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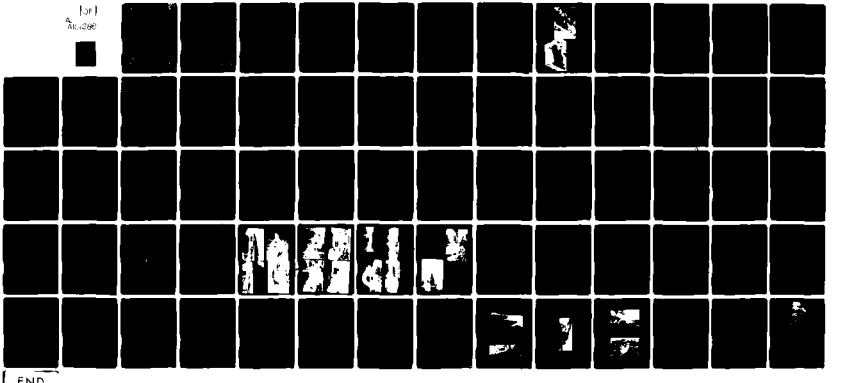

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DELAWARE RIVER BASIN
BRANCH OF SHEHAWKEN CREEK, WAYNE COUNTY

PENNSYLVANIA

STARLIGHT LAKE DAM

NDI ID NO. PA-00094
DER ID NO. 64-35

DONALD G. SCHENK

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Prepared by
Geo-Technical Services, Inc.
CONSULTING ENGINEERS & GEOLOGISTS
851 S. 19th Street
Harrisburg, Pennsylvania 17104

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

MAY 1981

DELAWARE RIVER BASIN
TRIBUTARY TO SHEHAWKEN CREEK
WAYNE COUNTY, PENNSYLVANIA

STARLIGHT LAKE DAM

NDI ID No. PA-00094
DER ID No. 64-035

DONALD G. SCHENK

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

National Dam Inspection Program. Starlight Lake Dam (NDI ID Number PA-00094, DER ID Number 64-35) Delaware River Basin, Branch of Shehawken Creek, Wayne County, Pennsylvania. Phase I Inspection Report.

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May 1981

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expediously 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 any need for such studies.

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

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

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonable 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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APPENDICES

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITIONS

AND

RECOMMENDED ACTION

Name of Dam:	Starlight Lake Dam NDI ID No. PA 00094 DER ID No. 64-35
Size:	Small (8.5 feet high; 616 acre-feet)
Classification:	Significant
Owner:	Donald G. Schenk Prudential Plaza Newark, N. J. 07101
State Located:	Pennsylvania
County Located:	Wayne
Stream:	Tributary of Shehawken Creek
Date of Inspection:	December 11, 1980

Based on visual inspection, the Starlight Lake Dam is judged to be in poor condition. Because of the size (small) and hazard classification (significant) of the dam, the recommended Spillway Design Flood (SDF) varies between the 100-year flood and the one-half Probable Maximum Flood (PMF). Based on the potential hazard survey downstream of the dam, the 100-year flood is selected as the SDF for the dam. The present spillway capacity will pass 60 cfs without overtopping the dam, or an estimated 8% of the SDF. Removal of the flashboard from the top of the spillway crest would increase the capacity of the spillway to 80 cfs, approximately 10% of the SDF. Since the spillway will not pass the SDF, the spillway capacity is rated as inadequate.

The estimated rate of leakage and seepage at the rock toe of the dam and the observed erosion hole on the top of the dam, opposite the observed leakage, indicate potentially hazardous conditions to the structural stability of the dam.

The relatively large hole in the right wall of the spillway is assumed to result from a concrete spall. Although the cause of such spall could

not be readily determined, continuous deterioration of the concrete will affect the structural integrity of the spillway and the stability of the dam.

The present condition of the dam indicates that maintenance of the dam is unsuitable. There is no warning system or evacuation plan in effect at the present time.

The following investigations and remedial measures are recommended for immediate implementation by the owner.

(1) Increase the spillway capacity to provide for passage of flood flow without overtopping the dam.

(2) Remove the trees from the upstream slope and the toe of the dam, under the supervision of a professional engineer.

(3) Engage a professional engineer experienced in the design of dams to evaluate the embankments stability with respect to internal erosion.

(4) Institute a monitoring program to detect any significant changes in the conditions of the dam and appurtenant structures during the investigations, design and implementation of the remedial measures. If significant changes occur, take appropriate action as required.

(5) Repair the concrete spall hole in the spillway culvert and provide erosion protection measures at the culvert outlet.

(6) In the absence of outlet works, a method for emergency drawdown of the reservoir should be developed in the event such action is necessary.

In addition, it is recommended that the owner take the following precautionary operational and maintenance measures:

(1) Develop a detailed emergency operation procedure and a warning system to facilitate timely and orderly evacuation of the downstream population should hazardous conditions develop. The anticipated hazard conditions include, but are not limited to, overtopping of the dam crest, undermining of the toe and excessive leakage or piping at the toe of the dam.

(2) After satisfactory implementation of the remedial measures resulting from the recommended additional investigations, institute a formal inspection and maintenance program for the dam. As presently required by the Bureau of Dams and Waterway Management of PENNDER, the program shall include an annual inspection of the dam by a professional engineer, experienced in the design and construction of dams. Deficiencies found during annual inspections should be remedied as necessary.

Submitted by:
GEO-TECHNICAL SERVICES, INC.

GIDEON YACHIN, P. E.

Date: May 13, 1981

Approved:
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

JAMES W. PECK
Colonel, Corps of Engineers
Commander and District Engineer

Date: 3 JUNE 1981

RESERVOIR AREA

DAM AREA

OVERVIEW OF STARLIGHT LAKE (PA. 00094)

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

STARLIGHT LAKE DAM

NDI# PA-00094, PENNDER# 64-35

SECTION 1

GENERAL INFORMATION

1.1 Authority.

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

1.2 Purpose.

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

1.3 Description of Project.

a. Dam and Appurtenances. Starlight Lake Dam is a composite structure consisting of an upstream earthfill embankment and a downstream near-vertical masonry wall. The dam has a maximum height of 8.5 feet and a total length of 105 feet, including the spillway. The spillway, located at the middle of the dam, consists of a concrete weir with a vertical downstream face, discharging into a rectangular concrete culvert. The present spillway crest is a 4.5 foot long rectangular shaped weir with an upstream flashboard attachment along its entire length. There are no other visible outlets through the dam.

b. Location. Starlight Lake Dam is located on an unnamed tributary of Shehawken Creek in Buckingham Township, Wayne County, 0.2 mile north west of Starlight, Pennsylvania. The dam and reservoir are contained within the Hancock, Pennsylvania 7.5 minute series USGS Quadrangle Map, at Latitude N 41°54'23" and Longitude W 75°20'00". A Location Map is shown on Exhibit E-1.

c. Size Classification. Small (8.5 feet high: 616 acre-feet storage capacity at top of dam).

d. Hazard Classification. Significant (see paragraph 3.1e).

e. Ownership. Donald G. Schenk, Prudential Plaza, Newark, New Jersey 07101.

f. Purpose of Dam. The original purpose of the impounded water was for ice harvesting and recreation. Presently, the lake is being used for recreation.

g. Design and Construction History. Information related to the design and construction of the dam is not available. Data obtained from the Pennsylvania Department of Environmental Resources (PENNDER) indicates that the dam was in existence prior to the 1914 "Survey of Lakes" in Pennsylvania. Although "as-built" drawings are not available, inspection reports, correspondence and photographs document repairs and maintenance activities since 1917. This information is on file with PENNDER.

h. Normal Operational Procedure. The pool is maintained at the spillway crest elevation with excess inflow discharging over the spillway into a branch of Shehawken Creek. The normal pool level can be lowered 0.6 foot by removing a flashboard from the top of the concrete weir. There are no other visible outlets from the reservoir.

1.4 Pertinent Data.

a. Drainage Area. (square miles)	2.15
b. Discharge at Damsite. (cfs)	
Maximum known flood at damsite since construction	Not Known
Outlet works at maximum pool elevation	Not Applicable
Spillway capacity at maximum pool elevation	
Design Conditions	Not Known
Existing Conditions (with flashboard)	60
c. Elevation. (feet above msl)	
Top of Dam	
Design Conditions	Not Known
Existing Conditions (lowest point)	1357.5
Maximum Pool	
Design Conditions	Not Known
Existing Conditions	1357.5
Normal Pool (spillway crest) w/flashboard	1355.0
w/o flashboard	1354.4
Upstream Invert Outlet Works	Not Applicable
Downstream Invert Outlet Works	Not Applicable
Streambed at toe of Dam	1349.0
Maximum Tailwater (at max. spillway discharge)	1350.0
d. Reservoir Length (feet)	
Normal Pool	2880
Maximum Pool (at top of dam, Elev. 1357.5)	2890

e. Storage. (acre-feet)

Normal Pool (top of flashboard Elev. 1355.0)	515
Maximum Pool	
Design Conditions	Not Known
Existing Conditions (top of dam Elev. 1357.5)	616

f. Reservoir Surface. (acres)

Normal Pool	37.7
Maximum Pool	
Design Conditions	Not Known
Existing Conditions	43.2

g. Dam.

Type - Composite earthfill & dry stone Masonry	
Length - (feet) (including spillway)	105
Height (feet)	8.5
Top Width (feet)	
Design Conditions	Not Known
Existing Conditions (varies from 12 to 25)	
Side Slopes - Upstream: varies from 1V on 6.7H to 1V on 10H	
Downstream: 4V on 1H	
Zoning - See type, above.	
Cut-off - Reported 2-feet below original ground, 21 feet upstream of masonry face.	
Impervious Core - Reported 12" cinder concrete wall with wood sheeting.	
Grout Curtain	Not Known

h. Diversion and Regulating Tunnel. None

i. Spillway.

Type - Rectangular shaped concrete weir.	
Length of Weir (feet)	4.5
Crest Elevation - with flashboard	1355.0
Crest Elevation - without flashboard	1354.4
Upstream Channel	None
Downstream Channel - Rectangular concrete culvert	

j. Outlet Works. None

Type	
Length (feet)	Not Applicable
Closure and Regulating Facilities	None
Access	Not Applicable

SECTION 2

ENGINEERING DATA

2.1 Design.

a. Data Available. There is no available information related to the design and construction of the dam. The earliest information available consists of data compiled in connection with a Survey of Lakes, made at the direction of the Pennsylvania Water Supply Commission in 1914. Inspection reports, accompanied with photographs, indicate the conditions of the dam in 1917, 1920, and 1965. The above cited information and related correspondence is available on file with PENNDER.

b. Design Features. The present Starlight Lake Dam is a composite structure with a near-vertical downstream dry stone masonry wall and an upstream earth embankment. The 1917 inspection report describes the dam as follows:

(1) "Dry masonry wall crossing what was formerly the outlet of a small natural pond. The side hills slope rather steeply from either side of the dam, the downstream face which is composed of a hand laid dry stone wall, the upstream face and spillway side walls being protected by a cinder-concrete wall 12" thick. Additional protection to the upstream face was afforded by a plank sheathing. The crest of the dam serves as a driveway from public highway to farmland on the left side of the valley."

(2) "Dimensions of Dam - Length of Crest 105 ft. Width of Crest - 21 ft. Maximum Height above streambed - 11 ft. (in 1917). Downstream Slope or Batter - 3" in 1'."

(3) "The Embankment (Foundation) - "Probably stone and earth fill." "Material used - Large 1 and 2-man field stones. Protection of the upstream slope - 12" cinder-concrete wall and 2" plank sheathing, the joints of which were lapped with 1" boards. Protection of Top - Earth fill serving as driveway. Protection of Downstream Slope - Hand laid dry stone wall, carried well into either hillside."

(4) "The Spillway is a Rectangular channel or sluiceway located about the center of the dam and constructed of Cinder-concrete side walls, paved bottom laid in cement mortar. The spillway is 4.5 feet long at an elevation of 5.6 feet below the crest of the dam. The bottom of the spillway sluiceway slopes 6" in 20 feet, the upstream approach defined by the cinder-concrete wall. Three flashboards were in place on top of the weir (in 1917). Each flashboard was 12" (high) by 1.5" (thick). Spillway capacity (with flashboard) was 47 cfs."

Dam features are documented in old photographs (1917, 1920, and 1965), presented in Appendix E, Exhibits E-2, E-3 and E-4.

2.2 Construction Records.

There are no records available for evaluation of construction methods and the classification or quality of materials placed in the dam. The extent of the dry stone wall is described by R.J. Gillis, Assistant Engineer, in his 1917 inspection report, as indicated by the underlined portion of the following quotation:

"The writer interviewed Dr. Underwood in connection with the cinder-concrete 12" wall and 2" plank sheeting which form the upstream face of this structure, and was advised that the dry stone fill of the dam proper had leaked badly up until last fall, at which time the cinder-concrete upstream protection was constructed; to be followed later by the 2" plank sheeting with lapped 1" boards at the joints when it developed that the cinder-concrete wall failed to stop the leaking. According to Dr. Underwood, this cinder-concrete wall is 105 feet long, extending across the entire upstream face of the dam, it being carried at the bottom in a trench 2 feet below the bottom of the reservoir and having a maximum height of about 13 feet. This cinder-concrete wall appeared to be of very poor construction, showing numerous instances of disintegration at this early date."

Inspection of the dam in 1920 indicated that heavy rock protection was added at the downstream toe of the dam, as shown in Exhibit E-3, Appendix E.

2.3 Operation.

There are no records available to indicate the past operation procedures for the dam. The present normal operation of the facility is described in paragraph 1.2 h, Section 1.

2.4 Other Investigations.

Available reports indicate that on-site inspections were made in May 1917, May 1920, and May 1965.

2.5 Evaluation.

a. Availability of Data. Engineering data were extracted from PENNDER files. The owner stated that he has no plans of the dam. Pertinent dam features were obtained by survey on the inspection dates (12/11 and 12/12/80). There are no other sources of information available for the evaluation of the facility.

b. Adequacy. There are no available plans, engineering specifications or construction records of the dam. Assessment of the structural integrity of the dam and its safety is based on the available cited data, visual inspection, performance history and the hydrologic and hydraulic analyses persented in Section 5. The data available are considered adequate for a Phase I Report.

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

SECTION 3
VISUAL INSPECTION

3.1 Observations.

a. General. The overall appearance of the dam is poor. Locations of observed deficiencies are shown on the General Plan presented in Exhibit A-1, Appendix A. The profile and typical sections of the dam are presented in Exhibits A-2 and A-3 and are based on field survey made on the days of inspection. The survey datum for this inspection is elevation 1355 feet above mean sea level for the normal water surface of the lake at the top of the spillway flashboard (see Exhibit E-1). On the inspection date (12/11/1980), the lake level was approximately at elevation 1355.5, or 0.5 foot above the spillway flashboard. Deficiencies observed during the field inspection are described below, and further illustrated in Exhibit A-1, Appendix A. Visible features are depicted in photographs, presented in Appendix C.

b. Dam. Observations made during inspection indicate that the dam is in poor condition. The upstream slope varies from 1V on 6.7H to 1V on 10H (see Exhibit A-3). In the vicinity of the spillway along a distance of 22 feet, there is an upstream vertical masonry wall (see Exhibit A-3). The top width of the dam varies from 12 feet at the left abutment to 25 feet at the right abutment. The lowest top of dam elevation is 1357.5, near the right abutment (see top of dam profile presented in Exhibit A-2). A 6-inch diameter erosion hole is located on the upstream side of the dam near the right end of the spillway headwall. A 12-inch diameter elm tree is located upstream of the dam, approximately at elevation 1356.8 near the termination of the spillway left headwall (see photographs 1 and 2, Appendix C). The downstream face of the dam includes a 58 foot long dry masonry wall with a slope of 4V on 1H (see photographs 3, 4 and 5, Appendix C). Dumped rock on the downstream face of the dam extends about 20 feet beyond the right end of the spillway culvert outlet and terminates at a dry stone wall on the right abutment. This wall begins at the downstream face of the dam and extends downstream for an approximate distance of 30 feet (see Exhibit A-1). The location and extent of the dumped rock and the downstream dry stone masonry wall is also shown in photograph 3, Appendix C. On the inspection dates, leakage emanating from the toe of the dumped rock was clear and its flow was estimated to be about 100 GPM. The location of the observed leadage is shown in Exhibit A-1.

c. Spillway. The overall appearance of the spillway is fair. Flow over the flashboard drops 4.4 feet to the floor of a rectangluar concrete culvert. A large hole 1.0'H x 1.5L x 1.0'D) located near the upstream end of the right concrete wall of the spillway culvert appears to be due to spalling of the concrete (see Exhibits A-1 and A-4). The span between the top of the culvert walls is covered with 6-inch sandstone rock slabs. Additional slabs, varying in thickness from 9 to 11 inches, overlay the first layer of slabs to form the road surfaces on the top of the dam (see Exhibit A-3 and photograph No. 6, Appendix C). Concrete ledges at the

bottom of the spillway walls reduce the net channel width to 4.3 feet. The height of the concrete ledge above the bottom slab is 1.7 feet on the right side and 1.4 feet above the slab on the left side. The 6-inch thick bottom slab of the culvert protrudes approximately 1.5 feet beyond the downstream face of the dam, creating a 1.5 foot drop to the bottom of the stream channel (see photograph 7, Appendix C and Exhibit A-4).

d. Reservoir Area. The watershed is predominantly wooded (70%), rising from elevation 1355 feet to elevation 1804 feet above mean sea level. With the exception of 12 acres of moderate to steeply sloped farmland near the left abutment of the dam, the lower part of the watershed along the banks of the lake is wooded. A narrow peripheral strip around Starlight Lake is approximately 250 feet wide with an average slope of 18%. Beyond this narrow strip, the slopes steepen to a maximum slope of 30%. There is no evidence of unstable slope conditions adjacent to the reservoir that could affect the stability of the dam. Development around the lake is limited within the narrow peripheral strip, consisting of a dozen permanent and seasonal residences and the Starlight Hotel. At the upstream end of the reservoir, the combined flow of the watershed streams crosses State Road LR63083 through a 10'8" x 6' 9" Corrugated Metal Multi-Plate Arch Culvert (see photograph 8, Appendix C). On the day of the inspection (12/12/1980), the top width of the water surface at the culvert's outlet was approximately 10 feet. The upstream end of Starlight Lake is marshy, consisting of sand and silt deposits. Pertinent watershed features are presented in Exhibit E-1, Appendix E. Geologic conditions in the area are described in Appendix F.

e. Downstream Channel. The average slope of the channel along the first 1200 foot stretch of the stream below Starlight Lake Dam is 0.0067 foot per foot (0.67%). Present stream encroachments downstream of the dam consist of a box culvert (5' H x 4'W) located 900 feet downstream, and a bridge (8'H x 20'W) across Shehawken Creek located 3500 feet downstream. There are three homes and a trailer within 2000 feet downstream of the dam (see photographs 9, 11, 12 and 13, Appendix C). Only one residence, located 600 feet downstream of the dam, may be subjected to flooding. Should the dam fail a few lives may be lost. Consequently, the Starlight Lake Dam is classified as a significant hazard structure.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Normal Operating Procedure.

The reservoir is maintained at normal pool level with excess inflow discharging over the weir into the spillway culvert and the downstream channel. There are no provisions for emergency drawdown of the Lake.

4.2 Maintenance of Dam.

Maintenance activities by the present owner could not be verified during the inspection and appear to be minimal. Past history of the dam indicates that maintenance was limited to removal of brush from the spillway entrance. Beaver activity was pronounced for several years prior to 1965, requiring the collecting and burning of tree debris several times in each year.

4.3 Maintenance of Operating Facilities.

The only visible operating facility at the dam is the flashboard, located on top of the spillway concrete weir. There is no evidence to indicate that the flashboard is removed or raised at any time during the year.

4.4 Warning System in Effect.

There is no emergency operation and warning system in effect at the present time.

4.5 Evaluation.

The maintenance of the dam is unsuitable and periodic inspections are necessary to verify conditions in the spillway and at the toe of the dam. The spillway entrance is susceptible to clogging by debris, by beaver activity or by large chunks of ice in winter. These conditions could result in overtopping of the dam under normal conditions of inflow into the reservoir. Consequently, frequent inspections are necessary to ascertain conditions at the spillway entrance and to maintain unobstructed flow over the weir and through the culvert. A method of emergency drawdown and an emergency warning system is necessary to reduce the risk of dam failure, should adverse conditions develop and to reduce loss of life resulting from dam failure.

SECTION 5
HYDROLOGY AND HYDRAULICS

5.1 Design Data.

A report prepared in 1917 by the Water Supply Commission of Pennsylvania rates the spillway capacity of Starlight Lake Dam at 47 cfs and 66 cfs, with and without flashboards, respectively. The required spillway design criteria is indicated by the Commission's 1917 report to be 1100 cfs for a 2.3 square mile contributing drainage area. Hydrologic and hydraulic analyses presented in Appendix D indicate that the drainage area is 2.15 square miles. The flow through the spillway is governed by weir discharge. When the entrance into the culvert type spillway is submerged, the flow is governed by orifice discharge conditions.

5.2 Experience Data.

The probable flood of record in Shehawken Creek and its tributaries is the August 1955 flood. Neither flood stage information nor flow records are availabe for the damsite. No records are available on the maximum stage of the reservoir nor to indicate the extent of past overtopping of the Starlight Lake Dam. Information obtained from a local resident (Mr. Jack McMahon) indicates that overtopping of the dam occurs every one or two years.

5.3 Visual Observations.

Based on visual inspection and field survey, described in Section 3 of this report, the observations relevant to hydrology and hydraulics are evaluated below:

a. Dam. The present low point on top of the dam is at elevation 1357.5. The present elevation of the spillway crest is 1355. Consequently, the maximum available freeboard for the dam is 2.5 feet. The rock toe reinforcement, added prior to 1920 (see photograph, Appendix E and Exhibit A-1), suggests that frequent overtopping of the dam has occured. A downstream rubble masonry wall along the right bank of the stream and abutting the aforementioned rock toe reinforcement was constructed prior to 1965 (see 1965 photograph, Appendix E, photograph 3, Appendix C and Exhibit A-1). Addition of this wall indicates the desire or the necessity to protect the right bank of the stream and the rock toe from erosion and undermining. The rock toe protection, placed prior to 1920, between the spillway outlet and the left abutment is not shown in the 1965 photograph (see 1920 and 1965 photographs, Appendix E, photograph 3, Appendix C and Exhibit A-1), suggesting that it has been partially washed away or that it is covered with sediments. Except for additional vegetation, present conditions on the left abutment are essentially the same as they were in 1965 (see photographs 3, 5, and 7, Appendix C).

b. Spillway. The available 2.5-foot freeboard for the dam indicates that the present maximum discharge capacity of the spillway is approximately 60 cfs. Should the present flashboard be removed, the available head will increase the present discharge by 33% to approximately 80 cfs. Should the top of the dam be raised to the level of the Public Road at the axis of the dam (El. 1358.5), the maximum discharge capacity of the spillway would increase from the present 60 cfs to 100 cfs.

c. Reservoir Area. There are no upstream structures of significant influence on the rate and time of flood peak inflow into Starlight Lake. There are no visible indications to expect drastic changes in the prevailing land use within the watershed to significantly alter the rate of inflow into the reservoir during extreme floods. The capacity of the multi-plate arch culvert, upstream of the inlet into Starlight Lake, considerably exceeds the spillway capacity of the dam at the lake's outlet (see Appendix D).

d. Downstream Conditions. The spillway capacity, as well as the overtopping discharge capacity over the dam, is not affected by tailwater conditions for the entire range of discharge considered in this study.

5.4 Method of Analysis.

Hydrologic and hydraulic evaluation was made in accordance with the procedures and guidelines established by the U.S. Army Corps of Engineers, Baltimore District, Phase I Safety Inspection of Dams. The analysis is presented in Appendix D.

5.5 Summary of Analysis.

a. Spillway Design Flood (SDF). According to criteria established by the Office of the Chief of Engineers (OCE), the Spillway Design Flood (SDF) for the size (small) and the hazard potential (significant) of the Starlight Lake Dam is between the 100-year Flood and the one-half Probable Maximum Flood (½PMF). Based on the potential hazard survey, downstream of the dam, the 100-year flood is selected as the SDF for Starlight Lake Dam.

b. Results of Analysis. Pertinent results are tabulated in Appendix D. The analysis reveals that under the existing top of dam and spillway crest elevations, the spillway discharge is 60 cfs when the water surface elevation in the reservoir reaches the low point of the dam crest. The computed peak discharge from a 100-year flood is 770 cfs. Therefore, the spillway discharge capacity is approximately 8% of the SDF. Removal of the flashboard would increase the spillway capacity to approximately 10% of the SDF.

5.6 Spillway Adequacy.

As a result of the analysis, the present spillway capacity of the Starlight Lake Dam will not pass the selected SDF of the 100-year flood without overtopping the dam. Since the hazard classification is significant, the spillway capacity is rated as inadequate.

SECTION 6

EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations:

The visual inspection of Starlight Lake Dam is described in Section 3. Observations that are relevant to structural stability of the dam and the appurtenant structures are evaluated below:

a. Dam. Seepage and leakage of about 100 GPM emanates from the toe of the dumped rock protection, below the downstream toe of the dam. Although the concentrated leakage flow is located directly downstream of a 6-inch diameter erosion hole on the upstream edge of the dam crest, a direct relationship could not be verified. The water discharging from the rock toe was clear; however, the possibility of internal erosion of embankment materials could not be ruled out by the observed conditions. On the basis of the present inspection observations, the structural integrity of the dam is questionable.

b. Spillway. The spillway weir and culvert appear to be structurally sound and in fair condition. The large hole, located in the right wall of the culvert, apparently resulted from concrete spalling. Although the cause of this spalling cannot readily be verified, the hole should be repaired immediately to minimize additional damage to the culvert wall.

When the present weir operates as an orifice (see Appendix D), water could splash into the hole and may affect the structural stability of the dam. The bottom slab of the culvert terminates with an 18-inch drop into the stream channel. Although there is no indication of detrimental slab undermining at present, protective measures should be provided to reduce the undermining potential at the culvert outlet.

6.2 Design and Construction Data.

Available design and construction data are inadequate to assess the structural integrity of the dam.

6.3 Past Performance.

The available data do not indicate any previous occurrences of structural failure in the dam and appurtenance. The addition of a heavy rock toe prior to 1920 (see Photographs, Appendix E) may have resulted from the desire to protect the original dam from undermining by overtopping water, as well as to increase its stability. A 1917 inspection report of the dam stated that it leaked very badly and that subsequent remedial measures failed to stop the leakage (see Section 2.2).

6.4 Seismic Stability.

The dam is located in Seismic Zone No. 1 and may be subject to minor dynamic forces induced by earthquake. Since the static stability of Starlight Lake Dam is questionable, its seismic stability cannot be assessed.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS FOR REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety.

(1) Based on visual inspection, the Starlight Lake Dam is judged to be in poor condition. Because of the size (small) and hazard classification (significant) of the dam, the recommended Spillway Design Flood (SDF) varies between 100-year flood and the one-half Probable Maximum Flood (½PMF). Based on the potential hazard survey downstream of the dam, the 100-year flood is selected as the SDF for the dam. The present spillway capacity will pass 60 cfs without overtopping the dam, or an estimated 8% of the SDF. Removal of the flashboard from the top of the spillway crest would increase the capacity of the spillway to 80 cfs, approximately 10% of the SDF. The computed 100-year flood is 770 cfs. Since the spillway will not pass the 100-year flood without overtopping the dam, the spillway capacity is rated as inadequate.

(2) The estimated rate of leakage, and seepage at the rock toe of the dam and the observed erosion hole on the top of the dam, opposite the observed leakage, indicate potentially hazardous conditions to the structural stability of the dam.

(3) The relatively large hole in the right wall of the spillway is assumed to result from a concrete spall. Although the cause of such a spall could not be readily determined, continuous deterioration of the concrete will affect the structural integrity of the spillway and the stability of the dam.

(4) The present condition of the dam indicates that maintenance of the dam is unsuitable.

(5) There is no warning system or evacuation plan in effect at the present time.

b. Adequacy of Information. The data collected from previously cited dam inspection reports, past performance, visual inspection and computations performed as part of this study are sufficient for the Phase I dam safety assessment, delineated in sub-paragraph a., above.

c. Urgency. The recommendations in Paragraph 7.2 should be implemented immediately.

d. Necessity for Further Investigations. In order to accomplish some of the medial measures outlined in Paragraph 7.2, further investigations by a professional engineer, experienced in the design and construction of dams, will be necessary.

7.2 Recommendations and Remedial Measures.

a. The following investigations and remedial measures are recommended for immediate implementation by the owner:

(1) Increase the spillway capacity to provide for passage of flood flow without overtopping the dam.

(2) Remove the trees from the upstream slope and the toe of the dam, under the supervision of a professional engineer.

(3) Evaluate the embankment stability with respect to internal erosion.

(4) Institute a monitoring program to detect any significant changes in the conditions of the dam and appurtenant structures during the investigations, design and implementation of the remedial measures. If significant changes occur, take appropriate action as required.

(5) Repair the concrete spall hole in the spillway culvert and provide erosion protection measures at the culvert outlet.

(6) In the absence of outlet works, a method for emergency drawdown of the reservoir should be developed in the event such action is necessary.

All investigations, monitoring programs, design of remedial measures and construction supervision should be performed by a professional engineer experienced in the design and construction of dams.

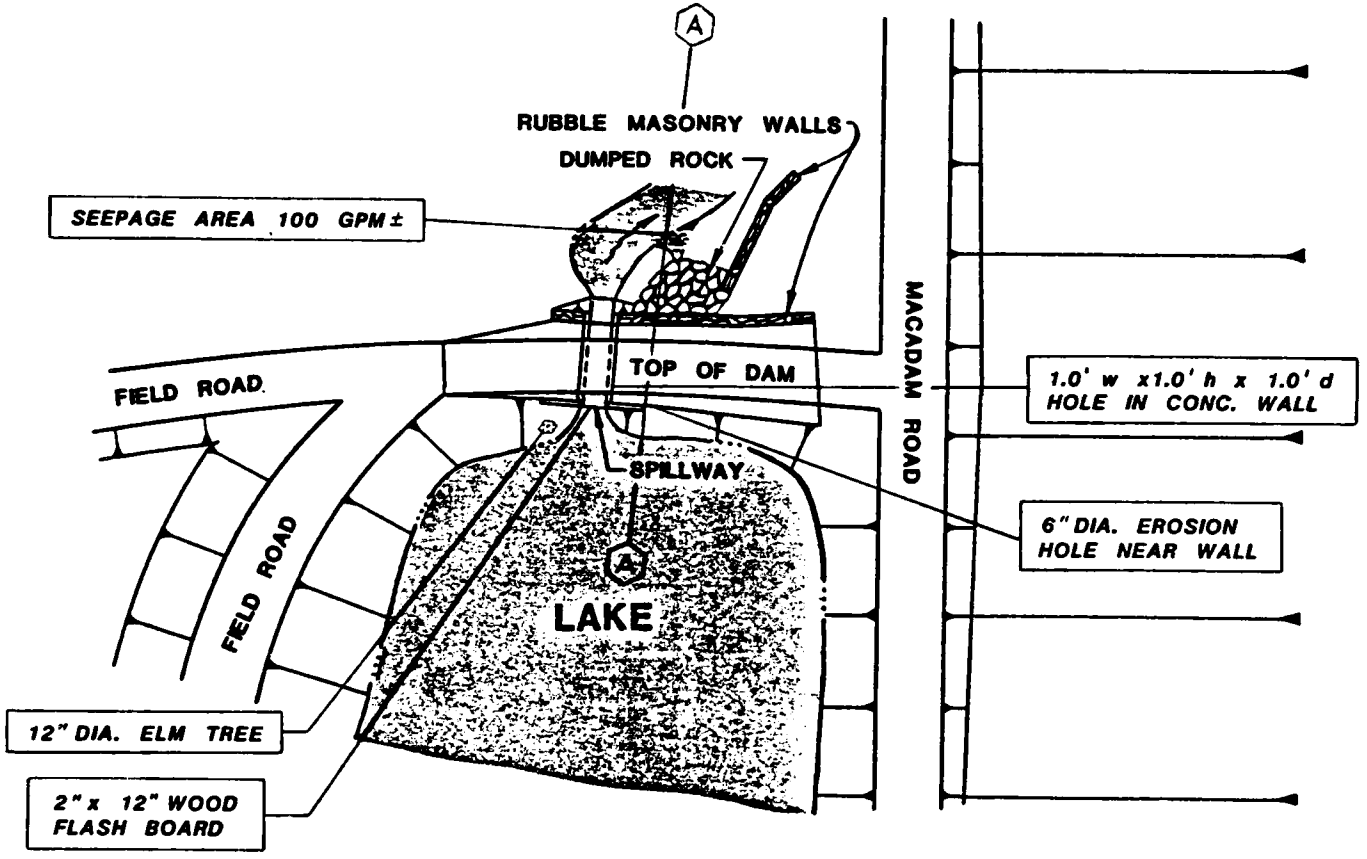
b. In addition, it is recommended that the owner take the following precautionary operational and maintenance measures:

(1) Develop a detailed emergency operation procedure and a warning system to facilitate timely and orderly evacuation of the downstream population should hazardous conditions develop. The anticipated hazard conditions include, but are not limited to, overtopping of the dam crest, undermining of the toe and excessive leakage, or piping at the toe of the dam.

(2) After satisfactory implementation of the remedial measures resulting from the recommended additional investigations, institute a formal inspection and maintenance program for the dam. As presently required by the Bureau of Dams and Waterway Management of PENNDER, the program shall include an annual inspection of the dam by a professional engineer, experienced in the design and construction of dams. Deficiencies found during annual inspections should be remedied as necessary.

APPENDIX A

VISUAL INSPECTION - CHECKLIST AND FIELD SKETCHES



STARLIGHT LAKE DAM
GENERAL PLAN - FIELD INSPECTION NOTES

EXHIBIT A-1

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB STARLIGHT LAKE DER 64-35
SHEET NO ____ OF ____
CALCULATED BY RJM DATE 1-26-81
CHECKED BY ____ DATE ____
SCALE HORZ. 1" = 25' VERT. 1" = 2'

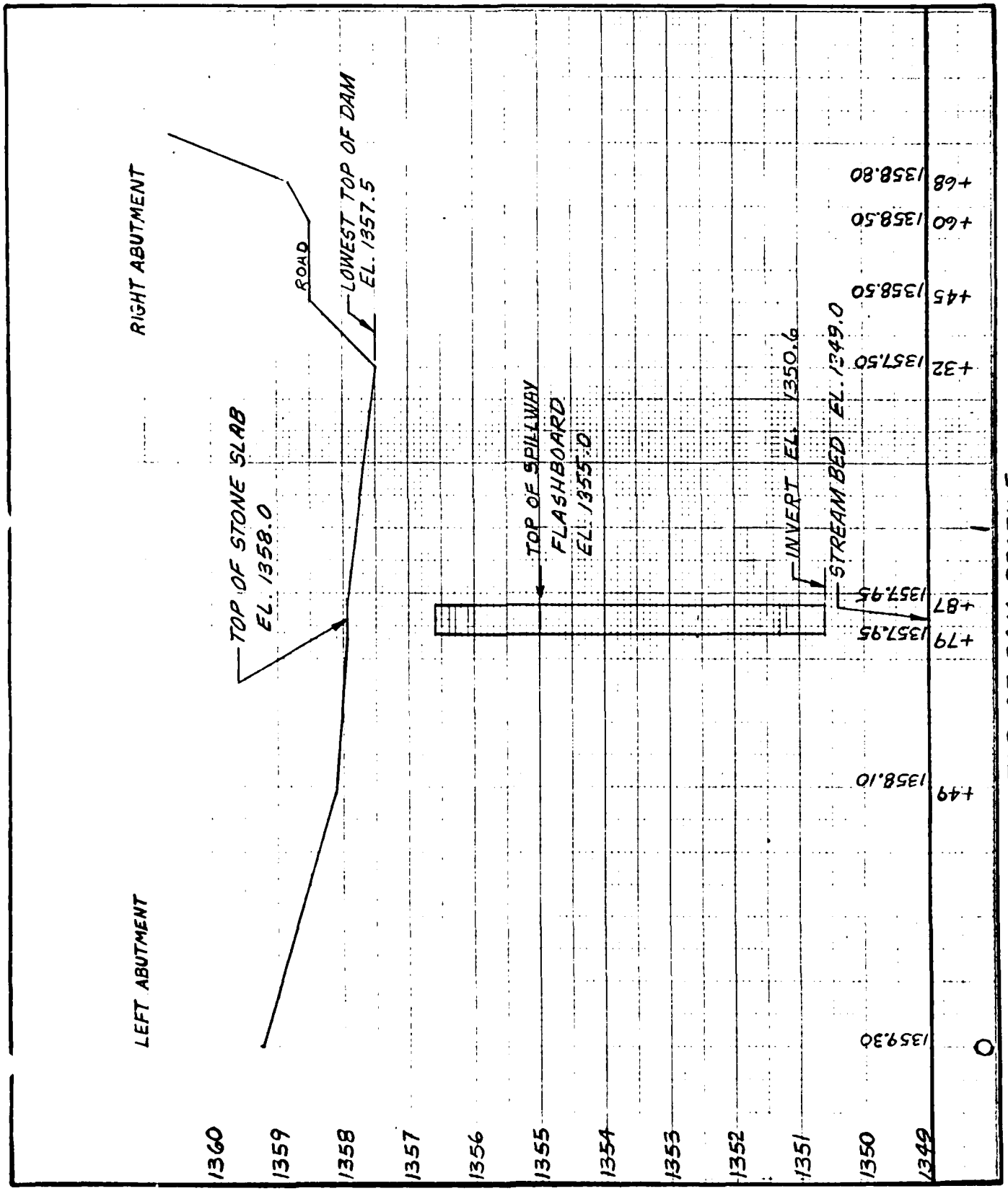
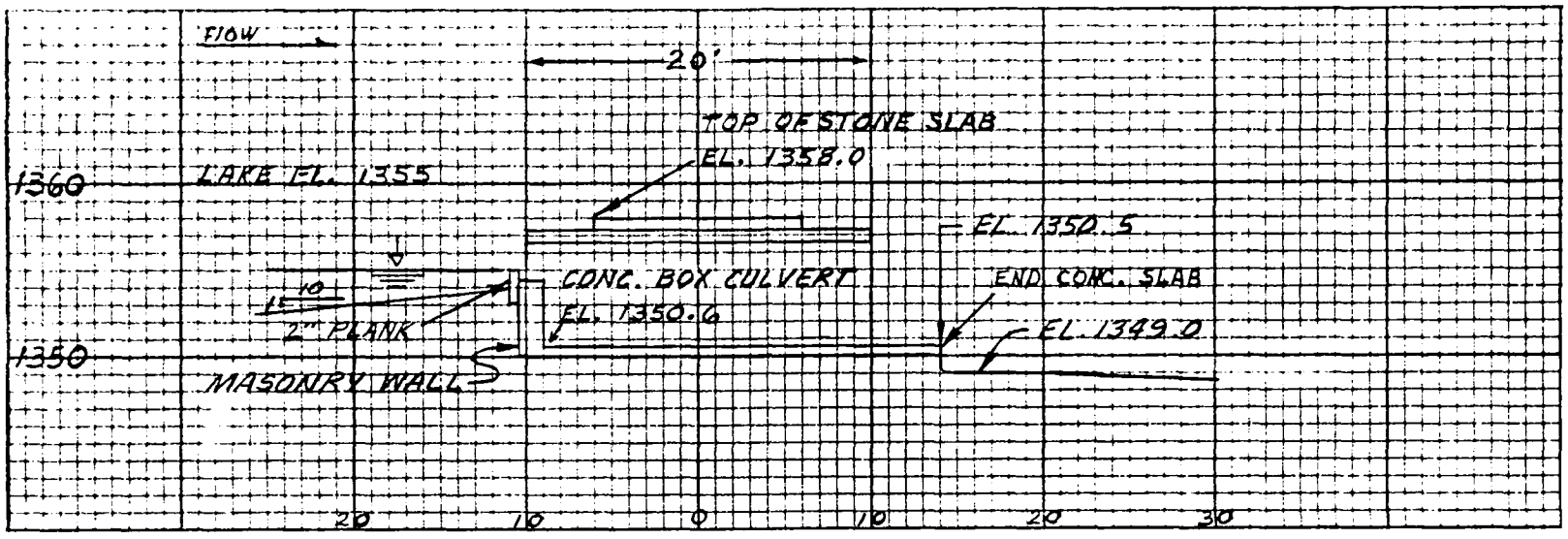
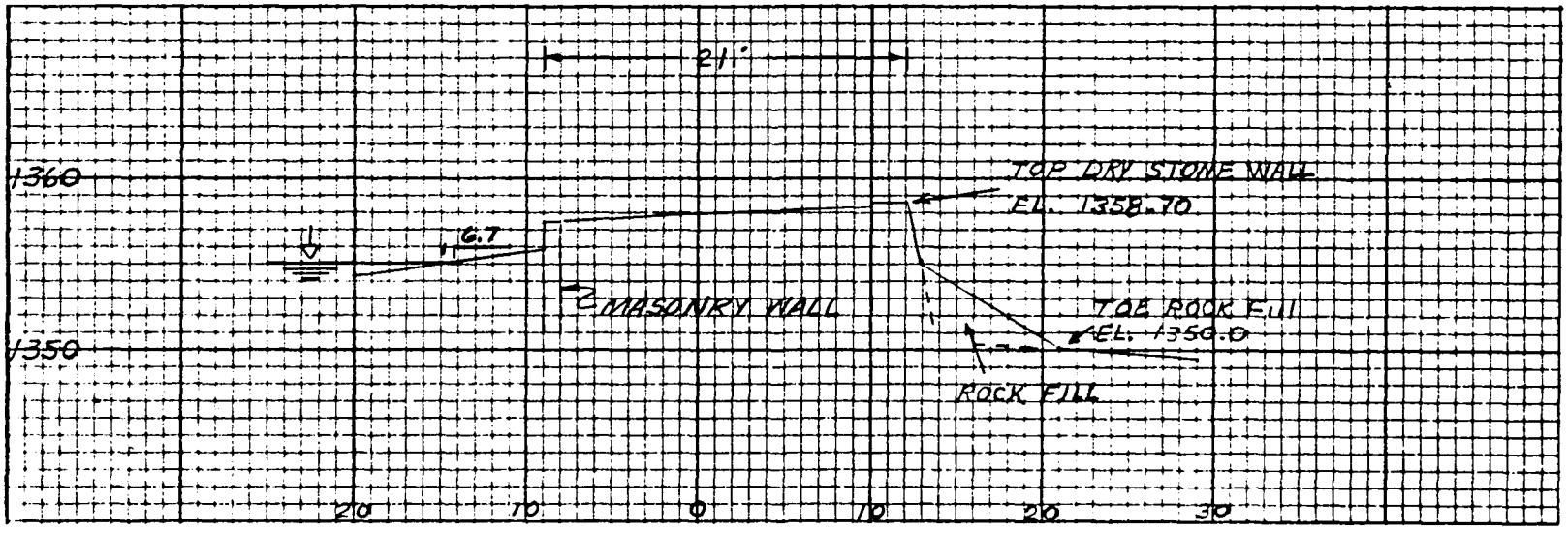


EXHIBIT A-2

TYPICAL DAM SECTIONS

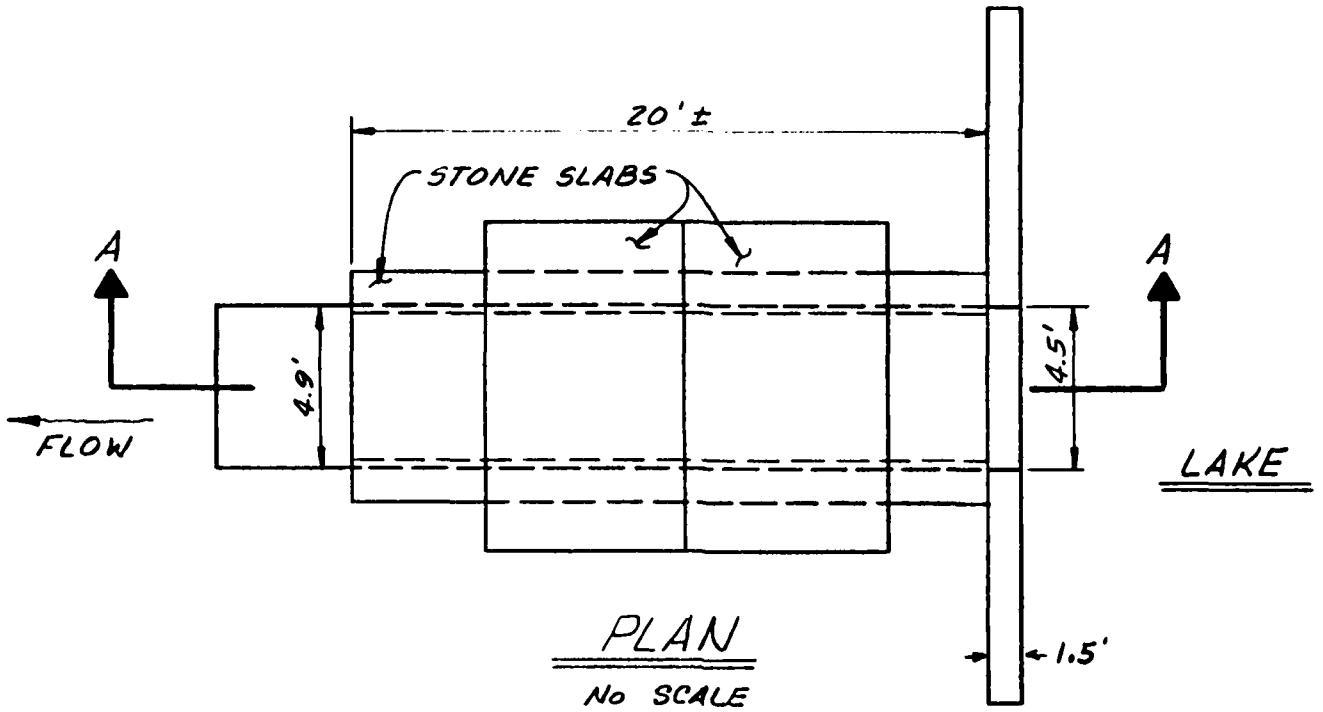


SPILLWAY SECTION



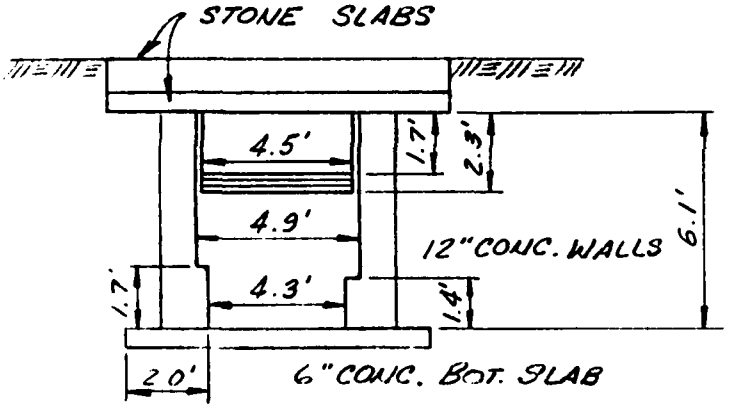
SECTION A

EXHIBIT A-9

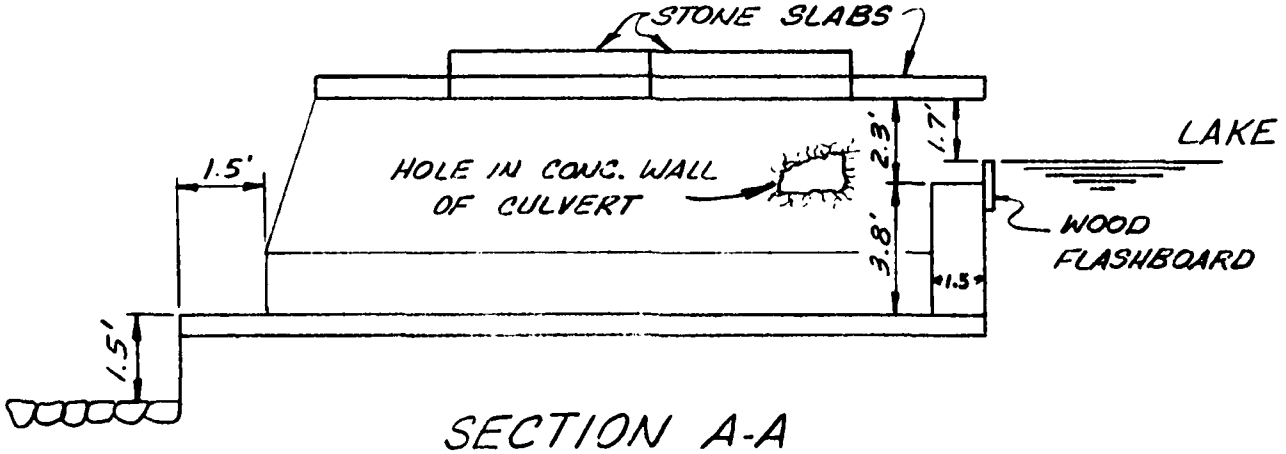


PLAN

No SCALE



VIEW LOOKING UPSTR.



SECTION A-A

NO SCALE

EXHIBIT A-4

CHECK LIST
VISUAL INSPECTION
PHASE 1

NAME OF DAM Starlight Lake Dam STATE Pennsylvania COUNTY Wayne

NDI # PA — 00094 PENNDER # 64-035

TYPE OF DAM Earth & Dry Masonry SIZE Small HAZARD CATEGORY Significant

DATE(S) INSPECTION December 11 & 12, 1980 WEATHER Cloudy TEMPERATURE 18°F @ 3:00 PM, 12/11/80

POOL ELEVATION AT TIME OF INSPECTION 1,355.0 M.S.L.

TAILWATER AT TIME OF INSPECTION 1,349.0 M.S.L.

INSPECTION PERSONNEL	OWNER REPRESENTATIVES	*OTHERS*
Gideon Yachin - Engineer	None	
James Daiz - Geologist		
Ronald Mather - Surveyor		

RECORDED BY James Diaz

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 094
SURFACE CRACKS	No cracks. However, a 6" diameter erosion hole is located on right end of upstream wall.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	For vertical alignment, see Exhibit A-2. Slightly curved horizontal alignment on left abutment (see Exhibit A-1).
RIPRAP FAILURES	None. However, dumped stone was placed against right stone wall on downstream side. No riprap on upstream face.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good transition between top of dam and the abutments on both upstream and downstream ends. Vertical spillway sluiceway walls abut the composite dam section at center of dam.

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 094
DAMP AREAS IRREGULAR VEGETATION (LUSH OR DEAD PLANTS)	None
ANY NOTICEABLE SEEPAGE	About 100 GPM leakage area at tow of dumped rock. This is directly downstream of erosion hole observed on right end of upstream wall.
STAFF GAGE AND RECORDER	None
DRAINS	None
ROCK OUTCROPS	None in vicinity of dam.
DAM FOUNDATION TREES, OTHER	Some small brush near right downstream stone wall. A 12" diameter Elm tree, on upstream face of dam and left of spillway. No visible undermining at the toe of dam.

OUTLET WORKS

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 094
INTAKE STRUCTURE	None
OUTLET CONDUIT (CRACKING AND SPALLING OF CONCRETE SURFACES)	None
OUTLET STRUCTURE	None
OUTLET CHANNEL	Natural stream channel
GATE(S) AND OPERATIONAL EQUIPMENT	None
CONCRETE SURFACES CRACKS, SPALLING JOINTS	N.A.

EMERGENCY SPILLWAY

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 094
TYPE AND CONDITION	None. Local resident Jack McMahon reports flood flows over-top dam every year or two.
APPROACH CHANNEL	NA
SPILLWAY CHANNEL AND SIDEWALLS	NA
STILLING BASIN PLUNGE POOL	NA
DISCHARGE CHANNEL	NA
BRIDGE AND PIERS EMERGENCY GATES	NA

SERVICE SPILLWAY

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA- 094
TYPE AND CONDITION	Good except for hole (1.0' h x 1.5' l x 0.3' to 1.0' d) in upstream end of right wall at spillway crest elevation.
APPROACH CHANNEL	None. Water flows over 2" x 12" wood flash boards on top of concrete weir. Spillway opening is 1.8' h x 4.5' w and drops 4.3' to the sluiceway slab.
OUTLET STRUCTURE	6.0' h x 4.9' w box constructed with concrete walls (12") and slab (6") and 6" to 12" thick sandstone slabs for roof which also serves as bridge over spillway.
DISCHARGE CHANNEL	Natural stream channel

INSTRUMENTATION

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 094
MONUMENTATION SURVEYS	NONE
OBSERVATION WELLS	NONE
WEIRS	NONE
PIEZOMETERS	NONE
OTHERS	
OPERATION & MAINTENANCE DATA	NONE

RESERVOIR AREA AND DOWNSTREAM CHANNEL

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 094
SLOPES: RESERVOIR	Steep wooded slopes on right abutment. Slight to moderately sloped wooded areas and farmland on left abutment
SEDIMENTATION	Two to three acres of sand and silt, marshy area at upstream of lake.
DOWNSTREAM CHANNEL (OBSTRUCTIONS, DEBRIS, ETC.)	Natural stream channel with small trees and bushes.
SLOPES: CHANNEL VALLEY	1 on 3 wooded slopes
APPROXIMATE NUMBER OF HOMES AND POPULATION	3 occupied homes
WATERSHED DESCRIPTION	Wooded mountain area.

APPENDIX B

ENGINEERING DATA - CHECKLIST

CHECK LIST
ENGINEERING DATA
PHASE I

NAME OF DAM Starlight Lake Dam

ITEM	REMARKS	NDI# PA. 094
PERSONS INTERVIEWED AND TITLE	None. Owner did not wish to be present during inspection.	
REGIONAL VICINITY MAP	See Exhibit E-1, Appendix E	
CONSTRUCTION HISTORY	Design and construction documents are not available. The dam was constructed prior to 1914.	
AVAILABLE DRAWINGS	None	
TYPICAL DAM SECTIONS	For typical sections obtained by survey 12/11/80, see Appendix A.	
OUTLETS PLAN DETAILS DISCHARGE RATINGS	None, other than service spillway.	

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS	NDI# PA - 094
SPILLWAY PLAN SECTION DETAILS	Design drawings not available. For present conditions, see Appendix A.	
OPERATING EQUIP- MENT PLANS AND DETAILS	Not available	
DESIGN REPORTS	None available	
GEOLOGY REPORTS	None available	
DESIGN COMPUTATIONS: HYDROLOGY AND HYDRAULICS STABILITY ANALYSES SEEPAGE ANALYSES	None available	
MATERIAL INVESTIGATIONS: BORING RECORDS LABORATORY TESTING FIELD TESTING	None available	

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS	NDI# PA - 094
BORROW SOURCES	Not known	
POST CONSTRUCTION DAM SURVEYS	None available prior to 1980. For conditions on 12/11/80, see top of dam profile and typical sections, Appendix A.	
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Inspection Reports (1917, 1920 and 1965) on file with PennDER.	
HIGH POOL RECORDS	No formal records are available	
MONITORING SYSTEMS	None	
MODIFICATIONS	Addition of upstream cinder concrete wall with plank sheeting to reduce leakage (1916 - 1917); Addition of large size stone rock toe below the downstream face of the rubble masonry dam (prior to 1920).	

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS	NDI# PA - 094
PRIOR ACCIDENTS OR FAILURES	Not reported	
MAINTENANCE RECORDS MANUAL	Not available	
OPERATION: RECORDS MANUAL	Not available	
OPERATIONAL PROCEDURES	Self-regulating.	
WARNING SYSTEM AND/OR COMMUNICATION FACILITIES	Not available	
MISCELLANEOUS		

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

NDI ID # 00094
PENNDER ID # 64-035

SIZE OF DRAINAGE AREA: 2.15 square miles

ELEVATION TOP NORMAL POOL: 1,355.0 STORAGE CAPACITY 515 acre-feet

ELEVATION TOP FLOOD CONTROL POOL: NA STORAGE CAPACITY: NA

ELEVATION MAXIMUM DESIGN POOL: Unk STORAGE CAPACITY: Unk

ELEVATION TOP DAM: 1,357.5 STORAGE CAPACITY: 616 acre-feet

SPILLWAY DATA

CREST ELEVATION: 1,355.0 feet

TYPE: Rectangular concrete weir

CREST LENGTH: 4.5 feet

CHANNEL LENGTH: 20 feet

SPILLOVER LOCATION: Center of dam

NUMBER AND TYPE OF GATES: 8" ± flashboard over concrete crest

OUTLET WORKS

TYPE: Not applicable - No other outlet

LOCATION: NA

ENTRANCE INVERTS: NA

EXIT INVERTS: NA

EMERGENCY DRAWDOWN FACILITIES: None

HYDROMETEOROLOGICAL GAGES

TYPE: None

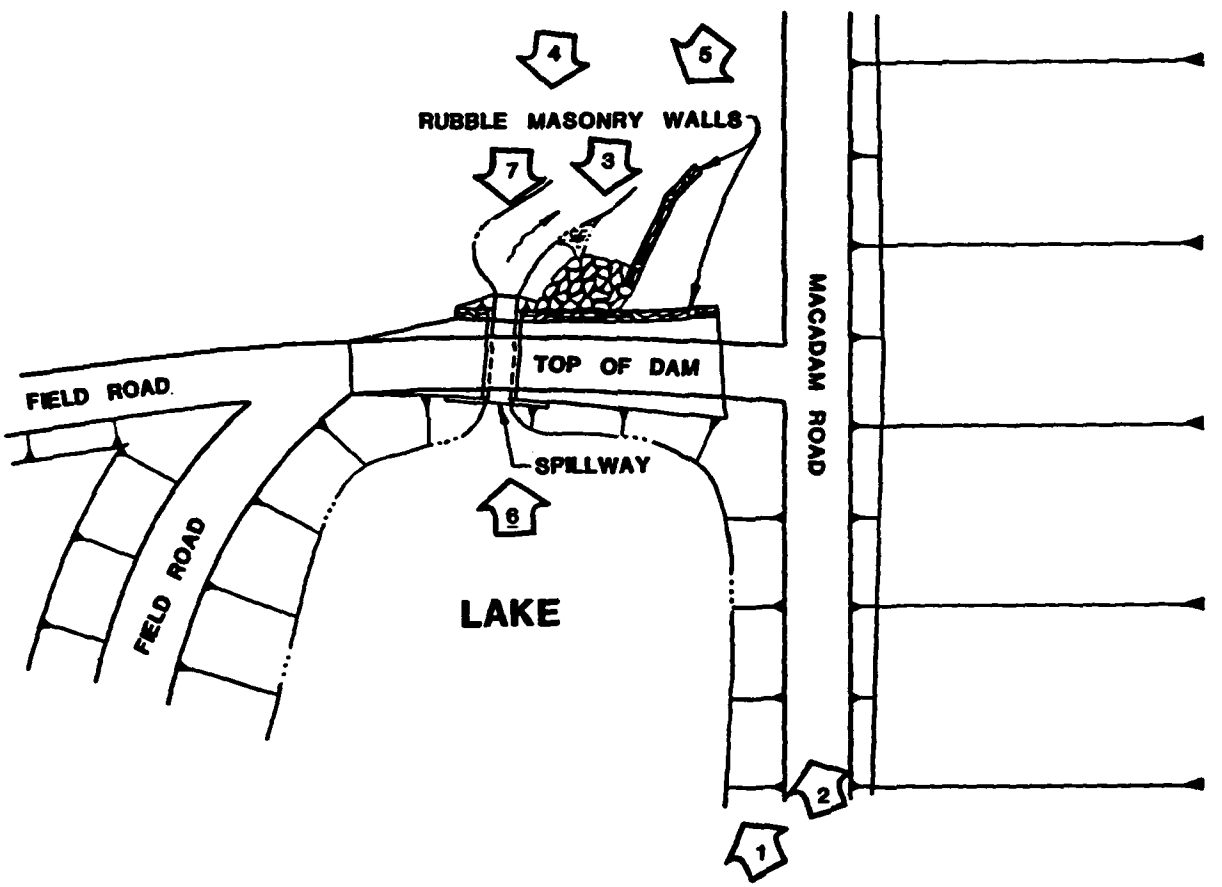
LOCATION: None

RECORDS: None

MAXIMUM NON-DAMAGING DISCHARGE: 57 cfs

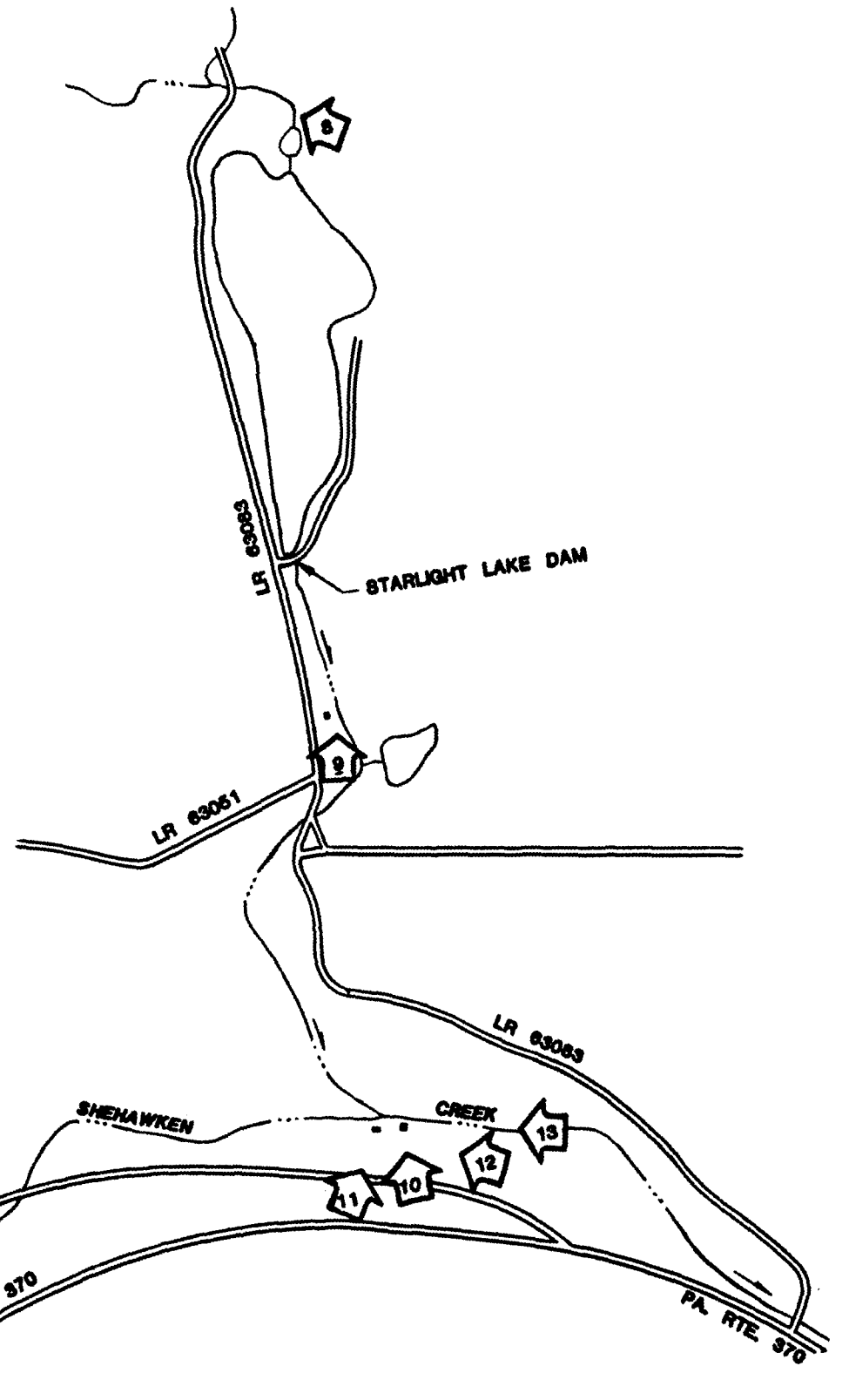
APPENDIX C

PHOTOGRAPHS



STARLIGHT LAKE DAM
PHOTOGRAPHS LOCATION MAP

EXHIBIT C-1

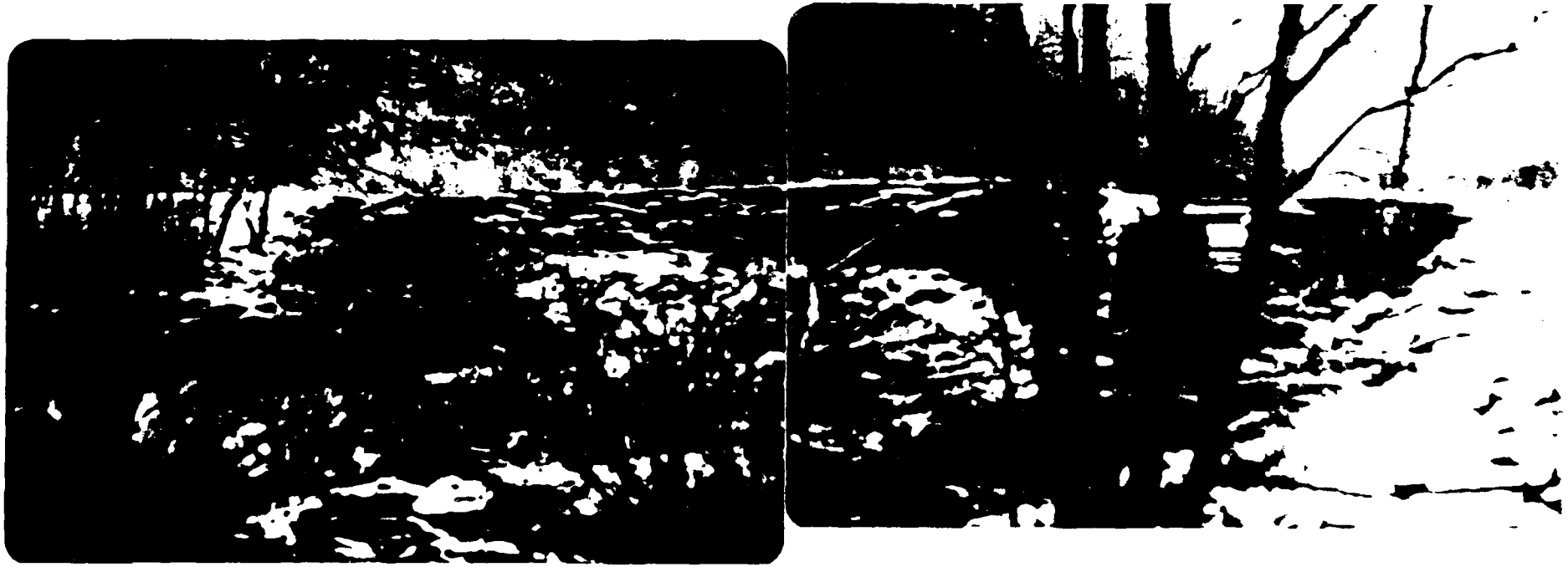


STARLIGHT LAKE DAM
DOWNSTREAM PHOTOGRAPHS LOCATION MAP

EXHIBIT C-2

1 UPSTREAM FACE OF DAM - LEFT ABUTMENT

2. UPSTREAM FACE OF DAM -RIGHT ABUTMENT

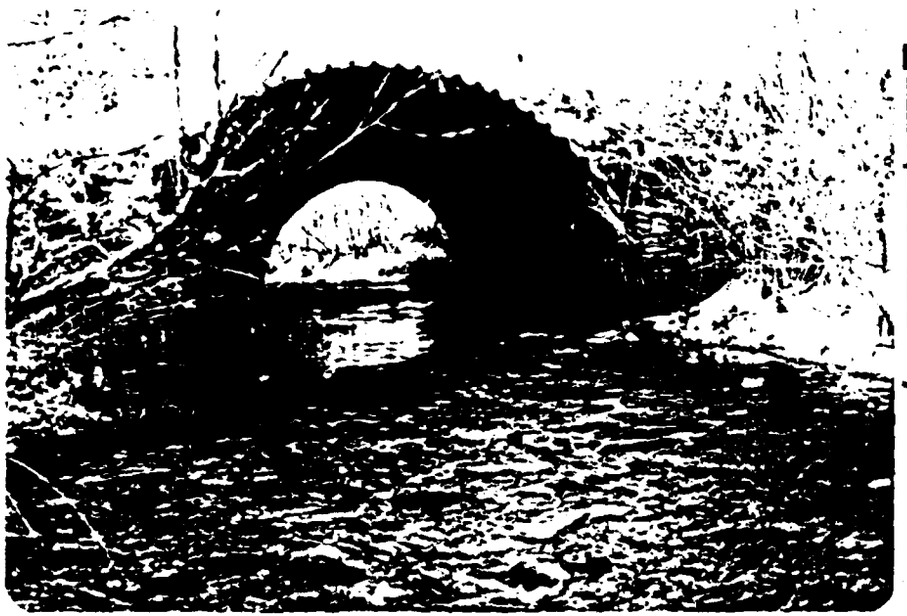


3 DOWNSTREAM OF DAM . SHOWING RUBBLE MASONRY WALL & SPILLWAY (RIGHT OF PHOTO)

4.

5.

4 & 5 SPILLWAY OUTLET AND STREAM CHANNEL



8. RESERVOIR INFLOW (LOOKING UPSTREAM ON CULVERT)

9 600' DOWNSTREAM OF DAM (STREAM AT EDGE OF SNOW)

10 STREAM AT REAR OF HOUSE

11. STREAM AT REAR OF TRAILER

DOWNSTREAM HAZARD (2000' BELOW DAM)

12. DOWNSTREAM AT CONFLUENCE WITH SHEHAWKEN CREEK. STREAM LOCATED BEHIND HOUSE & TRAILER (SEE PHOTO 13)

13. FACING UPSTREAM BELOW RED COTTAGE

APPENDIX D

HYDROLOGY AND HYDRAULICS

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB STARLIGHT DAM PA 0094
SHEET NO ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY ____ DATE ____
SCALE ____

SUMMARY OF HYDRAULIC COMPUTATIONS

1.) DETERMINE SPILLWAY DISCHARGE CAPACITY

2.) DETERMINE THE 100 YR. FREQUENCY FLOOD FLOW.

3.) DUE TO THE DOWNSTREAM HAZARD CONDITIONS, NO OVERTOPPING ANALYSIS, DOWNSTREAM ROUTING OR BREACH ANALYSIS WAS MADE.

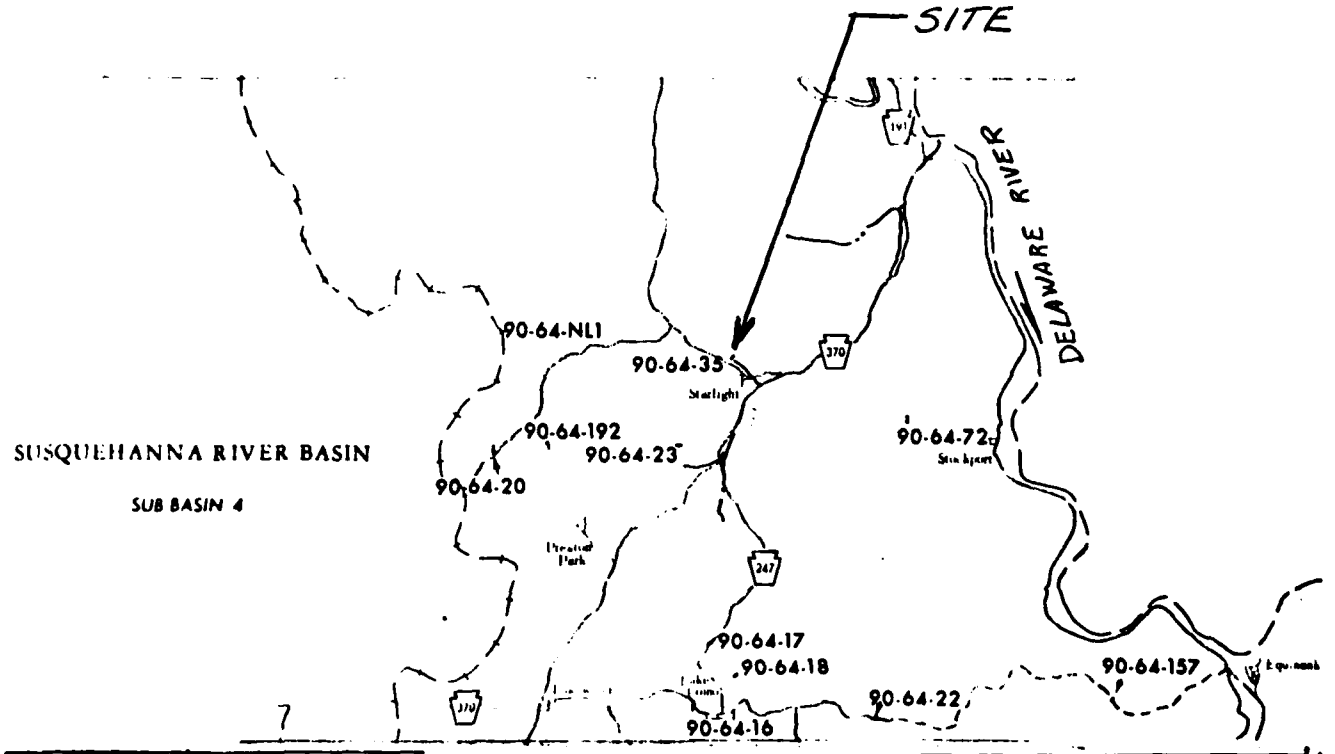
GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB STARLIGHT LAKE DAM; PA 0094
SHEET NO.
CALCULATED BY G.Y. DATE 1/19/1981
CHECKED BY DATE
SCALE

DELAWARE RIVER BASIN (PENNDER SUB-BASIN 1); DER# 64-035

STARLIGHT LAKE DAM
BUCKINGHAM TWP., WAYNE CO., PA.

LATITUDE: N 41°54'23"; LONGITUDE: 75°20'00" HYDROLOGIC ZONE 1

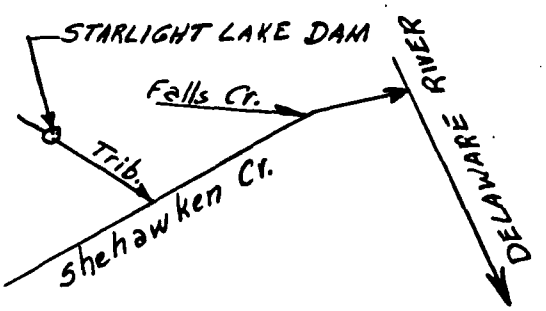


SCALE IN MILES

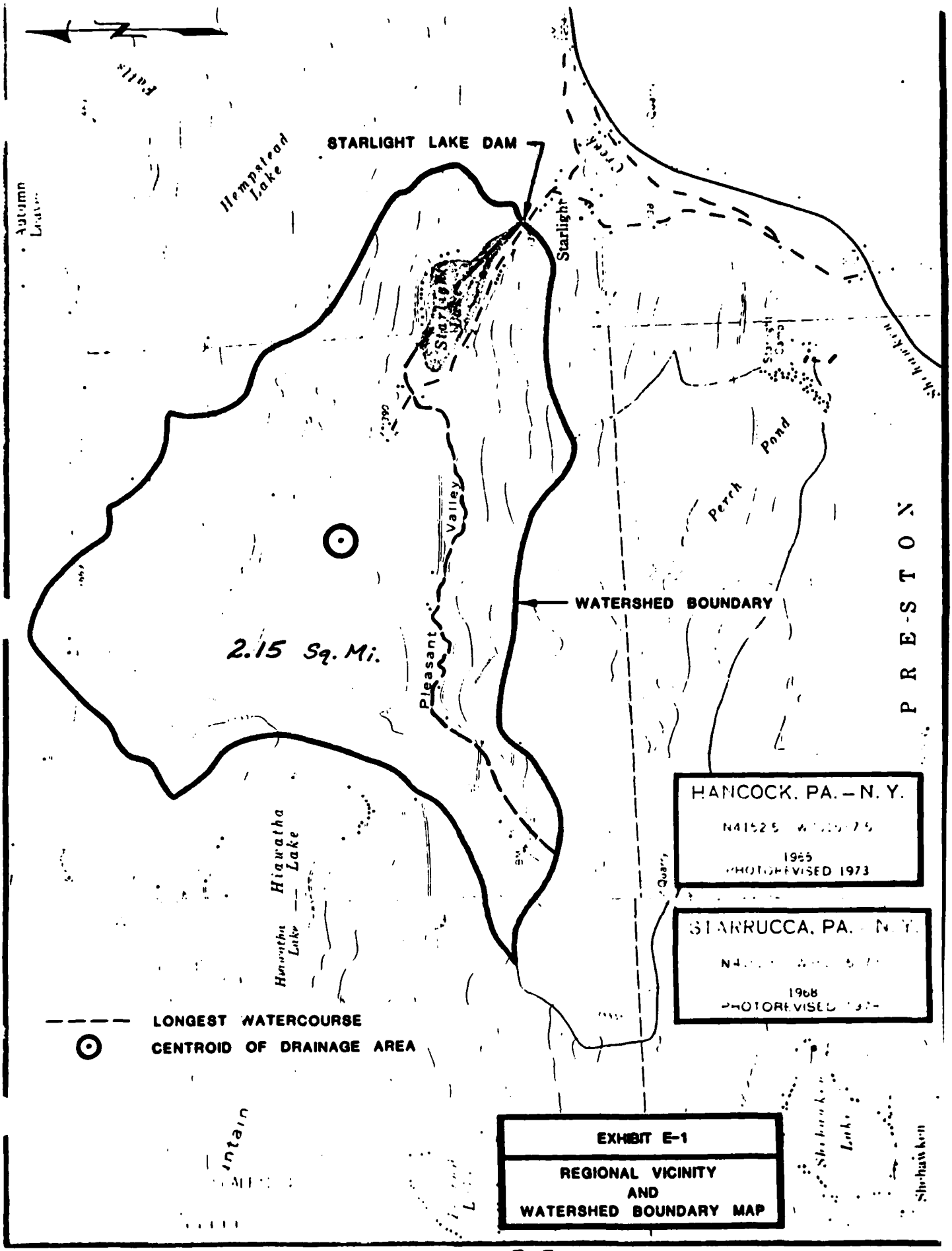
DELAWARE RIVER BASIN
SUB-BASIN 1
UPPER DELAWARE

SHEET NO. 1

NAME OF STREAM	DRAINAGE AREA MI² AT MOUTH
Tributary	2.26
Falls Creek	2.18
Shehawken Cr.	15.90



TRIBUTARY SCHEMATICS


STARLIGHT LAKE DAM
Hemptstead Lake
Starlight
Perch Pond
Pleasant Valley
WATERSHED BOUNDARY
2.15 Sq. Mi.
PRESTON
Hiawatha Lake
HANCOCK, PA.—N. Y.
1955
PHOTOREVISED 1973
STARRUCCA, PA.
1968
LONGEST WATERCOURSE
CENTROID OF DRAINAGE AREA
EXHIBIT E-1
REGIONAL VICINITY
AND
WATERSHED BOUNDARY MAP

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB STARLIGHT DAM PA 0094
SHEET NO OF
CALCULATED BY WEH DATE 1/26/81
CHECKED BY DATE
SCALE

PLANIMETERED AREAS FROM USGS

1314	0 Ac. *	BOT. OF RESERVOIR
W.S. @ 1355	37.7 Ac.	NORMAL W.S.
1357.5	43.2 Ac.	LOW POINT ON DAM
1360	48.7 Ac.	CONTOUR
1380	77.1 Ac.	CONTOUR

* ESTABLISH ELEV. @ 0 AREA
USE STORAGE PER BULLETIN 5 OF 168 MG. @ ELEV. 1355
= 514 Ac. Ft. **

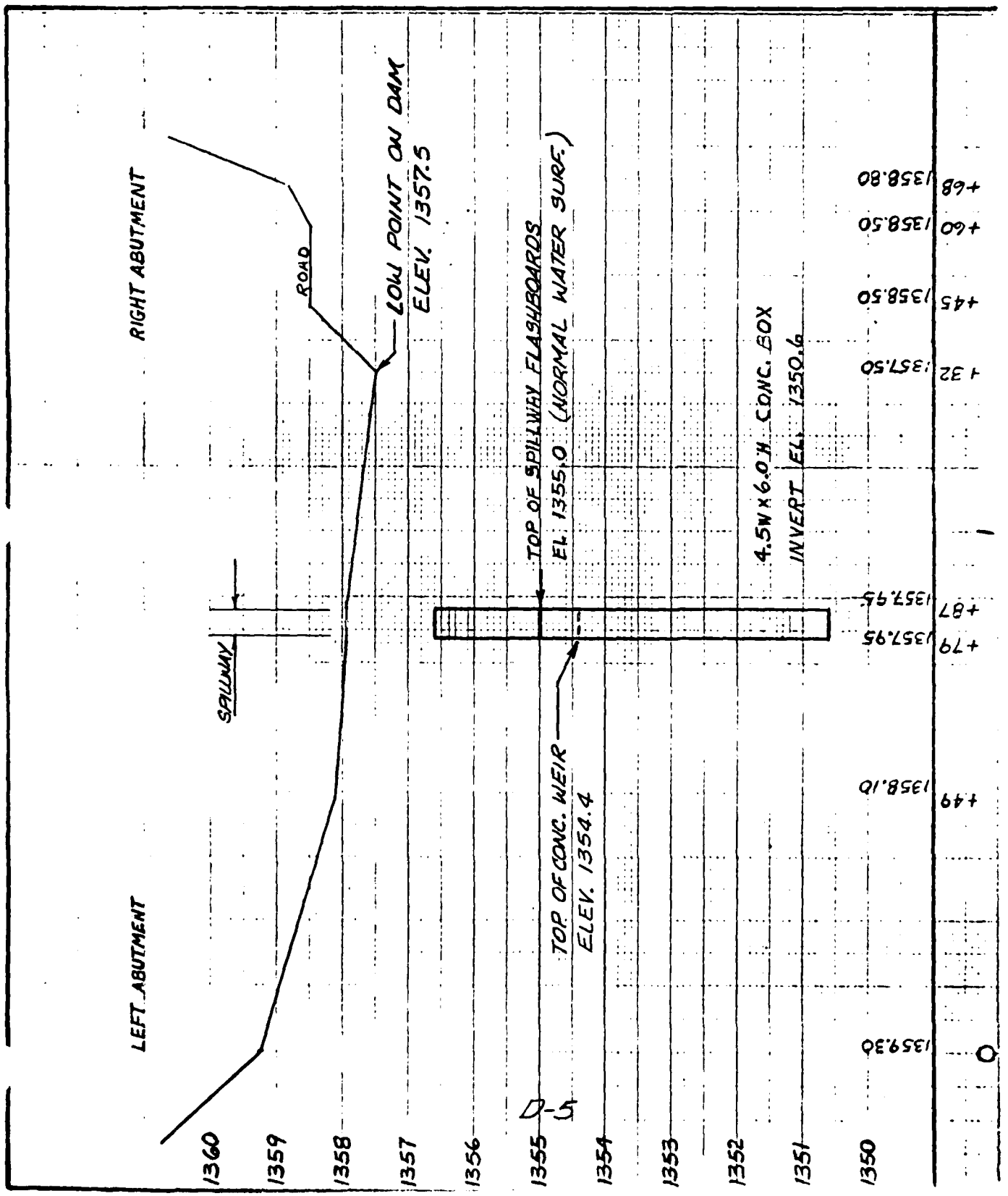
$\Delta E = 3 \times 514 / 37.7 = 40.9'$ CALL $41'$

∴ ELEV. @ 0 AREA = 1355 - 41 = 1314

** Including "Dead Storage" in Lake, below upstream toe of dam

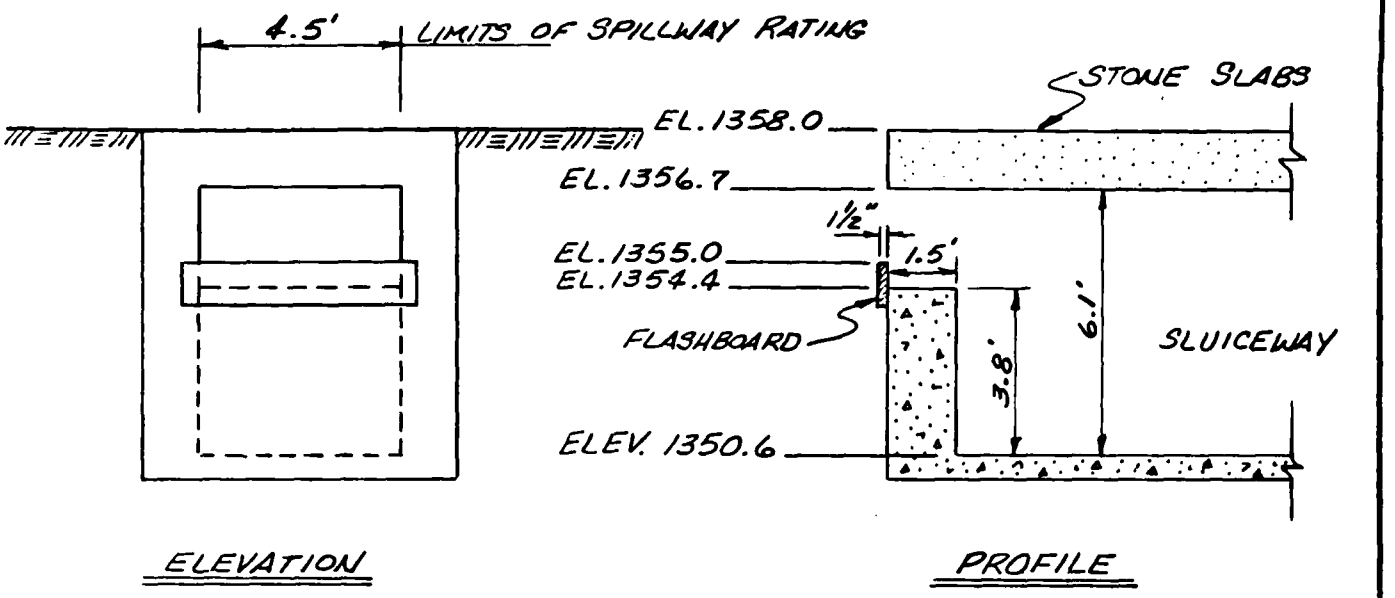
GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB STARLIGHT LAKE DER 64-35
SHEET NO ___ OF ___
CALCULATED BY RJM DATE 1-26-81
CHECKED BY ___ DATE ___
SCALE HORZ. 1" = 25' VERT. 1" = 2'



GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB STARLIGHT DAM PA-0094
SHEET NO OF
CALCULATED BY WEH DATE 2/20/81
CHECKED BY DATE
SCALE



ASSUME SHARP CRESTED WEIR FLOW UNTIL ENTRANCE IS SUBMERGED.

$Q = CLH_1^{3/2}$

$C = 3.1$

$L = 4.5'$

H_1 = DEPTH OF WATER ABOVE FLASHBOARD (W.S. - 1355.0)

AFTER THE ENTRANCE IS SUBMERGED USE ORIFICE FLOW

$Q = Ca\sqrt{2gh}$

$C = 0.7$

$a = 1.7 \times 4.5 = 7.65$ S.F.

$g = 32.2$ FT./SEC^2

h = DEPTH OF WATER ABOVE ℄ ORIFICE (W.S. - 1355.85)

ABOVE ELEV. 1358.0 THERE WILL BE ADDITIONAL WEIR FLOW OVERTOPPING

$Q = CLH_2^{3/2}$

$C = 3.0$

$L = 4.5'$

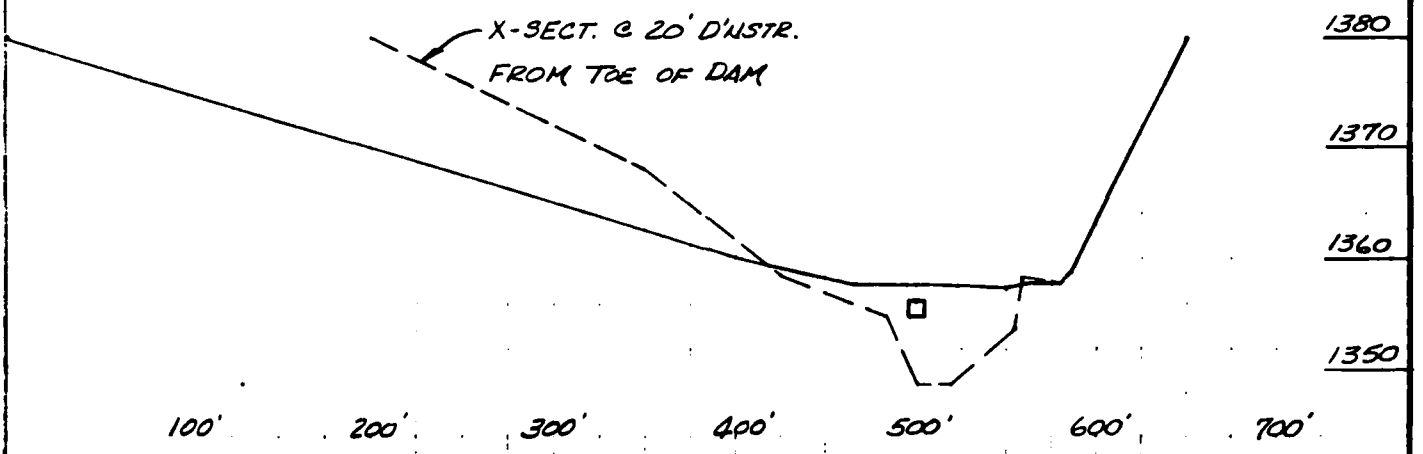
H_2 = DEPTH OF WATER ABOVE STONE SLAB (W.S. - 1358.0)

Note: Removal of the flashboards would provide additional head over the spillway crest (1357.5 - 1354.4 = 3.1') and the discharge prior to overtopping, $Q = 3.1 \times 4.5 \times 3.1^{3/2} = 76.5$ cfs

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB STARLIGHT DAM PA 0094
SHEET NO OF
CALCULATED BY WEH DATE 1/24/81
CHECKED BY DATE
SCALE

COMPUTE TAILWATER @ DOWNSTR. FACE OF DAM

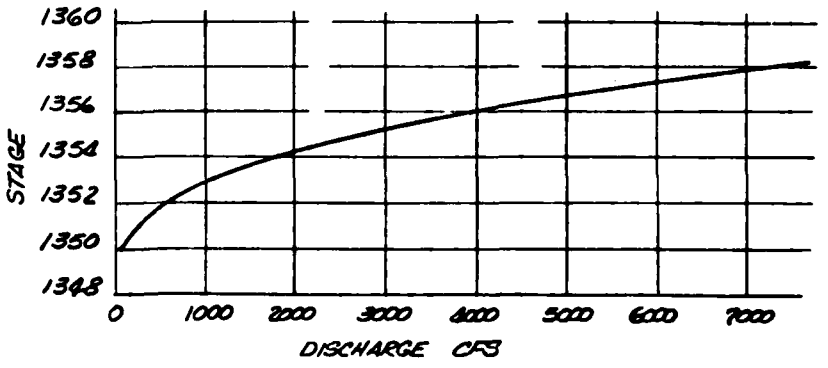


INPUT CRITERIA

n = 0.06 FOR OVER BANK
n = 0.035 FOR CHANNEL
SLOPE = 0.0071 %
DIST. FROM FACE OF DAM = 20'

STARLIGHT DAM
NORMAL DEPTH RATING CURVE
AT DAM FACE

ELEV.	CFS
1350.0	79
1351.0	281
1352.0	615
1353.0	1100
1354.0	1807
1355.0	2737
1356.0	3928
1357.0	5405
1358.0	7188
1359.0	9290
1360.0	11764



GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB STARLIGHT DAM PA-0094
SHEET NO OF
CALCULATED BY WEH DATE 2/23/81
CHECKED BY DATE
SCALE

W.S. ELEV.	H_1	h	H_2	CFS	TOTAL CFS
1355.0	0	—	—		0
1355.5	0.5	—	—		5
1356.0	1.0	—	—		14
1356.7	1.7	—	—		31
1357.5	—	1.7	—	56	56
1358.0	—	2.2	0	64 + 0	64
1359.0	—	3.2	1.0	77 + 14	91
1360.0	—	4.2	2.0	88 + 38	126
1361.0	—	5.2	3.0	98 + 70	168
1362.0	—	6.2	4.0	107 + 108	215
1363.0	—	7.2	5.0	115 + 151	266
1364.0	—	8.2	6.0	123 + 198	321
1365.0	—	9.2	7.0	130 + 250	380

SPILLWAY RATING CURVE (CONT.)

Raising the top of dam to the elevation of the Public Road (on the right abutment) and removing the flashboard:

New Top of Dam El. 1358.50	1358.50
Elevation of Spillway Crest 1354.40	
Elevation of ℄ orifice = (1354.4 + 1356.7)/2 =	El. 1355.55
Max. available head for orifice discharge = $h^* =$	2.95

Area of orifice flow $4.5' \times 2.3' = 10.35\ ft^2$

Max. discharge without overtopping

$$Q = C \cdot a \cdot \sqrt{2gh^*} = 0.7 \times 10.35 \times \sqrt{2g} \cdot \sqrt{2.95} = 100\ cfs$$

DISCHARGE CAPACITY OF CULVERT AT LAKE INLET

Observations during site inspection indicated super critical flow conditions through the culvert on 12/12/1980. Assuming upstream control and ignoring the skew, the estimated capacity of the 10'-8" x 6'-9" Multi-Plate CM ARCH PIPE culvert is 450 cfs (See attached Nomograph; HW/D = 1.0).

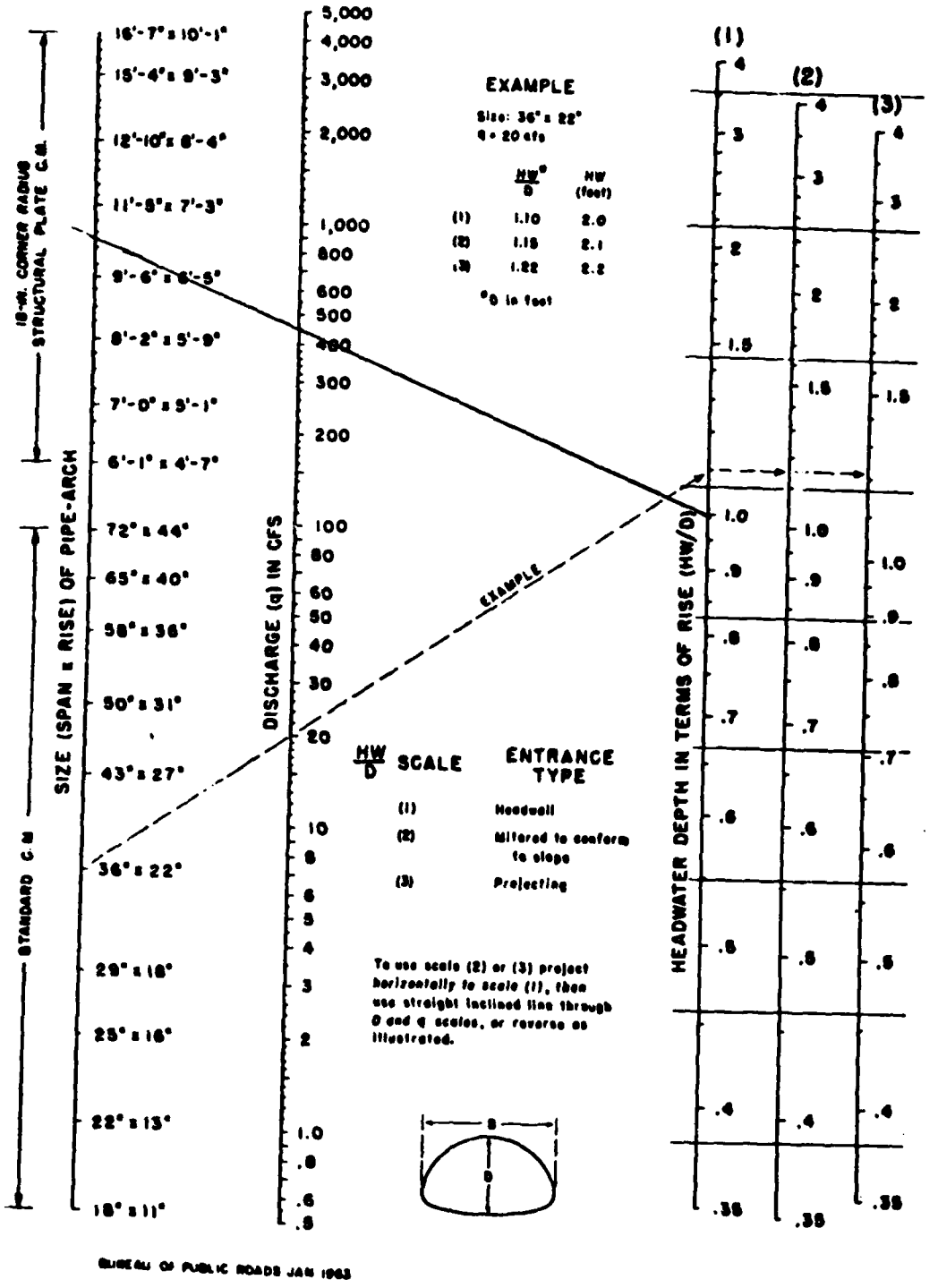


Exhibit 14.10. Headwater depth for C.M. pipe-arch culverts with inlet control.

Reference: National Engineering Handbook Section 4, Chapter 14; U.S. Department of Agriculture, Soil Conservation Service

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB STARLIGHT DAM
SHEET NO 1 OF 1
CALCULATED BY SJM DATE 5/81
CHECKED BY G.V. DATE 5/04/81

100 YR. FLOOD DETERMINATION

REF. "REGIONAL FREQUENCY STUDY, UPPER DELAWARE AND HUDSON RIVER BASINS" NEW YORK DIST. C.O.E. 1974
& C.O.E. 4/22/81 MEMO
LAT. N 41°54'23"; LONG. W 75°20'00"

$\text{Log } Q_m = C_m + 0.87 \text{ Log}(A)$

$A = 2.15 \text{ mi}^2$

$C_m = 1.8$ ✓

$\text{Log } Q_m = 1.8 + 0.87 \text{ Log}(2.15) = 2.09$ ✓

$S = C_s - 0.05 \text{ Log}(A)$

$C_s = 0.34$ ✓

$S = 0.34 - 0.05 \text{ Log}(2.15) = 0.323$

$\text{Log } Q_p = \text{Log } Q_m + K_{pg} S$

$p = 100 \text{ yr}$, $g = 0.2$ } $K_{pg} = 2.47$ *

$\text{Log } Q_{100} = 2.09 + 2.47(0.323) = 2.888$

$\therefore Q_{100} = 772 \text{ cfs}$; say **770 cfs**

* Guidelines for Determining Flood Flow Frequency, United States Water Resources Council; Washington, D.C.; Revised June, 1977 (Kpg for g = +0.2 is 2.47226)

APPENDIX E

EXHIBITS

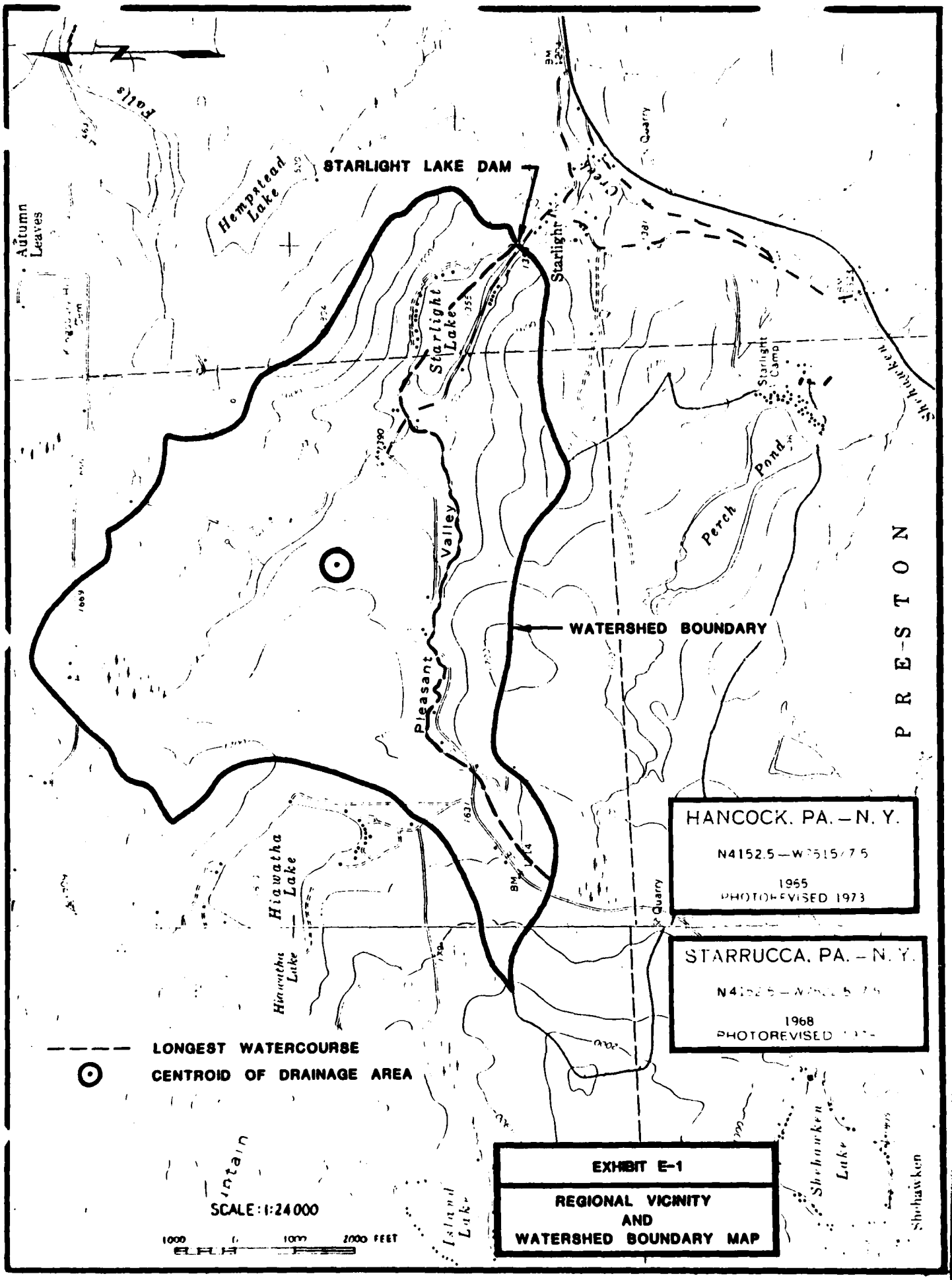


EXHIBIT E-1

REGIONAL VICINITY AND WATERSHED BOUNDARY MAP

UPSTREAM FACE OF DAM (LAKE IN FOREGROUND, FARMLAND IN BACKGROUND, DOWNSTREAM OF DAM)
SHOWING NEW SHEETING OVER CINDER CONCRETE WALL

DOWMSTREAM FACE OF DAM AND SLUICEWAY

APPEARANCE ON MAY 15. 1917

EXHIBIT E-2

DOWNSTREAM FACE OF DAM SHOWING HEAVY DUMPED ROCK PROTECTION

APPEARANCE ON MAY 21 .1920

EXHIBIT E-6

LOOKING DOWNSTREAM FROM TOP OF DAM AT SLUICEWAY

DOWNSTREAM FACE OF DAM AND SLUICEWAY

APPEARANCE ON MAY 13 . 1965

EXHIBIT E-4

APPENDIX F

GEOLOGY

STARLIGHT LAKE DAM

APPENDIX F

GEOLOGY

Starlight Lake Dam and reservoir area are located within the Glaciated Allegheny Plateau Section of the Appalachian Plateaus Physiographic Province. Deposits of glacial drift of variable thickness cover the entire area. The drift was deposited by the Wisconsin Ice Sheet during the Pleistocene period of geologic time.

The glacial drift is composed primarialy of till which is a reddish-brown, unsorted, compact mixture of clay, silt, sand, gravel, and cobbles with occasional boulder sized pieces. The stone pieces are sub-angular to rounded and consist mainly of sandstone and siltstone derived from the Catskill Formation, the dominant rock formation in the area. The clay content and compact nature of the till makes it a relatively impervious soil type.

Some deposits of glacial outwash are also found in the area. The outwash is composed of loose, poorly sorted to stratified deposits of silt, sand, and gravel. The outwash deposits are generally pervious.

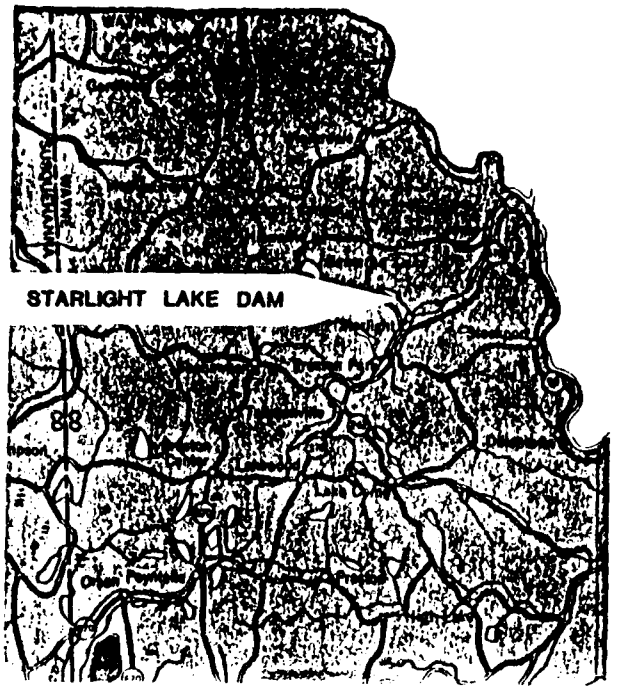
Other loose, pervious soils in the area are the recent deposits of alluvial silt, sand, and gravel with some clay. These soils are localized and limited to streambeds and flood plain areas. The flat, marshy area at the upstream end of the lake contains such alluvial deposits.

The bedrock underlying the entire dam and reservoir area is the Catskill Formation of the Susquehanna Group. This group of formations is of Upper Devonian age. The Catskill strata generally consists of well indurated red shale, siltstone and fine sandstone with some gray, green and brown shale, siltstone and sandstone layers. Occasional conglomeratic layers are encountered. The red shales are the dominant lithology and the residual soils derived from this rock are usually high in clay and silt and contain numerous flaky and angular fragments and flat, slabby boulders. The hillside left of the dam and reservoir area is covered with many such flat, slabby boulders and the dry masonry walls of the dam itself are constructed from similar one and two-man sized boulders.

The regional structure of the bedrock in the area indicates that the bedrock underlying the dam and reservoir area is near-horizontal. The regional strike of the strata is northeast-southwest.

Although depth to bedrock at the dam site is unknown, the steep earth slope on the downstream left abutment and the road cuts on the right abutment indicates at least 10 feet of overburden soil.

Ref.: Ground Water of Northeastern Pennsylvania, Stanley W. Lohman, 1937; Bulletin W-4, Pennsylvania Geologic Survey



0 1 2 3 4 5 10 MILES

SCALE: 1" = 4 MILES

LEGEND

DEVONIAN

UPPER

CENTRAL AND EASTERN PENNSYLVANIA

Oswayo Formation

Brownish and greenish gray, fine and medium grained sandstones with some shales and scattered calcareous lenses; includes red shales which become more numerous eastward. Relation to type Oswayo not proved.

Dck

Catskill Formation

Chiefly red to brownish shales and sandstones, includes gray and greenish sandstone tongues named Elk Mountain, Honesdale, Shohola, and Delaware River in the east.

Dm

Marine beds

Gray to olive brown shales, graywackes, and sandstones; contains "Chemung" beds and "Portage" beds including Burket, Brallier, Harrell, and Trimmers Rock; Tully Limestone at base.

Ds

Susquehanna Group

Barbed line is "Chemung-Catskill" contact of Second Pennsylvania Survey County reports, barbs on "Chemung" side of line.

NOTE:

GEOLOGIC MAP AND LEGEND OBTAINED FROM GEOLOGIC MAP OF PENNSYLVANIA BY PA. TOPOGRAPHIC AND GEOLOGIC SURVEY, DATED 1980

PHASE 1 INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

STARLIGHT LAKE DAM
GEOLOGIC MAP

GEO - Technical Services, Inc.
HARRISBURG, PA

FEBRUARY 1981

EXHIBIT F