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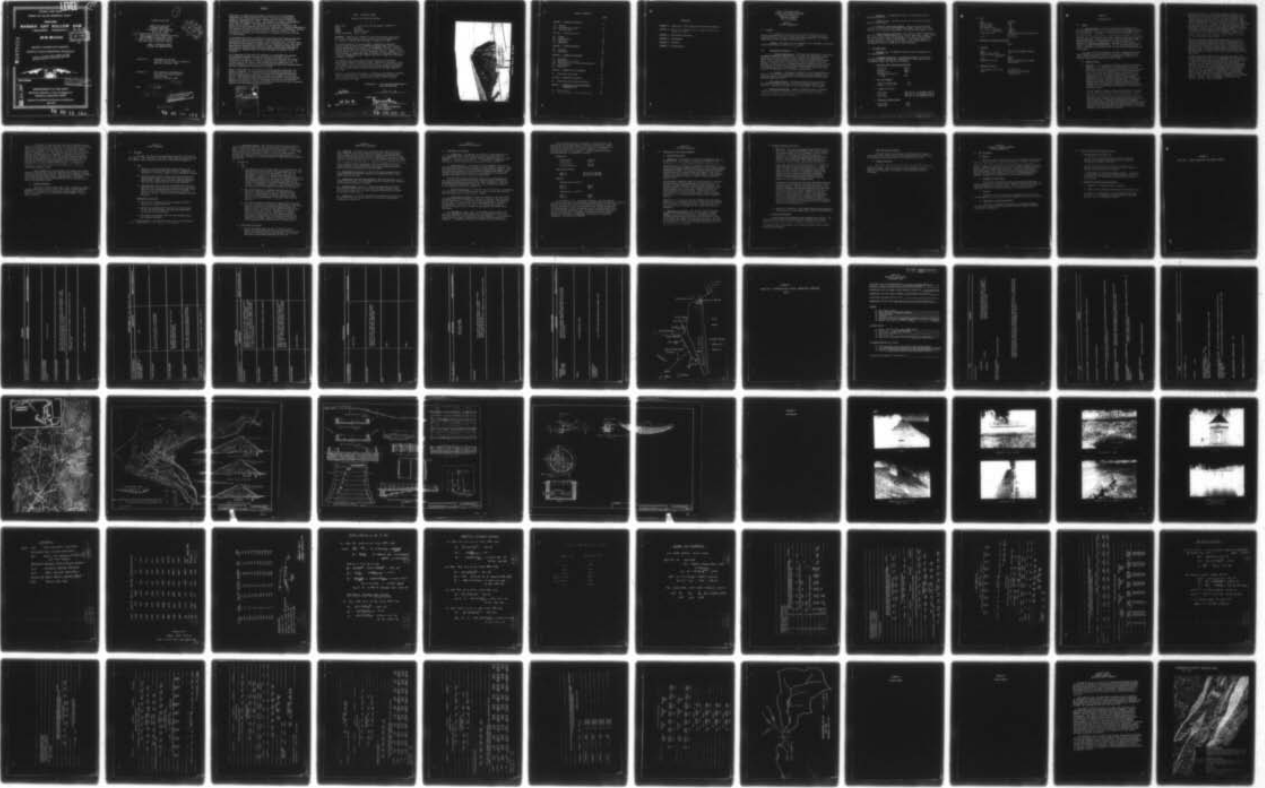
CORPS OF ENGINEERS BALTIMORE MD BALTIMORE DISTRICT
NATIONAL DAM INSPECTION PROGRAM. WARNER GAP HOLLOW DAM (EDGEMON--ETC(U)
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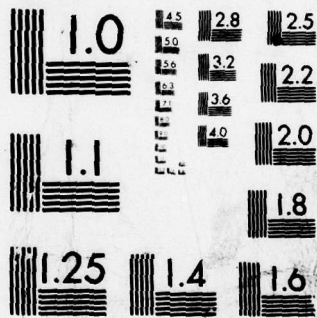
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MARYLAND

WARNER GAP HOLLOW DAM

(EDGEMONT RESERVOIR)

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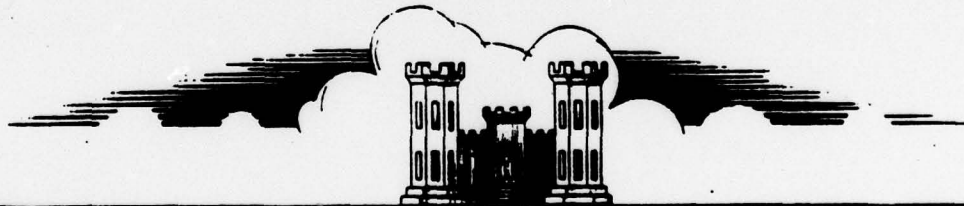
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**PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM**

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

Prepared By: Maryland Water Resources Administration
MAY 1979

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POTOMAC RIVER BASIN

WARNER GAP HOLLOW DAM
(EDGEMONT RESERVOIR)
WASHINGTON COUNTY, MARYLAND
NDI NO. MD 00006

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National Dam Inspection Program.
Warner Gap Hollow Dam (Edgemont Reservoir)
(NDI MD 00006). Potomac River Basin,
Warner Gap Hollow, Washington County,
Maryland. Phase I Inspection Report,

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

Prepared by: WATER RESOURCES ADMINISTRATION
Department of Natural Resources
Tawes Building
Annapolis, Maryland 21401

Date: 11 May 1979

12 83p.

10 Jeffrey O. Smith

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PREFACE

This report is prepared under guidance contained in the "Recommended Guidelines for Safety Inspection of Dams," for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. 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: Warner Gap Hollow Dam (Edgemont Reservoir)
STATE: Maryland
COUNTY: Washington
STREAM: Warner Gap Hollow
DATE OF INSPECTION: April 9, 1979

ASSESSMENT: Based on the evaluation of the conditions as they existed on the date of the inspection and as revealed by visual observations, the condition of Warner Gap Hollow Dam is assessed to be good.

The spillway capacity (17 percent PMF) is classified as inadequate because it will not pass the recommended spillway design flood of full Probable Maximum Flood according to the recommended criteria. Additional analyses of the downstream consequences in the event of a failure indicate that the dam is not in the seriously inadequate category. However, the owner should initiate an engineering study to evaluate the spillway capacity and to develop recommendations for remedial measures to reduce the overtopping potential of the dam.

The seepage at the left abutment should be monitored routinely for quantity and turbidity by means of a weir. Maintenance and repairs should be performed to restore the 30-inch drain valve to an operative condition and a positive seal should be provided on the upstream side. Maintenance work should include removal of woody vegetation on the downstream face of the dam.

Operation and maintenance procedures are unwritten and should be documented. A warning system should be developed to warn downstream residents of large spillway discharges during periods of heavy rainfall and run-off or failure of the dam.

SUBMITTED BY: WATER RESOURCES ADMINISTRATION
DAM SAFETY DIVISION

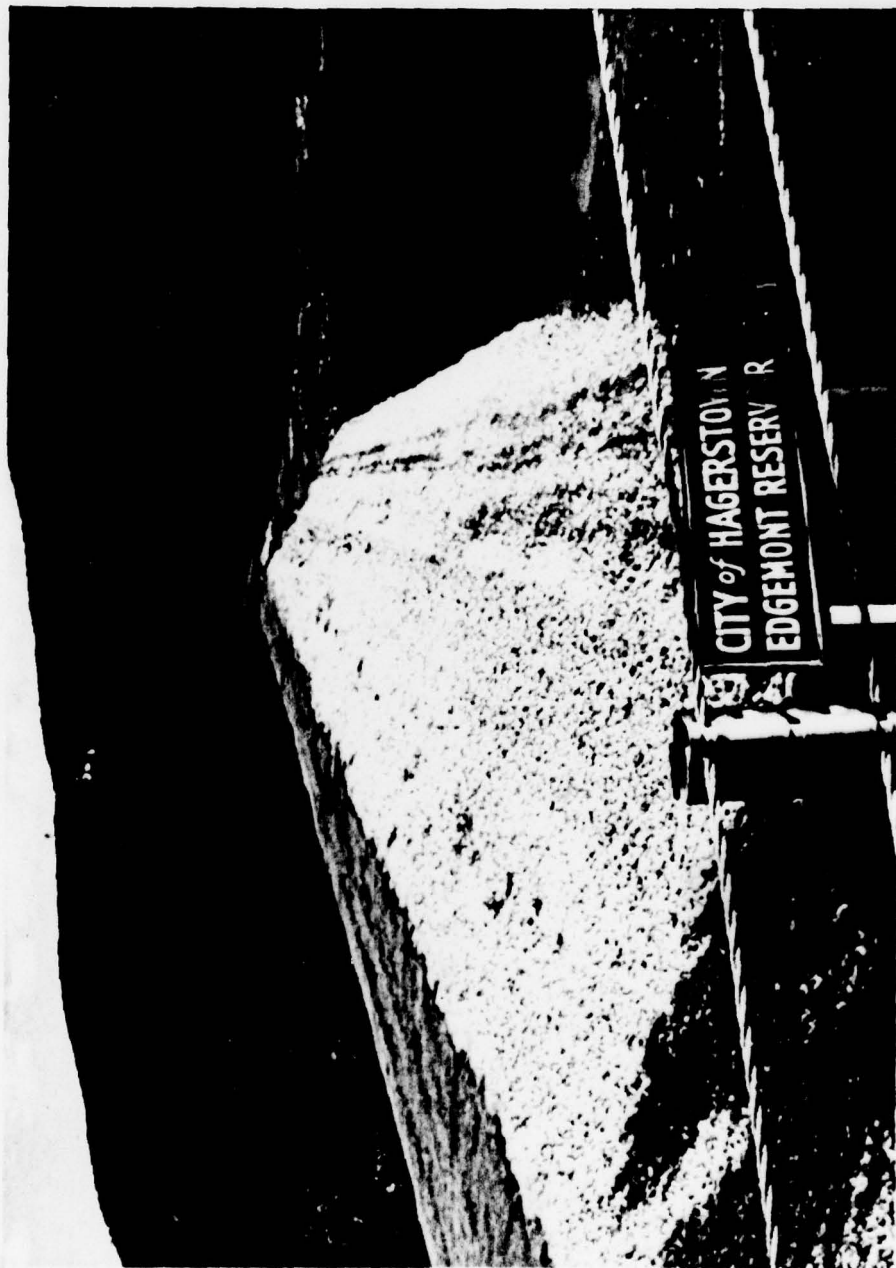
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Date

Jeffrey O. Smith

23 Jun 79
Date

APPROVED BY:

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



Edgemont Reservoir MD 00006

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APPENDICES

APPENDIX A - Check List, Visual Inspection, Site Sketch, Phase I

**APPENDIX B - Check List, Engineering Data, Design, Construction,
Operation, Phase I**

APPENDIX C - Location Map and Plans

APPENDIX D - Photographs

APPENDIX E - Analyses

APPENDIX F - Geology Report

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
WARNER GAP HOLLOW DAM
(EDGEMONT RESERVOIR)
NDI NO. MD 00006

SECTION 1
PROJECT INFORMATION

1.1 General

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

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

1.2 Description of Project

a. Dam and Appurtenances. The Warner Gap Hollow Dam, known locally as Edgemont Reservoir, consists of a zoned earth fill embankment approximately 65 feet high and 700 feet long. A puddle wall approximately 5 feet wide by 15 feet deep near the upstream toe is detailed on the design plans. The rip-rap covered slopes rise at $1\frac{1}{2}H:1V$ downstream and $2H:1V$ upstream. The spillway is a rectangular concrete channel with the entrance located near the right abutment and discharging approximately parallel to the longitudinal axis of the embankment. The spillway crest is at elevation 901.0, approximately 4 feet below the dam crest. *AS STATION* *KB 5/2/5*

b. Location. The Edgemont Reservoir is located approximately 1 mile east of the town of Smithsburg in Washington County, Maryland. The structure impounds the headwaters of the Little Antietam Creek drainage, known as Warner Gap Hollow.

c. Size Classification. The maximum height of the dam is 65 feet. The reservoir volume to the top of the dam at elevation 905.0 is 296 acre-feet. Therefore, the dam is in the "intermediate" size category.

d. Hazard Classification. Damage to downstream roads, railroads, commercial buildings, residences and loss of more than a few lives would likely result from a failure of the dam. Accordingly, the dam is classified in the high hazard category.

e. Ownership. The Edgemont Reservoir is owned by the City of Hagerstown, Maryland.

f. Purpose of Dam. The single purpose of the dam is to provide municipal water supply.

g. Design and Construction History. The present structure was designed by the American Pipe Manufacturing Company, Engineers and Contractors of Philadelphia, Pennsylvania. Construction took place in 1902.

h. Normal Operating Procedures. The reservoir supplies approximately 50% of the average 10 MGD demand for the City of Hagerstown. Normal inflow and releases from storage are discharged to the City or the Smithsburg Reservoir through a system of supply mains. A low masonry dam on the adjacent Raven Rock watershed may be used to divert inflow directly to the Edgemont Reservoir through a 30" terra cotta pipe.

1.3 Pertinent Data

a. Drainage Area The Edgemont Reservoir has a drainage area of 2.34 square miles.

b. Discharge at Dam Site The maximum discharge at the dam site through the ungated spillway at elevation 901.0 is 991 cubic feet/sec. The maximum flood at the dam site is unknown.

c. Elevation (feet above mean sea level)

Top of Dam	905.0
Low Point	904.6
Spillway Crest	901.0
Streambed at centerline of dam	840

d. Reservoir (miles)

Length of maximum pool	0.20
Length of normal pool	0.17

e. Storage (acre feet)

Normal pool	246 acre ft. at elevation 901.00
Low point	292 acre ft. at elevation 904.65
Top of dam	296 acre ft. at elevation 905.00

f. Reservoir Surface (acres)

Top of dam	13.5
Normal pool	12.0

g. Dam

Type	Earthfill
Length (feet)	700
Height (feet)	65
Top width (feet)	16
Side slopes - Upstream	2H:1V
- Downstream	1½H:1V
Impervious Core	Zoned construction, material not specified
Cutoff	Puddle Wall

h. Diversion and Regulating Tunnel

None

i. Spillway

Type	Concrete rectangular channel
Width of weir (feet)	25
Crest elevation (feet above M.S.L.)	901.0
Gates	None
Downstream channel	Spillway discharges to Raven Rocks Creek.

j. Regulating Outlets

Water Supply mains (two)	12 inch C.I.P.
Drain	30-inch C.I.P. blow-off (inoperative)

SECTION 2

ENGINEERING DATA

2.1 Design:

a. Data Available: Warner Gap Hollow Dam was designed and probably constructed by the American Pipe Manufacturing Company, Engineers and Contractors, Philadelphia, Pennsylvania, during 1902. The only engineering data available for the design of the dam is contained on drawings entitled "Plan" and "Details of 100 Million Gallon Impounding Reservoir for the Washington County Water Company, Hagerstown, Maryland", dated January 1902. These drawings were retraced by the City of Hagerstown Water Department in 1968 and the tracings are presented in Appendix C, "Location Map and Plans". Although test pit locations are shown on the plan view, subsurface data was not found during the data review. Hydrologic and hydraulic data was apparently not generated for this project.

Many years after construction of the dam, a seepage area at the right abutment was studied by Whitman, Requardt and Associates and a report entitled "Edgemont Reservoir, Investigation of Leakage with Remedial Grouting" was prepared in November 1968.

b. Design Features

1. Embankment - The construction drawings indicate the earthen embankment to be constructed in two zones with "selected material, compacted" beneath the upstream face and crest areas, and "ordinary material, compacted" in the downstream slope area. The dam was to be placed with a 2 horizontal to 1 vertical upstream slope and a 1½ horizontal to 1 vertical downstream slope. It should be noted that the graphic presentation on the drawings incorrectly shows the upstream slope to be steeper than the downstream slope. The slope configuration labels, however, indicate the intent of the designer and were apparently followed during construction. Rip-rap, 1 foot in thickness was provided on the upstream and downstream slopes.

The fill reaches a maximum height of 60 feet near the center of the profile and is shown to be placed against a gently sloping left abutment and a steep right abutment. A puddle wall, five feet in width and fifteen feet in depth was constructed in the original stream valley along the upstream toe of the embankment. Although the material of the puddle wall was not specified on the plans, puddle is generally defined as a mixture of clay and gravel or sand, which are well mixed together, carefully moistened; and rammed in place. Foundation Material is not specified on the plans.

2. Appurtenant Structures - An overflow spillway consisting of a rectangular concrete waste channel 550 feet in length, 25 feet in width and 3 to 4 feet in height, is located near the right abutment approximately parallel to the axis of the dam. The construction drawings show the channel floor to have a slope of 1 foot in 26 feet at the entrance rising to a peak at el. 901, and an exit slope of 1% transitioning to the natural grade of 20%. The spillway floor consists of plain concrete slabs 18 inches in thickness. In the vicinity of the spillway entrance, a cutoff is provided by increasing the slab thickness in steps to a maximum of 6 feet at the entrance. The drawings indicate the channel floor to be lined with pine boards attached to wooden stringers embedded in the concrete.

The side walls of the spillway are indicated to be of plain concrete, ranging in height from 4 feet at the entrance to 3 feet along the natural grade and varying in width from 3 feet at the base to 2 feet at the top of wall. The plans do not provide for any construction joints within or between the walls and floor slabs. A rip-rap filled timber crib, 24 feet long by 41 feet wide, is shown at the outfall of the spillway in the plunge pool.

A drain consisting of 30-inch cast iron bell and spigot pipe extends through the center of the embankment with an inlet invert at approximately el. 850 and an outlet invert at approximately el. 840. Two 12-inch water supply pipes of unspecified material pass through the right side of the dam at approximate els. 850 and 860. The drain and supply lines are controlled by valves and blow offs positioned just beyond the downstream toe of the dam. All pipes are provided with cut off walls within the upstream side of the embankment. An additional 12-inch supply pipe, existing prior to placement of the dam near the right abutment, was apparently intended to be preserved during construction, but no treatment, remedial work, or additions are specified on the plans.

c. Design Data

The only design data available consists of the construction drawings.

2.2 Construction.

The only construction data available is contained on construction drawings.

2.3 Operation.

Formal operating records have not been maintained. The only written records consist of daily pool levels within the impoundment, rain gage data at the dam, and limited stream flow data above the reservoir on the stream in Warners Gap Hollow.

2.4 Evaluation.

a. Availability. Construction drawings and the remedial study report prepared by Whitman, Requardt and Associates constitute the engineering data and are available in the files of the State of Maryland Department of Natural Resources. Daily pool levels are contained in the files of the City of Hagerstown Water Department.

b. Adequacy.

1. Hydrology and Hydraulics - The original design considerations are unavailable. Refer to Section 5, Hydrology and Hydraulics and Appendix E.
2. Embankment - The construction drawings address the embankment configuration only. Test pit locations are shown on the drawings, but subsurface data and interpretation of the data are not available. Although the original design data, if any existed, relative to soil strengths, foundation capacities, slope stability and seepage analyses were not available for review, the remedial study performed by Whitman, Requardt and Associates provides some indication of subsurface conditions within the embankment and foundation. Refer to Section 2.4.d. for discussion of the remedial grouting study.

3. Appurtenant Structures - Design data for the appurtenant structures is limited to dimensions and locations as shown on the construction drawings. Structural analyses of the concrete spillway were not available for review and comment.

c. Operating Records.

The daily pool levels, rainfall records and stream gage data for a limited period are the only written records. This data alone does not allow complete assessment of operating procedures relative to stability of the dam.

d. Post Construction Changes.

Subsequent to completion of the dam, pronounced seepage was observed at the right abutment. In the late 1930's, a hole appeared in the downstream face of the embankment, 8 feet down from the crest and 25 feet along the crest from the right abutment. The superintendent at the time, Mr. Lee Harne, filled the hole with concrete and no additional holes have been reported. In 1968, the City of Hagerstown retained Whitman, Requardt and Associates to study the seepage area and prepare remedial recommendations.

The Whitman, Requardt study consisted of a preliminary sub-surface exploration by test pits in the vicinity of the seepage points and utility trenches, monitoring of seepage outflow at several locations, test borings, and grouting program. The seepage monitoring indicated that the quantity of seepage varied directly with the height of water in the reservoir. Test pit observations suggested that the seepage was originating through the foundation and not through the embankment or along utility trenches. Anticipating a grouting program, six test borings were advanced at the right side of the dam along the crest. The test holes penetrated the embankment, extended into the rock foundation, and obtained soil samples, standard penetration blow counts, rock cores, and ground water levels. Dye was introduced into two of the test holes and was observed to issue from the seepage zones downstream of the dam shortly thereafter.

The results of the subsurface exploration indicated the embankment to consist of stiff silty clay with rock fragments corresponding to the "Selected Material, Compacted" zone shown on original construction drawings. No test holes were drilled in the "Ordinary Material, Compacted" zone. The foundation materials were found to be phyllite and shale which was weathered, fractured and relatively pervious in the seepage area. The initial test holes were pressure grouted and an additional 17 holes were drilled from 20 to 30 feet into the foundation and pressure grouted. Upon completion of the grouting program, the seepage stopped and has not re-occurred to date. Another seepage source beyond the left abutment was judged to be not directly related to the reservoir and dam and was not included in the Whitman, Requardt study.

Since completion of the spillway, the original pine planks lining the spillway floor have been removed and the concrete of both the floor and side walls restored. This work was allegedly performed in the 1930's by the Works Progress Administration. The timber crib at the spillway outfall has disappeared, but the plunge pool is rock lined and appears stable.

e. Seismic Stability.

The dam is located within seismic zone 1 immediately adjacent to zone 2 and static stability with normal safety factors should be sufficient to withstand minor earthquake induced dynamic forces. However, no calculations or studies have been performed to confirm static stability.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The dam and its appurtenant structures were found to be in good overall condition at the time of the inspection, April 9, 1979. The complete visual inspection check list is presented in Appendix A.

b. Dam.

1. There is a six-inch depression in the vicinity of the observation well near the right abutment. Otherwise, the horizontal and vertical alignment of the embankment is good.
2. There are minor surface irregularities in the rip-rap on the downstream slope. The slope has scattered trees and brush growth. Based upon an October, 1978, photograph at low pool, the upstream rip-rap is in good condition.
3. Flow from left side of the dam and downstream of the toe (springheads) are conveyed via a system of tile and plastic pipe to a stone outlet beyond the 30" blow-off pipe. The flow was clear and estimated to be between 10 and 15 gallons per minute. The pipe system was damaged in several locations.

c. Appurtenant Structures.

1. The concrete associated with the rectangular overflow spillway was in good condition.
2. Debris and sediment partially choke the outlet channel for the 30" blow-off pipe. The valve was inoperative at the time of the inspection.
3. The control and by-pass valves for the discharge mains are regularly operated.

d. Reservoir Area. The reservoir slopes are steep and heavily wooded. Sedimentation is not reported to be a problem.

e. Downstream Channel. The discharge from the overflow spillway joins the Raven Rock Stream to form the headwaters of Little Antietam Creek. There are boulder deposits within the stream channel as the slope becomes milder about 2000 feet downstream of the reservoir. In the event of a dam failure, approximately 5 homes, a commercial establishment, several State and County roads and the Western Maryland Railroad could be affected. Consequently, a hazard category of "high" appears appropriate for this dam.

3.2 Evaluation.

a. Dam

1. The depression near the right abutment is purportedly in the same general location where a hole appeared in the downstream face near the crest in the late 1930's. This area also corresponds to the area of seepage investigated in 1968. Referring to discussion in Section 2.4.d. and Section 6.1.a., the hole and depression is the result of internal erosion, loss of embankment material and subsequent "day-lighting" of voids. No indications of recent settlement were observed in this area during the inspection. The depression increases the potential for over-topping as discussed in Section 5.
2. The recent dumping of replacement rip-rap over the downstream slope may account for the non-uniform slope surface noted during the inspection. Tension cracks, toe heave, and/or alignment irregularities which might indicate deep seated movement of the dam slopes were not observed.
3. The 1968 investigation judged the seepage activity beyond the left abutment not as serious as the leakage at the right abutment and further evaluation was deferred until the spring of 1969. No record of the deferred evaluation was found during the data review. Based upon the relative clarity and apparent seasonal fluctuation of seepage, the source of discharge at the left abutment appears to be primarily spring activity not directly affecting the stability of the dam. However, the quantity and turbidity of seepage should be monitored on a routine basis.

b. Appurtenant Structures

1. Due to the annual draft and lack of formal operating policy, the 30-inch blow-off valve has not been exercised since a reservoir cleaning was accomplished in the 1940's. The valve is considered inoperable at this time.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedure. The purpose of this dam is to provide for municipal water supply for the City of Hagerstown, Maryland. The normal pool varies widely with the annual pattern of runoff, demand and diversion from the adjacent Raven Rock watershed. Discharges to the water supply system are accomplished by operation of valves downstream from the embankment toe. The drain valve (30-inch blow-off pipe) is presently thought to be inoperable. Uncontrolled discharges are through the overflow spillway at elevation 901.0, approximately four feet below the dam crest. Though unwritten, the diverted discharges from the Raven Rock watershed are ceased during periods of heavy rainfall.

4.2 Maintenance of the Dam. No written maintenance program has been established, but the general appearance of the dam indicates a high degree of pride and care.

4.3 Maintenance of Operating Facilities. With the exception of the inoperative drain gate, the operating facilities receive daily attention and as needed maintenance and repair.

4.4 Warning System. There is no formal warning system in effect although the resident manager at the dam site calls rainfall totals and reservoir stages into the County's Central Alarm which is linked to the Civil Defense System.

4.5 Evaluation. The general operational procedures are satisfactory except that no formal warning system is in effect and maintenance procedures are unwritten.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. The Edgemont Reservoir has a watershed area of 2.34 square miles and impounds a reservoir with a surface area of approximately 13 acres. The concrete overflow spillway beyond the right abutment can safely discharge 991 cfs. No hydrologic or hydraulic design data were available for the preparation of this report.

b. Experience Data. As previously stated, Edgemont Reservoir is classified as an intermediate size dam in the high hazard category. Under the recommended criteria for evaluating spillway discharge capacity, such structures are required to pass the Probable Maximum Flood (PMF). The maximum flood magnitude at the dam site is unknown but is believed by operating personnel to have occurred in March, 1936.

The PMF inflow hydrograph for the reservoir was determined utilizing the Dam Safety Version of the HEC-I computer program developed by the Hydrologic Engineering Center of the Corps of Engineers. The peak of the PMF inflow hydrograph is 5920 cfs. The input data and results of the program are presented in Appendix E.

c. Visual Observations. On the date of the inspection, no conditions were observed that would indicate that the spillway of the dam could not operate satisfactorily in the event of a flood.

d. Overtopping Potential. Various percentages of the PMF inflow hydrograph were routed through the reservoir to determine the percentage of PMF inflow that the dam can pass without overtopping. The analyses indicate that the 10% PMF level can be discharged without overtopping the embankment. Should the low point be filled and the dam crest brought to a uniform level, the dam can pass 20% of PMF without being overtopped.

e. Spillway Adequacy. Since the spillway can pass neither PMF nor $\frac{1}{2}$ PMF, the degree of inadequacy must be determined by first estimating the effect of overtopping upon the dam embankment. If overtopping causes the dam to fail, a breach analysis must then be performed to determine if a significant increase in hazard to loss of life exists.

The overtopping analysis of Appendix E indicates that $\frac{1}{2}$ PMF overtops the dam by approximately 1 foot for a period of 6.5 hours. The velocity over the dam crest at the low point is computed to be 4.8 feet per second which is considered sufficient to initiate erosional failure of the embankment. A breach analysis was therefore performed and is summarized as follows:

Assumption:

Breach Width	100 feet
Side Slopes	1V:1H
Failure Time:	2 hours
Failure Elevation:	905.65

Downstream Analyses:

Plan 1:	Dam fails @ 50% PMF
Plan 2:	No Failure @ 50% PMF

Results:

Maximum Stage, Section 3

Plan 1:	842.8
Plan 2:	840.1

Maximum Stage, Section 4

Plan 1:	786.6
Plan 2:	785.2

At the 50% PMF level, the analysis indicates that the breached structure would increase the downstream discharge rate from 2960 cfs to 5955 cfs. However, the wide flood plain in the danger reach/damage center results in minor increases in stage of less than 2 feet. The flood peak from the breached dam arrives at the damage center 15 minutes earlier than the peak assuming overtopping only. Based upon the visual observation of the downstream area, no significant increase in loss of life or damages are envisioned. Accordingly, the spillway is considered inadequate, not seriously inadequate.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

1. Embankment. The majority of the earthen embankment appears stable with no visible signs of cracking, settlement, or differential movement. The depression observed near the right abutment is judged to be the result of the internal seepage and loss of embankment material through the hydraulically open fracture system of the rock foundation which occurred prior to the grouting program implemented in 1968. Based upon the present absence of seepage, the grouting work is judged to have successfully treated the causes of internal erosion at the right abutment. The depressed area does not exhibit cracks or signs of recent movement and appears stable.

The downstream embankment slope of 1.5 horizontal to 1 vertical and the upstream slope configuration of 2 horizontal to 1 vertical are steep compared to modern design standards. The continued stability of these slopes under past operating conditions suggests that insitu soil strengths sufficient to resist sliding have been available. Since complete soil descriptions and laboratory strength tests are not available, the actual stability and factor of safety against sliding are unknown.

Seepage in the vicinity of the left abutment is clear with no signs of loss of embankment material. Considering the uniformity of the downstream slope and crest on the left side of the dam, the existence of seepage has not visibly affected the embankment.

2. Appurtenant Structures. The concrete overflow spillway appears to be in good condition with only minor cracking, spalling, and slight deterioration. Although flow in the spillway prevented direct observation of construction joints on the floor, some joints are suspected to be open. It could not be determined whether flow was occurring beneath the slabs, but the floor and walls appeared stable and settlement from undermining was not indicated.

b. Design and Construction Data

1. Embankment - The only design and construction data available are the construction drawings. The details shown on the drawings appear to be in accordance with the design practice of the period and reflect the project as completed. The remedial study and grouting work undertaken in 1968 provide subsurface data for at least a portion of the embankment. Split spoon sampling and standard penetration tests indicate the fill materials to be stiff to very stiff silty clays with rock fragments displaying penetration resistances of 15 to 30 blows per foot. Although the blow counts from the penetration tests could be affected by the presence of rock fragments, the test results are consistently high and the fill materials are judged to have been reasonably compacted during placement and subsequent consolidation. The test borings indicate that the fill was placed on rock and dense decomposed rock.

It should be noted that the silty clay embankment material indicated by the borings of the 1968 study is not a free draining material. As such, pore water pressures in the upstream embankment slope could become high and the factor of safety against shear failure reduced when the reservoir level is lowered rapidly. Ordinarily, upstream embankment slopes constructed of silty clay and subject to rapid drawdown (more than 6 inches of drawdown per day) would be designed at a configuration of between 3 to 4 horizontal to 1 vertical. The design slope configuration of 2 horizontal to 1 vertical is not in accordance with good engineering practice.

2. Appurtenant Structures - The details shown on the construction drawings are in accordance with accepted design practice.

c. Operating Procedures

Detailed operating procedures were unavailable for review. The daily pool level records and withdrawal rates indicate that drawdown on the order of 5 feet per day is possible. Considering the steeper than normal upstream slope and the relatively impervious clayey soils in the upstream zone of embankment, some stability problems could be generated by rapid drawdown.

d. Post Construction Changes

The post construction changes of foundation grouting and replacement of the timber spillway lining with concrete were performed as remedial work and should enhance the stability of the dam.

e. Seismic Stability

Edgemont Reservoir is located adjacent to seismic zone 2 and seismic stability is predicated upon static stability with conventional margins of safety. Since the static stability cannot be fully assessed with the data available, the stability of the dam under seismic activity is unknown.

SECTION 7
ASSESSMENT, REMEDIAL MEASURES
AND RECOMMENDATIONS

7.1 Dam Assessment:

a. Safety

Based upon visual inspection and review of design and construction data, the dam at Edgemont Reservoir appears to presently be in good condition. Some potential slope stability problems as addressed in section 2 and section 6 could exist, but do not pose an immediate safety hazard. Preliminary hydrologic and hydraulic analyses indicate the overflow spillway is capable of passing only 17 percent of PMF before the dam is overtopped. Since dam failure will not significantly increase loss of life or property damage in the event of overtopping by PMF, the spillway is judged to be inadequate, but not seriously inadequate.

b. Adequacy of Information

The available information consists of construction drawings, a remedial grouting study report, limited streamflow and rainfall data, and daily withdrawal rates and pool levels. With the exception of slope stability, this data is generally adequate to assess the project.

c. Urgency

Although immediate action is not required at this time, the recommendations of this section should be implemented as soon as possible.

d. Necessity for additional studies

Due to the inadequacy of the spillway, detailed hydrologic and hydraulic analyses should be performed so that remedial recommendations can be formulated.

7.2 Remedial Measures and Recommendations:

a. Dam and Appurtenant Structures

1. Initiate an engineering study to evaluate spillway capacity and determine remedial measures to reduce the overtopping potential at the dam.
2. The 30-inch drain valve should be restored to an operable condition and should be provided with a positive seal on the upstream side of the dam.
3. The seepage at the left abutment should be monitored on a routine basis to detect any changed conditions in quantity or turbidity. Flow measurements should be made with the use of a weir.

b. Operation and Maintenance Procedures

1. Document operating procedures in writing.
2. Remove woody vegetation from downstream embankment slope.
3. Develop a warning system to warn downstream residents of large spillway discharges during periods of heavy rainfall and runoff or failure of the dam.

APPENDIX A

CHECK LIST - VISUAL INSPECTION, SITE SKETCH, PHASE I

Check List
Visual Inspection
Phase I

Name of Dam Edgemont Reservoir County Washington State Maryland ID# MD-00006

Type of Dam Earth Hazard Category 1

Date(s) of Inspection 4/9/79 Weather Cloudy/Rain Temperature 45° F

Pool Elevation at Time of Inspection 901+ M.S.L. Tailwater 840+ M.S.L.

Inspection Personnel:

J. O. Smith

T. J. Moynahan

D. L. Moore

Owners Representatives:

William M. Breichner, Superintendent City of Hagerstown
Water Department

John Harne, Manager, Edgemont Reservoir

J. O. Smith, Recorder

EMBANKMENT

VISUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

SURFACE CRACKS

None

UNUSUAL MOVEMENT OR
CRACKING AT OR BEYOND
THE TOE

None

SLOUGHING OR EROSION OF
EMBANKMENT AND ABUTMENT
SLOPES

Riprap downstream slope-surface irregularities.

VERTICAL AND HORIZONTAL
ALIGNMENT OF THE CREST

Horizontal - good
Vertical - approximately 1/2 foot depression in vicinity of observation well #19
approximately 100 feet from right abutment

RIPRAP FAILURES

Upstream slope - good
Downstream slope - see above

EMBANKMENT

VISUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

JUNCTION OF EMBANKMENT
AND ABUTMENT, SPILLWAY
AND DAM

No erosion noted

ANY NOTICEABLE SEEPAGE

Flow from left side conveyed via system of tile and plastic pipe.
precise location of sources, if any, within dam foundation unknown:
flow clear and approximated at 15 gpm.

STAFF GAGE AND RECORDER

Stakes in pool area used by Manager to record daily pool levels
to nearest inch

DRAINS

No foundation drains on plans or noted in field

OUTLET WORKS- 30" C.I.P. blow off - drain

VISUAL EXAMINATION OF CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
	N/A	
INTAKE STRUCTURE	30" C.I.P. stub in pool at approximate elevation 850 condition not observable	
OUTLET STRUCTURE	30" geared valve and C.I.P. stub at toe at approximate elevation 840 operating condition unknown	
OUTLET CHANNEL	Debris noted, channel not used for reservoir releases since draining accomplished in 1940's.	
EMERGENCY GATE - Drain	Not operated since 1940's sediment level in	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Spillway consists of 25' wide rectangular concrete channel approximately 550 ft. long. Adverse approach slope, 25 ft. long @ 4%. Exit slope, approx. 125 ft. long @ 1%. Remainder of channel conforms to steep preconstruction natural grades and exits at approx. elevation 845.	
APPROACH CHANNEL	Clear of debris, concrete channel in good condition.	
DISCHARGE CHANNEL	Clear of debris, concrete channel in good condition slight spalling on side walls noted bituminous joint filler applied at construction joints approx. 2 yrs. ago. No differential movement or cracking noted.	
BRIDGE AND PIERS	Good condition.	

INSTRUMENTATION

VISUAL EXAMINATION OF INSTRUMENTATION/SURVEYS	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
	None noted	
OBSERVATION WELLS	Observation well number 19 near right abutment remains in place from 1968 remedial grouting readings not recorded since 1968 study.	
PIERS	None	
TEZOMETERS	None	

RESERVOIR

USUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

SLOPES

Steep and wooded.
No movement noted.

SEDIMENTATION

Not a great problem according to resident Manager.
Reservoir drained and cleaned in 1940's.
Volume removed unknown.
1976 police search by divers reported clear conditions on bottom.

DOWNSTREAM CHANNEL

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

CONDITION
(OBSTRUCTIONS,
DEBRIS, ETC.)

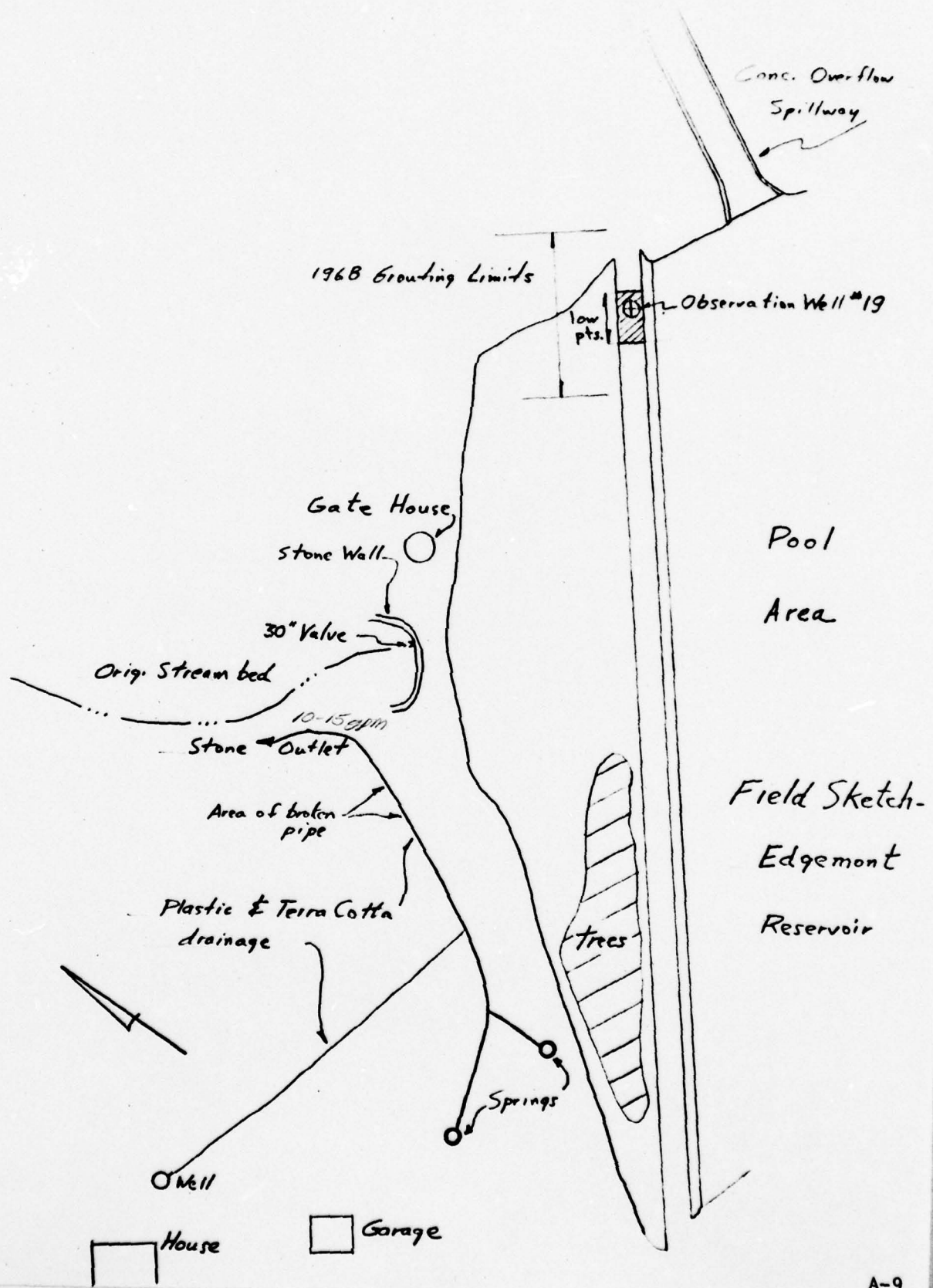
Confluence of Warner Gap Hollow and Raven Rocks stream
form Little Antietam Creek; boulder and cobble bed load
deposits noted.

SLOPES

Some degradation noted.

APPROXIMATE NO.
OF HOMES AND
POPULATION

5 to 10 homes and some commercial in danger reach.



APPENDIX B

CHECK LIST - ENGINEERING DATA, DESIGN, CONSTRUCTION, OPERATION,

PHASE I

DAM NAME: Edgemont Reservoir
ID # MD 00006

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 2.34 mi², City owns 907 acres
moderate to steeply sloping valley walls, heavily wooded.

ELEVATION TOP OF NORMAL POOL (STORAGE CAPACITY): 901.0(246 Ac-Ft)

ELEVATION TOP OF FLOOD CONTROL POOL (STORAGE CAPACITY): -----

ELEVATION MAXIMUM DESIGN POOL: -----

ELEVATION TOP OF DAM: 905 (296 Ac-Ft), low pt. 904.65(292 Ac-Ft)

CRESTS

- a. Elevation 901.0
- b. Type Concrete, rectangular channel
- c. Width 25 feet
- d. Length -----
- e. Location Spillover Discharges parallel to dam axis beyond rt.
- f. Number and Type of Gates None abutment.

OUTLET WORKS:

- a. Type Two 12" C.I.P. water supply mains
- b. Location Near right abutment
- c. Entrance Inverts -----
- d. Exit Inverts -----
- e. Emergency Drawdown Facilities 30" C.I.P. inoperable

HYDROMETEOROLOGICAL GAGES:

- a. Type Standard 8 inch precipitation gage (non-recording)
- b. Location Immediately below dam at site superintendant's residence
- c. Records Daily totals phoned to National Weather Service

MAXIMUM NON-DAMAGING DISCHARGES: -----

ITEM

REMARKS

SPILLWAY PLAN

SECTIONS

Available

DETAILS

Yellow pine flooring and sides of spillway is not present, allegedly due to damages sustained in flood of March, 1936 spillway is smoothly finished concrete.

OPERATING EQUIPMENT
PLANS & DETAILS

No operating equipment

Available plans and details are on three plans sheets dated October 1, 1968 which were traced from original plan sheets dated January 1902 by the American Pipe Manufacturing Company, Engineers and Contractors of Philadelphia, Penna.

ITEM

REMARKS

MONITORING SYSTEMS Well #19 from 1968 grouting program. No data available since 1968.

MODIFICATION No known modifications.

HIGH POOL RECORDS Daily pool levels maintained by resident superintendent and recorded at Hagerstown Water Department offices 790-3200 x 218.

POST CONSTRUCTION ENGINEERING "Edgemont Reservoir Investigation of Leakage with Remedial Grouting"
STUDIES & REPORTS dated November, 1968 by Whitman, Reguardt and Associates.

PRIOR ACCIDENTS OR FAILURE OF DAM Apparent internal erosion failure near right abutment in late 1930's. No
DESCRIPTION technical reports available.
REPORTS

MAINTENANCE OPERATION RECORDS Records of 1968 grouting program.

REMARKS

ITEM

DESIGN REPORTS None

GEOLOGY None

DESIGN COMPUTATIONS None
HYDROLOGY & HYDRAULICS None
DAM STABILITY None

SEEPAGE STUDIES No original, foundation seepage investigated in 1968

MATERIALS INVESTIGATIONS Test pits mentioned on plans, but information not available
BORING RECORDS None
LABORATORY None 23 borings taken thru embankment and into foundation, May - July, 1968
FIELD None

POST CONSTRUCTION SURVEY OF DAM None

BORROW SOURCES Thought to be in present pool

ITEM

REMARKS

AS BUILT DRAWINGS None

REGIONAL VICINITY MAP Available

CONSTRUCTION HISTORY None

TYPICAL SECTIONS OF DAM Available, note, upstream and downstream slope designators are correct, but drawing is reversed. i.e. the steeper slope, 1 1/2H:1V, is the downstream slope.

OUTLETS - PLANS Available

- DETAILS Not Available

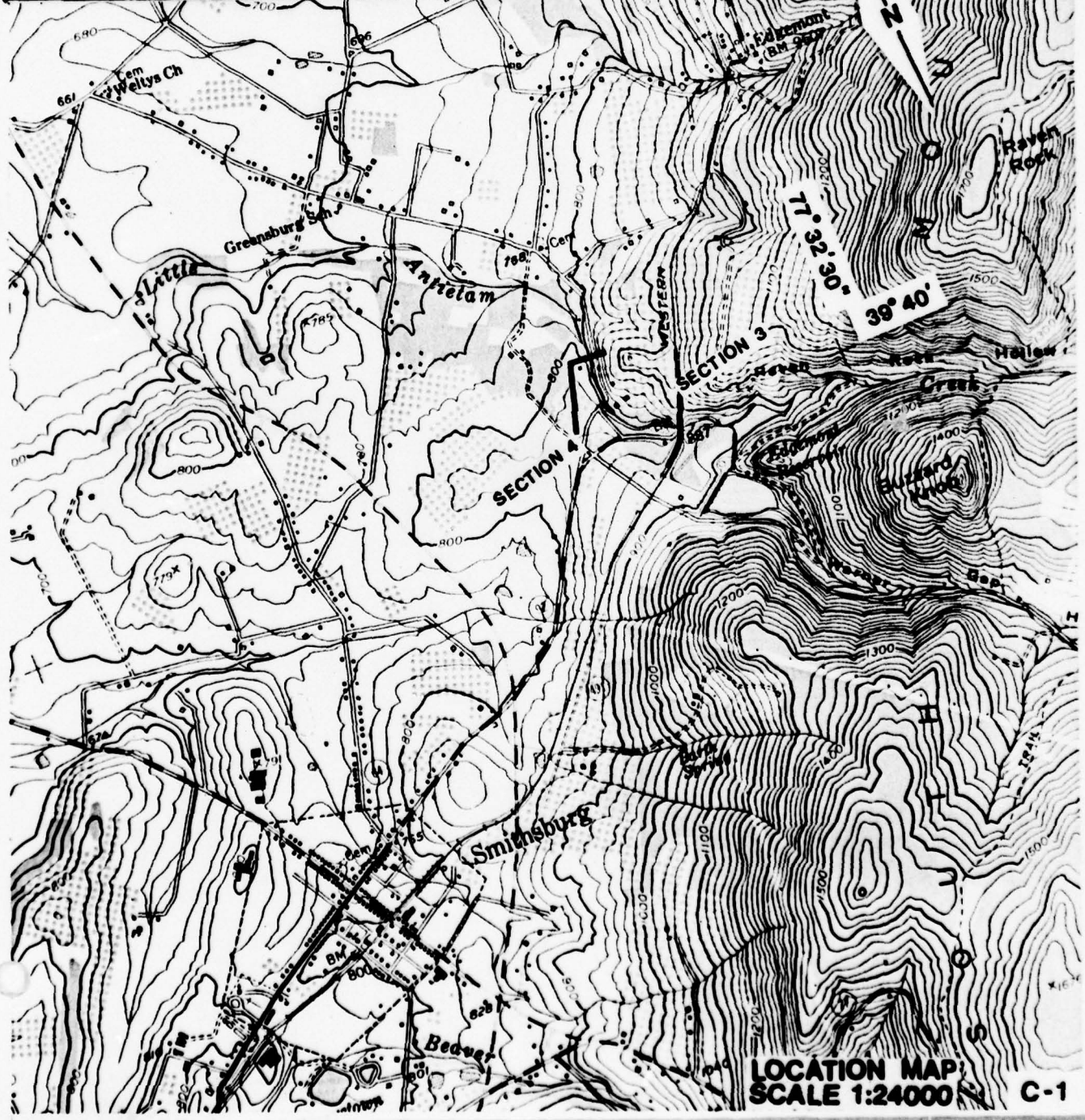
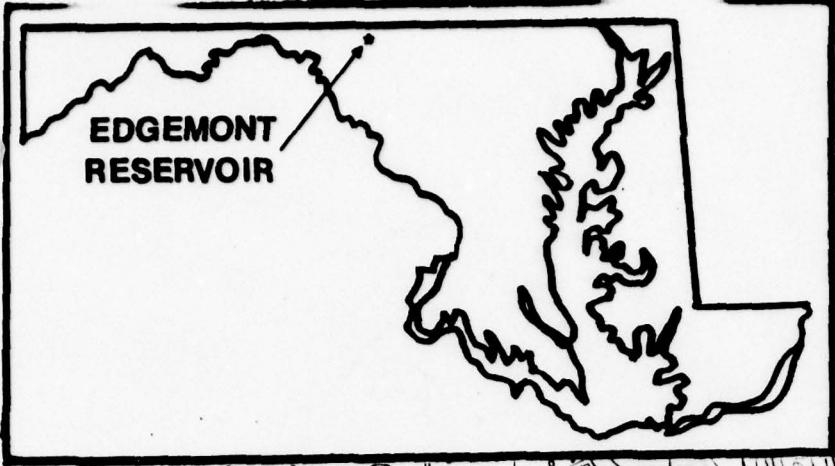
-CONSTRAINTS Drain not operable, additional valves have been added to by-pass gate house

- DISCHARGE RATINGS Not Available

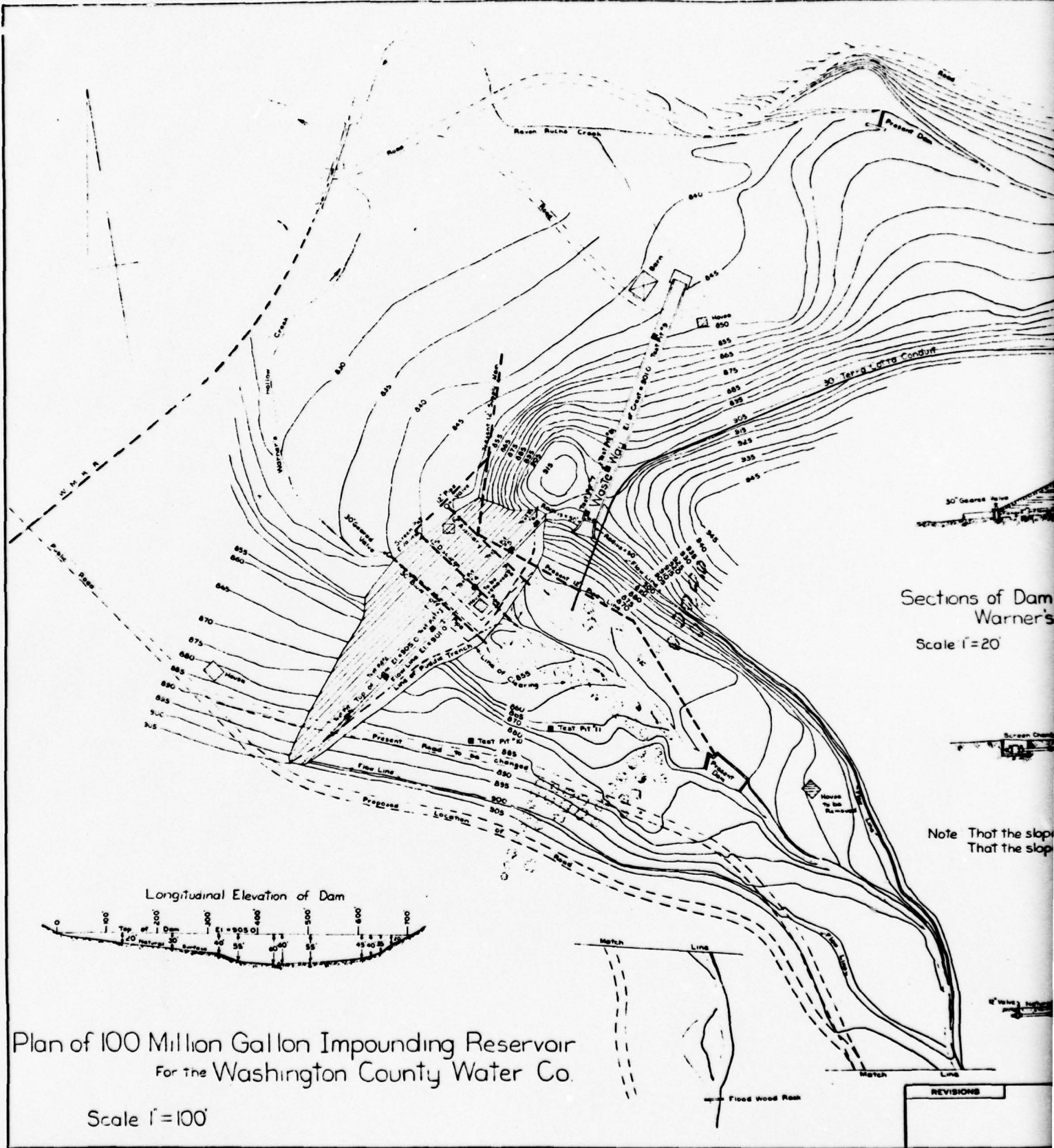
RAINFALL/RESERVOIR RECORDS

Daily records kept at Hagerstown Water Department Edgemont Gage- 40 yrs. of record.

APPENDIX C
LOCATION MAP & PLANS



**LOCATION MAP
SCALE 1:24000 C-1**



Sections of Dam
Warner's
Scale 1" = 20'

Note That the slope
That the slope

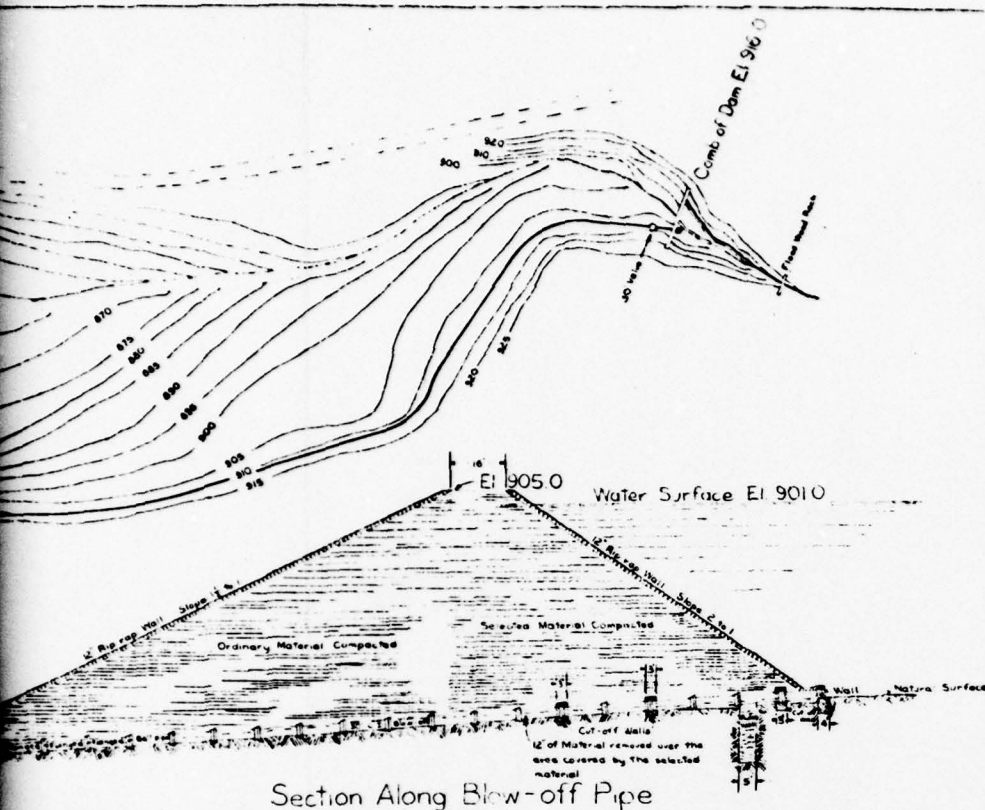
Longitudinal Elevation of Dam



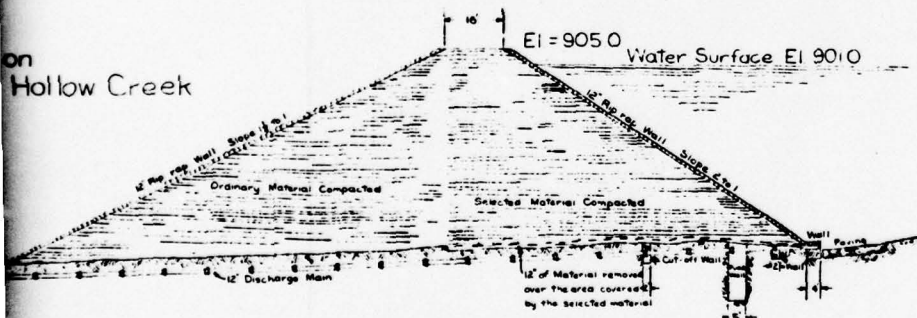
Plan of 100 Million Gallon Impounding Reservoir
for the Washington County Water Co.

Scale 1" = 100'

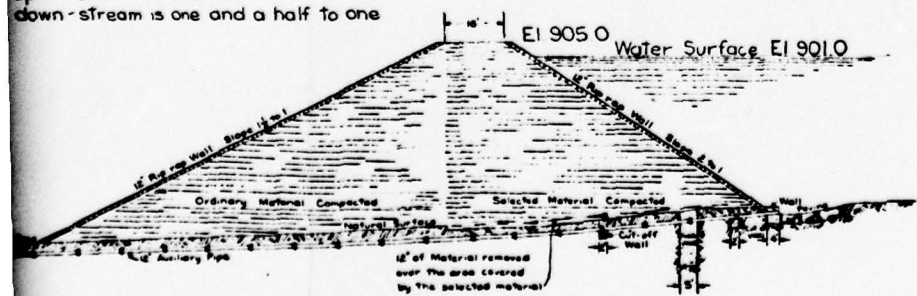
NO.	DATE	REVISIONS



on Hollow Creek

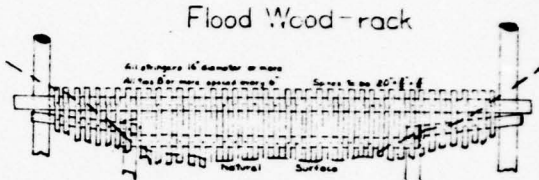
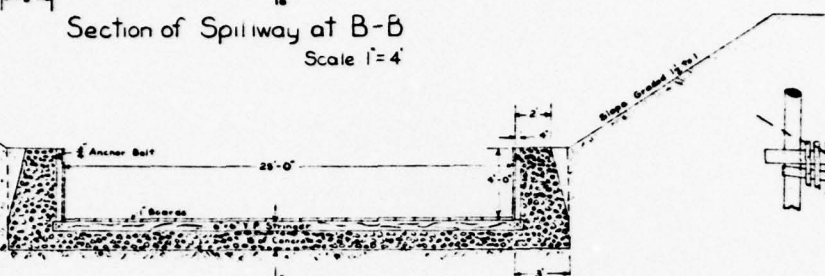
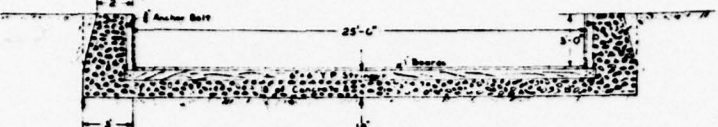
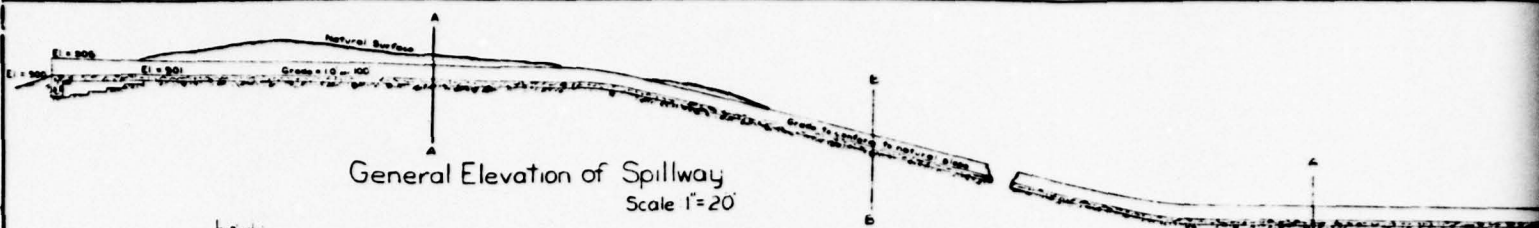


up-stream is two to one
down-stream is one and a half to one



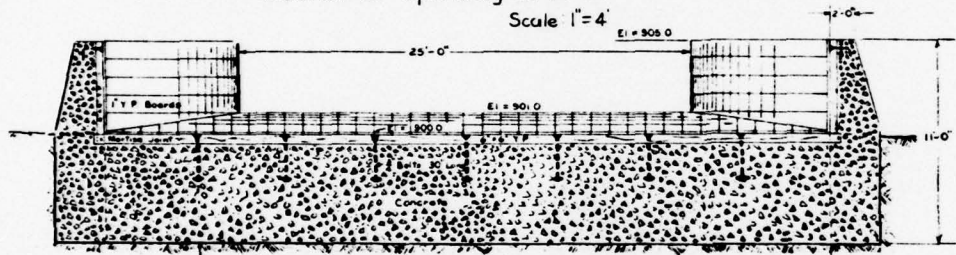
TITLE 100 Million Gallon Impounding Reservoir		CITY OF HAGERSTOWN, MARYLAND BOARD OF WATER COMMISSIONERS	
LOCATION Edgemont Reservoir		FILE NUMBER	
SCALE As Shown	DRAWN M.L.S.	DATE Oct 1, 1966	APPROVED SUPERVISOR DATE 6-3

2

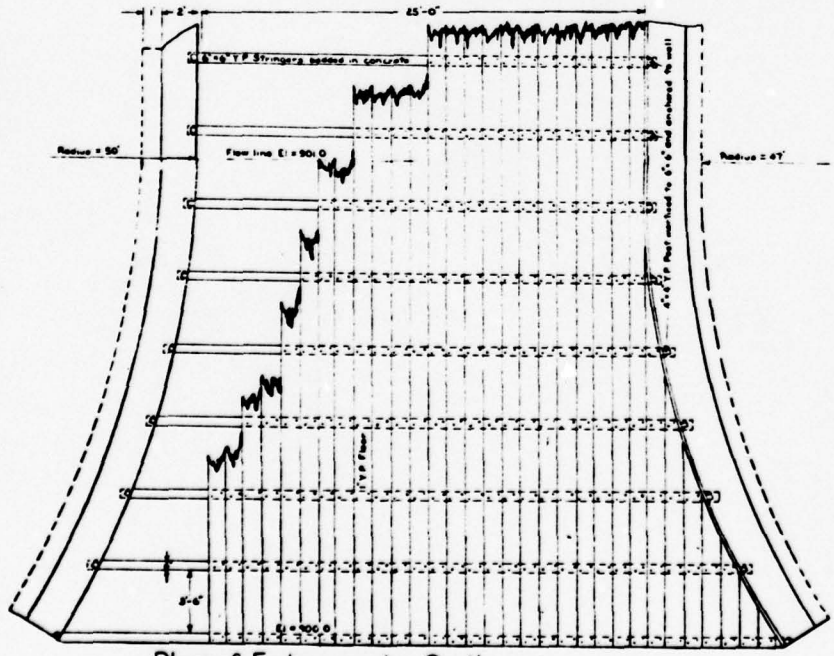


Elevation at End of Crib

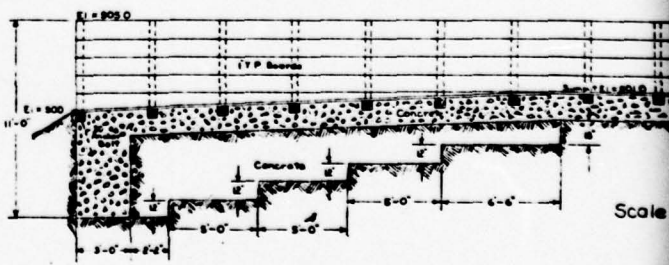
Detail of Intake Screen at Rave



Elevation of Entrance to Spillway



Plan of Entrance to Spillway

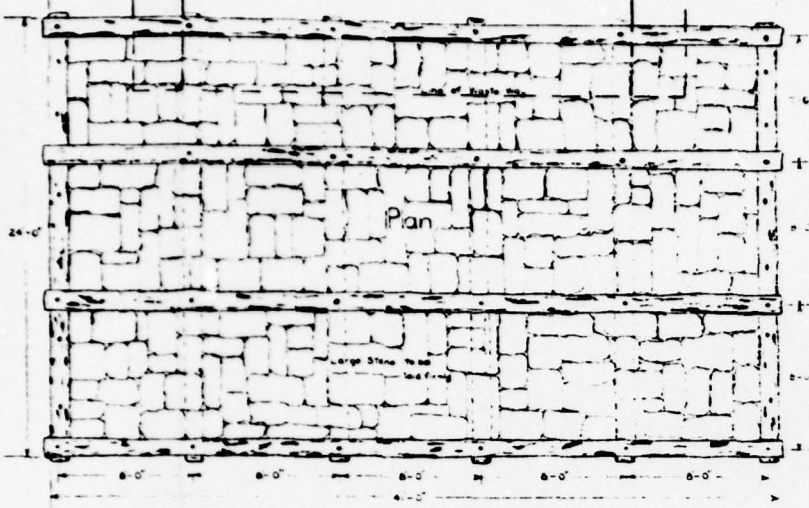


Sectional Elevation of Entrance to Spillway

REVISIONS

Crib at End of Spillway

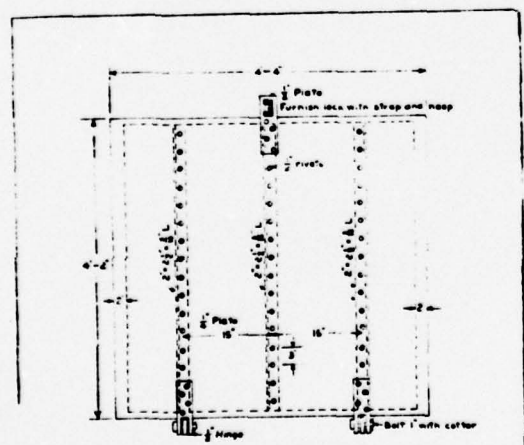
Scale 1"=4'



Front Elevation

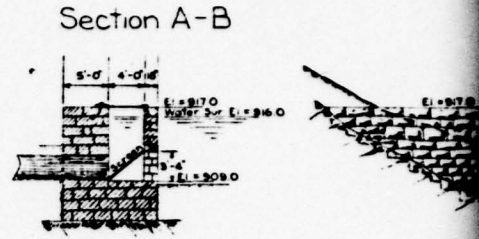
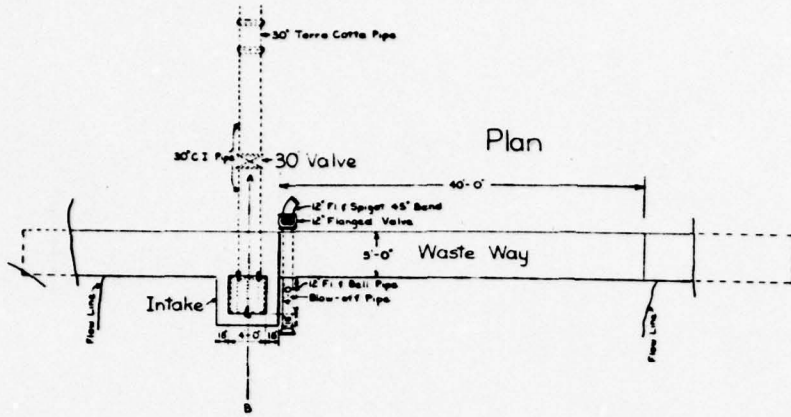
Raven Rocks Creek Dam

Scale 1"=1'

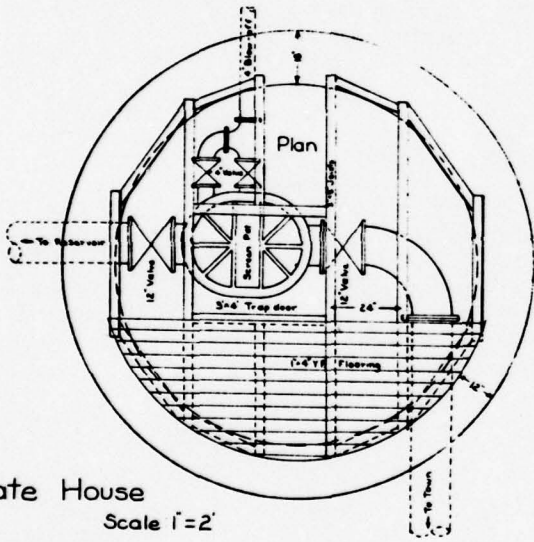


Detail of Iron Door on Intake
at Raven Rocks Creek Dam
Scale 1"=1'

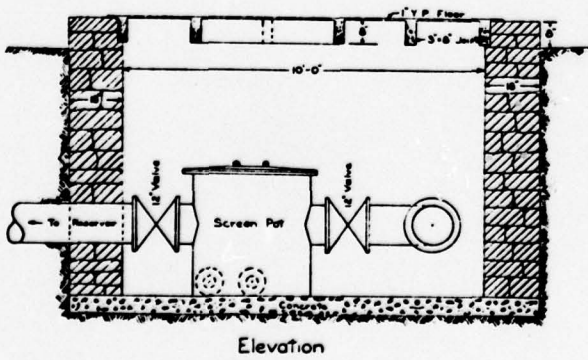
TITLE 100 Million Gallon Impounding Reservoir		CITY OF HAGERSTOWN, MARYLAND BOARD OF WATER COMMISSIONERS	
LOCATION Edgemont Reservoir		APPROVED _____	FILE NUMBER 6-3
SCALE As Shown	DRAWN BY M.L.S.	DATE OCT 1, 1968	



Details of Dam on Raven Rocks Creek
Scale 1"=8'

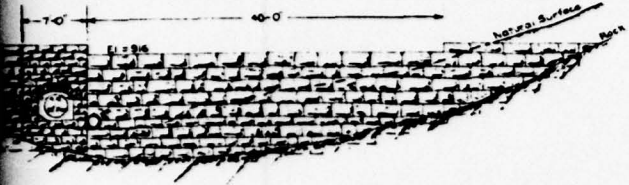


Gate House
Scale 1"=2'



REVISIONS

Elevation



TITLE <u>100 Million Gallon Impounding Reservoir</u>		CITY OF HAGERSTOWN, MARYLAND BOARD OF WATER COMMISSIONERS	
LOCATION <u>Edgemont Reservoir</u>		APPROVED _____	FILE NUMBER <u>6-3</u>
SCALE <u>As Shown</u>	DRAWN BY <u>M.L.S.</u>	DATE <u>Oct 1, 1966</u>	

2

C-4

APPENDIX D

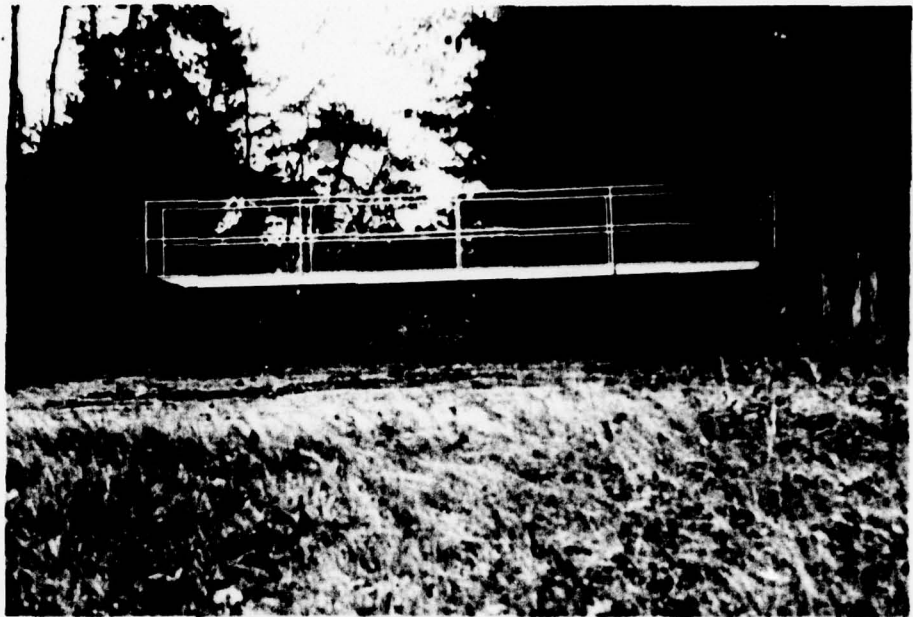
PHOTOGRAPHS



CREST



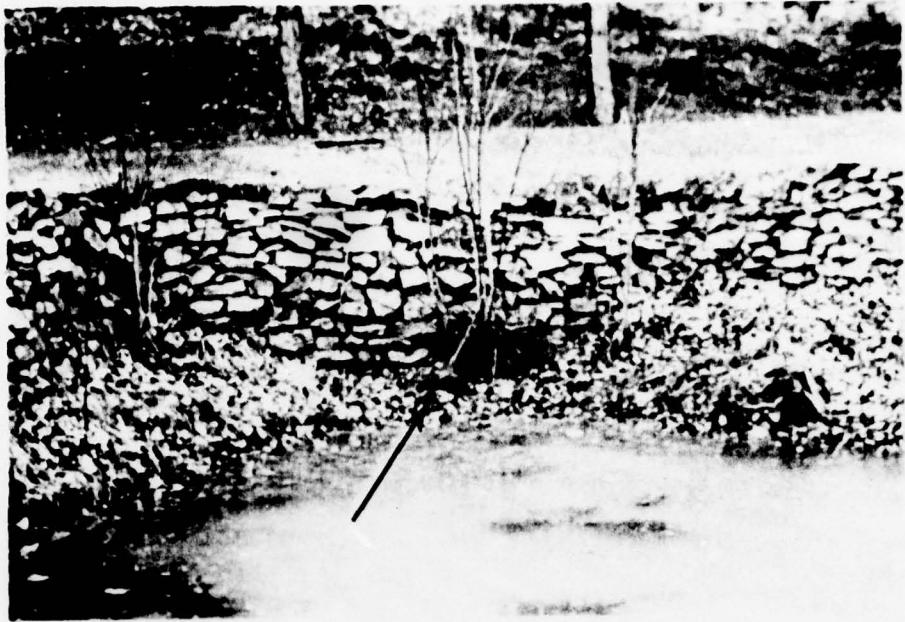
DOWNSTREAM FACE-VIEWED FROM
RIGHT ABUTMENT



OVERFLOW SPILLWAY-ENTRANCE



OVERFLOW SPILLWAY



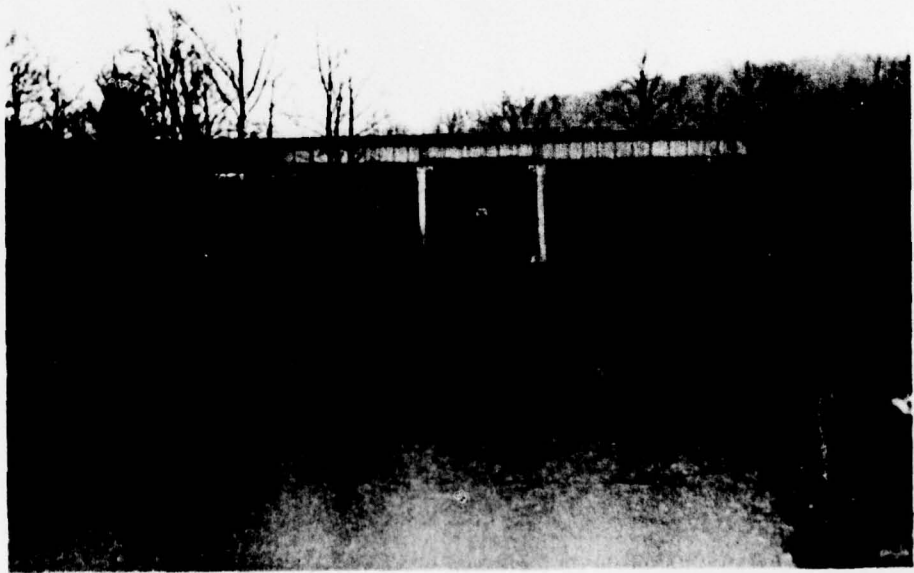
30" BLOW-OFF (DRAIN)



SEEPAGE, LEFT SIDE BEYOND TOE



GATE HOUSE



DOWNSTREAM R. R. CROSSING
(STATION #3 OF
HYDRAULIC ROUTINGS)



DOWNSTREAM COMMERCIAL



DOWNSTREAM DWELLING
(STATION #4 OF
HYDRAULIC ROUTINGS)

APPENDIX E
ANALYSES

Contents

Sheet	E-2	Stage-Area-Volume Calculations
	E-3 thru E-6	Stage-Discharge Calculations
	E-7	Snyder's Unit Hydrograph Coefficients and PMP Indices
	E-8 thru E-11	Overtopping Analysis, Computer Output
	E-12	Overtopping Velocity Calculation
	E-13	Breach Parameter Calculations
	E-14 thru E-21	Breach Analysis, Computer Output
	E-22	Drainage Area Map

Elev.	Area, in ²	Area, Ac	Avg. Area	Δ Vol, Ac-Ft	Cumul. Vol.
855	1.85	0.425	-	0	0
860	3.47	0.797	0.611	3.05	3.05
865	7.94	1.82	1.31	6.55	9.6
870	12.19	2.80	2.31	11.5	21.1
875	18.22	4.18	3.49	17.45	38.55
880	23.98	5.50	4.84	24.2	62.75
885	31.09	7.13	6.32	31.6	94.35
890	37.0	8.49	7.81	39.05	133.4
895	42.52	9.76	9.12	45.6	179.0
900	51.77	11.9	10.83	54.15	233.1
901					246 interpolated
905	58.8	13.5	12.7	63.5	296.65
910	Est.	15	14.25	71.25	367.9

Edgemont

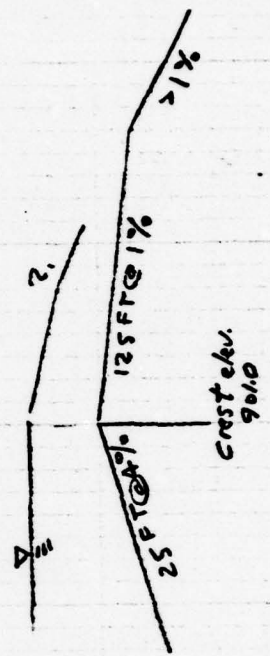
Stage - Area - Volume

from 1"=100ft. plan sheet (see C-2)

Stage	Depth	Area, Ft ²	Wet. Perim.	Hyd. Radius	R ^{1/3}	R ^{2/3}
901	0	0	0	0	0	0
901.5	.5	12.5	26	.48	.38	.61
902	1	25	27	.93	.90	.95
902.5	1.5	37.5	28	1.34	1.47	1.22
903	2	50	29	1.72	2.06	1.44
903.5	2.5	62.5	30	2.08	2.65	1.64
904	3	75	31	2.42	3.24	1.81
904.5	3.5	87.5	32	2.73	3.81	1.96
905	4	100	33	3.03	4.37	2.10
906	5	125	35	3.57	5.44	2.35
907	6	150	37	4.05	6.43	2.55
908	7	175	39	4.49	7.36	2.73

Spillway Data

Crest elev. - 901.0
 adverse entrance slope, 4%, length, 25 FT
 exit slope, 1%, length, 125 FT
 remaining length, 400 FT, > 1%
 width = 25 FT, vertical sides



Edge-mont Reservoir
 Stage - Discharge Calcs

Spillway Capacity at top of Dam

at stage 905, $d=4$, $A=100$, $T=25$, $R^{4/3} = 4.37$

Using: $Q^2/g = A^3/T$, S_c , critical slope, = $\frac{14.56n^2 d_m}{R^{4/3}}$

$d_m = Q_c^2 / A^3 g$ all referenced from Soil Cons. Service

NEH-5 p. 5.4-8 and 10

Assuming $n = 0.013$ for concrete

$$Q_c = (gA^3/T)^{1/2} = (32.2 \times (100)^3 / 25)^{1/2} = 1135 \text{ cfs}$$

$$d_m = Q_c^2 / A^3 g = (1135)^2 / (100)^2 \times 32.2 = 4 \text{ FT}$$

$$S_c = \frac{14.56n^2 d_m}{R^{4/3}} = \frac{14.56(0.013)^2 \times 4}{4.37} = 0.0023 \text{ FT/FT}$$

$0.01 > 0.0023$ \therefore critical depth

occurs at control & discharge = $Q_c = 1135 \text{ cfs}$

Overtopping Discharge thru Spillway

at stage 90B, $d=7$, $A=175$, $T=25$, $R^{4/3} = 7.36$

$$Q_c = (32.2 (175)^3 / 25)^{1/2} = 2627 \text{ cfs}$$

$$d_m = (2627)^2 / (175)^2 \times 32.2 = 7 \text{ FT}$$

$$S_c = 14.56 (0.013)^2 \times 7 / 7.36 = 0.0023 < 0.01 \text{ OK}$$

$$Q = Q_c = 2627 \text{ cfs}$$

Additional Discharges - Spillway

at stage 902, $d=1$, $A=25$, $T=25$, $R^{4/3} = 0.90$

$$Q_c = (32.2 (25)^3 / 25)^{1/2} = 142 \text{ cfs}$$

$$d_m = (142)^2 / (25)^2 \cdot 32.2 = 1 \text{ FT}$$

$$S_c = 14.56 (0.013)^2 / 0.90 = 0.0027 < 0.01 \text{ OK}$$

$$Q = Q_c = 142 \text{ cfs}$$

at stage 903, $d=2$, $A=50$, $T=25$, $R^{4/3} = 2.06$

$$Q_c = (32.2 (50)^3 / 25)^{1/2} = 401 \text{ cfs}$$

$$d_m = 2 \text{ FT} \quad [d_m = d \text{ due to channel uniformity}]$$

$$S_c = 14.56 (0.013)^2 / 2.06 = 0.0024 < 0.01 \text{ OK}$$

$$Q = Q_c = 401 \text{ cfs}$$

at stage 904, $d=3$, $A=75$, $T=25$, $R^{4/3} = 3.24$

$$Q_c = (32.2 (75)^3 / 25)^{1/2} = 737 \text{ cfs}$$

$$d_m = 3, \quad S_c = 14.56 (0.013)^2 / 3.24 = 0.023 < 0.01 \text{ OK}$$

$$Q = Q_c = 737 \text{ cfs}$$

at stage 904.5, $d=3.5$, $A=87.5$, $T=25$, $R^{4/3} = 3.81$

$$Q_c = (32.2 (87.5)^3 / 25)^{1/2} = 929 \text{ cfs}$$

$$d_m = 3.5, \quad S_c = 14.56 (0.013)^2 / 3.81 = 0.0023 < 0.01 \text{ OK}$$

$$Q = Q_c = 929 \text{ cfs}$$

Spillway Stage-Discharge Summary

	Stage, MSL	Discharge, cfs
spillway crest	901	0
	902	142
	903	401
	904	737
approx. 100 ft.	904.5	929
dam crest	905	1135
	908	2627

Snyders UH Coefficients

using Balto. District regional curves

$$\text{Zone 32} \rightarrow C_p = 0.75$$

$C_t = \text{Plate K, Potomac River West}$
of Monocacy

$$\text{use } t_p = 1.90 (L L_{ca})^{0.3} = 2.95$$

$$\text{where } L = 7.4'' \times 2000 \frac{\text{EI}}{\text{in}} = 14800 \text{ FT} = 2.8 \text{ mile}$$

$$L_{ca} = 4.1'' \times 2000 = 8200 = 1.55 \text{ mile}$$

From Hydromet 33, PMP Index = 23.7 inch, Zone 6

read	R_6	R_{12}	R_{24} from 10 mi^2 (pt. rainfall)
	113%	123%	132%

 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79

ANALYSIS
 SNYDER UNIT HYDROGRAPH, FLOOD ROUTING, AND DAM OVERTOPPING
 WARNERS HOLLOW CREEK DAM, WASHINGTON CO., MD. H.D.I. M000006
 FOR 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, AND 100% PMF

	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	A1	160	0	15	0	0	0	0	0	0
2	A2									
3	A3									
4	B									
5	B1									
6	J									
7	J1									
8	K									
9	K1									
10	M									
11	P									
12	T									
13	M									
14	X									
15	K									
16	K1									
17	Y									
18	Y1									
19	Y4									
20	Y5									
21	Y5									
22	Y5									
23	Y5									
24	Y5									
25	Y5									
26	Y5									
27	Y5									

 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79

RUN DATE* 79/04/23.
 TIME* 08.47.58.

SNYDER UNIT HYDROGRAPH, FLOOD ROUTING, AND DAM OVERTOPPING ANALYSIS
 WARNERS HOLLOW CREEK DAM, WASHINGTON CO., MD. N.O.I. M000006
 FOR 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, AND 100% PMF

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
160	0	15	0	0	0	0	0	-4	0

JOPER 5
 JOPFR 0 0 0

MULTI-PLAN ANALYSES TO BE PERFORMED
 NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS= .10 .20 .30 .40 .50 .60 .70 .80 1.00

SUB-AREA RUNOFF COMPUTATION

CALCULATION OF PMF RATIOS TO WARNERS HOLLOW CREEK DAM

ISTAO	ICOMP	IFCON	ITAPE	JPLT	JPR1	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYOG	IYHG	TAREA	SNAP	TPSDA	TPSPC	RATIO	ISNOV	ISAKE	LOCAL
1	1	2.34	0.00	2.34	0.00	0.000	0	1	0

PPFCIP DATA

SWFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.70	113.00	123.00	132.00	0.00	0.00	0.00

LOSS DATA

LPROPT	STRKR	DLTKR	RTIOL	IRAIN	STRKS	RTIOK	STRTL	CHSTL	ALSHX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

TPSPC COMPUTED BY THE PROGRAM IS ,ADD

UNIT HYDROGRAPH DATA
 TP= 2.95 CP= .75 NTAP= 0

PRECIPITATION DATA
 STRTO= -1.00 ORCSN= -.05 RTIQR= 2.00

UNIT HYDROGRAPH % END-OF-PERIOD ORIGINATES	LAG=	2.95 HOURS	CP=	.75	WTL=	1.00
10.	77.	170.	215.	263.	308.	345.
347.	370.	335.	293.	255.	222.	193.
145.	127.	96.	73.	63.	55.	48.
36.	31.	24.	18.	16.	14.	12.

9. 8. 7. 6. 5. 4.

MO. DA	HR. MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW	MO. DA	HR. MN	PERIOD	RAIN	EXCS	LOSS	COMP				
SUM													25.03	23.18	1.65	141613.	
													(636.11	599.11	47.11	4216.03)

HYDROGRAPH ROUTING

ROUTED FLOWS THROUGH EDGEWATER RESERVOIR

ISTAO 2 ICOMP 1 IECON 0 ITAPE 0 JPLT 0 JPRT 0 INAME 1 ISTATE 0 IAUTO 0

ROUTING DATA
 CROSS 0.000 AVG 0.000 ITRFS 1 ISAME 1 IOPT 0 IPMP 0 LSTR 0

MSIPS 1 NSTOL 0 LAG 0 AYSKK 0 TSK STORA ISPRAT -1

STAGE	321.00	902.00	903.00	904.00	904.50	905.00	905.00
FLOW	6.00	142.00	401.00	737.00	929.00	1135.00	2627.00
CAPACITY	0.	10.	39.	94.	133.	179.	233.
ELEVATION	955.	965.	975.	985.	990.	995.	900.

CRFL SVID COOW EXPW ELFVL COOL CAREA FPRL
 901.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

DAM DATA
 TOPEL COOC EXPD DAMVID
 906.7 3.1 1.5 700.

CREST LENGTH 0. 90. 700.
 AT OR BELOW
 ELEVATION 906.7 906.9 905.0

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

OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				.10	.20	.30	.40	.50	.60	.70	.80	1.00
HYDROGRAPH AT	1	2.34 (6.06)	1	592. (16.76)	1184. (33.53)	1776. (50.29)	2368. (67.06)	2960. (83.82)	3552. (100.58)	4144. (117.35)	4736. (134.11)	5920. (167.64)
ROUTED TO	2	2.34 (6.06)	1	577. (16.33)	1177. (33.32)	1775. (50.26)	2367. (67.04)	2960. (83.81)	3552. (100.58)	4144. (117.34)	4736. (134.11)	5920. (167.65)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION STORAGE	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	903.52	901.00	901.00	904.65
	905.00	246.	246.	292.
	905.31	0.	0.	991.
	905.52			
	905.71			
	905.88			
	906.04			
	906.18			
	906.44			

RATIO OF PMF	MAXIMUM RESERVOIR ELEV.	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	903.52	0.00	278.	577.	0.00	19.00	0.00
.20	905.00	.35	297.	1177.	2.25	18.75	0.00
.30	905.31	.66	301.	1775.	4.25	18.50	0.00
.40	905.52	.87	304.	2367.	5.50	18.50	0.00
.50	905.71	1.06	307.	2960.	6.50	18.50	0.00
.60	905.88	1.23	309.	3552.	7.25	18.50	0.00
.70	906.04	1.19	311.	4144.	7.75	18.50	0.00
.80	906.18	1.53	313.	4736.	8.00	18.50	0.00
1.00	906.44	1.81	317.	5920.	9.00	18.50	0.00

Over topping Velocities

thru low section: assume parabolic shape, top width = 50 FT
@ 0.2 PMF stage = 905.0 depth = 0.35 FT

$$\text{Area} = \frac{2}{3}(0.35)50 = 11.67 \text{ FT}^2$$

$$Q_c = (32.2 (11.67)^3 / 50)^{1/2} = 32 \text{ cfs}$$

$$V = Q/A = 32/11.67 = 2.7 \text{ fps}$$

over dam @ 0.5 PMF, stage = 905.71

$$\text{Area} = 700 \text{ FT} \times 0.71 \text{ FT} = 497 \text{ FT}^2$$

$$Q_c = (32.2 (497)^3 / 700)^{1/2} = 2376 \text{ cfs}$$

$$V = Q/A = 2376/497 = 4.8 \text{ fps for 6.5 hours}$$

velocities are high enough to assume an
erosional failure would begin during $\frac{1}{2}$ PMF

\therefore run breach analysis to assess the
degree of spillway inadequacy

Breach Parameters

as suggested by HEC-1 Dam Safety Version
& file information

Breach Width : ht. of dam = 60 FT
 $\frac{D}{2} \leq \text{breach width} \leq 3D$
 $60/2 \leq \text{breach width} \leq 180$
or $30 \leq \text{breach width} \leq 180$

USE 100 FT

Side Slope : $0 < Z < 1$ USE $Z = 1$

Failure Time : $0.5 < T_{\text{FAIL}} < 4$

USE $T_{\text{FAIL}} = 2$ hrs. based upon

rock slope protection & engineered fill

Failure Elevation: USE 905.65 for FAILED
or 1 FT above low pt. or 0.65 FT
above nominal dam crest

Run Multi-plan analysis @ 50% PTF

with 1 plan allowing a breach and 1 plan
not allowing a breach, so that downstream

stages and time to peaks can be compared in the
assessment of spillway inadequacy - seriously inadequate or not

 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79

A1 SNYDER UNIT HYDROGRAPH, FLOOD ROUTING, AND DAM BREACH ANALYSIS
 A2 WARNERS HOLLOW CREEK DAM, WASHINGTON CO., MD. N.D.I. M000006
 A3 FOR 50% PMF PLAN 1 IS FAILURE, PLAN 2 IS NO BREACH

1	B	160	0	15	0	0	0	-4	0
5	B1	5							
6	J	2	1	1					
7	J1	.50							
8	K	0	1						
9	K1								1
10	M	1	2.34		2.34				1
11	P		23.7	113	123	132			
12	T								1
13	W	2.95	0.75						.05
14	X	-1.0	-0.05	2.0					
15	K	1	2						1
16	K1								
17	Y								
18	Y1	1							246
19	Y4	901	902	903	904	904.5	905		908
20	Y5	0	142	401	737	929	1135	2827	
21	Y5	0	9.6	38.5	94.3	133.4	179.0	233.1	246.0
22	Y5	855	865	875	885	890	895	900	901
23	Y5	901							905
24	Y5	904.65	3.1	1.5	700				
25	Y5	0	50	700					
26	Y5	904.65	904.9	905					
27	Y5	100	1	860	2	901	905.65		
28	Y5	100	1	860	2	901	906.00		
29	Y5	1							
30	Y5	1	3						
31	Y								
32	Y1	1							
33	Y6	.04	.03	.04	835	880	1000	.02	
34	Y7	0	980	20	860	35	845	45	835
35	Y7	76	845	96	845	130	880		75
36	K	1	4						
37	K1								
38	Y								
39	Y1	1							
40	Y6	.04	.03	.04	780	830	1500	.037	
41	Y7	0	830	800	820	1400	783	1401	780
42	Y7	1417	783	1417	793	1540	830		
43	K	99							

 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79

SUN DATE# 79/04/23.
 TIME# 09.02.35.

SNYDER UNIT HYDROGRAPH, FLOOD ROUTING, AND DAM BREACH ANALYSIS
 WARNERS HOLLOW CREEK DAM, WASHINGTON CO., MD. N.D.I. H000006
 FOR 50% PMF PLAN 1 IS FAILURE. PLAN 2 IS NO BREACH

NO	MHR	NMIN	IDAY	JOB SPECIFICATION					
				IHR	IMIN	METRC	IPLT	IPRT	NSTAN
166	0	15	0	0	0	0	0	-4	0
	JOPER			NVT	LROPT	TRACE			
			5	0	0	C			

MULTI-PLAN ANALYSES TO BE PERFORMED
 NPLAN= 2 NRTIO= 1 LRTO= 1

RTIOS= .50

SUB-AREA RUNOFF COMPUTATION

CALCULATION OF PMF RATIOS TO WARNERS HOLLOW CREEK DAM

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

IHYDG IUNG TARFA SNAP TRSDA TRSPC RATIO ISNOW ISAME LOCAL
1 1 2.34 0.00 2.34 0.00 0.000 0 1 1 0

HYDROGRAPH DATA

PRECIP DATA
R6 R12 R24 R48 R72 R96
0.00 23.70 113.00 123.00 132.00 0.00 0.00

TRSPC COMPUTED BY THE PROGRAM IS .900

LOSS DATA

LROPT STRKP DLTKP RTIOL FRAIN STRKS RTIOK STRTL CNSTL ALSMX RTIMP
0 0.00 0.00 1.00 1.00 0.00 0.00 1.00 1.00 .05 0.00 0.00

UNIT HYDROGRAPH DATA

TP= 2.95 CP= .75 NTA= 0

RECESSION DATA

STRTO= -1.00 ORCSN= -.05 RTIDR= 2.00

UNIT HYDROGRAPH 46 END-OF-PERIOD ORDINATES, LAG= 2.95 HOURS, CP= .75 VOL= 1.00
10. 34. 77. 170. 167. 215. 263. 308. 346. 372.
387. 392. 387. 370. 336. 293. 255. 222. 193. 168.
145. 127. 110. 96. 83. 73. 63. 55. 49. 41.
36. 31. 27. 24. 21. 14. 16. 12. 10.

END-OF-PERIOD FLOW

MO,DA HR,MIN PERIOD RAIN EXCS LOSS COMP 0 MO,DA HR,MIN PERIOD RAIN EXCS LOSS COMP 0

SUM 25.03 23.18 1.85 141613.
(630.11 589.11 47.11 4010.031

HYDROGRAPH ROUTING

ROUTED FLOWS THROUGH EDGERMONT RESERVOIR

ISTAO 2 ICOMP 1 IECON 0 ITAPE 0 JPLI 2 JPRI 0 INAME 1 ISTAGE 1 AUTO 0

ALL PLANS HAVE SAME ROUTING DATA

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

NSTPS NSTDL LAG ANSKK X TSK STORA ISPRAT
 1 0 0 0.000 0.000 0.000 246. -1

STAGE	901.00	902.00	903.00	904.00	904.50	905.00	908.00
FLOW	0.00	142.00	401.00	737.00	929.00	1135.00	2627.00
CAPACITY	0.	10.	39.	94.	133.	179.	233.
ELEVATION	855.	865.	875.	885.	890.	895.	900.
							901.
							905.
							910.

CPEL SPVID COOH EXPM ELFVL COOL CAREA EXPL
 901.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

DAM DATA

TDRFL COOD EXPD DAMVID
 904.7 3.1 1.5 700.

CREST LENGTH 0. 52. 7004
 AT OR BELOW FLEWATTON 904.7 904.9 905.0

DAM BREACH DATA
 DRVID 2 ELBM TFAIL WSFL FAILFL
 100. 1.00 860.00 2.00 901.00 905.65

BEGIN DAM FAILURE AT 17.75 HOURS
 PEAK OUTFLOW IS 595% AT TIME 14.29 HOURS

DAM BREACH DATA
RRVID Z ELOP YFAIL WSEL FAILLE
100. 1.00 440.00 2.00 901.00 906.00

PEAK OUTFLOW IS 2960. AT TIME 18.50 HOURS

HYDROGRAPH ROUTING

CHANNEL ROUTING-MOD PULS REACH 2-3

ISTAG. ICOMP IFCM ITAPE JPLT JPRT INAME ISTAGE I AUTO
3 1 0 0 0 0 0 0 0 0

ALL PLANS WAVE SAME

QICSS CLOSS AVG IRES ISAME IOPT IPMP LSTR
0.0 0.000 0.00 1 1 0 0 0
NSTPS NSTOL LAG ANSKK X TSK STORA ISPRAT
1 0 0 C.000 0.000 0.000 0.0 0

NORMAL DEPTH CHANNEL ROUTING

ONE(1) ONE(2) ONE(3) FLNVT FLMAX RENTH SEL
.0400 .0300 .0400 890.0 1000. 02000

CROSS SECTION COORDINATES--STA,ELF,STA,ELFV--ETC

0.00 840.00 20.00 840.00 35.00 845.00 45.00 835.00 75.00 835.00
76.00 845.00 96.00 845.00 120.00 840.00

STORAGE 0.00 1.70 1.55 7.66 16.81 19.34 22.49 26.99
31.55 24.44 41.52 52.71 58.64 66.82 77.94 84.88

OUTFLOW 0.00 847.15 2606.91 5017.50 7995.14 12336.05 18107.12 25019.95 33029.95 42122.03
52264.24 63560.23 75961.39 94622.29 104099.28 119489.99 136852.97 155007.41 174372.97 194969.63

STAGE 835.00 837.37 837.74 842.11 846.84 849.21 851.59 856.32
859.69 861.05 863.42 865.79 868.16 872.89 875.26 877.63 880.00

FLOW 0.00 847.15 2406.91 5017.50 7995.14 12336.05 18107.12 25019.95 33029.95 42122.03
52264.24 63560.23 75961.39 94622.29 104099.28 119489.99 136852.97 155007.41 174372.97 194969.63

MAXIMUM STAGE IS 842.0

MAXIMUM STAGE IS 840.1

HYDROGRAPH ROUTING

CHANNEL ROUTING-MOD PULS REACH 3-4

ISTAQ 4 ICOMP 1 IECON 0 ITAPF 0 JPLT 0 JPRT 0 INAME 0 IASTG 0 IAUTD 0

ALL PLANS HAVE SAME

ROUTING DATA
 CLOSS CLOSS AVG IOPT IPMP LSTR
 C.O 0.000 0.00 1 0 0

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

NORMAL DEPTH CHANNEL ROUTING

ON(1) ON(2) ON(3) ELYVT FLMAX RLNTH SEL
 .0400 .0300 .0400 780.0 830.0 1500. .03700

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

0.00 830.00 800.00 820.00 1400.00 783.00 1401.00 780.00 1416.00 780.00
 1417.00 783.00 1437.00 783.00 1540.00 830.00

STORAGE	C.CC	1.44	6.16	15.48	29.20	47.30	69.79	96.67	127.94	163.61
	203.65	248.10	296.93	350.15	407.76	469.75	541.01	631.56	741.72	871.44
OUTFLOW	C.CC	640.68	3001.97	8939.63	18605.02	36080.53	59361.86	90379.26	130006.69	179031.51
	238402.20	308737.65	390830.75	435401.77	593150.59	714758.95	784453.54	816829.79	1033762.55	1223235.81
STAGE	78C.CC	782.63	785.26	787.99	790.53	793.16	795.79	798.42	801.05	803.61
	806.32	809.95	811.58	814.21	816.84	819.47	822.11	824.74	827.37	830.01
FLOW	C.CC	640.69	3001.97	8939.63	18605.02	36080.53	59361.86	90379.26	130006.69	179031.51
	238402.20	308737.65	390830.75	435401.77	593150.59	714758.95	784453.54	816829.79	1033762.55	1223235.81

MAXIMUM STAGE IS 795.6

MAXIMUM STAGE IS 745.2

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

RATIOS APPLIED TO FLOWS

OPERATION STATION AREA PLAN RATIO 1
 .50

HYDROGRAPH AT 1 2.34 1 2960.
 (5.06) (83.82)(
 2 2960.
 (83.82)(

ROUTED TO 2 2.34 1 5877.
 (6.06) (156.42)(
 2 2960.
 (83.80)(

ROUTED TO 3 2.34 1 5918.
 (6.06) (167.58)(
 2 2959.
 (83.74)(

ROUTED TO 4 2.34 1 5912.
 (6.06) (167.41)(
 2 2959.
 (83.80)(

SUMMARY OF DAM SAFETY ANALYSIS

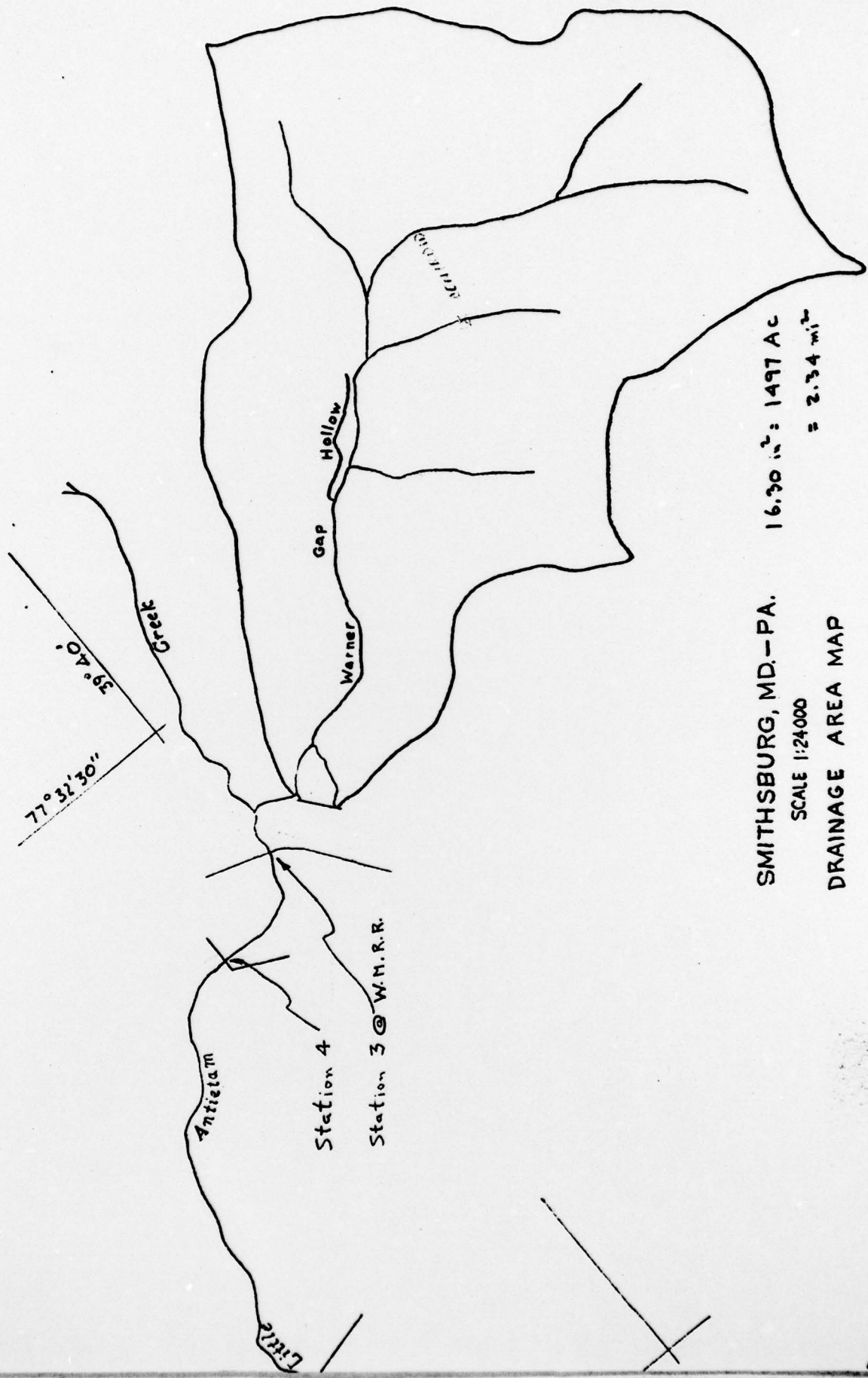
PLAN 1	ELEVATION STORAGE OUTFLOW	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM			
	MAXIMUM RESERVOIR W.S. ELEV	903.65	MAXIMUM OUTFLOW CFS	5955.	DURATION OVER TOP HOURS	2.46	TIME OF FAILURE HOURS
	MAXIMUM STORAGE AC-FT	306.	MAXIMUM OUTFLOW CFS	5955.	DURATION OVER TOP HOURS	2.46	TIME OF FAILURE HOURS
	MAXIMUM DEPTH OVER DAM	1.00	MAXIMUM STORAGE AC-FT	306.	DURATION OVER TOP HOURS	2.46	TIME OF FAILURE HOURS
	MAXIMUM STORAGE OUTFLOW	901.00	SPILLWAY CREST	901.00	TOP OF DAM	904.65	
	MAXIMUM STORAGE	246.	MAXIMUM STORAGE	246.	TOP OF DAM	904.65	
	MAXIMUM STORAGE OUTFLOW	0.	MAXIMUM STORAGE	0.	TOP OF DAM	901.	

PLAN 2	ELEVATION STORAGE OUTFLOW	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM			
	MAXIMUM RESERVOIR W.S. ELEV	905.71	MAXIMUM OUTFLOW CFS	2940.	DURATION OVER TOP HOURS	6.50	TIME OF FAILURE HOURS
	MAXIMUM STORAGE AC-FT	307.	MAXIMUM OUTFLOW CFS	2940.	DURATION OVER TOP HOURS	6.50	TIME OF FAILURE HOURS
	MAXIMUM DEPTH OVER DAM	1.06	MAXIMUM STORAGE AC-FT	307.	DURATION OVER TOP HOURS	6.50	TIME OF FAILURE HOURS
	MAXIMUM STORAGE OUTFLOW	901.00	SPILLWAY CREST	901.00	TOP OF DAM	904.65	
	MAXIMUM STORAGE	246.	MAXIMUM STORAGE	246.	TOP OF DAM	904.65	
	MAXIMUM STORAGE OUTFLOW	0.	MAXIMUM STORAGE	0.	TOP OF DAM	901.	

PLAN 3	RATIO	MAXIMUM FLOW CFS	MAXIMUM STAGE FT	TIME HOURS
	.50	5919.	842.9	19.25

PLAN 4	RATIO	MAXIMUM FLOW CFS	MAXIMUM STAGE FT	TIME HOURS
	.50	2959.	840.1	19.50

PLAN 5	RATIO	MAXIMUM FLOW CFS	MAXIMUM STAGE FT	TIME HOURS
	.50	2959.	786.6	18.25



SMITHSBURG, MD. - PA.
 SCALE 1:24000
 DRAINAGE AREA MAP

16.30 in.² = 1497 Ac
 = 2.34 mi.²

APPENDIX F
GEOLOGY REPORT

APPENDIX F
GEOLOGY REPORT

GEOLOGY REPORT
EDGEMONT RESERVOIR
WASHINGTON COUNTY, MARYLAND

Washington County is located in the Appalachian Highlands geologic division and is bounded by the western slope of the Blue Ridge province on the east and the center of the Ridge and Valley province on the west. The eastern portion of the county is traversed by the major structural unit known as the South Mountain Anticlinorium. Edgemont Reservoir is situated within this unit on the western slope of the South Mountain anticline.

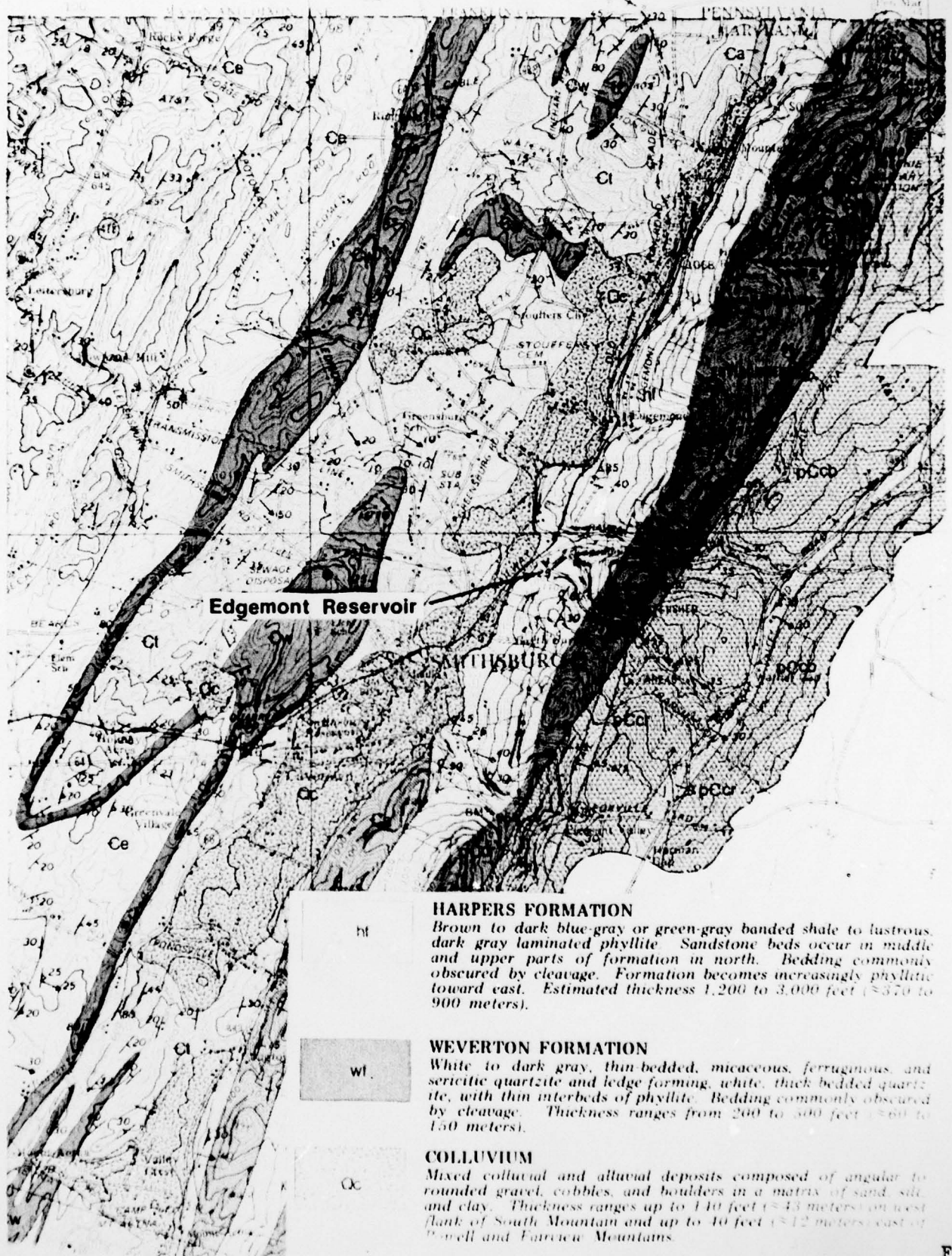
The reservoir, dam, and appurtenant structures are all underlain by the Harper's formation which is characterized by brown to dark blue gray banded shale and dark gray banded laminated phyllite of Cambrian age. The bedding of this formation is vertical or overturned and cleavage is intense. The cleavage strikes N45°E and dips 35°SE.

The Harper's formation weathers to a silty clay and silt of low plasticity with many rock fragments designated as Edgemont - Laidig channery loam and Chewacla silt loam by the USDA Soil Conservation Service. The soil cover is relatively thin ranging from 3 to 5 feet in thickness. The results of the limited subsurface explorations performed for the remedial grouting study in 1968 indicate the embankment to consist of clayey silt and silty clay with rock fragments, corresponding to the natural soil available in the reservoir area. These materials were placed on weathered phyllite of the Harper's formation. The rock in the upper portion of the foundation was found to be highly fractured and dye tests revealed the fractures to be hydraulically open. The consultant concluded that the primary source of leakage at the right abutment was through the fractured rock foundation and a successful grouting program was implemented.

The orientation of the cleavage planes alone, with strike paralleling the dam and dipping toward the dam, would ordinarily lead to predictions of only minor seepage through the foundation. The concentrated leakage at the right abutment and the seepage at the left side of the dam possibly indicate hydraulically open fractures oriented transverse to the axis of the dam. Although the foundation strength and competency should not be affected by seepage, the integrity of the embankment could be vulnerable to internal erosion.

WASHINGTON COUNTY GEOLOGIC MAP

Scale 1:62500



Edgemont Reservoir

HARPERS FORMATION

ht

Brown to dark blue-gray or green-gray banded shale to lustrous, dark gray laminated phyllite. Sandstone beds occur in middle and upper parts of formation in north. Bedding commonly obscured by cleavage. Formation becomes increasingly phyllitic toward east. Estimated thickness 1,200 to 3,000 feet (≈ 370 to 900 meters).

WEVERTON FORMATION

wl

White to dark gray, thin bedded, micaceous, ferruginous, and sericitic quartzite and ledge forming, white, thick bedded quartzite, with thin interbeds of phyllite. Bedding commonly obscured by cleavage. Thickness ranges from 200 to 500 feet (≈ 60 to 150 meters).

COLLUVIUM

cc

Mixed colluvial and alluvial deposits composed of angular to rounded gravel, cobbles, and boulders in a matrix of sand, silt, and clay. Thickness ranges up to 140 feet (≈ 43 meters) on west flank of South Mountain and up to 40 feet (≈ 12 meters) east of Powell and Fairview Mountains.

REFERENCES

1. Department of Geology, Mines, and Water Resources, The Water Resources of Allegany and Washington Counties, Bulletin 24, 1961.
2. Department of Geology, Mines, and Water Resources, The Physical Features of Washington County, 1951.
3. United States Department of Agriculture, Soil Conservation Service, Soil Survey of Washington County; Maryland, October 1962.