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NATIONAL DAM SAFETY PROGRAM. GEIST (CRUM CREEK) STORAGE DAM. DE--ETC(U)
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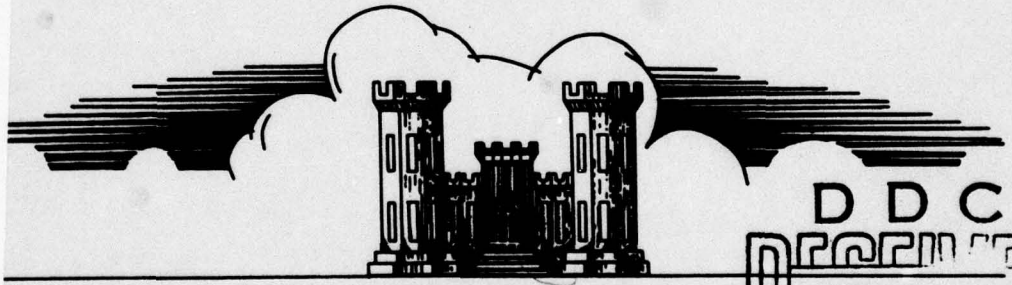
DELAWARE RIVER BASIN
CRUM CREEK, DELAWARE COUNTY
PENNSYLVANIA

GEIST STORAGE DAM (SPRINGTON RESERVOIR)

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



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

MAY 1978

LEVEL II

(1)

DELAWARE RIVER BASIN

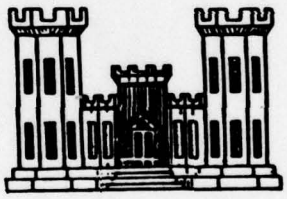
GEIST (CRUM CREEK) STORAGE DAM
DELAWARE COUNTY, PENNSYLVANIA
(NATIONAL I.D. NO. PA-00348)

Number

Delaware River Basin.

(6) PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM.

(15) DACW31-78-C-0048



Prepared by:

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Baltimore, Maryland 21203

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(11) May 1978

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Geist Dam

State Located: Pennsylvania
County Located: Delaware County
Stream: Crum Creek
Coordinates: Latitude 39° 52.9' Longitude 75° 23.4'
Date of Inspection: 6 April 1978

Geist Dam, also known as Springton Reservoir, has been in continual service since 1929 without incident, and has been classified as a High Hazard Potential dam. By virtue of its age, some deterioration of concrete appurtenances has occurred. However, none of the on-site observations or data reviewed revealed features that would suggest any immediate or near-term potentially hazardous condition. Therefore, the dam is considered to be in good condition.

This earth dam facility, constructed in 1929, was not designed to meet current Federal (OCE) hydrologic guidelines. A review of the available data indicates that the structure does not pass one-half the Probable Maximum Flood (PMF) without overtopping.

It has been estimated that the existing spillway will accommodate a flood at least equivalent to about 35 percent of the PMF without overtopping. As the earth dam has a concrete core wall as well as heavily riprapped upstream and downstream slopes and a paved crest, the effect of short-term overtopping on the integrity of the embankment will probably not lead to failure of the embankment. However, there is an unquantified risk that long-term overtopping would lead to failure and significantly increase the hazard potential downstream. Therefore, the spillway is considered "Inadequate" only for storms which produce short-term flows which overtop the dam crest.

The Owner's 1973 and 1975 studies have identified this condition as well as remedial measures to increase the outlet capacity or raise the dam crest. It is believed that further investigations would not significantly contribute to the assessment of the safety of Geist Dam. Rather, it is recommended that the Owner prepare a plan for around-the-

clock surveillance during periods of unusually heavy rains and develop a formal warning system for use in the event of an emergency. An operational maintenance procedure should also be established together with a program to monitor existing leaks with contingency plans for repairing these leaks.

Detailed remedial construction and monitoring recommendations are presented in Section 12.0 of this report.

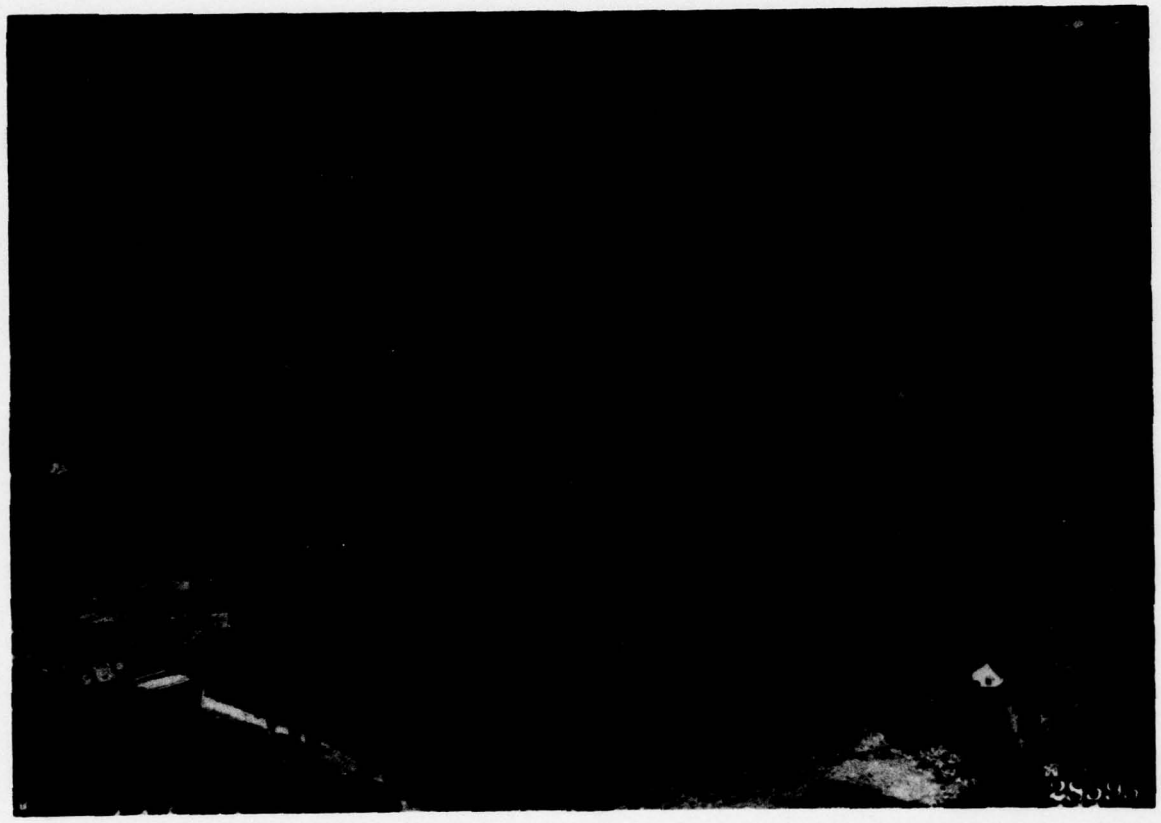
John H. Frederick, Jr., P.E. Date 6/1/78
Maryland Registration 7301

for William S. Gardner, P.E. Date 6/1/78
Penna. Registration 004302E

APPROVED BY:

JOHN H. KENWORTHY
LTC, Corps of Engineers
Acting District Engineer

DATE: 14 June 1978



OVERVIEW

GEIST STORAGE DAM (SPRINGTON RESERVOIR)

1.0 AUTHORITY

The Phase I investigation described in this report was made as a part of the National Dam Safety Program. This program is being implemented by the Secretary of the Army, through the Corps of Engineers, in response to the National Dam Inspection Act, Public Law 92-367, dated August 8, 1972.

~~2.0 PURPOSE~~

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

3.0 GENERAL

This Phase I investigation followed the procedures outlined in the "Recommended Guidelines for Safety Inspection of Dams", issued by the Department of the Army, Office of the Chief of Engineers. It consisted of a review of readily available engineering and operational data pertaining to the project and a visual inspection of the dam and appurtenant structures.

The Phase I investigation reported herein seeks to identify conditions which are potentially hazardous to a dam and provide judgements concerning measures leading to mitigation of such hazards. Potentially hazardous conditions are identified using the criteria and procedures presented by the Federal (OCE) dam safety inspection guidelines.

Much of the engineering data reviewed was derived from the files of the Philadelphia Suburban Water Company in Bryn Mawr, Pennsylvania, and the files of the Pennsylvania Department of Environmental Resources.

The field inspection was performed on April 6, 1978, by a team of engineers and geologists, listed in Appendix B. Local information concerning the operation and maintenance of the facility was provided by Messrs. Thomas M. Kiely and Richard Riegler, representing the Philadelphia Suburban Water Company, Bryn Mawr, Pennsylvania.

4.0 DESCRIPTION OF PROJECT

Geist Dam is situated on Crum Creek about 11 miles north of the confluence of Crum Creek and the Delaware River. The reservoir includes portions of both Chester and Delaware Counties, and serves to create a water supply impoundment for the area. A regional location plan of the dam and reservoir is enclosed as Plate 1.

The reservoir, created from impoundment of the waters of Crum Creek, is reported to have maximum storage of approximately 13,600 acre-feet. The contributing watershed covers approximately 21.5 square miles and varies in elevation from 690 feet to 200 feet above MSL. Although there is increasing development within the Crum Creek Basin, much of this area remains rural.

Geist Dam consists of a rolled essentially homogeneous earth fill structure containing a concrete core wall founded within bedrock. A typical cross-section, enclosed as Plate 4, shows the crest width to be 44 feet and the height of the dam to be about 75 feet above the valley floor. The upstream slope of the earth fill is inclined at 3 horizontal to 1 vertical and the downstream slope at 2 horizontal to 1 vertical.

Full protection of both slopes is provided by hand-placed riprap and dumped rock fill. Below elevation 180, the downstream rock fill facing is thickened to provide a 2-1/2 horizontal to 1 vertical slope and essentially forms an outer rock fill embankment zone. State Route 252 traverses the crest of the dam and bridges the spillway discharge channel, resulting in complete paving of the dam crest. An overview photograph of the dam is enclosed as the frontispiece.

As shown on Plate 2, the spillway is located at the west abutment of the dam and, as documented by construction records, is excavated and keyed into-rock. The length of the ogee crest is approximately 300 feet and has the form of a circular arc. The paved spillway channel discharges into an unpaved channel, joining Crum Creek below the dam. An auxiliary spillway has not been provided.

4.1 CLASSIFICATION

The dam is classified according to Corps' guidelines as an intermediate size dam by virtue of both its height of embankment and maximum storage capacity. Because failure of the dam could potentially result in the loss of life to several residents living downstream along Crum Creek, it is classified as a High Hazard Potential dam.

4.2 PURPOSE

The facility is owned by the Philadelphia Suburban Water Company and serves as a supply source for production of potable water.

4.3 DESIGN AND CONSTRUCTION HISTORY

During construction, the stream diversion was accomplished by means of a cast-in-place concrete conduit 10 feet wide and 10 feet high. Upon plugging of the diversion conduit, a 36-inch cast iron pipe was placed in the conduit and is connected to an intake tower located in the reservoir. Water is drawn through the tower via the 36-inch pipe connecting to a 24-inch pipe through a venturi and discharges into Crum Creek downstream of the dam.

Construction of the dam started in November, 1929. Both the diversion conduit and core wall were founded on rock, the latter extending to unaltered rock. A grout curtain installed along the alignment of the core wall was also largely constructed in 1929 by injecting neat cement grout under header pressures of about 40 psi. The 20 feet deep (average) grout holes were spaced 3 feet on-center, alternating with a one foot offset to the left and right of the core wall centerline.

During the 1930 working season, the core wall was completed and practically all the embankment was placed. Embankment materials were largely derived from borrow pits located within the reservoir area. The spillway structure was completed in the Spring of 1931. Impounding of the reservoir was initiated in February of 1931 and was substantially completed by January, 1932.

4.4 PERTINENT DATA

A summary of pertinent design and as-built statistics are tabulated on Table 1. Relevant dimensions were checked during the field inspection on April 6, 1978.

4.5 GEOLOGY

Geist Reservoir is located in the Piedmont Uplands section of the Piedmont Physiographic Province. A regional northeast striking thrust fault crosses the reservoir approximately one mile northwest of the dam. As shown on Plate 7, the predominant rock types in the reservoir area consist of Precambrian gabbroic gneiss and gabbro, and Lower Ordovician mica schist of the Wissahickon Formation.

Outcrops near the dam site indicate the rock to be a micaceous gneiss containing quartz, muscovite and feldspar. Construction photographs indicate the rock to have a distinct cleavage probably coincident with the attitude of foliation. The cleavage appears to dip about 60° downstream and to roughly strike parallel to the core wall alignment. Based on boring records, the depth to rock below the original ground surface at the dam centerline usually ranged between 0 and 20 feet and averaged about 10 feet.

5.0 SUMMARY OF ENGINEERING DATA AVAILABLE

Available data used for this Phase I investigation was primarily derived from the Philadelphia Suburban Water Company in Bryn Mawr, Pennsylvania. A listing of the principal data used is tabulated below:

(1) "Report Upon the Application of the Philadelphia Suburban Water Company" to construct Geist Dam, dated June 12, 1929.

(2) Assorted daily field reports of construction detailing items completed on a specific date.

(3) Assorted progress reports of construction by the Resident Engineer.

(4) Detailed construction photographs of various stages of construction.

(5) Hydraulic analyses of spillway.

(6) Preliminary Specifications of the dam and spillway.

(7) Philadelphia Suburban Water Company, "Crum Creek Storage Dam", Plan No. 9943, Sheets 1 through 11, August 1, 1929.

(8) Philadelphia Suburban Water Company, "Springton Dam", Typical Cross-Sections, Record Drawing, February 3, 1932.

(9) Philadelphia Suburban Water Company, Contract 116, Photographs 82 through 545, dated November 12, 1929 to September 8, 1931.

(10) Corps of Engineers, U.S. Army, "Flood Plain Information, Ridley Creek, Delaware County, Pennsylvania", April 11, 1970. U.S. Weather Bureau, "Hydrometeorological Report No. 33".

(11) McCurdy, H.S.R., "The Springton Dam and Reservoir", Journal of American Water Works Association, Vol. 24, No. 7, July 1932. Fidler, H.A., "The Springton Dam", a Senior Paper to the Drexel Institute of Technology, February, 1932.

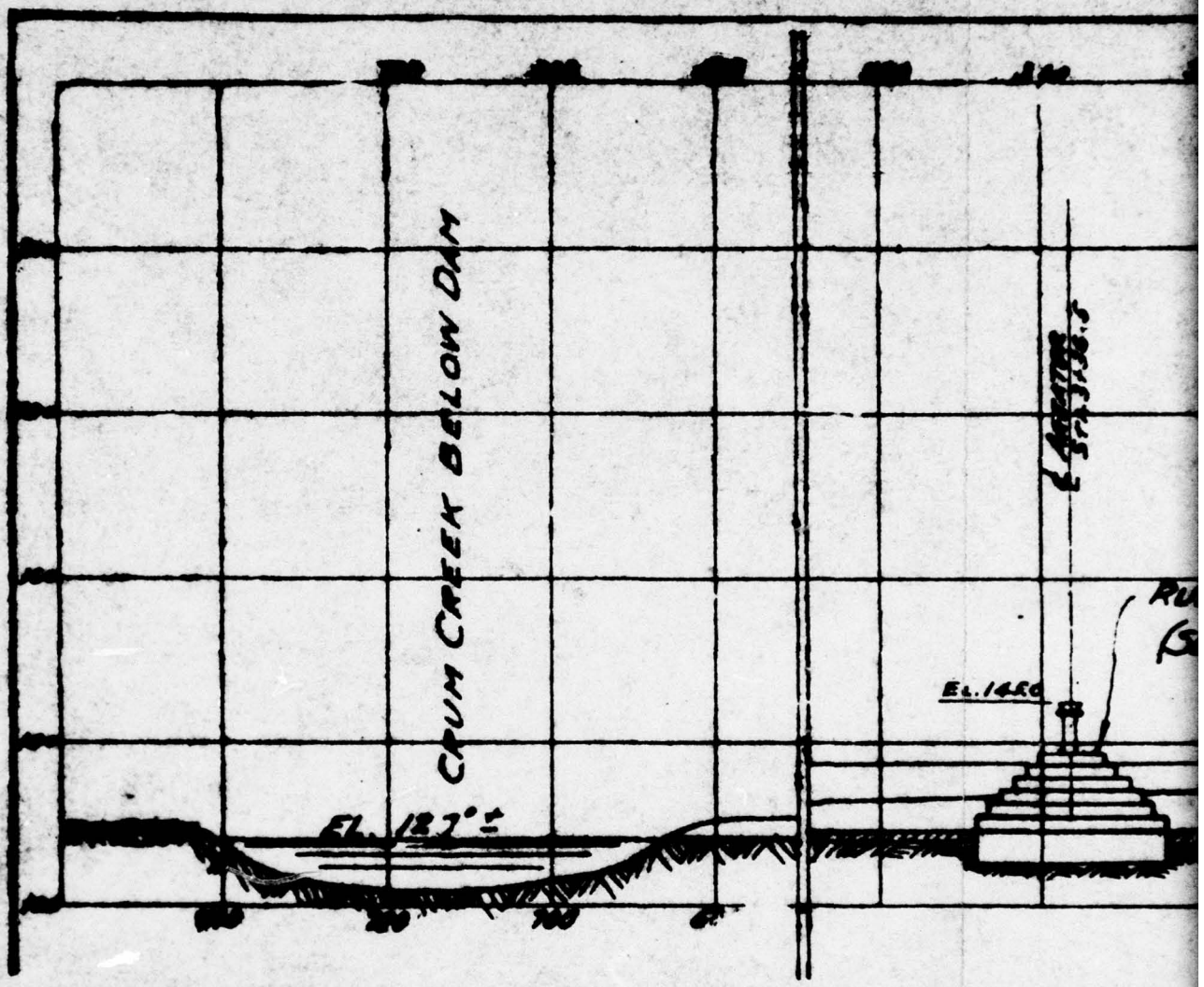
(12) Woodward-Clyde Consultants, reports to Philadelphia Suburban Water Company entitled "Safety Evaluation, Geist Dam", dated October 23, 1973 and September 25, 1975.

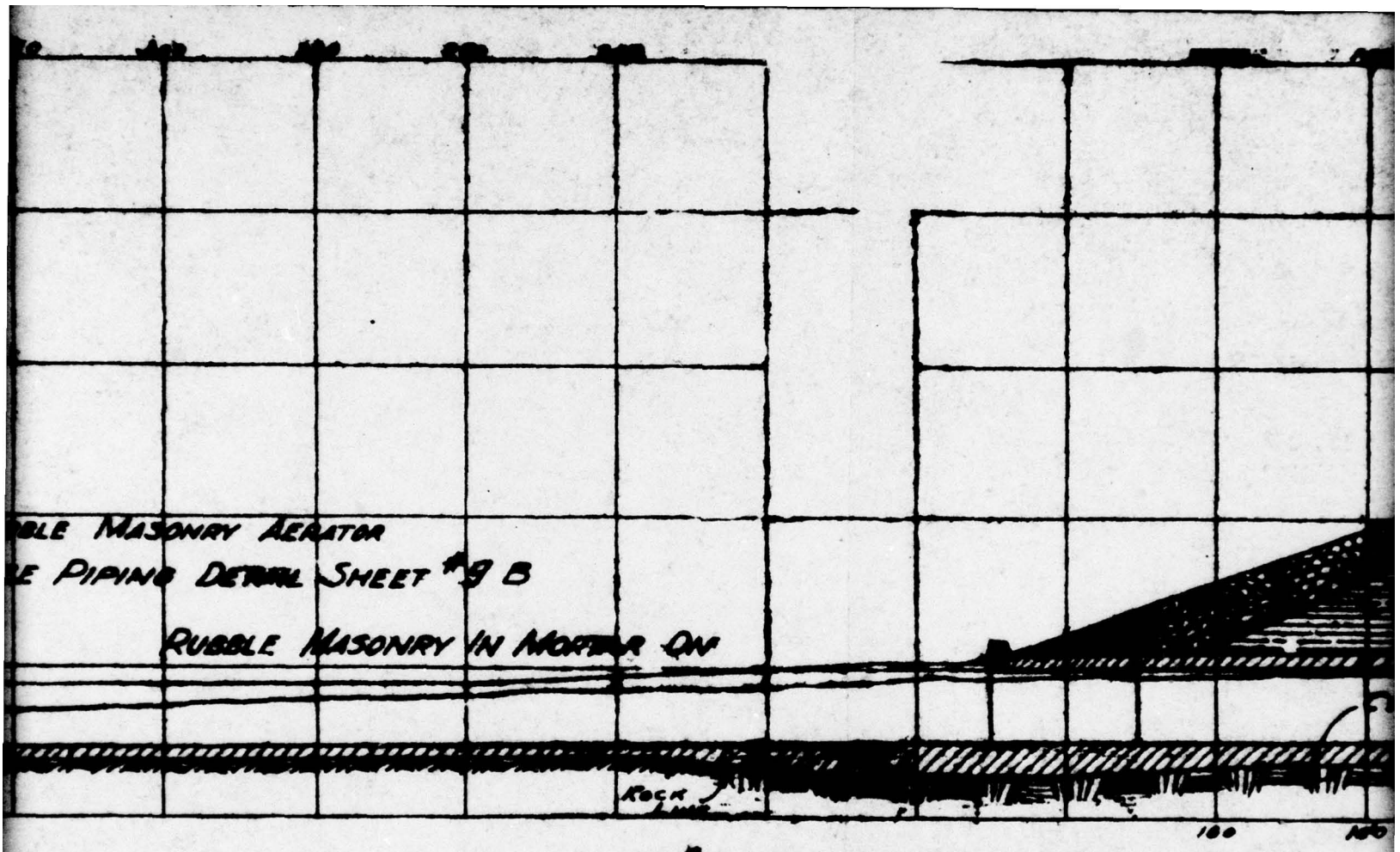
TABLE 1
GEIST STORAGE DAM
SUMMARY OF PERTINENT DATA

1.	Drainage Area	21.5 square miles
2.	Discharge at Dam Site	
	Max. Known Flood at Dam Site	3500 cfs (June 1972)
	Total Spillway Capacity at Maximum Pool	11,600 cfs
	Total Capacity of 36" diversion pipe	no rating curve
3.	Elevation	
	Top of Dam	207 feet
	Top of Spillway	200 feet
	Crest of Masonry Parapet Wall	210 feet
	Normal Pool Elevation	200 feet
	Maximum Pool Elevation	
	Upstream Intake Elevation (pipes)	155 and 180
	Downstream Discharge Elevation (pipe)	
	Maximum Tailwater Elevation	205 feet
4.	Reservoir	
	Length	2.3 miles
	Maximum Depth of Reservoir	66 feet
	Water Surface at Normal Pool	391 acres
	Storage (incremental)	design
	Normal Pool Elevation	10,740 Acre-Feet (design)
	Top of dam (207)	2,837 Acre-Feet
5.	Dam	
	Type	Rolled earth with concrete core wall to crest. Rip-rap slopes on both sides
	Length	2000 feet
	Height above Streambed	75 feet
	Height above deepest Portion of Core Walls	95 feet
	Crest Width	44 feet
	Upstream Slope	3H:1V
	Downstream Slope	2H:1V above El. 180 2.5H:1V below El. 180
	Grout Curtain	Yes, 3-row staggered 3 feet on-center

TABLE 1 (continued)

6. Spillway		
	Type	Masonry and Concrete Ogee
	Length	300 feet
	Downstream Channel	The channel passes through urban areas on its path to the Delaware River (approximately 11.1 miles) with many natural (trees and brush) obstructions and man-made (encroachment onto flood plains, bridges, etc.) obstructions.





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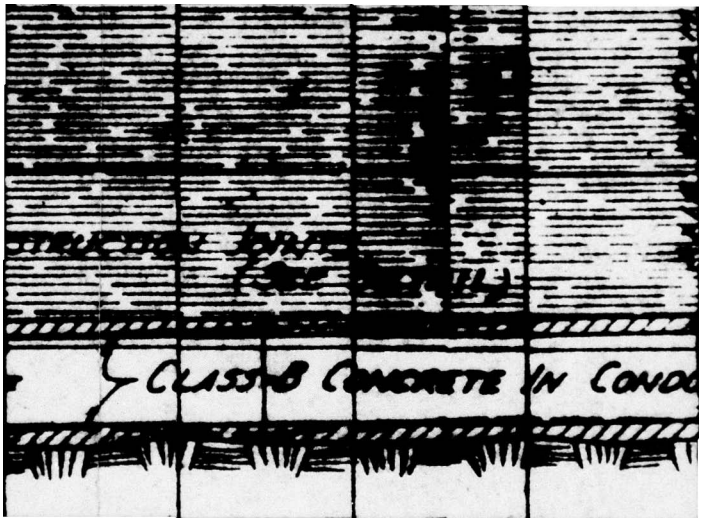
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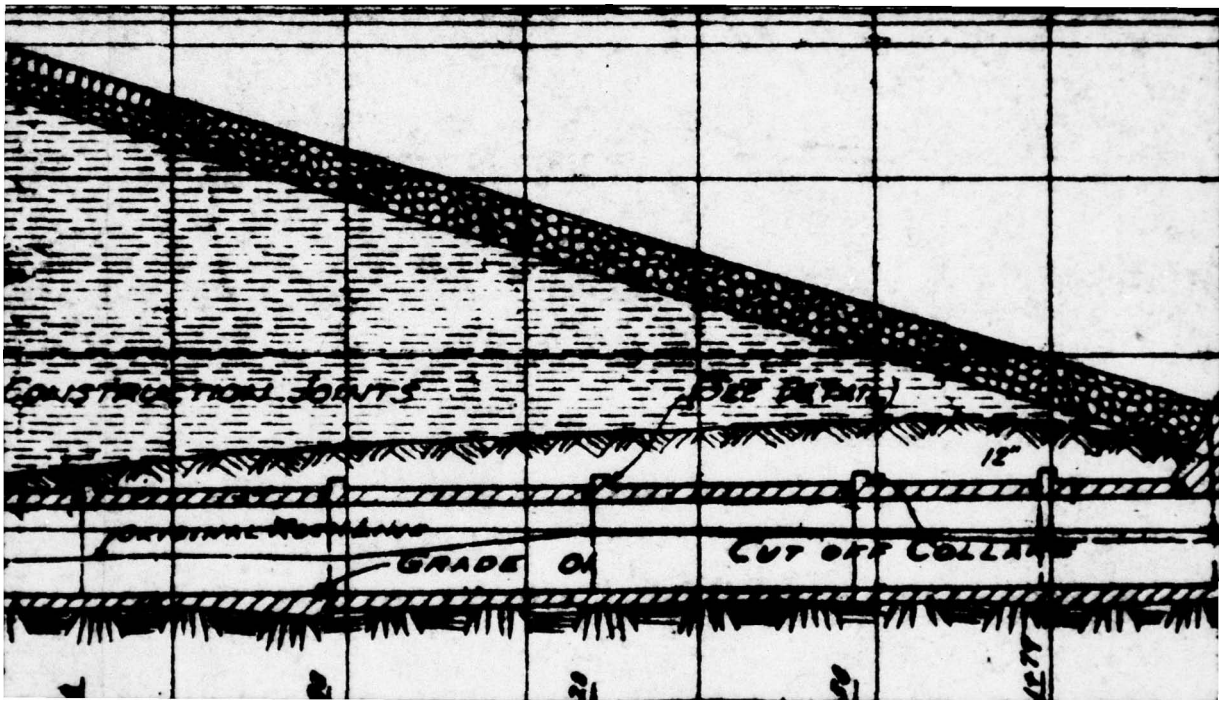
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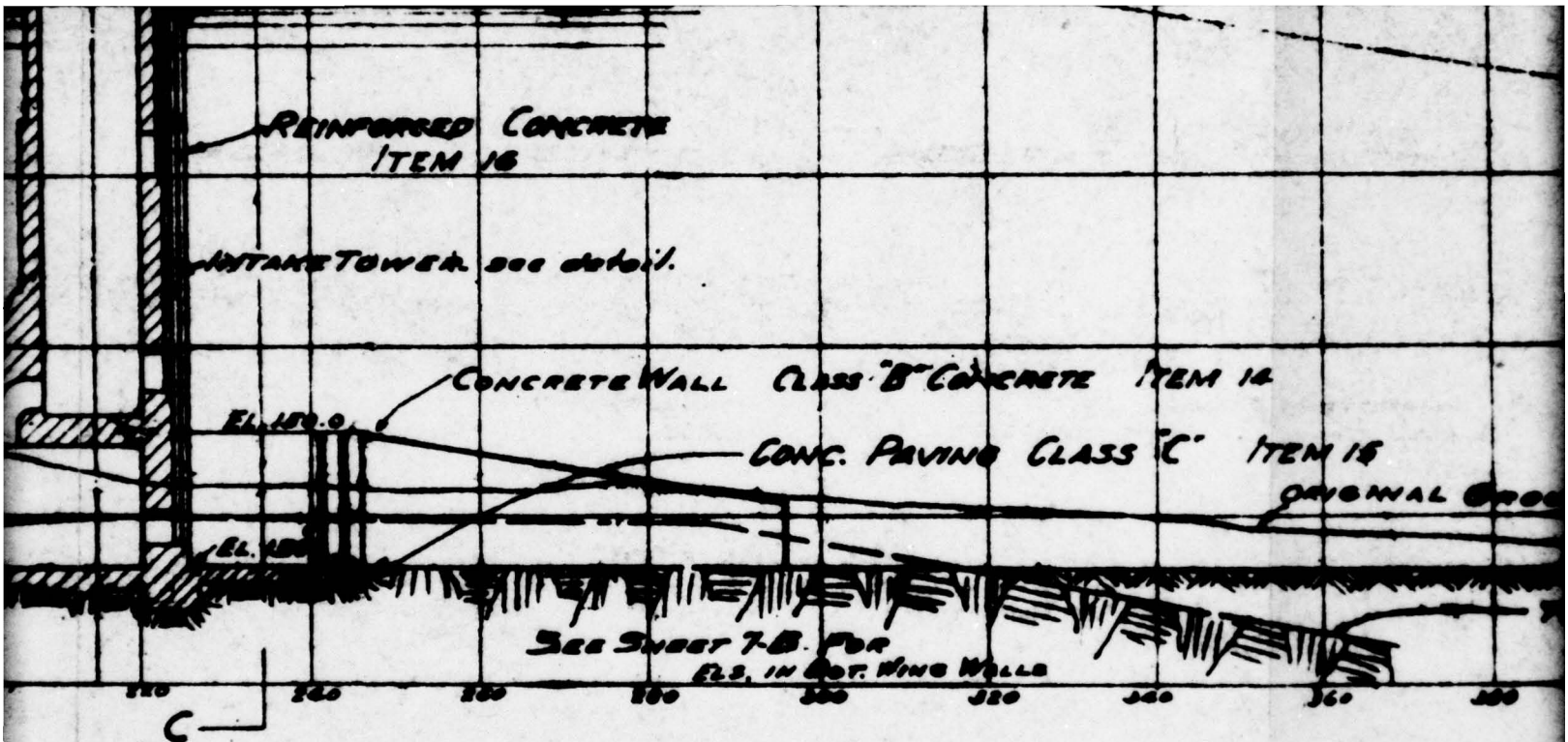

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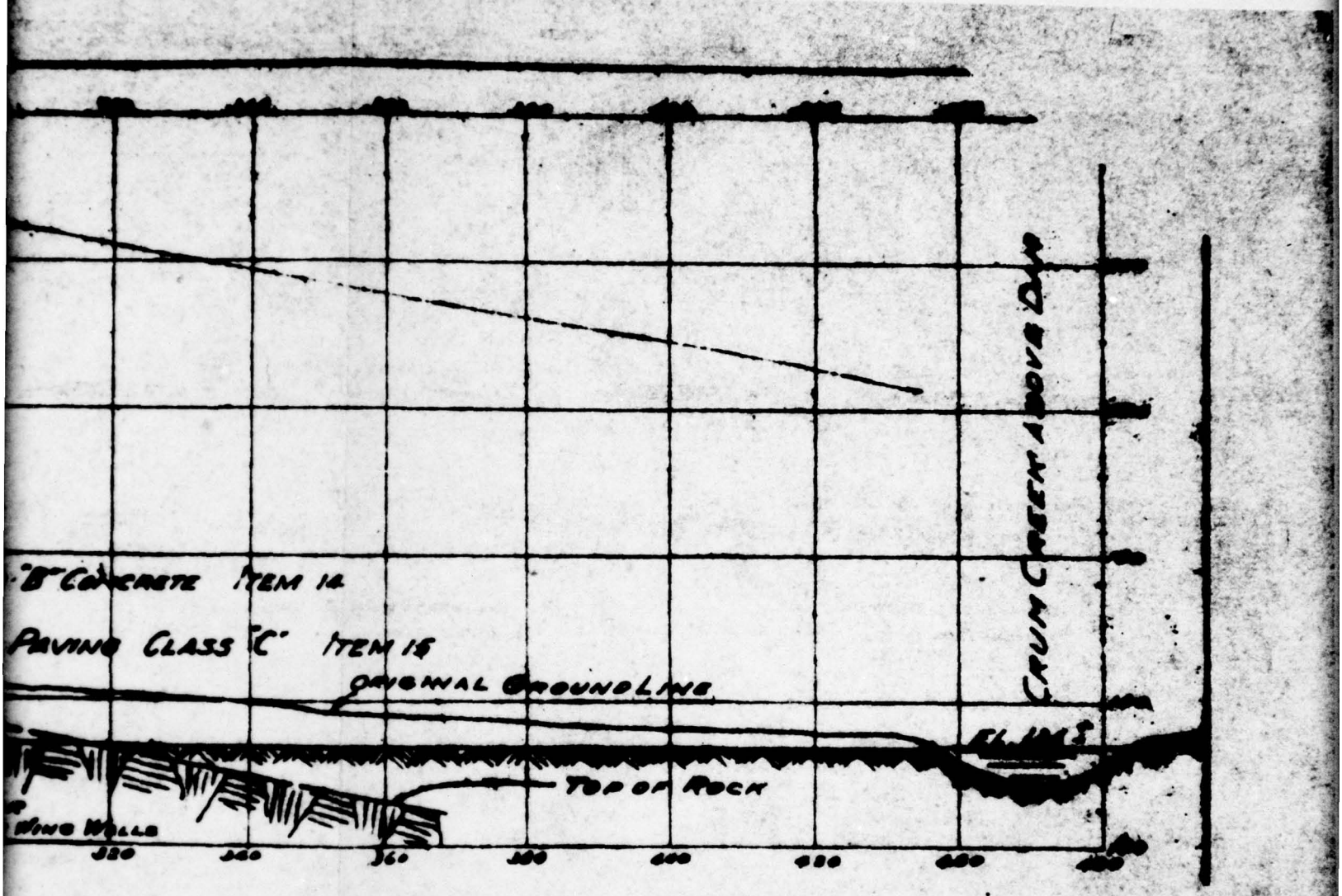

TYPICAL PROFILE ALONG CENTERLINE OF CONDUIT
AND INTAKE TOWER
GEIST STORAGE DAM

DELAWARE COUNTY PENNSYLVANIA

DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER
WATER COMPANY DOCUMENTS

PLATE 4

6.0 RESULTS OF VISUAL INSPECTION

The Phase I inspection of Geist Dam was made on April 6, 1978. During this inspection, a thorough visual survey was made of the dam, slopes and crest as well as the downstream conditions. Reservoir level at the time of this inspection was approximately 1 to 2 inches above the spillway crest. A composite of the significant observations and comments of this field inspection team is contained in the Checklist contained herein as Appendix B.

The survey failed to detect any evidence of distortions in alignment or grade which would be indicative of movement of the embankment or foundation. A careful inspection of the downstream slope and ground surface was conducted to observe any evidence of seepage emergence on or beneath the dam. Because of the porous rock fill mantling the downstream slope, no evidence of seepage was detected on this slope. However, small, clear-running springs were detected at two downstream locations during the inspection. It is understood that the Owner will be installing piezometers near the downstream toe to enable long-term observation of piezometric levels in the areas where there is existing seepage. The location of the springs are shown on Plate 3 and have been identified by previous inspections during 1972-73.

Observations within manholes servicing an 8-inch O.D. vitrified clay drainage pipe located within the downstream toe of the dam indicated that segments of the drain were blocked causing water levels in the manholes to be well above the invert of the drain pipe. This embankment toe drain was placed within open joints and collects the crest roadway storm drainage conveyed by a drop-inlet system. The outfall of the toe drain in Crum Creek was also observed to be partially inundated and silted. This condition was also observed during the 1972-73 inspections.

Inspections were made within the diversion conduit which extends beneath the dam from a downstream portal to the plug near the upstream toe. These inspections revealed limited seepage into the conduit, generally through construction joints and cracks. The highest crack frequency was noted in the vicinity of the conduit-core wall juncture. Previous monitoring of the seepage during March, 1972 indicated a rate of 3.5 gpm. This rate was checked and did not appear to have changed since that date. The seepage appeared to be clear with no evidence of suspended fines.

Since the spillway was flowing, a detailed inspection of the Ogee crest and upstream channel structure could not be made. However, the flow was smooth and uniform, indicating no unusual deformation of the spillway crest. Sections of the spillway surface and the spillway channel paving were found to be pitted and roughened, with the coarse aggregate of the concrete being partially exposed on the surface of the paving. Further downstream, the discharge channel bed was observed to be somewhat eroded. Erosion of the jointed rock of the unprotected channel was also noted to be occurring progressively up channel, undermining channel paving at the location of an abrupt grade change about 270 feet below the highway bridge opening. This condition was also observed during the 1972-73 inspections.

7.0 OPERATIONAL PROCEDURES

It is understood from the Owner's representatives that no written procedures currently exist for the operation of the Springton facility, although such procedures have been verbally established and are used by attendent personnel. Similarly, no formal procedures for maintenance are available although it is reported that the dam and appurtenant facilities are checked regularly and maintained as necessary to insure proper operation. In case any unusual conditions are observed, operating personnel immediately contact the Philadelphia Suburban Water Company offices or contact appropriate authorities.

In both instances, it is concluded that appropriate documents should be prepared to formalize operation and maintenance procedures. These documents should contain a history of all equipment, flow requirements and a schedule of regular maintenance to be performed for each component of the dam.

Pool levels are recorded on week days and during major storms. All data collected is sent to the Philadelphia Suburban Water Company offices.

8.0 MONITORING AND WARNING SYSTEMS

The inspection revealed that there are no monitoring or warning systems in effect. Conversations with representatives of the Owner indicated what course of action

individuals might take if emergency conditions developed. This action primarily consists of notifying a prescribed PSWCo. engineer. However, there is no formal document that delineates a predetermined response for potentially hazardous conditions.

Because of the value that an organized and documented emergency warning system can have on the outcome of an urgent situation, it is concluded that such a plan should be prepared and followed. This warning system would include notification of residents and other individuals responsible for structures that would be affected by abnormally high flows.

9.0 HYDROLOGIC AND HYDRAULIC EVALUATION

9.1 DESIGN EVALUATION DATA

Hydrologic design data was found in the 1929 application report, in a spillway hydraulic analysis, and in 1973 and 1975 Woodward-Clyde Consultants dam inspection reports. The watershed, as described in the application report and confirmed in the Woodward-Clyde Consultants report and current USGS maps, is approximately nine miles long and varies in width from 2.5 to 4 miles, covering an area of 21.5 square miles. The elevation in the upper reaches is approximately 590 feet and falls with an average slope of one percent for 4.5 miles to Grubb Mill Road, below which the slope averages 0.4 percent to Geist Reservoir. The drainage area is in a developing area, of which more than half is still in open farm and wooded lands. The basin runoff characteristics are reflected in a SCS runoff Curve No. 65 (an index evaluating the rainfall-runoff relationship) as of 1972. There are no upstream reservoirs or ponds.

According to the 1929 Application Report, the spillway structure was originally designed to discharge 12,000 cfs with the reservoir level at elevation 207, the crest of the dam. The peak design discharge was equivalent to a discharge of 12,000 cfs. Original design data also determined that a constant runoff for 4± hours of one inch/hour would raise the water level in the reservoir by 5.5 feet, a runoff of 2 inches/hour would raise the water level by 8 feet, and a runoff of 2.65 inches/hour would raise the water level by 10 feet. It is not known which frequency storms

these rainfalls were to represent. It was also recognized that the hydraulic control to a spillway discharge of 12,000 cfs would be a restriction caused by a highway bridge downstream of the spillway.

9.2 EXPERIENCE DATA

From available performance records, a maximum depth of flow over the spillway crest of 2.2 feet (3500 cfs) was recorded on June 22, 1972 as a result of a 3.33 inch rainfall measured at Crum Creek Pumping Station. The June 22nd rain followed several days of rain, including 1.10 inches of rain the day before. The reservoir level was at approximately elevation 199.7 the day before this storm occurred. The recorded minimum water elevation in the reservoir is 176.4, July 1963.

Tailwater just prior to overtopping is estimated to be at elevation 205 below the spillway and above the highway bridge and approximately 60 feet below the top of the dam downstream of the highway bridge.

9.3 VISUAL OBSERVATIONS

On the date of the inspection, no conditions were observed that would indicate that the capacity of the appurtenant structures would be significantly reduced during a flood occurrance (see Appendix B).

9.4 OVERTOPPING POTENTIAL

Hydraulic model studies of the spillway performed in 1946 and 1975 essentially confirmed the peak spillway discharge to be 12,000 cfs with the reservoir water level at the crest elevation (actual value of 11,600 cfs). These studies also confirmed the downstream highway bridge opening as being the hydraulic control for the spillway discharge. The 1975 report by Woodward-Clyde Consultants (WCC) to the PSWCo. contains a detailed hydrologic and hydraulic analyses and an evaluation of the effects of a PMF. The conventional flood routing methods used indicated that the calculated PMF inflow of 22,100 cfs will overtop the dam crest by approximately 6 feet and the parapet walls by 3 feet.

Approximate flood routing procedures as specified by the Corps' guidelines (Appendix C) indicate that the structure is not capable of passing 50 percent of the PMF without overtopping. The approximate method of flood routing in this Phase I evaluation used the peak inflow rate and volume as determined in the 1973 WCC report to approximate the prescribed triangular inflow hydrograph. The detailed WCC 1973 study predicted that a design flood equivalent to 35 percent of the PMF could be passed without overtopping and, therefore, any larger flood will overtop the structure. If the parapet walls are assumed not to fail, 43 percent of the PMF could be passed without overtopping. Copies of these evaluation studies are located in PSWCo. or WCC files.

9.5 SPILLWAY

The spillway capacity is classified as "Inadequate" as it will not pass the PMF without overtopping the dam. One-half the PMF will also overtop the dam. The parapet walls are judged to be able to withstand overtopping for only a short time and, therefore, will not significantly increase downstream damage over what would occur just prior to overtopping. Therefore, the spillway is not judged to be "Seriously Inadequate".

10.0 EVALUATION OF STRUCTURAL STABILITY

Stability evaluations were performed during the previous 1973 WCC study and were reviewed during this investigation. Visual inspections of the dam did not reveal any features which would significantly alter the results of these studies. These evaluations included assessment of failure due to shear deformation, piping and overtopping.

The 1973 stability evaluations were made for a variety of loading conditions (including seismic forces) and indicated that Geist Dam maintains an adequate margin of safety against excessive shear deformation of the embankment and foundation under the most extreme loading conditions which can be reasonably postulated. These analyses indicate the factor of safety to be at least 1.1 and 1.4 for seismic and static loading conditions, respectively. Based on the visual inspection, there is no evidence that a piping failure by any of the several possible mechanisms is imminent or may develop.

11.0 OVERALL ASSESSMENT

Visual inspections and review of available data concerning the Geist Dam and Reservoir have been made to provide a judgemental assessment of the present stability of this water storage impoundment. Based on these investigations and the long-term performance, it is judged that the earth dam embankment and foundation has an adequate margin of safety against failure under all credible loading conditions. Further, the dam does not exhibit any features which would indicate an embankment or foundation susceptible to piping failure.

It is estimated that the current spillway and reservoir system is capable of passing a flood of approximately 35 to 43 percent(1) of the calculated probable maximum flood (PMF). Consequently, the spillway capacity of Geist Dam does not meet the Federal (OCE) dam safety hydrologic guidelines and is deficient in this regard.

Because of envelopment of the dam by riprap and paving, overtopping of the dam crest during storms of low return frequency would not necessarily lead to a failure, although the risk of this occurrence cannot be completely discounted. As the site does not permit development of an auxiliary spillway and the primary spillway capacity is controlled by the downstream highway bridge obstruction. The discharge capacity of the spillway, as concluded by the 1975 WCC report, could be increased to pass a flood equivalent to about 50 percent PMF but not significantly more. Further increase would require an increase in the crest elevation of the dam.

Based on this data and the conclusion that short duration overtopping can occur for storms approaching one-half PMF without complete failure, the spillway is not considered "Seriously Inadequate". However, a warning and surveillance program, together with a formal operating procedure should be initiated as described in Sections 7 and 8 of this report.

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(1) The 43 percent PMF estimated is based on the parapet walls effectively raising the dam crest from elevation 207 to 210.

12.0 REMEDIAL CONSTRUCTION AND MONITORING

Exclusive of the question of spillway capacity, the following conclusions are offered concerning what is believed to be appropriate remedial measures to mitigate possible future development of impaired dam function.

12.1 SPILLWAY CHUTE PAVING

Repair of the eroded, spillway chute paving is recommended to prevent further deterioration of the channel and ultimate degradation of the discharge structure. In connection with repair of the chute paving, consideration should be given to stabilization of the underlying jointed rock using grouted-in rock bolts.

12.2 STORM DRAIN AND TOE DRAIN SYSTEM

To assure that blockage of the roadway storm drain system would not ultimately induce excess hydrostatic pressures within the downstream embankment, the existing open-joint toe drain should be cleaned together with the outfall pipe which conveys drainage to Crum Creek. Relocation of the toe drain outfall to a higher elevation should be made. Partial submergence of this outfall may inhibit drainage discharge and prohibit monitoring seepage discharge as recommended in Section 12.4 below. Periodic checking of the outfall discharge conditions should be made.

12.3 DIVERSION CONDUIT

Although seepage issuing through construction joints and cracks in the diversion conduit is judged to be too small to be detrimental, it is recommended that the amount of seepage be periodically documented together with the extent of cracking within the conduit. Should monitoring indicate a trend towards increasing seepage or crack growth, pressure grouting of the leaking portion of the conduit using a quick-set chemical grout or suitable alternate would be appropriate.

12.4 DOWNSTREAM SEEPAGE MONITORING

As planned by the Owner, the installation of sealed piezometers in the vicinity of springs noted immediately downstream of the toe of the dam should be accomplished to enable monitoring of hydrostatic heads. Should measurements indicate potentially excessive pore water pressures, the measurement system should be extended to include piezometers placed at the top of the downstream slope, along the shoulder of the roadway, and a determination should be made to determine if remedial measures are necessary to protect the toe of the dam.

Storm drain outfall discharge measurements should be made to detect any unusual increase in underseepage which may signify incipient piping development. Turbidity of the seepage should also be measured at regular intervals. Seepage, piezometric and turbidity readings should be maintained by the Owner.

12.5 SLOPE VEGETATION

It is recommended that vegetation, which includes trees and heavy brush, be removed from the downstream slope.

APPENDIX

A

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM *Crum Creek Storage Dam*

ID # *PA 00348*

ITEM	REMARKS
AS-BUILT DRAWINGS	*These are coincident with the design drawings which were available for review. Included are two spillway model studies.* 1. *Philadelphia Suburban Water Company, "Springton Spillway" (Model Studies), Drawing E-3728, January 8, 1946.* 2. *Spillway Model Testing performed by Verna Engineering, Carnegie, Pennsylvania 1975.*
REGIONAL VICINITY MAP	*U.S.G.S. Quad Sheet entitled "Media".*
CONSTRUCTION HISTORY	*The construction history and photographic documentation was recorded in the following documents: 1. McCurdy, H.S.R., "The Springton Dam and Reservoir", Journal of American Water Works Association, Vol. 24, No. 7, July 1932. Fidler, H.A., "The Springton Dam", A Senior Paper to the Drexel Institute of Technology, February 1932. 2. Philadelphia Suburban Water Company, Contract 226, Photographs 82 through 545, dated 11/12/29 to 9/8/31.*
TYPICAL SECTIONS OF DAM	*This data was available from the owner as follows: Philadelphia Suburban Water Company, "Springton Dam", Typical Cross Sections, Record Drawing, February 3, 1932.*
OUTLETS - PLAN	*Available from the Owner. Philadelphia Suburban Water Company, "Crum Creek Storage Dam", Plan No. 9943, Sheets 1 through 11, August 1, 1929.*
DETAILS	
CONSTRAINTS	
DISCHARGE RATINGS	
RAINFALL/RESERVOIR RECORDS	*These records are maintained by the Owner.*

ITEM	REMARKS
DESIGN REPORTS	*Most of these reports were available for review during this inspection.*
GEOLOGY REPORTS	*Geologic literature and maps indicate the Wissahickon Formation as the foundation rock at the dam site. The rock type has been mapped as a mica schist containing quartz and feldspar. Although moderately resistant, the rock is often differentially weathered to moderate depths with steeply dipping foliation planes. Near the spillway, an outcrop of the Wissahickon has a dip of approximately 60° ESE.*
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	*Data was available from an October 23, 1973 report by Woodward-Clyde Consultants entitled "Safety Evaluation, Geist Dam, Delaware County, Pennsylvania".*
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	*These records were available for review during this inspection. All construction work had a full time inspector provided by the Owner.*
POST-CONSTRUCTION SURVEYS OF DAM	*None.*
BORROW SOURCES	*Located within the reservoir area.*

ITEM	REMARKS
MONITORING SYSTEMS	*None, other than a reservoir level gage and the outlet control pipe valve to maintain minimum flows downstream.*
MODIFICATIONS	*None.*
HIGH POOL RECORDS	*Pool levels are read daily. The maximum recorded flow over the spillway was 2.225 feet (elevation 202.225) on June 22, 1972 at 4:00 p.m.*
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	*Woodward-Clyde Consultants performed a detailed investigation of the dam in 1973 and issued a report dated October 23, 1973, entitle "Safety Evaluation, Geist Dam, Delaware County, Pennsylvania". A detail H&H analysis was performed using three acceptable flood routing methods.*
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	*None.*
MAINTENANCE OPERATION RECORDS	*These were not readily available for review during this inspection.*

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	*These plans were available and reviewed prior to the inspection.*
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	*The equipment was noted on the plans and inspected during the field inspection.*

APPENDIX

B

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam *Geist Storage Dam (Crum Creek Dam)* County *Delaware* State *Pennsylvania* National ID # *PA 00348*

Type of Dam *Earth with concrete core wall* Hazard Category *I (High)*

Date(s) Inspection *4/6/78* Weather *cloudy, occas. rain* Temperature *50°±F*

Pool Elevation at Time of Inspection *200.5-* M.S.L. Tailwater at Time of Inspection *N/A* M.S.L.

Inspection Personnel:

John H. Frederick (Geotechnical) *Mary Beck (Hydrologist)* *Ray Lambert (Geologist)*

Noel Ravneberg (Geologist) *Vince McKeever (Hydrologist)*

John Boschuk, Jr. (Geotechnical)

John Boschuk, Jr. Recorder

Remarks:

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	*N/A*	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	*N/A*	
DRAINS	*N/A*	
WATER PASSAGES	*N/A*	
FOUNDATION	*N/A*	

CONCRETE/MASONRY DAMS

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

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	*No surface cracks were observed during this inspection.*	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	*None observed.*	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	*None observed. However, the downstream slope contains many coniferous trees which range up to 15 feet in height and should be removed.*	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	*No horizontal distorsions were observed but some vertical settlement has occurred. The settlement is located upstream of the core wall and can be observed as displacement between the core wall and embankment. Observed settlement ranges from zero at each abutment to a maximum of approximately 6 to 8 inches at the center of the dam. Construction records indicated that several earth zones in this area were puddle filled and, therefore, the vertical movement observed was expected.*	
RIPRAP FAILURES	*None observed.*	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	*No horizontal or vertical distorsions were observed. No seepage was observed at or near the contact between the earthened zones and the spillway walls.*	
ANY NOTICEABLE SEEPAGE	*Seepage was not observed on the downstream slope but was observed at several locations along the left abutment toe and downstream of the toe. (See Appendix C for photos.) There was no evidence of suspended fines in the seepage or sand boils at the spring locations.*	
STAFF GAGE AND RECORDER	*A water level gage was inspected in the water control tower and appeared to be operating properly.*	
DRAINS	*None observed.*	

OUTLET WORKS
CONTROL TOWER

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	*The system observed includes a control tower connected to a 10x10 feet concrete tunnel which emerges at the downstream toe. A 36" cast iron pipe located inside the tunnel (controlled by a valve) regulates flow into Crum Creek. The pipe was observed to be in good condition, but there were several cracks and some very minor spalling observed in the tunnel. Most of the cracks were noted in the vicinity of the tunnel-core wall junction. Flow was approximately 3.5 gallons per minute, clean and apparently under no significant hydrostatic pressure.*	
INTAKE STRUCTURE	*The intake tower and valves all appeared to be in good condition. The valves were exercised one turn and appeared to operate satisfactorily.*	
OUTLET STRUCTURE	*A downstream Aireation structure is connected to the 36" CIP outlet conduit. This structure is shaped in the form of a cone with ledges. The water is discharged through the center and allowed to flow down the sides to aerate the discharge. Since the system was operating its condition could not be investigated. However, it did appear to be operating as designed and is not relevant to the safety of the dam.*	
OUTLET CHANNEL	*The outlet channel between the tunnel and aeration cone was paved with rock and mortar. It appears to be in good condition. All but one weep hole along its base were dry. One weep hole located on the right side approximately 40 feet from the tunnel was weeping clear water at a rate of less than ½ gpm. Downstream of the aeration cone the channel was paved to the natural stream bed and was in good condition.*	
EMERGENCY GATE	*None observed.*	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	*The weir forms a segment of a circle and is 300 feet long with a top elevation of 200. Water over the crest was smooth flowing. Water over the spillway section was turbulent and consistent with the masonary type of construction used for the chute.*	
APPROACH CHANNEL	*N/A*	
DISCHARGE CHANNEL	*There is moderate spalling of concrete below the weir and above the bridge. After the water passes under the bridge the water falls over a rock ledge (which appears stable). The channel is essentially cut out of rock with final smooth contours formed by mortar and rock. Some minor deterioration has taken place on the right side and pieces of the mortar channel have dislodged. This channel should be repaired.*	
BRIDGE AND PIERS	*Should a storm produce a discharge of 10,000 cfs or more, a downstream highway bridge will be a hydraulic control restricting the spillway discharge. At elevation 207 (top of dam) the spillway capacity discharge is approximately 12000 cfs (this information obtained from a WCC report dated October 23, 1973).*	

GATED SPILLWAY

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

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	*None.*	
OBSERVATION WELLS	*None.*	
WEIRS	*A wooden weir was installed in the discharge tunnel to monitor flow from the cracks in the tunnel. Records of this flow were not readily available during this inspection but will be obtained and kept on file.*	
PIEZOMETERS	*None.*	
OTHER	*None.*	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	*The reservoir slopes are generally wooded with occasional fallen trees which may float during a major storm. It is unlikely that these trees will clog the spillway.*	
SEDIMENTATION	*There was no significant sedimentation observed in the flood storage area (above mean water level). However, it is understood that sedimentation is taking place in the water supply pool at the upper end of the reservoir.*	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	*The flood plain area is relatively flat laterally between rises on the left and right with a moderate slope longitudenally. The area has a dense growth of trees and many have debris lodged against the base of the trunks indicating that flows were across the flood plain several times in the past.*	
SLOPES	*For the most part the channel is on the right side of the flood plain adjacent to the valley slope. In a few cases, the slope has eroded leaving a 14-16 foot bank. The left side contains the relatively flat flood plain.*	
APPROXIMATE NO. OF HOMES AND POPULATION	*There are approximately 100 houses between the dam and Crum Creek Pumping Station located approximately 3.5 miles downstream.*	

APPENDIX
C

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: *Over one-half is open farm and woods. Surburbia developing in this area.*

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): *200.00 (3.5 million gallons)*

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): *207 (top of dam)*

ELEVATION MAXIMUM DESIGN POOL: *Top of dam (elevation 207) no free board*

ELEVATION TOP DAM: *207.00*

CREST:

a. Elevation *elevation 207 (dam); elevation 200 (spillway)*

b. Type *Earth dam with concrete core wall and Ogee spillway*

c. Width *44 feet*

d. Length *2000 feet (dam)*

e. Location Spillover *right abutment of dam*

f. Number and Type of Gates *None*

OUTLET WORKS:

a. Type *Ogee crest 300 feet long*

b. Location *right abutment of spillway*

c. Entrance inverts *elevation 200*

d. Exit inverts *N/A*

e. Emergency draindown facilities *36" CIP in control tower*

HYDROMETEOROLOGICAL GAGES:

a. Type *standard rainfall*

b. Location *pumping station*

c. Records *read once per day and up to three times during major storm*

MAXIMUM NON-DAMAGING DISCHARGE: *not determined*

DAM SAFETY ANALYSIS
HYDROLOGIC/HYDRAULIC DATA

Date: 4/3/78
By: MFB
Sheet: 2 of 8

DAM Geist Nat. ID No. PA 00348 DER No. 23-29

ITEM/UNITS	Permit/Design Files (A)	Calc. from Files/Other (B)	Calc. from Observations (C)
1. Min. Crest Elev., ft.	207		
2. Freeboard, ft.	0		
3. Spillway[1] Crest Elev, ft.	200	200 ft.	
3a. Secondary[2] Crest Elev, ft.	N/A	N/A	
4. Max. Pool Elev., ft.			
5. Max. Outflow[3], cfs	18,000 cfs	11,600 cfs	
6. Drainage Area, mi²	21.3 mile²	21.5 mile²	21.4 mile²
7. Max. Inflow , cfs		32,000 cfs	
8. Reservoir Surf. Area	375 Ac.	391 Ac.	359 Ac.
9. Flood Storage[4]		2037 Ac-Ft	
10. Inches of Runoff (PMF)		24.6 inches	

Reference all figures by number or calculation on attached sheets:

Example: 3A - Drawing No. xxx by J. Doe, Engr., in State File No. yyyy.

NOTES:

(1) Emergency spillway.

(2) Secondary ungated spillway.

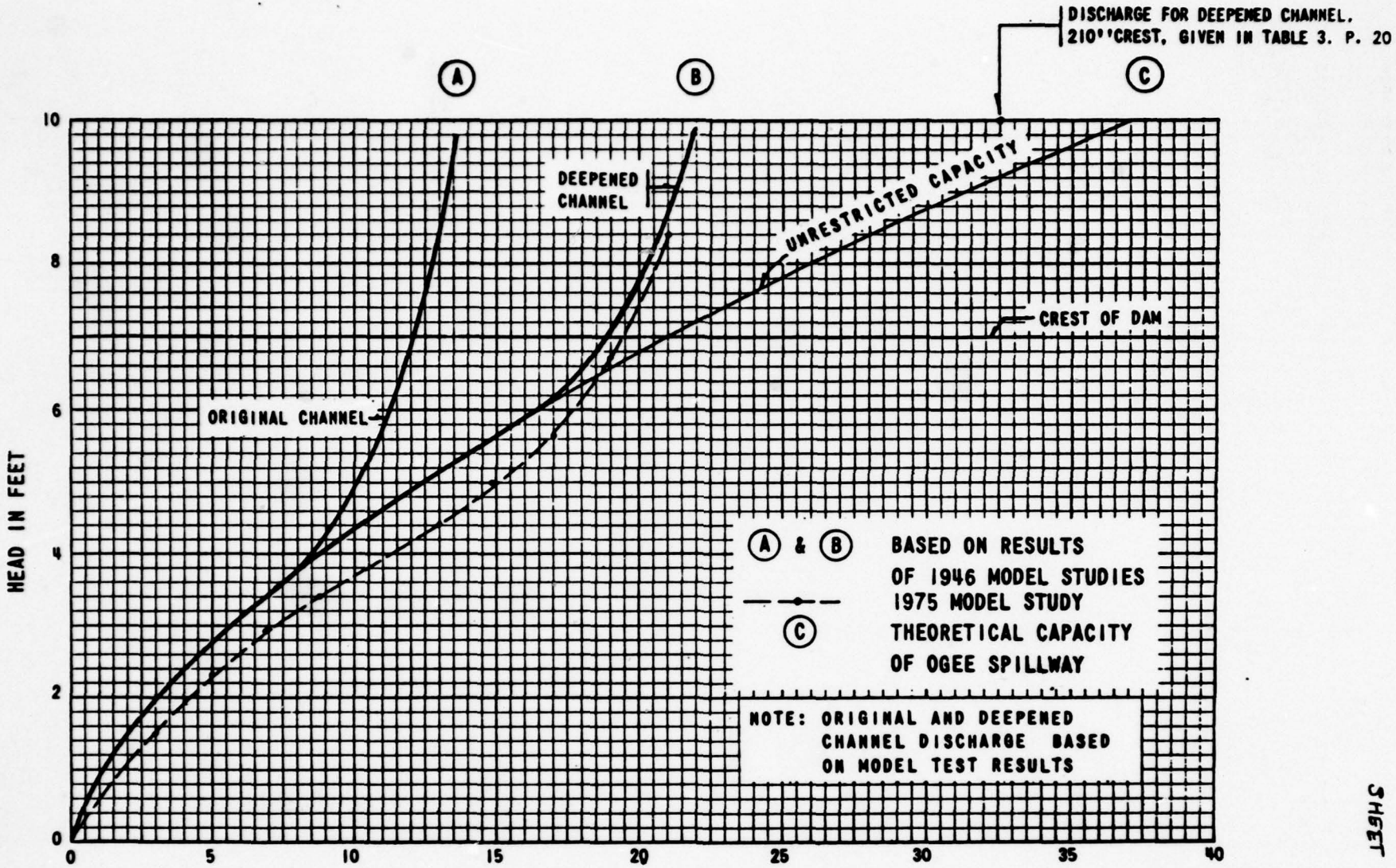
(3) At maximum pool, without freeboard.

(4) Between spillway and maximum pool.

Date: 4/3/78
By:
Sheet: 3 of 8

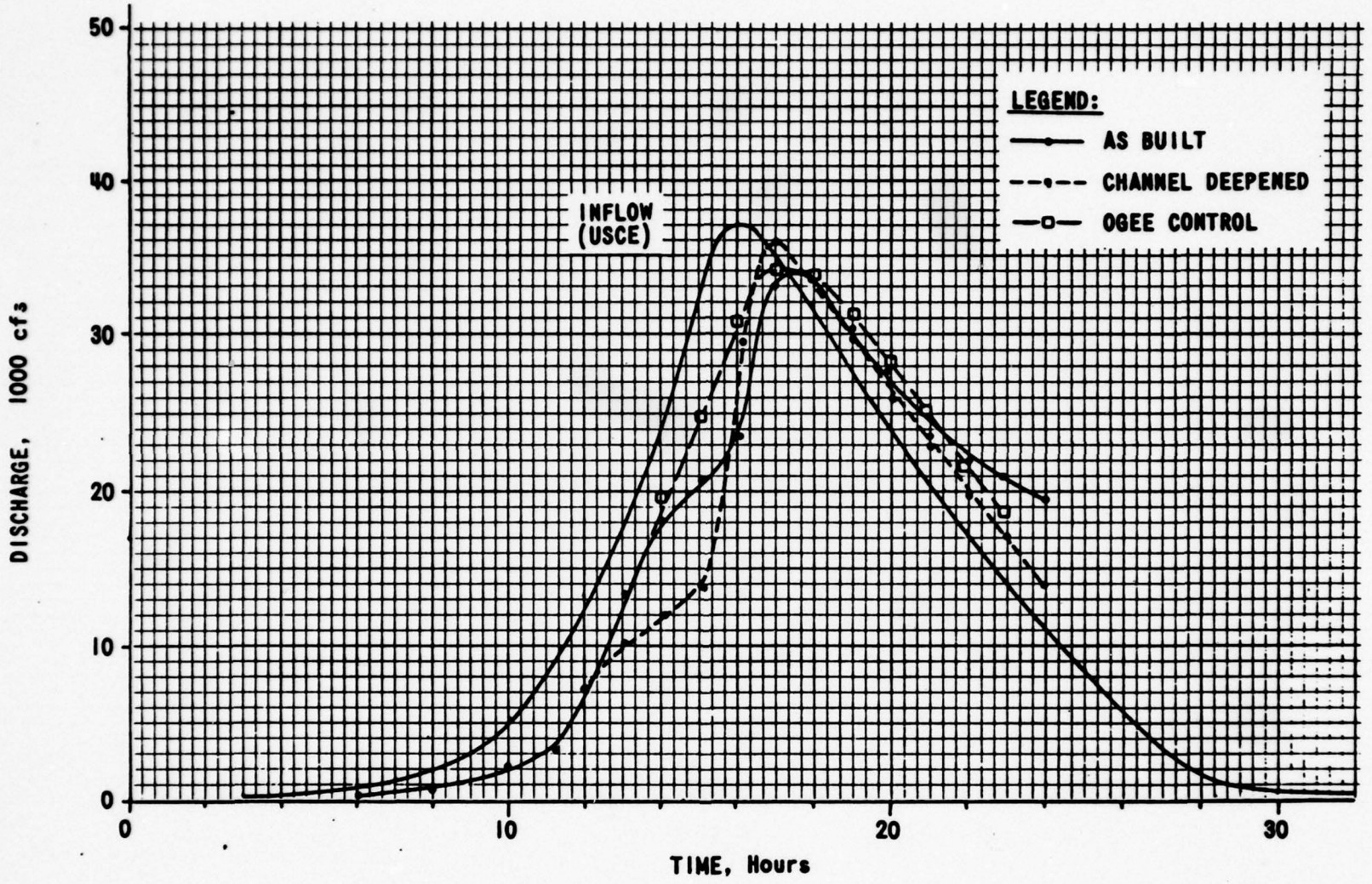
HYDROLOGIC/HYDRAULIC CALCULATIONS (cont.)

Item (from sheet 2)	Source
1A, 2A, 3A	PSWCo. Plans
6A, BA, 5A (5A)	Application Report July 6, 1929 (Verified by 1946 Model Study)
3B, 6B, BB	Plan located in Crum Creek Pumping Sta
5B	1975 Hydraulic Model Study by Verna Engineering, Carnegie, Pa.
7B, 9B, 10B	Calculations on file at PSWCo.
6C, BC	USGS Maps West Chester (1968) Malvern (1973) Valley Forge (1973) Media (1973)



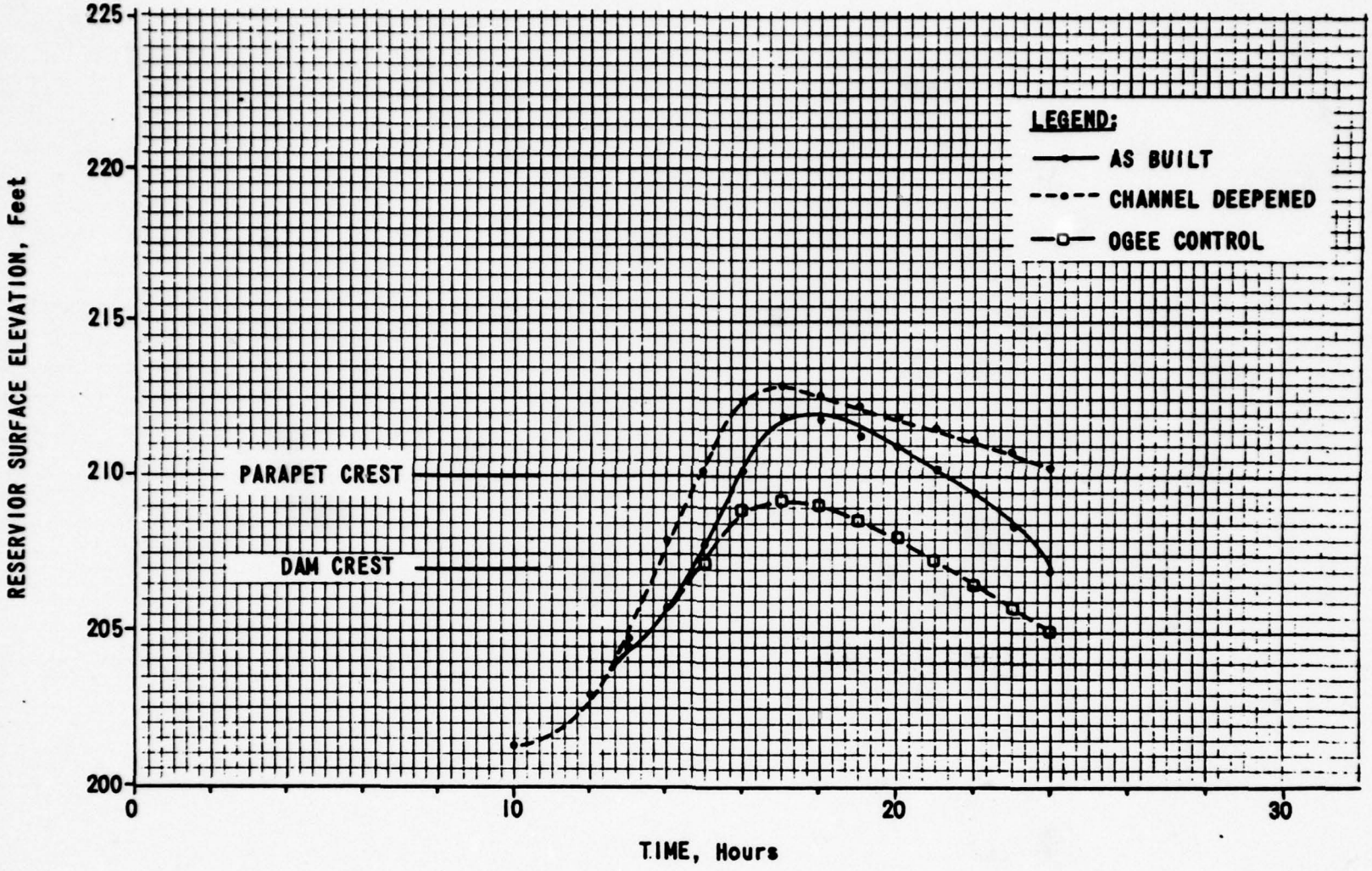
SHEET 4 OF 8

CAPACITY CURVE FOR SPILLWAY
GEIST DAM SPILLWAY



INFLOW AND OUTFLOW HYDROGRAPHS
GEIST DAM SPILLWAY
MAXIMUM PROBABLE STORM

SHEET 5 OF 8



SHEET 6 OF 8

RESERVOIR SURFACE ELEVATION
GEIST DAM SPILLWAY
MAXIMUM PROBABLE STORM

DAM SAFETY ANALYSIS
HYDROLOGIC/HYDRAULIC CALCULATIONS

Date: 4/6/78
By: VH / MFB
Sheet: 7 of 8

DAM Geist Nat. ID No. PA 00348 DER No. 23-79
Calculations for *Design* ☐, *As-Built* ☐, *Existing* ☑ Conditions

1. Spillway Discharge at Max. Pool*, Q_{omac} 11,600 *** cfs
   Freeboard at Max. Pool 0 ft.

2. Tributary Drainage Area*, A 21.5 mi^2

3. From: (See Sheet 2, Item 7)
   a) Inflow hydrograph peak flow, Q_{Imax} (18,500) 37,000 cfs at (50%) 100% PMF
   b) Inflow hydrograph duration, T — hrs.

IF Q_{omax} exceeds Q_{Imax}, check here and stop ☐

4. Calculate $p = Q_{omax}/Q_{Imax}$ = $\frac{11,600/37,000}{(11,600/18,500)}$ = $\frac{0.3135}{(0.6270)}$.

5. Calculate Volume of inflow hydrograph, V_I

$$V_I = \cancel{1800\ Q_{Imax}\ T = 1800} \times \frac{24.6}{12}\ 21.5 \times 640 = \frac{28,208}{(14,104)}\ \cancel{ft^3}\ Ac\text{-}Ft$$

6. Calculate volume of storage between normal and maximum pool, V_s

   Crest Elevation = 207 ft.
   Freeboard* = 0 ft.
   El. Max. Pool = 207 ft.
   El. Normal Pool* = 200 ft.
   Storage Height = 7 ft.

   Area of reservoir from USGS quad sheet*, _____ ft^2

   V_s = ~~Storage Height x Area~~ = 2837 $\cancel{ft^3}$ Ac-Ft

IF V_s exceeds V_I, check here and stop ☐.

---

* *See Sheet 2*
*** *The difference between 11,600 cfs and 12,000 cfs has little effect on the final result.*

HYDROLOGIC/HYDRAULIC CALCULATIONS (cont.)

Date: 4/6/78
By: VM/MFB
Sheet: 8 of 8

DAM Geist

Design ☐, *As-Built* ☐, *Existing* ☑

7. Calculate storage required to pass flood, V_R

$$V_R = (1-p)\ V_I = \frac{(1 - .3135)}{(1 - .6270)} \times \frac{28208}{(14,104)} = \frac{19,364}{(5,260)}\ ft^3\ Ac\text{-}Ft$$

IF V_S exceeds V_R, check here and stop ☐ .

8. Calculate freeboard storage, V_F

V_F = Freeboard x Area = _____ x _____ = 0 ft^3

Does V_R exceed $V_S + V_F$? yes . If yes, repeat for 1/2 PMF, if this calculation is for 1/2 PMF, and answer is still yes, dam may be unsafe.

SUMMARY

Dam passes
- PMF with _____ ft. freeboard . . . ☐
- PMF with no freeboard . . . . . ☐
- 1/2 PMF with _____ ft. freeboard . ☐
- 1/2 PMF with no freeboard . . . . . ☐
- None of the above . . . . . ☑

APPENDIX

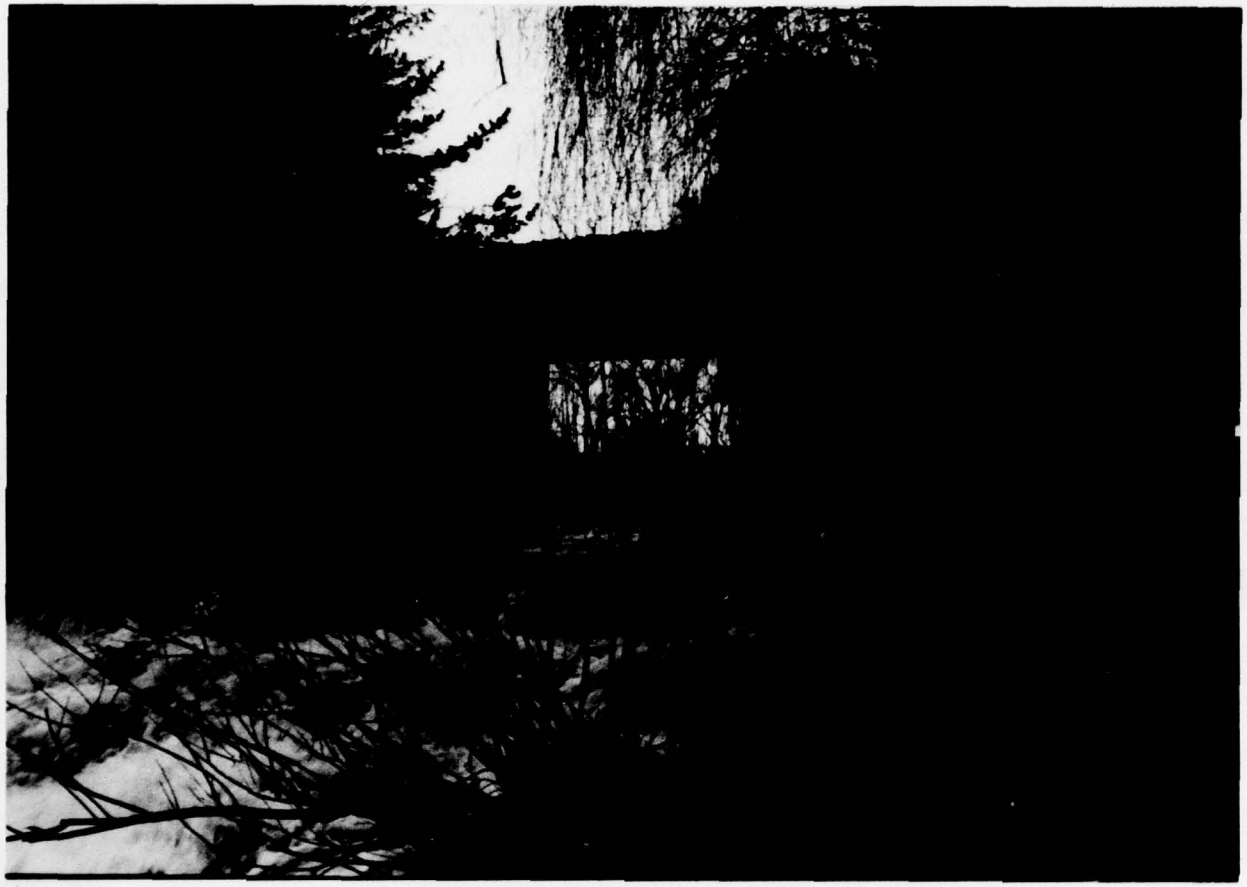
D

VIEW OF PRIMARY DISCHARGE STRUCTURE AND AERATION SYSTEM

PHOTO NO. 1

VIEW OF EMERGENCY SPILLWAY LOOKING FROM THE RIGHT ABUTMENT TOWARDS LEFT ABUTMENT OF THE SPILLWAY.

PHOTO NO. 2



VIEW LOOKING UPSTREAM TOWARDS HIGHWAY BRIDGE. THE SPILLWAY CAN BE SEEN BEHIND THE BRIDGE.

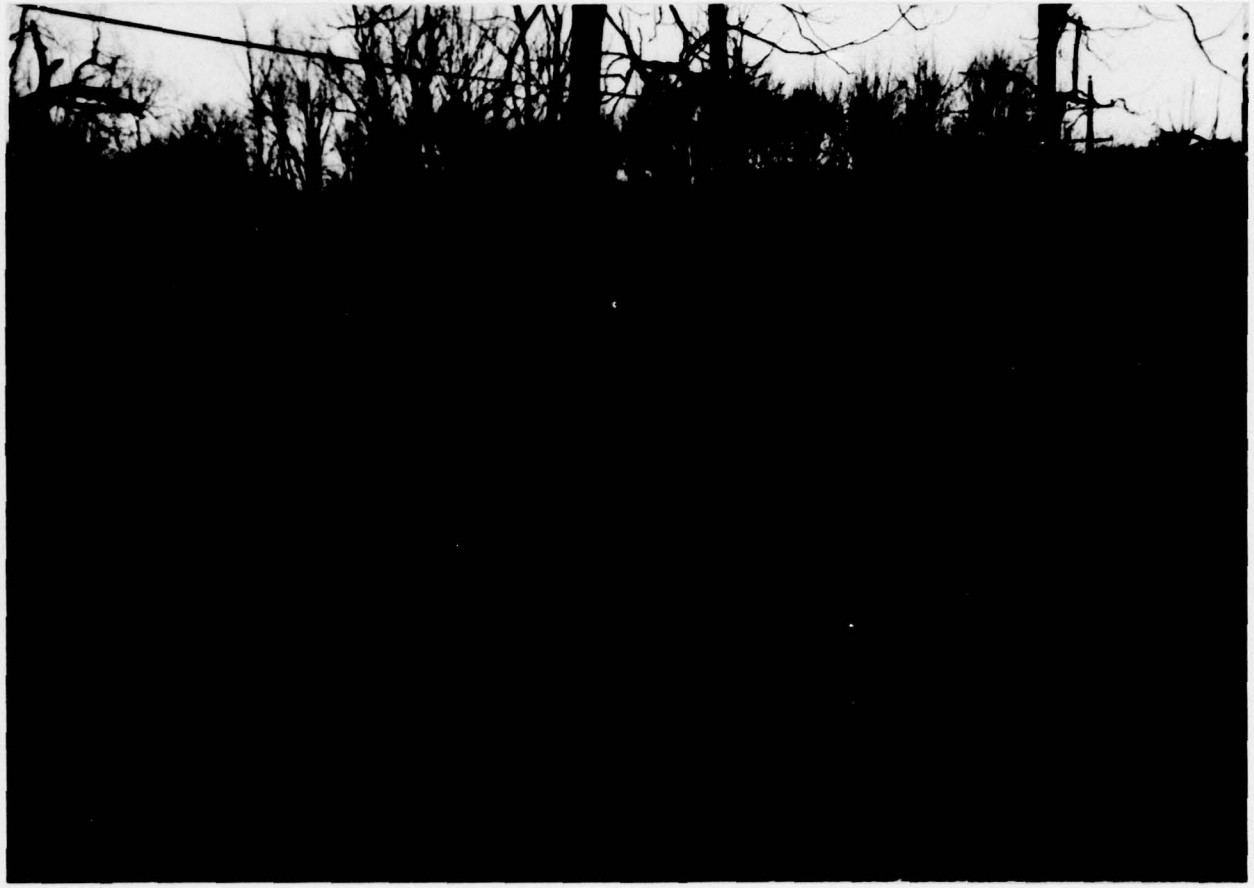
PHOTO NO. 3

VIEW OF PARAPET WALL ON THE UPSTREAM SIDE OF THE CREST.
NOTE THE SETTLEMENT BETWEEN THE WALL AND THE EMBANKMENT (6-8 inches).
THE BRIDGE TO THE CONTROL TOWER CAN BE SEEN ON THE LEFT.

PHOTO NO. 4

VIEW OF SEEPAGE NEAR THE DOWNSTREAM TOE OF THE LEFT ABUTMENT.
REPORTEDLY THE RATE HAS NOT CHANGED FOR SEVERAL YEARS.
ALL FLOW WAS OBSERVED TO BE CLEAR.

PHOTO NO. 5

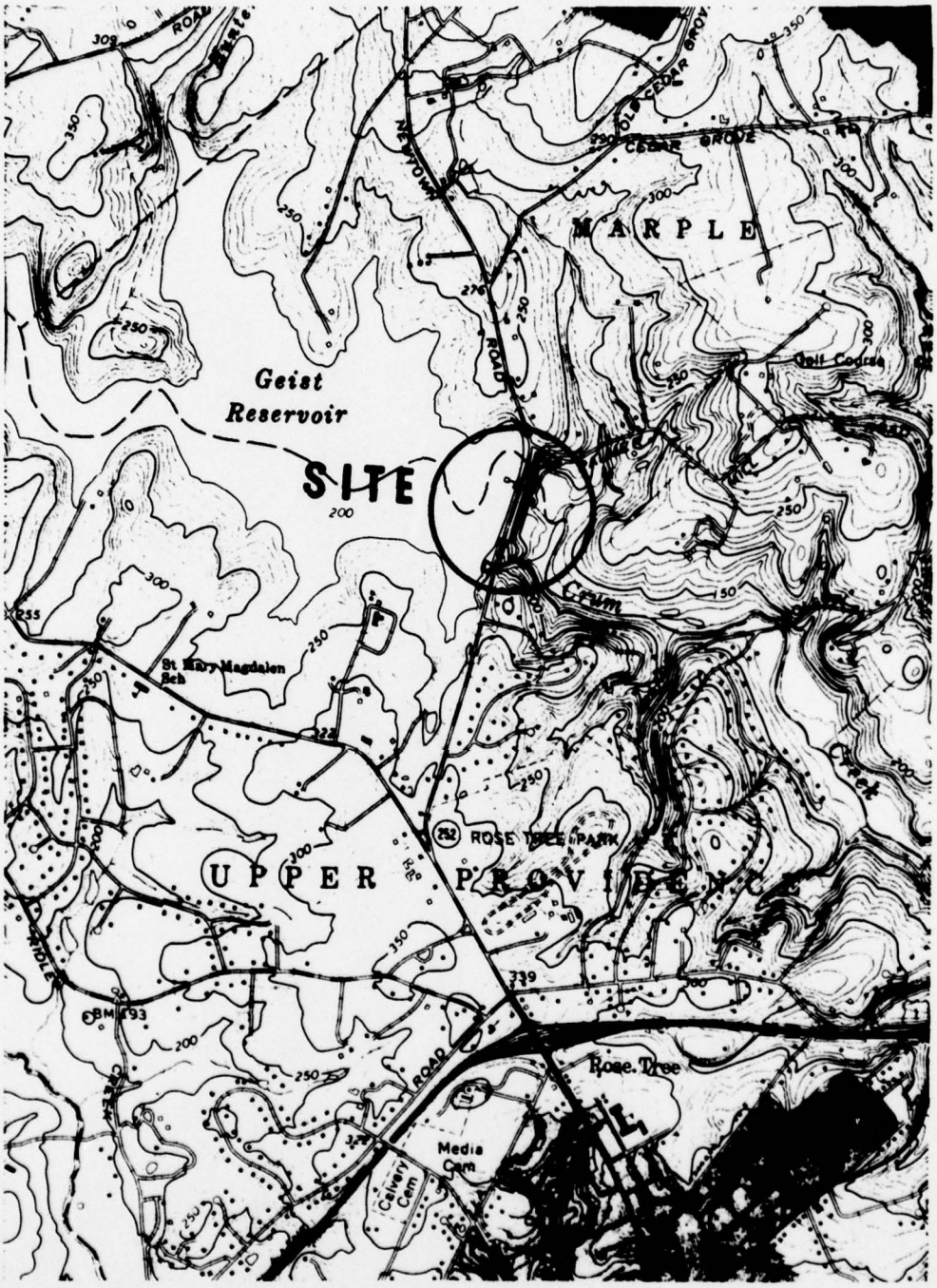


VIEW OF SEEPAGE IN THE FLOOD PLAIN AREA DOWNSTREAM OF THE EMBANKMENT NEAR THE LEFT ABUTMENT. SOME OF THE SEEPAGE SHOWN HERE COMES FROM THE SEEPAGE SHOWN IN PHOTO NO. 5.

PHOTO NO. 6

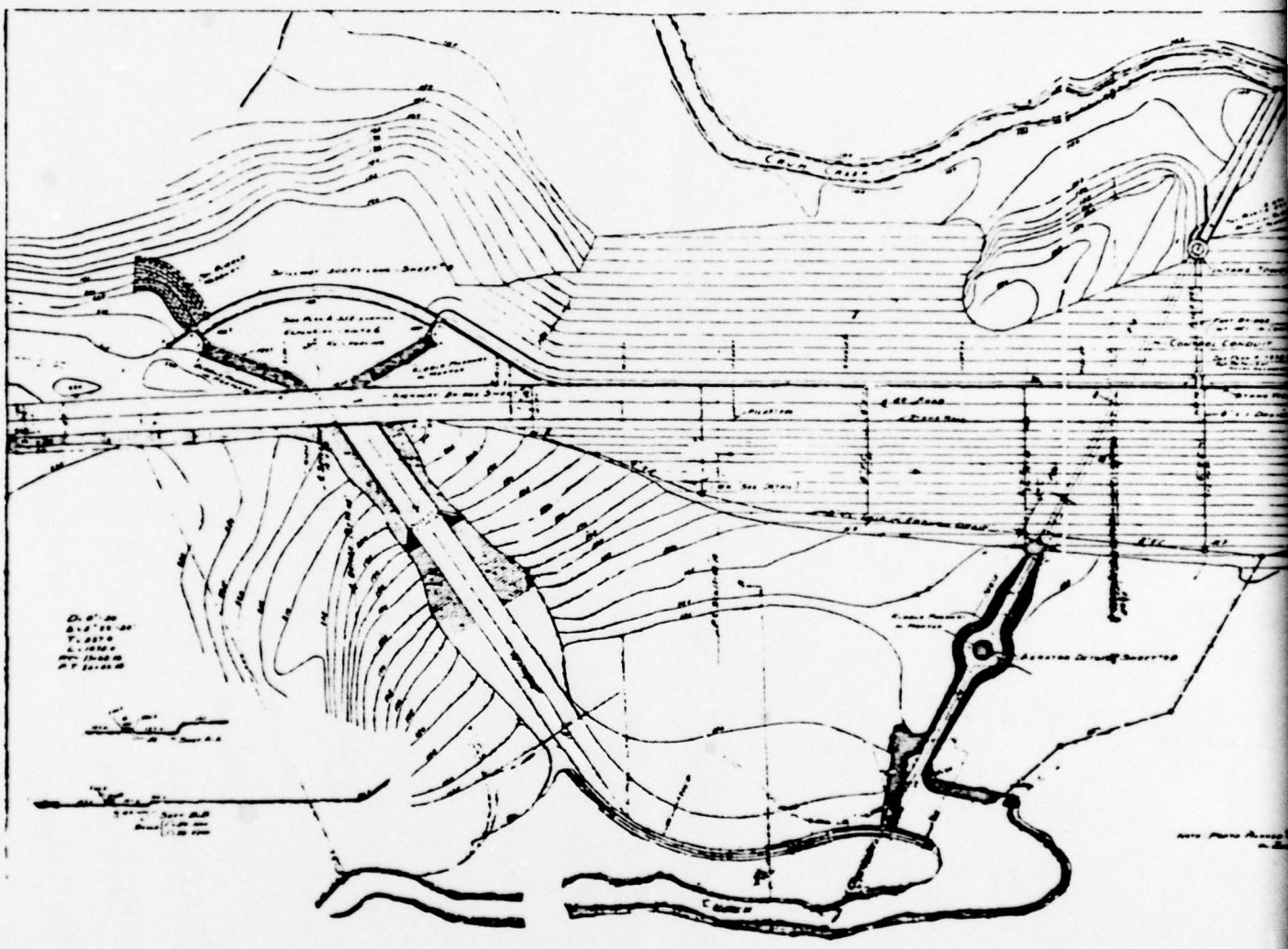
APPENDIX

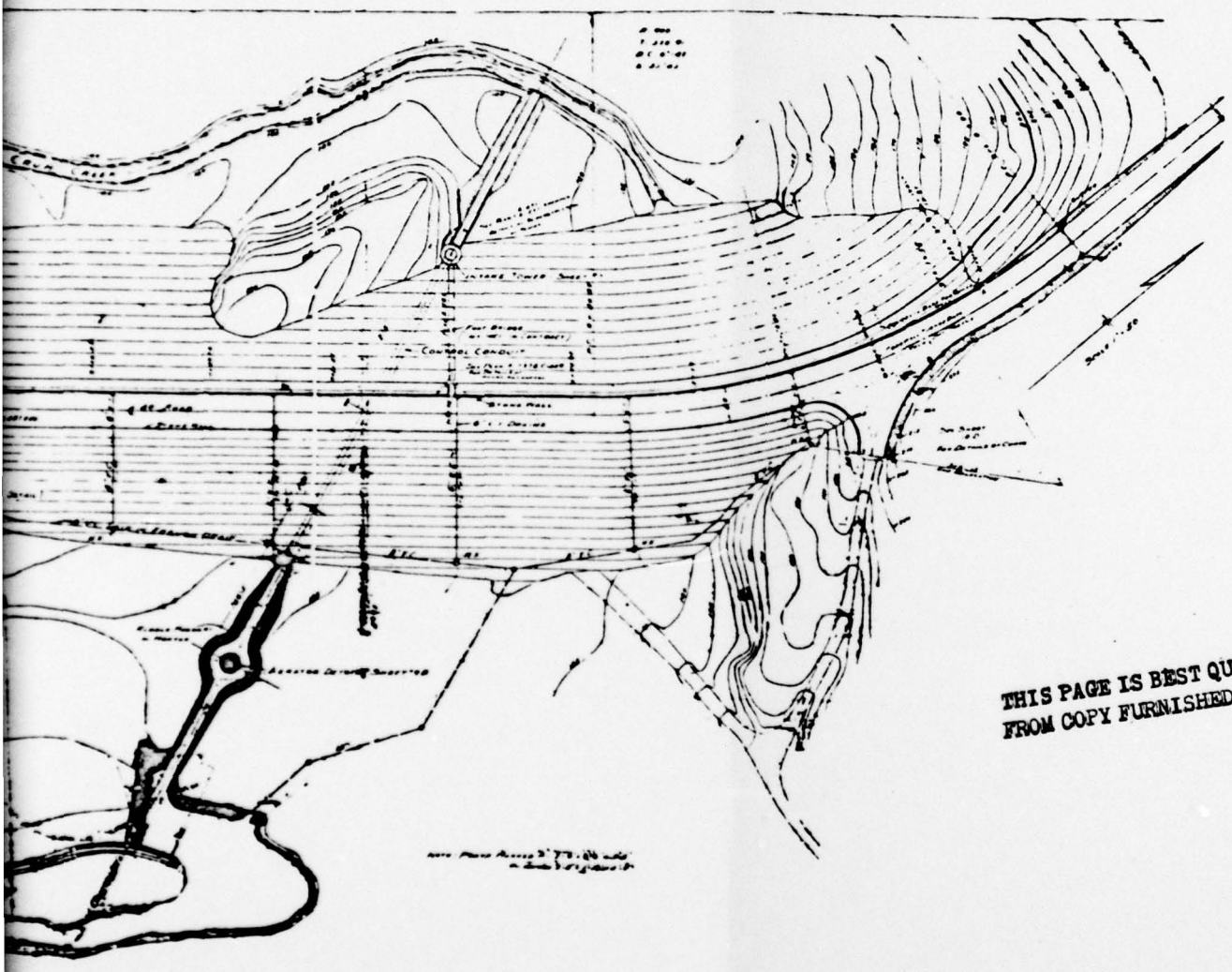
E



REGIONAL LOCATION PLAN
GEIST STORAGE DAM
U.S.G.S. QUAD SHEET 'MEDIA'

PLATE 1



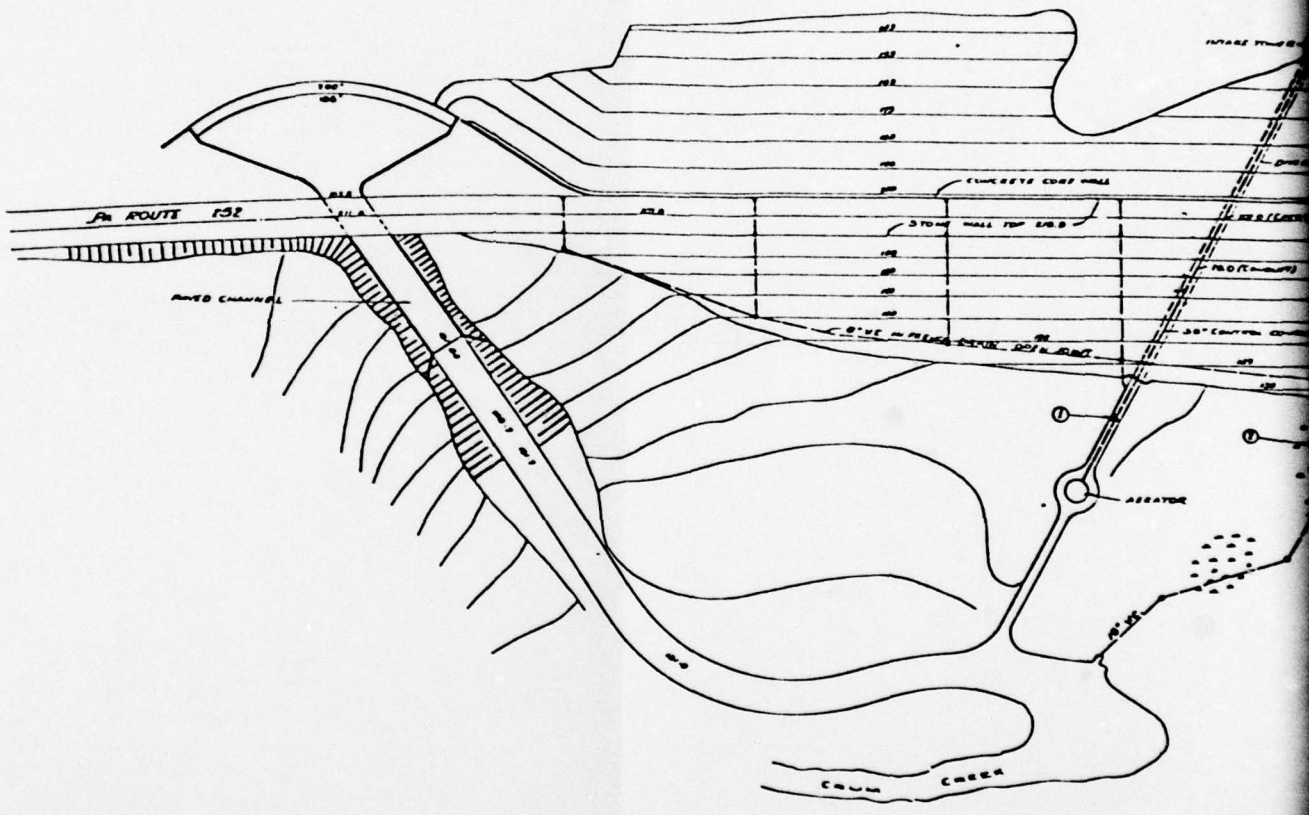


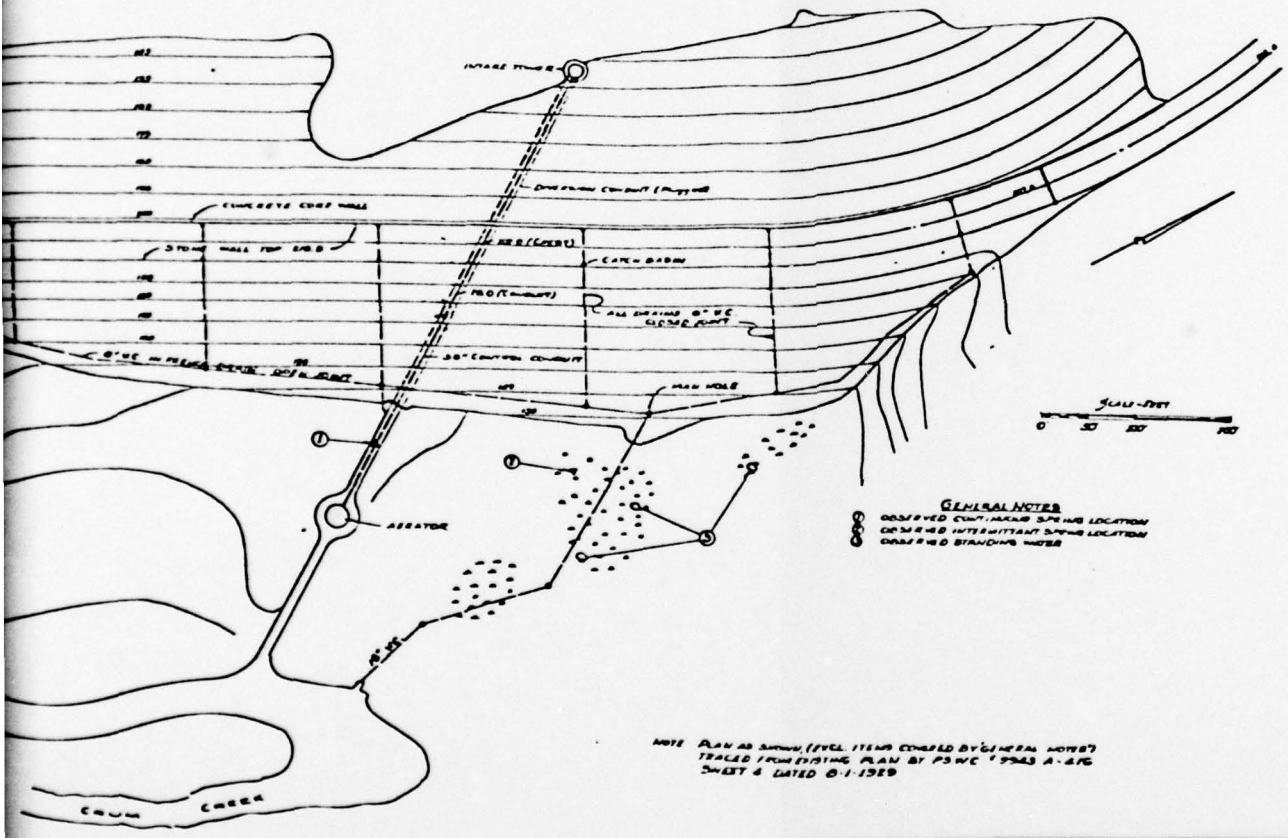
PLAN OF DAM AND APPURTENANCES
GEIST STORAGE DAM

DELAWARE COUNTY — PENNSYLVANIA

DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER WATER COMPANY DOCUMENTS

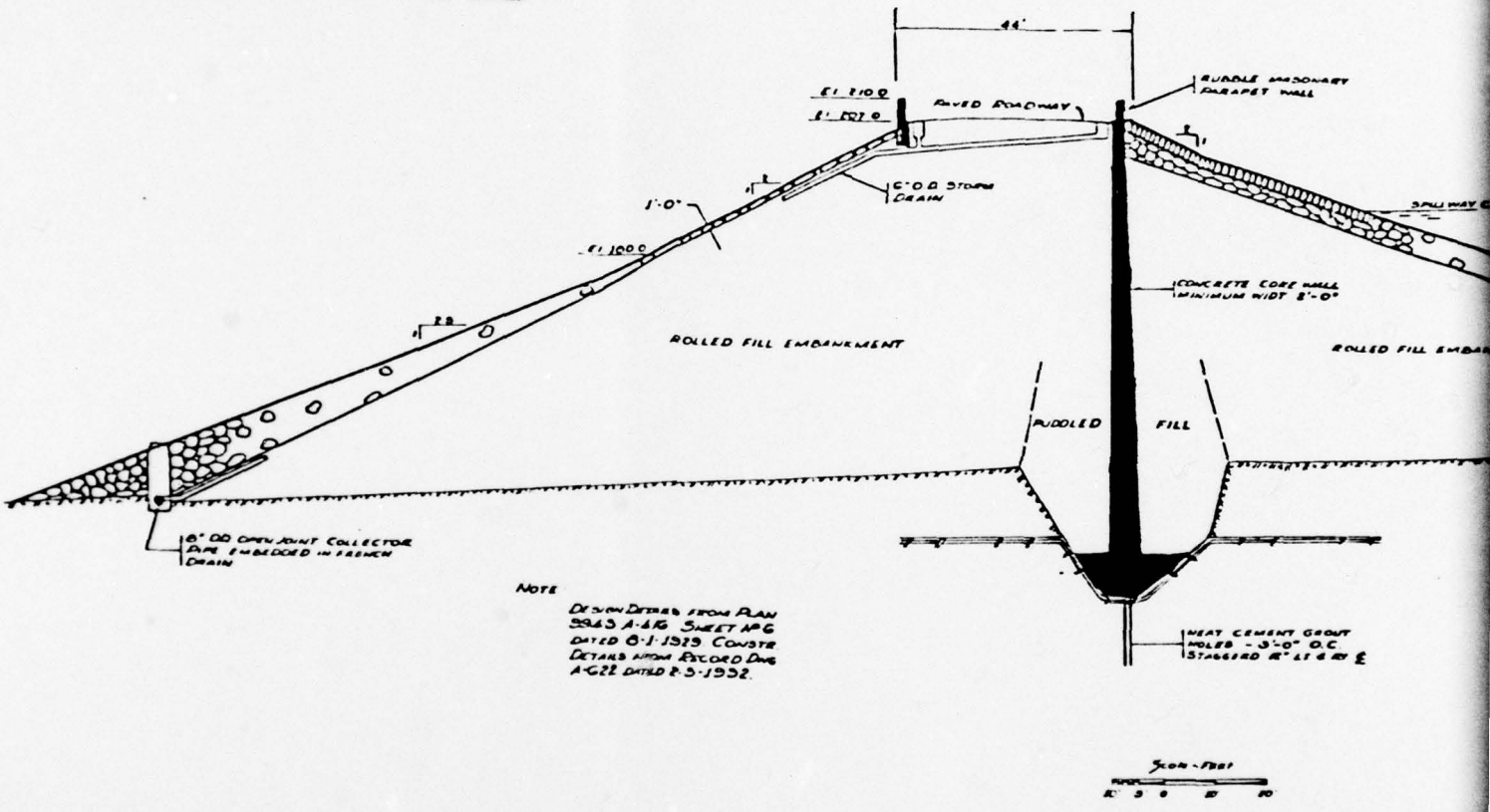
PLATE 2





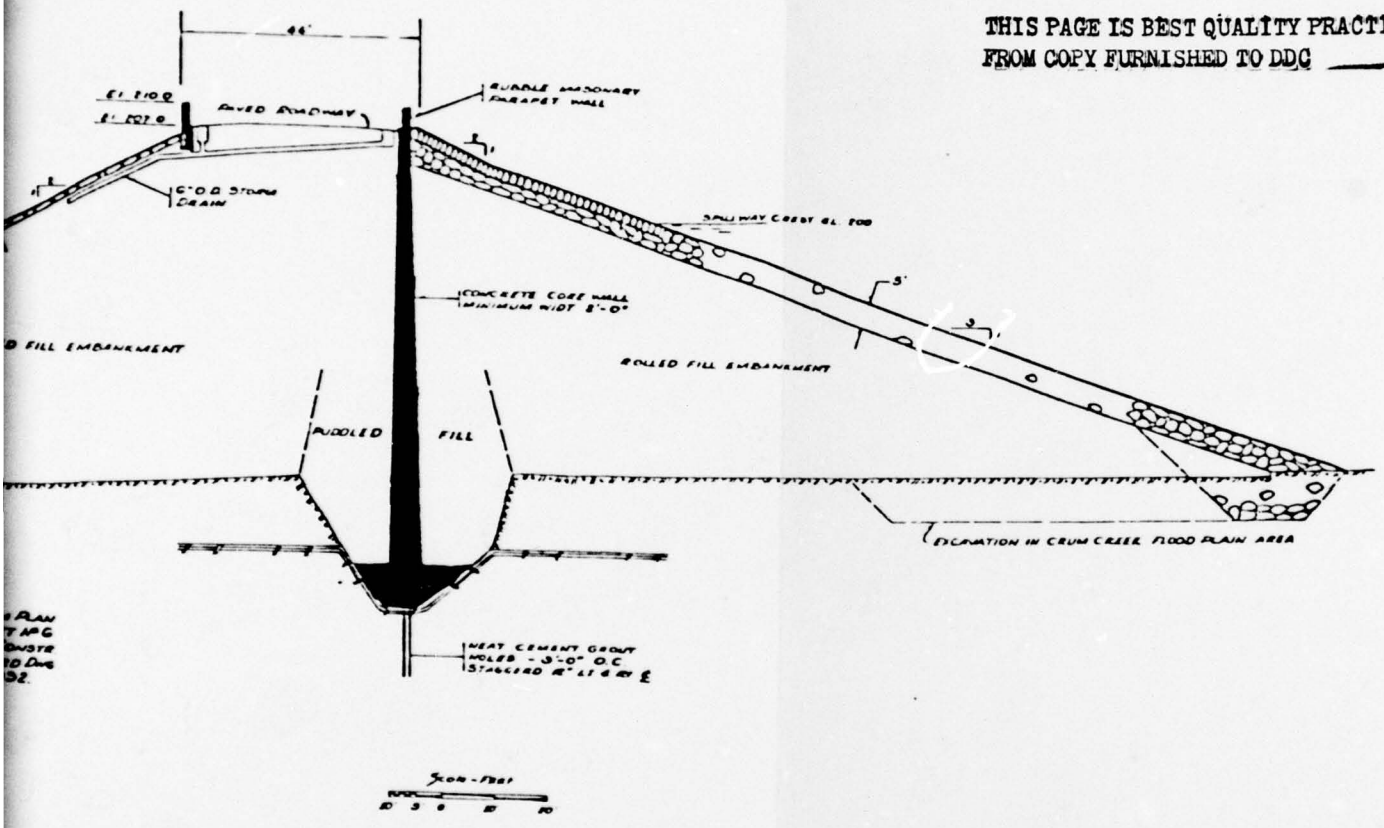
NOTE PLAN AS SHOWN (EXCL. ITEMS COVERED BY GENERAL NOTES) TRACED FROM EXISTING PLAN BY PSWC #7943 A-2 &C SHEET 4 DATED 6-1-1929

SEEPAGE LOCATION PLAN GEIST STORAGE DAM	
DELAWARE COUNTY	PENNSYLVANIA
DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER WATER COMPANY DOCUMENTS	
	PLATE 3

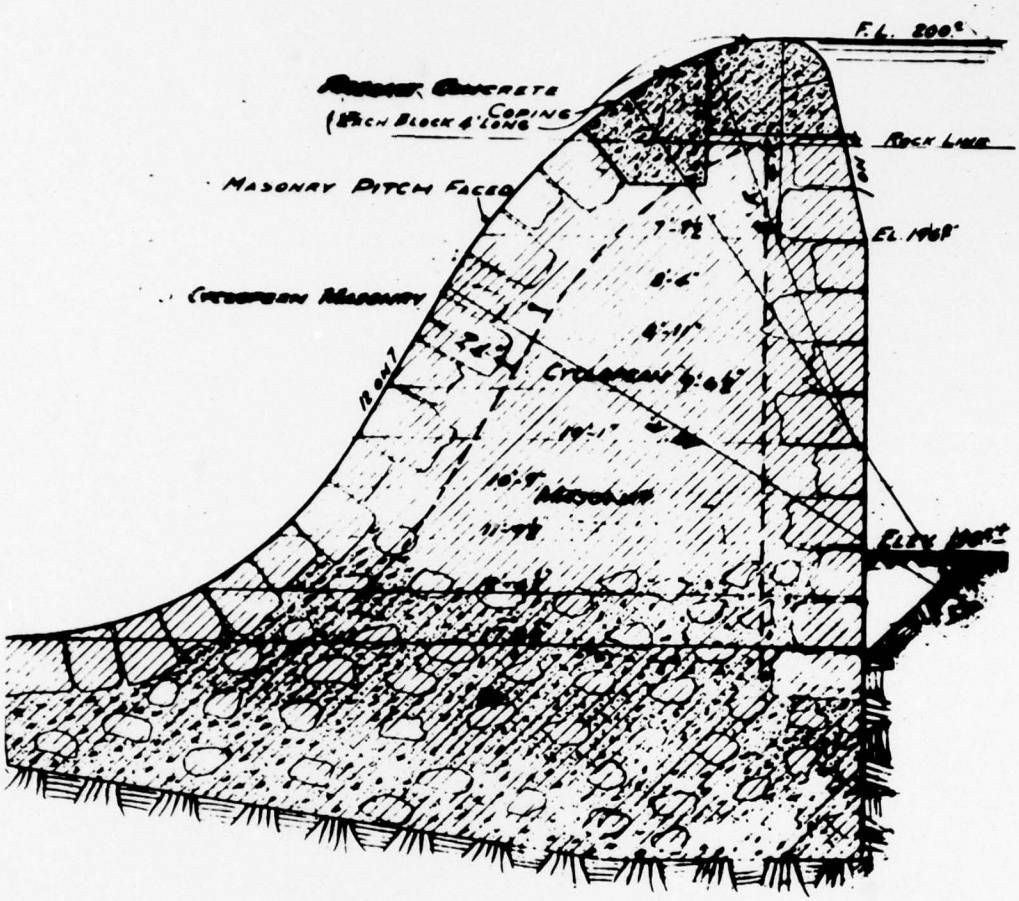


NOTE

DESIGN DETAILS FROM PLAN 3963 A-616 SHEET NO 6 DATED 6-1-1939 CONSTR DETAILS FROM RECORD DWG A-622 DATED 8-3-1952



TYPICAL CROSS-SECTION WITH CONSTRUCTION DETAILS GEIST STORAGE DAM	
DELAWARE COUNTY	PENNSYLVANIA
DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER WATER COMPANY DOCUMENTS	
	PLATE 5

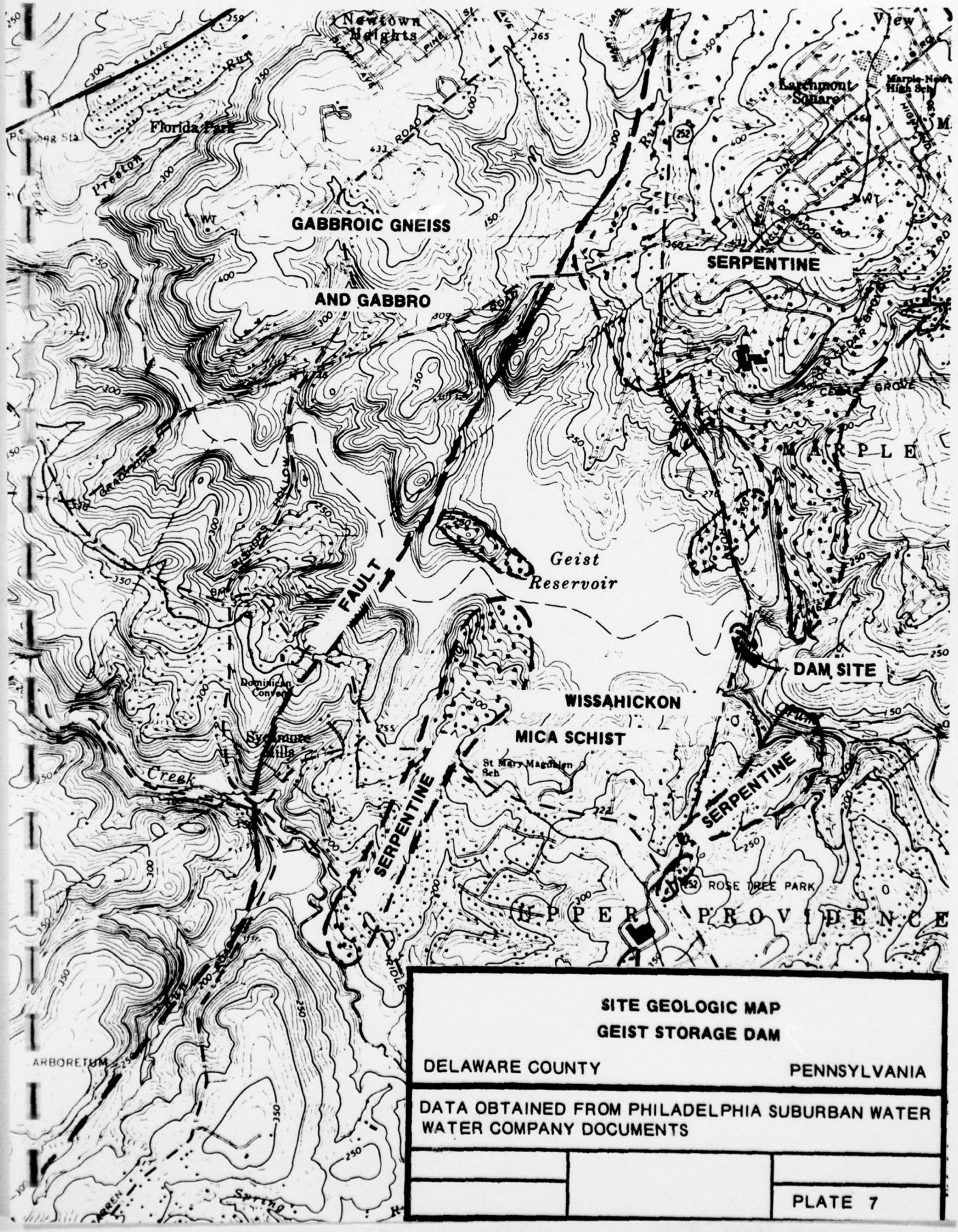


SPILLWAY CROSS-SECTION
GEIST STORAGE DAM

DELAWARE COUNTY PENNSYLVANIA

DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER WATER COMPANY DOCUMENTS

PLATE 6



SITE GEOLOGIC MAP
GEIST STORAGE DAM

DELAWARE COUNTY PENNSYLVANIA

DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER WATER COMPANY DOCUMENTS

PLATE 7