BE ANALYZED:

PLAN	FAILURE TIME (HRS)	ELEVATION AT WHICH BREACHING COMMENCES (FT)
①	12	1114.0 - (TOP OF DAM)
②	4	1115.0 - (1.0 FOOT ABOVE
③	2	1115.0 TOP OF DAM)
④	1	1115.0

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM
BY JJS DATE 7-10-81 PROJ. NO. 80-238-396
CHKD. BY DLB DATE 3-10-81 SHEET NO. 13 OF 14

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HEC-1 DAM BREACHING ANALYSIS OUTPUT SUMMARY

RESERVOIR DATA: (UNDER ½ PMF CONDITIONS)

PLAN*	FAILURE TIME (HRS)	ACTUAL MAX FLOW DURING FAIL TIME (CFS)	CORRESPONDING TIME OF PEAK (HRS)	INTERPOLATED OR HEC-1 ROUTED MAX FLOW DURING FAIL TIME (CFS)	CORRESPONDING TIME OF PEAK (HRS)	ACTUAL PEAK FLOW THROUGH DAM (CFS)	CORRESPONDING TIME OF PEAK (HRS)	TIME OF INITIAL BREACH (HRS)
①	12	1656	43.75	1656	43.75	1656	43.75	40.75
②	4	2493	45.75	2493	45.75	2493	45.75	41.75
③	2	3295	43.75	3295	43.75	3295	43.75	41.75
④	1	3519	42.75	3519	42.75	3519	42.75	41.75

* - SEE SHEET 12.

SUBJECT DAM SAFETY INSPECTION
WESTSOLANG LAKE DAM

BY DJS DATE 3-10-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3-10-81 SHEET NO. 14 OF 14

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DOWNSTREAM ROUTING DATA: (0.50 PMF CONDITIONS)

PLAN	FAILURE TIME (HRS)	PEAK FLOW * (CFS)	CORRESPONDING * WATER SURFACE ELEVATION (FT)	NON-BREACH * PEAK WATER SURFACE LEVEL (FT)	ELEVATION DIFFERENCE (FT)	APPROXIMATE ** DAMAGE LEVEL OF STRUCTURES (FT)
OUTPUT @ SECTION 2; 5730 FT D.S. FROM DAM						
①	12	1656	954.8	954.3	+0.5	955
②	4	2464	955.7	954.3	+1.4	
③	2	3180	956.4	954.3	+2.1	
④	1	3443	956.6	954.3	+2.3	
OUTPUT @ SECTION 3; 7350 FT D.S. FROM DAM						
①	12	1656	872.2	871.9	+0.3	875
②	4	2454	873.1	871.9	+1.2	
③	2	3201	873.5	871.9	+1.6	
④	1	3448	873.7	871.9	+1.8	
OUTPUT @ SECTION 4; 7900 FT D.S. FROM DAM						
①	12	1655	830.0	829.7	+0.3	830
②	4	2451	830.7	829.7	+1.0	
③	2	3204	831.3	829.7	+1.6	
④	1	3439	831.5	829.7	+1.8	

* - FROM SUMMARY INPUT/OUTPUT SHEETS, SHEET I.

** - FROM SHEET 11.

OVERTOPPING ANALYSIS

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM
BY RTS DATE 7-11-81 PROJ. NO. 80-238-396
CHKD. BY DLG DATE 7-11-81 SHEET NO. 4 OF 7

SUMMARY INPUT/OUTPUT SHEETS

DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM **** OVERTOPPING ANALYSIS ****
15-MINUTE TIME STEP AND 72-HOUR STORM DURATION

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	15	0	0	0	0	0	0	0
			JOPER	NWT	LKOPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= .10 .20 .50 1.00

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

SUB-AREA RUNOFF COMPUTATION

RESERVOIR INFLOW HYDROGRAPHS

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

HYDROGRAPH DATA

IHYDG	ITHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.40	0.00	2.40	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	21.00	111.00	123.00	133.00	142.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

INITIAL + CONSTANT RAINFALL LOSSES AS PER C.O.E.

LOSS DATA

LKOPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

BASE FLOW PARAMETERS AS PER C.O.E.

UNIT HYDROGRAPH DATA
TP= 1.30 CP= .45 NTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 5.62 AND R= 0.26 INTERVALS

UNIT HYDROGRAPH 47 END-OF-PERIOD ORDINATES, LAG= 1.30 HOURS, CP= .45 VOL= 1.00

38.	139.	280.	418.	511.	530.	488.	432.	383.	339.
300.	266.	236.	209.	185.	164.	145.	129.	114.	101.
89.	79.	70.	62.	55.	49.	43.	38.	34.	30.
27.	24.	21.	19.	16.	15.	13.	11.	10.	9.
8.	7.	6.	6.	5.	4.	4.			

	RAIN	LAGS	LOSS	CUM Q
SUB	23.86	21.47	2.38	134598.
	(606.1)	(545.)	(61.)	(3811.39)

SUBJECT DAM SAFETY INSPECTION

WESTCOLANG LAKE DAM

BY DTS DATE 7-11-81 PROJ. NO. 80-238-396

CHKD. BY DLG DATE 3-11-81 SHEET NO. 13 OF 15

GEI CONSULTANTS, INC.

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RESERVOIR INFLOWS

0.10 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	574.	186.	135.	47.	13460.
CMS	16.	11.	4.	1.	381.
INCHES		1.58	2.10	2.17	2.17
MM		38.02	53.36	55.22	55.22
AC-FT		192.	269.	278.	278.
THOUS CU M		236.	331.	343.	343.

0.20 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1148.	772.	271.	93.	26921.
CMS	33.	22.	8.	3.	762.
INCHES		2.99	4.20	4.35	4.35
MM		76.04	106.71	110.43	110.43
AC-FT		383.	537.	556.	556.
THOUS CU M		472.	663.	686.	686.

.0.50 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2869.	1931.	677.	234.	67302.
CMS	81.	55.	19.	7.	1906.
INCHES		7.48	10.50	10.87	10.87
MM		190.11	266.78	276.08	276.08
AC-FT		958.	1344.	1391.	1391.
THOUS CU M		1181.	1657.	1715.	1715.

PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	5739.	3862.	1355.	467.	134604.
CMS	163.	109.	38.	13.	3812.
INCHES		14.97	21.01	21.74	21.74
MM		380.22	533.57	552.15	552.15
AC-FT		1915.	2687.	2781.	2781.
THOUS CU M		2362.	3315.	3430.	3430.

HYDROGRAPH ROUTING

ROUTE THROUGH RESERVOIR

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
101	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	ISK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	2290.	-1

STAGE	1112.00	1113.00	1114.00	1114.20	1114.30	1114.50	1115.00	1115.50	1116.00
	1118.00	1119.00	1120.00						
FLOW	0.00	40.00	110.00	140.00	160.00	240.00	630.00	1170.00	1820.00
	6390.00	9630.00	14120.00						
CAPACITY=	0.	100.	530.	1260.	2290.	2760.	3220.	3740.	4290.
ELEVATION=	1088.	1094.	1100.	1106.	1112.	1114.	1116.	1118.	1120.

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
1112.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
1114.0	0.0	0.0	0.

SUBJECT DAM SAFETY INSPECTION

WESTCOLANG LAKE DAM

BY DJS DATE 7-11-81 PROJ. NO. 80-238-396

CHKD. BY DAS DATE 3-11-81 SHEET NO. C OF Z

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RESERVOIR OUTFLOWS

0.10 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	41.	41.	38.	16.	4712.
CMS	1.	1.	1.	0.	133.
INCHES		.16	.58	.76	.76
MM		4.03	14.85	19.33	19.33
AC-FT		20.	75.	97.	97.
THOUS CU M		25.	92.	120.	120.

0.20 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	109.	108.	95.	40.	11449.
CMS	3.	3.	3.	1.	324.
INCHES		.42	1.47	1.85	1.85
MM		10.61	37.27	46.96	46.96
AC-FT		53.	188.	237.	237.
THOUS CU M		66.	232.	292.	292.

0.50 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1395.	1103.	458.	167.	48020.
CMS	39.	31.	13.	5.	1360.
INCHES		4.27	7.10	7.76	7.76
MM		108.58	180.37	196.98	196.98
AC-FT		547.	908.	992.	992.
THOUS CU M		675.	1121.	1224.	1224.

PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4118.	3100.	1136.	397.	114442.
CMS	117.	88.	32.	11.	3241.
INCHES		12.02	17.81	18.48	18.48
MM		305.23	447.42	469.45	469.45
AC-FT		1537.	2254.	2364.	2364.
THOUS CU M		1896.	2780.	2917.	2917.

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1112.00	1112.00	1114.00
STORAGE	7290.	2290.	2760.
OUTFLOW	0.	0.	110.

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	1113.02	0.00	2530.	41.	0.00	48.50	0.00
.20	1113.99	0.00	2757.	109.	0.00	47.75	0.00
.50	1115.67	1.67	3145.	1395.	22.50	43.75	0.00
1.00	1117.17	3.17	3524.	4118.	26.75	42.75	0.00

(OVERTOPPING OCCURS @ ≈ 0.20 PMF)

SUBJECT DAM SAFETY INSPECTION

BY JJS DATE 7-11-91

CHKD BY DAE DATE 7-11-91

WESTCOLANG LAKE DAM

PROJ NO 90-378-396

SHEET NO 2 OF 2

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BREACH ANALYSIS

(INPUT SAME AS FOR OVERTOPPING ANALYSIS, WITH THE ADDITION OF THE BREACH CRITERIA GIVEN HERE.)

DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM **** BREACHING ANALYSIS ****
15-MINUTE TIME STEP AND 72-HOUR STORM DURATION

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	15	0	0	0	0	0	0	0
			JOPER	NWT	LRUPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 3 NRTIO= 1 LRTIO= 1

RTIOS= .50

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

DAM DATA

TOPEL	COOD	EXPD	DAMWID
1114.0	0.0	0.0	0.

PLAN

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
20.	2.00	1106.40	12.00	1112.00	1114.00

STATION 101. PLAN 1. RATIO 1

BEGIN DAM FAILURE AT 40.75 HOURS

(1) PEAK OUTFLOW IS 1656. AT TIME 43.75 HOURS

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
20.	2.00	1106.40	4.00	1112.00	1115.00

STATION 101. PLAN 2. RATIO 1

BEGIN DAM FAILURE AT 41.75 HOURS

(2) PEAK OUTFLOW IS 2493. AT TIME 45.75 HOURS

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
20.	2.00	1106.40	2.00	1112.00	1115.00

STATION 101. PLAN 1. RATIO 1

BEGIN DAM FAILURE AT 41.75 HOURS

(3) PEAK OUTFLOW IS 3295. AT TIME 43.75 HOURS

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
20.	2.00	1106.40	1.00	1112.00	1115.00

STATION 101. PLAN 2. RATIO 1

BEGIN DAM FAILURE AT 41.75 HOURS

(4) PEAK OUTFLOW IS 3519. AT TIME 43.75 HOURS

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJJ DATE 3-11-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3·11·81 SHEET NO. E OF I

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PLAN ④

THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF .021 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF .250 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	- COMPUTED BREACH HYDROGRAPH (CFS)	= ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
41.750	0.000	643.	643.	0.	0.	0.
41.771	.021	690.	746.	-55.	-55.	-0.
41.792	.042	737.	781.	-44.	-99.	-0.
41.813	.063	785.	818.	-34.	-133.	-0.
41.833	.083	832.	857.	-25.	-158.	-0.
41.854	.104	879.	896.	-18.	-176.	-0.
41.875	.125	926.	937.	-12.	-187.	-0.
41.896	.146	973.	980.	-7.	-194.	-0.
41.917	.167	1020.	1023.	-3.	-197.	-0.
41.938	.188	1067.	1068.	-1.	-198.	-0.
41.958	.208	1114.	1113.	1.	-197.	-0.
41.979	.229	1161.	1160.	1.	-196.	-0.
42.000	.250	1208.	1208.	0.	-196.	-0.
42.021	.271	1263.	1257.	6.	-191.	-0.
42.042	.292	1318.	1308.	10.	-181.	-0.
42.063	.313	1372.	1359.	13.	-167.	-0.
42.083	.333	1427.	1411.	16.	-151.	-0.
42.104	.354	1481.	1464.	17.	-134.	-0.
42.125	.375	1536.	1518.	18.	-116.	-0.
42.146	.396	1591.	1574.	17.	-99.	-0.
42.167	.417	1645.	1630.	16.	-84.	-0.
42.188	.437	1700.	1687.	13.	-71.	-0.
42.208	.458	1754.	1745.	10.	-61.	-0.
42.229	.479	1809.	1804.	5.	-56.	-0.
42.250	.500	1864.	1864.	0.	-56.	-0.
42.271	.521	1929.	1924.	4.	-52.	-0.
42.292	.542	1994.	1986.	8.	-44.	-0.
42.313	.562	2059.	2048.	11.	-33.	-0.
42.333	.583	2124.	2112.	12.	-21.	-0.
42.354	.604	2189.	2176.	14.	-7.	-0.
42.375	.625	2254.	2240.	14.	7.	0.
42.396	.646	2319.	2306.	13.	20.	0.
42.417	.667	2384.	2372.	12.	32.	0.
42.438	.687	2449.	2439.	10.	42.	0.
42.458	.708	2515.	2507.	7.	49.	0.
42.479	.729	2580.	2576.	4.	53.	0.
42.500	.750	2645.	2645.	0.	53.	0.
42.521	.771	2718.	2715.	3.	57.	0.
42.542	.792	2790.	2785.	6.	62.	0.
42.563	.812	2863.	2856.	7.	69.	0.
42.583	.833	2936.	2928.	9.	78.	0.
42.604	.854	3009.	3000.	9.	87.	0.
42.625	.875	3082.	3072.	10.	97.	0.
42.646	.896	3155.	3146.	9.	106.	0.
42.667	.917	3228.	3219.	8.	114.	0.
42.688	.937	3301.	3294.	7.	121.	0.
42.708	.958	3373.	3368.	5.	126.	0.
42.729	.979	3446.	3444.	3.	129.	0.
42.750	1.000	3519.	3519.	0.	129.	0.

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM

BY DJS DATE 3-11-81 PROJ. NO. 80-238-396

CHKD. BY DLB DATE 3-11-81 SHEET NO. E OF I

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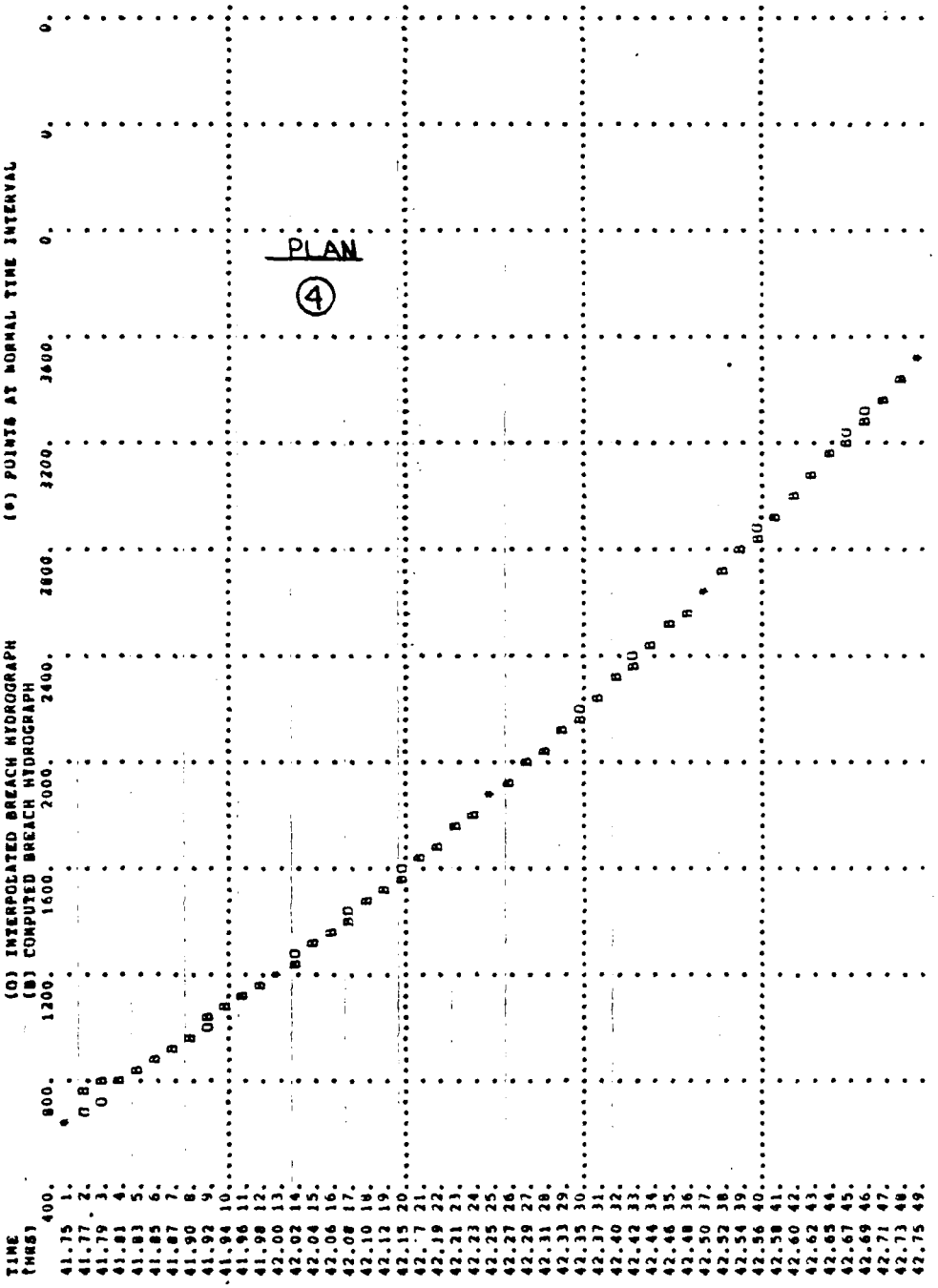

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HYDROGRAPH ROUTING

ROUTE FROM DAM TO SECTION 2, 5730 FT D.S. FROM DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
102	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0800	.0450	.0800	950.0	980.0	5730.	.04400

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00, 980.00, 20.00, 960.00, 82.00, 953.00, 85.00, 950.00, 100.00, 950.00, 103.00, 953.00, 150.00, 960.00, 240.00, 980.00

STORAGE	0.00	3.44	7.57	14.99	27.52	45.16	67.91	95.03	124.13
	187.75	222.27	258.59	296.71	336.64	378.37	421.90	467.24	514.39
OUTFLOW	0.00	221.51	721.73	1627.27	3064.33	5177.12	8089.59	12107.72	17108.31
	29666.52	37218.84	45626.50	54898.84	65047.44	76085.51	88027.42	100888.42	114684.43
STAGE	950.00	951.58	953.16	954.74	956.32	957.89	959.47	961.05	962.63
	965.79	967.37	968.95	970.53	972.11	973.68	975.26	976.84	978.42
FLOW	0.00	221.51	721.73	1627.27	3064.33	5177.12	8089.59	12107.72	17108.31
	29666.52	37218.84	45626.50	54898.84	65047.44	76085.51	88027.42	100888.42	114684.43

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

HYDROGRAPH ROUTING

ROUTE FROM SECTION 2 TO SECTION 3, 7350 FT D.S. FROM DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
203	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

SUBJECT DAM SAFETY INSPECTION

WESTCOLANG LAKE DAM

BY RTS DATE 7-11-81 PROJ. NO. 80-278-396

CHKD. BY PLA DATE 3-11-81 SHEET NO. 6 OF 7

CONSULTANTS, INC.
Engineers • Geologists • Planners
Environmental Specialists

SUBJECT DAM SAFETY INSPECTION
WESTCOLANG LAKE DAM
BY JJS DATE 3-11-81 PROJ. NO. 80-278-396
CHKD. BY DLS DATE 3-11-81 SHEET NO. 4 OF 7

GEI CONSULTANTS, INC
Engineers • Geologists • Planners
Environmental Specialists

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0800	.0450	.0800	868.0	900.0	1620.	.05400

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
0.00 900.00 270.00 880.00 442.00 871.00 445.00 868.00 460.00 868.00
463.00 871.00 720.00 880.00 850.00 900.00

STORAGE	0.00	1.05	2.42	7.35	17.30	32.29	52.31	77.35	106.30
	170.59	205.89	243.31	282.84	324.47	368.22	414.08	462.04	512.12
OUTFLOW	0.00	273.38	909.32	2366.70	5413.67	10681.10	18707.30	29978.31	46260.75
	69871.35	117040.16	147859.20	182402.06	220750.52	262991.85	309217.09	359519.77	413995.14
STAGE	868.00	869.68	871.37	873.05	874.74	876.42	878.11	879.79	881.47
	884.84	886.53	888.21	889.89	891.58	893.26	894.95	896.63	898.32
FLOW	0.00	273.38	909.32	2366.70	5413.67	10681.10	18707.30	29978.31	46260.75
	69871.35	117040.16	147859.20	182402.06	220750.52	262991.85	309217.09	359519.77	413995.14

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

HYDROGRAPH ROUTING

ROUTE FROM SECTION 3 TO SECTION 4; 7900 FT D.S. FROM DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
304	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	1	0	0		0
NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT	
1	0	0	0.000	0.000	0.000	-1.	0	

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0800	.0450	.0800	826.0	860.0	550.	.07700

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
0.00 860.00 270.00 840.00 507.00 829.00 510.00 826.00 525.00 826.00
526.00 829.00 750.00 840.00 880.00 860.00

STORAGE	0.00	.38	.92	2.79	6.34	11.58	18.50	27.11	37.40
	60.99	74.00	87.82	102.45	117.88	134.13	151.18	169.04	187.71
OUTFLOW	0.00	361.34	1228.24	3242.43	7329.61	14244.28	24637.10	39098.07	58573.35
	115688.82	151483.66	192217.90	238002.53	288959.73	345218.94	406914.31	474182.98	547164.03
STAGE	826.00	827.79	829.58	831.37	833.16	834.95	836.74	838.53	840.32
	843.89	845.68	847.47	849.26	851.05	852.84	854.63	856.42	858.21
FLOW	0.00	361.34	1228.24	3242.43	7329.61	14244.28	24637.10	39098.07	58573.35
	115688.82	151483.66	192217.90	238002.53	288959.73	345218.94	406914.31	474182.98	547164.03

SUBJECT DAM SAFETY INSPECTION

WESTCOLANG LAKE DAM

BY DJS DATE 3-11-81

CHKD. BY DLB DATE 3-11-81

PROJ. NO. 80-238-396

SHEET NO. 2 OF 2

GAI CONSULTANTS, INC.

Engineers • Geologists • Planners
Environmental Specialists

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1112.00	1112.00	1114.00
STORAGE	2290.	2290.	2760.
OUTFLOW	0.	0.	110.

PLAN	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
①	.50	1115.51	1.51	3108.	1656.	8.50	43.75	40.75
②	.50	1115.48	1.48	3100.	2493.	5.75	43.75	41.75
③	.50	1115.37	1.37	3076.	3295.	4.75	43.75	41.75
④	.50	1115.25	1.25	3048.	3919.	6.50	42.75	41.75
NON-BREACH	.50	1115.67	1.67	3145.	1395.	22.50	43.75	0.00

SECTION 2
STATION 102

PLAN	RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
①	.50	1656.	954.8	44.00
②	.50	2464.	955.7	45.75
③	.50	3180.	956.4	43.75
④	.50	3443.	956.6	43.00
NON-BREACH	.50	1391.	954.3	43.75

SECTION 3
STATION 203

PLAN	RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
①	.50	1656.	872.2	44.00
②	.50	2454.	873.1	45.75
③	.50	3201.	873.5	44.00
④	.50	3448.	873.7	43.00
NON-BREACH	.50	1391.	871.9	44.00

SECTION 4
STATION 304

PLAN	RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
①	.50	1655.	830.0	44.00
②	.50	2451.	830.7	45.75
③	.50	3204.	831.3	44.00
④	.50	3439.	831.5	43.00
NON-BREACH	.50	1392.	829.7	44.00

LIST OF REFERENCES

1. "Recommended Guidelines for Safety Inspection of Dams," prepared by Department of the Army, Office of the Chief of Engineers, Washington, D. C. (Appendix D).

2. "Unit Hydrograph Concepts and Calculations," by the U. S. Army, Corps of Engineers, Baltimore District (L-519).

3. "Seasonal Variation of Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24, and 48 Hours," Hydrometeorological Report No. 33, prepared by J. T. Reidel, J. F. Appleby and R. W. Schloemer, Hydrologic Service Division, Hydrometeorological Section, U. S. Army, Corps of Engineers, Washington, D. C., April 1956.

4. Design of Small Dams, U. S. Department of the Interior, Bureau of Reclamation, Washington, D. C., 1973.

5. Handbook of Hydraulics, H. W. King, and E. F. Brater, McGraw-Hill, Inc., New York, 1963.

6. Standard Handbook for Civil Engineers, F. S. Merritt, McGraw-Hill, Inc., New York, 1963.

7. Open-Channel Hydraulics, V. T. Chow, McGraw-Hill, Inc., New York, 1959.

8. Weir Experiments, Coefficients, and Formulas, R. E. Horton, Water Supply and Irrigation Paper No. 200, Department of the Interior, United States Geological Survey, Washington, D. C., 1907.

9. "Probable Maximum Precipitation, Susquehanna River Drainage Above Harrisburg, Pennsylvania," Hydrometerological Report No. 40, prepared by H. V. Goodyear and J. T. Riedel, Hydrometeorological Branch Office of Hydrology, U. S. Weather Bureau, U. S. Department of Commerce, Washington, D. C., May, 1965.

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

11. "Simulation of Flow Through Broad Crest Navigation Dams with Radial Gates," R. W. Schmitt, U. S. Army, Corps of Engineers, Pittsburgh District.

12. "Hydraulics of Bridge Waterways," BPR, 1970. Discharge Coefficient Based on Criteria for Embankment Shaped Weirs, Figure 24, page 46.

13. Applied Hydraulics in Engineering, H. M. Morris and J. N. Wiggert, Virginia Polytechnic Institute and State University, 2nd Edition, The Ronald Press Company, New York, 1972.

14. Standard Mathematical Tables, 21st Edition, The Chemical Rubber Company, 1973, page 15.

15. Engineering Field Manual, U. S. Department of Agriculture, Soil Conservation Service, 2nd Edition, Washington, D. C., 1969.

16. Water Resources Engineering, R. K. Linsley and J. B. Franzini, McGraw-Hill, Inc., New York, 1972.

17. Engineering for Dams, Volume 2, W. P. Creager, J. D. Justin, J. Hinds, John Wiley & Sons, Inc., New York, 1964.

18. Roughness Characteristics of Natural Channels, H. H. Barnes, Jr., Geological Survey Water-Supply Paper 1849, Department of the Interior, United States Geological Survey, Arlington, Virginia, 1967.

19. "Hydraulic Charts for the Selection of Highway Culverts," Hydraulic Engineering Circular No. 5, Bureau of Public Roads, Washington, D. C., 1965.

APPENDIX E

FIGURES

LIST OF FIGURES

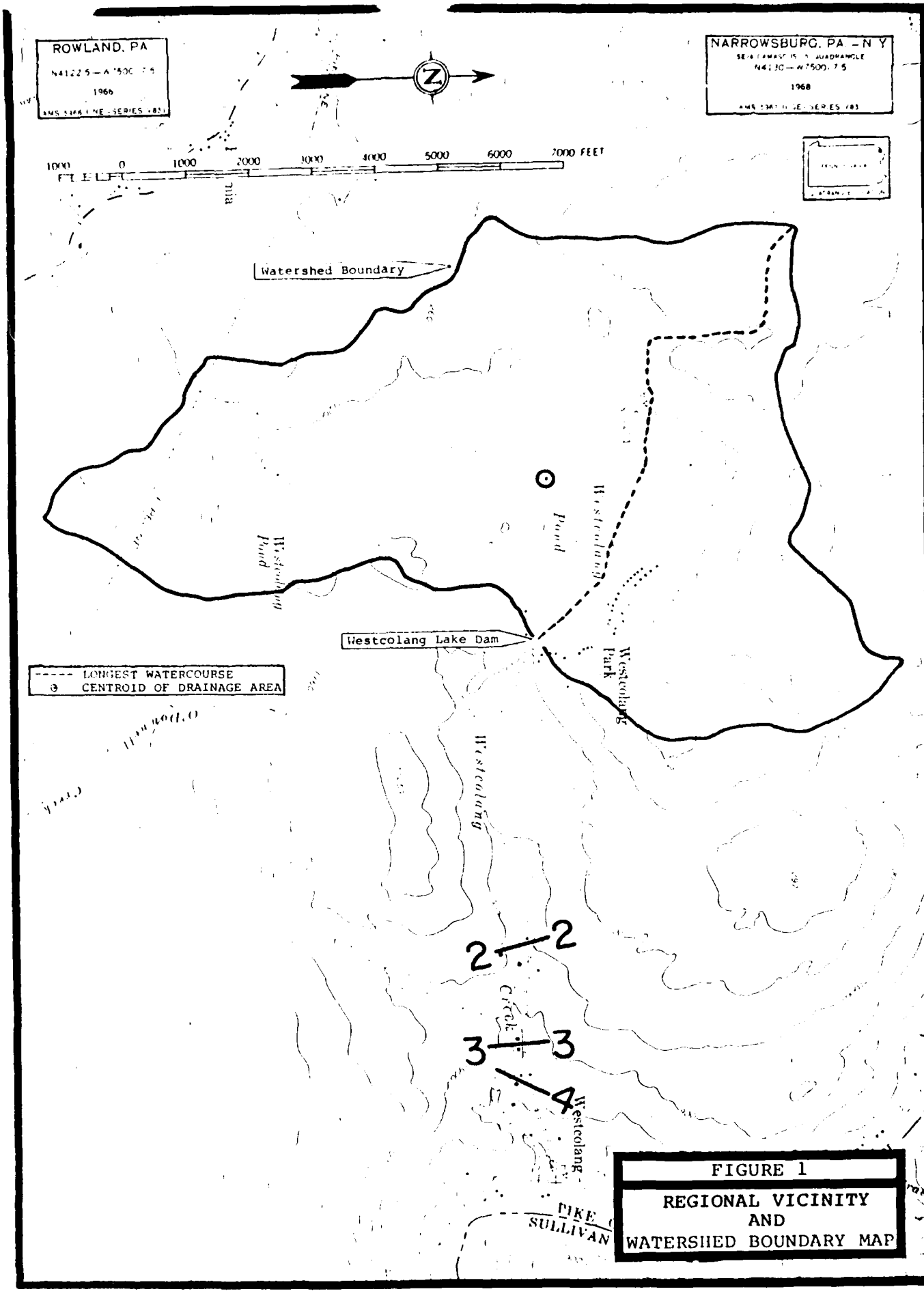


FIGURE 1

REGIONAL VICINITY AND WATERSHED BOUNDARY MAP

APPENDIX F

GEOLOGY

Geology

Westcolang Lake Dam is located in the glaciated Low Plateaus section of the Appalachian Plateaus physiographic province of eastern Pennsylvania. In this area, the Appalachian Plateaus province is characterized topographically by flat-topped, hummocky hills formed as a result of glaciation and subsequent stream dissection of nearly flat-lying strata. The Devonian age sedimentary rock strata in Pike County regionally strike N35°E and dip gently to the northwest. The Delaware River is the major drainage basin in the area. Major tributary streams intersect the Delaware River at right angles; whereas, smaller streams display a slightly more random tributary pattern. Both major and minor tributary stream systems are joint controlled and exhibit modified rectangular and trellis-type drainage patterns.

Structurally, the area containing Pike County lies on the south flank of a broad, asymmetrical synclinorium that plunges to the southwest. Superimposed on this broad structural basin are numerous anticlinal and synclinal folds characterized by planar limbs and narrow hinges. Due to prior glaciation, low relief and surficial soil cover, fold axes are difficult to trace.

The sedimentary rock sequences in the vicinity of the dam and reservoir are probably members of the Susquehanna Group of Upper Devonian age (see Geology Map). The sedimentological changes observed in the Catskill Formation indicate that the rate of sedimentation exceeded the rate of basin subsidence resulting in a facies change from marine to non-marine strata. On the accompanying geology map the delineation between the Middle and Upper Devonian age sedimentary rock sequences represents the Allegheny Front which separates the Valley and Ridge physiographic province from the Appalachian Plateaus physiographic province.

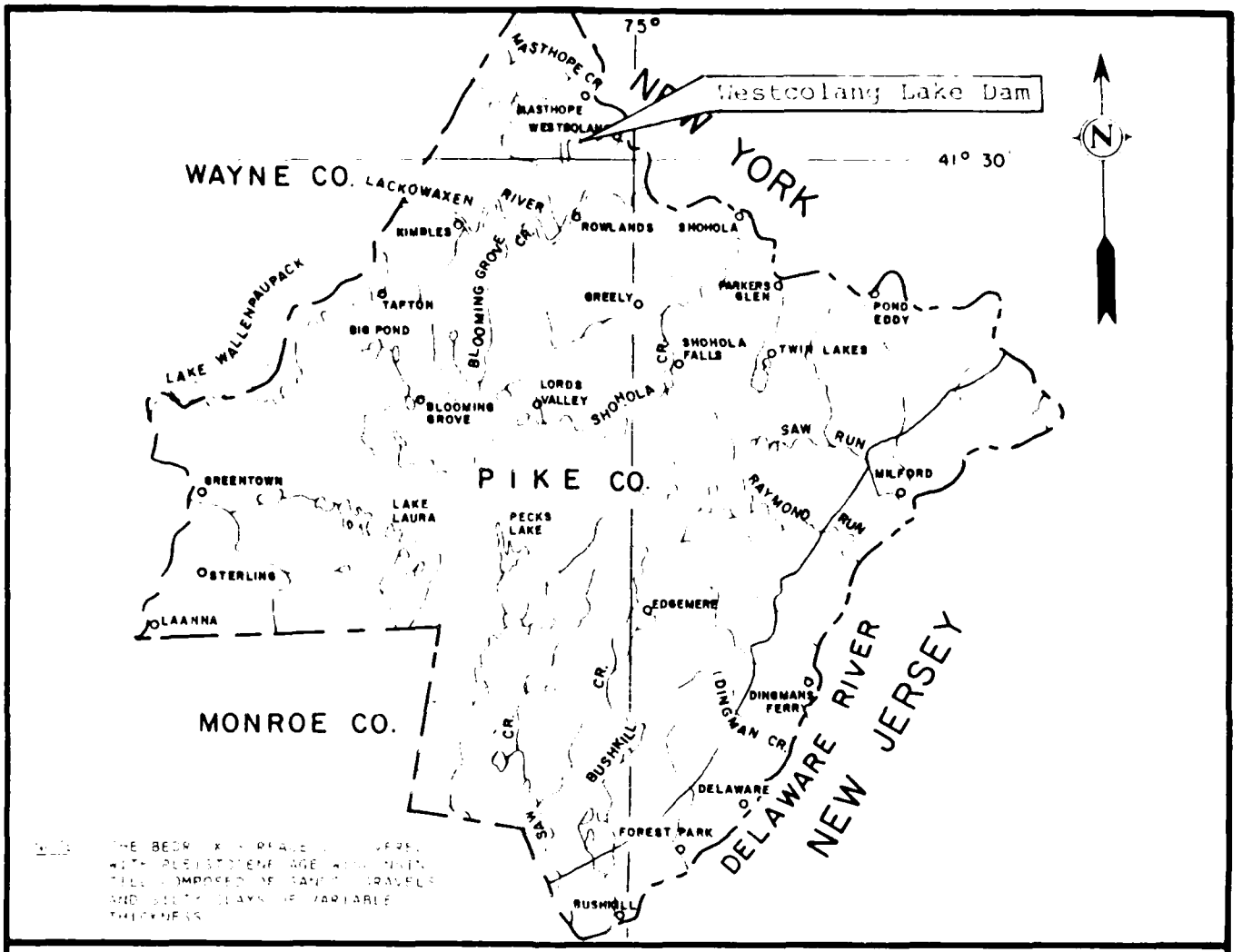
Approximately half of Pike County, including the dam site, is covered by a blanket of Wisconsin age (most recent) glacial drift which, based on the degree of weathering, was probably deposited during the Woodfordian stage. Valley bottoms are typically covered by recent alluvium and Woodfordian outwash of variable thickness, but typically less than 10 feet. These deposits are characteristically unconsolidated stratified sand and gravel usually with more gravel than sand and some small boulders. The direction of the Wisconsin ice advance, was from the northeast over the Catskill Mountains and from the north over the Appalachian Plateau. The terminal moraine resulting from the southern most advance of the Wisconsin ice sheet in this area is located in the southern portion of Monroe County which borders Pike County to the South.

References:

1. Fletcher, F. W., Woodrow, D. L., "Geology and Economic Resources of the Pennsylvania Portion of the Milford and Port Jervis 15 minute U.S.G.S. Topographic Quadrangles," Pennsylvania Geological Survey, Fourth Series, Harrisburg, Atlas 223, 1970.

2. Sevon, W. D., Berg, T. M., "Geology and Mineral Resources of the Skytop Quadrangle, Monroe and Pike Counties, Pennsylvania", Pennsylvania Geological Survey, Fourth Series, Harrisburg, Atlas 214A., 1978.

3. Sevon, W., Personal Communication, Commonwealth of Pennsylvania Department of Environmental Resources, Harrisburg, December 3, 1980.



THE BEDROCK SURFACE OF THE VALLEY WITH PLEISTOCENE AGE SEDIMENTS FILL COMPOSED OF SAND & GRAVELS AND SILTY CLAYS OF VARIABLE THICKNESS

LEGEND

UPPER DEVONIAN

SUSQUEHANNA GROUP

Catskill Formation

MIDDLE DEVONIAN

HAMILTON GROUP

Mahantango Formation

Marcellus Shale

SCALE

0 6 12 18 MILES

REFERENCE

GEOLOGIC MAP OF NORTHEASTERN PENNSYLVANIA COMPILED BY [illegible] AND U.S. GEOLOGICAL SURVEY COMMONWEALTH OF PENNSYLVANIA DEPT. OF CONSERVATION AND NATURAL RESOURCES BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY 1980, SCALE 1:250,000

GEOLOGY MAP

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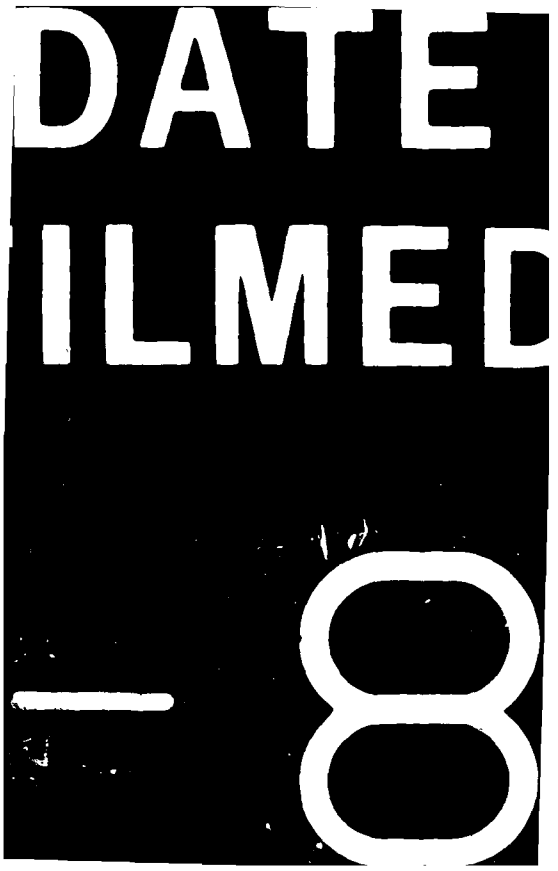
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