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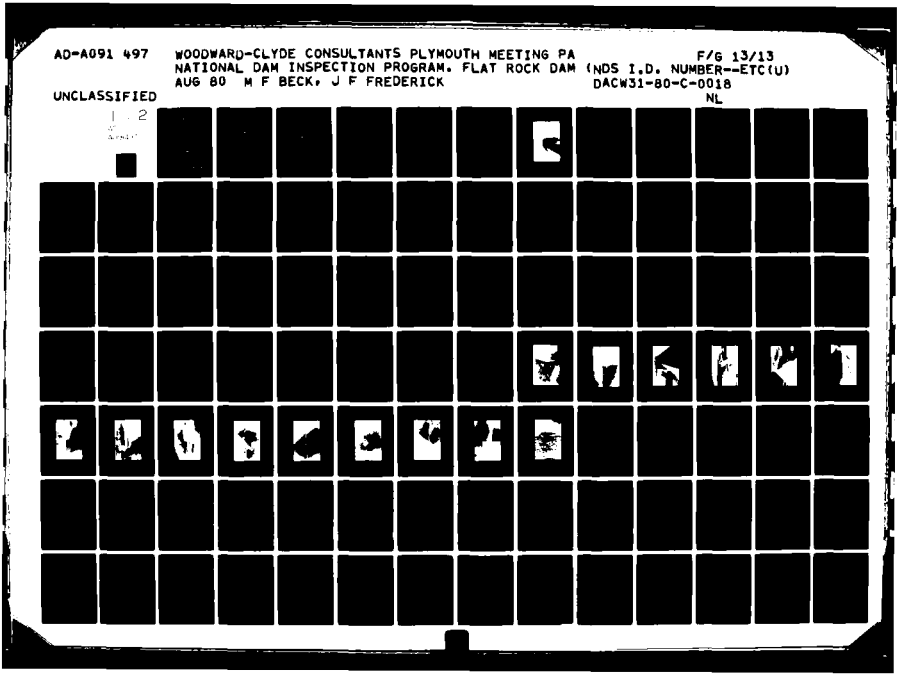

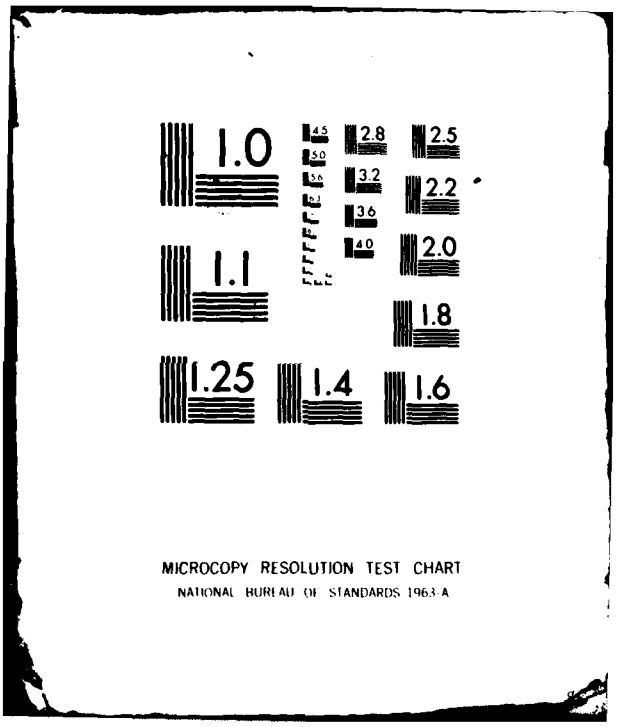
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DELAWARE RIVER BASIN

SCHUYLKILL RIVER
MONTGOMERY AND PHILADELPHIA COUNTIES

PENNSYLVANIA
NDS ID PA. 00886
DER ID 51-1

FLAT ROCK DAM

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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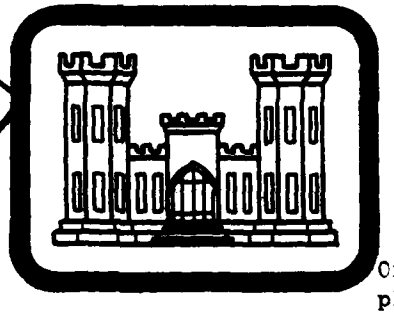

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DELAWARE RIVER BASIN

(6) National Dam Inspection Program.

FLAT ROCK DAM, ~~MONTGOMERY AND PHILADELPHIA COUNTIES, PENNSYLVANIA~~

Number

(NDS I.D. [redacted] PA 00896,
DER I.D. [redacted] 51-1), Delaware River Basin
Schuylkill River, Montgomery and Philadelphia Counties, Pennsylvania.

PHASE I INSPECTION REPORT,
~~NATIONAL DAM INSPECTION PROGRAM~~

(10) Mary F. /Beck
John F. /Frederick

(11) Aug 80

(12) 102

(15) DACW31-80-C-0018

Prepared by:

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Submitted to:

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

AUGUST 1980

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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 the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to expeditiously identify 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 investigations, testing and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies.

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

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

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

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam:	Flat Rock Dam
County Located:	Montgomery and Philadelphia Counties
State Located:	Pennsylvania
Stream:	Schuylkill River
Coordinates:	Latitude 40° 2.4' Longitude 75° 14.9'
Date of Inspection:	June 11, 1980

Flat Rock Dam is owned by the Commonwealth of Pennsylvania, and the pool formed is used primarily for recreational purposes. The left abutment of the dam abuts the Manayunk Canal wall owned by the City of Philadelphia. Visual inspection of the exposed sections of the dam, review of available data and simplified calculations presented in Appendix D indicate the dam is in good condition. No data other than Plate 12, Appendix E, were available for the canal wall. Calculations presented in Appendix G indicate the wall is marginally stable under assumed conditions. The results of the stability analysis are at variance with the canal wall's demonstrated performance history.

In accordance with criteria established by Federal (OCE) Guidelines, the recommended spillway design flood for this "Intermediate" size dam and "High" hazard potential classification is the Probable Maximum Flood (PMF).

Calculations presented in Appendix D indicate the structure will pass about 0.07 PMF without overtopping the right embankment. As the spillway will not pass the PMF without overtopping, it is considered to be "Inadequate". It is considered that the dam is not likely to fail; therefore, the spillway is not considered to be "Seriously Inadequate".

It is recommended that the following measures concerning the canal wall be undertaken immediately by the City of Philadelphia. Items (1) and (2) should be performed under the supervision of a registered professional engineer experienced in the design and construction of dams.

(1) As the canal wall stability analysis presented in Appendix G is at variance with its demonstrated performance history, further investigations should be made to verify the configuration of the section, assumed foundation and canal bottom conditions, and results of the analysis. If stability of the wall

cannot be demonstrated, measures should be taken to insure its stability under all expected conditions.

(2) Seepage through the canal wall should be monitored and evaluated.

(3) Surficial deteriorated concrete on the canal wall should be repaired.

(4) In conjunction with Item (3), all open cracks at the top of the wall at the construction joints should be sealed to prevent damage from freezing water in the winter.

An operation and maintenance manual for small dams has been prepared by the Department of Environmental Resources, Division of Completed Projects, Bureau of Operations. Portions of this manual apply to Flat Rock Dam. It is important that persons concerned with this structure be familiar with the procedures contained in the manual. The City of Philadelphia should develop a maintenance procedure to insure the canal wall is maintained in the best possible condition. Since the Schuylkill River is covered under the National Weather Service Flood Forecasting Service and procedures have been established to warn of potential flooding along the river downstream of the dam, it is not recommended that a separate warning procedure be developed for this structure.

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APPROVED BY:

James W. Peck 5 Sep 80

JAMES W. PECK Date
Colonel, Corps of Engineers
District Engineer

OVERVIEW
FLAT ROCK DAM, MONTGOMERY AND PHILADELPHIA COUNTIES, PENNSYLVANIA

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
FLAT ROCK DAM
NATIONAL ID NO. PA 00896
DER NO. 51-1

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

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

1.2 Description of Project.

a. Dam and Appurtenances. Flat Rock Dam is a run-of-the-river dam across the Schuylkill River. It is a concrete gravity structure with a 510 foot ogee spillway section and a spillway crest elevation of 37.7 throughout most of its length. The right abutment is in the right river bank, while the left abutment abuts the previously existing Manayunk Canal wall.

The ogee gravity spillway has a base width of 34 feet, and the total height from the minimum foundation elevation to the crest of the non-overflow section at the right abutment is about 36 feet. Two 60 foot long sections of the spillway crest, one near each of the abutments, are 0.5 foot lower than the rest of the spillway to form low flow sections. The spillway has a short apron, which discharges flow directly onto the river bed. The height of the spillway crest sections above the downstream apron is 14.7 feet, while the top of the right abutment is 21.2 feet above the adjacent spillway apron. The foundation was grouted, and rock anchors are located in the heel of the dam, as shown on Plates 5 and 9, Appendix E.

The dam was constructed about 12 feet downstream, at the right abutment, of the previously existing rock filled timber crib dam. The new right retaining wall was constructed downstream of the stone masonry abutment. The old abutment

extends about 65 feet into the right river bank, Plate 4, Appendix E. The abutment slope behind the new retaining wall and downstream of the old abutment is protected with grouted derrick stone over compacted rock fill.

The left abutment for the timber crib dam is of stone masonry at the entrance to the Manayunk Canal, Photograph 4. The upstream end of the concrete canal wall abuts the downstream end of the stone abutment. The left abutment for Flat Rock Dam, Plate 9, adjoins the previously existing canal wall and is anchored to the canal wall by No. 8 bars grouted into the existing masonry and concrete wall.

The canal wall, a concrete gravity structure, extends approximately 800 feet between the left abutment of the dam and the canal feeder house. The canal wall top width is 15 feet in the vicinity of the abutment and about six feet elsewhere. Throughout its length, the top of the canal wall is stepped in sections, with top elevations ranging from 42.5 to 49.9. At approximately the midpoint between the dam and the feeder house is an 87 foot wide weir at a crest elevation of 39.0. The maximum height of the canal wall above the river bed is about 29 feet adjacent to the dam. The canal bottom ranges from elevation 25 to 37.

The canal has not been used for navigation since 1917, but within the past few years was restored to a limited extent for a public park. The upstream entrance has a sheet piling cutoff wall in the vicinity of the feeder house. The feeder house has been burned and the gates are no longer operational. The towpath was renovated to a bicycle path. A new weir was installed between the old lock walls about two miles downstream to maintain the canal water level.

b. Location. Flat Rock Dam is located on the Schuylkill River approximately 2.9 miles upstream of U.S. Route 1. The dam is located in Montgomery and Philadelphia Counties, Pennsylvania. The dam site and reservoir are shown on USGS Quadrangle entitled "Germantown, Pennsylvania" at coordinates N 40° 2.4' W 75° 14.9'. A regional location plan of the dam is enclosed as Plate 1, Appendix E.

c. Size Classification. The dam is classified as an "Intermediate" size structure by virtue of its estimated 1,500 acre-foot total storage capacity and less than 100 foot height.

d. Hazard Classification. A "High" hazard classification is assigned consistent with the potential for property damage and possible loss of life along the Schuylkill River in the event of sudden failure of the dam.

e. Ownership. The dam is owned by the Department of Environmental Resources. All correspondence should be addressed to Bureau of Operations, Department of Environmental Resources, Post Office Box 1467, Harrisburg, Pennsylvania 17120. The canal wall is owned by the City of Philadelphia. Correspondence concerning the canal wall should be addressed to the Water Department, Municipal Services Building, Philadelphia, Pennsylvania 19107.

f. Purpose of Dam. The reservoir formed by the dam is used for recreational purposes and forms a desilting basin.

g. Design and Construction History. The original Flat Rock Dam was a rock fill timber crib structure started in 1815, by the Schuylkill Navigation Company as part of the transportation system to float barges between Philadelphia and the upper reaches of the Schuylkill River. A cornerstone in the canal wall near the feeder house is dated 1883. The Reading Railroad Company acquired the canal properties from the Schuylkill Navigation Company about 1890. The east (left) abutment of the dam and the lock chambers were rebuilt of concrete and stone masonry during the time the railroad company owned and operated the canal. Canal operations ceased in 1917, and in April 1947, the railroad company conveyed most of their canal holdings to the Commonwealth of Pennsylvania.

By 1952, inspections concluded that the stability of the timber crib dam was in question, and extensive repairs were required. As the City of Philadelphia used the reservoir as a water intake at the Shawmont Pumping Station, negotiations were begun in 1954, with the intent to transfer ownership of the dam and canal to the city. In July 1957, ownership of the canal, including the feeder house and canal wall, was transferred to the City of Philadelphia. On April 24, 1972, an application for a permit to reconstruct Flat Rock Dam was made. The issuing of the permit was held up for more than two years because of a dispute between different state agencies about provisions in the design for a fish passage facility for future shad migration in the Schuylkill River. The matter was resolved by acknowledging that fishway facilities may be necessary in the future. The "Report Upon the Application of the Office of Resource Management, Department of Environmental Services" was prepared by the Division of Dams and Encroachments, July 16, 1974. The permit was issued October 8, 1974, and in June 1975, Pettinaro Construction Company, Inc., was contracted by the General State Authority to build the new dam.

There are no documents in DER files regarding the construction of the dam. However, the as-built drawings give limited indications of the construction details of Flat Rock

Dam. Two sluice gates, ten feet by eight feet, together with trash rack and stop log structures were initially proposed to be built at the canal wall location, but were subsequently deleted from the design. The old timber crib dam was left in place during construction of the new concrete gravity dam. Reportedly, concrete blocks were used on top of the dam to divert water around through the canal wall. Two 30 inch corrugated metal pipes were used for diversion during construction of the right half of the dam. Upon completion of the dam, the pipes were grouted full. The top of the timber crib dam was removed to elevation 32.5. There are two dam completion certificates in the file: one dated October 6, 1977, and one dated December 20, 1977.

h. Normal Operating Procedures. All water flows over the weir of the dam. When the river level upstream of the dam increases to an elevation about 1.3 feet above the dam crest, water is also discharged into the river through the 87 foot long weir through the canal wall, shown on Photograph 6.

1.3 Pertinent Data.

A summary of pertinent data for Flat Rock Dam is presented as follows.

a.	Drainage Area (square miles)	1,809[1]
b.	Discharge at Dam Site (cfs)	
	Maximum Flood (Tropical Storm Agnes, 1972, measured at downstream gaging station)	103,000
	At Top of Right Abutment	30,000
c.	Elevation (feet above MSL)	
	Top of Dam	
	Right Abutment	44.2
	Left Abutment	44.8
	Spillway Crest	
	Low Flow Sections (total 120 feet long)	37.2
	Main Spillway (total 390 feet)	37.7
	Downstream Apron (toe)	23.0
	Tailwater (6/10/80)	22.7±
	Riverbed	19.0 to 23.0
	Minimum Foundation	8 ±

(1) Information obtained from DER, Water Resources Bulletin 4, "Water Resources Survey, The Schuylkill River, Pennsylvania".

d.	Reservoir (miles)	
	Length at Normal Pool	4.4[1]
	Fetch at Normal Pool (est)	1.5
e.	Storage (acre-feet)	
	Normal Pool	788[2]
	At Top of Non-overflow (est)	1,500
f.	Reservoir Surface (acres)	
	Normal Pool	105[2]
g.	Dam Data	
	Type	Concrete gravity overflow dam
	Length (overflow)	510 feet
	Height (above downstream apron)	21.2 feet
	Cutoff	Keyed where necessary to find sound rock
	Grout Curtain	Grouted under heel
h.	Spillway	
	Type	Ogee weir
	Elevation	37.7 feet
	Low Flow Notches	37.2 feet
	Length	510 feet
	Reservoir Drain	None
i.	Canal Wall	
	Type	Concrete and masonry gravity
	Length	800 feet
	Top Elevation	42.5 to 49.9 feet
	Top Width	6.0 to 15.5 feet
	Spillway	
	Type	Weir
	Size	87 feet
	Elevation	39.0 feet

(1) See footnote on previous page.
(2) From "Application Report" prepared by the state, July 16, 1974.

SECTION 2
ENGINEERING DATA

2.1 Design.

a. Data Available. A summary of engineering data for Flat Rock Dam is presented in the checklist attached as Appendix B. Principal documents containing pertinent data used for this report include the "Report Upon the Application of the Office of Resources Management, Department of Environmental Resources" dated July 16, 1974, as-built drawings, stability calculations and a summary of hydraulic calculations supplied by the Bureau of Design. Other data used to evaluate the engineering characteristics of the dam include the Water Resources Bulletin, Bulletin No. 4, "Water Resources Survey, The Schuylkill River, Pennsylvania", prepared for the Commonwealth of Pennsylvania by E. H. Bourquard & Associates, dated March 1968, and Bulletin No. 9, "Hydrologic Data of the June 1972 Flood in Pennsylvania", prepared in cooperation with the U.S. Department of the Interior, Geological Survey, August 1974.

b. Design Features. Principal design features are illustrated on the plan, profile and cross-section plates of this structure and are enclosed in Appendix E as Plates 2 through 10. These plates are reproduced from as-built drawings supplied by the Bureau of Operations, Pennsylvania Department of Environmental Resources (DER). A description of the design features is presented in Section 1.2, entitled "Description of Project".

2.2 Construction.

A limited description of the construction history is presented in Section 1.2.

2.3 Operational Data.

There are no operational records maintained. Since all flow passes over the overflow section, there are no minimum flow requirements downstream.

2.4 Evaluation.

a. Availability. All engineering data reproduced in this report and studied for this investigation were provided by the Pennsylvania DER, Bureau of Dams and Waterways Management, Bureau of Completed Projects and Bureau of Design.

b. Adequacy. Data included in Division of Dam Safety files and information received from various state representatives were not sufficiently adequate to evaluate the design features of the dam and appurtenant structures in accordance with Phase I guidelines.

c. Validity. There is no reason to question the validity of the available data.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. Observations and comments of the field inspection team are contained in the checklist enclosed herein as Appendix A, and are summarized and evaluated as follows. In general, the ogee section, right and left abutments, and the canal wall appear to be in good condition. At the time of the inspection, the river was flowing at a normal rate over the spillway and, thus, the ogee section and downstream apron of the spillway could not be inspected.

b. Dam. The exposed portions of Flat Rock Dam are extremely limited and consist of the right gravity wall and the left abutment adjoining the previously existing canal wall. At the right end of the dam, both the previously existing masonry abutment and the new concrete gravity abutment appear to be in good condition. There was no distortion in alignment that would be indicative of movement of the foundation. No concrete spalling or excessive deterioration or cracking was noted, although there are some leachate deposits on the concrete gravity wall downstream of the weir. The grouted riprap, both upstream and downstream of the dam centerline, appears to be in place and in good condition.

The left abutment is tied into the previously existing canal wall by No. 8 reinforcing anchor bars grouted into the wall. The exposed concrete surfaces were inspected, and no spalling, excessive concrete cracking or other concrete deterioration were noted. Leachate deposits were noted on the riverside face of the left abutment.

c. Appurtenant Structures.

1. Ogee Spillway. About one foot of water was flowing over the ogee weir at the time of the inspection. Water flowing over the spillway crest was smooth, with no indications of cracks or displacement between monoliths.

2. Canal Wall. The elevation of the canal wall ranges from a high of about 49.9 feet near the feeder house to a low of 42.5 near its midpoint. As shown on Sheet 5C of 11, Appendix A, the wall is divided into four sections of different elevations separated by steps, with the top of the wall being at nearly constant elevations within each section. The top width ranges from about 6.0 feet to a maximum of about

15 feet. The canal side face appears to be vertical, while the riverside of the wall is nearly vertical for the top several feet and then has a batter of about 0.4H:1V. About 490 feet downstream of the dam centerline is an 87 foot wide weir through the canal wall; see Photograph 6. At the time of the inspection, the canal water level was about four inches below the weir crest.

The riverside face of the canal wall displays leachate deposits over its entire length. Some seepage was also observed on the downstream river face of the wall. Spalls and concrete deterioration have occurred at both vertical and horizontal construction joints of the wall. Spalling on the top of the wall has typically occurred at the construction joints; see Photographs 5, 6 and 10.

At the left abutment of Flat Rock Dam, the canal wall is 15.25 feet wide. There is some vertical displacement at the construction joint where the 15.25 foot section joins the 6 foot section, apparently as constructed; see Photograph 11. The extreme upstream portion of the canal wall is the original stone masonry abutment to the old Flat Rock Dam. The stone masonry appears to be structurally sound.

d. Reservoir. At the time of the inspection, the impounding area was at normal pool, and slopes to the water's edge appear well vegetated and stable. It is reported that the water is 15 feet deep upstream of the dam.

e. Downstream Channel. The natural channel below the dam is the Schuylkill River, which appears to be in good condition with stable banks and a minimum amount of scour or deposition. Venice Island, downstream of the dam, is occupied primarily by industrial complexes. The minimum height of the bank above the water level at the northwest end of the island is about 16.5 feet, or an elevation of approximately 39.4 feet. The difference between the top of the bank and the river appears fairly constant all the way down to Green Lane Bridge. The occupied building closest to the river level is a canoe clubhouse approximately 2.8 miles downstream of the dam at the confluence of the Wissahickon Creek and the Schuylkill River. The first floor of the house is about 15 feet above the river surface. About seven miles downstream of Flat Rock Dam is Fairmount Dam. Immediately upstream of Fairmount Dam is Boathouse Row, where there are 11 boathouses built at the water's edge. The pool above Fairmount Dam is used extensively for recreational purposes, and parks are on both sides of the river upstream of the dam. Sudden failure of Flat Rock Dam not during an extreme event would create the possibility for many lives lost; therefore, the dam warrants a "High" hazard potential classification.

3.2 Evaluation.

Inspection of the dam and abutments disclosed no evidence of apparent past or present movement that would indicate existing instability of the concrete dam. Since flow was passing over the spillway at the time of the inspection, the toe of the spillway could not be inspected for undermining, scour or the condition of the apron or bedrock immediately downstream.

Inspection of the canal wall disclosed surficial concrete deterioration of the top and the downstream face. Construction joint deterioration is occurring within the canal wall as evidenced by leachate deposits on the riverside of the wall. There is no evidence detected by visual inspection that the structural integrity of the wall has been affected. In summary, the dam and canal wall are considered to be in good condition, with the canal wall requiring repairs to the concrete.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures.

Operation of the dam does not require a dam tender. All flow discharges directly over the ogee section and downstream into the Schuylkill River.

4.2 Maintenance of the Dam.

The dam is inspected yearly by the Department of Environmental Resources (DER), Bureau of Operations, in Harrisburg. The local Schuylkill River Project office provides routine maintenance of the structure, which includes removal of debris, painting and sealing of any surficial cracks. There was no evidence or acknowledgement of maintenance of the canal wall by the City of Philadelphia.

4.3 Maintenance of Operating Facilities.

There are no mechanical devices or operating facilities to maintain for this structure.

4.4 Warning Systems In Effect.

According to DER's representative during the time of the inspection, there are no formal warning procedures associated with Flat Rock Dam. The Schuylkill River is covered by the National Weather Service flood forecasting service. When flooding is expected, reports are broadcast on the NOAA radio service, provided to the national wire services, and the City of Philadelphia Emergency Coordinator is notified.

4.5 Evaluation.

Since there are no operating facilities and since the dam does not require a dam tender, it is judged that the current operating procedure is a satisfactory method of operating the dam.

SECTION 5
HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features.

a. Design/Evaluation Data. No original design data were located. Summary hydraulic data were supplied by DER, Bureau of Design, and additional calculations for this investigation are presented in Appendix D.

The large watershed is about 78 miles long and ranges from about 22 to 32 miles wide, having a total drainage area of 1,809 square miles above Flat Rock Dam. The Schuylkill River Watershed at its mouth drains an area of approximately 1,920 square miles. Elevations range from a high of 1,750 feet in the extreme upper reaches to 37.7, the weir elevation at Flat Rock Dam. From the headwaters at Tuscarora Springs in Schuylkill County to Flat Rock Dam, the river travels approximately 115 miles. The river passes through four major physiographic provinces in Pennsylvania, ranging from the Appalachian Ridge and Valley Province to the Atlantic Coastal Plain. Thus, the hydrology and stream flows of the Schuylkill River Watershed vary widely at different points along the river because of the varying topographic and climatological conditions along the river course. In general, higher average rainfalls and steeper topography in the northern provinces of the river above the Blue Ridge physiographic province (above Port Clinton, Pennsylvania) produce slightly greater average runoffs per square mile than those observed in the lower portions of the watershed. In addition, localized storms or short-term droughts may not be general over the entire basin.

The concrete ogee weir was designed based on a design head of 14.5 feet or a discharge of 98,000 cfs. Summary data provided indicates flows of 50,000 cfs will partially submerge the weir and, for flows exceeding 130,000 cfs, the tailwater elevation will equal the upstream water surface level.

In accordance with criteria established by Federal (OCE) Guidelines, the recommended spillway design flood for this "Intermediate" size dam and "High" hazard classification is the Probable Maximum Flood (PMF).

b. Experience Data. Reservoir water levels are not maintained for this dam. Large flows, such as Tropical Storm Agnes in June 1972, flood out Venice Island so that the industrial complex about one mile below the dam is also

flooded. Maximum river elevations during Tropical Storm Agnes are reported as 43.0 downstream of the dam (river mile 14.75) and 51.0 upstream of the dam (river mile 15.95). Flat Rock Dam is about river mile 15.75.

c. Visual Observations. On the date of the inspection, there were no conditions observed that would indicate a reduced spillway capacity during an extreme event. Observations regarding the condition of the downstream channel, spillway and reservoir are located in Appendix A and discussed in greater detail in Section 3.

d. Overtopping Potential. Because of the large drainage area above Flat Rock Dam, and because Flat Rock Dam is a run-of-the-river dam with limited flood storage capacity behind it compared to its large drainage area, along with the fact that the weir will be submerged during high flows, it is believed that an overtopping analysis is not significant for this structure. During a large storm, there is little attenuation of the inflow hydrograph by the available flood storage.

The spillway is capable of discharging about 30,000 cfs without overtopping the right abutment. The estimated tailwater elevation for flows of 50,000 cfs is 38.6, higher than the weir crest. It is estimated that storms of about 0.07 PMF will overtop the right abutment, considered to be the top of the dam. Flows greater than about 0.11 PMF, or 50,000 cfs, will have a tailwater elevation approximately equal to the weir crest. Flows greater than these values will begin to submerge the weir and reduce the weir capacity, shown in Appendix D. The Spillway Design Flood (SDF) hydrograph presented in Appendix D was supplied by the Corps of Engineers, Philadelphia District, and is assumed to equal 0.5 PMF. The estimated peak SDF inflow is about 225,700 cfs, greater than the estimated 100,000 cfs at Flat Rock Dam during Tropical Storm Agnes in June 1972. During Tropical Storm Agnes, it was reported that Venice Island downstream of the dam was flooded, and the canal wall and the whole dam was submerged.

e. Spillway Adequacy. As the spillway will not pass the PMF without overtopping the abutment, the spillway is rated as "Inadequate". As overtopping is estimated not to cause failure, the spillway is not rated "Seriously Inadequate".

f. Downstream Conditions. Between Flat Rock Dam and Fairmount Dam, seven river miles downstream, there are a limited number of permanent structures located within 16 feet of the top of the water. The canoe clubhouse is located 15 feet above the water at the confluence of the Wissahickon Creek and the Schuylkill River, and there are 11 boathouses located immediately upstream of Fairmount Park at the water level. During a large storm, it is unlikely that any of these structures would be occupied. However, Flat Rock Dam is located within an urban area and above a stretch of water that is heavily used for recreational purposes, boating and fishing, and parks are located along the river banks on both sides. Thus, the greatest potential to loss of life during failure of the dam would result from failure not occurring as a result of a large storm, justifying a "High" hazard potential rating.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. Visual observations detected no evidence of existing or pending instability of the right abutment, weir or left abutment of the dam. There was no distortion along the spillway crest to infer excessive scour downstream, monolith displacement or structural deterioration of the ogee section. However, the entire ogee section was covered with water and could not be thoroughly inspected. The 800 foot long canal wall was also inspected. Surficial concrete deterioration, spalling and cracking were noted on the top of the wall and along the river face of the wall. Some seepage and leachate deposits were also noted on the downstream face of the wall. Although concrete joint deterioration is occurring within the canal wall, as evidenced by the leachate deposits and seepage, there is no evidence detected by visual inspection that the structural integrity of the structure has been affected.

b. Design and Construction Data. Stability calculations for Flat Rock Dam were available. A stability analysis was performed on the dam itself based on a head of water 19.3 feet above the weir, or 167,000 cfs, and a tailwater depth based on Manning's Formula on the downstream channel. As-built drawings indicate that the dam is anchored to the underlying bedrock by rock anchors. The stability analysis results are summarized in Appendix G.

The stability analysis of the canal wall presented in Appendix G indicates adequate resistance to sliding under an assumed pool level. Neglecting tailwater in the overturning analysis indicates an unstable structure, while including the tailwater indicates a marginally stable structure. These results are at variance with the demonstrated performance of the dam during large events, such as Tropical Storm Agnes, June 1972, when the pool level exceeded the pool level used in the stability analysis.

c. Operating Records. There are no operational records for this structure.

d. Post-Construction Changes. Since the completion of the dam in 1977, there have been no modifications made to this structure.

e. Seismic Stability. The dam is located in Seismic Zone 1. Normally it can be considered that if a dam in this zone is stable under static conditions, it can be assumed safe for any expected earthquake conditions. As the dam is assessed to be stable under present static loading conditions, it can reasonably be assumed to be stable under seismic loading conditions. However, since the static stability of the canal wall is questionable, its seismic stability is also in doubt.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Evaluation. Visual inspection of the exposed sections of the dam and review of the limited available data indicate that Flat Rock Dam is in good condition. It is to be noted that the entire spillway and apron were submerged and could not be inspected; therefore, a complete visual assessment of the structure could not be performed. The canal wall was also inspected. Construction joint deterioration is occurring through the canal wall, as evidenced by leachate deposits and damp areas. There was no evidence detected by visual inspection that the structural integrity of the structure has been affected. Therefore, although repairs are required, the canal wall is considered to be in good condition.

In accordance with criteria established by Federal (OCE) Guidelines, the recommended spillway design flood for this "Intermediate" size dam and "High" hazard potential classification is the Probable Maximum Flood (PMF).

Calculations presented in Appendix D indicate the structure will pass about 0.07 PMF without overtopping the right embankment. As the spillway will not pass the PMF without overtopping, it is considered to be "Inadequate". It is considered that the dam is not likely to fail; therefore, the spillway is not considered to be "Seriously Inadequate".

b. Adequacy of Information. Information available for this investigation, the visual inspection, and simplified calculations presented in Appendices D and G were sufficient to indicate that no further investigations are required for the dam, but additional stability analysis is required for the canal wall.

c. Urgency. The recommendations presented in the following section should be implemented immediately.

7.2 Remedial Measures.

a. Facilities. It is recommended that the following measures concerning the canal wall be undertaken immediately by the City of Philadelphia. Items (1) and (2) should be performed under the supervision of a registered professional engineer experienced in the design and construction of dams.

(1) As the canal wall stability analysis presented in Appendix G is at variance with its demonstrated performance history, further investigations should be made to verify the configuration of the section, assumed foundation and canal bottom conditions, and results of the analysis. If stability of the wall cannot be demonstrated, measures should be taken to insure its stability under all expected conditions.

(2) Seepage through the canal wall should be monitored and evaluated.

(3) Surficial deteriorated concrete on the canal wall should be repaired.

(4) In conjunction with Item (3), all open cracks at the top of the wall at the construction joints should be sealed to prevent damage from freezing water in the winter.

b. Operation and Maintenance Procedures. An operation and maintenance manual for small dams has been prepared by the Department of Environmental Resources, Division of Completed Projects, Bureau of Operations. Portions of this manual apply to Flat Rock Dam. It is important that persons concerned with this structure be familiar with the procedures contained in the manual. The City of Philadelphia should develop a maintenance procedure to insure the canal wall is maintained in the best possible condition. Since the Schuylkill River is covered under the National Weather Service Flood Forecasting Service and procedures have been established to warn of potential flooding along the river downstream of the dam, it is not recommended that a separate warning procedure be developed for this structure.

APPENDIX

A

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam *Flat Rock Dam* County *Philadelphia* State *Pennsylvania* National ID # *PA 00896*

Type of Dam *Concrete gravity* Hazard Category *High*

Date(s) Inspection *6/9/80* Weather *Sunny* Temperature *60's*

Pool Elevation at Time of Inspection *38.8* M.S.L. Tailwater at Time of Inspection *22.7±* M.S.L.

Inspection Personnel:

Mary F. Beck (Hydrologist)
Richard E. Mabry (Geotechnical/ Civil)
David Chou (Structural)
Vincent McKeever (Hydrologist)
Raymond S. Lambert (Geologist)

Mary F. Beck Recorder

Remarks:

John Smith, Lock 60 Montclair and Clifford Romig, Harrisburg, Bureau of Operations, were on site and provided assistance to the inspection team.

Sheet 1 of 11

CONCRETE/MASONRY DAMS

GUIDE WALL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	*DAM* *No seepage noticed. Leachate deposits were noted on both the right gravity wall and left abutment.*	*CANAL WALL* *Leachate deposits visable and some seepage, see photographs, on river side of wall.*
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	*Structure built and completed in 1977. No deterioration observed.*	*Old masonry abutment remains structurally sound. The concrete abutment built prior to 1947 shows deterioration at horizontal joints*
DRAINS	*None*	*None*
WATER PASSAGES	*None*	*None*
FOUNDATION		

Sheet 2 of 11

CONCRETE/MASONRY DAMS

DAM *CANAL WALL*

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	*Water overflowing the spillway; no observation can be made.*	*A lot of spalled areas on the top of canal wall. Most of them are located at vertical construction joints. Several spalled areas are also found on the river face of wall near the water level.*
STRUCTURAL CRACKING	*Some shrinkage cracks at the new abutment but not serious.*	*Some shrinkage cracks on top of the canal wall, but they probably have been there for years.*
VERTICAL AND HORIZONTAL ALIGNMENT	*See Sheets 5B and 5C.*	
MONOLITH JOINTS		
CONSTRUCTION JOINTS		*Typically spallings occur at the vertical joints of the wall. Some leaching at the horizontal joint of river face of wall. Canal face is under the water.*

Sheet 3 of 11

EMBANKMENT

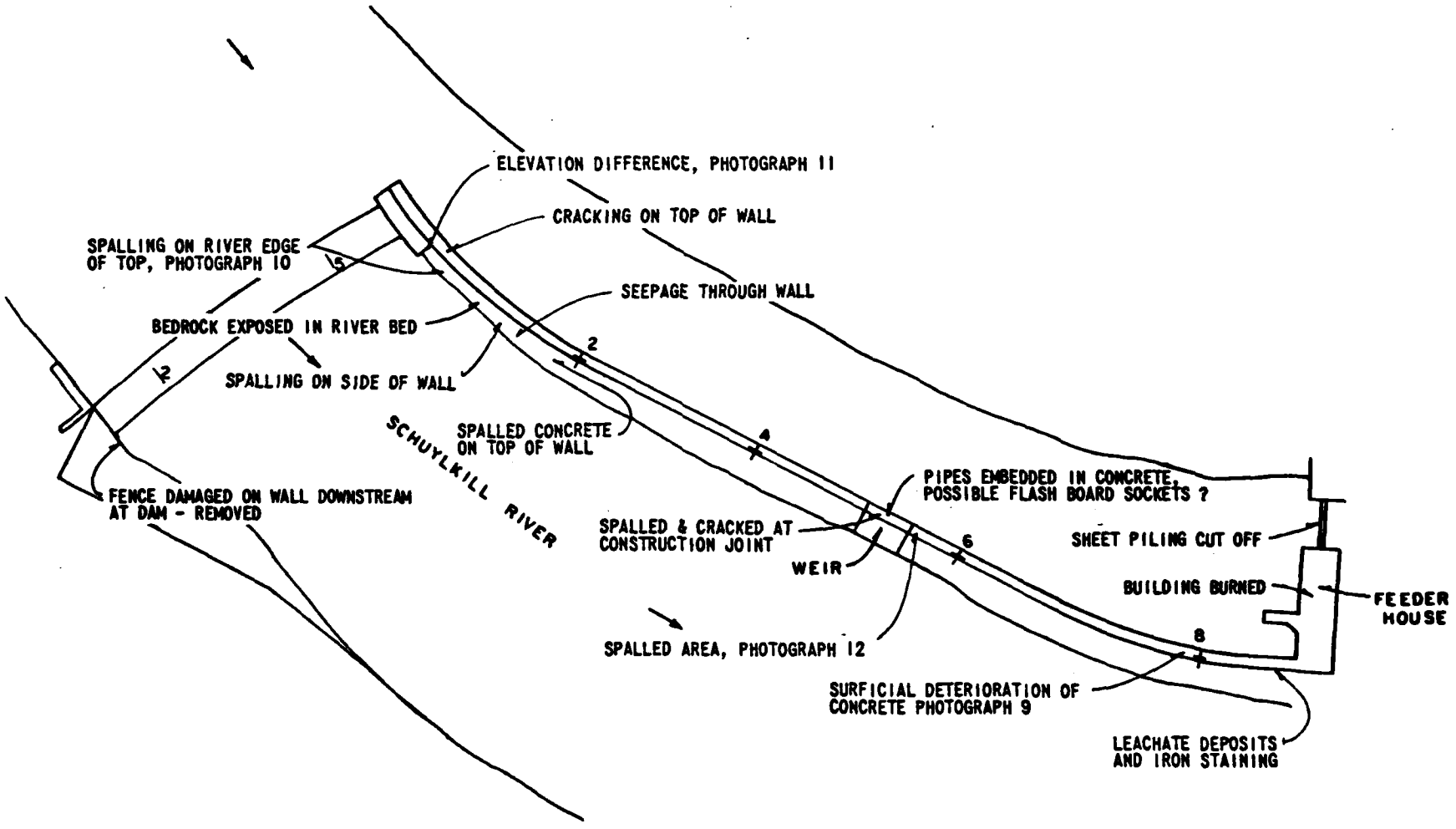
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	*N/A*	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	*N/A*	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	*N/A*	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	*N/A*	
RIPRAP FAILURES	*N/A*	

Sheet 4 of 11

EMBANKMENT

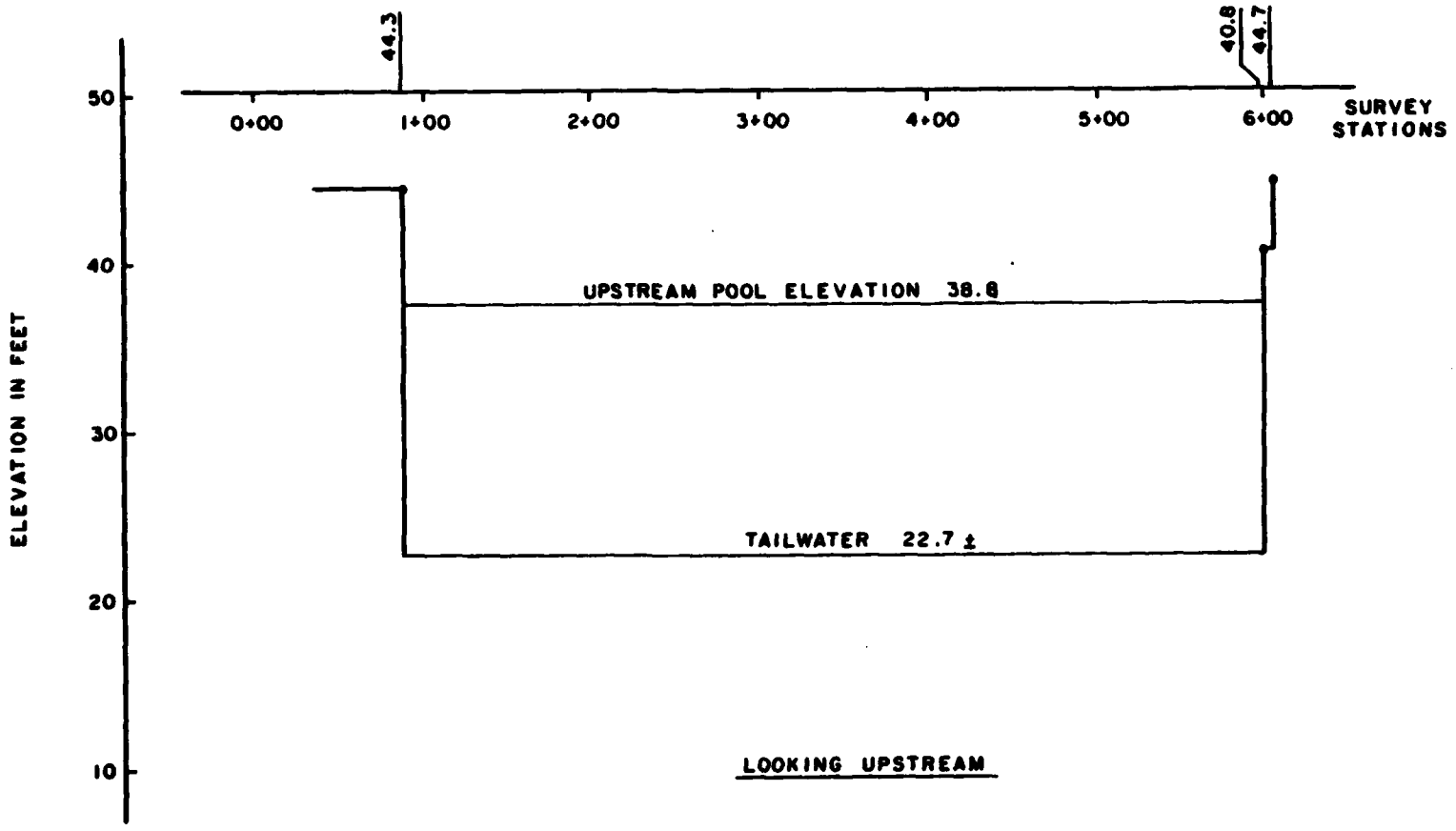
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	*N/A*	
ANY NOTICEABLE SEEPAGE	*N/A*	
STAFF GAGE AND RECORDER	*N/A*	
DRAINS	*N/A*	

Sheet 5 of 11



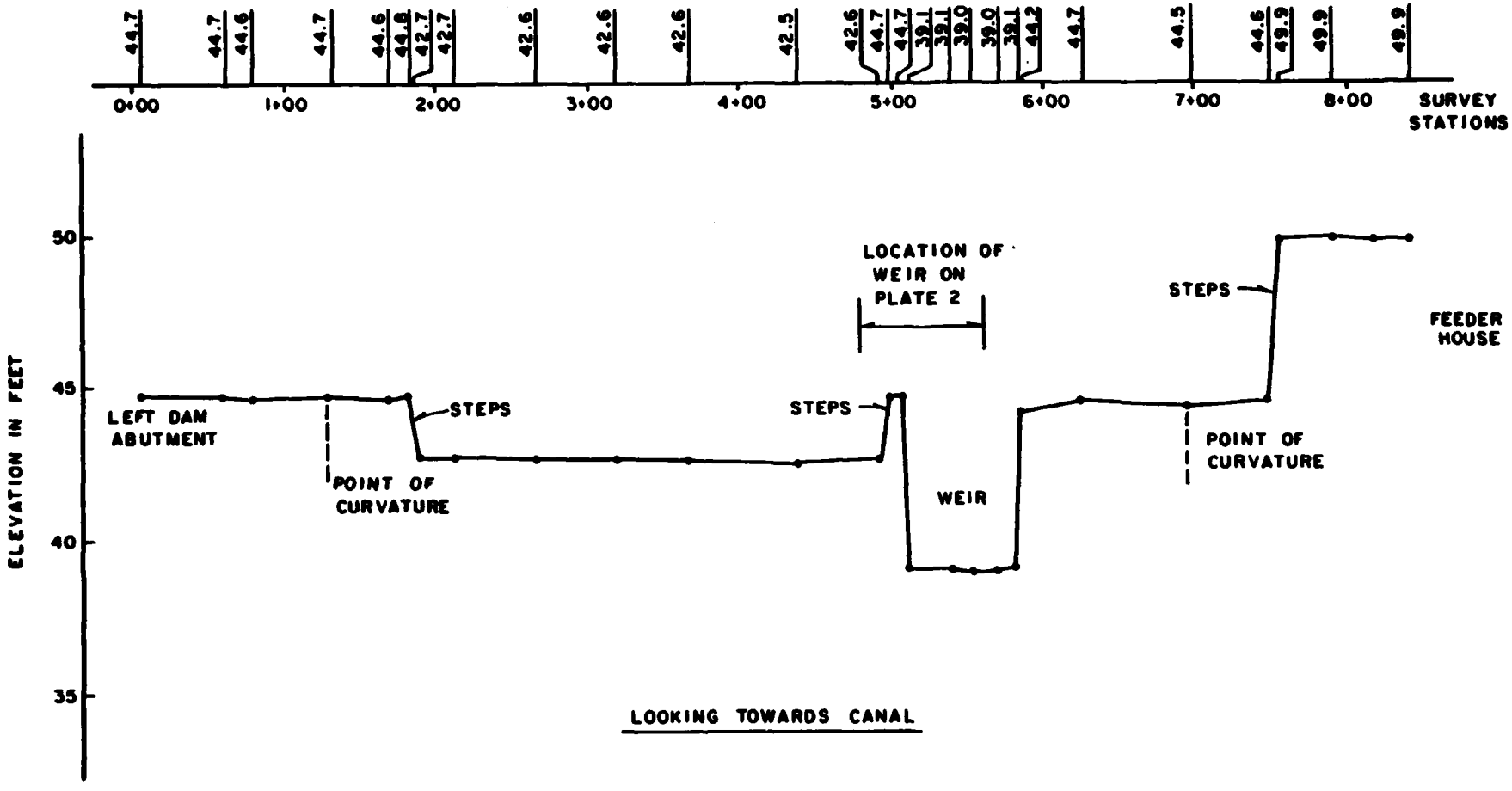
FIELD OBSERVATION PLAN
FLAT ROCK DAM

SHEET 5A OF 11



FIELD OBSERVATION PROFILE
FLAT ROCK DAM

SHEET 5B OF 11



FIELD OBSERVATION PROFILE
CONCRETE WALL ON EAST BANK
OF SCHUYLKILL RIVER
FLAT ROCK DAM
SHEET 5C OF 11

OUTLET WORKS

DAM *GUIDE WALL*

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	*Dam has no outlet works.*	*Water level in canal controlled by gates in control building and sheet pile cutoff (see sheet 5A).*
INTAKE STRUCTURE		*Brick control building was burned but masonry appears sound.*
OUTLET STRUCTURE		*Same as above.*
OUTLET CHANNEL		*Water is discharged into canal.*
EMERGENCY GATE		*No gates appear operational. One gate partly open.*

UNGATED SPILLWAY

DAM *GUIDE WALL*

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	*Weir completely under water, flow appeared uniform.*	*Concrete has spalled off weir crest.*
APPROACH CHANNEL	*None*	*None*
DISCHARGE CHANNEL	*Discharges into Schuylkill River.*	*Discharges into Schuylkill River.*
BRIDGE AND PIERS	*None*	*None*

Sheet 7 of 11

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	*None*	
APPROACH CHANNEL	*N/A*	
DISCHARGE CHANNEL	*N/A*	
BRIDGE AND PIERS	*N/A*	
GATES AND OPERATION EQUIPMENT	*N/A*	

Sheet 8 of 11

INSTRUMENTATION

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

Sheet 9 of 11

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	*The upstream river slopes are flat to moderate.*	
SEDIMENTATION	*It was reported by Mr. Smith that little sediment has accumulated upstream of the dam.*	

Sheet 10 of 11

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	*The Schuylkill River downstream of the dam has a rock bed. The banks appear stable with a minimum about of scour or deposition.*	
SLOPES	*The valley gradient is on the order of 0.001*	
APPROXIMATE NO. OF HOMES AND POPULATION	*Immediately downstream of the dam is an island on which there are several industrial complexes located about 16.5 feet above water level at the time of inspection. About 2.8 miles downstream of the dam is a clubhouse located about 15 feet above water level. About seven miles downstream of Flat Rock Dam is Fairmont Dam, above which is boathouse row. About 10 boathouses are built at the water's edge.*	

Sheet 11 of 11

APPENDIX

B

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM *Flat Rock Dam*

ID # *PA 00896*

ITEM	REMARKS
AS-BUILT DRAWINGS	*On file with Bureau of Operations and provided for this investigation*
REGIONAL VICINITY MAP	*Plate 1, Appendix E.*
CONSTRUCTION HISTORY	*See text, Section 1.2.*
TYPICAL SECTIONS OF DAM	*Appendix E.*
OUTLETS - PLAN	*Appendix E.*
DETAILS	
CONSTRAINTS	
DISCHARGE RATINGS	*Appendix D.*
RAINFALL/RESERVOIR RECORDS	*National Weather Service Rain Gaging Stations within watershed. No reservoir records maintained for this dam.*

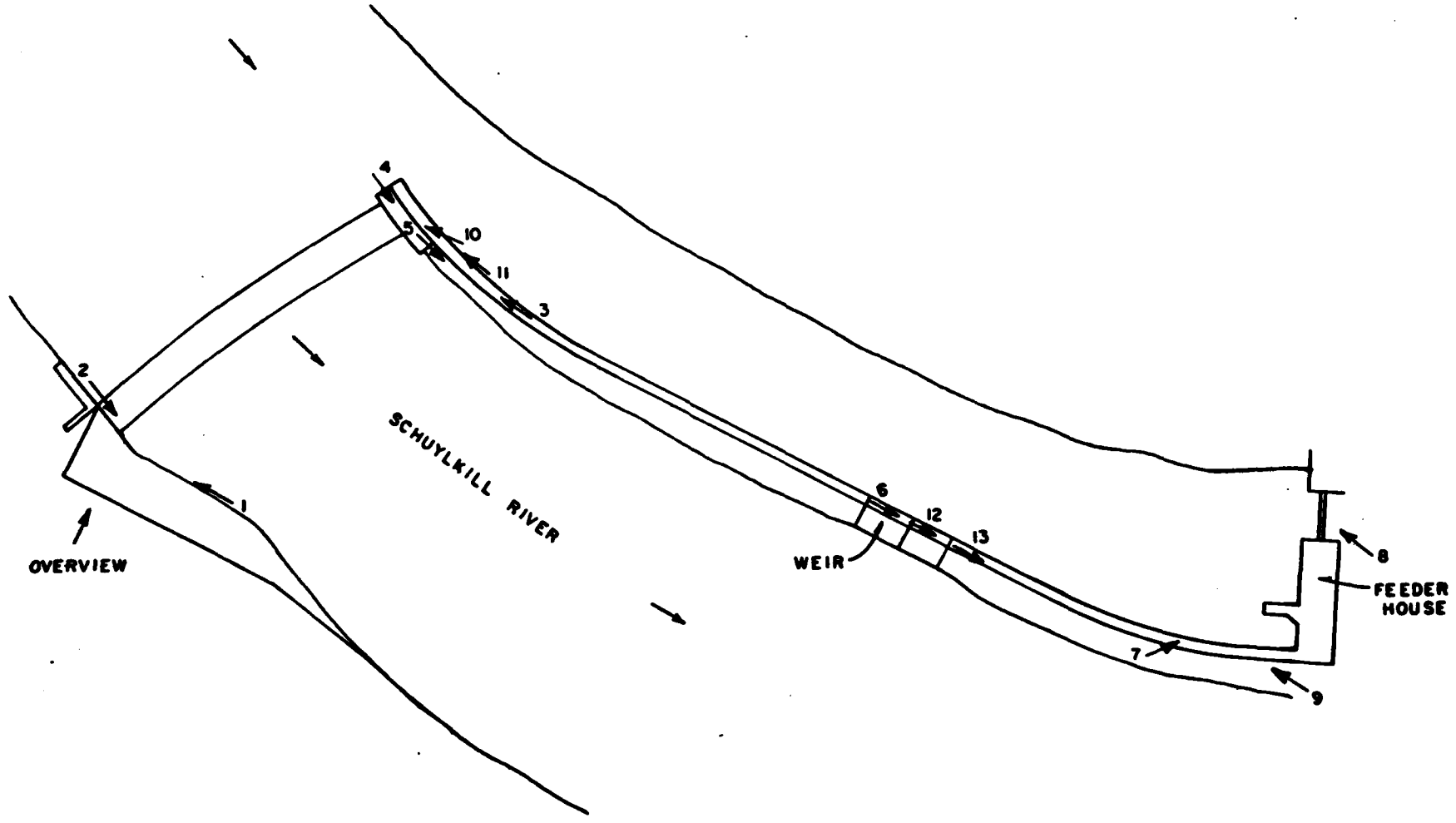
ITEM	REMARKS
DESIGN REPORTS	*None available.*
GEOLOGY REPORTS	*See Appendix F.*
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	*Stability analysis and a summary of elevation discharge data was provided by Bureau of Operations.*
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	*Only boring records available.*
POST-CONSTRUCTION SURVEYS OF DAM	*None*
BORROW SOURCES	*N/A*

ITEM	REMARKS
MONITORING SYSTEMS	*None*
MODIFICATIONS	*None*
HIGH POOL RECORDS	*None*
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	*None*
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	*None*
MAINTENANCE OPERATION RECORDS	*Maintained by Bureau of Operations*

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	*Appendix E.*
OPERATING EQUIPMENT PLANS & DETAILS	
MISCELLANEOUS	*Information in DER, Dams and Waterways Management, files concerning new Flat Rock Dam.* 1. *Maps and corresponence concerning the transfer of ownership of canal wall and canal to the City of Philadelphia.* 2. *"Report Upon the Application of the Office of Resources Management" prepared by state, dated July 16, 1974.*

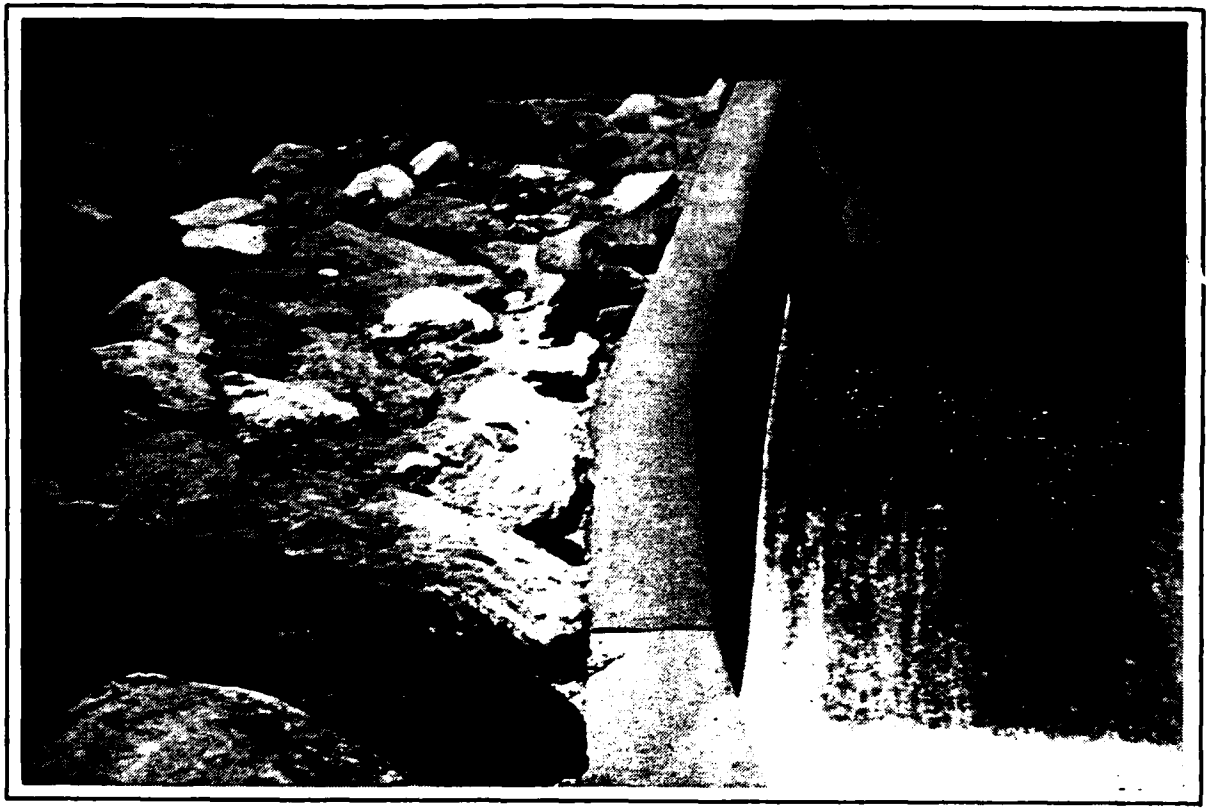
APPENDIX

C



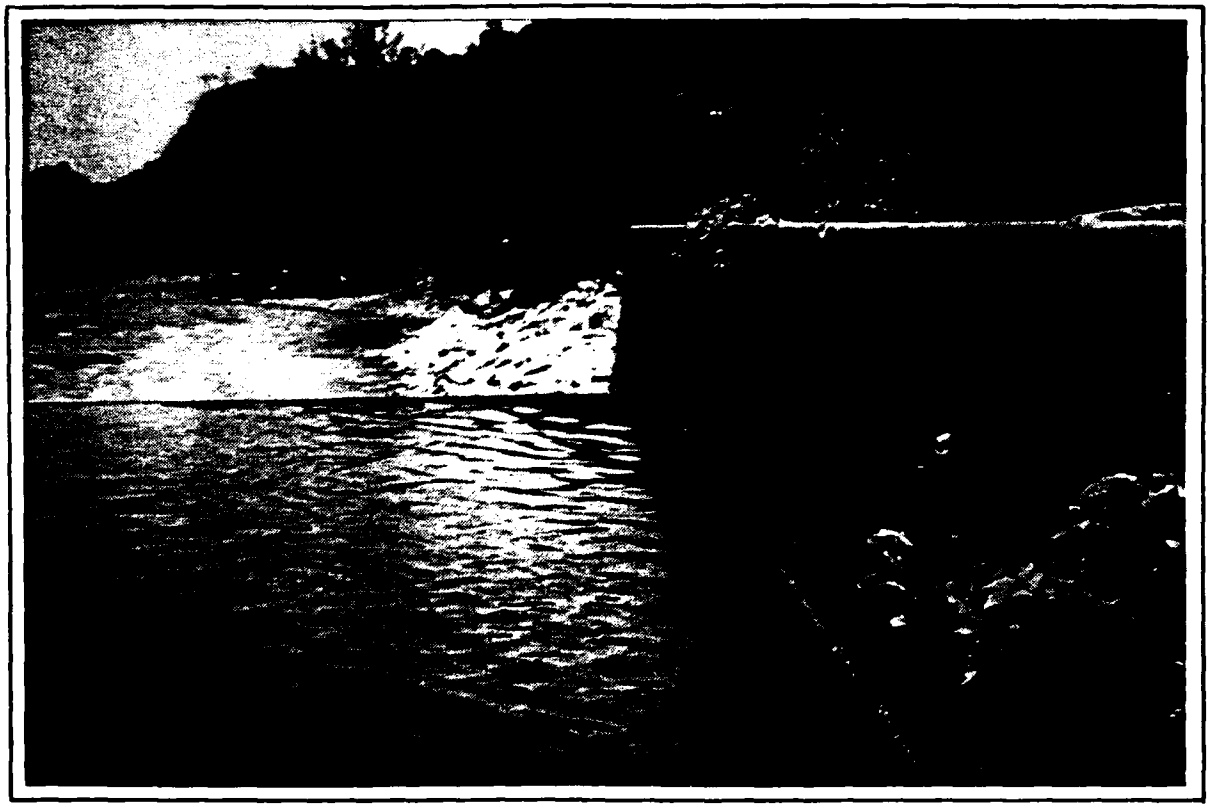
PHOTOGRAPH LOCATION PLAN
FLAT ROCK DAM

PLATE C-1



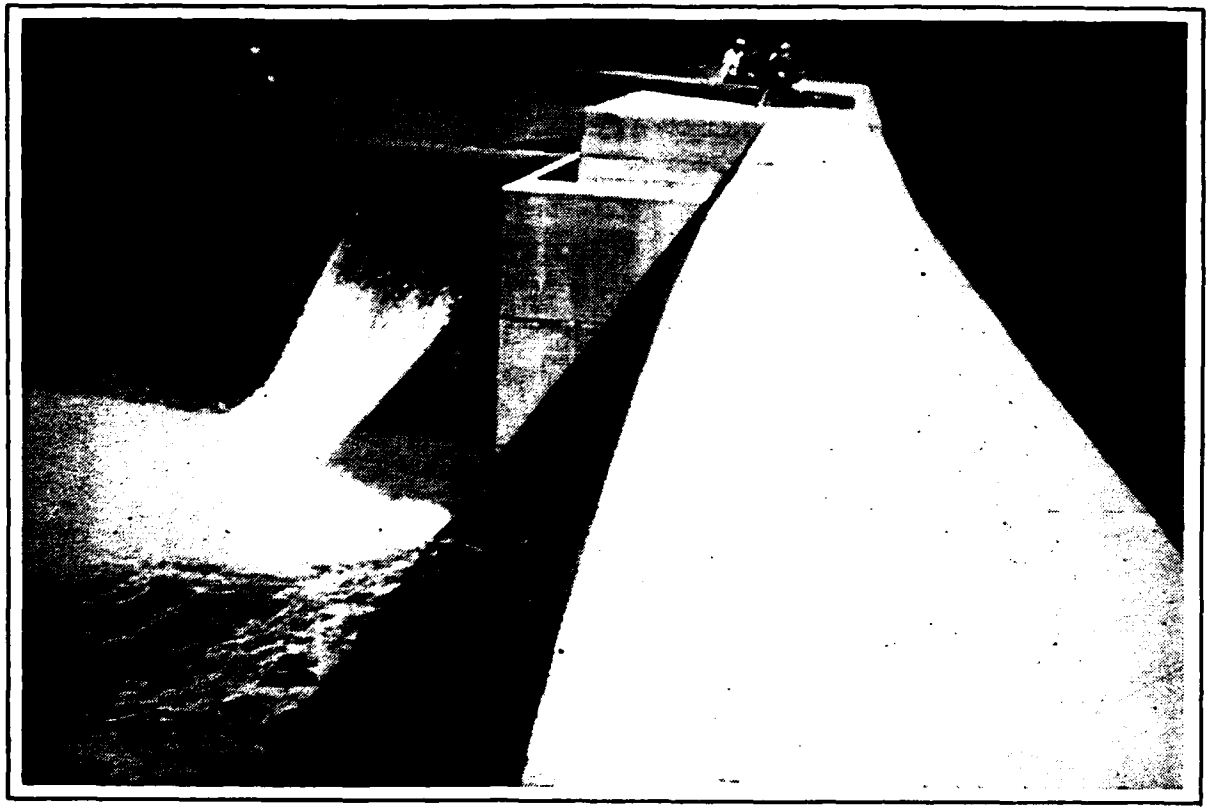
RIGHT ABUTMENT AREA WITH GROUTED RIPRAP.

PHOTOGRAPH NO. 1



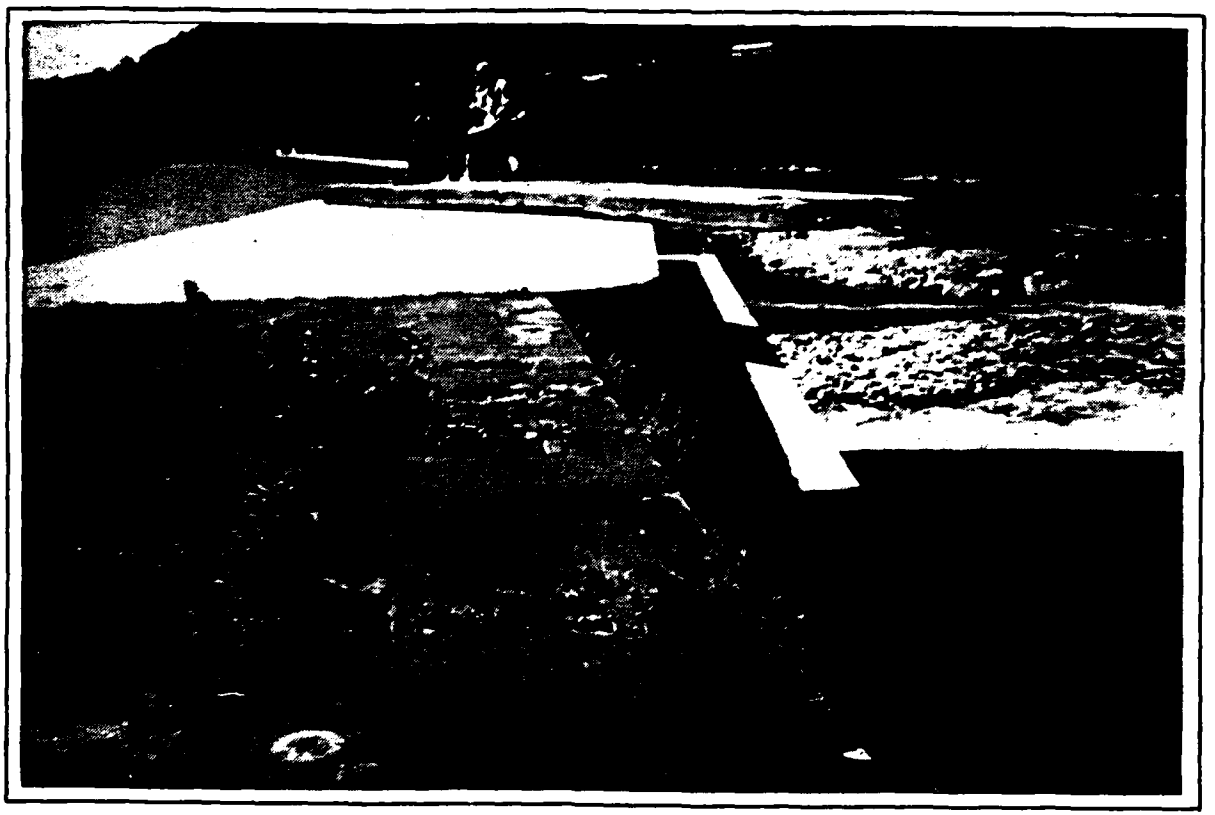
UPSTREAM RIGHT ABUTMENT.

PHOTOGRAPH NO. 2



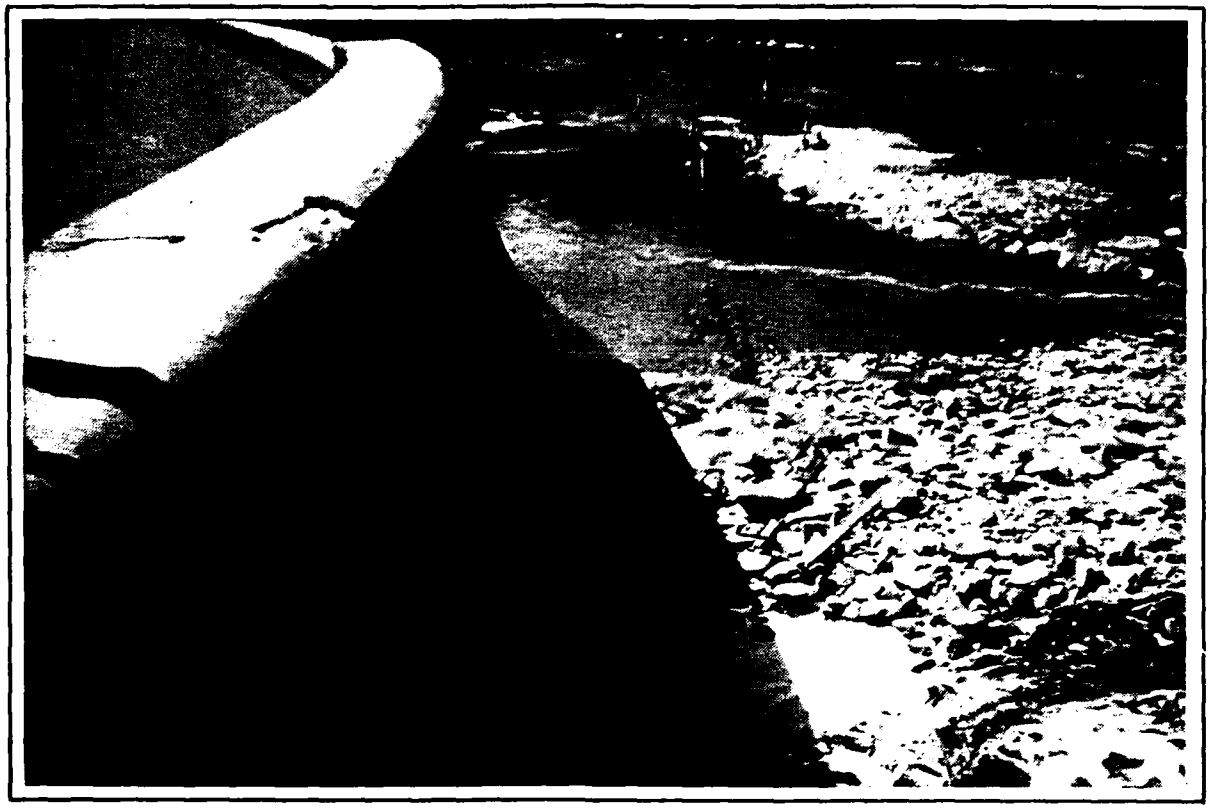
LEFT END OF DAM ABUTS CANAL WALL
OWNED BY THE CITY OF PHILADELPHIA.

PHOTOGRAPH NO. 3



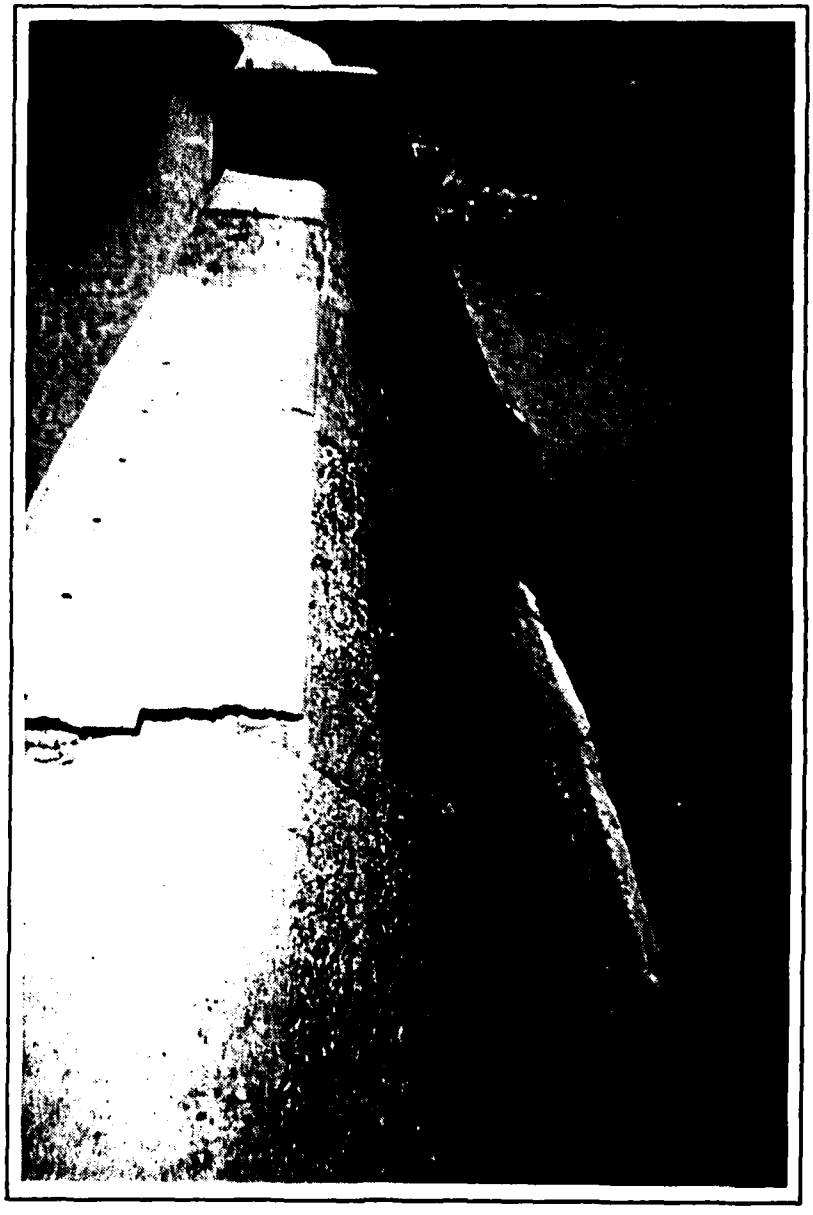
LEFT ABUTMENT FROM UPSTREAM SIDE.
STONE FORMED ABUTMENT FOR ORIGINAL
FLAT ROCK DAM, A TIMBER CRIB STRUCTURE.

PHOTOGRAPH NO. 4



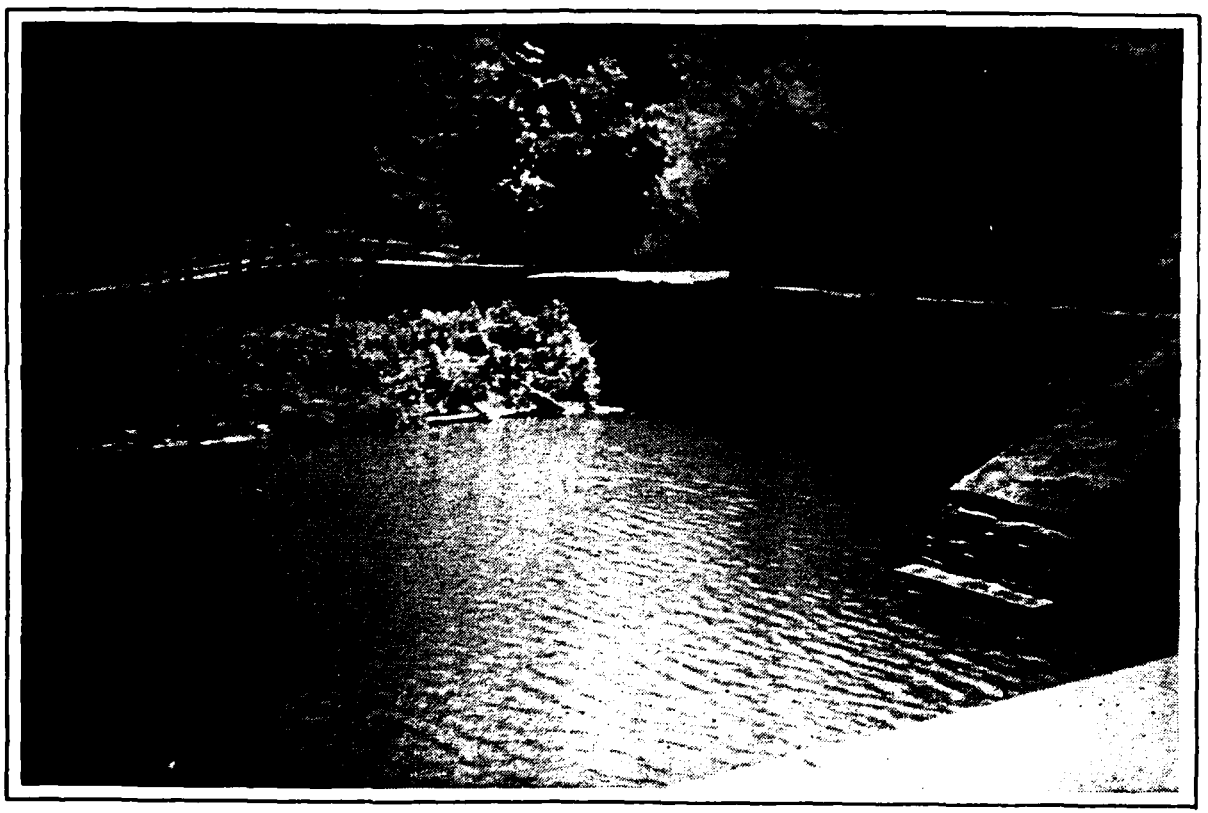
CANAL WALL IMMEDIATELY DOWNSTREAM OF THE DAM.

PHOTOGRAPH NO. 5



OVERFLOW WEIR OF CANAL WALL.

PHOTOGRAPH NO. 6

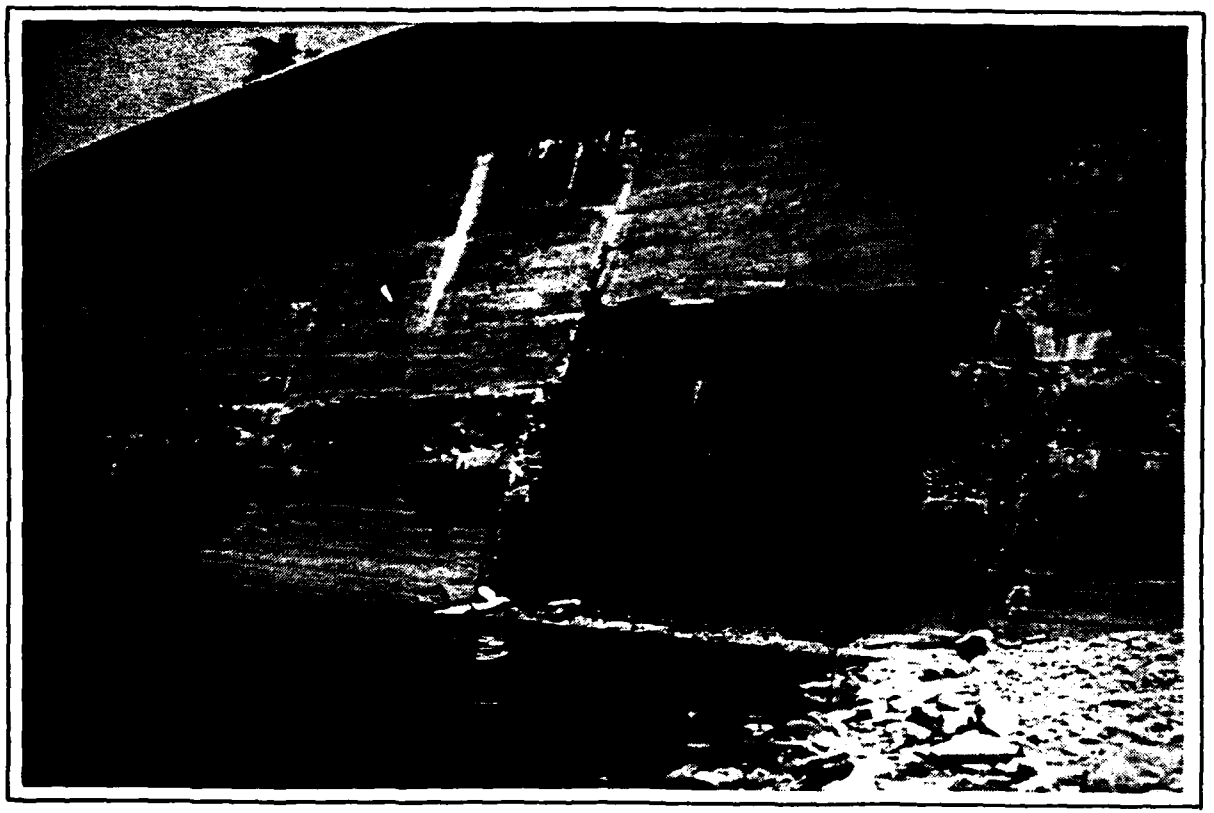


INLET HOUSE WHICH FORMALLY CONTROLLED
FLOW TO LOCKS.

PHOTOGRAPH NO. 7

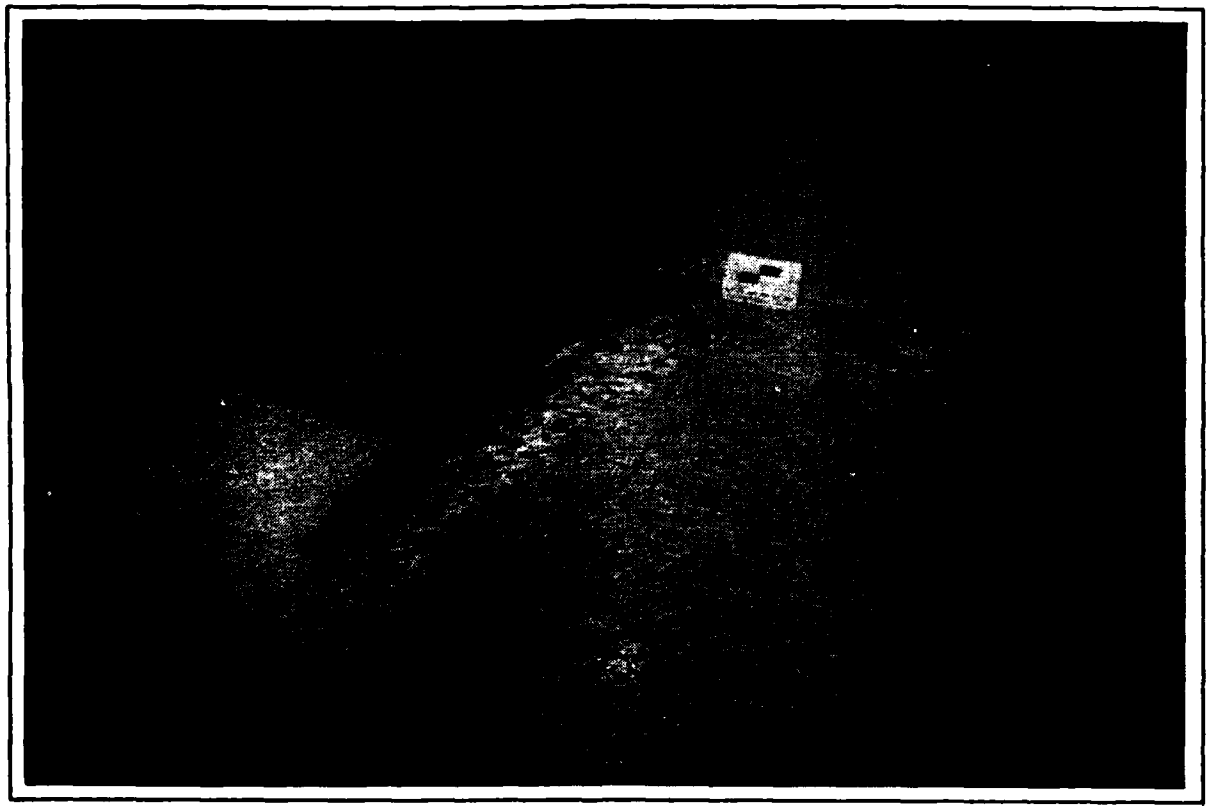
SHEET PILING CUTOFF TO CANAL.

PHOTOGRAPH NO. 8



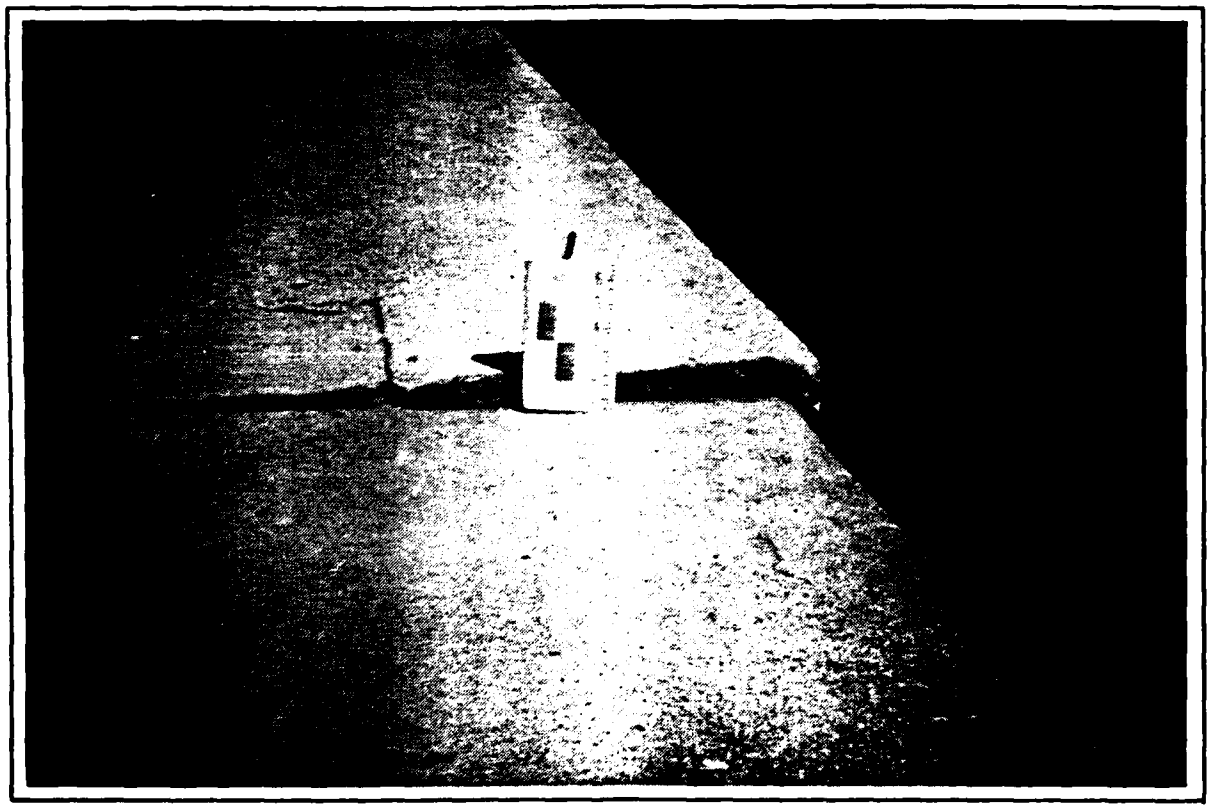
VIEW OF DOWNSTREAM SIDE OF CANAL
WALL NEAR INLET HOUSE.

PHOTOGRAPH NO. 9



JOINT DETERIORATION ON CANAL WALL NEAR
DAM ABUTMENT.

PHOTOGRAPH NO. 10

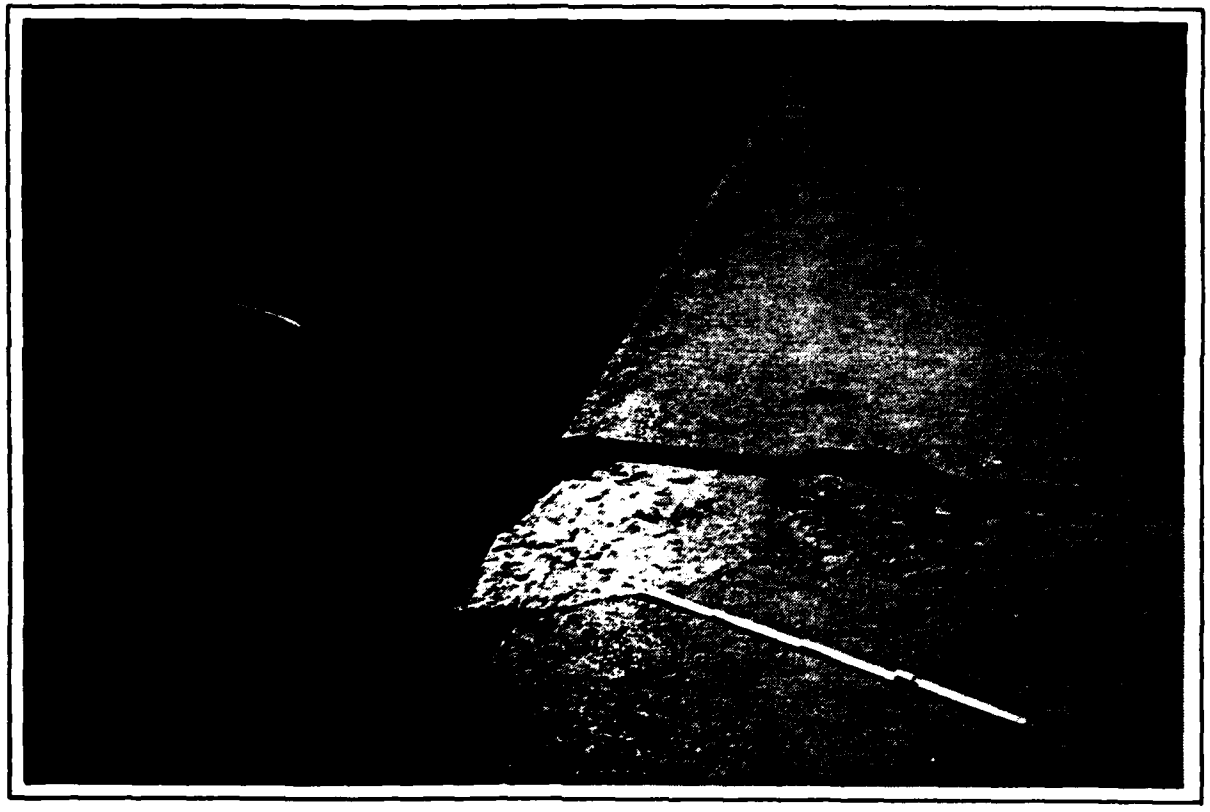


VERTICAL DISPLACEMENT BETWEEN
CONSTRUCTION JOINTS, APPARENTLY
AS CONSTRUCTED.

PHOTOGRAPH NO. 11

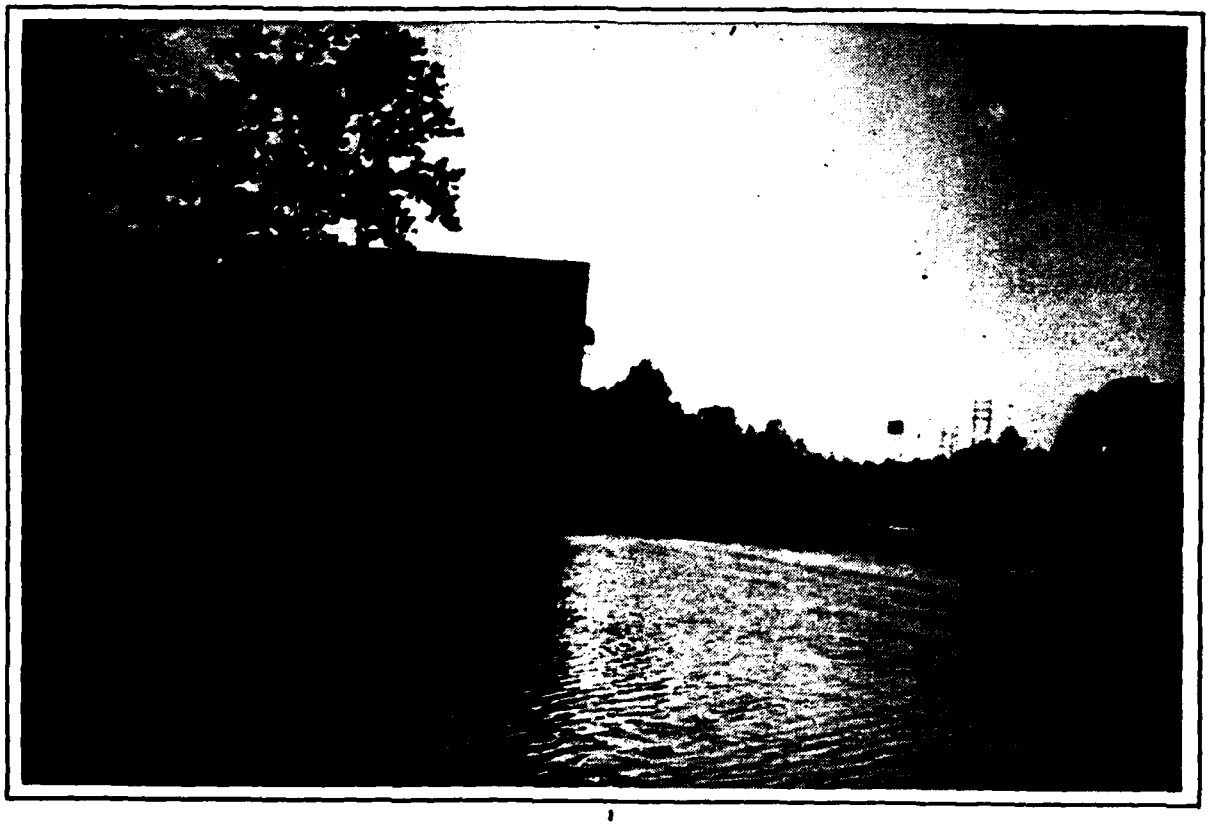
SPALLING IN CANAL WALL WEIR.

PHOTOGRAPH NO. 12



TYPICAL JOINT DETERIORATION OF
CONSTRUCTION JOINTS.

PHOTOGRAPH NO. 13



BUILDING ABOUT 8,000 FEET DOWNSTREAM OF DAM. FIRST FLOOR IS ABOUT 18 FEET ABOVE WATER LEVEL.

PHOTOGRAPH NO. 14

CANOE CLUB AT CONFLUENCE OF WISSAHICKON CREEK AND SCHUYLKILL RIVER. FIRST FLOOR 15 FEET ABOVE WATER LEVEL.

PHOTOGRAPH NO. 15

APPENDIX

D

BY MES DATE 2/23/80 SUBJECT Flat Rock Dam Hydrology / Hydraulics SHEET 2 OF 5

CHKD. BY [illegible] DATE 2/28/80 JOB No.

Classification (Ref- Recommended Guidelines for Safety Inspection of Dams)

1. The hazard classification is rated as "High" as there would be economic loss and loss of life in the event of a sudden failure of the dam not during an extreme event.

2. The size classification is "Intermediate" based on its estimated 1500 Ac-Ft total storage capacity and less than 100 ft. height.

3. The selected spillway design flood, based on size and hazard classification, is the PMF (Probable Maximum Flood), less than the recommended PMF.

Hydrology and Hydraulic Analysis

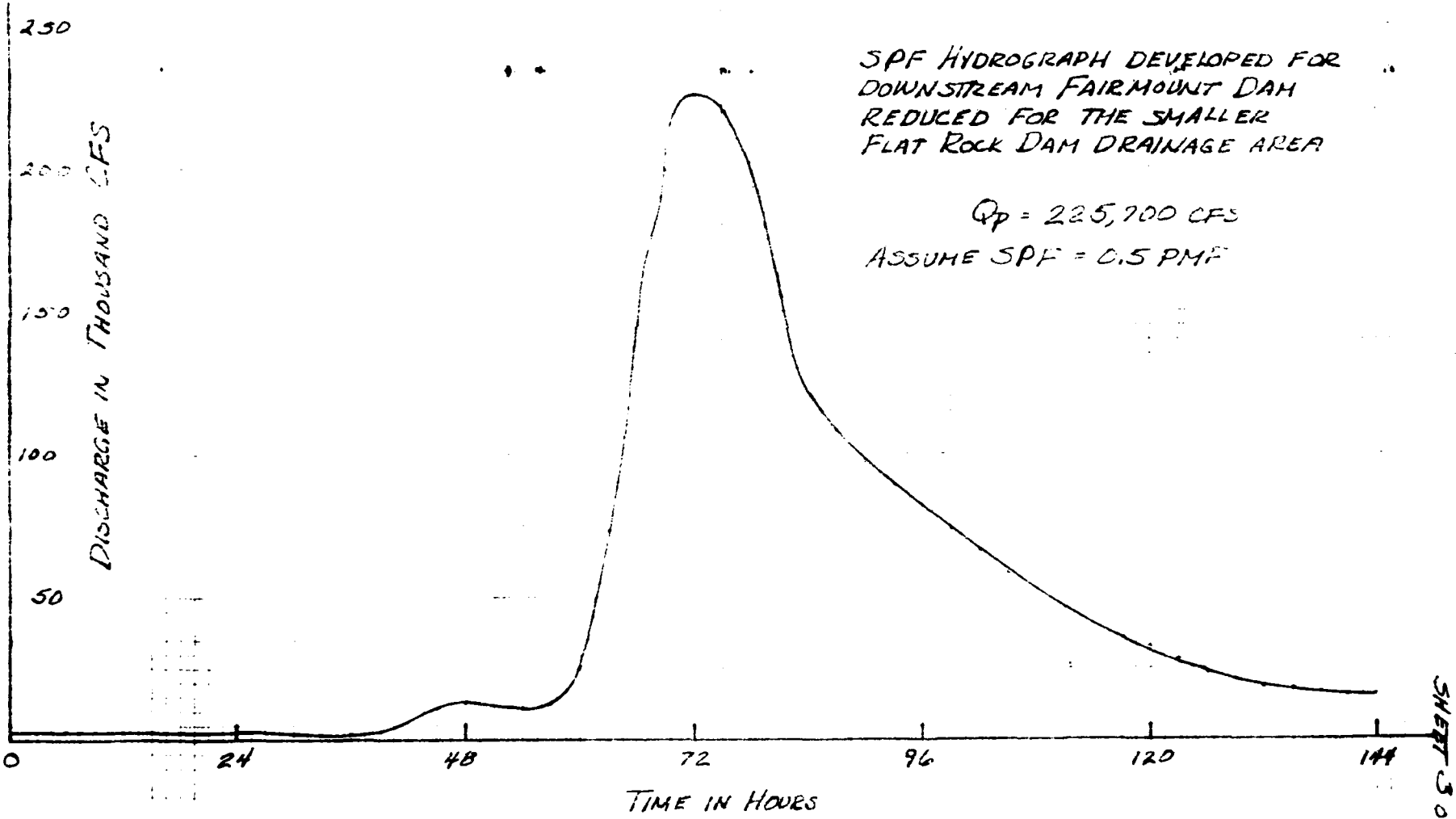
1. Original Data

As the concrete dam replaces an old timber crib structure, limited hydrologic / hydraulic analysis was performed. Original hydraulic analysis indicated that flows of 139,000 cfs would increase the tail-water elevation to 50.6, 0.3 ft below the pool elevation and flows exceeding 139,000 cfs would submerge the weir.

2. Evaluation Data.

The inflow hydrograph shown on sheet 3, was supplied by the Corps of Engineers, Philadelphia District, as the SPF (Standard Project Flood) for the downstream Fairmount Dam drainage area of 1893 square miles. The flows at Flat Rock Dam will be somewhat less, as Flat Rock Dam drainage area is 1809 square miles. Reduce flows by $(1809/1893)^{0.8}$.

The elevation-discharge data, shown on sheet 4, was supplied by DER, Bureau of Design.


SPF HYDROGRAPH DEVELOPED FOR
DOWNSTREAM FAIRMOUNT DAM
REDUCED FOR THE SMALLER
FLAT ROCK DAM DRAINAGE AREA
Q_p = 225,700 CFS
ASSUME SPF = 0.5 PMF
DISCHARGE IN THOUSAND CFS
250
200
150
100
50
0
24
48
72
96
120
144
TIME IN HOURS

SHEET 3 OF 5

BY MEB DATE 7/23/80 SUBJECT Flat Rock Dam Hydrology / Hydraulics SHEET 4 OF 5

CHKD. BY REM DATE 7/28/80 JOB No.

Flat Rock Dam
Weir Summary Data

Discharge (cfs)	Upstream Pool Elev.	Pool Energy Grade Elev.	Tail Water Elev.
30,000	44.0	44.5	31.7
40,000	45.1	45.7	35.6
50,000	46.2	47.1	38.6
60,000	47.0	48.3	41.1
70,000	47.8	49.3	43.2
80,000	48.7	50.3	45.0
90,000	49.4	51.2	46.5
98,000	50.0	51.9	47.7
110,000	50.5	53.0	49.3
120,000	50.9	53.7	50.6
130,000	51.8	54.5	51.8

Weir Crest 37.7
Notches 37.2

the above supplied by Bureau of Design (DER)

H_o = 14.5 ft (design head), confirmed by as-built shape of weir

L = 510 ft - from as built drawing

at H_e (total head on crest) = 8 ft

H_e/H_o = 8/14.5 = 0.55

C/C_o = 0.93 Ref. Design of Small Dams, Bureau of Reclamation, 2nd ed., p. 378

P ~ 5 ft, because old dam not completely removed

P/H_o = 5/14.5 = 0.34

C_o = 3.67

$Q = 3.67 \cdot 0.93 \cdot 510 \cdot 8^{1.5}$

= 39,400 cfs ~ 40,000 listed above

BY MFB DATE 2/23/82 SUBJECT Flat Rock Dam SHEET 5 OF 5

CHKD. BY MFB DATE 2/26/82 Hydrology / Hydraulics JOB No.

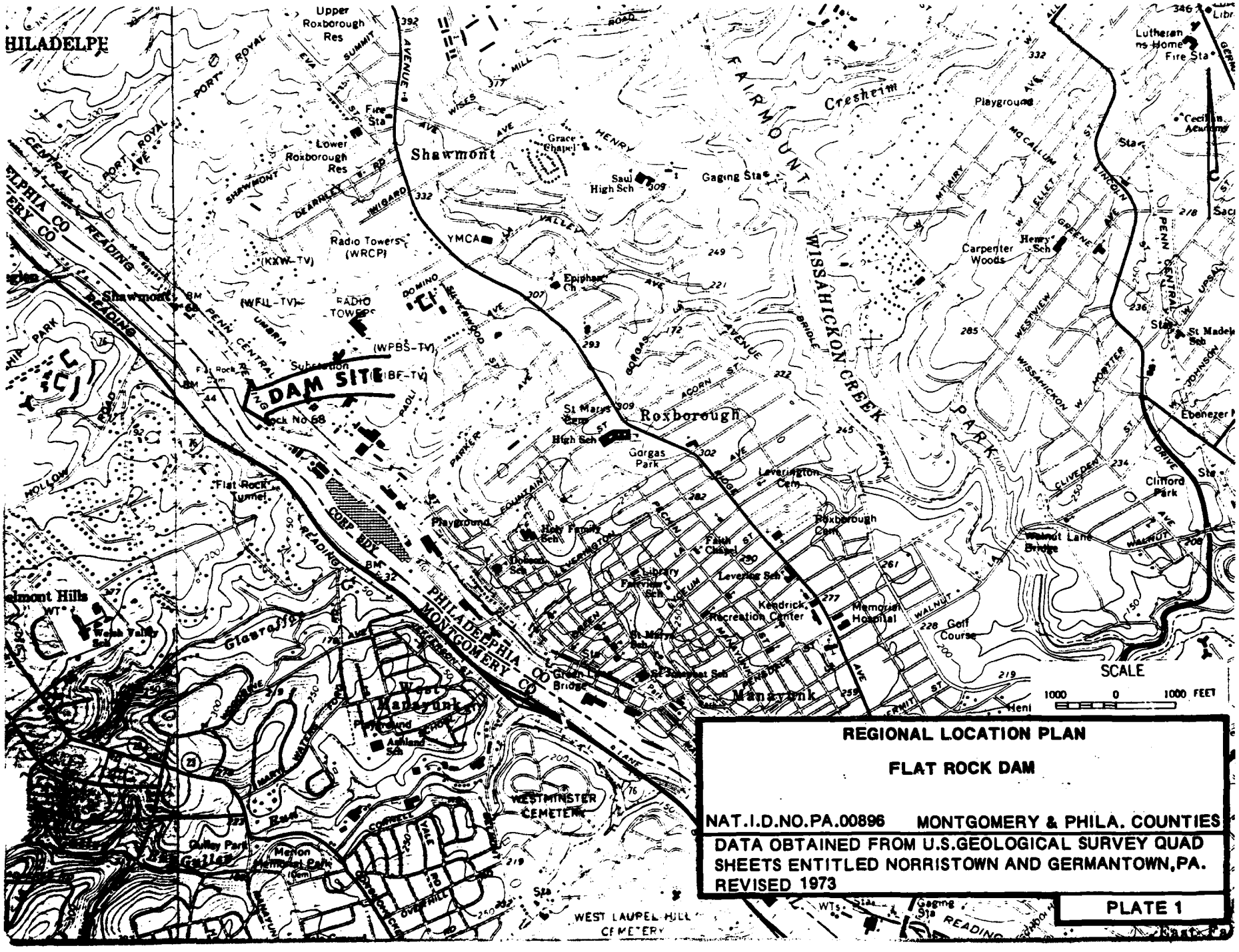
Considering the size of the watershed, available flood water storage by Flat Rock Dam is very limited. Therefore, assume no attenuation of flood hydrograph shown on sheet 3.

Assume the SDF (sheet 3) is the PMF.

The left abutment elevation is 40.8, adjacent to the existing gravity canal wall at 44.8. The right abutment elevation is 44.2. A pool elevation of 44.0 ft results in a weir discharge of about 30,000 cfs, or about 0.07 PMF

APPENDIX

E



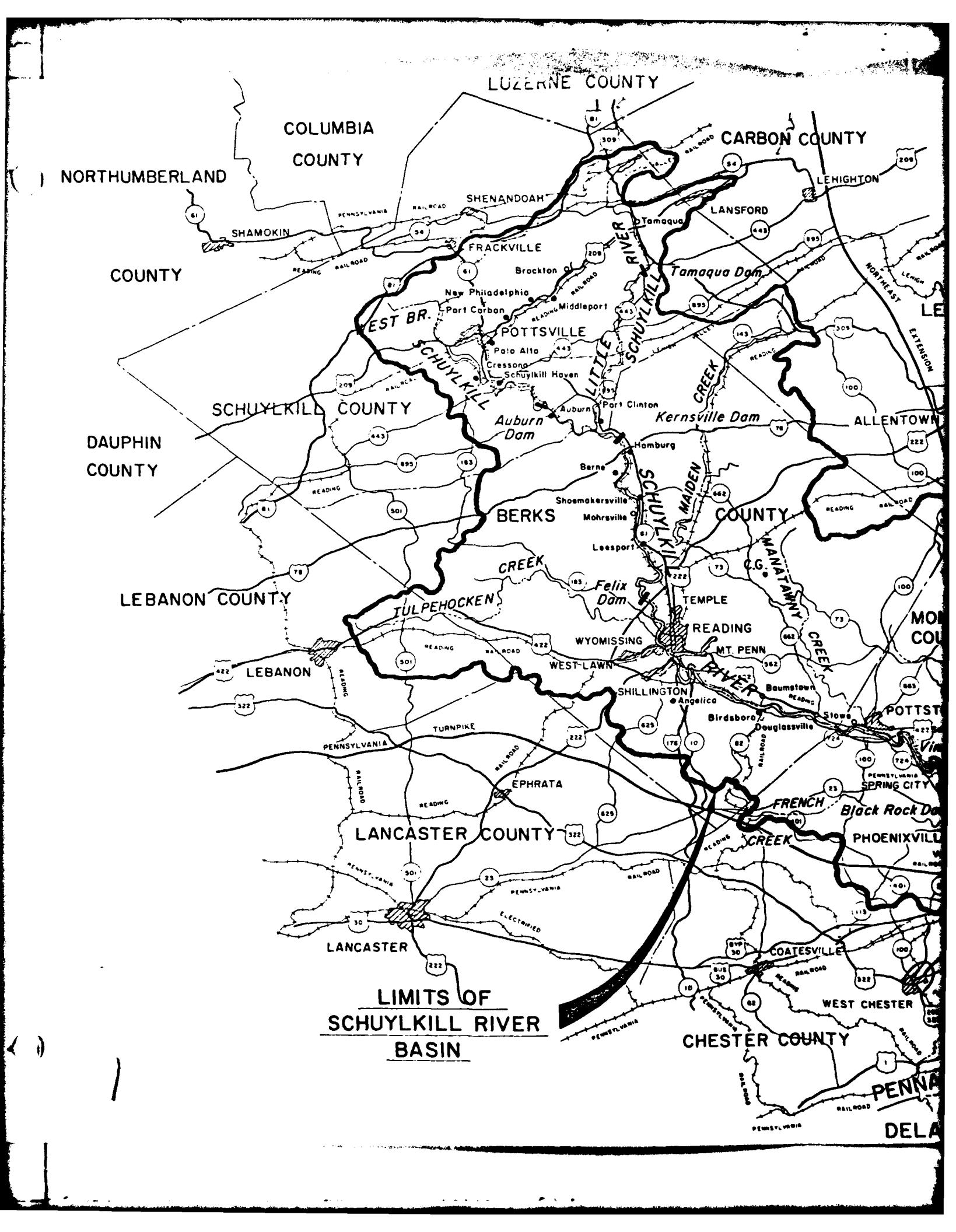
REGIONAL LOCATION PLAN

FLAT ROCK DAM

NAT.I.D.NO.PA.00896 MONTGOMERY & PHILA. COUNTIES

DATA OBTAINED FROM U.S.GEOLOGICAL SURVEY QUAD SHEETS ENTITLED NORRISTOWN AND GERMANTOWN,PA. REVISED 1973

PLATE 1


LUZERNE COUNTY
COLUMBIA COUNTY
CARBON COUNTY
NORTHUMBERLAND
SHENANDOAH
SHAMOKIN
LEHIGHTON
LANSFORD
Tamaqua
FRACKVILLE
COUNTY
Brockton
Tamaqua Dam
New Philadelphia
Port Carbon
Middleport
EST BR.
SCHUYLKILL
POTTSVILLE
Palo Alto
Cressona
Schuylkill Haven
LITTLE SCHUYLKILL RIVER
CREEK
SCHUYLKILL COUNTY
Auburn
Port Clinton
Auburn Dam
Kernsville Dam
ALLENTOWN
DAUPHIN COUNTY
Hamburg
Berne
Shoemakersville
Mohrsville
BERKS
COUNTY
MAIDEN
Leesport
MANATAWNY
CREEK
C.G.
CREEK
Felix Dam
TEMPLE
LEBANON COUNTY
TULPEHOCKEN
READING
WYOMISSING
MT. PENN
WEST LAWN
LEBANON
SHILLINGTON
Angelica
RIVER
Baumstown
Birdsboro
Douglassville
Stowe
TURNPIKE
PENNSYLVANIA
EPHRATA
SPRING CITY
FRENCH
Black Rock
CREEK
LANCASTER COUNTY
PHOENIXVILL
LANCASTER
COATESVILLE
WEST CHESTER
CHESTER COUNTY
LIMITS OF
SCHUYLKILL RIVER
BASIN

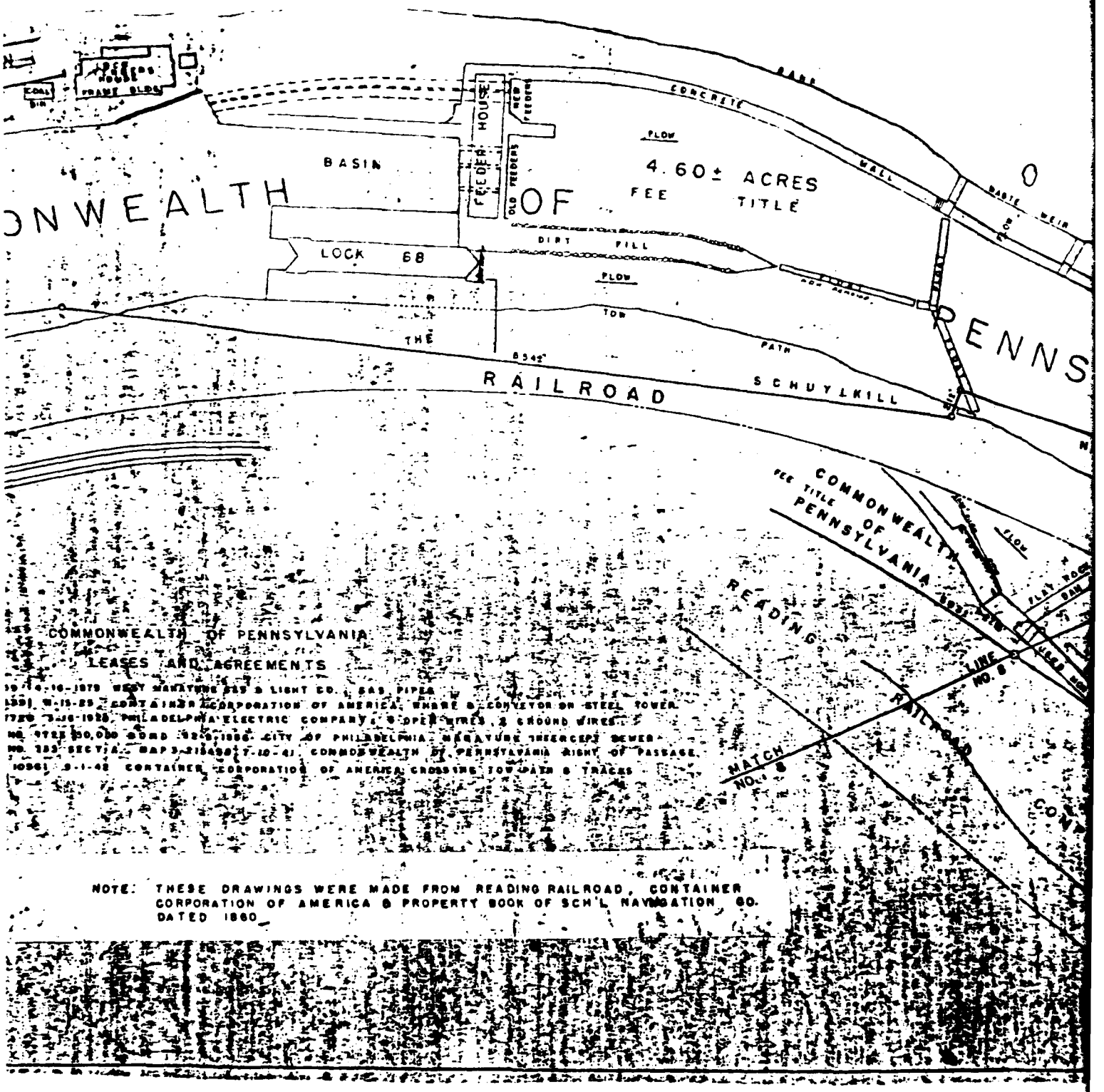
HYDROLOGIC MAP

FLAT ROCK DAM

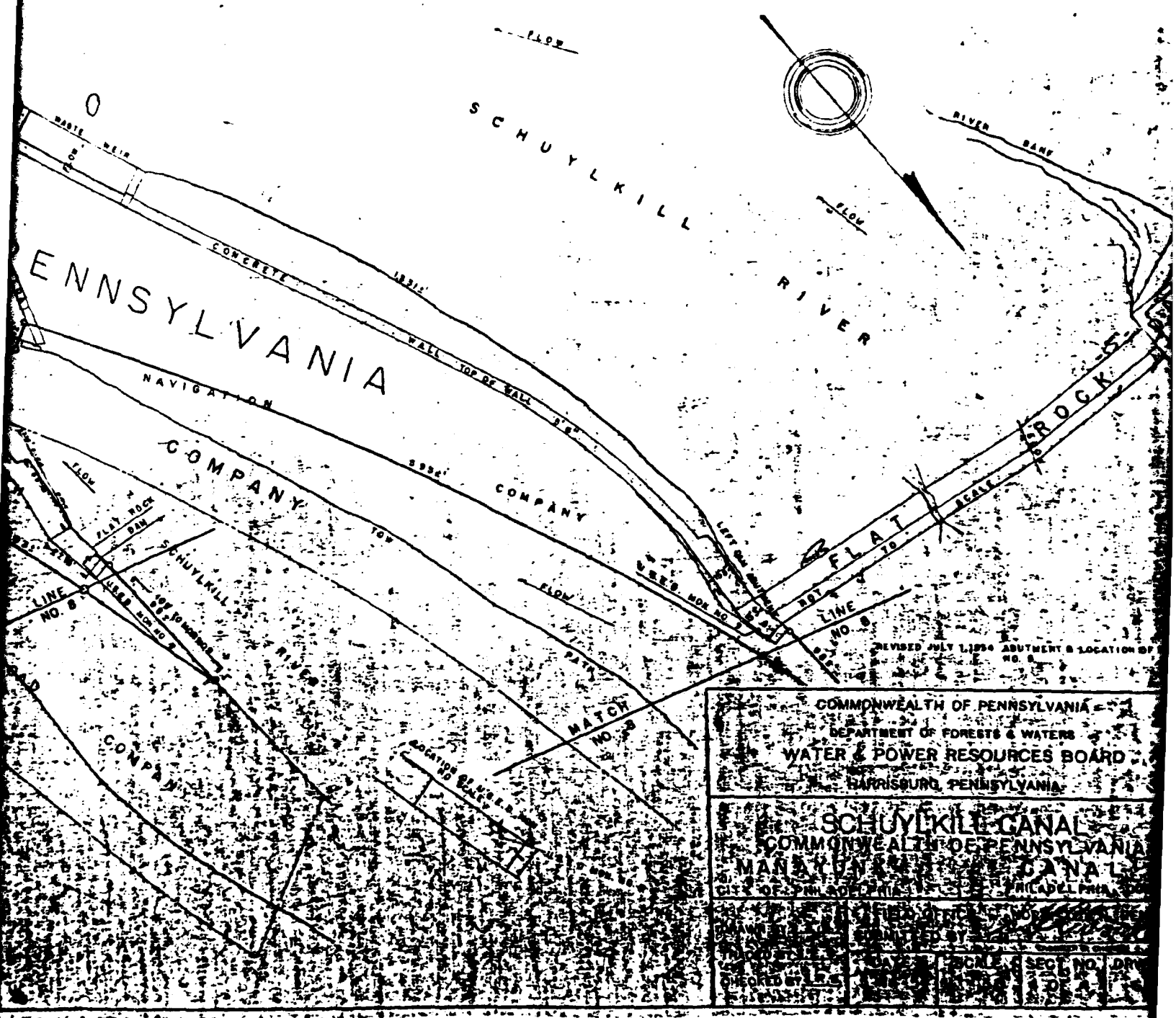
NAT.I.D.NO.PA.00896 PHILADELPHIA CO

DATA OBTAINED FROM DER WATER RESOURCES BULL
NO.4 WATER RESOURCES SURVEY, THE SCHUYLKILL
PA.

PLATE

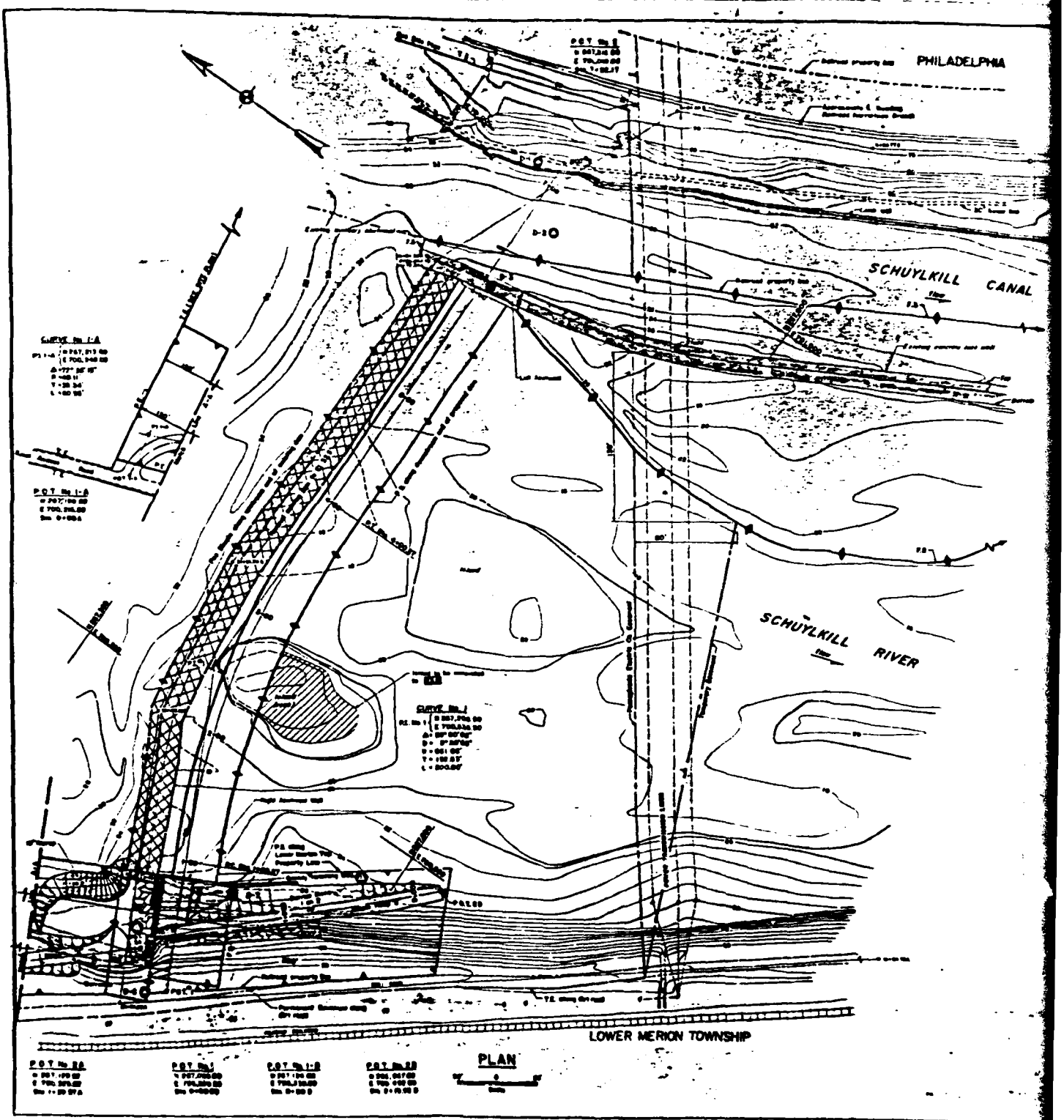


BASIN
FEEDER HOUSE
OLD FEEDERS
NEW FEEDERS
CONCRETE
WALL
FLOW
4.60± ACRES
FEE TITLE
ONWEALTH OF PENNS
LOCK 68
DIRT FILL
FLOW
TOW PATH
THE
RAILROAD
SCHUYLKILL
COMMONWEALTH OF PENNSYLVANIA
FEE TITLE
READING RAILROAD
LINE NO. 8
MATCH NO. 8
COMMONWEALTH OF PENNSYLVANIA
LEASES AND AGREEMENTS
CONTAINER CORPORATION OF AMERICA, WHARF & CONVEYOR ON STEEL TOWER
PHILADELPHIA ELECTRIC COMPANY, 6 OPEN WIRES, 2 GROUND WIRES
CITY OF PHILADELPHIA, MARATUNK INTERCEPT SEWER
COMMONWEALTH OF PENNSYLVANIA RIGHT OF PASSAGE
CONTAINER CORPORATION OF AMERICA CROSSING TOW PATH & TRACKS
NOTE: THESE DRAWINGS WERE MADE FROM READING RAILROAD, CONTAINER CORPORATION OF AMERICA & PROPERTY BOOK OF SCH'L NAVIGATION CO. DATED 1860


SCHUYLKILL RIVER
PENNSYLVANIA
NAVIGATION COMPANY
COMPANY
CONCRETE WALL
TOP OF WALL
FLOW
WASTE WEIR
RIVER BANK
FLAT ROCK
LINE NO. 8
MATCH NO. 8
SCHUYLKILL RIVER
COMPANY
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS & WATERS
WATER & POWER RESOURCES BOARD
HARRISBURG, PENNSYLVANIA
SCHUYLKILL CANAL
COMMONWEALTH OF PENNSYLVANIA
MANAYUNK CANAL
CITY OF PHILADELPHIA
PHILADELPHIA
CHECKED BY
SCALE
SECT. NO.

PLA

2


PHILADELPHIA
SCHUYLKILL CANAL
SCHUYLKILL RIVER
LOWER MERION TOWNSHIP
PLAN

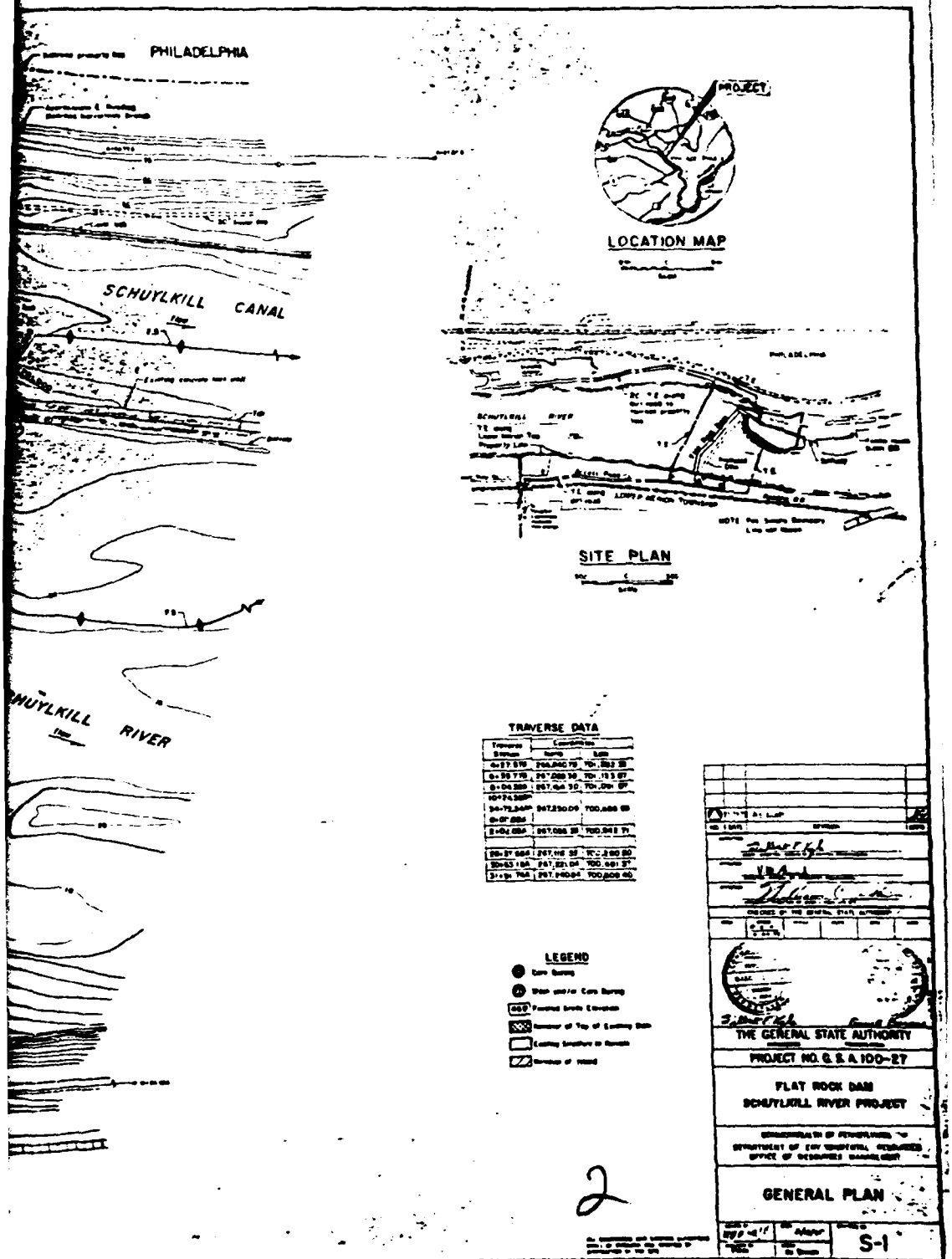
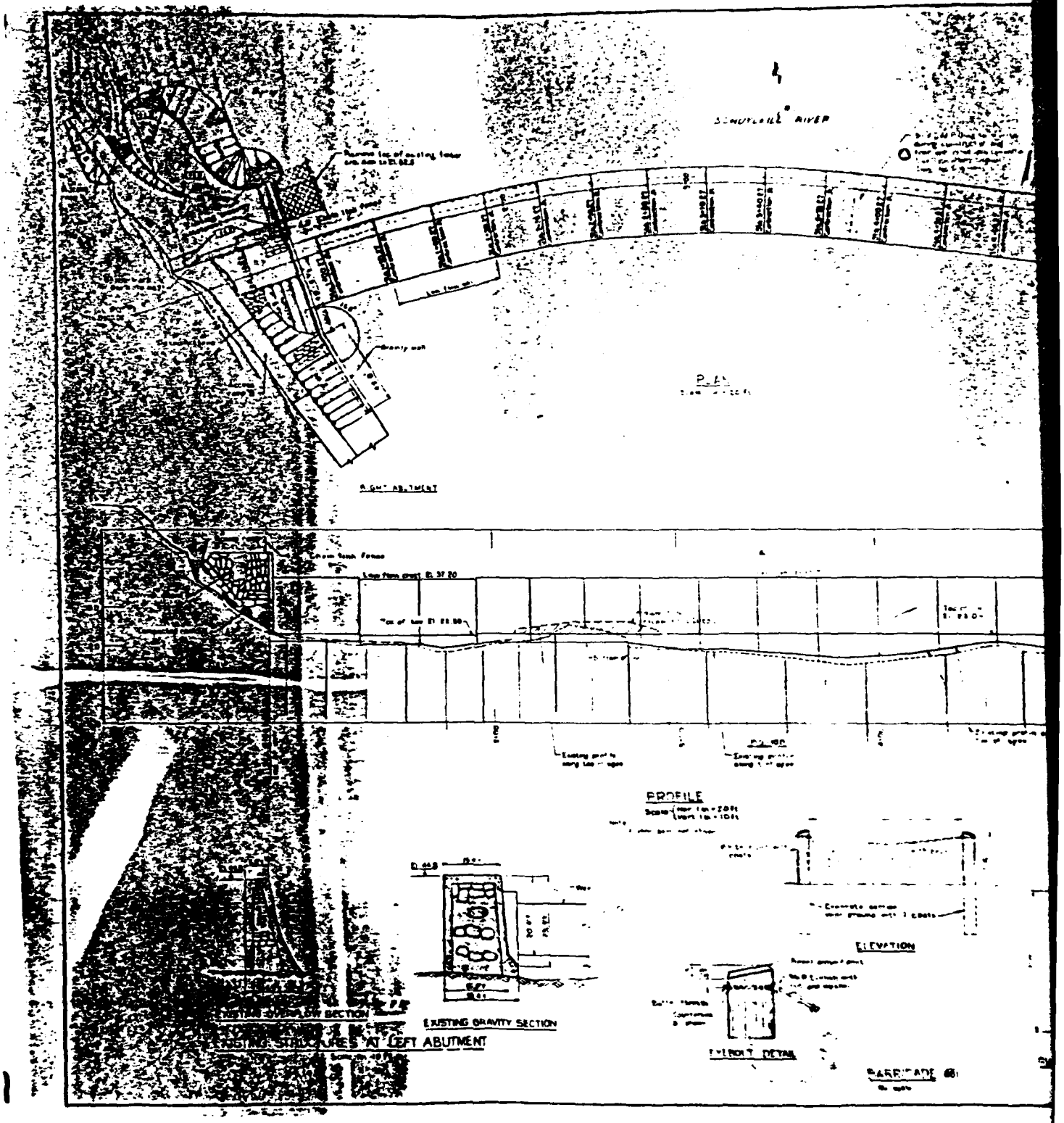

PHILADELPHIA
SCHUYLKILL CANAL
SCHUYLKILL RIVER
PROJECT
LOCATION MAP
SITE PLAN
TRAVERSE DATA
LEGEND
THE GENERAL STATE AUTHORITY
PROJECT NO. G. S. A. 100-27
FLAT ROCK DAM
SCHUYLKILL RIVER PROJECT
GENERAL PLAN
S-1

PLATE 3


SCHUYLKILL RIVER
PLAN
PROFILE
ELEVATION
EXISTING GRAVITY SECTION
EXISTING FLOODWALL SECTION
FLOODING STRUCTURES AT LEFT ABUTMENT
PARAPET DETAIL

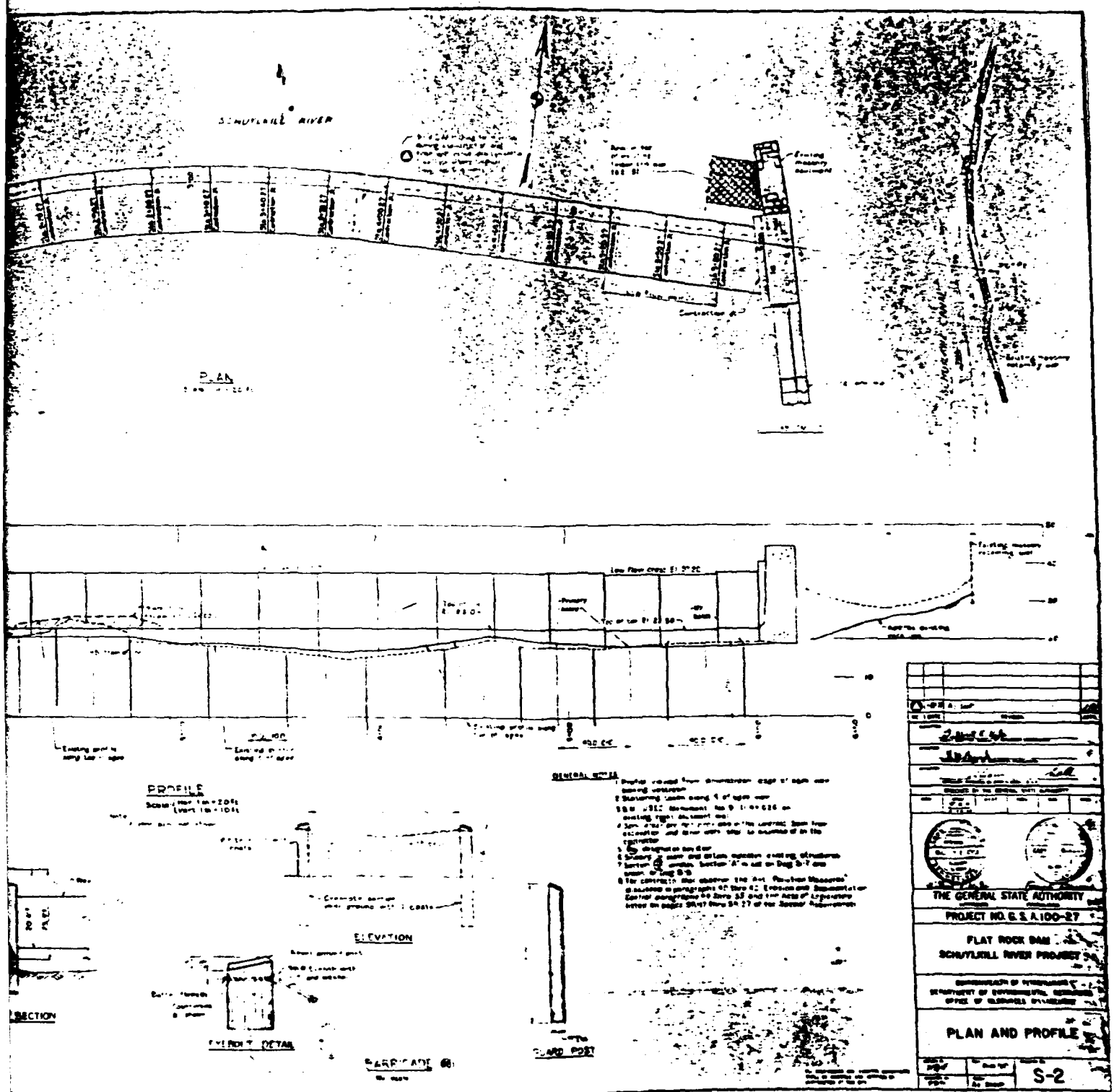
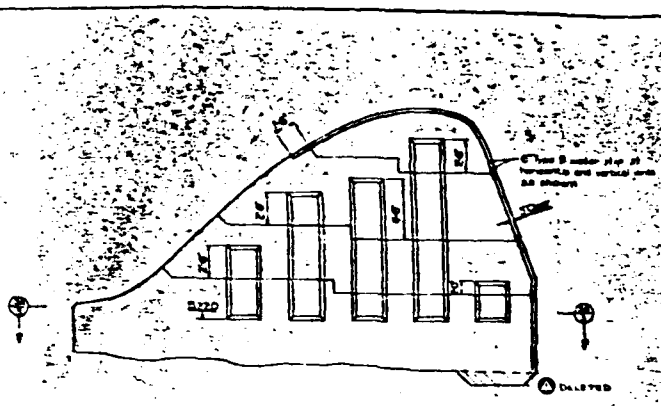
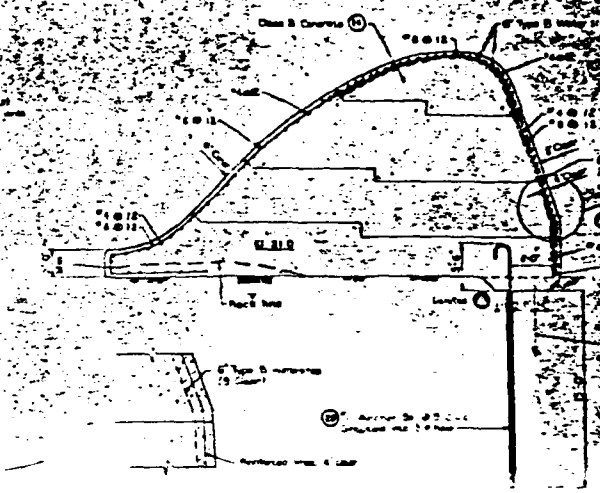

SCHUYLKILL RIVER
PLAN
PROFILE
ELEVATION
PARAPET DETAIL
GUARD POST
GENERAL NOTES
THE GENERAL STATE AUTHORITY
PROJECT NO. G.S.A.100-27
FLAT ROCK DAM
SCHUYLKILL RIVER PROJECT
PLAN AND PROFILE
S-2

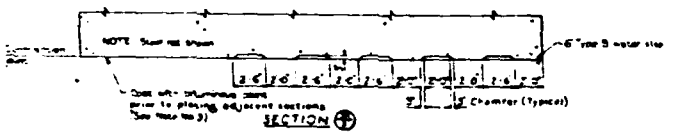
PLATE 4



ELEVATION

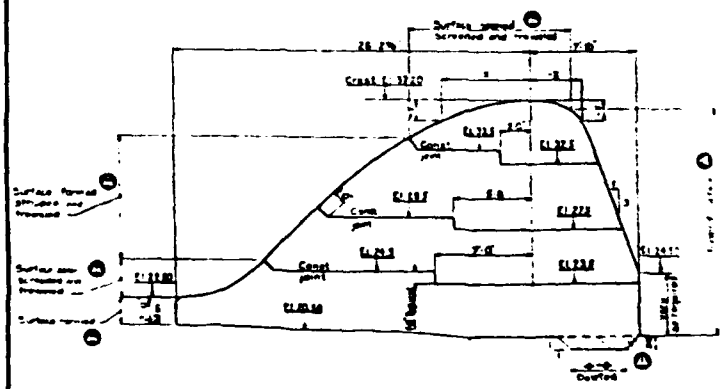


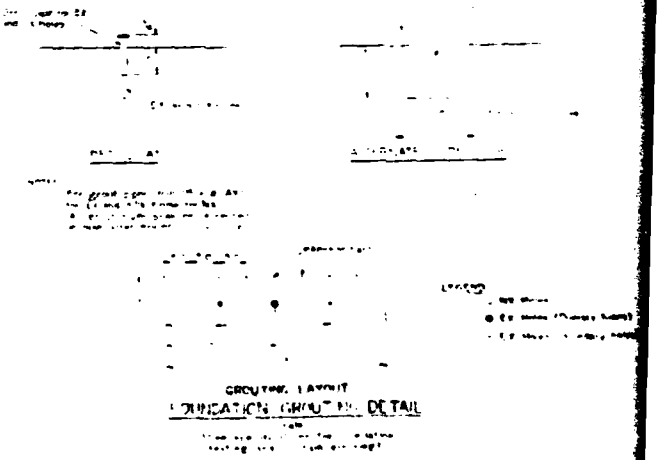
REINFORCEMENT DETAILS



SECTION

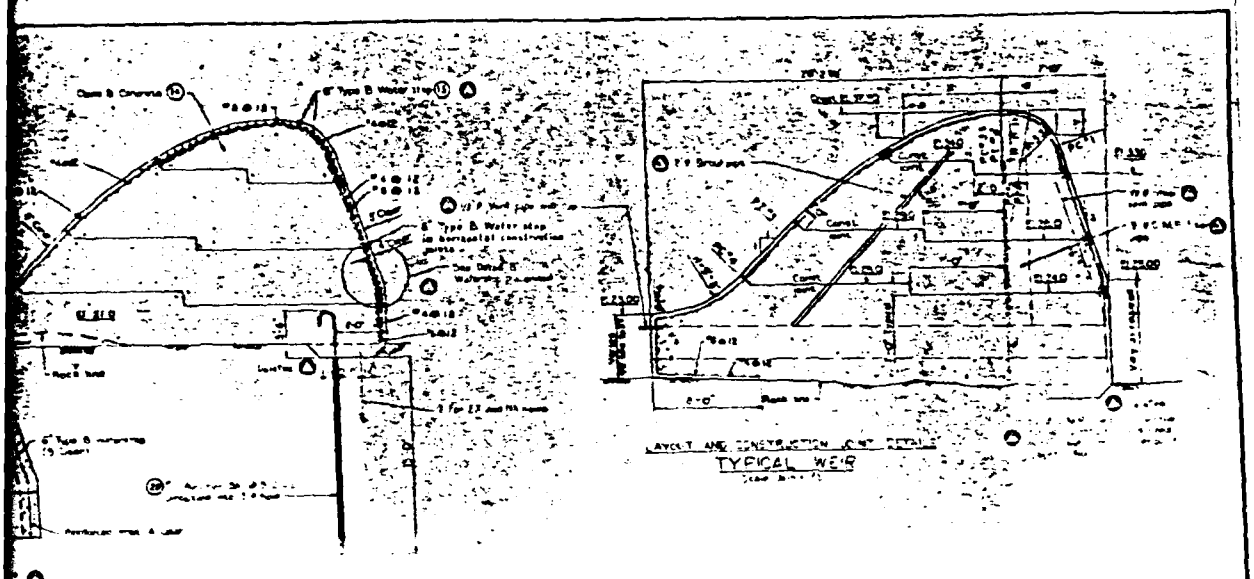
CONTRACTION JOINT DETAIL





LAYOUT AND CONSTRUCTION JOINT DETAILS

LOW FLOW WEIR



TYPICAL WEIR

REINFORCEMENT DETAILS

WEIR COORDINATES

NOTES:

THE GENERAL STATE AUTHORITY

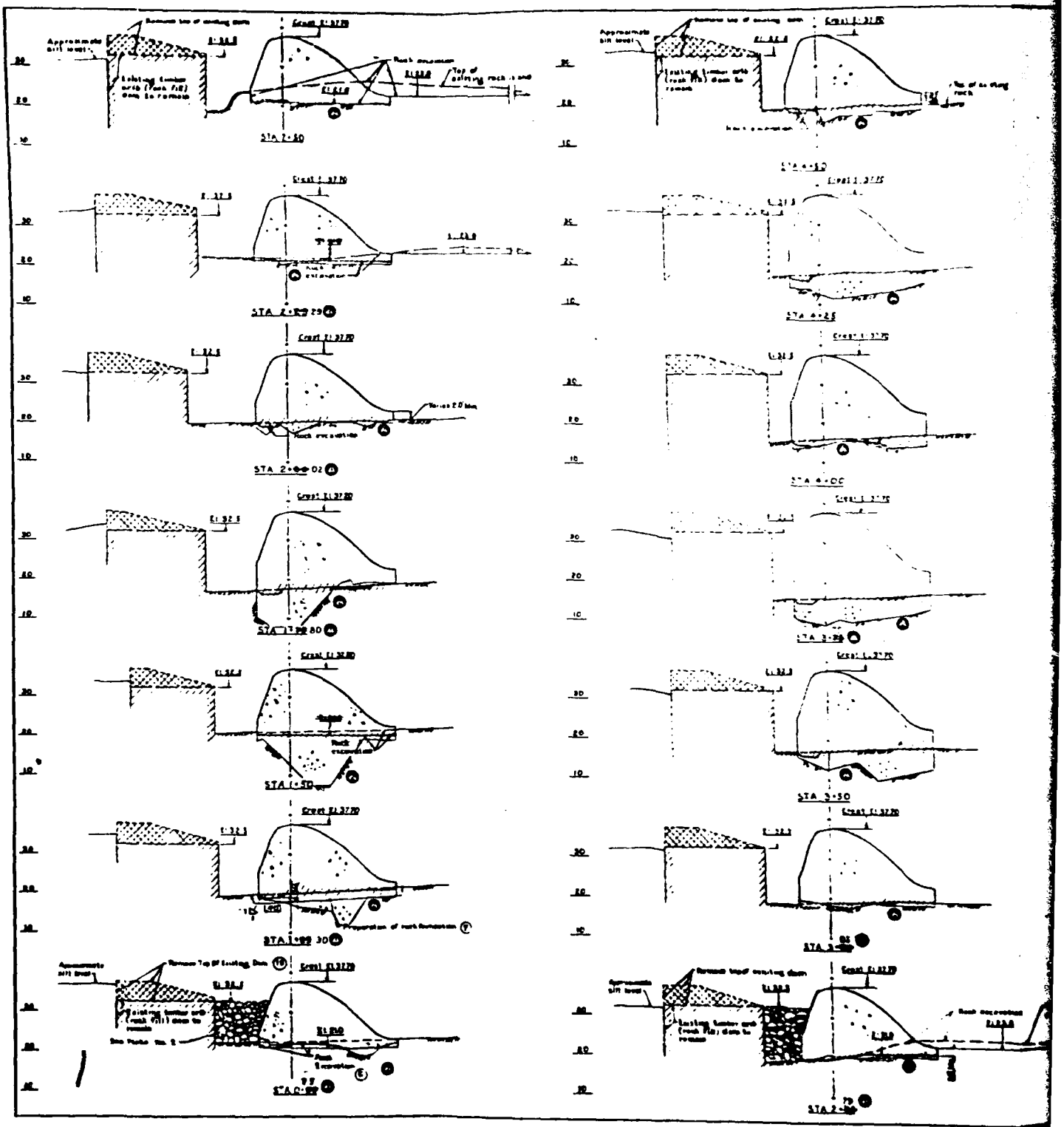
PROJECT NO G S A 100-27

FLAT ROCK DAM
SCHUYLKILL RIVER PROJECT

WEIR DETAILS

S-3

PLATE 5



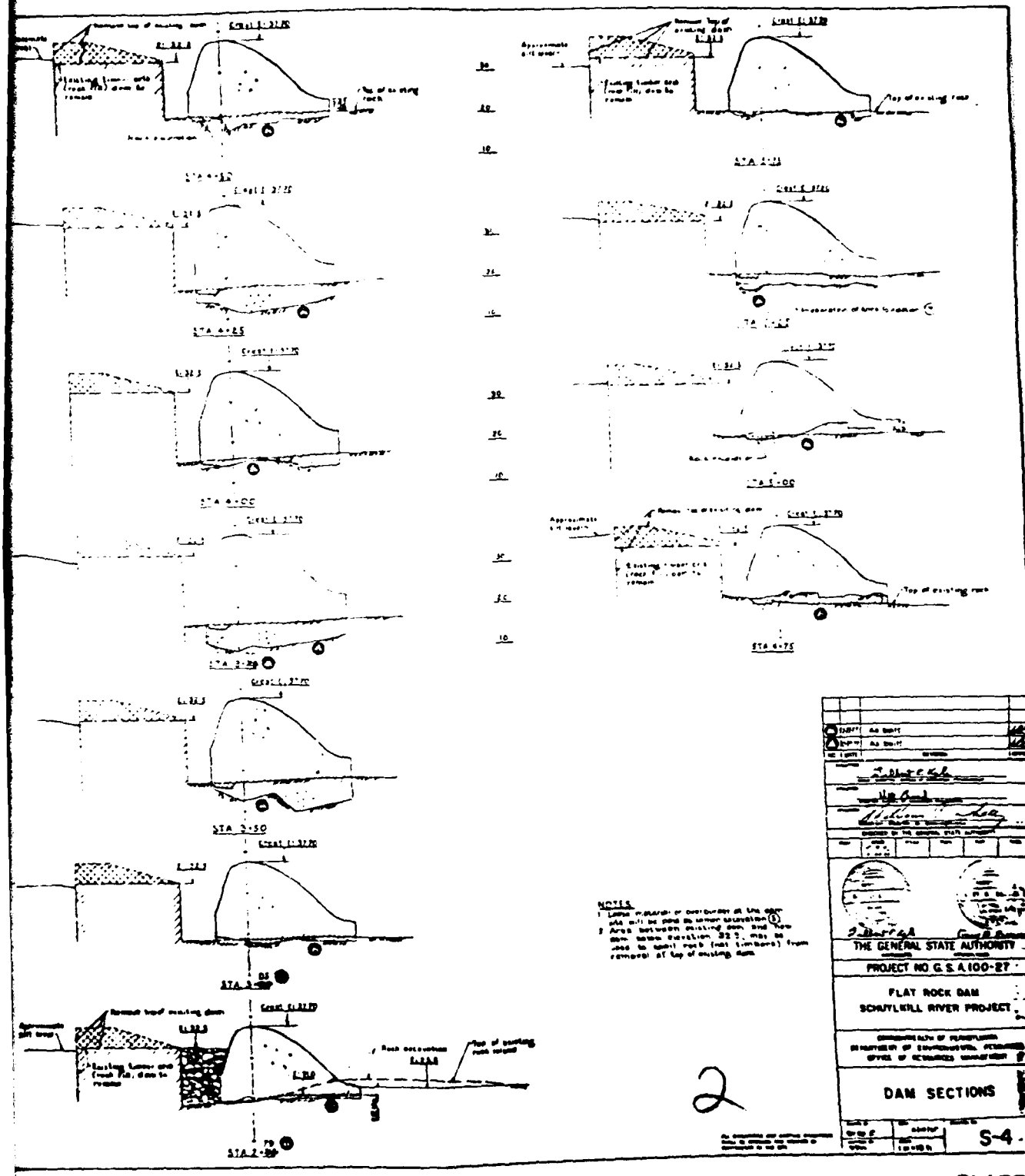
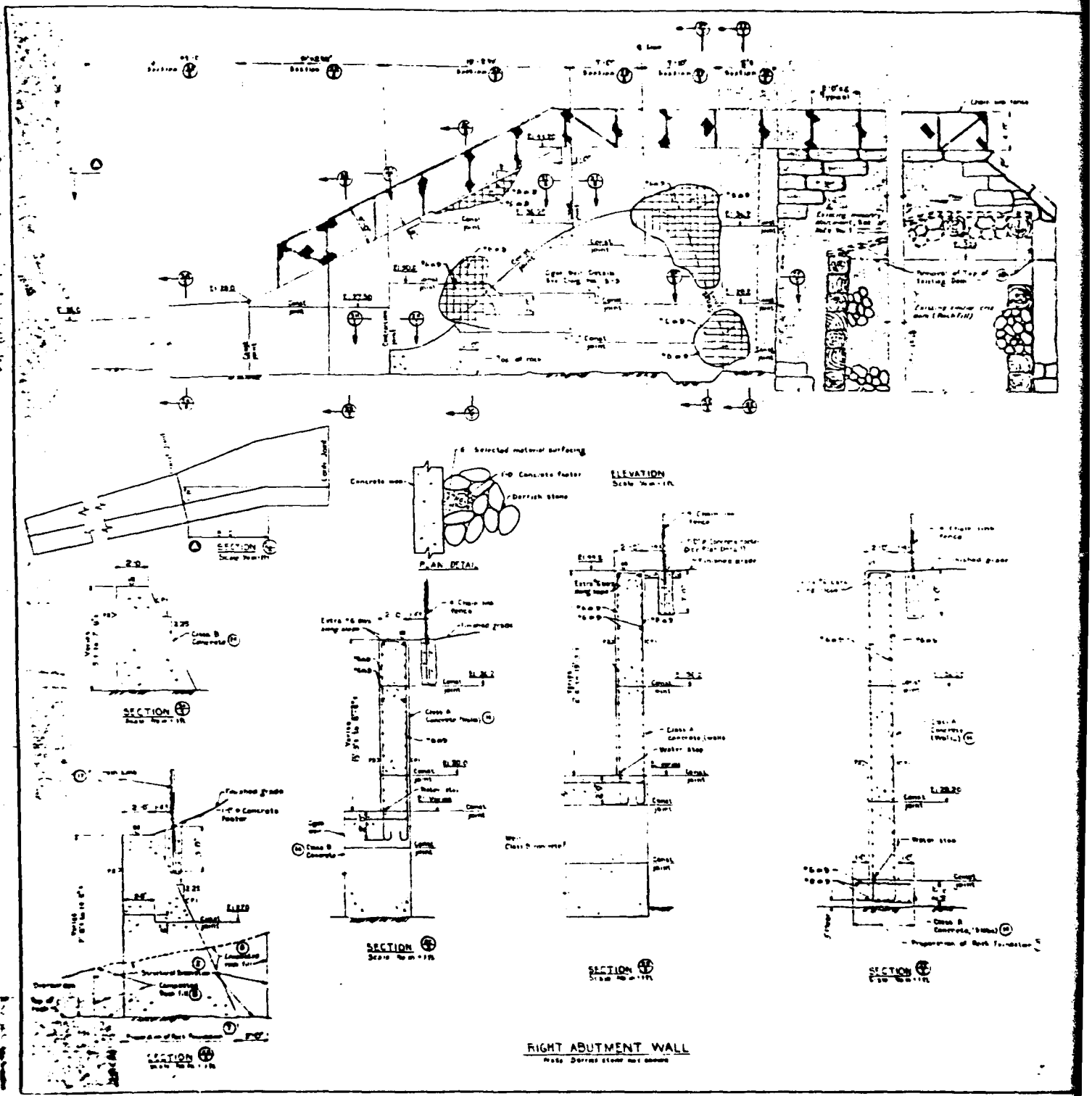

STA 4+25
STA 4+00
STA 3+50
STA 2+00
STA 5+00
STA 4+75
Top of existing rock
NOTES
THE GENERAL STATE AUTHORITY
PROJECT NO. G.S.A.100-27
FLAT ROCK DAM
SCHUYLKILL RIVER PROJECT
DAM SECTIONS
S-4
2

PLATE 6



RIGHT ABUTMENT WALL

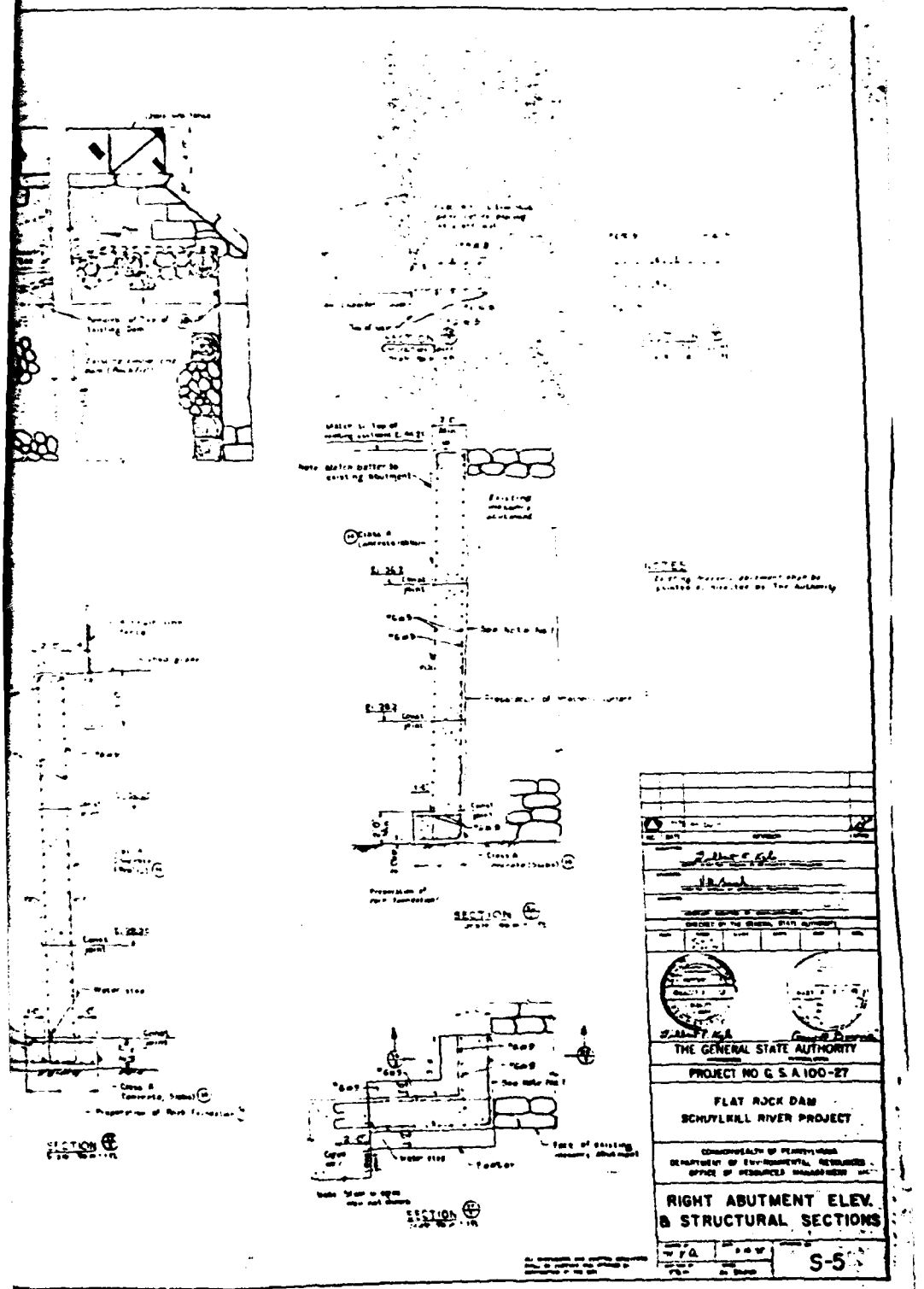
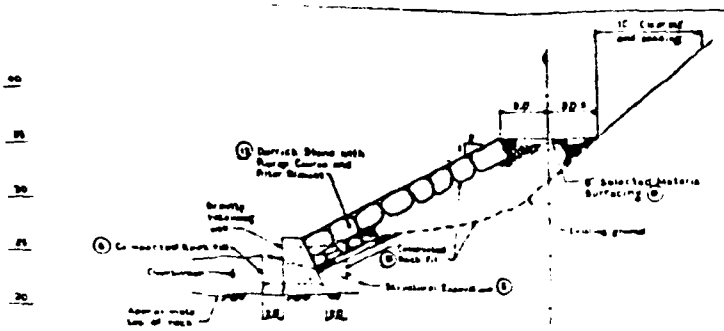
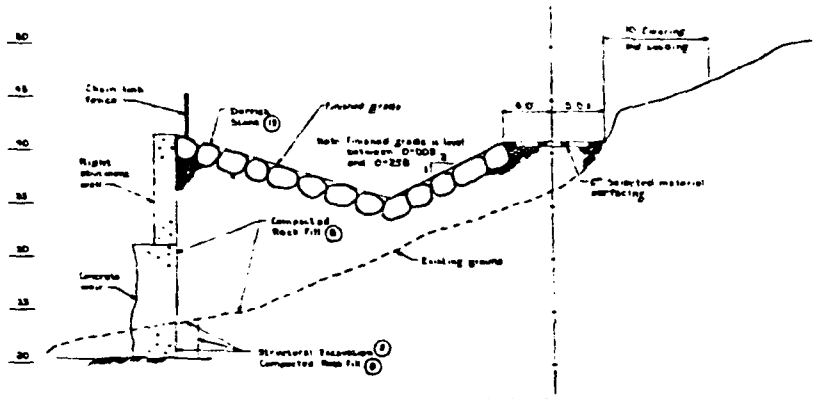

SECTION
SECTION
SECTION
NOTES
THE GENERAL STATE AUTHORITY
PROJECT NO G. S. A. 100-27
FLAT ROCK DAM
SCHUYLKILL RIVER PROJECT
RIGHT ABUTMENT ELEV.
& STRUCTURAL SECTIONS
S-5

PLATE 7

2

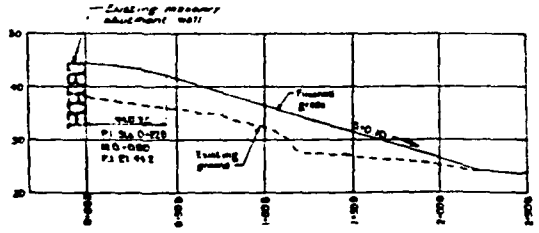


STA 0+258 TO 0+308

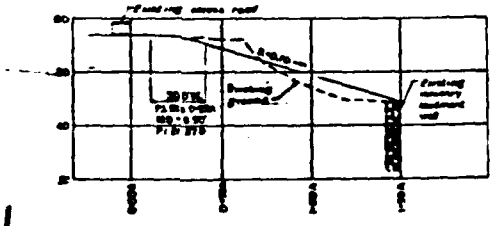


STA 0+258 TO 0+538

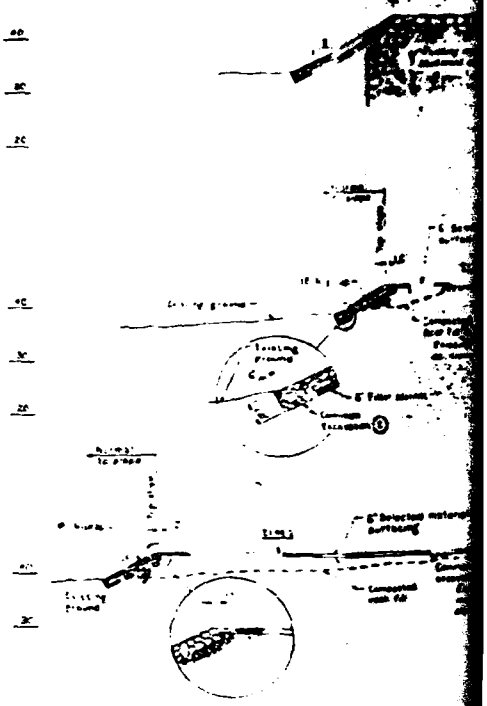
SECTIONS - RAMP B

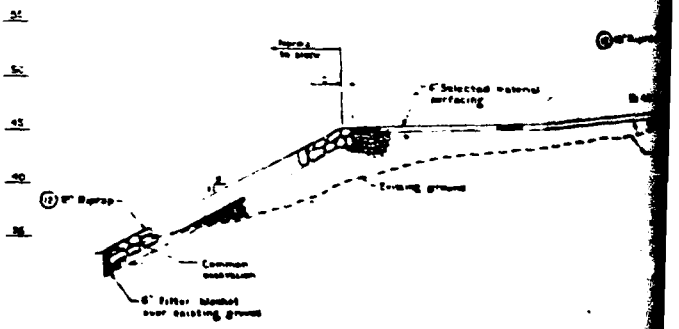


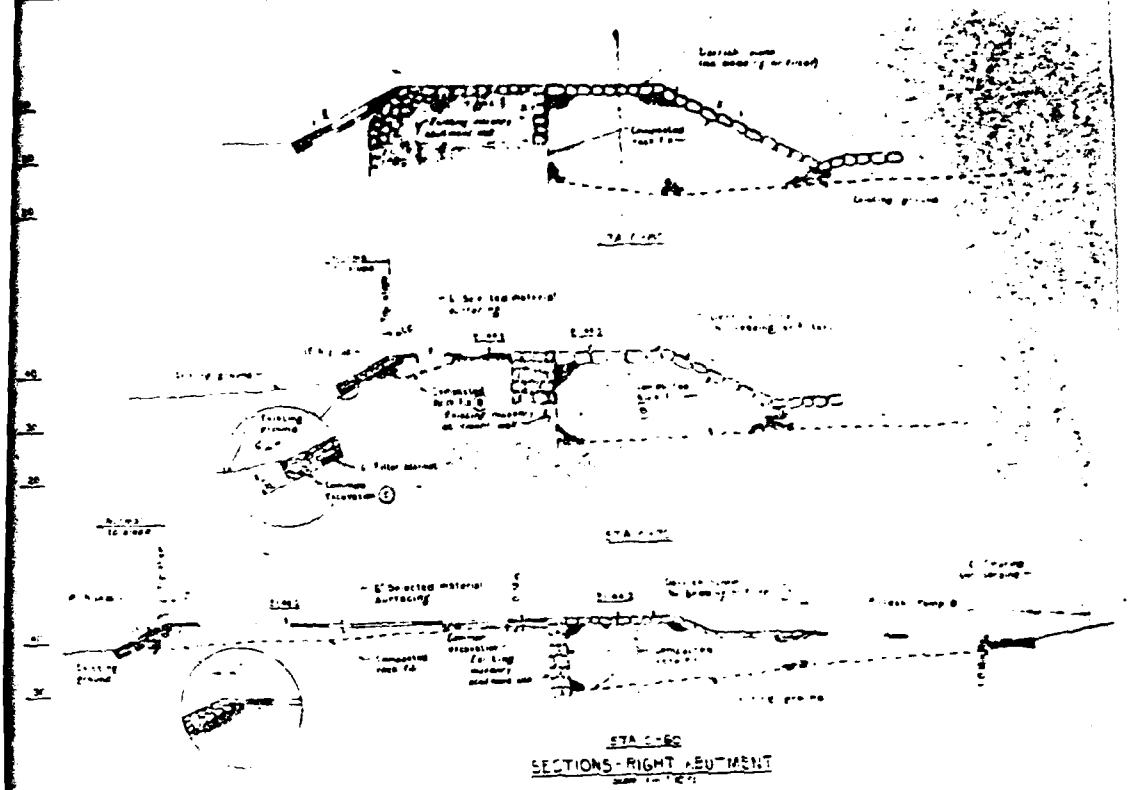
PROFILE RAMP B



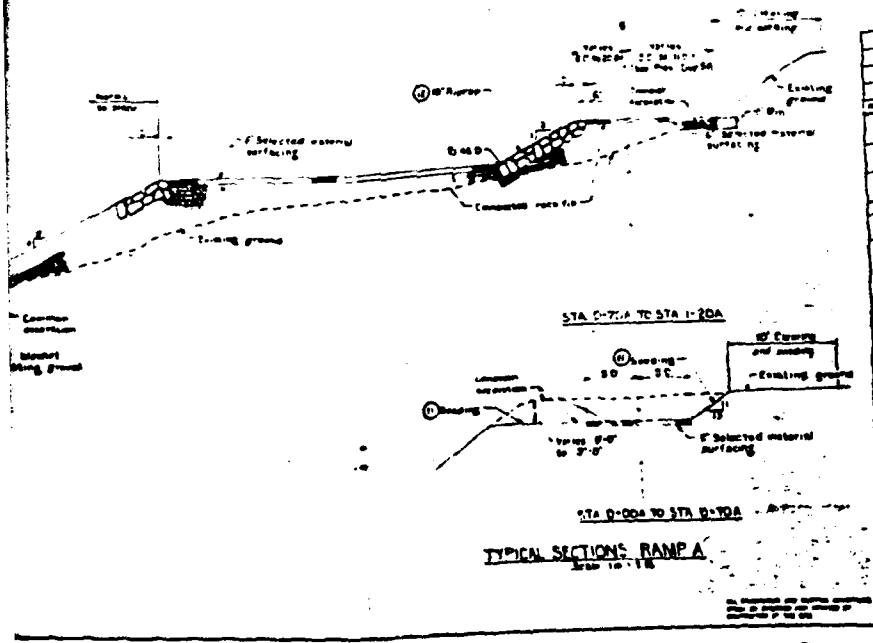
PROFILE RAMP A







SECTIONS - RIGHT ABUTMENT



TYPICAL SECTIONS RAMP A

THE GENERAL STATE AUTHORITY

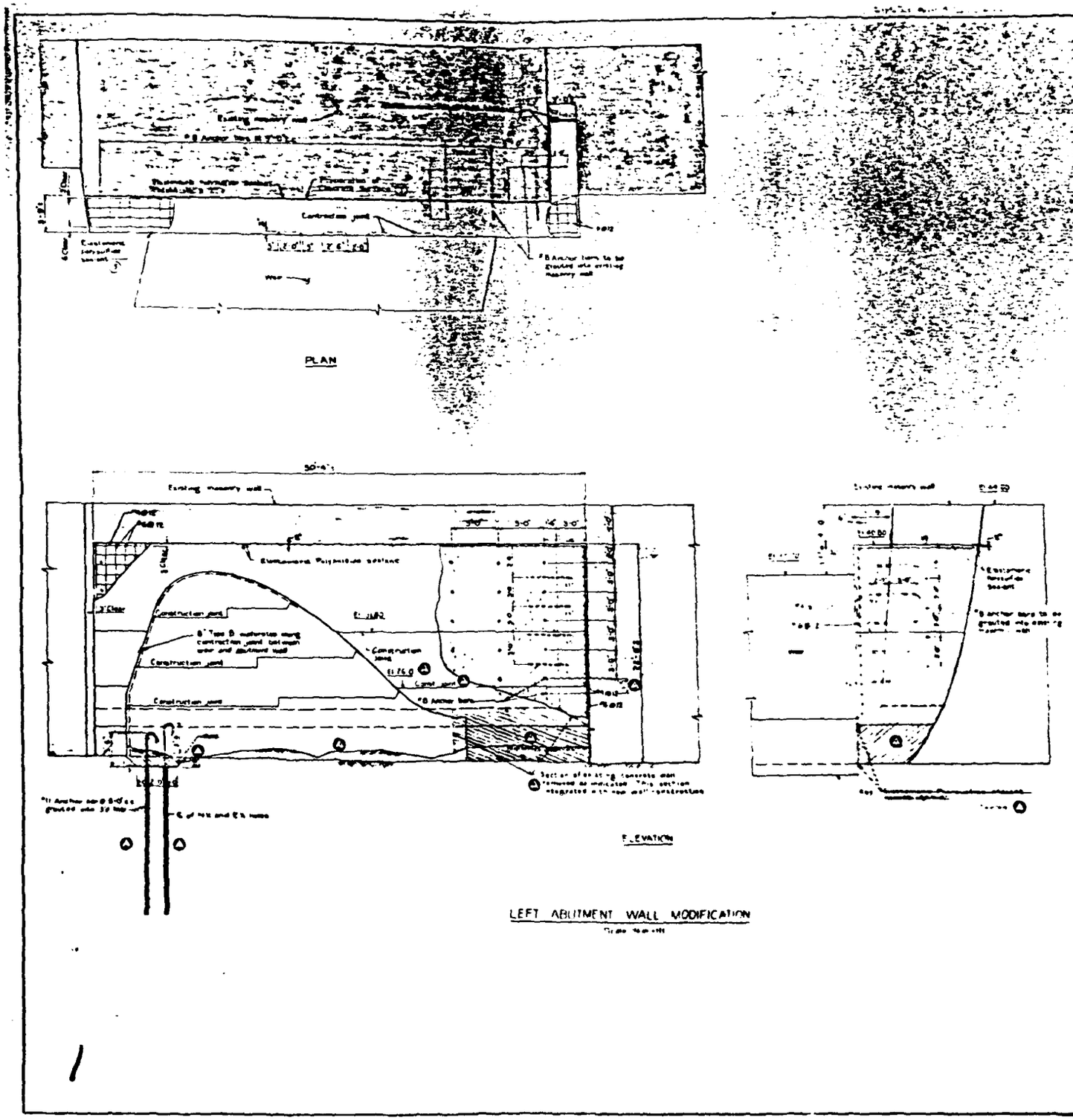
PROJECT NO. G. S. A 100-27

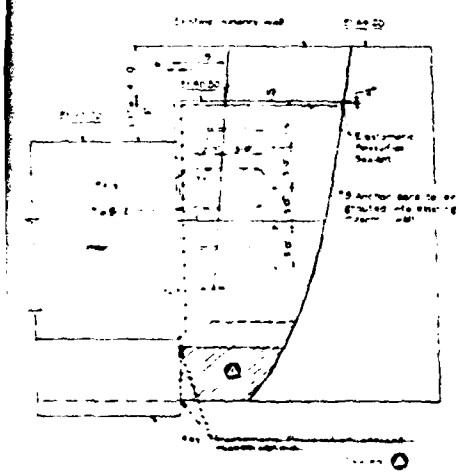
FLAT ROCK DAM
SCHUYLKILL RIVER PROJECT

RIGHT ABUTMENT SECTIONS

S-6

PLATE 8


PLAN
ELEVATION
LEFT ABUTMENT WALL MODIFICATION



THE GENERAL STATE AUTHORITY

PROJECT NO G S A

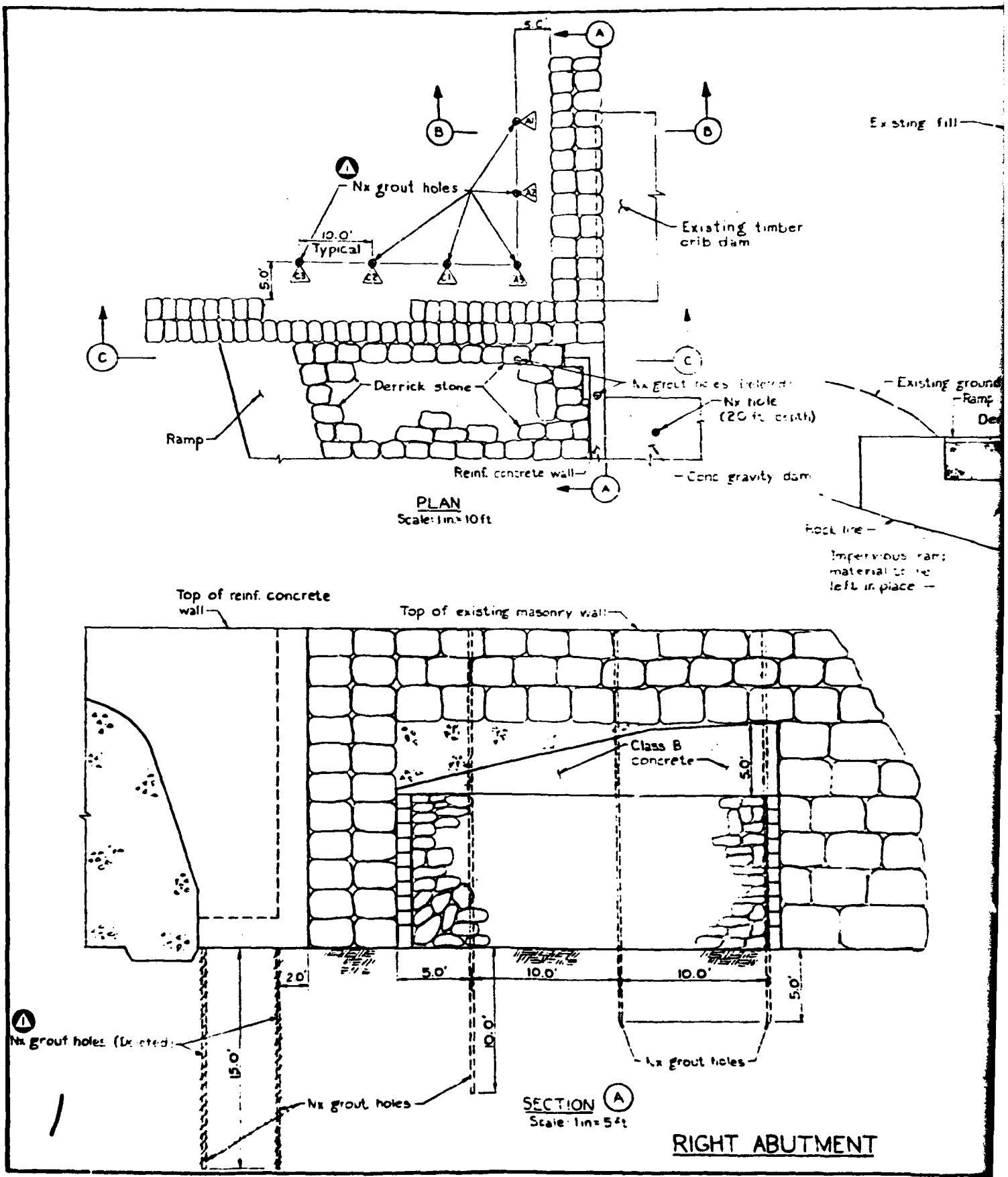
FLAT ROCK DAM
SCHUYLKILL RIVER PROJECT

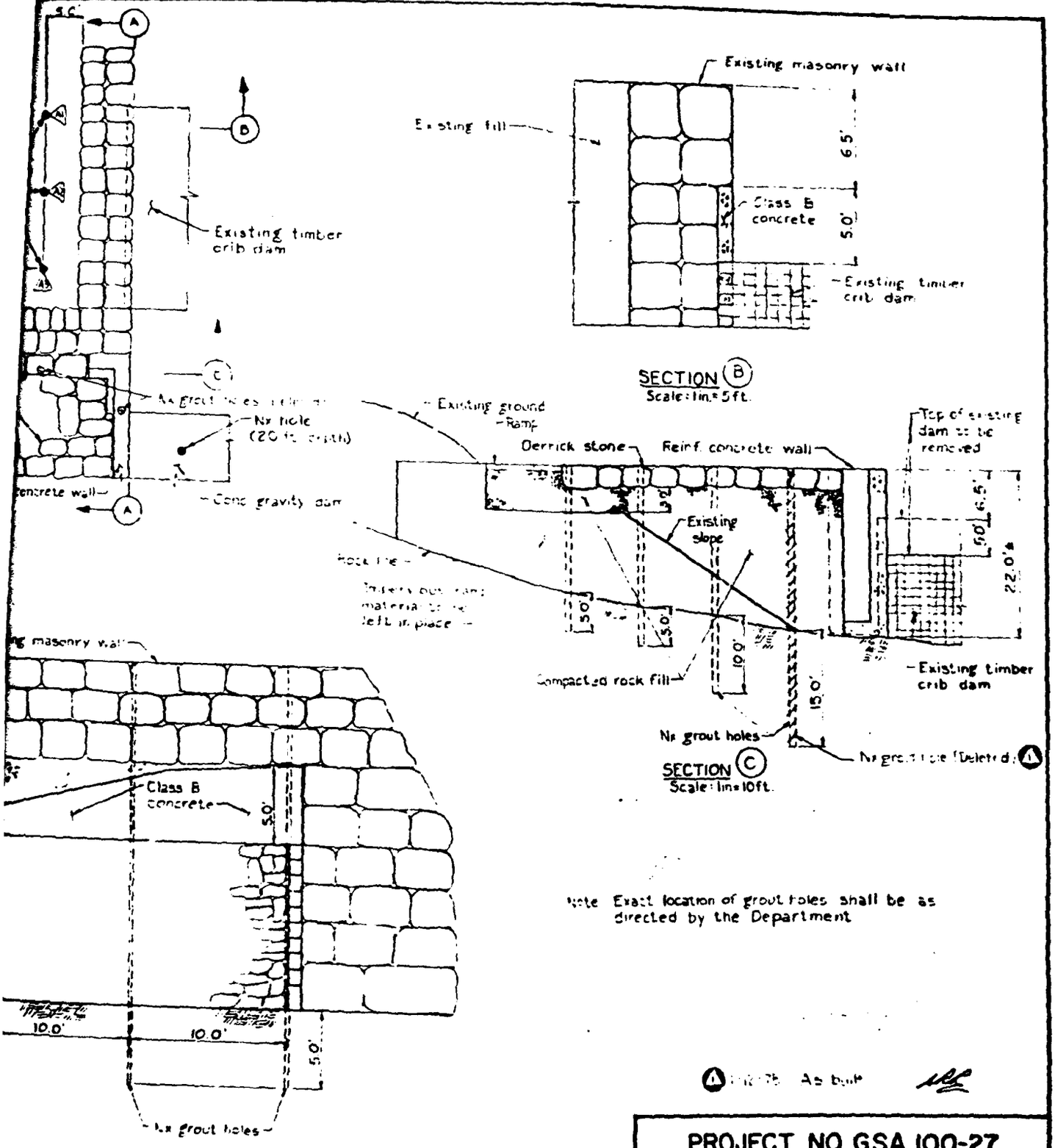
2

LEFT ABUTMENT
PLAN AND ELEVATION

S-7

PLATE 9


Nx grout holes
10.0' Typical
5.0'
Existing timber crib dam
Existing fill
Derrick stone
Ramp
Reinf. concrete wall
Conc gravity dam
Existing ground
Ramp
Nx hole (20 ft depth)
PLAN
Scale: 1in = 10ft
Top of reinf. concrete wall
Top of existing masonry wall
Class B concrete
5.0'
2.0'
5.0'
10.0'
10.0'
5.0'
10.0'
15.0'
Nx grout holes
Nx grout holes
Nx grout holes
SECTION (A)
Scale: 1in = 5ft
RIGHT ABUTMENT



SECTION (B)
Scale: 1in = 5ft.

SECTION (C)
Scale: 1in = 10ft.

SECTION (A)
Scale 1in = 5ft

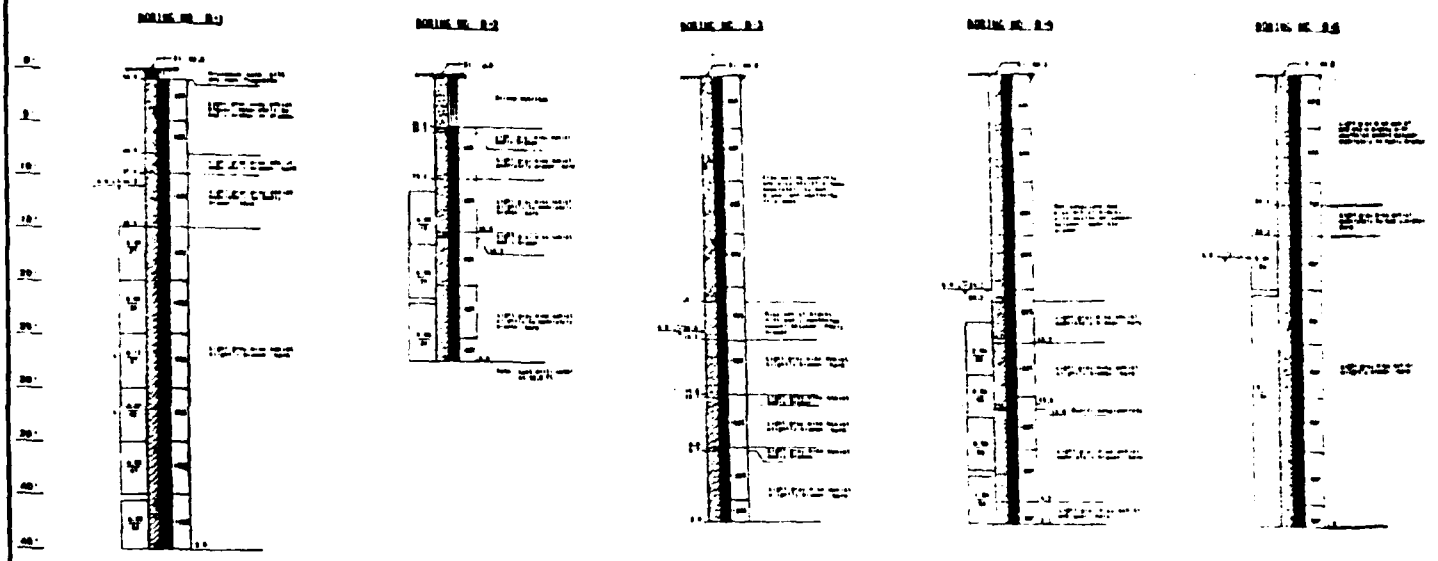
Note Exact location of grout holes shall be as directed by the Department

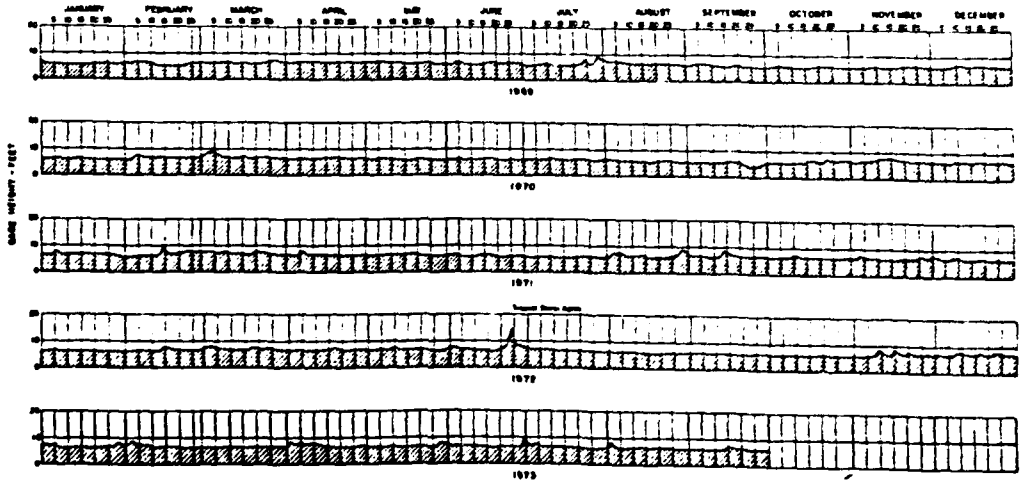
(A) As built

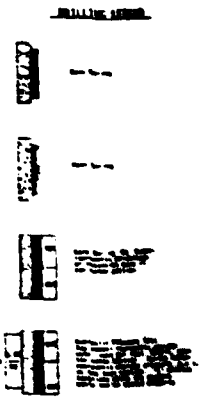
RIGHT ABUTMENT

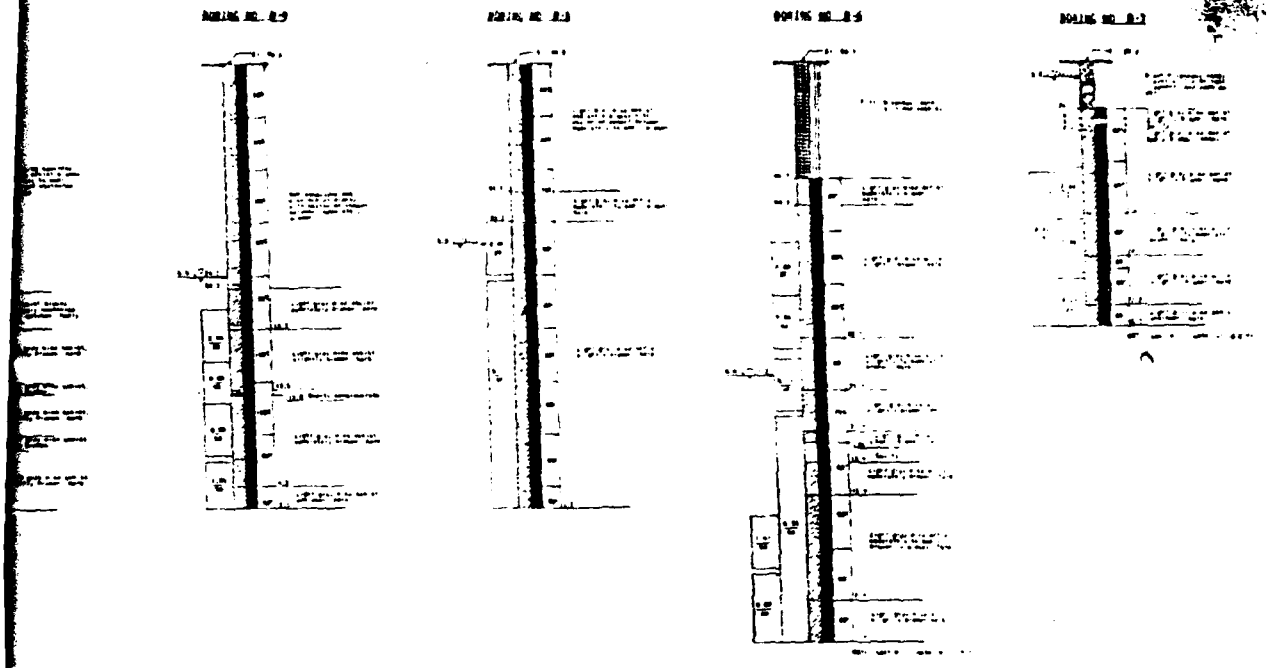
PROJECT NO. G.S.A. 100-27
FLAT ROCK DAM
SCHUYLKILL RIVER PROJECT
GROUTING DETAILS
20 NOVEMBER, 1975

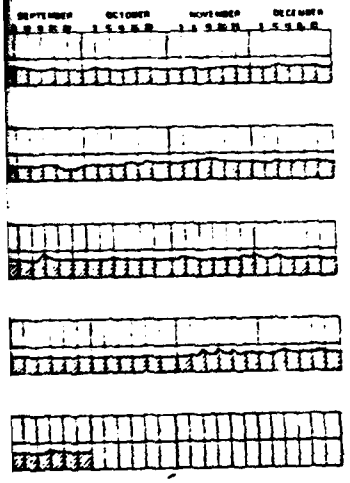
PLATE 10



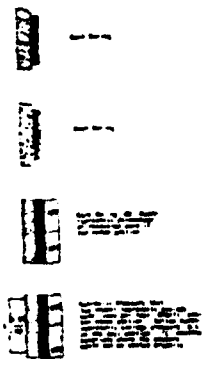

JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1969
1970
1971
1972
1973







DRILLING LEGEND



SUBSURFACE NOTES

1. [illegible]
2. [illegible]

THE GENERAL STATE AUTHORITY

PROJECT NO. G. S. A 100-27

FLAT ROCK DAM
SCHUYLKILL RIVER PROJECT

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
OFFICE OF RESOURCES MANAGEMENT

SUBSURFACE EXPLORATI
AND HYDROGRAPHS

S-9

2

PLATE

	Area of Section
— Design for withstanding (No. 1) Water Pressure against Full Height	296 sq. ft.
— Design used in Estimates	247 sq. ft.
— From Wegmann's Practical Type No. 2	307 sq. ft.
—	299 sq. ft.
— Design No. 2	302 sq. ft.

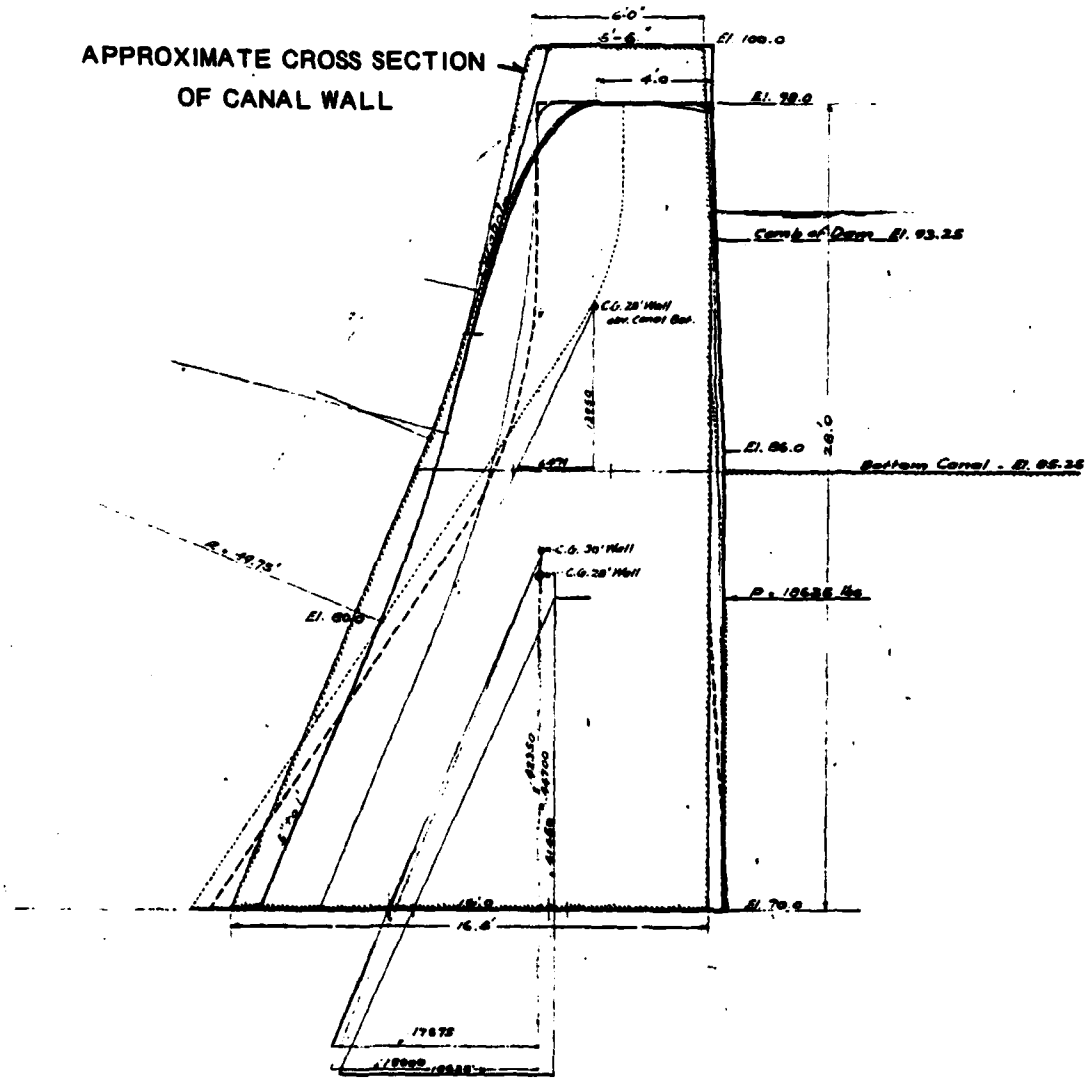


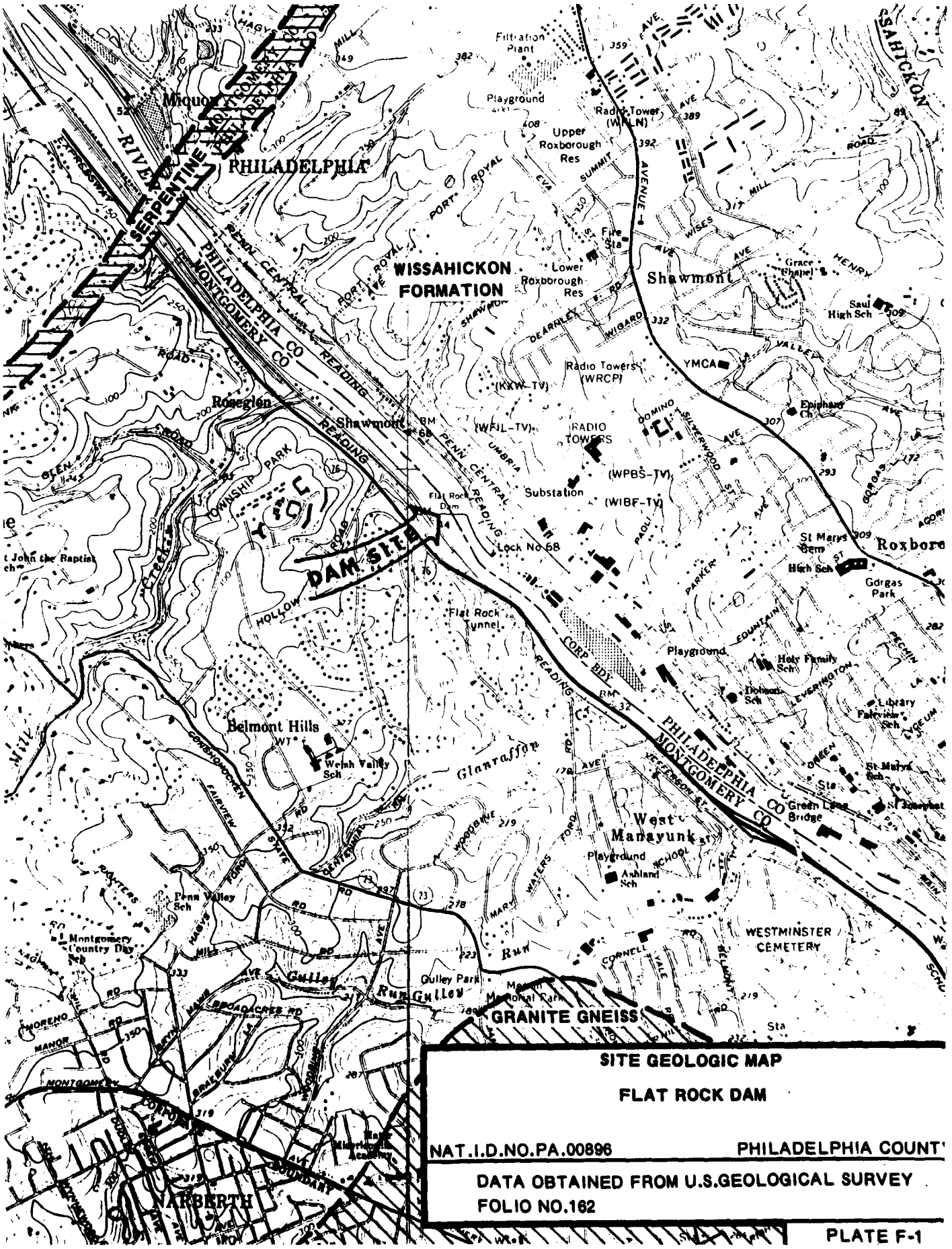
PLATE 12

APPENDIX

F

SITE GEOLOGY
FLAT ROCK DAM

Flat Rock Dam is located in the Piedmont Uplands Section of the Piedmont Physiographic Province. As shown in Plate F-1, the dam is underlain by the Wissahickon Formation of Lower Paleozoic age. An excellent exposure of gneissic schist occurs above the river bank in line with the left dam abutment. Rock foliation at this point strikes N65°W (oblique to dam centerline) and dips 15 degrees to the northeast. Minor rock jointing observed strikes N85°W and dips downstream at 81 degrees (near vertical) to the south. Exposures of the Wissahickon Formation occur in the vicinity of both dam abutments and downstream of the dam within the Schuylkill River. The dam is therefore most likely entirely founded upon the gneissic schist bedrock.



SITE GEOLOGIC MAP

FLAT ROCK DAM

NAT.I.D.NO.PA.00896 PHILADELPHIA COUNTY

DATA OBTAINED FROM U.S.GEOLOGICAL SURVEY
FOLIO NO.162

PLATE F-1

AD-A091 497 WOODWARD-CLYDE CONSULTANTS PLYMOUTH MEETING PA F/G 13/13
NATIONAL DAM INSPECTION PROGRAM. FLAT ROCK DAM (NDS I.D. NUMBER--ETC(U)
AUG 80 M F BECK, J F FREDERICK DACW31-80-C-0018

UNCLASSIFIED NL

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6.3
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963 A

APPENDIX

G

DESIGN CALCULATIONS

Woodward-Clyde Consultants Consulting Engineers, Geologists and Environmental Scientists	Owner:	Page 1 of 6
	Project: Flat Rock Dam	Job No./File No.
System:		Calculator R.E. Mabry Date 7-24-80
Calculation for: Stability		Reviewer MEB Date 7/22/80

Dam

Calculations of dam stability from State files were reviewed:

Calculations 7/13 → 7/18/73 for original design proposal for new dam

Calculations 2/27 → 3/7/75 for revised design "Supplemental Structural Report, Flat Rock Dam..." 3/10/75 - 1 page

Overturning - calculations for designed section showed a minimum safety factor of 1.45 for the condition of 18.8' of water over crest. Related calculations for original design without anchor bars showed a similar safety factor and the resultant of forces being within the middle 1/3 of dam base. Maximum foundation pressures were shown to be less than 4,000 psf.

Sliding - Calculations for weir section showed a minimum safety factor of 1.46 for the condition of 6.3' of water over the crest. The calculations are based entirely upon friction as the resisting force and do not include adhesion between the concrete and the foundation rock.

from State analysis $\Sigma F_H = 14{,}115$ lb/ft Coef. friction = 0.7

$\Sigma F_y = 29{,}407$ lb/ft

Use adhesion = 40 psi = 5,760 psf (min. value ETL1110-2-18)

$$F.S. = \frac{29{,}407 \times .7 + 5{,}760 \times 34}{14{,}115} = \underline{15.3} > 4$$

WCC-AD-32

DESIGN CALCULATIONS

Woodward-Clyde Consultants Consulting Engineers, Geologists and Environmental Scientists	Owner:	Page 2 of 6
	Project: Flat Rock Dam	Job No./File No.
System:		Calculator R.E. Mabry Date 1-26-90
Calculation for: Stability		Reviewer MEB Date 2/22/90

Canal Wall

Assumptions

Unit weight of concrete = 150 pcf ✓
Unit weight of water = 62.4 pcf ✓
Submerged weight of silt = 40 pcf ✓
Submerged weight of soil = 60 pcf ✓
Earth pressure coefficient of silt and soil = 0.5 ✓
Friction coefficient of rock and concrete to rock = 0.7 ✓
Compressive strength of rock = 1,000 psi

Analysis Condition

From hydrology/hydraulic analysis, dam and canal wall will be completely submerged during 0.5 PMF event. Therefore, critical condition for maximum net horizontal force on canal wall will be during a lesser magnitude event when tail water is much lower.

Use conditions of discharge = 30,000 cfs.
This is consistent with lowest safety factor for dam.

Q = 30,000 cfs ≈ 0.07 PMF
Reservoir Level = 44.0 (6.3' above crest)
Tail Water El. = 31.7
(Appendix D)

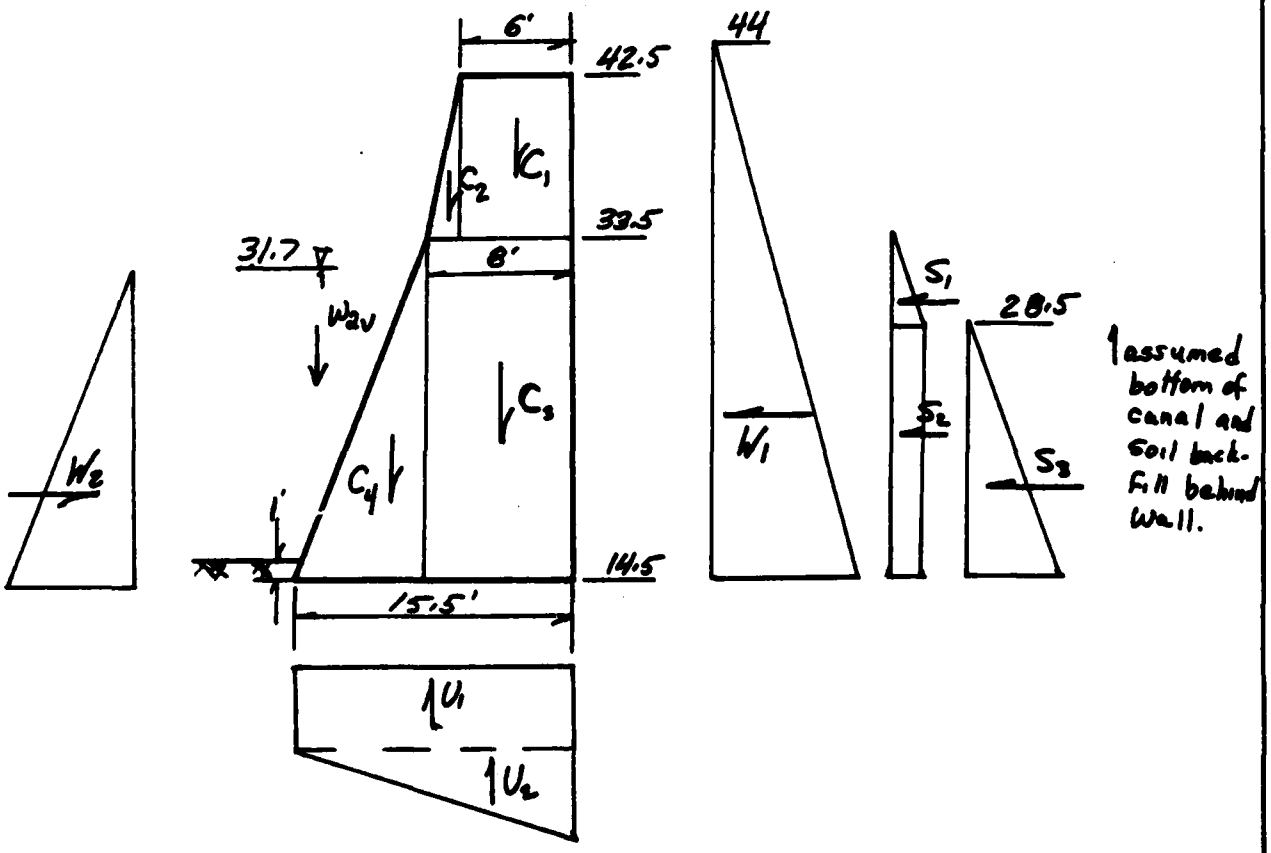
For conservatism, ignore lateral pressure of tail water due to possible turbulence

DESIGN CALCULATIONS

Woodward-Clyde Consultants Consulting Engineers, Geologists and Environmental Scientists	Owner:	Page 3 of 6
	Project: Flat Rock Dam	Job No./File No.
System:		Calculated RLB Date 2-24-89
Calculation for: Stability		Reviewed MEB Date 3/22/89

Cross Section and Loadings

Use low section of wall at maximum height above river bed - location approximately 350' from dam center line.



DESIGN CALCULATIONS

Woodward-Clyde Consultants Consulting Engineers, Geologists and Environmental Scientists	Owner:	Page 4 of 6
	Project: Flat Rock Dam	Job No./File No.
System:		Calculator R.G. Mabry Date 2-24-90
Calculation for: Stability		Reviewer MEB Date 3/22/90

Weights and Forces

Wall. $C_1 = 6 \times 9 \times 150 = 8,100'$ lb/ft
$C_2 = \frac{1}{2} \times 9 \times 2 \times 150 = 1,350'$
$C_3 = 8 \times 19 \times 150 = 22,800'$
$C_4 = \frac{1}{2} \times 7.5 \times 19 \times 150 = 10,687.5'$

Uplift $U_1 = 17.2 \times 62.4 \times 15.5 = 16,635.8'$
$U_2 = \frac{1}{2} \times 12.3 \times 62.4 \times 15.5 = 5,948.3'$

Water $W_1 = \frac{1}{2} \times 29.5^2 \times 62.4 = 27,151.8$

Silt $S_1 = \frac{1}{2}(\frac{1}{2} \times 40) 5^2 = 250'$
$S_2 = (\frac{1}{2} \times 40) \times 5 \times 14 = 1,400'$

Soil $S_3 = \frac{1}{2}(\frac{1}{2} \times 60) 14^2 = 2,940'$

ΣF_y $C_1 + C_2 + C_3 + C_4 - U_1 - U_2 = 20,353.4$ lb/ft ↓

Moments about toe

$\Sigma M \curvearrowright +$
$C_1 \times M_{C_1} = 8,100 \times 12.5' = 101,250$ ft-lb/ft
$C_2 \times M_{C_2} = 1,350 \times 8.8' = 11,880'$
$C_3 \times M_{C_3} = 22,800 \times 11.5' = 262,200'$
$C_4 \times M_{C_4} = 10,687.5 \times 5' = 53,437.5'$
$428,767.5'$

$\Sigma M \curvearrowleft -$
$U_1 \times M_{U_1} = 16,635.8 \times 7.75' = 128,927.5$ ft-lb/ft
$U_2 \times M_{U_2} = 5,948.3 \times 10.33' = 61,445.9'$
$W_1 \times M_W = 27,151.8 \times 9.83' = 266,902.2'$
$S_1 \times M_{S_1} = 250 \times 15.67' = 3,917.5'$
$S_2 \times M_{S_2} = 1,400 \times 7' = 9,800.0'$
$S_3 \times M_{S_3} = 2,940 \times 4.67' = 13,729.8'$
$484,722.9'$

Net moment = 55,955.4 ↺

DESIGN CALCULATIONS

Woodward-Clyde Consultants Consulting Engineers, Geologists and Environmental Scientists	Owner:	Page 5 of 6
	Project: Flat Rock Dam	Job No./File No.
System:		Calculator R.E. Mabry Date 7-24-80
Calculation for: Stability		Reviewer NFB Date 7/27/80

Location of Resultant

$$X = \frac{\Sigma M}{\Sigma F_y} = \frac{(-)\ 55,955.4}{20,353.4} = (-)\ 2.75'$$

Resultant is 2.75' beyond toe of wall

Add tail water to analysis

$W_{2v} = 0.5 \times 17.2 \times 7.09 \times 62.4 = 3804.8$ lb/ft

$W_2 = \frac{1}{2} \times 17.2^2 \times 62.4 = 9,230.2$ lb/ft

$+W_{2v} \times x_{w_2} = 3804.8 \times 2.36 = 8,992$

$\Sigma M \curvearrowright + \quad + W_2 \times y_{w_2} = 9,230.2 \times 5.73 = 52,889.0$

$+\ 428,767.5$

$490,648.5$

$\Sigma M = 5929.6\ (+)$

Resultant $X = \frac{(+)\ 5929.6}{24158} = 0.24'$

Resultant is 0.24' inside the toe of wall

$\Sigma F_x \quad W_1 + S_1 + S_2 + S_3 = 31,741.8$ lb/ft

Sliding (friction) $SF = \frac{\Sigma F_y (f)}{\Sigma F_x} = \frac{20,353.4 \times 0.7}{31,741.8} = \underline{\underline{0.45}}$

include tail water

$$SF = \frac{24,158 \times 0.7}{(31,741.8 - 9,230.2)} = \underline{\underline{0.75}}$$

(friction + adhesion)

for adhesion, use 15% of rock compressive strength

$$SF = \frac{24,158 \times 0.7 + 0.15(1,000 \times 144) \times 15.5}{31,741.8 - 9,230.2}$$

$$\underline{\underline{SF = 15.6}} > 4$$

DESIGN CALCULATIONS

le Consultants ners, Geologists ntal Scientists	Owner:	Page 6a of 6a
	Project: Flat Rock Dam	Job No./File No.
		Calculator MFB Date 7/22/80
Stability		Reviewer R.E. Hinkley Date 7/28/80

ressure = $\frac{2}{3} \frac{\Sigma F_y}{e_T}$ (e_T measured from toe)

Assuming tailwater $\Sigma F_y = 24,158.2$

$\frac{2}{3} \frac{24,158.2}{0.24}$ =

$\frac{2}{3} \frac{24,158}{7.51}$ = 67,105 psf